Recent developments in small arms and light weapons manufacturing, technology and design and their implications for effective marking, record-keeping and tracing.

Working paper
by Austria, Belgium and Germany

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1) Introduction

At the BMS5\(^1\) in 2014 States noted that developments in small arms and light weapons (SALW) manufacturing, technology and design had implications for the effective marking, record-keeping and tracing of SALW. States acknowledged the challenges and the opportunities these developments presented. With a view to ensure the continued effectiveness of the International Tracing Instrument (ITI), but also to identify the potential for enhanced marking, record-keeping and tracing, states decided to take a closer look at the subject at MGE2 in 2015.

With this working paper Austria, Belgium and Germany seek to contribute to the discussion of these topics at MGE2. After defining some relevant concepts, the paper looks at developments in SALW design that were not fully taken into account when the ITI was drafted. At the MGE1\(^2\) in 2011 some participants identified modular design and the increasing use of polymers in weapon frames as posing potential challenges for ITI-implementation. In particular the absence of an international standard on the marking of modular weapons risks creating a situation where the tracing of these weapons will be increasingly hampered and even become impossible. The paper puts forward suggestions that aim to preserve and potentially enhance the functionality of the ITI as the international standard for weapons marking, record-keeping and tracing. Besides pointing at challenges, the report of the UN Secretary-General\(^3\) on the recent developments in SALW design also highlighted opportunities that certain technologies, currently rarely or not at all applied to SALW design, could offer to enhance marking, record-keeping and tracing. The paper explores the potential contributions of these technologies for securing SALW and reducing the threat of diversion during the SALW lifecycle of production, transfer, stockpiling and use. On this basis it presents some concrete proposals for meeting certain challenges and points out possible next steps for the purpose of keeping the ITI up to date. This paper was drafted with inputs from experts from national industries and researchers from civil society.

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1 See A/CONF.192/BMS/2014/2
2 Chair’s summary A/66/157
3 A/CONF.192/BMS/2014/1
2) Definitions of concepts used in this paper:

- **Receiver/Frame:** the part of a firearm that houses its operating parts or components, including bolt, trigger group and magazine port.
- **Barrel:** the tube through which a controlled deflagration is released in order to propel a projectile out of the end at a high velocity, connected to the receiver of a firearm.
- **Parts and components:** any element or replacement element specifically designed for a firearm and essential to its operation, including a barrel, receiver/frame, slide or cylinder, bolt or breech block.
- **Accessory:** item that physically attaches to the firearm and increases its effectiveness or usefulness but, generally speaking, is not essential for the basic intended use of the firearm\(^4\). For example: any device designed or adapted in order to diminish the sound caused by firing a firearm\(^5\).
- **Modular weapon:** a weapon with a variable configuration, with parts and components that can be changed by the manufacturer, in an armory workshop or on the field by a user (with or without specific tools). Example: rifle with different interchangeable barrels that have different lengths. When a rifle can change caliber thanks to its modularity we speak of common receiver approach. When one model is offered in different calibers we speak of a family approach. On the military market the family approach is often combined with modularity.

3) Developments in SALW design with implications for the effectiveness of the ITI.

Trends in small arm technology and design with implications for the effectiveness of the ITI can be divided into the following categories:

a) **Architecture:** modular design.

b) **Materials:** increasing use of polymers.

3.a) **Architecture: modular design.**

20\(^{th}\) century military small arms configuration was straightforward: a model had one design and one caliber. Since the early 2000’s new designs were developed to fulfill new military requirements and increase the weapon’s effectiveness by adding adaptability to different operating environments. The development of modular weapons lead to the introduction of different calibers for a single model and ‘convertible’ or ‘re-configurable’ weapons with interchangeable parts and components. The different names for this technology included the modularity approach, family approach and common receiver approach (cfr. chapter 2). In this working paper we focus on weapons with a core component (usually

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\(^5\) Fire-arms protocol (A/RES/55/255)
the receiver, or the upper or lower receiver in the case of a split-receiver weapon) around which other major parts and components can be changed at a later stage by the manufacturer or user.

