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DEPARTMENT OF DEFENSE STANDARD PRACTICE

WORK BREAKDOWN STRUCTURES FOR DEFENSE MATERIEL ITEMS

AMSC 9915 AREA MISC

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FOREWORD

1. This Standard is approved for use by all Departments and Agencies of the Department of Defense (DoD). It is for direction and should be included as a contract requirement.

2. This Standard addresses mandatory procedures for all programs subject to DoD Instruction 5000.02.

3. This military standard is applicable to all defense materiel items (or major modifications) (a) established as an integral program element of the Future Years Defense Program (FYDP), or (b) otherwise designated by the DoD Component or the Under Secretary of Defense (Acquisition). This Standard is mandatory for all Acquisition Category (ACAT) programs. This revision has resulted in many changes being incorporated into MIL-STD-881D, but the most significant ones include the following:

   a. Appendix A - Aircraft Systems and Appendix H - Unmanned Aircraft Systems have been merged into a new Appendix A - Aircraft Systems, since unmanned aircraft are considered Aircraft Systems.

   b. Appendix C – Missile Systems and Appendix D – Ordnance Systems have been merged into a new Appendix C – Missile/Ordnance Systems which focuses on tactical missiles and munitions due to their commonality in structure and intent.

   c. Appendix D is now Strategic Missiles Systems which focuses on Intercontinental Ballistic Missiles (ICBM) and strategic missiles used by Missile Defense Agency. Previously strategic missiles were part of Appendix C – Missiles Systems.

   d. New and revised definitions have been incorporated into Appendix F – Space Systems to improve clarity and understanding of application.

   e. Changed the title of Appendix G from Surface Vehicle Systems to Ground Vehicle Systems to reflect the common terminology for land and amphibious systems.

   f. Changed the WBS in Appendix G – Ground Vehicle Systems to reflect the approach to buying family of systems vehicles (i.e., variants).

   g. Changed the title of Automated Information Systems (now Appendix J) to Information Systems/Defense Business Systems to reflect DoDI 5000.75: “Business Systems Requirements and Acquisition.”

   h. Added a Sustainment Structure for Information Systems/Defense Business Systems (Appendix J) to recognize the overlap of acquisition and sustainment activities on the acquisition contract. For IS/DBS, this structure

should be used to appropriately reflect sustainment activities on IS/DBS programs.

i. Added and defined in the Common Elements Appendix (Appendix K) required reporting elements under Systems Engineering, Program Management, and System Test and Evaluation related to Integrated Logistics Support, Software Engineering and Management, and Cybersecurity.

j. Required Rate Tooling to be separately identified within Integration, Assembly, Test, and Checkout at the appropriate level.

k. Further defined Peculiar Support Equipment and Common Support Equipment (Appendix K) to a lower level which identifies the subassembly the equipment supports, (e.g., Airframe/Hull/Vehicle, etc.).

l. Added Contractor Logistics Support (CLS) (Appendix K) to reflect that contractor sustainment support may be completed at the depot during the acquisition phase.

m. Added Data Rights under Data (Appendix K) to reflect the Government purchase of contractor data rights.

n. Included the Cost Assessment Program Evaluation (CAPE) Sustainment Cost Reporting Structure (CRS) (Appendix L) to provide a description of the transition between the Work Breakdown Structure (WBS) to the CRS during a program.

4. A Work Breakdown Structure (WBS) provides a consistent and visible framework for defense materiel items and contracts within a program. This Standard offers uniformity in definition and consistency of approach for developing all levels of the WBS. Generating and applying uniform work breakdown structures improves communication in the acquisition process. It also provides direction to industry in extending contract work breakdown structures.

5. This Standard supersedes MIL-STD-881C, dated 3 October 2011, titled Work Breakdown Structures for Defense Materiel Items. MIL-STD-881D is based on the cooperative efforts of the military services with assistance from industrial associations. Changes to the Standard specifically address advances in technology and modifications of the acquisition process, and incorporates new materiel items, development concepts, and approaches.

6. Comments (such as recommendations, additions, or deletions) and any pertinent information, which may be useful in improving this document, should be addressed to the Office of the Performance Assessment and Root Cause Analysis (PARCA), 3620 Defense Pentagon, Rm 3C889A, Washington DC 20301-3620. Since contact information can change, you may want to verify the currency of this address information using the ASSIST online database at https://assist.dla.mil.

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1. GENERAL INFORMATION

1.1 Standard Purpose and Structure. This Standard presents direction for effectively preparing, understanding, and presenting a Work Breakdown Structure (WBS). It provides the framework for Department of Defense (DoD) Program Managers to define their program's WBS and to defense contractors in their application and extension of the contract's WBS. Section 1 defines and describes the WBS. Section 2 provides instructions on how the WBS is applied as well as how to develop a Program WBS in the pre-award timeframe. Section 3 provides direction for developing and implementing a Contract WBS and Section 4 examines the role of the WBS in the post-award timeframe. This Standard also provides WBS definitions for specific defense materiel commodity systems in Appendices A through J. Appendix K addresses WBS elements that are common to all systems, as well as those which use unique elements (e.g., Space Systems, Information Systems/Defense Business Systems, Launch Systems, and Strategic Missile Systems). Appendix L presents for the DoD Sustainment Cost Reporting Structure (CRS) and its associated definitions for informational purposes. The purpose of providing sustainment information is to present an explanation of transitioning from reporting using a WBS to reporting sustainment costs using the CRS, regardless of acquisition phase or type of funds used.

The primary objective of this Standard is to achieve a consistent application of the WBS for all programmatic needs (including performance, cost, schedule, risk, budget, and contractual). Discussion and direction was compiled based on many years of lessons learned in employing WBSs on defense programs.

1.2 Support Documentation. The foundation for a WBS is contained in DoD Directive 5000.01 and DoD Instruction 5000.02. These documents identify responsibilities in the acquisition process from the Office of the Secretary of Defense to the DoD component field activities. Preparing a WBS is generally discussed in the context of planning and monitoring a defense system program.

DoD Directive 5000.01 "The Defense Acquisition System" requires a disciplined approach in establishing program goals over its life cycle with streamlined and effective management that "is accountable for credible cost, schedule, and performance reporting." The WBS is a critical tool in ensuring all portions of the program are covered. The WBS will also facilitate the required collaboration within the Integrated Product Team (IPT) structure by providing a tie between performance, cost, schedule, and risk information. The WBS can also facilitate the required technical rigor and integrated test and evaluation throughout the defense acquisition process.

DoD Instruction 5000.02 "Operation of the Defense Acquisition System" further outlines the required framework and provides impetus for use of a WBS. The evolution of the system through incremental development further drives the requirement to break down the system in a structure that clarifies which capabilities will be satisfied in a specific increment of the system development. The instruction sets the requirements for Integrated Master Schedules (IMS), Earned Value Management (EVM) and other statutory, regulatory, and contract reporting information and milestone requirements in which the WBS is a critical element.

The WBS is also a critical link to the Systems Engineering Plan (SEP), which is required to be developed prior to all milestone decisions for all Acquisition Category (ACAT) programs. Guidelines for the SEP are included in the SEP Annotated Outline (current version).

In addition, the purpose of the Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3170.01 (current version) in concert with the Manual for the Operation of the Joint Capabilities Integration and Development System (JCIDS) (current version) is to establish the policies and procedures of the JCIDS, which directly support the DoD acquisition process and hence has WBS implications.

The Program WBS and Contract WBS aid in documenting the work effort necessary to produce and maintain architectural products in a system life cycle. The DoD Architecture Framework (DoDAF) (current version) defines a common approach for DoD architecture description development, presentation, and integration for warfighting operations and business operations and processes.

Finally, the Defense Acquisition Guidebook (DAG) is a source of best practices and includes numerous references to the use of a WBS.

1.3 What Does a WBS Accomplish? The following will discuss Applications, Benefits, and Challenges with regard to the WBS.

1.3.1 Applications. This Standard addresses two fundamental and interrelated WBS structures: (1) the Program WBS and (2) the Contract WBS (including flow-down reporting requirements).

The Program WBS provides a framework for specifying program objectives. Each WBS element provides logical summary levels for assessing technical accomplishments, for supporting the required event-based technical reviews, and for measuring cost and schedule performance. The WBS defines the program in terms of hierarchically-related, product-oriented elements and includes “other Government” elements (for example, Program Office Operations, Manpower, Government Furnished Equipment (GFE), and Government Testing). It represents the entire program from the Government Program Manager’s responsibility. There is only one Program WBS.

The Contract WBS is the Government approved WBS for program reporting purposes and includes all program elements (for example, hardware, software, services, data, or facilities), which are the contractor’s responsibility. It includes the contractor’s discretionary extension to lower levels, in accordance with Government direction and the contract Statement of Work (SOW). Depending on the program, there may be multiple Contract WBSs if there is more than one prime contractor.

The WBS is defined, developed, and maintained throughout the system life cycle based on a disciplined application of the systems engineering process. The goal is to develop a WBS that defines the logical relationship among all program elements to a specific reporting level of indenture that does not constrain the contractor’s ability to define or manage the program and resources. However, if the Government considers some program elements to be high-cost, high-risk, high technical, and/or special interest, the system may be defined to a lower level of the WBS for those elements only; this is reasonable if the product-oriented logical extension is maintained. The contractor should extend all other elements to the level and form based on the way they are planning to develop, produce, and manage the system.

A secondary, but still important goal, is that the WBS serves as a coordinating medium. Through the Program WBS and the Contract WBS, work progress is documented as resources are allocated and expended. Performance, cost, schedule, and technical data are routinely generated for reporting purposes. The WBS is the infrastructure to summarize data for successive levels of management and provide appropriate information on projected, actual, and status of the individual elements. When appropriately structured and used in conjunction with systems engineering principles, cost estimating, EVM, integrated scheduling, and risk management, the WBS allows for program status to be continuously visible so the program manager and the contractor can identify, coordinate, and implement changes necessary for desired results.

The WBS applies to the specific categories of defense materiel items listed below. These are further discussed in 1.5 and complete definitions of each are included as Appendices A through K.

a. Aircraft Systems

b. Electronic/Generic Systems

c. Missile/Ordnance Systems

d. Strategic Missile Systems

e. Sea Systems

f. Space Systems

g. Ground Vehicle Systems

h. Unmanned Maritime Systems

i. Launch Vehicle Systems

j. Information Systems/Defense Business Systems

k. Common Elements

l. Sustainment Cost Reporting Structure (For Information Only)

1.3.2 Benefits. The WBS assists in several ways during the program life cycle:

a. Decomposes a defense materiel item into its component parts, clarifying the relationship among the parts, and the relationship of the tasks to be completed both to each other and to the end product.

b. Facilitates effective planning and assignment of management and technical responsibilities.

c. Aids status tracking of technical efforts, risks, resource allocations, expenditures, and cost/schedule/technical performance.

d. Helps ensure that contractors identify the item requirements and their relationship to the WBS.

e. Provides a common thread for the Earned Value Management System (EVMS), the Integrated Master Plan (IMP), the Integrated Master Schedule (IMS), and Cost and Software Data Report (CSDR) allowing consistency in understanding program cost and schedule performance.

1.3.3 Challenges. The primary challenge is to develop a WBS that defines the logical relationship between all program elements without constraining work necessary to achieve program objectives and meets all program reporting requirements. A WBS should be sufficient to provide necessary program insights for effective status reporting and risk mitigation, facilitating the contractor's ability to effectively execute the program.

A secondary challenge is to balance the program definition aspects of the WBS with its data-generating aspects. Using available data to build historic files to aid in the future development of similar defense materiel items is a very valuable resource. The information gathered is critical to understanding the cost drivers and risk impact on future systems. However, the primary purpose of the WBS is to define the program's structure based on the scope of work, while providing the contractor the ability to plan, establish, and manage the program for which they are responsible. The need for data should not distort or hinder the ability for the contractor to perform their responsibilities in developing, producing, and delivering the program.

1.4 How is the WBS Related to Other Contract Requirements? The WBS provides a basis for effective communication throughout the acquisition process. It is a common link, integrating planning, scheduling, cost estimating, budgeting, contracting, configuration management, performance reporting disciplines, and others. It permits the Government and Industry program managers to continually evaluate progress in terms of contract performance.

The WBS forms the basis of reporting structures used for contracts requiring compliance with EIA 748 EVMS Guidelines (current version) and reports placed on contract such as Cost and Software Data Reporting (CSDR), Integrated Program Management Report (IPMR) and its legacy Cost Performance Report (CPR).

1.5 Definitions. The following definitions are intended to improve continuity and support a common understanding of program expectations.

1.5.1 Program Element (PE). The program element is the basic building block of the Future Years Defense Program (FYDP). The PE describes the program mission and identifies the organization responsible for performing the mission. A PE may consist of forces, manpower, materiel (both real and personal property), services and associated costs, as applicable.

1.5.2 Defense Materiel Item. This term refers to equipment, apparatus, and supplies of a military force or other organization. It identifies a system or item usually established as an integral PE or identified as a project within an aggregated PE.

1.5.3 Work Breakdown Structure (WBS). This term is defined as:

a. A product-oriented family tree composed of hardware, software, services, data, and facilities. The family tree results from systems engineering efforts during the pre-acquisition and acquisition of a defense materiel item.

b. A WBS displays and defines the product, or products, to be developed and/or produced. It relates the elements of work to be accomplished to each other and to the end product. In other words, the WBS is an organized method to break down a product into sub-products at lower levels of detail.

c. A WBS can be expressed to any level of detail. The reporting level on any program or contract will be coordinated between the Government and the contractor. For effective management of complex programs, it may require WBS definition to go to lower levels. This is particularly true of items identified as high-cost, high-risk, high technical, and/or special interest. Under these circumstances, it is critical to define the product at the WBS level where this potential cost driving element appears. However, managers should distinguish between WBS definition and WBS reporting. The WBS should be defined at the level necessary to identify work progress and enable effective management, regardless of the WBS level reported for program oversight.

1.5.4 Common Elements. The term “Common Elements” refers to the elements listed below that are applicable to all major systems and subsystems as required:

a. Integration, Assembly, Test, and Checkout

b. Systems Engineering

c. Program Management

d. System Test and Evaluation

e. Training

f. Data

g. Peculiar Support Equipment

h. Common Support Equipment

i. Operational/Site Activation

j. Industrial Facilities

k. Initial Spares and Repair Parts

These common elements are described in further detail in Appendix K. Appendix K also contains sections for unique application for the following:

a. Common Elements K.4 – Space Systems

b. Common Elements K.5 – Launch Vehicle Systems

c. Common Elements K.6 – Information Systems/Defense Business Systems

d. Common Elements K.7 – Strategic Missile Systems

In addition to these common elements, each defense system has a unique combination of hardware and software, which defines the capability or end product of that system.

a. **Aircraft System** – Applies to fixed or movable wing, rotary wing, or compound wing manned or unmanned air vehicles designed for powered or unpowered (for example, a glider) guided flight

b. **Electronic/Generic System** – Applies to electronic system capability (for example, processor, radio, electronic warfare, radar, etc.). This appendix also serves as a generic structure to use for any system or subsystem which is stand-alone or does not appear in the MIL-STD.

c. **Missile/Ordnance System** – Applies to a tactical missile or munition (nuclear, biological, chemical, psychological, and pyrotechnic) in an operational endo-atmospheric environment, which produces a destructive effect on selected targets and the means of launching or firing them.

d. **Strategic Missile System** – Applies to a missile which is capable of completing missions exo-atmospheric and launched with the objective of delivering one or more warheads to a predetermined target, provide an orbital defense layer against hostile ballistic missiles, or may be used as an interceptor (i.e., kill vehicle) to disable or destroy a target

e. **Sea System** – Applies to manned surface and submersible ship platforms, systems, weapons, and equipment required for performing naval tasks at sea.

f. **Space System** – Applies to unmanned Earth orbiting space vehicles (satellites) which have specific orbit placement and operation.

g. **Ground Vehicle System** – Applies to tracked, wheeled and amphibious vehicles that navigate over the ground and water.

h. **Unmanned Maritime System** – Applies to unmanned surface and submersible ship platforms, systems, weapons, and equipment required to perform naval tasks at sea.

i. **Launch Vehicle System** – Applies to development delivery, and maintenance of launch vehicles or carrier rocket used to carry a payload from Earth's surface into outer space.

j. **Information System/Defense Business System** – Applies to development, delivery and maintenance of an assembly of computer hardware, software, firmware, or any combination of these, configured to accomplish specific information-handling operations, such as communication, processing, and storage of information. Included are Enterprise Resource Planning systems (ERPs), Management Information Systems (MIS), business systems, networks, or other electronic information handling systems, and associated equipment.

1.5.5 Level Identification. Each Appendix specifies at least three or four WBS levels. Some appendices specify five levels.

a. Level 1 is the entire system and/or program, a program element, project or subprogram, for example, an electronic system. An "electronic system" might be a command and control system, a radar system, a communications system, a sensor system, navigation or guidance system, or electronic warfare system.

b. Level 2 elements are the major elements subordinate to the Level 1 major elements, for example, an air vehicle of a missile or aircraft system. These major elements are prime mission products, which include all hardware and software elements. Level 2 elements also include aggregations of system-level services (for example, systems engineering, system test and evaluation, program management and data).

c. Level 3 elements are elements subordinate to Level 2 major elements and include hardware, software, and services. For example, avionics, vehicle subsystems, or the Development Test and Evaluation (DT&E) subordinate element of System Test and Evaluation, or equipment for instruction in Training.

d. Level 4 and 5 elements follow the same process of breakdown and are elements subordinate to Level 3 and represent a further definition of the hardware, software, and services. For example, major subsystems of the radar data processor. Lower level elements follow the same process.

1.5.6 Program WBS. The Program WBS encompasses an entire program, including the Contract WBS and "other Government" elements (for example, Program Office Operations, Manpower, Government Furnished Equipment (GFE), Government Testing). It defines at a high level what is to be procured. The Program WBS is used by the Government program manager and contractor to develop and extend a Contract WBS. It contains uniform terminology, definitions, and placement in the product-oriented family tree structure. For reporting purposes, the Program WBS serves as a consolidation mechanism for multiple subordinate contracts. The MIL-STD does not fully define a DoD Program WBS since "other Government" elements are not defined in this document.

1.5.7 Contract WBS. The Contract WBS encompasses the contract deliverable WBS elements which the Government awards to a contractor or supplier. It includes the complete WBS, extended to the agreed-to contract reporting level and any discretionary extensions to lower levels for reporting, which are considered high-cost, high-risk, high technical, and/or special interest. It defines these lower level components as to what is to be procured and includes all the product elements (hardware, software, services, data or facilities), which are defined by the contractor and are their responsibility. The intent is to allow the contractor to define and manage the program elements as they see fit, for it is the comprehensive Contract WBS which forms the framework for the contractor's management control system.

1.5.8 Subcontract WBS. The Subcontract WBS is the complete WBS as included in the DoD approved subcontract plan and WBS extended to the agreed to contract reporting level and any discretionary extension to lower levels for reporting which are considered high-cost, high-risk, high technical, and/or special interest. It defines these lower level components as to what is to be subcontracted and includes all the WBS elements which are defined by the subcontractor and are their responsibility. This comprehensive Subcontract WBS forms the framework for the subcontractor's management control system. The elements in the Subcontract WBS should not be duplicated in the Contract WBS. The prime contractor should report the subcontractor costs in summary against the applicable Contract WBS.

1.6 WBS Evolution. Throughout any system's life cycle, systems engineering leads the system development process. This function includes developing system specifications, functional specifications, or a set of configuration items through requirements analysis, functional analysis and allocation, synthesis and systems analysis, and controls. The important factor is satisfying total systems cost, schedule, and performance requirements at an acceptable level of risk.

As the system is defined and developed, the DoD program manager can better understand and identify the WBS structure that is appropriate for the program. Figure I below provides an illustration of a Weapon System Development Life Cycle.

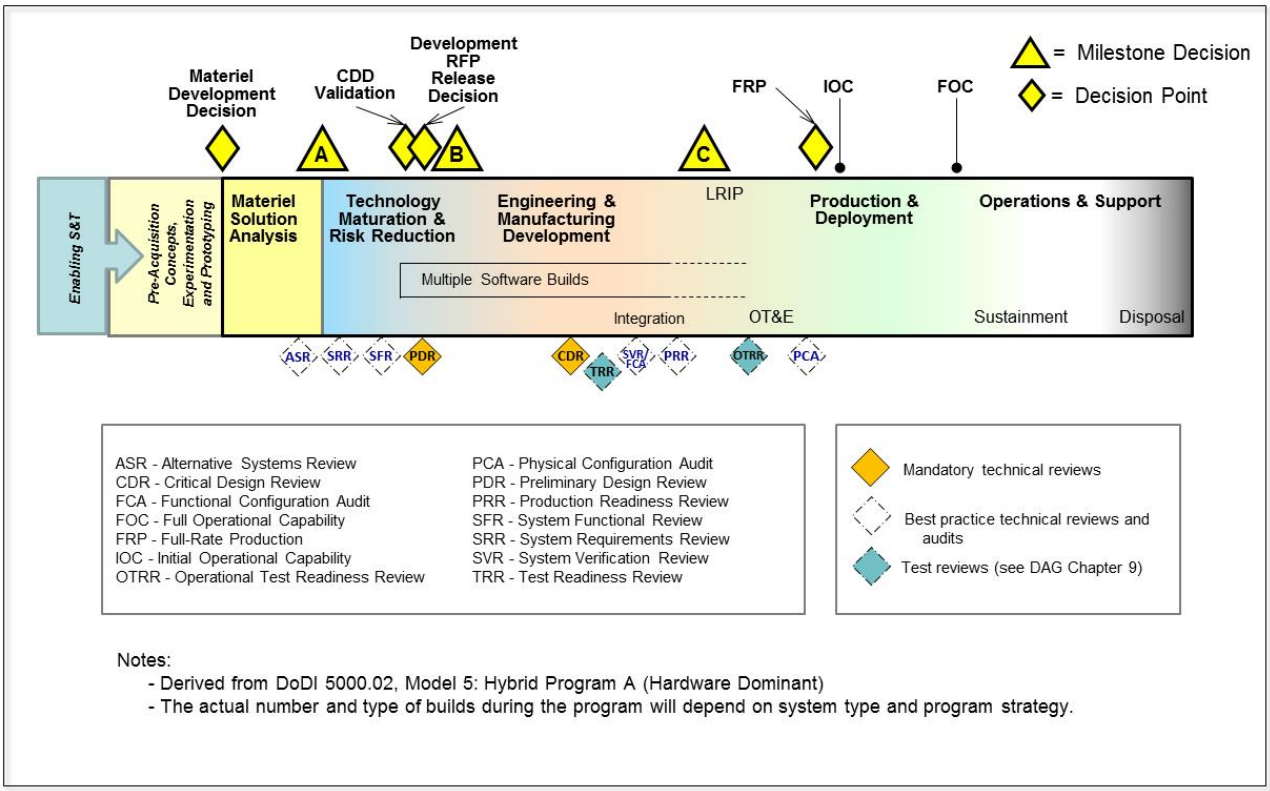

FIGURE I. Weapon system development lifecycle

The Materiel Development Decision (MDD) is the formal entry into the Materiel Solution Analysis phase and the acquisition process and is mandatory for all programs. The purpose of this phase is to pursue a materiel solution to an identified capability gap that meets an established capability need (such as a high technology type aircraft, with incremental improvement to an existing capability, or an entirely new “breakout” or other transformational capability). The Initial Capabilities Document (ICD) establishes conditions for the scope of alternatives to be considered in an Analysis of Alternatives (AoA). The AoA process plays a key role in the selection of a preferred system solution that satisfies the capability need documented in the approved ICD. Throughout the AoA process, a WBS is the key communication tool to establish life cycle cost estimates, the potential solution structure, and the baseline for measuring cost, schedule, and performance criteria.

Throughout the Materiel Solution Analysis phase into the Technology Maturation and Risk Reduction phase (TMRR), the Program WBS provides the basis for the system to be broken into its component parts and support the definition of a potential Contract WBS. The purpose of the TMRR phase is to reduce technical risk, determine the appropriate set of technologies to be integrated into a full system, demonstrate critical technologies on representative prototypes, and in many cases to initiate traceable requirements flow down to complete a preliminary design for the full requirement/full system. These activities form the more detailed development of the WBS.

Program offices planning a Preliminary Design Review (PDR) in the TMRR phase should have a well-documented and defined WBS and associated development schedules. This means that the Program WBS needs to be defined with its associated Contract WBS prior to Milestone B. It is essential that both the Government and the contractor can agree on a fully defined WBS at PDR and future Engineering and Manufacturing Development (EMD) activities.

By the end of the EMD phase, the establishment of the product baseline for all configuration items requires that production-representative articles be demonstrated in their intended environment and that manufacturing processes have been effectively demonstrated prior to Milestone C. Hence, by the end of EMD, the WBS is defined at its lowest levels, which best represents the entire system.

Just as the system is defined and developed throughout its life cycle, so is the WBS. The WBS will be

developed and maintained based on the systems engineering efforts throughout the system's life cycle. Prior to contract award the Program WBS and draft Contract WBS(s) are approved (through the CSDR process). The contractor and the Government will then agree to an extension of the Contract WBS to appropriate lower levels, to better define the complete contract scope. After contract award any change to the WBS must be approved through a contract change. When integrated with the Program WBS, the extended Contract WBS forms a complete WBS, which will be used throughout the program's life cycle. Figure II below displays the WBS Evolution.

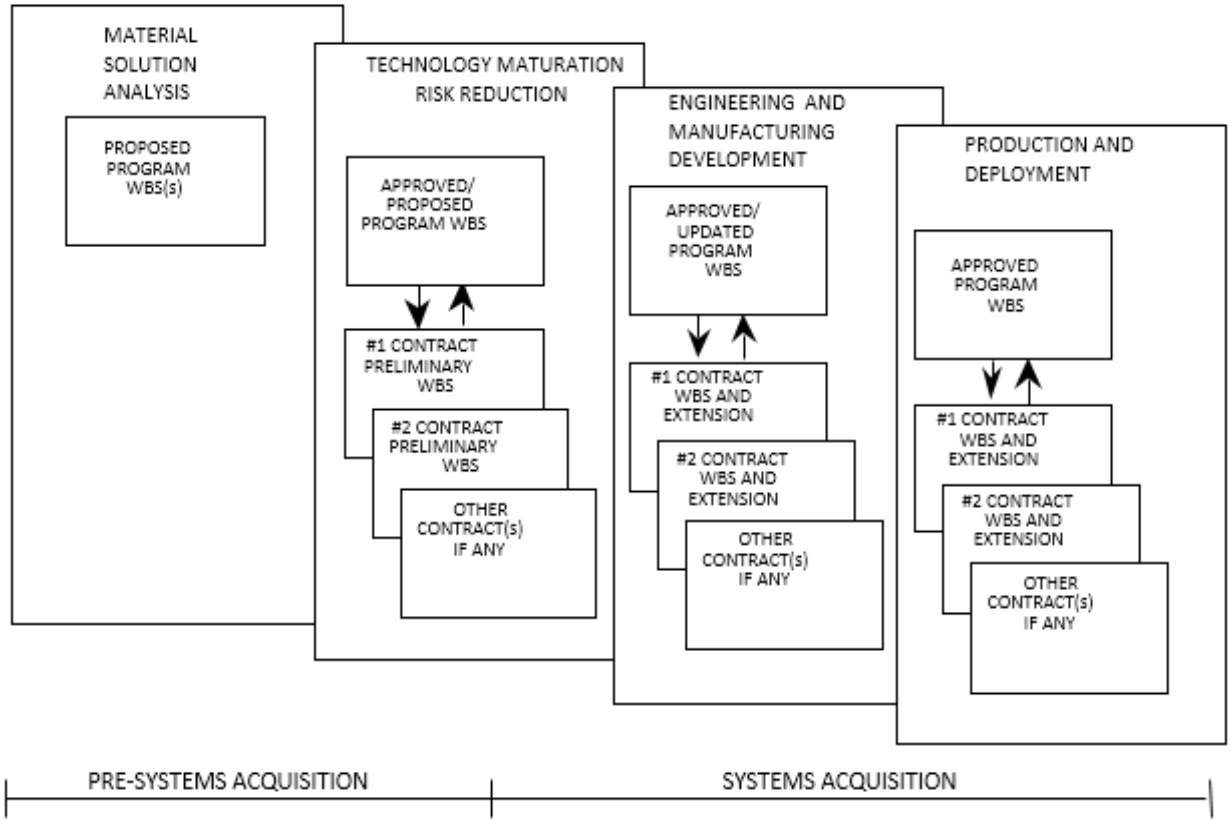

FIGURE II. WBS evolution

2. GOVERNMENT PROGRAM MANAGEMENT INSTRUCTIONS

2.1 Program WBS Attributes. The Program WBS is intended to structurally illustrate a clear understanding of the technical objectives and the end item(s) or end product(s) of the work to be performed by both Government and contract entities.

In order to use the Program WBS as a valuable framework for communicating the technical objectives, it must be product oriented. Its elements must represent identifiable work products, whether they are equipment, data, or related service products. A WBS is a product structure—not an organizational structure—which provides the complete definition of the work to be performed by all participants and the required interfaces between them.

2.2 Preparing a Program WBS.

2.2.1 Developing and Documenting a Program WBS. The Government program manager is responsible for maintaining the Program WBS as it develops through systems engineering and management planning processes.

The WBS may span one or more of the categories or elements defined in Appendices A-K. While these elements normally provide a basis for the Program or Contract WBS, tailoring may occur when a unique requirement exists. As a result, most appendices contain WBS elements designated as "Other" at the subsystem, element (product) levels that are restricted for unique requirements (products) that have not been envisioned or do not exist within the defined WBS elements in the Appendices. When a unique requirement exists, the WBS element

designated as “Other” should be used. If it is determined that the “other” element is needed, the element must be specified and defined and the word “Other” replaced by the newly defined WBS element. If it is determined that the “other” WBS element is not needed, this element should be deleted and not used in the WBS.

In addition, although each appendix relates to a specific category of defense items, any item from any appendix which is applicable to the program may be used, as long as the integrity of its relative level of placement and element definition is maintained. The Program and Contract WBS should always represent the system that is being developed and/or procured.

The Program WBS will guide development early in the program’s life cycle. It will evolve through iterative analysis of the program objective, functional design criteria, program scope, technical performance requirements, and other technical documentation. The documentation will describe the entire plan to build, field, and support the system through fielding. The approved Program WBS defines the approach the Government activity plans to manage, develop, produce, and deploy the system and ensure the program is properly executed.

2.2.2 Selecting Program WBS Elements. The WBS provides a framework for specifying the program objectives by first defining the program in terms of hierarchically related, product-oriented elements and the work processes required for their completion. Each element of the WBS provides logical summary points for assessing technical accomplishments and for measuring the cost and schedule performance accomplished in attaining the specified technical performance.

2.2.3 Determining Levels of Program WBS. The levels of the Program WBS must be related to the system requirements and conform to the product-oriented family tree. The detailed technical objectives are defined, and the scope of work is determined for each WBS element. Then, tasks are assigned to each WBS element. Resources, materials, and processes required for attaining the objectives are added incrementally. This relationship allows all items to be traced to the same WBS elements. Thus, the linkage between the requirements specification, the WBS, the Statement of Work (SOW), the Integrated Master Plan (IMP), and the Integrated Master Schedule (IMS) provides specific insights into the relationship between cost, schedule, and performance.

By following the Weapon System Development Life Cycle (see Figure I), when developing a Program WBS, systems engineers define the description of the system and its related levels. Early in the Materiel Solution Analysis phase, systems engineering efforts transform operational needs to system performance parameters and configurations. For example, suppose the established need is to “Destroy a Tank.” The objective is clear and achievable through numerous capabilities. Systems engineers perform tradeoffs, which ultimately define the preliminary system-level capabilities. In this case, the systems that will “Destroy the Tank” must be able to detect, maneuver, and shoot. The Program WBS is not formed around these functional capabilities but is developed out of the products that are expected to satisfy these requirements.

When the TMRR phase is initiated, the systems engineering development efforts will focus on technical requirements to meet system-level capabilities. Functional requirements are assigned under a system, all meeting the mission need of “Destroy a Tank.” If Government laboratories or in-house engineering support is accomplishing this work, a statement of work (SOW) may be prepared for a request for support in the TMRR phase. Otherwise, this may have already been accomplished at the end of Materiel Solution Analysis phase to obtain contractual support for the TMRR phase.

The TMRR phase should describe the system and the configuration items that make up the system. Once the system concept is determined, then major subsystems and configuration items can be identified, and lower level functions defined, so that lower level system elements can be created. As an example, using the AoA process it was determined that a fire control system of an aircraft would be the best solution to meet the user need. The fire control system is functionally able to detect, aim, track, and fire (see Figure III). Again, these are not WBS elements since they do not reflect a product.

TECHNOLOGY MATURATION/RISK REDUCTION

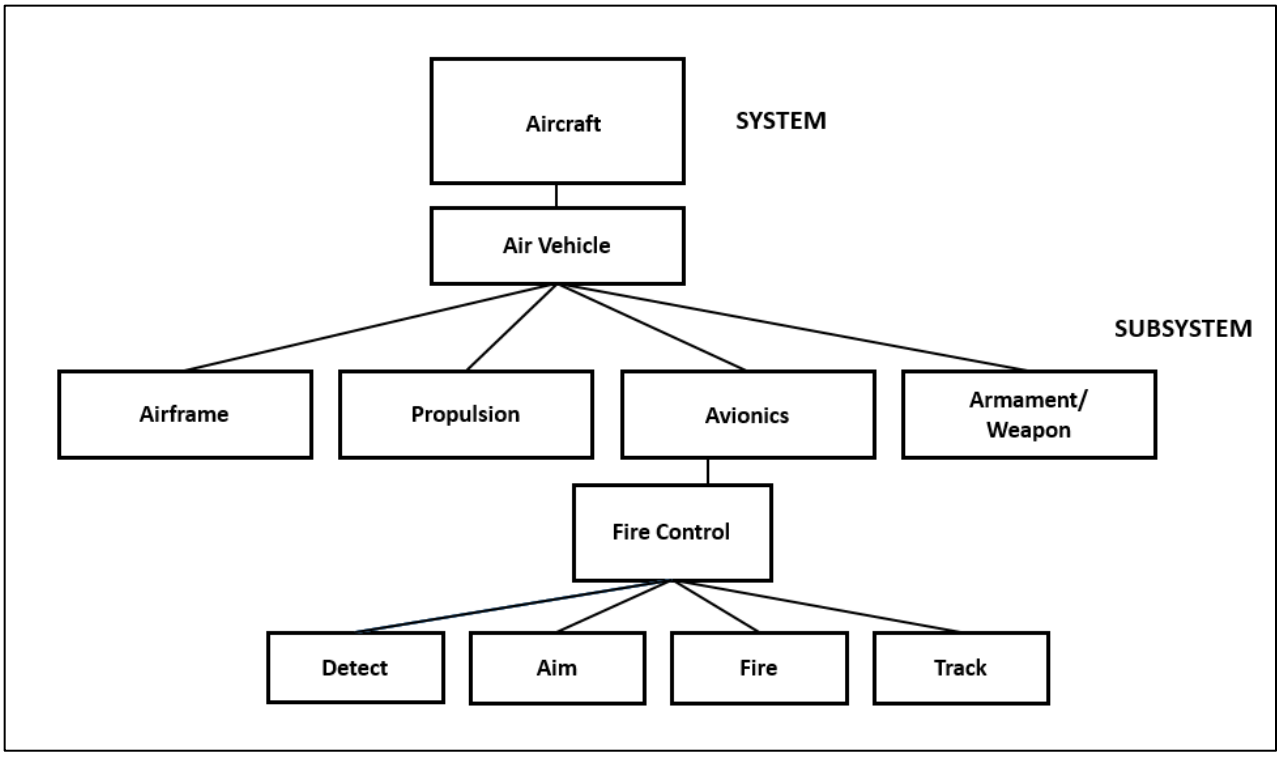

FIGURE III. Identification of major subsystems and functional requirements

The relationship of the functions shown in this example can now be translated into products that will meet the user's requirement. The resulting Program WBS should be defined in accordance with Appendix A, Aircraft Systems WBS and Definitions.

The WBS now defines the solution to the problem in terms of a product. Figure IV shows a simplified representation of the hierarchical relationship of the Aircraft System to the Fire Control Subsystem and to other elements. In practice, this WBS will be developed on the most refined technical representation of the end system available.

Since competitive prototyping is required to be accomplished in the TMRR phase, the TMRR units being developed and produced can be represented in the Program WBS. After appropriate approval to move forward, a request for proposals will be released with a proposed Contract WBS to each contractor developing prototypes.

Government and industry will work together during the TMRR phase to create an acquisition strategy for acquiring the technology required. An evolutionary approach delivers capability in militarily useful increments, recognizing, up front, the need for future capability improvements. This means that programs using an evolutionary acquisition strategy need to establish the approved program's objective and threshold boundaries, and link among the cost, schedule, and performance parameters. The program manager (PM) manages the program within that trade space and the WBS is the key communication tool to support these requirements. The PM will use this information to develop an optimal product within the available trade space for each increment in the evolutionary process. As the TMRR phase ends and activities move into EMD, the best product that meets the cost, schedule, and performance parameters is defined to the level possible within the Government's approved Program WBS. A contract is awarded to the contractor whose solution best meets user needs and cost, schedule, and performance criteria. The Contract WBS is extended to the desired level, reflecting those items considered high cost, high risk, high technical, and/or special interest as well as how the program is planned and will be managed.

TECHNOLOGY MATURATION/RISK REDUCTION

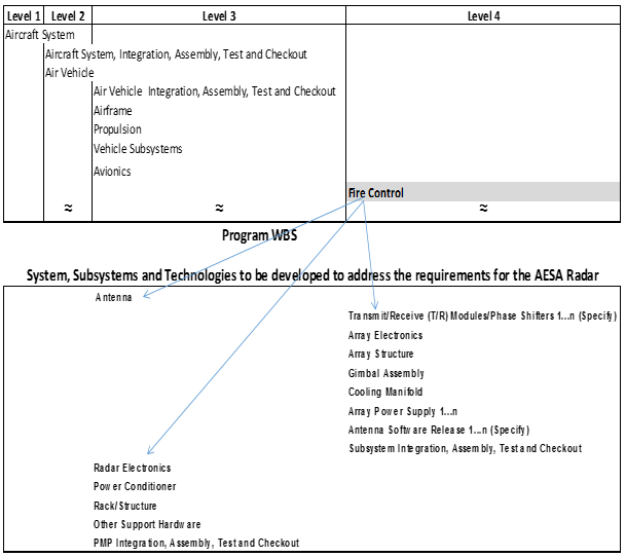

FIGURE IV. Program WBS description

Entering EMD, the effort is intended to define system functionality and interfaces, complete hardware and software detailed design, and reduce system-level risk. It also includes the establishment of the product baseline for all configuration items. Therefore, the configuration of the entire system has been defined, the relationship between the Program WBS and the Contract WBS is developed at its lowest level, and management of the program is accomplished. Figure V depicts a format suitable for documenting the subdivision of a program's work breakdown structure into contract work breakdown structures for each contractor/source. In the example below, the program work breakdown structure Level 4 element, Fire Control becomes Level 1 of the contract work breakdown structure, and all other Level 2 common program work breakdown structure elements (reference Appendix K) are included at Level 2 of the contract work breakdown structure. A separate contract for a Level 4 program work breakdown structure element, such as Aircrew Training Device, also follows the same procedure. The same contract work breakdown structure drawn from the program work breakdown structure will be used for each phase (development and production) of a program. At this point, the WBS is linked to major products and systems and fully integrated with the contractor's systems engineering, program management and financial functions.

During the Production and Deployment phase, the system is produced as defined in previous phases. The systems engineering efforts are actively involved in maintaining control over the system configuration as it is produced. The WBS is defined to the level appropriate for contract management and maintenance. When major modifications occur, the same WBS can be tailored or, if the changes are substantial, a new WBS can be developed according to the same rules.

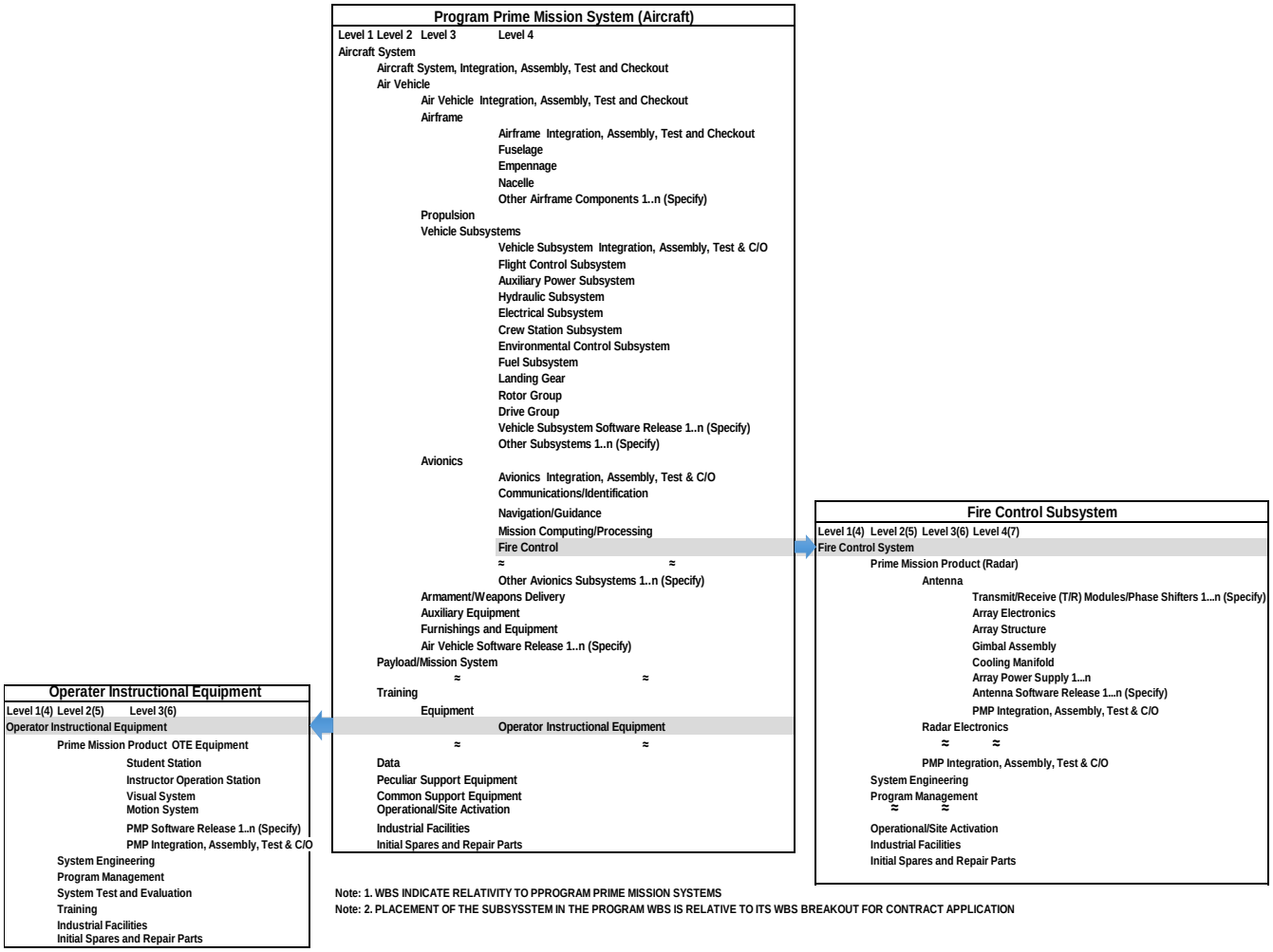

FIGURE V. Work Breakdown Structure Matrix (contract WBS)

Sustainment has become a critical part of the acquisition phase (specifically Production and Deployment) due to technology advancements, a greater use of software, and quicker deployment of capabilities. The timeframe to acquire defense materiel items has changed dramatically. With new development techniques, often requiring multiple builds over numerous contract increments, the warfighter is now getting capability faster than ever. This means that sustainment activities start earlier than they have in the past and continue into the Operations and Support (O&S) phase. The overlap between production and deployment with the sustainment phase means both activities will be accomplished in parallel. Therefore, sustainment will be part of the acquisition phase as well as the O&S phase. Appendix L of this Standard helps Government and contractor personnel understand the relationship between the Sustainment Cost Reporting Structure (CRS) and the WBS. The full Sustainment CRS can be found in the OSD CAPE Operating and Support Cost-Estimating Guide and should be used in conjunction with this guide to develop sustainment structures.

2.2.4 Creating the WBS Dictionary. As part of developing a Program WBS, the program manager will also develop a WBS dictionary. The dictionary lists and defines the WBS elements. Although initially prepared by the Government program manager, the contractor expands the dictionary as the Contract WBS is developed. The WBS dictionary will be developed starting with the generic definitions in this Standard and made program-specific to define the products being acquired to support effective Program Management by the contractor and to meet essential Request for Proposal (RFP) requirements.

The dictionary shows the hierarchical relationship of the elements and describes each WBS element and the resources and processes required to produce it. It also provides basic technical characteristics for the WBS elements

and provides a link to the detailed technical definition documents. The WBS dictionary is routinely revised to incorporate changes and must reflect the current status of the program throughout the program's life.

2.2.5 Avoiding Pitfalls in Constructing a WBS. An effective WBS clearly describes what the program manager intends to acquire. It has a logical structure and is tailored to a particular defense materiel item. It serves as a common thread among the specifications, SOW, Contract Line Item Number (CLIN) structure, IMS, IMP, EVMS and Risk Management Process. Remember, the WBS is product-oriented; addressing the products required, not the functions or costs associated with those products.

2.2.5.1 Requirement for WBS Element Exclusions.

Only include elements that are products (i.e., hardware, software, services (e.g., systems engineering, system test and evaluation, program management, data) and facilities). For example, a signal processor is a product, as are mock-ups and Computer Software Configuration Items (CSCIs) or Software Configuration Items (SCIs). On the other hand, items like design engineering, requirements analysis, test engineering, aluminum stock, and other direct costs are not products. Design engineering, test engineering, and requirements analysis are functional breakouts of engineering effort; aluminum is a material resource and direct cost is an accounting classification. Thus, none of these elements are appropriate WBS elements.

Program acquisition phases (for example, EMD, Production and Deployment) and types of funds used in various phases (for example, Research, Development, Test and Evaluation) **are not WBS elements**. The WBS is a life cycle structure. Program phases or color of money are not considered. The WBS is a living document which documents the total scope of work regardless of who pays for it or what life cycle phase is represented.

Rework, retesting, and refurbishing are not separate WBS elements. They should be treated as part of the appropriate WBS element affected. These are a means of developing or producing a product. While they are important to ensure its completion, they represent labor and materials necessary produce the end item. They should be included in the WBS element they support.

Nonrecurring and recurring classifications are not WBS elements. Segregation of each WBS element into recurring and nonrecurring is a function of the reporting requirements – not to be defined as distinct WBS elements.

Cost saving efforts, such as total quality management initiatives, acquisition reform initiatives, etc. are not part of the WBS. These efforts should be included in the cost of the items they affect, not captured separately.

Warranty is not a WBS element. Warranty is the cost for future effort that may or may not be realized. A separate warranty cost breakout may be requested as part of the reporting process in order to understand the actual cost of the PMP.

Do not use the organizational structure of the program office or the contractor's organization as the basis of a WBS.

Generic terms are inappropriate in a WBS. The WBS elements must clearly indicate the actual system names and nomenclature of the product to avoid semantic confusion. For example, if the Level 1 system is an F-35 Active Electronically Scanned Array (AESA) Radar, then the Level 2 item (prime mission product) is AN/APG-81 AESA Radar.

Recurring units of the same end item. This is captured by various CSDR submitted reports and not within the WBS reporting.

Tooling is typically not a WBS element. Tooling (e.g., special test equipment, automatic test equipment, and factory support equipment like assembly tools, dies, jigs, fixtures, master forms, and handling equipment) must be included in the functional cost of the equipment being produced. Programming costs for production automatic test equipment (ATE) must be included in the cost for the equipment being produced. (See discussion on Rate Tooling in 2.2.5.2)

2.2.5.2 Additional Considerations. Include software costs in the cost of the facility and associated equipment for which they support. For example, when a software development facility is created to support the development of software, the effort associated with this element is considered part of the CSCI it supports or, if more than one CSCI is involved, the effort should be included under Integration, Assembly, Test, and Checkout or the applicable software element. Software developed to reside on specific equipment should be identified as a subset of that equipment. System level labs that integrate both hardware and software are part of System Test and Evaluation.

When circumstances require, rate tooling may be specifically identified and placed as a WBS child element to the Integration, Assembly, Test, and Checkout level for which the tooling supports. For example, if the subsystem at Level 3 of the WBS uses rate tooling, rate tooling will be an element under Integration, Assembly, Test, and Checkout of that subsystem WBS.

Integration, Assembly, Test, and Checkout includes production acceptance testing (including first article test) of Research and Development (R&D) and production units but excludes all systems engineering/program management and system test and evaluation that are associated with the overall system.

This Standard has identified several Level 3 elements for systems engineering (SE) and program management (PM) which are considered high cost, high risk, high technical and/or special interest. The WBS elements for Systems Engineering are: 1) Software Systems Engineering, 2) Integrated Logistics Support (ILS) Systems Engineering, and 3) Cybersecurity Systems Engineering. For Program Management the WBS elements are: 1) Software Program Management, 2) Integrated Logistics Support (ILS) Program Management and 3) Cybersecurity Program Management. All other SE and PM activities are considered “Core” and the remainder of the effort should be captured in that category. The definitions in Appendix K illustrate typical systems engineering and program management efforts.

System test and evaluation (ST&E) must always separately identify tests performed in the development of a system (e.g., development test and evaluation (DT&E)), and tests performed by the operational user of the system (e.g., operational test and evaluation (OT&E)). In addition, a separate ST&E WBS element for Cybersecurity Test and Evaluation is preferred. If the contractor does not separate Cybersecurity DT&E and OT&E from normal system DT&E/OT&E effort, cybersecurity can be included in the system DT&E/OT&E WBS elements.

2.3 Solicitation and Proposal. The WBS used for a solicitation must be structured by selecting appropriate elements from the approved Program WBS and extended through the Contract WBS. The CLINs, configuration items, contract SOW tasks, contract specifications, and contractor responses may be traceable to the WBS. However, a one-to-one relationship might not exist, nor is it required.

2.3.1 Contractor Management Control System. The Contract WBS will serve as the framework for the contractor’s management control system. That system will provide auditable and traceable summaries of internal data generated by its performance measurement procedures.

2.3.2 Acquisition Logistics. All other acquisition logistics elements (not included in Systems Engineering) will be accommodated in the WBSs that they support. These areas are included as part of other WBS elements and reflect the work that needs to be accomplished. Examples of areas of acquisition logistics may include contractor logistics support, peculiar support equipment, initial spares, support data, training, and transition to sustainment (Operations and Support (O&S) phase).

2.3.3 Planning, Programming, Budgeting, and Execution (PPBE) System. The Program WBS will be the basis for program element data to support the PPBE submittals.

2.3.4 Life Cycle Cost. Life cycle cost (LCC) is the total cost for the weapon or support for defense acquisition system R&D, investment, O&S, and disposal. LCC commences at program initiation and ends with retirement or demilitarization and disposition of the system. The established WBS requirements in this standard are associated with those acquisition LCC phases of R&D and investment that are applicable to all contracted efforts

to include sustainment activities within those phases.

2.3.5 Procurement. The following will be relatable to elements of the program work breakdown structure:

a. Structure of work statements
b. Contract work breakdown structures
c. Contract line items
d. Configuration items
e. Technical and management reports
f. Government-furnished items

2.3.6 Reporting. All program status reporting requirements will be consistent with the Program WBS.

2.4 Contract Statement of Work (SOW). A standardized WBS is an effective template for constructing the SOW for a system acquisition; it helps to streamline the process. The WBS structure provides a framework for defining program technical objectives. Together with the contract SOW, the WBS aids in establishing an indentured data listing (specification tree), defining configuration items, and planning support tasks. The WBS also provides a logical arrangement of SOW elements, serving as a convenient checklist to ensure the contractor addresses all necessary program elements and meets specific contract reporting needs.

2.5 Request for Proposals (RFP).

2.5.1 Preparing a Preliminary Contract WBS. The DoD program manager will select the individual WBS elements from the Program WBS that apply to the contract to include in the RFP as described in Section 2.3. This may be the first opportunity for open dialogue between the Government and potential contractors. Acquisition approaches (e.g., a Performance Based Acquisition strategy) need to be outlined in the RFP and be inclusive to how the Government will measure technical performance. Technical measures of performance can be allocated to WBS elements. Innovative ideas or promising alternative solutions should be considered for inclusion in the RFP. The RFP will include a Government approved CSDR plan for the contract, DD Form 2974, and a related resource distribution table. The RFP will instruct potential contractors to bid against the proposed Contract WBS and define the complete contract scope, consistent with the contractor's proposed approach for executing the program.

2.5.2 RFP Solicitation Requirements. CLINs, configuration items, contract work statement tasks, contract specifications, and contractor responses should relate to the WBS so as to enhance its effectiveness in fully describing acquisition objectives. It is important to coordinate the development of the Program WBS and the CSDR plan with the development of the SOW to ensure consistency in document structure. When aggregated with the Program WBS, the extended Contract WBS will form a complete Program WBS, thus providing a logical work flow throughout the acquisition cycle.

2.5.3 Extended Contract WBS. Contractors are expected to extend the Contract WBS to the appropriate level that satisfies critical visibility requirements and allows them to manage the effort as they see fit using their management control system. A preliminary Government approved Contract WBS should be included in the RFP. The proposal will be based on the WBS in the RFP, although contractors should be encouraged to suggest changes needed to meet an essential RFP requirement or to enhance the effectiveness of the Contract WBS in satisfying program objectives.

2.6 Integrated Cost, Schedule, and Technical Performance and Risk Management. Planning tasks by WBS elements serves as the basis for mapping the technical baseline, estimating and scheduling resource requirements, and mitigating risks. By breaking the system into successively smaller entities, program managers can ensure all required products and system components are identified in terms of cost, schedule, and performance goals in order to reduce risk.

Time phasing performance budgets, assigning them to work segments, and identifying responsible units produce a plan against which actual performance can be measured. Corrective action can be taken to resolve deviations from the plan. This integrated approach to work planning also simplifies identifying the potential cost

and schedule impacts of proposed technical changes.

3. CONTRACTOR INSTRUCTIONS

3.1 Developing the Contract WBS. The Contract WBS provides the framework for the contractor's management control system. It must be tailored to the program so the contractor can meet the defined contract requirements.

3.1.1 Relationship of Program WBS to Contract WBS. The Program WBS captures all efforts of a program to include contract and Government efforts. Program WBS elements that will be contracted are reflected in the Contract WBS. The contracted system therefore will be identified at Level 1 of the Contract WBS with all applicable Level 2 Common WBS elements included. Figure VI depicts the development and relationship of the Program WBS with the Contract WBS. In this example, the Government activity is responsible for the Aircraft System reflected by the Program WBS. The Government activity has determined that it will award a contract for the Fire Control System, as reflected by the Contract WBS. Only contract efforts will be captured within the Contract WBS, while both the Government efforts and contract efforts will always be captured in the Program WBS.

Program Work Breakdown Structure

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Aircraft System			
1.1		Aircraft System, Integration, Assembly, Test and Checkout		
1.2		Air Vehicle		
1.2.1			Air Vehicle Integration, Assembly, Test and Checkout	
1.2.2			Airframe	
1.2.2.1				Airframe Integration, Assembly, Test and Checkout
1.2.2.2				Fuselage
1.2.2.3				Empennage
1.2.2.4				Nacelle
1.2.2.5				Other Airframe Components 1..n (Specify)
1.2.3			Propulsion	
1.2.4			Vehicle Subsystems	
1.2.4.1				Vehicle Subsystem Integration, Assembly, Test and Checkout
1.2.4.2				Flight Control Subsystem
≈				≈
1.2.4.13				Other Subsystems 1..n (Specify)
1.2.5			Avionics	
1.2.5.1				Avionics Integration, Assembly, Test and Checkout
≈				≈
1.2.5.4				Mission Computing/Processing
1.2.5.5				**Fire Control**
1.2.5.6				Data Displays and Controls
1.2.5.7				Survivability
1.2.5.8				≈
1.2.6			Armament/Weapons Delivery	
1.2.7			Auxiliary Equipment	
1.2.8			Furnishing and Equipment	
1.2.9			Air Vehicle Software Release 1..n (Specify)	
1.2.10			Other Air Vehicle 1..n (Specify)	
1.3		Payload/Mission System		
1.4		Ground/Host Segment		
1.5		Aircraft System Software Release 1..n (Specify)		
1.6		Systems Engineering		
≈				≈
1.14		Industrial Facilities		
1.15		Initial Spares and Repair Parts		

Government Awarded Contract Work Breakdown Structure

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	**Fire Control (1/4)**			
1.1		Prime Mission Product (Radar) (2/5)		
1.1.1			Antenna (3/6)	
1.1.1.1				Transmit/Receive (T/R) Modules/Phase Shifters 1...n (Specify) (4/7)
1.1.1.2				Array Electronics (4/7)
1.1.1.3				Array Structure (4/7)
1.1.1.4				Gimbal Assembly (4/7)
1.1.1.5				Cooling Manifold (4/7)
1.1.1.6				Array Power Supply 1...n (4/7)
1.1.1.7				Antenna Software Release 1...n (Specify) (4/7)
1.1.1.8				PMP Integration, Assembly, Test and Checkout (4/7)
1.1.2			Radar Electronics (3/6)	
≈ ≈			≈	≈
1.1.4			PMP Integration, Assembly, Test and Checkout (3/6)	
1.2		Platform Integration, Assembly, Test and Checkout (2/5)		
1.3		System Engineering (2/5)		
1.4		Program Management (2/5)		
1.5		System Test and Evaluation (2/5)		
1.6		Training (2/5)		
≈ ≈		≈		≈
1.12		Initial Spares and Repair Parts (2/5)		

FIGURE VI. Relationship of program WBS to contract WBS

3.1.2 Subcontractors. When a contract is awarded to a Prime contractor, the Prime will require subcontractors which meet reporting threshold requirements, to use the WBS to fulfill contractual requirements and control the subcontracted effort. The Prime or associate contractor is responsible for incorporating WBS requirements into the subcontract. Using the example on Figure VI, the Fire Control System was awarded to a Prime contractor. The Prime has further determined that it requires the Antenna System to be subcontracted. Figure VII shows how the Prime contractor further defined the Antenna System and created a Subcontract WBS for the subcontractor work to be managed.

Government Competed Prime Contract Fire Control System WBS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Fire Control (1/4)			
1.1		Prime Mission Product (Radar) (2/5)		
1.1.1			Antenna (3/6)	
1.1.1.1				Transmit/Receive (T/R) Modules/Phase Shifters 1...n (Specify) (4/7)
1.1.1.2				Array Electronics (4/7)
1.1.1.3				Array Structure (4/7)
1.1.1.4				Gimbal Assembly (4/7)
1.1.1.5				Cooling Manifold (4/7)
1.1.1.6				Array Power Supply 1...n (4/7)
1.1.1.7				Antenna Software Release 1...n (Specify) (4/7)
1.1.1.8				PMP Integration, Assembly, Test and Checkout (4/7)
1.1.2			Radar Electronics (3/6)	
≈ ≈			≈ ≈	
1.1.4			PMP Integration, Assembly, Test and Checkout (3/6)	
1.2		Platform Integration, Assembly, Test and Checkout (2/5)		
1.3		System Engineering (2/5)		
1.4		Program Management (2/5)		
1.5		System Test and Evaluation (2/5)		
1.6		Training (2/5)		
1.7		Data (2/5)		
1.8		Peculiar Support Equipment (2/5)		
1.9		Common Support Equipment (2/5)		
1.10		Operational/Site Activation (2/5)		
1.11		Industrial Facilities (2/5)		
1.12		Initial Spares and Repair Parts (2/5)		

Subcontract WBS from Prime Contractor Supplying the Fire Control System

WBS #	Level 1	Level 2	Level 3	Level 4	Level 5
1.0	Antenna System (1/6)				
1.1		Prime Mission Product (Radar) (2/7)			
1.1.1			Antenna (3/8)		
1.1.1.1				Subsystem Integration, Assembly, Test and Checkout (4/9)	
1.1.1.2				Transmit/Receive (T/R) Modules/Phase Shifters 1...n (Specify) (4/9)	
1.1.1.2.1					(T/R) Module Structure (5/10)
1.1.1.2.2					(T/R) Module Radiating Elements (5/10)
1.1.1.2.3					(T/R) Module Line Replaceable Units (LRUs) (5/10)
1.1.1.2.4					(T/R) Power Supply (5/10)
1.1.1.2.5					(T/R) Module Integration, Assembly, Test and Checkout (5/10)
1.1.1.3				Array Electronics (4/9)	
1.1.1.4				Array Structure (4/9)	
1.1.1.5				Gimbal Assembly (4/9)	
1.1.1.6				Cooling Manifold (4/9)	
1.1.1.7				Array Power Supply 1...n (4/9)	
1.1.1.8				Antenna Software Release 1...n (Specify) (4/9)	
1.1.1.9				Other (Specify) (4/9)	
1.1.2			Radar Electronics (3/8)		
≈ ≈			≈ ≈		
1.1.4			PMP Integration, Assembly, Test and Checkout (3/8)		
1.2		Platform Integration, Assembly, Test and Checkout (2/7)			
1.3		System Engineering (2/7)			
1.4		Program Management (2/7)			
1.5		System Test and Evaluation (2/7)			
≈ ≈			≈ ≈		
1.12		Initial Spares and Repair Parts (2/7)			

FIGURE VII. Relationship of contract WBS to subcontract WBS

3.1.3 Contractor's Organizational Structure. A WBS must not be influenced by a contractor's program organization. The contractor can organize according to corporate standards and still effectively report using of a product-oriented WBS.

3.1.4 Control Account Level. As the end product is subdivided into smaller sub-products at lower WBS levels, the work effort required by each element should be identified and assigned to functional organizational units. These functional organizations are part of the contractor's organizational structure. The juncture of the WBS element and organizational structure is where the control accounts and work packages are established (Figure VIII). For that WBS element, the contractor will assign management responsibility (i.e., Control Account Manager) for technical, schedule, and performance measures within the management control system. To this end, the technical requirements for the work and work product must be specified; the work scheduled, budgeted, and performed; and the attainment of specified technical requirements, verified through reports submitted. Virtually all aspects of the contractor's management control system (i.e., technical definition, budgets, estimates, schedules, risk management, work assignments, accounting, progress assessment, problem identification, and corrective actions) must utilize functional capabilities to bring together the effort at the control account level for its associated WBS element. Performance visibility is directly relatable to this level of detail.

For example, the management information needed by the Government to manage the development of a radar receiver is available from the control accounts that are part of that effort's WBS element. The information the contractor needs to manage the development is available from the same control accounts, which in this example are a part of the contractor's Electrical Design Department.

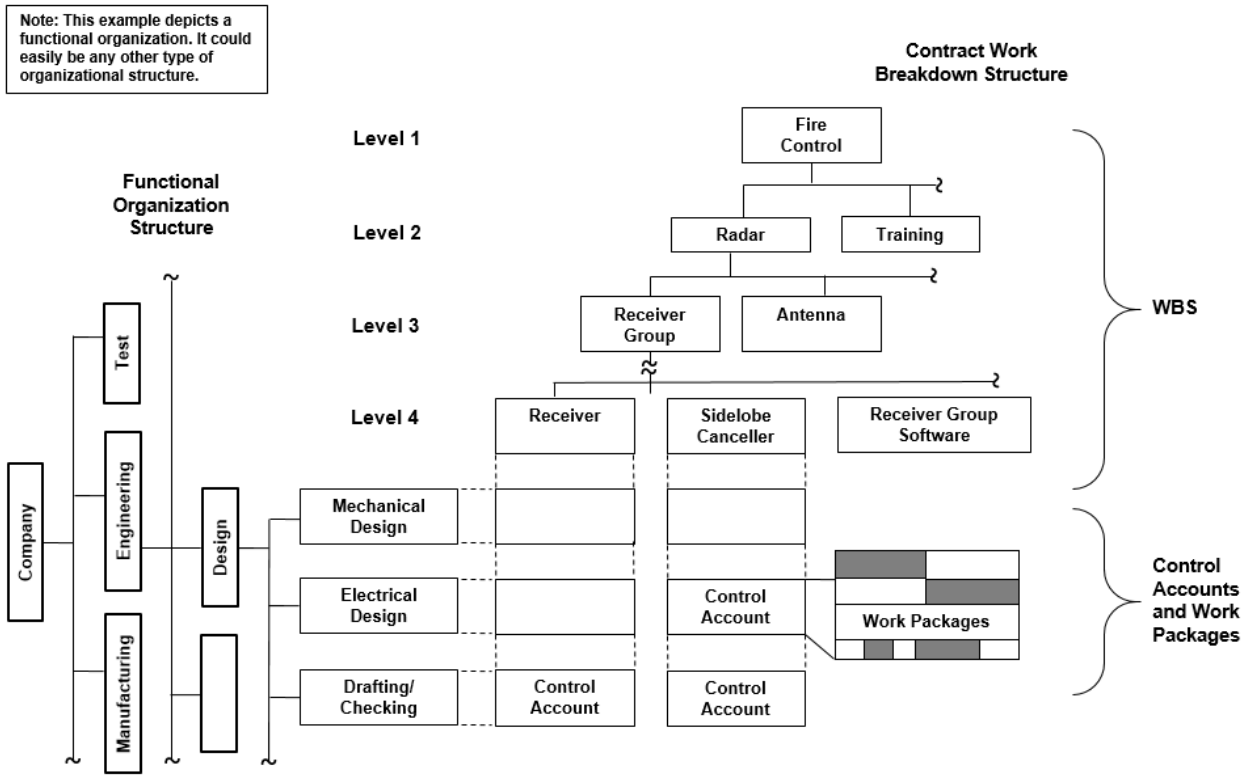

FIGURE VIII. Translation from function to product

3.2 Programmatic Issues in WBS Development.

3.2.1 System of Systems (SoS). A program can either have stand-alone systems or have interfaces with other systems, such as a fighter aircraft that has interfaces with the ordnance it carries. The aircraft and ordnance programs, traditionally separate, will each have a separate Program WBS. In a SoS program, such as the Missile Defense Program or the Cheyenne Mountain Complex, the program is actually a collection of systems and thus the Program WBS at the first tier will consist of the various systems that make up the SoS structure. A SoS Program will require the development of multiple system WBS definitions, found in Appendices A through J. SoS should be treated and managed as a system in their own right, and should therefore be subject to the same systems engineering processes and best practices as applied to individual systems. In this manner, the WBS requirements of a system also apply to a SoS.

Understanding the parent-child type relationship of various related programs and contracts and their impact on the WBS is important in the ever-increasing integrated and joint program environment. Often, individually baselined programs and their various prime or GFE elements are actually part of a SoS approach. The overall parent program, the SoS or joint program, needs to be associated with the various child programs. Each child program would develop a stand-alone WBS structure. The various child WBS elements then would be identified at Level 2 or 3, as appropriate, in the overall parent program. In some cases, common systems will be a child program to different parent program and may actually enter the parent WBS as a different level. In any case, the parent-child relationship should be thought through and understood by the parent program and the various child programs. The parent-child challenge will repeat itself in the Contract WBS as the Prime contractor decides to subcontract various portions of the system. Each substantial subcontract will in essence create a program for the subcontract and thus create a parent-child relationship between the Prime and the subcontractor.

3.2.2 Family of Systems. A family of systems is a grouping of systems having some common characteristic(s). For example, each system in a family of systems may belong to a domain or product line (e.g., a

family of missiles, ground vehicles, aircraft, situation awareness systems, etc.), each having a level of commonality and unique variants. In general, a family of systems is not considered to be a system per se because it does not necessarily create capability beyond the additive sum of the individual capabilities of its member systems. A family of systems lacks the synergy of a SoS. The family of systems does not acquire qualitatively new properties as a result of the grouping. In fact, the member systems may not be connected into a whole.

Developing a WBS for a program that has multiple variants and varying levels of commonality can result in a WBS that is very long. An acceptable approach to shorten the length is to define a child element as common to all variants and additional elements unique to a named single variant. See Figure X-Example 3, to show an approach as to how to develop a WBS for a family of systems product line.

3.2.3 Cybersecurity. Cybersecurity is a requirement for all DoD programs and must be fully considered and implemented in all aspects of acquisition programs across the life cycle. Attention must be paid to cybersecurity at all acquisition category levels and all classification levels, including unclassified, throughout the entire life cycle; this includes systems that reside on networks and stand-alone systems that are not persistently connected to networks during tactical and strategic operations. The responsibility for cybersecurity extends to DoD and its contractors. Both need to design, develop, and acquire systems that can operate in applicable cyber threat environments. MIL-STD-881D supports this effort by providing the structure to identify, collect, and report many of these critical costs. It is also recognized gathering this information is nearly impossible at the level of detail these systems are developed. It is for this reason, where cybersecurity related costs can be easily accounted for, they should be called out in the WBS. For example, for hardware/software elements, if the development or procurement of hardware in a system is specifically a cybersecurity artifact, then call it out as a WBS element to identify it. The same is true for software. If the development of a CSCI(s) is specifically cybersecurity or software is purchased that is specifically for cybersecurity, the CSCI should be identified as cybersecurity. Just as important are the engineering, management, and test activities that are used to ensure the systems are meeting the planned expectations. The MIL-STD has specifically called out these efforts associated with systems engineering, program management, and system test and evaluation WBS elements (See Appendix K).

3.2.4 Software and Software Intensive Systems. It is important to recognize the fundamental distinction between two types of software acquisition: 1) Information Systems/Defense Business Systems and 2) software embedded on a weapon system. Both of these are an increasingly important part of DoD acquisition, but affect the process in different ways and should therefore be treated differently from a WBS perspective.

3.2.4.1 Information Systems (IS)/Defense Business Systems (DBS). For IS/DBS, the software is itself the end item. The development is divided into discrete, manageable increments to facilitate development and implementation. Further, IS/DBS Milestone C provides for limited fielding as well as full deployment. This allows the systems produced to have ongoing software modifications and enhancements throughout the implementation and sustainment phases to improve its capabilities. For IS/DBSs such as business systems, Enterprise Resource Planning (ERP), and Service Oriented Architecture (SOA), use Appendix J.

3.2.4.2 Software Operating on Specific Equipment. Multi-function software will be identified as a subset of the equipment WBS element, which either includes the software in the element specification or exercises the most critical performance constraint. In cases where a conflict exists between selecting either the element specification or that which exercises the most critical performance constraint, selecting the specification relationship will take precedence. For example, an aircraft's electronic equipment typically has software included in each of the subsystem elements. Software that resides and interfaces with more than one piece of equipment will be called out at the appropriate work breakdown level. For example, elements of software development often are high cost, high risk, high technical, and/or special interest. Since all critical software should be identified, it may be appropriate to collect lower level information.

