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Dynamic Disposal

An Introduction to Mobile and Transportable Industrial Ammunition Demilitarization Equipment

Introduction

When governments are considering how to address their existing and future demilitarization requirements, they generally have two options. Where no demilitarization facilities exist, states can build new, fixed ones near to stockpiles. Alternatively, they can move their stockpiles to existing demilitarization facilities. In either scenario, surplus ammunition is typically transported from storage depots to purpose-designed, industrial demilitarization facilities.

Such internal or cross-border movement of ammunition is legislatively challenging and logistically costly. Consequently, commercial contractors have modified existing demilitarization technologies to be mobile—not fixed to a permanent installation, i.e. movable from stockpile to stockpile—and have developed modular, transportable technologies (set up on a temporary foundation) which can operate over a relatively long period in a place, before being moved to another. The strategy of bringing a self-contained plant to the munitions for the period required for a specific disposal reduces the cost of transporting munitions and circumvents the costs of creating permanent infrastructure.

Yet the user community is often unaware of the capabilities, assets, and limitations of mobile and transportable demilitarization equipment. In order to allow potential users and commercial providers to consolidate their respective requirements and create a viable business case for the use of mobile technology, the NATO Support Agency (NSPA, formerly NAMSA)[1] organized a conference on Mobile Equipments for Ammunition Demilitarization (MEAD) which was held in Capellen, Luxembourg, on 31 May 2012. That the event convened more than 132 participants from 32 countries indicates the interest of clients and providers in this type of equipment. NSPA has published a catalogue of mobile equipment and makes it available on request to authorized Ammunition Support Partnership (ASP) representatives. The catalogue provides details from the manufacturers of different types of equipment associated with MEAD, from individual tools and machines to complete systems.

This Regional Approach to Stockpile Reduction (RASR) *Issue Brief* compiles unclassified information gathered by the Small Arms Survey at the MEAD conference and aims to raise awareness about the technologies, capabilities, and limitations of mobile and transportable ammunition[2] demilitarization equipment within the RASR community. Instead of reporting on the full catalogue of equipment and technologies, it mentions *select* examples of systems that are being currently marketed, undergoing prototype development, or are at the concept and design phase. These examples are listed not to foster commercial competition, but simply because certain data was available or provided by contractors at the time of writing. Readers should consult NSPA for further details of capability and capacity.

The *Issue Brief*'s main findings are as follows:

- The main justification for mobile and transportable demilitarization equipment is to circumvent the logistics and costs associated with ammunition transportation.
- The majority of the mobile plants advertised on the demilitarization market are still prototypes under development, awaiting contractual funding. Few systems have a proven track record in the field.
- The demilitarization industry does not make a formal distinction between 'mobile' and 'transportable' equipment. Manufacturers use the terms interchangeably.
- Compared to fixed industrial processing lines, mobile or modular demilitarization processes tend to be slow, low-capacity, and better suited to small-calibre or low-net explosive quantity (NEQ)[3] items, which require simpler technologies to handle.
- Despite the logistical savings that system mobility provides, clients should anticipate a range of

requirements and expenditures pertaining to installation and start-up, personnel, resources, and maintenance.

- In South-east Europe (SEE), similar donor requirements, ammunition storage concerns, and gaps in existing demilitarization technology may plead in favour of mobile and transportable systems where financially viable.
- The specialist processing of relatively small quantities of munitions containing White Phosphorous (WP) in several different SEE locations provides a suitable opportunity for mobile equipment to be used.

Avoiding ammunition transportation

The main justification for mobile and transportable demilitarization equipment is to avoid the logistic constraints and costs associated with transporting ammunition.

Using a fixed demilitarization facility requires that ammunition be transported from the depot to the facility by either land (road or rail), sea, or air. In most countries, ammunition transportation is a significant logistical undertaking, demanding that specific safety and regulatory measures be adhered to. Significant challenges include: marking and palletizing ammunition, arranging for import/export permits and the relevant documentation, planning for emergency procedures, and taking out insurance for the ammunition in transit.

During transport, ammunition and explosives to be demilitarized are essentially categorized as dangerous goods and sometimes, in addition, as hazardous waste. Munitions classified as dangerous goods are transported in accordance with national legislation based on the UN classification system, the Orange Book. Rail and road transport are governed by comprehensive directives and regulations such as the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) (UNECE, 2009) and the UN Recommendations on the Transport of Dangerous Goods: Model Regulations (13th revised edition) (UN, 2003). When the ammunition is also classified as hazardous waste, the transportation and storage thereof will be subject to additional regulation and permit requirements, governed by countries' environmental agencies. This affects, for example, the transport of explosive-contaminated material for incineration at another facility. A consequence of classifying munitions as hazardous waste is the application of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (UNEP, 1989) which restricts the export of hazardous waste, in particular from developed countries to developing countries.

Vehicle, personnel, maintenance, and fuel logistics have tremendous effects on the overall cost of demilitarization (King and Diaz, 2011, pp. 30–32). In 2005, for instance, the US Army estimated that simply removing its ammunition stocks from storage facilities and stockpiling them outdoors cost, on average, an estimated USD 53 per tonne (Donaldson, 2005, p. 3). A recent study reveals that, in the United States, packaging, crating, handling, and transportation (PCHT) costs represent, on average, 35 per cent of average demilitarization costs (Boyer, 2012).

Transportation costs also have a significant impact on donor-funded demilitarization programmes, which often require that the host country provide essential resources and facilities and handle the logistics and transportation of weapons and munitions to the disposal site (Courtney-Green, 2007, p. 4). For instance, in the NATO PfP (Partnership for Peace) Trust Fund project, ammunition transportation costs relating to NSPA's Albania III project alone were estimated initially at EUR 3.8 million (USD 5.2 million) or EUR 50 (USD 68) per tonne[4] (NAMSA, 2009b, p. 11). This estimate represented about 44 per cent of the total Albanian Ministry of Defence (MoD) in-kind contribution to the project (Towndrow, 2010, slide 11). In 2011 alone, the Logistic Brigade of the Albanian Army moved over 6,600 tonnes of ammunition, representing 10 million separate items of ammunition, from individual depots around the country to Mjekes, Albania's main demilitarization factory (NAMSA, 2012a, p. 5).

Finally, avoiding the transportation of ammunition becomes especially relevant when its packaging has deteriorated or ammunition surveillance has not been carried out properly, and accordingly the ammunition cannot be declared safe to move. In the case of propellants containing nitrocellulose, the primary risk is that of autocatalytic decomposition, which can result in spontaneous ignition, leading to mass explosions in inappropriately managed ammunition storage sites (ASS).

For other munitions, the packaging may have deteriorated to the extent that it would no longer protect the munitions if they were dropped or damaged in a vehicle accident. This could lead to a major incident if, for example, friction-sensitive energetic material were to exude from damaged or deteriorated munitions.

The physical condition of the ammunition stockpile may not allow safe transport and may justify the in-situ industrial demilitarization of smaller quantities. Normally, open burning/open detonation (OB/OD) is carried out locally to deal with unsafe munitions, but there are cases when this is not possible and some relatively small-scale industrial processing is preferable.

Developing definitions

Technology Readiness Levels

When specific types of ordnance need to be disposed of in a limited time period, a number of commercial organizations can be called upon to provide mobile and transportable ammunition demilitarization plants. Given how costly designing, developing, and fielding a new system are, mobile plants are generally constructed subsequent to the signing of a contract. Consequently, many if not most of the mobile plants advertised in the demilitarization market are still prototypes in development, awaiting contractual funding. Some equipment is envisaged as modular components that can be assembled quickly and reliably, to fulfil a demilitarization contract. Few of these systems have a proven track record, however.

