Using the Performance Specification Process In Hazard Elimination and Control

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Abstract

Performance specifications define the functional requirements for the product, the environment in which it must operate, and interface and interchangeability characteristics. A performance specification states requirements in terms of the required results. However, a performance specification does not state the methods for achieving the required results. They translate operational requirements into more technical language that tells the manufacturer: what will be acceptable product performance, and how that product acceptability is determined. System Safety professionals can make use of the performance specification process to include those items which will verify the elimination or mitigation and control of a variety of hazards. This paper discusses the history and provides an overview of the DoD Performance Specification process. This paper will also provide guidance to the systems safety professional in writing related performance specifications and how to best use this process to the verify potential hazards have been eliminated or controlled.

Introduction

Since WWII, the Government used Technical Data Packages (TDPs) and Detailed Design Data (DDD) to procure most of its materiel. This included detailed military standards, specifications to drawings, and detailed manufacturing process specifications (ref. 1). Basically, the Government told the contractor exactly how to build a product. This helped ensure quality, but not innovation. This lasted until technology began to out-strip the Department of Defense's (DOD) ability to keep the applicable requirement specifications and details current (ref. 2). It was determined that there must be "greater interaction between the defense and commercial industries" to keep the "U.S. military technology the best in the world." It was also noted that many commercial items of comparable or higher quality were being made substantially cheaper than those made according to existing military specifications. (ref. 2)

Thus, "On June 29, 1994, the Secretary of Defense directed sweeping reform of military specifications and standards. The Secretary directed the Department of Defense to make greater use of performance and commercial requirements in the acquisition process. Performance specifications are preferred over detail specifications." (ref. 3) This was a part of the Department of Defense acquisition reform, in which all or most proscriptive requirements were replaced with performance related requirements in an effort to reduce costs while increasing access to advanced technological improvements.

Performance specifications were crucial to acquisition reform. They permitted the contractor needed flexibility to develop innovative product solutions. The government could then receive quality products and services at affordable prices from a larger industrial base more responsive to DOD needs. The use of performance based specifications resulted in cutting-edge products due to greater industry competition for government business, which significantly helped modernized today's military (ref. 1).

Another law, - the Federal Acquisition Streamlining Act of 1994 (FASA), was signed by President Clinton on October 13, 1994. This law streamlined the federal government's acquisition system significantly changing the way the government buys products. The government (1) put a heavier reliance on procuring commercial products and services; (2) made the process for high-volume, low-value acquisitions easier; (3) expanded opportunities for small businesses to sell to the government; (4) improved the bid protest process; and (5) extended the Truth in Negotiations Act to civilian agencies (ref. 4)

William J. Perry, Secretary of Defense to President Clinton, on 29 June 1994 stated (ref. 5),

> "I have repeatedly stated that moving to greater use of performance and commercial specifications and standards is one of the most important actions that DoD must take to ensure we are able to meet our military, economic, and policy objectives in the future. Moreover, the Vice President's National Performance Review recommends that agencies avoid government-unique requirements and rely more on the commercial marketplace... Performance specifications shall be used when purchasing new systems, major modifications, upgrades to current systems, and non-developmental and commercial items, for programs in any acquisition category… To the extent practicable, the Government should maintain configuration control of the functional and performance requirements only, giving-contractors responsibility for the detailed design."

Thus, specifications moved from detailed specifications (how to build) to performance based specifications (what it does).

Determine What Requirements Apply

To determine what the product should do, a program must first understand the needs of the user. Begin by reviewing the program's operational requirements. As stated in (ref. 6), "Requirements relate directly to the performance characteristics of the system being designed. They are the stated life-cycle customer needs and objectives for the system, and they relate to how well the system will work in its intended environment."

Safety critical design requirements and design criteria for a system under design/development and assesses existing requirements for safety impacts can be accomplished via a Safety Requirement/ Criteria Analysis (SRCA). The system safety professional reviews or creates the systems Preliminary Hazard List (PHL) and analyses the potential hazards to current system requirements, performance specifications, laws, standards and regulations to create a list of regulations or design requirements (ref. 7).

The system safety profession will need to assess the operating environment, materiel handling, and other issues which could potentially impact the safety of the operator or maintainer throughout the life of the system. Requirements can be categorized in various ways (ref. 6). See (Table 1) for common requirement categories.

Table 1 — Common Requirement Categories

Requirement	**Definition**
Operational Requirement	Statements that define the basic needs and expectations of the system in terms of mission objectives, environment, constraints, and measures of effectiveness and suitability (MOE/MOS).
Functional Requirements	The necessary task, action or activity that must be accomplished.
Performance Requirements	How well the system must perform – generally measured in terms of reliability, quality, other performance related goals.
Design Requirements	The actual how to build or buy types of requirement. Design requirements may include the types of coating to be used, etc.
Derived Requirements	Implied requirements or requirements that must be followed due to higher level requirements
Allocated Requirements	A requirement that is established by dividing or otherwise allocating a high-level requirement into multiple lower-level requirements.

