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Utilizing the IATG in Conflict-Affected and Low-Capacity Environments

Geneva International Centre for Humanitarian Demining (GICHD)

UTILIZING THE INTERNATIONAL AMMUNITION TECHNICAL GUIDELINES IN CONFLICT-AFFECTED AND LOW-CAPACITY ENVIRONMENTS

UN SaferGuard
Securing ammunition, protecting lives

UNIDIR
UNITED NATIONS INSTITUTE FOR DISARMAMENT RESEARCH

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EXECUTIVE SUMMARY

The illicit proliferation, excessive accumulation and misuse of arms and ammunition pose a persistent challenge for peace and security at the global, regional and national levels. States suffering from extremely high levels of organized armed violence and those in conflict-affected and post-conflict settings are often disproportionately burdened by the illicit flow and availability of arms and ammunition, which impedes their efforts to provide security to their populations, respond to humanitarian needs, and to create an environment conducive to sustainable development. Furthermore, poor ammunition safety management poses a significant hazard to personnel and has been assessed as a contributory factor in many catastrophic unplanned explosions at munitions sites (UEMS).

The International Ammunition Technical Guidelines (IATG) provide comprehensive and practical guidance on ammunition stockpile management. They incorporate three-ascending risk reduction process levels (RRPLs) to consider the realities and capacities in different contexts. This document provides practical advice and guidance on the implementation of safe and secure ammunition management practices in conflict-affected and low-capacity environments and in doing so it extracts essential elements from the IATG for guidance and information.

It covers:

- The context and need for improving ammunition management in conflict-affected and low-capacity environments;
- Guidance on how to improve safety at ammunition storage sites by reducing the risk of an accidental explosion and by mitigating the effects of an explosion, should it occur;
- Advice on implementing effective security measures to prevent stock diversion;
- Advice on how the problem of unclassified ammunition should be addressed;
- Guidance on the development of specific ammunition management competences and the training and development of personnel involved in ammunition management-related activities;
- Identification of problematic areas where the international community can assist states in conflict-affected and low-capacity environments;

This document is intended for use by:

- Government officials and policy makers
- Ammunition practitioners and those involved in the day-to-day management and operation of ammunition storage and processing facilities
- Staff of international entities and non-governmental organizations in the context of delivering ammunition safety enhancement projects.

This document offers practical information and guidance on how basic ammunition stockpile safety and security can be improved and risks reduced in ammunition storage and processing facilities with a view to more comprehensively utilizing the IATG in the longer term.

CONTENTS

LIST OF FIGURES AND TABLES

Figures

Tables

LIST OF ABBREVIATIONS AND ACRONYMS

ABDM	Advisory Board on Disarmament Matters
ACTO	(Ammunition) Attractive to Criminal or Terrorist Organizations
ALARP	As Low as Reasonably Practicable
APB	Ammunition-Processing Building
ASA	Ammunition Storage Area
ATGW	Anti-Tank Guided Weapons
CA	Conflict-Affected
CDS	Central Destruction Site
CEN	European Centre for Standardization
CG	Compatibility Group
EHS	Explosive Harvesting System
ERW	Explosive Remnants of War
ES	Exposed Site
ESC	Explosives Safety Case
ESH	Explosive Store House
DDR	Disarmament, Demobilization and Reintegration
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
GICHD	Geneva International Centre for Humanitarian Demining
HCC	Hazard Classification Code
HD	Hazard Division
HE	High Explosive
IATG	International Ammunition Technical Guidelines
IBD	Inhabited Buildings Distance
IDS	Intrusion Detection System
IED	Improvised Explosive Device
IMAS	International Mine Action Standard
IMD	Inter Magazine Distance
IQD	Inside Quantity Distance
LC	Low-Capacity
LO	Learning Objectives
LPS	Lightning Protection Systems
LTA	Long Term Agreement
MANPADS	Man-Portable Air Defence System
MCE	Maximum Credible Event
NEC	Net Explosive Content
NEQ	Net Explosive Quantity
OB/OD	Open Burning/Open Detonation
OQD	Outside Quantity Distance
PES	Potential Explosion Site
PPE	Personal Protective Equipment
PSSM	Physical Security and Stockpile Management
QD	Quantity Distance
QRF	Quick Reaction Force
RRPL	Risk Reduction Process Level

SALW	Small Arms and Light Weapons
SAT	Systems Approach to Training
SyOps	Security Operating Procedures
TNA	Training Needs Analysis
TO	Training Objectives
UEMS	Unplanned Explosion at Munitions Sites
UNIDIR	United Nations Institute for Disarmament Research
UNMAS	United Nations Mine Action Service
UNODA	United Nations Office for Disarmament Affairs
UXO	Unexploded Ordnance
VBD	Vulnerable-Building Distance
WAM	Weapons and Ammunition Management

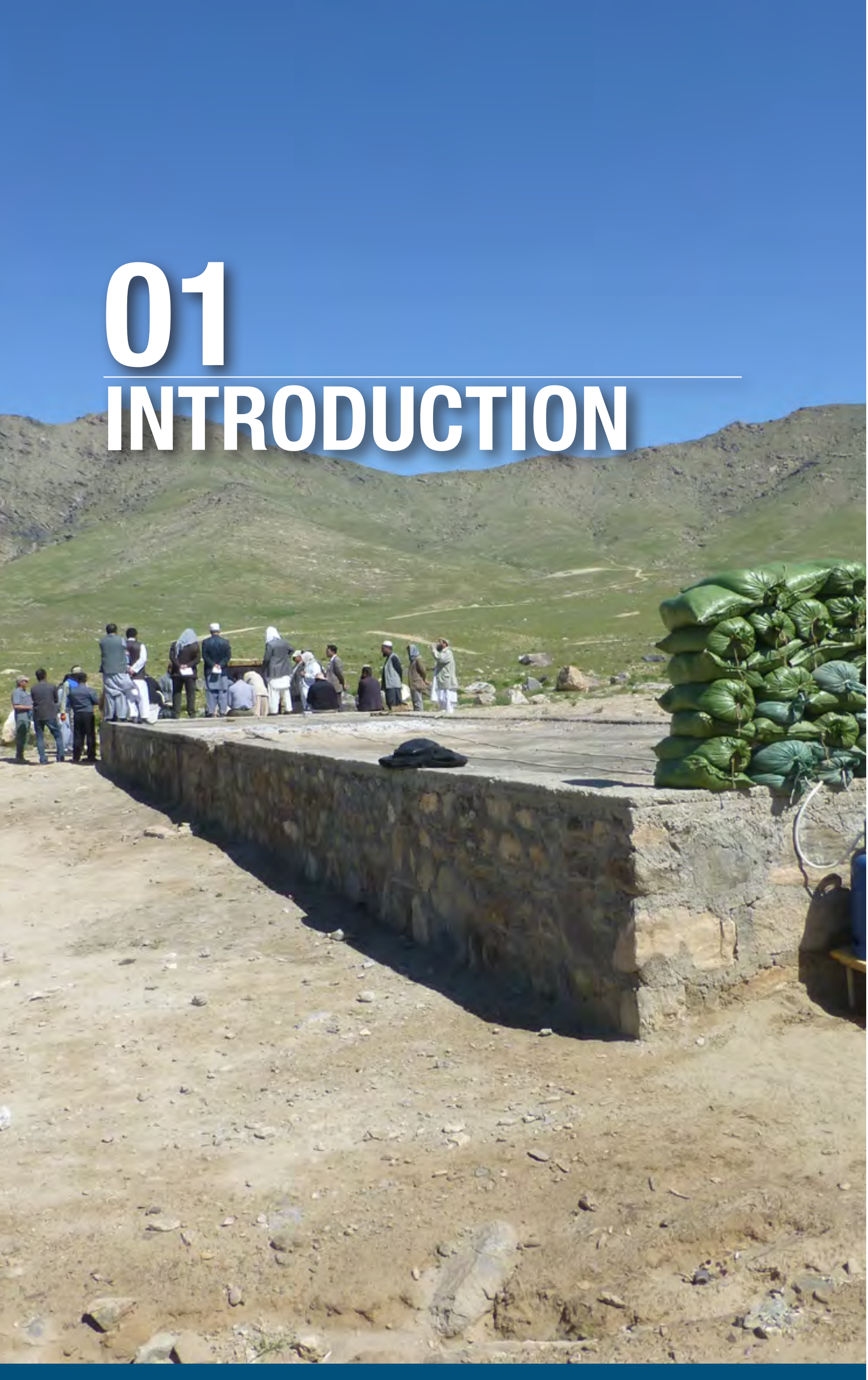
Terms and definitions

This document does not provide a comprehensive glossary of terms and definitions. A comprehensive list of terms and definitions is available in the International Ammunition Technical Guidelines (IATG 01.40 *Glossary of terms, definitions and abbreviations)* available at www.un.org/disarmament/ammunition.

Referencing to the International Ammunition Technical Guidelines

This document references the IATG throughout. Furthermore, Annex I enumerates all the IATG modules referenced in each section including the web source link to every module. Moreover, specific mentions are made in sections of this document that contain guidance additional to the IATG based on good practices (as defined by ammunition technical experts).

01
INTRODUCTION

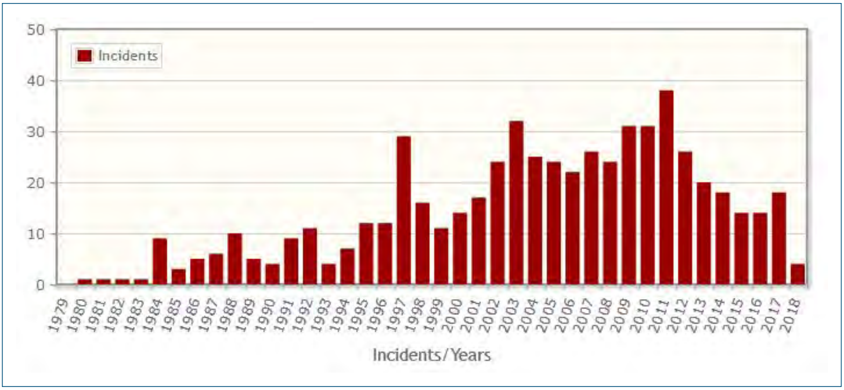


The illicit proliferation, excessive accumulation and misuse of arms and ammunition pose a persistent challenge for peace and security at the global, regional and national levels. The diversion of arms and ammunition – often occurring as a result of transfers without proper controls, unauthorized retransfers or leakages/thefts from poorly secured stockpiles – enables armed rebels, gangs, criminal organizations, pirates, terrorist groups and other unauthorized users to exponentially bolster their power. States suffering from extremely high levels of organised armed violence and those in conflict-affected and post-conflict settings are often disproportionately burdened by the illicit flow and availability of arms and ammunition, which impedes their efforts to provide both security and safety to their populations, respond to humanitarian needs, and to create an environment conducive to sustainable development.

Figure 1 – An Example of Poor Ammunition Management in West Africa.[1)]

Inadequate ammunition management poses a significant safety hazard to personnel, both within a storage facility and external to it. Figure 1 shows a real example of weapons and a variety of munitions kept carelessly in a shipping container adjacent to a populated area in West Africa. Poor ammunition safety management has been assessed as a contributory factor in a significant number of catastrophic unplanned explosions at munitions sites (UEMS). The chart at Figure 2 shows the number of recorded UEMS in the period up to February 2018.

Figure 2 – Unplanned Explosions at Munitions Sites.[2)]



While the cost of a UEMS in terms of loss of life and injuries is relatively simple to measure, the financial costs may also be extremely high. In February 2009 a substantial quantity of military propellant was intercepted by the US Navy on the Russia-owned, Cypriot-flagged MV Monchegorsk in the Red Sea, while in transit from Islamic Republic of Iran to the Syrian Arab Republic. A total of 98 shipping containers were seized and they were later stored in un-covered storage, with direct exposure to solar radiation, at the Evangelos Florakis Naval Base in Cyprus. The storage location was adjacent to the island's principal electricity generating station. On 11 July 2011, the contents of one of the containers ignited spontaneously and subsequently the entire stockpile detonated. Later analysis by the NATO Munitions Safety Information Analysis Center (MSIAC) estimated that the net explosive content of the stockpile was approximately 480,000 kg.[3)] The incident resulted in 13 fatalities, 62 injuries and over 3 billion Euro of infrastructure damage. The former Cypriot Defence Minister was also later convicted of manslaughter.

While this document focuses on ammunition safety management, it is important to consider that civil explosives may also be stored in government operated and managed ammunition storage facilities. Commercial explosives, particularly those associated with the quarrying and other resource extraction industries, may often have much shorter safe shelf lives than military ammunition natures[4)] and may also be packed in less robust packaging.

In addition to the safety threat posed by ammunition, there is a security dimension related to ammunition management. Inadequately regulated arms and ammunition are key enablers of armed conflict and high levels of organized armed violence and a means of sustaining it. As the UN Secretary General has emphasized: "Armed violence erodes legal and peaceful dispute resolution mechanisms and undermines the rule of law. Easily available and uncontrolled arms and ammunition threaten political processes, undermine police and military authority, and deeply harm security sector processes"[5)] Armed conflict and high levels of armed violence represent a grave impediment to economic growth and is one of the leading reasons that businesses decide not to invest in a country. There is a common denominator in these trends – that progress on virtually all security and development goals are severely hampered in areas where arms and ammunition are poorly regulated. Thus, weapons and ammunition management (WAM) has become crucial in the work of the United Nations (UN) in conflict-affected and post-conflict environments.

Diversion of ammunition may take place for a number of reasons including[6]:

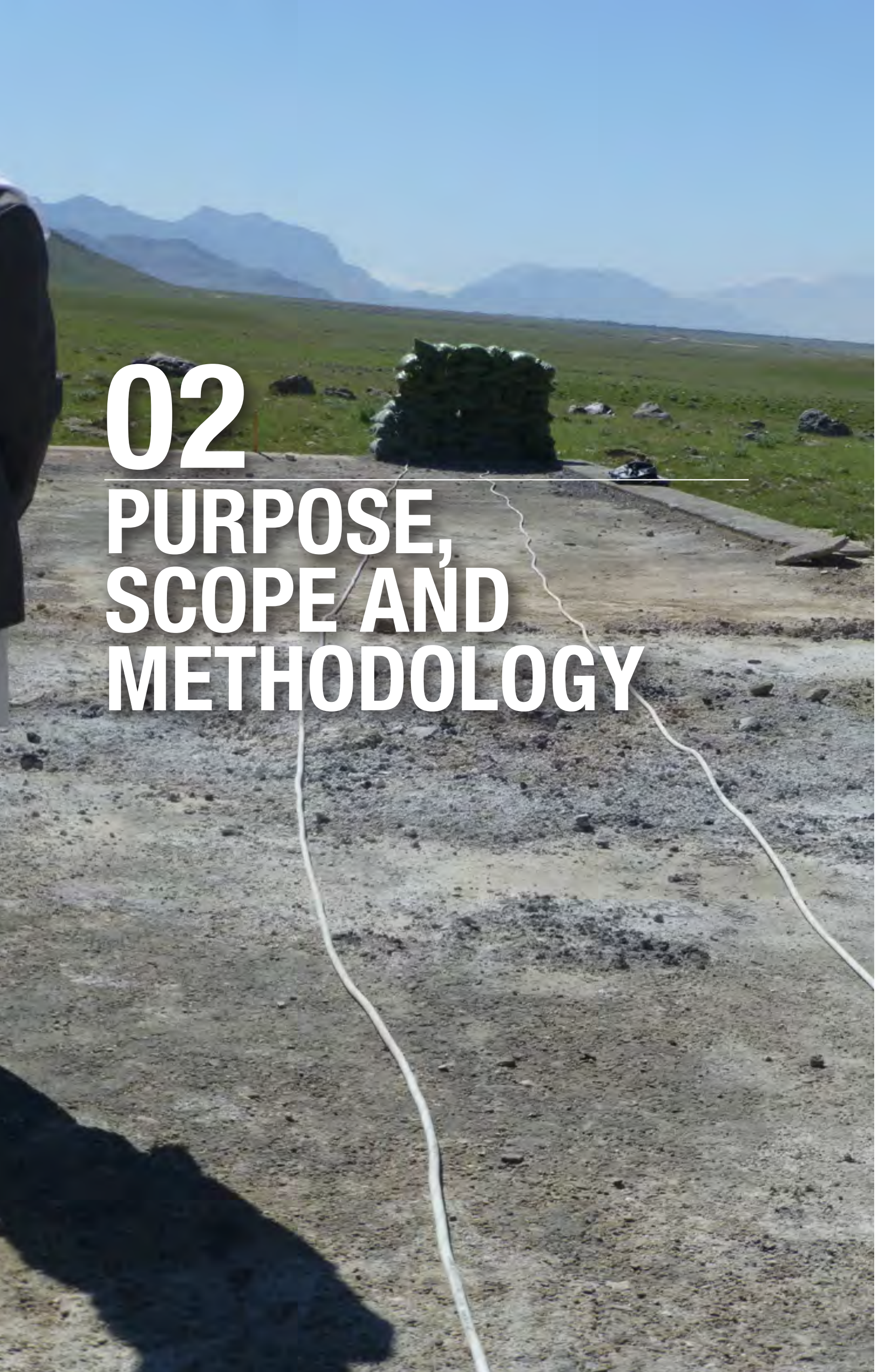
- Battlefield capture;
- Leakage due to ineffective physical security and stockpile management (PSSM);
- State sponsored diversion; or
- Loss following state collapse.

In addition, the Improvised Explosive Device (IED) has become the weapon of choice of any insurgent and terrorist groups and the ready availability of military munitions has acted as an accelerant for IED proliferation. Recent conflicts in Iraq, Libya and Syrian Arab Republic have demonstrated how a lack of security and control of military ammunition stockpiles can fuel insurgencies and terrorist campaigns based on the use of the IED. Indeed, the warheads and explosive contents of military munitions that are diverted, are perfect for inclusion in the main charges as IEDs as they are optimized to produce anti-personnel or anti-infrastructure effects and are thus extremely damaging when employed against non-hardened or other unprotected targets.

Figure 3 shows the aftermath of a massive suicide vehicle-borne IED used to attack the UN Headquarters in Baghdad, Iraq, on 19 August 2003. The IED was manufactured using military high explosive (HE) filled munitions that had been looted from an Iraqi Army ammunition storage area (ASA). The attack resulted in the deaths of at least 22 people, including Sérgio Viera de Mello, the Special Representative of the Secretary General in Iraq.

Figure 3 – Aftermath of the Bombing of the UN Headquarters in Baghdad, Iraq.[7]

02
PURPOSE, SCOPE AND METHODOLOGY



2.1 PURPOSE AND SCOPE OF THIS DOCUMENT

This document is first and foremost designed to assist those individuals and organisations operating in conflict-affected and resource-constrained settings.

This document offers practical advice and guidance on how basic ammunition stockpile safety and security can be immediately improved and the ways risks can be reduced in ammunition storage and processing facilities with a view to full application of the IATG in the longer term.

This document provides practical advice and guidance on the implementation of effective and safe ammunition management practices, based on the IATG, in conflict-affected (CA) and low-capacity (LC) environments. It provides the following:

- The context and need for improving ammunition management in conflict-affected and low-capacity environments;
- Guidance on how to improve safety at ammunition sites by reducing the risk of an accidental explosion and mitigating the effects of an explosion, should it occur;
- Advice on implementing effective security measures to prevent stock diversion;
- Advice on how the problem of unclassified[8)] ammunition should be addressed;
- Guidance on the development of specific ammunition management competences and the training and development of personnel involved in ammunition management and other ammunition-related activities;
- Identification of potential areas where the International Community can assist states in conflict-affected and low-capacity environments;

2.2 AUDIENCE OF THIS DOCUMENT

This document is intended for use by:

- **Government officials and policy makers** to influence those who have control over the allocation of resources and those who may be involved in the development of national policies and legislation relating to the management of explosives and ammunition.

- **Ammunition practitioners, including managers and technical officers** who are involved in the day-to-day management and operation of ammunition storage and processing facilities;

- **Staff of both international and non-government organisations** and other entities involved in the delivery of national capacity development projects relating to ammunition management. It is also relevant to those involved with implementation of regional initiatives and national capability enhancement measures.

The document does not seek to replace or supplant the IATG. It signposts the reader to the relevant section of the IATG, and other external resources, where more underpinning information is required. Ammunition management is always a potential hazardous activity, and unauthorized and unqualified staff should not handle and/or manage ammunition at any time.

2.3 STRUCTURE OF THIS DOCUMENT

This document is structured so that each section stands on its own merits. The core sections of the document are organized as follows:

- Section 3 – Context provides an overview of the subject and describes what is different for ammunition management in conflict-affected and low-capacity environments to better founded and resourced settings;
- Section 4 - Improving Safety – Reducing the Risk of Accidental Explosions examines those measures which may be taken to reduce the risk of accidental explosion occurring;
- Section 5 - Improving Safety – Mitigating and Managing the Effects of Accidental Explosions examines those measures which may be taken to reduce the effects and impact of an accidental explosion should it occur;
- Section 6 – Developing Ammunition Storage Infrastructure for Conflict-Affected and Low-Capacity Environments examines expedient methods which may be employed for the development of ammunition storage and processing infrastructure. This section contains guidance additional to the IATG based on good practices on the ground;
- Section 7 - Implementing Effective Security Measures and Preventing Stock Diversion examines methods which may be implemented in resource constrained environments and where conflict places particular demands on security forces;
- Section 8 - Managing Unclassified Ammunition provides advice and guidance on how the intractable problem of unclassified ammunition could be addressed. This section contains guidance additional to the IATG based on good practices on the ground;
- Section 9 -Training and Competence Development examines the basic ammunition management and technical competencies required for safe operation of ammunition storage and processing facilities;
- Section 10 - Engagement with International Stakeholders looks at areas where international stakeholders and donors can contribute to national capacity building in conflict-affected and low-capacity environments.

