ALLIED ORDNANCE PUBLICATION

AOP-15
Edition 3

NATO INTERNATIONAL STAFF – DEFENCE INVESTMENT DIVISION

GUIDANCE ON THE ASSESSMENT OF THE SAFETY AND SUITABILITY FOR SERVICE OF NON-NUCLEAR MUNITIONS FOR NATO ARMED FORCES

AOP-15

April 2009

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NORTH ATLANTIC TREATY ORGANIZATION

NATO STANDARDIZATION AGENCY (NSA)

NATO LETTER OF PROMULGATION

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Juan A. MORENO
Vice Admiral, ESP(N)
Director, NATO Standardization Agency

RECORD OF CHANGES

Change Date	Date Entered	Effective Date	By Whom Entered

NATION	SPECIFIC RESERVATIONS

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1. PURPOSE

1.1 The purpose of this AOP is to:

a. Provide a uniform guide for the assessment of the safety and suitability of a non-nuclear munition for use by NATO armed forces.

b. Recommend system safety design and development criteria for munition systems, subsystems, and components. Recommend system design and development criteria for the safety and suitability for service (S3) of munition systems, subsystems and components and the associated weapon system interfaces.

c. Present a methodology to identify and to reduce risks related to munitions and refer to analysis and test methods to demonstrate that the risks related to a munition are acceptable.

2. DEFINITIONS

2.1 The definitions listed below are included to facilitate the use of this document. Other definitions can be found in the NATO Glossary of Terms and Definitions, AAP-6 and in the AC/326 Glossary of Terms and Definitions concerning the Safety and Suitability for Service of Munitions, Explosives and Related Products, AOP-38

2.1.1 As Low as reasonably practicable (ALARP). A risk is considered to be "As Low As Reasonably Practicable" when the cost of any further Risk Reduction is demonstrated grossly disproportionate to the benefit obtained from that risk reduction. This cost includes the loss of defense capability as well as financial or other resource costs.

2.1.2 Hazard. Any real or potential condition that can cause injury, illness, or death to personnel, damage to or loss of a system, equipment or property; or damage to the environment.

2.1.3 Insensitive Munitions (IM) /Munitions à risques atténués (MURAT). Munitions which reliably fulfill performance, readiness and operational requirements on demand and which minimize the probability of inadvertent initiation and severity of subsequent collateral damage to the weapon platform, logistic systems and personnel when subjected to selected accidental and combat threats.

2.1.4 Mishap. An unplanned event or series of events resulting in death, injury, occupational illness, or damage to or loss of equipment or property, or damage to the environment.

2.1.5 Mishap Risk. An expression of the impact and possibility of a mishap in terms of potential mishap severity and probability of occurrence. A measure of the likelihood of the hazardous event occurring with the consequences if it does occur.

2.1.6 Safety. Freedom from those conditions that can cause death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment.

2.1.7 Safety Critical. A term applied to any condition, event, operation, process, or item whose proper recognition, control, performance, or tolerance is essential to safe system operation or support (e.g. safety critical function, safety critical path, safety critical component).

2.1.8 Subsystem. A grouping of items satisfying a logical group of functions within a particular system.

2.1.9 System. An integrated composite of people, products, and processes that provide a capability to satisfy a stated need or objective.

2.1.10 System Safety. The application of engineering and management principles, criteria, and techniques to achieve mishap risk as low as reasonably practicable (ALARP), within the constraints of operational effectiveness and suitability, time and cost, throughout all phases of the life cycle.

2.1.11 Unexploded Ordnance. A launched or emplaced munition that has been operationally employed but, where its propulsive, pyrotechnic and/or explosive content failed to function as intended.

2.1.12 Sustainability. Not leading to depletion of resources or degradation of the environment by assuring that munition constituents from the intended munition usage are environmentally manageable over the longer term.

2.1.13 Operational Life. The time during which material may be expected to remain safe and serviceable when used under service or training conditions, when these are different from its storage conditions, but which is within the envelope of its life cycle.

2.1.14 Service Life. The time during which material, in specified storage conditions and when subsequently used in its specified operational and/or training conditions, may be expected to remain safe and serviceable.

2.1.15 Storage Life. The time for which an item of supply, including explosives, given specific storage conditions, may be expected to remain serviceable and safe.

3. APPLICATION

3.1 This document applies to the assessment of safety and suitability for service of all non-nuclear munitions in all phases of their life cycle, from concept exploration and design, through eventual use or disposal. In addition, the guidance provided herein may be applied to the assessment of munitions being considered for exchange between NATO armed forces.

4. APPROACH TO ACHIEVING AN ASSESSMENT OF MUNITION SAFETY AND SUITABILITY FOR SERVICE

4.1 The assessment of safety and suitability for service of a munition needs to be addressed within the domain of System Safety. System Safety involves the application of engineering and management principles and criteria to identify hazards and either eliminate them or achieve a risk as low as reasonably practicable (ALARP) within the constraints of operational effectiveness, time, and cost throughout all phases of the system life cycle. While a munition may be viewed as a "system" in and of itself, it should also be seen as part of a larger weapon system when addressing System Safety. Thus, System Safety efforts traditionally encompass a thorough assessment of the intended use of all elements of the larger weapon system over its entire life - design concept, development, manufacture, use or disposal - as well as an assessment of any external influences that could impair safety and suitability for service.

4.2 A properly conducted System Safety program will work in harmony with the activities of project management, systems engineering, design engineers, and with the concurrent efforts of other disciplines (e.g. reliability, maintainability, human factors, health and environment, storage, and transportation) to achieve an integrated and balanced approach throughout the entire system life cycle. Early identification and elimination or control of hazards that may arise from design flaws, incorrect assembly, inadequate procedures, and general misuse must be carried out to ensure that the highest possible degree of safety consistent with mission effectiveness requirements and cost constraints is designed and built into each munition and weapon system. This integrated and coordinated approach will support management decisions, assist in managing risks, and should preclude wasted effort in the qualification of a design and the associated cost and time penalties of design changes. The end products of this process should include ample evidence to enable a positive assessment that the munition and the larger weapon system are acceptably safe and suitable for service use, consistent with mission requirements and cost.

4.3 Of particular relevance to the design of munitions is applying a system approach to the selection of the explosive material. By their nature, explosive materials can be hazardous if not properly designed in accordance with all military design standards.

As enemy targets become harder to defeat, new munitions employing more energetic explosives are being developed. To prevent those munitions from becoming an unacceptable risk, the sensitiveness of the energetic material to initiation by external stimuli must be a factor considered in energetic material selection, warhead and rocket case design, and container design. To mitigate risk, the use of materials and designs that are the least sensitive to such stimuli are recommended. Such munitions are potentially more effective than their predecessors, because system effectiveness is determined not only by such parameters as performance capability, reliability, availability, and logistics supportability, but also by survivability. That is, a munition that does not survive its operational environment cannot accomplish its purpose to destroy or deter a hostile force. Furthermore, such munitions may benefit system effectiveness at the higher mission level by avoiding collateral damage to or loss of the weapon launch platform or other mission-critical assets. Such munitions are identified as Insensitive Munitions (IM) or Munitions à risques atténués (MURAT) and are assessed for compliance in accordance with STANAG 4439.

4.4 Growing international concern with ecological issues and, in particular the potential environmental impact of munitions use on operational ranges and of industrial waste disposal processes, has focused munition suitability for service assessment attention on sustainability (i.e., assuring that munitions constituents from intended munition usage are environmentally manageable over the long term) and on the demilitarization and disposal of unused munitions. More stringent international environmental legislation and enforcement, the desire to protect and preserve natural resources and to reduce the amount of waste products, and limited space for disposal have contributed to this concern. Whereas munitions designs, to include the constituents therein, and demilitarization and disposal techniques have traditionally focused on being safe, efficient, and cost effective, new munitions designs and disposal methods must now also afford potentially exposed friendly assets appropriate protection of human health and the environment. Nations now have a responsibility to move away from munitions designs that are not “green” and from industrial processes that overlook the creation and destruction of waste towards those that minimize the inclusion of hazardous or offensive constituents and maximize the recyclability of munitions constituents. STANAG 4518 provides guidance for munitions demilitarization and disposal design matters.

4.5 Broadening international awareness and attention on hazardous conditions posed to NATO and Alliance forces during tactical and peacekeeping operations as well as to civilian populations over the long term by explosive remnants of war, particularly by unexploded ordnance (UXO), is expanding safety and suitability for service assessment into routinely evaluating the mitigation of such UXO hazards. Nations developing munitions have a growing responsibility to commonly consider incorporating systems engineering approaches and specific munition design features including fail-safe, sterilization, and self-destruct attributes to address UXO hazards. The safety and suitability for service assessment now typically includes consideration of the capability of incorporated UXO hazard mitigation aspects to effectively maintain the required degree of safety in credible post-operational employment scenarios.

5. SYSTEM SAFETY PRINCIPLES

The objective of System Safety is the application of engineering and management principles, criteria, and techniques to achieve a risk level that is as low as reasonably practicable (ALARP) and a suitability for service posture that is ethically and environmentally responsible within the constraints of operational effectiveness, time and cost, throughout all phases of the system life cycle. This objective is achieved through a five step process as follows: 1.Program Definition, 2. Hazard Identification and Tracking, 3. Risk Assessment. 4. Risk Reduction, and 5. Risk Acceptance.

5.1 Program Definition Early System Safety program planning is a key factor in ensuring the safety of the product being developed. This includes defining the design and verification requirements, as well as, a procedure for the assessment of Safety and Suitability for Service. The development of a System Safety Program Plan (SSPP) for the developer’s approach and a System Safety Management Plan (SSMP) for the program manager’s approach (or equivalent documentation), that defines the System

Safety tasks and responsibilities, along with their milestones, is necessary to define the roadmap for Safety Assessment of the munition under consideration. A risk management process should be a part of the SSMP and SSPP. For less complex systems, the safety assessment and risk management process may be combined into one plan.

5.2 Hazard Identification and Tracking Risk management begins with hazard identification which can be achieved through a systematic hazard analysis process, that begins early in the program development and continues throughout the development cycles, encompassing detailed analysis of system hardware and software, the environment (in which the system will exist), and the intended usage or application. Historical hazards and mishap data, including lessons learned from other similar systems should be considered and used. The hazard identification process should consider all credible hazards that could occur over the system life cycle. Hazard tracking is essential to make sure that the identified hazards are mitigated or the associated mishap risk is acceptable (meets ALARP). For each munition system there should be a current hazard log of identified hazards. The hazard log should be maintained throughout the system life cycle and should track hazards, their closure actions, and the residual mishap risk. The program manager should keep the system user advised of the hazards and residual mishap risk.