All integral software should be included in a Program or Contract WBS in conjunction with the hardware it supports. This allows for effective performance measurement and management control. When needed, a contractor's management system can use an identifier for each software element to produce summaries for software management purposes.

3.2.4.3 Visibility into Software Development Processes. Because the WBS has a product-oriented hierarchy, its progressive subdivision will result in common management or functional tasks (for example, development processes, etc.) occurring in many WBS elements. Software may be widespread throughout the

WBS and represent high risk in the contract. In such cases, the program manager should require specific visibility into software performance, but care must be taken to not overly complicate the Contract WBS and the contractor's management system. Appropriate reporting requirements should be specified in the SOW including a Software Development Plan and appropriate software metrics.

3.2.5 Integrated Master Plan and Integrated Master Schedule (IMP/IMS).

3.2.5.1 Integrated Master Plan (IMP). The IMP is an event-based plan consisting of a hierarchy of program events, with each event being supported by specific accomplishments associated with one or more WBS elements and specific criteria to be satisfied for its completion. In addition, the IMP demonstrates the maturation of the design/development of the product (WBS element) as it progresses through a disciplined systems engineering process. The WBS provides a suitable structure for the IMP, as each event is completed based on accomplishments which support the scope of work as defined in the WBS.

3.2.5.2 Integrated Master Schedule (IMS). The IMS flows directly from the IMP and indirectly from the WBS. The IMS supports multiple views (for example, event-based, WBS-based) to support the user's needs. The IMS should be defined to the level of detail necessary for effective management and execution of the program/project.

3.2.5.3 IMP/IMS Linkage. The IMS is directly traceable back to the IMP and, where applicable, should also be traceable to the program's Contract WBS, SOW, EVMS, and risk management system. Both the IMP and the IMS should be consistent with the contractor's management and scheduling system structure and format which the WBS is based. Figure IX illustrates these interrelationships.

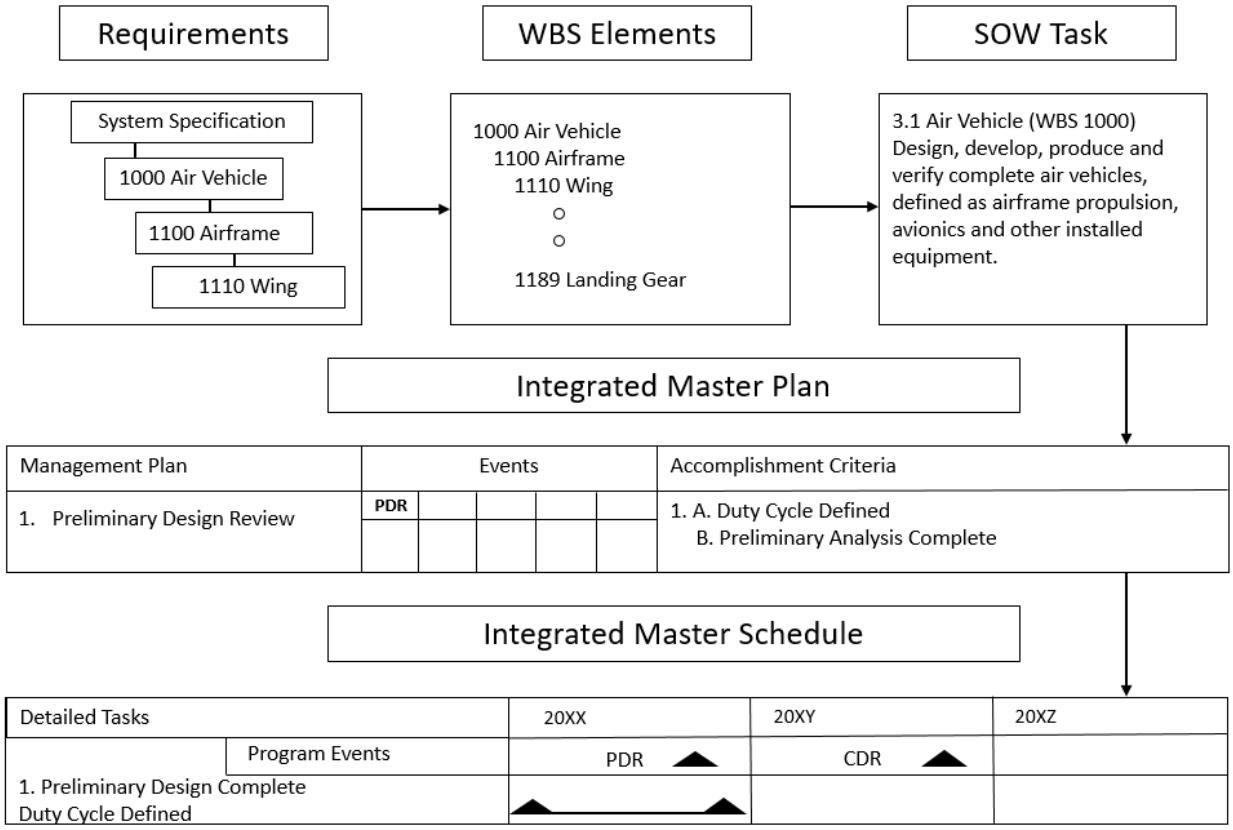

FIGURE IX. Relationship of IMP/IMS to WBS

3.2.6 Use of Common Elements. Common WBS elements (for example, Integration, Assembly, Test, and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) (see Appendix K) will be applied to the appropriate levels within the WBS they support. In other words, if systems engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports. For example, in Surface Vehicles common elements found at Level 2 of the WBS capture efforts associated with the "System" level as a total system (for example, training for the entire surface vehicle system). However, if training was required to support the Navigation and Remote Piloting System (Level 3 WBS element), the Training common element will also be associated with the element it supports (Navigation and Remote Piloting System) at Level 4 of the WBS. The training element should not be rolled into the "System" level training WBS element.

The intent is to understand the total effort associated with designing, developing, and producing a WBS element. Combining them into the "System" level misrepresents the true effort of delivering a complete Navigation and Remote Piloting System.

4. IMPLEMENTATION OF CONTRACT WORK BREAKDOWN STRUCTURE

The Contract Work Breakdown Structure (CWBS) included in a successful proposal serves as the basis for negotiating a Government-approved Contract WBS. The contractor may have proposed alternate approaches to accomplish the contract objectives. If the Government program manager accepts the alternatives, the Contract WBS will require revision to reflect those changes.

4.1 Contract Award and Contract WBS Approval. The requirement for providing the WBS dictionary using Data Item Description DI-MGMT-81334 (current version), "Contract WBS" identified in the Contract Data Requirements List (CDRL) is included in the contract development process. Additional WBS revisions may result from program changes. Additional contract elements will become the basis for contractor extension of the Contract WBS. The extension of the Contract WBS should be negotiated by the contractor and Government PCO at a CSDR conference according to the CSDR Manual (DOD 5000.04-M-1). Although there is no limit on the number of additional elements, each should be justified in terms of its contribution to effective program management. All extensions should be incorporated into the Contract WBS reporting level in the contract.

Users of this Standard should understand that the sequence described in the preceding paragraphs may be repeated as the program evolves, contracts are awarded, and the work effort progresses through major program phases. Revisions to the WBS are an essential component of this process. Whenever the WBS is revised, traceability to the previous WBS needs to be maintained. Once work begins, WBS changes should be controlled to preserve the cost baseline. The Contract WBS requires a contract modification before approved changes can be incorporated.

4.2 Reporting Relationships. The contractor maintains the Contract WBS, including change traceability. In accordance with the contract terms, only changes approved by the contracting officer may be incorporated. The contract will indicate levels of the Contract WBS at which costs will be reported to the Government. The contractor should determine those extended Contract WBS levels that are used to trace the cost accumulations for cost control purposes. In the extensions, consideration should be given to the specific contractual, technical, and managerial requirements of the defense materiel item. The contractor has complete flexibility to extend the Contract WBS below the reporting requirement to reflect how work is to be accomplished, assuming the additional elements are meaningful product or management-oriented indentures of a higher-level element. For reporting purposes, it is encouraged to align WBSs to an appropriate level.

4.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered. The purpose for the numbering is to provide visible clarity regarding level of indenture and parent-child content. Maintaining the WBS numbering is not an essential requirement of the standard.

4.3.1. "Other" WBS Elements. All appendices contain a WBS element titled "Other" at the subsystem, element (product) levels that acknowledge not all products have been envisioned or predicted within the defined WBS elements in the Appendix. This is available to provide flexibility within the system WBS for new or additional WBS elements that are not identified or pre-defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined, and it does not currently appear in the appendices of MIL-STD-881D. If it is determined that the "other" element is needed, the term "other" should not be retained and

the element must be defined and be placed in the WBS. If it is determined that the "other" WBS is not needed, this element should not be used in the WBS.

4.3.2 (1...n) WBS Element Definitions. Several appendices identify WBS elements with 1...n (Specify) or similar to denote that one or more components of that type of item may be used. Depending on the WBS identified, three approaches may be taken: 1) the parent WBS (e.g., 1...n) represents new or modified subsystems with each defined WBS using the appropriate title; or 2) the parent WBS (1...n) represents two or more WBS elements which are children of the parent, 3) the parent WBS (1...n) represents a family of systems which require the same numbering structure to maintain consistency, using the same WBS number and adding an alpha/numeric (a, b, c, etc.) at the end for reporting purposes to ensure the WBS numbering stays intact. See Figure X below for example of WBS breakout for each approach.

Example 1: Parent WBS (MIL-STD) represents new/modified subsystems

MIL-STD WBS:
1.1.1.6 Other Airframe Components 1…n (Specify)

Contractor WBS:
1.1.1.6 Stealth Special Airframe Part A
1.1.1.7 Stealth Special Airframe Part B

Note: The term "Other Airframe 1…n (Specify)" is not retained

Example 2: Parent WBS (MIL-STD) represents two or more children which are same as parent

MIL-STD WBS:
1.1.8. Air Vehicle Software Release 1…n (Specify)

Contractor WBS:
1.1.8. Air Vehicle Software Releases
1.1.8.1 AV Software Release 1
1.1.8.2 AV Software Release 2
1.1.8.3 AV Software Release 3

Note: Renumber the children as necessary. The term "1…n (Specify)" is not retained

Example 3: Parent WBS (MIL-STD) represents multiple variants within the same Family of Systems WBS

MIL-STD WBS:
1.1.2 Ground Vehicle Variant (2...n)

Contractor WBS:
1.1.2a Communications Ground Vehicle
1.1.2b Ambulance Ground Vehicle
1.1.2c Autonomous Ground Vehicle
Renumber the variants using an alpha ending to the WBS. Note the term "Ground Vehicle Variant (2…n)" is not retained

FIGURE X. Examples of 1...n (Specify) as applied to a contract WBS

4.4 Support for Management and Reporting Activities. Within the scope of the WBS, the contractor has flexibility to use the work breakdown elements to support ongoing cost and financial management activities. The WBS also provides critical structure for cost reporting. The DOD 5000.04-M-1, CSDR Manual, relies upon the WBS to enable effective reporting of cost and software data. The requirements for cost reporting are provided for contracts within ACAT programs regardless of contract type. Consequently, the guidelines for WBS construction specified in this Standard become directive in nature.

Detailed guidelines for the Contract WBS are provided in Data Item Description DI-MGMT-81334 (Current Version). This data item is invoked in the CDRL of the RFP and contract.

After contract award and at each point in the acquisition cycle, the Contract WBS continues to provide the framework for delineating the areas of responsibility, defining task requirements and supporting cost collection for the contract. In some cases, allocation of costs may be necessary if the contractor's management system cannot account for costs as defined in the Contract WBS. Therefore, the Contract WBS format should be used as a starting point for tailoring to help meet these requirements.

5. NOTES SECTION

5.1 Intended Use. This Standard is directed primarily at preparing a WBS for a defense system program. This includes all systems, materiel items, or major modifications established as an integral program element of the Future Years Defense Program or otherwise designated by the DoD component or the Under Secretary of Defense (AT&L).

The Standard is appropriate for use with any WBS developed for the Pre-Systems Acquisition (Materiel Solution Analysis, Technology Maturation/Risk Reduction) and Systems Acquisition (Engineering and Manufacturing Development, Production and Deployment) life cycle phases. The Sustainment Phase (Operations and Support) is addressed as it is included during the Systems Acquisition Phase until the Material Support Date (MSD) early in Operations and Support. The Standard focuses on identifying how a WBS is developed and maintained throughout the Pre-Systems Acquisition and Systems Acquisition phases including its transition to Sustainment.

This Standard clearly delineates the overlapping responsibilities of DoD program managers and contractors relative to the execution of WBSs.

5.2 Associated Data Item Description.

DID NUMBER	DID TITLE
DI-MGMT-81334 (Current Version)	Contract Work Breakdown Structure

5.3 Supersession Data. This Standard supersedes MIL-STD-881C dated 3 October 2011.

5.4 Subject Term (keyword) Listing.

Aircraft Systems
Contract Funds Status Report (CFSR)
Contract Work Breakdown Structure (CWBS)
Cost and Software Data Report (CSDR)
Contract Performance Report (CPR)
Control Accounts
Cost Estimating Reporting
Data
Defense Business Systems (DBS)
Earned Value Management (EVM)
Electronics/Generic Systems
Engineering Data
Family of Systems (FoS)
Information Systems (IS)
Integrated Master Plan (IMP)
Integrated Master Schedule (IMS)
Integrated Program Management Report (IPMR)
Launch Vehicle Systems

Life Cycle Cost
Missile Systems
Ordnance Systems
Planning, Programming, Budgeting, and Execution (PPBE) System
Program Management
Program Work Breakdown Structure (PWBS)
Request for Proposals (RFP)
Risk Management
Schedule
Sea Systems
Software
Strategic Missile Systems
Space Systems
Surface Vehicle Systems
Systems Engineering
System of Systems (SoS)
Unmanned Air Vehicle (UAV) Systems
Unmanned Maritime System (UMS)
Work Package

5.5 Changes from Previous Issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue due to the extent of the changes.

APPENDIX A: AIRCRAFT SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

A.1 SCOPE

A.1.1 Scope. This appendix provides the Work Breakdown Structure and Definitions for aircraft systems. Definitions for WBS elements common to all defense materiel items are given in Appendix K: Common Elements, Work Breakdown Structure and Definitions.

A.2 APPLICABLE DOCUMENTS

A.2.1 General. The documents listed in this section are specified in Appendix A of this standard. This section does not include documents cited in other Appendices of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendices of this standard, whether or not they are listed.

A.2.2 Government documents.

A.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

A.2.2.2 Other Government documents, drawings, and publications.

A.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 24765:2017 – *Systems and Software Engineering – Vocabulary*
ISO/IEC/IEEE 12207:2017 - *Systems and Software Engineering – Software Life Cycle Processes*

(Copies of these documents are available from www.ieee.org or The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-1331)

A.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Aircraft System			
1.1		Aircraft System, Integration, Assembly, Test, and Checkout		
1.2		Air Vehicle		
1.2.1			Air Vehicle Integration, Assembly, Test, and Checkout	
1.2.2			Airframe	
1.2.2.1				Airframe Integration, Assembly, Test, and Checkout
1.2.2.2				Fuselage
1.2.2.3				Wing
1.2.2.4				Empennage
1.2.2.5				Nacelle
1.2.2.6				Other Airframe Components 1...n (Specify)
1.2.3			Propulsion	
1.2.4			Vehicle Subsystems	
1.2.4.1				Vehicle Subsystem Integration, Assembly, Test, and Checkout
1.2.4.2				Flight Control Subsystem
1.2.4.3				Auxiliary Power Subsystem
1.2.4.4				Hydraulic Subsystem
1.2.4.5				Electrical Subsystem
1.2.4.6				Crew Station Subsystem
1.2.4.7				Environmental Control Subsystem
1.2.4.8				Fuel Subsystem
1.2.4.9				Landing Gear
1.2.4.10				Rotor Group
1.2.4.11				Drive Group
1.2.4.12				Vehicle Subsystem Software Release 1...n (Specify)
1.2.4.13				Other Subsystems 1...n (Specify)
1.2.5			Avionics	
1.2.5.1				Avionics Integration, Assembly, Test, and Checkout
1.2.5.2				Communication/Identification
1.2.5.3				Navigation/Guidance
1.2.5.4				Mission Computer/Processing
1.2.5.5				Fire Control
1.2.5.6				Data Display and Controls
1.2.5.7				Survivability
1.2.5.8				Reconnaissance
1.2.5.9				Electronic Warfare
1.2.5.10				Automatic Flight Control
1.2.5.11				Health Monitoring System
1.2.5.12				Stores Management
1.2.5.13				Avionics Software Release 1...n (Specify)
1.2.5.14				Other Avionics Subsystems 1...n (Specify)
1.2.6			Armament/Weapons Delivery	
1.2.7			Auxiliary Equipment	
1.2.8			Furnishings and Equipment	
1.2.9			Air Vehicle Software Release 1...n (Specify)	
1.2.10			Other Air Vehicle 1...n (Specify)	
1.3		Payload/Mission System		
1.3.1			Payload Integration, Assembly, Test, and Checkout	
1.3.2			Survivability Payload 1...n (Specify)	
1.3.3			Reconnaissance Payload 1...n (Specify)	
1.3.4			Electronic Warfare Payload 1...n (Specify)	
1.3.5			Armament/Weapons Delivery Payload 1...n (Specify)	
1.3.6			Payload Software Release 1...n (Specify)	

1.3.7 Other Payload 1...n (Specify)
1.4 Ground/Host Segment
1.4.1 Ground Segment Integration, Assembly, Test, and Checkout
1.4.2 Ground Control Systems
1.4.3 Command and Control Subsystem
1.4.4 Launch Equipment
1.4.5 Recovery Equipment
1.4.6 Transport Vehicles
1.4.7 Ground Segment Software Release 1...n (Specify)
1.4.8 Other Ground/Host Segment 1...n (Specify)
1.5 Aircraft System Software Release 1...n (Specify)
1.6 Systems Engineering
1.6.1 Software Systems Engineering
1.6.2 Integrated Logistics Support (ILS) Systems Engineering
1.6.3 Cybersecurity Systems Engineering
1.6.4 Core Systems Engineering
1.6.5 Other Systems Engineering 1...n (Specify)
1.7 Program Management
1.7.1 Software Program Management
1.7.2 Integrated Logistics Support (ILS) Program Management
1.7.3 Cybersecurity Management
1.7.4 Core Program Management
1.7.5 Other Program Management 1...n (Specify)
1.8 System Test and Evaluation
1.8.1 Development Test and Evaluation
1.8.2 Operational Test and Evaluation
1.8.3 Cybersecurity Test and Evaluation
1.8.4 Mock-ups/System Integration Labs (SILs)
1.8.5 Test and Evaluation Support
1.8.6 Test Facilities
1.9 Training
1.9.1 Equipment
1.9.1.1 Operator Instructional Equipment
1.9.1.2 Maintainer Instructional Equipment
1.9.2. Services
1.9.2.1 Operator Instructional Services
1.9.2.2 Maintainer Instructional Services
1.9.3 Facilities
1.9.4 Training Software 1...n (Specify)
1.10 Data
1.10.1 Data Deliverables 1...n (Specify)
1.10.2 Data Repository
1.10.3 Data Rights 1...n (Specify)
1.11 Peculiar Support Equipment
1.11.1 Test and Measurement Equipment
1.11.1.1 Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.11.1.2 Test and Measurement Equipment (Propulsion)
1.11.1.3 Test and Measurement Equipment (Electronics/Avionics)
1.11.1.4 Test and Measurement Equipment (Other Major Subsystems 1...n (Specify))
1.11.2 Support and Handling Equipment
1.11.2.1 Support and Handling Equipment (Airframe/Hull/Vehicle)
1.11.2.2 Support and Handling Equipment (Propulsion)
1.11.2.3 Support and Handling Equipment (Electronics/Avionics)
1.11.2.4 Support and Handling Equipment (Other Major Subsystems 1...n (Specify))
1.12 Common Support Equipment
1.12.1 Test and Measurement Equipment
1.12.1.1 Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.12.1.2 Test and Measurement Equipment (Propulsion)

1.12.1.3			Test and Measurement Equipment (Electronics/Avionics)
1.12.1.4			Test and Measurement Equipment (Other Major Subsystems 1...n (Specify))
1.12.2		Support and Handling Equipment	
1.12.2.1			Support and Handling Equipment (Airframe/Hull/Vehicle)
1.12.2.2			Support and Handling Equipment (Propulsion)
1.12.2.3			Support and Handling Equipment (Electronics/Avionics)
1.12.2.4			Support and Handling Equipment (Other Major Subsystems 1...n (Specify))
1.13	Operational/Site Activation by Site 1...n (Specify)		
1.13.1		System Assembly, Installation, and Checkout on Site	
1.13.2		Contractor Technical Support	
1.13.3		Site Construction	
1.13.4		Site/Ship/Vehicle Conversion	
1.13.5		Interim Contractor Support (ICS)	
1.14	Contractor Logistics Support (CLS)		
1.15	Industrial Facilities		
1.15.1		Construction/Conversion/Expansion	
1.15.2		Equipment Acquisition or Modernization	
1.15.3		Maintenance (Industrial Facilities)	
1.16	Initial Spares and Repair Parts		

A.3.1 Application of Common WBS Elements (Appendix K). WBS elements that are common (i.e., Integration, Assembly, Test, and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

A.3.2 Key Principles in Constructing a WBS. In the appendices of this MIL-STD, the WBS is defined to Level 3, 4, or 5 depending on the system, WBS elements in the appendices may be extended to appropriate levels below their MIL-STD definition for informational or reporting purposes. The purpose for these extensions is to ensure that the higher-level elements include the proper lower level elements when required to report at a lower level. If an extension below the MIL-STD definition is required, maintaining the product-oriented decomposition is required.

1) Extending the WBS to Lower Levels. The reporting level of the WBS depends on the level of interest where work is accomplished. Reporting at levels below those identified within the MIL-STD should be reported if they are considered high cost, high risk, and/or special interest. For those elements, extension of the WBS to lower levels may be necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. An example of the extension for this Appendix commodity can be found at http://cade.osd.mil/policy/csdr-plan.

2) 100% Rule. A key to WBS development is the principle that if the effort and resources can be associated with the element they support, they should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (Fire Control) has three child elements—transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the Fire Control system to make it a level equal to the Fire Control, it distorts the effort and resources that are required to complete that Fire Control system. The reason is that the transmitter has lost its parent (Fire Control)/child relationship because it assumes the transmitter is not included within the Fire Control system.

3) Identifying Parent/Child Relationship. In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter within the Fire Control. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, it may include more functionality than just the transmitter subsystem. It may, for instance,

include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to the inability to determine the effort for each functionality developed. It is, therefore, appropriate to associate that software to the next higher level (Fire Control) of the WBS. To accomplish this, it will be included in the Fire Control software element of the Fire Control system. This eliminates allocation of the effort across multiple WBS elements where it is difficult to determine what level of support each gets.

4) Recognizing Cybersecurity Processes/Products. Cybersecurity is a requirement for all DoD programs and must be fully considered and implemented in all aspects of acquisition programs across the life cycle. Attention must be paid to cybersecurity at all acquisition category levels and all classification levels, including unclassified, throughout the entire life cycle; this includes systems that reside on networks and stand-alone systems that are not persistently connected to networks during tactical and strategic operations. Since responsibility for cybersecurity extends to every member of the acquisition workforce, DoD and its contractors need to design, develop, and acquire systems that can operate in applicable cyber threat environments. As such it is critical to understand what the cost of these systems is (i.e., hardware, software, systems engineering, program management, and system test and evaluation). MIL-STD-881D supports this effort by providing the structure to identify, collect and report many of these critical costs. It is also recognized gathering this information is nearly impossible at the level of detail these systems are developed. It is for this reason, where cybersecurity related costs can be easily accounted for, they should be called out in the WBS. For example, for hardware/software elements, if the development or procurement of hardware in a system is specifically a cybersecurity artifact, then call it out as a WBS element to identify it. The same is true for software. If the development of a CSCI(s) are specifically cybersecurity or software is purchased that is specifically for cybersecurity, call it out as a WBS element to identify it. Just as important are the engineering, management, and test activities that are used to ensure the systems are meeting the planned expectations. The MIL-STD has specifically called out these efforts associated with systems engineering, program management, and system test and evaluation WBS (See Appendix K).

A.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. In addition, the numbering provides visible clarity regarding level of indenture and parent-child content. While the numbering system is numeric, several unique issues arise across appendices which require the numbering system to be modified to accommodate these anomalies (See Figure X). Additionally, if a WBS element is not required, it may be eliminated from the structure and the numbering would be logically adjusted.

A.3.3.1 “Other” WBS Elements. All appendices contain a WBS element titled “Other” at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. This is available to provide flexibility within the system WBS for new or additional WBS elements that are not identified or defined in the Standard. These “other” elements would be used if, for example, a new subsystem or modified subsystem is defined, and it does not currently appear in the appendices of MIL-STD-881D. If it is determined that the “other” WBS is not needed, this element should not be used in the WBS. If it is determined that the “other” element is needed, then each element must be defined and the word “other” replaced by the newly defined WBS element.

A.3.3.2 1...n (Specify) WBS Element Definitions. Several appendices identify WBS elements with 1...n (Specify) or similar to denote that one or more components of that type of item may be used. Depending on the WBS identified, three approaches may be taken: 1) the parent WBS (e.g., 1...n) represents new or modified subsystems with each defined WBS using the appropriate title; or 2) the parent WBS (1...n) represents two or more WBS elements which are children of the parent, or 3) the parent WBS (1...n) represents a family of systems which require the same numbering structure to maintain consistency, using the same WBS number and adding an alpha/numeric (a, b, c, etc.) at the end to ensure the WBS numbering stays intact. (See Figure X in the General section for examples of WBS breakouts for each approach).

A.4 DEFINITIONS

A.4.1 Aircraft System. The complex of equipment (hardware/software), data, services, and facilities required to develop, produce, and support air vehicles.

Includes, for example:

a. Those employing manned fixed, movable, rotary, or compound wing
b. Those unmanned air vehicles designed for powered or unpowered flight (i.e., gliders)

A.4.2 Aircraft System Integration, Assembly, Test, and Checkout. The integration, assembly, test, and checkout element includes all efforts as identified in Appendix K: Common Elements, Work Breakdown Structure and Definitions, to provide a complete aircraft system.

A.4.3 Air Vehicle. The complete flying aircraft. It includes the design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specification(s), regardless of end use).

Includes, for example:
a. Airframe, propulsion, vehicles subsystems, avionics systems and all other installed equipment (except those equipment considered as payloads, those are captured within their own Level 2 WBS element)

A.4.3.1 Air Vehicle Integration, Assembly, Test, and Checkout. The integration, assembly, test, and checkout element includes all efforts as identified in Appendix K: Common Elements, Work Breakdown Structure and Definitions, to provide a complete air vehicle.

A.4.3.2 Airframe. The assembled structural and aerodynamic components of the air vehicle that support subsystems essential to designated mission requirements.

Includes, for example:
a. Basic structure: fuselage, wing, empennage, and nacelle
b. All administrative and technical engineering labor to perform integration of Level 4 airframe elements; development of engineering layouts; determination of overall design characteristics; and determination of requirements of design review

Excludes, for example:
a. All effort associated with vehicle subsystems, avionics, and other Level 3 elements, and their integration into the airframe

A.4.3.2.1 Airframe Integration, Assembly, Test, and Checkout. The integration, assembly, test, and checkout element includes all efforts as identified in Appendix K: Common Elements, Work Breakdown Structure and Definitions, to provide a complete airframe.

NOTE: When rate tooling is deliverable to the Government, it should be shown at the next lower level breakout of integration, assembly, test, and checkout.

Included in this element are the efforts required to provide the integration, assembly, test, and checkout of the major airframe structures (fuselage, wing, empennage, nacelle, and other airframe) including modification installation. Included in this effort is all administrative and technical engineering labor to perform integration of Level 4 airframe elements.

Includes, for example:
a. Overall airframe design and producibility engineering
b. Detailed production design; acoustic and noise analysis
c. Loads analysis; stress analysis on interfacing airframe elements and all subsystems
d. Design maintenance effort and development of functional test procedures
e. Coordination of engineering master drawings and consultation with test and manufacturing groups
f. Tooling planning, design, and fabrication of basic and rate tools and functional test equipment, as well as the maintenance of such equipment
g. Production scheduling and expediting
h. Joining or installation of structures such as racks, mounts, etc.
i. Installation of wiring, ducting, engines, and miscellaneous equipment, and painting
j. Set up, conduct, and review of testing assembled components or subsystems prior to installation

Excludes, for example:

a. All integration, assembly, test, and checkout activities associated with non-airframe Level 3 elements

A.4.3.2.2 Fuselage. The structural airframe encompassing the forward, center, and aft fuselage sections of the aircraft.

Includes, for example:
a. Structural fuselage section for the forward, center, and aft fuselage sections to include the main and secondary structures
b. Efforts required to splice the forward, center, and aft sections
c. Windshield/canopy assembly
d. Radome
e. Access doors
f. Mounting provisions for mission peculiar avionics and armament/weapons delivery systems

A.4.3.2.3 Wing. The structure used to produce lift for flight through the air.

Includes, for example:
a. Wing torque box, inner and outer wing panels, leading edge extension wing tip, movable control surfaces to include ailerons and leading and trailing edge flaps, attach fittings for pylons, wing fold mechanism, installation of airframe related subsystems, and installation of flight test instrumentation
b. Fitting for store stations
c. Material for sealing the integral fuel tanks
d. Provisions for the electrical, hydraulic, fuel, aerodynamic flight controls, etc.

Excludes, for example:
a. Efforts for the structural splicing of the wing to the fuselage as provided by the Airframe Integration, Assembly, Test, and Checkout.

A.4.3.2.4 Empennage. The structural tail group encompassing the fin, stabilizer, and rudder as well as provisions for electrical wiring, plumbing, control linkages, antennae, and associated equipment.

Includes, for example:
a. Structural stabilators, vertical tails, rudders, installation of airframe related subsystems, and installation of flight test instrumentation
b. Tail boom for rotary wing

A.4.3.2.5 Nacelle. The streamlined enclosure, separate from the fuselage, used for sheltering the crew, cargo, or housing an engine.

A.4.3.2.6 Other Airframe Components 1...n (Specify). This element should be replaced with other product-oriented airframe components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

A.4.3.3 Propulsion. That portion of the air vehicle that pertains to installed equipment (propulsion unit and other propulsion) to provide power/thrust to propel the aircraft through all phases of powered flight.

Includes, for example:
a. The engine as a propulsion unit within itself (e.g., reciprocating, turbo with or without afterburner, or other type propulsion) suitable for integration with the airframe
b. Thrust reversers, thrust vector devices, nozzles, transmissions, gear boxes, and engine control units, if furnished as integral to the propulsion unit
c. Other propulsion equipment required in addition to the engine but not furnished as an integral part of the engine, such as booster units
d. The design, development, production, and assembly efforts to provide the propulsion unit as an entity

Excludes, for example:
a. All effort directly associated with the integration, assembly, test, and checkout of these elements into the air vehicle
b. All ancillary equipment that are not an integral part of the engine required to provide an operational primary power source—air inlets, instruments, controls, etc.

NOTE: For lower level information, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.4 Vehicle Subsystems. The collection of core non-avionics subsystems.

A.4.3.4.1 Vehicle Subsystems Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the vehicle subsystem parts and subsystems equipment (hardware/software) elements. Reference Appendix K: Common Elements, Work Breakdown Structure and Definitions for further detail.

A.4.3.4.2 Flight Control Subsystem. Primary and secondary mechanical devices and automatic equipment installed in the air vehicle when used with control surfaces, to control the flight path of the air vehicle as well as to provide additional lift, drag and trim effect.

Includes, for example:
a. Primary and secondary mechanical controls, linkage, and control surface actuators for ailerons, rudders, stabilators, leading edge flaps, trailing edge flaps, and speed brakes, which are used to control the flight path of the air vehicle and provide additional lift, drag, and trim effect.

Excludes, for example:
a. Structural control surfaces, ailerons, rudder, stabilizer, etc. included in airframe as well as the installation of flight control subsystems into the appropriate basis structures element

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.4.3 Auxiliary Power Subsystem. The equipment that performs engine start up on the ground, emergency starting during flight, ground checkout operations of aircraft accessories, and power takeoff for hydraulic pumps and electrical generator system and fuel motive flow pumps.

Includes, for example:
a. Power takeoff shafts and oil cooling lines
b. Auxiliary power unit (APU)
c. Airframe mounted accessory drive (AMAD)
d. Air turbine starter
e. Secondary power, furnishings—cargo, etc.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.4.4 Hydraulic Subsystem. This system provides hydraulic power for the actuation of landing/launching gear subsystems, in-flight refueling probe, gun drive and flight control surfaces.

Includes, for example:

a. Pumps, reservoirs, accumulators, valves, regulators and associated plumbing distribution systems to provide hydraulic power
b. Hydraulic tubing, check valves, etc., which interconnect the hydraulic equipment

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.4.5 Electrical Subsystem. Equipment installed to provide electrical power function, the AC and DC distribution of this power supply and the provision for exterior lighting.

Includes, for example:
a. Wire bundles and miscellaneous electrical parts, which provide the electrical power function, the AC and DC distribution of this power supply and exterior lighting in the center fuselage, aft fuselage and vertical tail
b. Generator system, battery system, a transformer rectifier unit and power contactors
c. Power relays, circuit breakers and distribution systems between electronic mission equipment

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.4.6 Crew Station Subsystem. The provisions and space allocated to the human component of the weapon system that allow performance of specific functions to ensure mission success. Aircraft system human interfaces and components that sustain and protect the human operators, troops, and passengers.

Includes, for example:
a. Life support systems; flight clothing, head protection, noise attenuation systems, communication systems, anti-exposure systems, cooling systems, gravity onset protective systems, laser threat protection, chemical/biological protection, physiological monitoring systems, body armor, oxygen systems, survival equipment, personal flotation devices, flotation platforms, survival radios/beacons
b. Escape systems; ejection seats, canopy/hatch removal or penetration systems, sequencing systems, restraint systems, seat survival kits, parachutes, emergency exits, slides, crashworthy seats, armored seats, personal connection systems
c. Crash protection devices; includes attenuating seats, airbag systems and inflatable restraints
d. Search and rescue equipment
e. Aero-medical equipment (AE)
f. Canopy/wind screen systems; transparencies, seals, actuators, frames
g. Crew, passenger, and troop compartment geometry and design, secondary structure, interior/exterior lighting, seat installations, consoles, instrument panels, glare shields, personal cargo stowage, and waste management systems
h. Display/control interfaces; display/control locations and configuration, display symbology definition, helmet mounted devices, lighting, switches, pedals, control grips such as those for the stick/yoke, throttle, cyclic and collective
i. Human interface; human factors design features, speech intelligibility, and anthropometry for air vehicle interface, control and mission tasks
j. Crew environment habitability considerations; acoustical noise, radiation hazard, thermal environment, relative humidity, air velocity, and pressurization
k. Integration tests related to human interface with the air vehicle, including part task and full mission simulations, workload and situational awareness evaluations, life support system man rating, ejection tests, bailout or emergency egress, and lighting mockup evaluations

Excludes, for example:
a. Primary structure supporting seat installations and restraints covered under the airframe WBS element

b. Display hardware/software covered under the data display and controls WBS element
c. Wiring and plumbing for aircrew support covered under the airframe or other Level 4 vehicle systems WBS elements

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.4.7 Environmental Control Subsystem. Environmental equipment and distribution systems on board the air vehicle for air conditioning and cooling equipment compartments, pressurization of seals, fuel tanks and anti-icing. The distribution system provides for air ducts, cooling lines, and other plumbing required in supplying air and other cooling media from supply sources to the controlled environment.

Includes, for example:
a. Environmental and distribution systems on board the air vehicle to include fabricated air ducts, cooling lines and other plumbing required for cockpit air conditioning and pressurization (manned aircraft only)
b. Equipment compartment and individual air units air conditioning, pressurization of canopy seal (manned aircraft only), and fuel tanks
c. Bleed air for the gun gas purging; and windshield anti-icing and defogging subsystems (manned aircraft only)
d. Air refrigeration system, liquid cooling system, air flow regulation system, and a suit ventilation system (manned aircraft only)
e. Environmental control, racks, mounts, intersystem cables, distribution boxes, etc., which are inherent to, and non-separable from the assembled structure

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.4.8 Fuel Subsystem. Equipment and distribution systems installed in the air vehicle to provide fuel to the engines and the auxiliary power unit, including associated functions such as fuel pressurization, venting, gauging, defueling, etc.

Includes, for example:
a. Equipment and distribution systems to provide fuel to the engines
b. Associated functions included in the system are fuel storage, pressurization, venting, gauging, defueling, and in-flight refueling
c. Rotary or manned pylons, air induction system, thrust reversers, thrust vector devices, starters, exhausts, fuel management, inlet control system
d. Fuel lines, plumbing, etc., which interconnect the fuel subsystem equipment and storage cell in the air vehicle

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.4.9 Landing Gear. The structural and mechanical gear and associated equipment, including doors, for maneuvering of the air vehicle while on the ground, the devices for extension, retraction, and locking this gear, and the mechanical devices for arresting the air vehicle.

Includes, for example:
a. Alighting gear; tires, tubes, wheels, brakes, hydraulics, etc.
b. Main landing gears, nose landing gear
c. Arresting hook system and related doors and mechanisms

A.4.3.4.10 Rotor Group. Items that impart the pitch, yaw, roll, and thrust forces, which provide the lift and direction for Air Vehicle powered flight for rotary aircraft.

Includes, for example:
a. Main rotor blade
b. Main rotor head
c. Tail rotor blade

A.4.3.4.11 Drive System. Those items that pertain to the engine control units such as transmissions and gear boxes.

Includes, for example:
a. Dynamic systems; transmissions, gear boxes, propellers, if not furnished as an integral part of the propulsion unit

A.4.3.4.12 Vehicle Subsystems Software Release 1...n. All vehicle subsystem software not associated with a specific Level 4 element.

NOTE 1: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

A.4.3.4.13 Other Vehicle Subsystems 1...n (Specify). This element should be replaced with other product-oriented vehicle subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.5 Avionics. Mission equipment embedded on board the air vehicle, which is primarily electronic in nature.

A.4.3.5.1 Avionics Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mission equipment, parts, materials, and software required to assemble and test the avionics suite parts and subsystems equipment (hardware/software) elements. Reference Appendix K: Common Elements, Work Breakdown Structure and Definitions for further detail.

A.4.3.5.2 Communication/Identification. That equipment (hardware/software) installed in the air vehicle for communications and identification purposes.

Includes, for example:
a. Intercoms, radio system(s), identification equipment (IFF), data links, and control boxes associated with the specific equipment
b. Integral communication, navigation, and identification package (if used)

Excludes, for example:
a. Speech intelligibility work performed under the Crew Station WBS element
b. Survival/radios/beacons included under the Crew Station WBS element
c. Aircrew mounted communication components included under the Crew Station WBS element

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.5.3 Navigation/Guidance. That equipment (hardware/software) installed in the air vehicle to perform the navigational guidance function.

Includes, for example:
a. Radio, or other essential navigation equipment, radar altimeter, direction finding set, doppler compass, computer, and other equipment homogeneous to the navigation/guidance function

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.5.4 Mission Computer/Processing. The master data processing unit(s) and memory devices responsible for coordinating and directing the major avionic mission systems. It should include any data bus used to pass information across the various components of avionics mission systems.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.5.5 Fire Control. That equipment (hardware/software) installed in the air vehicle, which provides the intelligence necessary for weapons delivery such as bombing, launching, and firing.

Includes, for example:
a. Radars and other sensors
b. Apertures/antennas, if integral to the fire control system, necessary for search, target identification, rendezvous, and/or tracking
c. Self-contained navigation and air data systems
d. Dedicated displays, scopes, or sights
e. Bombing computer and control and safety devices

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.5.6 Data Display and Controls. The equipment (hardware/software) that visually presents processed data by specially designed electronic devices through interconnection (on or offline) with computer or component equipment and the associated equipment needed to control the presentation of the primary flight information and tactical information to the crew.

Includes, for example:
a. Multi-function displays, control display units, display processors, and on-board mission planning systems

Excludes, for example:
a. Indicators and instruments not controlled by keyboard via the multiplex data bus, panels and consoles which are included under the crew station
b. Display size/location and symbology definition included under the crew station

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.5.7 Survivability. Those equipment (hardware/software) installed in, or attached to, the air vehicle which assist in penetration for mission accomplishment. This represents survivability equipment permanently installed as an integral part to the system.

Includes, for example:
a. Ferret and search receivers, warning devices and other electronic devices, electronic countermeasures, jamming transmitters, chaff, infra-red jammers, terrain-following radars, and other devices typical of this mission function

Excludes, for example:
a. Survivability equipment installed as a payload on an unmanned system, or as an easily removed/reconfigured item for a manned aircraft (i.e., not integral to the air vehicle function, in a podded system, for example) are children of the Level 2 payload element.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.5.8 Reconnaissance. Those equipment (hardware/software) installed or integral to the air vehicle which provides the ability to perform Intelligence, Surveillance, and Reconnaissance (ISR) missions through capabilities to locate sense, record, image and communicate threat attributes meteorological, hydrographical or geographical characteristics.

Includes, for example:
a. Photographic, electronic, infrared, and other sensors
b. Search receivers
c. Recorders
d. Warning devices
e. Magazines
f. Data link

Excludes, for example:
a. Gun cameras (included under armament/weapons delivery)
b. Reconnaissance equipment installed as a payload on an unmanned system or as an easily removed/reconfigured item for a manned aircraft (i.e., not integral to the air vehicle function, in a podded system, for example) are children of the Level 2 payload element.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.5.9 Electronic Warfare. Those equipment (hardware/software) installed on the air vehicle which assist in any action involving the use of the electromagnetic spectrum or directed energy to control the spectrum, attack of an enemy, or impede enemy assaults via the spectrum.

Includes, for example:
a. Electronic counter-countermeasures, jamming transmitters, electromagnetic detection equipment, and weapons that use electromagnetic or directed energy such as laser, radio frequency (RF) weapons, or particle beams.

Excludes, for example:

a. Electronic countermeasures, chaff, infra-red jammers, or other equipment utilized primarily for defensive purposes (include such equipment under A.4.2.5.7 Survivability)
b. Electronic warfare equipment installed as a payload on an unmanned system, or as an easily removed/reconfigured item for a manned aircraft (i.e., not integral to the air vehicle function, in a podded system, for example) are children of the Level 2 payload element.

A.4.3.5.10 Automatic Flight Control. Those electronic devices and sensors on-board the aircraft, which, in combination with the flight controls subsystem (under vehicle subsystems), enable the crew to control the flight path of the aircraft and provide lift, drag, trim, or conversion effects.

Includes, for example:

a. Flight control computers, software, signal processors, and data transmitting elements that are devoted to processing data for either primary or automatic flight control functions
b. Electronic devices required for signal processing, data formatting, and interfacing between the flight control elements; the data buses, optical links, and other elements devoted to transmitting flight control data
c. Flight control sensors such as pressure transducers, rate gyros, accelerometers, and motion sensors

Excludes, for example:

a. Devices—linkages, control surfaces, and actuating devices—covered under the airframe and vehicle subsystem WBS elements
b. Avionics devices and sensors—central computers, navigation computers, avionics data buses and navigation sensors, which are included under other avionics WBS elements

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.5.11 Health Monitoring System. That equipment (hardware/software) installed in the air vehicle for malfunction detection and reporting.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.5.12 Stores Management. The avionics subsystem that controls and monitors the operational state of aircraft installed stores, and provides and manages the communications between aircraft stores, other aircraft subsystems, and weapons.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.5.13 Avionics Software Release 1...n. All avionics software not associated with a specific Level 4 element.

A.4.3.5.14 Other Avionics Subsystems 1...n (Specify). This element should be replaced with other product-oriented avionics subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.6 Armament/Weapons Delivery. That equipment (hardware/software) installed in the air vehicle to provide the firepower functions and weapons delivery capability. (Armament/Weapons Delivery equipment installed as a payload on an unmanned system or as an easily removed/reconfigured item for a manned aircraft (i.e., not integral to the air vehicle function, in a podded system for example) are included in Level 2 payload element)

Includes, for example:
a. Guns, high energy weapons, mounts, turrets, weapon direction equipment, ammunition feed and ejection mechanisms, and gun cameras
b. Launchers, pods, bomb racks, pylons, integral release mechanisms, and other mechanical or electro-mechanical equipment specifically oriented to the weapons delivery function

Excludes, for example:
a. Bombing/navigation system (included in the fire control element)

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.7 Auxiliary Equipment. Auxiliary airframe, electronics, and/or armament/weapons delivery equipment not allocable to individual element equipment, or which provide the ancillary functions to the applicable mission equipment.

Includes, for example:
a. Auxiliary airframe equipment such as external fuel tanks, pods, and rotodomes
b. Multi-use equipment like antennas, control boxes, power supplies, environmental control, racks, and mountings, not homogeneous to the prescribed WBS elements

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.3.8 Furnishings and Equipment. This element includes the provisions that sustain and support the passengers, typically consists of non-mission specific removable items.

Includes, for example:
a. Carpets
b. Executive interiors
c. Seats

Excludes, for example;
a. All items pertaining to the crew station subsystem element
b. Primary structure supporting seat installations and restraints covered under the airframe WBS element
c. Displays hardware/software covered under the data display and controls WBS element
d. Wiring and plumbing for aircrew support covered under the airframe and vehicle subsystems WBS elements

A.4.3.9 Air Vehicle Software Release 1...n (Specify). All air vehicle software not associated with a specific Level 3 or Level 4 element.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

A.4.3.10 Other Air Vehicle 1...n (Specify). This element should be replaced with other product-oriented air vehicle elements that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

A.4.4 Payload/Mission System. Aircraft systems (manned or unmanned) may have single or multiple payloads attached to the aircraft versus embedded (avionics systems). Examples of payloads include targeting and ranging systems, bio/chemical detection sensors, meteorological sensors, and communication relay systems.

A.4.4.1 Payload Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of payload equipment, parts, materials, and software required to assemble and test the payload suite parts and subsystems equipment (hardware/software) elements. Reference Appendix K: Common Elements, Work Breakdown Structure and Definitions for further detail.

A.4.4.2 Survivability. Those equipment (hardware/software) installed in, or attached to, the air vehicle, which assist in penetration for mission accomplishment. This represents survivability equipment permanently installed as an integral part to the system

Includes, for example:
a. Ferret and search receivers, warning devices and other electronic devices, electronic countermeasures, jamming transmitters, chaff, infra-red jammers, terrain-following radar, and other devices typical of this mission function

Excludes, for example:
a. Survivability equipment installed on a manned system integral to the air vehicle element.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.4.3 Reconnaissance Payload 1...n (Specify). Those equipment (hardware/software) installed in, or attached to, the air vehicle necessary to the reconnaissance mission.

Includes, for example:
a. Photographic, electronic, infrared, and other sensors
b. Search receivers
c. Recorders
d. Warning devices
e. Magazines
f. Data link

Excludes, for example:
a. Gun cameras

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.4.4 Electronic Warfare. Those equipment (hardware/software) attached to the air vehicle which assist in any action involving the use of the electromagnetic spectrum or directed energy to control the spectrum, attack of an enemy, or impede enemy assaults via the spectrum.

Includes, for example:
a. Electronic counter-countermeasures, jamming transmitters, electromagnetic detection equipment, and weapons that use electromagnetic or directed energy such as laser, RF weapons, or particle beams.

Excludes, for example:
a. Electronic countermeasures, chaff, infra-red jammers, or other equipment utilized primarily for defensive purposes (include such equipment under A.4.3.2 Survivability).

b. Electronic Warfare equipment installed on a manned system integral to the air vehicle function.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.4.5 Armament/Weapons Delivery Payload 1...n (Specify). The equipment (hardware/software) installed in the air vehicle to provide the firepower functions and weapons delivery capability.

Includes, for example:
a. Guns, high energy weapons, mounts, turrets, weapon direction equipment, ammunition feed and ejection mechanisms, and gun cameras
b. Launchers, pods, bomb racks, pylons, integral release mechanisms, and other mechanical or electro-mechanical equipment specifically oriented to the weapons delivery function

Excludes, for example:
a. Bombing/navigation system (included in the fire control element)

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.4.6 Payload Software Release 1...n (Specify). All payload software not associated with a specific Level 4 element.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

A.4.4.7 Other Payload 1...n (Specify). Any other product or equipment not already mentioned in the above definition, but that is also transported or delivered by the aircraft system. This element should be replaced with other product-oriented payload elements that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.5 Ground/Host Segment. The Ground segment is defined as a fixed, transportable, or mobile assembly of hardware, software, and firmware that has a communications interface with the vehicle to receive only, or to receive and transmit data generated and mission data collected by the air vehicle. In addition, vehicle telemetry, tracking and command (TT&C) and mission data may be processed within collocated facilities or alternatively in remotely located facilities. For example, Ground 1 could represent an operations center and Ground 2 a network operations center or some other type of command and control facility.

Includes, for example:
a. Support for the system and vehicle level integration and testing provided by the producer/integrator of the ground portion of the system

A.4.5.1 Ground Segment Integration, Assembly, Test, and Checkout. The efforts as identified in Appendix K: Common Elements, Work Breakdown Structure and Definitions, to provide a complete ground system.

A.4.5.2 Ground Control Systems (GCS). This subsystem receives, down converts, demodulates, and conditions telemetry, tracking, command, and mission (payload) data. In addition, this subsystem generates the RF

uplink, accepts tracking and command signals, and modulates them onto the RF uplink.

Includes, for example:
a. Antennas, feeds, antenna positioners, antenna support pedestals, radomes, transmitters, receivers, up/down frequency converters, modulators, demodulators, data links front-end equipment (encryptors/decryptors, synchronizers), etc.
b. Ground terminal (GT) facilities/buildings, GT factory/contractor support facility, GT initial support, GT support equipment
c. Environmental control units (air conditioners), power generators, etc. that are required for operation of the ground control stations

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.5.3 Command and Control Subsystem. This subsystem decodes, demultiplexes, and decrypts air vehicle telemetry, generates commands for transmission to the aircraft, and processes tracking data to generate air vehicle ephemeris. This subsystem supports all ground subsystems that require the capability to prepare and output commands to, and receive and process data from, the air vehicle while in operation or under test.

Includes, for example:
a. Network, computer processing and display hardware such as routers, switches, servers, workstations, storage devices, etc.
b. Software for handling, processing, and executing air vehicle commands, as well as processing and analyzing air vehicle telemetry
c. Command and control ground facilities/building, command and control factory/contractor support facility, command and control initial support and support equipment

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.5.4 Launch Equipment. This is the equipment necessary to launch air vehicles during the performance of its mission.

Includes, for example:
a. Equipment required to launch the air vehicle with its mission payloads into flight
b. Air vehicle hydraulic/pneumatic launcher, rail, and jet/rocket assisted take-off (JATO/RATO) bottles for short take-off

NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the Ground/Host Segment is excluded.

A.4.5.5 Recovery Equipment. This is the equipment necessary to recover air vehicles during the performance of its mission.

Includes, for example:
a. Automatic landing beacon system
b. Arresting net or arresting lines
c. Parachute

A.4.5.6 Transport Vehicles. Any vehicles that have been specifically designed or modified for the

transportation of air vehicles, ground control station equipment or other mission equipment. This includes any vehicles used to perform movement of the prime mission vehicle, crew, maintenance equipment, and direct maintenance personnel, or any other special transport systems used in the relocation of the prime mission equipment so that it may perform its mission.

A.4.5.7 Ground Segment Software Release 1...n. All Ground Segment software not associated with a specific Level 3 element.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

A.4.5.8 Other Ground Segment 1...n (Specify). This element should be replaced with other product-oriented Ground Segment elements that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

A.4.6 Common Elements. Common WBS elements and definitions for all commodities can be found at Appendix K.3. Several commodities have unique elements that are applied which also appear in Appendix K, specifically, Space Systems (K.4); Launch Systems (K.5); Information Systems/Defense Business Systems (K.6); and Strategic Missile Systems (K.7).

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APPENDIX B: ELECTRONIC OR GENERIC SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

B.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for electronic or generic systems. Definitions for WBS elements common to all defense materiel items are given in Appendix K: Common Elements, Work Breakdown Structure and Definitions.

B.2 APPLICABLE DOCUMENTS

B.2.1 General. The documents listed in this section are specified in Appendix B of this standard. This section does not include documents cited in other Appendices of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendices of this standard, whether or not they are listed.

B.2.2 Government documents.

B.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-196F – *Joint Electronics Type Designation System*
MIL-STD-1464A – *Army Nomenclature System*
MIL-STD-1661 – *Mark and Mod Nomenclature System*
MIL-HDBK-1812 – *Type Designation, Assignment and Method for Obtaining*

(Copies of these documents are available online at http://quicksearch.dla.mil/ or from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5008)

B.2.2.2 Other Government documents, drawings, and publications.

B.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 24765:2017 – *Systems and Software Engineering – Vocabulary*
ISO/IEC/IEEE 12207:2017 - *Systems and Software Engineering – Software Life Cycle Processes*

(Copies of these documents are available from www.ieee.org or The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-1331)

B.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Electronic System/Generic System			
1.1		Prime Mission Product (PMP) 1...n (Specify)		
1.1.1			PMP Integration, Assembly, Test, and Checkout	
1.1.2			PMP Subsystem 1...n (Specify)	
1.1.2.1				Subsystem Integration, Assembly, Test, and Checkout
1.1.2.2				Subsystem Hardware 1...n (Specify)
1.1.2.3				Subsystem Software Release 1...n (Specify)
1.1.3			PMP Software Release 1...n (Specify)	
1.1.3.1				Computer Software Configuration Item (CSCI) 1...n (Specify)
1.1.3.2				PMP Software Integration, Assembly, Test, and Checkout
1.2		Platform Integration, Assembly, Test, and Checkout		
1.3		Systems Engineering		
1.3.1			Software Systems Engineering	
1.3.2			Integrated Logistics Support (ILS) Systems Engineering	
1.3.3			Cybersecurity Systems Engineering	
1.3.4			Core Systems Engineering	
1.3.5			Other Systems Engineering 1...n (Specify)	
1.4		Program Management		
1.4.1			Software Program Management	
1.4.2			Integrated Logistics Support (ILS) Program Management	
1.4.3			Cybersecurity Management	
1.4.4			Core Program Management	
1.4.5			Other Program Management 1...n (Specify)	
1.5		System Test and Evaluation		
1.5.1			Development Test and Evaluation	
1.5.2			Operational Test and Evaluation	
1.5.3			Cybersecurity Test and Evaluation	
1.5.4			Mock-ups/System Integration Labs (SILs)	
1.5.5			Test and Evaluation Support	
1.5.6			Test Facilities	
1.6		Training		
1.6.1			Equipment	
1.6.1.1				Operator Instructional Equipment
1.6.1.2				Maintainer Instructional Equipment
1.6.2			Services	
1.6.2.1				Operator Instructional Services
1.6.2.2				Maintainer Instructional Services
1.6.3			Facilities	
1.6.4			Training Software 1...n (Specify)	
1.7		Data		
1.7.1			Data Deliverables 1...n (Specify)	
1.7.2			Data Repository	
1.7.3			Data Rights 1...n (Specify)	
1.8		Peculiar Support Equipment		
1.8.1			Test and Measurement Equipment	
1.8.1.1				Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.8.1.2				Test and Measurement Equipment (Propulsion)
1.8.1.3				Test and Measurement Equipment (Electronics/Avionics)
1.8.1.4				Test and Measurement Equipment (Other Major Subsystems 1...n
1.8.2			Support and Handling Equipment	
1.8.2.1				Support and Handling Equipment (Airframe/Hull/Vehicle)
1.8.2.2				Support and Handling Equipment (Propulsion)
1.8.2.3				Support and Handling Equipment (Electronics/Avionics)
1.8.2.4				Support and Handling Equipment (Other Major Subsystems 1...n (Specify))
1.9		Common Support Equipment		
1.9.1			Test and Measurement Equipment	

1.9.1.1 Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.9.1.2 Test and Measurement Equipment (Propulsion)
1.9.1.3 Test and Measurement Equipment (Electronics/Avionics)
1.9.1.4 Test and Measurement Equipment (Other Major Subsystems 1...n (Specify))
1.9.2 Support and Handling Equipment
1.9.2.1 Support and Handling Equipment (Airframe/Hull/Vehicle)
1.9.2.2 Support and Handling Equipment (Propulsion)
1.9.2.3 Support and Handling Equipment (Electronics/Avionics)
1.9.2.4 Support and Handling Equipment (Other Major Subsystems 1...n (Specify))
1.10 Operational/Site Activation by Site 1...n (Specify)
1.10.1 System Assembly, Installation, and Checkout on Site
1.10.2 Contractor Technical Support
1.10.3 Site Construction
1.10.4 Site /Ship/Vehicle Conversion
1.10.5 Interim Contractor Support (ICS)
1.11 Contractor Logistics Support (CLS)
1.12 Industrial Facilities
1.12.1 Construction/Conversion/Expansion
1.12.2 Equipment Acquisition or Modernization
1.12.3 Maintenance (Industrial Facilities)
1.13 Initial Spares and Repair Parts

B.3.1 Application of Common WBS Elements (Appendix K). WBS elements that are common (i.e., Integration, Assembly, Test, and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

B.3.2 Key Principles in Constructing a WBS. In the appendices of this MIL-STD, the WBS is defined to Level 3, 4, or 5 depending on the system. WBS elements in the appendices may be extended to appropriate levels below their MIL-STD definition for informational or reporting purposes. The purpose for these extensions is to ensure that the higher-level elements include the proper lower level elements when required to report at a lower level. If an extension below the MIL-STD definition is required, maintaining the product-oriented decomposition is required.

1) Extending the WBS to Lower Levels. The reporting level of the WBS depends on the level of interest where work is accomplished. Reporting at levels below those identified within the MIL-STD should be reported if they are considered high cost, high risk, high technical, and/or special interest. For those elements, extension of the WBS to lower levels may be necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. An example of the extension for this Appendix commodity can be found at http://cade.osd.mil/policy/csdr-plan.

2) 100% Rule. A key to WBS development is the principle that if the effort and resources can be associated with the element they support, they should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (Fire Control) has three child elements—transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem

and pulls it out of the Fire Control system to make it a level equal to the Fire Control, it distorts the effort and resources that are required to complete that Fire Control system. The reason is that the transmitter has lost its parent (Fire Control)/child relationship because it assumes the transmitter is not included within the Fire Control system.

3) Identifying Parent/Child Relationship. In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter within the Fire Control. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, it may include more functionality than just the transmitter subsystem. It may, for instance, include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to the inability to determine the effort for each functionality developed. It is, therefore, appropriate to associate that software to the next higher level (Fire Control) of the WBS. To accomplish this, it will be included in the Fire Control Software element of the Fire Control system. This eliminates allocation of the effort across multiple WBS elements where it is difficult to determine what level of support each gets.

4) Recognizing Cybersecurity Processes/Products. Cybersecurity is a requirement for all DoD programs and must be fully considered and implemented in all aspects of acquisition programs across the life cycle. Attention must be paid to cybersecurity at all acquisition category levels and all classification levels, including unclassified, throughout the entire life cycle; this includes systems that reside on networks and stand-alone systems that are not persistently connected to networks during tactical and strategic operations. Since responsibility for cybersecurity extends to every member of the acquisition workforce, DoD and its contractors need to design, develop, and acquire systems that can operate in applicable cyber threat environments. As such it is critical to understand what the cost of these systems is (i.e., hardware, software, systems engineering, program management, and system test and evaluation). MIL-STD-881D supports this effort by providing the structure to identify, collect and report many of these critical costs. It is also recognized gathering this information is nearly impossible at the level of detail these systems are developed. It is for this reason, where cybersecurity related costs can be easily accounted for, they should be called out in the WBS. For example, for hardware/software elements, if the development or procurement of hardware in a system is specifically a cybersecurity artifact, then call it out as a WBS element to identify it. The same is true for software. If the development of a CSCI(s) are specifically cybersecurity or software is purchased that is specifically for cybersecurity, call it out as a WBS element to identify it. Just as important are the engineering, management, and test activities that are used to ensure the systems are meeting the planned expectations. The MIL-STD has specifically called out these efforts associated with systems engineering, program management, and system test and evaluation WBS (See Appendix K).

B.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. In addition, the numbering provides visible clarity regarding level of indenture and parent-child content. While the numbering system is numeric, several unique issues arise across appendices which require the numbering system to be modified to accommodate these anomalies (See Figure X). Additionally, if a WBS element is not required, it may be eliminated from the structure and the numbering would be logically adjusted.

B.3.3.1 “Other” WBS Elements. All appendices contain a WBS element titled “Other” at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. This is available to provide flexibility within the system WBS for new or additional WBS elements that are not identified or defined in the Standard. These “other” elements would be used if, for example, a new subsystem or modified subsystem is defined, and it does not currently appear in the appendices of MIL-STD-881D. If it is determined that the “other” WBS is not needed, this element should not be used in the WBS. If it is determined that the “other” element is needed, then each element must be defined and the word “other” replaced by the newly defined WBS element.

B.3.3.2 1...n (Specify) WBS Element Definitions. Several appendices identify WBS elements with 1...n (Specify) or similar to denote that one or more components of that type of item may be used. Depending on the WBS identified, three approaches may be taken: 1) the parent WBS (e.g., 1...n) represents new or modified

subsystems with each defined WBS using the appropriate title; or 2) the parent WBS (1...n) represents two or more WBS elements which are children of the parent, or 3) the parent WBS (1...n) represents a family of systems which require the same numbering structure to maintain consistency, using the same WBS number and adding an alpha/numeric (a, b, c, etc.) at the end to ensure the WBS numbering stays intact. (See Figure X in the General section for examples of WBS breakouts for each approach).

B.4 DEFINITIONS

B.4.1 Electronic System/Generic System. The complex of equipment (hardware/software), data, services, and facilities required to develop and produce an electronic system capability such as a command and control system, radar system, communications system, sensor system, navigation/guidance system, electronic warfare system, support system, etc. This structure may also be used if no structure is defined within the MIL-STD. The purpose is providing a generic, logical decomposition of the WBS of a product-oriented systems or subsystem (i.e., engines, electronics, communication systems, etc.).

NOTE 1: To differentiate between the Electronic/Generic System category and other defense materiel item categories, use the following rule: When the item is a stand-alone system or used on several systems but not accounted for within the system, use the Electronic/Generic System category.

NOTE 2: When the opportunity to collect lower level information on electronic and software items exists, regardless of which defense materiel item category is selected, the structure and definitions in this appendix apply.

B.4.2 Prime Mission Product (PMP). The standalone system or major end item used to accomplish the primary mission of the defense materiel item. This WBS element includes the segments, subsystems, and software items as well as the efforts associated with the design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use) and is comprised of the sub elements listed below.

Includes, for example:

a. Hardware, software, and integration, assembly, test, and checkout associated with the overall prime mission product (PMP). When the electronic or generic system comprises several PMPs, each PMP will be listed separately at Level 2.
b. Breadboards, brass boards, development test and qualification test units
c. Factory special test equipment, special tooling, and production planning required to fabricate the PMP.

Excludes, for example:

a. Test articles that are functionally configured to represent and test subsystems or components should be included in the System Test and Evaluation element.
b. Duplicate or modified factory special test equipment delivered to the Government for depot repair should be included in the Peculiar Support Equipment element.
c. Spares for initial fielding should be included in the Initial Spares and Repair Parts element.

B.4.2.1 Prime Mission Product Integration, Assembly, Test, and Checkout. This WBS element contains all of the resources in order to perform integration, assembly, test, and checkout of the PMP. This is the process of combining and evaluating CSCIs and hardware of a system or segment of a system that have undergone individual CSCI and hardware qualification test.

B.4.2.2 PMP Subsystem 1...n (Specify). The hardware and software components of the specific electronic or generic subsystem.

Includes, for example:

a. All associated special test equipment, special tooling, production planning, and all technical and management activities
b. Software components, consisting of the software required to direct and maintain the specific electronic subsystem

c. All in-plant integration, assembly, test, and checkout of hardware components and software into an electronic subsystem, including the subsystem hardware and software integration and test
d. Interface materials and parts required for the in-plant integration and assembly of other Level 4 components into the electronic subsystem and all materials and parts or other mating equipment furnished by/to an integrating agency or contractor
e. Cables, conduits, connectors, shelters, and other devices associated with the operational electronic subsystem
f. The design, development, production, and assembly efforts to provide each electronic subsystem as an entity

Excludes, for example:
a. All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the prime mission product

NOTE: All software that is an integral part of any specific equipment system, subsystem or component specification or specifically designed and developed for system test and evaluation should be identified with that system, subsystem, component or effort. It may be appropriate to collect lower level information when it exists. In such cases, the following structure and definitions should be used:

LEVEL X	**LEVEL Y**
Subsystem Hardware 1...n (Specify)	
Subsystem Software Release 1...n (Specify)	
	Computer Software Configuration Item (CSCI) 1...n (defined per B 4.2.3.1)
	Software Integration, Assembly, Test, and Checkout (defined per B.4.2.3.2)

B.4.2.2.1 Subsystem Integration, Assembly, Test, and Checkout. The resources specifically related to evaluating the CSCIs and hardware operation as a subsystem. (ISO/IEC/IEEE 12207)

Includes, for example:
a. All resources necessary to integrate the subsystem components as a complete subsystem
b. Subsystem integration management
c. Requirements definition, planning, and scheduling
d. Development of integration plans and procedures
e. Integration test preparations, conduct testing, post-test teardown and review analysis, and documentation of subsystem integration results.

B.4.2.2.2 Subsystem Hardware 1...n (Specify). The hardware and associated resource components of the specific electronic or generic subsystem.

B.4.2.2.3 Subsystem Software Release 1...n (Specify). The resources associated with the subsystem software for release 1...n. A software release is an aggregate of one or more CSCIs that satisfies a specific set or subset of requirements. When incremental, spiral, or other software development methods are used, multiple releases may be necessary to meet program requirements.

A release is a separately tested and delivered product. Within releases are CSCIs. When a release is complete, a portion or all of one or more CSCIs will be completed. Therefore, a CSCI may appear in one or more releases of software, but will be successively more functional as each release of software is completed. (Note: The term “release” used in agile development should not be confused with the release of software as defined above. The MIL-STD definition is similar to multiple EPIC level CSCIs in Agile. In other words, a release of one or more EPIC level CSCIs is equivalent to a release in the MIL-STD.)

Includes, for example:
a. Computer Software Configuration Item (CSCI) 1...n
b. Subsystem Integration, Assembly, Test, and Checkout

B.4.2.3 Prime Mission Product Software Release 1...n (Specify). The resources associated with PMP software that are not associated with a specific PMP subsystem (i.e., distributed software environment) for release (1...n).

Includes, for example:
a. Computer Software Configuration Item (CSCI) 1...n
b. Software Integration, Assembly, Test, and Checkout

B.4.2.3.1 Computer Software Configuration Item (CSCI) 1...n (Specify). An aggregation of software or any of its discrete portions that satisfies an end use function and has been designated by the Government or contractor, if the Government did not specify, for configuration management. CSCIs are the major software products of a system acquisition, which are developed in accordance with standard DoD or commercial practices and processes.

Includes, for example:
a. Software requirements
b. Software architecture and design
c. Software code and unit test
d. Software integration
e. Software qualification testing
f. Commercial off-the-shelf (COTS)/Government off-the-shelf (GOTS) approach
g. COTS/GOTS component identification
h. COTS/GOTS assessment and selection
i. COTS/GOTS prototyping
j. COTS/GOTS glue code development
k. COTS/GOTS tailoring and configuration

When software development is accomplished, items (a) through (e) are typical development activities. When COTS/GOTS is to be used and integrated, items (f) through (k) are typical integration activities. CSCIs may align to major capabilities that span the software architecture.

B.4.2.3.2 PMP Software Integration, Assembly, Test, and Checkout. The element includes the effort and material associated with integrating and testing subsystem software CSCIs and hardware of an individual (or group of) subsystem software that have undergone individual CSCI qualification test.

Excludes, for example:
a. Software development efforts necessary for external system interfaces

B.4.3 Platform Integration, Assembly, Test, and Checkout. The effort involved in providing technical and engineering services to the platform manufacturer or integrator during the installation and integration of the PMP into the host system.

Includes, for example:
a. Labor required to analyze, design, and develop the interfaces with other host vehicle subsystems
b. Drawing preparation and establishment of equipment requirements and specifications
c. Technical liaison and coordination with the military services subcontractors, associated contractors, and test groups

Excludes, for example:
a. All integration effort not directly associated with the host vehicle and management liaison with the

military services, subcontractors, and associated contractors

B.4.4 Common Elements. Common WBS elements and definitions for all commodities can be found at Appendix K.3. Several commodities have unique elements that are applied which also appear in Appendix K, specifically, Space Systems (K.4); Launch Systems (K.5); Information Systems/Defense Business Systems (K.6); and Strategic Missile Systems (K.7).

APPENDIX C: MISSILE/ORDNANCE SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

C.1 SCOPE

C.1.1 Scope. This appendix provides the Work Breakdown Structure and Definitions for missile/ordnance systems. Definitions for WBS elements common to all defense materiel items are given in Appendix K: Common Elements, Work Breakdown Structure and Definitions.

C.2 APPLICABLE DOCUMENTS

C.2.1 General. The documents listed in this section are specified in Appendix C of this standard. This section does not include documents cited in other Appendices of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendices of this standard, whether or not they are listed.

C.2.2 Government documents.

C.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

C.2.2.2 Other Government documents, drawings, and publications.

