A RATIONALE FOR ESTABLISHING SURVIVABILITY REQUIREMENTS FOR OBJECTIVE FORCE UNMANNED ARMY PLATFORMS AND SYSTEMS

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Abstract

The introduction of high-tech equipment into the Army inventory has substantially increased battle effectiveness, reduced personnel requirements, and in some cases allowed the replacement of several manned operational platforms and systems with unmanned equivalents. The continued trend toward digital robotics in the battlespace has become extremely attractive to military planners, so much so that future warfighters are expected to employ a considerable number of unmanned platforms and systems. Up to this point in time, however, nuclear hardening criteria have been applied principally to manned systems and have been balanced to the nuclear survivability of the operating crew.

This paper provides the rationale for establishing reasonable nuclear hardening criteria for objective force unmanned mission critical equipment. It starts with the survivability requirement and then identifies the process used to establish criteria for five unmanned equipment classes. Also included are the factors to be considered and the steps to be taken to establish hardening criteria for all nuclear weapons effects (NWE) and for all weapon yields of interest. The paper concludes with an application of the process to a hypothetical system. Details given in this paper form the basis for proposed Quadripartite Standardization Agreement (QSTAG) 2041, a standard for the Armies of the United States, the United Kingdom, Canada, and Australia.

1. Introduction

Quadripartite Armies (also known as ABCA Armies of America, Britain, Canada, and Australia) presently use QSTAG 244 for the philosophy, methodology and database in establishing nuclear hardening criteria for legacy and interim force manned equipment. QSTAG 1031 then uses this information to establish specific criteria for five mobile equipment classes: (1) Class I: Equipment Associated with Troops in the Open, (2) Class II: Equipment Associated with Troops in Wheeled Vehicles (Including Signal Shelters), (3) Class III: Equipment Associated with Troops in Main Battle Tanks, (4) Class IV: Equipment Associated with Troops in Light Armored Vehicles, and (5) Class V: Helicopters.

In all five classes, equipment criteria are designed to meet the minimum requirements for operator survivability; the rationale being that the equipment must work only as long as a specified number of operators survive. This rationale implies the operator becomes the "weak" link in all manned systems. Since operator survivability is dependent upon specific levels of nuclear-induced blast, thermal and INR, these criteria vary from class to class. EMP, on the other hand, is not fatal to operators; hence, there is a single set of source-region EMP (SREMP) criteria and high-altitude EMP (HEMP) criteria in QSTAG 244 and QSTAG 1031 for all equipment classes. Both QSTAG 244 and 1031 will continue to be used for manned equipment.

First generation unmanned platforms and systems are now entering the Army inventory as part of the objective force. Unmanned airborne vehicles and unmanned ground vehicles are two examples. If these vehicles are indicators of platforms and systems to come, objective force equipment will be lighter, faster, have a smaller profile, incorporate C4ISR and weapon systems on the same platform, and allow the human interface to be a considerable distance from the equipment. For first generation objective force unmanned equipment that operate near manned objective force equipment, hardening criteria will be the same as the manned-equivalent class stated in QSTAG 1031. When the equipment is designed to operate far from manned equipment, unmanned equipment will have nuclear hardening criteria that are equipment-centric, not operator-centric. The rationale for selecting specific criteria for these unmanned equipments is described in proposed QSTAG 2041. It begins with the survivability requirement itself.

2. The Survivability Requirement

Army equipment supporting a critical mission must meet a nuclear survivability requirement. This requirement generally stipulates that equipment must be operational a specified time after exposure and must be maintained throughout the equipment's life cycle. For some equipment, the requirement simply states it must not be permanently damaged after exposure. For other equipment, the requirement specifies an allowable time after exposure before the equipment must be back on line (e.g., it must operate with no down time, or it must be back on line after one minute, one hour, or some other specified time).

Although equipment hardening is the preferred option to meet the survivability requirement, other options include timely resupply, operational changes, software modifications, and even field mitigation. The logic tree used to define the approach is given in Figure 1.

(Figure 1 here or at top of next page)

3. The New Susceptibility Chart

First-generation unmanned equipment is similar to manned, legacy equipment (equipment developed and/or fielded in the 1980s and early 1990s). Figure 1 is therefore a modified logic tree derived from QSTAG 244 to illustrate the process for selecting criteria for unmanned platforms and systems.

It is then convenient to modify the Quadripartite-approved five classes given in QSTAG 1031 to establish first-generation susceptibility levels. For example, QSTAG 1031 Class IV (Equipment Associated with Troops in a Light Armored Fighting Vehicle) becomes Class IV (Unmanned Equipment in Light Armored Fighting Vehicles (LAFVs)). Similarly, Class V (Helicopters) is modified to be Class V (Unmanned Equipment in Airborne Systems).

Using these five new equipment classes, a susceptibility matrix (Table 1) is formed, with each NWE environment forming a row and each of the five equipment classes forming a column. Such a table will quantify the nuclear hardening criteria for each of the five unmanned equipment classes of legacy-like equipment. As new, unique equipment designs are added to the Army inventory, the matrix will expand to accommodate them.

(Table 1 here or at top of next page)

It should be noted that these equipment susceptibilities are derived from non-ideal blast tests on items from each of the five equipment classes and from INR tests on systems, subsystems and components.

Past testing has shown most Class I, Class II, and Class V equipment are susceptible to translation damage from blast-induced dynamic pressure impulse (DPI). These DPI levels can occur at large ranges from ground zero. Class III and Class IV equipment are also susceptible to DPI, but at much higher levels occurring closer to ground zero. The semiconductor technology that appears in all five equipment classes, however, has the same INR susceptibility.

The steps for establishing susceptibility criteria for Class I, Class II, and Class V equipment are:

(1) Use minimum blast DPI values that cause MOD I damage (as defined in NWE handbooks) to that equipment class for theater battlespace weapon yields. It is expected that each class will have a unique DPI value; hence, the table shows DPI_{classI} , $DPI_{classII}$, and DPI_{classV}.
(2) Select the thermal values associated with the DPI values for that equipment class. These are identified as $[fluence, flux]_{classI}$, $[fluence. flux]_{classII}$, and $[fluence, flux]_{classV}$.
(3) Identify a single set of INR threshold levels $[total\ dose, neutron\ fluence, gamma\ dose\ rate]_{allclasses}$ for all five equipment classes.
(4) Derive the SREMP values from the INR values in step (3).
(5) Use the HEMP values given in QSTAG 244 Volume II and QSTAG 1031 Volume II for all five equipment classes.

The steps for establishing Class III and Class IV criteria are:

(1) Use the DPI values that cause MOD I damage to equipment on the inside of Class III and Class IV vehicles. Equipment outside the vehicles must meet the same values.
(2) Use the thermal values associated with the above DPI levels for Class III and Class IV equipment.
(3) Use the same INR levels for all five equipment classes.
(4) Use the same SREMP values calculated earlier for the above INR levels.
(5) Use the same HEMP values for the previous three classes.

4. Example

Consider the following *hypothetical* unmanned system named Unmanned Armored Scout Vehicle (USAV). The USAV is a 15-ton, remotely operated and controlled combat vehicle designed to replace the LAFV in objective force armored cavalry units. It is an all-electric system, powered by a pulsed-power system of high-energy-density capacitors and batteries. The digital USAV has a suite of sensors that provides the warfighter with real-time detection and identification of enemy vehicles, C4I systems, NBC toxic industrial materials hazards, obstacles and minefields. It also has a remotely controlled 60-mm electromagnetic rail gun. The USAV will be used in the theater battlespace where the threat spectrum is expected to come from weapon yields of less than 500 kT.

By stepping through the process of Figure 1 and referring to Table 1, we see that UASV is an example of Class IV equipment. It is a heavy, wheeled system and it is high tech, judging from the real-time digital electronics and composite armor appliqués. Though it might not have an operate-through requirement, the system must be operational some time (minutes) after a nuclear detonation. For this reason, circuit upset is acceptable as long as the electronics self-correct within the system-specified time. A primary concern is that it must not suffer permanent damage after exposure to the HEMP criteria given in QSTAG 1031, Volume II.

From the discussion on Class IV susceptibility levels in Table 1, it is known that Class IV equipment are most susceptible to nuclear-induced blast, INR, and HEMP. Thermal and SREMP values are derived from the blast and INR criteria, respectively, while the HEMP criteria are found in Volumes II of QSTAG 244 and 1031.

In summary, the actual nuclear hardening criteria for this example are based upon known upset and damage susceptibility levels of similar Class IV equipment. When the UASV is designed to operate *near* manned equipment, Class IV hardening criteria in QSTAG 1031 is used. In the case when the UASV is designed to operate considerable distances from manned equipment, Class IV hardening criteria must be developed. Such a set of upset and failure information is necessarily classified, and so should appear in a separate, classified QSTAG or in a classified appendix to QSTAG 2041.

5. Conclusions

The philosophy and methodology for establishing nuclear hardening criteria for objective force unmanned operational platforms and systems are described in the terms and format used in QSTAG 1031 for establishing nuclear hardening criteria for legacy and interim force equipment associated with troops. Figure 1 identifies the logic tree for establishing these criteria, while Table 1 provides the criteria matrix for five unmanned equipment classes.

6. References

QSTAG 244, "Nuclear Hardening Criteria for Military Equipment" (UNCLASSIFIED), Edition 4, Volume I (CONFIDENTIAL), Volume II (SECRET), January 1992.

QSTAG 1031, "Consistent Sets of Nuclear Hardening Criteria for Classes of Equipment" (UNCLASSIFIED), Edition 1, Volume I (CONFIDENTIAL), Volume II (SECRET), 6 September 1996.

Proposed QSTAG 2041, "A Rationale for Establishing Nuclear Hardening Criteria for Unmanned Operational Platforms and Systems," Edition 1, pp. 1-11.

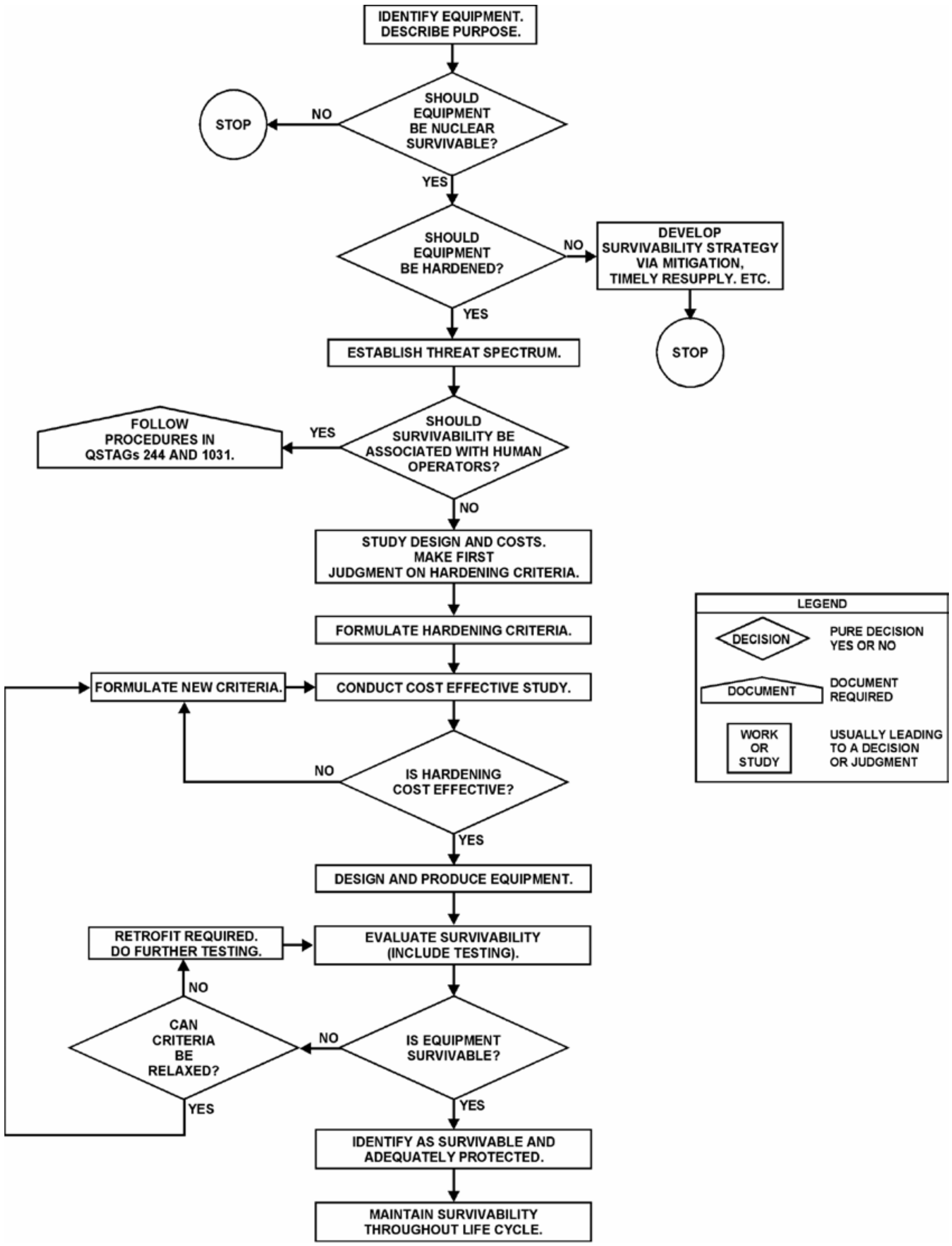

Figure 1. Nuclear Survivability Flow Chart.

Table 1. Predominant* Susceptibility Chart for Five Unmanned, Legacy-Like Equipment Classes.

	CLASS I Unmanned Equipment Exposed	**CLASS II** Unmanned Equipment in Shelters	**CLASS III** Unmanned Equipment in MBTs	**CLASS IV** Unmanned Equipment in LAFVs	**CLASS V** Unmanned Equipment in Airborne Systems
Blast	DPI_{classI}	$DPI_{classII}$	$DPI_{classIII}$	$DPI_{classIV}$	DPI_{classV}
Thermal	$[\text{fluence, flux}]_{classl}$	$[\text{fluence, flux}]_{classII}$	$[\text{fluence, flux}]_{classIII}$	$[\text{fluence, flux}]_{classIV}$	$[\text{fluence, flux}]_{classV}$
INR	$[\text{total dose, neutron fluence, gamma dose rate}]_{allclasses}$				
SREMP	Derived from $[\text{total dose, neutron fluence, gamma dose rate}]_{allclasses}$				
HEMP	ABCA Standard in Vol. II, QSTAG 244 and QSTAG 1031				

* Dominating susceptibility, but associated effects criteria are also stated.

DPI: dynamic pressure impulse

SREMP: source region electromagnetic pulse

INR: initial nuclear radiation

HEMP: high-altitude electromagnetic pulse