HSI and ESOH Handbook for Pre-Milestone A JCIDS and AoA Activities

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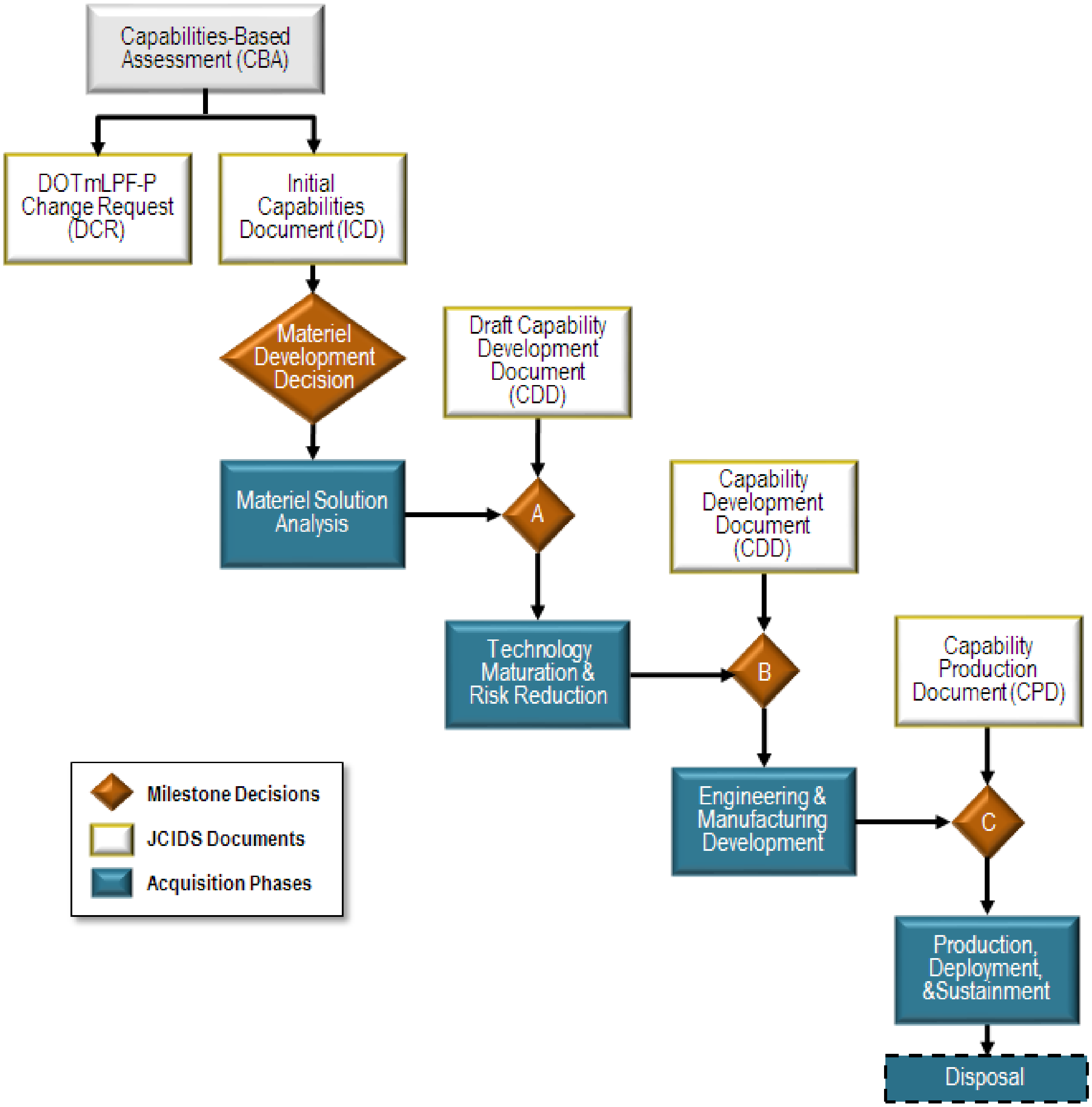
1. Introduction

To execute its mission and support the warfighter, the Department of Defense (DoD) established the Joint Capabilities Integration and Development System (JCIDS) process to identify, assess, validate, and prioritize joint military capability requirements. When the JCIDS process determines that a materiel solution is needed to meet a validated military capability requirement, the DoD Component Sponsor develops a capability requirement document to guide the Defense Acquisition System (DAS), commonly referred to as the acquisition process. The DAS is the management process by which the DoD provides effective, affordable, and timely systems to the users. In acquisition, a system is defined as an item (e.g., ships, tanks, self-propelled weapons, aircraft) and related spares, repair parts, and support equipment, but excluding real property, installations, and utilities.

Figure 1.1 illustrates the basic JCIDS and DAS framework starting with the completed Capabilities-Based Assessment (CBA) through each acquisition milestone decision point and shows when JCIDS documents are required. The scope of this Handbook is limited to describing opportunities for Human Systems Integration (HSI) and Environment, Safety, and Occupational Health (ESOH) practitioners to contribute to the Pre-Milestone (MS) A activities relating to JCIDS capability document development and the Analysis of Alternatives (AoA). This Handbook focuses only on those Post-CBA through MS A activities where HSI and ESOH practitioners can influence system capabilities performance criteria and help discriminate between alternative materiel solutions. The goal of this Handbook is to help HSI and ESOH practitioners provide appropriate inputs to those JCIDS capabilities documents and AoA related activities.

Historically, the HSI and ESOH communities have not been able to influence system development until later in the acquisition process, often after the system design had been set. This approach makes it difficult and expensive to address HSI and ESOH considerations. It is far more effective and efficient to apply HSI and ESOH principles early and consistently as part of the capability requirements document development and AoA activities. Consistent, active HSI and ESOH engagement offers the best opportunity to influence system design and reduce avoidable life cycle costs by eliminating or mitigating risks to personnel, equipment, and the environment.

This Handbook is intended for use by DoD or defense contractor personnel with particular expertise in manpower, personnel, training, human factors engineering, safety (including system safety engineering), occupational health, habitability, personnel survivability, and environmental science/engineering. To be able to integrate these HSI and ESOH considerations in the Pre-MS A activities, HSI and ESOH practitioners must be able to communicate how HSI and ESOH-related criteria can support the effort to meet the warfighters' capability needs and priorities.



Adapted from CBA User's Guide, Version 3, March 2009

Figure 1.1 Acquisition Framework and JCIDS Documents

This Handbook focuses on key JCIDS and AoA activities and documents developed before MS A in response to the CBA defined warfighter needs. These documents offer HSI and ESOH practitioners an opportunity to provide input and therefore influence the factors considered when selecting a candidate system or solution to fill a capability need. Each chapter of this Handbook provides guidance on how to effectively participate and frame input to the activity or document. For the sake of simple explanation, the descriptions of the processes and documents in this Handbook are based on a system to be developed in accordance with an ICD, entering the acquisition process at Materiel Development Decision (MDD) and proceeding to MS A. The following key activities and documents will be addressed in more detail in this Handbook.

- DCR – Chapter 3.
- ICD – Chapter 4.
- AoA Study Guidance – Chapter 5.
- AoA Study Plan – See Chapter 6.
- MDD – Chapter 7.
- AoA Execution –Chapter 8.
- Preferred Materiel Solution – Chapter 9.
- Draft CDD – Chapter 10.
- Draft CDD Capability Statements – Chapter 11.

The HSI and ESOH considerations and example capability statements for the Draft CDD in Chapter 11 are derived from past program experiences, best practices, and lessons learned by HSI and ESOH practitioners.

2. Participation in Pre-Milestone A Activities

The scope of this Handbook is limited to opportunities for Human Systems Integration (HSI) and Environment, Safety, and Occupational Health (ESOH) involvement in Pre-Milestone (MS) A activities relating to Joint Capabilities Integration and Development System (JCIDS) capability document development process and the Analysis of Alternatives (AoA) process. Figure 2.1 illustrates the focus of this Handbook on certain selected activities between Post-CBA and MS A. The figure identifies key JCIDS documents, AoA, and Defense Acquisition System milestone decision points leading up to, and including, MS A.

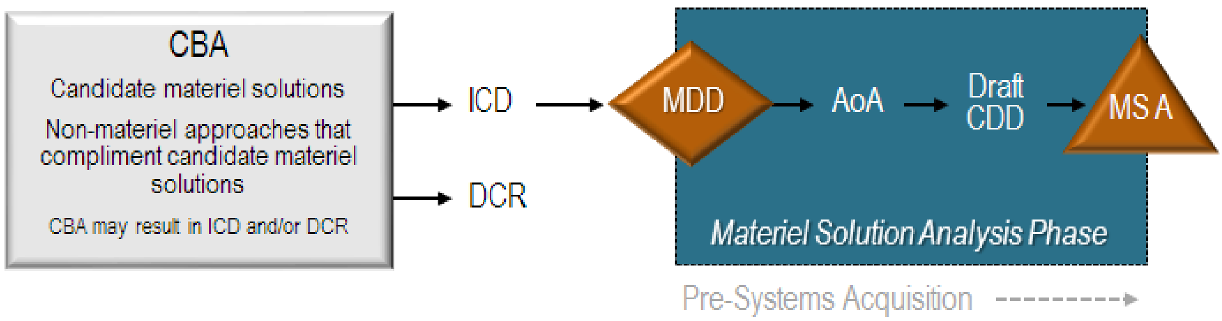


Figure 2.1 Key Activities Covered Between Post-CBA to MS A
(This Handbook describes activities done in support of JCIDS and the AoA. It should be noted that other technical activities are also required in order to meet Milestone A entrance criteria per DoDI 5000.02.)

HSI and ESOH practitioners should fully participate in the development process for the Initial Capabilities Document (ICD) and the Draft Capability Development Document (CDD) to build in appropriate of HSI and ESOH criteria for the materiel solution(s). Inclusion of HSI and ESOH criteria in these documents provides traceability to capability requirements to support system design requirements derived during Systems Engineering (SE) activities. HSI and ESOH practitioners should also fully participate in the planning and execution of the AoA to influence the selection of the preferred solution and lay groundwork for future systems engineering activities.

The Capabilities-Based Assessment (CBA) is an integral component of JCIDS and is conducted to identify capability requirements and associated capability gaps. The JCIDS Manual identifies a ten-step CBA process that includes study definition, needs assessments, and solution recommendations. The Joint Staff J-8/Joint Capabilities Division serves as the clearinghouse for the CBA process with participation from many sources, including Combatant Commands, Functional Capability Boards, Services, and other Department of Defense (DoD) Components. The CBA identifies the capabilities and operational performance criteria required to successfully execute missions; the shortfalls in existing weapon systems to deliver those capabilities, and the associated operational risks; the possible non-materiel approaches for mitigating or eliminating the shortfall; and when appropriate, recommends pursuing a full system materiel development solution. All CBAs include Doctrine, Organization, Training, materiel, Leadership and education, Personnel, Facilities and Policy (DOTmLPF-P) Analysis. When a CBA results in a recommendation for a non-materiel approach to fill capability gap(s), the recommended approaches are documented in one or more DOTmLPF-P Change Recommendations (DCRs). The DCR documents any recommended changes to doctrine, organization, training, materiel (less than full system materiel development), leadership, education, personnel, facilities and policy within a given organization/to meet the warfighters' needs. If a CBA results in a recommendation for a materiel solution to fill capability gap(s), the DoD Component Sponsor develops one or more ICDs to identify new capability requirements and associated capability gaps.

HSI and ESOH practitioners can be most effective by participating in the Post-CBA, Pre-MS A JCIDS and AoA activities. Successfully including HSI and ESOH elements early in these processes mitigates the potential for future rework. Rework of a design typically involves higher costs over up-front design considerations. In addition, the rework of materiel considerations often negatively impacts the program schedule and ultimately the fielding of the capability to the warfighter.

By participating in the development of the ICD and Draft CDD, HSI and ESOH practitioners can advocate for the inclusion of HSI and ESOH criteria as participants, rather than as reviewers during formal coordination of the document. It has proven to be very difficult to "inspect in" HSI and ESOH criteria after the document developers have completed the trades among the competing interests. HSI and ESOH practitioners should also support the development of the DCR by reviewing the recommended approaches in each of the non-materiel DOTmLPF-P elements and incorporating the necessary human and ESOH considerations into the proposed recommendations. Successful HSI and ESOH participation in JCIDS document development can help provide traceability (and justification for funding) for HSI and ESOH related technical requirements for the system in acquisition back to validated capability requirements from JCIDS.

Between the Materiel Development Decision (MDD) and MS A, HSI and ESOH practitioners should also conduct the relevant analysis and other technical and planning activities that refine requirements and support the selection of a concept for development. HSI and ESOH practitioners analyze the alternative materiel solutions such as potential systems to be developed and the concepts of operations to identify and prioritize appropriate HSI and ESOH considerations that can help discriminate between the alternatives under consideration. As a preferred materiel solution becomes more defined and is ultimately selected, HSI and ESOH practitioners continue to refine their analyses and recommendations for system requirements for inclusion in the Draft CDD. The objective of these efforts is to support informed decision making, with the goal of developing a preferred materiel solution with the fewest HSI and ESOH risks while meeting military capability requirements.

Because each activity or document has different purposes and goals, HSI and ESOH inputs must be tailored for each of them – thus, the level of detail for HSI and ESOH input in a given document or activity must be consistent with the level of that given document or activity. For instance, the level of detail increases between the ICD and Draft CDD. The ICD typically describes critical warfighter needs without specifying a specific system while the Draft CDD will contain very specific performance attributes for the specific system to be developed. It is critical that HSI and ESOH criteria be included in the Draft CDD because this document supports the system development activities in the Post-MS A Technology Maturation and Risk Reduction (TMRR) phase, including the Preliminary Design Review.

It is crucial for HSI and ESOH inputs to be coordinated for consistency. This is important because HSI and ESOH practitioners often evaluate similar aspects of a given DoD system, but they approach the analysis from different perspectives. For instance, HSI and ESOH both address safety and occupational health issues and use the system safety methodology described in MIL-STD-882E to assess and manage safety and occupational health risks. However, the HSI practitioner will typically focus on safety of the humans involved in the operation and maintenance of a system, while the ESOH practitioner will also consider the potential for mishaps that can cause damage to the system itself in addition to its operators and maintainers. In addition, ESOH practitioners will focus on a system's potential impacts on the environment, while the HSI practitioner is primarily focused on the environment's effect on the human involved in the operation and maintenance of the system. Both perspectives are important and need to address requirements in a complementary manner.

HSI and ESOH practitioner involvement in the Pre-MS A JCIDS document development and AoA activities can originate either as representatives of the system user community or as part of the overall SE process. As representatives of the user community, HSI and ESOH participants may be directly involved in the JCIDS document development and AoA activities. However, the HSI and ESOH participation in these activities may also be as part of the "early" SE activities. HSI and ESOH are among the SE technical design considerations and, depending upon the SE resources available during the Pre-MS A time period, the SE team may include HSI and ESOH participants or may request support from Service HSI and ESOH functional offices.