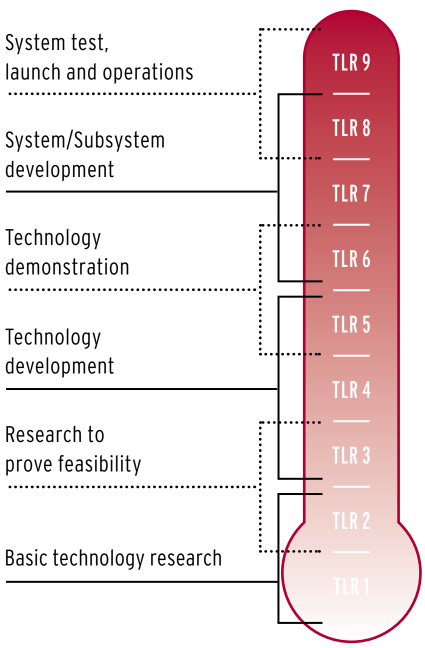
Government agencies and commercial companies use Technology Readiness Levels (TRLs) to assess the maturity and applicability of evolving technologies. TRLs indicate the maturity of a given type of equipment in a user context. They provide an indication as to whether the equipment is still in the research phase, whether a prototype exists, or whether the system is widely used. NATO proposes nine TRLs: from 1 (basic research with future military capability in mind) to 9 (an actual system that is operationally proven as a result of successful mission operations) (Schneider et al., 2008, Annex A). For instance, NSPA's calling notice for the MEAD conference specified that the event strive to showcase mobile and transportable equipment falling between TRLs 6 and 9 (NAMSA, 2012b, p. 1).

Some systems with low TRLs, although technologically advanced, are years away from completion or are not financially attractive to RASR-participating countries. As an example, General Atomics' Transportable Cryofracture[5] Project, which employs five ISO containers with equipment to support remote and automatic cryofracture operations, is currently at TRL 8. System test and live tests are to be conducted in 2013. The company allegedly anticipates charging USD 2.5–3 million for the system.[6] A further drawback for deployment in SEE is that cryofracture calls for large quantities of liquid nitrogen and is consequently unsuitable in locations where liquid nitrogen is not readily available (Follin, 2012).

The international donor community or a nation looking for a Commercial Off-The-Shelf (COTS) system will rarely take on the financial and technical risks of funding a system that has not been proven operationally. Rather, they will favour an operationally proven, environmentally compliant, continuous disposal system with a high production rate. Consequently, those RASR-participating countries interested in investing in mobile demilitarization technologies should look for TRL 9.

The allocation of TRLs to specific equipment or contractor plans is normally carried out only after detailed analysis and in agreement with the manufacturer. TRLs are evaluated at a particular time and can evolve rapidly (such as within a few months), with customer plans and funding. This *Issue Brief* refers to the TRL levels indicated by manufacturers in the 'Company Equipment Fact Sheets' that were provided to NSPA, prior to the MEAD conference.

Figure 1 **Technological Readiness Levels**



Source: Schneider et al. (2008, Annexe A)

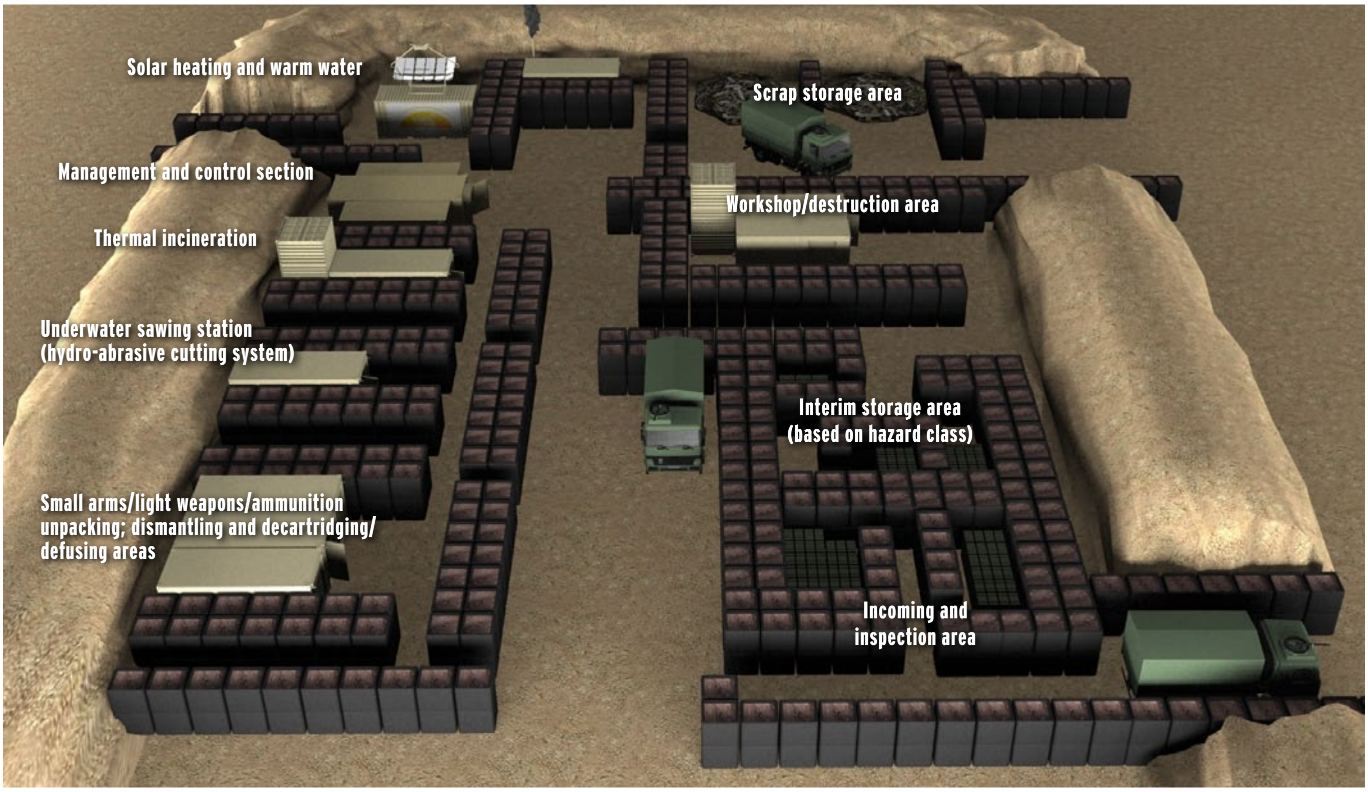
Mobile, modular, or transportable equipment?

In anticipation of the MEAD conference, NSPA distinguished between 'mobile' and 'transportable' equipment as follows: *mobile* equipment was defined as 'self contained equipment on wheels or ISO container based with no site preparation and ready to operate within 1 to 2 days' and *transportable* equipment as 'mobile equipment that can be set up on site with minimal preparation within 7 days' (NAMSA, 2012b, p. 7).

In both definitions, the defining factor is the length of set-up time required (excluding transport to the demilitarization site) before the system becomes operational. In reality, this delay must often be extended to accommodate the set-up time required for various utilities and permits (see the discussion under 'Resources and utilities').

Implicitly, the MEAD concept requires that certain technologies and machines be integrated into a demilitarization line that disposes of ammunition and leaves behind only *non-hazardous* waste. The concept also incorporates the following key features: operator training, the segregation of work staging areas with barriers and systems to ensure operator safety, as well as modularity and flexibility (application for different types and calibres of ammunition).

Mobile equipment components are often integrated into standardized ISO maritime containers and are frequently towed or self-propelled (wheeled). Their installation requires little or no



steep GmbH's prototype Modular Containerized Transportable Facility. © steep GmbH/2012

support infrastructure. The containers can be installed on any hard surface and to operate require fuel (oil or gas), electricity, and water supply and drainage (NAMSA, 2009a, p. B-3; see 'Resources and utilities'). An example of such a system is EODSolutions' Transportable Ammunition Destruction System (TRADS) (TRL 9). The entire system fits inside a 40-foot (12.19 x 2.44 x 2.59 m external dimensions) ISO container, including the generator, compressor, filtration, and lifting legs (EODSolutions, 2012). Other companies have chosen to design their systems to fit into the 20-foot (6.06 x 2.44 x 2.59 m external dimensions) format ISO 668 1CC of the standard shipping container, because it provides greater flexibility in transportation and on-site handling (Oliván, 2012).

Transportable equipment involves multi-containerized systems, in segregated modules, that often depend upon other components and set-up arrangements, such as a crane, to become operational. They usually occupy a larger surface area (footprint). Sketches of prototype systems—such as steep GmbH's deployable camp for ammunition demilitarization (TRL 3), a shared project of three firms, steep GmbH, Spreewerk Lübben GmbH, and FHF Flur-Fördergeräte GmbH (Germany)[7] —indicate a storage area, a dismantling and defusing area, an underwater sawing station, a thermal incineration area, a shell and grenade destruction area, a management and remote control area, and a scrap storage area (Spreewerk Lübben GmbH, 2012).

One example of an existing operational system is JAKUSZ's Planetarium system (TRL 9) which, although advertised as a containerized 'mobile demilitarization plant', fits the criteria of 'transportable' more accurately (JAKUSZ, 2012). Another example is

The ammunition disassembly component of JAKUSZ's Planetarium transportable system, processing a 100 mm UBK8 projectile. © JAKUSZ SZB/2011 the facility (TRL 9) that Expal has designed, built, and is currently assembling to destroy approximately 3.4 million PFM-1 and PFM-1S landmines in Belarus, through a project funded by the European Union. The facilities are being constructed at the premises of the 2271 Engineer Ammunition Base, in Rechitsa (Oliván, 2012).

Some contractors also market a third, intermediary type of equipment, termed 'modular'. *Modular* equipment is transportable by forklifts and designed to fit into protected cells in existing or temporary buildings. After purchase, this equipment is moved from plant to plant, thereby optimizing its production.

The demilitarization industry does not formally distinguish between 'mobile' and 'transportable' equipment. Manufacturers use the terms interchangeably. Esplodenti Sabino states that its 'mobile' rotary kiln (TRL 6) takes a maximum of three days to set up and claims its 'transportable' equipment for WP demilitarization (TRL 6) can be set up in two days (Esplodenti Sabino S.r.l. and AKANA Engineering Co. Ltd., 2012a; 2012b).

Both definitions need to be refined with additional criteria. As an example, SonUtec differentiates its Amunmobile S 'mobile' and 'transportable' (TRL 6) versions according to their NEQ capacities (NEQ 200 g trinitrotoluene (TNT) equivalent for the mobile version vs. NEQ 1 kg TNT equivalent for the transportable version) (sonUtec GmbH, 2012).

Systems overview

A number of commercial organizations offer mobile and transportable ammunition demilitarization plants and equipment.

Past developments

Mobile or transportable demilitarization systems first emerged in the early 2000s. They are not a new proposition from the demilitarization industry per se, yet proven and operational systems that comply with international environmental legislation are still rare.

Available literature shows that in the late 1990s and early 2000s, in the United States, the Defense Ammunition Center (DAC) and Armament Research Development and Engineering Center (ARDEC) commissioned and tested a number of road-transportable prototype systems to operate at ammunition storage locations throughout the continental United States (CONUS). These systems were mainly developed for R&D programmes in an effort to explore alternatives to OB/OD and to promote resource recovery, recycling, and re-use (R3). For instance, the 'Mobile' Plasma Treatment System (MPTS), designed to process fuses and related components, was entirely skid-mounted and transportable on eight flatbed trailers (Sullivan and Ansell, 2003; Goldstein et al., 2003).

A transportable prototype system was also developed to combine cryofracture munitions processing and plasma[8] arc thermal treatment, to respond rapidly to the site-specific demilitarization requirements related to small stockpiles of selected munitions (Sullivan and Ansell, 2004; Sullivan and Michaud, 2006). It must be noted that, in many cases, these complex technologies were developed only to function as components of a full demilitarization line, as *specific segments* intended to process energetic materials or certain small items of ammunition. Reports pertaining to their capacities and commercial viability need to be interpreted in the context of US demilitarization requirements and funding.

At the other end of the spectrum, a number of NGOs and Mine Action and Explosive Ordnance Disposal consultancies have developed simplified, but highly mobile systems for cutting bombs, cluster munitions, and large-calibre projectiles. The field techniques they use can only be applied to process small batches or items of munitions for which it would not be economically feasible to set up, buy, or rent dedicated and expensive logistical industrial demilitarization equipment. These programmes emphasize cost effectiveness and promote a 'self-help' approach to demilitarization, albeit only within a specific context and location.[9] They are not suitable for continuous, logistical *industrial* demilitarization, as discussed in this *Issue Brief*.

A number of donor-funded demilitarization programmes have resorted, in a more substantial manner, to using mobile industrial ammunition demilitarization and/or mobile chemical-processing systems. In an example of the latter, the Organization for Security and Co-operation in Europe (OSCE) and NSPA adopted the mobile approach to transform mélange rocket fuel into non-hazardous chemical compounds for industrial purposes in Eastern Europe.[10] Fixed industrial facilities were first used to process large quantities of mélange, in Ukraine for instance. Donor programmes then resorted to a transportable unit to process smaller quantities of mélange in non-industrial countries such as Armenia, Azerbaijan, Georgia, and Uzbekistan (Ural, 2012) at the approximate rate of 2.5 tonnes per day (OSCE, 2008, p. 15).

Finally, some precursor European countries, including Germany, are currently using mobile demilitarization equipment at ammunition depots, ammunition disposal sites, and firing ranges (Dynasafe Demil Systems AB, 2012).

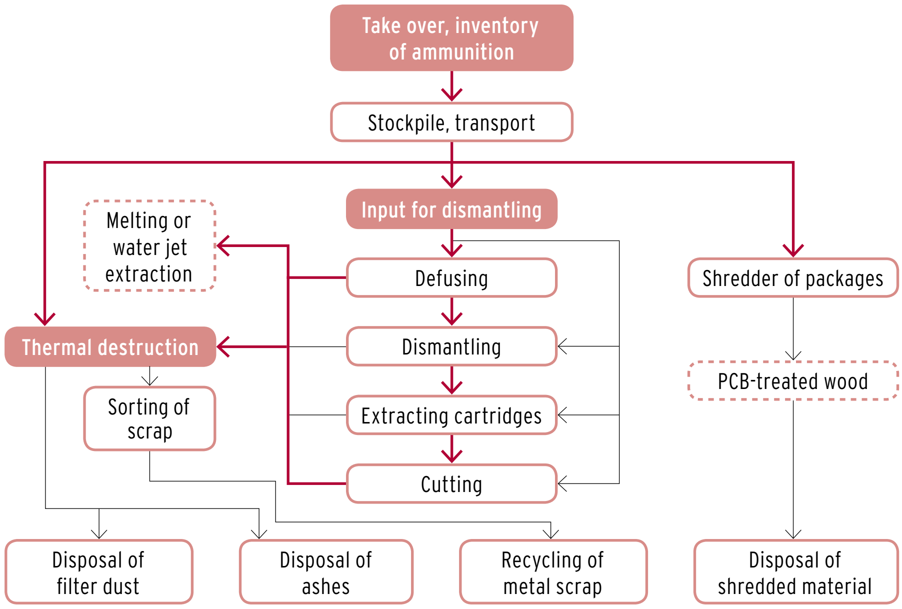
The phases of demilitarization

Demilitarization usually comprises the following key stages:

- preparing the ammunition for transportation (marking and palletizing);
- transporting the ammunition to the demilitarization site;

- receiving and unpacking transportation packages;
- accounting for and storing ammunition until demilitarization;
- disassembling, breaking down, and pre-treating the ammunition (providing access to the energetic material or reducing its size, prior to further treatment);
- removing energetics from munitions;
- destroying the energetics (and other elements of the ammunition which can also be destroyed);
- applying R3; and
- providing a certificate of destruction.

Figure 2 **A summary of the ammunition demilitarization processes**



Source: Dynasafe Demil Systems AB (2012)

Each stage of the demilitarization process has one or several associated processes or techniques. In general, demilitarization lines usually combine bulk and non-bulk methods.

Non-bulk techniques involve de-bulleting and de-priming machines, for instance to process simple-ball ammunition. The metals recovered from disassembly are more valuable as scrap than those recovered after incineration. Medium- and large-calibre ammunition can also be demilitarized by automatic and remote reverse assembly, however the remaining shells and fuses still need to be processed and the energetic materials disposed of or recovered.

TNT is usually recovered from projectiles by melting it in autoclaves. Cyclotrimethylenetrinitramine- (RDX) and octogen- (HMX) based explosives can be washed out by a high-pressure waterjet. Some explosives can be recovered by additional mechanical processes, primarily by cutting the shell in half with band saws. After proper tests, analysis, lotting, and batching have taken place, recovered explosives of suitable quality can be reprocessed into blasting explosives that are useful in civil engineering (NAMSA, 2009a).

Ammunition can be bulk processed in batches, or more efficiently via continuous feed systems. In such cases, munitions are fed through an automated loading system without disassembling them, which speeds up the destruction rates. Some bulk processing systems, such as rotary and static detonation chambers (SDCs) (also named static kilns), are becoming increasingly common. SDCs are chambers that heat up the ammunition until its energetics burn, deflagrate, or detonate, without using a donor charge. They are often used to process small- to medium-calibre munitions without pretreatment, bulk explosives, propellants, and pyrotechnics.[11]

Rotary kilns (also called Explosive Waste Incinerators or EWIs) allow ammunition to flow through the kiln, heating its energetics to the point of initiation as they progress through the kiln. This is one of the most widely used methods for the destruction of small-calibre ammunition up to and including 14.5 mm calibre and ammunition components from the disassembly lines such as fuses, boosters, and primers. Resulting metal scrap can then be recovered, certified as Free From Explosives (FFE), and sold. Detonation chambers,[12] another generic family of thermal treatment equipment, are armoured containers in which the energetics are detonated on command, by means of a donor charge (additional explosives).

The NATO Industrial Advisory Group's (NIAG) *Study on NATO Industrial Capability for Demilitarization and Disposal of Munitions* lists the technical processes used throughout NATO and partner countries to cover the vast majority of munitions (NIAG, 2010). For each of these processes, the industry has developed specific equipment. A single type of equipment does not, in itself, represent a complete demilitarization line. Rather, the systems complement one other. For example, a demilitarization line will incorporate components such as band saws, hydro-abrasive cutters,[13] melt-out systems, safety containment systems, and incineration and pollution control systems (PCS), all tailored into a fully integrated (containerized) mobile or transportable ensemble, configured to address the client or country requirements for a given site (see Figure 2). Importantly, the mobile concept demands that contractors combine or integrate these processes, so that all resulting materials are non-hazardous and can be disposed of.

As a result, contractors combine these processes in various configurations and levels of technological and operational readiness. The following examples were presented at the MEAD conference:

Example 1

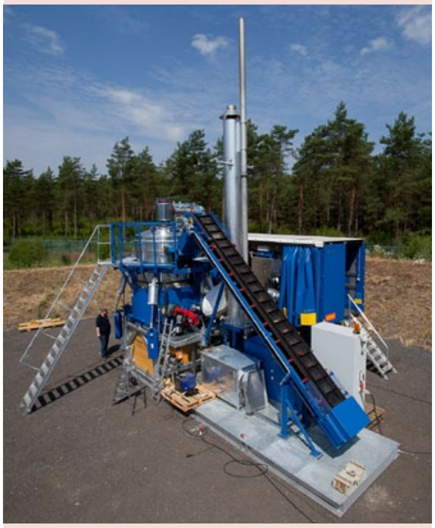
Esplodenti Sabino S.r.l. and AKANA Engineering Co. Ltd.'s mobile rotary kiln (TRL 6) is installed on two, towed trailer platforms that comprise an ammunition feed system, a rotary kiln incinerator, a PCS and heat recovery system, as well as utilities (Esplodenti Sabino S.r.l. and AKANA Engineering Co. Ltd., 2012a).

The mobile rotary kiln, conceived by Esplodenti Sabino S.r.l. and AKANA Engineering Co. Ltd.

© Esplodenti Sabino S.r.l./2012

Example 2

Dynasafe Demil Systems AB is currently marketing the MEA-2 mobile plant (TRL 9). The company operates one such plant in Winsen/Aller, Germany. The system comprises a detonation furnace and an off-gas treatment system. It can process small- and medium-calibre ammunition, components, hand grenades, AP mines, and shells of up to 500 g TNT equivalent (Dynasafe Demil Systems AB, 2012). MEA Systems currently operate in Germany, Italy, Morocco, Qatar, and Singapore.[14]



The MEA-2 mobile ammunition demilitarization plant, manufactured by Dynasafe Demil Systems AB.

© Dynasafe Demil Systems AB/2012

Example 3

EODSolutions' TRADS (TRL 9) integrates a complete small arms ammunition (SAA) demilitarization line into either one 40-foot ISO container or two 20-foot containers, housing a rotary kiln, generator, compressor, filtration system, and lifting legs. The system can be set up in less than three days for an approximate throughput of 700 kg of ammunition per hour, which equates to 5.6 tonnes per eight-hour shift in a continuous (i.e. not batch) process. The number of rounds processed depends on the calibre. For SAA, this equates to approximately 35,000 rounds of 7.62 mm, 55,000 rounds of 5.56 mm, or 5,000 rounds of 12.7 mm per hour (EODSolutions, 2012). According to specialists, this system has 70 per cent of the operational capacity of a full-size APE 1236 rotary kiln furnace, but operates at 25–40 per cent of the cost.[15] The system has been operationally proven in Albania and Bosnia and has been in use in Afghanistan since May 2012.

EODSolutions' Transportable Ammunition Destruction System (TRADS).

© EODSolutions/2012

Selecting an appropriate system

Seldom will one single, optimal technical option meet demilitarization needs. Rather, a mix of such options is often advisable. The decision to choose a particular technique should be based on important customer considerations and criteria. These include:

- the types and quantities of ammunition to be destroyed;
- the type and amount of energetics (explosives, propellants, and pyrotechnics) involved;
- the physical or chemical condition of the ammunition;
- the level of technical demilitarization difficulty for each type of ammunition to be destroyed (single or multiple processes);
- the location of ammunition to be destroyed;
- the value of recovered material;
- the available budget;
- the involvement and availability of MoD facilities, logistics, and transportation assets;
- safety;
- environmental compliance constraints;
- the timeframe; and
- permitting delays.

The client country should therefore gather a significant amount of preliminary information to assess the financial viability of using mobile or transportable demilitarization equipment. In doing so, prospective client countries should also bear in mind the following considerations.

Capacities

Contractors use various units to measure the throughput capacities of industrial demilitarization. There appears to be no standard unit of measurement. In general, maximum load rates are typically determined by the amount of Net Explosive Weight (NEW) or NEQ per item of ammunition. The capacities that contractors mention for their products may portray only the capacity of a *specific* part or component of the demilitarization line (usually the one they are promoting). The capacity of the specific part should not be mistaken for that of the entire demilitarization line.

Furthermore, capacity figures often portray either peak rates or maximum theoretical rates. According to Dynasafe, for instance, the MEA-2 mobile thermal ammunition disposal plant (TRL 9) can process up to 500 g TNT equivalent per feeding, which represents 28 kg of dry TNT, loose explosives, or propellants per hour. In terms of SAA, this represents a maximum of 10,000 rounds of 7.62 mm, 1,250 rounds of 12.7 mm, 700 rounds of 14.5 mm, or 250 AP grenades per hour (Dynasafe Demil Systems AB, 2012).

As discussed below, start-up times, maintenance, and non-standard or problematic ammunition all have a considerable impact on the rate of processing. Whenever possible, capacity figures should portray the average sustained rate of the whole system over a reasonable period.

The differing mobile and transportable demilitarization capabilities can allow for the disposal of a wide range of ammunition items, but at various rates and costs. Most systems are designed to process a small range of ammunition types, in batches, at an acceptable rate. Few systems offer a wide range of capacity, with a continuous-feed process, at a reasonable rate. Small arms ammunition destruction rates tend to be the highest, largely because of the technical ease of destruction. Destruction rates are slow for high explosive, TNT-filled medium- and heavy-calibre shells, and are much slower for high-explosive-filled (hexogen RDX and octogen HMX-based explosives) shells and for guided missiles that require significant manual pre-processing via which the various components and energetic materials are exposed.

Compared to fixed industrial processing lines, mobile or modular demilitarization processes tend to be slow, lower-capacity, and better suited to small-calibre or low-NEQ items which can be handled with simpler technologies. Mobile systems are limited to what can be achieved, especially when larger ordnance is to be processed. Since larger ordnance needs to be pre-cut or prepared prior to disposal, some mobile systems require several 20- or 40-foot ISO containers to house separate work stations with the necessary safety barriers and distances between them.

Because no single system can serve to destroy all kinds of munitions, a system's flexibility in handling different types of munitions or rates is critical. The customer can choose between fully tailored equipment and flexible lines. If the demilitarization line is too tailored, it may be unsuitable for destroying other ammunition types, possibly to be found in a neighbouring depot.

Logistics and operating costs

Due to their commercial sensitivity, it is difficult to obtain and publish the operating costs of mobile and transportable demilitarization equipment. Despite the advantages of circumventing the costs of transporting munitions or of establishing a permanent infrastructure, the mobile demilitarization process still calls for substantial resources and logistics. Potential clients must anticipate a range of requirements and expenditures pertaining to installation and start-up, personnel, resources, and maintenance.
Although the operational costs are reasonable when compared to those of a fixed installation, the cost per item certainly increases if amortized over a small number of items or a short timeframe (NAMSA, 2009a).

Deployment and installation

If political will on the part of the host nation or client country is lacking, the initial deployment, import, and exit of the system can become time-consuming and challenging. For certain projects, it can take up to a year to sort out administrative issues (such as import permits) and to set up supply routes before the real demilitarization process can begin.

Despite their general flexibility, the installation of mobile and transportable systems depends upon certain preconditions. Although they have a smaller footprint than fixed installations, they nonetheless call for a certain amount of space. Some transportable systems may require site preparation: hardening the ground for levelling systems, clearing access for roads to and within the processing site, preparing wastewater collection, accommodating personnel, and possibly building perimeter fencing.

Most contractors will provide infrastructure and physical and technical security means, in addition to handling equipment, such as cranes and forklifts. These costs are not always factored into the original demilitarization contract and planning, however.

Resources and utilities

The demilitarization process is dependent upon a power supply. For incinerators in general, fuel consumption is influenced by various parameters such as the type of system, burner efficiency, fuel type, type and mix of ammunition processed, rotational speed of the kiln, and type of pollution control system. A significant proportion of the energy is used in the pollution control equipment, particularly the afterburners which may be required in some circumstances or may be specified by some clients.[16]

As an example, it is estimated that an APE 1236 rotary kiln (with pollution control equipment) requires approximately 100 litres of fuel oil to destroy 12,000–14,000 rounds of 7.62X54R ammunition *per hour*. Smaller incinerators with a low air-throughput design would typically require about 10 litres of fuel to destroy 5,000 rounds of 7.62X54R ammunition per hour (Towndrow, 2012).

Mobile and transportable demilitarization systems usually incorporate self-contained electrical power generation in the form of an on-board diesel-fuelled generator. For example, EOD-Solutions' TRADS (TRL 9) draws on 200 litres of fuel per day (representing 25 litres per hour for 700 kg of ammunition) and other resources, such as water and sorbent. The company estimates the system's monthly running costs (20 working days) to be GBP 7,200 (USD 11,300) (EODSolutions, 2012), which equates to GBP 64 (USD 100) per tonne for SAA.[17]

Some systems can be configured for multiple fuel or energy sources (gas, oil, or electric), a consideration that clients should factor into their earliest requests for machinery specifications.

Maintenance

Demilitarization systems have different requirements for routine maintenance: replacing filters, greasing and lubrication, repair, calibrating emission monitoring probes, and technical support, all of which reduce the systems' operating time.

The modular components that make up mobile and transportable demilitarization systems require several hours of retooling in order to convert the line to another calibre, or in order to resume production after a major component has been replaced or repaired. With a mobile concept, the routine pre-planned maintenance is normally the responsibility of the user who receives the necessary manuals, training, and spare parts from the manufacturer.

Although some mobile equipment is relatively simple, more in-depth maintenance and repair can be undertaken by the users' skilled mechanics. However, for complex equipment, particularly systems that include incinerator pollution control equipment, plant optimization, maintenance, and repair will be beyond the user capability. A trained mechanic will then be called for, usually via the manufacturer.

Personnel requirements

Personnel requirements are an important consideration. Operators can be military, civilian, locally employed, or international contractor staff. The core demilitarization process usually requires few operators. For instance, sonUtec GmbH's Amunmobil S (TRL 6) requires only two operators (sonUtec GmbH, 2012). Yet other functions will certainly call for additional personnel such as shift workers, support labourers (forklift drivers responsible for loading and unloading), and supervisory and maintenance staff.

Similarly, Esplodenti Sabino S.r.l. and AKANA Engineering Co. Ltd.'s mobile rotary kiln (TRL 6) anticipates only two operators, but two additional operators are needed to unpack and prepare munitions and handle waste streams (Esplodenti Sabino S.r.l. and AKANA Engineering Co. Ltd., 2012a). Depending on the tasks assigned and the technology used, operators will often require training, either as standard munitions handlers or specifically for a given demilitarization system, which the contractor usually supplies. Clients should factor in training delays.

Environmental impact

The processing of propellants and energetics produces an exhaust stream with potentially hazardous gases and particulate emissions, such as lead and cadmium. The levels of pollution from off-gases can be high. Furthermore, some complex ammunition end-products may still need to be processed and destroyed via OB/OD, despite industrial processing.

Most demilitarization customers wish to ensure that there is minimal environmental impact and damage to their reputations. Many national emission regulations have so far adhered to EU *Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste* (EU, 2000) which sets, among other environmental parameters, the air quality requirements for where controlled burning is carried out in incinerators. Within the EU, this Directive was transposed into national legislation. The EU Industrial Emissions Directive (2010/75/EU) superseded the EU Waste Incineration Directive (2000/76/EC) on 6 January 2011. It is being transposed into national legislation by January 2013 (Environmental Compliance Ltd., 2012).

Demilitarization plants (both fixed and mobile) that fulfil environmental protection requirements for all kinds of ammunition with respect to safety and emissions are rather complex. In order for systems to comply with EU and most US emission regulations, air treatment systems are added to them, to capture and destroy the particulates (smoke, metal oxides, and lead), neutralize acid gases, and reduce any dioxin formation from the exhaust at the end of the mobile demilitarization line.

In some mobile systems, a number of control probes are fitted to the trailers to monitor oxygen and carbon monoxide levels and dust particle and nitrogen oxides content. Gases and particulates produced by the incinerator are then abated ('scrubbed') by the pollution control system to ensure that the emissions into the atmosphere are controlled. An example of such a system is El Dorado Engineering Inc.'s Transportable High Efficiency Particulate Abatement System (THEP AS) (TRL 9) (Teichert, 2010; El Dorado Engineering Inc., 2012, pp. 18–20).

In the United States, some contractors have argued that the simpler design of mobile systems decreases emissions and shortens the time necessary to obtain regulatory approval for operations in some jurisdictions (Gupta, 2007, p. 8). Yet, despite its lower capacities, the use of mobile demilitarization equipment in EU countries is still obliged to comply with national and local environmental compliance permitting. In fact, according to Honey (2011, p. 5): '[M]uch of the current legislation where a "permit" is required dictates a fixed location for any disposal activity and eliminates or seriously curtails the ability to have mobile disposal facilities'. If legislation becomes stricter in future, it may become more difficult to use demilitarization equipment.

International donor agencies in particular will not fund systems that are not proven to be environmentally compliant. Yet it must be noted that these PCS can be expensive, in terms of both capital expenditure and maintenance costs.

To a certain extent, a debate among practitioners and contractors prevails as to whether mobile systems *need* to incorporate such complex and expensive pollution abatement systems at all. Some argue that operating a small-scale incinerator with simple pollution control equipment for only short periods in one location has a minimal environmental impact, particularly if that location is remote, with no sensitive environmental receptors nearby. It is argued that, in such cases, the costs, complexity, and energy requirements needed to comply with legislation principally aimed at permanent large-scale industrial plants may be disproportionate. Ultimately it is for the country in question to specify the level of pollution control, given the use of the equipment.

Another debate pertains to the efficiency and sustainability of recycling capabilities of these mobile plants. Some systems try to maximize material recovery via supporting pre- and post-processing systems. Other systems that process larger ordnance can melt out TNT in an autoclave and subsequently repackage it for sale. Yet, in general, discussions continue as to how much recycled materials can pay for the demilitarization process and be commercially viable and more so in the case of temporary, mobile facilities.

Table 1 **Advantages and disadvantages of mobile and transportable industrial ammunition demilitarization equipment**

Advantages	Disadvantages
+ Avoiding the heavy investments required for building new, permanent infrastructure (such as construction, land use, permitting, and installation) + Reducing off-depot ammunition transportation, shipping, and logistics costs + Reducing the environmental footprint of transportation + Reducing cross-border restrictions + Reducing risk associated with transporting ammunition + Locating the demilitarization site close to ammunition depot is possible + Accessing a remote ammunition storage site on which a permanent demilitarization installation is not permitted + Using a single system at multiple sites that have the same ammunition conditions + Benefiting from the usually simpler design and its smaller footprint + Benefiting from fewer installation requirements + Benefiting from shorter start-up time + Promoting competition and efficiency with competitive public–private partnerships + Experiencing fewer barriers to regulatory approval (usually) + Being deployable to support the disposal requirements of overseas military training and operations	– Site limitations and production rates – Limited throughput and effectiveness of technical processes – Wear and tear on equipment and components through continuous movement[18] – Loss of demilitarization time, when relocating and moving equipment[19] – The cost per item may rise if amortized over a small number of items or a short timeframe – As levels of pollution from off-gases can be high, expensive PCS should be part of the process – Complex PCS add to the purchase cost – Some degree of permitting may be required

Procurement and ownership models

Two basic ownership models are in practice: the leasing and the outright purchasing of the system. Public–private partnerships are common.

The client (usually the MoD) can lease the system with or without contractor support, provided at varying levels. An assessment by NSPA of a business case involving a mobile SAA incinerator indicated that, beyond 36 months, outright ownership proved financially preferable (Towndrow, 2012).

In the case of the client purchasing the system from the contractor, either the contractor designs and manufactures the system or the client purchases it COTS. The client can choose between a full service (having the contractor operate the system) and a part service (operating the system itself, with differing levels of contractor support).

The purchase price is contingent on NEQ sizing, the desired capacity, and the range of supporting processes. Systems that integrate reverse-engineering (dismantling), recycling, and pollution abatement processes seem to cost at least 1–2 million euros (NAMSA, 2009a).

In principle, international organizations such as NSPA can purchase a system and then lease or provide it to nations, according to donor priority.

Precedents, opportunities, and challenges for South-east Europe

Precedents to date

In January and February 2011, the Small Arms Survey sent Physical Security and Stockpile Management (PSSM) questionnaires to the MoDs of each of the RASR participating countries. All of the MoDs responded in 2011, except for Bosnia and Herzegovina (BiH). In their replies to the

PSSM questionnaire, the MoDs of SEE expressed varying levels of interest in mobile ammunition plants.

Some countries, such as Croatia and Romania, clearly indicated that they had no use for mobile and transportable demilitarization plants (Croatia, 2011, Table 5; Romania, 2011, p. 4).

Other countries, such as Montenegro , indicated that they had not had the opportunity to use a mobile ammunition disassembly plant, but believed that it would be useful, especially for certain types of ammunition that they did not have the capacity to destroy (Montenegro, 2011, p. 7). It is worth highlighting that, in 2007, the South Eastern and Eastern Europe Clearinghouse for the Control of Small Arms and Light Weapons (SEESAC) *Ammunition Technical Assessment of Montenegro* advocated the procurement and installation of a transportable EWI to demilitarize low-explosive-content ammunition at the '4th November' Company (now Tara-Aerospace and Defence Products) (SEESAC, 2007, p. 15).

In BiH, UNDP purchased a TRADS from EODSolutions with UK funds and installed it at the GOF-18/TROM Doboj facility in January 2006. Until 2008, it was used effectively to destroy SAA of up to and including 14.5 mm, but the destruction rates achieved during that period have not been reported on. Apparently the system is still deployed in BiH Doboj, but is not operational due to a broken generator and a lack of funds for fuel and repair.[20] In May 2012, UNDP BiH indicated that, while mobile equipment was seen as a possible alternative to process ammunition at the GOF-18/TROM facility, current BiH regulations did not allow for ammunition to be treated on the premises of a storage facility.[21]

According to the Albanian MoD, mobile plants can be used to destroy small numbers of detonators or other items and in situations where transportation poses risk. For greater amounts or larger-calibre ammunition, the MoD stated that it prefers static equipment that provides added safety and capacity (Albania, 2011, p. 7). Currently, Albania is not using any mobile demilitarization equipment, yet interesting precedents exist. The state-owned Poliçan munitions factory near Berat in southern Albania used a TRADS, leased from the British contractor EODSolutions and funded by PM/WRA (US Department of State, Bureau of Political and Military Affairs/The Office of Weapons Removal and Abatement (PM/WRA)), to incinerate 7.62–14.5 mm calibre cartridges.[22] The TRADS design was reportedly susceptible to the build-up of dust from inert material in the propellant, which was particularly prevalent in some of the older Chinese-manufactured rounds. The capacity was reduced considerably, due to maintenance required. Nevertheless, the TRADS allegedly provided an incineration capacity of 2,700 tonnes per year (Albania, n.d., p. 10), and could burn between five and eight tonnes (5.54 and 7.26 metric tonnes) of cartridges per day (Goodyear, 2010). The TRADS was removed from Poliçan towards the end of 2010. Following a UK MoD assessment of different mobile solutions for the disposal principally of SAA, TRADS was deployed to Afghanistan in May 2012 where it is working effectively.[23]

Serbia's TRZ Kragujevac uses mobile ammunition maintenance equipment,[24] but does not currently own, use, or produce mobile demilitarization equipment (TRZK, 2012, p. 5).

Opportunities

The ideal of a fixed regional demilitarization centre is an oversimplification of several issues and has not been approved universally by regional demilitarization practitioners (Gobinet, 2012). Transport constraints, competing national interests, the lack of national ownership of demilitarization programmes, the absence of public support for demilitarization campaigns, and the lack of coordination among donors and national demilitarization stakeholders have a negative impact on regional demilitarization efforts. Economies of scale also make it more cost-effective for some of the RASR-participating countries to use their own, existing demilitarization facilities.

In the context of regional capacity, however, mobile disassembly plants could be examined as possible alternatives to a regional demilitarization centre. This section argues that opportunities exist for mobile and transportable demilitarization equipment to be used beneficially in RASR-participating countries.

Similar donor requirements for demilitarization in the region

The obstacles to demilitarization activities are largely monetary; allegedly, governments in the region lack the funds needed to initiate and implement large infrastructure and destruction projects. Donor requirements and expectations are similar throughout the RASR region: demilitarization operations should favour indigenous capacity or use COTS technologies that carry a proven track record, while maximizing the financial benefits and recycling of materials recovered in the demilitarization process. As donor countries and organizations tend not to consider SEE an appropriate environment in which to take the 'technical risk' of developing new demilitarization technology, they are likely to favour the principle of 'Best Available Technology Not Entailing Excessive Cost' (BATNEEC). Since very few companies in RASR-participating states have the background necessary to design and build proprietary mobile demilitarization systems, countries resort to foreign contractors.

Concerns regarding ammunition storage sites and conditions in South-east Europe

RASR participating states tend to reduce ASSs and weapons storage sites (WSSs) to a few prospective[25] locations in order to reduce storage and staffing costs. Large quantities of old ammunition, often with propellant experiencing stabilizer depletion, thus need to be moved around the country to facilitate the downsizing of the depots (Gobinet, 2011). Some items of large ordnance are especially difficult to move; the BiH MoD reported at the Regional Arms Control Verification and Implementation Assistance Centre (RACVIAC) conference in Pula that the surface-launched RFAB 275/4 weapons stored at the WSS Kula facility were problematic to transport and demilitarize (BiH, 2011).

Much of the surplus ammunition in SEE stockpiles has not been classified according to hazard divisions and compatibility groups[26] that would ensure the correct segregation during storage and transportation. Significant quantities of ordnance are still stored in the open. Rain, damp, and humidity exacerbate the degradation of ammunition and can render it more dangerous to handle.

In addition to transport regulations, some national statutes prevent the cross-border transportation of weapons and ammunition. As some countries, such as Bulgaria, cannot export weapons and ammunition for demilitarization purposes, they must destroy their surpluses within the country (Bulgaria, 2011, p. 6).

Technical gaps in indigenous demilitarization capacities in South-east Europe

States in SEE have disparate national capacities to destroy or demilitarize surplus weapons and ammunition. No single RASR-participating country is currently able to manage the full spectrum of surplus ammunition in its stockpiles.

In SEE, most donor-funded destruction programmes begin by destroying the 'simple' items to establish a track record and reassure potential donors that the project can be successful. Yet risks and costs rise as the demilitarization process evolves such that it often necessitates extra handling, manipulation, and the use of multiple technologies.

The Small Arms Survey PSSM questionnaires returned in 2011 by the MoDs reveal recurring items of concern to be: cluster ammunition, WP ammunition, mélange, fuel air explosives, and large ordnance such as deep-sea mines and torpedo warheads (Gobinet, 2012, p. 29). On the whole, munitions containing WP are repeatedly said to be a particular challenge due to their instability (TRZK, 2012, p. 5), which can lead to spontaneous combustion or initiation, even following a destruction effort.

For example, Serbia has one of the biggest stockpiles of WP ammunition in the region; the Capacity Development Programme for Conventional Ammunition Stockpile Management for the Republic of Serbia (CASM), a joint development programme of the Serbian MoD, UNDP, and OSCE, was launched in February 2012. The programme aims to facilitate the demilitarization and disposal of 1,023 tonnes of surplus stocks of WP-filled ammunition[27] and 110 tonnes of napalm powder-filled ammunition, and to strengthen the demilitarization capacities of the MoD. In addition, CASM anticipates developing infrastructure and improving two conventional ASSs in Serbia (SEESAC, 2012). The country has proposed to address WP disposal regionally. Although the Serbian MoD has not rented or used a mobile ammunition disassembly plant to date, its authorities recently expressed an interest in using one to dispose of ammunition containing WP (Serbia, 2011, p. 4).

WP therefore seems to be a potential market for mobile demilitarization equipment contractors. However, the challenge remains of what to do with the product after it has been processed: the commercialization, export, transport, and packaging of WP remain a regional problem (Gobinet, 2012, p. 31).

Conclusion

Mobile and transportable industrial ammunition demilitarization equipment is not a new proposition. R&D projects exist for many prototype systems to address specific demilitarization needs in a specific country or context. Hence a significant number of mobile plants advertised on the demilitarization market are still prototypes undergoing development and awaiting contractual funding. So far, few systems have achieved a proven track record in the field.

Lately, the rising costs of transporting ammunition and associated logistics seem to have revived NATO's interest in mobile and transportable industrial ammunition demilitarization equipment. In 2010, the NIAG report recommended the development of 'a best practice statement related to using mobile or modular [demilitarization] technologies', as well as the production of a 'discussion paper to define the parameters of deploying mobile and modular demilitarization processes within NATO and Partner nations, including best practices related to safety, environment, operations, and cost' (NIAG, 2010 p. 174; van Baalen and Honey, 2011). More recently, the MEAD conference proved that there is interest from clients and business in this type of equipment.

The renewed interest in mobile and transportable industrial ammunition demilitarization equipment indicates that potential customers are being realistic about their demilitarization needs and about the systems' capacities and limitations. A one-size-fits-all solution to the ammunition surplus conundrum does not exist. Compared to fixed industrial processing lines, mobile or modular demilitarization processes tend to be slower, lower-capacity, and better suited to small-calibre or low-NEQ items. Prospective customers and donor agencies should also anticipate a range of requirements and expenditures pertaining to installation and start-up, personnel, resources, and maintenance.

In SEE, the user community may not be fully unaware of the capabilities, assets, and limitations of mobile and transportable demilitarization equipment. Mobile and transportable systems may be relevant solutions to meet specific donor requirements, ammunition storage concerns, demilitarization technology gaps, and one-time stockpiles throughout the region.

This *Issue Brief* aims to encourage RASR-participating countries to examine the legalities and barriers to implementing a mobile demilitarization process and to consider existing COTS equipment with which to develop a plan and conduct a cost analysis. If this approach is technically and economically feasible domestically, it may also provide opportunities for regional deployment. A business case could certainly be made for the use of such equipment in a series of different projects, carried out across the region. Such a system could arguably be purchased by an international organization and subsequently rotated through different munitions locations, to amortize the operational costs of the unit. This option would enable the disposal of limited quantities of selected ammunition that do not justify the establishing of a permanent industrial capacity, in one or more countries. ■

Endnotes

1 At the Lisbon Summit held on 19–20 November 2010, heads of state and government agreed to merge NAMSA (NATO Maintenance Supply Agency), NAMA (NATO Airlift Management Agency), and CEPMA (Central Europe Pipeline Management Agency) into a single body: the new NATO Support Agency (NSPA), which became operational on 1 July 2012.

2 This *Issue Brief* does not cover specialist equipment for chemical or nuclear munitions.

3 NEQ is sometimes referred to as Net Explosive Content (NEC), Net Explosive Mass (NEM), or Net Explosive Weight (NEW, in US pounds). The NEQ, expressed in kilograms, is 'the total explosive content present in a container, ammunition, building etc, unless it has been determined that the effective quantity is significantly different from the actual quantity. It does not include such substances as white phosphorous, smoke or incendiary compositions unless these substances contribute significantly to the dominant hazard of the hazard division concerned.' (UNODA, 2011a, p. 20).

4 The proposal qualified that 'EUR 50 [(USD 68)] per tonne [is] irrespective of distance based on an average journey of 75 km. This includes fuel, personnel, and maintenance costs. This is a nominal figure used for the purpose of estimating Albania's financial contribution to the NAMSA project' (NAMSA, 2009b, p. 11).

5 Cryofracture 'cools munitions in liquid nitrogen prior to fracture/energetic accessing in a hydraulic press', then submits them to 'thermal treatment systems (APE-1236, APE-2210, Plasma Arc, SCWO, Induction Heating, etc.) or energetic recovery systems' (Follin, 2012).

6 Presentation and comments by John Follin during the MEAD conference in Capellen, Luxembourg, on 31 May 2012.

7 Correspondence from Eduard Becker and Stefan Ohlmann, senior consultants, steep GmbH, 13 August 2012.

8 Unlike conventional incineration, which burns a significant quantity of fossil fuel, a plasma furnace generates a plasma arc between two electrodes or an electrode and ground to destroy munitions at temperatures of up to 11,000 °C (Wilkinson and Watt, 2006, pp. 51–52).

9 For instance, the Golden West Humanitarian Foundation specially developed the Explosive Harvesting System (EHS) as part of a US Department of Defense (DoD) Humanitarian Demining R&D Project to convert excess stockpile ammunition into disposal charges for use during Landmine Clearance and Explosive Ordnance Disposal (EOD) Operations and was jointly funded by the US Department of State/Weapons Removal and Abatement programme for operations in Cambodia (Golden West Humanitarian Foundation, 2011).

10 The technique involved reformulating the nitric acid (OSCE) or producing potential soil enhancer (NSPA). Correspondence from Anton Martyniuk, Conflict Prevention Center, OSCE, October 2012.

11 According to Dynasafe, SDCs can process all types of ammunition, bulk material, pyrotechnics, propellant material, fuses, and chemical munitions, but cannot process hollow charges and armour-piercing ammunition (correspondence from Thomas Stock, managing director, Dynasafe Germany GmbH, 10 August 2012).

12 Detonation chambers are also referred to as Controlled Detonation Chambers (CDC).

13 Waterjet technology can be used for 'waterjet cutting (to remove the base fuze) and waterjet washout to remove the explosives' (Gradient Technology, 2012).

14 Correspondence from Thomas Stock, managing director, Dynasafe, 10 August 2012.

15 Correspondence from Adrian Wilkinson, ammunition consultant, Explosive Capabilities Limited, June 2012.

16 Correspondence from Adrian Wilkinson, ammunition consultant, Explosive Capabilities Limited, June 2012.

17 The TRADS can process 0.7 tonne per hour, which represents 5.6 tonnes per day over an eight-hour shift, or roughly 112 tonnes per month over 20 working days. If monthly running costs for 112 tonnes are GBP 7,200, then the running cost per tonne is 7,200/112 = GBP 64.30.

18 See Zahaczewsky (2012).

19 See Zahaczewsky (2012).

20 Correspondence from James Carr, ammunition technical officer, European Union Force (EUFOR), 2 July 2012.

21 Correspondence from Jasmin Porobic, project manager, United Nations Develop-

ment Programme Bosnia and Herzegovina, 18 May 2012.

22 Authorities initially leased the system for one year, but due to administrative and permit delays the system remained in the country for the first six months without any ammunition being processed (correspondence from Kenn Underwood, managing director, EODSolutions, 9 July 2012).

23 Correspondence from Kenn Underwood, managing director, EODSolutions, 9 July 2012.

24 TRZK's M85 mobile workshop is an integrated, trailer-mounted ammunition maintenance workshop used for technical inspections, cleaning ammunition, and repairing, dismantling, and replacing ammunition components (correspondence from Maj. Slobodan Malbasic, Sector for Material Resources, Department for Defence Technologies, Belgrade, 4 July 2012).

25 'Prospective' weapons and ammunition storage sites serve as permanent storage sites after all surpluses have been disposed of.

26 For the purposes of classification for transport, the UN hazard class and division system assigns explosives to one of six hazard divisions depending on the type of hazard they present, and to one of 13 compatibility groups, which identify the kinds of explosives substances and articles that are deemed to be compatible for storage (UNODA, 2011b, pp. 4–7).

27 This figure represents 159,173 pieces of ammunition (SEESAC, 2012).

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The Small Arms Survey serves as the principal international source of public information on all aspects of small arms and armed violence, and as a resource centre for governments, policy-makers, researchers, and activists. In addition to Issue Briefs, the Survey distributes its findings through Occasional Papers, Special Reports, Working Papers, Research Notes, a Book Series, and its annual flagship publication, the *Small Arms Survey*.

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About the Regional Approach to Stockpile Reduction (RASR) Initiative

The Regional Approach to Stockpile Reduction (RASR) is a long-term, coordinated, regional approach to address the threats posed by excess, unstable, loosely secured, or otherwise at-risk stockpiles of conventional weapons and munitions.

RASR encourages affected governments and relevant organizations to develop a proactive, coordinated, regional approach to secure and destroy small arms and light weapons by building local capacity, sharing best practices and lessons learned, and synchronizing resources in order to maximize their efficiency.

The ultimate aim of the RASR Initiative is to prevent disastrous explosions or destabilizing diversions of conventional weapons and munitions.

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