C.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 24765:2017 – *Systems and Software Engineering – Vocabulary*
ISO/IEC/IEEE 12207:2017 - *Systems and Software Engineering – Software Life Cycle Processes*

(Copies of these documents are available from www.ieee.org or The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-1331)

C.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1	Missile/Ordnance System			
1.1		Missile/Ordnance System Integration, Assembly, Test, and Checkout		
1.2		Air Vehicle/Munition		
1.2.1			Air Vehicle/Munition Integration, Assembly, Test, and Checkout	
1.2.2			Airframe	
1.2.2.1				Airframe Integration, Assembly, Test, and Checkout
1.2.2.2				Primary Structure
1.2.2.3				Secondary Structure
1.2.2.4				Aero-Structures
1.2.2.5				Other Airframe Components 1...n (Specify)
1.2.3			Propulsion Subsystem 1...n (Specify)	
1.2.3.1				Propulsion Integration, Assembly, Test, and Checkout
1.2.3.2				Motor/Engine (Specify)
1.2.3.3				Fuel Management
1.2.3.4				Thrust Vector Actuation
1.2.3.5				Attitude Control System
1.2.3.6				Arm/Fire Device
1.2.3.7				Flight Termination/Mission Termination
1.2.3.8				Propulsion Software Release 1...n (Specify)
1.2.3.9				Other Propulsion Subsystems 1...n (Specify)
1.2.4			Power and Distribution	
1.2.4.1				Power and Distribution Integration, Assembly, Test, and Checkout
1.2.4.2				Primary Power
1.2.4.3				Power Conditioning Electronics
1.2.4.4				Distribution Harness
1.2.4.5				Power and Distribution Software Release 1...n (Specify)
1.2.4.6				Other Power and Distribution Subsystems 1...n (Specify)
1.2.5			Guidance	
1.2.5.1				Guidance Integration, Assembly, Test, and Checkout
1.2.5.2				Dome Assembly
1.2.5.3				Seeker Assemblies
1.2.5.4				Mission Computer
1.2.5.5				Guidance Software Release 1...n (Specify)
1.2.5.6				Other Guidance Subsystems 1...n (Specify)
1.2.6			Navigation	
1.2.6.1				Navigation Integration, Assembly, Test, and Checkout
1.2.6.2				Sensor Assemblies
1.2.6.3				Navigation Software Release 1...n (Specify)
1.2.6.4				Other Navigation Subsystems 1...n (Specify)
1.2.7			Controls	
1.2.7.1				Controls Integration, Assembly, Test, and Checkout
1.2.7.2				Primary Structure
1.2.7.3				Fin/Canard Deployment System
1.2.7.4				Actuators
1.2.7.5				Control Power
1.2.7.6				Controls Software Release 1...n (Specify)
1.2.7.7				Other Control Subsystems 1...n (Specify)
1.2.8			Communications	
1.2.8.1				Communications Integration, Assembly, Test, and Checkout
1.2.8.2				Antenna Assembly
1.2.8.3				Transmitter
1.2.8.4				Receiver
1.2.8.5				Communications Software Release 1...n (Specify)

1.2.8.6			Other Communications Subsystems 1...n (Specify)
1.2.9		Payload	
1.2.9.1			Payload Integration, Assembly, Test, and Checkout
1.2.9.2			Target Defeat Mechanism
1.2.9.3			Target Detection Device
1.2.9.4			Fuze
1.2.9.5			Payload Software Release 1...n (Specify)
1.2.9.6			Other Payload Subsystems 1...n (Specify)
1.2.10		On Board Test Equipment	
1.2.11		On Board Training Equipment	
1.2.12		Auxiliary Equipment	
1.2.13		Air Vehicle Software Release 1...n (Specify)	
1.3	Encasement Device		
1.3.1		Encasement Device Integration, Assembly, Test, and Checkout	
1.3.2		Encasement Device Structure	
1.3.3		Encasement Device Software Release 1...n (Specify)	
1.3.4		Other Encasement Device Subsystems 1...n (Specify)	
1.4	Command and/or Launch		
1.4.1		Command and/or Launch Integration, Assembly, Test, and Checkout	
1.4.2		Surveillance, Identification and Tracking Sensors	
1.4.3		Communications	
1.4.4		Launcher	
1.4.5		Adapter Kits	
1.4.6		Launch and Guidance Control	
1.4.7		Ready Magazine	
1.4.8		Auxiliary Equipment	
1.4.9		Command and/or Launch Software Release 1...n (Specify)	
1.4.10		Other Command and/or Launch 1...n (Specify)	
1.5	Missile/Ordnance System Software Release 1...n (Specify)		
1.6	Platform Integration, Assembly, Test, and Checkout 1...n (Specify)		
1.7	Systems Engineering		
1.7.1		Software Systems Engineering	
1.7.2		Integrated Logistics Support (ILS) Systems Engineering	
1.7.3		Cybersecurity Systems Engineering	
1.7.4		Core Systems Engineering	
1.7.5		Other Systems Engineering 1...n (Specify)	
1.8	Program Management		
1.8.1		Software Program Management	
1.8.2		Integrated Logistics Support (ILS) Program Management	
1.8.3		Cybersecurity Management	
1.8.4		Core Program Management	
1.8.5		Other Program Management 1...n (Specify)	
1.8	System Test and Evaluation		
1.9.1		Development Test and Evaluation	
1.9.2		Operational Test and Evaluation	
1.9.3		Cybersecurity Test and Evaluation	
1.9.4		Mock-ups/System Integration Labs (SILs)	
1.9.5		Test and Evaluation Support	
1.9.6		Test Facilities	
1.10	Training		
1.10.1		Equipment	
1.10.1.1			Operator Instructional Equipment
1.10.1.2			Maintainer Instructional Equipment
1.10.2		Services	
1.10.2.1			Operator Instructional Services

1.10.2.2				Maintainer Instructional Services
1.10.3			Facilities	
1.10.4			Training Software 1...n (Specify)	
1.11	Data			
1.11.1			Data Deliverables 1...n (Specify)	
1.11.2			Data Repository	
1.11.3			Data Rights 1...n (Specify)	
1.12	Peculiar Support Equipment			
1.12.1			Test and Measurement Equipment	
1.12.1.1				Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.12.1.2				Test and Measurement Equipment (Propulsion)
1.12.1.3				Test and Measurement Equipment (Electronics/Avionics)
1.12.1.4				Test and Measurement Equipment (Other Major Subsystems 1...n (Specify))
1.12.2			Support and Handling Equipment	
1.12.2.1				Support and Handling Equipment (Airframe/Hull/Vehicle)
1.12.2.2				Support and Handling Equipment (Propulsion)
1.12.2.3				Support and Handling Equipment (Electronics/Avionics)
1.12.2.4				Support and Handling Equipment (Other Major Subsystems 1...n (Specify))
1.13	Common Support Equipment			
1.13.1			Test and Measurement Equipment	
1.13.1.1				Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.13.1.2				Test and Measurement Equipment (Propulsion)
1.13.1.3				Test and Measurement Equipment (Electronics/Avionics)
1.13.1.4				Test and Measurement Equipment (Other Major Subsystems 1...n (Specify))
1.13.2			Support and Handling Equipment	
1.13.2.1				Support and Handling Equipment (Airframe/Hull/Vehicle)
1.13.2.2				Support and Handling Equipment (Propulsion)
1.13.2.3				Support and Handling Equipment (Electronics/Avionics)
1.13.2.4				Support and Handling Equipment (Other Major Subsystems 1...n (Specify))
1.14	Operational/Site Activation by Site 1...n (Specify)			
1.14.1			System Assembly, Installation, and Checkout	
1.14.2			Contractor Technical Support	
1.14.3			Site Construction	
1.14.4			Site/Ship/Vehicle Conversion	
1.14.5			Interim Contractor Support (ICS)	
1.15	Contractor Logistics Support (CLS)			
1.16	Industrial Facilities			
1.16.1			Construction/Conversion/Expansion	
1.16.2			Equipment Acquisition or Modernization	
1.16.3			Maintenance (Industrial Facilities)	
1.17	Initial Spares and Repair Parts			

C.3.1 Application of Common WBS Elements (Appendix K). WBS elements that are common (i.e., Integration, Assembly, Test, and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

C.3.2 Key Principles in Constructing a WBS. In the appendices of this MIL-STD, the WBS is defined to Level 3, 4, or 5 depending on the system. WBS elements in the appendices may be extended to appropriate levels below their MIL-STD definition for informational or reporting purposes. The purpose for these extensions is to ensure that the higher-level elements include the proper lower level elements when required to report at a lower level. If an extension below the MIL-STD definition is required, maintaining the product-oriented decomposition is required.

1) Extending the WBS to Lower Levels. The reporting level of the WBS depends on the level of interest where work is accomplished. Reporting at levels below those identified within the MIL-STD should be reported if they are considered high cost, high risk, high technical, and/or special interest. For those elements, extension of the WBS to lower levels may be necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. An example of the extension for this Appendix commodity can be found at http://cade.osd.mil/policy/csdr-plan.

2) 100% Rule. A key to WBS development is the principle that if the effort and resources can be associated with the element they support, they should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (Fire Control) has three child elements—transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the Fire Control system to make it a level equal to the Fire Control, it distorts the effort and resources that are required to complete that Fire Control system. The reason is that the transmitter has lost its parent (Fire Control) child relationship because it assumes the transmitter is not included within the Fire Control system.

3) Identifying Parent/Child Relationship. In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter within the Fire Control. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, it may include more functionality than just the transmitter subsystem. It may, for instance, include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to the inability to determine the effort for each functionality developed. It is, therefore, appropriate to associate that software to the next higher level (Fire Control) of the WBS. To accomplish this, it will be included in the Fire Control Software element of the of the Fire Control system. This eliminates allocation of the effort across multiple WBS elements where it is difficult to determine what level of support each gets.

4) Recognizing Cybersecurity Processes/Products. Cybersecurity is a requirement for all DoD programs and must be fully considered and implemented in all aspects of acquisition programs across the life cycle. Attention must be paid to cybersecurity at all acquisition category levels and all classification levels, including unclassified, throughout the entire life cycle; this includes systems that reside on networks and stand-alone systems that are not persistently connected to networks during tactical and strategic operations. Since responsibility for cybersecurity extends to every member of the acquisition workforce, DoD and its contractors need to design, develop, and acquire systems that can operate in applicable cyber threat environments. As such it is critical to understand what the cost of these systems is (i.e., hardware, software, systems engineering, program management, and system test and evaluation). MIL-STD-881D supports this effort by providing the structure to identify, collect and report many of these critical costs. It is also recognized gathering this information is nearly impossible at the level of detail these systems are developed. It is for this reason, where cybersecurity related costs can be easily accounted for, they should be called out in the WBS. For example, for hardware/software elements, if the development or procurement of hardware in a system is specifically a cybersecurity artifact, then call it out as a WBS element to identify it. The same is true for software. If the development of a CSCI(s) are specifically cybersecurity or software is purchased that is specifically for cybersecurity, call it out as a WBS element to identify it. Just as important are the engineering, management, and test activities that are used to ensure the systems are meeting the planned expectations. The MIL-STD has specifically called out these efforts associated with systems engineering, program management, and system test and evaluation WBS (See Appendix K).

C.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. In addition, the numbering provides visible clarity regarding level of indenture and parent-child content. While the numbering system is numeric, several unique issues arise across appendices which require the numbering system to be modified to accommodate these anomalies (See Figure X). Additionally, if a WBS element is not required, it may be eliminated from the structure and the numbering would be logically adjusted.

C.3.3.1 “Other” WBS Elements. All appendices contain a WBS element titled “Other” at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. This is available to provide flexibility within the system WBS for new or additional WBS elements that are not identified or defined in the Standard. These “other” elements would be used if, for example, a new subsystem or modified subsystem is defined, and it does not currently appear in the appendices of MIL-STD-881D. If it is determined that the “other” WBS is not needed, this element should not be used in the WBS. If it is

determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element.

C.3.3.2 1...n (Specify) WBS Element Definitions. Several appendices identify WBS elements with 1...n (Specify) or similar to denote that one or more components of that type of item may be used. Depending on the WBS identified, three approaches may be taken: 1) the parent WBS (e.g., 1...n) represents new or modified subsystems with each defined WBS using the appropriate title; or 2) the parent WBS (1...n) represents two or more WBS elements which are children of the parent, or 3) the parent WBS (1...n) represents a family of systems which require the same numbering structure to maintain consistency, using the same WBS number and adding an alpha/numeric (a, b, c, etc.) at the end to ensure the WBS numbering stays intact. (See Figure X in the General section for examples of WBS breakouts for each approach).

C.4 DEFINITIONS

C.4.1 Missile/Ordnance System. The complex of hardware, software, data, services, and facilities required to develop and produce the capability of employing a missile or ordnance in an operational environment to detect and defeat selected targets. Missiles may be classified as tactical or strategic (such as ballistic missiles). This appendix is focused on tactical missiles and ordnance, specific examples for missiles include, but are not limited to: AIM-9X, AMRAAM, HARM, Javelin, TOW, RAM, Stinger, Standard Missile, Tomahawk, JASSM, GMLRS, JAGM, Patriot, AARGM, HTM, MOP, JDAM, GP Bombs, and Trident. Ordnances are unguided weapons unpowered after leaving its launching device that has as its purpose the destruction of some object or target. The term includes, but is not limited to, such items as ammunition, projectiles, mines, bombs, rockets, mortars, depth charges, and torpedoes. If guidance and control components are added to ordnance to increase accuracy those modified systems are still classified as ordnances. Specific examples of ordnances include, but are not limited to: Excalibur, JSOW, MRM, Paveway, SDB I, SDB II.

C.4.2 Missile/Ordnance System Integration, Assembly, Test, and Checkout. The integration, assembly, test, and checkout element includes all efforts as identified in Appendix K: Common Elements, Work Breakdown Structure and Definitions, to provide a complete missile/ordnance system.

C.4.3 Air Vehicle/Munition. An air vehicle or a munition is a guided weapon self-propelled after leaving its launching device that has as its purpose the delivery of a payload for destruction (or defeat) of some object or target. A munition can be guided or unguided. This WBS element includes the design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use) and is comprised of the sub elements listed below.

C.4.4 Air Vehicle/Munition Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing, and software required for the integration, assembly, test, and checkout of the Level 3 elements into their Level 2 element, Air Vehicle/Munition.

C.4.4.1 Airframe. This element comprises the structural framework that provides the aerodynamic shape, mounting surfaces, and environmental protection for the air vehicle components, which are not directly applicable to other specific Level 3 air vehicle subsystems.

Includes, for example:

a. Wings and fins that provide aerodynamic flight control in response to electro-mechanical signals and are attached to the air vehicle body
b. Structural body assemblies including the structure, fuel tanks that integrate with the structure, covers, skins, adhesives, and fairings not directly applicable to any other Level 3 air vehicle subsystem
c. Protection devices for stressing environmental conditions such as thermal protection system or rain erosion that are not directly applicable to other Level 3 air vehicle subsystems

C.4.4.1.1 Airframe Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing, and software required for the integration, assembly, test, and checkout of the Level 4 elements into their Level 3 element, Airframe.

C.4.4.1.2 Primary Structure. This element comprises the structural framework that provides for load carrying hardware such as the air carry system, interfaces to loading and launching devices, and other hard points needed to protect the air vehicle from environmental induced loads

C.4.4.1.3 Secondary Structure. This element comprises the secondary hardware needed to maintain aerodynamic shapes, interfaces between other subsystems, fuel tanks, protection subsystems such as a thermal protection system (TPS), and other structure not directly associated with the primary structure or other Level 3 subsystems.

C.4.4.1.4 Aero-Structures. This element comprises the hardware needed for aerodynamic flight effects. It includes, for example, the wings, fins, canards, stability systems, and inlets for air breathing propulsion.

C.4.4.1.5 Other Airframe Components 1...n (Specify). This element should be replaced with other product-oriented airframe components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

C.4.4.2 Propulsion Subsystem 1...n (Specify). The equipment to provide thrust to propel the air vehicle on its intended flight. The total propulsion system may be composed of one or more subsystems that ignite, burn, and may be jettisoned sequentially over the course of flight. Individual subsystems may employ solid, liquid, or air-breathing technologies. This element and the Level 4 elements below comprise the equipment to make up a single propulsion system.

C.4.3.3.1 Propulsion System Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, etc. required for the integration, assembly, test, and checkout of the Level 4 elements into their Level 3 element, Propulsion System.

C.4.3.3.2 Motor/Engine (Specify). The structure (integral to the propulsion system), propellant, controls, instrumentation, and all other installed subsystem equipment integral to the rocket motor or engine as an entity within itself.

Includes, for example:

a. Solid Rocket Motor. This element is applicable to a solid propulsion system and consists of the thrust producing component in which solid propellant, made up of fuel and oxidizer, is combusted and expelled through a nozzle. It includes the pressure vessel, an igniter, internal insulation, solid propellant, and a nozzle. If applicable it includes the functionality to move the nozzle or a portion of the nozzle but not the actuation subsystem to cause that movement. Where applicable, may include Booster Adapter.
b. Liquid Rocket Engine. This element is applicable to a liquid propulsion system and is a thrust producing device in which liquid fuel and oxidizer are delivered to the engine. Within the engine the fuel and oxidizer are combusted and expelled through a nozzle to produce thrust. It includes any turbines, pumps, valves, etc. to deliver the fuel and oxidizer to the combustion chamber. It may include valves or other control components to throttle the thrust level during operation as well as additional thrusters for vehicle control. If applicable, it includes the functionality to move the engine or a portion of the engine for thrust vector control but not the actuation subsystem to cause that movement.
c. Air Breathing Engine. This element is applicable to an air breathing propulsion system in which a stream of air is supplied to the engine along with a liquid fuel. The engine operates to mix and combust the air and fuel and to expel the products through a nozzle to produce thrust. It includes all the turbines, compressors, injectors, etc. to act on the air and fuel from the inlet to the engine through the exhaust from the engine. It does not include aerodynamic inlets on the air vehicle to deliver air to the engine.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

C.4.3.3.3 Fuel Management. All of the tanks, lines, pressurization system and/or pressure control, pumps, valves, etc. to deliver the fuel and oxidizer to the engine at the required conditions.

C.4.3.3.4 Thrust Vector Actuation. Those items integral to the propulsion system to move the nozzle, engine, or a portion of the nozzle or engine.

Includes, for example:
a. Actuator and all of the components needed to move the actuator

Excludes, for example:
a. Vanes or other similar items mounted external to the propulsion system that may act on the exhaust from the propulsion system unless they are part of an item integral to the propulsion system
b. Any other part of the control system for the air vehicle

C.4.3.3.5 Attitude Control System. The Attitude Control System (ACS) or Divert/Attitude Control Systems (DACS) that are separate from the propulsion rocket motor or engine. These systems can be of any type: cold gas, warm gas, liquid propellant, solid propellant, etc.

Includes, for example:
a. All of the thrusters, lines, valves, propellant tanks, gas tanks, manifolds
b. Control system for the ACS/DACS to the extent that the control system is integral to the propulsion system

Excludes, for example:
a. The control system or elements of the control system if these are separate from the ACS/DACS with the only interface being a signal to a valve or distributor on the ACS/DACS

C.4.3.3.6 Arm/Fire Devices. Hardware to arm, disarm, and initiate operation of the propulsion system.

C.4.3.3.7 Flight Termination/Mission Termination. Hardware and ordnance to cause the propulsion system to cease operation and, if applicable, cause the propulsion system to break up. It may include the ability to arm and disarm.

C.4.3.3.8 Propulsion Software Release 1...n (Specify). All propulsion subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

C.4.3.3.9 Other Propulsion Subsystems 1...n (Specify). This element should be replaced with other product-oriented propulsion components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

C.4.3.4 Power and Distribution. This element comprises prime power and distribution for the air vehicle/munition.

C.4.3.4.1 Power and Distribution Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing, and software required for the integration, assembly, test, and checkout of the Level 4 elements into their Level 3 element, Power and Distribution.

C.4.3.4.2 Primary Power. This element comprises primary power for the air vehicle.

Excludes, for example:
a. Batteries, which may be integral to other Level 3 elements

C.4.3.4.2 Power Conditioning Electronics. This element comprises prime power conditioning electronics. It excludes power conditioning integral to other Level 3 elements.

C.4.3.4.3 Distribution Harness. This element comprises prime power distribution harnesses.

Excludes, for example:
a. Harnessing integral to other Level 3 elements

C.4.3.4.4 Power and Distribution Software Release 1...n (Specify). All power and distribution subsystem software not associated with a specific Level 4 element above

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

C.4.3.4.5 Other Power and Distribution Subsystems 1...n (Specify). This element should be replaced with other product-oriented power and distribution components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

C.4.3.5 Guidance. Guidance is the process of maneuvering the air vehicle to engage the intended target. This WBS element is the compliment of hardware, software, and equipment for target detection, signal processing, implementation of guidance laws, and generation of guidance commands.

Excludes, for example:
a. Navigation
b. Control

C.4.3.5.1 Guidance Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing, and software required for the integration, assembly, test, and checkout of the Level 4 elements into their Level 3 element, Guidance.

C.4.3.5.2 Dome Assembly. Windows, domes, or radomes, and associated retention mechanisms, to cover the seeker(s) apertures used for target detection and are suitable to support seeker functionality. Contingent upon the design, this may be included within the Seeker Assemblies WBS element.

C.4.3.5.3 Seeker Assemblies. This element comprises the sensors (RF, EO, SAL, etc., as applicable), sensor electronics, gimbal assembly, on-gimbal electronics and integral structure(s), which constitute the seeker assembly.

Includes, for example:
a. Radio frequency (RF), electro optical (EO), and semi-active laser (SAL) sensors

C.4.3.5.4 Mission Computer. The master data processing unit(s) responsible for coordinating and directing the major avionic mission systems.

C.4.3.5.5 Guidance Software Release 1...n (Specify). All guidance subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

C.4.3.5.6 Other Guidance Subsystems 1...n (Specify). This element should be replaced with other product-oriented guidance components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

C.4.3.6 Navigation. The compliment of hardware, software, and equipment to measure or determine body angles and/or body linear motion and generation of navigation commands.

Excludes, for example:
a. Guidance
b. Control

C.4.3.6.1 Navigation Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing, and software required for the integration, assembly, test, and checkout of the Level 4 elements into their Level 3 element, Navigation.

C.4.3.6.2 Sensor Assemblies. Hardware that provides data for determination of air vehicle location and orientation.

Includes, for example:
a. Global Positioning System (GPS) receiver and antenna
b. Inertial sensors
c. Altimeter

C.4.3.6.3 Navigation Software Release 1...n (Specify). All navigation subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

C.4.3.6.4 Other Navigation Subsystems 1...n (Specify). This element should be replaced with other product-oriented navigation components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

C.4.3.7 Controls. The hardware, software, and equipment for controlling the motion of the air vehicle from launch to detonation or impact).

Includes, for example:
a. Control devices for canard, wing, tail, etc.
b. Thrust vector/jet van
c. Explosive charge/lateral thrusters

Excludes, for example:
a. Control surfaces themselves (such as canards, wings, tails, etc.) included in the airframe element.

C.4.3.7.1 Controls Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing, and software required for the integration, assembly, test, and checkout of the Level 4 elements into their Level 3 element, Controls.

C.4.3.7.2 Primary Structure. The structural framework not part of the airframe element.

C.4.3.7.3 Fin/Canard Deployment System. The hardware for fin/canard deployment.

C.4.3.7.4 Actuators. The hardware for actuation to include motors and servos.

C.4.3.7.5 Control Power. This element comprises power for the control element.

Excludes, for example:
a. Central power sources included in the Power and Distribution WBS element

C.4.3.7.6 Controls Software Release 1...n (Specify). All controls subsystem software not associated with a specific Level 4 element above.

C.4.3.7.7 Other Control Subsystems 1...n (Specify). This element should be replaced with other product-oriented airframe components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

C.4.3.8 Communications. The data link equipment to enable communications between the air vehicle and an external entity (or entities). Data links can be either receive only or send only (one-way) or bidirectional (two way).

Includes, for example:
a. Data transmission and reception for networking, command and control, battlespace awareness, and air traffic management enabling the air vehicle to be a node in the net

C.4.3.8.1 Communications Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing, and software required for the integration, assembly, test, and checkout of the Level 4 elements into their Level 3 element, Communications.

C.4.3.8.2 Antenna Assembly. The hardware comprising the Antenna Assembly or Assemblies

C.4.3.8.3 Transmitter. The equipment (hardware/software) used in telecommunications to produce radio frequencies in order to transmit or send data with the aid of an antenna.

C.4.3.8.4 Receiver. The equipment (hardware/software) used to receive analog electromagnetic signals or digital signals in terms of networking and communication.

C.4.3.8.5 Communications Software Release 1...n (Specify). All communication subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

C.4.3.8.6 Other Communications Subsystems 1...n (Specify). This element comprises the complex of equipment, not included in the above Level 4 elements, that is unanticipated at the time of issuance of this appendix due to the evolution of technology but necessary to complete this Level 3 element.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

C.4.3.9 Payload. The Target Defeat Mechanism (TDM) and its support assemblies. Normally, payload consists only of the TDM and its associated target detection, arming, and fuzing equipment. However, with complex air vehicles containing subair vehicles (submunitions), the payload subsystem may mimic the larger system by having its own

guidance and control, fuze, safe-arm, and propulsion. In multi-mission or adaptable payloads there may be a communication device that provides data to payload for output yield, real-time directions for aimable capabilities, or layer-counting type applications.

C.4.3.9.1 Payload Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing, and software required for the integration, assembly, test, and checkout of the Level 4 elements into their Level 3 element, Payload.

C.4.3.9.2 Target Defeat Mechanism. The hardware and software that produce(s) the desired effect on the target. TDMs include, but are not limited to, conventional high explosives (explosive outputs of blast, fragmentation, and penetrator-forming), directed energy devices, kinetic energy devices, dispensed submunitions, or others.

C.4.3.9.3 Target Detection Device (TDD). The hardware and software that detects and signals the presence of a target. TDDs include, but are not limited to, contact sensors (make or break electronics), EO or RF based proximity sensors and necessary hardware and software for signal processing.

C.4.3.9.4 Fuze. The equipment in the air vehicle that controls the capability of initiating the TDM (e.g., mechanical, hydrostatic, inertial, counters, and timers). It includes the hardware and software for the Safe, Arm and Fire (SAF) function; sensors and algorithms, if applicable, to enable “smart fuzing”; and the hardware and software associated with the firing train

C.4.3.9.5 Payload Software Release 1...n (Specify). All payload subsystem software not associated with a specific Level 4 element above.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

C.4.3.9.6 Other Payload Subsystems 1...n (Specify). This element should be replaced with other product-oriented airframe components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

C.4.3.10 On Board Test Equipment. This element comprises the payload that is interchangeable with the live warhead and suitable for development or operational testing in a free flight (post launch) environment.

Includes, for example:

a. Recovery systems
b. Special instrumentation
c. Telemetry equipment,
d. Flight termination equipment, etc., suitable for a launch and free flight environment

C.4.3.11 On Board Training Equipment. This element comprises the payload that is interchangeable with the live warhead and suitable for testing in a non-launch environment. Includes, for example, special instrumentation, telemetry equipment, etc., suitable for a non-launch environment.

C.4.3.12 Auxiliary Equipment. This element comprises the complex of additional external equipment generally excluded from other specific Level 3 elements.

Includes, for example:

a. Environmental control, safety and protective subsystems, destruct systems, etc., if these were not accounted for in other WBS elements

b. Equipment of a single purpose and function, which is necessary for accomplishing the assigned mission.

C.4.3.13 Air Vehicle/Munition Software Release 1...n (Specify). All air vehicle/munition software not associated with a specific Level 3 or Level 4 element.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

C.4.4 Encasement Device. The hardware and software associated with the air vehicle canister or encasement device, which may be for transportation or launch depending on the air vehicle/munition.

C.4.4.1 Encasement Device Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing, and software required for the integration, assembly, test, and checkout of the Level 3 elements into their Level 2 element, Encasement Device.

C.4.4.2 Encasement Device Structure. This element comprises the primary structure of the canister or encasement device.

C.4.4.3 Encasement Software Release 1...n (Specify). All Encasement software not associated with a specific Level 3 element above.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

C.4.4.4 Other Encasement Device Subsystems 1...n (Specify). This element should be replaced with other product-oriented encasement device subsystem components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

C.4.5 Command and/or Launch System. The subsystems at a launch site or aboard launch vehicles required to store, make ready, and launched missile or munitions on a desired course or trajectory.

Includes, for example:

a. Those equipment required to acquire and condition the necessary intelligence of selected targets, reach launch decisions, command the launch, and provide guidance and control where such capability is not self-contained aboard the air vehicle
b. Rifles, artillery pieces, naval guns, mortar cannons, machine guns, and the equipment for launching torpedoes and rockets or dropping bombs (e.g., the launcher, fire control equipment, and the ready magazine).

C.4.5.1 Command and/or Launch Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing, and software required for the integration, assembly, test, and checkout of the Level 3 elements into their Level 2 element, Command and/or Launch System.

C.4.5.2 Surveillance, Identification, and Tracking Sensors. The sensors required to support missile systems by maintaining surveillance against incoming targets and providing the data required for targeting, launch, midcourse guidance, and homing where such capability is not self-contained aboard a missile system air vehicle.

Includes, for example:

a. Tracking of the missile system air vehicles as required for guidance and control or range safety
b. Sensors of any spectrum (radar, optical, infrared, etc.), which are external to the air vehicle

Excludes, for example:
a. Subsystems used in safety, destruct, test, or training activities, unless they are required operational items

C.4.5.3 Communications. The equipment, not resident on the air vehicle, which distributes intelligence between the air vehicle and the command and launch equipment.

Includes, for example:
a. Inter-communication subsystems of launch sites for tactical and administrative message flow and ties between sensor, data processing, launch, and guidance control subsystems
b. Communications may interface with existing fixed communication facilities or communication subsystems of launch platforms, which are associated systems to the missile system

C.4.5.4 Launcher. The means to launch the missile/munitions from stationary sites or mobile launch platforms. The structural device designed to support and hold missile/munitions in position for firing or release, which serves as a platform to accommodate the other Level 3 elements and provides mobility to the complete launch system (e.g., T-frame, hull/chassis, wheels, tires, tubes, brakes, hydraulics, and secondary power batteries/generators).

Includes, for example:
a. Vehicles, rail launchers, canisters, capsules, tubes, pods, and devices, which support, suspend, or encase the air vehicle for firing. Such devices would be in addition to any encasement, if applicable, integral to an air vehicle
b. Associated hardware such as umbilicals, harnesses, pyrotechnics, and electronics
c. Storage facilities and checkout stations for readiness verification when these are integral to the launcher
d. (For guns and artillery) tubes, recoil assemblies, breech mechanisms, mounts, and rifle stocks
e. Safety and protective elements when these are not integral to the launch platform or site facilities

C.4.5.5 Adapter Kits. The equipment for adapting the launch system to particular applications (e.g., vehicle adapter kits for adaptation to different aircraft models, kits for backpacking, etc.).

C.4.5.6 Launch and Guidance Control. The equipment to target air vehicles, make launch decisions, command launch, and for controlling the direction, volume, and time of fire or release of missile/munitions through the use of electrical, electronic, optical, or mechanical systems, devices, or aids.

C.4.5.7 Ready Magazine. The structure or compartment for storing missile, ammunition, or explosives in a ready-for-use condition or position.

C.4.5.8 Auxiliary Equipment. The general purpose/multi-usage ground equipment utilized to support the various operational capabilities of the command and/or launch equipment, which is generally excluded from other specific Level 3 elements.

Includes, for example:
a. Power generators, power distribution systems, environmental control, cabling, malfunction detection, fire prevention, security systems, and other common-usage items not applicable to specific elements of the ground-based equipment

C.4.5.9 Command and Launch Software Release 1...n (Specify). All command and launch software not associated with a specific Level 3 element.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

C.4.5.10 Other Command and/or Launch 1...n (Specify). This element should be replaced with other product-oriented command and/or launch components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

C.4.6 Missile/Ordnance System Software Release 1...n. All missile system software not associated with a specific Level 2, Level 3 or Level 4 elements.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

C.4.7 Platform Integration, Assembly, Test, and Checkout. The effort involved in providing technical and engineering services to the platform manufacturer or integrator during the installation and integration of the missile into the host system.

Includes, for example:

a. Labor required to analyze, design, and develop the interfaces with other host vehicle subsystems
b. Drawing preparation and establishment of equipment requirements and specifications
c. Technical liaison and coordination with the military services subcontractors, associated contractors, and test groups

Excludes, for example:

a. All integration effort not directly associated with the host vehicle and management liaison with the military services, subcontractors, and associated contractors

C.4.8 Common Elements. Common WBS elements and definitions for all commodities can be found at Appendix K.3. Several commodities have unique elements that are applied which also appear in Appendix K, specifically, Space Systems (K.4); Launch Systems (K.5); Information Systems/Defense Business Systems (K.6); and Strategic Missile Systems (K.7).

APPENDIX D: STRATEGIC MISSILE SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

D.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for strategic missile systems. Definitions for WBS elements common to all defense materiel items are given in Appendix K: Common Elements, Work Breakdown Structure and Definitions.

D.2 APPLICABLE DOCUMENTS

D.2.1 General. The documents listed in this section are specified in Appendix D of this standard. This section does not include documents cited in other Appendices of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendices of this standard, whether or not they are listed.

D.2.2 Government documents.

D.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

D.2.2.2 Other Government documents, drawings, and publications.

D.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 24765:2017 – *Systems and Software Engineering – Vocabulary*
ISO/IEC/IEEE 12207:2017 - *Systems and Software Engineering – Software Life Cycle Processes*

(Copies of these documents are available from www.ieee.org or The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-1331)

D.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4	Level 5
1.0	Strategic Missile Systems				
1.1		Strategic Missile Systems Integration, Assembly, Test, and Checkout			
1.2		Air Vehicle Equipment (AVE)/Flight Vehicle Equipment (FVE)			
1.2.1			AVE/FVE SEIT/PM and Support Equipment		
1.2.2			Aero-Structures (Non-Stage Related)		
1.2.3			Stage (1...3) Interstage		
1.2.3.1				Stage 1 Interstage	
1.2.3.1.1					Stage 1 Interstage SEIT/PM and Support Equipment
1.2.3.1.2					Structures and Mechanisms
1.2.3.1.3					Separation Ordnance
1.2.3.1.4					Attitude Control System (ACS)
1.2.3.1.5					Interstage Peculiar Avionics
1.2.3.1.6					Cable and Harness Assembly
1.2.3.1.7					Flight Termination/Mission Termination
1.2.3.1.8					Instrumentation/Telemetry
1.2.3.2				Stage 2 Interstage	
1.2.3.3				Stage 3 Interstage	
1.2.4			Other AVE/FVE Structures 1...n (Specify)		
1.2.5			Stage (1...3)		
1.2.5.1				Stage 1	
1.2.5.1.1					Stage SEIT/PM and Support Equipment
1.2.5.1.2					Structures and Mechanisms
1.2.5.1.3					Propulsion System
1.2.5.1.4					Attitude Control System
1.2.5.1.5					Stage Peculiar Avionics
1.2.5.1.6					Cable Assembly
1.2.5.1.7					Flight Termination/Mission Termination
1.2.5.1.8					Instrumentation/Telemetry
1.2.5.2				Stage 2	
1.2.5.3				Stage 3	
1.2.6			Power and Distribution		
1.2.6.1				Power and Distribution SEIT/PM and Support Equipment	
1.2.6.2				Primary Power	
1.2.6.3				Power Conditioning Electronics	
1.2.6.4				Distribution Harness	
1.2.6.5				Power and Distribution Software Release 1...n (Specify)	
1.2.7			Guidance and Control		
1.2.7.1				Guidance and Control SEIT/PM and Support Equipment	
1.2.7.2				Guidance Computer	
1.2.7.3				Guidance and Control Electronics	
1.2.7.4				Navigation/Inertial Measurement Unit (IMU)	
1.2.7.5				Guidance and Control Cooling System	
1.2.7.6				Computer Memory Battery	
1.2.7.7				Guidance and Control Cables	
1.2.7.8				Guidance and Control Software Release 1...n (Specify)	
1.2.8			Communications		
1.2.8.1				Communications SEIT/PM and Support Equipment	
1.2.8.2				Antenna Assembly 1...n (Specify)	
1.2.8.3				Transceiver Assembly 1...n (Specify)	
1.2.8.4				Communications Software Release 1...n (Specify)	
1.2.9			Post Boost/Attitude Control Module (PBACM)		
1.2.9.1				PBACM SEIT/PM and Support Equipment	
1.2.9.2				Structures and Mechanisms	

1.2.9.3 Propulsion System
1.2.9.4 Countermeasures
1.2.9.5 PBACM Peculiar Avionics
1.2.9.6 Cable Assembly
1.2.9.7 Flight Termination/Mission Termination
1.2.9.8 Instrumentation/Telemetry
1.2.10 Payload/Reentry Systems
1.2.10.1 Payload/Reentry Systems SEIT/PM and Support Equipment
1.2.10.2 Payload/Reentry Vehicle 1...n (Specify)
1.2.10.3 Countermeasures
1.2.10.4 Deployment Housing/Bulkheads
1.2.11 Ordnance Initiation Set
1.2.12 On Board Test Equipment
1.3 Encasement Device
1.3.1 Encasement Device SEIT/PM and Support Equipment
1.3.2 Encasement Device Structure
1.3.3 Encasement Device Software Release 1...n (Specify)
1.3.4 Other Encasement Device Subsystems 1...n (Specify)
1.4 Command and Launch
1.4.1 Command and Launch SEIT/PM and Support Equipment
1.4.2 Launch and Guidance Control/Fire Control
1.4.3 Communications
1.4.4 Launch and Encasement Equipment
1.4.5 Auxiliary Equipment
1.4.6 Command and Launch (Ground) Software Release 1...n (Specify)
1.4.7 Infrastructure
1.4.8 Other Command and Launch 1...n (Specify)
1.5 Systems Engineering
1.5.1 Software Systems Engineering
1.5.2 Integrated Logistics Support (ILS) Systems Engineering
1.5.3 Cybersecurity Systems Engineering
1.5.4 Nuclear Hardening and Survivability (NH&S)
1.5.5 System Safety
1.5.6 Nuclear Surety
1.5.7 Core Systems Engineering
1.5.8 Other Systems Engineering 1...n (Specify)
1.6 Program Management
1.6.1 Software Program Management
1.6.2 Integrated Logistics Support (ILS) Program Management
1.6.3 Cybersecurity Management
1.6.4 Program Control
1.6.5 Core Program Management
1.6.6 Other Program Management 1...n (Specify)
1.7 System Test and Evaluation
1.7.1 Development Test and Evaluation
1.7.2 Operational Test and Evaluation
1.7.3 Cybersecurity Test and Evaluation
1.7.4 Mock-ups/System Integration Labs (SILs)
1.7.5 Test and Evaluation Support
1.7.6 Test Facilities
1.8 Training
1.8.1 Equipment
1.8.1.1 Operator Instructional Equipment
1.8.1.2 Maintainer Instructional Equipment
1.8.2 Services
1.8.2.1 Operator Instructional Services

1.8.2.2				Maintainer Instructional Services
1.8.3		Facilities		
1.8.4		Training Software Release 1...n (Specify)		
1.9	Data			
1.9.1		Data Deliverables 1...n (Specify)		
1.9.2		Data Repository		
1.9.3		Data Rights 1...n (Specify)		
1.10	Peculiar Support Equipment			
1.10.1		Test and Measurement Equipment		
1.10.1.1			Test and Measurement Equipment (Airframe/Hull/Vehicle)	
1.10.1.2			Test and Measurement Equipment (Propulsion)	
1.10.1.3			Test and Measurement Equipment (Electronics/Avionics)	
1.10.1.4			Test and Measurement Equipment (Other Major Subsystem 1...n (Specify))	
1.10.2		Support and Handling Equipment		
1.10.2.1			Support and Handling Equipment (Airframe/Hull/Vehicle)	
1.10.2.2			Support and Handling Equipment (Propulsion)	
1.10.2.3			Support and Handling Equipment (Electronics/Avionics)	
1.10.2.4			Support and Handling Equipment (Other Major Subsystem 1...n (Specify))	
1.11	Common Support Equipment			
1.11.1		Test and Measurement Equipment		
1.11.1.1			Test and Measurement Equipment (Airframe/Hull/Vehicle)	
1.11.1.2			Test and Measurement Equipment (Propulsion)	
1.11.1.3			Test and Measurement Equipment (Electronics/Avionics)	
1.11.1.4			Test and Measurement Equipment (Other Major Subsystem 1...n (Specify))	
1.11.2		Support and Handling Equipment		
1.11.2.1			Support and Handling Equipment (Airframe/Hull/Vehicle)	
1.11.2.2			Support and Handling Equipment (Propulsion)	
1.11.2.3			Support and Handling Equipment (Electronics/Avionics)	
1.11.2.4			Support and Handling Equipment (Other Major Subsystem 1...n (Specify))	
1.12	Operational/Site Activation by Site 1...n (Specify)			
1.12.1		System Assembly, Installation, and Checkout		
1.12.2		Contractor Technical Support		
1.12.3		Site Construction		
1.12.4		Site/Ship/Vehicle Conversion		
1.12.5		Deployment Planning		
1.12.6		Aerospace Ground Equipment		
1.12.7		Real Property Installed Equipment		
1.12.8		Interim Contractor Support (ICS)		
1.13	Contractor Logistics Support (CLS)			
1.14	Initial Spares/Repair Parts			

D.3.1 Application of Common WBS Elements (Appendix K). WBS elements that are common (i.e., Integration, Assembly, Test, and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

D.3.2 Key Principles in Constructing a WBS. In the appendices of this MIL-STD, the WBS is defined to Level 3, 4, or 5 depending on the system. WBS elements in the appendices may be extended to appropriate levels below their MIL-STD definition for informational or reporting purposes. The purpose for these extensions is to ensure that the higher-level elements include the proper lower level elements when required to report at a lower level. If an extension below the MIL-STD definition is required, maintaining the product-oriented decomposition is required.

1) Extending the WBS to Lower Levels. The reporting level of the WBS depends on the level of interest where work is accomplished. Reporting at levels below those identified within the MIL-STD should be reported if they are considered high cost, high risk, high technical, and/or special interest. For those elements, extension of the WBS to lower levels may be necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. An example of the extension for this Appendix commodity can be found at http://cade.osd.mil/policy/csdr-plan.

2) 100% Rule. A key to WBS development is the principle that if the effort and resources can be associated with the element they support, they should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (Fire Control) has three child elements—transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the Fire Control system to make it a level equal to the Fire Control, it distorts the effort and resources that are required to complete that Fire Control system. The reason is that the transmitter has lost its parent (Fire Control)/child relationship because it assumes the transmitter is not included within the Fire Control system.

3) Identifying Parent/Child Relationship. In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter within the Fire Control. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, it may include more functionality than just the transmitter subsystem. It may, for instance, include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to the inability to determine the effort for each functionality developed. It is, therefore, appropriate to associate that software to the next higher level (Fire Control) of the WBS. To accomplish this, it will be included in the Fire Control Software element of the of the Fire Control system. This eliminates allocation of the effort across multiple WBS elements where it is difficult to determine what level of support each gets.

4) Recognizing Cybersecurity Processes/Products. Cybersecurity is a requirement for all DoD programs and must be fully considered and implemented in all aspects of acquisition programs across the life cycle. Attention must be paid to cybersecurity at all acquisition category levels and all classification levels, including unclassified, throughout the entire life cycle; this includes systems that reside on networks and stand-alone systems that are not persistently connected to networks during tactical and strategic operations. Since responsibility for cybersecurity extends to every member of the acquisition workforce, DoD and its contractors need to design, develop, and acquire systems that can operate in applicable cyber threat environments. As such it is critical to understand what the cost of these systems is (i.e., hardware, software, systems engineering, program management, and system test and evaluation). MIL-STD-881D supports this effort by providing the structure to identify, collect and report many of these critical costs. It is also recognized gathering this information is nearly impossible at the level of detail these systems are developed. It is for this reason, where cybersecurity related costs can be easily accounted for, they should be called out in the WBS. For example, for hardware/software elements, if the development or procurement of hardware in a system is specifically a cybersecurity artifact, then call it out as a WBS element to identify it. The same is true for software. If the development of a CSCI(s) are specifically cybersecurity or software is purchased that is specifically for cybersecurity, call it out as a WBS element to identify it. Just as important are the engineering, management, and test activities that are used to ensure the systems are meeting the planned expectations. The MIL-STD has specifically called out these efforts associated with systems engineering, program management, and system test and evaluation WBS (See Appendix K).

D.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. In addition, the numbering provides visible clarity regarding level of indenture and parent-child content. While the numbering system is numeric, several unique issues arise across appendices which require the numbering system to be modified to accommodate these anomalies (See Figure X). Additionally, if a WBS element is not required, it may be eliminated from the structure and the numbering would be logically adjusted.

D.3.3.1 "Other" WBS Elements. All appendices contain a WBS element titled "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. This is available to provide flexibility within the system WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined, and it does not currently appear in the appendices of MIL-STD-881D. If it is determined that the "other" WBS is not needed, this element should not be used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element.

D.3.3.2 1...n (Specify) WBS Element Definitions. Several appendices identify WBS elements with 1...n (Specify) or similar to denote that one or more components of that type of item may be used. Depending on the WBS identified, three approaches may be taken: 1) the parent WBS (e.g., 1...n) represents new or modified subsystems with each defined WBS using the appropriate title; or 2) the parent WBS (1...n) represents two or more WBS elements which are children of the parent, or 3) the parent WBS (1...n) represents a family of systems which require the same numbering structure to maintain consistency, using the same WBS number and adding an alpha/numeric (a, b, c, etc.) at the end to ensure the WBS numbering stays intact. (See Figure X in the General section for examples of WBS breakouts for each approach).

D.4 DEFINITIONS

D.4.1 Strategic Missile Systems. The complex of hardware, software, data, services, and facilities required to develop and produce the capability of employing a strategic missile system. This can include intercontinental/intermediate/medium/and short range ballistic missile weapons, targets, or interceptors.

D.4.2 Strategic Missile Systems Integration, Assembly, Test, and Checkout. The integration, assembly, test, and checkout element includes all efforts as identified in Appendix K: Common Elements, Work Breakdown Structure and Definitions, to provide a complete strategic missile system.

D.4.3 Air Vehicle Equipment (AVE)/Flight Vehicle Equipment (FVE). An air vehicle equipment (AVE)/flight vehicle equipment (FVE) is a self-propelled guided weapon that delivers a payload for destruction of some object/target or for the emulation of an adversary's capability. It also includes the design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specification(s), regardless of end use).

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.7.

D.4.3.1 AVE/FVE SEIT/PM and Support Equipment. This element includes the systems engineering, integration and test, program management, and support equipment WBS activities associated with the AVE/FVE. The definition of SEIT/PM and support equipment can be found in the Common Elements Appendix K, in section K.7.

D.4.3.2 Aero-Structures (Non-Stage Related). This element comprises the hardware needed for aerodynamic flight effects. It includes, for example, the wings, fins, canards, stability systems, and inlets for air breathing propulsion.

D.4.3.3 Stage (1-3) Interstage. The structures that connect one stage to another and includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, and support of the stage (1-3) interstage of the AVE/FVE. The AVE/FVE can include multiple (expandable and/or reusable) interstages.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.7.

D.4.3.3.1 Stage 1 Interstage. The purpose of each interstage is to provide the electrical and mechanical interface between stages in an AVE/FVE vehicle and/or payload.

D.4.3.3.1.1 Stage 1 Interstage SEIT/PM and Support Equipment. This element includes the systems engineering, integration and test, program management, and support equipment WBS activities associated with the interstage. The definition of SEIT/PM and support equipment can be found in the Common Elements Appendix K, in section K.7.

D.4.3.3.1.2 Structure and Mechanisms. This element comprises the structural framework and mechanisms that provides for load carry hardware such as interfaces to loading, launching, and stage separation devices, and other hard points needed to transfer static or dynamic loads.

D.4.3.3.1.3 Separation Ordnance. The separation ordnance is initiated upon receipt of a signal from the ordnance initiation set. Firing units convert the signal into ordnance outputs to the detonating cords.

Includes, for example:
a. Through bulkhead initiators, ordnance test harnesses, firing units/exploding bridge wires, stage separation mechanisms such as ordnance bolts and springs (e.g., retro rockets, staging motors, pyrotechnic valves and bolts)
b. Other separation ordnance and other necessary mechanisms to assure that the payload fairing successfully separates from the launch vehicle and space vehicle

D.4.3.3.1.4 Attitude Control System (ACS). This element determines and controls AVE/FVE orbital positions, attitudes, velocities, and angular rates using onboard sensors and torque application devices. It may also send control signals to propulsion subsystem components and communication electronics.

Includes, for example:
a. All of the thrusters, lines, valves, propellant tanks, gas tanks, manifolds
b. Control system for the ACS to the extent that the control system is integral to the propulsion system

Excludes, for example:
a. The control system or elements of the control system if these are separate from the ACS with the only interface being a signal to a valve or distributor on the ACS

D.4.3.3.1.5 Interstage Peculiar Avionics. Electronic systems used to control communications, navigation, the display and management of multiple systems, and those systems that are fitted to the missile to perform individual functions

Includes, for example:
a. Power elements such as batteries and power conditioners that provide power to components located on a specific interstage
b. Instrumentation componentry used for collecting in-flight data from a specific Stage
c. Separate and independent avionics (power systems, telemetry, sensors, command and control), for example, fly along sensor payloads, cameras, etc.

Excludes, for example:
a. Avionics that are part of the main vehicle avionics systems

D.4.3.3.1.6 Cable and Harness Assembly. This element is the collection of items used to route and

provide electrical power and signals throughout the interstage. This is also commonly referred to as “wiring.”

Includes, for example:

a. Coaxial and fiber optic cables, along with installation hardware

D.4.3.3.1.7 Flight Termination/Mission Termination. A system used in conjunction with test flights that allows for the safe destruction of the missile in flight if anomalies appear.

D.4.3.3.1.8 Instrumentation/Telemetry. This element provides monitoring and recording equipment fitted to the air vehicle used to monitor various parameters during flight such as: measuring, recording, formatting, and transmitting AVE/FVE telemetry data; accepting, decoding, verifying, and storing uplink/downlink commands.

D.4.3.3.2 Stage 2 Interstage. The work breakdown structure and definitions for Stage 2 Interstage are the same as those for Stage 1 Interstage.

D.4.3.3.3 Stage 3 Interstage. The work breakdown structure and definitions for Stage 3 Interstage are the same as those for Stage 1 Interstage.

D.4.3.4 Other AVE/FVE Structures 1...n (Specify). This element should be replaced with other product-oriented airframe components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

D.4.3.5 Stage (1...3). This element (the stage), provides thrust to propel the air vehicle on its intended flight.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.7.

D.4.3.5.1 Stage 1. The stage propulsion system may be composed of one or more subsystems that ignite, burn, and may be jettisoned sequentially over the course of flight. Individual subsystems may employ solid, liquid, or air-breathing technologies.

D.4.3.5.1.1 Stage SEIT/PM and Support Equipment. This element includes the systems engineering, integration and test, program management, and support equipment WBS activities associated with the stage. The definition of SEIT/PM and support equipment can be found in the Common Elements Appendix K, in section K.7.

D.4.3.5.1.2 Structures and Mechanisms. This element comprises the structural framework and mechanisms that provides for load carry hardware such as interfaces to loading, launching, and stage separation devices, and other hard points needed to transfer static or dynamic loads.

D.4.3.5.1.3 Propulsion System. This element provides thrust to propel the air vehicle on its intended flight. The propulsion system may be composed of one or more subsystems that ignite, burn, and may be jettisoned sequentially over the course of flight. Individual subsystems may employ solid, liquid, or air-breathing technologies.

D.4.3.5.1.4 Attitude Control System. This element determines and controls AVE/FVE orbital positions, attitudes, velocities, and angular rates using onboard sensors and torque application devices. It may also send control signals to propulsion subsystem components and communication electronics.

Includes, for example:

a. All of the thrusters, lines, valves, propellant tanks, gas tanks, manifolds
b. Control system for the ACS to the extent that the control system is integral to the propulsion system

Excludes, for example:

a. The control system or elements of the control system if these are separate from the ACS with the only interface being a signal to a valve or distributor on the ACS

D.4.3.5.1.5 Stage Peculiar Avionics. This element is the electronic systems used to control communications, navigation, the display and management of multiple systems, and those systems that are fitted to the missile to perform individual functions.

D.4.3.5.1.6 Cable Assembly. This element is the assembly of cables or wires (also known as a wire harness) which transmit signals or electrical power.

D.4.3.5.1.7 Flight Termination/Mission Termination. This element is used in conjunction with test flights that allow for the safe destruction of the missile in flight if anomalies appear.

D.4.3.5.1.8 Instrumentation/Telemetry. This element provides the monitoring and recording equipment fitted to the air vehicle used to monitor various parameters during flight.

D.4.3.5.2 Stage 2. The work breakdown structure and definitions for Stage 2 are the same as those for Stage 1.

D.4.3.5.3 Stage 3. The work breakdown structure and definitions for Stage 3 are the same as those for Stage 1.

D.4.3.6 Power and Distribution. This element provides prime power and distribution for the AVE/FVE.

D.4.3.6.1 Power and Distribution SEIT/PM and Support Equipment. This element includes the systems engineering, integration and test, program management, and support equipment WBS activities associated with the power and distribution. The definition of SEIT/PM and support equipment can be found in the Common Elements Appendix K, in section K.7.

D.4.3.6.2 Primary Power. This element comprises primary power for the AVE/FVE.

Excludes, for example:

a. Batteries, which may be integral to other Level 3 elements

D.4.3.6.3 Power Conditioning Electronics. The electronics that control the distribution of the power to the AVE/FVE.

D.4.3.6.4 Distribution Harness. An assembly of cables or wires (also known as a wire harness) which transmit signals or electrical power.

Excludes, for example:

a. Harnessing integral to other Level 3 elements

D.4.3.6.5 Power and Distribution Software Release 1...n. All distribution and power subsystem software not associated with a specific element above.

D.4.3.7 Guidance and Control. Guidance is the process of maneuvering the AVE/FVE to engage the intended target and control is the hardware (excluding actual control surfaces), software and equipment for controlling the motion of the AVE/FVE from launch to intercept. This element is the hardware, software, and equipment for target detection, signal processing, implementation of guidance laws, and generation of guidance commands as wells as control devices for canard, wing, tail, thrust vector, jet vanes, explosive charges, lateral thrusters, etc.

D.4.3.7.1 Guidance and Control SEIT/PM and Support Equipment. This element includes the systems

engineering, integration and test, program management, and support equipment WBS activities associated with the guidance and control. The definition of SEIT/PM and support equipment can be found in the Common Elements Appendix K, in section K.7.

D.4.3.7.2 Guidance Computer. This element provides central processing functions and timing signals; performs on-board attitude determination, and ACS equipment control; thruster control, positioner control; and power and distribution system monitoring/and control (if this is not performed by dedicated power and distribution system components). These elements process data according to a list of computer software instructions. This includes, for example, central processing units (CPUs) or onboard computers (OBCs). Computer and processor memory may also be included.

Includes, for example:

a. Computers and processors that perform general AVE/FVE computing functions and control, such as command execution.

D.4.3.7.3 Guidance and Control Electronics. This element is the embedded circuit module that controls the IMU.

D.4.3.7.4 Navigation/Inertial Measurement Unit (IMU). This element is the hardware that provides data for determination of air vehicle location and orientation. The gyro-stabilized platform (GSP) measures acceleration and transforms it to velocity which is provided with attitude information to the guidance computer during flight. This data is required so that accurate and proper flight control of the missile is obtained.

Excludes, for example:

a. Guidance
b. Control

D.4.3.7.5 Guidance and Control Cooling System. This element serves to maintain the IMU and guidance computer within temperature limits.

Includes, for example:

a. Bottles, coolant loops, heat exchangers

D.4.3.7.6 Computer Memory Battery. This element is a battery that maintains the time, date, hard disk, and other configuration settings for the guidance computer

D.4.3.7.7 Guidance and Control Cables. This element is the collection of items used to route and provide electrical power and signals throughout the G&C subsystem. This is also commonly referred to as “wiring.”

Includes, for example:

a. Coaxial and fiber optic cables, along with installation hardware

D.4.3.7.8 Guidance and Control Software Release 1...n (Specify). All guidance and control subsystem software not associated with a specific G&C element above. Contains the operational software for the AVE (missile). Provides instructions to the computer hardware to perform the required operations.

D.4.3.8 Communications. This element is the data link equipment to enable communications between the AVE/FVE and an external entity (or entities). Data links can be either receive only or send only (one-way) or bidirectional (two way).

Includes, for example:

a. Data transmission and reception for networking, command and control, and battlespace awareness; enabling the vehicle to be a node in the net

D.4.3.8.1 Communications SEIT/PM and Support Equipment. This element includes the systems engineering, integration and test, program management, and support equipment WBS activities associated with communications. The definition of SEIT/PM and support equipment can be found in the Common Elements Appendix K, in section K.7.

D.4.3.8.2 Antenna Assembly 1...n (Specify). This element is the hardware comprising the antenna assembly or assemblies.

D.4.3.8.3 Transceiver Assembly 1...n (Specify). This element performs functions such as: formatting, transmitting, receiving, encrypting, decrypting, and storing signals or data.

Includes, for example:

a. Passive, active, or mixed signal radio frequency (RF) and digital components such as; combiners, beamformers, transmitters, receivers, transponder, modulators, demodulators, modems, power amplifiers, downconverters, upconverters, processors (signal/digital), memory, decoders, command units, command sequencers, timing units, frequency generators, signal conditioners, data switches, and other electronics.

D.4.3.8.4 Communications Software Release 1...n (Specify). All communication subsystem software not associated with the specific Level 4 elements which cannot be broken out separately.

D.4.3.9 Post Boost/Attitude Control Module (PBACM).

Includes, for example:

a. Exo-atmospheric missiles; provides the roll rate control and the final velocity to adjust and deploy the payload
b. Single warhead missile; structure, external protection material, velocity control system, and deployment group
c. Multiple warhead missile; structure, axial engines, attitude control equipment, propellant storage assembly, and pressurized system

D.4.3.9.1 PBACM SEIT/PM and Support Equipment. This element includes the systems engineering, integration and test, program management, and support equipment WBS activities associated with the post booster/attitude control module (PBACM). The definition of SEIT/PM and support equipment can be found in the Common Elements Appendix K, in section K.7

D.4.3.9.2 Structures and Mechanisms. This element comprises the structural framework and mechanisms that provides for load carry hardware such as interfaces to loading, launching, and stage separation devices, and other hard points needed to transfer static or dynamic loads.

D.4.3.9.3 Propulsion System. This element provides thrust to propel the PBACM on its intended flight. The total propulsion system may be composed of one or more subsystems which ignite and burn. Individual subsystems may employ solid, liquid, or catalyst bed technologies.

D.4.3.9.4 Countermeasures. This element is the missile-borne countermeasure subsystem, and aids designed to saturate, confuse, evade, or suppress missile defenses.

D.4.3.9.5 PBACM Peculiar Avionics. This element is the electronic systems used to control communications, navigation, the display and management of multiple systems, and the hundreds of systems that are fitted to the missile to perform individual functions.

Includes, for example:

a. Power elements such as batteries and power conditioners that provide power to components located on the PBACM.
b. Instrumentation componentry used for collecting in-flight data from the PBACM
c. Separate and independent avionics (power systems, telemetry, sensors, command and control)

Excludes, for example:

a. PBACM peculiar avionics that are separate from the main vehicle avionics system.

D.4.3.9.6 Cable Assembly. This element is the collection of items used to route and provide electrical power and signals throughout the PBACM. This is also commonly referred to as "wiring."

Includes, for example:

a. Coaxial and fiber optic cables, along with installation hardware.

D.4.3.9.7 Flight Termination/Mission Termination. This element is the system used in conjunction with test flights that allow for the safe destruction of the missile in flight if anomalies appear. It may include the ability to arm and disarm.

D.4.3.9.8 Instrumentation/Telemetry. This element is the monitoring and recording equipment fitted to the AVE/FVE used to measure, record, format and transmit PBACM telemetry data; accepting, decoding, verifying, and storing uplink/downlink commands.

D.4.3.10 Payload/Reentry Systems. The aggregate of prime equipment items consisting of a deployment module, reentry vehicles, payload, penetration aids, and ascent shroud, which provide structural support and environmental protection of nuclear payloads during the ground deployment and flight. This element comprises the complex of equipment and support assemblies required to defeat or emulate a target. Normally, payload consists only of the reentry vehicle(s) (RV) and associated target detection, arming and fuzing equipment. However, with complex AVE/FVEs, the payload may contain countermeasures and associated deployment systems. Note for Missile Defense target applications, the payload will replace a functioning RV with an emulation of a threat (target) RV. This "target" RV can include special instrumentation/telemetry equipment for hit detection and indication. For Missile Defense interceptor applications, the payload will replace a functioning RV with a detailed kinetic kill vehicle (KV) WBS (as defined by the specific missile defense requirement).

D.4.3.10.1 Payload/Reentry Systems SEIT/PM and Support Equipment. This element includes the systems engineering, integration and test, program management, and support equipment WBS activities associated with the payload/reentry vehicle. The definition of SEIT/PM and support equipment can be found in the Common Elements Appendix K, in section K.7.

D.4.3.10.2 Payload/Reentry Vehicle 1...n (Specify). This element is the delivery package that can place one or more payloads over each of several separate targets. For exo-atmospheric missiles, the reentry system is the aggregate of prime equipment items consisting of a deployment module, reentry vehicles, payload, penetration aids and ascent shroud, which provide structural support and environmental protection of nuclear payloads during the ground deployment and flight.

Includes, for example:

a. Reentry vehicle (aero-structure) which provides reentry protection for the internally carried warheads
b. For independent maneuvers, the reentry vehicle will contain navigation, guidance, control, sensors, and processing systems which provide the reentry systems capability to acquire and track targets and execute the necessary flight path to the selected target
c. The arming and fuzing system which provides the proper electrical signals to detonate the warhead

D.4.3.10.3 Countermeasures. This element is the missile-borne countermeasure subsystem, and aids designed to saturate, confuse, evade, or suppress missile defenses.

D.4.3.10.4 Deployment Housing/Bulkheads. This element is the structural and mechanical components that protect and deploy payloads/reentry vehicles.

D.4.3.11 Ordnance Initiation Set. This element in exo-atmospheric missiles, initiates all ordnance

events throughout the missile and ground system (except reentry system components). Upon receipt of an electrical signal from the AVE/FVE guidance and control system, the ordnance initiation set firing units convert the signal into ordnance outputs to the detonating cords. Among these ordnance events are stage separation, motor ignition, gas generator ignition, shroud separation, etc.

D.4.3.12 On Board Test Equipment. This element is the monitoring and recording equipment fitted to the AVE/FVE used to monitor various parameters during flight. This element comprises the payload that is interchangeable with the live warhead and suitable for development or operational testing in a free flight (post launch) environment.

Includes, for example:

a. Recovery systems
b. Special instrumentation
c. Telemetry equipment,
d. Flight termination equipment, etc., suitable for a launch and free flight environment

D.4.4 Encasement Device. This element is the hardware and software associated with the air vehicle canister or encasement device.

D.4.4.1 Encasement Device Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, interconnect harnessing, and software required for the integration, assembly, test, and checkout of the Level 3 elements below into their Level 2 element, Encasement Device

D.4.4.2 Encasement Device Structure. This element comprises the primary structure of the canister or encasement device.

D.4.4.3 Encasement Device Software Release 1...n (Specify). This element includes all encasement software associated with the specific Level 2 element above, Encasement Device.

D.4.4.4 Other Encasement Device Subsystems 1...n (Specify). This element should be replaced with other product-oriented encasement devices components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

D.4.5 Command and Launch. This element is the system installed at a launch site or aboard launch vehicles required to store, make ready, and launch the air vehicles of the missile system.

Includes, for example:

a. Those equipment required to acquire and condition the necessary intelligence of selected targets, reach launch decisions, command the launch, and provide guidance and control where such capability is not self-contained aboard the air vehicle
b. Design, development and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specification(s), regardless of end use)

D.4.5.1 Command and Launch SEIT/PM and Support Equipment. This element includes the systems engineering, integration and test, program management, and support equipment WBS activities associated with command and launch. The definition of SEIT/PM and Support Equipment can be found in the Common Elements Appendix K, in section K.7.

D.4.5.2 Launch and Guidance Control/Fire Control. The equipment used by crews to control and launch the missile as well as target air vehicles, make launch decisions, and command launch.

Includes, for example:

a. Control and checkout console, data displays, secure code device, programmer group, communication control console, command message processing group, and digital data group
b. Equipment at the launch facility/vehicle and/or the launch control center(s) (air, sea, or mobile)
c. Launch code processing system

D.4.5.3 Communications. This element is the equipment, not resident on the air vehicle, which distributes intelligence between the air vehicle and the command and launch equipment.

Includes, for example:
a. Inter-communication subsystems of launch sites for tactical and administrative message flow and ties between sensor, data processing, launch, and guidance control subsystems
b. Communications may interface with existing fixed communication facilities or communication subsystems of launch platforms, which are associated systems to the missile system

D.4.5.4 Launch and Encasement Equipment. This element is the means to launch the missile air vehicle from stationary sites or mobile launch platforms, including equipment in the ground structures that houses the missile prior to launch and the structures that house the crews to send launch commands to the missile.

Includes, for example:
a. Silos, vehicles, rail launchers, canisters, capsules, tubes, pods, and devices, which support, suspend, or encase the air vehicle for firing. Such devices would be in addition to any encasement, if applicable, integral to an air vehicle
b. Associated hardware such as umbilicals, harnesses, pyrotechnics, and electronics
c. Storage facilities and checkout stations for readiness verification when these are integral to the launcher
d. Safety and protective elements when these are not integral to the launch platform or site facilities

D.4.5.5 Auxiliary Equipment. This element is all command and launch equipment not associated with a specific Level 3 element.

D.4.5.6 Command and Launch (Ground) Software Release 1...n (Specify). This element is all command and launch software not associated with a specific Level 3 element.

D.4.5.7 Infrastructure. This element is basic physical and organizational structures and facilities (e.g., buildings, roads, and power supplies) needed for the missile command and launch.

D.4.5.8 Other Command and Launch 1...n (Specify). This element should be replaced with other product-oriented command and launch components that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

D.4.6 Common Elements. Common WBS elements and definitions for all commodities can be found at Appendix K.3. Several commodities have unique elements that are applied which also appear in Appendix K, specifically, Space Systems (K.4); Launch Systems (K.5); Information Systems/Defense Business Systems (K.6); and Strategic Missile Systems (K.7).

APPENDIX E: SEA SYSTEMS
WORK BREAKDOWN STRUCTURE AND DEFINITIONS

E.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for sea systems. Definitions for WBS elements common to all defense materiel items are given in Appendix K: Common Elements, Work Breakdown Structure and Definitions.

E.2 APPLICABLE DOCUMENTS

E.2.1 General. The documents listed in this section are specified in Appendix E of this standard. This section does not include documents cited in other Appendices of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendices of this standard, whether or not they are listed.

E.2.2 Government documents.

E.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

E.2.2.2 Other Government documents, drawings, and publications.

DEFENSE TECHNICAL INFORMATION CENTER

S9040-AA-IDX-010/SWBS 5D Volume 1 and S9040-AA-IDX-020/SWBS 5D Volume 2 - *Users Guide for Expanded Ship Work Breakdown Structure (ESWBS) for All Ships and Ship/Combat Systems*

If there are high costs, high risk, high technical and/or special interest elements that must be reported below Level 3 of the WBS, users should reference the Navy ESWBS document in order to ensure consistency in reporting.

(Copies of this document are available from Defense Technical Information Center (DTIC), 8725 John J. Kingman Road, Fort Belvoir, VA 22060-6218.)

E.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 24765:2017 – *Systems and Software Engineering – Vocabulary*
ISO/IEC/IEEE 12207:2017 - *Systems and Software Engineering – Software Life Cycle Processes*

(Copies of these documents are available from www.ieee.org or The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-1331)

E.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Sea System			
1.1		Ship		
1.1.1			Hull Structure	
1.1.2			Propulsion Plant	
1.1.3			Electric Plant	
1.1.4			Command, Communications, and Surveillance	
1.1.5			Auxiliary Systems	
1.1.6			Outfit and Furnishings	
1.1.7			Armament	
1.1.8			Total Ship Integration/Engineering	
1.1.9			Ship Assembly and Support Services	
1.2		Systems Engineering		
1.2.1			Software Systems Engineering	
1.2.2			Integrated Logistics Support (ILS) Systems Engineering	
1.2.3			Cybersecurity Systems Engineering	
1.2.4			Core Systems Engineering	
1.2.5			Other Systems Engineering 1...n (Specify)	
1.3		Program Management		
1.3.1			Software Program Management	
1.3.2			Integrated Logistics Support (ILS) Program Management	
1.3.3			Cybersecurity Management	
1.3.4			Core Program Management	
1.3.5			Other Program Management 1...n (Specify)	
1.4		System Test and Evaluation		
1.4.1			Development Test and Evaluation	
1.4.2			Operational Test and Evaluation	
1.4.3			Cybersecurity Test and Evaluation	
1.4.4			Mock-ups/System Integration Labs (SILs)	
1.4.5			Test and Evaluation Support	
1.4.6			Test Facilities	
1.5		Training		
1.5.1			Equipment	
1.5.1.1				Operator Instructional Equipment
1.5.1.2				Maintainer Instructional Equipment
1.5.2			Services	
1.5.2.1				Operator Instructional Services
1.5.2.2				Maintainer Instructional Services
1.5.3			Facilities	
1.5.4			Training Software 1...n (Specify)	
1.6		Data		
1.6.1			Data Deliverables 1...n (Specify)	
1.6.2			Data Repository	
1.6.3			Data Rights 1...n (Specify)	
1.7		Peculiar Support Equipment		
1.7.1			Test and Measurement Equipment	
1.7.1.1				Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.7.1.2				Test and Measurement Equipment (Propulsion)
1.7.1.3				Test and Measurement Equipment (Electronics/Avionics)
1.7.1.4				Test and Measurement Equipment (Other Major Subsystem 1...n (Specify))
1.7.2			Support and Handling Equipment	
1.7.2.1				Support and Handling Equipment (Airframe/Hull/Vehicle)

1.7.2.2			Support and Handling Equipment (Propulsion)
1.7.2.3			Support and Handling Equipment (Electronics/Avionics)
1.7.2.4			Support and Handling Equipment (Other Major Subsystem 1...n (Specify))
1.8	Common Support Equipment		
1.8.1		Test and Measurement Equipment	
1.8.1.1			Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.8.1.2			Test and Measurement Equipment (Propulsion)
1.8.1.3			Test and Measurement Equipment (Electronics/Avionics)
1.8.1.4			Test and Measurement Equipment (Other Major Subsystem 1...n (Specify))
1.8.2		Support and Handling Equipment	
1.8.2.1			Support and Handling Equipment (Airframe/Hull/Vehicle)
1.8.2.2			Support and Handling Equipment (Propulsion)
1.8.2.3			Support and Handling Equipment (Electronics/Avionics)
1.8.2.4			Support and Handling Equipment (Other Major Subsystem 1...n (Specify))
1.9	Operational/Site Activation by Site 1...n (Specify)		
1.9.1		System Assembly, Installation, and Checkout	
1.9.2		Contractor Technical Support	
1.9.3		Site Construction	
1.9.4		Site/Ship/Vehicle Conversion	
1.9.5		Interim Contractor Support (ICS)	
1.10	Contractor Logistics Support (CLS)		
1.11	Industrial Facilities		
1.11.1		Construction/Conversion/Expansion	
1.11.2		Equipment Acquisition or Modernization	
1.11.3		Maintenance (Industrial Facilities)	
1.12	Initial Spares and Repair Parts		

E.3.1 Application of Common WBS Elements (Appendix K). WBS elements that are common (i.e., Integration, Assembly, Test, and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

E.3.2 Key Principles in Constructing a WBS. In the appendices of this MIL-STD, the WBS is defined to Level 3, 4, or 5 depending on the system. WBS elements in the appendices may be extended to appropriate levels below their MIL-STD definition for informational or reporting purposes. The purpose for these extensions is to ensure that the higher-level elements include the proper lower level elements when required to report at a lower level. If an extension below the MIL-STD definition is required, maintaining the product-oriented decomposition is required.