The SE process establishes a technical framework for delivering materiel capabilities to the warfighter. The SE process includes an integrated, disciplined, and consistent set of iterative activities that help the engineering team implement a balanced approach to system development with respect to cost, schedule, and performance. The technical planning for SE activities begins prior to the MDD and continues throughout the Materiel Solution Analysis (MSA) phase and is the foundation for documents, tools, and related data transitioned to the designated program. HSI and ESOH analyses conducted during this early stage should be integral parts of the SE process and support development of the AoA and Draft CDD.

HSI and ESOH practitioners involved in the technical planning should have the functional expertise to provide meaningful HSI and ESOH contributions in support of Pre-MS A SE analytic, engineering, and programmatic activities. During the MSA phase, HSI and ESOH practitioners should conduct the relevant analysis and other technical and planning activities needed to support the selection of a concept for development, refine requirements, and document planning as part of the ongoing SE activities during the TMRR phase. Several program documents are required for the MS A decision that may incorporate HSI and ESOH technical planning information as a result of HSI and ESOH participation on the SE team. These include the Systems Engineering Plan, parts of Acquisition Strategy, parts of Test and Evaluation Master Plan, Life Cycle Sustainment Plan, Program Protection Plan, Reliability and Maintainability Cost Analysis, and the Request for Proposal. HSI and ESOH practitioners can refer to the Defense Acquisition Guidebook, Chapter 4 on SE, for more detailed descriptions of these documents.

To be most effective, it is important that HSI and ESOH practitioners collaborate and exchange information during development of these key technical planning documents, as well as the development of the Draft CDD.

3. DOTmLPF-P Change Recommendation (DCR)

Doctrine, Organization, Training, materiel, Leadership and education, Personnel, Facilities, and Policy (DOTmLPF-P) Analysis is part of the analytical work of every Capabilities-Based Assessment (CBA). This analysis generally results in the Document Sponsor's team developing one or more DOTmLPF-P Change Recommendation (DCR) documents to address the validated capability gap with a non-materiel solution. Non-materiel solutions are changes to one of eight areas to satisfy one or more capability requirements (or needs) and reduce or eliminate one or more capability gaps. The Sponsor (Department of Defense (DoD) Component, Command, or Agency) is responsible for drafting the DCR. The eight DOTmLPF-P areas are:

- **Doctrine**. Fundamental principles that guide the employment of United States (U.S.) military forces in coordinated action toward a common objective.
- **Organization**. A joint unit or element with varied functions enabled by a structure through which individuals cooperate systematically to accomplish a common mission and directly provide or support joint warfighting capabilities.
- **Training**. Training, including mission rehearsals, of individuals, units, and staffs using joint doctrine or joint tactics, techniques, and procedures to prepare joint forces or joint staffs to respond to strategic, operational, or tactical requirements.
- **materiel.** All items (e.g., ships, tanks, self-propelled weapons, aircraft), and related spares, repair parts, and support equipment, but excluding real property, installations, and utilities necessary to equip, operate, maintain, and support joint military activities without distinction as to its application for administrative or combat purposes. The letter "m" in the acronym is lower case because DCRs do not advocate for a full system materiel development or major modification, but rather advocate for increased quantities of existing materiel capability solutions or use in alternate applications, potentially with less-than-major modifications.
- **Leadership and education.** Professional development of the joint leader is the product of a learning continuum that comprises training, experience, education, and self-improvement. The role of joint professional military education is to provide the education needed to complement training, experience, and self-improvement to produce the most professionally competent individuals possible.
- **Personnel.** The personnel component primarily ensures that qualified personnel exist to support joint capability requirements.
- **Facilities.** Real property consisting of one or more of the following: buildings, structures, utility systems, associated roads and other pavements, and underlying land.
- **Policy**. Any DoD, interagency, or international policy issues that may prevent effective implementation of changes in the other eight DOTmLPF-P elemental areas.

3.1 Staffing, Validation, and Approval Process

The Joint Staff Gatekeeper (J-8/Deputy Director for Joint Requirements) manages the overall flow of documents into and out of the Joint Capabilities Integration and Development System (JCIDS) process for staffing and validation, in addition to other activities in support of the JCIDS process. The DCR is staffed for review and validation through the lead Functional Capability Board (FCB) and is also sent to all affected process participants, including the Sponsor, supporting FCBs, Joint Staff Directors, validation authorities (typically the Service Requirements Oversight Councils), and endorsing/certifying organizations (e.g., the Joint Requirements Oversight Council Joint Weapons Safety Technical Advisory Panel). The staffing process ensures stakeholders have an opportunity to review proposed new capability requirements, or changes to previously validated capability requirements.

3.2 HSI and ESOH Inputs in the DCR

HSI and ESOH practitioners should participate in the Sponsor's DCR development team. HSI and ESOH practitioners should conduct iterative reviews of recommended changes in the DOTmLPF-P areas, and incorporate the necessary human and ESOH considerations into the proposed recommendations.

The JCIDS Manual provides guidance for drafting a DCR. Figure 3.1 presents the DCR outline included as Appendix B in the manual. HSI and ESOH input may be appropriate in the following DCR sections.

1. Executive Summary
2. Purpose
3. Background
4. Description
5. Analysis Process
6. Joint DCR Findings and Proposed Implementation Plan
7. Constraints
8. Policy
9. Issues
10. Recommendation Summary

Figure 3.1 DCR Outline

- The Findings and Proposed Implementation Plan section should include HSI and ESOH inputs in each DOTmLPF-P area, as appropriate. For example, when a new facility is recommended, consideration of National Environmental Policy Act or Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, is required; a new facility workspace should include consideration of the ergonomics of the new design.
- The Constraints section should address ESOH regulatory compliance constraints and human limitations (physical and cognitive).
- The Policy section should address consideration of human and ESOH requirements as part of the recommended changes to policy and guidance.
- The Recommendations Summary section should include the HSI and ESOH recommendations to mitigate potential impacts to people, equipment, or the environment.

Table 3.1 provides several HSI and ESOH-related questions practitioners may want to consider when contributing to the DCR.

Table 3.1 DCR Considerations

HSI	
Considerations	1. Is there a need to budget for HSI organizational activities with this capability? 2. How will the DOTmLPF-P recommendations impact the domains of HSI? Will they force tradeoffs? 3. Are individuals appropriately qualified to support the needed capabilities? 4. With facility modification/development, are there human factors, manning, personnel, training, and habitability implications (e.g., aircraft hangar, barracks) associated with these changes? 5. Does the policy identify who is responsible for the human considerations regarding the operations and use of a system or implementation of a process? If not, should it include that information? 6. Any changes to the other DOTmLFP-P areas will affect the training category. Are they addressed? 7. What are the human constraints and limitations (physical, emotional, cognitive)? 8. Will the humans trust and embrace new ideas and technologies? 9. Will the DOTmLPF-P recommendations create a common understanding of HSI across the Services and different levels of leadership?
ESOH	
Considerations	1. Is there a need to budget for ESOH organizational activities with this capability? 2. A DCR could have ESOH implications, for example an increase in operational tempo at a specific location and/or along a specific route could impact community noise restrictions or cause additional air or water emissions. 3. A DCR that affects facilities should be assessed to determine if ESOH-related recommendations are needed. For example, a DCR impacting known locations that are home to endangered species could include a recommendation to evaluate existing National Environmental Policy Act assessments to determine if the change will require new or different actions. 4. A DCR that affects facilities may have the potential to impact ESOH, such as consideration of asbestos-containing buildings. 5. How will new or unique training be evaluated to understand the ESOH implications, such as potential new hazards and associated ESOH risks to personnel, equipment, or the environment? DoD systems are designed and used with a specific concept of operations, which, if changed, could pose hazards to personnel, equipment, or the environment.

4. Initial Capability Document (ICD)

The Capabilities-Based Assessment (CBA) may identify gaps in military capability requirements to successfully execute missions. When such gaps are identified, the Sponsor's team develops one or more Initial Capabilities Documents (ICDs) to identify new capability requirements and associated capability gaps. A materiel solution, as defined in the Joint Capabilities Integration and Development System (JCIDS) Manual, is defined as a new item (e.g., ships, tanks, self-propelled weapons, aircraft) and related spares, repair parts, and support equipment, but excluding real property, installations, and utilities, developed or purchased to satisfy one or more capability requirements (or needs) and reduce or eliminate one or more capability gaps. The Document Sponsor (Department of Defense (DoD) Component, Command, or Agency) is responsible for drafting the Joint ICD. Once validated, an ICD typically leads to an Analysis of Alternatives (AoA) and then the Draft Capability Development Document (CDD) to support the development of a new materiel solution or major modification of an existing one.

> The Joint Weapons Safety Technical Advisory Panel (JWSTAP) to the Joint Staff validates a draft ICD.

4.1 ICD Content

An ICD documents one or more new capability requirements, associated capability gaps, and the intent to partially or wholly address identified capability gap(s) with a materiel solution. For each capability requirement identified in the CBA, the ICD includes an explanation of why the capability requirements are essential for the Sponsor to achieve assigned goals and objectives. Capability requirements are described in terms of the required operational attributes, with appropriate qualitative parameters and metrics. The requirements should be general enough to avoid a slant in favor of a particular capability solution, yet specific enough to evaluate alternative approaches to achieve the capability. An ICD is usually not updated once it is validated and approved, but rather, is superseded by successor JCIDS documents, such as the Draft CDD.

4.2 Review, Validation, and Approval Process

The Joint Staff Gatekeeper (J-8/Deputy Director for Joint Requirements) manages the overall flow of documents into and out of the JCIDS process for staffing and validation. The ICD is staffed for review and validation through the lead Functional Capability Board (FCB), and is also sent to all affected process participants, including the Sponsor, supporting FCBs, Joint Staff Directors, validation authorities (e.g., JWSTAP), and endorsing/certifying organizations. The staffing process ensures stakeholders have an opportunity to review proposed new capability requirements, or changes to previously validated capability requirements.

4.3 HSI and ESOH Inputs in the ICD

HSI and ESOH practitioners should participate in the Document Sponsor's ICD development team. As active team members, HSI and ESOH practitioners should conduct iterative reviews as the document is developed and incorporate pertinent human and ESOH considerations into the capability statements. While the ICD is not a solution or system specific document, a few well-placed words relating to necessary human and ESOH considerations in the ICD can support HSI and ESOH analyses as part of future Pre-Milestone A activities. In addition, by including these considerations in the initial documents, the foundation will be set for including HSI and ESOH criteria in the Draft CDD.

Figure 4.1 presents the ICD outline in the JCIDS Manual (Enclosure B). HSI and ESOH language may be appropriate in several sections of the ICD. However, the ICD has a page limit restriction. Therefore, HSI and ESOH inputs must be consistent with the degree and specificity of detail found in the rest of the document. To provide valuable input and manage this constraint, HSI and ESOH practitioners should include references to potentially applicable statutes, regulations, standards, policies, instructions, etc. in the references section which does not have a page limit. A program office can later leverage this input to support derived technical requirements during the acquisition process.

1. Concept of Operations (CONOPS) Summary
2. Joint Capability Areas
3. Capability Requirements
4. Capability Gaps and Overlaps/Redundancies
5. Threat and Operational Environment
6. Assessment of Non-Materiel Approaches
7. Final Recommendations
8. References

Figure 4.1 ICD Outline

Table 4.1 identifies potential HSI or ESOH input for each section of the ICD; the examples are not intended to be directive or comprehensive. Table 4.2 presents sample HSI and ESOH considerations that may be used to help develop ICD input.

Table 4.1 HSI and ESOH Contributions to Sections of the ICD

Section	HSI/ESOH Contributions
1. CONOPS Summary Describes what mission areas this capability contributes to, what operational outcomes it provides, what effects it must produce to achieve those outcomes, how it complements the integrated point warfighting force and what enabling capabilities are required to achieve its desired operational outcomes.	• HSI or ESOH input is not recommended for this section.

Table 4.1 HSI and ESOH Contributions to Sections of the ICD

Section	HSI/ESOH Contributions
2. Joint Capability Areas Describes the applicable functional areas, including the range of military operations and the timeframe under consideration.	• HSI or ESOH input is not recommended for this section.
3. Capability Requirements Describes the specific aspects of the applicable functional areas that the ICD addresses and explains why the desired capabilities are essential to achieve the military objectives.	• Ensure HSI and/or ESOH implications identified in the CBA are mentioned.
4. Capability Gaps and Overlaps / Redundancies Describes the missions, tasks, and functions that cannot be performed or are unacceptably limited, as well as the attributes of the desired capabilities in terms of desired effects.	• Human performance limitations should be included in this section with reference to relevant Military/Industry Standards. • Include real or potential constraints on operations due to ESOH regulatory requirements (including Military/Industry Standards), e.g., limitations on the ability of transport aircraft to use worldwide commercial airports without compliance with International Civil Aviation Organization requirements.
5. Threat and Operational Environment Describes, in general terms, the operational environment in which the capability must be utilized including where the current projected threat capabilities are expected to be encountered.	• HSI concepts, such as personnel survivability, should be included when describing in general terms the operational environment. • Include ESOH concepts, such as availability of energy sources, vulnerabilities to energy supply line, or threats that may cause inadvertent weapon detonation.

Table 4.1 HSI and ESOH Contributions to Sections of the ICD

Section	HSI/ESOH Contributions
6. Assessment of Non-Materiel Approaches Summarizes the results of the DOTmLPF-P analysis, provides ideas for materiel approaches, and analyzes materiel approaches.	• Include HSI or ESOH related considerations for materiel approaches that relate to this ICD.
7. Final Recommendations Describes the best materiel approaches based on analysis of the relative cost, efficacy, performance, technology maturity, delivery time frame and risk.	• Include HSI activities related to the materiel approaches regarding cost, efficacy, human performance, technology maturity, etc. Also include a statement describing the importance of human-related considerations during the design and development of the system to reduce safety issues and minimize total ownership costs. • Eliminate or mitigate ESOH risk to ensure mission readiness, maximize operational suitability, and minimize total ownership cost of the solution so operators, maintainers, and support personnel can test, train, use and dispose of the potential solution across its life cycle. Historically, this involves full compliance with applicable US and US-ratified international ESOH laws and regulations. This is necessary to support the DoD goals of zero mishaps and fielding sustainable systems.*
8. References Includes relevant statutes, regulations, policies, instructions, and standards	• Include relevant HSI and ESOH policies, regulations, and standards (e.g., MIL-STD-1472G, "DoD Design Criteria Standard – Human Engineering"; MIL-HDBK-46855A, "Human Engineering Program Process and Procedures"; MIL-STD-882E, "Standard Practice for System Safety") and DoDI 5000.02.

*Subject Matter Experts who participated in the development of Defense Acquisition University Continuous Learning Module CLR030, "ESOH in JCIDS", agreed to include this standard ESOH criteria statement for Sections 7.

5. Analysis of Alternatives (AoA) Study Guidance

The AoA is a fundamental element of the acquisition process. After identifying validated capability needs in the Initial Capabilities Document (ICD), a study team performs an AoA to objectively evaluate the alternatives that may satisfy those needs. The AoA is an objective comparison of operational effectiveness, suitability, and life cycle cost that enables the Milestone Decision Authority (MDA) to select the preferred materiel solution.