5.3 Risk Assessment Risk Assessment involves assigning, for each hazard, a mishap severity category and probability or frequency of occurrence. The end result is the assessed risk that a particular hazard could result in a particular mishap. The system risk assessment must address all the identified hazards associated with the system. There are several methods available to assess the risk including expert judgment, numerical analysis, computer models, Failure Modes, Effects and Criticality Analysis (FMECA), and Fault Tree Analysis (FTA). Mishap probability levels may be based on qualitative, and where appropriate, quantitative assessment. Annex D provides an approach for Quantitative Risk Assessment.

5.3.1 Mishap Severity Categories

Mishap severities may be categorized according to the severity of the repercussion to personnel, materiel assets, and the environment as a consequence of a mishap. Thus, a catastrophic mishap is one that could reasonably generate severe consequences such as death or loss of a major asset. The engineering judgment of the safety analyst/engineer is a critical factor in determining the most severe consequence that could reasonably ensue should a mishap occur.

5.3.2 General guidance on classifying mishap severity categories with respect to a range of mishap outcomes delineated in terms of fatalities, injuries, property damage, environmental impacts or other loss is provided in Table 1. The mishap severity categories may be tailored based on the system being considered.

TABLE 1: Example Mishap Severity Category Matrix

DESCRIPTION	CATEGORY	ENVIROMENTAL, SAFETY AND HEALTH CRITERIA		
		PEOPLE	ASSET/SYSTEM	ENVIRONMENT
Catastrophic	**I**	Death or Permanent total disability	Loss > $1M	Irreversible severe environmental damage that violates law or regulation
Critical	**II**	Permanent partial disability/ injuries or occupational illness that may result in hospitalization of at least three personnel	$200K<Loss < $1M	reversible environmental damage causing a violation of law or regulation
Marginal	**III**	Injury or occupational illness resulting in one or more lost days	$10K <Loss< $ 200K	Mitigable Environmental damage without violation of law or regulation where restoration can be accomplished
Negligible	**IV**	Injury or illness not resulting in a lost work day	$2K < Loss < $10K	Minimal Environmental damage not violating law or regulation

5.3.3 Mishap Probability Levels

System Safety practitioners use various qualitative and quantitative methods to assess the probability of occurrence of a mishap. For munition systems, qualitative methods are most frequently used due to the lack of credible statistically significant data that could serve as the basis for a quantitative assessment. Judgment by competent authorities based on review of safety databases, analysis of similar systems, research, and available test data usually provides adequate information for making qualitative mishap probability assessments related to munition systems. Quantitative mishap probabilities are generally not possible to define exactly. However, for specified parts of the life cycle (e.g. firing, flight) failure probabilities of a system, subsystem or component may be estimated with reasonable precision by means of Fault Tree Analysis. This may enable recognition of major failure causes and reduction of the failure (mishap) probability and thus the risk level. Table 2 depicts a qualitative as well as a quantitative ranking of the likelihood of mishap occurrence. The "SPECIFIC INDIVIDUAL ITEM" column of Table 2 refers to the probability of one mishap occurring with a single materiel item during a specified period. The "NATIONAL FLEET OR INVENTORY" column refers to the frequency of accidents occurring over the entire inventory of materiel items over their life cycle. The mishap probability levels may be tailored based on the system being considered.

TABLE 2: Example Mishap Probability Levels

DESCRIPTION	LEVEL	SPECIFIC INDIVIDUAL ITEM	NATIONAL FLEET OR INVENTORY
FREQUENT	A	Likely to occur often in the life of an item, with the probability of occurrence greater than 10^{-1} in that life.	CONTINUOUSLY EXPERIENCED
PROBABLE	B	Will occur several times in the life of an item, with a probability of occurrence less than 10^{-1} and greater than 10^{-2} in that life.	LIKELY TO OCCUR MANY TIMES
OCCASIONAL	C	Likely to occur some time in the life of an item, with a probability of occurrence less than 10^{-2} and greater than 10^{-3} in that life.	LIKELY TO OCCUR SEVERAL TIMES
REMOTE	D	Unlikely but possible to occur in the life of an item, with a probability of occurrence less than 10^{-3} and greater than 10^{-6} in that life.	UNLIKELY, BUT CAN REASONABLY BE EXPECTED TO OCCUR
IMPROBABLE	E	So unlikely, it can be assumed occurrence may not be experienced, with a probability of occurrence less than 10^{-6} and greater than 10^{-7} in that life	UNLIKELY TO OCCUR, BUT POSSIBLE
EXTREMELY IMPROBABLE	F	So improbable, it can be assumed occurrence is impossible, probability of occurrence less than 10^{-7} in item life	EXTREMELY UNLIKELY TO OCCUR, BUT NOT IMPOSSIBLE

TABLE 3a: Example Risk Level Matrix

MISHAP SEVERITY	MISHAP PROBABILITY					
	FREQUENT (A)	PROBABLE (B)	OCCASIONAL (C)	REMOTE (D)	IMPROBABLE (E)	EXTREMELY IMPROBABLE (F)
CATASTROPHIC (I)	1	1	1	1	2	3
CRITICAL (II)	1	1	1	2	3	3
MARGINAL (III)	1	2	2	3	3	3
NEGLIGIBLE (IV)	2	3	3	3	3	3

HIGH	(red)
MEDIUM	(yellow)
LOW	(green)

TABLE 3b: Example Risk Level Matrix

MISHAP SEVERITY	MISHAP PROBABILITY					
	FREQUENT (A)	PROBABLE (B)	OCCASIONAL (C)	REMOTE D)	IMPROBABLE (E)	EXTREMELY IMPROBABLE (F)
CATASTROPHIC (I)	I-A	I-B	I-C	I-D	I-E	I-F
CRITICAL (II)	II-A	II-B	II-C	II-D	II-E	II-F
MARGINAL (III)	III-A	III-B	III-C	III-D	III-E	III-F
NEGLIGIBLE (IV)	IV-A	IV-B	IV-C	IV-D	IV-E	IV-F

HIGH	(red)
MEDIUM	(yellow)
LOW	(green)

5.3.4. Whether a safety or suitability risk assessment is based on qualitative factors or on numerics predicted in a quantitative analysis, the resulting Risk Level Assessment is usually noted by the application of a descriptor that describes the risk level for a group of hazards into mishap risk categories. Table 3a depicts an example of a Risk Level Matrix which describes the risk using three levels which are depicted numerically as 1, 2 & 3 and defined as High, Medium & Low respectively. Table 3b depicts an example of a Risk Level Matrix which similarly describes the risk in three levels where risk assessment values I-A through I-D, II-A through II-C, and III-A constitute High risk, and values I-E, II-D, III-B through III-C, and IV-A constitute Medium risk.

5.4 Risk Reduction

The risk reduction process is a four step process which begins with understanding risk drivers. Once the hazard is fully understood and the causal factors are known, step 2 is the development of a set of candidate mitigating factors. The hierarchy of risk levels provided by the Risk Level Matrix should be used to prioritize hazards for corrective action (ie., high risk hazards receive the highest priority for establishing hazard mitigations). The system safety order of precedence defines the order to be followed for satisfying System Safety requirements and reducing risk. The third step is the selection of mitigators, which is influenced by requirements, cost, effectiveness, feasibility and schedule. Finally step 4 is the verification of the risk reduction method used by ensuring implementation and confirming evidence of effectiveness.

5.5 System Safety Order of Precedence

5.5.1 Safety is best achieved when it is inherent in the features of the design. Therefore, it is recommended that all risks be eliminated or controlled/reduced in accordance with the following order of system safety precedence:

a. Eliminate hazards or reduce risk through design selection.

b. Incorporate safety devices if unable to eliminate the hazard through design selection.

c. Provide warning devices to alert personnel to a particular hazard if safety devices do not adequately lower the risk of the hazard.

d. Develop procedures and training when it is impractical to eliminate or reduce/control risk through design selection or use of safety and warning devices. Procedures may include the use of personal protective equipment. For hazards assigned Catastrophic or Critical mishap severity categories, avoid using warning, caution, or other written advisory as the only risk reduction method.

5.5.2 Since human performance is the least reliable approach to avoiding a mishap, progression down the order of precedence is prudent only when design alternatives have been examined and have been proven to be impractical. Such examination and actions should be documented. The tactical configuration of an item shall be designed and assessed during the development phase to ensure compliance with all applicable safety requirements needed for fielding/operational use. However, if some technology/design feature is not mature enough for a development test, control of hazards associated with testing of prototype test hardware may be possible on an interim basis by implementing special test procedures or constraints. Similar procedures would be unsatisfactory for fielding a production item if incorporation of inherently safe design features were judged to be a viable alternative.

5.6 Safety Design Criteria.

5.6.1 To minimize mishaps resulting from the inadvertent, premature, or incorrect operation of materiel, applicable system safety criteria shall be used for the design and development of munition systems, subsystems, and components. For example, STANAG 4187 establishes design safety criteria for fuzes and Safety and Arming (S&A) devices that are subsystems of fuzes.

5.7 Risk Acceptance. The application of the ALARP concept implies that after all planned mitigations have been implemented there still remains a residual mishap risk. The designated risk acceptance authority determines whether or not the mishap risks or the total system risk have been reduced to as low as reasonably practicable (ALARP) within the constraints of operational effectiveness and suitability, time and cost. The appropriate authority designated to accept the risk is usually correlated to the risk level and it will vary for each nation. Timing and management authority for risk acceptance shall be accomplished in accordance with each nation's requirements.

6. SAFETY AND SUITABILITY ASSESSMENT PROCESS

6.1 All munition development plans should include a methodical process to assess safety and suitability for service. Those plans should include analyses and testing regimes aimed at ensuring that the explosive components as well as the complete munition will function as designed with a degree of safety and suitability that has been achieved in balance with system effectiveness, in-service schedule and life cycle cost. The methodical safety and suitability for service assessment process should commence as soon as possible after inception of the development project and should actively progress so that all relevant analyses and tests are completed in sufficient time to allow the safety evaluation organization to advise on the safety and suitability of the munition prior to any required in-service date.