2.4 METHODOLOGY

This document has been developed from the work conducted by an informal group of expert practitioners on weapons and ammunition management (WAM) during a UNIDIR-led series of meetings between June 2017 and September 2018. The expert meeting series was entitled "Exploring Technical Processes to Operationalize Essential Weapons and Ammunition Management Elements in Conflict-Affected Settings". This document highlights critical aspects of the IATG, which are particularly relevant for conflict-affected and low-capacity environments.[9] Some of the material presented in this document is based on the practical experience of the informal group of expert practitioners. This document is subject to updates based on revisions of the IATG, related tools and support documents.

03
CONTEXT

3.1 THE IATG PHILOSOPHY AND GUIDING PRINCIPLES

The IATG follow the philosophy of a safe, secure, effective and efficient conventional ammunition stockpile management system, which should be to ensure the implementation of certain minimum protection criteria for personnel and property, whilst maintaining effective security and control of ammunition and explosives.

The IATG are shaped by four guiding principles [10] and these apply equally to conflict-affected and low-capacity environments:

- **National Responsibilities and Obligations.** National governments hold the primary responsibility to develop and apply national standards to their national stockpile. This should normally be vested in an authority, which is responsible for the development and enforcement of national legislation and regulations and oversees the coordination and management of the state's ammunition stockpile. In conflict-affected environments, where there is an absence of state control and authority, it may be necessary for international organizations, such as the UN, to implement *ad hoc* ammunition management practices normally in accordance with the principles enshrined in the IATG.
- **Explosives Safety.** Explosives safety is paramount and this includes the need to protect those most at risk from undesirable explosive events, such as local civilian communities and explosives workers. The IATG contains risk management guidance on how the risks of an unplanned explosion at an ammunition storage site could be reduced, as well as measures to mitigate the hazard to those beyond the perimeter of a storage facility. Duty of care requires the risk of any hazard being realised shall be as low as reasonably practicable (ALARP).
- **Capacity Building.** Many states possess only a limited capacity to manage ammunition effectively, safely, and securely in their national stockpile. A key element of the IATG is the requirement to build up the national capacity to develop, maintain and apply appropriate standards in order to support well-adapted stockpile management. In this context, capacity building is concerned with assisting states to develop national capabilities to: reduce and dispose of excess or unnecessary stocks; develop safe systems of storage for existing and retained stockpiles; and to improve the overall safety and effectiveness of ammunition stockpile management.
- **Adherence with International Regulations and Guidelines.** The IATG have been developed to maintain consistency and adherence with other international norms, conventions and agreements. [11]

Each national regulatory context is unique. The IATG are not meant to be a blue print to be replicated in every country at the national level, regardless of the circumstances. Rather, they provide the authoritative, tested underpinning principles and guidance on which sound national policy, regulations and technical operating procedures may be based.

3.2 WHAT ARE THE CHALLENGES OF APPLYING THE IATG IN CONFLICT-AFFECTED AND LOW-CAPACITY ENVIRONMENTS ?

Ammunition management in conflict-affected and low-capacity environments may be characterised by one, and usually more, of the following :

Regulatory Issues

- There can be a limited national legislative or regulatory framework covering the storage, transport and processing of ammunition ;
- Proper accounting of stock may not be taking place and surplus ammunition not defined. Surplus stock may be seen as an asset, rather than a liability, and insufficient emphasis is placed on the disposal of surplus and unserviceable ammunition ;
- There may be insufficient national guidelines and legislation governing the transport of dangerous goods, including ammunition and explosives ;
- There may be limited technical or standard operating procedures governing the processing and storage of military munitions ;
- There may be insufficiently rigorous procedures in place to assure the safety and security of ammunition stockpiles and there may be a significant risk of illicit diversion, fuelling national and regional instability ;
- Basic procedures for ammunition safety management, such as : risk assessments, fire-fighting, emergency rescue plans, and safety drills may have not been developed, implemented or tested.

Resources

- Resources may be constrained and there may be insufficient national funds to cover capital and operating cost expenditure on ammunition management systems ;
- Ammunition may not be systematically procured for associated weapon systems in amounts relative to use, shelf-life, storage capacity etc. There can even be a disconnect between ammunition stored and weapons which are in service i.e. ammunition may be stored for which the state no longer has any compatible weapon in service.

Technical

- The safety and security risks associated with ammunition storage, transport and processing might be generally not well understood. Furthermore, the risks may not be communicated to senior managers and ministers and those in governments who should either accept or take steps to mitigate the risk ;
- Hazard classification data (hazard division and compatibility group) may be missing from the markings on ammunition packages. The ammunition may not have been subjected to hazard classification testing and certification by a competent national authority[12] ;

- The condition of ammunition stocks may be unclear, and no surveillance or inspection regime is in place. Ammunition may be unpackaged, badly packaged, or inadequately marked;
- There may be few, or no, technical measures implemented to reduce the hazard to stored ammunition by lightning or static electricity.

Security

- Access to ammunition sites may not be rigorously controlled and there may be a significant risk of both diversion of explosives, for example for use in IEDs, and sites may be vulnerable to sabotage;
- Basic fire prevention measures may not be implemented, and insufficient vegetation control takes place during the most hazardous (dry) seasons. Contraband restrictions and non-smoking policies in ammunition facilities may not be in force.

Infrastructure

- The infrastructure associated with the storage and processing of ammunition can be rudimentary, and not fit for purpose;
- Ammunition storage facilities can be located close to inhabited civilian dwellings and the concept of safeguarding[13)] cannot be understood;
- Ammunition facilities may be located close to critical national infrastructure, or other sources of hazard such as: toxic industrial chemicals, flammable gases and liquids; all of which would exacerbate the effects of a UEMS.

Competences

- National personnel may lack the core competences required in ammunition management;
- Training of ammunition personnel may be rudimentary or incomplete.

3.3 LOW-CAPACITY ENVIRONMENTS

The term 'low-capacity' covers a category of environment where for a variety of reasons ammunition management maturity may be at a relatively basic level. Often the key issue is one of a lack of resources or prioritization, but other issues may also have a significant impact.

Resources and Capital

A lack of resources and capital has a fundamental impact in determining the 'art of the possible' in low-capacity environments. In all States there is a requirement to balance investment in the state sector according to national priorities and needs. In low-capacity environments there are seldom sufficient resources for states to implement the guidelines and measures recommended in the IATG (even considering the IATG's ascending risk reduction level process) and it is necessary for them to apply their limited resources where they will have greatest effect. There is a significant role that the international community and donors can play in assisting states develop national ammunition management capabilities and this is covered in greater detail in Section 10.

Legislative and Regulatory Frameworks

A lack of a defined legislative and regulatory framework is a significant problem in developing effective ammunition management practices in low-capacity environments. Ensuring that national leaders, ministers and other senior stakeholders are aware of the hazards posed by poorly managed ammunition is important. All too often this knowledge is gained the hard way *i.e.* dealing with the aftermath of a catastrophic UEMS.

The development of national frameworks for ammunition management necessarily requires top-level support from government ministers. In circumstances where there is limited or no national legislation or regulation, it will also require the attention of those involved in the drafting of primary legislation. [14)]

Issues of Numeracy and Literacy

Developing effective ammunition management personnel competencies is difficult when there is an absence of fundamental numeracy and literacy skills. Basic numeracy is a prerequisite for sound ammunition accounting and the ability to read is critical to understanding the markings on ammunition packages. For this reason, pictograms form an important safety element in the marking of ammunition packages and assist those with poor literacy skills in assessing the hazards associated with particular ammunition natures. Similarly, the use of fire division symbols on the approaches to explosive store-houses can assist fire fighters in evaluating the hazard posed by a fire in a storage location.

Technical Skills and Education

The more advanced aspects of ammunition management and regulatory oversight require a measure of engineering and technical knowledge which may not be present in some less developed states. [15)] While it is tempting for donors to try and impose an advanced ammunition management system on recipient nations, it is important that a broad approach is taken to the development of personnel competences. Assistance in future manager and leader education programmes may be as important as implementing practical ammunition management projects on the ground.

The ability to construct and maintain ammunition storage and processing facilities is sometimes limited by lack of technical knowledge and the general civil engineering capabilities that are present within a low-capacity environment. Often, even basic civil engineering plant and equipment associated with simple earth moving and construction is not readily available. Similarly, materials such as sand, cement and rebar may not be available in large enough quantities and/or quality to construct heavy walled buildings or structures with reinforced concrete roofs. Infrastructure projects which are possible to implement with simple tools and widely available local materials are most appropriate for low-capacity environments

Military Procurement Focus on Equipment

A challenge most Armed Forces face, not just those in low-capacity environments, is to focus on technical equipment matters without considering the broader capability integration issues associated with the acquisition of a particular weapon system. All too often this overriding focus on equipment results in a neglect of running costs, logistics, training and infrastructure considerations. Some complex weapon systems, such as air defence missile systems and maritime guided missiles, give rise to lifecycle management requirements e.g. storage costs and manpower for maintenance procedures within complex ammunition processing facilities. A coherent approach to the effective lifecycle management of ammunition is a prerequisite for the implementation of an effective ammunition safety management system. [16)]

Arms exporting nations should exercise caution in transferring, either through sale or gift, complex weapon systems that require substantial supporting infrastructure, in particular to low-capacity environments. For some weapon systems, particularly those containing toxic items such as liquid propellants, the financial and environmental costs, and organizational capacity needed for subsequent disposal can be substantial. In addition, from an importing perspective, it is essential that a thorough analysis of through-life issues is undertaken before any complex weapon system is acquired.

3.4 CONFLICT-AFFECTED ENVIRONMENTS

Characteristics of Conflict-Affected Environments

Conflict-affected environments often have some or all of the characteristics of the low-capacity environments described in the previous subsection but are further complicated by conflict. In this context, major combat operations may have ended but there may still be considerable security challenges posed by violent extremists or other non-state actors. In addition, conflict may have resulted in the loss of control of centralized state stockpiles of weapons and ammunition and these may have been looted. Inadequate ammunition management in one state may also have regional consequences. There are well documented examples of terrorist organisations or armed groups transferring ammunition across international borders and over considerable distances to meet their specific operational requirements. [17)]

Lack of Central or Local Government Control

A common feature in many conflict-affected environments is a lack of authority exerted by either central or local government. In the worst cases, on-going civil wars make the enforcement of national laws and regulations impossible. In situations where regional or UN peacekeeping operations are filling the governance vacuum, it is strongly recommended that best international practices, such as those described in the IATG, are followed for ammunition management.[18)]

Problems of IED Proliferation

Recent conflicts in Iraq, Libya and Syrian Arab Republic have demonstrated how a lack of security and control of military ammunition stockpiles can fuel insurgencies and campaigns of armed violence based on the use of the IED.[19)] This was demonstrated clearly in Iraq during the period 2003 to 2011 where violent extremist groups gained access to the former regime's stockpile of military munitions. HE-filled shells, warheads and aircraft bombs formed the principal constituents of IED main charges during this period. Figure **4** shows a typical suicide-vehicle-borne improvised explosive device (SVBIED), which was intercepted by Libyan security force personnel and rendered safe in January 2018. It demonstrates clearly how military munitions, in this case large calibre HE artillery shells, may be re-purposed to form effective IED main charges.

Figure 4 – ISIL/Da'esh Suicide-vehicle-borne IED, Abugrein, Libya.[20)]

A well-documented lesson to be learned from Libya, Iraq and Syrian Arab Republic is that violent extremist groups are quick to exploit available sources of explosive and the IED is now the weapon of choice for many groups. Military munitions, such as aircraft bombs, HE shells and missile warheads, are usually included in IEDs as the main charges and they have an impact far greater than that of most homemade explosives. From a national security and cost-benefit perspective, it is far more effective to deal with surplus and unserviceable munitions while they are stored centrally and properly secured in an ammunition storage area (ASA) awaiting destruction, than to wait for them to be dispersed and then deal with them as individual IEDs.

3.5 OPERATIONAL CONTEXT RELEVANT TO APPLYING THE IATG IN HIGH-RISK AND LOW-CAPACITY SETTINGS

Gaining National Ownership and Buy-In

A critical success factor in implementing any effective ammunition safety management system is gaining buy-in and commitment from the highest levels of government. It is important that senior government ministers are made aware of the safety and security hazards posed by poorly stored or large stockpiles of unserviceable or surplus ammunition. In circumstances where military munitions are not stored in a manner consistent to the IATG then this resulting risk should be quantified and accepted by the appropriate authority.[21)]

Applying the IATG

Governments applying the IATG will need to identify what should be done first and how their limited resources be employed to best effect to minimise risks to people.

The following sections in the document describe a number of discrete approaches that could be taken either sequentially or in parallel to reduce the hazards associated with ammunition storage and processing sites. Every situation is different, and it is recommended that a top-level risk assessment be conducted first before decisions are taken on how to employ scarce resources to best effect.

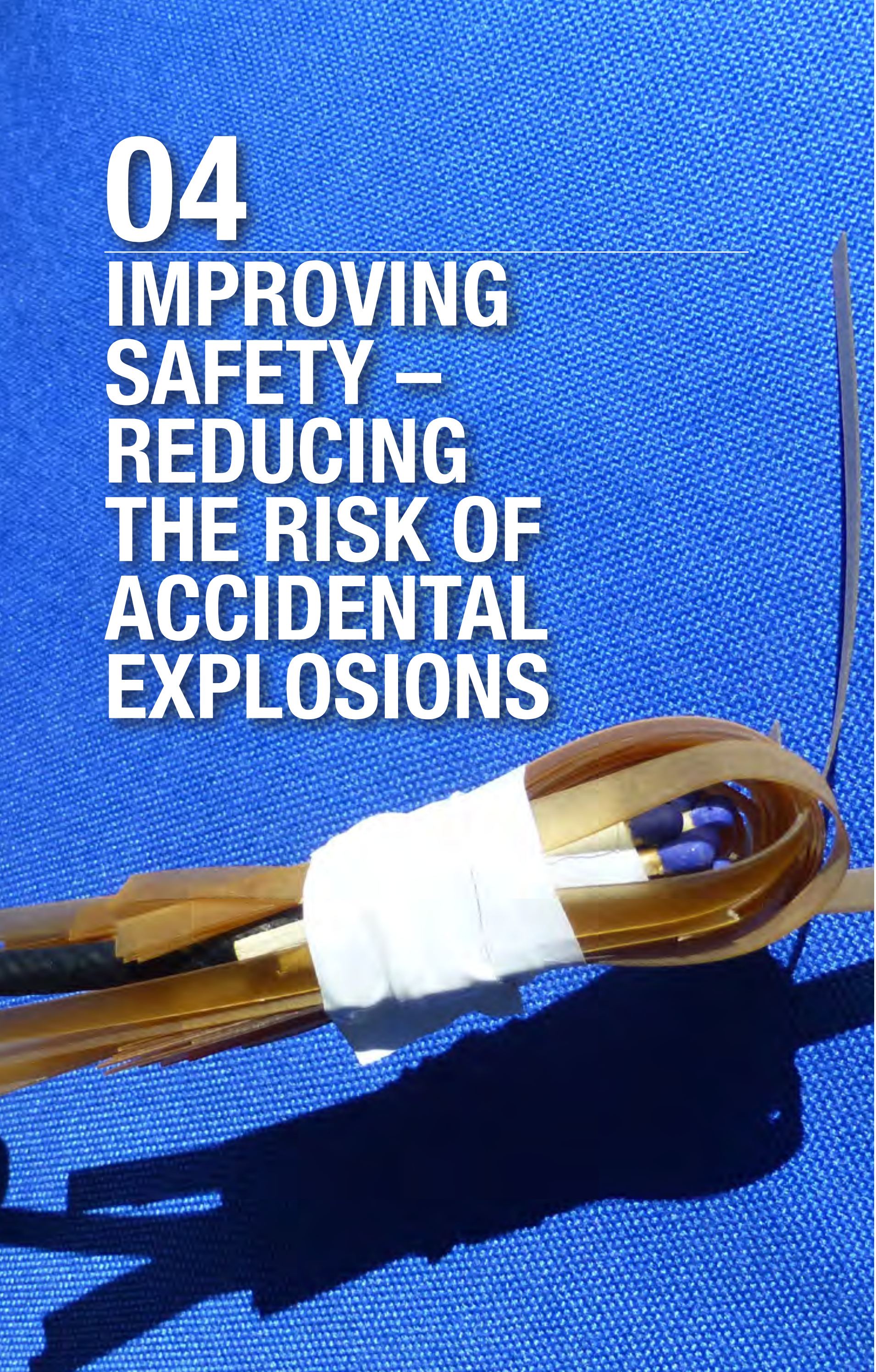
Understanding the Technical Terms Used within the IATG

Ammunition management is a domain replete with complex technical terms and can be difficult to understand for those without formal training in the subject. It is essential that those involved in ammunition management take every opportunity to explain in simple terms why certain processes and approaches are required for dealing with ammunition, which are different to other military commodities or dangerous goods. The IATG contains a comprehensive guide to the technical terms associated with ammunition safety management.[22)]

Lack of Competences in the Planning, Management and Operation of Safe Systems of Work in Ammunition Facilities

A lack of competences in the areas of planning, management and operation of safe systems of work in ammunition facilities imposes severe limitations on what can be achieved by states operating in conflict-affected and low-capacity environments. There is an onus on the International Community and donor states to ensure that where support is given to addressing ammunition management issues, due cognisance is given to the development of personnel competences. This is covered in greater detail in Section 10.

04
IMPROVING SAFETY – REDUCING THE RISK OF ACCIDENTAL EXPLOSIONS



This section provides an overview of the methods and approaches which could be employed to reduce the risk of an accidental explosion occurring within an ammunition storage or processing facility. A fundamental element of any effective ammunition safety management system is a coherent approach to the identification of hazards and the evaluation of risk. In all environments, time spent developing or refining a baseline risk assessment is seldom wasted as it contributes to a broader understanding of the specific risks associated with the operation of a particular site.

4.1 ASSESSING AND MANAGING RISK IN AMMUNITION STORAGE AND PROCESSING FACILITIES

Conduct of Risk Assessments

The IATG provides substantial guidance on how risk assessments should be conducted.[23] In its most basic form, a simple risk assessment could look at individual processing and storage sites and make an estimate of the worst-case effects of an accident occurring. The IATG Implementation Support Toolkit provides useful software applications, which, with some training, may be used to predict worse case explosion effects. Risk assessments should be conducted by personnel who are trained and sufficiently experienced in ammunition or explosives safety management.

The ALARP (as low as reasonably practicable) concept is widely used in ammunition management and it is an objective for states' ammunition safety management systems which should be sought by national authorities.[24] In the early stages of implementing ammunition safety management principles and processes, it is recommended that those actions that have the greatest impact on improving safety are implemented first. Determining whether a particular process at an ASA, or ammunition processing facility, is ALARP usually requires some technical judgment and knowledge on the part of the person conducting the risk assessment. Such qualitative assessments may be significantly affected by the skill and experience of the person conducting the risk assessment hence they should be peer reviewed.

If a risk assessment is to provide meaningful and technically appropriate outputs, it is essential that the risk analysis exercise be conducted by an entity with sufficient knowledge in ammunition safety management. Risk assessments should be conducted for individual ammunition holding and processing units. A top-level risk assessment may also identify existing system-wide vulnerabilities. These may also identify vulnerabilities in national accounting systems or the susceptibility of ammunition to be diverted for illicit purposes when it is being transported or used without adequate supervision, for example during training on live firing ranges.

Should the risk assessment at a particular site indicate that there is a high probability of a potentially catastrophic UEMS then this must be immediately brought to the attention of the relevant authorities. In such a situation, the following additional actions should be initiated:

- The production of an Explosive Safety Case (ESC)[25)] which details the likely consequences of a UEMS;
- The development of an action plan to mitigate the risks identified in the risk assessment, which should also identify the outline level of resources required;
- Acceptance by the senior responsible personnel that while the identified risks are not ALARP, they are acknowledged (in a form of a 'Letter of Authority' as established in the IATG).[26)]

An Explosive Safety Case is an effective method for communicating the unmitigated risks associated with the operation of an ammunition storage or processing facility. It is essential that the ESC is generated by staff who possess the appropriate technical competences to identify potential hazards and to assess possible consequences and effects. The principal findings and recommendations of the ESC should be clear, concise and understood by those who are responsible for accepting the risk, normally senior military commanders or government ministers.

In conflict-affected environments where there is an absence of a recognised central or local government, and a regional or international peacekeeping contingent is in place, then the risk assessment could be conducted by appropriately qualified and experienced ammunition professionals within the deployed peacekeeping contingent and, if possible, with the participation of the local authorities.

Use of the IATG Implementation Support Toolkit[27)]

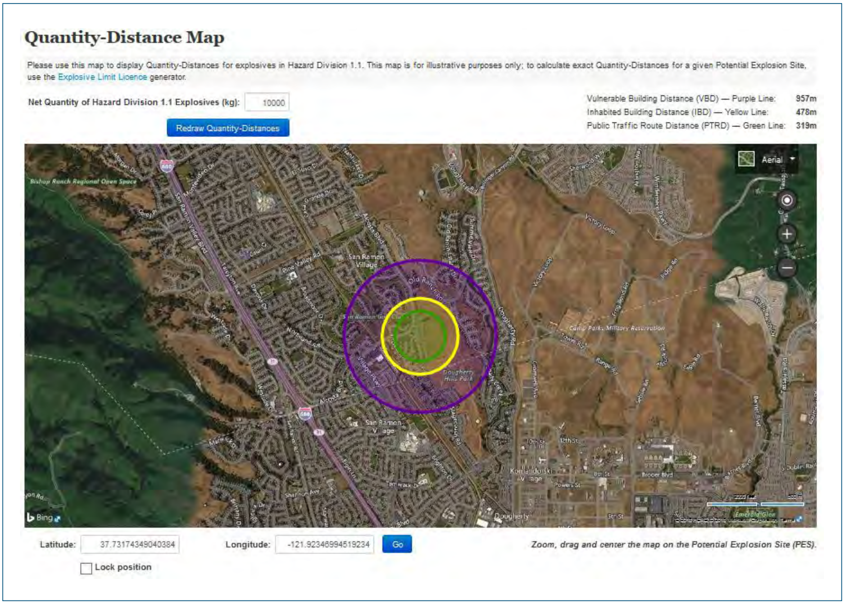
The following tools of the IATG Implementation Support Toolkit are particularly useful in assessing risk and reducing the probability of an accidental explosion at a particular location. It is important that the limitations of each tool are understood and that they are used by an appropriately trained person. The tools are subject to periodic enhancement and updating. The use of these tools in conflict-affected and low-capacity environments is strongly recommended.[28)]

- **Explosion Consequence Analysis.** The Explosion Consequence Analysis tool[29)] allows a user to determine the likely blast effects of the detonation of a specific quantity of explosives at varying distances. The tool allows an estimation of the distances at which specific injuries will occur to exposed personnel, distances at which glazing damage will be sustained, and the predicted level of damage to buildings constructed from brick and masonry.[30)]

- **Quantity Distance Map.** The Quantity-Distance Mapping Tool[31)] uses a map-based graphical interface to display the radii within which for a given net quantity of explosive there should be restrictions on inhabited buildings, buildings of vulnerable construction, or public traffic routes. If buildings and public traffic routes already exist, this tool can be used iteratively to determine the Net Explosive Quantity (NEQ) of explosives that can be stored before an accident would adversely impact on an existing route or building. Figure 5 shows an example of typical results that may be obtained from using Quantity Distance tool.

Where non-explosive hazardous material is stored in proximity to explosive sites, such as toxic industrial chemicals, then it may be necessary to employ other tools to assess and evaluate the combined hazard. For example, WebWISER[32)] is an internet-based application that is designed to assist emergency responders in hazardous material incidents.

Figure 5 – Example output from the Quantity-Distance tool.



- **Risk Reduction Check List.** Within the IATG, the tasks and activities necessary for safe, efficient and effective stockpile management equate to one of three risk reduction process levels (RRPLs). These are indicated within each IATG as being either LEVEL 1, LEVEL 2 or LEVEL 3, depending on the degree of complexity of each task or activity. The Risk Reduction Check List[33)] tool provides a simple method to determine the RRPL for a particular stockpile.

4.2 AMMUNITION HANDLING AND STORAGE MANAGEMENT

Ammunition Storage Planning[34)]

Ammunition storage planning is the critical activity concerned with assigning ammunition to individual storage locations. At the strategic level, prioritization should be given to the storage of operationally essential ammunition natures in storage locations which provide the required levels of physical and environmental protection.

At the individual ASA level, in considering whether it is appropriate to store an ammunition nature in a particular ESH, the following factors should be considered:

- The Net Explosive Quantity of the Explosive Storehouse and the current Net Explosive Quantity of ammunition natures stored in that location. Will the inclusion of additional ammunition exceed the maximum licensed Net Explosive Quantity permitted to be stored in that location?[35)]
- Is the ammunition compatible with the compatibility group of the ammunition already stored in the Explosive Storehouse?[36)]
- Does the ammunition nature contain materials which require segregated storage e.g. natures containing White Phosphorus or liquid propellants?
- Does the ammunition nature require any specific equipment for safe storage?
- Is the ammunition nature propulsive? If it is, can it be stored such that it is orientated in a safe direction?

Ammunition Storage Management[37)]

At its most basic level the ammunition stockpile should be segregated such that serviceable and unserviceable munitions are not stored in the same physical ESH location. It is particularly important that hazardous ammunition, such as that within inadequate or badly damaged packaging, or containing shelf life expired propellants, is not stored with other serviceable ammunition. In some circumstances the serviceability of ammunition may be a matter of perspective and technical judgment. Safety and serviceability may require the use of ammunition surveillance techniques. For example, the assessment of serviceability and safety of military propellants is almost impossible without the use of diagnostic chemical analytical techniques. Deciding whether ammunition is safe to store, move or use requires personnel with the requisite technical competences.

There is a fundamental difference between ammunition that is safe to store and ammunition that is safe to use. Many types of ammunition, particularly warheads, shell fillings based on melt cast compositions of TNT, and large diameter rocket grains may crack and degrade when subject to extreme temperatures in diurnal cycling. While such cracking does not pose a significant hazard in storage, it may result in catastrophic accidents if such ammunition natures are fired.

It is essential that serviceable and unserviceable ammunition natures be segregated. Certain ammunition natures may deteriorate into an unsafe condition when they have exceeded their safe shelf life and these natures should be disposed of at the earliest opportunity.

Ammunition Accounting

A robust ammunition accounting system is fundamental to the effective management of ammunition. An ammunition accounting system does not have to be computer-based. Perfectly satisfactory manual accounting systems exist. In its most basic form, a robust ammunition accounting system must account for ammunition by type, quantity and location. It is impossible to conduct a meaningful risk assessment at an ASA unless the types and quantities of ammunition stored are known.[38)]

When taken in conjunction with some basic technical information, such as the NEQ, hazard division and compatibility group of the ammunition nature, it is possible to draw some simple conclusions regarding the hazard posed by the ammunition in a particular storage location to other potential explosion sites (PES) *i.e.* other sites which may be processing and storing ammunition. It is also possible to determine the degree of hazard posed to external entities such as : inhabited and vulnerable buildings, public traffic routes and other locations.

While a basic assessment of risk can be conducted based on simple ammunition stock quantities, unless the technical condition of the ammunition is known, it is not possible to determine whether that ammunition is safe to transport and use. In conflict-affected and low-capacity environments it is recommended that a simple system of technical condition be employed, and that ammunition is assigned to one of the following categories :

- Ammunition is safe to store and transport and is serviceable and fit for issue and use in all conditions ;
- Ammunition is safe to store and transport but is unserviceable or shelf life has expired and requires disposal.
- Ammunition is unsafe and requires immediate destruction.

Fundamental elements of any effective ammunition accounting system are the need for an accurate inventory of the stockpile and its condition (e.g. serviceable, unserviceable or requiring disposal) and a robust approach to auditing. No effective safety or security related stockpile management decisions or actions can be taken if a state does not know what ammunition it has or the condition of that ammunition. Once the inventory is completed, then accurate accounting practices can be implemented. Independent and comprehensive auditing then become essential backstops against corruption and the prevention of diversion. A rigorous audit system includes a hierarchy of internal audits, external audits and regulatory oversight. As a practical matter, it is the independence of the auditors, a mechanism for corrective action, and recourse to political oversight that will ensure an effective auditing system is established and maintained. In the end, an audit is meant for assurance, not insurance. Auditors only check the standards ; they do not design or implement them. Given the human, financial and political resource constraints on auditors, a government may need to design a system of controls and risk management to set the proper foundation for the auditors' work.

4.3 AMMUNITION HANDLING, STACKING AND ESH MANAGEMENT

Ammunition Handling

Ammunition must always be handled with care. Rough handling, including dropping, must be avoided. Even seemingly robust items, such as artillery shells, can have the integrity of their HE fillings dangerously compromised by rough or incorrect handling. More delicate natures, such as thin-skinned items and those containing solid fuel rocket motors, liquid propellants, white phosphorous, or safety and arming mechanisms, may become unserviceable or unsafe for further storage if subjected to improper handling. The IATG provides further specific guidance on ammunition handling.[39] If mechanical handling equipment (MHE) is employed then operators will require appropriate training in its use. The safe storage of fuel and the maintenance of the MHE must also be considered.[40]

Ammunition Stack Management

Ammunition should be separated by nature[41] within the storehouse and by lot or batch if that is known. Palletized ammunition should not be stored against the walls of the store nor should it be stacked higher than the recommended maximum height. Stability of stacks is important and ammunition boxes and pallets should not be stacked above a designated safe height as collapsing stacks pose both a hazard to personnel and are a potential source of fire or accidental explosion. Figure **6** shows an example of an unsafe ammunition stack ; in this example the palletized 155 mm artillery shells are not designed to be stacked more than one pallet high.

Unpalletized ammunition should be stacked using pallets and dunnage. Stacks should be separated by gangways to facilitate personnel access and stocktaking actions. Gangways also permit airflow over the ammunition stack helping cool ammunition stocks during high ambient temperature storage conditions. Gangways also facilitate easy access to stock and facilitate accurate stocktaking and audit. It is essential that ammunition is not stored directly on the ground and that air flows underneath packages when possible. In hot-wet conditions, particularly in areas prone to flooding, ammunition pallets and wooden boxes will deteriorate quickly if stored on the ground.[42] Non-palletized, boxed ammunition may be stored on loose pallets, separate dunnage, or on racking.

Figure 6 – Unsafe Ammunition Stacks at an Ammunition Storage Area in North Africa.[43)]

Maintenance of Store Cleanliness

Explosive storehouses (ESHs) should be swept clean and be free from debris. It is particularly important that material which could pose a fire hazard is not permitted to accumulate. Explosive or propellant dusts and residues pose a significant hazard if they build up within ammunition processing areas. All areas should be swept clean at the end of each working day and explosive waste should be disposed of in a safe and authorised fashion. Only approved tools and equipment shall be present or used inside ESHs.

Only ammunition natures should be stored in ESHs. Non-explosive components and other parts of weapon systems should be stored in other suitable locations.

Storage of Propulsive Munitions

Ammunition natures containing their own means of propulsion, such as missiles and free flight rockets, should be orientated in storage such that the projection hazard presented in the event of an accidental initiation is reduced i.e. they should be orientated to point away from doors and towards substantial walls or barricade or away from populated areas (in the absence of intervening barricades).[44)]

Management of Empty Ammunition Boxes[45)]

Empty ammunition boxes should be removed from the explosives area and stored in a designated area. If allowed to accumulate, empty wooden ammunition boxes pose a fire hazard. All hazard markings and labels should be removed from empty ammunition packaging.

Specialist Equipment

If ammunition that contains white phosphorous (WP) is stored, then appropriate specialist equipment to deal with leaks should be readily available. Similarly, ammunition items containing liquid propellants may require specialist draining kits to deal with leakage.[46)]

Movement of Non-Palletized Ammunition[47)]

The movement of unpalletized ammunition is a personnel-intensive activity and requires heavy manual labour. As this activity is most often conducted by those with limited technical ammunition knowledge it is important that it is appropriately supervised in order to ensure that suitable care is exercised in the handling of ammunition.

4.4 CLIMATIC PROTECTION

Ammunition deteriorates quickly if stored in open conditions without protection from the weather.[48)] In wet conditions, even robust natures, such as plugged artillery shell and aircraft bombs will corrode rapidly. Corrosion around fuze wells and driving bands may quickly render these natures unserviceable. In high-temperature climatic conditions, repeated diurnal temperature cycling may affect the integrity of explosive fillings and melt cast compositions based on TNT are particularly susceptible to damage. Condensation may also form inside ammunition packaging after hot-cold temperature cycling and can lead to accelerated corrosion of metal items. Propellant stability is also particularly at risk from high humidity and high temperatures, and those risks are further discussed in sub section 4.8. The IATG recommends that ammunition should ideally be stored at a temperature between 5° C and 25° C with a relative humidity no greater than 75%.[49)] Where possible, stand-off solar protection should be provided for shipping containers to reduce the direct effects of solar heating. Figure **7** shows an example of environmental protection fitted above containers used for the storage of ammunition in Central Asia. Simple measures, such as painting storage containers white can significantly reduce the effects of direct solar heating. Similarly, the opening of doors during the hottest parts of the day can improve airflow and lower the maximum temperature of the stock within the container. Field expedient methods of using water bottles to assess the risk of condensation are also simple and effective to implement.

Figure 7 – Environmental Protection on Shipping Container Based Ammunition Storage.[50)]

Lightning is a particular hazard in tropical conditions where thunderstorms may be both violent and prevalent. Lightning hazards should be mitigated through the use of lightning protection systems (LPS) and this is considered in greater detail in Section 4.6.5.

4.5 STORAGE BY HAZARD DIVISION AND COMPATIBILITY GROUP

Ammunition Storage by Hazard Division

To promote the safe transport of dangerous goods, an internationally agreed system for classification was devised by the UN[51)], which is now used globally. Whilst initially produced for the transport of dangerous goods, the principles have been applied by many states as the basis for a simplified consequential hazard and risk assessment for the storage of ammunition.[52] In most low-capacity and conflict-affected environments it is likely that responsibility for transport will rest with a government department other than the Ministry of Interior or the Ministry of Defence and the facilitation of international trade, rather than hazard management, will be the most important factor governing the development of national legislation and regulations.

Ammunition, under the generic term 'explosives', is one of nine internationally recognised categories of dangerous goods as shown in Table **1.**[53]

Table 1 – International Dangerous Goods Class Definitions.

Class	Description	Comments
1	Explosive substances and articles	Divided into 6 hazard divisions
2	Gases	Divided into 3 hazard divisions
3	Flammable Liquids	
4	Flammable Solids, Spontaneously Combustible Materials, and Dangerous when Wet Materials	Divided into 3 hazard divisions
5	Oxidisers and Organic Peroxides	Divided into 2 hazard divisions
6	Toxic Materials and Infectious Substances	Divided into 2 hazard divisions
7	Radioactive Materials	
8	Corrosive Materials	
9	Miscellaneous Dangerous Substances and Articles	

It is an essential rule that ammunition classified in International Dangerous Goods Class 1 shall not be stored or transported with other dangerous goods in any other class.

The hazard classification code (HCC) assigned to an ammunition item relates to its packaged condition. Unpackaged or poorly packaged ammunition may have a different, and more hazardous HCC, to the properly packaged item.

Ammunition Storage by Compatibility Group

The IATG provides comprehensive guidelines on the mixing rules governing the storage of ammunition by compatibility group.[54] In conflict-affected and low-capacity environments it is strongly recommended that the minimum number of differing types of ammunition nature by compatibility group are stored in the same storage location. The following natures should always be stored in separate or segregated[55] storage:

- Ammunition containing white phosphorous;
- Detonators;
- Damaged ammunition;
- Recovered or captured ammunition[56];
- Ammunition in an unknown condition;
- Bulk propellants and artillery and tank propelling charges;
- Pyrotechnics and fireworks;
- Ammunition designated for disposal.

Ammunition containing a white phosphorous filling (compatibility group H) poses challenges in storage as white phosphorous melts at a relatively low temperature thus is prone to leakage.[57] The IATG specifies additional measures that should be taken regarding the storage of ammunition containing white phosphorous in order to reduce the hazard associated with leaking ammunition.[58] Some complex munitions that contain liquid propellants also have specific handling characteristics and safety issues, which must be considered during storage and processing.

Ammunition Stock Segregation and Separation

Where space or resources preclude or render it impossible to apply the compatibility group mixing rules specified in the IATG[59] then the following practical measures may be taken to mitigate risk in the immediate term with a view to applying the IATG more comprehensively in the longer term:

- Use of Inert Barriers within ESHs. Inert barriers are an effective method of achieving segregation of stock within an ESH. Some purpose designed barrier systems consist of interlocking polymer box sections that can be filled with water or sand. Such systems, being transportable, are ideal for use around ready-use ammunition associated with aircraft. An example of a polymer-filled modular interlocking barrier system is shown in Figure 8 and a water-filled barrier system in Figure 9. A similar, but less robust, effect may be achieved with inert filled sandbags or ammunition boxes.

Figure 8 – Polymer Modular Interlocking Barrier System.[60)]

Figure 9 – Water Filled Barriers in a Multi-National Ammunition Storage Point.[61)]

- **Use of Lower Hazard Division Ammunition within ESHs.** Interposing ammunition in hazard division 1.4 between stacks of ammunition with a higher hazard division can also be effective. In the event of an incident in an ESH, the separation of stacks of hazard division 1.1 ammunition with hazard division 1.4 will reduce[62], but not eliminate the probability of an entire ESH contents being subjected to prompt initiation. It should be noted though that all stock in the affected ESH will be rendered unserviceable.
- **Use of Detonator Bays.** If detonators[63] or fuzes in compatibility group B must be stored with their parent natures it is important that a degree of separation is interposed between them. This may be achieved using sandbags, filled empty ammunition boxes, or other expedient barrier systems. The objective of the barrier should be to prevent direct line of site between any of the ammunition containing compatibility group B natures and other ammunition stock, particular in hazard division 1.1, contained within the ESH.
- **Separation of Unserviceable Stock.** Unserviceable ammunition should be segregated from serviceable ammunition and should be disposed of at the earliest opportunity. A common factor in many previous UEMS has been the accumulation of excessive quantities of unserviceable ammunition. It is important that states do not regard unserviceable ammunition as an asset and that its safe disposal is afforded a high priority. In most conflict-affected and low-capacity environments the expeditious disposal of unserviceable munitions will have an immediate and positive impact on safety.

4.6 FIRE PREVENTION

Fire prevention is a critical element of ammunition safety management. The IATG provides comprehensive guidance on fire prevention measures and also those steps that can be taken to prevent fires in vegetation and vehicles from spreading to structures containing ammunition.[64] The keys to effective fire prevention are the systematic elimination of ignition sources within the explosives storage or processing area and preventing the uncontrolled spread of fire.

Fire Prevention – Planning and Risk Assessment

For all sites where ammunition is stored and processed, a written fire plan and set of fire orders should be created. For major sites, contingency planning should also include any actions required by the local authorities adjacent to the site and should specify areas which may need to be evacuated in the event of a fire taking place. Planning for evacuation is critically important if civilian dwellings have encroached on the safeguarded area around the ammunition site *i.e.* buildings are within the calculated inhabited buildings distance (IBD) of the site.

All staff within the site should be trained in immediate fire-fighting measures and suitable instructions should be displayed on signs. For ammunition natures that present a special hazard, such as those containing white phosphorus or liquid propellants, instructions should also be displayed in ESHs close to where these natures are stored.

Fire Fighting Equipment

The types and quantity of fire-fighting equipment which are available within a site should be capable of extinguishing the most likely sources of fire *i.e.* those originating from vehicles or fire propagated through dry vegetation. In most conflict-affected and low-capacity environments it is unlikely that a pressurized emergency water supply system will be available to support fire-fighting operations throughout the site. In these circumstances, appropriate use should be made of static water supplies in tanks and ponds. Simple fire beaters are the most effective means of extinguishing grass fires. Fire extinguishers are expensive to acquire and maintain and may not be available in sufficient quantities to equip every individual ESH. In these circumstances, provision should be made to have fire extinguishers on hand during routine vehicle movements of ammunition. They could also be usefully carried on immediate response vehicles.

Prohibited Articles and Enforcement of No Smoking Areas

A major aspect of fire prevention is the denial of access of ignition sources into all areas where ammunition is stored and processed, this includes:

- Strict enforcement of contraband regulations and all smoking materials, lighters and matches should be prohibited;
- Strict enforcement of no smoking areas and a clearly designated smoking area, outside of the explosives area, should exist. Pictogram based signs of a type similar to that shown at Figure 10 should be displayed prominently at all entrances to ammunition sites;

Figure 10 – Pictogram Based No Smoking Sign.

- Prohibition of the use of non-approved tools and equipment;
- Mobile telephones and unauthorized radio transmitters should not be permitted within the explosives area[65];
- Cooking should only take place in nominated administrative areas and not within the explosives area;
- Only authorised and serviceable vehicles should be permitted within the explosives area and all should be fitted with a fire extinguisher capable of extinguishing an engine or a tyre fire.

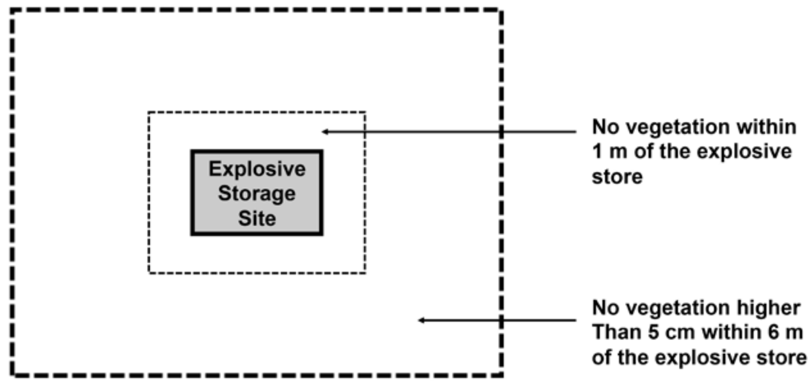
Contraband signs should indicate that the following items, unless specifically authorised, shall not be taken into an explosives facility:

- Matches and/or any other means of producing flame or high temperatures.
- Tobacco in any form, including snuff;
- Any articles used in connection with smoking;
- Radio transmitters or receivers, including mobile phones;
- Tools and other equipment;
- Any battery or mains operated item;
- Unauthorized explosives;
- Dangerous or flammable substances;
- Cameras;
- Firearms;
- Drugs and medicines;
- Metal shod footwear.

Control of Vegetation

Vegetation control is critically important to prevent the spread of fires within ASAs. The IATG provides basic guidance[66] on the control of vegetation as shown in Figure **11**.

Figure 11 – Fire Prevention – Vegetation Control in Explosive Storage Sites.



Where resources for grass cutting and vegetation control are limited, prioritization should be given to vegetation control during the periods of greatest fire hazard *i.e.* during dry seasons. The nature of the ammunition storage infrastructure present in the site determines the priority for vegetation control. It is recommended that vegetation control is addressed in the following descending order of priority :

- Open storage / stacks[67)];
- Any explosive storage buildings constructed from flammable materials, such as those made of wood ;
- Explosives stored within unprotected or un-barricaded shipping containers ;
- Heavy walled buildings (reinforced concrete, concrete block, or brick) ;
- Earth covered buildings.

In some circumstances, trees may have been planted within the ASA in order to afford camouflage and concealment. Careful consideration should be given to balancing the needs of security and cover from observation, with the requirements of fire safety. Certain types of tree may eject firebrands over large distances when they are subject to fire and trees of this type should never be allowed to grow close to ammunition storage and processing buildings which incorporate flammable structural materials.

Vegetation should also be controlled adjacent to perimeter fences in order to prevent fires started outside propagating into the ASA. Where possible, all substantial accumulations of fuel such as trees and brushwood should be reduced within 30 m of an explosive storage or processing site. On completion of vegetation control, all cuttings should be removed from the ASA to reduce the latent fire hazard. Removal of vegetation adjacent to perimeter fences also aids observation thus improving security.

Vegetation control should be carried out with appropriate and locally available equipment. Hand tools and mechanical trimmers are entirely appropriate for vegetation control close to buildings containing explosives. More sophisticated machinery, required for extensive areas of grass cutting, may be too expensive to use in some low-capacity environments. Livestock are an effective way of controlling the growth of grasses and may be permitted to graze inside the safeguarded area of explosive facilities. Rodents and other burrowing mammals must be controlled within the explosive area as they can undermine and affect the integrity of barricades.

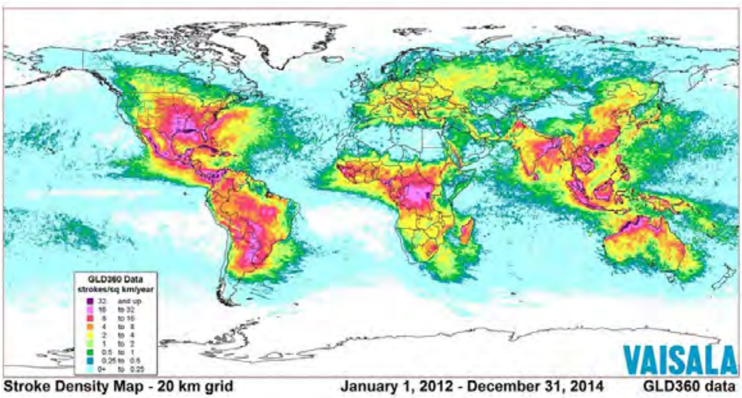
Lightning Protection

The distribution of lightning across the world is not evenly spread and in tropical areas the number of lightning episodes may be many times that seen in temperate regions. Figure 12 shows a graphical representation of global lightning activity.

In all areas, but especially those prone to a high-level of lightning strikes, LPS should be viewed not as an optional safety measure but a mandatory safety requirement. Where possible, ammunition should be stored within buildings equipped with serviceable LPS. For ammunition storage solutions based on shipping containers or lightweight metal buildings, the metal fabric of the building should be earthed. Where open stacks of ammunition are employed then fixed air termination type suspended LPS should be employed. LPS are vulnerable to damage and should be checked with appropriately calibrated equipment on a regular basis.[68)]

The installation, maintenance and periodic testing of LPS is a specialist activity and it is essential that it is conducted by competent personnel. LPS should be considered during the planning stages of new facilities. Where LPS are required to be installed to protect existing facilities then suspended air termination network systems are often the simplest to install.

Figure 12 – Distribution of World Lightning Strikes.[69)]



4.7 MANAGEMENT AND SEGREGATION OF MILITARY PROPELLANTS

Hazards Associated with Military Propellants

The accidental or premature ignition of military propellants has been the assessed cause of some catastrophic UEMS.[70] Military propellants have an undesirable characteristic in that they deteriorate with age, the rate of deterioration being dependent on the prevailing ambient temperature and humidity levels.[71] Ultimately, they can ignite spontaneously with devastating consequences. Most solid propellants used in military munitions are based on compositions which include nitrocellulose and other materials. Nitrocellulose, an energetic material which falls within the nitrate ester group of chemical compounds, poses some significant issues in terms of its safety and longevity in storage. Propellants form a key component of many military munitions and examples are shown at Figure 13.

Figure 13 – Military Propellants.[72]

The inherent instability of propellants based on nitrocellulose is well known and has been studied extensively. The effects of weather, hot temperatures, direct solar radiation, daily temperature changes (diurnal cycling) and high humidity may rapidly degrade the performance and safety of explosives. Ammunition is designed for use under stated climatic conditions, and its service life will be significantly reduced if it is stored under climatic conditions that it was not designed for. In some cases, the ammunition may rapidly become unserviceable and unsafe. Prolonged storage at elevated temperatures and humidity has a definite detrimental effect on propellant shelf life. During prolonged periods of storage, the rate of chemical deterioration of propellant is approximately doubled for every 10°C rise in temperature above 30°C.[73)]

Accidental or UEMS caused by propellant fires are far from uncommon as evidence gathered by a number of sources suggests.[74)] It has been suggested that auto-ignition of propellant is a significant cause of explosions and is a major risk where ammunition surveillance is limited or non-existent; however, it becomes a minor risk where appropriate ammunition surveillance practices are applied.[75)]

Reducing the Hazard Posed by Military Propellants

The following steps should be taken to reduce the hazard posed by ammunition containing propellants. Ammunition containing military propellants should:

- Be stored in separate storage;
- Not be stored with ammunition classified in hazard division 1.1 i.e. ammunition possessing a mass-explosion hazard[76)];
- Have its shelf-life monitored closely through a process of in-service surveillance and shelf life expired propellants should be disposed of as quickly as possible;
- Be stored in storage locations with minimum vulnerability to fire (see section on fire prevention);
- Stored so that storekeepers can gain easy access to all stock in order that they may detect early evidence of propellant deterioration.[77)]

Mortar primary and augmenting cartridges often contain substantial quantities of double base propellants, which are prone to stabilizer depletion and spontaneous ignition and have been the suggested cause of a number of UEMS. It is recommended that mortar ammunition is stored in a separate ESH to other ammunition classified in hazard division 1.1.

If appropriate temperature logging equipment is available, consideration should be given to monitoring the temperature inside ESHs used for the storage of propellants. The data derived from logging may be used, over time, to inform decisions on the safe shelf life of ammunition natures.[78)]

4.8 DESTRUCTION OF UNSAFE AND SURPLUS STOCK

Overview of Destruction Methods

The methodology to be adopted is governed by the quantity of ammunition that requires disposal and the environmental conditions applicable in the country of operation. Open burning (OB) or open detonation (OD) is often the most cost-effective method.[79] Disposal by demilitarization is usually more complex and expensive than disposal by OB/OD and this may be a significant consideration for most low-capacity environments.

Open Burning (OB) and Open Detonation (OD)

Disposal by OB/OD is the simplest and most effective method of achieving the safe disposal of large quantities of stocks. OB is a technique particularly appropriate for the disposal of bulk propellants. Figure **14** shows a number of artillery propelling charges laid out in preparation for OD. Figure **15** shows the same charges after ignition.

Figure 14 – Preparation of Propelling Charges for Open Burning.[80]

Figure 15 – Propelling Charges Undergoing Open Burning.[81)]

For OD, it is important that sufficient quantities of HE donor charges are made available if OD is to be conducted reliably and safely. In planning the disposal of munitions by OD, care should be taken to ensure that sufficient high NEQ munitions are included when low NEQ munitions are selected for destruction. Reliable OD, with correspondingly low toxic gaseous emissions, requires an appropriately sized explosive donor charge if unexploded items ejected from demolition pits are to be prevented.

Figure 16 shows the large-scale disposal of missiles being undertaken using OD ; note the extensive use of high NEC anti-tank mines as donor charges and each individual donor charge is connected to a detonating cord ring main to ensure that all charges are detonated near simultaneously.

Destruction of Small Arms Ammunition

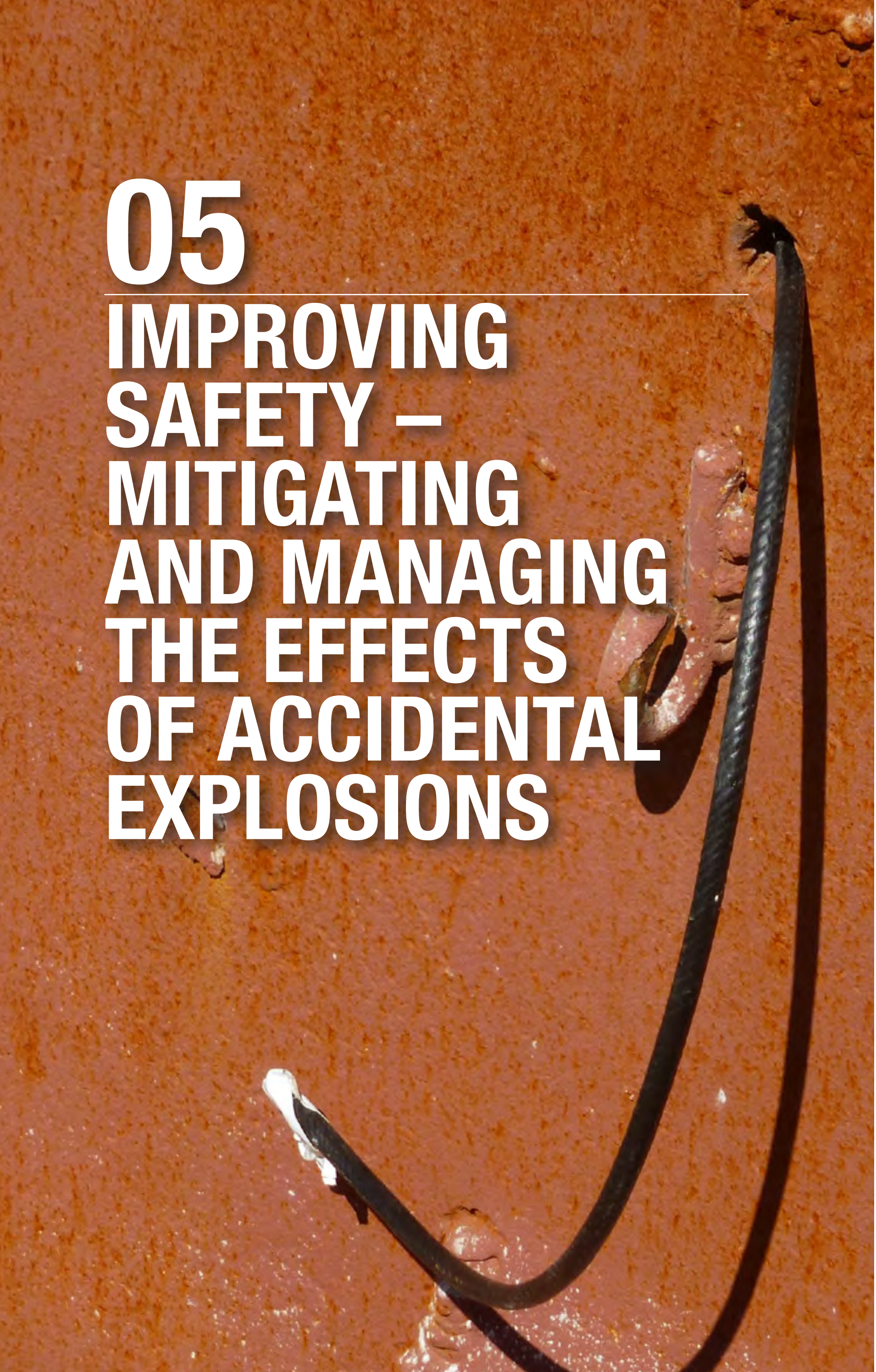
The disposal of small arms ammunition and other low NEQ items such as pyrotechnics can be a problem in conflict-affected and low-capacity environments. While purpose-built incinerators are the most effective means of destroying these items, simple field-expedient burning tanks may be fabricated from sheet metal and employed to good effect.

Figure 16 – Large-Scale Logistic Ammunition Disposal using Open Detonation.[82)]

Logistic disposal of large quantities of ammunition is a complex and potentially hazardous activity, especially when conducted in areas of high population density. It is essential that demolitions are appropriately planned and supervised, and that due cognisance is taken of safety at all stages in the disposal process. It is especially important that central demolition sites (CDS) are located in safe areas and have been subject to a safety assessment conducted by a competent person.

05

IMPROVING SAFETY – MITIGATING AND MANAGING THE EFFECTS OF ACCIDENTAL EXPLOSIONS



The previous section focused on those activities which could be undertaken to improve safety at ammunition sites by preventing an accidental explosion occurring in the first place. This section focuses on those actions which could be taken to mitigate the effects of an accidental explosion, should it occur.

5.1 EXPLOSIVE LICENSING AND THE USE OF QUANTITY DISTANCES

The single most important measure in mitigating the effects of an accident or a UEMS is the appropriate use of Quantity Distances (QDs). This subject is covered in detail in the IATG.[83)]

It should be noted that the use of QDs does not guarantee that damage and injuries will not occur in the event of an accident or explosion. It is possible that injuries may still be caused through high angle fragments being projected from an explosion site and secondary fragments from glazing may also be a particular problem. Air blast from large explosions may also interact in a catastrophic way with poorly constructed dwellings and structures.

Inside Quantity Distances

The inside quantity distance (IQD) is the minimum permissible distance between a potential explosion site (PES) and an exposed site (ES) inside the explosives area. The inter-magazine distance (IMD) refers to the minimum permissible distance between a building or stack containing explosives and the location of other such buildings or stacks which will prevent the immediate propagation of explosions or fire from one to the other by missile, flame or blast.[84)]

The most important consideration in an ASA is ensuring that the quantity of explosives stored in individual ESHs does not exceed that permitted by the available IMD. If the IMD is exceeded then it is probable that an explosion at a single ESH will lead to the prompt propagation of explosions at adjacent ESHs, meaning the resultant consequences will be based on the aggregated NEQ of all affected ESHs, with potentially catastrophic results far beyond what was originally envisioned.

The principal difference between achieving and not achieving compliance with IMD is the magnitude of the event associated with an accidental explosion at a single ESH. If IMD quantity distances are achieved, then an accidental explosion at a single site is likely to affect only a single ESH. If IMD quantity distances are not achieved, then it is probable that the ammunition contents at multiple sites will detonate promptly and this may result in the propagation of a mass explosion to other adjacent ESHs, with probable catastrophic implications. The necessity of compliance with IQDs is shown in the scenarios described at Figure 17 and Figure 18.

Figure 17 – Inside Quantity Distance Example – Inter Magazine Distance Not Achieved.[85)]

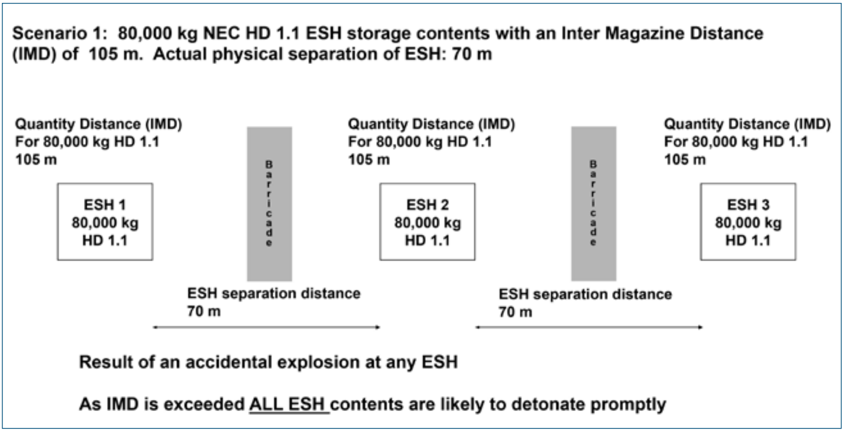
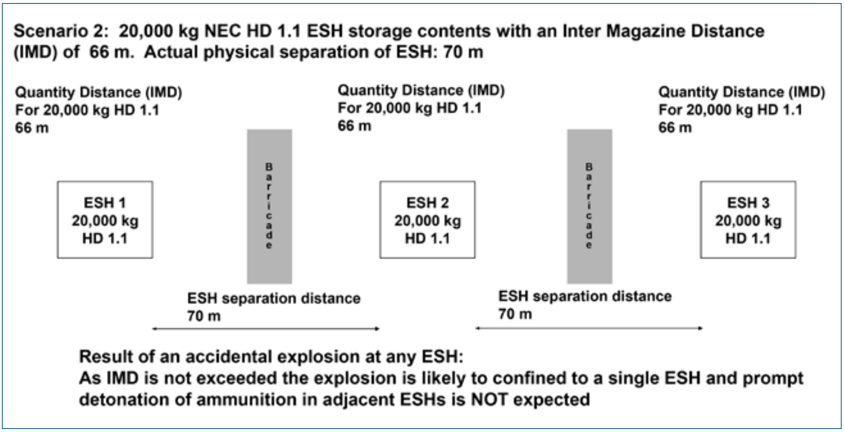


Figure 18 – Inside Quantity Distance Example – Inter Magazine Distance Achieved.



In evaluating QDs at ammunition sites it is recommended that IQDs are considered first and that the total NEQ of explosives stored at individual PESs is adjusted so that a satisfactory IMD can be achieved. This approach will ensure that if an accident or explosion does occur, it is likely to affect only a single PES. While the QD tables in the IATG provide separation distances on stored quantities of explosive up to 250,000 kg, it is strongly recommended that in conflict-affected and low-capacity environments ESH explosive contents are generally restricted to less than 10,000 kg NEQ.

In most existing ammunition storage and processing facilities it will be necessary to calculate the maximum NEQ of ammunition in a given hazard division which may be stored based on the current 'as built' facility configuration. If adjacent ESHs are of light structure and are un-barricaded then for QD purposes they must be considered as open stacks when calculating the IMD. If space and the ground permits, the IMD may be reduced or the NEQ of explosive stored increased, by the use of receptor and interceptor barricades between the ES and PES. The use of barricades is considered in greater detail later in this section.

Outside Quantity Distances

The outside quantity distance (OQD) is the minimum permissible distance between a PES and an ES outside the explosives area. The inhabited building distance (IBD), vulnerable building distance (VBD) and public traffic route distance (PTRD) are all types of OQD. To minimize the risk of casualties during a potential UEMS, it is the IBD which should be considered. QD tables in the IATG are extrapolated from empirical data and trials and relate to buildings which may have substantially more robust methods of construction than those which may be found in many conflict-affected and low-capacity environments. In considering the use of OQDs in conflict-affected and low-capacity environments it is recommended that a conservative approach be adopted and that if buildings adjacent to ammunition storage and processing facilities are assessed to be of poor construction then the QDs relating to the VBD should be employed.

The maintenance of a safeguarded area around ASAs in conflict-affected and low-capacity environments may be quite difficult, especially where there is limited national legislation or regional regulations relating to building planning and consent. Where possible, new ASAs should be planned and sited such that the IBD for the planned amount of explosive stored falls within the perimeter of the site thus eliminating the potential for future encroachment on the safeguarded area. Over time, it is possible that new public traffic routes or footpaths may be brought into use which encroach on the safeguarded area. Where possible, these public traffic routes should be re-routed and those particularly hazarded by the ASA should be closed.

Reducing the Size of the Maximum Credible Event

The maximum credible event (MCE) is a measure of the size of the worst-case explosive event which could take place at an ammunition storage site. The size of the MCE is determined largely by the type of infrastructure in use at the site and the effective and appropriate use of IQDs.

The size of the MCE may be reduced by the use of compartmentalization within a given site such that the risks associated with the prompt detonation of an entire ESH contents are reduced. This may be achieved through the use of internal barricades, or interposing ammunition stock in HD 1.4 between and higher hazard division stacks.

In ammunition processing facilities, care should be taken to ensure that excessive quantities of stock do not build up and only a reasonable amount of exposed ammunition, sufficient to facilitate efficient processing operation, is present at any one time. Similarly, the quantity of ammunition packages which are opened within a processing facility at any one time should also be limited.

Explosive Licensing

Comprehensive guidance is provided in the IATG on the rationale and process for development of explosive limit licences (ELL).[86] The analysis of an ammunition and explosive processing area provides the firm baseline on which explosive risks can be demonstrated to be ALARP. The use of QD tables and ELLs has the following prerequisites:

- It should be conducted by competent and experienced staff who are capable of assessing ASA infrastructure, applying QD tables and producing ELLs;
- It requires that the ammunition stock has either been hazard classified by a competent authority or has been assigned an interim hazard division and compatibility group;
- Technical information relating to the NEQ of ammunition is known, or can be acquired from a reliable source;
- The personnel charged with the operation of the site are capable of reading and understanding ELLs, applying aggregation rules, and calculating the total NEQ of ammunition stored in a particular ESH.

As an early step in implementing an ammunition safety system based on ELLs it is recommended that rather than solely specifying the total NEQ of explosive which may be stored, it is also specified in terms of a specific quantity of ammunition natures. For example, in a given ESH the maximum quantity of HD 1.1 ammunition to be stored may be expressed as:

- 10,000 kg NEQ hazard division 1.1; or
- 1,460 Shell 155mm M107 HE (73 pallets).

5.2 SAFEGUARDING EXPLOSIVES STORAGE AREAS

Safeguarding is the means by which hazards caused by the location and operation of ammunition storage and processing facilities in proximity to the civilian population are reduced to an acceptable level. In order to minimise these hazards should an explosion occur, QDs from inhabited buildings, roads, railways and other places frequented by people are used. Given that the safe distances defined by QDs often extend beyond the physical perimeter of an explosive storage or processing facility. Safeguarding is the process by which encroachment into these areas is prevented.[87]

A common feature in many previous catastrophic UEMS has been uncontrolled building within the safeguarded areas in the proximity of munitions storage facilities. There are a number of unpalatable choices for states in situations where uncontrolled urban expansion has resulted in large numbers of inhabited dwellings being built in safeguarded areas, they are :

- Close the site and move ammunition to an area where QDs can be achieved ;
- Reduce the quantity of explosive stored at the site to protect the inhabited buildings which are now in the safeguarded are ;
- Remove the inhabited buildings which are within the safeguarded area.

The UEMS which occurred in Lagos[88)] and Brazzaville[89)] provide ample example of the catastrophic impact of UEMS where inhabited buildings exist within the safeguarded area.

In the longer term, the enforcement of safeguarded areas needs to be enshrined in national legislation and regulations which prohibit the development of structures within the safeguarded areas of ammunition facilities. All problems of safeguarded are encroachment can be eliminated if ammunition storage and processing facilities are developed in areas of low population and the safeguarded area *i.e.* the area inside the IBD or VBD, is contained entirely within the perimeter of the facility.

5.3 PRACTICAL MEASURES TO PREVENT THE PROMPT INITIATION OF ADJACENT EXPLOSIVE STORE HOUSES

Barricades

Barricades have an important part to play in reducing the risk of prompt initiation of multiple ESHs following an explosion at a single site. Barricades can either act as a screen at potential explosion sites, by intercepting low-angle high velocity fragments which pose the greatest risk of prompt initiation of other HE munitions or, to a more limited extent, protect exposed sites containing explosives in the same manner.

Barricades may be fabricated from a wide variety of materials and in their simplest form may be bulldozed and compacted mounds of earth. They should be constructed to an appropriate height and geometry to screen the structure being protected. In areas prone to high seasonal rainfall, earth mounds may be vulnerable to damage through the erosion effects of water runoff. Rodents and other small burrowing mammals can also quickly affect the integrity of barricades or earth covered buildings.

If the QD associated with barricaded storage is to be used then it is essential that the barricade is constructed in accordance with the IATG.[90] The effectiveness of gabion-based barricade solutions is shown at Figure 19. The barricade (on the left of the photograph), with a stand-off of less than 8 metres, intercepted all low-angle fragments from the ESH (on the right of the photograph) in which the explosion occurred.

Figure 19 – Container-Based Barricade Demonstrated in a Large-Scale Explosive Storage Trial.[91]

Overhead Protection

Overhead protection on ESHs and APBs serves a number of important functions:

- It provides a measure of protection from high-angle projected munitions in the event of an explosion at an adjacent ESH;
- It provides a degree of stock protection where indirect fire weapons such as mortars and free flight rockets are a threat;
- Earth covered buildings and blast resistant structures also provide considerable protection from blast, fragmentation and thermal effects from explosions in adjacent ESHs.

In order to be effective, overhead protection should consist of a minimum of 600 mm of earth or other loose material. A lesser thickness of reinforced concrete will have the same effect.

5.4 MANAGING EXPLOSIONS IN AMMUNITION STORAGE AREAS

An accidental explosion at an ASA is a very serious event and all actions taken following an explosion should be aimed at reducing the risk to life and serious injury, and to preventing further explosions from occurring. Responding to an explosion at an ASA is a complex activity and specialized skills are necessary to address these hazards and is covered in the IATG.[92] The following specific hazards should be considered:

- **Ammunition Armed on Ejection.** Ammunition may have been projected some distance from the explosion site. If the ammunition has been stored in a fuzed state, then it is possible that the forces imparted to the ammunition during the explosion could be similar to the forces required to arm the fuze. In these circumstances the munition must be considered to be armed and dealt with accordingly;
- **Partially Burnt Ammunition.** Some explosive compositions become significantly more sensitive when exposed to high temperatures or fires[93];
- **Exposure of Hazardous Fillings.** Some ammunition natures may have been broken open leading to the exposure of other hazardous fillings or explosive items, such as white phosphorous or sub munitions. Damaged fuzes and detonators may also contain exposed sensitive primary explosives;
- **Exposure of Sensitive Initiation Systems.** Ammunition may have been broken open leading to exposed electrical leads, rendering the item more vulnerable to accidental initiation through lightning or static electricity;
- **Propellant Hazards.** Propellant which has not burnt during the explosion may spontaneously ignite during EOD clearance operations; such ignition will be dependent on the chemical condition of the propellant and the ambient temperature;
- **Buried Munitions.** Buried munitions will remain at the site of the initial explosion;
- **Vulnerability to Environmental Hazards.** Ammunition that has been involved in an explosion, but did not deflagrate or detonate, may be more susceptible to deterioration in poor weather. The risks of premature detonation will increase significantly during thunder storms and further explosive events initiated by lightning strikes may occur;
- **Potential Collapse of Buildings.** The remaining ESH infrastructure is very likely to be in an unstable condition, thus posing a collapse risk to personnel;
- **Contamination of Water Sources.** Exposed explosives may contaminate surface and sub-surface water. TNT, the HE most commonly used in indirect fire munitions and other large warheads, poses a particular environmental hazard through contamination of ground water sources.

Wherever ammunition stores have exploded, explosive items will contaminate the surrounding area. Mechanical inspection is the most efficient method to remove the contamination from areas that are close to the storage site whereas manual techniques are more effective in areas of lower density UXO contamination. Sub-surface clearance requires the use of sensitive search equipment.

In the event of a significant UEMS it may be necessary for the assistance of international entities to be sought in order that an expeditious clearance may take place. This is covered in greater detail in Section 10.

5.5 MINIMISING PERSONNEL EXPOSURE INSIDE AMMUNITION FACILITIES

Access Control[94)]

The simplest method of reducing the number of personnel exposed to hazard within and ammunition storage and processing facility is through the strict enforcement of access control. It is also good practice to ensure that only those personnel which have a requirement to be located within the limits defined by the IBD are provided with authority to enter the site. Administrative facilities, such as offices, canteens and garaging should normally be located at a greater distance than that defined by the IBD.

Enforcement of Personnel Limits[95)]

All activities and licensed locations within a site should have defined personnel limits. The authorized personnel limit should be set at the minimum level to complete a specified task and if there is a requirement to exceed this limit then authority should be granted by the supervisory staff at the site. Personnel limits are particularly important for those activities which are assessed as high risk, such as the processing of ammunition within a workshop or APB.

06 DEVELOPING STORAGE INFRASTRUCTURE FOR CONFLICT-AFFECTED AND LOW-CAPACITY ENVIRONMENTS

The physical infrastructure *i.e.* the location of the ASA and the buildings[96] where ammunition is stored has an important part to play in any ammunition safety management system.[97] As resources are often limited, it may not be feasible to construct new facilities and existing infrastructure may need to be modified to improve safety. This section examines the practical considerations in acquiring new and modifying existing ammunition storage and processing infrastructure.

The development of new or the enhancement of existing ammunition facilities is often a resource intensive activity and it is essential that expert advice is obtained on the suitability and appropriateness of a proposed solution. It is recommended that all plans are subject to peer-review and adherence with the IATG at the planning stage is evaluated.

This section contains guidance additional to the IATG based on good practices on the ground.

6.1 PLANNING CONSIDERATIONS

Land Rights and Availability of Real Estate

Land rights and ownership of land should be considered before a site is selected for the storage of ammunition. Ideally, the entire site covered by the physical ammunition storage infrastructure and the area which is required to be safeguarded should all be under the ownership or lease of the state.

Strategic National Plan for Ammunition Infrastructure

The following factors should be considered during the requirements specification phase for new or upgraded ammunition facilities:

- The total size of the ammunition stockpile which is required to be stored;
- Any geographical requirements which may impact on the location of the facility, such as: proximity to operational units, requirements to support training, and external threats;
- Any requirements for munitions with specialist handling or processing characteristics.

Affordability

Cost is paramount in low-capacity environments and it is essential that both national and international donor-delivered ammunition storage and processing solutions are capable of being maintained locally, especially given the scarcity of resources. In tropical conditions, steel storage systems will degrade quickly if they are not treated with an effective corrosion inhibitor. Generally, complex electronic intrusion detection systems and video camera systems should be avoided in conflict-affected and low-capacity environments as they are both costly and difficult to maintain.

Ease of Construction and Availability of Materials

Ease of construction is a significant factor for consideration in developing ammunition storage and processing infrastructure for conflict-affected and low-capacity environments. In low-capacity environments the most appropriate solutions are often those which involve modular systems, fabricated off-site, which can be installed without the need for complex plant and equipment. Alternatively, simple concrete block-built structures with reinforced concrete roofs are entirely appropriate, if the basic raw materials and the personnel to build them are available.

In many conflict-affected and low-capacity environments, basic construction materials of a quality standard appropriate for the construction of ammunition facilities are not available. In these circumstances it may be appropriate to source materials or solutions directly from experienced providers in foreign countries.

Modular Solutions

Modular ammunition processing and storage solutions are available from a number of suppliers and some may be procured under UN long term agreement (LTA) procurement procedures.

Environmental Protection of Stock

In many conflict-affected and low-capacity environments the climate is an enemy and high temperatures during diurnal cycles as well as high humidity are often a problem. In these circumstances, priority should be given to providing environmental protection for ammunition.

Licensing of Ammunition Sites and Acknowledgement of Residual Risks

At all stages in the planning and construction of an ammunition facility consideration should be given to how the site will eventually be licensed and, where possible, adherence with the IATG should be sought. In circumstances where it is not possible to achieve adherence with the IATG then an ESC should be developed in order that the residual risks present with the operation of the site are known and acknowledged by the local and national authorities.[98] In conflict-affected settings, where UN or a regional force is responsible for providing security under an international mandate, the ESC should be acknowledged by the UN or Regional Force Commander.

6.2 USE OF OPEN AMMUNITION STACKS

Open stacks represent the simplest form of ammunition storage though it is more often employed during field storage operations. For explosive licensing purposes, lightweight buildings are often regarded as open stacks for licensing purposes. Open stacks are not recommended for permanent or semi-permanent storage facilities for the following reasons:

- Ammunition is completely exposed to the elements and has no protection from extreme temperatures in diurnal cycling;
- Open stacks represent the least secure form of ammunition storage and if ASA perimeter protection systems are compromised then direct access to ammunition is possible;
- Open and un-barricaded stacks represent the worst case QDs (i.e. greatest separation distances) for both IQD and OQD;
- Open stacks are particular vulnerable to attack by indirect fire or by weaponized drones)[99];
- Uncut vegetation in proximity to open stacks poses a significant fire risk.

6.3 SHIPPING CONTAINER BASED STORAGE SOLUTIONS

Ammunition storage solutions based on shipping containers have been widely used and have the advantage of being based on a readily available product, the ISO standard shipping container. An example of an ammunition store based on a shipping container is shown at Figure 20. There are some significant disadvantages associated with the use of standard shipping containers for ammunition storage:

- In hot conditions stand-off shades must be provided to prevent the containers heating up through the direct effects of solar radiation;
- Shipping containers lack inherent strength and rigidity to support overhead protection without substantial supporting members being put in place. These additional structural supports may pose a significant secondary fragmentation hazard in the event of an explosion inside the store;
- Shipping containers may be become warped and the doors difficult to open and close if the supporting structures are not built to close tolerances;
- Security may be a problem with shipping containers as the walls and doors are simple to penetrate with commonly available tools.

Figure 20 – Shipping Container Based Magazine with Overhead Protection.[100)]

An alternative solution, which is particularly suitable for surface laid solutions with barricades but no overhead protection, is the purpose-built magazine. Figure **21** shows an example of a magazine that has been employed in conflict-affected and low-capacity environments in Africa. It has the handling advantages of a shipping container, but its bespoke nature addresses the disadvantages highlighted above regarding ISO shipping containers when used as ammunition storage solutions.

Figure 21 – Example of a Purpose Made Surface Magazine.[101)]

6.4 LIGHT WALLED STRUCTURES

Light walled ammunition storage and processing structures are ideal for providing environmental protection to ammunition stock where there is sufficient space to achieve the IMD IQD, usually with barricading, and there is no requirement for overhead protection from indirect fire. A key benefit of light structures is that the building materials do not generally add significantly to the secondary fragmentation hazard in the event that an explosion occurs within the ESH.

A light-walled ammunition storage solution is shown in Figure 22. In this example, individual ESHs have been barricaded with multiple layers of container-based barricades and the barricades have been stacked to a sufficient height to reduce the probability of a low-angle high velocity fragments from an explosion at one ESH causing prompt sympathetic detonation of ammunition in adjacent ESHs. In most countries the construction materials to be used are widely available in the commercial buildings sector and facilitate the simple inclusion of electrical services, air conditioning and lightning protection systems.

Figure 22 – Barricaded Light Walled Frangible Ammunition Storage Solution.[102)]

6.5 COMPARTMENTED LIGHT-WALLED STRUCTURES

Compartmented light-walled structures are appropriate for a variety of conflict-affected and low-capacity environments and are particularly useful for small storage units, especially where ammunition natures with different compatibility groups must be stored. An example of a compartmented light-walled structure, which was built in North Africa, is shown in **Figure 23**. The building is made from entirely non-flammable materials and has walls fabricated from concrete blocks, a reinforced concrete roof, and each compartment has individually lockable metal doors. The advantages of this type of ESH are :

- It allows incompatible munitions to be stored in separate compartments ;
- Each compartment may be secured separately thus allowing individual sub units to have secure access to their own compartments, but not others ;
- The entire store may be licensed as a single PES, in this case in IATG terms, a barricaded light building or open stack ;
- It provides environmental protection to the stored munitions ;
- It is inexpensive and requires only simple plant and machinery to construct ;
- It may be used with both palletized and boxed ammunition ;
- The reinforced concrete roof provides some protection from fragmenting indirect fire weapons or in the event of an explosion at an adjacent ESH, lobbed firebrands and munitions.

Figure 23 – Compartmented Light-Walled Structure in North Africa.[103]

6.6 PRE-FABRICATED EARTH COVERED MAGAZINE

There are a number of issues associated with implementing concrete 'igloo'-type earth covered magazines. While the 'igloo' magazine represents the safest solution in terms of minimising IQDs and OQDs, they are very expensive to construct and require fairly advanced civil engineering capabilities to be present in the country of construction.

One possible solution is to use pre-fabricated metal box structures which are placed on a concrete pad and then covered with earth to the desired depth. This type of structure can be implemented quickly and for the fraction of the cost of a conventional 'igloo' type magazine. Figure 24 and Figure 25 show a schematic and an 'as built' example of a pre-fabricated earth covered magazine.

Figure 24 – Pre-Fabricated Metal Earth Covered Magazine – Schematic.[104)]

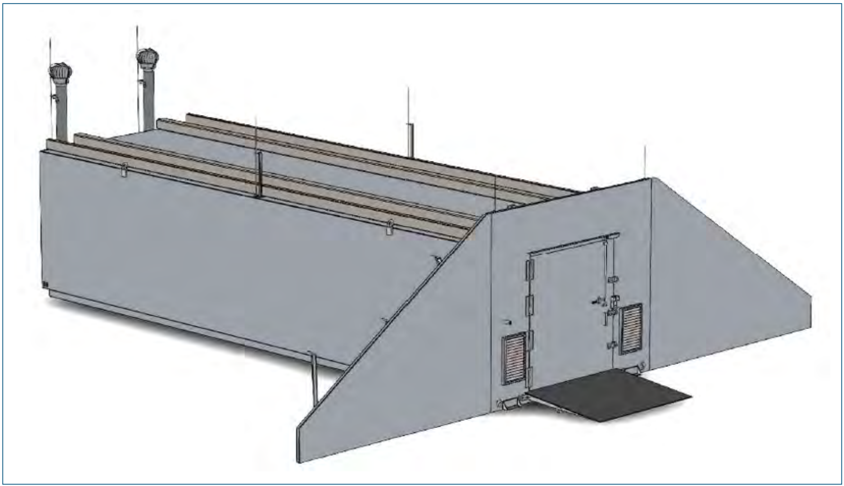


Figure 25 – Pre-Fabricated Metal Earth Covered Magazine - As Built.[105)]

The advantages of this type of ESH are:

- It can be delivered to the site fully constructed and requires only basic site preparation, positioning and earth covering before it is taken into use;
- The complete kit can be delivered to the site with all necessary services such as ventilation and LPS;
- It is a significantly more affordable solution than a purpose built reinforced concrete earth covered magazine;
- The completed store may be licensed under the IATG as an earth covered magazine with consequent benefits for IQD and OQD;
- The earth covering and metal structure provides excellent protection from indirect fire munitions and lobbed munitions and firebrands from adjacent ESHs.

6.7 ENHANCING EXISTING AMMUNITION INFRASTRUCTURE

General Considerations for Rehabilitation and Reinforcement of Existing ASA Structures

In reviewing the appropriateness of upgrading or replacing [106] existing ammunition storage and processing structures, the following should be considered:

- The cost of rehabilitation – is it cheaper to refurbish or build new?
- Is the existing site configuration suitable in terms of QDs?
- Is it necessary to introduce additional barricades in order to provide satisfactory IQD and OQD?
- Are existing buildings appropriate for use as ESH or APB i.e. are they: constructed from flammable materials; have tiled roofs; and are there windows in the structures [107]?
- Is the structure secure or capable of being secured?
- Is site contamination a potential issue?

07 IMPLEMENTING EFFECTIVE SECURITY MEASURES AND PREVENTING STOCK DIVERSION

The term 'security' refers to the measures taken to prevent the theft of ammunition, entry by unauthorised persons into explosive storage areas, and other undesirable acts, such as sabotage.[108] There is a temptation when considering security measures to only concentrate on 'hard' security infrastructure, such as fences, gates, barriers, locks and intrusion detection systems. Yet often, the weakest link in a security system is that introduced by humans and due cognisance must be taken of personnel security measures such as: selection and vetting personnel, personnel access controls, and searching at the entrances to ammunition storage and processing facilities. A thorough security risk assessment is at the foundation of any effective security management system. It is useful when evaluating security threats to consider an 'insider' or 'outsider' threat-based model. Significant investment in physical security measures may be wasted if staff are poorly paid and prone to bribery and corruption. Crime and terrorism often exploit people at the low wage end of the economy thus it may be more cost effective in low-capacity environments to invest in better paid people than expensive and difficult-to-maintain security equipment. A key aspect of all security infrastructure is to impose delay on those attempting to gain unauthorised access to ammunition. It is important that physical security checks and patrols within ammunition facilities are conducted at a frequency which denies unauthorised personnel the time to access the facility, gain access to an individual ESH, and then leave the facility undetected.

7.1 SECURITY RISK ASSESSMENT

A baseline security risk assessment is a key prerequisite to developing security systems which are appropriate to the level of threat posed to the ammunition stockpile. The local context and threats are particularly important in developing the security risk assessment and a wide range of relevant factors should be considered before any steps are taken to develop security systems or implement security infrastructure projects. In conflict-affected and low-capacity environments, the following criteria in particular should be considered:

- The probability of stockpile diversion given prevailing threats;
- The security hazards arising as a result of catastrophes such as floods, earthquakes, and fires;
- Vulnerability of the stockpile to theft or diversion;
- Vulnerability of the stockpile to sabotage or terrorist attack.

In defining the requirements for security management, the IATG recommends that all security measures are based on a thorough evaluation of the security risks. Ideally, physical security measures should be developed at the same time as the ammunition facility is being designed. Personnel security is a critical part of any security system and suitable measures should be incorporated for vetting staff as well as ensuring that visitors or temporary staff are escorted at all times.

Security plans and security operating procedures (SyOPs) form an important part of any security management system and it essential that all staff associated with the operation and management of ammunition facilities are accountable and aware of the site-specific plans and SyOPs.

7.2 SECURITY INFRASTRUCTURE APPROPRIATE FOR CONFLICT-AFFECTED AND LOW-CAPACITY ENVIRONMENTS [109)]

Screening of Personnel

Security screening of personnel should take place on two levels. Firstly, all full-time members of the ammunition facility should be subjected to some form of vetting process to ensure that they are not affiliated to criminal or terrorist organisations or have previously committed crimes of violence or dishonesty. In conflict-affected and low-capacity environments the thoroughness of the vetting process will depend on the maturity of national criminal justice system and the availability of police records as well as the capabilities and records of the domestic intelligence service, if they exist at all.

All personnel entering and exiting ammunition sites should be subject to some form of screening and be searched if thought necessary. Personnel screening serves two purposes: firstly, from a security perspective, it reduces the opportunity of unauthorized items such as weapons and explosives from being brought or taken out from the site; secondly, from a safety perspective, it ensures that contraband materials are not brought onto the site. [110)] The searching of personnel on departure from ammunition sites acts as a deterrent to theft.

Perimeter Security and Lighting

The most effective approach to perimeter security is to consider defence in depth. Perimeter fences serve to provide a degree of physical, psychological or legal deterrence to intrusion. The approach to the outer perimeter fence should be cleared of all vegetation and no trees should be permitted to overhang any part of the fence. Vegetation should be cut back so that any attempts cut through or dig under the fence are immediately apparent to perimeter security patrols. It is strongly recommended that an outer perimeter fence be established and this should be of at least 2 metres height and affixed with warning signs in order to keep out the unwary or the curious. If dogs or armed guards are present then this should be indicated using pictograms on signs affixed to the fence. One possible approach to signs is shown in Figure 26. Any written words on the signs should be in the language(s) of the local population.

Figure 26 – Perimeter Access Warning Signs.

The outer fence should not be fitted with any device which could inadvertently injure any person outside of the site perimeter. An inner fence represents the principal obstacle to personnel climbing into the site. It should have the following characteristics :

- Be difficult to climb in terms of height and configuration. Narrow welded meshes are much better than chain link ;
- Be fitted with barbed or razor wire sloping outwards from the site ;
- Be generally as straight as possible so as to reduce the vulnerabilities associated with corners and changes of direction in the fence ;
- Be securely buried in the ground to prevent an intruder from burrowing under the fence.

A number of options may be used to secure the area between inner and outer perimeter fences, such as :

- Stacked razor or barbed wire ;
- Cleared vegetation and free-running guard dogs ;
- Low-wire barbed wire entanglements with thorny vegetation (if it is available locally).

Fences should not be regarded as a significant barrier to entry and some would rightly consider them as a filter to keep out the harmless. Security fences do however serve a very useful purpose in permitting the freer use of armed guards and dogs with stronger rules of engagement for the use of force within the perimeter.

The use of anti-personnel mines, or other victim operated explosive devices affixed to or between fences is strongly discouraged.

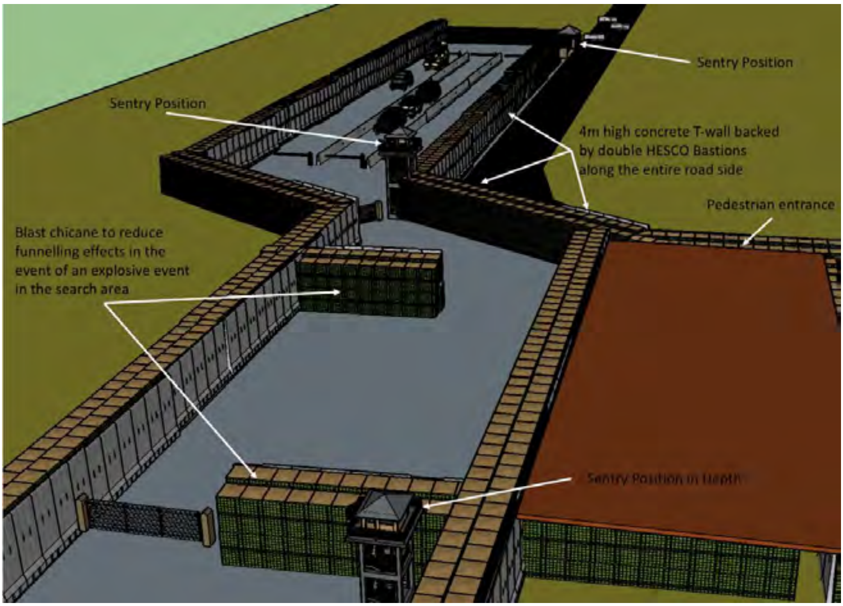
Perimeter lighting if planned and used carefully and in conjunction with regular patrols by dogs and armed guards can be an effective security measure. Perimeter lighting can however assist intruders as much as it assists the site security force.[111] Perimeter lighting is therefore not considered a priority for installation at ammunition sites in conflict-affected and low-capacity environments.

Main Gate and Perimeter Access Controls

The approach taken to site access control depends on the level of threat which exists at the site. In both low-capacity and conflict-affected settings it is necessary to implement measures which guarantee that personnel or vehicles cannot gain access to the site without going through some form of security screening process.

In conflict-affected environments, particularly where terrorism is a significant concern, much more robust measures must be taken to prevent concealed VBIEDs or armed extremists from gaining access to the site. Defence in depth is paramount in these circumstances. One possible main gate configuration is shown in Figure **27**. The key requirement in these scenarios is to ensure that a thorough search of each vehicle and all personnel is conducted before they reach the final gate which grants access to the site. Appropriate use should be made of barricades around the access control point to limit the effects of a suicide VBIED being detonated during the search process.

Figure 27 – Site Access Control in High Risk and Conflict-Affected Settings.[112]



7.3 SEPARATION OF WEAPONS AND AMMUNITION

Bulk ammunition stocks should always be stored in a separate location to the weapon system they are designed to be fired from. The only time ammunition and weapon systems should be stored in the same place is when operational circumstances demand that weapons and ammunition be stored together, or ammunition is stored on operational vehicles. No single person should be able to gain unauthorised or unsupervised access to both weapons and ammunition.

For sub units and guardrooms, separate lockable storage should be provided for small arms and small arms ammunition. The IATG provides comprehensive guidelines on small unit ammunition storage.[113)] It is recommended that only the minimum quantity of ammunition necessary to meet immediate operations is stored in such conditions. Where shift changeovers mandate multiple personnel having access to weapons and ammunition, then security checks should be conducted at a suitable frequency to identify loss and discourage diversion. Small arms ammunition should generally not be stored in weapon magazines for long periods of time. Where possible, ready use ammunition should be stored in its sealed original factory packaging.

Weapon systems which are particularly prone to diversion include man portable anti-tank guided weapons (ATGW) and man portable air defence systems (MANPADS), so these should have their firing units or grip stocks stored in separate locations. Any ammunition nature which is deemed particularly attractive to criminal or terrorist organizations (ACTO) should be subject to more frequent checks. In conflict-affected environments, particularly where extremist groups are making use of IEDs, all ammunition natures containing HE or fragmentation warheads should be considered vulnerable to illicit diversion and protected accordingly.

If ammunition is required to be removed from its outer packaging and stored on operational vehicles, then all packaging should be retained to facilitate the safe unloading and return to storage at the end of the operational period.

7.4 SECURITY INFRASTRUCTURE FOR CONFLICT-AFFECTED AND LOW-CAPACITY SETTINGS

Locks

Locks represent a part of many access control systems for ammunition facilities. High security locks and padlocks are expensive and may not be available in conflict-affected and low-capacity environments. Furthermore in tropical conditions, locks deteriorate very quickly and require regular replacement. Another issue with the use of locks and padlocks is that key control is essential to the maintenance of security. If duplicate keys are obtained then unauthorized and undetected access to ammunition may become possible. Control of keys is important and is covered in the IATG.[114)]

One possible low-technology approach to securing buildings which contain ammunition is to use single-use numbered seals on doors. These seals are used frequently in the international logistics domain to identify if shipping containers are tampered with during transit. Their use in ammunition storage facilities, in conjunction with any form of lock or padlock, provides a quick and easy means of determining whether unauthorised access has been gained to an ESH. An example of a non-reusable security seal is shown in Figure 28. Where locks without seals are used then robust methods should be adopted for the control of keys and the auditing of access to ESHs.

Figure 28 – Non-Reusable Security Seals.

Use of Electronic Surveillance Systems

The use of electronic surveillance and intrusion detection systems (IDS) is problematic in most conflict-affected and low-capacity environments. Modern electronic systems tend not to be very reliable in harsh climates and require frequent maintenance to remain serviceable. Electronic surveillance systems should only be employed in circumstances where there is the capability to support and maintain them and there are sufficient resources to cover operational running costs.

Electronic surveillance systems and IDS are only appropriate if backed up by a suitable responsive and equipped quick reaction force (QRF). The response time of the QRF must be quicker than the assessed time for an intruder to penetrate the perimeter security measures and gain access to ammunition in an ESH.

7.5 PREVENTION OF DIVERSION

Ammunition Attractive to Criminal and Terrorist Organizations (ACTO)

Some ammunition natures are more desirable than others for terrorist and criminal organisations and are more likely to be stolen or diverted. The IATG defines a number of ACTO categories[115)] and these ammunition natures should never be stored in open stacks, and should always be stored in robust and locked ESHs. It is recommended that ACTO items are subject to stocktake and audit at a greater frequency than other types of ammunition.

In some conflict-affected environments, particularly where violent extremists are employing IEDs, the ACTO ammunition category may be quite broad and include all ammunition natures containing bulk HE which could be incorporated into an IED main charge. Generally, those ammunition natures most susceptible to diversion should be stored in the most secure ESHs which are available.

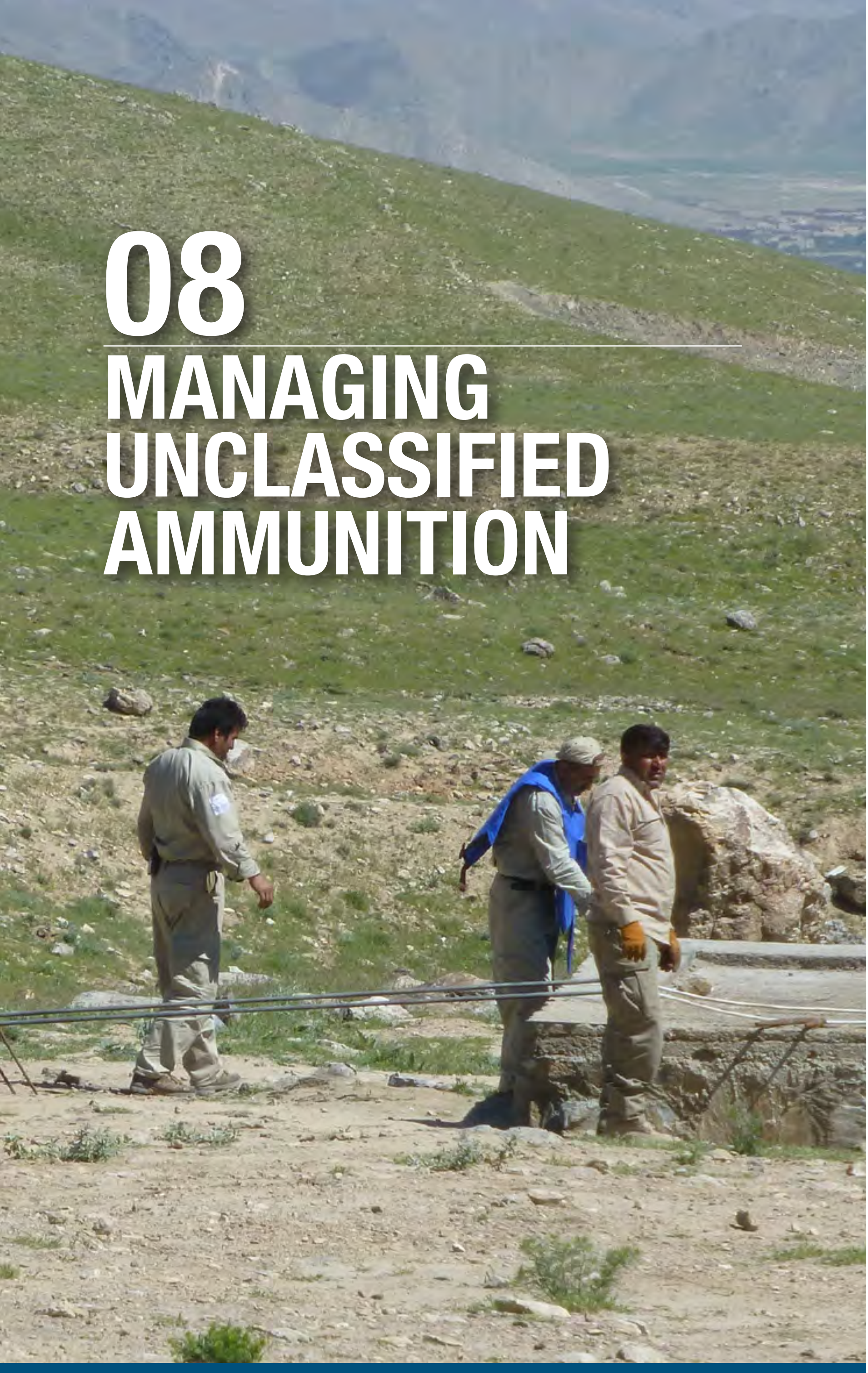
Supervision of Personnel

Adequate supervision of personnel is essential in reducing the risk of illicit diversion of ammunition. Two-person control over access to ESH keys and mandatory 'no lone' zones within ammunition storage and processing areas reduces the opportunity for a single person gaining access to ammunition and the creation of opportunities for diversion. It does not preclude two or more persons from conspiring to gain access to ammunition, but it does remove the opportunity for clandestine attack or illicit removal of ammunition by a person operating alone.

Random Searching of Vehicles and Personnel Leaving Sites

The random searching of personnel and vehicles leaving an ammunition site is an effective method of deterring the illicit removal of ammunition.

08
MANAGING UNCLASSIFIED AMMUNITION



This section contains guidance additional to the IATG based on good practices on the ground.

8.1 INTRODUCTION TO THE HAZARD CLASSIFICATION OF AMMUNITION

The UN system of hazardous goods classification is described in the IATG.[116] Where possible ammunition should be marked with an HCC derived from testing conducted by a competent national authority. With few exceptions, the international transport of ammunition requires packages to be formally certified and appropriately marked.[117] The remainder of this section describes a method by which a temporary HCC may be assigned to unclassified ammunition in order to mitigate explosive safety risks of ammunition in storage. The classification of ammunition i.e. determining its hazard division and compatibility group is fundamental to ensuring safety during transport and storage.

8.2 OVERVIEW OF THE PROBLEM

Ammunition that has not been formally tested by a competent authority poses the unique challenge of classification. Figure 29 shows an example of ammunition packages not marked in accordance with the UN system at a storage site in North Africa.

Figure 29 – Example of Non-UN Classified Ammunition in North Africa.[118]

Most countries have now adopted, or have plans to adopt, the GHS for the classification, labelling and packaging of dangerous goods and, over time, new ammunition will appear with the appropriate markings on its packaging. There are however very large quantities of ammunition now in storage that does not bear appropriate markings and this section provides advice on how this issue could be addressed. It will probably take many years for the legacy of unclassified ammunition to be adequately addressed.

8.3 METHODOLOGY OF ASSESSMENT

Where possible, the classification of a packaged ammunition item should be based on empirical data derived from testing directed by a competent national authority.

It is possible to draw meaningful conclusions, by analogy, from classification tests conducted on similar natures with identical explosive compositions. Caution should be exercised if the ammunition packaging is significantly different, particularly if the nature being assessed is now packaged in a container of a more combustible nature and is likely to be degraded quickly by fire.

Where test data is not available, or it is not possible to assign an interim classification by analogy, then it will require the technical judgement of an appropriately competent person to assess the hazard division of the item and determine its interim hazard classification. Where there is any doubt in the classification of an item, then the higher, or most hazardous classification, should be adopted.

8.4 ASSESSING HAZARD DIVISION

It is recommended that unclassified ammunition is assigned an interim classification based on the hazard divisions shown in Table **2**.

Table 2 – Interim Hazard Classification of Ammunition.

Hazard Division	Description	Pictogram for Ammunition Packages	Fire Division Symbol for Explosive Store Houses
1.1	Ammunition that has a mass explosion hazard		
1.2	Ammunition that has a projection hazard but not a mass explosion hazard		
1.3	Ammunition that has a fire hazard and either a minor blast hazard or a minor projection hazard, or both, but not a mass explosion hazard		
1.4	Ammunition that presents no significant hazard		

Criteria for Assigning Interim Hazard Division 1.1

The following ammunition types could generally be assigned an interim hazard division of 1.1 :

- HE filled aircraft bombs ;
- HE filled shells with a calibre greater than 76 mm ;
- Bulk demolition explosives, detonators, boosters and detonating cords ;
- Anti-tank mines ;
- Specialist combat engineer munitions, such as line clearance charges ;
- HE filled mortar bombs with a calibre greater than 82 mm ;
- High-energy tank propelling charges (i.e. those with a mass explosive hazard) ;
- Free flight rockets with a calibre of 100 mm or greater, fitted with a unitary HE warhead ;
- Air-to-air and air-to-ground missiles fitted with a HE warhead ;
- Anti-ship missiles ;
- Torpedoes fitted with a high-explosive warhead ;
- Anti-submarine depth charges ;
- Anti-ship and anti-submarine mines.

Criteria for Assigning Interim Hazard Division 1.2

The following ammunition types could generally be assigned an interim hazard division of 1.2 :

- Rocket propelled grenades contained within substantial wooden or metal packaging ;
- HE filled grenades contained within substantial wooden or metal packaging ;
- All non-HE filled mortar ammunition ;
- HE filled mortar bombs with a calibre of 82 mm or less contained within substantial wooden or metal packaging ;
- Man-portable anti-tank guided missiles contained within substantial wooden or metal packaging ;
- Man-portable surface to air missiles contained within substantial wooden or metal packaging ;
- Pyrotechnic rockets and flares ;
- Rifle grenades ;
- High-explosive cannon ammunition with a calibre of 57 mm, or less ;
- Free flight rockets with a calibre of 100 mm or greater that are fitted with cluster munition or scatterable mine warheads.

Criteria for Assigning Interim Hazard Division 1.3

The following ammunition types could generally be assigned an interim hazard division of 1.3 :

- Artillery propelling charges (but not charges contained within the same package or container as HE shell) ;
- Tank propelling charges (but not charges contained within the same package or container as HE shell, or containing a high-energy propellant posing a mass detonation hazard) ;
- Non-HE cannon ammunition with a calibre of 57 mm or less ;
- Large pyrotechnic items such as aircraft flares, vehicle screening and incendiary devices ;
- Small arms ammunition with a calibre greater than 12.7 mm.

Criteria for Assigning Interim Hazard Division 1.4

The following ammunition types could generally be assigned an interim hazard division of 1.4 :

- All small arms ammunition with a calibre of 12.7 mm or less ;
- Small pyrotechnic items such as mini-flares and smoke screening grenades (but not those filled with white or red phosphorous).

8.5 ASSESSING COMPATIBILITY GROUP

A suitably qualified and experienced ammunition practitioner is able to assess a particular ammunition nature and assign it to one of the compatibility groups detailed in the IATG.[119)] It is recommended that only a subset of compatibility groups is used for interim consideration and that this is : B, C, D, E, F, G, H and S.

Criteria for Assigning Interim Compatibility Group B

The following ammunition types could generally be assigned an interim compatibility group of B :

- Fuzes and initiators containing primary explosives ;
- Electric and plain detonators.

Criteria for Assigning Interim Compatibility Group C

The following ammunition types could generally be assigned an interim compatibility group of C:

- Artillery propelling charges (but not charges contained within the same package or container as HE shell);
- Tank propelling charges (but not charges contained within the same package or container as HE shell, or containing a high-energy propellant posing a mass detonation hazard);
- Non-HE cannon ammunition with a calibre of 57 mm or less;
- Small arms ammunition with a calibre greater than 7.62 mm.

Criteria for Assigning Interim Compatibility Group D

The following ammunition types could generally be assigned an interim compatibility group of D:

- HE filled aircraft bombs not fitted with a fuze;
- HE filled shells not fitted with a fuze (but not those packaged with a propelling charge);
- Bulk demolition explosives, detonators, boosters and detonating cords;
- Anti-tank mines not fitted with a fuze;
- High-energy tank propelling charges (i.e. those with a mass explosive hazard);
- Anti-submarine depth charges not fitted with a fuze;
- Anti-ship and anti-submarine mines not fitted with a fuze.

Criteria for Assigning Interim Compatibility Group E

The following ammunition types could generally be assigned an interim compatibility group of E (see note below on assigning interim compatibility group F):

- HE filled shells in the same package as a propelling charge;
- Specialist combat engineer munitions, such as line clearance charges;
- HE filled mortar bombs;
- HE filled tank ammunition in the same package as a propelling charge;
- Free flight rockets with a calibre of 100 mm or greater, fitted with a unitary HE warhead;
- Air-to-air and air-to-ground missiles fitted with a HE warhead (but not missiles with liquid propellants);
- Anti-ship missiles (but not missiles with liquid propellants).

Criteria for Assigning Interim Compatibility Group F

Assessing munitions for interim compatibility group F is potentially problematic. Any munition which contains a secondary detonating explosive and a propelling charge and its own means of initiation should be considered as compatibility group F. However, many fuzes and initiators which are fitted to shells, missile warheads and cannon ammunition are considered to possess multiple safety features in order that they and the parent munition to which they are affixed is allocated compatibility group E rather than F. In assessing the safety features present in a fuze consideration should be given, if known, as to whether the detonator is in an 'in-line' or 'out of line' configuration in the unfired munition. 'Out of line' configurations are generally considered safer. Assessing fuze design on recovered munitions is difficult and in the absence of published safety or design data. In the event of uncertainty, munitions should be assessed as compatibility group F.

Criteria for Assigning Interim Compatibility Group G

The following ammunition types could generally be assigned an interim compatibility group of G:

- Large pyrotechnic items such as aircraft flares, vehicle screening and incendiary devices;
- Small pyrotechnic items such as mini-flares and smoke screening grenades (but not those filled with white or red phosphorous).

Criteria for Assigning Interim Compatibility Group H

The following ammunition types could generally be assigned an interim compatibility group of H:

- All tank, artillery and mortar ammunition containing WP;
- All hand and vehicle screening grenades containing WP.

Criteria for Assigning Interim Compatibility Group S

The following ammunition types could generally be assigned an interim compatibility group of S:

- All small arms ammunition with a calibre of 7.62 mm or less which is contained within substantial metal or wooden packaging;
- Ammunition items with an extremely small NEQ not containing a detonating substance contained within substantial metal or wooden packaging e.g. igniters, initiators.

8.6 MARKING OF AMMUNITION PACKAGES

Ammunition packaging forms an important part of an effective ammunition safety management system. Ammunition packages may be encountered which are poorly or incorrectly marked.[120] It is strongly recommended that states classify ammunition in accordance with UN guidelines and best international practice.[121] It is suggested that all ammunition packages be marked with at least the following information :

- Hazard classification code ;
- Nature or designation of ammunition item ;
- Quantity contained within the package ;
- Lot or batch number.

Package markings may be applied at the individual package level or at the pallet level for ammunition natures that are palletized. The condition of ammunition packaging has a critical role to play in maintaining the safety and integrity of the ammunition nature.

8.7 MANAGEMENT OF RECOVERED AND CAPTURED AMMUNITION

Overview of the Problem

Recovered or captured ammunition, including from disarmament, demobilization and reintegration (DDR) programmes, presents a number of issues for authorities :

- The provenance of the ammunition is usually completely unknown ;
- There is usually limited or no technical data on the design, explosive compositions, and NEQ of the nature ;
- The method of operation of the safety and arming of any fuzing or initiation system may not be known ;
- The ammunition natures may be : unpackaged, stored in non-original packaging, or mixed with other potentially incompatible natures.

Safety Considerations for Recovered and Captured Ammunition

Safety is the primary consideration when handling recovered or captured ammunition and it is essential that personnel with both appropriate ammunition technical competences and the necessary explosive ordnance disposal (EOD) skills are used to assess recovered or captured munitions. Figure 30 provides an indication of the technical complexity that may be faced when dealing with recovered or captured ammunition. In this example a large number of differing ammunition natures, some unpackaged and some in a dangerously exposed condition, were identified at a site in central Africa.

Before any large-scale interventions are considered on recovered or captured ammunition, it is essential that a safe area for a CDS is established.

The following issues may be encountered with recovered or captured ammunition:

- It may be poorly or incorrectly packaged;
- It may have been prepared for firing and safety pins or other safety related devices may have been removed;
- It may have been fired and returned incorrectly to store, in effect forming a UXO hazard;
- Incompatible ammunition natures may be stored together;
- Energetic compositions may be hazardous due to age or poor environmental storage.

Figure 30 – Recovered Ammunition at a Collection Site in Central Africa.[122)]

09
TRAINING AND COMPETENCE DEVELOPMENT

People form an essential element in all safety management systems and this is particularly true of ammunition safety management. It is important that training is closely related to and based on the national approach to ammunition safety management.

In conflict-affected and low-capacity environments training is often delivered in an *adhoc* fashion without significant thought given to the development of long-term structures and national capabilities. It is suggested that a systems approach to training (SAT) is adopted and that where national ammunition technical guidelines are not present, the national ammunition safety management system is based on the IATG.

The IATG training courses developed by the UN SaferGuard Programme are fully compliant with SAT and form an excellent basis on which broader ammunition management and technical competences could be developed in conflict-affected and low-capacity environments.

9.1 CORE AMMUNITION TECHNICAL AND MANAGEMENT COMPETENCES

The IATG makes the following comments regarding developing the competences of personnel involved in the operation and management of ammunition storage and processing facilities[123]:

> *The nature of ammunition and explosives with their potential for unplanned, violent reaction makes it necessary to develop recommendations and guidelines for safe conventional ammunition management stockpile management. The effective implementation of the IATG requires well-trained and educated individuals with specialist knowledge. There are no international standards that lay down exactly what competences are required for the various roles within an ammunition management system.*

A fundamental element of any safe system of work is that activities are conducted by appropriately trained and competent personnel. The term 'competence' refers to *the ability of an individual to do the job properly* and the term 'competency' refers to *the related knowledge, skills, abilities, attributes and behavioural traits of an individual.*

The IATG suggests that a functional approach should be taken and the key functional ammunition management roles are defined as follows[124]:

- Ammunition Operator. Assist in the handling and movement of ammunition and explosive substances and articles during issue, receipt, storage and distribution.
- Ammunition Accountant. Accurately account for ammunition and explosive substances and articles.

- **Ammunition Supervisor.** Supervise the issue, receipt, storage, distribution and maintenance and disposal of ammunition and explosive substances and articles.
- **Ammunition Manager.** Manage the storage, issue, receipt, distribution, maintenance and stockpile management of ammunition and explosive substances and articles.
- **Ammunition Processor.** Inspect, maintain and repair ammunition or other explosive substances and articles.
- **Ammunition Inspector.** Develop, implement and audit the policy and technical instructions for all aspects of the stockpile management of ammunition and explosive substances and articles.
- **Ammunition Regulator.** Develop national policy and technical instructions for all aspects of the stockpile management of ammunition and explosive substances and articles.

For conflict-affected and low-capacity environments the acquisition of sufficient technical and management competences to implement an ammunition management and safety system can be daunting. It is recommended that training is delivered incrementally and that it should be in accordance with the UN SaferGuard Programme raining courses on the IATG, which is covered in greater detail in the next section.

9.2 AMMUNITION TECHNICAL AND AMMUNITION SAFETY MANAGEMENT TRAINING

National Defence Policy Drivers for Training

There are a variety of models that can be adopted to provide effective training for the personnel that are involved in the management, receipt, processing, preparation for firing, and issuing of weapons and ammunition. Some armed forces have adopted an almost entirely joint approach[125)] to the training of their armaments engineering officers and technicians. The advantages of this approach are that it allows for national training resources to be focused on specific requirements and economies of scale may be achieved through delivery of training to a larger pool of individuals. The joint approach also helps foster inter-service cooperation. The principal disadvantage of joint training is that it requires a broader range of training to be delivered to all personnel, which increases cost. It also requires purely single service training to be still delivered on a single service basis *i.e.* there is little point in training naval weapon engineering technicians on land force systems, or for training land armaments engineering technicians on naval systems.

Some armed forces deliver training purely on a single service basis. The advantage of this approach is that it allows training to be specifically tailored to the requirements of the individual service, the principal disadvantage is unnecessary duplication of basic level training across a number of separate services with consequent cost implications.

Training Syllabus and National Policies

International training is delivered by a number of states, often on a bilateral basis. In order to achieve consistency of approach it is strongly recommended that all donor funded ammunition technical and management training is delivered in accordance with the IATG, in preference to individual national standards.

9.3 UN SAFERGUARD PROGRAMME TRAINING COURSES ON THE IATG

UNODA provides web-based, publicly accessible training material. [126)] This training should be delivered by appropriately qualified and competent instructors as defined by UNODA. The UN SaferGuard training described below provides satisfactory training to fully cover the functions of the Ammunition Operator, Ammunition Accountant and covers most of the non-technical functions of the Ammunition Supervisor and Ammunition Manager. Further details on the UNODA courses, which are particularly relevant for conflict-affected and low-capacity environments, are shown below:

Small Unit Ammunition Stockpile Management

The aim of the *Small Unit and Ammunition Stockpile Management Course* is to introduce Police, Military, Customs and Border Guard staff as to the specific requirements of the IATG for the safe, effective and efficient storage and handling of ammunition and explosive at the small unit level. [127)]

Small unit ammunition storage is considered to cover the storage of relatively small quantities of primarily hazard division 1.4 in military units and police stations, although the requirements for small quantities of hazard divisions 1.1 to 1.3 are included. It does not cover the storage requirements for large quantities of ammunition of hazard divisions 1.1 to 1.3 at the logistic level in ammunition depots.

The course is only designed to introduce and explain the basic requirements of the IATG for small unit ammunition storage. It does not qualify individuals as being competent as Ammunition Specialists.

Military Ammunition Stockpile Management

The aim of the *Military Ammunition Stockpile Management Course* is to introduce Police, Military, Customs and Border Guard staff as to the specific requirements of the IATG for the safe, effective and efficient storage and handling of ammunition and explosive at the logistic / ammunition depot level.

The course is only designed to introduce and explain the basic requirements of the IATG for ammunition stockpile management at the logistic level in ammunition depots. It does not qualify individuals as being competent as Ammunition Specialists.

Ammunition Accounting and Tracing

The aim of the *Ammunition Accounting and Tracing Course* is to introduce Civil Service, Diplomatic, Police, Military, Customs and Border Guard staff to the appropriate techniques for ammunition accounting and tracing in accordance with the IATG and other international agreements.

9.4 ADDRESSING THE AMMUNITION TECHNICAL COMPETENCE SHORTFALLS IN CONFLICT-AFFECTED AND LOW-CAPACITY SETTINGS

Ammunition Technical Competence Gaps

The following are the critical ammunition technical competence gaps which need to be addressed in order to establish safe systems of work. They are particularly relevant in conflict-affected and low-capacity environments, where captured or recovered ammunition may be present and the overall stockpile may be of unknown technical provenance.

Ammunition Processing

The Ammunition Processor requires the technical competence to conduct the following ammunition processing operations :

- Inspection of Ammunition. Ammunition inspection [128] competences include :
  - Confirmation of the physical condition and quantity of ammunition within an ammunition package and confirmation that the items is stored in approved service packaging ;
  - A visual examination to confirm whether ammunition which has been issued to training or operations and the package have been opened are still fit for use ;
  - Visual detection of signs of corrosion or other deterioration which may indicate the requirement for future ammunition repair tasks or the ammunition nature is deteriorating to the extent that it will soon be unusable and require disposal.

- **Breakdown of Ammunition.** It may often be necessary to breakdown ammunition items as part of a broader ammunition disposal task. The breakdown of ammunition is inherently more hazardous than the inspection of ammunition because explosive fillings are often exposed during the process. There may also be particular hazards associated with the removal of items such as fixed fuzes which mandate the use of remotely operated equipment.
- **Ammunition Packaging.** Ammunition packaging forms an important part of an effective ammunition safety management system. It is often necessary for ammunition to be re-packed or broken down into fraction packs before it is issued.

Ammunition processing is often also associated with ammunition repair and surveillance. It is considered that both activities are unlikely to be achievable in most conflict-affected and low-capacity environments.

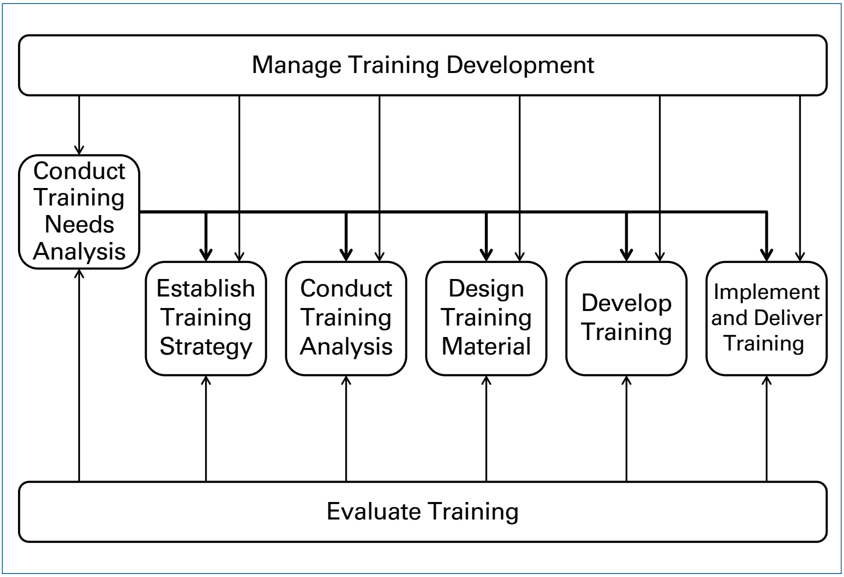
Ammunition Inspector/Manager

Personnel involved in the oversight and technical management of ammunition require to have a more detailed technical understanding of the ammunition natures which stored or processed in order that they can satisfactorily identify hazards and manage risks. The level of technical training required depends largely on the complexity of the munitions which are being stored. Simple natures, such as small arms ammunition require little additional technical training. More complex natures, such as surface-to-air missiles [129)] or most modern sea or air-delivered munitions, require a significant level of technical training if they are to be stored and processed safely.

Using a Systems Approach to Training

A variety of methodologies and models are available and a generic approach that has been adopted by many armed forces is based on the ADDIE model [130)] and this has been further refined into a systems-based approach to training. The advantages of using a systematic approach to training development are that it ensures that a rigorous review of requirements is undertaken and scarce resources are employed efficiently. The SAT is shown in the process diagram at Figure 31.

Figure 31 – Overview of the Systems Approach to Training.



The ISO *Guidelines for Training* articulate a four-stage process for training: defining training needs; designing and planning training; providing for the training; and evaluating the outcome of training.[131)]

9.5 EXPLOSIVE ORDNANCE DISPOSAL TRAINING

Requirement for EOD Training

The ability to destroy unsafe or unserviceable ammunition is a fundamental capability required by all facilities which store and process ammunition

EOD is covered in the IATG in the context of the demilitarization and destruction of ammunition[132)] and in dealing with ASA explosions.[133)] EOD competences and qualifications are not generally covered in the IATG and other international or national references should be consulted[134) 135)]. The most recent definition of recognized international EOD training competences is contained within International Mine Action Standards (IMAS).[136)]

A prerequisite for the safe conduct of EOD within the confines of an ammunition storage and processing facility is the establishment of a safe CDS for the safe disposal of ammunition by OB or OD. The types and size of munitions to be disposed of will determine the detailed safety requirements relating to the planning and implementation of a CDS. It is essential that this informed by a person with suitable ammunition technical competences who is aware of the hazards associated with the munitions which are planned to be destroyed.

Application of IMAS EOD Training Levels

Given the complexity of most OB / OD ammunition disposal tasks, it is only IMAS Level 3, with specific training on logistic demolitions, which is appropriate for personnel concerned with ammunition destruction tasks at ammunition storage and processing facilities.

IMAS training levels are designed to be progressive in order to aid training and development of personnel.

- IMAS Level 1. The IMAS Level 1 EOD qualification enables the trained holder of the qualification, under supervision, to locate, expose and to destroy *in situ*, when possible, single items of mines and specific ERW on which the individual has been trained.
- IMAS Level 2. In addition to the competences at Level 1, the IMAS Level 2 EOD qualification enables the holder to determine when it is safe to move and transport munitions and to conduct the simultaneous disposal of multiple items of ordnance using line mains or ring mains. This qualification extends only to those mines and specific ERW on which the individual has been trained.
- IMAS Level 3. In addition to the competences at Level 1 and 2, the IMAS Level 3 EOD qualification enables the holder to conduct render-safe procedures and final disposal of a wide range of specific types of explosive ordnance on which the individual has been trained ; and, with further training may include :
  - Clearance of armoured fighting vehicles (AFVs) ;
  - Handling and disposal of depleted uranium EO and related hazards ;
  - Handling and disposal of fired and unfired guided weapons ;
  - Intact cluster munitions ;
  - Underwater EOD.

The key to delivering effective EOD training is the identification and selection of personnel with the right temperament and technical suitability to conduct EOD operations. The most effective forms of EOD training are delivered progressively, whereby periods of technical EOD training are interspersed with practical experience.

10

INTERNATIONAL CO-OPERATION AND ASSISTANCE

10.1 WHY INTERNATIONAL CO-OPERATION AND ASSISTANCE IS NEEDED IN CONFLICT-AFFECTED AND LOW-CAPACITY SETTINGS

International stakeholders and donors have an important role to play in developing ammunition management capabilities in conflict-affected and low-capacity environments. The most common reasons for states in conflict-affected and low-capacity settings requiring international assistance are due to : a lack of national resources to fund the project from national resources ; a lack of technical skills to complete the project using the state's own armed forces ; and in post-conflict situations there may be an urgent requirement to manage recovered ammunition.

Resource Constraints

Insufficient resources, capacity, and knowledge are the primary reasons why many states in conflict-affected and low-capacity environments are unable to conduct ammunition safety management projects using their own resources. Government officials with no experience of UEMS will often assign a low priority to ammunition projects when compared to other pressing demands on national budgets. International stakeholders are often better placed to prioritize donor funding for ammunition safety management projects than national entities. In conflict-affected settings, it is often the UN or regional peacekeeping force which can identify ammunition safety issues which require addressing as a matter of urgency.

One of the aims of any development project should be to build long-term national capabilities. It is therefore essential that any projects which are delivered using donor funding do not impose long-term operating cost expenditure on the recipient state. All projects should also be logistically sustainable using national resources and capacities and not require additional downstream international sup-+port in terms of equipment support expertise or replacement parts.

Lack of National Technical Capability

A lack of indigenous capabilities is a very common reason for projects being delivered through international donors ; any training which is delivered as part of the project must be tailored to the operating environment and be specific to the recipient state's needs.

Recovery from Conflict

States recovering from conflict may have limited national and regional government institutions to address issues relating to weapons and ammunition management. If the conflict has resulted in the centralization and collection of weapons, there is likely to be substantial quantities of ammunition which are either unsafe or unserviceable and will require disposal. There may also be a requirement for international entities to assist in the clearance of ERW and UXO inside ASAs.

10.2 ROLE OF NATIONAL AUTHORITIES

National authorities have an essential role to play in the implementation of effective ammunition management systems. In conflict-affected environments, where central government may be playing a minimal role, it is essential that steps are taken at the earliest opportunity to develop national ownership of ammunition management processes. It is a fundamental guiding principle of the IATG that national governments have the right to apply national standards to their national stockpile. [137)]

National Co-ordination

The delivery ammunition management capability enhancements must be co-ordinated and to an agreed national plan. Donors should resist the temptation to deliver training and capability enhancements based on their own national processes and should engage with national and international stakeholders on delivering solutions which meet the specific needs of the recipient nation.

National Programme Considerations for donors ?

The following should be considered in evaluating assistance projects in the ammunition domain :

- National policy (if it exists) ;
- Adherence with international best-practice i.e. are the ammunition management aspects of the project in accordance with the IATG ?
- Enduring benefits of the project if it is delivered i.e. will it contribute to increased public safety ?
- Does it promote or support long-term goals to help institutionalize national explosives safety and security standards ?

Where possible, assistance should be provided with a view to developing domestic standalone capabilities that are compatible with best international practice. Where no existing national regulatory or competence framework exists, it is strongly recommended that the measures described in the IATG are adopted. The development of a national strategy or roadmap on ammunition management is also recommended, especially where there is the involvement of multiple international donors and a requirement to de-conflict projects, and to prevent the duplication of effort.

10.3 DEVELOPMENT OF INFRASTRUCTURE

Assistance in the development of ammunition processing and storage infrastructure is often a high-priority issue and can be addressed by donors through the implementation of discrete projects. The principal issues to be considered in developing ammunition storage and processing infrastructure were covered in Section 6 of this document. Where multiple projects are being delivered it is strongly recommended that a coordinating group be established to oversee the following:

- Specification of project requirements and constraints;
- Oversight of project planning and the specification of key milestones;
- Co-ordination of elements relating to the delivery of the project;
- Project quality assurance;
- Assistance in post-project evaluation.

The project to deliver an enhanced ammunition storage infrastructure in Côte d'Ivoire in 2011 [138)] is a good example of a complex project implemented to meet an urgent operational need in a conflict-affected setting. Figure **32** shows newly constructed ESHs at Seguela. The projected was funded by the UNOCI DDR division, coordinated by UNMAS and delivered by an implementing partner, HALO Trust.

Figure 32 – Construction of New Ammunition Storage Infrastructure in Côte d'Ivoire. [139)]

10.4 TRAINING OF PERSONNEL

Training of personnel is an important element of most capacity development projects in conflict-affected and low-capacity environments. Training is often funded by donors in connection with other ammunition capacity development projects, such as the upgrading or construction of physical infrastructure. In delivering ammunition training in conflict-affected and low-capacity environments, international donors and coordinating entities should consider the following:

- Is the training in accordance with national ammunition strategy, framework or roadmap?
- Is the training pitched at a suitable level where it will be understood by the target audience?
- Is the training part of an integrated package and is it compatible with the IATG?

Training may be delivered in a variety of ways but on the ground practical training is invariably the most appropriate method for acquiring skills for those with a relatively low technical background. Higher level technical training is appropriate for those with the academic and language skills which will fulfil senior appointments in management and regulatory positions. This type of training is invariably best delivered 'out of country' at recognized centres of excellence.

10.5 ASSISTANCE WITH THE DESTRUCTION OF UNSAFE, OBSOLETE, UNSERVICEABLE OR SURPLUS AMMUNITION STOCK

The disposal of unsafe, obsolete or surplus ammunition is a key challenge and significant effort is usually needed to convince states to regard surplus and unserviceable stock as liabilities rather than assets. The technical requirements for the large-scale logistic disposal of ammunition are very different to that of single item demolition of UXO. All EOD training is best delivered in stages with the initial priority being to establish safe explosive handling techniques. In low-capacity and conflict-affected environments it is very likely that EOD training will be required to be provided in conjunction with ammunition safety management training. Figure 33 shows a prepared multi-item demolition during training funded by international donors for a country in the Middle East.

Figure 33 – Multi-Item Demolition Training.[140)]

10.6 ASSISTANCE WITH THE SECURITY OF AMMUNITION STOCKPILES

The security of ammunition stockpiles is particularly important in conflict-affected environments because the availability of unsecured weapons and ammunition can act as an accelerant to armed conflict. In conflict-affected and post-conflict environments, where security is maintained by an international or regional peacekeeping force, then attention should be given to the following:

- Securing central weapons storage facilities and preventing the illicit diversion of weapons and ammunition;
- Denying extremists access to ammunition natures containing bulk HE in order to limit IED proliferation;
- Prioritized destruction of unsafe, obsolete, surplus and unserviceable ammunition;
- If safe to do so, the movement of ammunition from locations where it poses an immediate risk to civilian personnel.

ATTACHMENTS

ANNEX A: REFERENCE TO RELEVANT IATG MODULES

To better understand the relationship between each section of this support document and the IATG, this annex includes each relevant IATG module referenced in each section of the document Utilizing the IATG in Conflict-Affected and Low-Capacity Environments:

Section 3. Context

- IATG 01.10 Guide to the International Ammunition Technical Guidelines (IATG): https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-01.10-Guide-to-IATG-V.2.pdf
- IATG 01.30 Policy Development and Advice: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2017/05/IATG-01.30-Policy-Development-and-Advice-V.2.pdf
- IATG 01.40 Glossary of Terms, Definitions and Abbreviations: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-01.40-Glossary-and-Definitions-V.2.pdf
- IATG 01.90 Ammunition Management Personnel Competences: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-01.90-Personnel-Competences-V.2-rev.pdf
- IATG 02.10 Introduction to Risk Management Principles and Processes: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-02-10-Introduction-to-Risk-Management-Principles-V.2.pdf

Section 4. Improving Safety – Reducing the Risk of Accidental Explosions

- IATG 01.20 Index of Risk Reduction Process Levels (RRPL) within IATG: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-01.20-Index-of-Risk-Process-Levels-V.2.pdf
- IATG 01.50 UN Explosive Hazard Classification System and Codes: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-01.50-UN-Explosive-Classification-System-and-Codes-V.2.pdf
- IATG 01.80 Formulae for Ammunition Management: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-01.80-Formulae-for-Ammunition-Management-V.2.01.pdf
- IATG 01.90 Ammunition Management Personnel Competences: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-01.90-Personnel-Competences-V.2-rev.pdf
- IATG 02.10 Introduction to Risk Management Principles and Processes: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-02-10-Introduction-to-Risk-Management-Principles-V.2.pdf

- IATG 02.20 Quantity and Separation Distances : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-02-20-Quantity-and-Separation-Distances-V-2.pdf
- IATG 02.30 Licensing of Explosive Facilities : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-02.30-Licensing-of-ESA-V.2.pdf
- IATG 02.50 Fire Safety : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-02.50-Fire-Safety-V.2.pdf
- IATG 03.10 Inventory Management : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-03.10-Inventory-Management-V.2.pdf
- IATG 03.20 Lotting and Batching : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-03.20-Lotting-and-Batching-V.2.pdf
- IATG 03.30 International Transfer of Ammunition Module : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-03.30-International-Transfer-Module-V.2.pdf
- IATG 03.40 End-user and End-use of Internationally Transferred Ammunition Module : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-03.40-End-Use-Module-V.2.pdf
- IATG 03.50 Tracing of Ammunition : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-03.50-Tracing-V.2.pdf
- IATG 05.20 Types of Buildings for Explosives Facilities : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-05.20-Types-of-Buildings-for-Explosives-Storage-V.2.pdf
- IATG 05.30 Barricades : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-05.30-Barricades-V.21.pdf
- IATG 05.40 Safety Standards for Electrical Installations : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-05.40-Electrical-Installation-V.2.pdf
- IATG 05.50 Vehicles and MHE in Explosives Facilities : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-05.50-MHE-V.2.pdf
- IATG 05.60 Radio Frequency Hazards : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-05.60-RF-Hazards-V.2.pdf
- IATG 06.10 Control of Explosives Facilities : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-06.10-Control-of-Explosives-Facilities-V.2.pdf
- IATG 06.20 Storage Space Requirements : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-06.20-Storage-Space-Requirements-V.2.pdf
- IATG 06.30 Storage and Handling : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-06.30-Storage-and-Handling-V.2.pdf
- IATG 06.40 Ammunition Packaging and Marking : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-06.40-Packaging-and-Marking-V.2.pdf

- IATG 06.80 Inspection of Ammunition: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/12/IATG-06.80-Inspection-of-Ammunition-V.2REV-cat-D3.pdf
- IATG 07.20 Surveillance and In-service Proof: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-07.20-Surveillance-and-In-Service-Proof-V.2.pdf
- IATG 10.10 Demilitarization and Destruction of Conventional Ammunition: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-10.10-Demilitarization-and-Destruction-V.2.pdf

Section 5. Mitigating and Managing the Effects of Accidental Explosions

- IATG 02.20 Quantity and Separation Distances: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-02-20-Quantity-and-Separation-Distances-V-2.pdf
- IATG 02.30 Licensing of Explosive Facilities: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-02.30-Licensing-of-ESA-V.2.pdf
- IATG 02.40 Safeguarding of Explosive Facilities: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-02.40-Safeguarding-of-Explosive-Facilities-V.2.pdf
- IATG 05.30 Barricades: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-05.30-Barricades-V.21.pdf
- IATG 07.10 Safety and Risk Reduction (Ammunition Processing Operations): https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-07.10-Safety-and-Risk-Reduction-V-2.pdf
- IATG 09.10 Security Principles and Systems: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-09.10-Security-Principles-and-Systems-V.2.pdf
- IATG 11.30 Ammunition Storage Area Explosions - EOD Clearance: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-11.30-ASA-Explosions-EOD-Clearance-V.2.pdf

Section 6. Planning Considerations

- IATG 05.10 Planning and Siting of Explosives Facilities: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-05.10-Planning-and-Siting-Explosives-Facilities-V.2.pdf
- IATG 05.20 Types of Buildings for Explosives Facilities: https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-05.20-Types-of-Buildings-for-Explosives-Storage-V.2.pdf
- IATG 06.60 Work Services (Construction and Repair): https://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/IATG-06.60-Works-Services-V.2.pdf

Section 7. Implementing Effective Security Measures and Preventing Stock Diversion

- IATG 09.10 Security Principles and Systems : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/ IATG-09.10-Security-Principles-and-Systems-V.2.pdf

Section 8. Managing Unclassified Ammunition

- IATG 01.50 UN Explosive Hazard Classification System and Codes : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/ IATG-01.50-UN-Explosive-Classification-System-and-Codes-V.2.pdf
- IATG 06.40 Ammunition Packaging and Marking : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/ IATG-06.40-Packaging-and-Marking-V.2.pdf

Section 9. Training and Competence Development

- IATG 01.90 Ammunition Management Personnel Competences : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/ IATG-01.90-Personnel-Competences-V.2-rev.pdf
- IATG 06.80 Inspection of Ammunition : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/12/ IATG-06.80-Inspection-of-Ammunition-V.2REV-cat-D3.pdf
- IATG 12.20 Small Unit Ammunition Storage : https ://s3.amazonaws.com/unoda-web/wp-content/uploads/2016/11/ IATG-12.20-Small-Unit-Ammunition-Storage-V.2.pdf

NOTES

1) Photo : British Army Principal Ammunition Technical Officer, 2009.
2) Small Arms Survey, updated February 2018 with data covering the period January 1979 to February 2018,
3) *Cyprus Accident Part 2,* presentation by Dr Michael Sharp, Emmanuel Schultz and Thomas Taylor, NATO MSIAC, at the Australian Defence Force Explosive Safety Symposium (Parari), 2013.
4) The term ammunition nature is used to specify a generic type of ammunition and encompasses all explosive items required to form a fireable load ; for example for artillery ammunition, it includes the propelling charge, igniter, shell and fuze.
5) *Small Arms and Light Weapons Report of the Secretary General*, S/2017/1025, UNSC, 6 December 2017.
6) *Diversion Digest,* Conflict Armament Research, 1 August 2018.
7) Photo : MSGT J Bowman, United States Air Force, released under DF-SD-OF-02188 dated 22 August 2003.
8) In this context 'unclassified' means ammunition which has not been tested or assessed by a competent body for the purposes of evaluating its hazard classification code.
9) See UNIDIR WAM documentation here http://www.unidir.ch/publications
10) IATG 01.10 *Guide to the International Ammunition Technical Guidelines (IATG),* second edition, UNODA, 2015.
11) IATG 01.30 *Policy development and advice (IATG),* second edition, UNODA, 2015.
12) The lack of provenance and an absence of hazard classification data is a particular problem associated with captured ammunition.
13) The concept of safeguarding *i.e.* ensuring inhabited buildings or other vulnerable structures are not constructed within the area hazarded by an ammunition site is covered later in this document.
14) The development of the structural element and the importance of national ownership is covered in : *A Practical Guide to Life-cycle Management of Ammunition,* Section 2.6.1, Carapic, Deschambault, Holtom and King, Small Arms Survey, April 2018
15) IATG 01.90 *Ammunition management personnel competences,* second edition, UNODA, 2015.
16) *Op Cit* Small Arms Survey, 2018.
17) *Weapons of the Islamic State,* Conflict Armament Research, December 2017.
18) *General and complete disarmament : problems arising from the accumulation of conventional ammunition stockpiles in surplus,* UNGA Resolution 72/55, document A/C.1/72/L.43, 12 October 2017.
19) *Effective Control of Explosive Ordnance – A Critical Factor in Upstream IED Proliferation – Lessons Learned in Libya,* a paper by Bob Seddon, Paul Grimsley and Lance Malin presented at the Meeting of National Mine Action Programme Directors and UN Advisors, 15 February 2018.
20) SVBIED intercepted at a checkpoint in the vicinity of Abugrein by Libyan Security Force personnel and rendered safe by a Libyan Police/MOI IEDD team on 11 January 2018. Photo : Libyan MOI.
21) IATG 02.10 *Introduction to risk management principles and processes,* second edition, UNODA, 2015
22) IATG 01.40 *Glossary of terms, definitions and abbreviations,* second edition, UNODA, 2015.

23) IATG 02.10 *Introduction to risk management principles and processes,* second edition, UNODA, 2015.
24) IATG 02.30 *Licensing of explosive facilities,* second edition, UNODA, 2015.
25) *Op Cit* IATG 02.10 Annex G.
26) IATG 02.30 *Licensing of explosive facilities,* second edition, UNODA, 2015.
27) At present, the Toolkit can only be accessed via internet, which could be a constraining limitation in low-capacity and conflict-affected settings
28) Calculations in these tools are based on : IATG 01.80 *Formulae for ammunition management* and IATG 02.20 *Quantity and separation distances,* second edition, UNODA, 2015.
29) https ://www.un.org/disarmament/un-saferguard/explosion-consequence-analysis/
30) The ECA provides an assessment of the effects of blast, but not primary or secondary fragmentation resulting from an explosion.
31) https ://www.un.org/disarmament/un-saferguard/map/
32) https ://webwiser.nlm.nih.gov/getHomeData.do WISER is also available for standalone PCs and a variety of mobile platforms.
33) https ://www.un.org/disarmament/un-saferguard/risk-reduction-process-levels/
34) IATG 03.10 *Inventory management,* second edition, UNODA, 2015 and IATG 06.20 *Storage space requirements,* second edition, UNODA, 2015
35) IATG 02.30 *Licensing of explosive facilities,* second edition, UNODA, 2015.
36) IATG 01.50 *UN explosive hazard classification system and codes,* second edition, UNODA, 2015 and this subject is covered in greater detail in Section 8 of this document.
37) IATG 03.10 *Inventory management,* second edition, UNODA, 2015 and IATG 06.20 *Storage space requirements,* second edition, UNODA, 2015
38) Ammunition accounting is covered in several IATG including : 03.10 *Inventory management ;* 03.20 *Lotting and batching* ; 03.30 *International transfer of ammunition ;* 03.40 *End-user and end-use of internationally transferred ammunition ;* 03.50 *Tracing of ammunition ;* UNODA, 2015.
39) IATG 06.30 *Storage and handling,* second edition, UNODA, 2015
40) IATG 05.50 Vehicles and mechanical handling equipment (MHE) in explosives facilities, second edition, UNODA, 2015.
41) IATG 06.30 Storage and handling, second edition, UNODA, 2015
42) In tropical conditions pallets and wooden boxes should be treated with an appropriate insecticide to prevent damage from wood boring insects. In the past, pentachlorophenol (PCP) was used to preserve wood used for the manufacture of ammunition boxes and pallets ; this material though poses a potential long-term toxic hazard and necessitates disposal as hazardous waste.
43) Photo : UNMAS, 2012.
44) IATG 05.20 *Types of buildings for explosive facilities,* second edition, UNODA, 2015.
45) IATG 06.40 *Ammunition packaging and marking,* second edition, UNODA, 2015
46) IATG 06.50 *Specific safety precautions (storage and operations),* second edition, UNODA, 2015.
47) IATG 06.30 *Storage and handling,* second edition, UNODA, 2015
48) IATG 06.10 *Control of explosives facilities,* second edition, UNODA, 2015.
49) *Op Cit* IATG 06.50 Section 10.
50) Photo : Samuel Paunila, 2016.

51) *The Globally Harmonized System of Classification and Labelling of Chemicals* (GHS) is an internationally agreed upon standard managed by the UN. It provides standardized testing criteria, universal warning symbols, and harmonized safety data sheets. The GHS complements the UN Numbered system of regulated hazardous material transport. GHS implementation is *managed through the UN Secretariat and has been enacted in EU law under the Classification, Labelling and Packaging* (CLP) regulations and in the US under *Occupational Safety and Health Administration* (OSHA) standards.
52) IATG 01.50, *UN explosive hazard classification system,* second edition, UNODA, 2015.
53) The pictograms in this table adhere to the Classification, Labelling and Packaging (CLP) Regulation (EC No 1272/2008) and is based on the UN GHS.
54) *Op Cit* IATG 01.50 Section 7.1.
55) A certain degree of segregation in storage may be achieved by interposing small arms ammunition with a hazard classification of 1.4S between other natures which may be incompatible in storage.
56) Recovered or captured ammunition often presents safety issues due to its unknown provenance. Often captured ammunition is unpackaged, or poorly packaged thus representing a significant challenge in determining the appropriate hazard classification code.
57) White Phosphorus (WP) melts at 44˚ C, a temperature often reached inside ESHs in hot-dry and tropical areas of the world. In liquid form, WP can migrate through fuze wells and fuze or plug threads and spontaneously ignite on contact with air. It is for this reason, where possible, that plugged or fuzed WP filled ammunition items should be stored with the plug or fuze uppermost.
58) *Op Cit* IATG 06.30 Section 5.5.3.
59) *Op Cit* IATG 01.50 Section 7.1.
60) Photo : KF Armory, www.kfarmory.com 2018.
61) Photo : Canadian DoD, 2010.
62) IATG 05.30 *Barricades,* para 9.2.1, second edition, UNODA, 2015.
63) The compatibility group of a given ammunition nature is highly dependent on the type and configuration of packaging. It is possible to procure detonators with packaging with a hazard division of 1.4 *i.e.* presenting no significant hazard. Where segregated or separate ammunition storage is at a premium, consideration should be given to procuring detonators with a 1.4 hazard division.
64) IATG 02.50 *Fire safety,* second edition, UNODA, 2015.
65) IATG 05.60 *Radio frequency hazards,* second edition, UNODA, 2015.
66) IATG 02.50, *Fire safety,* UNODA, 2015.
67) Open stacked ammunition poses the greatest fire vulnerability and ammunition which is easy to ignite, such as that contained within wooden packaging or natures containing explosive materials with a low ignition temperature, such as propellants, should not generally be stored in open stacks.
68) IATG 05.40 *Safety standards for electrical installations,* Section 8, *Lightning protection systems,* second edition, UNODA, 2015
69) Image : Vaisala Global Lightning Data.

70) On 11 July 2011 a catastrophic explosion occurred at the Evangelos Florakis Naval Base in Cyprus, the incident involved the spontaneous ignition of a substantial quantity of bulk military propellants and resulted in the deaths of 13 personnel, including the head of the Cyprus Navy. The explosion badly damaged a nearby electricity generation station and caused approximately €3 billion of damage.
71) IATG 07.20 *Surveillance and in-service proof,* Section 7.3, Table 1, second edition, UNODA, 2015.
72) Photo : Paul Grimsley, UNMAS Libya, 2012. This image shows exposed propellants from artillery propelling charges found at an ASA in Libya after the 2011 revolution.
73) *Op Cit* IATG 07.20 Section 7.3.
74) *Unplanned Explosions at Munitions Sites (UEMS) - Excess Stockpiles as Liabilities rather than Assets,* EG Berman and P Reina, Small Arms Survey, June 2014.
75) *Ammunition Depot Explosions* in : *Conventional Ammunition in Surplus - A Reference Guide,* A Wilkinson, edited by J Bevan, Small Arms Survey, 2008.
76) This is achievable if propellants are configured in separate packages to their parent projectiles as is often the case with artillery propelling charges. It may not be feasible to separate propellants with certain QF fixed or QF semi-fixed ammunition natures.
77) There are often no visible signs that ammunition containing propellants has dangerously low stabilizer content. Any visible signs of deterioration, such as scorching or expansion on ammunition packages should be treated as a danger signal and acted on immediately.
78) IATG 06.80 *Inspection of ammunition,* second edition, UNODA, 2015
79) IATG 10.10 *Demilitarization and destruction of conventional ammunition,* second edition, UNODA, 2015.
80) Photo : Graham Brooks, 2014.
81) Photo : Graham Brooks, 2014.
82) Photo : Rory James, 2018.
83) IATG 02.20 *Quantity and separation distances,* second edition, UNODA, 2015.
84) *Op Cit* IATG 02.20 para 3.
85) Quantity distances calculated assuming both the PES and ES are barricaded open stacks or light buildings.
86) IATG 02.30 *Licensing of explosive facilities,* second edition, UNODA, 2015.
87) IATG 02.40 *Safeguarding of explosive facilities,* second edition, UNODA, 2015.
88) The UEMS at the Ikeja Military Cantonment in Lagos, Nigeria, which occurred on 27 January 2002 resulted in the deaths of over 1,100 people and the displacement of a further 20,000.
89) The UEMS at the army ammunition depot in Brazzaville which took place on 4 March 2012 killed over 250 people.
90) IATG 05.30 *Barricades,* second edition, UNODA, 2015.
91) Photo : British Army Principal Ammunition Technical Officer, 2009.
92) IATG 11.30, *Ammunition storage area explosions – EOD clearance,* second edition, UNODA, 2015.

93) HMX undergoes a phase transition when subjected to elevated temperatures below its deflagration temperature which very significantly increases its sensitiveness. Similarly, the melting and re-crystallising of TNT may expose more sensitive isomers or cause sensitive explosive compositions to migrate into fuze threads or other joints or interfaces in the munition, thus posing a hazard to any one handling the item.
94) IATG 09.10 *Security principles and systems,* second edition, UNODA, 2015.
95) IATG 07.10 *Safety and risk reduction (ammunition processing operations),* second edition, UNODA, 2015
96) IATG 05.20 *Types of buildings for explosives facilities,* second edition, UNODA, 2015.
97) IATG 05.10 *Planning and siting of explosives facilities,* second edition, UNODA, 2015.
98) *Op Cit* IATG 02.10 Annex G.
99) Also known as drones.
100) Photo : British Army Principal Ammunition Technical Officer, 2009.
101) Photo source : ARMAG www.armagcorp.com 2018.
102) Photo source : British Army Principal Ammunition Technical Officer, 2007
103) Photo : Paul Grimsley, UNMAS Libya, 2013.
104) Image : ARMAG www.armagcorp.com 2018.
105) Photo : ARMAG www.armagcorp.com 2018.
106) IATG 06.60 *Works services (construction and repair),* second edition, UNODA, 2015.
107) Windows should be avoided because of the high risk of fatalities associated with glass shards produced by an explosion. Buildings with windows should have them covered, or removed, to prevent the generation of glass shards in the event of an explosion.
108) IATG 09.10 *Security principles and systems,* second edition, UNODA, 2015.
109) IATG 09.10 *Security principles and systems,* second edition, UNODA, 2015
110) Preventing smoking materials and other ignition sources from being brought into the facility enhances safety through the elimination of potential ignition sources.
111) Lighting can illuminate security patrols and can also produce deep areas of shadow which can be exploited by intruders.
112) Image : Séamus McMenamin and Paul Grimsley, UNMAS, 2017.
113) IATG 12.20 *Small unit ammunition storage,* second edition, UNODA, 2015.
114) *OP Cit* IATG 09.10 Section 8.5.1.
115) *Op Cit* IATG 09.10 Table 1.
116) IATG 01.50 *UN explosive hazard classification system and codes,* second edition, UNODA, 2015.
117) Multilateral Agreement M266 developed initially by the Swedish Civil Contingencies Agency, 1 Aug 13, provides a mechanism for contracting parties of ADR to overpack and mark explosive substances and articles belonging to armed forces which are destined for destruction.
118) Photo : UNMAS, 2011.
119) *OP Cit* IATG 01.50 Section 6.2 – Compatibility Groups.
120) Incorrect marking of ammunition packages may have been undertaken in order to disguise the source of the ammunition or to facilitate illicit transfers across borders in contravention of prevailing arms embargoes or sanction.

Notes

121) IATG 01.50 *UN explosive hazard classification system and codes,* second edition, UNODA, 2015.
122) Photo : Daniel Perkins, 2014.
123) IATG 01.90 *Ammunition management personnel competences,* second edition, UNODA, 2015.
124) *Op Cit* IATG 01.90 para 3, Table 1,
125) In this context ‘joint’ means all naval, land, air, and air defence forces.
126) www.un.org/disarmament /ammunition/iatg/training. The training materials are based on 2011 version of the IATG
127) IATG 12.20 *Small unit ammunition storage,* second edition, UNODA, 2015.
128) IATG 06.80 *Inspection of ammunition,* second edition UNODA, 2015.
129) Surface-to-air missiles which employ toxic liquid propellants have particular, hazards, not all of them explosive, which could affect the civilian population beyond the perimeter of the ammunition storage and processing facility.
130) The ADDIE (Analyse, Design, Development, Implement, Evaluation) Model is an instructional design model first created by the Center for Educational Technology at Florida State University in 1975.
131) ISO 10015 :1999, *Quality management – Guidelines for training,* edition 1, 1999.
132) IATG 10.10 *Demilitarization and destruction of conventional ammunition,* second edition, UNODA, 2015.
133) IATG 11.30 *Ammunition storage area explosions – EOD clearance,* second edition, UNODA, 2015.
134) *Explosive Ordnance Disposal (EOD) Principles and Minimum Standards of Proficiency,* NATO Allied EOD Publication 10, Edition B, Version 1, September 2014.
135) Test and Evaluation Protocol 09.30 *EOD Competency Standards,* Version 1.0, UNMAS, 30 October 2014.
136) IMAS 09.30 *Explosive ordnance disposal,* second edition, amendment 5, October 2014.
137) *Op Cit* IATG 01.10 Section 6.
138) *UNMAS Physical Security and Stockpile Management Pilot Project, Cote d’Ivoire Case Study,* GICHD, September 2012.
139) Photo : Richard Boulter, UNMAS, 2012.
140) Photo : Graham Brooks 2014.

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