The AoA Study Guidance is developed and approved by the Director, Cost Assessment and Program Evaluation (DCAPE), or designated lead DoD Component organization (Sponsor) for non-acquisition category I programs, to document the critical elements that senior decision-makers want to ensure are addressed during the AoA. The study guidance establishes requirements for full consideration of possible tradeoffs between cost, performance and schedule for each alternative considered. The study guidance incorporates Joint Requirements Oversight Council recommended cost and schedule objectives for meeting capability requirements. Because the study guidance is high-level, the lead organization does not convene a multi-disciplined team to develop the document. Therefore, there is little opportunity for Human Systems Integration and Environment, Safety, and Occupational Health practitioners to influence the document.

The study guidance builds upon analyses performed as part of the Capabilities-Based Assessment and documented in the ICD. The ICD limits the scope of alternatives to be considered in the AoA. It is important that the study guidance provide for a fair balance between focusing the AoA and ensuring the AoA considers a robust set of different alternatives. The study guidance provides overarching recommendations for minimum alternatives for analysis – legacy system, modified legacy system, and new system designs. Prior to the Materiel Development Decision review, DCAPE provides the study guidance to the DoD Component designated by the MDA. The study guidance is a resource for the Sponsor in developing the AoA Study Plan.

6. Analysis of Alternatives (AoA) Study Plan

The AoA Study Plan is designed in accordance with the AoA Study Guidance and facilitates full consideration of possible tradeoffs between cost, performance, and schedule objectives for each alternative considered. A well-crafted AoA Study Plan is critical to successful execution of the AoA. The Study Plan establishes a roadmap of how the analysis will proceed and identifies roles and responsibilities. The Sponsor establishes a multi-disciplined Study Team to develop the AoA Study Plan. The Director, Cost Assessment and Program Evaluation approves the Study Plan for acquisition category (ACAT) I and IA programs prior to the Materiel Development Decision. For all other ACAT programs, the designated DoD Component AoA procedures and approval authorities apply.

It is important that Human Systems Integration (HSI) and Environment, Safety, and Occupational health (ESOH) practitioners participate in the Study Team to identify any human and ESOH considerations that could discriminate between alternatives. The HSI and ESOH practitioners can participate either as representatives of the user community or as part of the early System Engineering activities.

Because each AoA is unique, the Sponsor may tailor or streamline the Study Plan content in accordance with applicable AoA Study Guidance and Component policy to support a given situation. Figure 6.1 shows a recommended AoA Study Plan outline provided in the Defense Acquisition Guidebook, Chapter 3.

6.1 HSI and ESOH Inputs in the AoA Study Plan

1. Introduction
2. Ground Rules
3. Effectiveness Measures
4. Effectiveness Analysis
5. Cost Analysis
6. Cost-Effectiveness Comparisons
7. Organization and Management

Figure 6.1 AoA Study Plan Outline

While the Study Plan is not a requirements document, a few well-placed words relating to human and ESOH considerations as potential discriminators can provide justification for including HSI and ESOH analyses during the AoA. Identifying environmental, safety, and human-related implications of the alternatives in the study plan will ensure they are considered during the AoA, and may influence conclusions in the AoA Final Report. The amount of input and level of detail provided by HSI and ESOH practitioners is dependent upon the complexity and range of alternatives, as well as the scenarios, threats, and concept of operations.

Table 6.1 shows potential input HSI or ESOH practitioners may provide for each section of the AoA Study Plan. When preparing the Study Plan contributions, HSI and ESOH practitioners should carefully consider information in the applicable reference documents to include the Initial Capabilities Document, AoA Study Guidance, and any other pertinent documents. The intent is to provide value-added support for the selection of the preferred materiel solution. The examples are provided to help illustrate the types of potential HSI or ESOH considerations, but are not intended to be directive or comprehensive.

Table 6.1 HSI and ESOH Input to the AoA Study Plan

Section	HSI/ESOH Input
1. Introduction • Background • Purpose • Scope Describes what led to the AoA, including prior relevant analyses	• The Introduction is not likely to require specific HSI or ESOH contributions. However, the introduction may address overarching questions concerning HSI and ESOH such as, significant capability gaps or lessons learned from legacy systems and discuss the need for the AoA to identify potential, significant HSI and ESOH risks associated with each alternative.
2. Ground Rules • Scenarios • Threats • Environment (physical) • Constraints and Assumptions • Timeframes (future) • Excursions (planned analytic excursions to the baseline scenarios) Describes how each of the above will be considered as part of the AoA	• Include potential HSI or ESOH-related constraints. For example, HSI and ESOH constraints are often driven by regulatory requirements, Military/Industry Standards, safety certification requirements, and personnel limitations. • HSI constraints may include insufficient system performance, unfavorable HSI issue mitigation, high human error rates, risks to mission performance due to high mental workload, anthropometric limitations, and no training pipeline or personnel with the required skill levels. • ESOH constraints may include limitations on time or location of operation of the alternative system due to proximity to endangered species, far-field noise, or ability to confine regulated emissions/effluents (e.g., contaminated ballast or waste water); and potential limitations on operator exposure to hazards associated with the system during operation and maintenance (e.g., vibration and/or noise affecting operator effectiveness and endurance).
3. Range of Alternatives • Description of Alternatives • Nonviable Alternatives • Operations Concepts • Sustainment Concepts	• This description of the range of alternatives is not likely to require specific HSI or ESOH input.

Table 6.1 HSI and ESOH Input to the AoA Study Plan (Continued)

Section	HSI/ESOH Input
4. Determination of Effectiveness Measures • Mission Tasks (MT) • Measures of Effectiveness (MOE) • Measures of Performance (MOP) Describes how the AoA will establish metrics associated with the military worth of each alternative.	• The explanation of how the AoA will establish military worth of each alternative is not likely to require specific HSI or ESOH input. • Military worth often is portrayed in the AoA as a hierarchy of MTs, MOEs, and MOPs.
5. Effectiveness Analysis • Effectiveness Methodology • Models, Simulations, and Data • Effectiveness Sensitivity Analysis Spells out the analytic approach to the effectiveness analysis, which is built upon the hierarchy of military worth, the assumed scenarios and threats, and the nature of the selected alternatives.	• The study plan should document HSI and ESOH practitioner will conduct the analysis of HSI and ESOH considerations for each alternative. • Identify that HSI and ESOH practitioners will review models and simulations under consideration for use in the AoA and include HSI and ESOH input as appropriate. • Consider the identified HSI and ESOH constraints applicable to each alternative system/technology concept and design (if available). Identification of constraints may require request for information and data from potential fielding locations and similar legacy systems. Information needed to analyze the alternatives may include Notice of Violation, safety certification/board findings, mishap reports, accident reports, and other data for similar or legacy systems. • Identify data (e.g., technical drawings and specifications, hazard analyses results, hazardous materials usage) needed to analyze system/technology alternatives. The data may be requested from alternative product manufacturers or may be developed through analysis of available information on an alternative.

Table 6.1 HSI and ESOH Input to the AoA Study Plan (Continued)

Section	HSI/ESOH Input
6. Cost Analysis • Life Cycle Cost Methodology • Additional Total Ownership Cost Considerations (if applicable) • Fully Burdened Cost of Delivered Energy (if applicable) • Models and Data • Cost Sensitivity and/or Risk Analysis Describes the approach to the life-cycle cost (or total ownership) cost analysis	• Potential human-related cost drivers should be included in the cost analysis approach. The approach can identify the use of legacy system cost data as one data point during the conduct of the cost analysis. Considering human-related costs up front as part of the AoA is necessary to minimize life cycle costs. • HSI-related cost data considerations include: manning numbers, designing for the users (operators, maintainers, and support personnel) up front to reduce redesign and the need for more skilled personnel, hearing loss, back and neck pain, and the loss of a life. Critical human-related costs occur later in the system life cycle or through long-term health problems. • ESOH cost drivers should also be included in the approach. Such drivers include: use of hazardous materials (HAZMAT), management of waste streams from operation and maintenance activities, hazardous waste treatment and disposal, HAZMAT handling and storage, procurement and management of personal protective equipment and medical surveillance, pollution control devices, required bookkeeping and reporting activities (e.g., Toxics Release Inventory), permitting for environmental releases or taking of endangered species, and modifications to system/buildings/structures to incorporate safety devices (such as warning signals, cut-offs, relief valves). The costs for ESOH engineering planning and activities during the acquisition process should also be included, as well as costs for the National Environmental Policy Act/Executive Order 12114 analysis and documentation process.
7. Cost-Effectiveness Comparisons • Cost-Effectiveness Methodology • Displays or Presentation Formats • Criteria for Screening Alternatives Identifies the planned approach for the cost-effectiveness comparisons of the study alternatives	• The HSI and ESOH driven costs should be included as a factor in the overall scoring of cost comparisons between alternatives (based on the cost analysis results).
8. Organization and Management • Study Team/Organization • AoA Review Process • Schedule	• The HSI and ESOH practitioners should be identified as part of the Study Team.

7. Materiel Development Decision (MDD)

The MDD is the formal entry into the acquisition process and is mandatory for all acquisition programs. However, an acquisition program is not formally initiated until Milestone (MS) B or at C for programs that enter directly at MS C. The MDD is based on a validated Initial Capabilities Document and the completion of the Analysis of Alternatives (AoA) Study Guidance and AoA Study Plan. The Milestone Decision Authority (MDA) conducts the MDD. Depending on the designated acquisition category (ACAT) for the program, the MDA may be the Component Acquisition Executive or the Program Executive Officer (or equivalent) within the Sponsor organization. The ACAT is determined by procedures and criteria contained in the Department of Defense (DoD) and Component acquisition policies. At the MDD, the Director, Cost Assessment & Program Evaluation (or Component equivalent) presents the AoA Study Guidance, and the Sponsor presents the AoA Study Plan. The Sponsor also provides the plan to staff and fund the actions that will precede the next decision point (usually MS A), such as the analytic, engineering, and programmatic activities.

At MDD, the MDA designates the lead DoD Component, determines the acquisition phase of entry, and identifies the initial review milestone. These decisions are documented in an Acquisition Decision Memorandum (ADM). The approved AoA Study Guidance and AoA Study Plan are attached to the ADM.

As part of the MDD, the MDA may authorize entry into the acquisition process, at any point, based on the materiel solution's technical maturity and risk. Technical risk has several elements, including technology risk, engineering risk, and integration risk. If the Component-recommended entry point is beyond the Materiel Solution Analysis phase, the DoD Component provides evidence that the solution's technical maturity supports entry at the phase being proposed. The MDA decision is based on the soundness of the supporting technical documentation and planning not just completeness of the required documents.

HSI and ESOH practitioners do not participate in the MDD process because it is an executive decision point. However, HSI and ESOH practitioners' assessments of technical risks, and plans to staff and fund the analytic, engineering, and programmatic activities that will occur during the next acquisition phase are included in documents reviewed as part of the MDD process.

8. Analysis of Alternatives (AoA) Execution

The AoA is a fundamental element of the acquisition process and is congressionally mandated for Major Defense Acquisition Programs. The AoA is initiated after the Materiel Development Decision (see Chapter 7) and entry into the Materiel Solution Analysis phase. The AoA results are documented in the AoA Final Report. It is important to note that the AoA Final Report does not recommend a preferred alternative, but rather provides information that the Sponsor uses to select which materiel solution to recommend for further maturation during the acquisition process.

8.1 HSI and ESOH and the AoA Study Team

The AoA is typically conducted by a diverse group of government and contractor personnel on an AoA Study Team led by the Study Director who is responsible for all execution aspects of the AoA and the AoA Final Report. The Study Director briefs leadership and key stakeholders periodically throughout the AoA process to report on progress and ensure the AoA execution is meeting leadership expectations. The Study Team should include experts in manpower, personnel, training, human factors engineering, safety (including system safety engineering), occupational health, habitability, personnel survivability, and environmental science/engineering. The Human Systems Integration (HSI) and Environment, Safety, and Occupational Health (ESOH) practitioners review the alternatives from a human, system, and environmental (including energy) standpoint.

As the AoA is executed, it is important that HSI and ESOH practitioners ensure environmental, safety, and human-related discriminators between the alternatives are considered and reflected in the AoA Final Report. HSI and ESOH practitioners should evaluate the alternative solutions to help identify alternatives that maximize human performance, minimize HSI and ESOH-related costs, and minimize regulatory compliance requirements for safe and effective operation, maintenance, and support functions. When executing the AoA, HSI and ESOH practitioners should build on the findings of the pre-acquisition solution concepts (alternatives) analysis. Most of the contributions will be developed throughout the analysis processes as part of the study execution.

The Study Director establishes Workgroups (WGs) to conduct the AoA such as Effectiveness Analysis (EA), Cost Analysis (CA), Technology and Alternatives, and Operational Concepts (OC). HSI and ESOH practitioners should work with the Study Director to participate in the EA, Technology and Alternatives, and OC WGs. HSI and ESOH personnel may not need to have full membership in the CA WG. However, the practitioners should review and provide feedback regarding the HSI and ESOH implications of the CA findings. As members of the EA WG, HSI and ESOH practitioners will evaluate, refine, and sometimes develop mission tasks (MT), measures of effectiveness (MOE), and measures of performance (MOP) developed as part of the EA. EA WG participation is covered in more detail later in this Chapter. As members of the Technology and Alternatives WG, HSI and ESOH practitioners will review the different technologies and alternatives identified as part of the

AoA. HSI and ESOH activities should focus on each alternative's implications for operational concepts, sustainment concepts (including life cycle costs derived from ESOH regulatory compliance), training concepts, and test considerations.

The Study Director and Study Team finalize the scope the AoA by clearly defining constraints and assumptions, scenarios and threats, the physical environment, and the concept of operations that will be used during conduct of the AoA. The scope is primarily based on the Initial Capabilities Document (ICD), previous analyses completed during the Capabilities-Based Assessment, AoA Study Guidance, and AoA Study Plan. HSI and ESOH practitioners should maintain awareness of scoping activities, review outcomes, and update/identify HSI and ESOH constraints. The decisions made when scoping the AoA shape the analysis methodologies and the execution of the plan.

Table 8.1 provides examples of HSI and ESOH that may be taken into account when conducting the AoA. These examples are provided to help illustrate the types of potential HSI or ESOH input, but are not intended to be directive or comprehensive.