1) Extending the WBS to Lower Levels. The reporting level of the WBS depends on the level of interest where work is accomplished. Reporting at levels below those identified within the MIL-STD should be reported if they are considered high cost, high risk, high technical, and/or special interest. For those elements, extension of the WBS to lower levels may be necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. An example of the extension for this Appendix commodity can be found at http://cade.osd.mil/policy/csdr-plan. In addition, users should reference the Navy ESWBS document in order to ensure consistency in reporting. (See E.2.2.2)

2) 100% Rule. A key to WBS development is the principle that if the effort and resources can be associated with the element they support, they should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (Fire Control) has three child elements—transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the Fire Control system to make it a level equal to the Fire Control, it distorts the effort and resources that are required to complete that Fire Control system. The reason is that the transmitter has lost its parent (Fire Control)/child relationship because it assumes the transmitter is not included within the Fire Control system.

3) Identifying Parent/Child Relationship. In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter within the Fire Control. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, it may include more functionality than just the transmitter subsystem. It may, for instance, include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to the inability to determine the effort for each functionality developed. It is, therefore, appropriate to associate that software to the next higher level (Fire Control) of the WBS. To accomplish this, it will be included in the Fire Control Software element of the of the Fire Control system. This eliminates allocation of the effort across multiple WBS elements where it is difficult to determine what level of support each gets.

4) Recognizing Cybersecurity Processes/Products. Cybersecurity is a requirement for all DoD programs and must be fully considered and implemented in all aspects of acquisition programs across the life cycle. Attention must be paid to cybersecurity at all acquisition category levels and all classification levels, including unclassified, throughout the entire life cycle; this includes systems that reside on networks and stand-alone systems that are not persistently connected to networks during tactical and strategic operations. Since responsibility for cybersecurity extends to every member of the acquisition workforce, DoD and its contractors need to design, develop, and acquire systems that can operate in applicable cyber threat environments. As such it is critical to understand what the cost of these systems is (i.e., hardware, software, systems engineering, program management, and system test and evaluation). MIL-STD-881D supports this effort by providing the structure to identify, collect and report many of these critical costs. It is also recognized gathering this information is nearly impossible at the level of detail these systems are developed. It is for this reason, where cybersecurity related costs can be easily accounted for, they should be called out in the WBS. For example, for hardware/software elements, if the development or procurement of hardware in a system is specifically a cybersecurity artifact, then call it out as a WBS element to identify it. The same is true for software. If the development of a CSCI(s) are specifically cybersecurity or software is purchased that is specifically for cybersecurity, call it out as a WBS element to identify it. Just as important are the engineering, management, and test activities that are used to ensure the systems are meeting the planned expectations. The MIL-STD has specifically called out these efforts associated with systems engineering, program management, and system test and evaluation WBS (See Appendix K).

E.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. In addition, the numbering provides visible clarity regarding level of indenture and parent-child content. While the numbering system is numeric, several unique issues arise across appendices which require the numbering system to be modified to accommodate these anomalies (See Figure X). Additionally, if a WBS element is not required, it may be eliminated from the structure and the numbering would be logically adjusted.

E.3.3.1 “Other” WBS Elements. All appendices contain a WBS element titled “Other” at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. This is available to provide flexibility within the system WBS for new or additional WBS elements that are not identified or defined in the Standard. These “other” elements would be used if, for example, a new subsystem or modified subsystem is defined, and it does not currently appear in the appendices of MIL-STD-881D. If it is determined that the “other” WBS is not needed, this element should not be used in the WBS. If it is determined that the “other” element is needed, then each element must be defined and the word “other” replaced by the newly defined WBS element.

E.3.3.2 1...n (Specify) WBS Element Definitions. Several appendices identify WBS elements with 1...n (Specify) or similar to denote that one or more components of that type of item may be used. Depending on the WBS identified, three approaches may be taken: 1) the parent WBS (e.g., 1...n) represents new or modified subsystems with each defined WBS using the appropriate title; or 2) the parent WBS (1...n) represents two or more WBS elements which are children of the parent, or 3) the parent WBS (1...n) represents a family of systems which require the same numbering structure to maintain consistency, using the same WBS number and adding an alpha/numeric (a, b, c, etc.) at the end to ensure the WBS numbering stays intact. (See Figure X in the General section for examples of WBS breakouts for each approach).

E.4 DEFINITIONS

E.4.1 Sea System. Identifies the function of equipment (hardware/software), data, services, and facilities required to attain the capability of operating or supporting the operation of naval missions or performing other naval tasks at sea.

E.4.2 Ship. The waterborne vessel and components of a sea system.

Includes, for example:
a. All classes of surface and subsurface water vessels such as combatants, auxiliaries, amphibious, and special-purpose ships
b. Design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use)

NOTE: Further breakouts of Level 3 elements under the Level 2 Ship element are defined in the Expanded Ship Work Breakdown Structure (ESWBS).

E.4.2.1 Hull Structure. The assembled main hull body including all hull support structure, superstructure, bulkheads, platforms, masts, and foundations.

Includes, for example:
a. Shell plating, longitudinal and transverse framing, platforms and decks, superstructure, foundations, structural bulkheads, enclosures, and sponsons
b. Castings, forgings, and welds; fixed ballast; doors and closures; king-posts, masts, and service platforms; sonar domes
c. Tank/compartment tightness testing

E.4.2.2 Propulsion Plant. The major components installed primarily for propulsion and the systems necessary to make these components operable.

Includes, for example:
a. Boilers and energy converters, propulsion units, main condensers and air ejectors, shafting, bearings, propellers, combustion air supply system, uptakes, propulsion control equipment, main steam, feed water and condensate, circulating and cooling water, fuel oil service system and lubricating oil system
b. Electric power
c. Nuclear steam generators, reactors, reactor coolant and auxiliary systems, nuclear power plant control, and radiation shielding

E.4.2.3 Electric Plant. The power generating, and distribution systems installed primarily for ship service and emergency power and lighting.

Includes, for example:
a. Electric power generation, power distribution switchboards, power distribution system, and lighting system

E.4.2.4 Command, Communication, and Surveillance. The equipment (hardware/software) and associated systems installed to receive information from off-ship source, to transmit to off-ship receivers, and to distribute information throughout the ship.

Includes, for example:
a. Sensing and data systems required for navigation and weapon fire control
b. Navigation equipment, interior communication systems, gun fire control system, non-electronic countermeasure systems, electronic countermeasure systems, missile fire control systems, antisubmarine warfare fire control and torpedo fire control systems, radar systems, radio communication systems, electronic navigation systems, space vehicle electronic tracking systems, sonar systems, electronic

tactical data systems, all associated software, computer systems, fiber optic plant, inter/intranet and entertainment systems

NOTE 1: If lower level information can be collected, use the ESWBS.

NOTE 2: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the ship is excluded.

E.4.2.5 Auxiliary Systems. The support systems for ship control, main propulsion components, ship safety, deck operations and environmental control.

Includes, for example:

a. The auxiliary machinery and piping systems; the hull mechanical handling systems; and ship control systems and surfaces such as rudders, hydrofoils, and diving planes
b. Heating, ventilation, and air conditioning systems; refrigeration plant and equipment
c. Gasoline, JP-5, all liquid cargo piping, oxygen-nitrogen and aviation lubricating oil systems
d. Plumbing installation, saltwater service systems, fire extinguishing systems, drainage, ballast, trimming, heating, and stabilizer tank systems
e. Fresh water system, scuppers and deck drains
f. Fuel and diesel oil filling, venting, stowage and transfer systems
g. Tank heating systems, compressed air system, auxiliary steam, exhaust steam and steam drains, buoyancy control system, distilling plant
h. Mooring, towing, anchor and aircraft handling systems; deck machinery; elevators; moving stairways; stores strikedown and stores handling equipment; operating gear for retracting and elevating units; aircraft elevators
i. Aircraft arresting gear, barriers, and barricades
j. Catapults and jet blast deflectors, replenishment at sea and cargo handling systems
k. Design, development, production, and assembly efforts to provide each auxiliary system as an entity

NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the ship is excluded.

E.4.2.6 Outfit and Furnishings. The outfit equipment and furnishings required for habitability and operability, which are not specifically included in other ship elements.

Includes, for example:

a. Hull fittings
b. Boats, boat stowage and handlings
c. Rigging and canvas; ladders and gratings; nonstructural bulkheads and doors; painting, deck covering, hull insulation; cathodic protection systems; refrigerated spaces; storerooms, stowage and lockers
d. Equipment for utility space, workshops, laboratories, test areas, galley, pantry, scullery and commissary outfit
e. Furnishings for living spaces, offices, control centers, machinery spaces, medical, dental and pharmaceutical spaces; and non-propulsion space shielding
f. Design, development, production, and assembly efforts to provide the outfit and furnishing element as an entity

E.4.2.7 Armament. The complex of armament and related ammunition handling, stowage, and support facilities; and cargo munitions handling, stowage, and support facilities.

Includes, for example:

a. Guns and gun mounts; ammunition handling systems and stowage; special weapons handling and storage
b. Rocket and missile launching devices, handling systems and stowage
c. Air launched weapons handling systems and stowage; and cargo munitions handling and stowage

d. Torpedo, mines, small arms and pyrotechnic launching devices, handling systems and stowage systems
e. Design, development, production, and assembly efforts to provide the armament element as an entity

NOTE: All effort directly associated with the remaining Level 3 WBS elements and the integration, assembly, test, and checkout of these elements into the ship is excluded.

E.4.2.8 Total Ship Integration/Engineering. The engineering effort and related material associated with the design, development, and rework to provide the ship as a whole exclusive of that included under the Systems Engineering and Program Management elements.

Includes, for example:
a. Construction drawings, engineering calculations, weighing and weight calculations, photographs, models, and shipbuilders' information drawings

E.4.2.9 Ship Assembly and Support Services. The efforts and material associated with construction that cannot be logically and practicably identified with, or related to, other Level 3 elements.

Includes, for example:
a. Staging, scaffolding, and cribbing; temporary utilities and services; molds, templates, jigs, fixtures, and special production tools; dry-docking, inspection, insurance, launching, and delivery
b. Production and construction planning; dock, sea and inclining trials

E.4.3 Common Elements. Common WBS elements and definitions for all commodities can be found at Appendix K.3. Several commodities have unique elements that are applied which also appear in Appendix K, specifically, Space Systems (K.4); Launch Systems (K.5); Information Systems/Defense Business Systems (K.6); and Strategic Missile Systems (K.7).

Sea specific common elements are identified in Appendix K see K.3.2.4, K.3.3.4, K.3.4.1, and K.3.6.1.

APPENDIX F: SPACE SYSTEMS
WORK BREAKDOWN STRUCTURE AND DEFINITIONS

F.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for space systems. Definitions for WBS elements common to all defense materiel items are given in Appendix K: Common Elements, Work Breakdown Structure and Definitions.

F.2 APPLICABLE DOCUMENTS

F.2.1 General. The documents listed in this section are specified in Appendix F of this standard. This section does not include documents cited in other Appendices of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendices of this standard, whether or not they are listed.

F.2.2 Government documents.

F.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

F.2.2.2 Other Government documents, drawings, and publications.

F.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 24765:2017 – *Systems and Software Engineering – Vocabulary*
ISO/IEC/IEEE 12207:2017 - *Systems and Software Engineering – Software Life Cycle Processes*

(Copies of these documents are available from www.ieee.org or The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-1331

F.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4	Level 5
1.0	Space System				
1.1		SEIT/PM and Support Equipment			
1.1.1			Systems Engineering		
1.1.2			Assembly, Integration and Test		
1.1.3			Program Management		
1.1.4			Support Equipment		
1.2		Space Vehicle 1...n (Specify)			
1.2.1			SEIT/PM and Support Equipment		
1.2.1.1				Systems Engineering	
1.2.1.2				Assembly, Integration and Test	
1.2.1.3				Program Management	
1.2.1.4				Support Equipment	
1.2.2			Bus		
1.2.2.1				SEIT/PM and Support Equipment	
1.2.2.1.1					Systems Engineering
1.2.2.1.2					Assembly, Integration and Test
1.2.2.1.3					Program Management
1.2.2.1.4					Support Equipment
1.2.2.2				Structures and Mechanisms Subsystem (SMS)	
1.2.2.2.1					SEPM
1.2.2.2.2					Assembly, Integration and Test
1.2.2.2.3					Support Equipment
1.2.2.2.4					Structures
1.2.2.2.5					Mechanisms and Pyrotechnics
1.2.2.2.6					SMS Other
1.2.2.3				Thermal Control Subsystem (TCS)	
1.2.2.3.1					SEPM
1.2.2.3.2					Assembly, Integration and Test
1.2.2.3.3					Support Equipment
1.2.2.3.4					Cryogenic Devices
1.2.2.3.5					Liquid Loops
1.2.2.3.6					Electric Coolers
1.2.2.3.7					Heaters, Thermisters, and Thermostats
1.2.2.3.8					Passive Devices
1.2.2.3.9					TCS Other
1.2.2.4				Electrical Power Subsystem (EPS)	
1.2.2.4.1					SEPM
1.2.2.4.2					Assembly, Integration and Test
1.2.2.4.3					Support Equipment
1.2.2.4.4					Solar Array
1.2.2.4.5					Solar Array Positioner
1.2.2.4.6					Radioisotope Thermionic Generator
1.2.2.4.7					Other Power Sources
1.2.2.4.8					Power Control, Switching, and Distribution Electronics
1.2.2.4.9					Power Conditioning, Conversion, and Regulation
1.2.2.4.10					Power Dissipation Devices
1.2.2.4.11					Rechargeable Batteries
1.2.2.4.12					Charge Control Electronics
1.2.2.4.13					Harnesses and Cables
1.2.2.4.14					EPS Other
1.2.2.5				Attitude Control Subsystem (ACS)	
1.2.2.5.1					SEPM
1.2.2.5.2					Assembly, Integration and Test
1.2.2.5.3					Support Equipment
1.2.2.5.4					Star Tracker/Sensors 1...n (Specify)
1.2.2.5.5					Earth (Horizon) Sensors 1...n (Specify)
1.2.2.5.6					Sun Sensors 1...n (Specify)
1.2.2.5.7					Magnetometers

1.2.2.5.8	Global Positioning System (GPS) Receiver
1.2.2.5.9	Inertial Reference Unit (IRU)/Inertial Measurement Unit (IMU) 1...n (Specify)
1.2.2.5.10	Rate Gyros 1...n (Specify)
1.2.2.5.11	Accelerometers 1...n (Specify)
1.2.2.5.12	Bearing and Power Transfer Assembly (BAPTA)
1.2.2.5.13	Attitude Control Wheels 1...n (Specify)
1.2.2.5.14	Magnetic Control Devices
1.2.2.5.15	Spin Control Devices
1.2.2.5.16	Control Electronics 1...n (Specify)
1.2.2.5.17	ACS Other
1.2.2.6	Propulsion Subsystem 1...n (Specify)
1.2.2.6.1	SEPM
1.2.2.6.2	Assembly, Integration and Test
1.2.2.6.3	Support Equipment
1.2.2.6.4	Tanks 1...n (Specify)
1.2.2.6.5	Plumbing
1.2.2.6.6	Thrusters 1...n (Specify)
1.2.2.6.7	Solid Rocket Motors
1.2.2.6.8	Liquid Propellant and Pressurant
1.2.2.6.9	Power Electronics
1.2.2.6.10	Propulsion Other
1.2.2.7	Telemetry, Tracking, and Command Subsystem (TT&C)
1.2.2.7.1	SEPM
1.2.2.7.2	Assembly, Integration and Test
1.2.2.7.3	Support Equipment
1.2.2.7.4	Antennas
1.2.2.7.5	Passive Signal Flow Control
1.2.2.7.6	Transmitter/Receiver/Transceiver/Transponder 1...n (Specify)
1.2.2.7.7	Modulators/Demodulators/Modems
1.2.2.7.8	Amplifiers
1.2.2.7.9	Frequency Upconverter/Downconverter
1.2.2.7.10	Computers and Processors 1...n (Specify)
1.2.2.7.11	Command/Telemetry Units 1...n (Specify)
1.2.2.7.12	Command Sensors 1...n (Specify)
1.2.2.7.13	Frequency and Timing
1.2.2.7.14	Signal Conditioners
1.2.2.7.15	Communications Security 1...n (Specify)
1.2.2.7.16	Data Storage, Handling and Interface 1...n (Specify)
1.2.2.7.17	TT&C Other
1.2.2.8	Bus Flight Software
1.2.2.8.1	SEPM
1.2.2.8.2	Assembly, Integration and Test
1.2.2.8.3	Support Equipment
1.2.2.8.4	CSCI 1...n (Specify)
1.2.3	SEIT/PM and Support Equipment (If applicable for integration of Multiple Payloads)
1.2.3.1	Systems Engineering
1.2.3.2	Assembly, Integration and Test
1.2.3.3	Program Management
1.2.3.4	Support Equipment
1.2.4	Payload 1...n (Specify)
1.2.4.1	SEIT/PM and Support Equipment
1.2.4.1.1	Systems Engineering
1.2.4.1.2	Assembly, Integration and Test
1.2.4.1.3	Program Management
1.2.4.1.4	Support Equipment
1.2.4.2	Structures and Mechanisms
1.2.4.2.1	SEPM
1.2.4.2.2	Assembly, Integration and Test
1.2.4.2.3	Support Equipment
1.2.4.2.4	Structures

1.2.4.2.5		Mechanisms and Pyrotechnics
1.2.4.2.6		Structures and Mechanisms Other
1.2.4.3	Thermal Control	
1.2.4.3.1		SEPM
1.2.4.3.2		Assembly, Integration and Test
1.2.4.3.3		Support Equipment
1.2.4.3.4		Cryogenic Devices
1.2.4.3.5		Liquid Loops
1.2.4.3.6		Electric Coolers
1.2.4.3.7		Electric Heaters, Thermisters, and Thermostats
1.2.4.3.8		Passive Devices
1.2.4.3.9		Sun Shields
1.2.4.3.10		Thermal Control Other
1.2.4.4	Electrical Power	
1.2.4.4.1		SEPM
1.2.4.4.2		Assembly, Integration and Test
1.2.4.4.3		Support Equipment
1.2.4.4.4		Power Sources
1.2.4.4.5		Power Control, Switching, and Distribution Electronics
1.2.4.4.6		Power Conditioning, Conversion, and Regulation
1.2.4.4.7		Harnesses and Cables
1.2.4.4.8		Electrical Power Other
1.2.4.5	Pointing, Command, and Control Interface System	
1.2.4.5.1		SEPM
1.2.4.5.2		Assembly, Integration and Test
1.2.4.5.3		Support Equipment
1.2.4.5.4		Computers and Processors 1...n (Specify)
1.2.4.5.5		Command/Telemetry Units 1...n (Specify)
1.2.4.5.6		Control Electronics 1...n (Specify)
1.2.4.5.7		Pointing Sensors 1...n (Specify)
1.2.4.5.8		Payload Positioners1...n (Specify)
1.2.4.5.9		Security, Encryption and Decryption Devices 1...n (Specify)
1.2.4.5.10		Data Storage, Handling and Interface 1...n (Specify)
1.2.4.5.11		Multifunctional Digital Electronic Boxes 1...n (Specify)
1.2.4.5.12		Pointing, Command, and Control Interface Other
1.2.4.6	Payload Antenna 1...n (Specify)	
1.2.4.6.1		SEPM
1.2.4.6.2		Assembly, Integration and Test
1.2.4.6.3		Support Equipment
1.2.4.6.4		Structures and Mechanisms
1.2.4.6.5		Antenna Positioners
1.2.4.6.6		Reflector/Horn 1...n (Specify)
1.2.4.6.7		Feed 1...n (Specify)
1.2.4.6.8		Waveguide/Coax/Cabling
1.2.4.6.9		Transmit/Receive Modules
1.2.4.6.10		Antenna Other
1.2.4.7	Payload Signal Electronics	
1.2.4.7.1		SEPM
1.2.4.7.2		Assembly, Integration and Test
1.2.4.7.3		Support Equipment
1.2.4.7.4		Passive Signal Flow Control
1.2.4.7.5		Transmitter/Receiver/Transceiver/Transponder 1...n (Specify)
1.2.4.7.6		Modulators/Demodulators/Modems 1...n (Specify)
1.2.4.7.7		Multiplexers/Demultiplexers 1...n (Specify)
1.2.4.7.8		Amplifiers 1...n (Specify)
1.2.4.7.9		Frequency Upconverters/Downconverters 1...n (Specify)
1.2.4.7.10		Frequency and Timing 1...n (Specify)
1.2.4.7.11		Signal Conditioners 1...n (Specify)
1.2.4.7.12		Multifunctional Signal Electronic Boxes 1...n (Specify)
1.2.4.7.13		Signal Electronics Other

1.2.4.8 Optical Assembly
1.2.4.8.1 SEPM
1.2.4.8.2 Assembly, Integration and Test
1.2.4.8.3 Support Equipment
1.2.4.8.4 Structure/Outerbarrel/Cover
1.2.4.8.5 Mirrors/Optics 1...n (Specify)
1.2.4.8.6 Aft Optics Assembly
1.2.4.8.7 Alignment and Calibration 1...n (Specify)
1.2.4.8.8 Thermal 1...n (Specify)
1.2.4.8.9 Control Electronics 1...n (Specify)
1.2.4.8.10 Optical Assembly Other
1.2.4.9 Sensor
1.2.4.9.1 SEPM
1.2.4.9.2 Assembly, Integration and Test
1.2.4.9.3 Support Equipment
1.2.4.9.4 Enclosure 1...n (Specify)
1.2.4.9.5 Focal Plane Array 1...n (Specify)
1.2.4.9.6 Sensor Positioners 1...n (Specify)
1.2.4.9.7 Sensor Electronics 1...n (Specify)
1.2.4.9.8 Alignment and Calibration 1...n (Specify)
1.2.4.9.9 Magnetometer 1...n (Specify)
1.2.4.9.10 Spectrometer 1...n (Specify)
1.2.4.9.11 Radiometer 1...n (Specify)
1.2.4.9.12 Camera 1...n (Specify)
1.2.4.9.13 Sounder 1...n (Specify)
1.2.4.9.14 Other Sensor Types 1...n (Specify)
1.2.4.9.15 Mission Sensor Other
1.2.4.10 Payload Flight Software
1.2.4.10.1 SEPM
1.2.4.10.2 Assembly, Integration and Test
1.2.4.10.3 Support Equipment
1.2.4.10.4 CSCI 1...n (Specify)
1.2.4.11 Payload Other
1.2.5 Booster Adapter
1.2.6 Space Vehicle Storage
1.2.7 Launch Systems Integration (LSI)
1.2.8 Launch Operations
1.2.9 Mission Operations Support
1.2.10 Space Vehicle Other
1.3 Ground Segment
1.3.1 SEIT/PM and Support Equipment
1.3.1.1 Systems Engineering
1.3.1.2 Assembly, Integration and Test
1.3.1.3 Program Management
1.3.1.4 Support Equipment
1.3.2 Ground Functions 1...n (Specify)
1.3.2.1 SEIT/PM and Support Equipment
1.3.2.1.1 Systems Engineering
1.3.2.1.2 Assembly, Integration and Test
1.3.2.1.3 Program Management
1.3.2.1.4 Support Equipment
1.3.2.2 COTS Hardware 1...n (Specify)
1.3.2.2.1 SEPM
1.3.2.2.2 Assembly, Integration and Test
1.3.2.2.3 Support Equipment
1.3.2.2.4 Workstations 1...n (Specify)
1.3.2.2.5 Servers 1...n (Specify)
1.3.2.2.6 Storage and Archive 1...n (Specify)
1.3.2.2.7 Network Equipment
1.3.2.2.8 Interface Equipment

1.3.2.2.9			Security Encryption/Decryption 1...n (Specify)
1.3.2.2.10			Data Processing 1...n (Specify)
1.3.2.2.11			COTS Hardware Other
1.3.2.2.12			Pre-Operations Maintenance 1...n (Specify)
1.3.2.2.13			Environments 1...n (Specify)
1.3.2.3		Custom Hardware 1...n (Specify)	
1.3.2.3.1			SEPM
1.3.2.3.2			Assembly, Integration and Test
1.3.2.3.3			Support Equipment
1.3.2.3.4			Custom Hardware Configured Item 1...n (Specify)
1.3.2.3.5			Pre-Operations Maintenance 1...n (Specify)
1.3.2.4		Ground Function Software	
1.3.2.4.1			SEPM
1.3.2.4.2			Assembly, Integration and Test
1.3.2.4.3			Support Equipment
1.3.2.4.4			GF Software CSCI 1...n (Specify)
1.3.2.4.5			Pre-Operations Maintenance 1...n (Specify)
1.3.2.5		Pre-Operations Mission Support	
1.3.3	Ground Terminal/Gateway (GT) 1...n (Specify)		
1.3.3.1		SEIT/PM and Support Equipment	
1.3.3.1.1			Systems Engineering
1.3.3.1.2			Assembly, Integration and Test
1.3.3.1.3			Program Management
1.3.3.1.4			Support Equipment
1.3.3.2		Antenna 1...n (Specify)	
1.3.3.2.1			SEPM
1.3.3.2.2			Assembly, Integration and Test
1.3.3.2.3			Support Equipment
1.3.3.2.4			Pedestal
1.3.3.2.5			Radome
1.3.3.2.6			Other Structure and Mechanisms
1.3.3.2.7			Aperture
1.3.3.2.8			Feed 1...n (Specify)
1.3.3.2.9			Waveguide/Coax/Cabling
1.3.3.2.10			Antenna Other
1.3.3.3		Optical Communication Assembly 1...n (Specify)	
1.3.3.3.1			SEPM
1.3.3.3.2			Assembly, Integration and Test
1.3.3.3.3			Support Equipment
1.3.3.3.4			Structure/Outerbarrel/Cover
1.3.3.3.5			Mirrors/Optics 1...n (Specify)
1.3.3.3.6			Aft Optics and Bench
1.3.3.3.7			Alignment Sensors/Calibration
1.3.3.3.8			Optical Assembly Other
1.3.3.4		RF Electronics Band 1...n (Specify)	
1.3.3.4.1			SEPM
1.3.3.4.2			Assembly, Integration and Test
1.3.3.4.3			Support Equipment
1.3.3.4.4			Passive Signal Flow Control
1.3.3.4.5			Transmitter/Receiver/Transceiver/Transponder 1...n (Specify)
1.3.3.4.6			Modulators/Demodulators/Modems 1...n (Specify)
1.3.3.4.7			Multiplexers/Demultiplexers 1...n (Specify)
1.3.3.4.8			Power Amplifiers 1...n (Specify)
1.3.3.4.9			Frequency Upconverters/Downconverters 1...n (Specify)
1.3.3.4.10			Signal Conditioners 1...n (Specify)
1.3.3.4.11			Signal Electronic Boxes 1...n (Specify)
1.3.3.4.12			Focal Plane Array 1...n (Specify)
1.3.3.4.13			RF Electronics Other
1.3.3.5		Timing	
1.3.3.5.1			SEPM

1.3.3.5.2			Assembly, Integration and Test
1.3.3.5.3			Support Equipment
1.3.3.5.4			Receiver
1.3.3.5.5			Antenna 1...n (Specify)
1.3.3.5.6			Frequency and Timing Generators
1.3.3.5.7			Amplifier and Distribution 1...n (Specify)
1.3.3.5.8			Timing Other
1.3.3.6		Baseband-Network	
1.3.3.6.1			SEPM
1.3.3.6.2			Assembly, Integration and Test
1.3.3.6.3			Support Equipment
1.3.3.6.4			Switches/Hubs and Routers
1.3.3.6.5			Network Interface and Other Hardware
1.3.3.6.6			Modems
1.3.3.6.7			Security/Encryption and Decryption Devices 1...n (Specify)
1.3.3.6.8			Baseband-Network Electronic Boxes 1...n (Specify)
1.3.3.6.9			Baseband-Network Other
1.3.3.7		Monitor and Control Hardware	
1.3.3.7.1			SEPM
1.3.3.7.2			Assembly, Integration and Test
1.3.3.7.3			Support Equipment
1.3.3.7.4			Workstations 1...n (Specify)
1.3.3.7.5			Servers 1...n (Specify)
1.3.3.7.6			Storage and Archive 1...n (Specify)
1.3.3.7.7			Hardware Configured Item 1...n (Specify)
1.3.3.8		GT Software	
1.3.3.8.1			SEPM
1.3.3.8.2			Assembly, Integration and Test
1.3.3.8.3			Support Equipment
1.3.3.8.4			CSCI 1...n (Specify)
1.3.3.9		Pre-Operations Maintenance 1...n (Specify)	
1.3.3.10		Pre-Operations Mission Support	
1.3.4	External Network (T-COMM)		
1.3.4.1		SEIT/PM and Support Equipment	
1.3.4.1.1			Systems Engineering
1.3.4.1.2			Assembly, Integration and Test
1.3.4.1.3			Program Management
1.3.4.1.4			Support Equipment
1.3.4.2		Leased Circuit 1...n (Specify)	
1.3.4.3		Purchased Circuits	
1.3.4.3.1			Purchased Circuit 1...n (Specify)
1.3.4.3.2			Pre-Operations Maintenance 1...n (Specify)
1.3.5	User Equipment		
1.3.5.1		SEIT/PM and Support Equipment	
1.3.5.1.1			Systems Engineering
1.3.5.1.2			Assembly, Integration and Test
1.3.5.1.3			Program Management
1.3.5.1.4			Support Equipment
1.3.5.2		Equipment 1...n (Specify)	
1.3.5.2.1			SEPM
1.3.5.2.2			Assembly, Integration and Test
1.3.5.2.3			Support Equipment
1.3.5.2.4			Hardware Configured Item 1…n (Specify)
1.3.5.2.5			Equipment Software 1...n (Specify)
1.3.5.3		Pre-Operations Maintenance 1...n (Specify)	
1.3.6	Facilities 1...n (Specify)		
1.3.6.1		SEIT/PM and Support Equipment	
1.3.6.1.1			Systems Engineering
1.3.6.1.2			Assembly, Integration and Test
1.3.6.1.3			Program Management

1.3.6.1.4			Support Equipment
1.3.6.2		Site Preparation	
1.3.6.2.1			SEPM
1.3.6.2.2			Assembly, Integration and Test
1.3.6.2.3			Support Equipment
1.3.6.2.4			Graded Land
1.3.6.2.5			Roads
1.3.6.2.6			Pads
1.3.6.2.7			Retaining Walls/Fencing
1.3.6.2.8			Utilities
1.3.6.2.9			Site Preparation Other
1.3.6.3			Landscape
1.3.6.4		Buildings 1...n (Specify)	
1.3.6.4.1			SEPM
1.3.6.4.2			Assembly, Integration and Test
1.3.6.4.3			Support Equipment
1.3.6.4.4			Foundation and Sub Structure
1.3.6.4.5			Superstructure and Finishing
1.3.6.4.6			Buildings Other
1.3.6.5		Equipment and Building Fit Out 1...n (Specify)	
1.3.6.5.1			SEPM
1.3.6.5.2			Assembly, Integration and Test
1.3.6.5.3			Support Equipment
1.3.6.5.4			Heating Venting and Air Conditioning (HVAC)
1.3.6.5.5			Power Conditioning/UPS
1.3.6.5.6			Network Wiring/Cable Trays
1.3.6.5.7			Generators
1.3.6.5.8			Computer Flooring
1.3.6.5.9			Appliances
1.3.6.5.10			Furniture
1.3.6.5.11			Fire Protection
1.3.6.5.12			Security Systems
1.3.6.5.13			Equipment and Building Fit Out Other
1.3.6.6		Pre-Operations Maintenance 1...n (Specify)	
1.3.7	Vehicles and Shelters		
1.3.7.1		SEIT/PM and Support Equipment	
1.3.7.1.1			Systems Engineering
1.3.7.1.2			Assembly, Integration and Test
1.3.7.1.3			Program Management
1.3.7.1.4			Support Equipment
1.3.7.2		Vehicles 1...n (Specify)	
1.3.7.3		Shelters 1...n (Specify)	
1.3.7.4		Pre-Operations Maintenance 1...n (Specify)	
1.4	Orbital Transfer Vehicle (OTV)		
1.5	Launch Vehicle 1...n (Specify)		

F.3.1 Application of Common WBS Elements as they pertain to Space (Appendix K – Section K.4) (including SEIT/PM and Support Equipment). Normally, WBS elements that are common (i.e., Integration, Assembly, Test, and Checkout; Systems Engineering; Program Management; Acquisition Logistics; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. Definitions for the Common WBS elements, and all other defense materiel items, are included in Appendix K. Section K.4 consists of Definitions of Common Elements Applicable to Space Programs.

F.3.2 Contract WBS Naming Conventions. The contract WBS shall use the appropriate Space System WBS elements and shall not include elements that are not within the scope of the contract. The contract element titles need not be identical to the Space WBS and may use the contractor names of hardware units and software CSCIs. Wherever possible, these titles should be descriptive of the element and not generic. For example, the following should not be used as complete titles: “Other Costs,” “Digital Electronic Box 1,” and “Bus Flight Software CSCI Application 2.” As a

specific example, the preferred title is "S-Band Helix Antenna," as opposed to merely "Antenna" or "S-Band Helix." Additionally, SEIT/PM and Support Equipment references should be replaced with terminology that accurately reflects its level and specific content, such as: "Space Vehicle Systems Engineering." WBS elements that appear within multiple legs of the WBS should also indicate to which portion of the WBS it belongs. For example, a Receiver within an EHF Payload could be named "Wideband EHF Receiver."

F.3.3 Application of 1...n (Specify) convention. This document uses a 1...n after WBS element titles where the element often has multiple unique occurrences. The 1...n convention can be used for any WBS element where applicable. When creating the WBS for a specific program or contract, the 1...n shall be replaced with a specific name for the item. For example, where this WBS references Star Trackers 1...n and the Attitude Control subsystem contains two types of Star Trackers, the contract WBS shall specifically identify them as separate Level 5 elements, such as Narrow Field Of View (NFOV) Star Tracker and Wide Field Of View (WFOV) Star Tracker. The contract dictionary definition for these elements shall provide detailed descriptions of the content associated with these added WBS elements.

F.3.4 Use of "Other" WBS Elements. The Other WBS elements at the system, subsystem, and element (product) levels are restricted to products that have not been envisioned or predicted in the other defined WBS elements. This element should only be used when all other elements have been thoroughly examined and do not fit the definition of the other product. Multiple elements, with appropriate titling, should be detailed down to the element level (Level 5) whenever possible. In addition, the WBS dictionary should clearly define the elements.

F.3.5 Use of the word "separable." Some of the definitions use the term "separable" with reference to hardware or software. Hardware and software are "separable" (from other hardware and software) if their costs are identifiable from each other.

F.3.6. Key Principles in Constructing a WBS. In the appendices of this MIL-STD, the WBS is defined to Level 3, 4, or 5 depending on the system. WBS elements in the appendices may be extended to appropriate levels below their MIL-STD definition for informational or reporting purposes. The purpose for these extensions is to ensure that the higher-level elements include the proper lower level elements when required to report at a lower level. If an extension below the MIL-STD definition is required, maintaining the product-oriented decomposition is required.

1) Extending the WBS to Lower Levels. The reporting level of the WBS depends on the level of interest where work is accomplished. Reporting at levels below those identified within the MIL-STD should be reported if they are considered high cost, high risk, high technical, and/or special interest. For those elements, extension of the WBS to lower levels may be necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. An example of the extension for this Appendix commodity can be found at http://cade.osd.mil/policy/csdr-plan.

2) Recognizing Cybersecurity Processes/Products. Cybersecurity is a requirement for all DoD programs and must be fully considered and implemented in all aspects of acquisition programs across the life cycle. Attention must be paid to cybersecurity at all acquisition category levels and all classification levels, including unclassified, throughout the entire life cycle; this includes systems that reside on networks and stand-alone systems that are not persistently connected to networks during tactical and strategic operations. Since responsibility for cybersecurity extends to every member of the acquisition workforce, DoD and its contractors need to design, develop, and acquire systems that can operate in applicable cyber threat environments. As such it is critical to understand what the cost of these systems is (i.e., hardware, software, systems engineering, program management, and system test and evaluation). MIL-STD-881D supports this effort by providing the structure to identify, collect and report many of these critical costs. It is also recognized gathering this information is nearly impossible at the level of detail these systems are developed. It is for this reason, where cybersecurity related costs can be easily accounted for, they should be called out in the WBS. For example, for hardware/software elements, if the development or procurement of hardware in a system is specifically a cybersecurity artifact, then call it out as a WBS element to identify it. The same is true for software. If the development of a CSCI(s) are specifically cybersecurity or software is purchased that is specifically for cybersecurity, call it out as a WBS element to identify it. Just as important are the engineering, management, and test activities that are used to ensure the systems are meeting the planned expectations. The MIL-STD has specifically called out these efforts associated with systems engineering, program management, and system test and evaluation WBS (See Appendix K.3).

F.3.7 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been

numbered for reporting purposes only. In addition, the numbering provides visible clarity regarding level of indenture and parent-child content. While the numbering system is numeric, several unique issues arise across appendices which require the numbering system to be modified to accommodate these anomalies (See Figure X). Additionally, if a WBS element is not required, it may be eliminated from the structure and the numbering would be logically adjusted.

F.4 DEFINITIONS

F.4.1 Space System. The complex of equipment (hardware/software) and all of the resources associated with the design, development, production, integration, assembly, test, and operation of the entire space system.

Includes, for example:
a. Space vehicle(s); ground segment; ground terminals; launch vehicle(s); and any mission equipment or other items necessary to provide an operational capability in space.
b. Any efforts done within a development/acquisition contract, including such things as integrated logistic planning, space vehicle on-orbit checkout, calibration, and orbit raising.
c. Program management, systems engineering, integration and test, and support equipment at all levels of indenture where they are necessary

Excludes, for example:
a. On-orbit operations beyond checkout and acceptance
b. Ground operations and maintenance

F.4.2 Space Vehicle 1...n (Specify). This WBS element is intended for space vehicle(s) that are unmanned satellites orbiting the Earth. Each unique space vehicle configuration should be assigned a unique space vehicle level WBS element. It contains all of the resources associated with the design, development, production, integration, assembly, and test to include verification testing of each space vehicle as required.

Includes, for example:
a. The design, development, production, integration, assembly, test, and checkout of complete elements (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specification, regardless of end use)
b. Sub-elements to the space vehicle, including the bus, payload, booster adapter, space vehicle storage, launch systems integration, launch operations, and mission operations support (F.4.2.1-F.4.2.7)

F.4.2.1 Bus. The portion of the space vehicle that serves as a housing or platform for carrying payloads and provides necessary support functions (power, thermal control, etc.). It also interfaces with the launch vehicle (F.4.7) via the booster adapter (F.4.2.3).

Includes, for example:
a. Structures and mechanisms (S&M), thermal control (TCS), electrical power (EPS), attitude control (ACS), propulsion (PS), telemetry, tracking, and command (TT&C) subsystems; and bus flight software.
b. All design, development, production, integration, assembly, test, and checkout efforts to provide the bus as an entity or as subsystems for integration with other WBS Level 3 elements (i.e., payload equipment) hardware elements

NOTE 1: On more complicated space vehicles, there may be an integrated digital system (single electronic box or set of boxes) that performs processing functions for both the bus and payloads. In these cases, it is acceptable to consider the multi-processor system as a single payload or as part of a specific payload. The multi-processor system may integrate functions normally included under ACS, TT&C, communication and other payloads. The relevant point is to keep the cost in a single element and not allocate over multiple WBS elements.

NOTE 2: For lower level Common Elements such as SEIT/PM, reference Appendix K, section K.4.

F.4.2.1.1 Structures and Mechanisms Subsystem (SMS). This subsystem provides structural support,

deployment and locking functions for the space vehicle.

Includes, for example:

a. Items such as structure, mechanisms, structures with integral (non-removable) thermal control, pyrotechnics
b. Equipment compartments, trusses, frames and shells for carrying primary loads; and secondary structures for equipment support; structural assemblies for interfacing with the booster adapter and/or with the launch vehicle.
c. All load carrying devices, such as payload equipment panels that are provided to payload equipment suppliers for supporting payload equipment components
d. Springs, cables, latches and other mechanisms and support structures that are not defined elsewhere within the WBS and for which the costs are separable

Excludes, for example:

a. Mechanisms that are identified with specific elements they support, such as solar array positioners and gimbals for antennas
b. Booster adapters not integral with spacecraft structures
c. Payload fairings that are included in the launch vehicle element
d. Small equipment compartments or pallets that house payload electronics, which are part of the payload element
e. Booms that are used to exclusively support payload components or assemblies in the payload element

NOTE 1: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.1.1.1 Structures. This collection of items provides structural support for all bus and payload components and assemblies. They include items such as equipment compartments (structural elements that protect from radiation, thermal, electromagnetic, and other effects; excluding single unit chassis integral to that unit); trusses, frames and shells for carrying primary loads; and secondary structures for equipment support. This element includes all load-carrying devices, such as payload equipment panels that are provided to payload equipment suppliers for supporting payload equipment components. However, structural elements such as small equipment compartments or pallets that house payload electronics and are provided as part of payload equipment are excluded from this WBS element and included in the appropriate payload equipment structures element. Booms exclusively for supporting payload equipment components or assemblies are also included in payload structures.

F.4.2.1.1.2 Mechanisms and Pyrotechnics. The collection of items that deploy or lock space vehicle components, excluding antenna and solar array mechanisms (to the extent that the mechanisms are separable from the components they support). This element also includes items that provide reaction force to initiate release for separation or deployment. These devices include squibs and ordnance separation units. Pyrotechnic initiation electronics are normally included within the electrical power subsystem. Includes, for example: hinges, springs, cables, latches, motors, separation bolts, and squibs. Excludes, for example: antenna, optics, sensor, solar array mechanisms.

F.4.2.1.1.3 SMS Other. This WBS element contains all the resources associated with unique structures and mechanisms subsystem hardware not included in WBS elements above.

F.4.2.1.2 Thermal Control Subsystem (TCS). This subsystem maintains the temperatures of all bus components, and those payload suites without their own thermal control provisions, within acceptable limits. Includes, for example: active and passive components such as cryogenic devices, liquid loops, electric coolers, multi-layer thermal insulation blankets (MLI), surface coatings (thermal paint), mirrors, thermal tape, heat pipes, heat sinks, insulation, conductive structures and materials, louvers, sun shields, electric coolers, heaters, thermisters, thermostats, shutters, thermal conducting elements, and radiator panels/fin.

NOTE 1: In cases where a payload contains its own thermal control provisions, the thermal control components are included in the payload WBS element.

NOTE 2: **When a component or unit has integral (non-removable) thermal control provisions such as heat sinks, thermisters, or heaters then that item should be included within that component or unit.**
NOTE 3: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.1.2.1 Cryogenic Devices. This collection of items facilitates the control of operating temperatures of bus components and those payload suites without their own thermal control provisions by obtaining or operating at cryogenic temperatures. Examples include cryo-coolers and cryostats.

F.4.2.1.2.2 Liquid Loops. This collection of items composes a heat transfer system that helps control temperatures of Bus components, and those payload suites without their own Thermal Control provisions. This system is usually comprised of fluid (gas or liquid) conduits (tubing), heat exchangers, and pumps.

F.4.2.1.2.3 Electric Coolers. This collection of items electrically reduces operating temperatures of Bus components, and those payload suites without their own thermal control provisions. Includes, for example: Peltier devices, Peltier diodes, Peltier heat pumps, solid state refrigerators, thermoelectric coolers (tecs) or any electronics for controlling the coolers.

F.4.2.1.2.4 Heaters, Thermisters, and Thermostats. This collection of items actively controls heat loss by generating heat and controlling and monitoring temperatures. Thermisters and thermostats are equivalent terms. Heater switching is included within the electrical power subsystem.

F.4.2.1.2.5 Passive Devices. This collection of items passively maintains the temperatures of all bus components, and those payload suites without their own thermal control provisions. Includes, for example: radiator panels/fins, coatings, heat pipes, insulation, conductive structures, louvers/shutters, and sun shields.

F.4.2.1.2.6 TCS Other. This WBS element contains all the resources associated with unique thermal control subsystem hardware items not included in WBS elements above.

F.4.2.1.3 Electrical Power Subsystem (EPS). This subsystem generates, converts, regulates, stores, distributes, and switches electrical energy to bus and payload components.

Includes, for example:

a. Electric power generation: solar array (to include substrates, solar cells, support structure), solar array positioner (to include drive assembly and drive electronics), radioisotope thermionic generator, other power sources
b. Electric power conditioning and distribution: power control electronics (to include junction boxes and pyrotechnics/heater controls), power conversion electronics (to include inverters, converters and regulators), power dissipation devices (to include shunt resistor banks and dissipaters)
c. Electric power storage: rechargeable batteries (to include cells, support structure and interconnects), charge control electronics
d. Harnesses and cables

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.1.3.1 Solar Array. These elements generate power by converting solar energy into electricity with strings of solar cells. This WBS includes substrates, solar cells, interconnecting wiring, concentrators, cover-glass and supporting structure, which together form a solar panel. A solar array is made up of one or more solar panels (for example, a solar

array wing) and mechanisms for deployment and latching.

F.4.2.1.3.2 Solar Array Positioner. This element orients the solar array to get the best sun incidence angle in order to maximize solar cell efficiency. This WBS includes both the drive assembly and any integral drive control electronics. Control electronics for the positioner are typically located in the attitude control subsystem.

F.4.2.1.3.3 Radioisotope Thermionic Generator. This element converts heat into electricity via thermionic emission using nuclear-reactor or radioisotope energy sources. They are typically used for deep space missions where long mission life is required and when distances from the sun are large enough to render solar arrays ineffective.

F.4.2.1.3.4 Other Power Sources. These elements contain all the resources associated with electrical power generation hardware not included in WBS elements above. These elements include items such as non-rechargeable batteries and fuel cells (which convert chemical energy into electrical energy) and are typically used as backup power systems, using an energy source other than the space vehicle's main power source.

F.4.2.1.3.5 Power Control, Switching, and Distribution Electronics. This collection of items allows for power flow throughout the space vehicle. This WBS element includes power control, switching and distribution units; junction boxes; pyrotechnics initiation, heater switching, propulsion valve drive modules (PVDM), and battery switching units.

F.4.2.1.3.6 Power Conditioning, Conversion, and Regulation. This collection of items condition, convert, and regulate power throughout the space vehicle. Includes, for example: inverters, converters, and regulators.

F.4.2.1.3.7 Power Dissipation Devices. This collection of items dissipate power not used by the space vehicle electrical loads. This includes shunt resistor banks and other dissipaters.

F.4.2.1.3.8 Rechargeable Batteries. This collection of items stores and subsequently releases electrical energy. Batteries convert chemical energy into electrical energy during discharge and electrical energy into chemical energy during charge. Incudes, for example: battery cells, supporting structure (or packs), interconnects, reconditioning equipment.

F.4.2.1.3.9 Charge Control Electronics. This collection of items charges the batteries. This element controls the level to which a battery is charged or discharged. This includes battery charge assembly (BCA) and diodes.

F.4.2.1.3.10 Harnesses and Cables. This element is the collection of items used to route and provide electrical power and signals throughout the space vehicle. This is also commonly referred to as "wiring." Includes, for example: coaxial, fiber optic cables, installation hardware. Excludes, for example: harnessing within a payload.

F.4.2.1.3.11 EPS Other. This WBS element contains all the resources associated with unique electrical power subsystem hardware items not included in WBS elements above.

F.4.2.1.4 Attitude Control Subsystem (ACS). This element determines and controls space vehicle orbital positions, attitudes, velocities, and angular rates using onboard sensors and torque application devices. It may also send control signals to propulsion subsystem components (e.g., thrusters), the electrical power subsystem, solar array positioners, and communication/payload positioner electronics.

Includes, for example:

a. Attitude determination: attitude reference (to include star tracker/sensors, Earth (horizon) sensors, sun sensors, magnetometers), inertial reference (to include inertial reference units, rate gyros, accelerometers), bearing and power transfer assemblies (BAPTAs), and global position system (GPS) receivers
b. Attitude control: gyro stabilization devices (to include reaction wheels, momentum wheels, control moment gyros, energy storage devices (flywheels)), magnetic control devices, spin control devices, control electronics

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.1.4.1 Star Tracker/Sensors 1...n (Specify). These elements are optical devices measuring the direction to one or more stars, typically using a photocell or solid-state camera to observe the star(s) for purposes of attitude determination.

F.4.2.1.4.2 Earth (Horizon) Sensors 1...n (Specify). These elements are optical instruments that detect light from the 'limb' of the Earth's atmosphere, i.e., at the horizon. This can be a scanning or a staring instrument. Infrared is often used, which can function even on the dark side of the Earth. These elements provide orientation with respect to the Earth about two orthogonal axes.

F.4.2.1.4.3 Sun Sensors 1...n (Specify). These elements sense the direction to the Sun. This can be as simple as some solar cells and shades, or as complex as a steerable telescope, depending on mission requirements.

F.4.2.1.4.4 Magnetometers. These elements are used to measure the strength and/or direction of the Earth's magnetic field. A commonly used device is a three axis magnetometer (TAM), which helps the momentum management functions to generate signals to the magnetic torque assembly (MTA). The TAM outputs three analog signals that are proportional to the components of the Earth's magnetic field in the magnetometer coordinate frame.

F.4.2.1.4.5 Global Positioning System (GPS) Receiver. This element calculates position by using timing signals sent by the constellation of GPS satellites. A GPS constellation is comprised of medium Earth orbit satellites that transmit precise microwave signals, that enable GPS receivers to determine their location, speed, direction, and time. Excluded from this is the GPS antenna and coax cabling that is included in the TT&C subsystem.

F.4.2.1.4.6 Inertial Reference Unit (IRU)/Inertial Measurement Unit (IMU) 1...n (Specify). These elements are a type of inertial sensor that uses only gyroscopes to determine the space vehicle's change in angular direction (referred to as "delta-theta" or $\Delta\theta$) over a period of time. Unlike an inertial measurement unit, inertial reference units (IRUs) are generally not equipped with accelerometers, which measure acceleration forces. IRUs are typically used for attitude determination and navigation of vehicles with relatively constant acceleration rates, such as geosynchronous satellites and deep space probes.

F.4.2.1.4.7 Rate Gyros 1...n (Specify). These elements are sensors used to measure the angular rate measurements (3-degree axis—roll, pitch and yaw) of the space vehicle to help with maintaining the stabilization and pointing accuracy of the space vehicle.

F.4.2.1.4.8 Accelerometers 1...n (Specify). These elements are devices for measuring acceleration and gravity induced reaction forces. Single and multi-axis models are available to detect magnitude and direction of the acceleration as a vector quantity. Accelerometers can be used to sense inclination, vibration, and shock.

F.4.2.1.4.9 Bearing and Power Transfer Assembly (BAPTA). This element is a mechanism that transmits electrical power and signals across rotating joints between the "spun" and "despun" sections of spin-stabilized space vehicles. They also control the orientation of the despun section about the spin axis in inertial space. A BAPTA usually consists of three main parts: (1) a bearing unit, (2) a drive unit, and (3) a slip ring unit.

F.4.2.1.4.10 Attitude Control Wheels 1...n (Specify). These elements, also known as gyro stabilization devices, provide angular stabilization of the space vehicle. These wheels control the attitude via the internal torques created by the electrically generated rotation of wheels. Usually, the wheels can be commanded to spin in either a clockwise or a counterclockwise direction, thereby creating the necessary angular momentum to counter the space vehicle's momentum, in order to provide stability and pointing accuracy. Examples include: reaction wheels, control moment gyros (CMGs), and momentum wheels. Control electronics for wheel devices are included in the control electronics element (F.4.2.1.4.13) if they are separable from the wheel devices.

F.4.2.1.4.11 Magnetic Control Devices. These elements are electromagnets that apply torques to the space

vehicle by interacting with the Earth's magnetic field. They typically consist of a solid metal core, which is wound with two independent coils of copper wire, a case that protects them from physical damage and ultraviolet radiation, and mounting blocks and a connector.

F.4.2.1.4.12 Spin Control Devices. These elements dampen disturbance accelerations in spin-stabilized space vehicles. They include nutation and wobble dampers.

F.4.2.1.4.13 Control Electronics 1...n (Specify). These elements provide electrical interfaces between the space vehicle processor and sensors and effectors (reaction control wheels, BAPTAs, magnetic control devices, solar array positioners, valves and thrusters, etc.). This WBS element also includes computers or processors that are dedicated to attitude control subsystem functions. For effectors, the control electronics receive the input command from the space vehicle processor and convert it to the corresponding electrical interface stimulus, e.g., pulses, digital to analog converter (DAC), etc. for the effector. For sensors, the control electronics condition the telemetry signal (such as tach pulses, active analogs, etc.) to either an analog signal within the analog-to-digital converter (ADC) range and/or convert to a corresponding digital output.

F.4.2.1.4.14 ACS Other. This WBS element contains all the resources associated with unique attitude control subsystem hardware items not included in WBS elements above.

F.4.2.1.5 Propulsion Subsystem 1...n (Specify). This subsystem provides thrust for attitude control and orbit corrections as required to accomplish the specified mission. It may also provide thrust for orbit injection and changes. Includes, for example: tanks, plumbing, thrusters, solid rocket motors, liquid propellant, and pressurant.

F.4.2.1.5.1 Tanks 1...n (Specify). These elements provide for storage of propellants and pressurants used in the propulsion subsystem. Includes, for example, fuel tanks, oxidizer tanks, monopropellant tanks, helium (pressurant) tanks, xenon tanks, etc.

F.4.2.1.5.2 Plumbing. This collection of items provides for the Distribution and flow control of propellants and pressurants. Includes, for example, lines (tubing), fittings, regulators, filters, valves (squib, latch, fill/drain, and check), manifolds, transducers, and installation hardware.

F.4.2.1.5.3 Thrusters 1...n (Specify). Thrusters provide the force to alter the attitude and velocity of a space vehicle. Includes, for example, liquid apogee engine (LAE), liquid apogee motor, and thrusters of different LBFs (pounds force), monopropellant, bipropellant, Xenon, and Hall effect. This element also includes any gimbal mechanism required for vector movement. This element excludes the electronics controlling the liquid thrusters, which are included in either the attitude control subsystem or the TT&C subsystem.

F.4.2.1.5.4 Solid Rocket Motors. These elements provide reaction force for the final space vehicle maneuver into orbit and for orbit changes. Nozzles may be fixed or steerable. Includes, for example, nozzle, casing, solid fuel propellant (grain), and igniter. Motors may be single use only, extinguished and re-ignited, or contain segments that are ignited by command. One specific example would be an apogee kick motor (AKM).

F.4.2.1.5.5 Liquid Propellant and Pressurant. This collection of items provides for the propellant and pressurant (liquids and gasses) used to generate force (Delta V) or pressure. Includes, for example, bipropellant fuel and oxidizer, monopropellant fuel, helium pressurant, xenon (for electric propulsion) and other gasses/fuel used in the Propulsion subsystem.

F.4.2.1.5.6 Power Electronics. This element is a collection of items provide for the electric power used for an electric Propulsion subsystem. Includes, for example, power supplies and relay units. Excludes the power generation and distribution associated with the electrical power subsystem.

F.4.2.1.5.7 Propulsion Other. This element contains all the resources associated with unique propulsion subsystem hardware items not included in WBS elements above.

NOTE 1: A propulsion subsystem can either be liquid or electric; if the space vehicle contains both types, create two separate subsystems (1...n). Solid fuel propulsion components, integral to the space vehicle, are booked with liquid propulsion subsystem items.

NOTE 2: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.1.6 Telemetry, Tracking, and Command Subsystem (TT&C). This element performs functions such as: formatting and transmitting telemetry (typically on narrowband links); accepting, decoding, verifying, and storing uplink commands; and generating command and control signals for the bus and payload suites based on uplink commands and/or internally generated data. The TT&C subsystem may also: provide central processing functions, provide timing signals to the bus and payload suites; perform on-board attitude determination, ephemeris calculations and attitude control equipment control (if these are not performed by dedicated attitude control computers/electronic components); and perform thruster control, positioner control, electrical power monitoring and control (if this is not performed by dedicated electrical power subsystem components).

Includes, for example: passive radio frequency (RF) components (such as antennas, passive signal flow control), other RF equipment (such as transmitters, receivers, transponder, modulators, demodulators, power amplifiers, traveling wave tube assembly, solid state power amplifiers, downconverters, and upconverters), processors (such as onboard computers (obcs)), solid state memory, decoders, command units, telemetry units, command sequencers, timing units, frequency generators, signal conditioners, data switches, and other electronics. Excludes, for example: pointing command and control equipment integral or dedicated to payload functions.

F.4.2.1.6.1 Antennas. These elements are primarily used for TT&C specific functions. They receive RF signals for the command and control of the space vehicle and transmit space vehicle telemetry to the ground. These elements are typically omni-directional antennas including support structure and mechanisms, but can also be feeds, reflectors, and arrays. Antennas that are primarily used for mission objectives should be located within the payload WBS. Includes the antenna for the GPS receiver.

F.4.2.1.6.2 Passive Signal Flow Control. This element is a collection of items that provide various passive RF signal flow and conditioning functionality within the TT&C subsystem. Includes, for example, RF plumbing, diplexers, triplexers, multiplexers, multicouplers, coaxial switches, RF switches, filters, waveguides, TT&C internal harnesses and cables, and other similar low-value items.

F.4.2.1.6.3 Transmitter/Receiver/Transceiver/Transponder 1...n (Specify). These electronics send and/or receive signals to and/or from TT&C antennas and separate them into analog or digital signals. TT&C transmitters typically convert digital telemetry signals into modulated RF signals. TT&C receivers receive RF signals and convert them to digital command signals. TT&C transceivers contain both a transmitter and a receiver. TT&C transponders relay RF signals.

F.4.2.1.6.4 Modulators/Demodulators/Modems. Modulators modify the amplitude, phase frequency of sinusoidal carrier signals to include information in the resultant (modulated) output signal. The input signals to modulators are usually digital signal streams, such as telemetry. Demodulators perform the inverse of modulators, separating digital information from carrier signals. Modems, which perform both operations, are also included in this WBS element.

F.4.2.1.6.5 Amplifiers. These elements are devices that change/increase the amplitude of a signal. Includes, for example: solid state power amplifiers (SSPAs), traveling wave tube amplifiers (TWTAs), low noise amplifiers (LNAs).

F.4.2.1.6.6 Frequency Upconverter/Downconverter. These elements receive RF signals of one frequency and output at a different frequency. This is typically done by combining (mixing) the input signal with a sinusoidal signal from a local oscillator. Includes, for example: frequency converters, upconverters, and downconverters. An RF

upconverter is a device that takes an input of radio frequency energy of a specific frequency range and outputs it on a higher frequency. Likewise, downconverters take an input frequency and reduce it to a lower output frequency.

F.4.2.1.6.7 Computers and Processors 1...n (Specify). These elements process data according to a list of computer software instructions (see bus flight software) controlling the bus subsystems and payload functions not handled by payload specific processors. This includes, for example, central processing units (CPUs) or onboard computers (OBCs). Computer and processor memory may also be included within this WBS element.

Includes, for example:

a. Computers and processors that perform general spacecraft bus (and possibly payload) computing functions, such as command execution.

Excludes, for example:

a. Computers and processors dedicated to ACS attitude determination and control functions, or to payload functions, to the extent that those are separable from the TT&C computers and processors performing general functions

F.4.2.1.6.8 Command/Telemetry Units 1...n (Specify). These elements (digital) provide the engineering definitions used to configure and determine the health and status of the space vehicle. Typical command units perform: on/off, enable/disable, flight software (FSW) modes and states, unit configurations and operations, such as reaction control wheel speed bias, voltage regulation percentage, thruster valve firing durations, solar array angles, etc. Telemetry units are used in conjunction with calculation curves to convert raw data telemetry to engineering units, in order to determine the health and status of the space vehicle. Typical telemetry units perform unit configuration and operational status: on/off, converter voltages, current draw, on-board fault management (OBFM) configuration and status, FSW modes and states, attitude rates, RF signal strength, etc. Includes, for example: command processing units, telemetry processing units, integrated command and telemetry (C&T) processing units, central and remote C&T elements. (Many space vehicles employ both central command and telemetry units as well as remote units that interface with a limited number of payload or bus equipment)

F.4.2.1.6.9 Command Sensors 1...n (Specify). These elements are sensors (survivability, proximity, etc.) that detect events (e.g., nuclear, electromagnetic) or the presence of nearby objects without any physical contact for the safety of the space vehicle. A proximity sensor often emits an electromagnetic or electrostatic field, or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. Different proximity sensor targets demand different sensors. For example, a capacitive or photoelectric sensor might be suitable for a plastic target; an inductive proximity sensor requires a metal target.

F.4.2.1.6.10 Frequency and Timing. These elements provide stable timing and frequency reference signals (RF and digital) to other space vehicle electronics components including payload components without their own frequency and timing capabilities. This WBS element includes frequency generators, oscillators, and timing units.

F.4.2.1.6.11 Signal Conditioners. These elements alter (e.g., filter, eliminate noise, compress, amplify) analog signals to meet the requirements of the next processing stage. For example, the output of an electronic temperature sensor may be too low for an analog-to-digital converter (ADC) to process directly. In such a case, the signal conditioner will amplify the sensor output to bring the voltage level up to that required by the ADC.

F.4.2.1.6.12 Communications Security 1...n (Specify). Communications security (COMSEC) electronics encrypt digital telemetry data and decrypt digital command data. It may also encrypt low-volume payload digital data. Inputs to encryption devices usually come from telemetry units, while decryption inputs are usually the outputs of command receivers.

In some cases, COMSEC circuit boards or chips may be packaged along with command and telemetry electronics. In these cases, the integrated electronic box is included in the command and telemetry electronics WBS element. Similarly, if COMSEC equipment is integrated with TT&C transmitters or receivers, the electronics box is included in the transmitters, receivers and transponders WBS element.

F.4.2.1.6.13 Data Storage, Handling and Interface 1...n (Specify). These elements carry, process, and/or store

housekeeping, telemetry and mission data and may interface between bus and/or payload units. Includes, for example, interface units, data handling units, solid state recorders (SSRs), telemetry storage units (TSUs), tape recorders and disk recorders. These elements can include compression, and other interface functions, and digital multiplexers/demultiplexers. Excludes data storage units used primarily for storing payload data.

F.4.2.1.6.14 TT&C Other. This WBS element contains all the resources associated with unique TT&C subsystem hardware items not included in WBS elements above.

F.4.2.1.7 Bus Flight Software. This element includes all resources associated with bus flight software functions. Reference Appendix B for software definitions.

The following CSCIs should be used when applicable (lower levels of these CSCIs may be used if more appropriate): operating system and/or boot code, command and data handling; database; health maintenance and status; telemetry, tracking and control; attitude control; electrical power management; and thermal control.

The Bus Flight Application Software should be more than a single CSCI.

Excludes, for example:

a. ASIC and FPGA design, coding, and testing. These are included in the WBS elements containing the hardware in which ASICs and FPGAs are contained.
b. Software development integral to each bus hardware unit (Level 5 items)

NOTE 1: Flight software that is not segregable between the bus and payload is included within this WBS. Otherwise, software for performing payload processing is included in the payload flight software WBS element. Payload TT&C software CSCIs that run on the bus processor are included in the bus flight software WBS element. Space framework software is also included here.

NOTE 2: For lower level Common elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.2 Payload 1...n (Specify). Payloads are the sets of hardware and software on a space vehicle that perform mission functions. Examples of space system mission functions are communications, remote sensing, surveillance and scientific exploration. A space vehicle may have multiple payloads. All elements and components that are shared between distinct payloads can either be included within the first payload or a separate unique payload can be created for the shared units. A typical space vehicle configuration includes a communication subsystem and optionally a complement of one or more sensing, surveillance, additional communication or exploration payloads. On a communication satellite each service or band should be considered a payload. A space vehicle with a space to ground link, a crosslink, and a phased array system should have three distinct payloads. Common items between them could be included in one of them or a fourth payload can be used to house the common hardware, software, and/or SEIT/PM. For example, a weather satellite that includes an imager, instrument B, instrument C, and two communication services should have five distinct payloads.

Includes, for example:

a. All of the resources associated with the design, development, production, integration, assembly, and test to include verification testing of the payload WBS equipment
b. Payload subsystems: structures and mechanisms, thermal control, electrical power, pointing command and control interface, antenna, signal electronics, optical assembly, prime mission sensor, and payload flight software
c. Hardware components shared with the TT&C, such as antennas and RF electronics, that are primarily used for mission objectives (see a. below)
d. Command and Telemetry/Interface Units that are integral to the payload suite (see b. below)

Excludes, for example:

a. Hardware components that are devoted primarily to TT&C functions (except the command and

telemetry interfaces described in c. above)

b. Command and telemetry/interface units that interface with payload equipment are included in the bus TT&C subsystem unless they are integral to the payload suite

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.2.1 Structures and Mechanisms. This subsystem is a summing element for payload structures and mechanisms. It includes structure, mechanisms, and pyrotechnics devoted to payload functions (see bus structures and mechanisms for further definition).

NOTE 1: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.2.1.1 Structures. This collection of items provides structural support for all payload equipment, components, and assemblies.

Includes, for example:

a. Structural support components
b. Booms (excluding antenna booms)
c. Frames, optical benches (that support the whole payload)
d. Equipment compartments or pallets that house payload components and are integral to the payload equipment
e. Optical benches may also be present within the optical assembly and aft optics elements

F.4.2.2.1.2 Mechanisms and Pyrotechnics. These elements are hardware end items, which stow, deploy, lock, or support payload components (excluding gimbals or positioners). This element also includes items that provide reaction force to initiate release for separation or deployment specific to the payload. These elements are specific to the payload. Excludes, for example: payload gimbals and positioners.

For a general definition, see mechanisms and pyrotechnics within the bus structures and mechanisms subsystem.

F.4.2.2.1.3 Structures and Mechanisms Other. This element contains all the resources associated with unique payload structures and mechanisms subsystem hardware items not included in elements above.

F.4.2.2.2 Thermal Control. This element uses payload-specific thermal control equipment to maintain payload component temperatures. Includes, for example: active and passive components such as cryogenic devices, liquid loops, electric coolers, multi-layer thermal insulation blankets (MLI), surface coatings (thermal paint), mirrors, thermal tape, heat pipes and sinks, insulation, conductive structures, louvers, sun shields, heaters, thermistors, thermostats, shutters, thermal conducting elements, radiator panels/fins.

NOTE 1: In cases where payload thermal control is an integral portion of bus thermal control, the payload thermal control equipment is included in the bus thermal control subsystem.

NOTE 2: When a payload component or unit has integral (non-removable) thermal control provisions such as heat sinks, thermisters, or heaters then that item should be included within that component or unit.

NOTE 3: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.2.2.1 Cryogenic Devices. This collection of items facilitates the control of operating temperatures of

payload components by obtaining or operating at cryogenic temperatures. Includes, for example: cryo-coolers and cryostats.

F.4.2.2.2.2 Liquid Loops. This collection of items composes a heat transfer system that helps control temperatures within payload components. This system is usually comprised of fluid (gas or liquid) conduits (tubing), heat exchangers, and pumps.

F.4.2.2.2.3 Electric Coolers. This collection of items electrically reduces operating temperatures of payload components. Includes, for example: Peltier devices, Peltier diodes, Peltier heat pumps, solid state refrigerators, thermoelectric coolers (TECs), and electronics for controlling the coolers.

F.4.2.2.2.4 Electric Heaters, Thermisters and Thermostats. This collection of items actively controls payload heat loss by generating heat and controlling and monitoring temperatures. Thermisters and thermostats are equivalent terms. Heater switching is included within the payload electrical power or the bus electrical power subsystems.

F.4.2.2.2.5 Passive Devices. This collection of items passively maintains the temperatures of all payload components. Examples include radiator panels/fins, coatings, heat pipes, insulation, conductive structures, and louvers.

F.4.2.2.2.6 Sun Shields. These elements, which are deployable, minimize thermal (and other energy) fluctuations by shielding the payload from the sun. Additionally, sunshields can be employed to compensate for solar disturbances to pitch and yaw (solar torque balancing). Low-cost (passive) payload sun shields may be included within passive devices.

F.4.2.2.2.7 Thermal Control Other. This element contains all the resources associated with unique payload thermal control subsystem hardware items not included in elements above.

F.4.2.2.3 Electrical Power. This element generates, converts, regulates, stores, and distributes electrical energy to the payload. Included in the payload electrical power subsystem are power supplies, power control switching and distribution, power conversion, and harnesses and cables. It excludes electrical power supply equipment in the bus.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.2.3.1 Power Sources. This collection of items generates and sometimes stores the electrical power for payload elements requiring a power alternative to the power generated in the bus electrical power subsystem. Includes, for example, solar arrays, batteries, and capacitors.

F.4.2.2.3.2 Power Control, Switching, and Distribution Electronics. This element is a collection of electronics specific to the payload that provides electrical power to payload components. Includes, for example: payload power control, switching and distribution electronics, payload junction boxes, payload pyrotechnics initiation electronics, payload heater switching electronics, payload battery switching electronics.

F.4.2.2.3.3 Power Conditioning, Conversion, and Regulation. These elements condition, convert, and regulate power throughout the payload. Includes, for example: inverters, converters, power supplies, and regulators.

F.4.2.2.3.4 Harnesses and Cables. This collection of items is used to route and provide electrical power and signals throughout the payload. For a general definition, see harnesses and cables within the bus electrical power subsystem.

F.4.2.2.3.5 Electrical Power Other. This element contains all the resources associated with unique payload electrical power subsystem hardware items not included in WBS elements above.

F.4.2.2.4 Pointing, Command, and Control Interface System. This element determines and controls payload positions and pointing orientations, independent of the space vehicle. This subsystem also provides processing primarily

associated with payload. It is also the primary electronic interface between the payload and the spacecraft bus and/or other payloads. It may also send control signals to other payload equipment. Includes, for example: computers and processors, command and telemetry electronics, control electronics, pointing sensors, payload positioners, and data handling/switching. Excludes, for example: positioners dedicated to payload antennas, and sensors.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.2.4.1 Computers and Processors 1...n (Specify). These elements process payload data according to a list of computer software instructions (see payload flight software) for the payload subsystems. This excludes payload functions handled by bus processors. This includes, for example, central processing units (CPUs) or onboard computers (OBCs). Computer and processor memory may also be included within this WBS element.

F.4.2.2.4.2 Command/Telemetry Elements 1...n (Specify). These elements (digital) provide the engineering definitions used to configure and determine the health and status of the payload. For a general definition, see command/telemetry units within the bus telemetry, tracking, and command subsystem.