Table adapted and quoted from (ref. 6)

Review all of the Operational, Functional, Performance, and Design requirements for any potential safety impacts and determine any related derived or allocated requirements. Thoroughly review the expected/required operational environments as they may create additional safety impacts to operators and maintainers. The impacts likely will cause allocated safety requirements. Also consider any safety critical impacts which could be caused by software failures.

Many times system safety related requirements may seem vague or missing. Requirements are rarely defined explicitly. Because MIL-STD-882_ is required in accordance with DODI 5000.02, it is an automatic derived requirement. A thorough review of safety related Military and industry standards is important as they likely contain other derived or allocated requirements. OSHA Standards, MIL-STD-1472, MIL-STD-1474, and various branch specific standards such as OPNAVINST are excellent places to start. Also consider researching industry standards such as ANSI, IEEE, and SEC standards. Some other sources of requirements are:

- Architecture Documentation
- Statements of Work (from previous increments)
- Design Documents from Previous Increments
- Documents from Similar Programs
- Lessons Learned Documentation
- Initial Capabilities Document
- Capability Production Document
- Capability Development Document
  (ref. 8)

Key for system safety professionals is to understand all the stated and implied requirements and how to best meet those requirements. This understanding is based on use of integrated ESOH Working groups composed of all engineers, test, logistics, Human Systems Integration personnel and the like. The ESOH WG must ensure that the safety strategy and approach addresses the potential hazards and adequately demonstrates the safety of the design in the expected operational environment during test events. The safety professional must work closely with T&E to assist in the development of a Requirements Testability Matrix (RTM) depicting how each safety requirement will be tested (ref. 9)

Below are some basic questions to ask to help determine operational requirements (ref. 6).

- Where will the system be used?
- How will the system accomplish its mission objective?
- What are the critical system parameters to accomplish the mission?
- How are the various system components to be used?
- How effective or efficient must the system be in performing its mission?
- How long will the system be in use by the user?
- What environments will the system be expected to operate in an effective manner?

Other areas to consider when analyzing requirements for potential safety issues are listed in (Table 2) (ref. 6).

Table 2 — Considerations for Requirements Analysis

Consideration	Description
Customer Expectations	(What the customer wants the system to accomplish)
Project & Enterprise Constraints	(Cost, schedule, available manpower, management decisions, etc.)
External Constraints	(Available technology, public and international law, external equipment)
Measures of Effectiveness	(Mission performance, safety, reliability, etc.)
Measures of Suitability	(Maintainability, ease of use, etc.)
System Boundaries	(What systems or components are under assessment, what falls outside of the area of control?)
Interfaces	(What other equipment is necessary for the component or system to operate? What tools are necessary for maintenance or test?)
Utilization Environments	(Weather, temperature extremes, vibration, noise, operational time of day, etc.)
Lifecycle	(Operations, maintenance, test, disposal, etc.)
Functional Requirements	(What the system must accomplish)
Performance Requirements	(How the system must perform)
Modes of Operation	(Types of operations and conditions under which they must operate)
Technical Performance Measures	(Thresholds & objectives)
Physical Characteristics	(Size, weight, type of coating, etc.)
Human Systems Integration	(Noise, lighting, reach, space limits, ergonomics, etc.)

As you review these requirements, develop or add to the system's Preliminary Hazard List. Keep in mind potential hazards that could happen in operations, maintenance, test, and disposal phases. Depending on the complexity of the system, you may be able to begin a Preliminary Hazard Assessment. Consider ways that proactively following the derived requirements you've found could mitigate or eliminate these potential hazards. From this point, one can begin to develop a performance specification to eliminate or mitigate the hazard while still in the design stage.

Coordinate with Systems Engineers and Test and Evaluation personnel to ensure the requirement is added to the Requirements Traceability Matrix and addressed at the System Requirements Review.

Performance Specifications

According to MIL-STD-961E (ref. 10) , a Performance Specification is "a written requirement that describes the functional performance criteria required for a particular equipment, material, or product. The overall purpose of a specification is to provide a basis for obtaining a product or service that will satisfy a particular need at an economical cost and to invite maximum reasonable competition."

In 1908, the United States Signal Corps drafted a general document to identify the required specifications of the Wright Brothers' heavier-than-air flying machine (ref. 11). The document included specifications such as:

- be easily taken apart for transport in Army wagons
- be capable of being reassembled for operation in an hour
- carry 350 pounds for 125 miles
- maintain 40 miles per hour in still air

The Wright Brothers won the contract, awarded about 2 months after the announcement, at a cost of $25,000.