The impact of modular design on ITI implementation and possible ways of addressing the resulting challenges

The ITI states in para. 10 that “A unique marking should be applied to an essential or structural component of the weapon where the component’s destruction would render the weapon permanently inoperable and incapable of reactivation, such as the frame and/or receiver, in compliance with paragraph 7 above. States are encouraged, where appropriate to the type of weapon, also to apply the marking prescribed in subparagraph 8 (a) above or other markings to other parts of the weapon such as the barrel and/or slide or cylinder of the weapon, in order to aid in the accurate identification of these parts or of a given weapon.”

1. The ITI’s requirement to mark an ‘essential or structural component’ such as the frame and/or receiver of the weapon requires further elaboration in the case of a modular weapon with a split receiver. This paper suggests is that it’s up to the original manufacturer to indicate which part of the split receiver (for example: upper or lower) is the core component of the weapon and should thus be considered ‘essential or structural’ and marked in line with the ITI. Any other future manufacturer of the same weapon (for example under license) should obviously adhere to this designation. This information should be notified by the manufacturers to UN member states and consequently shared with UNODA.

2. The marking content also needs to take the modular nature of the weapon into account. Art. 8a of the ITI recommends the marking of type, model and caliber; yet type and caliber can be changed on fully modular weapons. To avoid inconsistencies during a weapon’s life cycle one solution could be to mark only the serial number and the model on fully modular weapons. Additional information on all possible configurations could either be added to the marking or made available to states by the manufacturer.

3. For tracing purposes it could be useful that marks indicate the modular nature of a weapon. To this end the core component of such a weapon could be additionally marked with “[1]” and secondary or non-core components like the non-core part of a split receiver and the barrel could be marked with “[2]”, thereby indicating their non-core component nature. “[1]” and “[2]” are simple alphanumeric digits easy to record and copy, type or fill out in a form. The 1 and 2 stand respectively for primary/core and secondary/non-core. The brackets/parenthesis would distinguish these markings from the other markings.

4. The ITI’s encouragement to mark other parts of the weapon could prove problematic for the tracing of modular weapons. Especially the marking of serial numbers on core as well as on
non-core components could create confusion and hamper tracing. **Therefore this paper suggests applying the visible markings required by the ITI exclusively to the core component, and not to the non-core/secondary components.** As mentioned in the paragraph above this doesn’t exclude the marking of secondary components with a symbol that indicates their nature as non-core components in a modular weapon (“2”). Neither does this exclude the marking of barrels with stamps from proof houses, or the marking of secondary components with embedded/electronic/micro-markings invisible for the naked eye or clearly distinguishable from the markings required by the ITI. Whatever solutions are identified, shared guidance on the unique identification and marking of modular weapons should be developed by states and information on the control components of different models shared.

5. To facilitate international cooperation and avoid ambiguity in record-keeping of modular weapons this paper suggests that **the markings on the core-component should be used to create the record associated with the weapon (1 core component= 1 weapon= 1 record - 1/1/1) and held for tracing purposes.** In addition to the 1/1/1 record, manufacturers and states are of course free to keep records on secondary-components of modular weapons. In order to keep track of multiple potential configurations it is recommended that relevant producer information (list of all configurations) be attached to the register. But for ITI-related marking, record keeping and tracing, only the core-component counts.

3.b) **Materials: increasing use of polymers.**

Until the early 80s, steel, wood and Bakelite were the only materials used to design and manufacture firearms. Wood and Bakelite were used for handgrips and butt stocks, but all other firearm parts were made of steel. Plastics were introduced at the end of the 70s. Currently most new military SALW include parts made of plastic, aluminum or composite. While, earlier, only hand grips and butt stocks were made of polymer, now receivers and entire frames can also be made of light and highly resistant polymer.

**Impact on marking**

Para. 7 of the ITI specifies that “**all marks required under this instrument are on an exposed surface, conspicuous without technical aids or tools, easily recognizable, readable, durable and, as far as technically possible, recoverable.**” Under paragraph 8e, States undertake to encourage manufacturers to develop measures against the removal or alteration of markings. Paragraph 10 specifies that “**A unique marking should be applied to an essential or structural component of the weapon where the component’s destruction would render the weapon permanently inoperable and incapable of reactivation, such as the frame and/or receiver.**”
Since marks on a polymer surface are relatively easy to alter or remove in comparison with marks on metal, manufacturers will need to take appropriate measures to ensure that polymer frame weapons meet ITI requirements. In the ITI, States have undertaken to ensure that the manufacturers on their territory comply with the ITI.