Table 8.1 HSI and ESOH Considerations for the AoA

HSI	
Considerations	1. Are there changes to the current manpower mix (military, civilian, contractor)? 2. Will there be changes to the baseline manpower footprint (legacy)? 3. Does the alternative support the baseline personnel selection/organization criteria? 4. Does the alternative have media and/or equipment sufficiency to ensure training effectiveness? 5. If there is a ground based training system, will it minimize changes to the current footprint? 6. Have training concepts been identified? 7. Are there human-system interface changes and/or modifications from legacy systems for operators and maintainers (e.g., glass cockpit)? 8. Are there anthropometric limitations associated with the system? 9. Is the alternative operable and maintainable in extreme environmental conditions? 10. Are there life support implications or requirements (e.g., oxygen)?
ESOH	
Considerations	1. Will the alternative require a significant ESOH regulatory compliance effort? 2. Will natural resources, wildlife, aviary, or living marine resources be significantly affected? 3. Does the alternative have the potential to impact protected or endangered species? 4. Can system safety hazards be minimized to the maximum extent possible through design? 5. Do the types of materials (such as hazardous materials) used for the alternative potentially impact normal operating and maintenance costs of legacy or similar systems? 6. Does the alternative generate hazardous waste? 7. Does the alternative abide by current design requirements that minimize injury? 8. Are there ESOH implications for surrounding communities where the alternative may be operated, deployed, and maintained? 9. Are there new technologies involved that will require extensive ESOH evaluation?

8.2 Effectiveness Analysis

The EA is normally the most complex element of the AoA and consumes a significant fraction of the AoA resources. The analytical approach to the EA focuses on determining military worth based on the assumed scenarios and threats, the nature of the alternatives, and identification of suitable analytical tools and input data sources. Military worth often is portrayed in AoAs as a hierarchy of MTs, MOEs, and MOPs. Military worth is the ability to perform mission tasks, which are derived from the ICD.

MTs are usually statements of general tasks to be performed or effects to be achieved (e.g., hold targets, provide countermeasures against surface-to-air missiles, or communicate in a jamming environment). MTs should not be stated in solution-specific language. MOEs are qualitative or quantitative measurements of how well each alternative performs the MTs. Each MT should have at least one MOE supporting it, and each MOE should support at least one MT. MOEs do not have established threshold values because of the subjective nature of the MOE criterion. Because the AoA tries to identify the most promising solution(s), MTs should not be stated in solution-specific language and MOEs call for optimizing aspects of a task or effect. Either of these actions could cause unintended impacts to cost or other aspects of performance of alternatives. In general, MOEs:

- Should be quantitative, when feasible (e.g., "How many targets are held at risk?" or "The number of targets by type that you can hold at risk in daytime and nighttime conditions?");
- May be qualitative or subjective, calling on the opinion of a knowledgeable person or group, (e.g., "In your opinion, does the solution provide a day-night capability?");
- Should be independent of the alternatives, as all alternatives are evaluated using all MOEs;
- Should not be strongly correlated with one another (to avoid overemphasizing particular aspects of the alternatives); and
- May be supported by one or more MOPs.

MOPs are usually a quantitative measure of a system characteristic (e.g., range, velocity, mass, scan rate, weapon load-out) chosen to enable calculation of one or more MOEs. MOPs may apply universally to all alternatives or, they may be system specific in some instances. To determine how well an alternative performs, each MOP has a threshold value determined by subject matter experts (SMEs) during the AoA. An MoP may also have an objective value which is more demanding than the threshold value. Generally, objective values are not needed for an AoA because the Study Team is looking for the minimum acceptable value.

HSI and ESOH practitioners should participate in MT, MOE, and MOP development. Ideally, the EA WG will develop one or more HSI-related MTs, along with accompanying MOE(s) and MOP(s). There may not be a specific ESOH-related MT, but there likely will be MOEs that would support an ESOH-related MOP. ESOH-related MOPs will most often be converted to binary language (i.e., yes/no) to simplify the assessment process and focus the analysis on the identified threshold values.

To support the EA, HSI and ESOH practitioners should review models and simulations planned for the AoA to ensure they include potential HSI and ESOH input. It is important that the overall EA approach consider the identified HSI and ESOH constraints across the relevant functional areas.

Information and data from potential fielding locations and similar legacy system programs, such as drawings, hazard analyses, or hazardous materials usage, may be useful in identifying constraints. Practitioners should also ensure that data requested from the alternative product manufacturers includes relevant HSI and ESOH data. When specific technical information is not available from an alternative manufacturer/vendor, the data may be developed through an analysis of available information for an alternative.

8.3 AoA Final Report

The entire AoA process and results are documented in a written Final Report. This Report is approved by the Sponsor and fully coordinated within the lead Department of Defense (DoD) Component and joint partners (if appropriate).

The Final Report is extremely important because it is the principal supporting documentation for any decisions made as a result of the AoA. The format for the final report corresponds closely to that of the Study Plan to help adapt material from the Study Plan to the Final Report. In addition to the Study Plan sections, the following additional sections should be added to the Final Report:

- Executive Summary
- Effectiveness Results
- Life Cycle Cost Results
- Risk Analysis Results
- Alternative Comparison Results
- AoA Conclusions and Recommendations

As a minimum, HSI and ESOH data and results should be discussed in the Life Cycle Cost, Risk Analysis, and Alternative Comparison Results sections of the report. Any significant HSI and ESOH finding or risk relevant to the recommended alternative solution(s) should be captured as part of the AoA Conclusions and Recommendations section. The final results of an AoA are typically briefed to senior leadership within the lead DoD Component and joint partners (if appropriate) and, for acquisition category I programs, within the Office of the Secretary of Defense. Interested parties will include the Sponsor organization, the Integrating Integrated Product Team, the Overarching Integrated Product Team, and ultimately the Milestone Decision Authority at the Milestone Decision Review. These briefings should logically present the case for selection of the best alternative(s) in meeting the capability requirements outlined in the ICD.

9. Preferred Materiel Solution

The preferred materiel solution is selected by the Sponsor towards the end of the Materiel Solution Analysis (MSA) phase. After completion of the Analysis of Alternatives (AoA), the Sponsor conducts additional engineering and trade analyses support selection of their preferred materiel solution from the potential solutions identified in the AoA. Ideally, the Human Systems Integration (HSI) and Environment, Safety, and Occupational Health (ESOH) practitioners who worked the Initial Capabilities Document and AoA planning and execution will continue on as part of the Sponsor's team conducting technical or engineering analyses following the AoA. If a new group of HSI and ESOH practitioners support the program team, it is vitally important that all available HSI and ESOH technical data be passed to the program team to support continued technical and engineering analyses to select and define the preferred materiel solution.

The AoA Report characterizes each alternative (or alternative approach) relative to the others and provides information that the Sponsor uses to select a preferred materiel solution to recommend for further maturation during the acquisition process. The Sponsor recommends the preferred material solution for approval by the Milestone Decision Authority (MDA) at the Milestone (MS) A Decision Review.

The preferred materiel solution selected by the MDA should have the potential to be affordable, operationally effective and suitable, sustainable, and technically achievable (e.g., able to provide a timely solution to the stated operational capability need at an acceptable level of risk). Selection of the preferred materiel solution is formally documented in the MS A Acquisition Decision Memorandum. Selection of the preferred materiel solution is important because it enables the program team to now focus its engineering activities on one alternative approach.

10. Draft Capability Development Document (CDD)

The Draft Capability Development Document (CDD) is more specific than the Initial Capabilities Document (ICD) and provides more refined capability requirements directed toward a particular materiel approach for a capability solution. The Draft CDD includes system-specific technical and sustainment-related characteristics necessary to provide the operational capabilities required by the warfighter.

1. Capability Discussion
2. Analysis Summary
3. CONOPS Summary
4. Threat Summary
5. Program Summary
6. Development of KPPs, KSAs, and additional performance attributes
7. SoS Synchronization
8. Spectrum Requirements
9. Intelligence Supportability
10. Weapon Safety Assurance
11. Technology Readiness Assessment
12. Assets Necessary to Achieve IOC
13. IOC and FOC
14. DOTmLPF-P Considerations
15. Other System Attributes
16. Program Affordability

Figure 10.1 Draft CDD Outline

Figure 10.1 contains an example outline of the Draft CDD from the Joint Capabilities Integration and Development System (JCIDS) Manual. However, JCIDS is an ever-evolving process, and the Joint Staff is currently evaluating whether to require that the Draft CDD only address a few of the sections of a complete CDD. The Draft CDD proposes refined performance capability requirements associated with the Sponsor's preferred materiel solution to be presented for approval at Milestone (MS) A. The Sponsor prepares the Draft CDD based on the ICD, results of the Analysis of Alternatives (AoA), and the continued technical and engineering analysis of their preferred solution conducted during Materiel Solution Analysis phase.

The Draft CDD defines authoritative, measurable, and testable parameters across one or more increments of a materiel capability solution. In the Draft CDD, the Sponsor establishes Key Performance Parameters (KPPs), Key System Attributes (KSAs), additional performance attributes, and Other System Attributes (OSAs) necessary for the acquisition community to design and propose systems and to establish programmatic baselines. KPPs and KSAs are those attributes that are so significant that they must be verified by testing and evaluation, or analysis. KPPs and KSAs have specified measurable thresholds that the <System X> *must* meet, as well as objectives that *should* be met; thresholds and objectives are not necessary for OSAs. During program maturation, if technology readiness, cost, and schedule constraints do not allow meeting or exceeding thresholds, then new thresholds must be staffed and coordinated in the full JCIDS process. The validated CDD must be finalized for MS B.

Draft CDD Chapter 10, Weapon Safety Assurance, contains information related to munitions capable of being handled, transported, used, or stored by any Service in joint warfighting environments. These munitions programs are considered to be joint weapons and are required undergo a joint weapons review. The Weapon Safety Assurance chapter addresses system safety, insensitive munitions, fuze safety, explosive ordnance disposal, demilitarization/disposal, and laser safety requirements associated with the joint weapons program.

It is not impossible, but extremely unlikely, that an ESOH criterion would be a KPP. In rare cases, it could be argued that a given ESOH criterion was most critical to meeting the warfighter need. ESOH requirements codified in DoD or Service policy should not be incorporated verbatim in JCIDS documents. However, it is appropriate to develop an ESOH criterion that tailors such policy to a given system solution.

The Draft CDD supports the system development activities that occur in the Technology Maturation and Risk Reduction phase leading up to the Preliminary Design Review (PDR) that precedes MS B. According to the Defense Acquisition Guidebook, approximately 40 percent of all detailed drawings are completed by PDR, and the Draft CDD significantly influences the system design. Therefore, it is critical to include Human Systems Integration (HSI) and Environment, Safety, and Occupational Health (ESOH) criteria in the Draft CDD. The CDD must be finalized and validated prior to the pre-Engineering and Manufacturing Development Review leading up to MS B.

The Sponsor coordinates and staffs the CDD development team, and includes the requirements manager and other members of the Program Office team. It is important that staff with functional and requirements development expertise participate in developing the CDD. HSI and ESOH practitioners supporting the Program Office team should ensure that appropriate HSI and ESOH specific attributes are considered. These practitioners should also analyze other capability statements in the CDD for HSI and ESOH implications. Additionally, HSI and ESOH practitioners should participate in the CDD review teams to ensure critical HSI and ESOH capability requirements are justified to the larger groups of stakeholders. Stakeholder buy-in is important so that the requirements are not removed during team negotiations.

KPPs are those performance attributes considered most critical or essential for an effective military capability. Failure to meet a KPP threshold will result in a reassessment of the program and possible cancellation. Programs minimize the number of KPPs to maintain program design flexibility, and they must be able to be traced back to the capabilities defined in the ICD. JCIDS identifies six mandatory KPPs: Force Protection, Survivability, Sustainment, Net Ready, Training, and Energy. For each Mandatory KPP, the Joint Staff specifies situations when the KPP is mandatory, when it is not mandatory, or when it may be waived.

KSAs are those system attributes considered essential, but not as critical as KPPs, for an effective military capability. KSAs provide decision makers with an additional level of capability prioritization below the KPP which use useful when making trade decisions. KSAs can either directly support a KPP, or can stand alone, such as attributes not considered critical enough to be a KPP. Both KPPs and KSAs may contain HSI and ESOH criterion. However, attributes are the most likely to contain HSI and ESOH. Attributes are found in the JCIDS Manual Section 6 (KPPs, KSAs, additional performance attributes) and Section 15 (Other System Attributes). Section 6 attributes have a higher priority than attributes in Section 15. Section 6 attributes have defined Thresholds and Objectives; Section 15 attributes do not contain Thresholds or Objectives. Section 14 (Other DOTmLPF-P Considerations) may contain HSI and ESOH constraints associated with the system.

It is important that HSI and ESOH practitioners understand what Threshold and Objective Values are and how they are derived so they can provide meaningful input into the Draft CDD. Threshold and Objective Values are derived from the Capabilities-Based Assessment, documentation of the gap in the ICD, and the AoA measures of performance. Threshold Value is the minimum acceptable value considered achievable within the available cost, schedule, and technology at low-to-moderate risk. Performance below the threshold value is not operationally effective or suitable, or may not provide an improvement over current capabilities. Threshold values should consider the human limitations, and should be achievable based on the current state of technology, or on new technology that can be matured at low risk. Objective Value is the desired operational goal achievable but at higher program risk in cost, schedule, and technology. The objective values may be defined based on a goal for the end state of the system.

There is no simple formula to follow for writing contributions to the CDD, but the following guidelines should make the HSI and ESOH contributions more effective.

- Prepare for writing the capability statements. Research legacy systems and their HSI and ESOH-related documents for lessons learned. Examine the capability gap (ICD), materiel solution (AoA Final Report) and the operational context of the system (Concept of Operations). Review the specifications and standards in the ICD; be sure to ask yourself, "Do I have the most current list of military and industry standards referenced?"
- Understand the context in which you are working. The warfighter community (Joint Staff and uniformed Services) runs the JCIDS process to provide the war fighting tools needed to prevail in combat. The warfighter community is a key stakeholder and HSI and ESOH practitioners should foster that working relationship. The HSI and ESOH practitioners should first demonstrate to the warfighter community how HSI and ESOH criteria contribute to the warfighters' needs. The practitioners could also explain how, if not addressed, a HSI or ESOH factor could negatively impact the warfighter's ability to meet their mission.
- Understand the rules of engagement for the JCIDS document development working group you are supporting. Know how and when participation is expected, and be ready to justify

your statements. Make arrangements for a more senior individual, uniformed if available, to attend and ensure they are ready to publicly corroborate your position if needed.

- Employ capability based language instead of providing input limited to statutory or regulatory compliance statements.
- Ensure the capability is testable.
- Do not reiterate known policy directives.
- When possible, demonstrate cost savings of proposed capability to increase its attractiveness.
- Characterize the potential cost impacts of the capability statements (capability statements can affect cost growth of the project; e.g., including Engineering Change Proposals, Rapid Engineering Assessments, and contract modifications. The unintended consequence of a capability statement could make the system unbuildable and expose the program to delays, over-runs, and legal damage compensation).
- Consider the –ilities (e.g., maintainability, availability, usability, sustainability, supportability) and the implications on HSI and ESOH.
- Address the life cycle implications of the capability statements (includes addressing operations, support, and disposal of the system as well as the design).

The most effective skill for working with the JCIDS process is identifying HSI and ESOH capability needs for a given system, and linking those needs to the warfighters' capability needs. Below are some resources that should be used as a guide.