F.4.2.2.4.3 Control Electronics 1...n (Specify). These elements provide electrical interfaces between the payload and/or bus processor(s)/sensors and payload effectors. For a general definition, see control electronics within the bus attitude control subsystem.

F.4.2.2.4.4 Pointing Sensors 1...n (Specify). These elements provide directional information for payloads. Includes star trackers and sun sensors, inertial reference units and other sensors dedicated to payload pointing/positioning. For a general definition, see corresponding sensors within the bus attitude control subsystem.

F.4.2.2.4.5 Payload Positioners 1...n (Specify). These elements position, point and/or move the entire payload. This excludes those positioning elements dedicated to payload antennas, and sensors, which are included within the corresponding WBS elements below.

F.4.2.2.4.6 Security, Encryption and Decryption Devices 1...n (Specify). These elements encrypt and/or decrypt payload data. For a general definition, see communications security (COMSEC/encryption and decryption devices) within the bus telemetry, tracking, and command subsystem.

F.4.2.2.4.7 Data Storage, Handling and Interface 1...n (Specify). These elements carry, process, and/or store housekeeping, telemetry, and mission data and may interface with payload units. Includes, for example: interface units, data handling units, solid state recorders (SSRs), telemetry storage units (TSUs), tape recorders and disk recorders, compression, and other interface functions. Excludes, for example: data storage units used primarily for storing bus data.

F.4.2.2.4.8 Multifunctional Digital Electronic Boxes 1...n (Specify). These elements are unique digital electronic devices that may combine multiple functions identified above and therefore do not fit into a single element above and are specific to the payload. These units may also include functions from other subsystems such as multifunctional signal electronic boxes (therefore these units can include analog/RF devices also). These units are likely to contain ASICs, FPGA, or processors and may also run software. Includes, for example: digital signal processors, A/D and D/A converters, digital channelizers, digital modems, routers, and remote access servers.

F.4.2.2.4.9 Pointing, Command, and Control Interface System Other. This WBS element contains all the resources associated with unique pointing, command, and control interface subsystem hardware items not included in elements above.

F.4.2.2.5 Payload Antenna 1...n (Specify). These units transmit and/or receive RF signals. These antennas are primarily used for mission data and may also carry TT&C data. It includes structure and mechanisms, feeds, reflectors, positioners, wiring and waveguides and, for phased array antennas, transmit/receive modules.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.2.5.1 Structures and Mechanisms. This element is a collection of items that provides structural support for antenna equipment and components. Includes: for example: antenna structural support components, booms, locks, small equipment compartments or pallets that house antenna electronics and are integral to the payload antenna.

F.4.2.2.5.2 Antenna Positioners. These elements typically point entire antennas in a desired direction. Alternatively, antenna positioners might move a reflector or feed to point the antenna beam in the desired direction.

Includes, for example:

a. Positioner mechanism and its control electronics if integral with the mechanism
b. Control electronics in separate enclosures are included in payload control electronics above

F.4.2.2.5.3 Reflector/Horn 1...n (Specify). These elements focus received and/or transmitted electromagnetic waves (signals). The most common reflectors are parabolic reflectors, which focus a received signal into one point or direct a transmitted signal into a beam; flat reflectors that reflect the signal like a mirror and are often used as passive repeaters; and corner reflectors that reflect the incoming signal back in the direction it came from. A horn is an open-ended waveguide of increasing cross-sectional area, which feeds to a reflector that forms a beam, or alternatively radiates directly (without a reflector). Includes, for example: both primary and sub-reflectors.

F.4.2.2.5.4 Feed 1...n (Specify). These elements receive and/or transmit signals. Functionally, they are usually located between a reflector and an amplifier, such as a high-power amplifier (HPA), used for transmitting signals, or a low noise amplifier (LNA), used for receiving signals. A feed typically consists of a horn, spiral element or a set of dipoles and RF components (if they are not separable from the feed itself), such as orthomode transducers, polarizers, frequency diplexers, and waveguide or coaxial cable connections. This element also includes complete antennas. Includes, for example: horn, spiral, patch, dipole and helix, and any antenna that cannot be separated into components.

F.4.2.2.5.5 Waveguide/Coax/Cabling. This element is a collection of items that route transmitted signals to the antenna feed or feed electronics. It also routes received signals to the first stage receiving electronics. Other signals and power routing, such as for antenna positioners, are also included in this element.

F.4.2.2.5.6 Transmit/Receive Modules. These elements provide power amplification of input signals for transmission, low noise amplification of received signals, both coupled to and received from the module's radiating elements, phase shifting in the transmit and receive mode for beam steering, and variable gain setting for aperture weighting during reception. Phased array antennas are typically made up of arrays of transmit/receive modules, coupled to a common signal source or load, to produce a directional radiation pattern. In some cases, transmit/receive modules are fully integrated assemblies in the form of tiles that can be laid side-by-side on support structures.

F.4.2.2.5.7 Antenna Other. This element contains all the resources associated with a unique payload subsystem hardware not included in WBS elements above.

F.4.2.2.6 Payload Signal Electronics. This subsystem is a summing element for a wide range of payload RF and analog signal processing electronics and RF plumbing. Includes, for example: passive signal flow control, transmitters, receivers, transceivers, modulators, demodulators, multiplexers, demultiplexers, power amplifiers, frequency converters, frequency and timing units, signal conditioners.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.2.6.1 Passive Signal Flow Control. This element is a collection of items including a wide range of RF and other analog signal processing electronics and RF plumbing within the payload. Includes, for example: multicouplers,

coaxial switches, RF switches, filters, waveguides (excluding those in antenna), payload internal harnesses and cables, and other similar low-value items.

F.4.2.2.6.2 Transmitter/Receiver/Transceiver/Transponder 1...n (Specify). These elements are electronic devices that send and/or receive signals to and/or from antennas and separate them into useful analog or digital signals. These elements are specific to the payload. For a general definition, see transmitters/receivers/transceivers within the bus telemetry, tracking, and command subsystem.

F.4.2.2.6.3 Modulators/Demodulators/Modems 1...n (Specify). These elements include modulators, demodulators, and modems that are specific to the payload. For a general definition, see TT&C modulators and demodulators in the bus telemetry, tracking, and command subsystem.

F.4.2.2.6.4 Multiplexers/Demultiplexers. These elements allow efficient transmission and subsequent reception of multiple signals via a single signal. A multiplexer combines several input signals into one output signal containing several communication channels. A demultiplexer separates a single input signal that carries many channels into multiple output signals. Includes, for example: only RF and analog multiplexers and demultiplexers. Excludes, for example: digital multiplexers/demultiplexers that are located in data storage handling and interface.

F.4.2.2.6.5 Amplifiers 1...n (Specify). These elements are devices that change/increase the amplitude of payload signals. This element includes amplifiers that are specific to the payload. For a general definition, see TT&C amplifiers in the bus telemetry, tracking, and command subsystem.

F.4.2.2.6.6 Frequency Upconverter/Downconverter 1...n (Specify). These elements receive radio signals of one frequency and output at a different frequency. These elements are specific to the payload. For a general definition, see frequency upconverters/downconverters within the bus telemetry, tracking, and command subsystem.

F.4.2.2.6.7 Frequency and Timing 1...n (Specify). These elements provide stable timing and frequency reference signals (RF and digital) to the other payload electronics units. Includes, for example frequency generators, oscillators, timing units.

F.4.2.2.6.8 Signal Conditioners 1...n (Specify). These elements alter (e.g., filter, eliminate noise, compress, amplify) analog signals to meet the requirements of the next processing stage. These elements are specific to the payload. Excludes power amplifiers. For a general definition, see signal conditioners within the bus telemetry, tracking, and command subsystem.

F.4.2.2.6.9 Multifunctional Signal Electronic Boxes 1...n (Specify). These elements are unique analog electronic devices, which may combine multiple functions identified above and therefore do not fit into a single element above and are specific to the payload. Excludes, for example: units that contain digital electronics (see F.4.2.2.4.8 Multifunctional Digital Electronic Boxes).

F.4.2.2.6.10 Signal Electronics Other. This element contains all the resources associated with unique payload signal electronics hardware items not included in WBS elements above.

F.4.2.2.7 Optical Assembly. Optical assemblies (e.g., telescopes) have optical elements that collect and focus optical energy or create optical waveforms for transmission. They are often used to place images or optical patterns on focal plane sensors for detection, or for transmitting optical communication signals as in laser communications terminals. Includes, for example: optical assembly structure and mechanisms, thermal control provisions, fore optics, aft optics, alignment sensors, and calibration equipment.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.2.7.1 Structure/Outerbarrel/Cover. This equipment supports and stabilizes optical elements, sensors and other optical assembly equipment.

Includes, for example:

a. Enclosing structure (including tubes/outer barrel, tube doors, and associated integration, mounting, and interface hardware)
b. Load-bearing structure (includes equipment compartment, equipment shelf, support tubes, mounts, struts, and associated integration, mounting, and interface hardware and secondary hardware if not separable)
c. Secondary structure (including baffles), and integration, mounting, and interface hardware)
d. Door actuators (includes control electronics if costs not separable); optical bench (supporting entire optical assembly)
e. Optical-assembly specific thermal control elements (including thermostats, thermistors, thermal control electronics, heaters, insulation, and paints) when not separable from structure
f. Other structures and mechanisms

Excludes, for example:

a. Sun shields (which are in payload thermal control) if separable

F.4.2.2.7.2 Mirrors/Optics 1...n (Specify). These elements are principal light-gathering surfaces of a reflective (using mirrors) and refractive (using lenses) telescopes and related instruments. Primary mirrors can be monolithic blocks of glass or other material, curved to exact shapes and coated with a reflective layer; or constructed from small segments of mirrors, merged (by physical contact or later by optics) into one large primary mirror. Primary optics (also called objective) refers to the lens in a refractive telescope, camera or other optical instrument that receives the first light rays from the object being observed. A secondary mirror (or secondary) is a second light gathering and focusing surface in a reflector telescope. Light gathered by the primary mirror is directed towards a focal point typically past the location of the secondary. The secondary directs the light either out a side opening of the tube (Newtonian reflector) or back towards a focal point behind and through the primary mirror/optics. Tertiary optics are used to change the focal point to a convenient viewing angle or location. This element includes primary, secondary, and tertiary mirror assemblies (assembly may include associated mounts, mount pads, and other frames).

F.4.2.2.7.3 Aft Optics Assembly. This element is a collection of items that provide additional focusing and manipulation of radiation from the tertiary optics before it enters the collection sensor. Optical splitters, prisms, filters and relay mirrors are typical aft optical elements. Optical benches supporting the aft optics and collection sensor are made of very thermally stable materials such as Invar or graphite epoxy composites. This optical bench is integral to the aft optics.

Excludes, for example:

a. Collection sensors that are contained in payload sensors.

F.4.2.2.7.4 Alignment and Calibration 1…n (Specify). This element is a collection of items that compensate for the effects of launch shock and vibration, temperature changes, release of gravitational stress, age-related distortion and other changes to the optical assembly equipment alignment. These elements are specifically designed for and dedicated to the optics assembly. Includes, for example: alignment positioners, actuators, sensors, internal electronics, internal cables, calibration light sources, optics dedicated to calibration, lasers used for alignment.

F.4.2.2.7.5 Thermal 1...n (Specify). This element contains all the resources associated with the design, development, coding, production, procurement, assembly, integration, verification, and test of the optics thermal control. Thermal control maintains the temperatures of the optics within acceptable limits during ground test, launch and on orbit operations.

F.4.2.2.7.6 Control Electronics 1...n (Specify). Electronics that interface with mechanisms, heaters, telemetry diagnostics, and alignment sensors/calibration, providing power conditioning to the telescope, command interface, heater power control, focus actuator control, alignment drive actuator control, and thermal monitoring collection.

F.4.2.2.7.7 Optical Assembly Other. This element contains all the resources associated with unique optical payload assembly hardware items not included in WBS elements above.

F.4.2.2.8 Sensor. Payload sensors collect photonic, electromagnetic, and other energy and convert it into

electrical signals. The most common sensors detect light in various spectrums (such as ultra-violet, visible, infrared, x-ray). Mission sensors may include enclosures, focal planes, electronics, positioners, calibration equipment, and other sensors. Thermal control and optics equipment are also included if they are integral to the sensor (i.e., not separable).

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.2.8.1 Enclosure 1...n (Specify). These elements are a collection of items that are cabinets or housings to protect the critical elements of the sensor equipment from the environment. Enclosures protect against mechanical loads and vibration, stabilize sensor temperatures, provide electromagnetic interference (EMI) and RF interference (RFI) shielding for electronic components and prevent contamination. Focal planes and optics are typically protected by enclosures. Excludes, for example: enclosures that are integral to the sensors.

F.4.2.2.8.2 Focal Plane Array 1...n (Specify). Focal planes convert photonic radiation (visible, IR, etc.) into electronic pixels representing the image projected on a plane. Focal planes have image-sensing detectors arranged in arrays (typically rectangular) on sensor chip assemblies (SCAs). One or more SCAs comprise the total focal plane complement of detectors. A focal plane assembly includes SCAs, support structure, optical filters, wiring, and thermal control devices such as cold fingers and thermal enclosures.

F.4.2.2.8.3 Sensor Positioners 1...n (Specify). These elements position, point and/or move the sensor. This excludes those positioning elements dedicated to complete payloads, antennas, and optical assemblies.

F.4.2.2.8.4 Sensor Electronics 1...n (Specify). These elements perform front-end signal conditioning/processing, signal analog-to-digital conversion, digital-to-analog conversion, focal plane excitation, command execution, telemetry feed-back, and other related electrical power, analog and digital functions. This element only includes electronics that are segregable from the sensor.

F.4.2.2.8.5 Alignment and Calibration 1...n (Specify). These elements are a collection of items that compensate sensors for the effects of launch shock and vibration, temperature change, release of gravitational stress, age-related and other changes to sensor equipment alignment. This alignment function may be accomplished with the use of an alignment sensor and positioners. Includes, for example: black bodies, light sources, RASNIKS, lamps.

F.4.2.2.8.6 Magnetometer 1...n (Specify). These elements measure the magnitude and/or direction of the Earth's magnetic field. Excludes magnetometers used on the bus for attitude control.

F.4.2.2.8.7 Spectrometer 1...n (Specify). These elements measure properties of light over a specific portion of the electromagnetic spectrum. They are typically used in spectroscopic analysis to identify materials. They usually separate the light signals into different frequencies, producing a dispersive or non-dispersive spectrum. A dispersive spectrometer is like a prism: it scatters light of different energies to different locations. A non-dispersive spectrometer measures the energy directly.

F.4.2.2.8.8 Radiometer 1...n (Specify). These elements detect and measure the intensity of radiation. Radiometers can also be applied to detectors operating any wavelength in the electromagnetic spectrum. Radiometers can measure radiation from clouds, snow, ice, bodies of water, the Earth's surface and the sun.

F.4.2.2.8.9 Camera 1...n (Specify). These elements usually employ a sensor charge coupled device (CCD) or composite metal oxide semiconductor (CMOS) charge injection device (CID) focal planes to record images. Excludes, for example: complex imaging payloads that are segregable into their major components (optical assembly, sensor, structure, etc.)

F.4.2.2.8.10 Sounder 1...n (Specify). These elements measure the vertical distribution of physical properties of the atmosphere such as pressure, temperature, wind speed, and direction (thus deriving wind shear), liquid water content, ozone concentration, and pollution. Remote sensing soundings generally use passive infrared and microwave radiometers, but some actively transmit a signal and use the returned signal to measure characteristics of the atmosphere.

F.4.2.2.8.11 Other Sensor Types 1...n (Specify). These elements are other types of sensors not above.

F.4.2.2.8.12 Mission Sensor Other. This element contains all the resources associated with unique prime mission sensor subsystem hardware items not included in elements above.

F.4.2.2.9 Payload Flight Software. This element includes all resources associated with payload flight software functions. Reference Appendix B for software definitions.

The payload flight software is segregated into logical products (CSCIs). The following CSCIs should be used when applicable (lower levels of these CSCIs may be used if more appropriate): operating system and/or boot code, payload management, thermal control, payload processing, alignment, calibration, and payload control.

Excludes, for example:
a. ASIC and FPGA design, coding, and testing. These are included in the WBS elements containing the hardware in which ASICs and FPGAs are contained.
b. Software development integral to each payload hardware element (Level 5 items)

NOTE 1: Flight software for performing payload processing is included here. Flight software that cannot be separated between the bus and the payload equipment is included within the bus flight software WBS element. Payload TT&C software CSCIs that run on the bus processor is included in the bus flight software WBS element.

NOTE 2: For lower level software information, use the structure and definitions in Appendix B, Electronic/Generic Systems.

NOTE 3: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.2.2.10 Payload Other. This element contains all the resources associated with unique payload system hardware or software items not included in WBS elements above and not applicable within the provided payload subsystems.

F.4.2.3 Booster Adapter. The booster adapter provides the mechanical and electrical interface between the launch vehicle's uppermost stage and the space vehicle. It can be as simple as a snap ring device, but it is usually a more complex shell or frame structural assembly. This element is also called a payload adapter or payload attach fitting.

Includes, for example:
a. All of the material and effort associated with the design, development, production, integration, assembly, and test of the booster adapter
b. Adapter structures, attachment and release devices, thermal control, instrumentation, and umbilical provisions
c. Adapters located between space vehicles on a multi-vehicle launch that are segregable

Excludes, for example:
a. Booster adapters integral to bus structure
b. Adapters included as part of the launch vehicle

F.4.2.4 Space Vehicle Storage. This element contains activities associated with storing space vehicles or portions of space vehicles. This includes preparation for storage, recovery from storage and post storage testing. The costs of holding portions of the space vehicle while waiting for the use of test facilities and/or equipment, or the completion of other portions of the space vehicle are also included. The storage period typically starts when production testing is complete and continues until the space vehicle is ready for shipping to the launch site.

Includes, for example:

a. Planning, preparation, movement, storage, maintenance, removal, refurbishment, and retesting of the space vehicle and/or its subsystems
b. Costs for storage facility use and environmental control equipment
c. Reinstallation of previously installed and tested components
d. Shipping between storage and refurbishment sites, including any required shipping container/packing material (if the same shipping container is used during launch operations then the container falls within the F.4.2.6 launch operations element)

Excludes, for example:
a. Final space vehicle assembly and test activities of previously unassembled and/or untested portions of the space vehicle
b. Shipping to the launch site

F.4.2.5 Launch Systems Integration (LSI). LSI effort is primarily the engineering studies and analyses required to integrate a space vehicle with its launch vehicle and orbital transfer vehicle, and insure the space vehicle is placed into orbit, as required. LSI effort is a coordinated activity between the space vehicle developer and the launch vehicle provider. The effort within this element is performed by space vehicle developer with support from the launch vehicle provider. The launch vehicle element also contains an associated LSI element.

Includes, for example:
a. Space vehicle contractor studies, analysis, and tests supporting the integration of the space vehicle with the launch vehicle
b. Review, verification, and validation of launch vehicle capability and compatibility with the space vehicle
c. Definition, allocation, and decomposition of requirements to be placed on the space vehicle and launch vehicle, and the review, verification, and validation of these requirements
d. Development and analyses of interface control documents with the launch vehicle to the space vehicle or ground segment
e. Launch and range safety compliance, environmental test plans, and mission analysis
f. Space vehicle contractor inputs to the launch vehicle provider to support the launch vehicle provider launch system integration activities
g. Trajectory analyses, coupled dynamic loads analyses, induced environments analyses (acoustic, shock, vibration, thermal loads)

Excludes, for example:
a. Booster adapters that are in the booster adapter WBS
b. Physical integration of the launch vehicle with the space vehicle
c. Integration activities performed by the launch vehicle provider, which are included in the launch vehicle portion of the WBS

NOTE: The complete suite of launch systems integration activities normally occurs only once with each launch vehicle type, but a smaller subset of these activities is repeated for each launch, primarily for launch vehicle trajectory and performance analyses. Other launch systems integration activities may be repeated for subsequent launches due to mission changes that could impact the launch vehicle, booster adapter, orbital transfer vehicle, or launch site facilities.

F.4.2.6 Launch Operations. Launch operations are those efforts performed by the provider(s) of the space vehicle and payload(s) to prepare for and support space vehicle launches, primarily at the launch base and, to a lesser degree, the space vehicle factory.

Includes, for example:
a. Satellite contractor effort associated with pre-launch planning and preparation to include: training; trailblazers; pathfinders; and documentation
b. Preparation of the space vehicle for shipment to the launch site
c. Shipping of the space vehicle to the launch site, including any required shipping

container/packing material
d. Payload (space vehicle) processing facility services
e. Final assembly, test and checkout, fueling of the space vehicle at the launch site
f. Setup of support equipment
g. Mating the space vehicle to the launch vehicle
h. Engineering and maintenance support of the space vehicle at the launch site
i. Pack-up and shipment of any support equipment back from the launch site
j. Final reports

Excludes, for example:
a. Launch systems integration that is contained in its own Level 3 element

F.4.2.7 Mission Operations Support. This element encompasses the resources required for the deployment and operations of the space vehicle to achieve initial operational capability (IOC).

Includes, for example:
a. Telemetry (health and status) monitoring during launch, and separation;
b. Planning, commanding, monitoring, and reporting for orbital maneuvers, deployment, calibration, on-orbit engineering tests (as required), and initial operations;
c. Preparation, planning, and coordination of the hand-over to the long-term mission operations team, which includes: orbit maneuvering deployment, initial calibration, on-orbit testing, monitoring of space vehicle health and status, fault detection, anomaly investigation and resolution, and transition activity for long-term mission operations team

NOTE: The mission operations support period typically begins pre-launch and ends when the space vehicle achieves initial operational capability.

F.4.2.8 Space Vehicle Other. This element contains all the resources associated with the space vehicle not included in elements above.

F.4.3 Ground Segment. This element is the summing collector for most all of a space system's terrestrially operated hardware and software (and related efforts) that command the space vehicle, process and disseminate bus and payload data, and provide (transmit/receive) end-user functionality. The constituent components of a ground segment are:
a. Ground Functions - mission operations and processing effort)
b. Ground Terminal/Gateway (GT) - communications hardware and software)
c. External Network (T-COMM) - leased and/or purchased circuits (communication lines)
d. User Equipment - satellite phones, field terminals, hand-held receivers, etc.
e. Facilities - land and buildings housing ground equipment/software
f. Vehicles and Shelters - transportable ground processing and communication
g. Associated SEIT/PM

Primarily a ground segment provides one or more functions such as: command and control (CC), mission management (MM), mission data processing, mission data analysis, engineering development network, collection management, and infrastructure and framework (I&F). Each of these functions may be performed at single or multiple sites.

The ground segment includes, for example:
a. All of the resources associated with design, development, production, procurement, integration, assembly, and test of ground segment hardware and software
b. Commercial off-the-shelf (COTS) hardware
c. Custom hardware
d. Software (custom and COTS)
e. Ground segment buildings and other facilities

F.4.3.1 Ground Functions 1...n (Specify). This element provides for a functional breakout of the ground

segment. The appropriate functional structure should be used. Functions may be combined or modified based on architecture and include their own storage and archival equipment and software. Common acquisition of equipment (e.g., workstations) across functions can be collected within the infrastructure and framework (I&F) function. The I&F function can collect all the resources for that equipment/commodity, which reduces the need for allocations. The I&F function also includes any hardware or software that interfaces between multiple functions.

Includes, for example:

a. Mission Management (MM) - The mission (payload data) management function receives tasking, generates and provides the system and mission plans, schedules, and timelines for the space vehicle(s) and ground segment elements.
b. Command and Control (CC) - The command and control function decodes, demultiplexes, and decrypts space vehicle telemetry, generates and encrypts commands for transmission to the spacecraft, and processes tracking data to generate space vehicle ephemeris. This function provides the capability to prepare and output commands to, receive and process telemetry from the space vehicle, tracking, and other non-mission data. This function includes CC for the bus and may also include CC for the payload if not included in the mission data processing function.
c. Mission Data Processing - The mission data processing function decodes, demultiplexes, decrypts, and processes mission data from the payload(s) and may generate commands for payload control if not included in CC function. Further data processing may take place external to this ground segment function such as: a second ground segment function site, a national processing center, and/or on end-user equipment.
d. Mission Data Analysis - The mission data analysis function is responsible for examination of mission data (dissection, investigation, cross-referencing, etc.), from the payload(s) on the space vehicle.
e. Collection Management - The collection management function supports the end user by generating requests for tasking and subsequently tracking the fulfillment of each request. This function may also receive and analyze processed mission data and other external information. It could include the collection of tasking for multiple space systems, which subsequently forwards tasking to the mission management function.
f. Infrastructure and Framework (I&F) - The infrastructure and framework function is responsible for the interchange or transfer of wideband data, narrowband data, command and control, telemetry, and other support data between functions within a site (e.g., between the mission data processing and mission data analysis functions). It also can include hardware and/or software that are common to multiple functions, the engineering development or administrative networks, or required to interface to other ground segment missions (other programs) at the same ground site. This function is also responsible for encryption and external transmission of data from the ground segment.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.1.1 <u>COTS Hardware 1...n (Specify).</u> This subsystem covers all commercial off-the-shelf (COTS) hardware items required to implement the intended function(s) of the ground segment. Multiple instances of this element may be used to collect logical groupings of hardware by function or environment. Each occurrence/use of the COTS Hardware element should be assigned a name (title) and definition that clearly indicate the common characteristic(s) of the underlying equipment each contains. The following environments are suggested:

a. Development – hardware items facilitating development of operational hardware/software
b. Test – hardware items required for testing towards operational hardware/software
c. Operational – end-user operational hardware

Note that each lower-level element defined below for COTS hardware might constitute its purchase, rent/lease, or the purchase of online or cloud services that provide the equivalent function (e.g. storage, processing, interfacing, etc.)

F.4.3.1.1.1 <u>Workstations 1...n (Specify).</u> These elements are computers often optimized for displaying and manipulating complex data such as engineering simulation, animation, image rendering, and mathematical plots. For

further definition, see workstations within the ground terminal monitor and control hardware subsystem.

F.4.3.1.1.2 Servers 1...n (Specify). These elements are computers dedicated to providing one or more services over a computer network. For further definition, see servers within the ground terminal monitor and control hardware subsystem. This WBS element includes, for example, super-computers, mainframes, and mini-computers.

F.4.3.1.1.3 Storage and Archive 1...n (Specify). These elements store housekeeping, telemetry, and mission data for processing and dissemination by other ground segment function equipment. Includes, for example: magnetic tape, magnetic disks, optical disks, high density digital recorders (HDDR), longitudinal recorders, helical recorders (video-cassette tapes), direct archiving, reconfigurable frame recorders (RFR), redundant array of independent discs (RAID), network-attached storage (NAS), storage area network (SAN), tape/optical library or jukeboxes, RAM disks (solid state memory). Excludes, for example: storage devices integral to workstation elements.

F.4.3.1.1.4 Network Equipment. This element is a collection of items that facilitate the use of a computer network. Includes, for example: routers, switches, hubs, gateways, access points, network interface cards, network bridges, modems, ISDN adapters, firewalls and other related hardware.

F.4.3.1.1.5 Interface Equipment. These elements enable the recovery or creation of digital data from other formats (e.g., RF to digital, serial to parallel, fiber optic to RJ11) or to convert digital information into other formats for interfacing with other ground equipment. Excludes, for example: network equipment (including modems).

F.4.3.1.1.6 Security Encryption/Decryption 1...n (Specify). These elements encrypt and/or decrypt data. For a general definition, see communications security (COMSEC/encryption and decryption devices) within the bus telemetry, tracking, and command subsystem.

F.4.3.1.1.7 Data Processing 1...n (Specify). These elements are COTS equipment that perform specialized data processing functions; typically using ASIC or FPGA technologies. Note that the resources required to develop and produce custom ASICs or to program an included FPGA is under custom hardware, below. Excludes, for example: workstations and servers that perform data processing functions.

F.4.3.1.1.8 COTS Hardware Other. These elements contain all the resources associated with unique COTS subsystem hardware not included in elements above.

F.4.3.1.1.9 Pre-Operations Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (pre-ops) maintenance of COTS hardware subsystem equipment. This function begins with the acceptance of the COTS hardware and ends with the start of operations.

F.4.3.1.1.10 Environments 1...n (Specify). This WBS element contains logically grouped collections of COTS hardware end items (may include COTS software that is not separable from COTS hardware in the costs). Utilize the 1...n nomenclature to group the COTS hardware by environment. For example: development environment, test environment, backup operations, operations, etc.

F.4.3.1.2 Custom Hardware 1...n (Specify). This element covers all custom (non-COTS) hardware items required to implement the intended function. This WBS element contains all the resources associated with the design, development, production, procurement, assembly, and test of custom equipment. Includes the resources required to develop and produce custom ASICs or to program FPGAs (including those inserted into COTS hardware). Multiple instances of this element may be used to collect logical groupings of hardware by function or environment. Each occurrence/use of the custom hardware element should be assigned a name (title) and definition that clearly indicate the common characteristic(s) of the underlying equipment each contains. The following environments are suggested:

a. Development – hardware items facilitating development of operational hardware/software
b. Test – hardware items required for testing towards operational hardware/software
c. Operational – end-user operational hardware

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.1.3.1 Custom Hardware Configured Item 1...n (Specify). These elements are custom hardware devices that perform unique or specific functions.

F.4.3.1.3.2 Pre-Operations Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (pre-ops) maintenance of custom hardware subsystem equipment. This function begins with the acceptance of the custom hardware and ends with the start of operations.

F.4.3.1.4 Ground Function Software. This element includes all resources associated with a software function as listed in F.4.3.1 Functions. Reference Appendix B for software definitions.

This element includes all resources associated with a software configuration item.

Includes, for example:

a. Pre-operations Maintenance 1...n (Specify) that contains all the resources related to the pre-operations (pre-ops) maintenance of software. This function begins with the acceptance of the software and ends with the start of operations

Excludes, for example:

a. ASIC and FPGA design, coding, and testing. These are included in the WBS elements containing the hardware in which ASICs and FPGAs are contained.
b. Software development integral to each hardware element (Level 5 items)

F.4.3.1.4.1 GF Software CSCI 1...n (Specify). This element is a summing level for all effort for a particular software subsystem, a logical element composed of multiple CSCIs and the associated SEIT/PM and Support Equipment elements which integrate them.

F.4.3.1.4.2 Pre-Operations Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (pre-ops) maintenance of ground function software. This function begins with the acceptance of the ground function software and ends with the start of operations.

NOTE 1: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.1.5 Pre-Operations Mission Support. This element includes all the resources required for the operation of the ground segment function prior to turnover.

Includes, for example:

a. On-orbit testing
b. Routine monitoring of space vehicle equipment health and status
c. Fault detection
d. Anomaly investigation and resolution.

The mission support period typically begins after installation and a specified time prior to launch and ends when the space vehicle achieves initial operational capability.

F.4.3.2 Ground Terminal/Gateway (GT) 1...n (Specify). These elements receive, demodulate, and condition telemetry, tracking, command, and mission (payload) data. In addition, this subsystem generates the radio frequency (RF) uplink, accepts tracking and command signals, and modulates them onto the RF uplink.

Includes, for example:

a. Resources associated with the design, development, production, procurement, assembly, test, and site activation of the Ground Terminal (GT)
b. Antenna
c. RF electronics
d. Timing subsystem equipment
e. Baseband/network equipment
f. Monitor and control hardware
g. Ground terminal software

Excludes, for example:

a. Ground terminal buildings and other facilities. These are included within facilities above.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.2.1 Antenna 1...n (Specify). These elements transmit and/or receive RF signals that carry TT&C and/or mission data. Includes, for example: pedestals, radomes, other structures, mechanisms, apertures, feeds, waveguides/coax cabling.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.2.1.1 Pedestal. This element is the structure that supports and positions the antenna aperture in both azimuth and elevation. It also may serve as a housing or enclosure for other antenna equipment. Includes, for example: structure, gimbals, support.

F.4.3.2.1.2 Radome. This element protects the antenna from weather hazards (e.g., wind, rain, sand, ultraviolet (UV) light, ice, etc.). The material used in building the radome allows for unattenuated electromagnetic signals. Radomes can be constructed in several shapes (spherical, geodesic, planar, etc.) using various materials (fiberglass, polytetrafluoroethylene (PTFE) coated fabric, etc.).

F.4.3.2.1.3 Other Structure and Mechanisms. This element is a collection of items that include equipment compartments, racks, or pallets that house antenna related electronics, and other structural or mechanical elements not integral to the other antenna equipment. Excludes for example: parts integral to the pedestal (e.g., pointing gimbals).

F.4.3.2.1.4 Aperture. This element determines the aperture (effective area of radiation/energy absorption/generation) of the antenna. This can be as simple as a reflector or a complex phased-array. In most cases a parabolic reflector with an associated feed (see below) is used.

F.4.3.2.1.5 Feed 1...n (Specify). These elements receive and/or transmit signals. Feed refers to the components functionally between a reflector and an amplifier. A feed may consist of a horn, spiral element or a set of dipoles; an orthomode transducer, a polarizer, a frequency diplexer and a waveguide or coaxial cable connection.

F.4.3.2.1.6 Waveguide/Coax/Cabling. This collection of items routes transmitted signals to the antenna feed or feed electronics. It also routes received signals to the first stage receiving electronics. Other signal and power routing, such as to the pedestal, is also included in this element.

F.4.3.2.1.7 Antenna Other. This element contains all the resources associated with unique ground antenna subsystem hardware items not included in elements above.

F.4.3.2.2 Optical Communication Assembly 1...n (Specify). An optical communication assembly (e.g., telescope) has optical elements that collect and focus optical energy or that create optical waveforms for transmission. It is used for transmitting and receiving optical communication signals as in laser communications terminals. Includes, for example: optical assembly structure and mechanisms, thermal control provisions, fore optics, aft optics, alignment sensors, positioners, calibration equipment.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.2.2.1 Structure/Outerbarrel/Cover. This equipment supports and stabilizes optical elements, sensors and other optical assembly equipment.

Includes, for example:

a. Enclosing structure (including tubes/outer barrel, tube doors, and associated integration, mounting, and interface hardware)
b. Load-bearing structure (includes equipment compartment, equipment shelf, support tubes, mounts, struts, and associated integration, mounting, and interface hardware and secondary hardware if not separable)
c. Secondary structure (including baffles, and integration, mounting, and interface hardware)
d. Door actuators (includes control electronics if costs not separable)
e. Optical-assembly specific thermal control elements (including thermostats, thermistors, thermal control electronics, heaters, insulation, and paints)
f. Other structures and mechanisms

F.4.3.2.2.2 Mirrors/Optics 1...n (Specify). These elements are principal light-gathering surfaces of a reflective (using mirrors) and refractive (using lenses) telescopes and related instruments. Primary mirrors can be monolithic blocks of glass or other material, curved to exact shapes and coated with a reflective layer; or constructed from small segments of mirrors, merged (by physical contact or later by optics) into one large primary mirror. Primary optics (also called objective) refers to the lens in a refractive telescope, or other optical instrument that receives the first light rays from the object being observed. A secondary mirror (or secondary) is a second light gathering and focusing surface in a reflector telescope. Light gathered by the primary mirror is directed towards a focal point typically past the location of the secondary. The secondary directs the light either out a side opening of the tube (Newtonian reflector) or back towards a focal point behind and through the primary mirror/optics. Tertiary optics are used to change the focal point to a convenient viewing angle or location. Includes, for example: primary, secondary, tertiary mirror assemblies (assembly may include associated mounts mount pads, and other frame.)

F.4.3.2.2.3 Aft Optics and Bench. This collection of items provides additional focusing and manipulation of radiation from the tertiary optics before it enters the collection sensor. Optical splitters, shutters, prisms, filters and relay mirrors are typical aft optical elements. Optical benches usually support the aft optics and collection sensor and are made of very thermally stable materials such as Invar or graphite epoxy composites. This optical bench is integral to the aft optics.

F.4.3.2.2.4 Alignment Sensors/Calibration. This collection of items compensates for the effects of vibration, temperature changes, age-related distortion and other changes to the optical assembly equipment alignment. These elements are specifically designed for and dedicated to the optics assembly. Includes, for example: alignment positioners, actuators, sensors, integral electronics, internal cables, calibration light sources, optics dedicated to calibration, lasers used for alignment.

F.4.3.2.2.5 Optical Assembly Other. This element contains all the resources associated with unique optical communication assembly hardware items not included in WBS elements above.

F.4.3.2.3 RF Electronics Band 1...n (Specify). These elements are a summing element for a wide range of Ground Terminal RF and analog signal processing electronics and RF plumbing. Includes, for example: passive signal flow control, transmitters, receivers, transceivers, modulators, demodulators, multiplexers, demultiplexers, power

amplifiers, frequency converters, signal conditioners, focal-plan arrays for optical communications.

NOTE 1: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.2.3.1 Passive Signal Flow Control. This collection of items includes a wide range of RF and other analog signal processing electronics and RF plumbing within the ground terminal. Includes, for example: multicouplers, coaxial switches, RF switches, filters, waveguides (excluding those in antenna, ground terminal interconnecting harnesses and cables, other similar low-value items.

F.4.3.2.3.2 Transmitter/Receiver/Transceiver/Transponder 1...n (Specify). These elements are electronic devices that send and/or receive signals to and/or from antennas and separate them into useful analog or digital signals. For a general definition, see transmitters/receivers/transceivers within the bus telemetry, tracking, and command subsystem.

F.4.3.2.3.3 Modulators/Demodulators/Modems 1...n (Specify). Modulators modify the amplitude and phase the frequency of sinusoidal ─carrier signals to include information in the resultant (modulated) output signal. The input signals to modulators are usually digital signal streams. Demodulators perform the inverse of modulators, separating digital information from carrier signals. Modems, which perform both operations, are also included in this element.

F.4.3.2.3.4 Multiplexers/Demultiplexers 1...n (Specify). These elements allow efficient transmission and subsequent reception of multiple signals via a single signal. A multiplexer combines several input signals into one output signal containing several communication channels. A demultiplexer separates a single input signal that carries many channels into multiple output signals. This element includes only RF and analog multiplexers and demultiplexers.

F.4.3.2.3.5 Power Amplifiers 1...n (Specify). These elements are devices that change/increase the amplitude of signals. Includes, for example, solid state power amplifiers (SSPAs), traveling wave tube amplifiers (TWTAs), and low noise amplifiers (LNAs), and optical power amplifiers.

F.4.3.2.3.6 Frequency Upconverter/Downconverter 1...n (Specify). These elements receive radio signals of one frequency and output at a different frequency. For a general definition, see frequency upconverters/downconverters within the bus telemetry, tracking, and command subsystem.

F.4.3.2.3.7 Signal Conditioners 1…n (Specify). These elements alter (e.g., filter, eliminate noise, compress, amplify) analog signals to meet the requirements of the next processing stage. Excludes power amplifiers. For a general definition, see signal conditioners within the bus telemetry, tracking, and command subsystem.

F.4.3.2.3.8 Signal Electronic Boxes 1...n (Specify). These elements are RF electronic devices that may combine multiple functions identified above and therefore do not fit into a single element above.

F.4.3.2.3.9 Focal Plane Array 1...n (Specify). Focal planes convert photonic radiation (visible, IR, etc.) into electronic pixels representing the image projected on a plane. Focal planes have image sensing detectors arranged in arrays (typically rectangular) on sensor chip assemblies (SCAs). One or more SCAs comprise the total focal plane complement of detectors. A focal plane assembly includes SCAs, support structure, optical filters, wiring and thermal control devices such as cold fingers and thermal enclosures.

F.4.3.2.3.10 RF Electronics Other. This element contains all the resources associated with unique ground terminal RF electronics subsystem hardware items not included in WBS elements above.

F.4.3.2.4 Timing. The subsystem generates and distributes accurate and stable timing and frequency references.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.2.4.1 Receiver. This element calculates position by using timing signals sent by the constellation of GPS satellites (or other timing sources).

F.4.3.2.4.2 Antenna 1...n (Specify). These elements receive RF signals for the receiver. Most current systems use GPS (L-band), while in some systems the signals could be WWV (HF-band) or other source.

F.4.3.2.4.3 Frequency and Timing Generators. These elements provide stable timing and frequency reference signals (RF and digital) to the other electronics elements. Includes, for example: frequency generators, oscillators, timing units.

F.4.3.2.4.4 Amplifier and Distribution 1...n (Specify). These elements increase the frequency signal received from the antenna and optionally distributes the frequency to several receivers. Includes, for example: any cabling between antennas and receivers.

F.4.3.2.4.5 Timing Other. This element contains all the resources associated with unique timing subsystem hardware items not included in WBS elements above.

F.4.3.2.5 Baseband-Network. This element receives RF signals from the RF electronics subsystem, converts them into a digital (or baseband signal) format, and subsequently interfaces with the communications element. It also receives digital (or baseband signal) information from the communications element, converts it to the proper RF signal interfacing with the RF electronics.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.2.5.1 Switches/Hubs and Routers. These elements provide junctions for digital equipment and route and forward the information to other electronic equipment.

F.4.3.2.5.2 Network Interface and Other Hardware. These elements interconnect, interface, and can house other baseband-network equipment. These elements may also interface with the network or communications hardware within a ground segment function(s) or the external network. Includes, for example, networking hardware, cables, racks, etc.

F.4.3.2.5.3 Modems. These elements convert digital information into the baseband RF signal or the baseband signal into digital format, depending on the direction of information flow.

F.4.3.2.5.4 Security/Encryption and Decryption Devices 1...n (Specify). These elements encrypt and/or decrypt ground data. For a general definition, see communications security (COMSEC/encryption and decryption devices) within the bus telemetry, tracking, and command subsystem.

F.4.3.2.5.5 Baseband-Network Electronic Boxes 1...n (Specify). These elements are electronic devices that may combine multiple functions identified above and therefore do not fit into a single element above.

F.4.3.2.5.6 Baseband-Network Other. This element contains all the resources associated with unique ground terminal baseband-network subsystem hardware or software items not included in WBS elements above.

F.4.3.2.6 Monitor and Control Hardware. This element configures (e.g., power, antenna position, frequency)

the station for communications to the space vehicle (for a satellite pass) and monitors (usually autonomous) other ground terminal subsystem equipment. In addition, it can provide monitoring, health status, and commanding of the space vehicle as a back-up to ground segment function(s).

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.2.6.1 Workstations 1...n (Specify). These elements are computers often optimized for displaying and manipulating complex data such as engineering simulation, animation, image rendering, and mathematical plots. They can support multiple displays. These elements are intended for use by one person at a time and are commonly connected to each other through a local area network via a server. Includes, for example: workstations, desktop and laptop computers, displays (monitors), keyboards, mice, cables and software bought as part of the workstation.

F.4.3.2.6.2 Servers 1...n (Specify). These elements are computers dedicated to providing processing services over a computer network. These services are furnished by specialized server applications, which are computer programs designed to handle multiple concurrent requests. Includes, for example: application servers

F.4.3.2.6.3 Storage and Archive 1...n (Specify). These elements record and store GT transmissions for buffering or retransmission, and other data assurance requirements. Includes, for example: magnetic tape, magnetic disks, optical disks, high density digital recorders (HDDR), longitudinal recorders, helical recorders (video-cassette tapes), direct archiving, reconfigurable frame recorders (RFR), redundant array of independent discs (RAID), network-attached storage (NAS), storage area network (SAN), tape/optical libraries or juke boxes, RAM disks (solid state memory). Excludes, for example: storage devices integral to workstation elements.

F.4.3.2.6.4 Hardware Configured Item 1...n (Specify). These elements are hardware devices that perform unique or specific ground terminal, monitor and control functions. Excludes, for example: workstations and servers.

F.4.3.2.7 GT Software. This element includes all resources associated with GT software functions.

Excludes, for example:

a. ASIC and FPGA design, coding, and testing. These are included in the WBS elements containing the hardware in which ASICs and FPGAs are contained.
b. Software development integral to each GT hardware unit (Level 5 items)

NOTE 1: For lower level software information, use the structure and definitions in Appendix B, Electronic/Generic Systems.

NOTE 2: For lower level Common Elements (e.g., SEIT/PM), reference Appendix K, section K.4.

F.4.3.2.8 Pre-Operations Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (pre-ops) maintenance (hardware repair and software updates) of ground terminal equipment and software. This function begins with the acceptance of the ground terminal element and ends with the start of operations.

F.4.3.2.9 Pre-Operations Mission Support. This element includes all the resources required for the operation of the ground terminal prior to turnover.

Includes, for example:

a. On-orbit testing; routine monitoring of space vehicle equipment health and status
b. Fault detection
c. Anomaly investigation and resolution. (The mission support period typically begins after installation and a specified time prior to launch and ends when the space vehicle achieves initial operational capability.)

F.4.3.3 External Network (T-COMM). This element contains all the resources associated to design, develop, produce, procure, lease, assemble, and test external communication. External communication refers to hardware (equipment, lines or circuits) and software effort required for a system that moves data along external communication paths between required points. Includes, for example: leased and owned transmissions methods transmitted through analog, digital, electronic, optical, or other methods and can be via terrestrial, undersea, or space.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.3.1 Leased Circuits 1...n (Specify). These elements include all the resources required for each point-to-point leased circuit.

F.4.3.3.2 Purchased Circuits. This element is associated with the purchased transmission circuits.

F.4.3.3.2.1 Purchased Circuit 1...n (Specify). These elements include all the resources required for each point-to-point purchased circuit.

F.4.3.3.2.2 Pre-Operations Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (pre-ops) maintenance of purchased circuit equipment. This function begins with the acceptance of the circuit and ends with the start of operations.

F.4.3.4 User Equipment. This element (hardware/software) pertains to end-user equipment purchased or built as part of the space system acquisition. User equipment includes, for example, satellite phones, field terminals (mobile or fixed), satellite modems, and hand-held GPS receivers.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.4.1 Equipment 1...n (Specify). These elements are a collection of items for a complete delivered unit of unique user equipment.

F.4.3.4.1.1 Hardware Configured Item 1...n (Specify). These elements are the unique configuration-controlled portions or sub-units whose totality composes a completed piece of user equipment.

F.4.3.4.1.2 Equipment Software 1...n (Specify). This element includes all resources associated with a single user equipment software configuration item.

NOTE: For lower level software information, use the structure and definitions in Appendix B, Electronic/Generic Systems.

F.4.3.4.2 Pre-Operations Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (pre-ops) maintenance of user equipment. This function begins with the acceptance of the user equipment and ends with the start of operations.

F.4.3.5 Facilities 1...n (Specify). These elements encompass all the physical infrastructure required to access, house and support ground terminal, ground segment function, and external network equipment and personnel.

Includes, for example:

a. All of the resources associated with the design, development, construction, integration,

landscaping, and fitting of the facilities WBS entities

b. Facilities subsystems: site preparation, landscape, buildings, equipment and building fit out, pre-operations maintenance, and mission support

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.5.1 Site Preparation. This subsystem includes the grading (land preparation), roads, pads, walls, fencing, utilities and subsystem other related costs needed to house, service and operate a space system ground site(s).

F.4.3.5.1.1 Graded Land. This item comprises the acquisition and the effort (land preparation) and resources necessary for ensuring a level (or possibly sloped to specific degree) base for a construction work such as: pads or other foundations; or the base course for roads or railways.

F.4.3.5.1.2 Roads. This element provides access to the ground segment buildings and equipment and encompasses all the effort and resources for road construction including excavation, removal of material, filling, compacting, construction, trimming, and finishing (paving, gravel, etc.).

F.4.3.5.1.3 Pads. This element provides for a flat stable base for antennas, telescopes, and other structures or equipment. Pads are usually composed of concrete.

F.4.3.5.1.4 Retaining Walls/Fencing. These items retain earth and can restrict vision and or passage to ground equipment, housing, and other ground facilities.

F.4.3.5.1.5 Utilities. This element delivers utility services (electricity, water, gas, etc.) up to ground buildings or to other structures and comprises the effort and resources for the installation of the utility infrastructure (electrical cables, pipes, transformers, etc.).

F.4.3.5.1.6 Site Preparation Other. This element contains all the resources associated with unique site preparations subsystem resource items not included in WBS elements above.

F.4.3.5.2 Landscape. This collection of items improves the appearance of the ground segment. Includes, for example: trees, shrubs, or grass, altering the contours of the ground, or other aesthetic material or objects.

F.4.3.5.3 Buildings 1...n (Specify). These items permanently support and shelter ground equipment and occupancy use.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.5.3.1 Foundation and Sub Structure. This element transfers the weight of buildings into the ground strata or earth. A common type of shallow foundation is a slab-on-grade foundation where the weight of the building is transferred to the soil through a concrete slab placed at the surface. Deeper foundations are used to transfer a load from a structure through an upper weak layer of soil to a stronger deeper layer of soil. Includes, for example: helical piles, impact driven piles, drilled shafts, caissons, piers, and earth stabilized columns, basements and fallout shelters.

F.4.3.5.3.2 Superstructure and Finishing. This element provides protection from the elements (wind, rain, sun, etc.) and partitioning for equipment and personnel. It includes, for example, roofing, walls, floors, framing, exterior and interior wall finishing. It excludes specialized flooring for computers and other equipment.

F.4.3.5.3.3 Buildings Other. This element contains all the resources associated with unique building subsystem resource items not included in the WBS elements above.

F.4.3.5.4 Equipment and Building Fit Out 1...n (Specify). These elements adapt equipment (e.g. radomes)

and buildings (and other facilities) for suitability to accomplish their designed purposes.

Includes, for example:
a. Heating, venting, and air conditioning (HVAC)
b. Power conditioning/uninterrupted power supply (UPS)
c. Network wiring/cable trays, generators
d. Computer flooring, appliances
e. Furniture and subsystem other items needed to build, service and operate the space system ground segment

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.5.4.1 Heating Venting and Air Conditioning (HVAC). These elements maintain desired air temperatures and flow for comfort, safety, and proper operating environments. This includes equipment related to the heating, venting, and air conditioning (HVAC) needed to accommodate facilities and equipment at a space system ground site.

F.4.3.5.4.2 Power Conditioning/Uninterruptible Power Supplies (UPS). These elements provide stable electrical power within a ground terminal or station.

Includes, for example:
a. Power conditioning units and uninterruptible power supplies (UPS) themselves, as well as the building modifications, cabling, and other support hardware required for the installation and operation of the units

Excludes, for example:
a. Elements and related hardware external to and leading up to buildings, which is included under utilities within site preparation
b. Motor generators (included within generators)

F.4.3.5.4.3 Network Wiring/Cable Trays. This collection of items holds up and distributes cables and wiring. A cable tray system is a unit or assembly of units or sections (including associated fittings) that form a rigid structural system used to securely fasten or support cables and wiring. This element includes raceways.

F.4.3.5.4.4 Generators. These elements generate electrical energy, generally using electromagnetic induction. Generators are often employed for —back-up electrical power generation for ground equipment during extended periods when the normal electrical supply is interrupted. This includes motor generators.

F.4.3.5.4.5 Computer Flooring. This element provides a means of routing interconnecting cables and wires and often the cooled air required by computing and related electrical equipment. A computer floor is a raised floor in offices, labs, and stations with a high requirement for servicing/change-out.

Includes, for example:
a. Tiles, framing, and structural support.

F.4.3.5.4.6 Appliances. This element performs various simple or narrow functions, such as providing light. Appliances are usually operated electrically. Includes, for example: lamps and other lighting, refrigerators and freezers, individual room heaters and air conditioners, sinks, toilets, etc. Excludes, for example: telecommunications equipment and computer and network appliances such as servers and back-up units.

F.4.3.5.4.7 Furniture. This collection of items supports the human body, provide storage, or hold objects. Storage furniture is used to hold or contain smaller objects such as tools, books, small equipment, and other goods. Includes, for example: chairs, tables, desks, cabinets, and shelves.

F.4.3.5.4.8 Fire Protection. This WBS element contains all the resources associated with fire detection and

extinguishing equipment that is installed at the ground site.

F.4.3.5.4.9 Security Systems. This WBS element contains all the resources associated with security monitoring and reporting equipment that is installed at the ground site.

F.4.3.5.4.10 Equipment and Building Fit Out Other. This WBS element contains all the resources associated with unique equipment and building fit out subsystem items not included in WBS elements above.

F.4.3.5.5 Pre-Operations Maintenance 1...n (Specify). These subsystems contain all the resources related to the pre-operations (pre-ops) maintenance of the building(s) and other facilities. This function begins with the completion and initial functioning of the items (buildings, roads, etc.) and ends with the start of operations.

F.4.3.6 Vehicles and Shelters. These elements provide the ability for ground segment functions and terminals to be transportable.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.3.6.1 Vehicles 1...n (Specify). These items include all the resources required for each unique powered vehicles used for transportable ground segment function and ground terminal equipment.

Includes, for example:
a. Trucks and Humvees

F.4.3.6.2 Shelters 1...n (Specify). These items include all the resources required for each unique items that protect and house transportable ground segment function and ground terminal equipment. A shelter is usually made of foam-and-beam sandwich panels that consist of a polyurethane foam core, aluminum skins and a framework of high strength aluminum alloy extrusions.

Includes, for example:
a. Shelters, trailers, and shells

F.4.3.6.3 Pre-Operations Maintenance 1...n (Specify). These elements contain all the resources related to the pre-operations (pre-ops) maintenance of the specified type of vehicles and shelters. This function begins with acceptance of the vehicles and shelters and ends with the start of operations.

NOTE: For lower level Common Elements, e.g., SEIT/PM and Support Equipment, reference Appendix K, section K.4.

F.4.4 Orbital Transfer Vehicle (OTV). This element is a single propulsion upper-stage that thrusts the space vehicle into a new orbit, for example, a low Earth orbit to a medium or high Earth orbit. Includes, for example: inertial upper stage (IUS), transfer orbit stage (TOS), payload assist module (PAM), and centaur. These elements are separate from the space and launch vehicles. They can be solid or liquid propulsion systems. If the booster adapter is not captured under the space vehicle element, it should be captured within this element or the launch vehicle element.

F.4.5 Launch Vehicle 1...n (Specify). A complete launch vehicle in a multiple or dissimilar launch vehicle configuration. This WBS element is intended for launch vehicle(s) that boost unmanned satellites into Earth orbits. It contains all of the resources associated with the design, development, production, integration, assembly, and test to include verification testing of each launch vehicle as required, as well as commercial-like launch services. This element also includes the launch vehicle contractor's efforts to receive, store, and transport the launch vehicle and associated ground equipment; to stack and assemble the launch vehicle; to mate the space vehicle to the launch vehicle; to perform integrated system test and checkout; and to track and measure launch vehicle performance during the ascent phase. List each unique configuration as a separate launch vehicle using sequential indices for each configuration; e.g., first

configuration is launch vehicle 1, second configuration is launch vehicle 2, etc.

Includes, for example:

a. Design, development, production, integration, assembly, test, and checkout of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specification, regardless of end use)
b. If the booster adapter is not captured under the space vehicle element, it should be captured within this element or the OTV element.
c. Payload fairings

NOTE: For lower level information, use the structure and definitions in Appendix I, Launch Vehicle if required.

F.4.6 Common Elements. Common WBS elements and definitions for all commodities can be found at Appendix K.3. Several commodities have unique elements that are applied which also appear in Appendix K, specifically, Space Systems (K.4); Launch Systems (K.5); Information Systems/Defense Business Systems (K.6); and Strategic Missile Systems (K.7).

The National Reconnaissance Office maintains a standard WBS that extends MIL-STD-881D Appendix F to lower levels for ground and software. This can be found at https://acq.westfields.net/. Registration is required for Government and contractor personnel.

APPENDIX G: GROUND VEHICLE SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

G.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for ground vehicle systems. Definitions for WBS elements common to all defense materiel items are given in Appendix K: Common Elements, Work Breakdown Structure and Definitions.

G.2 APPLICABLE DOCUMENTS

G.2.1 General. The documents listed in this section are specified in Appendix G of this standard. This section does not include documents cited in other Appendices of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendices of this standard, whether or not they are listed.

G.2.2 Government documents.

G.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

G.2.2.2 Other Government documents, drawings, and publications.

G.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 24765:2017 – *Systems and Software Engineering – Vocabulary*
ISO/IEC/IEEE 12207:2017 - *Systems and Software Engineering – Software Life Cycle Processes*

(Copies of these documents are available from www.ieee.org or The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-1331)

G.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Ground Vehicle System			
1.1		Family of Vehicles		
1.1.1			Lead Variant	
1.1.1.1				Lead Variant Integration, Assembly, Test, and Checkout
1.1.1.2				Hull/Frame/Body/Cab
1.1.1.3				System Survivability
1.1.1.4				Turret Assembly
1.1.1.5				Suspension/Steering
1.1.1.6				Vehicle Electronics
1.1.1.7				Power Package/Drive Train
1.1.1.8				Auxiliary Automotive
1.1.1.9				Fire Control
1.1.1.10				Armament
1.1.1.11				Automatic Ammunition Handling
1.1.1.12				Navigation and Remote Piloting Systems
1.1.1.13				Special Equipment
1.1.1.14				Communications
1.1.1.15				Lead Variant Software Release 1...n (Specify)
1.1.1.16				Other Lead Variant Subsystems 1...n (Specify)
1.1.2			Variant 2...n (Specify)	
1.1.2.1				Variant Integration, Assembly, Test, and Checkout
1.1.2.2				Hull/Frame/Body/Cab
1.1.2.3				System Survivability
1.1.2.4				Turret Assembly
1.1.2.5				Suspension/Steering
1.1.2.6				Vehicle Electronics
1.1.2.7				Power Package/Drive Train
1.1.2.8				Auxiliary Automotive
1.1.2.9				Fire Control
1.1.2.10				Armament
1.1.2.11				Automatic Ammunition Handling
1.1.2.12				Navigation and Remote Piloting Systems
1.1.2.13				Special Equipment
1.1.2.14				Communications
1.1.2.15				Variant Software Release 1...n (Specify)
1.1.2.16				Other Variant Subsystems 1...n (Specify)
1.1.3			Equipment Kits 1...n (Specify)	
1.2		Secondary Vehicle		
1.3		Systems Engineering		
1.3.1			Software Systems Engineering	
1.3.2			Integrated Logistics Support (ILS) Systems Engineering	
1.3.3			Cybersecurity Systems Engineering	
1.3.4			Core Systems Engineering	
1.3.5			Other Systems Engineering 1...n (Specify)	
1.4		Program Management		
1.4.1			Software Program Management	
1.4.2			Integrated Logistics Support (ILS) Program Management	
1.4.3			Cybersecurity Management	
1.4.4			Core Program Management	
1.4.5			Other Program Management 1...n (Specify)	
1.5		System Test and Evaluation		
1.5.1			Development Test and Evaluation	
1.5.2			Operational Test and Evaluation	
1.5.3			Cybersecurity Test and Evaluation	
1.5.4			Mock-ups/System Integration Labs (SILs)	

1.5.5		Test and Evaluation Support	
1.5.6		Test Facilities	
1.6	Training		
1.6.1		Equipment	
1.6.1.1			Operator Instructional Equipment
1.6.1.2			Maintainer Instructional Equipment
1.6.2		Services	
1.6.2.1			Operator Instructional Services
1.6.2.2			Maintainer Instructional Services
1.6.3		Facilities	
1.6.4		Training Software 1...n (Specify)	
1.7	Data		
1.7.1		Data Deliverables 1...n (Specify)	
1.7.2		Data Repository	
1.7.3		Data Rights 1...n (Specify)	
1.8	Peculiar Support Equipment		
1.8.1		Test and Measurement Equipment	
1.8.1.1			Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.8.1.2			Test and Measurement Equipment (Propulsion)
1.8.1.3			Test and Measurement Equipment (Electronics/Avionics)
1.8.1.4			Test and Measurement Equipment (Other Major Subsystems 1...n (Specify))
1.8.2		Support and Handling Equipment	
1.8.2.1			Support and Handling Equipment (Airframe/Hull/Vehicle)
1.8.2.2			Support and Handling Equipment (Propulsion)
1.8.2.3			Support and Handling Equipment (Electronics/Avionics)
1.8.2.4			Support and Handling Equipment (Other Major Subsystems 1...n (Specify))
1.9	Common Support Equipment		
1.9.1		Test and Measurement Equipment	
1.9.1.1			Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.9.1.2			Test and Measurement Equipment (Propulsion)
1.9.1.3			Test and Measurement Equipment (Electronics/Avionics)
1.9.1.4			Test and Measurement Equipment (Other Major Subsystems 1...n (Specify))
1.9.2		Support and Handling Equipment	
1.9.2.1			Support and Handling Equipment (Airframe/Hull/Vehicle)
1.9.2.2			Support and Handling Equipment (Propulsion)
1.9.2.3			Support and Handling Equipment (Electronics/Avionics)
1.9.2.4			Support and Handling Equipment (Other Major Subsystems 1...n (Specify))
1.10	Operational/Site Activation by Site 1...n (Specify)		
1.10.1		System Assembly, Installation, and Checkout	
1.10.2		Contractor Technical Support	
1.10.3		Site Construction	
1.10.4		Site/Ship/Vehicle Conversion	
1.10.5		Interim Contractor Support	
1.11	Contractor Logistics Support (CLS)		
1.12	Industrial Facilities		
1.12.1		Construction/Conversion/Expansion	
1.12.2		Equipment Acquisition or Modernization	
1.12.3		Maintenance (Industrial Facilities)	
1.13	Initial Spares and Repair Parts		

G.3.1 Application of Common WBS Elements (Appendix K). WBS elements that are common (i.e., Integration, Assembly, Test, and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if

Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

G.3.2 Key Principles in Constructing a WBS. In the appendices of this MIL-STD, the WBS is defined to Level 3, 4, or 5 depending on the system. WBS elements in the appendices may be extended to appropriate levels below their MIL-STD definition for informational or reporting purposes. The purpose for these extensions is to ensure that the higher-level elements include the proper lower level elements when required to report at a lower level. If an extension below the MIL-STD definition is required, maintaining the product-oriented decomposition is required.

1) Extending the WBS to Lower Levels. The reporting level of the WBS depends on the level of interest where work is accomplished. Reporting at levels below those identified within the MIL-STD should be reported if they are considered high cost, high risk, high technical, and/or special interest. For those elements, extension of the WBS to lower levels may be necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. An example of the extension for this Appendix commodity can be found at http://cade.osd.mil/policy/csdr-plan.

2) 100% Rule. A key to WBS development is the principle that if the effort and resources can be associated with the element they support, they should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (Fire Control) has three child elements—transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the Fire Control system to make it a level equal to the Fire Control, it distorts the effort and resources that are required to complete that Fire Control system. The reason is that the transmitter has lost its parent (Fire Control)/child relationship because it assumes the transmitter is not included within the Fire Control system.

3) Identifying Parent/Child Relationship. In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter within the Fire Control. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, it may include more functionality than just the transmitter subsystem. It may, for instance, include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to the inability to determine the effort for each functionality developed. It is, therefore, appropriate to associate that software to the next higher level (Fire Control) of the WBS. To accomplish this, it will be included in the Fire Control Software element of the of the Fire Control system. This eliminates allocation of the effort across multiple WBS elements where it is difficult to determine what level of support each gets.

4) Recognizing Cybersecurity Processes/Products. Cybersecurity is a requirement for all DoD programs and must be fully considered and implemented in all aspects of acquisition programs across the life cycle. Attention must be paid to cybersecurity at all acquisition category levels and all classification levels, including unclassified, throughout the entire life cycle; this includes systems that reside on networks and stand-alone systems that are not persistently connected to networks during tactical and strategic operations. Since responsibility for cybersecurity extends to every member of the acquisition workforce, DoD and its contractors need to design, develop, and acquire systems that can operate in applicable cyber threat environments. As such it is critical to understand what the cost of these systems is (i.e., hardware, software, systems engineering, program management, and system test and evaluation). MIL-STD-881D supports this effort by providing the structure to identify, collect and report many of these critical costs. It is also recognized gathering this information is nearly impossible at the level of detail these systems are developed. It is for this reason, where cybersecurity related costs can be easily accounted for, they should be called out in the WBS. For example, for hardware/software elements, if the development or procurement of hardware in a system is specifically a cybersecurity artifact, then call it out as a WBS element to identify it. The same is true for software. If the development of a CSCI(s) are specifically cybersecurity or software is purchased that is specifically for cybersecurity, call it out as a WBS element to identify it. Just as important are the engineering, management, and test activities that are used to ensure the systems are meeting the planned expectations. The MIL-STD has specifically called out these efforts associated with systems engineering, program management, and system test and evaluation WBS (See Appendix K).

G.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. In addition, the numbering provides visible clarity regarding level of indenture and parent-child content. While the numbering system is numeric, several unique issues arise across appendices which

require the numbering system to be modified to accommodate these anomalies (See Figure X). Additionally, if a WBS element is not required, it may be eliminated from the structure and the numbering would be logically adjusted.

G.3.3.1 "Other" WBS Elements. All appendices contain a WBS element titled "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. This is available to provide flexibility within the system WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined, and it does not currently appear in the appendices of MIL-STD-881D. If it is determined that the "other" WBS is not needed, this element should not be used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element.

G.3.3.2 1...n (Specify) WBS Element Definitions. Several appendices identify WBS elements with 1...n (Specify) or similar to denote that one or more components of that type of item may be used. Depending on the WBS identified, three approaches may be taken: 1) the parent WBS (e.g., 1...n) represents new or modified subsystems with each defined WBS using the appropriate title; or 2) the parent WBS (1...n) represents two or more WBS elements which are children of the parent, or 3) the parent WBS (1...n) represents a family of systems which require the same numbering structure to maintain consistency, using the same WBS number and adding an alpha/numeric (a, b, c, etc.) at the end to ensure the WBS numbering stays intact. (See Figure X in the General section for examples of WBS breakouts for each approach).

G.4 DEFINITIONS

G.4.1 Ground Vehicle System. The complex of vehicle electronics equipment, data, services, and facilities required to develop and produce a vehicle system with the capability to navigate over the surface or ground. Ground vehicle categories include vehicles primarily intended for general purpose applications and those intended for mating with specialized payloads.

Includes, for example:

a. Manned and unmanned cargo and logistics vehicles, trucks, mobile work units, and tactical vehicles
b. Combat vehicles serving as armored weapons platforms, reconnaissance vehicles, and amphibians

G.4.2 Family of Vehicles. The mobile element of the system embodying means to meet the performing operational missions on its own. (Reference: Family of Systems description in Guidance, paragraph 3.2.2 for applications of the WBS when variants/family of vehicles exists.)

Includes, for example:

a. Means of propulsion and structure for adaptation of mission equipment or accommodations for disposable loads
b. Design, development, and production of complete units (i.e., prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use)

G.4.2.1 Lead Variant. Family of vehicles typically have a significant amount of commonality between variants. When a family of vehicles is being developed it is more efficient to design a lead vehicle for the common design elements and then modify that design to be tailored to specific mission roles. The lead vehicle of the family of vehicle design may be referred to as a lead vehicle, lead variant, base vehicle or leader vehicle. For purposes of this Appendix, the term lead variant will be used. The lead variant is defined by the density or volume of the variant parts, parts commonality, parts percentage, or other like descriptions which make it the logical lead variant. Typically, this vehicle is the most common vehicle in the family of vehicles or used for generic purposes. When developing a WBS within the family of vehicles, the lead variant should be listed first in the listing of family of vehicle specific variant/configurations.

For ground vehicle systems that are not a family of vehicles, the lead variant will be used for the only primary vehicle system and no Variant (2...n) WBS elements will be used.

G.4.2.1.1 Lead Variant Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating common surfaces, structures, equipment, parts, materials, and software required to assemble and test the vehicle subsystem parts and subsystems equipment (hardware/software) elements. Reference Appendix K: Common Elements, Work Breakdown Structure and Definitions for further detail.

G.4.2.1.2 Hull/Frame/Body/Cab. The vehicle's primary load bearing component, which provides the structural integrity to withstand the operational loading stresses generated while traversing various terrain profiles (hull/frame), and (if applicable) the major component to be mated to a chassis to provide a complete vehicle having a defined mission capability (body/cab).

Includes, for example:
a. Simple wheeled vehicle frame or combat vehicle hull that satisfies the structural requirements including armor integral to the frame
b. Structural subassemblies and appendages that attach directly to the primary structure
c. Towing and lifting fittings, bumpers, hatches, and grilles
d. Provision to accommodate other subsystems such as mountings for suspension, weapons, turret, truck body, cab, special equipment loads
e. Accommodations for personnel, cargo, and such subsystems as need to be placed in proximity to operators

Excludes, for example:
a. Non-integral armor and radiological shielding (included in survivability element)

G.4.2.1.3 System Survivability. The equipment required to maximize the survivability of the crew and the system.

Includes, for example:
a. Active protection systems and defensive aids for both short and long-range threats
b. Radiological shielding for hull and turret. This includes supplemental ballistic protection, attachment approaches for external armor, liners, and behind armor debris shielding
c. Signature management hardware associated with reducing system susceptibility and vulnerability
d. Improvised explosive device (IED) countermeasure subsystems
e. Fire detection and suppression
f. Survivability systems control hardware. This includes electronics, sensors, and miscellaneous equipment that have functionality in more than one survivability WBS element
g. Ballistic crew seats for crew protection during ballistic events
h. Sensor subsystems, threat warning systems, and hostile weapon fire detection sensor subsystems
i. Chemical, biological, radiological, and nuclear survivability
j. Combat identification systems
k. Anti-tamper systems

G.4.2.1.4 Turret Assembly. The structure, including armor integral to the turret and equipment installations required to provide the fighting compartment element of combatant vehicles.

Includes, for example:
a. Turret rings, slip rings
b. Attachments and appendages, such as hatches and cupolas
c. Accommodations for personnel, weapons, and command and control
d. Drive motors
e. Turret drive stabilization system

Excludes, for example:
a. Non-integral armor and radiological shielding (included in survivability element)

G.4.2.1.5 Suspension/Steering. The means for generating tractive efforts, thrust, lift, and steering forces generally at or near the Earth's surface and adapting the vehicle to the irregularities of the surface.

Includes, for example:
a. Wheels, tracks, brakes, and steering gears for traction and control functions
b. Rudder thrust devices and trim vanes for amphibians
c. Springs, shock absorbers, skirts, and other suspension members

G.4.2.1.6 Vehicle Electronics. All electronic subsystems and components (hardware/software), distributed throughout the vehicle not directly attributable to other WBS Level 3 elements.

Includes, for example:
a. Computers and other devices for command and control
b. Data control and distribution
c. Controls and displays
d. Power distribution and management
e. Health management systems

Excludes, for example:
a. Hardware and software directly associated with other WBS elements

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

G.4.2.1.7 Power Package/Drive Train. The means for generating and delivering power.

Includes, for example:
a. Engine
b. Engine-mounted auxiliaries such as air ducting and manifolds, controls and instrumentation, exhaust systems, and cooling means
c. Power transport components as clutches, transmission, shafting assemblies, torque converters, differentials, final drivers, and power takeoffs
d. Brakes and steering when integral to power transmission rather than in the suspension/steering element
e. Hybrid electric drive systems
f. Energy storage systems
g. Raw power generators

G.4.2.1.8 Auxiliary Automotive. Hardware and software subsystems that provide services to all of the primary vehicle subsystems (as distinguished from the mission equipment subsystems).