The practice of polymer weapons marking has up to now yielded a limited number of viable technical solutions, including laser engraving, dot-peon/micro-percussion and the use of metallic inserts in the polymer frame as a more durable marking solution. This is also the recommendation of the ISACS document\(^6\) on marking.

Weapons with polymer frames pose challenges for import marking by the receiving country. Where to put the import mark? Is the marking technology available to the country suitable for this kind of weapon in the sense it will produce a durable mark? Laser engraving machines and the infrastructure and training needed for reliable long term use represent a challenge to widespread diffusion, especially in developing countries. Metallic inserts should have a size allowing additional markings, including import markings. But also more broadly, independent from the material of the frame, the marking of imported arms often meets logistical and physical obstacles that can result in a failure to mark weapons at import. Yet the marking of imported weapons with the year and country of import, as the ITI recommends and the Firearms Protocol requires, greatly facilitates the tracing of seized weapons. Especially for the tracing and tracking of weapons in (post-) conflict zones, characterized by greater numbers of weapons and requiring a different kind of scrutiny in comparison with tracing in the context of a criminal investigation, proper import marks significantly accelerate the tracing process. Firearms for governmental use and military small arms are often produced when the order is placed and the end-user is known (make-to-order). This means that for small arms, in the case of international transfer, the required import markings can be put on the weapon by the manufacturer at the time of production. This way of working also alleviates the difficulties encountered by receiving countries in putting import marks on polymer frame weapons.

To conclude, marking a firearm with a polymer frame according to the rules of the ITI is more challenging than marking a weapon with a metal frame. The existing ITI requirements are well defined, but for their sound and widespread implementation further guidance on the marking of polymer frame weapons should be developed and shared. In the case of make-to-order production the required import markings can be put on the weapon at the time of manufacture, thus alleviating the difficulties of marking polymer frame weapons at the time of import.

\(^6\) ISACS 05.30 marking and record keeping
4) Technologies for reducing the threat of diversion of SALW during its life cycle

Ubiquitous in every aspect of modern life, technological progress is affecting weapons and weapons systems, including small arms and light weapons. While electronics dominate financial networks, transport systems, communications, medical equipment and many more aspects of our lives, surprisingly little use has been made of it so far for arms control purposes. These technologies can offer new solutions for all stages of a SALW’s life cycle, with the aim of reducing potential sources of diversion. Only by exploring and – wherever possible and useful – embracing the potential of new technologies can we create the necessary political support and guidance for their adoption. Factors such as impact, cost, acceptance by producers and users, and requirements in terms of infrastructure and know-how, especially in the countries most affected by SALW, must be taken into account.

4.1. Marking and Tracing

There is a large variety of marking technologies available that can be used to apply a marking that complies with the requirements of the ITI: “on an exposed surface, conspicuous without technical aids or tools, easily recognizable, readable, durable and, as far as technically possible, recoverable.” The main aim of the marking is to allow for full traceability of each individual weapon, be it during their legal use or, especially, when seized in a conflict setting or at a crime scene. New technologies that have recently entered the market comprise the use of RFID-transponders, microdot, and nano trace. Since they are invisible to the naked eye, they cannot replace the classic marking methods. These new marking methods, however, bear the potential to improve the traceability of the weapon and its security at successive stages in the weapon’s life cycle. Therefore these methods should be considered as complementary to the classic marking methods. These methods can be used to create hidden marks that are difficult to find and erase, although there is a danger, if new standards are introduced, that their specifications will eventually become public, causing them to lose their hidden character. From a technical point of view some important factors determine the applicability of a given method.

For example:
- Is this marking method feasible at large volumes?
- Is it applicable on all kinds of SALW / on all materials?
- What is the quantity of stored information? Can small surfaces be marked?
- What is the durability of the marking? Can it be recovered after removal?
- Can assembled firearms be marked (in the case of import marking for example)?
- Is the mark readable everywhere in the world and in all conditions? With or without a reading device?
a. **RFID**

This technology enables contact-less information exchange between a set commonly called a "tag", comprising a microchip and an antenna, and a reading device ("transponder") that generates an electromagnetic field into which the tag is placed when the stored information is to be read.