Tools to Identify Capability Needs:

- Data from the AoA and/or specific system and subsystem design data
- Energy Source Hazard Analysis
- Functional Allocation Baseline
- Functional Analysis
- Hazard logs from legacy or similar systems
- Human Factors modeling
- Job Analysis
- Laboratory research (e.g., new training methodologies Live, Virtual, Constructive)
- Mishap Reports from legacy or similar systems
- National Environmental Policy Act documents
- Notices of Violation from potential receiving installations, ranges, units
- Parameter Assessment List
- Preliminary Hazard List (identify hazard sources)
- ESOH Compliance Review
- Safety Center documents
- Standards and Handbooks (e.g., MIL-STD-1472G, MIL-HDBK-46855A, MIL-STD-882E)
- Survivability modeling
- Systems Engineering staffs for legacy or similar systems

- Target Audience Description
- Task Analysis

11. Draft Capability Development Document (CDD) Statements

Prior to Milestone A, the most effective way to influence the design of the system is to include Human Systems Integration (HSI) and Environment, Safety, and Occupational Health (ESOH) criterion in the Draft CDD. Inclusion of HSI and ESOH criteria in Key Performance Parameters (KPPs) and Key System Attributes (KSAs) would be effective, but historically HSI and ESOH criterion are most likely to be included as CDD Section 6 - additional performance attributes (APA), or as Section 15 – Other System Attributes (OSA). HSI and ESOH criteria are most often included in the CDD as OSAs because OSAs address any other attributes not previously identified in KPPs, KSAs, or APAs, but do tend to be design, cost, or risk drivers.

In the past, HSI and ESOH practitioners have found it difficult to include system-specific capability statements as KPPs, KSAs, ASAs, or OSAs when competing against the multitude of other capability requirements required for the system. HSI and ESOH often provided inputs late in the process during the Stakeholder review of the Draft CDD when it is very difficult to add new requirements to the document. It is far more effective to participate in the Draft CDD development and make the case for HSI and ESOH criteria inclusion as part of the trade discussions. As a last resort, more general HSI and ESOH contributions may be included in CDD Section 14, Doctrine, Organization, Training, materiel, Leadership and education, Personnel, Facilities and Policy (DOTmLPF-P) Considerations as constraints associated with the system. Two types of DOTmLPF-P changes should be considered for inclusion in the CDD - changes that enable the implementation, operations, and support of the specific system, and changes that must be made to support integration of this system with existing capability solutions. Inclusion of general statements is not optimal, but if carefully crafted, the statements will provide traceability back to a Joint Capabilities Integration and Development System "requirement" as the system specification and other technical requirements are defined.

Table 11.1 identifies HSI and ESOH considerations that should be taken into account during development of the Draft CDD. Table 11.2 includes a list of example, general Draft CDD statements related to HSI and ESOH considerations that span multiple types of platforms.

11.1 Cross-Platform Considerations and General CDD Statements

Table 11.1 Example Cross-Platform HSI and ESOH Considerations

Habitability
• Ability for bladder relief when in gear • Berthing area (noise, vibration, temperature, ergonomics) • Distinguished visitor accommodations • Facility design and operator accommodations (break room, bladder relief, environment) • Living and working environment (ergonomics, temperature, noise, lighting) • Mission extension (bladder relief, food storage, berthing) • Operating environment (temperature, noise, lighting) • Potable water access • Thermal stress from layers • Weight of gear
Human Factors Engineering (HFE)
• Anthropometry of gear (sizing and fit) • Autonomy and trust • Cognitive and physical overload leading to safety hazards • Cognitive workload • Communication networks with mission control, air traffic control, other operators, other Ground Control System • Compatibility with other equipment (interfaces with uniform, transportation) • Component location and type standardization • Consider changing missions and additional needs with design • Crew fatigue • Design the system for and around the users (operators, maintainers, support personnel, trainers) • Display design and configuration (ergonomics, usability, interface) • Ergonomic design of gear • Ergonomic design of munitions concerning maintenance • Ergonomic design of workstation • Ergonomics of loading/unloading requirements • Human-in-the-loop • Human-on-the loop • Interfaces (functional, informational, environmental, operational, organizational, cognitive, physical) • Maintainer access to systems for repair and replacement • Physical workload • Redundancy in processes and components • Situational awareness • Standardized symbology • Usability for operators/maintainers

Table 11.2 Example Cross-Platform HSI and ESOH Considerations (Continued)

Manpower
• Legacy manpower requirements against new technology advances and capability needs for operational, maintenance, and support functions • Availability • Crew rest effect on needed manpower • Effect from environmental conditions • Limitations to situation awareness and effect on manpower requirements • Manning mix (military, civilian, contractor) • Manning required to maintain systems • Mission duration • Surge requirements • Workload on personnel required to operate, repair/maintain, and support the system
Personnel
• Availability of personnel with the appropriate knowledge, skills, and abilities • Development or use of a target audience description • Personnel classification • Personnel reliability • Post-traumatic stress disorder for non-deployed troops • Recruitment • Retention
Survivability
• Ability to perform rapid egress • Considerations unique to deployed environment • Deployed ground control system • Integrity of the warfighter compartment from attack • Limitations to situation awareness • Risks of detectability • Risks of fratricide • Threat protection (munitions, survival)
Training
• Cross-training for positions • Engagement of external organizations to perform training function/role • Identification of needed training systems (e.g., simulators) • Specialized training on proper use of gear and component locations • Training pipeline for specific positions • Types (e.g., technical manuals, computer-based, live, virtual)

Table 11.3 Example Cross-Platform HSI and ESOH Considerations (Continued)

Environment
• Air, land, and water emissions quantities for operational modes and subsequent actions needed to meet regulatory requirements at planned training, operations, and fielding locations • Demilitarization and disposal planning • Endangered/threatened species, migratory birds, and living marine resources which are protected by environmental regulations • Management (storage, handling, disposal) of hazardous materials required for operation, maintenance and support of the system • Management and disposal of hazardous waste generated during system operation and support • Use of water-efficient products, including those meeting EPA's WaterSense standards to minimization of water usage for operation and support • National Environmental Policy Act/Executive Order 12114 compliance and associated system data needed to conduct environmental assessments • Use of Energy Star®, Federal Energy Management Program (FEMP)-designated energy-efficient products, and Electronic Product Environmental Assessment Tool (EPEAT)-registered electronic products to reduce energy consumption
Safety
• Air worthiness and other safety certifications • Bandwidth, data legacy, data aging that could lead to degradation of safety critical systems • Battery safety • Egress and environment in confined spaces • Electrical shock safety • Equipment guarding • Escape and descent • Explosives environment and ordnance hazards • Fail-safe coding of software • Fail-safe design features • Fire hazards • Hazards associated with electro-magnetic radiation to personnel, ordnance, and fuels (Hazards of Electromagnetic Radiation to Personnel, Hazards of Electromagnetic Radiation to Ordnance (HERO), Hazards of Electromagnetic Radiation to Fuel) (MIL-HDBK-237D, MIL-HDBK-240A)) • High voltage hazards • Hydraulic and pneumatic pressures • Identification of hazards present during the various system states • Independent, redundant safety features • Level of situational awareness for the human operator • Maintaining control links for the human operator • Positive assurance of power discharge prior to work on hardware • Resistance to electromagnetic interference or jamming of safety critical systems • Rotating equipment • Safe flair and infrared countermeasures release • Safe weapons release • Safety critical functions and data • Safety restraint (non-ejection seat) • Sharp corners and edges on equipment • Slips, trips, and falls • Storage/use of hazardous materials that can result in system damage or loss if involved in a mishap (e.g., fire, explosion) • Weapons release authorization validation

Table 11.4 Example Cross-Platform HSI and ESOH Considerations (Continued)

• Weapons state – safe or armed • Working at elevation (platforms, railings, stairs, ladders)
Occupational Health
• Exposure of personnel to hazardous and toxic materials due to proximity to the system • Exposure to electromagnetic radiation • Exposure to excessive noise levels due to proximity to the system • Exposure to high voltages due to proximity to the system • Exposure to laser emissions • Exposure to radioactive materials • Exposure to X-rays during system maintenance and support • Occupational injuries due to repetitive movements, vibration, body positioning, poor lighting, poor work station design etc.

Table 11.5 Example General CDD Statements

Domain/ Category	Type of Capability Statement	Example Language	Justification
HSI	14. DOTmLPF-P	Comprehensive HSI planning shall be developed and executed within systems engineering processes for <system X>. Design of <System X> shall assess the implications across the HSI domain areas (Habitability, HFE, Manpower, Personnel, Occupational Health, Safety, Survivability, and Training). Specific attention shall be assigned to the following components: users (operators, maintainers, support personnel, trainers), displays, anthropometrics, crew compartment, simulators, workload, physical and cognitive capabilities, egress, usability, sustainability, maintainability, personnel availability, human error prevention, force protection, knowledge, skills, abilities, and hazards.	Per DoD Instruction 5000.02 HSI planning must be considered as part of the acquisition process. The Defense Acquisition Guide identifies HSI as a part of the systems engineering process.
HFE	6. Key System Attribute	<System X> warfighters require real-time situational awareness displays that fuse location, capabilities, resources, weather, and enemies. This data shall be integrated into a common display. The system shall provide environmental indicators and warnings using multiple sensory cues (e.g., visual, aural and tactile) (T) and provide an aural warning when <System X> is nearing operational conditions that exceed normal parameters (O).	The system should be designed around/for the warfighter population for workstation and console safety and anthropometric limitations.
HFE	6. Key System Attribute	<System X> shall accommodate the central 98% of all operators (male and female) to accommodate for variation in body size and shape (T). Accommodate 100% of all operators (O).	The system must be designed around the using population. Limiting the number of sizes will minimize the logistics footprint and may allow for shared assets.
Personnel	15. Other System Attribute	<System X> shall be maintained by a <X skill level X> for <X percent > of minor/major/ system maintenance.	The ability to safely and effectively maintain the system could be compromised if the individual does not have the appropriate knowledge, skills, and abilities.

Table 11.5 Example General CDD Statements (Continued)

Domain/ Category	Type of Capability Statement	Example Language	Justification
Training	15. Other System Attribute	Training devices and part task trainers shall replicate the operational equipment, controls, and displays as necessary for mission accomplishment. The training plan must ensure <Service> personnel (operators and maintainers) are trained and available to operate and maintain the system prior to IOC.	The system training plan must ensure personnel and maintainers are trained and available to operate and maintain the system.
Manpower	6. Additional Performance Attribute	<System X> shall be operated, maintained, and sustained within <projected manpower authorizations> (T=O).	The system should be designed considering manpower/workload requirements against new technology advances and capability needs for operational, maintenance, and support functions.
Manpower	15. Other System Attribute	Cognitive workload for normal crewmember operations shall not exceed 80% of workload capacity as measured by the Subjective Workload Assessment Technique.	The system should be designed considering manpower/workload requirements against new technology advances and capability needs for operational, maintenance, and support functions.
ESOH	15. Other System Attribute	ESOH considerations shall be addressed throughout the life cycle of the <system> to identify and eliminate ESOH hazards, minimize ESOH risks when hazards cannot be eliminated, and contribute to affordability of <the system> through reduction of operation, support, and disposal costs. The methodology in MIL-STD-882E shall be used to identify and analyze hazards, assess and mitigate ESOH risks, and provide information needed for informed design decisions. All ESOH hazards shall be tracked and associated risks accepted by the designated approval authority, with user representative concurrence when required, per DoD Instruction 5000.02.	The system should be designed to minimize ESOH risks during all life cycle phases by complying with applicable DoD and Component policy and regulatory requirements.

Table 11.5 Example General CDD Statements (Continued)

Domain/ Category	Type of Capability Statement	Example Language	Justification
ESOH	15. Other System Attribute	<The system> design shall incorporate lessons learned from a review of accidents/ incidents, etc., conducted on previous programs (to include but not limited to <list legacy systems>); these lessons learned will be applied in the design and development phases of the program. There shall be an ongoing risk mitigation effort throughout the program's life to respond to discoveries of issues and minimize impact to future operations with subsequent reduction in mishap rates.	The system should be designed to minimize ESOH risks during all life cycle phases by complying with applicable DoD and Component policy and regulatory requirements.
ESOH	15. Other System Attribute	The user and receiving installations/units shall have the capability to field, train, operate, maintain, and dispose of <the system> in full compliance with applicable Federal, State, local regulations; international treaties and agreements; and DoD/Service instructions/standards at the time of fielding . The National Environmental Policy Act and Executive Order 12114, *Environmental Effects Abroad of Major Federal Actions*, analyses and documentation shall be conducted, as required, in accordance with Component implementing regulations and policy.	The system should be designed to minimize ESOH risks during all life cycle phases by complying with applicable DoD and Component policy and regulatory requirements.
ESOH	15. Other System Attribute	Less-hazardous equipment and materials shall be used in <the system> design, operation, and maintenance where possible. Hazardous materials selected for use on the system, generation of hazardous wastes and pollutants during operation and maintenance, and the potential for adverse impacts shall be minimized, consistent with the program's cost, schedule and performance goals.	The system should be designed to minimize ESOH risks during all life cycle phases by complying with applicable DoD and Component policy and regulatory requirements.
Environment	6. Additional Performance Attribute	<System X> operational, design and statutory trades must be considered in meeting the Clean Air Act General Conformity Requirements at planned training and fielding locations. <System X> air pollutant emissions shall be equal to or less than <legacy system or value> for each criteria pollutant (T = O).	Restrictions on operational tempo at a specific location may be required to work around regulatory limitations on emissions.

Table 11.5 Example General CDD Statements (Continued)

Domain/ Category	Type of Capability Statement	Example Language	Justification
Environment	15. Other System Attribute	<System X> design, operation, and maintenance shall eliminate the use of hexavalent chromium in the system according to DFAR Subpart 223.73, *Minimizing the Use of Hexavalent Chromium*.	Efforts should be made to eliminate the use of hexavalent chromium and use suitable, qualified alternatives, because inhaled hexavalent chromium is a known carcinogen.
Environment	15. Other System Attribute	A hazardous materials map of <System X> shall be generated during design to document where-used information for the thousands of parts that make <System X>. The hazardous materials map shall identify the hazardous materials contained in parts and components used in the system, and their quantities and locations on the system.	The hazardous materials will be used as a resource during maintenance, overhaul, or disposal where information is needed to identify a component's hazardous constituents.
Environment	15. Other System Attribute	<System X> shall incorporate sustainable environmental practices throughout its life cycle to reduce environmental quality life cycle costs and environmental quality impacts.	Sustainable environmental practices are promoted via DoD's Sustainability Plan
Environment	15. Other System Attribute	<System X> design shall minimize or eliminate the use of lead solder to meet future international trends banning lead in electronic equipment, as well as beryllium and other conflict minerals. However, <System X> design shall carefully evaluate alternatives to lead, which may have potential reliability or safety concerns (i.e., tin solder producing lead whiskers).	The system should be designed to avoid known material fault modes and phenomena such as solder joints prone to "whiskering." The system should be designed in accordance with sustainable material management and green chemistry principles when feasible to follow international trends in regulatory approaches toward chemicals.

Table 11.5 Example General CDD Statements (Continued)

Domain/ Category	Type of Capability Statement	Example Language	Justification
Safety	6. Key System Attribute	Explosives safety requirements shall be addressed and tests conducted to ensure the safe use, handling, storage, maintenance, and disposal of <System X> in accordance with MIL-STD-2105B, and other applicable Military and NATO standards. Explosives safety initiatives include the following: hazards relating to warhead detonation within safe separation distances, Hazards of Electromagnetic Radiation to Ordnance testing of the loaded Vertical Launch System canister, lithium battery safety testing, command and control system tests, various explosives hazard classification and qualification tests, Insensitive Munitions (IM) testing, and transportation and vibration testing. (T=O)	The development of a safety and insensitive munitions assessment test program is critical for non-nuclear munitions. The most probable, credible threats that are expected to cause the greatest damage to life, property, or combat effectiveness should be tested. The sensitivity of explosive materials and the ability to restrict the potential impact of external stimuli during transportation and storage is a vital element for consideration in an explosives safety analysis.
Safety	6. Additional Performance Attribute	Any lithium batteries used in <System X> shall meet the requirements of the <Service Lithium Battery Safety Program>. (T=O)	The system will need to be designed in accordance with the Component's policy on lithium batteries.
Occupational Health	6. Additional Performance Attribute	<System X> shall minimize noises to <85dBA based on an 8-hr Time Weighted Average for personnel working around the system by incorporating noise mitigation technologies and other mitigations (T=O).	Ability to safely operate and maintain the system may be impaired by exposure to excessive noise; hearing loss may occur after exposure to excessive noise.
Occupational Health	15. Other System Attribute	<System X> hardware and software elements shall be ergonomically designed with respect to the operating environment to minimize user fatigue, discomfort, and injury.	Ergonomic design of the workstation will minimize the potential for long-term occupational health issues and costs (e.g., carpal tunnel)

11.2 Manned Aircraft

Table 11.6 Manned Aircraft HSI & ESOH Considerations

Survivability
• Ability to perform rapid egress (e.g., ejection)
Environment
• Individual Air Installation Compatible Use Zones prior to basing/training location decisions • Criteria to analyze far field noise emissions from the system and to analyze planned operational profiles and tempo at specific planned locations to support National Environmental Policy Act analyses and public outreach.
Safety
• Air Worthiness and other safety certifications
Occupational Health
• Exposure to excessive noise levels

Table 11.7 Manned Aircraft Example Draft CDD Statements (

Domain/ Category	Type of Capability Statement	Example Language	Justification
Habitability	15. Other System Attribute	<System X> shall support four crew members, three evacuees, and one attending medic for an operational no-refuel combat search & rescue mission, at T = half range, at O = full range.	The system must be designed to accommodate and support the crew for the entire mission duration in order to maintain personnel and system performance at the required level of combat readiness
HFE	6. Key System Attribute	The cockpit shall accommodate the central <98%> (T) / <100%> (O) <anthropometrics, height, or weight> of the target operator population.	The system should be designed around/for the target aircrew population (e.g., pilots) for workstation and console safety and anthropometric limitations of the users. A cockpit design-imposed restriction on operator size minimizes the available aircrew and has the potential to

Table 11.7 Manned Aircraft Example Draft CDD Statements (Continued)

Domain/ Category	Type of Capability Statement	Example Language	Justification
			stress the training pipeline.
Survivability	6. Key Performance Parameter	<System X> crew compartment shall be able to withstand engagement by man-portable air defense systems at tactical ranges <T = x km>, <O = y km> while maintaining controlled flight.	Personnel survivability and force protection is a critical component of overall system survivability and should be considered as part of the force protection KPP.
Training	6. Key System Attribute	<System X> shall have system training and training support using a live, virtual, constructive training environment to satisfy <System X> unique training needs for pilot, co-pilot and loadmaster positions, T = x hours of contact time, O = y hours of contact time plus z minute exit oral exam on emergency procedures with a minimum passing score of <95%>.	Efficient use of a variety training will facilitate the learning process, provide a safe training environment, and replicate environmental conditions to provide a more accurate training environment.
Environment	6. Additional System Attribute	<System X> components using liquid fuel shall be designed to incorporate DoD available low-emission fuels (T). The design shall incorporate bio-fuel technology (O).	Restrictions on operational tempo at a specific location may be required to work around regulatory limitations on emissions. Fines may be imposed if emissions limitations are exceeded.
Environment	6. Additional Performance Attribute	<System X> generated far field noise levels must be less than 75 dB Day Night Average Sound Level (DNL)/Community Noise Equivalent Level (CNEL) (T) or 65 dB DNL/CNEL (O) outside the perimeter (or buffer zones) of each range, installation, or base where testing, training, or fielding of <System X> can reasonably be expected.	Restrictions on operational tempo and flight patterns may be required to comply with local regulatory (community noise) limitations on noise emissions.

Table 11.7 Manned Aircraft Example Draft CDD Statements (Continued)

Domain/ Category	Type of Capability Statement	Example Language	Justification
Occupational Health	6. Additional Performance Attribute	<System X> shall limit noise exposure to aircrew in the cockpit and personnel working around aircraft with running engines and rotating flight components by incorporating noise mitigation technologies and other mitigations . T = no emissions > 110dB from 63 to 1,000 Hz; O = no emissions > 85 dB from 63 to 1,500 Hz.	Ability to safely operate or maintain the system may be impaired by exposure to excessive noise; hearing loss may occur after exposure to excessive noise.

11.3 Unmanned Aircraft

Table 11.8 Unmanned Aircraft HSI & ESOH Considerations

Human Factors Engineering (HFE)
• Communication networks with mission control, air traffic control, other operators, other GCS
Personnel
• Retention of pilots and sensor operators
• Post-Traumatic Stress Disorder for non-deployed troops
• Personnel classification (officer vs. enlisted)
Survivability
• Deployed Ground Control System (GCS)
Training
• Versioning of Ground Control System (GCS) and Aircraft (software upgrades and modifications)
Environment
• Individual Air Installation Compatible Use Zones prior to basing/training location decisions
• Criteria to analyze far field noise emissions from the system and to analyze planned operational profiles and tempo at specific planned locations to support National Environmental Policy Act analyses and public outreach.
Safety
• Air worthiness and other safety certifications to include use in public air space
• Collision and obstacle avoidance
• Fail safe mechanisms
• Fail-safe coding of software
• Fail-safe design features
• Independent, redundant safety features
Occupational Health
• Exposure to excessive noise levels

Table 11.9 Unmanned Aircraft Example Draft CDD Statements

Domain/ Category	Type of Capability Statement	Example Language	Justification
Habitability	15. Other System Attribute	< Facility X> shall house all control station hardware required to operate <System X> and execute tasked missions. It shall require all functionality, data interfaces, computer systems, and personnel requirements (facilities, potable water, heat/cooling) and a backup power source.	The system must be designed to accommodate and support the crew for the entire mission duration in order to maintain personnel and system performance at the required level.

Table 11.9 Unmanned Aircraft Example Draft CDD Statements (Continued)

Domain/ Category	Type of Capability Statement	Example Language	Justification
HFE	6. Key System Attribute	The aircrew requires near-real-time situational awareness displays in the Ground Control System that fuse mapping, charting, geodetic information, aircraft position, sensor pointing information, and weather. Situational awareness data (i.e., Link-16) must be fused into a common visual display (T). Aircrew situational awareness shall be provided by advanced flight indicators and warnings using multiple sensory cues (i.e., aural and tactile) and provide an aural warning when the aircraft is nearing flight conditions that exceed normal operating parameters (O).	Mission crew workload/ergonomics and Human Engineering Standards will be a key factor in system design.
Environment	6. Additional System Attribute	<System X> components using liquid fuel shall be designed to incorporate DoD available low-emission fuels (T). The design shall incorporate bio-fuel technology (O).	Restrictions on operational tempo at a specific location may be required to work around regulatory limitations on emissions. Fines may be imposed if emissions limitations are exceeded.
Safety	6. Key Performance Parameter	<System X> shall execute commands through a process that, at a minimum, accepts commands only from authorized entities; determines whether the command is valid; and performs only valid commands(T=O). This process shall be designed to safely initialize in the intended state, safely and verifiably change modes and states, and prevent hazardous system mode combinations or transitions.	Reduces potential for hostile, inadvertent or unauthorized control of the system and its weapon systems; unauthorized or invalid commands that may lead to unintended motion or weapon action resulting in death, injury, system damage or environmental damage. Ensures safety critical software does not contain “dead code” that could invoke hazardous unintended functionality

11.4 Space Launch Vehicles

Table 11.10 Space Launch Vehicles HSI & ESOH Considerations

Safety
• Transportation • Launch radius criteria • Launch abort/destruction requirements and hazards

Table 11.11 Space Launch Vehicles Example Draft CDD Statement

Domain/Category	Type of Capability Statement	Example Language	Justification
Habitability	15. Other System Attribute	< Facility X> shall house all control station hardware required to operate <System X> and execute tasked missions. It shall require all functionality, data interfaces, computer systems, personnel requirements (facilities, potable water, heat/cooling) and a backup power source.	The system must be designed to accommodate and support the crew for the entire mission duration in order to maintain personnel and system performance at the required level.
Habitability	15. Other System Attribute	Lighting shall be adjustable throughout the range from dim to bright illumination (<x to y lumens>) to balance needs for optimizing display viewing and maintaining alertness at night. A centralized lighting control panel shall be included for the personnel to change individual position lighting along with area illumination and shall be accessible by the primary crew members from their seated positions.	The system must be designed to accommodate and support the crew's working environments.
HFE	6. Key System Attribute	The overall human machine interface (HMI) shall be designed such that critical information for situational awareness is not occluded, and is continuously viewable including <alerts, warnings, safety critical messages, communications status, network status, and/or classification> (T= O). In addition, non-critical mission relevant information shall be accessible to the crewmember <60%> of the flight duration time (T)/<80%> of the flight duration time (O), with a maximum time lag of <30 seconds>. Appendix X includes all <System X critical information>.	The system should be designed to provide pre-defined critical information continuously to ensure operators have access to mission relevant information at all times.

Table 11.11 Space Launch Vehicles Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
Environment	6. Key System Attribute	<System X> shall comply with orbital debris minimization policies to minimize creation of mission-related debris (T). The program shall assess and limit the amount of debris released in a planned manner during normal operations; the probability of accidental explosion during and after completion of mission operations; and the probability of operating systems becoming a source of debris by collisions with man-made objects or meteoroids (O). The program shall also have a plan, consistent with mission requirements, for cost-effective disposal procedures for launch vehicle components, upper stages, and other payloads at the end of the mission life to minimize impact on future space operations (O).	The space segment must comply with applicable national, international, DoD, and U.S. Strategic Command orbital debris minimization policies. Unless a waiver has been granted, the system should incorporate debris mitigation and disposal procedures.
Environment	15. Other System Attribute	Recovery and clean up procedures shall be developed and documented to address anticipated effects from launch.	Based on lessons learned, special attention must be given to recovery and clean up procedure planning.

11.5 Satellites

Table 11.12 Satellite HSI & ESOH Considerations

Environment
• Space debris minimization • Launch abort debris impact
Safety
• Air Worthiness and other safety certifications • Transportation • On orbit or return to earth disposal procedures • Launch abort • Debris impact • Contamination risks

Table 11.13 Satellites Example Draft CDD Statements

Domain/Category	Type of Capability Statement	Example Language	Justification
Habitability	15. Other System Attribute	< Facility X> shall house all control station hardware required to operate <System X> and execute tasked missions. It shall require all functionality, data interfaces, computer systems, and personnel requirements (facilities, potable water, heat/cooling) and a backup power source.	The system must be designed to accommodate and support the crew for the entire mission duration to maintain personnel and system performance at the required level.
HFE	6. Key System Attribute	<95% (T)/99% (O)> of critical information (<fused mapping, charting, geodetic information, aircraft position, sensor pointing information, and/or weather>) shall always be available to the crew with a time lag of less than <5 seconds> (Time lag is defined as time from system receipt of information to time the crewmember becomes aware of information).	The system should be designed to provide the target population with pre-defined critical information continuously during the mission.

Table 11.13 Satellites Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
Environment	6. Additional Performance Attribute	<System X> shall comply with orbital debris minimization policies to minimize creation of mission-related debris (T). The program shall assess and limit the amount of debris released in a planned manner during normal operations; the probability of accidental explosion during and after completion of mission operations; and the probability of operating systems becoming a source of debris by collisions with man-made objects or meteoroids (O). The program shall also have a plan, consistent with mission requirements, for cost-effective disposal procedures for satellite components at the end of the mission life to minimize impact on future space operations (O).	The space segment must comply with applicable orbital debris minimization policies. Unless a waiver has been granted, the system should incorporate debris mitigation and disposal procedures.
Safety	6. Key System Attribute	<System X> shall have control system redundancy for both on orbit maneuvering and positioning and during de-orbit or on-orbit disposal procedures (T=O)	Redundancy is needed to mitigate against catastrophic system loss and is a best practice based on lessons learned.

11.6 Surface Ships

Table 11.14 Surface Ship HSI & ESOH Considerations

Habitability
• Mission extension (bladder relief, food storage, berthing) • Berthing area (noise, vibration) • Distinguished visitor accommodations • Breathing air quality, assurance, monitoring, alarms • Drinking water quality, assurance, monitoring, alarms
Human Factors Engineering (HFE)
• Personnel classification • Working and berthing area anthropometry, noise, vibration, temperature, lighting
Manpower
• Mission duration and the manning available to perform required tasks. • Crew rest effect on manpower
Environment
• Compliance with applicable Maritime Environmental Regulations • Air Emissions • Solid Waste Management and storage • Oil Pollution Abatement • Sewage and Graywater System Requirements • Living Marine Resources Considerations • Other Vessel Liquid Discharge Requirements (i.e., Uniform National Discharge Standards (UNDS)
Safety
• Safety of Life At Sea (SOLAS) • Ladder safety (rise, stair treads, handrails) • Anchorages, fall protection systems and other considerations for fall hazards • Confined spaces, tanks, voids • Hatch guards • Potential reactions from exposure of materials/components to water • Fire hazards • Systems of systems interactions • Flight safety (aircraft carriers) • Launch/landing operation (aircraft carriers) • Propulsion system hazards
Occupational Health
• Provision of noise-free areas for crew members exposed to excessive noise levels (especially aircraft carriers) • Exposure to power generation energy • Electromagnetic dosing • Propulsion system noise levels and potential for toxic gas leaks in workspaces.

Table 11.15 Surface Ship Example Draft CDD Statements

Domain/Category	Type of Capability Statement	Example Language	Justification
Habitability	15. Other System Attribute	In <System X> berthing areas, the difference between the inside of the bulkhead adjacent to the berthing area and the average air temperature within the space shall be within <18 degrees F>.	Since the ship is both the living and working environment for sailors the berthing area should be located in non-industrial areas of the ship where there noise pollution will be minimized and where the ambient temperature will not fluctuate drastically within and between compartments. This creates a more habitable sleeping environment.
Training	6. Key Performance Parameter	<System X> onboard facilities shall include space and equipment to support the onboard integrated learning environment to provide for cross-training of sea frame core personnel, <aviation component personnel> and mission package personnel. Cross-training shall include general ship platform skills and knowledge and specific skills to meet watch, quarter and station bill assignments, deck evolutions, fire-fighting, <flying squad support>, and collateral duties. (T=O).	Due to the potential for being deployed for extended periods of time, the ship should have onboard training capabilities to ensure personnel are up-to-date with required training and to provide for cross-training capabilities when the appropriately trained individuals are indisposed.