6.2 Figure 1 depicts the safety and suitability assessment process. It illustrates a logical process for evaluating a munition life cycle to determine the environments that adversely affect the munition to which the munition may be exposed. The assessment includes identification and examination of failure causes, modes and effects, and associated risks resulting from internal failures, external effects from friendly or enemy munitions and battlefield conditions, environmental effects, human errors, and accidents during the entire life cycle. The assessment is based on analytical, empirical, experimental, and historical data. The steps of this process can be followed in sequence at any level of System Safety complexity without destroying the basic idea. What follows is a step-by-step explanation of the process. AOP-52 (Guidance on Software Safety Design and Assessment of Munition-Related Computing Systems) provides guidelines to achieve a reasonable level of assurance that the software and software-like devices will behave within the system context and operational environment with an acceptable level of risk.

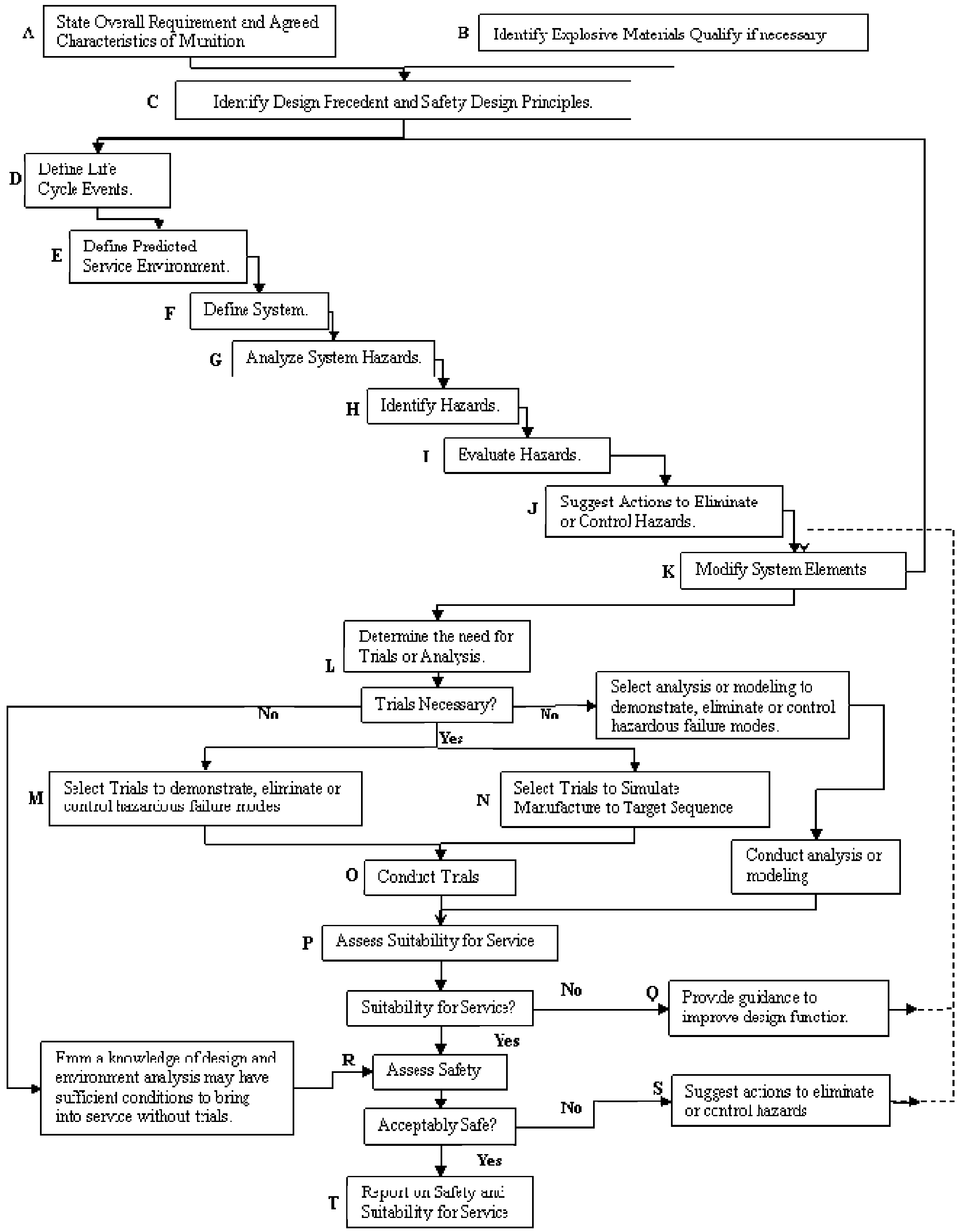

Figure 1 - Safety and Suitability Assessment Process

6.2.1 Block A (State Overall Requirements and Agreed Characteristics of Munition) The safety and suitability assessment process can begin at any point in the life cycle of a system, but the maximum advantage is achieved when it is first applied during early stages of development of a new munition, preferably during initial conceptual studies or the feasibility study. In any case, a detailed statement of the overall operational requirements and the agreed characteristics of the munition system are essential.

6.2.2 Block B (Identify Explosive Materials and Qualify if Necessary). In parallel with the actions in Block A, it is necessary to identify the explosive materials, including primary and secondary explosives, boosters, propellants, and pyrotechnics proposed for use, and to qualify them in accordance with STANAG 4170. Unless those materials have a satisfactory service history in similar roles and operated in the same environments, their safety characteristics must be determined and the results assessed by the appropriate national authority. That assessment should include a determination of the probability that the materials will present a toxic or environmental hazard at any time during the subject munitions life. Ideally, such safety and suitability assessments should be completed in time to be taken into account along with such data as explosive output, life cycle cost, and logistics (supply and production) during trade-off analyses when a decision to proceed with the design of the munition incorporating the explosive material is imminent. The assessment, leading to qualification by the national authority, involves study of the results of appropriate tests to determine the safety characteristics of a new material or an existing material used in a different role. The methodology for such qualification is contained in STANAG 4170 and details of the appropriate tests used by NATO countries are referenced in AOP-7.

6.2.3 Block C (Identify Design Precedents and Safety Principles). Knowledge of the design and operations of previous systems related to the one under consideration establishes a basis for identifying design safety principles to be considered during the design and assessment of the new munition. Of particular interest will be those measures taken previously to correct design features that had resulted in injuries, illness, deaths to personnel; damage to or loss of a system, equipment, or property; or damage to the environment.

6.2.3.1 The inadvertent, premature, or incorrect operation of munition systems can result in a mishap to personnel and equipment. To ensure that adequate and uniform standards of safety are achieved and maintained, STANAGs have been developed to define and standardize the design safety principles for generic classes of munition systems. STANAGs presenting design safety principles for various generic classes of munitions are listed in Annex B. The principles set forth in those STANAGs shall be adhered to unless it can be clearly demonstrated that they are not applicable. Any proposed deviation from the principles given therein must be documented with rationale given.

6.2.4 Block D (Define Life Cycle Events). Since the safety effort should encompass a thorough assessment of the intended use of the proposed munition and weapon system over their entire life cycle, it is necessary to identify the major events expected to occur in the planned life cycle of the munition from manufacture to operational use or disposal. This manufacture-to-target or disposal sequence of events will be based on the details of the operational requirements identified in

Block A. For existing munitions, details may also be documented in the munition design specification.

6.2.5 Block E (Define Predicted Service Environment). It is essential to establish the service environment before defining design and test requirements. Environments to be considered during analysis and testing of munition systems are:

a. Natural environments.

b. Induced environments associated with the handling and transportation from manufacture through storage to loading into munitions systems.

c. Induced environments associated with carriage in the munition system (land, sea, and air).

d. Induced environments associated with projection, launch or ejection and free flight of the munition.

e. Induced electromagnetic, electrostatic and nuclear environments resulting from human intervention.

f. Extreme but credible accident environments or enemy action. During the life cycle events sequence, identified in Block D, a munition may encounter severe conditions. The individual explosive components or the complete munition, whether packaged in a container or on a pallet or unpackaged, may be subjected to storage, handling, transportation, launch and combat conditions. All the effects described in the following paragraphs should be considered when defining the anticipated service environments and when developing the test and evaluation programs. The safety and suitability for service test program that is developed based on those factors shall be readily translatable into requirements of national/service safety evaluation organizations. Moreover, the program should conform to internationally accepted safety-related test criteria for the specific class of munitions. The questionnaire of Annex A should be used to assist in identifying the service environments of a munition.

6.2.5.1 Land and Sea Environments. The land and sea environments associated with storage, handling, and transportation by road, rail, and sea account for the major part of the overall service environment reflected in the manufacture-to-target or disposal sequence. The land and sea environmental conditions that shall be considered for packaged and/or unpackaged explosive components and complete munitions are as follows:

6.2.5.1.1 Packaged (Logistical Configuration) and Unpackaged (TacticalConfiguration).

a. Temperature and Humidity. Temperature and humidity environments are dependent on each other, geography, and time of day. Temperature and humidity conditions, taking into account any environmental protection provided, shall be considered for all climatic categories as defined in STANAG 4370 that are relevant to the storage, transportation, and deployment environments of the munition. Conditions that cause moisture penetration into the munition explosive components should be considered.

b. Solar Radiation. Thermal and radiant effects of direct solar heating of the munition, in addition to the prevailing ambient temperature, shall be considered for those hot climatic categories defined in STANAG 4370 that are relevant to the storage and deployment environments of the munition.

c. Precipitation. Driving precipitation conditions will vary depending primarily on geography, temperature, and wind conditions. Protection against water ingress into the munition shall be considered, e.g. sealing and containers.

d. Sand and Dust. The severity of the sand and dust environments is dependent on geography, humidity, temperature, wind conditions, and the operational scenario, e.g. the presence of tracked vehicles or helicopters. The resistance of materials to sand and dust abrasion and the sealing of the munition and container shall be considered.

e. Salt Fog. The corrosive effects of salt on materials shall be considered. This requirement is particularly relevant to munitions stored or deployed in coastal areas or at sea.

f. Fungus (Mold). The fungus environment should be considered with respect to temperature, humidity, nutrient supply, time, and exposure. The effects of biological hazards may be minimized by the use of fungus resistant materials.

g. Shock. Shocks associated with acceleration, deceleration, impact, bump, and bounce expected to be encountered in the land and sea environments shall be considered.

h. Shipboard Shock. Effects on the munition, whether restrained or not, of exposure to underwater explosions shall be considered if the munition is to be transported in naval ships.

i. Vibration. Vibration conditions associated with handling and transportation in the land and sea environments shall be considered (STANAGs 4370 AECTP 200, Section 245).

j. Freefall. Freefall drops associated with handling the components or the complete munition in the land and sea environment shall be considered (STANAG 4375).