Performance specifications provide specific parameters that describe a product from the basis of how the end result will satisfy a particular need, so that industry, through a competitive environment, can provide the best solution at the most economical cost. According to reference ((ref. 10), "A good specification should do four things: (1) identify minimum requirements, (2) list reproducible test methods to be used in testing for compliance with specifications, (3) allow for a competitive bid, and (4) provide for an equitable award at the lowest possible cost."

As stated in (ref. 12), "Performance specifications define the complete performance required of the product, the intended use, service environmental conditions, maintainability, and necessary interface and interchangeability characteristics." Performance Specifications must be quantitative (or measureable) rather than qualitative (or subjective). See (Table 3) below for additional guidance on qualities of a well written performance specification.

Table 3 — Qualities of a Well Written Performance Specification

Clear	A performance specification is clear if it is written in plain English. Although most performance specifications are written in a positive sense, there is no need to do so if stating it in the negative sense improves its clarity.
Consistent	A performance specification is consistent if it does not conflict with any other specification.
Correct	A performance specification is correct if the users agree the performance specification reflects their need.
Not Redundant	A performance specification should not be redundant. It is redundant if there is another performance specification that means the same thing.
Unambiguous	A performance specification is unambiguous if it has only one interpretation.
Verifiable	A performance specification is verifiable if the specified behavior of the characteristic can be checked in a repeatable manner.

Adapted from: (ref. 13)

There generally are System Safety, Environmental and Human Systems Integration sections included in the draft Performance Specification document that is included in the Request for Proposal. Typically there may be two limits, a Threshold limit, (the specification that must be met) and an Objective limit, (the specification that is desired). However, some specifications list only one when the objective and the threshold is at the same level.

A general system safety performance specification may state something to the effect of,

> "The operation, maintenance, storage, transportation, or disposal of the system shall not present any hazards that are assessed as more severe than Serious risks as specified in MIL-STD-882E (Threshold). It is desired that the operation, maintenance, storage, transportation, or disposal of the system does not present any hazards that are assessed as more severe than Low risks as specified in MIL-STD-882E (Objective)."

For a system with lithium batteries, a performance specification may state,

> "If the system contains Lithium batteries, the system and the battery shall be capable of meeting all requirements needed for approval by the Navy Lithium Battery Review Board (Threshold); is already approved (Objective)."

For a system that might have the potential for hazardous noise levels, a performance specification may be,

> "In an operational state, the internal acoustic noise level shall not exceed an A-weighted steady state noise limit of 70 db(A)."

It is important to work with the systems engineering and test and evaluation team, as safety is a trade-off between cost, schedule and performance. While safety related performance specifications can be a valuable way to proactively eliminate or mitigate hazards early while the system is in the design phase.

Verification/Validation Techniques

All specifications must be verified and validated. Verification ensures the system was *built* according to specification requirements. Validation ensures the system *operates* according to those specification requirements. The verification and validation process allows the government to avoid unnecessary cost, schedule and performance risks while ensuring the system or component under consideration actually meets the users' needs and performance requirements. There are four types of verification and validation activities used to determine if a system or component meets the stated requirements (ref.10):

1. **Demonstration:** Involves the actual operation of an item to prove that the system functions as necessary during specified scenarios. The system or component may have instruments attached.
2. **Examination or Inspection:** Generally a nondestructive type of verification that includes the use of sight, hearing, smell, touch, and/or taste; simple physical manipulation; and can include the use of mechanical or electrical gauging to verify the item performs as required.
3. **Analysis:** Uses established technical or mathematical models or simulations, algorithms, charts, graphs, circuit diagrams, or other scientific principles and procedures to provide evidence that stated requirements were met.
4. **Test:** A verification method in which scientific principles and procedures are applied to determine the properties or functional capabilities of items.

As stared in (ref. 14),

> "The type of verification techniques used in a performance specification and the amount of test and evaluation needed depends upon various risk factors, such as whether the item is used in critical applications, whether development is required or if acceptable nondevelopmental items exist, or whether the technology is well-understood and stable or if it is a rapidly changing technology."

Each requirement must be verified as implemented into the system. If the requirement cannot be verified, it is not a valid requirement. Once implemented, the requirement must be validated as performing in an expected manner according to requirements. Thus, both are necessary to determine if a system meets required performance specification requirements. More than one verification and validation activity may be used to determine if a system or component meets the stated performance specification. It is important to work with the systems engineers and test and evaluations personnel to determine the proper type of activity is applicable to verify and validate each system safety performance specification.