Table 11.15 Surface Ship Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
Manpower	15. Other System Attribute	<System X> shall use the Total Crew Model to identify minimum manpower resourcing to perform all required tasks and functions in an operational environment up to Condition I (General Quarters / General Emergency).	The minimum required manpower should be identified based on actual functional and task needs, not based on legacy or a percentage reduction from legacy.
Environment	15. Other System Attribute	<System X> shall be equipped with Type II or Type III Marine Sanitation Devices (MSD) certified by the Technical Authority (COMNAVSEASYSCOM) and designed to prevent the discharge of untreated or inadequately treated sewage, or of any waste derived from sewage (e.g., sludge), within 0-3nm of the U.S. <System X> shall have the capability to collect and transfer graywater to shore while pierside.	Compliance with US Navy Pollution Control Discharge Restrictions

11.7 Submarines

Table 11.16 Submarine HSI & ESOH Considerations

Habitability
• Mission extension (bladder relief, food storage, berthing) • Berthing area (noise, vibration) • Distinguished visitor accommodations
Human Factors Engineering (HFE)
• Working and berthing area anthropometry, noise, vibration, temperature, lighting
Manpower
• Crew rest effect on manpower
Survivability
• Ensure the integrity of the crew compartment from attack and on-board hazards • Ability to perform rapid egress • Limitations to situation awareness
Environment
• Compliance with applicable Maritime Environmental Regulations • Solid Waste Management and Storage • Oil Pollution Abatement • Sewage and Graywater System Requirements • Living Marine Resources Considerations
Safety
• SOLAS • Ladder safety (rise, stair treads, handrails) • Anchorages, fall protection systems and other considerations for fall hazards • Confined spaces, tanks, voids • Hatch guards • Potential reactions from exposure of materials/components to water • Fire hazards • Systems of systems interactions • Static electricity • Propulsion system safety hazards to operations and support personnel
Occupational Health
• Provision of noise-free areas for crew members exposed to excessive noise levels (especially aircraft carriers) • Electromagnetic dosing • Propulsion system health hazards to operations and support personnel

Table 11.17 Submarines Example Draft CDD Statements

Domain/Category	Type of Capability Statement	Example Language	Justification
Habitability	6. Additional Performance Attribute	<System X> shall not exceed noise levels defined as 100% Acoustic Dose, for crew positions in <X%> (T)/ <X%> (O) of the system. <System X> shall not subject any personnel to acoustic noise levels that result in a Total Daily Exposure (TDE) greater than <X#>. (T=O)	With a common living and working environment the system must not exceed noise exposure values or there is the potential for short- and/or long- term hearing loss.
HFE	15. Other System Attribute	<System X> shall provide crew situational awareness with non-hull penetrating systems (<e.g., sensors, photonics>). This information shall be fused into <#> display<s> for the common workstation. There shall be complete redundancy of the fused display<s>.	Without the need for a traditional periscope there is more flexibility in the submarine design regarding where to locate the combat command center and other compartments. Redundancy is needed in case of a system failure, to ensure that the crew is cognizant of the external environment.
Survivability	6. Key Performance Parameter	In accordance with MIL-STD-901 and individual submarine class specifications, <System X> shall withstand dynamically applied impact loads at <X speed / X surface area> while maintaining structural integrity of the crew compartments. (T) <System X> shall withstand a dynamically applied impact loads at <X speed / X surface area> while maintaining structural integrity of the entire system (O).	Personnel survivability and force protection is a critical component of overall system survivability and should be considered as part of the force protection KPP.
Safety	6. Key Performance Parameter	Minimizing and controlling the secondary effects associated with a flooding event shall be incorporated into the design of <System X>. Ballast system shall be capable of 110% of floodable volume at patrol depth (T). Emergency blow at test depth or beyond (O).	Design must conform to Submarine Safety standards.

11.8 Manned Tactical Ground Vehicles

Table 11.18 Manned Tactical Ground Vehicle HSI & ESOH Considerations

Survivability
• Limited situational awareness
Training
• Driver crew and training for vehicle operations (normal and emergency response)
Safety
• Terrain considerations • Rollovers • Load stowage/securing • Incorporate measures to mitigate against rollover (stability) • Seat belt design needs to account for soldiers and their gear • Gunner restraints need to account for soldiers and their gear • Three-plane egress points

Table 11.19 Manned Tactical Ground Vehicle Example Draft CDD Statements (

Domain/Category	Type of Capability Statement	Example Language	Justification
Habitability	6. Key Systems Attribute	<System X> shall be able to cool the occupant spaces by a minimum <30F> below ambient temperature or heat the occupant spaces to a minimum of <41F> (T) in hot, basic, and cold environments while the engine is operating and the vehicle is isolated from an environmentally hostile ambient area, e.g., a Chemical, Biological, Radiological, and Nuclear (CBRN) plume. The system shall be able to maintain occupant space temperature in the range of <65-85 degrees> F (O) in hot, basic, and cold environments while the engine is operating and the vehicle is isolated from an environmentally hostile ambient area.	Excessive heat or cold significantly reduces the warfighter's ability to perform. A comfortable environment enhances troop combat readiness, i.e., alertness, by allowing them to focus on the mission in different climates and allows for operation of key hardware and software systems.
HFE	15. Other System Attribute	<System X> shall display information required to operate the system in logical menus with no more than <3> layers and the capability for single action return to the top-level menu. Any single menu action that could result in the probability of causing harm to the warfighters shall require a warning display and confirmatory step prior to execution.	Designing for usability provides the ability for personnel to effectively and efficiently operate the system.

Table 11.19 Manned Tactical Ground Vehicle Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
Survivability	6. Key Performance Parameter	<System X> shall provide a crashworthy vehicle structure capable of maintaining structural integrity in a rollover; quantified as a crush resistant roof structure capable of supporting 100% (T)/150% (O) of the vehicle weight, to include all mission support equipment and maximum crew size and weight after a dynamically applied impact load.	Maintaining the integrity of the structure will increase the personnel survivability when involved in a crash or roll-over. Lessons Learned from OIF and OEF are that tactical vehicles capable of surviving IEDs require a high center of gravity and weight which makes the probability of a rollover Frequent or Probable so must try to mitigate the severity of the consequences of the rollover.
Survivability	6. Key Systems Attribute	<System X> shall allow for rapid egress for all combat-equipped crew and troops in Mission Oriented Protective Posture (MOPP) <X seconds> (T). <System X> shall allow for an alternate egress option for all combat-equipped crew and troops in the event that the hatch/door immediate to an occupant becomes non-functional (O).	In the event of a dangerous system situation or crash, the crew will be able to effectively and quickly egress from the system. This increases the opportunity to survive a life threatening situation.

Table 11.19 Manned Tactical Ground Vehicle Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
Training	6. Key Systems Attribute	<System X> training shall include in-vehicle training to encompass demonstrating a capability to negotiate operationally relevant terrain profiles, which include basic organic vehicle instrumentation, controls and crew drills, and emergency response procedures to any High or Serious risk mishaps, e.g., rollover (T=O).	Experience in a simulated operational environment allows the operator and crew to be more likely to react appropriately in a deployed operational environment.
Environment	6. Additional System Attribute	<System X> components using liquid fuel shall be designed to incorporate DoD available low-emission fuels (T). The design shall incorporate bio-fuel technology (O).	Restrictions on operational tempo at a specific location may be required to work around regulatory limitations on emissions. Fines may be imposed if emissions limitations are exceeded.
Environment	15. Other System Attribute	<System X> shall be designed to reduce the rate of fuel consumption while the system is idling by 20% compared to <legacy system X>	Efforts should be made to minimize fuel consumption due to the logistics tail associated with fuel. Additionally, reduced fuel consumption is expected to reduce emissions which can impact operational tempo, fielding, etc.

Table 11.19 Manned Tactical Ground Vehicle Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
Safety	6. Additional Performance Attribute	<System X> shall provide, quick-release seating restraints designed for crew personnel in full military combat gear, secure gear storage capable of preventing gear from becoming projectiles, and blast mitigating seats to minimize crew/passenger injury during attack or in the event of a mishap, especially a rollover. (T=O)	The system needs to be designed to minimize hazards and protect personnel from injuries both hostile situations and accidents. Lessons Learned from OIF and OEF are that tactical vehicles capable of surviving IEDs require a high center of gravity and weight which makes the probability of a rollover Frequent or Probable so must try to mitigate the severity of the consequences of the rollover.
Safety	10. Key System Attribute	<System X> shall comply with MIL-STD-464, Department of Defense Interface Standard: Electromagnetic Environmental Effects, Requirements for Systems. (T=O to protect personnel from hazardous effects of electromagnetic radiation.	Personnel need to be protected from electromagnetic radiation hazards. Compliance will be verified by test, analysis, inspections, or a combination thereof.

Table 11.19 Manned Tactical Ground Vehicle Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
Safety	6. Key Systems Attribute	If <System X> includes provision for a gunner (vice remotely operated weapon system), it shall include a gunner restraint system that is comfortable, minimally restraining, and capable of being worn for standard patrol duration by gunner in full combat equipment during combat operations to prevent inadvertent ejection in an accident or blast event (T=O). The gunner restraint for <System X> shall allow for adjustable seating heights and be designed so the gunner positions and visibility during patrol and weapon firing are not affected (T=O).	The restraint system is required to minimize catastrophic injury resulting from an accident and to prevent the gunner from being inadvertently ejected during rough terrain operations. The restraint system must be ergonomically designed such that it is comfortable enough for long duration use by gunners.
Safety	6. Key Systems Attribute	<One> rollover egress trainer shall be provided for each pre-deployment training site (T=O)	Lesson learned from legacy systems.

11.9 Unmanned Tactical Ground Vehicles

Table 11.20 Unmanned Tactical Ground Vehicle HSI & ESOH Considerations

Survivability
• Concerns related to survivability in a deployed environment
Safety
• Air Worthiness and other safety certifications • Independent/redundant safety features • Incorporate stability (e.g., shifting the center of gravity) into design to prevent inadvertent rollovers • Batteries need to be designed and managed to prevent overheating/fire of batteries • Tracking requirements • Autonomous operations • Jamming/interference in controls • Fail safe design features and coding of software • Self-destruct capabilities

Table 11.21 Unmanned Tactical Ground Vehicle Example Draft CDD Statements

Domain/Category	Type of Capability Statement	Example Language	Justification
Habitability	6. Key System Attribute	<System X> Control Station lighting shall be adjustable throughout the range from dim to bright illumination (<x to y lumens> to balance needs for optimizing display viewing and maintaining alertness at night (T=O). A centralized lighting control panel shall be included for the operator to change individual position lighting along with area illumination and shall be accessible by the primary operators from their seated positions (T=O); lighting shall be controllable for changing combat environments so as not to expose the operator to adversarial detection; e.g., tactical-blue or tactical red illumination (T=O).	The system should be designed to accommodate and support the operator for the entire mission duration in order to maintain personnel and system performance at the required level.
Habitability	15. Other System Attribute	< Facility X> shall house all control station hardware required to operate <System X> and execute tasked missions. It shall require all functionality, data interfaces, computer systems, and personnel requirements (facilities, potable water, heat/cooling) and a backup power source.	The system must be designed to accommodate and support the crew for the entire mission duration in order to maintain personnel and system performance at the required level.

Table 11.21 Unmanned Tactical Ground Vehicle Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
HFE	6. Key System Attribute	<System X> shall accommodate the central 90% of the target population (T=O).	Mission crew workload/ergonomics and Human Engineering Standards will be a key factor in system design in accordance with DoDI 5000.02.
Survivability	6. Key Performance Parameter	<System X> Control Station shall have features to disconnect primary power, disconnect back-up power (Uninterrupted Power Supply (UPS)), and send the unmanned vehicle on its emergency lost link mission and egress from the control station from their primary duty positions in <20 seconds> (T)/<10 seconds> (O).	Personnel survivability and force protection is a critical component of overall system survivability so should be considered as part of the force protection KPP.
Training	6. Additional Performance Attribute	Training devices and part task trainers shall replicate the operational equipment, controls, and displays for mission accomplishment.	The system training plan must ensure personnel and maintainers are trained and available to operate and maintain the system.
Environment	6. Additional System Attribute	<System X> components using liquid fuel shall be designed to incorporate DoD available low-emission fuels (T). The design shall incorporate bio-fuel technology (O).	Restrictions on operational tempo at a specific location may be required to work around regulatory limitations on emissions. Fines may be imposed if emissions limitations are exceeded.
Safety	6. Key System Attribute	<System X>, when in the weapons delivery or armed mode, shall have a fail-safe feather (e.g., health check) that prevents unintentional completion of the firing control circuit or uncontrollable movement that could lead to an unsafe situation (T=O).	The system should be designed to mitigate/prevent unsafe situations, such as unintentional firing of the explosive charges or uncontrollable movement.

Table 11.21 Unmanned Tactical Ground Vehicle Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
Safety	6. Key System Attribute	<System X> shall actively (automatically) control its stability (e.g., by shifting its center of gravity) to prevent rollovers or other loss of vehicle control. (T=O).	The system should be designed to prevent system rollovers, which could render the system inoperable, or damage the system.
Safety	6. Additional Performance Attribute	<System X> shall have an eye-safe laser range finder capability to aid in determining the distance to the target and to support intelligence gathering (T=O).	Lasers that are incorporated into the system design need to be eye-safe to protect personnel who may come in contact with the laser sight during operations.
Safety	15. Other System Attribute	<System X> should be designed to minimize human errors and maximize system safety. The system display design and decision support development/integration design shall maximize operator efficiency and minimize human errors. The system shall include fail-safe operation to avoid personnel injury and/or equipment damage due to system failure or operator error.	The system should be designed to mitigate/prevent unsafe situations; system components and software should default to a fail-safe condition.

11.10 Command, Control, Communications, Computers, and Intelligence (C4I)

Table 11.22 C4I HSI & ESOH Considerations

Safety
• System safety issues associated with human error input • Electromagnetic interference or jamming • Condition based maintenance (CBM) strategies

Table 11.23 C4I Example Draft CDD Statements

Domain/Category	Type of Capability Statement	Example Language	Justification
Habitability	15. Other System Attribute	< Facility X> shall house all control station hardware required to operate <System X> and execute tasked missions. It shall require all functionality, data interfaces, computer systems, and personnel requirements (facilities, potable water, heat/cooling) and a backup power source.	The system must be designed to accommodate and support the crew for the entire mission duration in order to maintain personnel and system performance at the required level.
HFE	15. Other System Attribute	<System X> graphical user interface shall be designed to be useable by all end user skill levels in the aspects of learnability, flexibility, and tailorability which shall be verified by iterative user testing.	Usability of the system by the operators optimizes human performance of the system, therefore overall system performance. Designing the system for the users by minimizing the potential for errors and mistakes increases user satisfaction and performance.