k. Sympathetic Reaction. Effects on adjacent munitions of the premature function of a munition shall be considered (STANAGS 4396 and 4439).

l. Electromagnetic Radiation, Electrostatic Discharge. Hazards of electromagnetic radiation and effects of electrostatic discharge and lightning on the munition - especially on any Electro Explosive Device (EED) - shall be considered. The assessment shall emphasize the defined environments for those parameters (STANAG 4370, AECTP 200)

m. Fuel Fire (Fast Heating). The response of the munition to a liquid fuel fire shall be established (STANAG 4240 and 4439).

n. Nuclear Hardening. Effects on the munition of exposure to nuclear radiation, thermal radiation, and electromagnetic pulse shall be considered (STANAG 4147, AEP 4).

o. Icing. An icing test should be considered to evaluate the effect of icing produced by freezing rain, mist, or sea spray on the safety of the munition.

p. Low Temperature. The effects of cold temperature, in addition to the pertinent ambient temperature, shall be considered for those cold climatic categories that are relevant to the storage and deployment environments of the munition.

q. Thermal Shock. Evaluation for thermal shock shall be considered to determine the resistance of the munition to extreme changes in temperature and the effect of alternate exposure to these extremes.

r. Slow Heating. The response of the munition to a gradual but continuous temperature rise shall be considered (STANAG 4382 and 4439).

s. Bullet Attack. The response of the munition to bullet attack by AP projectiles shall be considered (STANAG 4241 and 4439).

t. Fragment Impact. The response of the munition to fragment impact shall be considered (STANAG 4496 and 4439).

u. Shaped Charge Jet. The response of the munition to shaped charge (jet) impact shall be considered (STANAG 4526 and 4439).

6.2.5.1.2 Packaged

a. Replenishment at Sea. The transfer of munitions at sea by jack-stay shall be considered.

b. Lifting and Stacking. The ability of the munitions to be lifted and stacked shall be considered.

6.2.5.1.3 Unpackaged

a. Contamination. Effects on the munition of contamination by fuel, oils, greases, etc., shall be considered (STANAG 4370, AECTP 300).

b. Electrical Safety. Electrical safety of the EEDs within the munition when attached to test equipment shall be considered.

c. Shock and Acceleration. Shocks and acceleration associated with launch of the munition in land and sea environments shall be considered.

6.2.5.2 Air Environment. The munition may be transported packaged or unpackaged in transport aircraft or helicopters, or as an underslung load with helicopters. The unpackaged munition may be carried internally (bomb bay) or externally on fixed wing aircraft or externally on helicopters. The air environmental conditions associated with the air transportation and captive and free flights of a munition that shall be considered are as follows:

6.2.5.2.1 Packaged or Unpackaged (Air Transportation Including Helicopters)

a. Temperature and Humidity. Effects of temperature and humidity on the munition when carried in heated and unheated aircraft or underslung from a helicopter shall be considered.

b. Pressure. Effects on the munition of being transported in pressurized or unpressurized aircraft shall be considered.

c. Vibration. The response of the munition to vibration associated with carriage by aircraft shall be considered. Aircraft vibration caused by aerodynamic loads, rotary equipment and runway roughness are transmitted structurally; vibration caused by jet engine exhaust is transmitted acoustically.

d. Shock. Shocks associated with aircraft accelerations during takeoff, flight, landing, and "winching down" of an underslung helicopter load shall be considered.

e. Rapid/Explosive Decompression. Effects on the munition of rapid and explosive decompression of the aircraft shall be considered.

f. Parachute Delivery/Low-Level Extraction Procedures. Shocks associated with the delivery of munitions by parachute or low-level extraction procedures from aircraft shall be considered if this mode of delivery has been specified. The environmental conditions should include shock, freefall, impact, precipitation, salt fog, and immersion, using containers specifically designed for the mode of delivery.

g. Vertical Replenishment (VERTREP) Helicopter. The ability of the munition to be transported at sea and over land by helicopter shall be considered. The environmental considerations shall include freefall, impact, shock, precipitation, salt spray, dust, immersion, jolt, and electrostatic discharge.

h. Electromagnetic Radiation, Electrostatic Discharge. Hazards of electromagnetic radiation and effects of electrostatic discharge and lightning on the munition - especially on any Electro Explosive Device (EED) - shall be considered. The assessment shall include the defined environments for those parameters. (STANAGs 1307, 4234, 4235, and 4236)

i. Bullet Attack. The response of the munition to bullet attack by AP projectiles shall be considered (STANAG 4241 and 4439).

j. Fragment Impact. The response of the munition to fragment impact shall be considered (STANAG 4496 and 4439).

k. Shaped Charge Jet. The response of the munition to shaped charge (jet) impact shall be considered (STANAG 4526 and 4439).

l. Fuel Fire (Fast Heating). The response of the munition to a liquid fuel fire shall be considered (STANAG 4240 and 4439).

m. Slow Heating. The response of the munition to a gradual but continuous temperature rise shall be considered. (STANAG 4382 and 4439).

6.2.5.2.2 Unpackaged (Captive and Free Flight)

a. Temperature and Humidity. Due to aerodynamic heating (associated with high-speed flight) and cold-soaking (associated with high altitude flight), temperature extremes associated with captive and free flight of munitions are generally more severe than those associated with deployment of munitions in the land and sea environments. The captive flight temperature of a munition may be calculated from the parameters of the defined aircraft sortie patterns and geographical deployment areas. Similarly, the higher temperatures associated with the munition in free flight may be calculated from the known launch conditions and the munition performance specification. The ability of the munition to survive the air carriage temperature profiles for the full required operational life shall be considered. Effects of humidity on the munition during air carriage and free flight shall also be considered.

b. Precipitation. Effects of precipitation on the munition during air carriage and free flight shall be considered.

c. Pressure. Effects of pressure changes in conjunction with changes in temperature and humidity on the munition during air-carriage and free flight shall be considered. Rates of pressure changes may be calculated from the defined aircraft sortie and free flight profiles; the rates of pressure change will be large during rapid aircraft ascents and descents.

d. Vibration. The levels of vibration associated with air carriage (cruise and maneuver) and free flight (land, sea or air launched) of munitions are very different and approach much higher frequencies than those levels associated with deployment in the land and sea handling environments. The air carriage vibration environment of the host vehicle should ideally be obtained from test measurements. For internal bay carriage the vibration associated with open bay cavity acoustics shall be considered. The ability of a munition to survive the vibration environment for the required operational life shall be considered. The vibration environment of the munition in free flight shall also be considered and may be estimated from the defined launch envelope and the performance specification. The vibration environment experienced by a munition mounted near a gun that is firing shall also be considered. (STANAG 4370).

e. Shock. Shocks associated with aircraft takeoff (normal and catapult assisted), landing (normal and arrested), munition launch sequence, and free flight shall be considered.

f. Acceleration. Steady state accelerations associated with air carriage as well as extreme acceleration levels associated with launch and landing shall be considered. The maximum acceleration levels associated with free flight may be calculated from the munition performance specification.

g. Acoustic Noise. Effects of acoustic noise on the munition during air carriage and free flight shall be considered. For internal bay carriage the noise associated with open bay cavity acoustics shall be considered.

h. Electromagnetic Radiation, Electrostatic Discharge. Hazards of electromagnetic radiation and the effects of electrostatic discharge and lightning on the munition - especially on any Electro Explosive Device (EED) - shall be considered. The assessment shall emphasize the defined RF environments for those parameters (STANAGs 1307, 4234, 4235, and 4236) and the induced electrostatic charge environment due to captive carry/free flight.

i. Electrical Safety. Electrical safety of the host vehicle/munition, with respect to safety breaks and inadvertent functioning, shall be considered.

j. Safe Function. The ability of the munition to function and be launched safely shall be considered. Considerations shall be given to normal launch, safe separation, safe escape maneuver, adjacent firing, and jettison under all conditions in the defined envelopes of the host aircraft.

6.2.5.3 Concurrent/Sequential Environmental Conditions. Effects on the munition of exposure to a combination of concurrent or sequential environments shall be considered. The combined concurrent or sequential environmental conditions may be more damaging than the cumulative effects of each environment individually. Further guidance can be found in commodity specific documents (e.g. STANAG 4224, 4225, 4433, 4493, 4516 etc.). Concurrent or sequential environments which may be considered include:

a. Humidity and contamination during storage, transportation, and handling activities.

b. Temperatures, humidity, shock, and vibration during transportation.

c. Aerodynamic heating, pressure changes, humidity, shock, vibration, and acoustic noise.

d. Temperature, humidity, and electrostatic charge.

6.2.6 Block F (Define System). It is necessary to clearly state what system is under consideration. The boundaries of the system and its elements must be defined as early as possible. Included in this step is the definition of the system operating conditions and the human role in the system operations. Such delineation establishes the limits for succeeding steps in the process and reduces complex systems to manageable parts. For instance, if an aircraft weapon system is being considered, it is essential to know whether the aircrew, munition carrier, munition selection arrangements, fire control system, and avionics systems are being thought of as part of the system or not. Careful attention to this step prevents confusion later in the process and for the evaluation of modifications.

6.2.7 Block G (Analyze System Hazards). The heart of the assessment process is the hazard analysis of the system and its elements using various techniques to systematically examine the system for hazards. Included in such a process is a comparison of the system design features with the design safety principles and design criteria that have been internationally agreed for specific classes of munitions systems. The detailed methods and techniques for performing these analyses are selected based on their suitability for the particular system element under consideration and the applicable level of detail in the design, and they must be applied in a comprehensive and methodical manner. By comprehensive, it is meant that everything that could happen to the system is thought of in terms of the consequence that may result; examples might include hangfire, misfire and other problems of launch. It should be emphasized that analyses are performed to identify hazardous conditions/events. Hazard identification is the first activity of hazard elimination and control. Hazard analyses are usually designed so that their output acts as the input for the next step in the assessment process. In other words, a hazard analysis should be viewed as an essential step in the conduct of the assessment process and not as an isolated activity. None of the hazard analyses described below are intended to stand alone. Starting with the Preliminary Hazard Analysis (PHA), there are aspects of each analysis type described that relate to the other types of analyses. Differences between the types of analyses are primarily in point of view or detail. Therefore, it is important that the conduct of hazard analyses be coordinated and integrated within the entire assessment process. In no other way can a program be confident that a munition system has been examined for hazards from every reasonable viewpoint and that the assessment process has been comprehensive. Among the aids to hazard analysis are the design safety principles and design criteria for specific classes of munitions. Analysis at all levels should take into account the principles and criteria to ascertain that the design conforms with requirements that have been agreed as the minimum for adequate safety.