Includes, for example:
a. On-board diagnostics/prognostics system not included in other subsystems
b. Winch and power take-off, tools, and on-vehicle equipment
c. Crew accommodations (when otherwise not provided for)
d. Lighting systems

Excludes, for example:
a. Electrical subsystems and components that are now included in the vehicle electronics WBS element
b. Fire detection and suppression system and controls associated with survivability

G.4.2.1.9 Fire Control. The equipment (hardware and software) installed in the vehicle, which provides intelligence necessary for weapons delivery such as launching and firing.

Includes, for example:
a. Radars and other sensors necessary for search, recognition, and/or tracking
b. Controls and displays
c. Sights or scopes
d. Range finders, computers, computer programs, gun drives, and stabilization systems

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

G.4.2.1.10 Armament. The equipment (hardware and software) for vehicles to deliver fire on targets.

Includes, for example:
a. Main gun and secondary guns
b. Missile launchers
c. Non-lethal weapons
d. Other offensive weapon systems

Excludes, for example:
a. Fire control systems

G.4.2.1.11 Automatic Ammunition Handling. The equipment (hardware and software) for selecting ammunition from a stored position in the vehicle, transferring it, and loading the armament system.

Includes, for example:
a. The means to eject spent cases and misfired rounds
b. Ammunition storage racks, transfer/lift mechanisms, ramming and ejecting mechanisms, as well as specialized hydraulic and electrical controls

G.4.2.1.12 Navigation and Remote Piloting Systems. The equipment (hardware and software) installed in the vehicle that enables the vehicle or its operators to plan and control vehicle speed and direction, determine vehicle location, plot the course of the vehicle and perform other mission functions.

Includes, for example:
a. Equipment that senses and processes imagery data such as vision systems, laser scanners, multiple sensor-fusion algorithms and processors, image-enhancement algorithms and processors, etc.
b. Equipment that performs mobility intelligence analysis and planning functions such as automated route planners, image-understanding algorithms and processors, computer-aided-driving algorithms and processors, etc.
c. Navigation systems such as dead reckoning, inertial, and global positioning systems
d. Landmark recognition algorithms and processors

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

G.4.2.1.13 Special Equipment. The equipment (hardware and software) to be mated to a hull/frame/body/cab assembly to achieve a special mission capability.

Includes, for example:
a. All items required to convert basic vehicle configurations to special-purpose configurations
b. Blades, booms, winches, robotic arms or manipulators, etc., to equip wreckers, recovery vehicles, supply vehicles and other field work units
c. Furnishings and equipment for command, shop, medical and other special-purpose vehicles
d. Specialized sensors not included elsewhere
e. Mine detection, neutralization, and marking equipment

G.4.2.1.14 Communications. The equipment (hardware and software) within the system for communicating information to systems and personnel interior and exterior to operating vehicles.

Includes, for example:
a. Radio frequency equipment, microwave and fiber optic communication links, networking equipment for multiple vehicle control, and intercom and external phone systems
b. Means for supplementary communication like visual signaling devices
c. Network integration equipment

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

G.4.2.1.15 Lead Variant Software Release 1...n. All base variant vehicle software not associated with a specific Level 3 element.

NOTE: Refer to Appendix B, Electronic/Generic Systems for further breakout and definitions for Software.

G.4.2.1.16 Other Lead Variant Subsystems 1...n (Specify). This element should be replaced with other product-oriented base variant subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

G.4.2.2 Variant 2...n (Specify). This element includes all other units beyond the lead variant, within the family of vehicles and represents those characteristics unique to one or more other variants being developed. The work breakdown structure and definition for Variant 2...n is the same as those for the lead variant vehicle. **(**Note: These variants are derivatives of the base variant.)

G.4.2.3 Equipment Kits 1...n (Specify). An accessory which may be attached to a system to provide capability beyond that of the original design and is removable without detracting from the serviceability of the system. A kit can be installed during system build or after the system is fielded.

Includes, for example:
a. Non-integral armor (turret)
b. Non-integral armor (hull/frame/body/cab)

G.4.3 Secondary Vehicle. The vehicles required to supplement, expand, or otherwise contribute to the capabilities of primary vehicles to provide the vehicle system with the required operational characteristics. Secondary vehicles are not necessarily self-contained operational units capable of operating outside the system.

Includes, for example:
a. Cargo and tank trainers of truck-trailers systems; carriers and tanker units of articulated train-type systems; and transporters as employed in systems when the primary vehicle has limited roadability.

NOTE: Work breakdown structure and definitions for Secondary Vehicle are the same as those for the lead variant vehicle.

G.4.4 Common Elements. Common WBS elements and definitions for all commodities can be found at Appendix K.3. Several commodities have unique elements that are applied which also appear in Appendix K, specifically, Space Systems (K.4); Launch Systems (K.5); Information Systems/Defense Business Systems (K.6); and Strategic Missile Systems (K.7).

APPENDIX H: UNMANNED MARITIME SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

H.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for unmanned maritime systems. Definitions for WBS elements common to all defense materiel items are given in Appendix K: Common Elements, Work Breakdown Structure and Definitions.

H.2 APPLICABLE DOCUMENTS

H.2.1 General. The documents listed in this section are specified in Appendix H of this standard. This section does not include documents cited in other Appendices of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendices of this standard, whether or not they are listed.

H.2.2 Government documents.

H.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

H.2.2.2 Other Government documents, drawings, and publications.

H.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 24765:2017 – *Systems and Software Engineering – Vocabulary*
ISO/IEC/IEEE 12207:2017 - Systems *and Software Engineering – Software Life Cycle Processes*

(Copies of these documents are available from www.ieee.org or The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-1331)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM F2541-06 *Standard Guide for Unmanned Underwater Vehicle (UUV) Autonomy and Control*

(ASTM Standards can be found online at: www.astm.org or 100 Barr Harbor Drive West Conshohocken, Pennsylvania, USA Phone: (610) 832-9500 Fax: (610) 832-9555)

H.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Unmanned Maritime System			
1.1		UMS Integration, Assembly, Test, and Checkout		
1.2		Maritime Vehicle		
1.2.1			Vehicle Integration, Assembly, Test, and Checkout	
1.2.2			Hull and Structure	
1.2.3			Propulsion	
1.2.4			Energy/Storage/Conversion	
1.2.5			Electrical Power	
1.2.6			Vehicle Command and Control	
1.2.6.1				Vehicle Command and Control Integration, Assembly, Test, and Checkout
1.2.6.2				Mission Control
1.2.6.3				Navigation
1.2.6.4				Guidance and Control
1.2.6.5				Health Status Monitoring
1.2.6.6				Rendezvous, Homing and Docking Systems
1.2.6.7				Fire Control
1.2.6.8				Vehicle Command and Control Software Release 1...n (Specify)
1.2.6.9				Other Vehicle Command and Control 1...n (Specify)
1.2.7			Surveillance	
1.2.8			Communications/Identification	
1.2.9			Ship Control Systems	
1.2.9.1				Ship Control System Integration, Assembly, Test, and Checkout
1.2.9.2				Steering and Dive Control
1.2.9.3				Hovering and Depth Control
1.2.9.4				Ballast and Trim
1.2.9.5				Maneuvering System
1.2.9.6				Ship Control Systems Software Release 1...n (Specify)
1.2.9.7				Other Ship Control Systems 1...n (Specify)
1.2.10			Auxiliary Systems	
1.2.10.1				Auxiliary Equipment Integration, Assembly, Test, and Checkout
1.2.10.2				Emergency Systems
1.2.10.3				Launch and Recovery System
1.2.10.4				Environmental Control System
1.2.10.5				Anchoring, Mooring and Towing
1.2.10.6				Miscellaneous Fluid Systems
1.2.10.7				Auxiliary Systems Software Release 1...n (Specify)
1.2.10.8				Other Auxiliary Systems 1...n (Specify)
1.2.11			Vehicle Software Release 1...n (Specify)	
1.3		Payload 1...n (Specify)		
1.3.1			Payload Integration, Assembly, Test, and Checkout	
1.3.2			Survivability Payload 1...n (Specify)	
1.3.3			Intelligence, Surveillance, and Reconnaissance (ISR) Payload 1...n (Specify)	
1.3.4			Armament/Weapons Delivery Payload 1...n (Specify)	
1.3.5			Mission Payload 1...n (Specify)	
1.3.6			Payload Software Release 1...n (Specify)	
1.3.7			Other Payload 1...n (Specify)	
1.4		Shipboard Segment		
1.4.1			Shipboard Segment Integration, Assembly, Test, and Checkout	

1.4.2 Unmanned Maritime System Command and Control Subsystem
1.4.2.1 Unmanned Maritime System Control Console(s)
1.4.2.2 Payload Control Console(s)
1.4.3 Communication Subsystem
1.4.4 Power Subsystem
1.4.5 Launch and Recovery Equipment
1.4.6 Storage Subsystems
1.4.7 Vehicle Handling Equipment
1.4.8 Auxiliary Equipment
1.4.9 Shipboard Software Release 1...n (Specify)
1.4.10 Other Shipboard Subsystems 1...n (Specify)
1.5 Shore Segment
1.6 Transportation Segment/Vehicles
1.7 UM System Software Release 1...n (Specify)
1.8 Systems Engineering
1.8.1 Software Systems Engineering
1.8.2 Integrated Logistics Support (ILS) Systems Engineering
1.8.3 Cybersecurity Systems Engineering
1.8.4 Core Systems Engineering
1.8.5 Other Systems Engineering 1...n (Specify)
1.9 Program Management
1.9.1 Software Program Management
1.9.2 Integrated Logistics Support (ILS) Program Management
1.9.3 Cybersecurity Management
1.9.4 Core Program Management
1.9.5 Other Program Management 1...n (Specify)
1.10 System Test and Evaluation
1.10.1 Development Test and Evaluation
1.10.2 Operational Test and Evaluation
1.10.3 Cybersecurity Test and Evaluation
1.10.4 Mock-ups/System Integration Labs (SILs)
1.10.5 Test and Evaluation Support
1.10.6 Test Facilities
1.11 Training
1.11.1 Equipment
1.11.1.1 Operator Instructional Equipment
1.11.1.2 Maintainer Instructional Equipment
1.11.2 Services
1.11.2.1 Operator Instructional Services
1.11.2.2 Maintainer Instructional Services
1.11.3 Facilities
1.11.4 Training Software 1...n (Specify)
1.12 Data
1.12.1 Data Deliverables 1...n (Specify)
1.12.2 Data Depository
1.12.3 Data Rights 1...n (Specify)
1.13 Peculiar Support Equipment
1.13.1 Test and Measurement Equipment
1.13.1.1 Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.13.1.2 Test and Measurement Equipment (Propulsion)
1.13.1.3 Test and Measurement Equipment (Electronics/Avionics)
1.13.1.4 Test and Measurement Equipment (Other Major Subsystems 1...n (Specify))
1.13.2 Support and Handling Equipment

1.13.2.1			Support and Handling Equipment (Airframe/Hull/Vehicle)
1.13.2.2			Support and Handling Equipment (Propulsion)
1.13.2.3			Support and Handling Equipment (Electronics/Avionics)
1.13.2.4			Support and Handling Equipment (Other Major Subsystems 1...n (Specify))
1.14	Common Support Equipment		
1.14.1		Test and Measurement Equipment	
1.14.1.1			Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.14.1.2			Test and Measurement Equipment (Propulsion)
1.14.1.3			Test and Measurement Equipment (Electronics/Avionics)
1.14.1.4			Test and Measurement Equipment (Other Major Subsystems 1...n (Specify))
1.14.2		Support and Handling Equipment	
1.14.2.1			Support and Handling Equipment (Airframe/Hull/Vehicle)
1.14.2.2			Support and Handling Equipment (Propulsion)
1.14.2.3			Support and Handling Equipment (Electronics/Avionics)
1.14.2.4			Support and Handling Equipment (Other Major Subsystems 1...n (Specify))
1.15	Operational/Site Activation by Site 1...n (Specify)		
1.15.1		System Assembly, Installation, and Checkout	
1.15.2		Contractor Technical Support	
1.15.3		Site Construction	
1.15.4		Site/Ship/Vehicle Conversion	
1.15.5		Interim Contractor Support (ICS)	
1.16	Contractor Logistics Support (CLS)		
1.17	Industrial Facilities		
1.17.1		Construction/Conversion/Expansion	
1.17.2		Equipment Acquisition or Modernization	
1.17.3		Maintenance (Industrial Facilities)	
1.18	Initial Spares and Repair Parts		

H.3.1 Application of Common WBS Elements (Appendix K). WBS elements that are common (i.e., Integration, Assembly, Test, and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

H.3.2 Key Principles in Constructing a WBS. In the appendices of this MIL-STD, the WBS is defined to Level 3, 4, or 5 depending on the system. WBS elements in the appendices may be extended to appropriate levels below their MIL-STD definition for informational or reporting purposes. The purpose for these extensions is to ensure that the higher-level elements include the proper lower level elements when required to report at a lower level. If an extension below the MIL-STD definition is required, maintaining the product-oriented decomposition is required.

1) Extending the WBS to Lower Levels. The reporting level of the WBS depends on the level of interest where work is accomplished. Reporting at levels below those identified within the MIL-STD should be reported if they are considered high cost, high risk, high technical, and/or special interest. For those elements, extension of the WBS to lower levels may be necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. An example of the extension for this Appendix commodity can be found at http://cade.osd.mil/policy/csdr-plan.

2) 100% Rule. A key to WBS development is the principle that if the effort and resources can be associated with the element they support, they should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (Fire Control) has three child elements—transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the Fire Control system to make it a level equal to the Fire Control, it distorts the effort and resources that are required to complete that Fire Control system. The reason is that the transmitter has lost its parent (Fire Control)/child relationship because it assumes the transmitter is not included within the Fire Control system.

3) Identifying Parent/Child Relationship. In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter within the Fire Control. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, it may include more functionality than just the transmitter subsystem. It may, for instance, include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to the inability to determine the effort for each functionality developed. It is, therefore, appropriate to associate that software to the next higher level (Fire Control) of the WBS. To accomplish this, it will be included in the Fire Control Software element of the of the Fire Control system. This eliminates allocation of the effort across multiple WBS elements where it is difficult to determine what level of support each gets.

4) Recognizing Cybersecurity Processes/Products. Cybersecurity is a requirement for all DoD programs and must be fully considered and implemented in all aspects of acquisition programs across the life cycle. Attention must be paid to cybersecurity at all acquisition category levels and all classification levels, including unclassified, throughout the entire life cycle; this includes systems that reside on networks and stand-alone systems that are not persistently connected to networks during tactical and strategic operations. Since responsibility for cybersecurity extends to every member of the acquisition workforce, DoD and its contractors need to design, develop, and acquire systems that can operate in applicable cyber threat environments. As such it is critical to understand what the cost of these systems is (i.e., hardware, software, systems engineering, program management, and system test and evaluation). MIL-STD-881D supports this effort by providing the structure to identify, collect and report many of these critical costs. It is also recognized gathering this information is nearly impossible at the level of detail these systems are developed. It is for this reason, where cybersecurity related costs can be easily accounted for, they should be called out in the WBS. For example, for hardware/software elements, if the development or procurement of hardware in a system is specifically a cybersecurity artifact, then call it out as a WBS element to identify it. The same is true for software. If the development of a CSCI(s) are specifically cybersecurity or software is purchased that is specifically for cybersecurity, call it out as a WBS element to identify it. Just as important are the engineering, management, and test activities that are used to ensure the systems are meeting the planned expectations. The MIL-STD has specifically called out these efforts associated with systems engineering, program management, and system test and evaluation WBS (See Appendix K).

H.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. In addition, the numbering provides visible clarity regarding level of indenture and parent-child content. While the numbering system is numeric, several unique issues arise across appendices which require the numbering system to be modified to accommodate these anomalies (See Figure X). Additionally, if a WBS element is not required, it may be eliminated from the structure and the numbering would be logically adjusted.

H.3.3.1 “Other” WBS Elements. All appendices contain a WBS element titled “Other” at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. This is available to provide flexibility within the system WBS for new or additional WBS elements that are not identified or defined in the Standard. These “other” elements would be used if, for example, a new subsystem or modified subsystem is defined, and it does not currently appear in the appendices of MIL-STD-881D. If it is determined that the “other” WBS is not needed, this element should not be used in the WBS. If it is determined that the “other” element is needed, then each element must be defined and the word “other” replaced by the newly defined WBS element.

H.3.3.2 1...n (Specify) WBS Element Definitions. Several appendices identify WBS elements with 1...n (Specify) or similar to denote that one or more components of that type of item may be used. Depending on the WBS identified, three approaches may be taken: 1) the parent WBS (e.g., 1...n) represents new or modified subsystems with each defined WBS using the appropriate title; or 2) the parent WBS (1...n) represents two or more WBS elements which are children of the parent, or 3) the parent WBS (1...n) represents a family of systems which require the same numbering structure to maintain consistency, using the same WBS number and adding an alpha/numeric (a, b, c, etc.) at the end to ensure the WBS numbering stays intact. (See Figure X in the General section for examples of WBS breakouts for each approach).

H.3.4 Unmanned Maritime System WBS Guidance. The following guidance may be used to help determine which Unmanned Maritime System WBS element should include different types of material:

a. If an item has more than one function it is grouped with its primary function.
b. Welding materials, hardware, fittings, and similar items are included with the functional system.
c. Insulation should be classified with the system where the insulation is installed.
d. Foundations that are integral with the component supported are included with the component system.
e. Mechanical and electrical penetration sleeves into structural members are part of the mechanical or electrical system that they support.
f. Pipe markings are included in the system where they are applied.
g. Piping is included with the system with which it is associated.
h. Equipment such as heat exchanger for a cooling system is associated with that system.
i. Electric driven pumps and electric motors are included within the system they service.
j. Electric signal cabling is included with the system that produces the signal up to the first panel or signal processor of another system.
k. Electric power cabling is included with the system that consumes the power. The boundary is at the power distribution system bus bar.
l. If the electrical cabling cannot be easily separated into subsystems because there is a single wire harness, there may be a single WBS element for cabling.
m. Built-in tanks that have at least one surface homogeneous with principal structure are included in the structural group. All other tanks are included in the system they support.
n. Items such as hull fasteners, pipe hangers, associated valves, valve operators, strainers, filters, flex connections, resilient and sound mounts, are included within the system they support.
o. Label plate installation is included in the system where they are attached.
p. Elements attached to or an integral part of a system are considered parts of the component and belong to that system unless specifically not included in the boundary definitions.
q. Attached or local indicating instrumentation is included with the supported system.
r. Remote reading instrumentation that is part of the general indicating system servicing many individual systems will be found under one of the interior sensing systems.
s. Fluid coolers are included within the system whose fluid they cool.
t. Hydraulic control valves, and associated hydraulic piping, including hydraulic valve actuators, hydraulic cylinders, or hydraulic pumps and motors are included in the hydraulic system.
u. Valve actuators (electric, air, mechanical) are included in the system they support.

H.4 DEFINITIONS

H.4.1 Unmanned Maritime System (UMS). The complex of equipment (hardware/software), data, services, and facilities required to design, develop, produce, test, operate, and support unmanned maritime systems.

Includes all classes of surface and subsurface (undersea) water vessels:
a. Unmanned Surface Vehicles (USVs)
b. Unmanned Undersea Vehicles (UUVs)

H.4.2 Unmanned Maritime System Integration, Assembly Test, and Checkout. All efforts as identified in Appendix K: Common Elements, Work Breakdown Structures and Definitions, to provide the integration, assembly, test, and checkout of all elements into the maritime vehicle to form the unmanned maritime system as a whole. Includes efforts associated with integrating the maritime vehicle, payloads, shipboard segment, and shore segment systems to form the UMS system.

H.4.3 Unmanned Maritime Vehicle. The complete waterborne vessel. It also includes design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use).

Includes, for example:

a. Hull and structure, propulsion, energy/storage/conversion, electrical power, vehicle command and control, surveillance, communications/identification, ship control systems and other installed equipment

H.4.3.1 Vehicle Integration, Assembly, Test, and Checkout. The integration, assembly, test and checkout element includes all efforts as identified in Appendix K: Common Elements, Work Breakdown Structure and Definitions, to provide a complete unmanned maritime vehicle.

H.4.3.2 Hull and Structure. The assembled structural and hydrodynamic components including primary pressure vessels, hatches, access panels, hull and support structures, and bulkheads.

Includes, for example:

a. Pressure hull, shell plating, longitudinal and transverse framing, foundations, and structural bulkheads
b. Non-pressure hull and supporting structures
c. Primary structural frame if there is no pressure hull per se
d. Ballast and trim tanks and other tanks that are integral to the structure
e. Hull structure watertight closures and access panels
f. Water tight hatches and doors including their respective hinge and operating mechanisms (electrical and mechanical)
g. Special structures such as castings, forgings, weldments, stiffeners, inserts, etc.
h. Exostructure including supporting structure, hydrodynamic fairings, sonar domes, access panels
i. Foundations (internal and external), sponsons, mounting provisions for mission peculiar equipment, armament/weapons delivery systems
j. Fixed ballast and floatation with associated mounts, brackets, and fasteners
k. Equipment masts, foundations, hinges, and associated operating mechanisms, and electrical devices (sensors, switches)
l. Pressure hull inserts and penetrations
m. Hull and structure assembly, test, and checkout including pressure testing, tank/compartment tightness testing

Excludes, for example:

a. Piping
b. Sacrificial anodes
c. Equipment inside the pressure hull, housings, or structure
d. Sound or shock/vibration mounts integral with mounted components. (They belong with the supported system.)
e. Tanks, ballast and trim systems that are not integral to the structure
f. Pressure housings, pressure bottles, end plates, and associated support structures that are not integral to the primary hull and structure. (This would include energy storage, ballast and trim tanks, and other pressure vessels that house equipment that are part of other subsystems).

H.4.3.3 Propulsion. The equipment and assembled components installed primarily to propel the vehicle and the systems necessary to make these components operable.

Includes, for example:

a. Main, secondary, and auxiliary propulsion units (e.g., engines or propulsion motors)
b. Transmission, gearing, shafting, bearings, propellers, propulsors, tracks, treads
c. Propulsion shrouds and ducts
d. Propulsion control equipment (e.g., motor controllers)
e. Supporting systems such as circulating and cooling water, and lubricating oil system necessary to make these components operable
f. Associated structural foundations, resilient mounts to support the equipment
g. Associated piping
h. Associated cabling
i. Associated electrical equipment e.g., control sensors, valves and actuators
j. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:

a. Energy sources, energy storage, energy conversion such as batteries or fuel cells, which are included under Energy/Storage/Conversion
b. All effort directly associated with the integration, assembly, test, and checkout of these elements into the maritime vehicle
c. All ancillary equipment that are not an integral part of the propulsion units required to provide an operational system, e.g., instruments, controls, etc.

H.4.3.4 Energy/Storage/Conversion. The energy storage, conversion, monitoring, and control systems that are separate from electrical power and distribution systems.

Includes, for example:

a. Energy storage and conversion system
b. Energy storage and conversion monitoring and control system
c. Associated enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated piping
e. Associated cabling
f. Associated electrical equipment such as batteries, fuses, bus bars, sensors, battery scanners
g. Supporting systems such as fuel tanks, fuel pumps, fuel monitoring and control, etc.
h. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:

a. Power distribution system
b. Peculiar support equipment – battery handling equipment

H.4.3.5 Electrical Power. The power generating, monitoring and control, and distribution systems to provide electrical power and lighting.

Includes, for example:

a. Electric power generation
b. Power conversion equipment
c. Power relays, circuit protection, power distribution system
d. General purpose lighting (if any) (internal and external)
e. Electric power monitoring and control system
f. Electrical wiring and cabling to provide power to other equipment
g. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
h. The design, development, production, assembly, and test efforts to provide the subsystem, equipment or unit as an entity

Excludes:
a. Special lighting for electro-optical sensor systems
b. Navigation lighting

H.4.3.6 Vehicle Command and Control. The onboard equipment (hardware/software) that allows a properly designated command authority to exercise control over the UMS in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission and may include shipboard and/or shore-based command and control equipment.

H.4.3.6.1 Vehicle Command and Control Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the vehicle command and control parts and subsystems equipment (hardware/software) elements. Reference Appendix K: Common Elements, Work Breakdown Structure and Definitions for further detail.

H.4.3.6.2 Mission Control. That equipment (hardware/software) installed in the UMS to provide mission control functions and facilitate its autonomy. Autonomy is the UMS's own ability of sensing, perceiving, analyzing, communicating, planning, decision making, and acting, to achieve its goals as assigned by its authorized client(s). (Source: ASTM F2541-06 Guide for UUV Autonomy and Control).

Includes, for example:
a. Mission or sortie control computers, software, algorithms
b. Autonomous mission or sortie control computers, software, algorithms
c. Vehicle control computers, software, algorithms
d. Payload control computers, software, algorithms
e. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly, and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Communications

H.4.3.6.3 Navigation. That equipment (hardware/software) installed in the UMS to perform the navigation function.

Includes, for example:
a. Electrical and electronic navigation equipment and systems
b. Integrated navigation systems
c. Inertial navigation sensors and systems
d. Heading, attitude, velocity, and depth sensors
e. Radio navigation, satellite navigation, radar
f. Acoustic navigation equipment, sonar altimeter, upward looking sonar
g. Terrain and/or obstacle avoidance sonar
h. Navigation lights
i. Navigation computer
j. Other equipment essential to the navigation/guidance function
k. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
l. Associated cabling
m. Associated electrical equipment e.g., control sensors, actuators
n. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Rendezvous, homing and docking systems (reference H.4.3.6.6)

H.4.3.6.4 Guidance and Control. That equipment (hardware/software), which, in combination with the propulsion, hovering, depth, steering, and dive control subsystems (under vehicle control subsystems), provide guidance and controls the flight path and vehicle state (i.e., speed, depth, heading, pitch, yaw, roll).

Includes, for example:
a. Guidance and control computers
b. Vehicle state (i.e., speed, depth, heading, pitch, yaw, roll) control software, algorithms and/or sensors such as pressure transducers, rate gyros, accelerometers, and motion sensors
c. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated cabling
e. Associated electrical equipment e.g., control sensors, actuators
f. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Hovering and depth control thrusters, jets or control surfaces or actuators
b. Steering and dive control thrusters, jets or control surfaces or actuators, central computers, navigation computers, data buses and navigation sensors, which are included under other WBS elements

H.4.3.6.5 Health Status Monitoring. That equipment (hardware/software) installed in the vehicle for malfunction detection and reporting.

Includes, for example:
a. Health monitoring hardware/software such as temperature and water intrusion sensors that are dedicated to that function and not part of another system
b. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
c. Associated cabling
d. Associated electrical equipment e.g., control sensors, valves and actuators
e. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Health monitoring hardware/software that is an integral part of other systems (e.g., motor speed sensors, hydraulic leak detection sensors or computer built-in-test)

H.4.3.6.6 Rendezvous, Homing, and Docking Systems. That equipment (hardware/software) installed in the vehicle for rendezvous, homing and docking.

Includes, for example:
a. Rendezvous or homing beacon or receiving system, docking sonar
b. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
c. Associated cabling
d. Associated electrical equipment e.g., control sensors, valves and actuators
e. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Hardware/software that is part of other systems

H.4.3.6.7 Fire Control. The equipment (hardware/software) installed in the vehicle that provides the intelligence necessary for weapons delivery such as launching and firing.

Includes, for example:
a. Sonars, radars and other sensors including sonar and radomes
b. Transducers, antennas, if integral to the fire control system, necessary for search, target identification, rendezvous and/or tracking
c. Self-contained navigation and air data systems
d. Weapon control and safety devices
e. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

H.4.3.6.8 Vehicle Command and Control Software Release 1...n. All vehicle command and control software that cannot be associated with a specific Level 4 element.

H.4.3.6.9 Other Vehicle Command and Control 1...n (Specify). These elements should be replaced with other product-oriented vehicle command and control elements that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

H.4.3.7 Surveillance. That equipment (hardware/software) installed in the vehicle that provides the UMS with situational awareness needed for the operation and safety of the system, regardless of the mission.

Includes, for example:
a. Electronic countermeasures (ECM) equipment such as radar warning detection systems
b. Acoustic intercept systems
c. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated cabling
e. Associated electrical equipment e.g., control sensors, valves and actuators
f. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Special or mission specific intelligence, surveillance, and reconnaissance (ISR) equipment that would be part of a mission payload

H.4.3.8 Communications/Identification. That equipment (hardware/software) installed in the maritime vehicle for communications and identification purposes.

Includes, for example:
a. Radio communication system(s), including transceivers, amplifiers, couplers, antennas, and associated controls
b. Underwater communication systems, including transceivers, amplifiers, projectors, hydrophones, transducers and associated controls
c. Automatic identification systems (AIS), including transceivers, amplifiers, couplers, antennas, and associated controls
d. Communication security systems such as identification equipment (IFF) and crypto equipment
e. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly, and test efforts to provide the subsystem,

equipment, or unit as an entity

Excludes, for example:
a. Internal data processing communication systems (i.e., data buses) that are part of other systems

H.4.3.9 Ship Control Systems.
a. Steering and diving control
b. Hovering and depth control
c. Ballast and trim system
d. Maneuvering system

H.4.3.9.1 Ship Control System Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the ship control parts and subsystems equipment (hardware/software) elements. Reference Appendix K: Common Elements, Work Breakdown Structure and Definitions for further detail.

H.4.3.9.2 Steering and Diving Control. Equipment (hardware/software) associated with controlling the vehicle heading, driving/surfacing, ballast, trim, maneuvering and stability.

Includes, for example:
a. Rudders, stabilizing fins, dive planes
b. Control actuators
c. Deployment/retraction mechanisms
d. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
e. Associated piping
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Ballast and trim systems

H.4.3.9.3 Hovering and Depth Control. Equipment (hardware/software) associated with controlling a predetermined assigned depth/altitude and to remain, or hover, at that predetermined location for a given period of time.

Includes, for example:
a. Depth control thrusters
b. Deployment/retraction mechanisms
c. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated piping
e. Associated cabling
f. Associated electrical equipment e.g., control sensors, valves and actuators
g. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Ballast and trim systems

H.4.3.9.4 Ballast and Trim. That equipment (hardware/software) installed in the vehicle to control vehicle buoyancy and trim.

Includes, for example:

a. Flood, drain and trim equipment
b. Trim and ballast tanks that are not integral to the hull and structure
c. Ballast and trim pumps or other mechanisms
d. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
e. Associated piping
f. Associated cabling
g. Associated electrical equipment such as control sensors, valves and actuators
h. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Fixed ballast
b. Trim and ballast tanks that are integral to the hull structure
c. Vehicle buoyancy/trim control software that is part of the guidance and control function

H.4.3.9.5 Maneuvering System. That equipment (hardware/software) installed in the vehicle to assist in controlling the vehicle, usually at slow speeds, if separate from the steering, diving, and hovering systems.

Includes, for example:
a. Slow speed propulsion, steering and/or depth control thrusters
b. Deployment/retraction mechanisms
c. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated piping
e. Associated cabling
f. Associated electrical equipment e.g., control sensors, valves and actuators
g. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Trim and ballast tanks that are integral to the hull structure
b. Steering and diving control

H.4.3.9.6 Ship Control Systems Software Release 1...n. All ship control systems software that cannot be associated with a specific Level 4 element.

H.4.3.9.7 Other Ship Control Systems 1...n (Specify). This element should be replaced with other product-oriented ship control system elements that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

H.4.3.10 Auxiliary Systems. Auxiliary support systems for vehicle emergency systems, on-board launch and recovery mechanisms, environmental control, anchoring and mooring, mast or buoy deployment mechanisms, sensor or other device deployment.

H.4.3.10.1 Auxiliary Equipment Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the auxiliary parts and subsystems equipment (hardware/software) elements. Reference Appendix K: Common Elements, Work Breakdown Structure and Definitions for further detail.

H.4.3.10.2 Emergency Systems. That equipment (hardware/software) installed in the vehicle to provide emergency functions such as surface, scuttle, emergency location aids.

Includes, for example:
a. Emergency floatation or scuttling systems
b. Emergency location devices and actuators

c. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated piping
e. Associated cabling
f. Associated electrical equipment e.g., control sensors, valves and actuators
g. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Ship control systems (steering and diving control, hovering and depth control, ballast and trim system, maneuvering system)
b. Hardware/software that is integral to other equipment (e.g., anti-tamper devices)

H.4.3.10.3 Launch and Recovery Systems. That equipment (hardware/software) installed in the vehicle to facilitate or enable launch and recovery.

Includes, for example:
a. Launch release mechanisms, recovery lines and floats, mechanisms, devices, controllers that are part of the vehicle
b. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
c. Associated piping
d. Associated cabling
e. Associated electrical equipment e.g., control sensors, valves and actuators
f. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Rendezvous, homing and docking systems that are part of the vehicle command and control system
b. Launch and recovery systems that are part of the shipboard equipment

H.4.3.10.4 Environmental Control System. Environmental equipment and distribution systems that provide control of temperature, humidity, pressurization, or other environmental parameters. The distribution systems provide for air ducts, cooling lines, other plumbing required in supplying air, and other cooling media from supply sources to the controlled environment.

Includes, for example:
a. Air refrigeration system, liquid cooling system, air or liquid flow regulation system such as compressors, heat exchangers, pumps
b. Humidity or condensation control
c. Heaters, heater blankets, deicing equipment
d. Temperature or humidity controller
e. Air ducts, refrigerant cooling lines, plumbing
f. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
g. Associated piping
h. Associated cabling
i. Associated electrical equipment e.g., control sensors, valves and actuators
j. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Environmental control hardware/software that is an integral part of other systems (e.g., computer heat sinks, fans) and not integrated with other systems

H.4.3.10.5 Anchoring, Mooring and Towing. Equipment that provides capabilities to anchor, moor, or tow the UMS.

Includes, for example:
a. anchors, anchor handling and stowage system, winches
b. Control actuators
c. Deployment/retraction mechanisms
d. Mooring and towing cables
e. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
f. Associated piping
g. Associated cabling
h. Associated electrical equipment e.g., control sensors, valves and actuators
i. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:
a. Mooring and towing systems that are part of the shipboard equipment

H.4.3.10.6 Miscellaneous Fluid Systems. Equipment that provides miscellaneous fluid systems.

Includes, for example:
a. Hydraulic power for the actuation mechanical systems such as mast or thruster deployment, flight control surfaces
b. Pumps, reservoirs, accumulators, valves, regulators and associated plumbing distribution systems to provide hydraulic power or compensation systems
c. Hydraulic tubing, check valves, etc. That interconnect the hydraulic equipment
d. Fire extinguishing systems
e. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
f. Associated piping
g. Associated cabling
h. Associated electrical equipment e.g., control sensors, valves and actuators
i. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Fluid system hardware/software that is an integral part of other systems (e.g., local motor lubrication or hydraulic system) and not integrated with other systems

H.4.3.10.7 Auxiliary Systems Software Release 1...n. All auxiliary systems software that cannot be associated with a specific Level 4 element.

H.4.3.10.8 Other Auxiliary 1...n (Specify). This element should be replaced with other product-oriented auxiliary elements that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

H.4.3.11 Vehicle Software Release 1...n. All maritime vehicle software that cannot be associated with a specific Level 3 or Level 4 element.

H.4.4 Payload 1...n (Specify). Unmanned Maritime Systems (UMSs) may have single or multiple payloads represented at Level 3 of the WBS. In addition to the types of payloads listed below, an UM system may also have other payloads. If a UM system has other payloads, they too should be represented within the WBS structure at Level 3 below the Level 2 Payload element. Examples of other payloads include targeting and ranging systems, bio/chemical detection sensors, meteorological sensors, and communication relay systems.

H.4.4.1 Payload Integration, Assembly, Test, and Checkout. This element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble and test the payload suite parts and subsystems equipment (hardware/software) elements. Reference Appendix K: Common Elements, Work Breakdown Structure and Definitions for further detail.

H.4.4.2 Survivability Payload 1...n (Specify). Those equipment (hardware/software) installed in, or attached to, the maritime vehicle that assists in penetration for mission accomplishment.

Includes, for example:

a. Sonar or radar detection receivers, warning devices and other electronic devices, electronic countermeasures, jamming transmitters, chaff, infra-red jammers, acoustic jammers, countermeasures, and other devices typical of this mission function

H.4.4.3 Intelligence, Surveillance, and Reconnaissance (ISR) Payload 1...n (Specify). Those equipment (hardware/software) installed in, or attached to, the marine vehicle necessary to provide capabilities peculiar to the ISR mission.

Includes, for example:

a. Acoustic sensors
b. RF sensors
c. Photographic, electro-optic, infrared, and other sensors
d. Sensor data recorders
e. Sensor processing
f. Payload controller
g. Data link
h. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
i. Associated cabling
j. Associated electrical equipment e.g., control sensors, valves and actuators
k. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:

a. Sensors or processing provided for vehicle functions required for all or most missions

H.4.4.4 Armament/Weapons Delivery Payload 1...n (Specify). That equipment (hardware/software) installed in the maritime vehicle to provide the firepower functions and weapons delivery capability.

Includes, for example:

a. Torpedoes, mines, guns, high energy weapons, mounts, turrets, weapon direction equipment, ammunition feed and ejection mechanisms, and gun cameras
b. Launchers, pods, torpedo or mine racks, pylons, integral release mechanisms, and other mechanical or electro-mechanical equipment specifically oriented to the weapons delivery function
c. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
d. Associated piping
e. Associated cabling
f. Associated electrical equipment such as control sensors, valves and actuators
g. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Navigation or fire control

H.4.4.5 Mission Payload 1...n (Specify). That equipment (hardware/software) installed in the maritime vehicle to provide a mission specific capability not listed above.

Includes, for example:
a. Mine warfare (MIW) including offensive mining and/or mine countermeasures (MCM)
b. Anti-submarine warfare (ASW)
c. Electronic warfare (EW) to include electronic countermeasures, jamming transmitters, chaff, infra-red jammers, other jamming equipment, electromagnetic deception equipment, or weapons that use electromagnetic or directed energy such as laser, RF weapons, or particle beams
d. Information operations (IO), oceanography, or other payload equipment specific to a naval warfare mission
e. Associated protective enclosures, pressure housings, structural foundations, resilient mounts to support the equipment
f. Associated piping
g. Associated cabling
h. Associated electrical equipment e.g., control sensors, valves and actuators
i. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

H.4.4.6 Payload Software Release 1...n. All payload software not associated with a specific Level 3 payload element.

H.4.4.7 Other Payload 1...n (Specify). Any other product or equipment not already mentioned in the above definition, but that is also transported or delivered by the UMS.

H.4.5 Shipboard Segment. The shipboard (or shore-based) segment of the UMS includes all shipboard (or shore-based) equipment (hardware/software) that provides command and control, communication, power generation, conditioning and distribution, launch/recovery, storage, handling and auxiliary support capabilities deployed on the host platform. This equipment is used during pre-launch, launch, mission/sortie, recovery, and post-recovery operations.

Includes, for example:
a. Design, development, and production of complete units (for example, the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use)
b. Integration and test of subsystems into the shipboard systems

H.4.5.1 Shipboard Segment Integration, Assembly, Test, and Checkout. All efforts as identified in Appendix K: Common Elements, Work Breakdown Structures and Definitions, to provide the integration, assembly, test, and checkout of all elements into the Shipboard/host deployed system to form the maritime vehicle as a whole.

H.4.5.2 Unmanned Maritime System Command and Control Subsystem. Equipment (hardware/software) that provides the capability to command and control the unmanned vehicle from the ship, deployment platform, or shore-based facility. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, procedures and systems employed by a commander or command team in planning, directing, coordinating, and controlling the UMS and its operations in the accomplishment of the mission.

Includes, for example:
a. Operator control console(s), computers, software, algorithms
b. Mission planning console(s), computers, software, algorithms
c. Shipboard communication equipment
d. Integration and test of subsystems into the shipboard systems
e. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators

h. The design, development, production, assembly and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Command and control equipment located in or on the UM system

H.4.5.2.1 Unmanned Maritime System Control Console(s). Equipment (hardware/software) that provides shipboard operator(s) with the capabilities to plan, checkout, launch/recover, control, communicate with, and/or operate one or more UMSs and/or payloads. Note – there may be more than one operator console, such as a vehicle control console, a mission planning console, and a payload control console.

Includes, for example:
a. Equipment (hardware/software) that provides the mission planning capability by which goals, constraints, capabilities, and environmental data are processed to create a plan to include tactical goals, a route (general or specific), command structure, coordination, and timing. Plans can be generated either in advance by authorized clients or in real-time by the onboard software systems or by external control. (Source: ASTM F 2541 – 06, Standard Guide for Unmanned Undersea Vehicles (UUV) Autonomy and Control)
b. Equipment (hardware/software) that provides post-mission analysis capability, which may include extraction, review, and/or analysis of mission data and results, generation of mission reports, and archiving data

H.4.5.2.2 Payload Control Console(s). Equipment (hardware/software) that provides shipboard operator(s) with the capabilities to plan, checkout, control, communicate with, and/or operate one or more UMS payloads. There may be more than one operator console, for example, a vehicle control console, a mission planning console, and a payload control console.

Includes, for example:
a. Equipment (hardware/software) that provides the capability to directly control the payload from the ship, deployment platform or shore facility
b. Payload control computers, software, algorithms
c. Payload planning computers, software, algorithms
d. Dedicated payload communication equipment
e. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity
i. Equipment (hardware/software) that provides for the storage, retrieval, or dissemination of payload data
j. Computers, software, data storage, and recording devices
k. Equipment (hardware/software) that provides information processing and operations (e.g., handling, merging, sorting, and computing) of payload data

Excludes, for example:
a. Payload control equipment that is part of the vehicle command and control system
b. Payload control equipment located in or on the UMS
c. Data storage equipment that is part of the vehicle command and control system
d. Data processing equipment that is part of the vehicle command and control system

H.4.5.3 Communication Subsystem. This subsystem includes shipboard (or shore-based) equipment (hardware/software) to provide communications with unmanned maritime systems, other manned or unmanned air, surface and subsurface vehicles, satellites and/or ground stations. This subsystem supports all shipboard (or shore-based) subsystems that require the capability to prepare and output commands to, and receive and process data from, the maritime vehicle while in operation or under test.

Includes, for example:

a. Network, computer processing and display hardware such as routers, switches, servers, workstations, storage devices, etc.
b. Software for handling, processing, and executing maritime vehicle commands, as well as processing and analyzing maritime vehicle telemetry
c. RF, laser, or acoustic antennas, transmitters, receivers, processing, etc.
d. Communication enclosures (e.g., ISO van), factory/contractor support facility, initial support and support equipment
e. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
f. Associated piping
g. Associated cabling
h. Associated electrical equipment e.g., control sensors, valves and actuators
i. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:

a. Communication equipment that is organic to the ship

H.4.5.4 Power Subsystem. Equipment (hardware/software) associated with generating, conditioning, monitoring, controlling and distribution of power to shipboard (or shore-based) components of the UMS.

Includes, for example:

a. Electric power generation such as a diesel power generator dedicated to the UMS
b. Power distribution switchboards, circuit protection, power distribution system
c. Ground fault detection and interruption
d. Power monitor and control system
e. Battery charging system
f. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
g. Associated cabling
h. Associated electrical equipment e.g., control sensors, valves and actuators
i. The design, development, production, assembly and test efforts to provide the subsystem, equipment or unit as an entity

Excludes, for example:

a. Power generation and distribution equipment that is organic to the host ship or shore facility

H.4.5.5 Launch and Recovery Equipment. Equipment that provides the capability to launch and recover unmanned surface or underwater vehicles from a ship or shore-based facility.

Includes, for example:

a. Launch and recovery ramps, track systems, lifting equipment
b. Vehicle capture, and release mechanisms installed on the ship or dockside equipment
c. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
d. Associated piping
e. Associated cabling
f. Associated electrical equipment e.g., control sensors, valves and actuators
g. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:

a. Handling and lifting equipment that is organic to the ship or dockside facility and not dedicated to support of UMS
b. Rendezvous, homing, and docking sensors/systems used to control the vehicle

H.4.5.6 Storage Subsystems. Equipment that provides shipboard (or shore-based) storage of the vehicle and its equipment.

Includes, for example:
a. Shipboard (or shore-based) storage van/shelter, maintenance van/shelter, equipment storage containers
b. Self-contained heating, air conditioning or other environmental control systems
c. Self-contained power conversion and distribution equipment
d. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
e. Associated piping
f. Associated cabling
g. Associated electrical equipment e.g., control sensors, valves and actuators
h. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Buildings, shelters or other enclosures located at dockside facilities that are not dedicated to support of UMS system

H.4.5.7 Vehicle Handling Equipment. Shipboard (or shore-based) equipment dedicated to handling the vehicle.

Includes, for example:
a. Dollies, maintenance cradles, track systems, lifting equipment
b. Integral power and control systems
c. Integral electrical or hydraulic systems
d. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
e. Associated piping
f. Associated cabling
g. Associated electrical equipment such as control sensors, valves and actuators
h. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Launch and recovery system
b. Handling and lifting equipment that is organic to the ship and not dedicated to support of UMS

H.4.5.8 Auxiliary Equipment. Auxiliary shipboard/shore-based systems, equipment not allocable to individual elements equipment.

Includes, for example:
a. Battery charging equipment, hydraulic system support equipment, refrigerant purge/charge equipment, pressure housing dry nitrogen backfill equipment
b. Associated protective enclosures, structural foundations, resilient mounts to support the equipment
c. Associated piping
d. Associated cabling
e. Associated electrical equipment e.g., control sensors, valves and actuators
f. The design, development, production, assembly, and test efforts to provide the subsystem, equipment, or unit as an entity

Excludes, for example:
a. Other peculiar support equipment such as special test equipment that is needed for intermediate or depot level maintenance, but not shipboard operation and maintenance

H.4.5.9 Shipboard Software Release 1...n (Specify). All shipboard (or shore-based) software not associated with specific Level 3 or Level 4 elements.

H.4.5.10 Other Shipboard Subsystems 1...n (Specify). This element should be replaced with other product-

oriented shipboard (or shore-based) subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

H.4.6 Shore Segment. The shore segment of the UMS includes all shore-based equipment (hardware/software), if any, that provides command and control, communication, power generation, conditioning and distribution, launch/recovery, storage, handling and auxiliary support capabilities at a temporary or permanent shore base supporting UMSs. This equipment is used during pre-launch, launch, mission/sortie, recovery, and post-recovery operations. This is essentially the same type of equipment that would be included in the shipboard segment. Most UMSs are ship deployed, but some systems may be launched and recovered from a shore base. A system may have only a shipboard or shore segment, or some systems may include both segments.

Includes, for example:

a. Shore segment WBS elements found under the shipboard segment in H.4.5
b. Design, development, and production of complete units (i.e., the prototype or operationally configured units, which satisfy the requirements of their applicable specifications, regardless of end use)
c. Integration and test of subsystems into the shore-based systems

H.4.7 Transportation Segment/Vehicles. Any vehicles that have been specifically designed or modified for the transportation of the unmanned maritime vehicles, shipboard equipment or other mission equipment. This includes any vehicles used to perform movement of the prime mission vehicle, crew, maintenance equipment, and direct maintenance personnel, or any other special transport systems used in the relocation of the prime mission equipment so that it may perform its mission.

Includes, for example:

a. Transport trailers that are dedicated to the unmanned maritime systems and its equipment

Excludes, for example:

a. Ship or shore-based handling equipment

H.4.8 Unmanned Maritime System Software Release 1...n (Specify). All UMS system level software not associated with a specific Level 2 element.

H.4.9 Common Elements. Common WBS elements and definitions for all commodities can be found at Appendix K.3. Several commodities have unique elements that are applied which also appear in Appendix K, specifically, Space Systems (K.4); Launch Systems (K.5); Information Systems/Defense Business Systems (K.6); and Strategic Missile Systems (K.7).

APPENDIX I: LAUNCH VEHICLE SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

I.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for launch vehicle systems. Definitions for WBS elements common to all defense materiel items are given in Appendix K: Common Elements, Work Breakdown Structure and Definitions.

I.2 APPLICABLE DOCUMENTS

I.2.1 General. The documents listed in this section are specified in Appendix I of this standard. This section does not include documents cited in other Appendices of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendices of this standard, whether or not they are listed.

I.2.2 Government documents.

I.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

I.2.2.2 Other Government documents, drawings, and publications.

I.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 24765:2017 – *Systems and Software Engineering – Vocabulary*
ISO/IEC/IEEE 12207:2017 - Systems *and Software Engineering – Software Life Cycle Processes*

(Copies of these documents are available from www.ieee.org or The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-1331)

I.3 WORK BREAKDOWN STRUCTURE LEVELS

WBS #	Level 1	Level 2	Level 3	Level 4	Level 5
1.0	Launch Vehicle System				
1.1		Systems Engineering, Integration, Test, Program Management (SEIT/PM)			
1.1.1			Systems Engineering (SE)		
1.1.2			Assembly, Integration and Test		
1.1.3			Program Management (PM)		
1.2		Launch Vehicle			
1.2.1			SEIT/PM		
1.2.2			Stages 1...n (Specify)		
1.2.2.1				SEIT/PM	
1.2.2.2				Structures and Mechanisms	
1.2.2.3				Propulsions System	
1.2.2.4				Reaction Control System	
1.2.2.5				Recovery System	
1.2.2.6				Environmental Control System	
1.2.2.7				Stage Peculiar Avionics	
1.2.2.8				Other Systems 1...n (Specify)	
1.2.3			Payload Accommodations 1...n (Specify)		
1.2.3.1				SEIT/PM	
1.2.3.2				Payload Fairings	
1.2.3.3				Payload Adapter (Pedestals)	
1.2.3.4				Mission Unique Hardware (Launch Vehicle) 1...n (Specify)	
1.2.4			Avionics		
1.2.4.1				SEIT/PM	
1.2.4.2				Guidance, Navigation, and Control	
1.2.4.3				Power	
1.2.4.4				Data Acquisition and Telemetry	
1.2.4.5				Range Tracking and Safety (Airborne)	
1.2.4.6				Flight Software Release 1...n (Specify)	
1.2.4.7				Other Avionics 1...n (Specify)	
1.3		Mission Integration and Analysis 1...f (Specify)			
1.3.1			Mission Standard Integration and Analysis		
1.3.2			Mission Unique Integration and Analysis 1...n (Specify)		
1.4		Launch Operations Site 1...n (Specify)			
1.4.1			SEIT/PM		
1.4.2			Vehicle Processing and Checkout		
1.4.3			Mission Services		
1.4.3.1				Mission Unique Hardware (Launch Operations) 1...n (Specify)	
1.4.3.2				Space Vehicle Processing	
1.4.4			Launch		
1.4.5			Flight Operations		
1.4.6			Post Launch		
1.4.6.1				Recovery Operations and Services	
1.4.6.2				Post Launch Refurbishment	
1.4.7			Site Maintenance		
1.4.8			Base Support		
1.4.9			Range Tracking and Safety (Ground)		
1.4.9.1				Range Ground System	
1.4.9.2				Range Operations	
1.5		Launch Site 1...n (Specify)			
1.5.1			SEIT/PM		
1.5.2			Operational/Site Activation		
1.5.3			Peculiar Support Equipment		
1.5.4			Ground Command, Control, and Communications (GC3)		
1.5.4.1				SEIT/PM	
1.5.4.2				Command, Control, and Communications	
1.5.4.3				Other Ground Command, Control, and Communications 1...n (Specify)	
1.6		System Test and Evaluation			
1.6.1			Development Test and Evaluation		
1.6.2			Operational Test and Evaluation		
1.6.3			Cybersecurity Test and Evaluation		
1.6.4			Mock-ups/System Integration labs (SILs)		

1.6.5		Test and Evaluation Support	
1.6.6		Test Facilities	
1.7	Training		
1.7.1		Equipment	
1.7.1.1			Operator Instructional Equipment
1.7.1.2			Maintainer Instructional Equipment
1.7.2		Services	
1.7.2.1			Operator Instructional Services
1.7.2.2			Maintainer Instructional Services
1.7.3		Facilities	
1.7.4		Training Software 1...n (Specify)	
1.8	Data		
1.8.1		Data Deliverables 1...n (Specify)	
1.8.2		Data Repository	
1.8.3		Data Rights 1...n (Specify)	
1.9	Peculiar Support Equipment		
1.9.1		Test and Measurement Equipment	
1.9.1.1			Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.9.1.2			Test and Measurement Equipment (Propulsion)
1.9.1.3			Test and Measurement Equipment (Electronics/Avionics)
1.9.1.4			Test and Measurement Equipment (Other Major Subsystems 1...n (Specify))
1.9.2		Support and Handling Equipment	
1.9.2.1			Support and Handling Equipment (Airframe/Hull/Vehicle)
1.9.2.2			Support and Handling Equipment (Propulsion)
1.9.2.3			Support and Handling Equipment (Electronics/Avionics)
1.9.2.4			Support and Handling Equipment (Other Major Subsystems 1...n (Specify))
1.10	Common Support Equipment		
1.10.1		Test and Measurement Equipment	
1.10.1.1			Test and Measurement Equipment (Airframe/Hull/Vehicle)
1.10.1.2			Test and Measurement Equipment (Propulsion)
1.10.1.3			Test and Measurement Equipment (Electronics/Avionics)
1.10.1.4			Test and Measurement Equipment (Other Major Subsystems 1...n (Specify))
1.10.2		Support and Handling Equipment	
1.10.2.1			Support and Handling Equipment (Airframe/Hull/Vehicle)
1.10.2.2			Support and Handling Equipment (Propulsion)
1.10.2.3			Support and Handling Equipment (Electronics/Avionics)
1.10.2.4			Support and Handling Equipment (Other Major Subsystems 1...n (Specify))
1.11	Industrial Facilities		
1.11.1		Construction/Conversion/Expansion	
1.11.2		Equipment Acquisition or Modernization	
1.11.3		Maintenance (Industrial Facilities)	
1.12	Initial Spares and Repair Parts		

I.3.1 Application of Common WBS Elements (Appendix K). For Launch Vehicles, the common WBS elements must include, as a minimum, systems engineering, integration and test, and program management (SEIT/PM). Common elements are found throughout all levels of a WBS and are located one WBS level below the product-oriented WBS they support (e.g., Launch Vehicle SEIT/PM would be captured at Level 3 under the Launch Vehicle element). Other common elements, such as training or data, as applicable, should be included in the WBS structure. The WBS structure is not complete without the application of common elements. Definitions for all common elements are in Appendix K. For the uniquely applied Systems Engineering, Integration and Test, Program Management (SEIT/PM) and Operational Site Activation for Launch Vehicles, reference Appendix K, section K.5.

I.3.2 Application of (1...n), and (1...f) convention. This document uses a (1...n) after WBS element titles where the element may have multiple unique occurrences. When creating the WBS for a specific program or contract, the (1...n) shall be replaced with a specific name for the item. The (1...f) convention is similar to the 1...n convention above but refers to different payload "flight" configurations

I.3.3 Key Principles in Constructing a WBS. In the appendices of this MIL-STD, the WBS is defined to Level 3, 4, or 5 depending on the system. WBS elements in the appendices may be extended to appropriate levels below their MIL-STD definition for informational or reporting purposes. The purpose for these extensions is to ensure that the higher-level elements include the proper lower level elements when required to report at a lower level. If an extension below the MIL-STD definition is required, maintaining the product-oriented decomposition is required.

1) Extending the WBS to Lower Levels. The reporting level of the WBS depends on the level of interest where work is accomplished. Reporting at levels below those identified within the MIL-STD should be reported if they are considered high cost, high risk, high technical, and/or special interest. For those elements, extension of the WBS to lower levels may be necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. An example of the extension for this Appendix commodity can be found at http://cade.osd.mil/policy/csdr-plan.

2) 100% Rule. A key to WBS development is the principle that if the effort and resources can be associated with the element they support, they should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (Fire Control) has three child elements—transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the Fire Control system to make it a level equal to the Fire Control, it distorts the effort and resources that are required to complete that Fire Control system. The reason is that the transmitter has lost its parent (Fire Control)/child relationship because it assumes the transmitter is not included within the Fire Control system.

3) Identifying Parent/Child Relationship. In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter within the Fire Control. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, it may include more functionality than just the transmitter subsystem. It may, for instance, include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to the inability to determine the effort for each functionality developed. It is, therefore, appropriate to associate that software to the next higher level (Fire Control) of the WBS. To accomplish this, it will be included in the Fire Control Software element of the of the Fire Control system. This eliminates allocation of the effort across multiple WBS elements where it is difficult to determine what level of support each gets.

4) Recognizing Cybersecurity Processes/Products. Cybersecurity is a requirement for all DoD programs and must be fully considered and implemented in all aspects of acquisition programs across the life cycle. Attention must be paid to cybersecurity at all acquisition category levels and all classification levels, including unclassified, throughout the entire life cycle; this includes systems that reside on networks and stand-alone systems that are not persistently connected to networks during tactical and strategic operations. Since responsibility for cybersecurity extends to every member of the acquisition workforce, DoD and its contractors need to design, develop, and acquire systems that can operate in applicable cyber threat environments. As such it is critical to understand what the cost of these systems is (i.e., hardware, software, systems engineering, program management, and system test and evaluation). MIL-STD-881D supports this effort by providing the structure to identify, collect and report many of these critical costs. It is also

recognized gathering this information is nearly impossible at the level of detail these systems are developed. It is for this reason, where cybersecurity related costs can be easily accounted for, they should be called out in the WBS. For example, for hardware/software elements, if the development or procurement of hardware in a system is specifically a cybersecurity artifact, then call it out as a WBS element to identify it. The same is true for software. If the development of a CSCI(s) are specifically cybersecurity or software is purchased that is specifically for cybersecurity, call it out as a WBS element to identify it. Just as important are the engineering, management, and test activities that are used to ensure the systems are meeting the planned expectations. The MIL-STD has specifically called out these efforts associated with systems engineering, program management, and system test and evaluation WBS (See Appendix K).

I.3.4 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. In addition, the numbering provides visible clarity regarding level of indenture and parent-child content. While the numbering system is numeric, several unique issues arise across appendices which require the numbering system to be modified to accommodate these anomalies (See Figure X). Additionally, if a WBS element is not required, it may be eliminated from the structure and the numbering would be logically adjusted.

I.3.4.1 "Other" WBS Elements. All appendices contain a WBS element titled "Other" at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. This is available to provide flexibility within the system WBS for new or additional WBS elements that are not identified or defined in the Standard. These "other" elements would be used if, for example, a new subsystem or modified subsystem is defined, and it does not currently appear in the appendices of MIL-STD-881D. If it is determined that the "other" WBS is not needed, this element should not be used in the WBS. If it is determined that the "other" element is needed, then each element must be defined and the word "other" replaced by the newly defined WBS element.

I.3.4.2 1...n (Specify) WBS Element Definitions. Several appendices identify WBS elements with 1...n (Specify) or similar to denote that one or more components of that type of item may be used. Depending on the WBS identified, three approaches may be taken: 1) the parent WBS (e.g., 1...n) represents new or modified subsystems with each defined WBS using the appropriate title; or 2) the parent WBS (1...n) represents two or more WBS elements which are children of the parent, or 3) the parent WBS (1...n) represents a family of systems which require the same numbering structure to maintain consistency, using the same WBS number and adding an alpha/numeric (a, b, c, etc.) at the end to ensure the WBS numbering stays intact. (See Figure X in the General section for examples of WBS breakouts for each approach).

I.4 DEFINITIONS

I.4.1 Launch Vehicle System. The complex of equipment (hardware/software), facilities and all of the resources associated with the design, development, production, refurbishment, integration, assembly, test, and operation of the entire payload lift launch vehicle system required to insert the space vehicle or probe into a space orbit/trajectory.

I.4.2 Launch Vehicle. Includes all resources associated with the design, development, production, refurbishment, integration, assembly, test and evaluation, and launch operations support of the entire launch vehicle. The launch vehicle is an Earth-to-space transfer vehicle that is self-propelled after leaving its launching platform. It can be expendable or reusable as it relates to the delivery of payloads to specific trajectories or orbits in space.

Includes, for example:

a. All applicable stages
b. Payload accommodations
c. Avionics
d. Requalification and inventory restock due to obsolescence and/or shelf life

I.4.2.1 Stages 1...n (Specify). Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operations support and support of the stages of the launch vehicle. A launch vehicle can be comprised of multiple (expandable and/or reusable) stages (1...n). The purpose of each stage is to propel the remaining portion of the launch vehicle and/or space vehicles to a certain elevation, trajectory and orbit. During flight, as each stage is expended, it is typically separated from the active portion of the launch vehicle to improve efficiency and eliminate unnecessary mass.

As an example, a multi-stage launch vehicle could consist of a liquid core booster stage (Stage 1) with attached solid rocket motors (Stage 2), known as “strap-ons,” and with additional sequential numbered stages being liquid (or solid) propulsion system, (Stage 3). Stage 4, etc. The numeric “Stage” numbering continues until the stage below the payload and launch vehicle adapters.

The elements of a stage may include a wide variety of subsystems depending on the design, configuration and the specific mission.

Includes, for example:
a. Structures and mechanisms (including operational ordnances and range safety ordnances)
b. Propulsion system
c. Power systems
d. Reaction control system
e. Recovery system (if required)
f. Environmental control systems deemed necessary
g. Stage peculiar avionics

I.4.2.1.1 Structures and Mechanisms. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operations support, and support of the structures and mechanisms element of the launch vehicle.

Includes, for example:
a. The structural framework that provides the aerodynamic shape, mounting surfaces and physical structures and tanks such as environmental protection for the launch vehicle stage elements
b. Mechanical elements for the launch vehicle stages containing structural members that serve some functional mechanical movements that interfaces with other dynamic or static elements or subsystems. Mechanical elements may be actuated by electrical, gas, pyrotechnic, or hydraulic forces.
c. Stage separation mechanisms such as ordnance bolts and springs (e.g., retro rockets, staging motors, pyrotechnic valves, and bolts)
d. Paint and corrosion control
e. Other mechanisms and support structures that are not defined elsewhere within the WBS and are cost separable

Examples of structures include:
a. Wings, tails, fins, canards and other control surfaces that provide aerodynamic flight control in response to actuators, electro-mechanical signals and are attached to the air vehicle body
b. Structural body assemblies including the structure, pipe and tube lines, and fuel tanks that are integral with the structure
c. Electrical harnesses, cords and wiring with associated brackets, stays, fasteners, and grommets
d. Thrust structure, heat shields, intertank adapters and connectors, interstage adapters, skirts, nose cones, and miscellaneous mounting brackets and supporting structures

Examples of mechanisms include:
a. Miscellaneous deployment devices, landing gear, and struts

Excludes, for example:
a. Adapters that fall under payload accommodations

I.4.2.1.2 Propulsion System. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operations support, and support of the propulsion system element of the launch vehicle. The propulsion system includes the equipment to provide thrust to propel the launch vehicle on its intended flight. The total propulsion system may be composed of one or more subsystems that ignite, burn, and may (or may not) be jettisoned sequentially over the course of flight. Individual subsystems may employ solid, liquid, and/or air-breathing technologies.

Includes, for example:

a. Primary propulsion elements such as solid rocket motors, liquid rocket engines, and/or air breathing engines
b. Subsystems required to generate propulsion such as manifolds, bell-housing, pumps, lines and tubing, fuel and oxidizer injectors, valves (mechanical, electro-servo, pyrotechnic etc.), start cartridges and engine/motor performance sensors
c. Components associated with thrust vector control (TVC) and fuel/oxidizer liquid management (i.e., feed lines, pressurization system and/or pressure control, pumps, valves, actuators, etc.)

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

I.4.2.1.3 Reaction Control System (RCS). Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support of the RCS element of the launch vehicle. The RCS includes hardware resident on a stage used for attitude control and steering. The RCS is capable of providing small amounts of thrust in any desired direction or combination of directions, providing torque to allow control of rotation (pitch, yaw, and roll). The RCS often uses combinations of large and smaller (vernier) thrusters (e.g., cold gas, warm gas, liquid propellant, solid propellant), to allow different levels of response from the combination.

Includes, for example:
a. All of the thrusters, lines, valves, propellant tanks, gas tanks, manifolds, etc. associated with the RCS

Excludes, for example:
a. The control system or elements of the control system if these are separate from the RCS (i.e., included under the guidance, navigation, and control element) with the only interface being a signal to a valve, actuators or distributor on the RCS
b. The thrust vector control (TVC) system associated with the main propulsion system, which is included within the propulsion system

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

I.4.2.1.4 Recovery System. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support of the recovery system element of the launch vehicle.

Includes, for example:
a. Equipment required to control final descent velocity and attitude after separation
b. Items used to protect hardware being recovered from adverse environmental elements
c. Equipment used to facilitate recovery and transport operations
d. Parachutes, methods of sequencing and deploying these parachutes and parachute separation components
e. Flotation and/or landing pad devices and/or landing gear
f. Impact resilient devices
g. Location aids that assist in the search and retrieval operations for the expended elements

Excludes, for example:
a. Recovery operations and services, which are included under recovery operations and services

I.4.2.1.5 Environmental Control System. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support of the ECS for the launch vehicle. The ECS is used to maintain and control an appropriate heat balance between absorbed radiation, internal heat dissipation and emitted energy within the stage(s). It includes both active and passive thermal control (as applicable).

Includes, for example:

a. Active thermal control elements that may include pumped-loop systems, heaters, and mechanical refrigerators
b. Passive thermal control elements that may include radiator panels/fins, coatings, thermal paint, heat shield tiles, heat pipes, insulation, conductive structures and materials, and louvers and sunshields
c. Acoustic or shock absorbing materials or devices

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

I.4.2.1.6 Stage Peculiar Avionics. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment and support of any avionics elements whose functionality is specifically associated with Stages 1...n. Stage peculiar avionics are separate from the main launch vehicle avionics system.

Includes, for example:

a. Power elements such as batteries and harnesses that provide and distribute power to components located on a specific stage
b. Instrumentation componentry used for collecting in-flight data form a specific stage
c. Separate and independent avionics (power systems, telemetry, command and control) for an upper stage for transfer orbital insertions

I.4.2.1.7 Other Systems 1...n (Specify). This element should be replaced with other product-oriented stage subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

I.4.2.2 Payload Accommodations 1...n (Specify). Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support required to implement the physical integration of the space vehicle(s) with the launch vehicle, resulting in successful delivery of the space vehicle to the specified orbit to meet mission requirements. In order to deliver a payload to its intended orbit/trajectory certain considerations must be taken into account to protect the payload from unacceptable environmental conditions during flight. The purpose of the payload accommodations is to assure the payload arrives at its final destination safely. This element also includes all physical mechanical/electrical interfaces between the launch vehicle and space vehicle. Payload accommodations include the following elements, which vary as a function of mission requirements.

Includes, for example:

a. Payload fairing
b. Payload adapter
c. Mission unique hardware

I.4.2.2.1 Payload Fairings. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support of the payload fairings element of the launch vehicle. The payload fairing consists of the aerodynamic shroud and equipment mated to the launch vehicle that protects the space vehicle from external environments and contamination. The payload fairing provides this protection from encapsulation of the space vehicle and its upper stage, as applicable, through atmospheric phase of the launch vehicle flight.

Includes, for example:

a. Payload fairing structure (e.g., panels, modules and nose assemblies) and mechanisms

b. Separation ordnance and other necessary mechanisms to assure that the payload fairing successfully separates from the launch vehicle and space vehicle
c. Environmental control systems, including thermal paint, insulation, heat shields and tiles or any other active or passive means necessary to maintain appropriate temperature of the shroud and mission equipment within it. Structural interface required between the shroud and launch vehicle, such as an interstage adapter or boat tail
d. Fairing recovery hardware (i.e., thrusters and parachutes).

Excludes, for example:
a. The hardware production and installation activities associated with implementing mission unique hardware requirements to the payload adapter, which are included under WBS I.4.2.2.3 - Mission Unique Hardware (Launch Vehicle) 1...n (Specify))
b. The engineering and analysis activities performed to define mission unique hardware requirements (included under WBS I.4.3.2-Mission Unique Integration and Analysis 1...n (Specify))
c. Linear pyrotechnic separation cords
d. Thermal blankets and/or installations
e. Payload access windows and doors

I.4.2.2.2 Payload Adapter (Pedestals). Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support of the payload adapter element of the launch vehicle. This element may be called a payload adapter, booster adapter or payload attach fitting or pedestal. The payload adapter includes the physical mechanical and electrical interface between the launch vehicle's uppermost stage and the space vehicle's attach points. It can be as simple as a snap ring device, but it is typically a more complex shell or frame structural assembly.

Includes, for example:
a. Adapter structures and space vehicle(s) separation mechanisms for each payload
b. Hardware and brackets
c. Attachment and release devices/deployment devices
d. Umbilical provisions
e. Adapters located between space vehicles on a multi-launch configuration
f. Harnesses, cords and plugs

Excludes, for example:
a. The hardware production and installation activities associated with implementing mission unique hardware requirements to the payload adapter, which are included under WBS I.4.2.2.3 - Mission Unique Hardware 1...n (Specify)
b. The engineering and analysis activities performed to define mission unique hardware requirements (included under WBS I.4.3.2 - Mission Unique Integration and Analysis 1...n (Specify)

I.4.2.2.3 Mission Unique Hardware (Launch Vehicle) 1...n (Specify). Includes all resources required to produce and install mission hardware necessary to meet mission unique (i.e., non-standard) space vehicle electrical/mechanical interface requirements with the launch vehicle (i.e., airborne) element.

Includes, for example:
a. Adapters for space vehicle
b. Spin table for space vehicle
c. Umbilical retract system
d. Air conditioning ducting

Excludes, for example:
a. The engineering and analysis activities performed to define mission unique hardware requirements, included under WBS I.4.3.2 -Mission Unique Integration and Analysis 1...n (Specify)
b. The hardware production and installation activities associated with implementing mission unique

hardware requirements associated with launch operations, mission services, included in WBS I.4.4.2.1 - Mission Unique Hardware (Launch Operations) 1...n (Specify)

I.4.2.3 Avionics. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support and support of the avionics element of the launch vehicle. Guidance elements are used for generating or receiving telemetry data to produce command and control signals. Instrumentation elements are used for collecting specified vehicle performance and health data and relaying these data to the telemetry collection system.

Includes, for example:
a. Power, data acquisition, communications and other avionics functions required for a specific launch vehicle
b. Flight software to support all processing activities associated with the power-up, prelaunch, and flight states of the launch vehicle
c. The software resident within the on-board inertial navigation unit (INU) (or equivalent) and flight control subsystem (FCS) processor of the launch vehicle avionics system
d. The flight termination system(s) used to intentionally destroy the launch vehicle if needed and determined by flight range safety

Excludes, for example:
a. Physical control such as thrust vector control (TVC) and reaction control system (RCS)
b. Guidance, navigation, and control (GN&C)
c. Power systems and batteries

I.4.2.3.1 Guidance, Navigation, and Control (GN&C). Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support and support of the GN&C element. The purpose of the GN&C system is to achieve precise injection of the space vehicle into its required orbit while maintaining launch vehicle stability and control. During the launch vehicle flight trajectory, GN&C components determine and provide (autonomously) the following functions: 1) guidance: steering the vehicle to its final target, 2) navigation: determining the vehicle’s position, velocity and attitude and 3) control: implementing guidance commands to achieve propulsion deflections or changes in thrust vector.