Verification and Validation Events

System safety verification and validation activities take place at various verification test events throughout the system lifecycle. Both the type of verification and validation event would, depending on the complexity of the system or component under consideration, be part of the System Verification Plan, Validation Plan, Test and Evaluation Master Plan and/or System Test Evaluation Strategy. Validation testing typically simulates real world conditions, such as road testing for vehicles. Ongoing testing done as part of computer monitoring of a vehicle's performance during real world situations also validates the effectiveness of the system. System safety professionals must work closely with test personnel to coordinate the verification and validation of safety performance specifications at the earliest applicable event.

Verification and validation events are typically grouped into three classes of events, Design Verification Events, First Article Testing (FAT), and Conformance Events, Operator Evaluations (OE), Performance Article Testing (PAT), Post Implementation Evaluations (PIE), and Independent Logistic Assessments (ILA). Scheduling the verification and validation of safety related performance specifications in the earlier events such as FAT and OEs allows for changes to the system with a lower risk for cost, schedule and performance issues. Typically, most safety verification and validation will occur during FAT. However, there is a need to continue to ensure safety verifications and validations during later events such as the PAT, PIE and ILA, and if possible after the system has been delivered through ongoing analyses.

When determining what is needed to verify and validate a performance specification, test and evaluation personnel may find it helpful to create a specification/verification cross reference matrix such as the one in (Table 4) below:

Table 4 — Specification/Verification Cross Reference Matrix

METHOD OF VERIFICATION	CLASSES OF VERIFICATION
1 – Analysis	A – Design Verification
2 – Demonstration	B – First Article Test
3 - Examination	C - Conformance
4 – Test	

Section 3 Performance Specification		Verification Methods				Verification Class		
		1	2	3	4	A	B	C
4.5.3.1	In an operational state, the internal acoustic noise level shall not exceed an A-weighted steady state noise limit of 70 db(A).				x		x	x
4.5.3.2	Equipment requiring more than one (1) person to lift shall be clearly labeled to indicate the weight and the number of personnel required to lift.			x			x	X

Adapted from (ref. 14)

Conclusion

When system safety is properly integrated in the early acquisition process, many hazards can be eliminated or mitigated as contractors are considering solutions during the proposal stage. When potential safety issues are tied to performance, verification of a hazard's elimination or mitigation is given an earlier priority. The system safety professional will need to work closely with other systems engineers, test and evaluation personnel and acquisitions professionals to ensure an appropriate balance between safety, cost, schedule, and performance.

References

References

1. "AMC-P 715-17." *Procurement Guide for the Preparation and Use of Performance Specifications.* Headquarters U.S. Army Materiel Command, Feburary 11, 1999.

2. Grasso, Valerie Bailey. "Defense Acquisition Reform: Status and Current Issues." CSR Issue Brief for Congress.

3. Performance Specification Guide. Standardization Program Division, Falls Church, VA: Office of the Assistant Secretary of Defense (Economic Security), 1995.

4. Cohen Segias Pallas Greenhall & Furman P.C. *Federal Acquisiton Streamlining Act.* http://www.cohenseglias.com/government-contracts.php?action=view&id=331.

5. Perry, William J. "Specifications & Standards - A New Way of Doing Business." 1994.

6. Defense Acquisition Univesity Press. *Systems Engineering Fundamentals.* Supplementary Text. Fort Belvoir, VA: Defense Acquisition Univesity Press, Jan 2001.

7. "ESOH Handbook." Marine Corps Systems Command, January 06, 2006.

8. Kies, Michael. "Creating the System Performance Specification." *QinetiQ NA internal presentation.* Stafford, VA, April 2011.

9. *Incorporating Test and Evaluation into Department of Defense Acquisition Contracts.* Washington, DC: Office of the Deputy Under Secretary of Defense for Acquisition and Technology, 2009.

10. "MIL-STD-961E with Change 1." *DEFENSE AND PROGRAM-UNIQUE SPECIFICATIONS FORMAT AND CONTENT.* Ft. Belvoir, VA, April 2, 2008.

11. Wright Brothers Aeroplane Company. *Signal Corps Specification No. 486.* http://www.wright-brothers.org/History_Wing/Wright_Story/Showing_the_World/Back_in_Air/Signal_Corps_Spec.htm (accessed October 18, 2011).

12. Office of the Assistant Secretary of Defense for Economic Security. "SD-15." *Performance Specification Guide.* June 29, 1995.

13. "Requirements Document for System Approach for Safety Oversight (SASO)." Washington, DC: Federal Aviation Administration, May 23, 2003.

14. "Guide for Performance Specification." *SD-15.* Defense Standarization Program, August 24, 2009.