Table 11.23 C4I Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
Manpower	6. Key Performance Parameter	<System X> shall be manned <24 hours> a day, except when <system X> is scheduled for maintenance or update. Work shall be conducted with two <12 hour> shifts <per workstation/system function> daily (T). Work shall be conducted with three 8 hour shifts <per workstation/system function> daily (O).	Shift work is a critical component of systems that are operated on a continuous basis.
Personnel	6. Key System Attribute	<System X> operators shall have all of the appropriate security clearances and classifications to access the required system platform networks (T=O).	Personnel must be appropriately qualified to operate the system.

11.11 Individual Combat Gear

Table 11.24 Individual Combat Gear HSI & ESOH Considerations

Habitability
• Weight of gear • Thermal stress from layers • Ability for bladder relief when in gear
Human Factors Engineering (HFE)
• Anthropometry of gear (sizing and fit) • Usability for operators/maintainers • Compatibility with other equipment (interfaces with uniform, transportation) • Ergonomic design of gear
Survivability
• Threat protection (munitions, survival) • Color and type of material and their effects on detectability
Safety
• Safety restraint (non-ejection seat) compatibility • Escape and descent restrictions imposed by gear

Table 11.25 Individual Combat Gear Example Draft CDD Statements

Domain/Category	Type of Capability Statement	Example Language	Justification
HFE	15 Other System Attribute	<System X> shall enable full range of motion of the central 90% of the target population, allowing the operator to reach all controls and instrumentation within the duty station.	The user must be able to perform his primary duties while wearing combat gear.
Survivability	6. Key Performance Parameter	<System X> shall allow all operations both in and out of the <manned system> to include emergency egress, survival, evasion, and ground combat operations. <System X> shall provide protection against flash fires less than <# seconds>, blast overpressure at <pressure per unit area per second>, and the ability to stop bullet/fragment at <# velocity> (T). <System X> shall provide protection against flash heat (temperature degrees F), blast overpressure at <pressure per unit area per second>, and the ability to stop bullet/fragment at <# velocity> (O).	Personnel survivability is a critical component to the development and use of combat gear in an operational environment.

Table 11.25 Individual Combat Gear Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
Survivability	6. Key Performance Parameter	<System X> shall have the capability to include soft armor, hard armor or a combination of the two to provide operator protection. The operator shall be able to install a soft armor system compliant with the US Army Individual Body Armor (IBA) standards for threat resistance and environmental exposure, which provides modular protection to the front, back, and sides of the torso; shoulders, neck; upper arms; and groin. The operator shall be able to install a hard armor system, equivalent to the US Army Enhanced Small Arms Protective Insert (ESAPI) standard that provides modular protection to the front, back, and sides of the torso. Neither the soft armor nor the hard armor shall preclude or restrict required operator movement (T). Operators shall be able to release the hard armor with one hand without significant hazard of inadvertent release (O).	Allowing the system to be configurable reduces the number and variety of different equipment needed by the operator. Utilizing currently available standards for the soft and hard armor reduces the training for both operators and maintainers and increases affordability. Plate location will protect the critical organs and bodily systems.

Table 11.25 Individual Combat Gear Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
Safety	6. Key Performance Parameter	<System X> shall enable the aircrew to safely withstand ejection at up to <value> Knots Equivalent Air Speed (KEAS). <System X> (and integrated legacy components) shall be safely retained, remain structurally intact, retain functionality, not interfere with the ejection sequence, and not pose a safety hazard to aircrew during ejection (T=O). <System X> shall not interfere with post ejection/bailout procedures to include parachute descent, parachute landing fall, and water/land drag (T=O).	The loss of survival equipment and functionality degrades aircrew survivability. This capability is required for aircrew safety during emergency egress from the aircraft. The aircrew member must be able to perform post ejection/bailout procedures for personal safety and to facilitate their own recovery. The inability to perform these procedures may increase potential for injury/death.
Safety	15. Other System Attribute	<System X> shall provide a safety restraint feature for fixed-wing (non-ejection) and rotary-wing aircrew that can be integrated with standard aircraft or aircraft configured with the Mobile Aircrew Restraint System (MARS). The restraint feature shall enhance mobility for mission duties, prevent the aircrew from falling out of the aircraft, and reduce the potential for striking interior structures. <System X> shall distribute/dissipate loads and provide a quick release capability to reduce potential injury to aircrew members.	The safety restraint is considered an integral component of the system. Safety concerns have been identified with legacy devices.

Table 11.25 Individual Combat Gear Example Draft CDD Statements (Continued)

Domain/Category	Type of Capability Statement	Example Language	Justification
Safety	15. Other System Attribute	Rescue swimmers wearing the <System X> shall be able to perform water survival procedures (e.g., swim, life raft boarding, extraction). The <system X> shall not retain water sufficient to produce a load bearing strain safety hazard during extraction.	USCG Rescue Swimmers and USAF Parachute Jumpers will be wearing the system when flying over water and may have to eject/bail out of the aircraft and perform water survival operations.

11.12 Munitions

Table 11.26 Munitions HSI & ESOH Considerations

Human Factors Engineering (HFE)
• Anthropometry of loading/unloading requirements • Usability for operators/maintainers • Redundancy in processes and components
Safety
• Joint and Component weapons certification requirements • Identification of system states • Independent redundant safety features • Safe weapons release • Safety critical functions and data • Weapons state – safe or unarmed • Explosives environment and ordnance • Electromagnetic interference or jamming • Fail-safe mechanisms

Table 11.27 Munitions Example Draft CDD Statements

Domain/Category	Section and/or Type of Capability Statement	Example Language	Justification
HFE	15. Other System Attribute	<The delivery system (e.g., weapon, electronic targeting system)> shall provide a confirmatory step prior to the execution of a launch or deployment of <System X> to prevent errors and unintended harm (T). <The delivery system> shall provide redundant multi-sensory warnings with the confirmatory step prior to the execution of launch or deployment of <System X> (O).	To minimize the potential adverse effects and unintended harm to operators and allies' redundancy is needed for any critical action involving munitions deployment.
Manpower	10. Weapons Safety Assurance	Loading/unloading of <System X> shall not exceed <2 man> lift and carry as defined by MIL-STD-1472G.	For security reasons two or more personnel are required to hand-load munitions.

Table 11.27 Munitions Example Draft CDD Statements (Continued)

Domain/Category	Section and/or Type of Capability Statement	Example Language	Justification
Personnel	6. Key System Attribute	A personnel reliability assessment shall be conducted for operators and maintainers working with <System X (nuclear)>. They shall also complete the required training to qualify as <personnel classification> working with nuclear munitions (T=O).	Nuclear weapons require special personnel reliability and training courses. It is critical to include this requirement so the recruitment and training pipelines will be created for system resources.
Environment	10. Weapons Safety Assurance	The program shall provide for access (without having to cut or detonate) to energetic materials and fuzing technology as part of the design process to facilitate safer and affordable demilitarization of the system.	The system must be designed with safe and environmentally acceptable demilitarization and disposal of the components.
Safety	15. Other System Attribute	<System X> design shall incorporate lessons learned from a review of hazards and risks (e.g., Preliminary Hazard Lists) conducted on previous munitions programs (to include but not limited to BLU 109 Bunker Buster) to be applied in design and development phases of the program.	Modern shipboard and battlefield environments have numerous emitters (radars and communications devices) that can produce waveforms that couple with ordnance items and control systems, inducing voltage and current in firing and control circuits that can create hazards described as HERO.

Appendix A. Acronyms

ACAT	Acquisition category
ADM	Acquisition Decision Memorandum
AoA	Analysis of Alternatives
APA	Additional Performance Attributes
CA	Cost Analysis
CBA	Capabilities-Based Assessment
CBM	Condition Based Maintenance
CBRN	Chemical, Biological, Radiological, and Nuclear
CDD	Capability Development Document
CNEL	Community Noise Equivalent Level
COMNAVSEASYSCOM	Commander, Naval Sea Systems Command
CONOPS	Concept of Operations
DAS	Defense Acquisition System
DAU	Defense Acquisition University
DCAPE	Director, Cost Assessment & Program Evaluation
DCR	DOTmLPF-P Change Recommendation
DFAR	Defense Federal Acquisition Regulation
DNL	Day Night Average Sound Level
DoD	Department of Defense
DOTmLPF-P	Doctrine, Organization, Training, materiel, Leadership and education, Personnel, Facilities, and Policy
DTM	Directive-Type Memorandum
EA	Effectiveness analysis
EPEAT	Electronic Product Environmental Assessment Tool
ESAPI	Enhanced Small Arms Protective Insert
ESOH	Environment, Safety, and Occupational Health
FCB	Functional Capability Board
FEMP	Federal Energy Management Program
GCS	Ground Control System
HAZMAT	Hazardous Materials
HERO	Hazards of Electromagnetic Radiation to Ordnance
HFE	Human Factors Engineering
HMI	Human Machine Interface
HSI	Human Systems Integration
IA	Information Assurance
IBA	Individual Body Armor
ICD	Initial Capabilities Document
IM	Insensitive Munitions
INCOSE	International Council on Systems Engineering
IOC	Initial Operational Capability

JCIDS	Joint Capabilities Integration and Development System
JWSTAP	Joint Weapons Safety Technical Advisory Panel
KEAS	Knots Equivalent Air Speed
KPP	Key Performance Parameter
KSA	Key System Attribute
MANPRINT	Manpower and Personnel Integration
MARS	Mobile Aircrew Restraint System
MDA	Milestone Decision Authority
MDD	Milestone Development Decision
MIL-STD	Military Standard
MOE	Measures of Effectiveness
MOP	Measures of Performance
MOPP	Mission Oriented Protective Posture
MS	Milestone
MSA	Materiel Solution Analysis
MT	Mission task
OC	Operational Concepts
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
OSA	Other System Attribute
PDR	Preliminary Design Review
SE	Systems Engineering
SOLAS	Safety of Life at Sea
TDE	Total Daily Exposure
TMRR	Technology Maturation and Risk Reduction
UNDS	Uniform National Discharge Standards
UPS	Uninterrupted Power Supply
WG	Working Group

Appendix B. Definitions

Doctrine, Organization, Training, materiel, Leadership and education, Personnel, Facilities and Policy (DOTmLPF-P). The eight areas analyzed for possible solutions identified as a result of a Capabilities-Based Assessment (CBA) or other study to satisfy a gap in capability requirements. *Source: Defense Acquisition University (DAU) Glossary of Defense Acquisition Acronyms and Terms, Fifteenth Edition, 2012*

Environment, Safety, and Occupational Health (ESOH). ESOH refers to the combination of disciplines that encompass the processes and approaches for addressing laws, regulations, Executive Orders, Department of Defense (DoD) policies, environmental compliance, and hazards associated with environmental impacts, system safety (e.g., platforms, systems, system-of-systems, weapons, explosives, software, ordnance, combat systems), occupational safety and health, hazardous materials management, and pollution prevention. *Source: MIL-STD-882E, DoD Standard Practice System Safety*

Human Systems Integration (HSI). The interdisciplinary technical and management processes for integrating human considerations within and across all system elements. HSI focuses on the human, an integral element of every system, over the system life cycle. HSI promotes a "total system" approach that includes humans, technology (e.g., hardware, software), the operational context, and the necessary interfaces between and among the system elements to make them all work in harmony. Manpower and Personnel Integration (MANPRINT) is the Army's implementation of HSI. Thus, MANPRINT is used to refer to HSI within Army programs. *Source: International Council on Systems Engineering, Systems Engineering Handbook, Version 3.2.2; DoD Human Systems Integration Management Plan, Version 1.0*

The HSI domains are:

- **Manpower.** The number and mix of personnel (military, civilian, and contractor) authorized and available to train, operate, maintain, and support each system acquisition.
- **Personnel.** The human aptitudes, skills, knowledge, experience levels, and abilities required to operate, maintain, and support the system at the time it is fielded and throughout its life cycle.
- **Training**. The instruction and resources required to provide personnel with requisite knowledge, skills, and abilities to properly operate, maintain, and support the system.
- **Human Factors Engineering**. The comprehensive integration of human capabilities and limitations (cognitive, physical, sensory, and team dynamic) into system design, development, modification and evaluation to optimize human-machine performance for both operation and maintenance of a system.
- **Safety and Occupational Health**. Safety factors are design and operational characteristics that minimize the possibilities for accidents or mishaps to operators that threaten the survival of the system. Occupational Health factors are design features that minimize the

risk of injury, acute and/or chronic illness, or disability, and/or reduced job performance of personnel who operate, maintain, or support the system.

- **Habitability.** Factors of living and working conditions that are necessary to sustain the morale, safety, health, and comfort of the user population which contribute directly to personnel effectiveness and mission accomplishment, and often preclude recruitment and retention problems.
- **Personnel Survivability**. The characteristics of a system that reduce risk of fratricide, detection, and the probability of being attacked, and that enable the crew to withstand man-made or natural hostile environments without aborting the mission or suffering acute and/or chronic illness, disability, or death.
  Source: DoD Human Systems Integration Management Plan, Version 1.0

Joint Capabilities Integration and Development System (JCIDS). The JCIDS process is a collaborative effort that uses joint concepts and DoD Information Enterprise Architecture and solution architectures to identify prioritized capability gaps and integrated solutions (materiel and non-materiel) to resolve those gaps. *Source: Chairman of the Joint Chiefs of Staff Instruction 6212.01D, Interoperability and Supportability of Information Technology and National Security Systems*

Measure of Effectiveness (MOE). The data used to measure the military effect (mission accomplishment) that comes from the use of the system in its expected environment. That environment includes the system under test and all interrelated systems, that is, the planned or expected environment in terms of weapons, sensors, command and control, and platforms, as appropriate, needed to accomplish an end-to-end mission in combat. *Source: DAU Glossary of Defense Acquisition Acronyms and Terms, Fifteenth Edition, 2012*

Measure of Performance (MOP). System-particular performance parameters such as speed, payload, range, time-on-station, frequency, or other distinctly quantifiable performance features. Several MOPs may be related to the achievement of a particular MOE. *Source: DAU Glossary of Defense Acquisition Acronyms and Terms, Fifteenth Edition, 2012*

Milestone A. The decision to enter the Technology Maturation and Risk Reduction Phase. Milestone A's focus is on reducing technology risk using competitive prototyping. *Source: DoD Instruction 5000.02, Operation of the Defense Acquisition System*

Objective. The objective value for an attribute is applicable when a higher level of performance represents significant increase in operational utility. If applicable, the objective value is the desired operational goal achievable but at higher risk in cost, schedule, and technology. Performance above the objective does not justify additional expense. *Source: Manual for the Operation of the Joint Capabilities Integration and Development System, 19 January 2012, henceforth referred to as the JCIDS Manual*

Threshold. The threshold value for an attribute is the minimum acceptable value considered achievable within the available cost, schedule, and technology at low-to-moderate risk. Performance below the threshold value is not operationally effective or suitable, or may not provide an improvement over current capabilities. *Source: JCIDS Manual*

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