Includes, for example:
a. Inertial measurement unit (IMU)
b. Inertial navigation unit (INU)
c. Gyros
d. Accelerometers
e. Altimeters
f. Flight computer
g. Control units
h. GPS receiver

Excludes, for example:
a. Control actuators such as the thrust vector control (TVC) for the main propulsion system, which is included under WBS I.4.2.1.2 Propulsion System

I.4.2.3.2 Power. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support and support of the power element of the launch vehicle. The power element includes equipment required for generation, conversion, regulation, storage, distribution and switching of electrical energy to launch vehicle components.

Includes, for example:
a. Batteries
b. Generators
c. Power conditioners
d. Switches
e. Distribution harnesses and cables

f. Connectors

Excludes, for example:
a. Power components (e.g., batteries) for the flight termination system (FTS), which are included under range tracking and safety

I.4.2.3.3 Data Acquisition and Telemetry. Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support, and support of the data acquisition and telemetry element of the launch vehicle. The data acquisition and telemetry system provides the means of collecting and transmitting measured instrumentation data either directly back to a ground receiving station or indirectly via an airborne or space-based relay communication asset.

Includes, for example:
a. The data acquisition system, which provides launch vehicle and payload conditioned, digitized, vehicle health and system performance information (e.g., guidance and navigation data, vibration, temperature, fuel and liquid levels, pressures and G-force) during pre-launch, launch, and post-flight operations
b. The telemetry system, which, after receiving data from the data acquisition system, encrypts, encodes and modulates, and transmits the data via a telemetry transmitter

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

I.4.2.3.4 Range Tracking and Safety (Airborne). Includes all resources associated with the design, development, test and evaluation, integration, production, refurbishment, launch operation support and support of the range tracking and safety system.

Includes, for example:
a. On-board tracking system (e.g., global positioning system, C-Band receivers and transmitters) that provides the necessary data to determine vehicle position in support of the flight termination system (FTS) from liftoff through park orbit insertion. The tracking system enables ground tracking and airborne/space radar systems to accurately track the vehicle through its flight
b. Transponders and antennas for telemetry data and for command and control instructions
c. Flight termination system (FTS), which provides range safety, the capability to destroy the launch vehicle during non-nominal performance either by secure radio link (i.e., command destruct system), or autonomously after the detection of a vehicle break-up, or unintentional separation of launch vehicle stages (automatic destruct system)
d. Batteries, command receiver decoders (CRDs), antennas, safe/arm devices, pyrotechnic initiators, and destruct ordnance

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

I.4.2.3.5 Flight Software Release 1...n. All avionics flight software not associated with a specific Level 4 element.

I.4.2.3.6 Other Avionics (Specify). This element should be replaced with other product-oriented avionics subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

I.4.3 Mission Integration and Analysis (1...f). Includes all resources associated with the design, development, dissemination, and verification of requirements and schedules and for ensuring hardware configuration and schedule compliance with mission requirements. Includes both the standard and unique mission integration and analysis efforts required to define integration requirements to unite the space vehicle with the launch system to achieve the specified orbit.

I.4.3.1 Mission Standard Integration and Analysis. Includes engineering and services pertaining to "standard" mission integration tasks for all missions.

Includes, for example:

a. Mission integration control documentation (ICD)
b. Mission design and performance definition
c. Flight software parameters
d. Environmental analysis
e. Guidance system analysis
f. Launch vehicle/space vehicle coupled loads analysis
g. Integrated launch vehicle/space vehicle thermal analysis
h. Space vehicle separation analysis
i. Electrical analysis
j. Post launch/flight analysis
k. Independent verification and validation (IV&V) is conducted for flight readiness

I.4.3.2 Mission Unique Integration and Analysis (1...n). Includes all engineering, analysis, and management resources required to define the airborne and ground mission hardware and software necessary to meet mission unique (i.e., non-standard) space vehicle electrical/mechanical interface requirements with the launch system.

Includes, for example:

a. Mission unique design modifications to launch vehicle hardware (engineering and analysis only)
b. Mission unique design modifications to launch operations hardware (engineering and analysis only)
c. Other engineering and analysis not considered to be part of I.4.3.1 Mission Standard Integration and Analysis element
d. Vault or sensitive compartmented information facility (SCIF) activities

Excludes, for example:

a. Modifications or updates to standard integration configurations
b. The hardware production and installation activities associated with implementing mission unique hardware requirements to the launch vehicle, which are included under WBS I.4.2.2.3 – Mission Unique Hardware (Launch Vehicle)1...n (Specify)
c. The hardware production and installation activities associated with implementing mission unique hardware requirements at the Launch Site, which are included under WBS I.4.4.2.1 – Mission Unique Hardware (Launch Operations) 1...n (Specify)

I.4.4 Launch Operations Site 1...n (Specify). Includes all activities at the launch operations site(s) required to receive, inspect, store, process, assemble, checkout, monitor, test, conduct launch operations, control, track, recover (as applicable), and logistically support the launch system. It includes the maintenance and refurbishment of the facilities and equipment at the launch site in addition to the ongoing site maintenance and base support activities, which are not directly associated with the launch cycle. Excludes sustaining engineering in support of the launch vehicle elements provided during launch operations, which is included under WBS I.4.2 Launch Vehicle elements.

I.4.4.1 Vehicle Processing and Checkout. Includes all technical and management resources required to receive and process the launch vehicle at the launch site prior to launch.

Includes, for example:

a. Receipt, inspection and testing of the individual launch vehicle elements (e.g., liquid rocket engine and/or solid rocket motor stages, strap-ons (solid rocket motor or liquids, payload fairing, etc.), following delivery from their production facility to the launch site
b. Launch vehicle assembly, integration, test and checkout (AIT&CO), during which the launch vehicle elements (e.g., assembled stages, encapsulated space vehicle and upper stage, etc.) are assembled into an integrated launch vehicle
c. Launch vehicle subsystem checks and system verification, installing the encapsulated space vehicle, performing integrated system test and verification, final installations, and vehicle closeouts
d. Transfer (vertically or horizontally) between the assembly areas, processing areas and/or the launch pad (or runway) if required
e. Fueling of the launch vehicle
f. Final test and checkout including post assembly testing and verification of stack integration and flight readiness

I.4.4.2 Mission Services. Includes the hardware production and installation activities associated with implementing mission unique hardware requirements associated with launch operations, including space vehicle processing.

I.4.4.2.1 Mission Unique Hardware (Launch Operations) 1...n (Specify). Includes all resources required to produce and install mission hardware necessary to meet mission unique (i.e., non-standard) space vehicle electrical/mechanical interface requirements with the launch operations (i.e., ground) element.

Includes, for example:

a. Mission unique ground support equipment
b. Mission unique umbilicals

I.4.4.2.2 Space Vehicle Processing. Includes all resources for processing (e.g., fueling) of the spacecraft and encapsulation of the space vehicle within the payload fairing. It also includes space vehicle and upper stage (if required) transportation to the launch vehicle (if required).

I.4.4.3 Launch. Includes the resources associated with launch rehearsal activities, launch countdown operations, launch management functions and launch delays.

I.4.4.4 Flight Operations. Includes all resources required to command, control, track, and communicate with the launch vehicle during its mission.

Includes, for example:

a. Real-time mission control
b. Telemetry processing
c. Communications
d. Data reduction and analysis

I.4.4.5 Post Launch. Includes all resources associated with recovery operations and post launch refurbishment, if applicable.

Excludes, for example:

a. Post launch analysis included in I.4.3.1 Mission Standard Integration and Analysis

I.4.4.5.1 Recovery Operations and Services. Includes all resources required to effect recovery of the applicable launch vehicle elements identified as reusable/recoverable.

Includes, for example:

a. Transportation to reentry site
b. Reentry site recovery operations

c. Transportation of recovered equipment to assigned facilities
d. Logistics support to recovery operations

I.4.4.5.2 Post Launch Refurbishment. The resources required for the inspection, cleaning, repair, refurbishment, replacement, testing, and/or checkout of assets utilized during the launch operations cycle.

I.4.4.6 Site Maintenance. Includes ongoing planned maintenance, preservation, repair, and calibration of physical launch operations-related assets utilized during the launch operations cycle.

Excludes, for example:
a. Maintenance of industrial facilities

I.4.4.7 Base Support. Includes the physical infrastructure and personnel resources resident at the launch site that provides support to but is not directly attributable to launch operations activities.

Includes, for example:
a. Facilities
b. Security, fire, and emergency medical support
c. Transportation
d. Roads
e. Food

I.4.4.8 Range Tracking and Safety (Ground). Includes all the resources associated with the design, development, test and evaluation, integration, acquisition, installation, monitoring of launch operations, and maintenance of the range ground system.

I.4.4.8.1 Range Ground System. Includes all the resources associated with the design, development, test and evaluation, integration, installation and maintenance of the range ground system. This WBS element includes the acquisition and maintenance of ground tracking radar systems (hardware and software) used to accurately track the launch vehicle through flight, analyze the data, and issue a destruct command if necessary.

I.4.4.8.2 Range Operations. Includes all resources utilized during pre-launch and flight operations used to accurately track and acquire telemetry data of the launch vehicle during flight and up to flight termination. This WBS element includes the operations and maintenance of ground tracking radar and telemetry systems.

I.4.5 Launch Site 1...n (Specify). Includes all the development, design, construction, conversion, or expansion of roadways, real estate, utilities, and buildings/facilities required to house, service, process, launch and support launch vehicle hardware/software. Included are the efforts due to environmental concerns or laws regarding impacts to the human, ecological, or bio spherical environment. It includes installation design, system assembly, installation, and checkout, and integrated system tests for ground command, control, and communications mission equipment/software and support equipment/software.

I.4.5.1 Operational/Site Activation. Reference Appendix K Common Appendix for definition.

I.4.5.2 Peculiar Support Equipment. Reference Appendix K Common Appendix for definition.

I.4.5.3 Ground Command, Control, and Communications (GC3). Includes all resources associated with the design, development, test and evaluation, integration, launch operations and support of the GC3 system. The system provides the communications, monitoring, and ground control between the launch vehicle/space vehicle and ground processing stations. It consists of the hardware and software used to provide command, control, communications, and power for launch vehicle checkout and launch, and data display from launch vehicle checkout to launch and through flight operations.

I.4.5.3.1 Command, Control, and Communications. Includes all ground hardware and software for monitoring and ground control and communication between the launch vehicle and ground processing capabilities.

Includes, for example:

a. Ground based sensors
b. Telemetry, tracking and control
c. External communications
d. Data processing equipment
e. Automated launch processing equipment
f. Software and auxiliary equipment required for conducing launch vehicle system mission planning, launch processing, health management, launch and flight operations
g. Range safety

I.4.5.3.2 Other Ground Command, Control, and Communications 1...n (Specify). This element should be replaced with other product-oriented ground command, control, and communications subsystems that are either not listed above or that cannot be categorized into one of the above elements. Each additional element is to be clearly identified and defined.

NOTE: If lower level information can be collected, use the structure and definitions in Appendix B, Electronic/Generic Systems.

I.4.6 Common Elements. Common WBS elements and definitions for all commodities can be found at Appendix K.3. Several commodities have unique elements that are applied which also appear in Appendix K, specifically, Space Systems (K.4); Launch Systems (K.5); Information Systems/Defense Business Systems (K.6); and Strategic Missile Systems (K.7).

APPENDIX J: INFORMATION SYSTEMS/DEFENSE BUSINESS SYSTEMS WORK BREAKDOWN STRUCTURE AND DEFINITIONS

J.1 SCOPE

This appendix provides the Work Breakdown Structure and Definitions for information systems/defense business systems. Definitions for WBS elements common to all defense materiel items are given in Appendix K: Common Elements, Work Breakdown Structure and Definitions.

J.2 APPLICABLE DOCUMENTS

J.2.1 General. The documents listed in this section are specified in Appendix J of this standard. This section does not include documents cited in other Appendices of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendices of this standard, whether or not they are listed.

J.2.2 Government documents.

J.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

J.2.2.2 Other Government documents, drawings, and publications.

J.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 24765:2017 – *Systems and Software Engineering – Vocabulary*
ISO/IEC/IEEE 12207:2017 - *Systems and Software Engineering – Software Life Cycle Processes*

(Copies of these documents are available from www.ieee.org or The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-1331)

J.3 WORK BREAKDOWN STRUCTURE LEVELS (INVESTMENT)

WBS #	Level 1	Level 2	Level 3	Level 4
1.0	Information Systems (IS)/Defense Business Systems (DBS) (Investment)			
1.1		IS/DBS Development/Customization/Configuration		
1.1.1			Custom Application 1...n (Specify)	
1.1.1.1				Subsystem Hardware (Specify)
1.1.1.2				Subsystem Software CSCI 1...n (Specify)
1.1.1.3				Subsystem Software Level Integration, Assembly, Test, and Checkout
1.1.2			Enterprise Service Element 1...n (Specify)	
1.1.2.1				Enterprise Service Element Hardware (Specify)
1.1.2.2				Enterprise Service Element Software CSCI 1...n (Specify)
1.1.2.3				Enterprise Service Element Integration, Assembly, Test, and Checkout
1.1.3			Enterprise/Management Information System 1...n (Specify)	
1.1.3.1				Business Area Hardware (Specify)
1.1.3.2				Business Area Software CSCI 1...n (Specify)
1.1.3.3				Business Area Integration, Assembly, Test, and Checkout
1.1.4			External System Interface Development 1...n (Specify)	
1.1.4.1				External System Interface Hardware (Specify)
1.1.4.2				External System Interface Software CSCI 1...n (Specify)
1.1.4.3				External System Interface Integration, Assembly, Test, and Checkout
1.1.5			System Level Hardware (Specify)	
1.2		System Level Integration		
1.3		Systems Engineering		
1.3.1			Software Systems Engineering	
1.3.2			Integrated Logistics Support (ILS) Systems Engineering	
1.3.3			Cybersecurity Systems Engineering	
1.3.4			Core Systems Engineering	
1.3.5			Other Systems Engineering 1...n (Specify)	
1.4		Program Management		
1.4.1			Software Program Management	
1.4.2			Integrated Logistics Support (ILS) Program Management	
1.4.3			Cybersecurity Program Management	
1.4.4			Core Program Management	
1.4.5			Other Program Management 1...n (Specify)	
1.5		Change Management		
1.6		Data Management		
1.7		System Test and Evaluation		
1.7.1			Development Test and Evaluation	
1.7.2			Operational Test and Evaluation	
1.7.3			Cybersecurity Test and Evaluation	
1.7.4			Mock-ups/System Integration Labs (SILs)	
1.7.5			Test Facilities	
1.8		Training		
1.8.1			Equipment	
1.8.2			Services	
1.8.3			Facilities	
1.8.4			Training Software 1...n (Specify)	
1.9		Data		
1.9.1			Data Deliverables 1...n (Specify)	
1.9.2			Data Repository	
1.9.3			Data Rights 1...n (Specify)	
1.10		Peculiar Support Equipment		
1.10.1			Test and Measurement Equipment	
1.10.2			Support and Handling Equipment	
1.11		Common Support Equipment		

1.11.1		Test and Measurement Equipment	
1.11.2		Support and Handling Equipment	
1.12	Operational Infrastructure/Site Activation By Site 1...n (Specify)		
1.12.1		Initial Hardware Procurement	
1.12.1.1			End User Equipment
1.12.1.2			Cybersecurity Equipment
1.12.1.3			IT Infrastructure and Enterprise Software Equipment
1.12.1.4			Other 1...n (Specify)
1.12.2		Initial Software License Procurement	
1.12.2.1			End User Software License
1.12.2.2			Cybersecurity Software Licenses/Services
1.12.2.3			IT Infrastructure and Equipment
1.12.2.4			Other 1...n (Specify)
1.12.3		Initial Software Release (Pre-IOC) Modification/Enhancement	
1.12.3.1			Routine Fixes/Deficiency Correction
1.12.3.2			Deployment Independent Verification and Validation
1.12.3.3			Installation/Test
1.12.4		Site Activation	
1.12.4.1			Data Migration
1.12.4.2			User Training
1.12.4.3			User Documentation
1.12.4.4			Management/Engineering Support
1.12.4.5			Site Installation, Test, and Checkout
1.12.5		Interim Operations and Support (Pre-IOC)	
1.12.5.1			Help Desk
1.12.5.2			System Database Administrator
1.12.5.3			Installation, Test, and Checkout
1.12.5.4			IT Equipment Maintenance
1.13	Industrial Facilities		
1.13.1		Construction/Conversion/Expansion	
1.13.2		Equipment Acquisition or Modernization	
1.13.3		Maintenance (Industrial Facilities)	
1.14	Initial Spares and Repair Parts		

J.3.1 Application of Common WBS Elements (Appendix K). WBS elements that are common (i.e., Integration, Assembly, Test, and Checkout; Systems Engineering; Program Management; System Test and Evaluation; Training; and Data) should be applied to the appropriate levels within the WBS for which they support. For example, if Systems Engineering is required to support a Level 3 WBS element, the Systems Engineering WBS element would appear at Level 4 of the WBS under the Level 3 element it supports.

J.3.2 Key Principles in Constructing a WBS. In the appendices of this MIL-STD, the WBS is defined to Level 3, 4, or 5 depending on the system. WBS elements in the appendices may be extended to appropriate levels below their MIL-STD definition for informational or reporting purposes. The purpose for these extensions is to ensure that the higher-level elements include the proper lower level elements when required to report at a lower level. If an extension below the MIL-STD definition is required, maintaining the product-oriented decomposition is required.

1) Extending the WBS to Lower Levels. The reporting level of the WBS depends on the level of interest where work is accomplished. Reporting at levels below those identified within the MIL-STD should be reported if they are considered high cost, high risk, high technical, and/or special interest. For those elements, extension of the WBS to lower levels may be necessary to get needed visibility, but only for those elements. Not all WBS elements should be extended to the lowest level. In addition, for each system being defined only those WBS elements that define the system shall be used. An example of the extension for this Appendix commodity can be found at http://cade.osd.mil/policy/csdr-plan.

2) 100% Rule. A key to WBS development is the principle that if the effort and resources can be associated with the element they support, they should be included within that element. This is called the 100% rule, which states the next level of decomposition of a WBS element (child level) must represent 100% of the work applicable to the next higher level (parent level). For example, the parent level WBS (Fire Control) has three child

elements—transmitter, antenna, and receiver. If the program manager decides he/she wants more visibility into the transmitter subsystem and pulls it out of the Fire Control system to make it a level equal to the Fire Control, it distorts the effort and resources that are required to complete that Fire Control system. The reason is that the transmitter has lost its parent (Fire Control)/child relationship because it assumes the transmitter is not included within the Fire Control system.

3) Identifying Parent/Child Relationship. In some cases, items cannot be specifically associated with the element they support. For example, software is a critical element of that transmitter within the Fire Control. Under normal circumstances, software would be the child level to the parent level transmitter. However, depending on how software is developed, it may include more functionality than just the transmitter subsystem. It may, for instance, include functionality for the receiver as well. In this case the software cannot be associated with the specific elements they support, due to the inability to determine the effort for each functionality developed. It is, therefore, appropriate to associate that software to the next higher level (Fire Control) of the WBS. To accomplish this, it will be included in the Fire Control Software element of the Fire Control system. This eliminates allocation of the effort across multiple WBS elements where it is difficult to determine what level of support each gets.

4) Recognizing Cybersecurity Processes/Products. Cybersecurity is a requirement for all DoD programs and must be fully considered and implemented in all aspects of acquisition programs across the life cycle. Attention must be paid to cybersecurity at all acquisition category levels and all classification levels, including unclassified, throughout the entire life cycle; this includes systems that reside on networks and stand-alone systems that are not persistently connected to networks during tactical and strategic operations. Since responsibility for cybersecurity extends to every member of the acquisition workforce, DoD and its contractors need to design, develop, and acquire systems that can operate in applicable cyber threat environments. As such it is critical to understand what the cost of these systems is (i.e., hardware, software, systems engineering, program management, and system test and evaluation). MIL-STD-881D supports this effort by providing the structure to identify, collect and report many of these critical costs. It is also recognized gathering this information is nearly impossible at the level of detail these systems are developed. It is for this reason, where cybersecurity related costs can be easily accounted for, they should be called out in the WBS. For example, for hardware/software elements, if the development or procurement of hardware in a system is specifically a cybersecurity artifact, then call it out as a WBS element to identify it. The same is true for software. If the development of a CSCI(s) are specifically cybersecurity or software is purchased that is specifically for cybersecurity, call it out as a WBS element to identify it. Just as important are the engineering, management, and test activities that are used to ensure the systems are meeting the planned expectations. The MIL-STD has specifically called out these efforts associated with systems engineering, program management, and system test and evaluation WBS (See Appendix K).

J.3.3 Numbering of the WBS. In each appendix, the work breakdown structure for that commodity has been numbered for reporting purposes only. In addition, the numbering provides visible clarity regarding level of indenture and parent-child content. While the numbering system is numeric, several unique issues arise across appendices which require the numbering system to be modified to accommodate these anomalies (See Figure X). Additionally, if a WBS element is not required, it may be eliminated from the structure and the numbering would be logically adjusted.

J.3.3.1 “Other” WBS Elements. All appendices contain a WBS element titled “Other” at the subsystem, element (product) levels that are restricted for products that have not been envisioned or predicted within the defined WBS elements in the Appendix. This is available to provide flexibility within the system WBS for new or additional WBS elements that are not identified or defined in the Standard. These “other” elements would be used if, for example, a new subsystem or modified subsystem is defined, and it does not currently appear in the appendices of MIL-STD-881D. If it is determined that the “other” WBS is not needed, this element should not be used in the WBS. If it is determined that the “other” element is needed, then each element must be defined and the word “other” replaced by the newly defined WBS element.

J.3.3.2 1...n (Specify) WBS Element Definitions. Several appendices identify WBS elements with 1...n (Specify) or similar to denote that one or more components of that type of item may be used. Depending on the WBS identified, three approaches may be taken: 1) the parent WBS (e.g., 1...n) represents new or modified subsystems with each defined WBS using the appropriate title; or 2) the parent WBS (1...n) represents two or more WBS elements which are children of the parent, or 3) the parent WBS (1...n) represents a family of systems which

require the same numbering structure to maintain consistency, using the same WBS number and adding an alpha/numeric (a, b, c, etc.) at the end to ensure the WBS numbering stays intact. (See Figure X in the General section for examples of WBS breakouts for each approach).

J.4 DEFINITIONS

J.4.1 Information Systems/Defense Business Systems. The complex of enterprise elements, equipment (hardware), software, legacy systems, users, business rules, data and facilities required to develop, test, and deploy an information system/defense business system.

NOTE: When the opportunity to collect lower level information on electronic and software items exists, regardless of which defense materiel item category is selected, the structure and definitions in Appendix B – Electronic/Generic Systems, apply.

J.4.2 IS/DBS Configuration/Development/Customization. The hardware, software, and associated effort used to analyze, design, integrate, and test the entire information system (IS)/defense business system (DBS) prime mission product.

J.4.2.1 Custom Application 1...n (Specify). Custom application is anything that is not considered enterprise services such as intelligence system, mission planning system, etc. This element includes all the hardware, software, and associated effort needed to analyze, design, build, and test a custom software application, at the system developer's site, to fulfill a capability gap not captured by COTS only software packages. (COTS only are captured under J.4.2.2.2 Enterprise Service Element Software CSCI (1...n)). Examples: of custom applications are mission planning systems for aircraft/ship (e.g. JMPS), intelligence systems (e.g. DCGS-IC), shipboard (or shore-based) communication subsystem (e.g. GCCS-M, DCGS-N), ground operations and processing center for spacecraft (e.g. GPS OCX, JMS).

Excludes, for example:
a. Software development necessary for external system interfaces

J.4.2.1.1 Subsystem Hardware (Specify). This element includes all the associated hardware equipment needed to analyze, design, build, and test a custom software application at the system developer's site to fulfill a capability gap not captured by the COTS only software packages. Use lower levels to identify individual hardware items (servers, routers, etc.).

Includes, for example:
a. Development and test hardware

Excludes, for example:
a. Deployment hardware at each operational site

J.4.2.1.2 Subsystem Software CSCI 1...n (Specify). This element includes all the associated effort needed to analyze, design, build, and test a custom software application to fulfill a capability gap not captured by the COTS only software packages. Use lower levels to identify individual custom computer software configuration items (CSCI).

Includes, for example:
a. Software requirements
b. Software architecture and design
c. Software code and unit test
d. Software integration
e. Software qualification testing
f. Software COTS/GOTS approach (requirements negotiation)
g. Software COTS/GOTS component identification
h. Software COTS/GOTS assessment and selection
i. Software prototyping

j. Software COTS/GOTS glue code development
k. Software COTS/GOTS tailoring and configuration
l. Subsystem software product engineering (e.g., configuration management, quality assurance, managed services, etc.)

NOTE: When the opportunity to collect lower level information on electronic and software items exists, regardless of which defense materiel item category is selected, the structure and definitions in Appendix B — Electronic/Generic Systems, apply.

J.4.2.1.3 Subsystem Software Integration, Assembly, Test, and Checkout. The element includes the effort and material associated with integrating and testing subsystem software CSCIs and hardware of an individual (or group of) subsystem software applications that have undergone individual CSCI qualification test.

Excludes, for example:
a. Software development efforts necessary for external system interfaces

J.4.2.2 Enterprise Service Element 1...n (Specify). This element includes all the hardware, software, and associated effort needed for developing functionality or software services: unassociated, loosely coupled units of functionality that have no calls to each other embedded in them. These services can be integrated or used by several organizations, even if their respective client systems are substantially different. Examples of enterprise service elements are cloud services (SaaS), enterprise email, and Office 365 migration.

Includes, for example:
a. Enterprise service management (monitoring, fault management)
b. Machine-to-machine messaging
c. Service discovery
d. People and device discovery
e. Metadata discovery
f. Mediation
g. Service security
h. Content discovery and delivery
i. Federated search
j. Enterprise catalog service
k. Data source integration
l. Enterprise content delivery network (caching specification, distributed caching, forward staging)
m. Session management
n. Presence and awareness
o. Audio over internet protocol (IP)
p. Video over IP
q. Text collaboration (chat, instant messaging)
r. White boarding and annotation
s. Application sharing
t. Application broadcasting
u. Virtual spaces
v. Identity management (people and device discovery)
w. Content discovery
x. Collaboration
y. User profiling and customization

NOTE: Service Oriented Architecture is based on a mesh of software services as shown above. It packages functionally as interoperable services.

J.4.2.2.1 Enterprise Service Element Hardware (Specify). This element includes all the associated hardware equipment needed at the system developer's facility for assessing and tailoring COTS software applications or modules that can be attributed to a specific software service or bundle of services within the IS/DBS system. Use lower levels to identify individual hardware items.

Includes, for example:
a. Development and test hardware

Excludes, for example:
a. Deployment hardware at each operational site

J.4.2.2.2 Enterprise Service Element Software CSCI 1...n (Specify). This element includes all the associated effort for assessing and tailoring COTS software applications or modules that can be attributed to a specific software service or bundle of services within the IS/DBS system.

Includes, for example:
a. Software COTS/GOTS approach (requirements negotiation)
b. Software COTS/GOTS component identification
c. Software COTS/GOTS assessment and selection
d. Software prototyping
e. Software COTS/GOTS glue code development
f. Software COTS/GOTS tailoring and configuration
g. Subsystem software product engineering (e.g., configuration management, quality assurance, managed service contract, etc.)

Excludes, for example:
a. COTS software procurement: licenses, warranties, etc. included below the operational infrastructure/site activation by site element

NOTE: When the opportunity to collect lower level information on electronic and software items exists, regardless of which defense materiel item category is selected, the structure and definitions in Appendix B – Electronic/Generic Systems, apply.

J.4.2.2.3 Enterprise Service Element Integration, Assembly, Test, and Checkout. The element includes the effort and material associated with integrating and testing the required software and hardware of an individual (or group of) Enterprise Service Element(s).

J.4.2.3 Enterprise/Management Information System 1...n (Specify). This element includes all the hardware equipment and effort to plan, analyze, design, build, and test functionality(s) of an enterprise information system that uses an integrated database to support typical business processes within business/functional areas and consistent information access across areas and systems. Examples of enterprise/management information systems are ERPs (DEAMS, NMMES) and other COTS-based enterprise/management information systems (e.g. JOMIS, DHMSM), etc.

Includes, for example:
a. Enterprise resource planning
b. Enterprise data warehouse
c. Data mart
d. Operational data store

Excludes, for example:
a. General ledger
b. Accounts payable
c. Revenue and accounts receivable
d. Funds control and budgetary accounting
e. Cost management
f. Financial reporting

g. Real property inventory and management

J.4.2.3.1 Business Area Hardware (Specify). This element includes all the associated hardware equipment needed at the system developer's facility for planning, analyzing, designing, building, and testing functionalities that can be attributed, in whole or in-part, to a specific functional/business area or module within the Enterprise Information System.

Includes, for example:
a. Development and test hardware

Excludes, for example:
a. Deployment hardware at each operational site

J.4.2.3.2 Business Area Software CSCI 1...n (Specify). This element includes all the associated effort needed at the system developer's facility for planning, analyzing, designing, building, and testing functionalities that can be attributed, in whole or in-part, to a specific functional/business area or module within the EIS system.

Includes, for example:
a. All necessary labor and materials for analyzing, designing, building, configuring, and testing the required business objects—reports, forms, interfaces, conversions, workflows, fact tables, dimension tables, scripts, enhancements, etc.—that can be attributed, in whole or in-part, to a specific functional module or business area within the EIS system
b. Effort for assessing and tailoring COTS software applications or modules that can be attributed, in whole or in-part, to a specific functional module or business area within the EIS system

NOTE: When the opportunity to collect lower level information on electronic and software items exists, regardless of which defense materiel item category is selected, the structure and definitions in Appendix B – Electronic/Generic Systems, apply.

J.4.2.3.3 Business Area Integration, Assembly, Test, and Checkout. The element includes the effort and material associated with integrating and testing the required software and hardware of an individual (or group of) Business Area Element(s).

J.4.2.4 External System Interface Development 1...n (Specify). The hardware equipment and effort necessary for developing the set of software artifacts (threads, reports, queries, or scripts, or data export schemas) for a specific external system interface. Use lower levels to identify each specific external system interface that must be developed or modified. Example of external system interface development are interfaces between external systems and reporting systems.

Includes, for example:
a. Design of the interface specification and the development of the interface

Excludes, for example:
a. Data migration/cleansing

NOTE: An external system interface is required for proper transmission of data and/or control between the IS/DBS solution and separate systems for which a mutual dependency exists.

J.4.2.4.1 External System Interface Hardware. The hardware equipment necessary at the system integrator's facility for developing the set of software artifacts (threads, reports, queries, scripts, or data export schemas) for a specific external system interface. Use lower levels to identify each specific hardware item.

Includes, for example:
a. Development and test hardware if different from developer's equipment.

Excludes, for example:

a. Deployment hardware at each operational site
b. Hardware and system developer's facility

J.4.2.4.2 External System Interface Software CSCI 1...n (Specify). The effort associated with developing the set of software artifacts (threads, reports, queries, scripts, portlets, or data export schemas) needed for a specific external system interface. Use lower levels to identify specific artifacts that must be developed or modified.

Includes, for example:

a. Software requirements
b. Software architecture and design
c. Software code and unit test
d. Software integration
e. Software qualification testing
f. Software COTS/GOTS approach (requirements negotiation)
g. Software COTS/GOTS component identification
h. Software COTS/GOTS assessment and selection
i. Software prototyping
j. Software COTS/GOTS glue code development
k. Software COTS/GOTS tailoring and configuration
l. Subsystem software product engineering (e.g., configuration management, quality assurance, managed services, etc.)
m. Both the design of the interface specification and the development of the interface

NOTE: When the opportunity to collect lower level information on electronic and software items exists, regardless of which defense materiel item category is selected, the structure and definitions in Appendix B – Electronic/Generic Systems, apply.

J.4.2.4.3 External System Interface Integration, Assembly, Test, and Checkout. The element includes the effort and material associated with integrating and testing the required software and hardware of an individual (or group of) external system interface(s).

J.4.2.5 System Level Hardware (Specify). This element includes all the associated hardware equipment needed at the system developer's facility for planning, analyzing, designing, building, and testing functionalities that can be attributed to all system level functional/business areas.

Excludes, for example:

a. All associated hardware equipment needed at the system developer's facility for planning, analyzing, designing, building, and testing functionalities that can be attributed to specific functional/business areas or modules within the custom application, enterprise service, and enterprise/management information systems.
b. The hardware equipment necessary at the system integrator's facility for developing the set of software artifacts for specific external system interfaces.
c. Deployment hardware at each test site

J.4.3 System Level Integration. This element includes all effort and equipment to assemble, integrate, and test the entire IS/DBS system as a whole at the system developer's facility.

J.4.4 Common Elements. Common WBS elements and definitions for all commodities can be found at Appendix K.3. Several commodities have unique elements that are applied which also appear in Appendix K, specifically, Space Systems (K.4); Launch Systems (K.5); Information Systems/Defense Business Systems (K.6); and Strategic Missile Systems (K.7).

J.5 WORK BREAKDOWN STRUCTURE LEVELS (SUSTAINMENT)

WBS #	Level 1	Level 2	Level 3	Level 4	Level 5
2.0	Information Systems/Defense Business Systems (IS/DBS) (Sustainment)				
2.1		Program Management			
2.2		Systems/Sustainment Engineering			
2.3		Change Management			
2.4		Help Desk			
2.5		Data Cleansing/Data Maintenance			
2.6		System/Database Administration			
2.7		IT Infrastructure/Network Maintenance Support			
2.7.1			IT Infrastructure Hardware/Equipment Maintenance		
2.7.2			IT Infrastructure Software License Support Services		
2.7.3			IT Infrastructure Management		
2.7.4			Other IT Infrastructure Support 1...n (Specify)		
2.8		Operational Hardware Refresh/Upgrade			
2.8.1			End-User Equipment		
2.8.2			Cybersecurity Equipment		
2.8.3			IT Infrastructure and Enterprise Services Equipment		
2.8.4			Other (Specify)		
2.9		Operational Software License Refresh/Update			
2.9.1			End-User Software License		
2.9.2			Cybersecurity Software Licenses/Services		
2.9.3			IT Infrastructure and Enterprise Software Licenses/Services		
2.9.4			Other (Specify)		
2.10		Cybersecurity Maintenance Management			
2.10.1			Cybersecurity Compliance Operations and Tracking		
2.10.2			Follow-on Cybersecurity Test and Evaluation		
2.10.3			Cybersecurity and IT Certification and Accreditation		
2.11		Follow-on User Training			
2.12		System Independent Verification and Validation			
2.13		Continuing System Improvements			
2.13.1			Operational Hardware Modification		
2.13.1.1				Mod Kit Hardware Development	
2.13.1.2				Mod Kit Hardware Procurement	
2.13.1.3				Mod Kit Hardware Installation	
2.13.2			Software Release Modification/Enhancement 1...n (Specify)		
2.13.2.1				Modifications/Enhancements	
2.13.2.2				Routine Fixes and Deficiency Correction	
2.13.2.3				Installation/Test	
2.13.2.4				IAVAs	
2.14		AW/Safety/Networthiness Certification			
2.15		Facilities			

J.5.1 Information Systems/Defense Business Systems (Sustainment). Sustainment is a critical part of delivering and ensuring information systems/defense business systems (IS/DBS) hardware and software are continuously maintained, updated, and enhanced throughout the acquisition process until Material Support Date (MSD). Since IS/DBS systems are often deployed incrementally over time, the effort to keep them functionally up to date needs to be captured. This sustainment structure is intended to be used for IS/DBS sustainment activities vs. the CAPE O&S structure, which does not address sustainment for IS/DBS projects/systems.

J.5.2 Program Management. This element includes costs for management activities continuing from development or production or started during the sustainment phase. Program management activities are similar to those performed during development or production. This element also includes management efforts related to maintenance and supply chain, possibly started in production and continuing into sustainment.

J.5.3 Systems/Sustainment Engineering. The cost associated with software specific sustaining engineering activities such as studies/investigations for software specific issues. Sustaining engineering does not include any effort or cost for either maintenance (corrections) or capability enhancements: these are included in the release data. User support should not include field software engineering, nor data in other subcategories.

J.5.4 Change Management. Change management refers to the broad process for managing organizational change. Change management encompasses planning, oversight, governance, project management, testing and implementation.

J.5.5 Help Desk. This element captures the costs of providing help desk support for end users. It includes Level I through III. This support will include user account management. The reporting system must specify which tier is applicable. The help desk/operations support team (OST) will provide Tier I level support for problems related to systems administration and monitoring, event management, and database administration including restart, recovery, backups, and restorals. The help desk support staff is the initial focal point for answering questions and providing status information for the hosted site. The typical support hours are 24 x 7 x 365.

J.5.6 Data Cleansing/Data Maintenance. This element includes the effort for translating data from one format to another. This should cover only those efforts that are incurred at the maintenance site. Also include any expense associated with the transition of data from the legacy systems to the IS/DBS solution. Use lower levels to identify individual legacy systems.

Includes, for example:
a. Data translation
b. Data cleansing
c. Data loading

Excludes, for example:
a. External system interface development

Note: Data migration is necessary when an organization decides to use a new computing systems or database management system that is incompatible with the current system. Typically, data migration is performed by a set of customized programs or scripts that automatically transfer the data.

J.5.7 System/Database Administration. This element captures the costs of providing system/database administration for the IS/DBS solution computer resources once operational site activation is complete and the system has reached full operational capability (FOC). These could be costs incurred as a result of continuing contractor support or by the Government.

J.5.8 IT Infrastructure/Network Maintenance Support. Provide day-to-day management and operation of IT assets and processes. IT management are divided into three key sub-segments: operations services (for IT infrastructure), application management services, and help desk management services.

J.5.9 Operational Hardware Refresh/Upgrade. This element includes the costs of periodic replacement of computers and peripherals, including end-user, cybersecurity, and IT infrastructure and enterprise services.

Includes, for example:
a. End-user equipment
b. Cybersecurity equipment
c. IT infrastructure and enterprise services equipment

J.5.10 Operational Software License Refresh/Update. The cost associated with the procurement and renewal of software licenses for operational software. Also includes effort to manage licenses for the maintenance facility as well as deployed systems.

Includes, for example:

a. End-user software license
b. Cybersecurity software license/services
c. IT infrastructure and enterprise services software licenses/services

J.5.11 Cybersecurity Maintenance Management. The cost associated with activities such as software cybersecurity and information assurance vulnerability management (IAVM), which is the management of the overall IAVA process. Cybersecurity and the risk management framework (RMF) for DoD information technology verifies the software system against externally defined domain performance criteria.

Includes, for example:
a. Cybersecurity compliance operations and tracking
b. Follow-on cybersecurity test and evaluation
c. Cybersecurity and IT certification and accreditation

J.5.12 Follow-on User Training. The cost associated with follow-on user training.

Includes, for example:
a. New release training/periodic training events driven by a software change

J.5.13 System Independent Verification and Validation. This element contains all costs associated with information system and software independent verification and validation (IV&V). IV&V is a third-party review that ensures that the system is well engineered (verification) and that the system meets the users' needs (validation). This may be performed by the Government.

J.5.14 Continuing System Improvements. This element includes the costs of hardware and software updates that occur after deployment of a system. These updates improve a system's safety, reliability, maintainability, or performance characteristics and enable the system to meet its basic operational requirements throughout its life.

Excludes, for example:
a. All changes to a system developed subsequent to the initial delivered configuration.
b. System improvements identified as part of an incremental evolutionary acquisition strategy or pre-planned product improvement program that are included in the acquisition phase

J.5.15 Operational Hardware Modification. The cost of development, procurement, and installation of modification kits. Modification kits will consist of both kits of equipment to be installed and kits for provisions such as cables, brackets, or other interface devices. Also includes costs associated with the modifications for support equipment, training equipment, technical publications/data, and initial spares and repair parts (consistent with the approved modification content). These modifications are needed to achieve critical capabilities.

Excludes, for example:
a. Modifications undertaken to provide additional operational capability not called for in the original system design or performance specifications; such modifications costs are treated as modernization (and not O&S) costs, since most of these modifications will be considered as ACAT programs in their own right

J.5.16 Software Release Modification/Enhancement 1...n (Specify). The cost of modifying/enhancing, performing routine fixes and deficiency corrections on software, as well as IAVAs/security patches which include the cost associated with changing the software to address information assurance vulnerability alert.

J.5.17 AW/Safety/Networthiness Certification. This element includes the cost to prepare, support, and execute certification activities for a software release to include airworthiness, safety, and networthiness certifications.

J.5.18 Facilities. This element contains all costs associated with facilities operations which can be directly attributed to the system being fielded or in support of its personnel. These costs include, but are not limited to: facilities, power requirements, special material and supplies, leased or owned facilities and construction, operations, and maintenance of facilities.

APPENDIX K: COMMON ELEMENTS DEFINITIONS

K.1 SCOPE

This appendix provides the definitions for services elements (i.e., Integration, Assembly, Test and Checkout; Program Management; Systems Engineering; Training; Peculiar Support Equipment; etc.) whether common or unique to the Defense Materiel Items defined in Appendices A-J. All elements that are common and appear in all appendices, are defined in K.3. Elements that are specifically unique to Space Systems are defined in K.4. Elements that are specifically unique to Launch Vehicles are defined in K.5. Elements that are specifically unique to Information Systems/Defense Business Systems are defined in K.6. Elements that are specifically unique to Strategic Missile Systems are defined in K.7.

K.2 APPLICABLE DOCUMENTS

K.2.1 General. The documents listed in this section are specified in Appendix K of this standard. This section does not include documents cited in other Appendices of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendices of this standard, whether or not they are listed.

K.2.2 Government documents.

K.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEFENSE ACQUISITION UNIVERSITY

Defense Acquisition Guidebook (DAG)

(Copies of these documents are available from https://www.dau.mil/tools/t/Defense-Acquisition-Guidebook or Defense Acquisition University, 9820 Belvoir Rd, Fort Belvoir, VA 22060)

K.2.2.2 Other Government documents, drawings, and publications.

K.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE 24765:2017 – *Systems and Software Engineering – Vocabulary*
ISO/IEC/IEEE 12207:2017 - *Systems and Software Engineering – Software Life Cycle Processes*

(Copies of these documents are available from www.ieee.org or The Institute of Electrical and Electronics Engineers, Inc. (IEEE) Operations Center, 445 Hoes Lane, Piscataway, NJ 08854-1331)

K.3 DEFINITIONS OF COMMON ELEMENTS

K.3.1 Integration, Assembly, Test, and Checkout. In those instances in which an integration, assembly, test, and checkout element is used (Appendices A-D, G, H, and J), this element includes all effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble the subsystem equipment (hardware/software) elements into a mission system (including modification installation) as a whole and not directly part of any other individual subsystem element.

When applicable, rate tooling may be shown at the next lower level breakout of integration, assembly, test, and checkout.

Includes, for example:

a. The development of engineering layouts, determination of overall design characteristics, and determination of requirements of design review
b. The set-up, conduct, and review of testing assembled components or subsystems prior to installation
c. The detailed production design, producibility engineering planning (PEP), and manufacturing process capability, including the process design development and demonstration effort to achieve compatibility with engineering requirements and the ability to produce economically and consistent quality
d. Inspection activities related to receiving, factory and vendor liaison
e. Overall design and producibility engineering
f. Design maintenance effort and development of functional test procedures
g. Detailed production design
h. Quality planning and control
i. Tooling (initial production facilities, factory support equipment) including planning, design, and fabrication of basic and rate tools and functional test equipment, as well as the maintenance of such equipment
j. Production scheduling and expediting
k. Administrative engineering
l. The joining or mating and final assembly of hardware and software items to form a complete system or subsystem when the effort is performed at the manufacturing facility
m. Integration of software (including loading and verification of firmware)
n. Conduct of production acceptance testing

Excludes, for example:

a. All systems engineering, program management, and system test and evaluation that are associated with the overall system

NOTE: When an integration, assembly, test, and checkout element is utilized at lower levels of the contract work breakdown structure, it will be summarized into the next higher-level equipment (hardware/software) WBS element and should never be summarized directly into a higher-level integration, assembly, test, and checkout element.

K.3.2 Systems Engineering. The technical and management efforts of directing and controlling a totally integrated engineering effort of a system or program. The following represent many, but not all, of the systems engineering efforts needed for a system or program. If required, one or more areas of effort (e.g., software systems engineering, cybersecurity, etc., may be identified at the next level below systems engineering. In those cases, the remaining totality of systems engineering efforts will be defined as “core systems engineering” at the level equal to the segregated items.

K.3.2.1 Software Systems Engineering. The efforts which encompass software systems technologies, software engineering methods, and management techniques that improve the quality and delivery of software intensive systems and applications.

Includes, for example:

a. The application of a systematic, disciplined, quantifiable approach to the development and operations and support (O&S) of software
b. The determination of software development or software test facility/environment requirements
c. Application of systems engineering to software, that is, the systematic application of scientific and technical knowledge, methods, and experience to the design, implementation, testing, and documentation of software
d. Analyzing the system requirements allocated to the software, developing the software requirements, developing the software architecture, designing the software, implementing the software in the code, integrating the software components, and testing the software to verify that the software satisfies the specified requirements allocated to the software component of a system or subsystem.

K.3.2.2 Integrated Logistics Support (ILS) Systems Engineering. The efforts to ensure the integrated planning and action of a number of disciplines in concert with one another to assure system availability. The planning of each element of ILS (e.g., integrated product support (IPS) elements) is developed in coordination with systems engineering and other efforts.

Includes, for example:

a. Product support management
b. Design interface
c. Sustaining engineering
d. Supply support
e. Maintenance planning and management
f. Packaging, handling, storage, and transportation
g. Technical data
h. Support equipment
i. Training and training support
j. Manpower and personnel
k. Facilities and infrastructure
l. Computer resources

K.3.2.3 Cybersecurity Systems Engineering. The efforts to apply scientific and engineering principles to identify security vulnerabilities and minimize or contain risks associated with these vulnerabilities.

Includes, for example:

a. Cybersecurity requirements evaluation
b. Cyberattack surface characterization
c. Cooperative vulnerability identification
d. Vulnerability analysis
e. System cross-functional cyber analysis
f. Advise on RMF compliance tasks/documents (security assessment plan, etc.)
g. Security configuration management (assess planned services for risk and impact)
h. Develop system-level security architecture
i. Design, develop, and implement system security measures that meets technical requirements
j. Develop and implement specific security countermeasures for the system
k. Develop approaches to mitigate system vulnerabilities
l. Ensure the design of hardware, operating systems, and software applications adequately address cybersecurity requirements for the system

K.3.2.4 Core Systems Engineering. The technical and management efforts that establish the technical framework for delivering materiel capabilities and ensure the effective development and delivery of capability through the implementation of a balanced approach with respect to cost, schedule, performance, and risk. This effort uses integrated, disciplined and consistent systems engineering activities and processes for development of resilient systems that are trusted, assured and easily modified. Systems engineering is composed of 16 processes: eight technical processes and eight technical management processes. These processes provide a structured approach to increasing the technical maturity of a system and increasing the likelihood that the capability being developed balances mission performance with cost, schedule, risk, and design constraints.

To fulfill that purpose, a program implements the systems engineering technical processes to support the

iterative maturation of the system solution or operational need. The technical processes enable the systems engineering team to ensure that the delivered capability accurately reflects the operational needs of the stakeholders. The technical processes include top down design processes such as stakeholder requirements definition, requirements analysis, and architecture design, as well as bottom-up realization processes such as transition, validation, verification, integration, and implementation.

The eight technical management processes are implemented across the acquisition life cycle and provide insight and control to assist the program manager and systems engineer to meet performance, schedule, and cost goals. The eight technical processes closely align with the acquisition life cycle phases and include the top-down design processes and bottom-up realization processes that support transformation of operational needs into operational capabilities. The eight technical management processes are: decision analysis, technical planning, technical assessment, requirements management, risk management, configuration management, technical data management, and interface management.

Also included are specialty engineering disciplines which bring together the hardware, software, and human elements of the systems.

Includes, for example:

a. System safety which is applicable to most DoD systems; this reflects the ubiquitous nature of software-driven functions, network connectivity, and systems of systems; specific certifications include safety, security, cybersecurity and airworthiness
b. Reliability and maintainability – ensure that design interface and integration of the quantitative systems engineering design characteristics (i.e., reliability, maintainability, etc.) with the functional integrated product support elements
c. Quality – ensures configuration item level requirements for the systems and subsystems meet critical functions and key quality attributes.
d. Manufacturing and producibility – ensure manufacturing and producibility readiness, processes assessed and demonstrated, and risks identified, managed and reduced throughout the program's life cycle
e. Human systems integration – optimize total system performance and total ownership costs, while ensuring that the system is designed, operated, and maintained to effectively provide the user with the ability to complete their mission; ensure ergonomics, human factors engineering, and cognitive engineering is employed to provide for effective human-machine interfaces; define the human performance characteristics of the user based on the system description, projected characteristics of target occupational specialties, and recruitment and retention trends; establish requirements for the physical environment; determine the most efficient and cost-effective mix of DoD manpower and contract support; develop training options for operators, maintenance and support personnel; ensure that appropriate environmental safety and occupational health; assess risks to personnel and address, in terms of system design, protection from direct threat events and accidents (such as chemical, biological, and nuclear threats).
f. System of systems (SoS) and system level architecting, modeling and simulation, verification and validation and external interface definition and management
g. For sea systems; the Expanded Ship Work Breakdown Structure (ESWBS), configuration management (811), human factors (892), standardization (893), value engineering (894), and reliability and maintainability (895) elements

Excludes, for example:
a. Actual design engineering and the production engineering directly related to the WBS element with which it is associated
b. Any systems engineering efforts that are called out in software systems engineering, ILS systems engineering, cybersecurity systems engineering, or "other" systems engineering effort separately identified in the WBS.

K.3.2.5 Other Systems Engineering 1...n (Specify). This element should be replaced with other systems engineering elements that cannot be categorized into one of the above elements or need to be separately identified due to high cost, high risk concerns within systems engineering. Each additional element is to be clearly identified and defined.

K.3.3 Program Management. The business and administrative planning, organizing, directing, coordinating, controlling, and approval actions designated to accomplish overall program objectives, which are not associated with specific hardware elements and are not included in systems engineering. If required, one or more areas of effort (e.g., software program management, cybersecurity program management, etc.,) may be identified at the next level below program management. In those cases, the remaining totality of program management efforts will be defined as "core program management" at the level equal to the segregated items.

K.3.3.1 Software Program Management. The software program management encompasses the management of the full software life cycle, from conception to deployment. The function focuses at the system level of applying business and project management skills needed to produce high-quality software products.

Includes, for example:

a. Overseeing requirements analysis and design, and effective implementation and delivery of all fully-tested software
b. Ensure sufficient end-user involvement
c. Maintain communication among customers, developers, users, and project managers
d. Establish realistic or articulated project goals
e. Develop accurate estimates of needed resources
f. Define system requirements and specifications
g. Assure reporting of the project's status
h. Proper management of risks
i. Ensure the use of mature technology and handle the project's complexity

K.3.3.2 Integrated Logistics Support Program Management. The efforts to manage the planning and execution of the ILS disciplines to assure system acquisition logistics availability.

Includes, for example:

a. Support element management, defined as the logistics tasks management effort and technical control, and the business management of the support elements. The logistics management function encompasses the support evaluation and supportability assurance required to produce an affordable and supportable defense materiel system.
b. Planning and management of all the functions of logistics. Examples are: maintenance support planning and support facilities planning; other support requirements determination; support equipment requirements determination; supply support; packaging, handling, storage, and transportation; provisioning requirements determination and planning; training system requirements determination; computer resource determination; organizational, intermediate, and depot maintenance determination management; and data management

K.3.3.3 Cybersecurity Program Management. The management and understanding of cybersecurity program and its ramifications across the organization (only if costs are collected in this manner).

Includes, for example:

a. Overseeing cybersecurity risk assessment, management, and mediation
b. Cybersecurity threat vectors and mitigation processes
c. Ensuring design and management of secure information systems
d. Emerging tools and resources for organizational and platform security

K.3.3.4 Core Program Management. The efforts to understand and manage multiple discipline areas in order the successfully accomplish program objectives for development, production, and sustainment of systems to meet the user's operational needs

Includes, for example:

a. Cost, schedule, performance measurement management, warranty administration, contract management, vendor liaison, subcontract management, etc.
b. For sea systems; the Expanded Ship Work Breakdown Structure (ESWBS), project management (897); data management (896); and supply support (853) elements

Excludes, for example:

a. Actual program management directly related to another WBS element

b. Any program management efforts that are called out in software program management, cybersecurity program management, or "other" program management effort separately identified in the WBS.

K.3.3.5 Other Program Management 1...n (Specify). This element should be replaced with other program management elements that cannot be categorized into one of the above elements or need to be separately identified due to high cost or high risk concerns within program management. Each additional element is to be clearly identified and defined.

K.3.4 System Test and Evaluation. The use of pilot, prototype, production, or specifically fabricated hardware/software to obtain or validate engineering data on the performance of the system during the developmental phase of the program. It also includes all effort associated with the development of any specialized tools or data in support of the system level test program.

Includes, for example:

a. Detailed planning, conduct, support, data reduction and reports (excluding the contract data requirements list data) from such testing, and test articles that are functionally configured to represent and test subsystems/components of the defense materiel end item being developed or produced
b. Design and production of models, specimens, fixtures and instrumentation
c. System level labs that integrate both hardware and software

NOTE: Test articles that are functionally configured to represent and test the complete defense materiel end item being developed or produced, are excluded from this WBS element.

Excludes, for example:

a. All formal and informal testing up through the subsystem level, which can be associated with the hardware/software element acceptance testing

NOTE: These excluded efforts are to be included with the appropriate hardware or software elements.

K.3.4.1 Development Test and Evaluation. The test and evaluation conducted by the developing agency of the DoD component.

It includes test and evaluation conducted to:

a. Demonstrate that the engineering design and development process is complete
b. Demonstrate that the design risks have been minimized
c. Demonstrate that the system will meet specifications
d. Assess the system's military utility when introduced
e. Determine whether the engineering design is supportable (practical, maintainable, safe, etc.) for operational use
f. Provide test data with which to examine and evaluate trade-offs against specification requirements, life cycle cost, and schedule
g. Perform the logistics testing efforts to evaluate the achievement of supportability goals, the adequacy of the support package for the system, (e.g., deliverable maintenance tools, test equipment, technical publications, maintenance instructions, and personnel skills and training requirements, etc.)

Includes, for example:

a. All contractor/system developer in-house effort
b. Where applicable, models, tests and associated simulations (e.g., such as wind tunnel, static, drop, and fatigue); integration ground tests; test bed aircraft and associated support; qualification test and evaluation, development flight test, test instrumentation, environmental tests, ballistics, radiological, range and accuracy demonstrations, test facility operations, test equipment (including its support equipment), chase and calibrated pacer aircraft and support thereto, and logistics testing
c. For aircraft; avionics integration test composed of the following:
    i. Test bench/laboratory, including design, acquisition, and installation of basic computers and test equipment that will provide an ability to simulate in the laboratory the operational environment of the

avionics system/subsystem

ii. Air vehicle equipment, consisting of the avionics and/or other air vehicle subsystem modules that are required by the bench/lab or flying test bed in order to provide a compatible airframe avionics system/subsystem for evaluation purposes

iii. Flying test bed, including requirements analysis, design of modifications, lease or purchase of test bed aircraft, modification of aircraft, installation of avionics equipment and instrumentation, and checkout of an existing aircraft used essentially as a flying avionics laboratory

iv. Avionics test program, consisting of the effort required to develop test plans/procedures, conduct tests, and analyze hardware and software test results to verify the avionics equipment's operational capability and compatibility as an integrated air vehicle subsystem

v. Software, referring to the effort required to design, code, de-bug, and document software programs necessary to direct the avionics integration test

d. For engines: engine military qualification tests and engine preliminary flight rating tests
e. For sea systems: model basin, hydrostatic, fatigue, shock, special sea tests and trials, etc., including the Expanded Ship Work Breakdown Structure (ESWBS), trials agenda preparation, data collection and analysis (842); dock and sea trials (9823); and hull vibration survey (9825) elements
f. For missiles: test articles such as inert measurement vehicles, launch separation vehicles, separation and control test vehicles, boost test vehicles
g. For ordnance: test articles such as ballistic test rounds, inert measurement rounds, dummy rounds, launch separation rounds, etc.

K.3.4.2 Operational Test and Evaluation. The test and evaluation conducted by agencies other than the developing command to assess the prospective system's military utility, operational effectiveness, operational suitability, logistics supportability (including compatibility, inter-operability, reliability, maintainability, logistic requirements, etc.), cost of ownership, and need for any modifications.

Includes, for example:

a. Initial operational test and evaluation conducted during the development of a system
b. Such tests as system demonstration, flight tests, sea trials, mobility demonstrations, on-orbit tests, spin demonstration, stability tests, qualification operational test and evaluation, etc., and support thereto, required to prove the operational capability of the deliverable system.
c. Contractor support (e.g., technical assistance, maintenance, labor, material, etc.) consumed during this phase of testing
d. Logistics testing efforts to evaluate the achievement of supportability goals and the adequacy of the support for the system (e.g., deliverable maintenance tools, test equipment, technical publications, maintenance instructions, personnel skills and training requirements, and software support facility/environment elements)

K.3.4.3 Cybersecurity System Test and Evaluation. The developmental test and evaluation and operational test and evaluation conducted and monitored by the developing agency of the DoD. The technical efforts of ensuring the confidentiality, integrity, and availability of information and technology by monitoring and defending against cyber (network) attacks.

Includes, for example:

a. Vulnerability scanning and interpretation
b. Vulnerability testing and penetration testing (usually linked to patch management)
c. Security information and event management
d. Destructive and non-destructive exploitation
e. Test conducted in an operational environment with certified red teams
f. Cybersecurity compliance tracking and reporting
g. Malware scanning, detection, and prevention services
h. Security, IT certification, and accreditation compliance services

K.3.4.4 Mock-ups/System Integration Labs (SILs). The design engineering and production of system or subsystem mock-ups that have special contractual or engineering significance or that are not required solely for the conduct of one of the above elements of testing. SILs are often used in lieu of (or in addition to) mock-ups. SILs are risk reduction facilities where software and hardware can be developed, integrated, tested, and evaluated for both standalone functionality and/or interoperability prior to being fielded.

Includes, for example:
a. Hardware/lab equipment
b. SIL Software (written to simulate the operating environment or written to operate the SIL)

K.3.4.5 Test and Evaluation Support. The support elements necessary to operate and maintain, during test and evaluation, systems and subsystems, which are not consumed during the testing phase and are not allocated to a specific phase of testing.

Includes, for example:
a. Repairable spares, repair of reparables, repair parts, consumables, warehousing and distribution of spares and repair parts, test and support equipment, test bed vehicles, drones, surveillance aircraft/chase aircraft, tracking vessels, contractor technical support

Excludes, for example:
a. Operational and maintenance personnel, special fixtures, special instrumentation, etc., that are utilized and/or consumed in a single element of testing and that should be included under that element of testing

K.3.4.6 Test Facilities. The special test facilities required for performance of the various developmental tests necessary to prove the design and reliability of the system or subsystem.

Includes, for example:
a. Test tank test fixtures, propulsion test fixtures, white rooms, test chambers, range/targeting facilities

Excludes, for example:
a. Brick and mortar-type facilities identified as industrial facilities

K.3.5 Training. Deliverable training services, devices, accessories, aids, equipment, and parts used to facilitate instruction through which personnel will learn to operate and maintain the system with maximum efficiency.

Includes, for example:
a. All effort associated with the design, development, and production of deliverable training equipment and its associated software as well as the execution of training services

Excludes, for example:
a. Overall planning, management, and task analysis functions inherent in the WBS element systems engineering/program management

K.3.5.1 Equipment. Distinctive deliverable end items of training equipment, assigned by either a contractor or military service, required to meet specific training objectives.

Includes, for example:
a. Operational and Maintenance Trainers and training equipment including items such as cutaways, mock-ups, and models (e.g. Operator Instructional Equipment, Maintainer Instructional Equipment)

K.3.5.2 Services. Deliverable training services, accessories, and courseware aids necessary to accomplish the objectives of training.

Includes, for example:
a. Operational and Maintenance Training Services including courses, course materials; and curriculum required to design, execute, and produce a contractor developed training program and related software programs (e.g. operator instructional services, maintainer instructional services)

Excludes, for example:
a. Deliverable training data associated with support data (see Data Deliverables 1...n (Specify), Support Data)

K.3.5.3 Facilities. The special construction necessary to accomplish training objectives.

Includes, for example:

a. Modification or rehabilitation of existing training facilities and infrastructure used to accomplish training objectives

Excludes, for example:

a. Installed equipment used to acquaint the trainee with the system or establish trainee proficiency
b. The brick and mortar-type facilities identified as industrial facilities

K.3.5.4 Training Software Release 1...n (Specify). Updated/upgraded software for training purposes delivered to the field during the acquisition phase.

K.3.6 Data. The deliverable data required to be listed on a contract data requirements list.

Includes, for example:

a. Only such effort that can be reduced or avoided if the data item is eliminated
b. Government-peculiar data; acquiring, assembling, reproducing, packaging and shipping the data
c. Transforming data into Government format, reproducing and shipping data identical to that used by the contractor but in a different format

K.3.6.1 Data Deliverables 1...n (Specify). Deliverable data which provides technical, engineering, management, support, or other data required for contract delivery.

Includes, for example:

a. Technical Publications. Technical data, providing instructions for installation, operation, maintenance, training, and support, formatted into a technical manual. Data may be presented in any form regardless of the form or method of recording. Technical orders that meet the criteria of this definition may also be classified as technical manuals. For sea systems: Expanded Ship Work Breakdown Structure (ESWBS), technical manuals and other data (856) element.
b. Engineering Data. Recorded scientific or technical information (regardless of the form or method of recording) including computer software documentation. Engineering data defines and documents an engineering design or product configuration (sufficient to allow duplication of the original items) and is used to support production, engineering, and logistics activities. For sea systems; Expanded Ship Work Breakdown Structure (ESWBS), design support, ship's selected records (8302); design support, services, reproduction (8303); and engineering drawings and specifications (855) elements.
c. Management Data. The data items necessary for configuration management, cost, schedule, contractual data management, program management, etc., required by the Government. For sea systems; Expanded Ship Work Breakdown Structure (ESWBS), contract data requirements (988) element.
d. Support Data. The data items designed to document support planning in accordance with functional categories

K.3.6.2 Data Repository. The activity and enterprise data storage entity (or sometimes entities) for Government approved documents that are the property of the Government into which data has been specifically partitioned for analytical or reporting purposes. As custodian for the Government, the repository, authorized by approved change orders, maintains master documents at the latest approved revision level.

Includes, for example:

a. All effort necessary to maintain documents

K.3.6.3 Data Rights 1...n (Specify). Government's license rights of valuable intellectual property including technical data of any recorded information of a scientific or technical nature (e.g., product design or maintenance data, computer databases, and computer software documentation); and computer software including executable code, source code, code listings, design details, processes, flow charts, and related material.

Includes, for example:

a. Unlimited Rights. Developed exclusively at Government expense, and certain types of data (e.g., Form, Fit, and Function data (FFF); Operation, Maintenance, Installation, and Training (OMIT)). These rights involve

the right to use, modify, reproduce, display, release, or disclose technical data in whole or in part, in any manner, and for any purpose whatsoever, and to have or authorize others to do so.

b. Government Purpose Rights. This right involves the right to use, duplicate, or disclose technical data for Government purposes only, and to have or permit others to do so for Government purposes only. Government purposes include competitive procurement, but do not include the right to permit others to use the data for commercial purposes.
c. Limited Rights. A limited rights agreement permits the Government to use proprietary technical data in whole or in part. It also means that the Government has to obtain the expressed permission of the party providing the technical data to release it, or disclose it, outside the Government.

K.3.7 Peculiar Support Equipment. The design, development, and production of those deliverable items and associated software required to support and maintain the system or portions of the system while the system is not directly engaged in the performance of its mission, and which are not common support equipment. Items should be designated by commodity subassembly (airframe, engine, avionics, etc.).

Includes, for example:

a. Vehicles, equipment, tools, etc., used to fuel, service, transport, hoist, repair, overhaul, assemble, disassemble, test, inspect, or otherwise maintain mission equipment
b. Any production of duplicate or modified factory test or tooling equipment delivered to the Government for use in maintaining the system. (Factory test and tooling equipment initially used by the contractor in the production process but subsequently delivered to the Government will be included as cost of the item produced.)
c. Any additional equipment or software required to maintain or modify the software portions of the system

Excludes, for example:

a. Overall planning, management, and task analysis functions inherent in the work breakdown structure elements Systems Engineering and Program Management
b. Common support equipment, presently in the DoD inventory or commercially available, bought by the using command, not by the acquiring command

K.3.7.1 Test and Measurement Equipment. The peculiar or unique testing and measurement equipment that allows an operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening, or quality assurance effort at an organizational, intermediate, or depot level of equipment support.

Includes, for example:

a. Test measurement and diagnostic equipment, precision measuring equipment, automatic test equipment, manual test equipment, automatic test systems, test program sets, appropriate interconnect devices, automated load modules, tapes, and related software, firmware and support hardware (power supply equipment, etc.) used at all levels of maintenance
b. Packages that enable line or shop replaceable units, printed circuit boards, or similar items to be diagnosed using automatic test equipment

K.3.7.1.1 Test and Measurement Equipment (Airframe/Hull/Vehicle). This element captures the cost of the airframe, ship hull, or ground vehicle hull/frame related test and measurement equipment. Identify the related WBS subassemblies associated with the airframe/hull/vehicle. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested

K.3.7.1.2 Test and Measurement Equipment (Propulsion). This element captures the cost of the propulsion system, engines, prime movers, turbines, etc. related test and measurement equipment. Identify the related WBS subassemblies associated with propulsion. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.7.1.3 Test and Measurement Equipment (Electronics/Avionics). This element captures the cost of the electronics/avionics related test and measurement equipment. Identify the related WBS subassemblies associated with electronics/avionics. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.7.1.4 Test and Measurement Equipment (Other Major Subsystem 1...n (Specify)). This element captures the cost of other major subsystems (e.g., armament, weapons, vehicle subsystems, etc.) not captured above related test and measurement equipment. Identify the related WBS subassemblies associated with the other major subsystems. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.7.2 Support and Handling Equipment. The peculiar or unique tools and handling equipment used for support of the mission system at an organizational, intermediate, or depot level

Includes, for example:

a. Ground support equipment, vehicular support equipment, powered support equipment, non-powered support equipment, munitions material handling equipment, materiel handling equipment, and software support equipment (hardware and software)

K.3.7.2.1 Support and Handling Equipment (Airframe/Hull/Vehicle). This element captures the cost of the airframe, ship hull, or ground vehicle hull/frame related support and handling equipment. Identify the related WBS subassemblies associated with airframe/hull/vehicle. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.7.2.2 Support and Handling Equipment (Propulsion). This element captures the cost of propulsion related support and handling equipment. Identify the related WBS subassemblies associated with propulsion. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.7.2.3 Support and Handling Equipment (Electronics/Avionics). This element captures the cost of the electronics/avionics related support and handling equipment. Identify the related WBS subassemblies associated with electronics/avionics. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.7.2.4 Support and Handling Equipment (Other Major Subsystem 1...n (Specify)). This element captures the cost of other major subsystems (e.g., armament, weapons, vehicle subsystems, etc.) not captured above related support and handling equipment. Identify the related WBS subassemblies associated with the other major subsystems. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.8 Common Support Equipment. The items required to support and maintain the system or portions of the system while not directly engaged in the performance of its mission, and which are presently in the DoD inventory for support of other systems.

Includes, for example:

a. Acquisition of additional quantities of this equipment needed to support the item
b. All efforts required to assure the availability of this equipment to support the item

K.3.8.1 Test and Measurement Equipment. The common testing and measurement equipment that allows an operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening, or quality assurance effort at an organizational, intermediate, or depot level of equipment support.

Includes, for example:

a. Test measurement and diagnostic equipment, precision measuring equipment, automatic test equipment, manual test equipment, automatic test systems, test program sets, appropriate interconnect devices, automated load modules, tapes, and related software, firmware, and support hardware (power supply equipment, etc.) Used at all levels of maintenance
b. Packages that enable line or shop replaceable units, printed circuit boards, or similar items to be diagnosed using automatic test equipment

K.3.8.1.1 Test and Measurement Equipment (Airframe/Hull/Vehicle). This element captures the cost of the airframe, ship hull, or ground vehicle hull/frame related test and measurement equipment. Identify the related WBS subassemblies associated with the airframe/hull/vehicle. If necessary, further breakdown by maintenance level

(operational/intermediate/depot), may be requested.

K.3.8.1.2 Test and Measurement Equipment (Propulsion). This element captures the cost of the propulsion system, engines, prime movers, turbines, etc. related test and measurement equipment. Identify the related WBS subassemblies associated with propulsion. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.8.1.3 Test and Measurement Equipment (Electronics/Avionics). This element captures the cost of the electronics/avionics related test and measurement equipment. Identify the related WBS subassemblies associated with electronics/avionics. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.8.1.4 Test and Measurement Equipment (Other Major Subsystem 1...n (Specify)). This element captures the cost of other major subsystems (e.g., armament, weapons, vehicle subsystems, etc.) not captured above related test and measurement equipment. Identify the related WBS subassemblies associated with the other major subsystems. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.8.2 Support and Handling Equipment. The common tools and handling equipment used for support of the mission system at an organizational, intermediate, or depot level

Includes, for example:

a. Ground support equipment, vehicular support equipment, powered support equipment, non-powered support equipment, munitions material handling equipment, materiel handling equipment, and software support equipment (hardware/software)

K.3.8.2.1 Support and Handling Equipment (Airframe/Hull/Vehicle). This element captures the cost of the airframe, ship hull, or ground vehicle hull/frame related support and handling equipment. Identify the related WBS subassemblies associated with airframe/hull/vehicle. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.8.2.2 Support and Handling Equipment (Propulsion). This element captures the cost of propulsion related support and handling equipment. Identify the related WBS subassemblies associated with propulsion. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.8.2.3 Support and Handling Equipment (Electronics/Avionics). This element captures the cost of the electronics/avionics related support and handling equipment. Identify the related WBS subassemblies associated with electronics/avionics. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.8.2.4 Support and Handling Equipment (Other Major Subsystem 1...n (Specify)). This element captures the cost of other major subsystems (e.g., armament, weapons, vehicle subsystems, etc.) not captured above related support and handling equipment. Identify the related WBS subassemblies associated with the other major subsystems. If necessary, further breakdown by maintenance level (operational/intermediate/depot), may be requested.