This technology has several advantages:
- The ability to read from a (short) distance, without the need of direct line of sight
- The ability to read a moving object or a large number of devices at once
- The ability to update tag information as required
- The ability to store large amounts of information (much more than in bar codes)
- The technical compatibility with standard IT systems facilitates the comprehensive automation of the process. This characteristic is particularly interesting for an advanced stockpile management system. All movement of items in a weapons depot – as in a commercial warehouse – could be easily and immediately tracked with this technology. As the reader could be easily integrated into an existing IT system this technology would be most suitable for fully automating the management of a large stock of SALW.

This technology does not, however, allow for the direct, i.e. visual, reading of the information. The main value of RFID lies in the optimized management of legal SALW stockpiles (including weapons transfer and control over authorized use). Technological challenges exist, however: how to integrate the tag into the frame, in a way that it cannot be removed, altered or destroyed easily; and how to avoid the erasure or manipulation of stored information. RFID is not particularly suitable for retrofitting, but for new rifles, the tag could be inserted permanently during the production process.

b. **Microdot**

The micro dot is a very small piece of identifying information (<1mm) that can be read at a short distance (20 -25 cm) by a magnification device. They are widely used in the industry, including the automotive industry, and are easily and cheaply available for commercial and private use. They are normally applied using a dispenser that contains a large number of microdots and glues them directly to the surface. Most of the microdots are invisible to the naked eye. UV light is used to locate and read them. The microdot can be designed to be highly resistant to extreme temperatures and even when burned, it still contains all its information.
Two sides of a microdot (0.5 mm size) seen under a microscope 100 X

**Analysis**
- This technology can be used on small, medium or large weapons components
- There are some limitations regarding certain materials
- Only a small amount of information, such as the serial number, can be stored
- A specific reading device is needed
- Retrofitting is possible and simple
- As microdots can be applied cheaply to multiple locations, their complete erasure by third parties is difficult
- Challenge: the exact location of the microdots must be known to investigators, but not to traffickers

Conclusion: This technology is well adapted to duplicate a serial number. Due to its low price and easy application, at any stage of the life cycle, it can be recommended as an additional security marking (hidden marking).

c. **Nano trace**

Nano trace is already being used to secure and identify certain valuable kind of objects such as works of art, diamonds, etc. It consists of microscopic particles containing information to uniquely identify any given object by examination under a microscope or using lamps with a specific wavelength. It may take the form of alphanumeric data depicted on small flakes or threads or fragments of multicolored, multilayered laminates with a signature color combination. This technology doesn’t appear to be the most adequate for SALW. It could be used as a security marking but seems to be less adapted to this use than microdot for example.
4.2 Stockpile Management

In many respects the management of a weapons depot is comparable to a commercial warehouse operation or a library. Items enter the warehouse, are registered and stored, lent out to identified users, transferred to other locations, or, finally, discharged. Globally active retail companies, such as Amazon, have demonstrated how important the use of information technology for such purposes has become in recent years. Yet weapon depots, even in developed nations, still rely heavily on pencil and paper.

This section briefly outlines some effective and relatively affordable technological solutions to stockpile management. It should be mentioned that these apply to all items to be handled by large organizations such as the police or the military. They can add value to existing systems by improving data on the locations and availability of – often valuable – stock:
- Access: The stockpile manager and other authorized personnel are equipped with smart ID-cards, possibly verified by biometric data (fingerprint), to gain access to the depot.
- Registration: all weapons that enter or leave the depot are registered by either scanning a data matrix (or similar code) or by reading a RFID tag. The weapons can only be handed out when the user presents a valid ID with the necessary authorization; the weapon is then automatically assigned to this person in the register. All record-keeping systems from one facility or one organization can be connected to a central register. The technology allows all movements of weapons to be monitored and analyzed. Alerts can be set when weapons are not returned.

In certain specific circumstances the following technological solutions can be used:
- Locks: advanced electronic locks can be programmed for individual weapons and users, to open only when a user’s identity has been verified by biometric or other scanners. These locks could be connected directly to the register, reporting on each movement of a weapon.
- Use: some weapons could be equipped with chips that register their use (bullets fired etc.). When back in the armory, this information would be fed automatically into the register.

Naturally, no technology, however good, can work without a functioning weapons management system covering such things as infrastructure, procedures, training, enforcement and staff responsibilities. The main weaknesses of existing SALW stockpiles can be remedied through adherence to such basic requirements. Physical security and technological tools can be applied at a second stage, according to assessed risk, available infrastructure, resources and know-how. Pilot projects in countries affected by SALW diversion from government stockpiles could be implemented to find workable solutions and exchange findings among UN member states.
4.3 Record-keeping

Alongside the necessity of managing government owned stockpiles and maintaining appropriate records for all stored SALW, national authorities could also use IT to set up a national electronic register for all SALW within their national jurisdictions. One of the main advantages of such a system is the reduction in the time and effort needed to follow up tracing requests, both by a requesting state and by national police authorities. The functioning of such a national register would be greatly enhanced if the technologies outlined under section 4.2 were introduced.

4.4 Transfers

The risk of SALW diversion is particularly high during the transfer of weapons, whether from the supplier to the final user or between different parts of the same organization. In the case of authorized international transfers, GPS tracking and electronic seals for containers/crates holding SALW are already being used and could be applied more broadly, putting a large degree of responsibility with the producer/exporter. For weapons movements between facilities, highly mobile electronic locking devices can be used to permanently lock individual SALW, allowing them to be unlocked only when a pin-code or user-specific biometric data is provided. Currently the price of these locking technologies is relatively high, but it could be reduced substantially with higher production numbers and as the technology matures. Trial use should be encouraged to deepen our knowledge on the effectiveness of this technology in common settings.

4.5 Avoiding unauthorized use

Many of the solutions presented above are intended to minimize the risks of diversion from government stockpiles. Once a weapon enters the black market via theft, corruption etc., those measures show no effect anymore. For this reason, preventing diversion should be a priority for governments and legitimate private users around the world and the tracing of diverted weapons will help to increase the effectiveness of these preventive measures. What can we do after a weapon is diverted? One of the main innovations in this respect is the so called smart gun. The basic idea is to allow only the duly authorized user to operate a smart gun, rendering it useless to all others. As a consequence, the incentive for diversion would – assuming that the process is irreversible – diminish substantially. Identification of the user can be proved in different ways, the main difference being whether it is the user her/himself (through biometric data or an individual handgrip profile) or some additional device (ring, tag or similar) worn by
the user that activates the gun. Newer developments go even further and try to define targets in such a way that “friendly fire” becomes impossible. While smart gun technology has much potential to reduce the risk of misuse of a firearm in certain circumstances, many challenges remain:

- **Reliability.** As it is a safety device, its proven reliability must be at least as high as in conventional weapons.

- **False acceptance rate** (the gun working despite the fact that the user is not the authorized user) and the **false rejection rate** (the gun not working despite the fact that the user is the authorized user) must be extremely low to be accepted by potential users.

- **The potential for Tampering should be extremely low.** This, however, will require the development of completely new systems. Retrofitting will not be possible.

- **Biometric technology** is more adapted to the concept of a smart gun than having an identification tag or entering a code.

Another possible means of reducing incentives for the diversion of certain light weapons, such as MANPADs, would be built-in GPS sensors, similar to the ones commonly used in mobile phones and cars. As with RFID chips, the main technological challenges include the physical integration of such sensors into the weapon during production and protection against tampering. Broad acceptance will depend on the development of technology that allows only legitimate owners and users to trace the weapon’s whereabouts.

5) **Next steps**

Through this working paper and through national interventions at MGE2, we hope to present some useful elements that the chair could choose to include in his summary of the meeting and which could, at a later stage (e.g. at BMS6), form part of an agreed political guidance for the interpretation of the ITI in light of the new developments. Over the longer-term, the MGE2 chair’s summary and any agreed political guidance that emerges from it could form the basis of negotiations among UN member states on a legally binding ITI that incorporates the political guidance on the new developments.