6.2.7.1 Preliminary Hazards Analysis (PHA). The PHA is conducted as the initial analysis task. This analysis is a general qualitative study of the system design concept in its intended operating environment to identify and define hazards. Such hazard information contributes to the identification of high risk components in the system, identifies safety critical subsystems or components and software, and initiates controlling design criteria for safety. The result of this analysis is not simply a list of possible hazards that may or may not be encountered during the system life cycle. Rather, this analysis identifies all known design features that can impair mission capability through accidental damage or loss, and aids in developing steps that can be taken to ensure avoidance of such features. The PHA should include, but not be limited to, the following for identification of hazards:

a. Hazardous components (e.g. energy sources, fuels, propellants, explosives, and pressure systems).

b. Safety-related interface considerations among various elements of the system (e.g. material compatibilities, electromagnetic interference and other possibilities of inadvertent activation, fire/explosive initiation and propagation, and hardware and software controls).

c. Environmental constraints including the normal operating environments (e.g. drops, shock, extreme temperature, noise and health hazards, fire, electrostatic discharge, lightning, X-ray, electromagnetic radiation, and laser radiation).

d. Operating, test, maintenance, and emergency procedures (e.g. human error analysis of operator functions, tasks, and requirements; effect of environmental factors such as equipment layout and lighting requirements on human performance; life support requirements and their safety implication in manned systems; crash safety; egress, rescue, survival, and salvage).

6.2.7.2 Subsystem Hazards Analysis (SSHA). The SSHA is performed on subsystems (elements) of the overall system to identify hazards associated with component failure modes and functional relationships of components and equipment comprising each subsystem, including software. Such analysis should identify all components and equipment whose performance, performance degradation, functional failure, or inadvertent functioning could result in a hazard. The analysis should include a determination of the modes of failure and should include all single point failures and multiple point failures with unacceptable combined probabilities of failure arising from faults in subsystem components. The SSHA should be started as soon as the actual design of the subsystem has been refined to the point where detailed design information is available. The choice of specific analytical techniques employed for the SSHA is at the discretion of the safety analyst/engineer, but, as a minimum he/she should consider the following: subsystem definition, operational condition, potential failure or malfunction, hazardous consequences, detectability and correction of failure or malfunction, interrelationship with the components, hazard categorization and evaluation, and possible corrective actions.

6.2.7.3 System Hazards Analysis (SHA). The SHA is performed on the total system to identify hazards at the interface of the system elements (subsystems) including software. The assembly of individual hazard-free components does not necessarily ensure that the resulting system is also hazard-free.

6.2.7.3.1 The techniques of conducting an SHA are by far the most challenging because of the requirement to examine a very large number of interfaces in a complex system. The question of multiple failures is also addressed in the SHA.

6.2.7.4 Operating and Support Hazard Analysis (O&SHA). The O&SHA is performed to identify and control hazards and to determine safety requirements for procedures and equipment used in production, installation, maintenance, testing, modification, transportation, storage, operation and disposal during all phases of intended use. Results of these analyses should provide the basis for:

a. Actions required to minimize risk during a hazardous period or event.

b. Design changes to eliminate and control hazards.

c. Requirements for safety devices and equipment and required maintenance procedures to detect their functional failure.

d. Warnings, cautions, and special and emergency procedures for operating and maintenance, and modification.

e. Special procedures for handling, storage, transportation, maintenance, and modification.

6.2.7.5 Software Hazards Analysis. To reduce the safety risk associated with software performing safety-critical or safety-significant functions, hazard analyses must identify the system hazards and failure modes and which hazards and failure modes are caused or influenced by software or lack of software. AOP-52 provides detailed guidance on performing software hazard analyses.

6.2.7.6 IM Assessment. As part of a comprehensive safety and suitability for service assessment, it is necessary to glean useful and meaningful information about a munition’s response to selected representative threats and to compare, for compliance, such responses with the IM requirements defined in STANAG 4439. A focused examination may be needed to identify specific accidental and combat threats to which the munition may be exposed during its life cycle and to prescribe modeling, simulation, testing, and analyses that will provide requisite information. Threat analysis should (a) be based on analytical and empirical data; (b) consider the threat level and duration and the likelihood of threat exposure; and (c) should identify the most vulnerable configuration(s) of a munition to a particular threat. The accumulated threat information may then be used to prescribe appropriate modeling, simulation, testing, and analyses regimes and munition configurations.

6.2.7.7 Disposal Assessment. The disposal assessment is performed to identify and control the hazards associated with the demilitarization and disposal of a munition at its end-of-life. This assessment shall include an analysis of the munition’s proposed demilitarization and disposal design features, processes, and by-products to ensure that they are environmentally acceptable, physically safe, free of health hazards, practicable, and cost effective. STANAG 4518 provides guidance on the safe disposal of munitions.

6.2.7.8 Range Sustainability Assessment. A range sustainability assessment may be necessary to characterize the environmental impacts of a munition's use on operational ranges (e.g. the deposition of hazardous substances, and pollutants and contaminants). Such characteristics may be required to ensure the long-term viability of operational ranges and to enhance the ability to prevent or respond to a release or substantial threat of a release of munitions constituents from an operational range to off-range areas.

6.2.7.9 Health-hazard Assessment. A health-hazard assessment may be necessary to examine the potential health risks, such as carcinogenicity, posed by the elements or combinations present in a munition, including the effects of embedded munition fragments on NATO and Allied forces.

6.2.8 Block H (Identify Hazards). Through application of the foregoing systematic hazard analyses, the designer or engineer identifies those features of a system that may cause death/injury, damage, or destruction. A hazard must be identified before it can be eliminated or controlled and this may require special trials to identify hazardous failure modes. As the design progresses, additional hazards may be identified during successive iterations of the assessment process.

6.2.9 Block I (Evaluate Hazards). To eliminate every hazard identified in the previous step is usually impractical. For example, analysis of a helicopter system will show that separation of a rotor mast is a hazard with catastrophic consequences. As a result, the mast can be redesigned to be stronger or more reliable, but the hazard can neither be eliminated nor can a l00% assurance be given that the mast will never fail. While similar situations arise in examining the role of the human being in a manned system, it is unlikely that the potential for making mistakes will ever totally be eliminated. The procedure described in Section 5 by which hazards can be categorized and evaluated will enable decisions to be made with regard to appropriate hazard mitigation actions to be taken.

6.2.10 Block J (Suggest Actions to Eliminate or Control Hazards). The process produces no useful result until some action is actually taken to eliminate or control the hazards that have been identified. Without proper and timely action, the process becomes ineffective. However, all steps taken up to this point have been designed so that the most appropriate action can be taken.

6.2.11 Block K (Modify System Elements). Any action taken in the previous step will result in the modification of some elements of the system. This modification may not only involve hardware; procedures can be revised, initial assumptions on operating environment can be amended, or basic specifications can be changed. Any such action modifies the system and may require changing the definition of the system; Block F should then be revised accordingly. The process is then repeated as required until such time as no unacceptable additional hazards are generated by system modification. These repetitive steps ensure that actions taken to correct one hazard do not induce other hazards in the system. The concluding action at this step is to ensure that all means by which mishaps can occur have been satisfactorily eliminated or controlled. Any remaining hazards must be accepted by the appropriate Decision Authority.

6.2.12 Block L (Determine the Need for Trials or Analysis). After the munition system requirements are established, explosive materials are identified and qualified if necessary, design and safety principles are identified, and the life cycle events and service environments are defined, the overall system can be defined. System hazards can then be analyzed and evaluated for actions needed to eliminate or control the identified hazards, and the system can be modified as necessary. Through some systematic analyses and the knowledge about the munition system at this point, a decision can be made on the necessity for trials, further analysis, or modeling. There may be sufficient knowledge to assess the system to determine if it is safe and suitable for service without trials, analysis, or modeling.

6.2.13 Blocks M, N, & O (Select and Conduct Trials or Analysis Program). Block M concerns the selection of trials and analyses or modeling to provide evidence that elimination or control of hazardous failure modes has occurred. The adequacy of analytical techniques alone to identify system hazards and provide evidence of elimination or control of hazardous failure modes usually cannot be justified. Development programs for complex systems include testing to verify performance and to demonstrate system capability. Additionally, in Block N, a sequence of tests is called for to simulate the manufacture-to-target or disposal sequence of the munition. The coordinated environmental and safety trials program would be carried out at a stage represented by Block O. Tests and demonstrations must be defined to validate selected safety features of the system. Tests or demonstrations are performed on safety critical equipment and procedures to determine the hazard severity or to establish the margin of safety of the design. Induced or simulated failures should be considered to demonstrate the failure mode and acceptability of safety critical equipment. Where hazards are identified during the development effort and it cannot be analytically determined whether the action taken will adequately control the hazard, safety-related tests are conducted to evaluate the effectiveness of the controls. Where costs for safety-related testing would be prohibitive, consideration may be given to assessing if safety characteristics or procedures can be adequately verified by engineering analyses, analogy, laboratory test, functional mockups, or subscale/model simulation. Specific safety-related tests should be integrated into appropriate system test and demonstration plans to the maximum extent possible. The purpose of the environmental and safety-related testing is to assess the probable response of the munition and to establish confidence that:

a. The explosive components remain safe and suitable for service under all defined service life cycle conditions.

b. The probability of Category I, II, or III mishaps occurring under abnormal, but credible service conditions is acceptably low.

c. Munitions remain safe, suitable for service, and function within acceptable performance limits after being exposed to severe handling and extreme climatic conditions comparable with those that may be found during handling, storage and transport and when the munition is used in its operational launcher environment.

d. There is no damaging interaction between munition explosive components (or the complete munition) and the associated packaging when subjected to service conditions.

6.2.13.1 It is the agreed position of Alliance Nations that a uniform method for safety evaluation of munition systems, including munition hazard assessment testing, be established to avoid unnecessary duplication of testing by a non-developing nation. Munition sensitiveness test plans should be tailored, to the maximum extent possible within the guidelines contained in this publication, so that all safety-related tests can be addressed in one coordinated test program with the minimum number of samples. Accordingly, project managers and munition developers will conduct a system hazard assessment and in so doing, will determine the adequacy of munition sensitiveness tests as specified in related NATO or national documents. If that assessment indicates that environmental hazards or threats to the weapon system pose special or additional vulnerability problems, tests to assess munition sensitiveness will be tailored to address those problems and a rationale to support the assessment and any test tailoring will be documented.

6.2.13.2 A safety evaluation that includes any or all of the safety-related tests included in the applicable STANAGs must use the test procedures specified. Any tests not included in those documents that are considered necessary by the testing nation will be carried out in accordance with the national document concerning the method of the test.

6.2.13.3 In order to ensure that the essential minimum tests are agreed to by participating nations for particular classes of munitions, a family of STANAGs has been prepared that provide safety-related test criteria for generic classes of munitions. Annex B provides a list of related STANAGs.

6.2.13.4 To ensure that adequate data are available to national/service safety evaluation organizations for the assessment of a munition's safety and suitability for service, the nation developing the munition is expected to compile a munition safety data package in accordance with Annex C. That package should describe the test methods used and the detailed results obtained during development tests as well as during safety and suitability for service tests.

6.2.14 <u>Blocks P, Q, R, S, and T (Assess Safety and Suitability for Service, Provide Guidance and Report).</u> The final steps in the assessment process are to examine all analysis data and the results of the trials/analyses programs. If this evaluation indicates that further action is necessary to eliminate or control hazards or to improve the effectiveness of the munition, then portions of the assessment process will need to be repeated following a decision to modify the design or implement remedial actions. Upon receipt of a valid request through appropriate national channels, nations with primary responsibility for developing a munition and compiling a safety data package will supply their safety and suitability for service assessment information to a nation participating in a collaborative weapon development or procurement program and where necessary to assist in the Interoperability of NATO Forces (see annex C for Munitions Safety Data Package Content).

7. <u>SAFETY AND SUITABILITY ASSESSMENT PROCESS SUMMARY</u>

7.1 The preceding paragraphs describe the safety and suitability assessment process. It is a specialized problem-solving process; one step leads naturally to the next when combined with a commitment to carry out a selected program of trials to develop confidence that a munition is safe and suitable for service. The assessment process also has several distinct characteristics that enable it to be applied in a practical manner. Provisions are made to repeat the steps as often as necessary to achieve the desired results. The process can be applied at any level of system complexity, from broad general design concepts to the final design details of a subsystem or component. Another significant practical characteristic of the process is that it prescribes the application of judgment and management decisions at the juncture between what is ideal and what is practical. Thus, the assessment process produces results that are consistent with the definition of System Safety, i.e. attainment of an "... optimum degree of hazard elimination within the constraints of operational effectiveness, time, and cost."

7.2 The application of the assessment process is not simple, but neither is a sophisticated munition system. The advantage of the process lies in being able to examine such extremely complex subjects in simpler related parts. This examination proceeds in a logical and systemic fashion from one part to the next until the entire complex subject is covered.

QUESTIONNAIRE TO IDENTIFY THE ENVIRONMENT LIFE CYCLE PROFILE OF A MUNITION IN SERVICE

1. The safety and suitability of a munition for service use may be influenced by the natural or induced environments that the munition experiences in service use. This questionnaire has been designed to identify the planned service environments of a new munition prior to its development. It may also be applied to existing munitions being considered for use in alternative applications or by other NATO countries. The resulting information will be used by safety evaluation organizations to devise trials of appropriate rigor for use when making their assessments.

2. The questionnaire is divided into five sections. Section 1 provides for certification of the information. Section 2 contains questions applicable to all munitions. Sections 3-5 specify the additional requirements for munitions subjected to the sea, land, and air service environments, respectively. Not all sections will apply to all munitions. It is also understood that not all participating nations are in the practice of certifying the life-cycle environments of their munitions.

3. Precise answers should be given where possible, but best estimates may need to be used initially. Where an answer cannot yet be given, or where the question is not applicable, this should be indicated. A target date should be given for the provision of information not yet available.

Section 1 – Certification

The information given in this questionnaire is consistent with the operational requirements and the design specification (where applicable) of this munition.

Signature.....................................	Signature..
Date...	Date..
Operational Requirement or Accepting Authority	Service Department Project Manager
Name______________________________	Name______________________________
Appointment_______________________	Appointment_______________________

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Section 2 - Applicable to all Stores

No.	Question	Answer	Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)
(a)	**(b)**	**(c)**	**(d)**
2.1	**Application** Which of the Services are likely to use this munition? State from which type of weapon platform (land, sea, or air) the weapon will be operated.		
2.2	If the munition is to have detachable explosive components, are these to be stored separately? Give details. (If answer is "yes", questions 2.4-2.16 should be answered for each item.) When and where will these components be assembled to constitute the complete store?		
2.3	Is there to be a practice version which contains explosives? Is the practice version to be stored separately? (If the answer is "yes", questions 2.4-2.16 should also be answered for the practice version.)		
2.4	**Life Information** What is the minimum acceptable service life of the munition? The required operational and storage lives should be given where specified. What is the ultimate planned life for this store? (intended phase-out date)		
2.5	Can the minimum acceptable service life be achieved by replacing short-lived components? In order to achieve the minimum acceptable service life of the munition, must components having an inadequate shelf-life be replaced?		
2.6	Will the shelf-lives of all replaceable components either be approximately the same or be multiples of the shorter shelf-life?		
2.7	If there is likely to be a requirement to extend the life beyond the minimum value given in 2.4, is it acceptable to do it by using additional protection either to the package or the store itself?		
2.8	At what stage in the life of the munition will it be necessary to know whether its life can be extended?		
2.9	What will be done with munitions that exceed their service life?		
2.10	What is the proposed maintenance cycle for the munition in service?		
2.11	**Climatic and Storage Conditions** In which climatic categories (defined in STANAG 4370) or geographical areas will the munition be: a. Transported? b. Stored? c. Maintained? d. Operated?		

No.	Question	Answer	Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)
(a)	(b)	(c)	(d)
2.12	For how long and how often will the munition be kept in each of these locations in the course of its life? Need to consider both the duration of exposure to climatic conditions and the frequency.		
2.13	Under which of the following conditions in depots (CF unit storage, 2-15) is the munition required to be stored and for how long in each: a. Air-conditioned? (with temperature and humidity control) b. Temperature controlled only? c. Humidity controlled only? (Storehouses with dehumidifiers) d. Well-ventilated storehouses giving complete protection from sun and rain but where the inside temperature would be expected to follow variations in shade temperature? This includes well ventilated canvas covers or containers. e. Unventilated storage (e.g. other storehouses, thin-walled structures, canvas covers or containers) affording direct cover from sun and precipitation but limited or non existent ventilation? f. No climatic protection?		
2.14	What are the temperature and humidity conditions likely to be experienced in depot storehouses (defined in 2.13a, 2.13b, 2.13c, 2.13d, and 2.13e)?		
2.15	Under which of the following conditions in unit storage (for storage at sea, see Section 3), including peacetime exercises, and operations, is the munition required to be stored and for how long in each: a. Air-conditioned? (with temperature and humidity control) b. Temperature controlled only? (Storehouses with thermostatically controlled heating and cooling) c. Humidity controlled only? (Storehouses with dehumidifiers) d. Well-ventilated storehouses giving complete protection from sun and rain but where the inside temperature would be expected to follow variations in shade temperature? This includes well-ventilated canvas covers or containers. e. Unventilated storage (e.g. other storehouses, thin-walled structures, canvas covers or containers) affording direct cover from sun and precipitation but limited or non-existent ventilation? f. Storehouses with thermostatically controlled heating only? g. No climatic protection?		
2.16	What are the temperature and humidity conditions likely to be experienced in unit storage described in 2.15a - 2.15g?		
2.17	Is the munition and/or the package required to be water tight or vapor tight? If so, is this to be achieved with or without desiccants?		

No.	Question	Answer	Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)
(a)	(b)	(c)	(d)
2.18	Are there any items of service assembly and test equipment which may be susceptible to environmental conditions and which would require similar testing to the munition?		
2.19	Nuclear Environments Is it required to assess the ability of the store to withstand: a. . Standard NATO exo-atmospheric EMP? b . Standard NATO endo-atmospheric EMP?		
2.20	Specify the threat level (See STANAG 4145 and AEP-04) if it is required to assess the ability of the munition to withstand: a. Air blast. b Thermal radiation. c. Ionizing radiation. d. Underwater and air blast induced shock. e. Initial nuclear radiation (INR).		
2.21	Is the munition to survive a nuclear environment? If so, is it required to remain: a. Safe but not necessarily serviceable? b. Safe and serviceable? If required to remain serviceable: a. serviceable during the nuclear event? b. serviceable within minutes of the nuclear event? c. serviceable within hours of the nuclear event?		
2.22	Electromagnetic and Electrostatic Environment Is it required to assess the ability of the munition to withstand an RF environment (such as those specified in STANAGs 1307 and 4234)? What RF environments are envisaged for the munition during: a . Manufacture & assembly? b. Testing & Inspection? c. Transport? d. Storage? e. Handling/Loading/Unloading? f. Maintenance? g. Operational Use?		

No.	Question	Answer	Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)
(a)	**(b)**	**(c)**	**(d)**
2.23	Is it required to assess the ability of the munition to withstand a discharge of electrostatic energy (see STANAG 4235) during: a. Personnel handling? b. Vertical replenishment? c. Other sources (eg., induced during flight)		
2.24	Is it required to assess the ability of the munition to withstand lightning conditions such as those specified in STANAG 4236 during: a. A direct lightning strike? b. The effects of a nearby lightning strike?		
2.25	Is it required to assess the effects of electrical transients generated by the carriage vehicle or launch platform upon the munition?		
2.26	Is it required to assess the ability of the munition to withstand the effects of magnetic fields e.g. those generated by ship degaussing systems, or deperming.		
2.27	**Packaging** Is it intended to package the munition and/or components at any time during its life in service? Is so, describe the packaging intended.		
2.28	If containers are required, will they hold: a. The entire munition? b. Individual sections or components of the munition?		
2.29	If containers are required, are they intended for: a. Storage? b. Transit? c. As a launcher or tube or box? d. Any other purpose? Specify role. Are boxes approved to the requirements of the UN 'Orange Book (Recommendations on the Transport of Dangerous Good, ST/SG/AC 10/1) to be used?		

No.	Question	Answer	Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)
(a)	(b)	(c)	(d)
2.30	**Logistic Transportation** Will the munition be transported by wheeled or tracked vehicles? If so, state: a. Packaged, unpackaged, or both. b. Types of vehicles. c. The class of road or track or nature of the ground. d. Maximum likely speed and duration of the journey. (Total throughout service life.)		
2.31	Will the munition be transported by rail? If so, state whether packaged, unpackaged or both.		
2.32	Will the munition be transported by sea: a. As cargo? b. As part of the equipment of an Embarked Military Force? If so, state for each case whether the munition will be packaged, unpackaged or both, and the class or generic type of ship.		
2.33	Will the munition be carried as deck cargo?		
2.34	State the maximum heights through which the munition might be dropped during embarkation into a ship/vessel.		
2.35	Will the munition be transported by amphibious vehicle including hovercraft? If so, state: a. Packaged, unpackaged, or both. b. Type of vehicle. c. Nature of terrain. d. Maximum likely speed and duration. (Total throughout service life.)		
2.36	Will the munition be transported by fixed-wing aircraft? If so, state: a. Packaged, unpackaged, or both. b. Type of aircraft (Turbo prop or jet powered). c. Whether or not the aircraft will be pressurized.		
2.37	Will the munition be transported by helicopter? If so, state: a. Whether packaged, unpackaged, or both. b. Whether as an internal load or underslung, e.g. vertical replenishment. c. Helicopter type(s) if known.		
2.38	What is the estimated total time in the life of the munition that will be spent in each of the modes of transportation in questions 2.30 to 2.33 and 2.35 to 2.37?		

No.	Question	Answer	Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)
(a)	(b)	(c)	(d)
2.39	Will the munition be transferred at sea either by jackstay or helicopter and in what packaged state?		
2.40	State the maximum height through which the munition might be dropped during jackstay transfer at sea and onto what surface?		
2.41	Will the munition be air dropped? If so, state method and condition of packaging/palletization for delivery.		
2.42	What environmental protection is to be provided for the munition in its stowage position?		
2.43	**Evaluation of Munition Sensitivity (Vulnerability)** Specify the acceptable level of response of the munition to: a. Fuel Fire, as defined in STANAG 4240 b. Slow Heating, as defined in STANAG 4382 c. Bullet/fragments, resulting from saboteur attack or enemy action as defined in STANAG 4241and STANAG 4496 d. Blast from adjacent munitions as defined in STANAG 4396 e. Shaped Charge weapon attack, as defined in STANAG 4526 f. Behind Armor debris from armor attack		
2.44	How much time is likely to be available for fire-fighting (or other emergency measures) in the event of the munition being involved in a fire?		
2.45	Specify the acceptable effects of premature functioning of this munition, in either the packaged or unpackaged state, on adjacent stores as defined in STANAG 4396.		
2.46	Is the munition required to survive prolonged exposure to elevated temperatures experienced, for example, by a round of ammunition held for a time in a hot gun chamber or by fire extinguisher cartridges kept close to power plants in aircraft? If so, give full particulars.		
2.47	Are there any special features of intended use which may expose the munition to environments not addressed in this questionnaire?		
2.48	How is it intended to demilitarize, if appropriate, and dispose of the munition at the end of its service life? (See STANAG 4518)		

Section 3 - Sea Environment - Operational

No.	**Question**	**Answer**	**Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)**
(a)	**(b)**	**(c)**	**(d)**
3.1	In which sea areas will the ship operate with the munition embarked, and what are the expected times that the ship will remain in the marine climatic categories defined in STANAG 4370? (Account should be taken of ship deployment in coastal waters where the appropriate land climatic categories should be included).		
3.2	Identify the installations regions of the ship or submarine in which the munition will be stored Surface Ship Masthead Exposed upper deck Adjacent to a flight deck or helicopter landing pad Adjacent to a designated vehicle park Protected compartment Hull, below water line Submarine Inside pressure hull (not subject to diving pressures) Inside pressure hull (subject to diving pressures) Outside pressure hull (below water line) Outside pressure hull (above water line)		
3.3	What are the temperature and humidity conditions of the magazines in which the munition will be located?		
3.4	If the munition is to be stowed in locations other than magazines, what will be the temperature and humidity conditions at these locations?		
3.5	Will the munition be stowed packaged or otherwise protected in the conditions of 3.3 or 3.4?		

No.	Question	Answer	Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)
(a)	**(b)**	**(c)**	**(d)**
3.6	Will any components containing explosives or electrical/explosive devices be carried separately from the main frame of the munition? If so, state: a. Where they will be stored. b. For how long. c. In what form of packaging.		
3.7	Identify the region of the ship or submarine in which the munition will be operated: Surface Ship Masthead Exposed upper deck On or adjacent to a flight deck or helicopter landing pad On or near a designated vehicle park Protected compartment Hull, below water line Submarine Inside pressure hull (not subject to diving pressures) Inside pressure hull (subject to diving pressures) Outside pressure hull (below water line) Outside pressure hull (above water line)		
3.8	Where a launcher/mounting is used, how long will the munition remain on the ship's launcher/mounting: a. At any one time? b. As a cumulative total during its life in service?		
3.9	Is the launcher/mounting likely to be exposed to solar radiation, wind, precipitation including salt spray, green water loading, dust, sand, and ice, or contamination from other ship equipments, e.g. gun or missile blast? If so, give details.		

No.	Question	Answer	Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)
(a)	**(b)**	**(c)**	**(d)**
3.10	What protection will be provided to the munition while in the launcher/mounting?		
3.11	What assessments or measurements have been made of the resultant mechanical environment transmitted to the munition by the launcher, e.g. from sources such as ship vibration.		
3.12	What conditions of shock or gun blast will be experienced: a. In magazines? b. On the launcher/mounting?		
3.13	What is the minimum distance to the nearest personnel who could be exposed to the following products of launch/firing of the munition. a. Biological (including carcinogens)? b. Toxic material (including gases)? c. Dust? d. Noise?		
3.14	If the munition is to be launched from a torpedo tube, or submerged explosive stores ejector, state for how long and at what pressure and how many times is it likely to be in the tube.		
3.15	When the munition is a sea mine: a. What is the method of laying? (If by air, complete Section 5) b. What is the user's requirement for laid life? c. What is the user's requirement for sterilization? d. What are the environmental conditions associated with laid life?		

Section 4 - Land Environment - Operational

No.	**Question**	**Answer**	**Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)**
(a)	**(b)**	**(c)**	**(d)**
4.1	Will the munition be transported by wheeled or tracked vehicles? If so, state: a. Packaged, unpackaged or both. b. Types of vehicles. c. The class of road or track or nature of the ground. d. Maximum likely speed and duration of the journey. (Total throughout service life.)		
4.2	Will the munition be carried operationally by amphibious vehicle including hovercraft? If so, state: a. Packaged, unpackaged or both. b. Type of vehicle. c. Nature of terrain. d. Maximum likely speed and duration. (Total throughout service life.) (See also 2.35)		
4.3	Will the munition be carried operationally by helicopter? If so, state: a. Whether packaged, unpackaged or both b. Whether as an internal load or underslung, e.g. vertical replenishment c. Whether the munition will experience the shock and vibration effects of gun-fire or the blast effects from rocket launch. d. Type(s) of helicopter (Total throughout service life) (See also 2.37)		
4.4	When the munition is carried in AFV or other operational vehicle, what are the conditions of stowage?		
4.5	What are the methods of packaging and handling in the field?		
4.6	Where a launcher is used, how long will the store remain on the launcher: a. At any one time? b. As a cumulative total during its life in service?		

No.	Question	Answer	Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)
(a)	**(b)**	**(c)**	**(d)**
4.7	Is the launcher likely to be exposed to solar radiation, wind, precipitation including salt spray, green-water loading, ice, sand and dust, or contamination from other equipments? Give details.		
4.8	What protection will be provided to the munition while on the launcher?		
4.9	What is the minimum distance to the nearest personnel who could be exposed to the following products of launch/firing of the munition. a. Biological (including carcinogens)? b. Toxic material (including gases)? c. Dust? d. Noise?		
4.10	When the munition is a land mine: a. What is the method of laying? b. What is the requirement for laid life? c. What is the requirement for sterilization? d. What are the environmental conditions associated with the laid life? e. How is the mine activated, e.g. pressure plate?		
4.11	Will the munition be issued for use in NATO Military Ships? If the answer is "yes," complete Section 3.		
4.12	Will the munition be used as a helicopter weapon? If the answer is "yes," complete Section 5.		

Section 5 - Air Environment - Operational

No.	Question	Answer	Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)
(a)	**(b)**	**(c)**	**(d)**
5.1	On what types of aircraft and in what positions will the munition be carried?		
5.2	What is its resultant mechanical environment in terms of: a. Vibration (including gun-fire)? b. Shock (airborne munition firing)? c. Shock (landing)? d. Acceleration (on the aircraft and on launch)? (consider variations of response within the munition.)(Specify maximum g loading and duration) e. Arrested landing?		
5.3	What is the maximum time that the munition is required to remain fitted to the aircraft on the ground/flight deck: a. At any one time? b. As a cumulative total during its life in service?		
5.4	What is the maximum time that the munition is expected to remain fitted to the aircraft in the air: a. At any one time? b. As a cumulative total during its life in service?		
5.5	What are the operational flight profiles for the aircraft when carrying the munition?		
5.6	What is the desired flying life in hours of the munition when carried by its parent aircraft?		
5.7	How many sorties represented by the flight profiles will be flown during the life of the munition?		
5.8	On how many sorties will any guns fitted be fired and for how long?		
5.9	In which climatic categories (defined in STANAG 4370) or geographical areas will the munition be exposed during standby and carriage by air? Will the munition be exposed to solar radiation?		

No.	**Question**	**Answer**	**Source Reference (e.g. Staff Requirement, Design Spec., etc. as appropriate)**
(a)	**(b)**	**(c)**	**(d)**
5.10	What form of environmental protection, if any, will be given to the munition when fitted to aircraft: a. On the ground/flight deck? b. In the air?		
5.11	Is it intended that the munition be fitted when the aircraft is in transit to operational airfields away from its main base (e.g. involving long ferry flights)?		
5.12	Is it required to assess the hazards involved when an aircraft carrying the munition crash lands: a. Makes a controlled emergency landing? b. Crashes under attempted control? c. Crashes out of control?		
5.13	Is it required to assess whether jettisoned munitions are likely to remain safe?		
5.14	Will the store be issued for use in NATO military ships? (If so, complete Section 3)		

LIST OF APPLICABLE STANAGS FOR GENERIC CLASSES OF MUNITION

(List to be updated as required)

STANAG 2818	Demolition Materiel, Design Testing and Assessment
STANAG 3441	Design of Aircraft Stores
STANAG 4187	Fuzing Systems - Safety Design Requirements
STANAG 4333	Underwater Munitions, Principles for Safe Design
STANAG 4368	Electric and Laser Ignition Systems for Rockets and Guided Missile Motors - Safety Design Requirements
STANAG 4432	Air-Launched Guided Munitions, Principles for Safe Design.
STANAG 4433	Field Mortar Munitions, Design Safety Requirements
AOP-16	Fuzing Systems: Guidelines for STANAG 4187
STANAG 4157	Fuzing Systems; Test Requirements for Assessment of Safety and Suitability for Service
STANAG 4224	Large Caliber Artillery and Naval Gun Ammunition Greater than 40 mm, Safety and Suitability for Service Evaluation
STANAG 4225	The Safety Evaluation of Mortar Bombs
STANAG 4239	Electrostatic Discharge, Munition Test Procedures – AOP-24
STANAG 4242	Vibration Test Method and Severities for Munitions Carried in Tracked Vehicles
STANAG 4497	Hand Emplaced Munitions (HEM), Principles for Safe Design
STANAG 4324	Electromagnetic Radiation Hazard Assessment and Testing of Munitions and Associated Systems
STANAG 4327	Lightning, Munition Assessment and Test Procedures – AOP-25
STANAG 4337	Surface-Launched Munition Appraisal, Safety and Environmental Tests
STANAG 4338	Underwater-Launched Munitions, Safety Evaluation
STANAG 4370	Environmental Testing, covering AECTP 100, 200, 300, 400 500 and 600 Series
STANAG 4423	Cannon Ammunition (12.7 to 40 mm), Safety and Suitability for Service Evaluation
STANAG 4439	Policy for the Introduction and Assessment of Insensitive Munitions (IM)
STANAG 3786	Safety Design Requirements for Airborne Dispenser Weapons
STANAG 4325	Air-Launched Munitions Safety and Suitability for Service Evaluation
STANAG 4516	Cannon (greater than 12.7 mm) Design Safety Requirements and Safety and Suitability for Service Evaluation of the Weapon/Munition Combination

STANAG 4518	Safe Disposal of Munitions, Design Principles and Requirements and Safety Assessment
STANAG 4519	Gas Generators, Design Safety Principles and Safety and Suitability for Service Evaluation
STANAG 4599	Weapon Launched Grenade Systems - Design Safety Requirements Safety and Suitability for Service Evaluation
STANAG 4608	Ammunition Below 12.7mm Calibre - Design Safety Requirements and Safety and Suitability for Service Evaluation
STANAG 4238	Munition Design Principles, Electrical/Electromagnetic Environments
STANAG 4170	Principles and Methodology for the Qualification of Explosive Materials for Military Use
AOP-7	Manual of Data Requirements and Tests for the Qualification of Explosive Materials for Military Use
STANAG 1307	Maximum NATO Naval Operational Electro-magnetic Environment Produced by Radio and Radar
STANAG 4234	Electromagnetic Radiation (Radio Frequency) 200 kHz to 40 GHz Environment Affecting The Design of Materiel for Use by NATO Forces
STANAG 4235	Electrostatic Discharge Environment
STANAG 4236	Lightning Environment
STANAG 4240	Liquid Fuel/ External Fire, Munition Test Procedures
STANAG 4241	Bullet Impact, Munition Test Procedures
STANAG 4375	Safety Drop, Munition Test Procedure
STANAG 4382	Slow Heating, Munitions Test Procedures
STANAG 4396	Sympathetic Reaction, Munition Test Procedures
STANAG 4433	Field Mortar Munitions, Design Safety Requirements
STANAG 4493	Tank Ammunition, Safety and Suitability for Service Evaluation

MUNITIONS SAFETY DATA PACKAGE CONTENT

The safety data package should contain a body of evidence that provides a compelling, comprehensive and validated assessment that a system is safe for a given application in a given environment. The body of evidence in the safety data package should provide a "Safety Case", and contain all the necessary information to enable the safety of the system to be assessed. The safety data package should identify all principal safety requirements and provide evidence that demonstrates how safety requirements have been met.

1. DESCRIPTION OF MUNITION SYSTEM

a. Intended operational use.

b. Total system description to include munition, launch vehicle and support equipment. All explosive components should be specifically addressed as well as the interface between the complete munition and the launch vehicle. Components addressed should include, but not necessarily be limited to, fuze, ignition system, warhead, propulsion and ancillary equipment. Compliance or non-compliance with national safety standards and STANAGs should be addressed for all components and the complete munition. Rationale for non-compliance is required.

2. DEFINITION OF THE SERVICE ENVIRONMENT. Definition of the service environment including the manufacture-to-target or disposal sequence for the munition, established from the environmental questionnaire given at ANNEX A.

3. SAFETY PROGRAM AND RESULTS

a. Environmental, Safety and Health Hazard Identification and Analyses:

(1) Type.

(2) Depth: Interfaces with test equipment, fire control, launcher, etc.

(3) Environmental, Safety and Health Hazards identified.

(4) Environmental, Safety and Health Hazard Control: Design change, method of hazard control, failure to control hazard.

(5) Risk assessment - provide a summary on safety criteria and methodology used to classify and rank hazards (Mishap Severity Categories, Mishap Probability Levels and residual mishap risk levels). Identify residual mishap risks and associated levels.

b. Safety Trials: (provide a summary of the results of any safety trials and assessments carried out)

(1) Type and rationale to establish adequacy in assessing efficiency of hazard control techniques.

(2) Parameters and procedures and rationale indicating similarity to environmental profile.

(3) Test results and rationale for acceptance, if required.

(4) Safety anomalies identified in tests performed for other purposes, e.g. operational, performance etc., and remedial actions to eliminate or control the hazard identified.

c. Design Assessment

(1) Explosives Qualification

(2) Explosive Hazard Data Sheets

(3) Explosive compatibility matrices

(4) Explosive Hazard Classification

(5) Electrical Environment: provide a summary of any electrical/electromagnetic trials and assessments

(6) Mechanical and Climatic Environment: provide a summary of any mechanical and climatic trials and assessment

(7) Insensitive Munition Assessment

(8) Munition Life Assessment: in-service test plans

(9) Software: identify the integrity level of all safety related software and provide safety case evidence that the functionality of the software is safe IAW AOP-52.

(10) Airworthiness Certification/Release if the munition is intended for airborne use.

(11) Radioactive (ionizing radiation) materials licensing or authorizations, if applicable

(12) Nonionizing radiation (e.g. laser and RF) assessment

d. Range and Laser Safety: provide a summary of any range and laser safety assessments. Provide Surface Danger Zone (SDZ) data.

e. Environmental Management and Assessment

(1) Environmental Impact Screening and Scoping Study: provide a summary of the impact study.

(2) Environmental Impact Assessment

(3) Environmental Impact Statement

4. AUDIT TRAIL. If weapon has been modified, provide changes since the basic program was conducted and details of the program conducted on changes to verify that the safety of original design has not been degraded.

5. QUALITY CONTROL. Identify design features of critical safety nature requiring specific quality control considerations.

6. FINAL SAFETY APPROVAL. Together with the stated safety approval should be included a summary of waivers to normal acceptance standards.

QUANTITATIVE RISK ASSESSMENT

1. INTODUCTION In some circumstances it is appropriate to use a quantitative approach to risk assessment. Statistical analysis can easily lead to misleading or meaningless results unless the process is logically valid and confidence levels in the data being used are taken into account. When the proper circumstances are present, however, a quantitative approach to risk assessment offers advantages such as:

   a. The outcome may indicate that the risk is so large or so small that further work is not necessary. This conclusion is not always intuitive.

   b. The increase or reduction of risk as a specified change in the activity can be mathematically related to the cost effectiveness of that change.

   c. It provides a method of comparing risks or identifying a change of risk even if the numbers are, on their own, potentially misleading or inaccurate.

   d. A quantitative statement of risk may be more meaningful to decision makers and the public than qualitative statements.

2. Quantitative risk assessment is a process used to calculate the level of risk associated with specified situations. It is important at an early stage to agree whether quantitative procedures for risk assessment are appropriate. The process requires estimates of the frequency or probability of an accident/events and the associated consequences. Estimates may be produced in a number of ways.

3. PROCESS

   a. Frequency Analysis. The first step in a quantitative risk assessment is to predict the frequency of future mishaps. Two basic approaches may be taken:

      (1) Historical. This analysis uses historical data on which to base judgements and predictions regarding the likely frequency of future accidents or incidents.

      (2) Predictive. This analysis is the process of predicting accident or failure frequencies using techniques such as Fault Tree Analysis and Event Tree Analysis. Numerical data on all relevant events, including equipment failure, human error and other published data are then combined with the logical structure to produce an estimate of the likelihood of an accident.

   These approaches are complementary and, whenever possible, both should be used.

   b. Consequence Analysis. Consequence analysis is the estimation of the impact of an accident on people, equipment, property, and the environment. An example would be to estimate the population densities in the area of a possible accident and combine these figures with the predicted harm resulting from the accident.

4. It is normal to express risk in terms of the predicted occurrences frequency from a stated inventory of items or a bounded process. For example the number of deaths per year resulting from the peacetime operations of a warship. This figure can be built up from the predicted number of deaths from natural causes, weapon accidents, seamanship activities etc.

5. Event Tree Analysis (ETA). ETA may be used to identify the possible outcomes and their probability, given the occurrence of an initiating event. ETA is used for facilities provided with engineered accident mitigating features, to identify the sequence of events that might lead to specified consequences. It is generally assumed that each event in the sequence is either a success or a failure. Figure D-1 shows a simple event tree with what would be the predicted probabilities associated with each event.

Initiating Event (per firing)	Flight Termination System Functions	Missile Remains Within Weapon Danger Area	Missile Impacts Close to Personnel	Outcome	Frequency (per firing)
	Yes			No Fatality	9.8 x 10^{-4}
Missile Guidance Failure Rate 10^{-3}	0.98	Yes		No Fatality	2.0 x 10^{-6}
		0.1			
	No				
	.02		No	No Fatality	1.6 x 10^{-5}
			0.9		
		No			
		0.9			
			Yes	Fatality	1.8 x 10^{-6}
			0.1		

Figure D-1. Example of an Event Tree

If 55 missiles were fired per year the annual predicted death rate would be:

55 x (1.8 x 10^{-6}) = 10^{-4} or one death every 10,000 years.

(In this example, there is an assumption that there is only 1 person killed when the missile impacts close to personnel.)

The degree of acceptability or non-acceptability of the predicted result would be determined by the appropriate safety authority.