K.3.9 Operational/Site Activation by Site 1...n (Specify). The real estate, construction, conversion, utilities, and equipment to provide all facilities required to house, service, and launch prime mission equipment at the organizational and intermediate level.

Includes, for example:

a. Conversion of site, ship, or vehicle
b. System assembly, checkout, and installation (of mission and support equipment) into site facility or ship to achieve operational status
c. Contractor support in relation to operational/site activation

K.3.9.1 System Assembly, Installation, and Checkout. The materials and services involved in the assembly of mission equipment at the site.

Includes, for example:

a. Installation of mission and support equipment in the operations or support facilities and complete system checkout or shakedown to ensure operational status. Where appropriate, specify by site, ship, or vehicle.
b. The efforts and activities associated with shipping the system from contractor facility to customer site. That site could be a DT&E site, an installation and checkout site, or any similar site that is outside the direct control of the contractor.

Excludes, for example:

a. Field team installation

K.3.9.2 Contractor Technical Support. The materials and services provided by the contractor related to activation.

Includes, for example:

a. Repair of reparables, standby services, and final turnover

K.3.9.3 Site Construction. Real estate, site planning and preparation, construction, and other special-purpose facilities necessary to achieve system operational status.

Includes, for example:

a. Construction of utilities, roads, and interconnecting cabling

K.3.9.4 Site/Ship/Vehicle Conversion. The materials and services required to convert existing sites, ships, or vehicles to accommodate the mission equipment and selected support equipment directly related to the specific system.

Includes, for example:

a. Operations, support, and other special purpose facilities conversion necessary to achieve system operational status, e.g., launch. Where appropriate, specify by site, ship, or vehicle

K.3.9.5 Interim Contractor Support (ICS). The effort required to provide temporary contractor support in lieu of a permanent support solution (organic or commercial) for a predetermined time, while a permanent support capability is put in place. Interim support is usually required for support of prototypes and early test and production assets during development and initial fielding (i.e., Initial Operating Capability (IOC)).

Includes, for example:

a. Providing life cycle logistics in accordance with the integrated product support (IPS) elements in support of the prime mission product.

Excludes, for example:

a. The development and production of the original prime mission product.

K.3.10 Contractor Logistics Support (CLS). Contracted weapon system sustainment including performance of maintenance and/or materiel management functions for a DoD weapon system by a commercial activity or contractor sustainment of a weapon system that is intended to start after a permanent decision is made to cover the operations and support efforts of the weapon system. CLS generally starts before FOC (final operating capability) or when performance based logistics (PBL) is implemented in the operating and support (O&S) phase.

Includes, for example:

a. Prime Mission Product (PMP) maintenance and refurbishment. The cost for this element includes maintenance and refurbishment (including the development and production) of existing operational systems.
b. Support functions required to maintain the system, such as sustaining engineering, program management, logistics support, and supply chain management
c. Test and evaluation for system and subsystem modifications
d. Repair of reparable items; replacement of condemned items (including all PMP, support equipment, and training equipment)
e. Operational, maintenance and other personnel required at the operational unit level

f. Unit operations costs, including operating material and support services at the operating unit
g. Installation and personnel support functions in support of the unit level manpower

Excludes, for example:
a. Does not include interim contractor support (ICS), a temporary measure for a system's initial period of operation before a permanent form of support is in place.
b. Contractor sustainment support for a specific sustainment task that a service would otherwise conduct itself.

K.3.11 Industrial Facilities. The construction, conversion, or expansion of industrial facilities for production, inventory, and contractor depot maintenance required when that service is for the specific system.

Includes, for example:
a. Equipment acquisition or modernization, where applicable
b. Maintenance of these facilities or equipment
c. Industrial facilities for hazardous waste management to satisfy environmental standards

Excludes, for example:
a. Capital equipment

K.3.11.1 Construction/Conversion/Expansion. The real estate and preparation of system peculiar industrial facilities for production, inventory, depot maintenance, and other related activities.

K.3.11.2 Equipment Acquisition or Modernization. The production equipment acquisition, modernization, or transfer of equipment for the particular system. This pertains to Government owned and leased equipment under facilities contract.

K.3.11.3 Maintenance (Industrial Facilities). The maintenance, preservation, and repair of industrial facilities and equipment.

K.3.12 Initial Spares and Repair Parts. The deliverable spare components, assemblies, and subassemblies used for initial replacement purposes in the materiel system equipment end item.

Includes, for example:
a. Repairable spares (reparables) and repair parts required as initial stockage to support and maintain newly fielded systems or subsystems during the initial phase of service, including pipeline and war reserve quantities, at all levels of maintenance and support. Lower level WBS breakouts should be by subsystem.
b. Spare training and support equipment items
c. The combination of resources, processes, planning, procedures, design, considerations, methods, and all hardware to ensure that all system, equipment, and support items are preserved, packaged, handled, and transported properly, including environmental considerations, equipment preservation for short and long term storage, and transportability. This includes requirements such as special environmentally controlled, shock isolated containers for transport to and from repair facilities and ensuring proper Care of Supplies in Storage (COSIS) program requirements are followed.

Excludes, for example:
a. Development test spares and spares provided specifically for use during installation, assembly, and checkout on site

K.4 DEFINITIONS OF COMMON ELEMENTS APPLICABLE TO SPACE SYSTEMS ONLY.

When the Space Appendix is used the common elements have been specifically grouped into four subcategories. These subcategories shall be used when creating program/contract WBS. Lower level elements to the four categories may be created but must sum to the correct category. The four common elements to be used are systems engineering, integration and test, program management, and support equipment (SEIT/PM and Support Equipment).

K.4.1 Space Systems. The Space community must report, at a minimum, the common elements of systems engineering, integration and test and program management (SEIT/PM) and Support Equipment. The following

paragraphs represent WBS elements common to all Space System WBS elements.

K.4.1.1 SEIT/PM and Support Equipment. This section provides the WBS elements common to all Space System WBS elements. Consistent with the manner in which space systems are designed, built, and tested, there are multiple levels of systems engineering (SE), assembly, integration and test (AI&T), program management (PM), and support equipment throughout the WBS. It is expected that, whenever possible, SEIT/PM and Support Equipment costs be reported with the item(s) they are supporting. For example, subsystem management of the attitude control subsystem should be booked under the ACS WBS element. If a contractor (or other developer) manages the project by a different means and does not collect any or all SEIT/PM and Support Equipment elements at this level, then the costs for those elements shall be reported at the next higher-level WBS element. For example, an electronics product manager with areas of responsibility spanning both ACS and the TT&C subsystems cost should have their effort defined and collected within the space vehicle bus SEIT/PM element. SEIT/PM and Support Equipment shall be broken out into their individual elements (i.e., systems engineering; assembly, integration and test; program management; and support equipment each defined below) for WBS levels one through four (subsystem). At level five (product level), systems engineering and program management (SEPM) responsibilities are often indistinct and may be combined into a single SEPM element

K.4.1.1.1 Systems Engineering. This WBS element contains all the resources associated with all engineering from functional specialists who provide technical planning, technical management analysis, and support efforts for development and production activities. The Systems Engineering entity is responsible for the analysis, derivation, allocation, and traceability, of requirements, design, and interfaces. Sub-elements to Systems Engineering are defined below and include: SE - Management and Control; SE - Requirements Analysis; SE - Logical (Functional) Analysis; SE - Physical Design; SE - Design Verification and Validation; SE - Performance/Analysis; SE - Specialty Engineering; and SE - Mission Analysis.

Systems Engineering includes, for example:

a. Systems definition
b. Systems analysis (e.g., thermal, power, mass properties, environments, dynamics, modeling and simulation)
c. Requirements analysis and allocation
d. Interface definition and control
e. Performance assessment and verification/validation
f. Technical direction (SE leadership, planning, and coordination)
g. System safety
h. Quality assurance, product assurance
i. Mission assurance and critical skill protection and retention
j. Logistics Support Analysis (LSA including reliability, availability, maintainability, producibility)
k. Engineering services
l. Configuration control
m. System documentation
n. Algorithm development
o. Recommended Operating Procedures (PROCs), Satellite Databases
p. Risk management
q. Human engineering
r. Security engineering
s. Electromagnetic Compatibility (EMC)/Electromagnetic Interference (EMI)
t. Radiation and survivability
u. Contamination and control
v. Autonomy and fault management
w. Other specialty engineering
x. Engineering and design (excluding box level) including Electrical Design Integration (EDI), Mechanical Design Integration (MDI), Thermal Design Integration (TDI), and Facility Design
y. Parts, materials, and processes (PM&P)
z. Trade studies
aa. System studies

Excludes, for example:

a. Launch systems integration that is contained in its own Level 3 element

K.4.1.1.1.1 SE - Management and Control. This element is the primary collector of the following SE functions: SE planning and monitoring, interface management, configuration control, risk management

This element encompasses all the tasks necessary to plan, execute, and control the other engineering efforts. In addition, it ensures the appropriate flow-down of requirements and technical guidance of subcontractors and vendors. Control activities include monitoring (measurements/metrics programs, technical reviews and audits, corrective action programs), interface management/control, configuration control, data management, decision-making, architecture management, requirements management, and risk management. It may also include, for example: SE associated data management; technical direction of subcontractor/vendor efforts, SE associated business management and performance measurement.

K.4.1.1.1.2 SE - Requirements Analysis. This element is the primary collector of the following SE products/functions:

a. Requirements baseline
b. Requirements allocation
c. Requirements traceability
d. Requirements and specification development

This element encompasses the initial (beginning process of the classic systems engineering loop) effort to develop, validate, approve, and maintain the system requirements documentation which will ultimately define all requirements and constraints at the related WBS level, and their allocations to the next lower level. Requirements Analysis examines, evaluates, and translates the customer's external inputs into a set of functional and performance requirements (the requirements baseline) that is the basis for the subsequent Logical (Functional) Analysis process step. As the program matures, Requirements Analysis will include maintaining traceability between evolving system architecture and requirements. It may also include for example: Interoperability needs; tradeoff documentation; customer reviews (requirement validation and documentation agreement); specification documents and trees.

K.4.1.1.1.3 SE - Logical (Functional) Analysis. This element is the primary collector of the following SE products/functions:

a. Functional architecture
b. Design functional analysis
c. Functional baseline
d. Data flows
e. Design operations/system concept development

This element encompasses the systems engineering effort to develop a logical representation (functional architecture) of the system by performing allocations/role assignments based on tradeoff analyses. The development of the resulting logical solution representation (a functional architecture) would encompass the following efforts:

a. Establishing minimum or threshold required operational capabilities
b. Modeling system behavior
c. Analysis of data flow relationships
d. Baseline of allocated or derived performance/functional requirements at the next lower level
e. Documentation of the relationships to the physical implementation in a decision database
f. Definition of both the internal and external interfaces
g. Record decisions for functional decomposition, grouping, sequencing, timing, iteration, concurrency, etc.
h. Validation through customer involvement to ensure all requirements can be met and are consistent with cost and schedule constraints, and traceability between and compliance with each element of the requirements

SE - Logical (Functional) Analysis may also include, for example:

a. Concept of operations development
b. Scenario demonstrations with pertinent states and modes analyses
c. Functional decomposition tracking and data flow traces

K.4.1.1.1.4 SE - Physical Design. This element is the primary collector of the following SE products/functions:

a. Design-to baseline
b. Allocated baseline
c. Design release baseline
d. Design and Design Integration

e. Algorithm requirements/development

This element encompasses the physical design which is the systems engineering process (effort and resultant design) of selecting and organizing the parts, materials, and organizational processes (manpower and skill levels) necessary to comply with the requirements created in the Requirements Baseline (see SE-Requirements Analysis) and implemented here in the allocated baseline. The physical design defines an integrated system or product, including the interaction of the lower-level elements. It delivers the validated, approved, and maintained "design-to" allocated baseline. The allocated baseline includes specifications and interface documents grouped by each system element such as segment, subsystem, component (hardware and software), computer software unit, and part. Additionally, this process will document the engineering basis for all design solutions (design release baseline). The resulting physical architecture includes design, design integration, and algorithm requirements and their development.

SE - Physical Design may also include, for example:
a. Creation and maintenance of a configured item list
b. Architecture views
c. Interface control documentation
d. Configuration control description
e. Mathematical algorithm requirements
f. Software algorithm descriptions
g. Engineering and operational algorithm descriptions; for hardware: drawings, parts lists, and assembly and process instructions; for software: descriptions such as flow diagrams that define inputs, actions, outputs, and response time constraints.

K.4.1.1.1.5 SE - Design Verification and Validation. This element is the primary collector of the following SE products/functions:
a. Validation (design) activities
b. Verification (design) activities

This element comprises the verification of the system's design and development to confirm that the system meets all documented requirements, validation of the evolving physical solution, and development of the associated required systems engineering products. Each completed or integrated product is verified to comply with its requirements in the allocated and design release baselines (see SE - Physical Design), and the system is subsequently verified to comply with the requirements baseline (see SE - Requirements Analysis).

SE - Design Verification and Validation may also include, for example:
a. System effectiveness evaluation and manufacturing process proofing
b. Maintaining a record of all discrepancies
c. Definition of verification to demonstrate proof of concept
d. Verification plan
e. Design qualification (verification) data
f. Acceptance verification data
g. Product configuration baseline
h. System validation plan and data

K.4.1.1.1.6 SE - Performance/Analysis. This element is the primary collector of the following SE products/functions:
a. Performance and Analysis
b. Value engineering
c. Trades
d. Decision analyses
e. Operational analyses
f. Environmental analyses and impact assessments
g. Analysis/assessment of training (end item)
h. Transition (deployment) analyses
i. Supportability analyses
j. Disposal analyses

This element includes the broad range of assessments, trades, and analyses performed over the entire life cycle

of a system. This work is performed as necessary to determine balanced technical solutions pertaining to system concepts, technologies, requirements, and designs of a system and its components. This element includes the effort to:

a. Determine analyses required to meet contractual requirements, objectives, applicable standards, engineering practices, and data item descriptions that apply.
b. Determine and define each analysis methodology applying the specific analytical attributes and guidance provided below:
    i. Define the analytical tasks to be performed.
    ii. Plan analysis such that their performance is timed to provide optimal benefit to support other required analyses and trades as well as system and program design, production, and test decisions.
    iii. Retain analysis results in the decision and verification databases.
    iv. Periodically validate models used to support the analysis.
    v. Perform the analysis following the approved method or procedure.
    vi. Prepare the analysis report.
    vii. Leverage the analytical results with the other engineering and program activities

SE - Performance/Analysis may also include, for example:

a. Assessments of system effectiveness, cost, schedule, and risk as inputs to support SE – Management and Control and Program Management measurement/evaluation/reporting tasks
b. Tradeoff analyses
c. Schedule assessments and reports
d. Risk assessments and reports
e. Documenting implemented decisions

K.4.1.1.1.7 <u>SE - Specialty Engineering.</u> This element is the primary collector of the following SE disciplines:

a. Parts, materials, and processes (PMP)
b. Structural/dynamics
c. Manufacturing - producibility and methods evaluation
d. Quality assurance - processes and policy
e. Specialty/detailed engineering support to test
f. Survivability
g. Environmental, safety, and occupational health (ESOH)
h. Contamination
i. Mass properties
j. Logistics
k. Human system integration (HSI)
l. EMI/EMC analysis
m. System safety

This element is a grouping of engineering disciplines, each with a narrower (specialty) focus than the more general engineering disciplines. These specialty areas are responsible for reviewing the entire design and development process for the impact on their areas of responsibility, performing required analyses, and for recommending areas for improvement. Most analysis methods in these disciplines are based on the construction and exploration of models or simulations that address specialized engineering areas, such as electromagnetic compatibility, reliability, safety, and security.

It may also include, for example: parts control; radiation-hardening design solutions; addressing/assessing qualified sources of supply and industrial base; static and dynamic loads analysis; structural analysis incorporating applied mechanics/mathematics and materials science; computing structural deformations, internal forces, stresses, support reactions, accelerations, and stability; producibility engineering and analyses; manufacturing methods and processes; long lead item determination; qualified inspection/test processes; verifying design test requirements are defined, allocated, and traced to system-level requirements; threat assessments and analysis; ensuring system-level ESOH requirements are defined, allocated, baselined, and traced to the system-level requirements; developing a containment program, including procedures for product safe use and disposal; cleanliness; critical mass properties; weight balancing.

K.4.1.1.1.8 <u>SE - Mission Analysis.</u> This element is the primary collector of the following SE products/functions:

a. Mission systems engineering

b. Modeling and Simulation (mission and system level)
c. Reliability, maintainability, and supportability
d. System security and cybersecurity (information assurance)

Mission analysis is the structured method of defining a mission and ensuring that the mission success criteria are clear and well understood. It ensures that the mission fulfills the overall success criteria and at the same time stays within the project boundary conditions technical, political and financial. This element is usually performed at early stages (e.g. program concept, pre-milestone A), but some sub-elements can continue throughout the program life cycle in order to monitor and update the analysis and products to support mission success. The following activities are performed iteratively:

a. Definition of mission objectives and their success criteria
b. Define preliminary mission requirements and constraints
c. Conduct mission characterization
d. Identify applicable mission concepts
e. Define mission architectures for subsequent system level trades
f. Perform mission concept evaluation and selection
g. Document baseline characteristics and rational for selection

It may also include, for example:

a. Baseline mission architecture
b. Stakeholder needs and capability gap assessments
c. Technology development plan
d. Mission system performance
e. Mission analysis facilities/computing labs (or modifications)
f. Failure reporting analysis, corrective action system (FRACAS)
g. Failure modes effects and criticality analysis (FMECA/FMEA/Component Inherent Characteristics (CIC))
h. Fault coverage
i. Redundancy/single string analysis
j. Security key management plan
k. Program protection plan
l. Program security plan
m. Cryptographic verification plans, procedures, and reports

K.4.1.1.2 Assembly, Integration and Test (AI&T). This element includes the effort of technical and functional activities required to assemble and test at one level into a next higher level (e.g., from product level to subsystem level) as a whole and not directly part of any other individual element. Sub-elements to AI&T are defined below and include AI&T - Management and Support; AI&T - Test Engineering; AI&T - Assembly, Integration and Test Execution; and AI&T - Environmental/Special Testing.

Assembly, Integration and Test includes, for example:

a. Development of test plans and procedures
b. Test preparations
c. Test support and management
d. Hardware/software integration
e. Software CSCI integration
f. Hardware integration and assembly (e.g., electrical and mechanical integration, including kitting)
g. Test, checkout, inspection and acceptance
h. System test and evaluation to include: developmental test and evaluation, operational test and evaluation
i. I&T management, leadership, planning, and scheduling
j. Analysis and documentation of test results
k. Transportation and movement (excludes transportation of the space vehicle to the launch pad covered under the launch operations WBS element)
l. Integration hardware
m. Processing/handling of delivered initial spares and other repair parts
n. I&T facilities

Excludes, for example:

a. Integration and test efforts that can be associated specifically with the equipment (hardware/software) for a

unit or CSCI (Level 5 element)

K.4.1.1.2.1 AI&T - Management and Support. This element is the primary collector of the following AI&T products/functions:

a. AI&T - leadership, planning, scheduling (including test scheduling), staffing
b. AI&T Management support to test engineering
c. AI&T product assurance
d. Inspection
e. Integration hardware and material
f. AI&T training
g. Initial spares and repair parts processing (delivery preparation, kitting, packaging, etc.); excludes cost of hardware itself (booked in hardware WBS elements).
h. AI&T facilities and factory infrastructure support

This Management and Support element includes the leadership of the technical and functional efforts of AI&T. At lower-levels it provides management support of the associated lower-level elements (such as components, software units, and configured items,) into the next-higher level assembly. At higher levels it supports final assembly and test. It includes, as accomplished at the various levels of the AI&T hierarchy, the management, control, and support of business operations (e.g. planning, cost, schedule, performance measurement, etc.), administrative support, and any logistical and supply chain management activity required for AI&T activities.

AI&T - Management and Support efforts include, for example:

a. Leadership for test planning, execution and reporting;
b. Support to Test Engineering for execution of the test events
c. AI&T support for product assurance level-of-effort activities (e.g. quality assurance and engineering, inspection, system safety)
d. Other organizational inspection activities related to receiving, factory and vendor liaison
e. Test readiness review
f. AI&T facility and factory infrastructure support activities (e.g. factory equipment maintenance)
g. Test completion meetings, material review board, discrepancy review, failure board
h. AI&T property control
i. Integration hardware, material, and consumables, including their management
j. Payload or instrument provider AI&T training
k. Inter-facility shipping, transportation, and handling (excludes final shipping of end item to customer and storage shipment - see Launch Operations and Storage WBS elements)

AI&T - Management and Support may also include the following processes/products as they pertain to AI&T, for example: management plans; organizational charts and staffing plan; program policies, procedures, processes, and instructions; status reports; training materials; Contract Work Breakdown Structure (CWBS) creation for area of responsibility and work packages in the Earned Value Management System (EVMS).

K.4.1.1.2.2 AI&T - Test Engineering. This element is the primary collector of the following AI&T processes/products:

a. Test engineering
b. Test planning (excludes scheduling, see AI&T Management and Support)
c. Test requirements, plans, and procedures
d. Test aids
e. AI&T database
f. Test data and analysis
g. Test reports

The AI&T - Test Engineering element includes all test engineering efforts to develop requirements, plans, and test procedures to support AI&T. It also includes direct organizational support during test operations to ensure test plan execution and to analyze test results.

AI&T - Test Engineering efforts include, for example:

a. Developing AI&T technical requirements and plans
b. Test (mechanical, electrical, software) planning activities to include instrumentation planning

c. Preparing, maintaining, and controlling test procedures and documentation
d. Analysis and identification of AI&T critical processes and risks
e. Developing testing aids and related activity
f. AI&T (test) database development and test data production
g. Calibration of GFE and internal test equipment as necessary
h. Sustaining mechanical, electrical, and software test engineering activities
i. Test engineering support to higher level AI&T activities
j. AI&T (test) trouble shooting
k. Preparing test reports
l. Excludes support to test engineering covered within AI&T - Management and Support (for example, excludes test engineering performed by the AI&T manager)

AI&T - Test Engineering may also include the following processes/products as they pertain to AI&T, for example: AI&T requirements and technical plans; test procedures; test aids; test data, test analysis and other documentation; test reports.

K.4.1.1.2.3 AI&T - Assembly, Integration and Test Execution. This element is the primary collector of the following AI&T processes/products:

a. Electrical and mechanical crews/technicians/floor
b. Hardware/software integration
c. Test operations and checkout (excluding tests under environmental/special testing element)
d. Instrumentation insertion and interfacing (excludes instrumentation hardware/equipment costs)

This element includes the mechanical, electronic, and software crew/technician/floor efforts for the assembly, integration and testing (AI&T) of associated lower-level elements. At lower-levels it encompasses assembly and test of components, software units, and configured items and integrates them into the next-higher level assembly. At higher levels it embodies final assembly and testing.

AI&T - Integration, Assembly and Test Execution efforts include:
a. Hands-on assembly and integration activities (e.g. joining, mating, final assembly) through delivery (to next higher level or final)
b. Direct integration and testing of software (e.g. CSCI integration)
c. Electrical and mechanical crews/technicians/floor operations
d. Electrical and mechanical organizational skill retention training
e. Mechanical and electrical factory support equipment operation
f. Software integration tool (e.g. software integration laboratory-SIL) operations
g. Test and checkout operations (if test effort not included in AI&T - Environmental/Special Testing)
h. Instrumentation insertion and interfacing (excludes instrumentation hardware/equipment costs)
i. Excludes shipment (including preparation) cost and related packaging material and containers (see launch operation and the space vehicle storage WBS elements in Appendix F)

K.4.1.1.2.4 AI&T - Environmental/Special Testing 1...n (Specify). This element provides for a functional breakout of specified environmental or special testing.

This element is the primary collector of the following AI&T tests:
a. Thermal vacuum
b. Thermal cycle
c. Acoustic
d. Shock
e. Sine vibration
f. Infra-red and flash x-ray
g. Dynamics
h. EMI/EMC
i. Modal survey and static loads

It may also include the following tests, for example: functional/acceptance; deployment; separation; antenna (pattern and closed-loop tracking); attitude control closed-loop functional.

K.4.1.1.3 Program Management. Program management (PM) includes the resources necessary to manage, direct, and control all effort contributing to the development, production of custom and commercial off-the-shelf (COTS) procurements, and integration. Additionally, it includes training related items used to facilitate instruction through which personnel will learn to operate and maintain the system and elements of the system. Data related items are also captured here, such as the deliverable data required to be listed on a Contract Data Requirements List (CDRL). Sub-elements to program management are defined below and include PM - Management and Administration; PM - Planning and Controls (Business Management); PM - Contracts, Subcontracts and Material Acquisition; PM - Configuration and Data Management; PM - Proposal Preparation; and PM - Production Management and Product Assurance Management.

Includes, for example:

a. Project management
b. Business management (includes business operations, scheduling, accounting, and finance)
c. Project control and planning
d. Configuration management
e. Contract/subcontract management
f. Security management
g. Delivered data and data summaries, including, for example:
    i. Technical publications and technical manuals
    ii. Cost and Schedule Reporting (CPR, CFSR, IMS, IPMR, WBS, etc.)
    iii. Training plans, manuals, guides
h. Data management including data repository and associated drafting and clerical effort to maintain master, Government approved, and Government owned documents
i. Administration
j. Product effectiveness
k. Training services to include: course development, material preparation, and conducting initial training

K.4.1.1.3.1 PM - Management and Administration. This element is the primary collector of the following PM processes/products:

a. Management and leadership
b. Product/system effectiveness measurement
c. Administration
d. Travel (excluding travel related to AI&T and launch operations)
e. Customer interface
f. Training
g. Program protection, cybersecurity, information assurance, security
h. Service centers

This element includes the effort to provide the management and administration needed to exercise overall responsibility and authority for implementing all cost, schedule, technical, and support aspects of the program or sub-program element effort contributing to the development and acquisition of contracted products. Additionally, it may include training related items, and procedures to maintain the system and/or system elements.

PM - Management and Administration efforts may include, for example:

a. Providing management and control, to include: direction, coordination, advice, guidance, performance monitoring, status reporting, and customer interface contacts
b. Establishing the formal management organization and establishing processes and metrics.
c. Providing staff as needed to implement plans and activities ensuring satisfactory completion of the Integrated Master Plan (IMP), the WBS, and other management deliverables
d. Monitoring, and communicating the overall program/subprogram ability to meet customer and user requirements regarding availability, dependability, capability, and other product effectiveness measures
e. Developing and implementing program policies, procedures and processes in accordance with compliance documents
f. Providing program administrative functions such as travel and briefing/reporting support
g. Providing programmatic interface with the Government and associate contractors
h. Providing direction to other program management WBS element efforts as necessary
i. Training effort associated with deliverable training services, devices, accessories, aids, equipment, and parts used to facilitate instruction through which personnel learn to operate and maintain the system

j. Program protection, cybersecurity, and information assurance planning and implementation; including subcontractors, and vendors. Included are program protection for all of the resources, facilities, and information
k. Service center (personal computing, telecommunication, etc.) activities not directly associated with lower level WBS elements

PM - Management and Administration may also include the following processes/products as they pertain to PM, for example: management plans; organizational charts and staffing plans; program policies, procedures, processes, and instructions; status reports; formal review agendas, reports, action items; training materials; security, program protection, cybersecurity, and information assurance plans; product/system effectiveness measurement and evaluation reports; make/buy plans and decision.

K.4.1.1.3.2 PM - Planning and Controls (Business Management). This element is the primary collector of the following PM processes/products:

a. Financial planning and control
b. Performance measurement baseline, earned value
c. Schedule control
d. Life cycle cost
e. Property control
f. Government furnished property/equipment tracking

This element encompasses the effort to plan, organize, and manage business management resources to ensure accomplishment of program tasks. This effort includes conduct of Program Management Reviews (PMRs), Integrated Baseline Reviews (IBRs) and other management reviews. Management meeting preparation and action item management and resolution for Integrated Product Team (IPT) and/or functional leads supporting the program.

This element includes the effort to:

a. Perform financial planning and control.
b. Develop detailed work plans and budgets, establish program metrics
c. Develop and maintain the performance measurement baseline
d. Monitor and status in-house and subcontractor performance measurement (e.g. EVM)
e. Maintain cost performance objectives
f. Integrate organization and subcontractor preparation of cost and schedule CDRLs
g. Implement the schedule control system, which includes effort to update, maintain, and status all Integrated Master Schedule (IMS) tasks and progress on the Integrated Master Plan (IMP)
h. Conduct periodic program management and status reviews
i. Provide necessary coordination to identify program performance issues in all areas of hardware and software
j. Plan, implement and maintain design-to-cost (DTC) and/or life cycle cost (LCC)
k. Track Government Furnished Equipment (GFE) and property and perform any additional property control related functions

PM - Planning and Controls (Business Management) may also include the following processes/products as they pertain to PM, for example: program work breakdown structure (WBS); performance measurement and cost reports (e.g. Earned Value Management-EVM, Integrated Program Management Report-IPMR, Cost and Software Data Reporting-CSDR); other cost and schedule CDRLs; detailed plans (e.g. IMP, IMS); customer meetings and reviews (e.g. integrated baseline review - IBR); program budgets; life cycle cost analyses; Government furnished property/equipment (GFP/GFE) reports.

K.4.1.1.3.3 PM - Contracts, Subcontracts and Material Acquisition. This element is the primary collector of the following PM processes/products:

a. Contracts
b. Subcontract management
c. Intercorporate work transfer (IWO, IPCO, IWTA, etc.)
d. Hi-Rel parts acquisition

This element comprises the effort to perform contract management tasks including: contract initiation, warranty

administration, processing and administering contract changes, establishing and maintaining any associate contractor agreements. This element also incorporates subcontract management tasks including: oversight of the administration of subcontracts and purchase orders with vendors and interdivisional agreements and providing guidance to the organization for developing and administering subcontract agreements, purchase orders, and interdivisional agreements. Some multiproduct procurement and control effort can be accounted for within this WBS element; notably, the procurement of high value or complex items (e.g. hi-rel parts and material); however, product WBS configured items material and labor should be included in their constituent WBS element.

Specific contracts, subcontracts, and material efforts may include, for example:

a. Providing a single point of contact for the receipt of and response to contractual direction and correspondence
b. Creating and maintaining a database of nontechnical requirements (e.g. non-engineering)
c. Preparing, negotiating, maintaining, and supporting such memoranda of agreement
d. Coordinating contractual actions between the program and related subcontracts
e. Keeping the Government contracting officer informed about external interface activities
f. Coordinating necessary Government action regarding external interfaces
g. Processing and negotiating contract/engineering/task change proposals
h. Ensuring compliance with all contractual requirements
i. Coordinating requests for, receipt of, and verification of suitability of Government furnished property
j. Issuing and administering cross-corporate (intercompany) work transfers authorizations (e.g. IWOs, IPCOs, IWTAs, etc.)
k. Performing procurement activity for high value or complex items from identification of sources through subcontract closure

It may also include the following processes/products, for example:

a. Contracts
b. Memoranda of agreement, and other contractor and subcontractor agreements
c. Intercompany and cross-divisional work authorizations (e.g. IWO, IPCO, IWTA)
d. Contractual direction and correspondence
e. Non-technical requirements and program action item databases; material acquisition (labor and NRE material) not allocable to hardware WBS elements
f. Bills of Material
g. High-value and complex material items lists

K.4.1.1.3.4 PM - Configuration and Data Management. This element is the primary collector of the following PM processes/products:

a. Configuration management (CM) - see distinction from Configuration Control within SE - Management and Control WBS element
b. Data management (DM)
c. Software configuration management
d. Management Information Systems, electronic data and management systems

The overall objective of Configuration Management (CM) is to manage, document, and inform project stakeholders of the ongoing status of system interfaces by establishing methods and tools to control configured items (CI). This element includes the effort to 1) Establish and implement a configuration management plan to ensure integrity of work products used by the program for configuration identification, configuration control, configuration status accounting, and configuration audits; 2) Perform as a single point of contact for the system configuration management function for the program office and across associated sites; 3) Maintain the baseline control of program configuration items by an authorized change control processes, tools, and accounting records; and 4) Provide resources, tools, and training regarding configuration management and control.

NOTE: Actual implementation (including proposing, justifying, evaluating, and coordinating approvals of configuration changes) of the CM plan described above is a systems engineering function and is part of the configuration control effort within the SE - Management and Control WBS element.

Configuration Management (CM) also includes the effort to manage the software and hardware across the program including the following establishing the following processes if not existing as part of organizational policy: 1) Configuration process definition and improvement; including updating software development plans; 2) Definition and

integration of common tools, procedures and standards; 3) Integration of program-specific software/hardware products and supporting databases; 4) Management of engineering process working groups (e.g. SEPG, for software); 5) Interface between all program specific software, database, and hardware platforms to assist in integrating interface requirements, delivery dates and independent status assessment as required; 6) Management of program CDRLs and metrics reporting; 7) Software release integrity audits; 8) Configuration board support

Data Management (DM) includes the effort for development oversight and/or acquisition and subsequent management and control of prepared data both for both internal program purposes and for delivery to external customers. This element includes efforts to establish and maintain electronic communications and data systems required for management and product development by the program. Data management includes the efforts to: 1) plan, schedule, and release program CDRL documents for delivery to the Government; 2) Establish and operate program data center with electronic data management and management information systems. However, manufacturing control systems (e.g. Enterprise Resource Planning (ERP) systems) should be accounted within the PM-Production Management and Product Assurance Management WBS element; 3) Provide products electronically to the Government, program, and site customers; 4) Archive required program and CDRL data; 5) Provide the Government and program personnel the required documentation handling assistance necessary to effectively manage the program.

PM - Configuration and Data Management may also include the following processes/products as they pertain to PM, for example: a) Configuration and data management plans; b) Configured items list; c) Released documents; d) Configuration and data management systems and databases. (e.g., Management Information Systems - MIS, Electronic Data and Management System - EDAMS); e) Data archives; f) Configuration and data audits and reports

K.4.1.1.3.5 PM - Proposal Preparation. This element is the primary collector of the following PM processes/products:

a. Change proposals
b. Follow-on proposals

Proposal preparation includes the effort to propose and support negotiation of contracts or contract changes for new requirements and/or for final determination of, as yet, unpriced contractual activities. Depending on the company's disclosure statement, these charges may be made to non-program accounts. However, some reasons for charging proposal preparation and negotiations cost directly to a program include:

a. Changes directed by the Government under a changes clause
b. Value engineering change proposals
c. Engineering change proposals
d. Follow-on procurements
e. New requirements added to the existing contract
f. Definitization of unpriced contractual actions

PM - Proposal Preparation may also include the following documentation, for example:

a. Change and/or follow-on proposals
b. Bases of Estimates (BOEs)
c. Task Descriptions (TDs)
d. Formal cost estimates

K.4.1.1.3.6 PM - Production Management and Product Assurance Management. This element is the primary collector of the following PM processes/products:

a. Product assurance management - procedures, staffing, readiness, documentation
b. Production management - requirements, readiness, inventories, audit support
c. Quality management - procedures, staffing, readiness, documentation
d. Acceptance documentation
e. Production planning
f. Enterprise Resource Planning (ERP)
g. Demand/Change management

This element includes the production management effort for:

a. Managing production planning to ensure a logical planned sequence of activities, to include a continuing appraisal of production risks and their resolution
b. Identifying production requirements and other documentation

c. Establishing and maintaining an enterprise resource planning (ERP) process for the purchase and build of program hardware, material, service and supplies
d. Establishing and maintaining a structured demand management process to measure and manage collective resources and/or capacity (supply) to meet program requirements (demand) and to resolve resource conflicts
e. Administering change management procedures to evaluate and authorize appropriate modifications
f. Establishing and maintaining systematic methods to ensure executable design solutions are incorporated in program products and processes
g. Applying prime contractor command media processes and guidelines for management of program inventories
h. Supporting functional configuration audits and physical configuration audits.
i. Conducting readiness reviews as required

This element also includes all the product assurance management effort to manage product assurance procedures as defined in program product assurance plan and in accordance with the requirements of ISO and/or other quality management standards. Management responsibilities include:

a. Assignment of product/quality assurance personnel to responsible organizations for assessments of program compliance to approved processes and to verify product quality
b. Identification and mitigation management of quality-related risks.
c. Issues resolution with program staff and escalate unresolved problems to management for resolution
d. Assess the design, manufacturing, test and mission readiness
e. Document acceptance of configuration-controlled products, facilitate preparation of final acceptance following end-to-end testing and certification of the total system
f. Lead ISO and other quality management auditor tasks. The lead auditor performs internal audits of program organizations for compliance to prescribed standards and contract requirements

It may also include the following processes/products, for example:

a. Product assurance plans
b. Material inspection and receiving reports (e.g. DD250 preparation)
c. Quality assurance surveillance plans (e.g. QASP)
d. Production requirements and documentation

K.4.1.1.4 Systems Engineering and Program Management (SEPM). This element can be used at Level 5 (and below) of the WBS when systems engineering and program management are inseparable. This WBS element is a combination of the systems engineering and the program management responsibility, task, and deliverable content defined above.

K.4.1.1.5 Support Equipment. This element pertains to the design, development, and production of those items and associated software required to build, assemble, integrate, move, support, and maintain the system or portions of the system. This also pertains to the testing and measurement equipment that allows an operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening, or quality assurance efforts.

Includes, for example:

a. Peculiar Support Equipment (PSE)
b. Common Support Equipment (CSE)
c. Tooling, (e.g., taps, dies, etc.)
d. Mock-ups/System Integration Labs (SILs), simulators, stimulators, and training equipment (excludes engineering models of space vehicle hardware that are included within the space vehicle hardware WBS elements)
e. Vehicles, equipment, tools, and the like used to fuel, service, transport, hoist, repair, overhaul, assemble, disassemble, test, inspect, or otherwise maintain mission equipment
f. Any production of duplicate or modified factory test or tooling equipment delivered to the Government for use in maintaining the system
g. Support and handling equipment including ground, vehicular, powered, non-powered, and materiel handling
h. Electrical Aerospace Ground Equipment (AGE) and Mechanical (AGE)
i. Precision measuring equipment

j. Instrumentation hardware
k. Automatic test equipment
l. Manual test equipment
m. Test program sets
n. Automated load modules
o. Support equipment software

K.5 DEFINITIONS OF COMMON ELEMENTS APPLICABLE TO LAUNCH VEHICLE SYSTEMS ONLY.

The Launch Vehicle community has unique application of systems engineering, integration and test and program management (SEIT/PM). The following paragraphs represent the SEIT/PM WBS elements common to launch vehicle system elements. For the remaining Common Elements, reference paragraph K.3 Definitions of Common Elements.

K.5.1 SEIT/PM. This section provides the WBS elements common to all launch vehicle system WBS elements. Consistent with the manner in which launch vehicle systems are designed, built, and tested, there are multiple levels of Systems Engineering, Integration and Test, and Program Management (SEIT/PM) throughout the WBS. It is expected that, whenever possible, SEIT/PM costs be reported with the item(s) they are supporting. For example, subsystem management of the reaction control subsystem should be booked under the reaction control system WBS element.

K.5.1.1 Systems Engineering. This WBS element contains all the resources associated with all engineering from functional specialists who provide technical planning, technical management, analysis, and support efforts for development and production activities. The systems engineering entity is responsible for the analysis, derivation, allocation, and traceability of requirements and interfaces.

Includes, for example:
a. Systems definition
b. Systems analysis (e.g., thermal, power, mass properties, environments, dynamics, modeling, and simulation)
c. Requirements analysis and allocation
d. Interface definition and control
e. Performance assessment and verification/validation
f. Technical direction (SE leadership, planning, and coordination)
g. System safety
h. Quality assurance, product assurance
i. Mission assurance and critical skill protection and retention
j. Logistics Support Analysis (LSA including reliability, availability, maintainability, producibility)
k. Engineering services
l. Configuration control
m. System documentation
n. Algorithm development
o. Recommended operating procedures (ROPs), Procedures (PROCs), Satellite Databases
p. Risk management
q. Human engineering
r. Security engineering
s. Electromagnetic Compatibility (EMC)/Electromagnetic Interference (EMI)
t. Radiation and survivability
u. Contamination and control
v. Autonomy and fault management
w. Other Specialty Engineering
x. Engineering and design (excluding box level) including Electrical Design Integration (EDI), Mechanical Design Integration (MDI), Thermal Design Integration (TDI), and Facility Design
y. Parts, materials, and processes (PM&P)
z. Trade studies
aa. System studies

Excludes, for example:

a. Systems engineering efforts that can be associated specifically with the equipment (hardware/software)

K.5.1.2 Assembly, Integration and Test. This element includes the effort of technical and functional activities required to assemble and test at one level into a next higher level (e.g., from product level to subsystem level) as a whole and not directly part of any other individual element.

Includes, for example:
a. Development of test plans and procedures
b. Test preparations
c. Test support and management
d. Hardware/software integration
e. Software CSCI integration
f. Hardware integration and assembly (e.g., electrical and mechanical integration, including kitting)
g. Test, checkout, inspection, and acceptance
h. System test and evaluation, to include developmental test and evaluation, operational test and evaluation
i. I&T management, leadership, planning and scheduling
j. Analysis and documentation of test results
k. Transportation and movement (excludes transportation of the space vehicle to the launch pad (covered under the launch operations WBS element))
l. Integration hardware
m. Delivered initial spares and repair parts
n. I&T Facilities

Excludes, for example:
a. Integration and test efforts that can be associated specifically with the equipment (hardware/software)

K.5.1.3 Program Management. Program management (PM) includes the resources necessary to manage, direct, and control all effort contributing to the development, production of custom and commercial off-the-shelf (COTS) procurements and integration. Additionally, it includes training related items used to facilitate instruction through which personnel will learn to operate and maintain the system and elements of the system. Data related items are also captured here, such as the deliverable data required to be listed on a Contract Data Requirements List (CDRL).

Includes, for example:
a. Project management
b. Business management (includes business operations., scheduling, accounting, and finance)
c. Project control and planning
d. Configuration management
e. Contract/subcontract management
f. Security management
g. Delivered data, including, for example:
    i. Technical publications and technical manuals
    ii. Cost and Schedule Reporting (CPR, CFSR, IMS, WBS, etc.)
    iii. Training plans, manuals, guides
h. Data management including data repository and associated drafting and clerical effort to maintain master, Government approved, and Government owned documents
i. Administration
j. Product effectiveness
k. Training services to include: course development, material preparation, and conducting initial training

Excludes, for example:
a. Program management efforts that can be associated specifically with the equipment (hardware/software)

K.6 DEFINITIONS OF COMMON ELEMENTS APPLICABLE TO INFORMATION SYSTEMS/DEFENSE BUSINESS SYSTEMS ONLY.

The Information Systems/Defense Business Systems (IS/DBS) commodity has unique application of change management, data management, operational infrastructure/site activation, and interim operations and support (Pre-IOC). For the remaining Common Elements, reference paragraph K.3 Definitions of Common Elements.

K.6.1 Change Management. Change management refers to the broad process for managing organizational change. Change management encompasses planning, oversight or governance, project management, testing, and implementation.

K.6.2 Data Management. This element includes data stewardship, quality management, governance, and data security management in support of the IS/DBS.

K.6.3 Operational Infrastructure/Site Activation by Site 1...n (Specify). The costs associated with deploying the IS/DBS solution at the user site(s). This should cover only those efforts that are incurred at the implementation site. Any upfront effort involved with designing/engineering the solution for a particular site should be included in under client-side site development. Any effort related to redesign of the solution once implementation has begun should be captured here.

Note: This element will also include the real estate, construction, conversion, utilities, and equipment to provide all facilities required to house, service, and launch the IS/DBS solution at the user sites.

K.6.3.1 Initial Hardware Procurement. Commercial off-the-shelf (COTS) hardware required for various types of facilities supporting end-user equipment, cybersecurity equipment, and IT infrastructure and enterprise software equipment.

Includes, for example:
a. Processing equipment (servers, CPUs, etc.)
b. Network/communications
c. Storage
d. Security/crypto
e. UPS
f. Other/ancillary equipment

Excludes, for example:
a. Development/test hardware (captured with the prime mission product)

K.6.3.2 Initial Software License Procurement. COTS software purchased for the various site types. This would include the purchase of software licenses related to the IS/DBS solution.

Includes, for example:
a. End-user software licenses
b. Cybersecurity software licenses/services
c. IT infrastructure and enterprise services software
d. Other 1...n (Specify)

K.6.3.3 Initial Software Release (Pre-IOC) Modification/Enhancement. This element includes the effort to modify or enhance the software developed for the system to meet the site requirements necessary to support the IS/DBS.

Includes, for example:
a. Routine fixes/deficiency correction
b. Deployment independent verification and validation
c. Installation and test

K.6.3.4 Site Activation. This element includes the costs associated with shipping costs to the site, site survey, site preparation, equipment installation, equipment integration, test, and checkout to allow implementation of the IS/DBS

solution. This should cover only those efforts that are incurred at the implementation site. Any effort related to redesign of the solution once implementation has begun should be captured here.

K.6.3.4.1 Data Migration. This element includes the effort for translating data from one format to another. This should cover only those efforts that are incurred at the implementation site. Also include any expense associated with the transition of data from the legacy systems to the IS/DBS solution. Use lower levels to identify individual legacy systems.

Includes, for example:
a. Data translation
b. Data cleansing
c. Data loading

Excludes, for example:
a. External system interface development

Note: Data migration is necessary when an organization decides to use a new computing systems or database management system that is incompatible with the current system. Typically, data migration is performed by a set of customized programs or scripts that automatically transfer the data.

K.6.3.4.2 User Training. This element represents the effort involved with training the users of the implemented IS/DBS solution at the user sites. The primary cost captured here will be the labor costs of instructors to train users on the new system and business processes required to operate within the new system(s). Any costs incurred as a result of revising the training courses and/or materials once implementation has begun should also be captured here.

Excludes, for example:
a. Any upfront costs associated with training the trainers, as well as course development and material costs that are not incurred as a result of circumstances encountered at the user sites

K.6.3.4.3 User Documentation. This element is documentation on how systems are set up and used. This includes practices, procedures, and set up information. It is maintained by the application system users who are responsible for the operation of the application system.

K.6.3.4.4 Management/Engineering Support. This element captures those support elements that are attributable only to specific user/implementation sites. This would include systems engineering/program management effort associated with a specific site, as well as any system test and evaluation specific to particular user sites.

K.6.3.4.5 Site Installation, Test and Checkout. This element provides the support and services required to install, test, and checkout the information system/defense business system at the site and ensure it conforms to the requirements for site activation.

K.6.3.5 Interim Operations and Support (Pre-IOC). The effort required to operate, maintain, and support the IS/DBS completed prior to initial operating capability.

Includes, for example:
a. Help Desk support
b. System Database Administration
c. Installation, Test, and Checkout
d. IT Equipment maintenance

K.7 DEFINITIONS OF COMMON ELEMENTS APPLICABLE TO STRATEGIC MISSILE SYSTEMS ONLY

When the Strategic Missile Systems Appendix is used the unique elements have been specifically grouped into four subcategories. Lower level elements of these categories may be created but must sum to the correct category. The unique common elements to be used are systems engineering, integration and test, program management, and support equipment (SEIT/PM and Support Equipment). Also, Operational/Site Activation is also unique to the Strategic Missile Systems.

K.7.1 SEIT/PM and Support Equipment. This section provides the WBS elements common to all Strategic Missile System WBS elements. Consistent with the manner in which strategic missile systems are designed, built, and tested, there are multiple levels of Systems Engineering (SE), Integration and Test (AI&T), and Program Management (PM) and Support Equipment throughout the WBS. It is expected that, whenever possible, SEIT/PM and support equipment costs be reported with the item(s) they are supporting. For example, subsystem management of the attitude control subsystem should be booked under the ACS WBS element. If a contractor (or other developer) manages the project by a different means and does not collect any or all SEIT/PM and Support Equipment elements at this level, then the costs for those elements shall be reported at the next higher-level WBS element. For example, an electronics product manager with areas of responsibility spanning both ACS and the Communications subsystems cost should have their effort defined and collected within the AVE/FVE SEIT/PM element. SEIT/PM and Support Equipment shall be broken out into their individual elements (i.e. Systems Engineering Assembly Integration and Test, Program Management, and Support Equipment each defined below) for all WBS levels. At the lowest level, Systems engineering and program management (SEPM) responsibilities are often indistinct and may be combined into a single SEPM element

K.7.1.1 Systems Engineering. This WBS element contains all the resources associated with all engineering from functional specialists who provide technical planning, technical management, analysis, and support efforts for development and production activities. The systems engineering entity is responsible for the analysis, derivation, allocation, and traceability, of requirements, design, and interfaces. Systems engineering are defined below.

Systems Engineering includes, for example:

a. Systems definition
b. Systems analysis (e.g., thermal, power, mass properties, environments, dynamics, modeling and simulation)
c. Requirements analysis and allocation
d. Interface definition and control
e. Performance assessment and verification/validation
f. Technical direction (SE leadership, planning, and coordination)
g. System safety
h. Quality assurance, product assurance
i. Mission assurance and critical skill protection and retention
j. Logistics Support Analysis (LSA including reliability, availability, maintainability, producibility)
k. Engineering services
l. Configuration control
m. System documentation
n. Algorithm development
o. Risk management
p. Human engineering
q. Security engineering
r. Electromagnetic Compatibility (EMC)/Electromagnetic Interference (EMI)
s. Radiation and survivability
t. Contamination and control
u. Autonomy and fault management
v. Other specialty engineering
w. Engineering and design (excluding box level) including Electrical Design Integration (EDI), Mechanical Design Integration (MDI), Thermal Design Integration (TDI), and Facility Design
x. Parts, materials, and processes (PM&P)
y. Trade studies
z. System studies

K.7.1.1.1 Nuclear Hardening and Survivability (NH&S). This element is a quantitative description of the physical attributes and capability of a system or component that will allow it to survive in a given nuclear environment and continue to accomplish its mission. Nuclear hardness levels must be quantified and validated.

K.7.1.1.2 System Safety. Other system engineering support including system requirement and architecture definition, overall system design and margin management, design integrity analysis, system optimization, system/cost effectiveness analysis, and intra-system and inter-system compatibility assurance, etc.; safety engineering, human health, environmental protection, quality assurance program, value engineering. Also includes Interface Management, Human

Systems Integration, Supportability analyses, and Configuration Management.

K.7.1.1.3 Nuclear Surety. Efforts to assure nuclear weapons and their components do not become vulnerable to loss, theft, sabotage, damage, or unauthorized use.

K.7.1.2 Assembly, Integration and Test (AI&T). This element includes the effort of technical and functional activities required to assemble and test at one level into a next higher level (e.g., from product level to subsystem level) as a whole and not directly part of any other individual element.

Includes, for example:

a. Development of test plans and procedures
b. Test preparations
c. Test support and management
d. Hardware/software integration
e. Software CSCI integration
f. Hardware integration and assembly (e.g., electrical and mechanical integration, including kitting)
g. Test, checkout, inspection and acceptance
h. System test and evaluation, to include developmental test and evaluation, operational test and evaluation
i. I&T management, leadership, planning and scheduling
j. Analysis and documentation of test results
k. Transportation and movement (excludes transportation of the space vehicle to the launch pad covered under the Launch Operations WBS element)
l. Integration hardware
m. Processing/handling of delivered initial spares and other repair parts
n. I&T Facilities

K.7.1.3 Program Management. Program Management (PM) includes the resources necessary to manage, direct, and control all effort contributing to the development, production of custom and commercial off-the-shelf (COTS) procurements and integration. Additionally, it includes training related items used to facilitate instruction through which personnel will learn to operate and maintain the system and elements of the system. Data related items are also captured here, such as the deliverable data required to be listed on a Contract Data Requirements List (CDRL).

Includes, for example:

a. Project management
b. Business management (includes business operations., scheduling, accounting, and finance)
c. Configuration management
d. Contract/subcontract management
e. Security management
f. Delivered data and data summaries, including, for example:
    i. Technical publications and technical manuals
    ii. Cost and Schedule Reporting (IPMR, CFSR, IMS, WBS, etc.)
    iii. Training plans, manuals, guides
g. Program control
h. Data management including data repository and associated drafting and clerical effort to maintain master, Government approved, and Government owned documents
i. Administration
j. Product effectiveness
k. Training services to include: course development, material preparation, and conducting initial training

K.7.1.3.1 Program Control. Program/Project control and planning (i.e., business management, business operations, scheduling, accounting and finance), and cost, schedule, and performance measurement management.

K.7.1.4 Support Equipment. This element pertains to the design, development, and production of those items and associated software required to build, assemble, integrate, move, support, and maintain the system or portions of the system. This also pertains to the testing and measurement equipment that allows an operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening, or quality assurance efforts.

Includes, for example:

a. Peculiar support equipment (PSE)
b. Common support equipment (CSE)
c. Tooling, (e.g., taps, dies, etc.)
d. Mock-ups/System Integration Labs (SILs), Simulators, Stimulators, and training equipment
e. Vehicles, equipment, tools, and the like used to fuel, service, transport, hoist, repair, overhaul, assemble, disassemble, test, inspect, or otherwise maintain mission equipment
f. Any production of duplicate or modified factory test or tooling equipment delivered to the Government for use in maintaining the system
g. Support and handling equipment including ground, vehicular, powered, non-powered, and materiel handling
h. Precision measuring equipment
i. Instrumentation hardware
j. Automatic test equipment
k. Manual test equipment
l. Test program sets
m. Automated load modules
n. Support equipment software

K.7.2 Operational/Site Activation. The real estate, construction, conversion, utilities, and equipment to provide all facilities required to house, service, and launch prime mission equipment at the organizational and intermediate level.

K.7.2.1 Deployment Planning. Outlining the scope, approach, and execution for the deployment of the missile system in a deployment plan. The plan includes, where relevant, information about system operation and support, escalation processes, roles and responsibilities before, during, and after deployment. The deployment plan is intended to operators, stakeholders, and support personnel with a smooth transition of operational deployment. The deployment plan describes each step of the deployment process at each deployment location, whether there is one site or multiple sites, or one deployment or a phased deployment planned. The deployment plan defines all of the work steps for complete deployment, and who does them.

K.7.2.2 Site Construction. Real estate, site planning and preparation, construction, and other special-purpose facilities necessary to achieve system operational status.

K.7.2.3 Aerospace Ground Equipment. Support equipment that supplies electricity, hydraulic pressure, air pressure, and other items required for missile maintenance and preparation for flight.

K.7.2.4 Real Property Installed Equipment. Items of equipment that are affixed and built into the facility as an integral part of the facility. Equipment that is an integral part of the facility, which if removed would destroy or reduce the usefulness of the facility, heating, cooling, and electrical system and included in the cost of construction and/renovation.

K.7.2.5 Site/Ship/Vehicle Conversion. The materials and services required to convert existing sites, ships, or vehicles to accommodate the mission equipment and selected support equipment directly related to the specific system. Includes operations, support, and other special purpose facilities conversion necessary to achieve launch.

K.7.2.6 System Assembly, Installation, and Checkout. All effort of technical and functional activities associated with the design, development, and production of mating surfaces, structures, equipment, parts, materials, and software required to assemble the Air Vehicle and Command & Launch equipment (hardware/software) elements into the Missile System as a whole.

APPENDIX L: RELATIONSHIP BETWEEN THE SUSTAINMENT COST REPORTING STRUCTURE AND THE WORK BREAKDOWN STRUCTURE

L.1 SCOPE

This appendix provides an understanding of how the sustainment cost reporting structure is related to the defense materiel systems work breakdown structure reporting, as defined in Appendices A–I. Since the purpose of the MIL-STD is to address work breakdown structures, this appendix is for information only. However, if sustainment reporting supports an information system/defense business system, the sustainment structure in Appendix J.5 will apply.

L.2 APPLICABLE DOCUMENTS

L.2.1 General. The documents listed in this section are specified in Appendix L of this standard. This section does not include documents cited in other Appendices of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in Appendices of this standard, whether or not they are listed.

L.2.2 Government documents.

L.2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

DEFENSE ACQUISTION UNIVERSITY

Defense Acquisition Guidebook (Latest Edition)

(Copies of this document are available from https://www.dau.mil/tools/t/Defense-Acquisition-Guidebook or Defense Acquisition University, 9820 Belvoir Rd, Fort Belvoir, VA 22060)

COST ASSESSMENT AND PROGRAM EVALUATION (CAPE)

Cost Assessment and Program Evaluation (CAPE) Operating and Support Cost Estimating Guide (Latest edition)

(Copies of this document are available from https://www.dau.mil/tools/t/OSD-Cost-Assessment-and-Performance-Evaluation-(CAPE)-Operating-and-Support-(OandS)-Cost-Estimating-Guide or Defense Acquisition University, 9820 Belvoir Rd, Fort Belvoir, VA 22060)

L.2.2.2 Other Government documents, drawings, and publications.

L.2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

L.3 Relationship of MIL-STD WBS to CRS. This appendix describes the relationship between the Cost Assessment and Program Evaluation (CAPE) sustainment cost reporting structure (CRS) and the MIL-STD work breakdown structure (WBS). While the MIL-STD does not mandate the use of the CRS, this appendix identifies the process to report acquisition and sustainment costs in the WBS using the CRS.

The MIL-STD requires the use of a WBS for all ACAT programs. Sustainment cost reporting is required using the Cost Data Summary Report (CDSR) process based on the reporting requirements defined in the Cost and Software Data Reporting Plan. DoDI 5000.04-M1 establishes the policy, assigns responsibilities, and provides procedures for the conduct of cost estimation and analysis in the DoD.

When MIL-STD-881 was first developed in 1968, it was designed to be the operating structure for defining, acquiring, managing, estimating, etc. major defense systems. Sustainment was not addressed since the focus was on the pre-systems acquisition and acquisition phases. Sustainment was, at that time, related mainly to the Operations and Support (O&S) phase.

Due to technology advancements, a greater use of software and quicker deployment of capabilities, the timeframe to acquire defense materiel items has changed dramatically. With new development techniques, often requiring multiple builds over numerous contract increments, the warfighter is now getting capability faster than ever. What is being delivered is an incremental set of capabilities over time, to ensure the warfighter is getting what they need, when they need it. This also means that sustainment activities start earlier in the systems acquisition phase (i.e., EMD) than they have in the past and continue into the O&S phase. As a result, the sustainment phase has become more prominent during the life cycle of a system and often production and O&S phases overlap throughout full deployment (see Figure XI – Blue Oval).

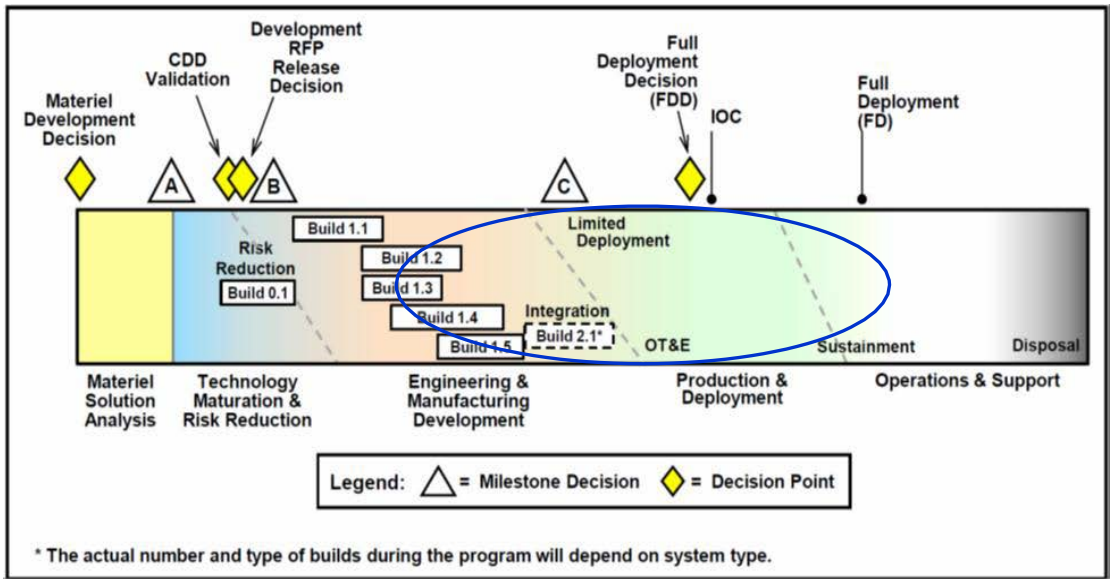

FIGURE XI. Sustainment starts early in EMD and continues through full deployment

Early in the acquisition phase, the contractor is responsible for the sustainment effort and therefore must report their activities for contract purposes. A product-oriented work breakdown structure (WBS) as defined in MIL-STD-881 is used for reporting contractual efforts. Yet sustainment activities do not follow a WBS format. Instead it uses a CRS focused on the cost of repair and maintenance of subsystems, hardware, software, components, etc.

In 2011, MIL-STD-881C identified sustainment in the acquisition phase as “Interim Contractor Support” (specifically under operational/site activation) to address what was required to account for sustainment within the total contract cost. This meant that both the WBS and CRS needed to be used. As an example, Figure XII shows the WBS for Operational/Site Activation by Site 1...n (Specify). The element circled is the “Interim Contractor Support (ICS)” WBS element. Using this WBS element, the contractor reports their efforts associated with the sustainment of the prime mission product, up to the determination and

implementation of a permanent sustainment support effort (i.e., Contractor Logistics Support (CLS) or organic support). CLS will also be applied when Performance Based Logistics (PBL) is implemented in the O&S phase. To account for this, CLS has been added as a level 2 WBS element (1.11) after Operational Site/Activation by Site 1…n (Specify).

1.10		Operational/Site Activation by Site 1...n (Specify)			
1.10.1			System Assembly, Installation, and Checkout		
1.10.2			Contractor Technical Support		
1.10.3			Site Construction		
1.10.4			Site/Ship/Vehicle Conversion		
1.10.5			Interim Contractor Support (ICS)		
1.11		Contractor Logistics Support			

FIGURE XII. WBS for ground vehicle systems - interim contractor support

Sustainment will be either ICS or CLS but never both at the same time. The use of CLS may be earlier or later depending on the system being procured and the complexity of the sustainment activities of the system. Therefore, the need to understand the sustainment activities for both the acquisition and O&S phase is critical. Ultimately, the sustainment cost effort is what will be reported. Regardless of what phase the work is performed, sustainment will be reported using the CRS, thereby providing reporting consistency between the two phases.

In order to gather these costs, the Cost and Software Data Reporting Plan (DD Form 2794) defines what ICS data will be collected and reported using the CRS.

1. MAJOR PROGRAM: a. NAME: AN/MPQ 64A4 Sentinel
b. PHASE/MILESTONE: Pre-A; A; B; X C-LRIP; C-FRP; O&S
2. PRIME MISSION PRODUCT
3. REPORTING ORGANIZATION TYPE: X PRIME/ASSOCIATE CONTRACTOR; DIRECT REPORTING SUBCONTRACTOR; GOVERNMENT
4. NAME/ADDRESS (Include ZIP Code): a. PERFORMING ORGANIZATION; b. DIVISION
5. APPROVED PLAN NUMBER
6. CUSTOMER (Direct-reporting subcontractor use only)
7. CONTRACT TYPE
8. CONTRACT PRICE
9. CONTRACT CEILING
10. TYPE ACTION: a. CONTRACT NO.: ; b. LATEST MODIFICATION: ; c. SOLICITATION NO.: ; d. NAME: ; e. TASK ORDER/DELIVERY ORDER/LOT NO.:
11. PERIOD OF PERFORMANCE: a. START DATE (YYYYMMDD): ; b. END DATE (YYYYMMDD):
12. APPROPRIATION: RDT&E; X PROCUREMENT; O&M
13. REPORT CYCLE: INITIAL; INTERIM; FINAL
14. SUBMISSION NUMBER
15. RESUBMISSION NUMBER
16. REPORT AS OF (YYYYMMDD)
17. NAME (Last, First, Middle Initial)
18. DEPARTMENT
19. TELEPHONE NUMBER (Include Area Code)
20. EMAIL ADDRESS
21. DATE PREPARED (YYYYMMDD)

WBS ELEMENT CODE	WBS REPORTING ELEMENTS	NUMBER OF UNITS TO DATE	COSTS INCURRED TO DATE (thousands of U.S. Dollars)			NUMBER OF UNITS AT COMPLETION	COSTS INCURRED AT COMPLETION (thousands of U.S. Dollars)		
			NONRECURRING	RECURRING	TOTAL		NONRECURRING	RECURRING	TOTAL
A	B	C	D	E	F	G	H	I	J
1.0	Interim Contractor Support								
1.1	Unit-Level Manpower								
1.1.1	Operations								
1.1.2	Unit-Level Maintenance								
1.1.3	Other Unit-Level								
1.2	Unit Operations								
1.2.1	Operating Material								
1.2.2	Support Services								
1.2.3	Temporary Duty								
1.2.4	Transportation								
1.3	Maintenance								
1.3.1	Consumable Materials And Repair Parts								
1.3.2	Depot Level Reparables (DLR)								
1.3.3	Intermediate Maintenance (External To Unit-Level)								
1.3.4	Depot Maintenance								
1.3.5	Other Maintenance								
1.4	Sustaining Support								
1.4.1	System Specific Training								
1.4.2	Support Equipment Replacement And Repair								
1.4.3	Sustaining/Systems Engineering								
1.4.4	Program Management								
1.4.5	Information Systems								
1.4.6	Data And Technical Publications								
1.4.7	Simulator Operations And Repair								
1.4.8	Other Sustaining Support								
1.5	Continuing System Improvements								
1.5.1	Hardware Modifications								
1.5.2	Software Maintenance								
1.6	Indirect Support								
1.6.1	Installation Support								
1.6.2	Personnel Support								
1.6.3	General Training And Education								

FIGURE XIII. DD Form 1921 - Cost Data Summary Report based on the CRS

DD Form 1921, Cost Data Summary Report (CDSR) (Figure XIII) provides the results of the data collection efforts. The total dollar amount will then be applied to the WBS for ICS (1.10.5).

Figure XIV provides a summary of the flow of information starting with the ICS WBS through DD Forms 2794 and 1921, resulting with the total dollar amount entered on the WBS in the ICS element (1.10.5).

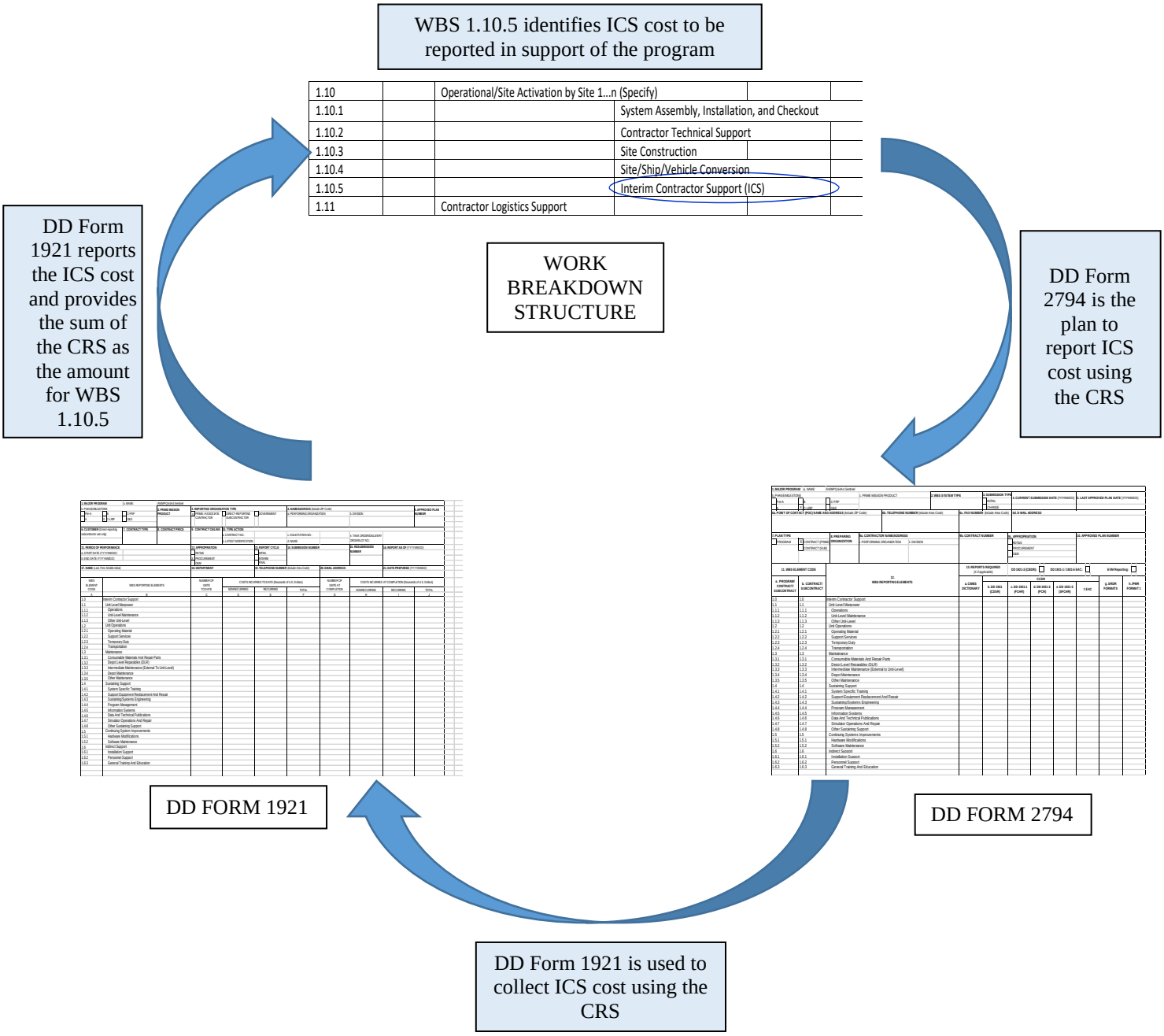

FIGURE XIV. Relationship of WBS reporting using the CRS

The CRS and its definitions can be found in the Cost Assessment and Program Evaluation (CAPE) Operating and Support Cost Estimating Guide. Included are the cost reporting structure elements and their definitions. For IS/DBS programs, use MIL STD 881D Appendix J "IS/DBS Sustainment structure" (J.5) since the reporting structure in the O&S Cost Estimating Guide does not take IS/DBS programs into consideration.

CONCLUDING MATERIAL

Custodians:
Army – MI
Navy-SH
Air Force – 10

Preparing Activity
OSD-WB

(Project No. MISC-2017-013)

Review Activities:
Army-AR, AT, AV, CR
Navy-AS, MC, OS
Air Force-11, 16, 19, 70, 71, 84

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil