Emerging Technologies Affecting Small Arms and Light Weapons Controls

Recent advances in a range of technologies that may affect small arms and light weapons (SALW) control systems could profoundly impact global initiatives aimed at combating the illicit trade in such weapons. These developments include the adoption of unconventional materials, such as polymers, as well as increasingly modular weapon configurations and technologies relevant for the marking, record-keeping, and tracing of SALW. Such innovations include laser engraving, microstamping, and automated systems for data collection, information management, and tracking, as well as for the delivery and positioning of weapons.

The risks that some technologies may result in the diversion, illicit trade, and misuse of SALW is increasingly being discussed by States. In addition, the opportunities posed by some technologies for improving SALW controls are also the subject of discussion. Such risks and opportunities began to be recognized by participating States at the Third and the Fourth Review Conferences on the UN Programme of Action on the illicit trade in SALW (UNPoA), which were held in June 2018 and June 2024 respectively. At the Fourth Review Conference, States decided to establish an Open-Ended Technical Expert Group (OETEG), convening within the week of the Biennial Meetings of States in 2026 and 2028. The purpose of the OETEG is to develop and agree recommendations by consensus to ensure that the use of new technologies will not undermine and may even enhance the full and effective implementation of the UNPoA and the International Tracing Instrument (ITI). Civil society organisations (CSOs), especially think tanks, have been contributing research and policy proposals for consideration but more can be done by CSOs to raise the awareness of parliaments and media of this important problem and its potential solutions.

1. Recent Trends in SALW Manufacturing, Technology and Design

1.1. Advanced Materials

Plastics and polymers have increasingly substituted metal in the manufacture of SALW frames and receivers. These materials offer several benefits: including reduced production costs, lighter weight, improved resistance to moisture, greater ergonomic flexibility, and enhanced thermal insulation properties. However, the use of such materials could hinder marking and tracing of SALW.

Implications for marking

Markings placed directly on polymer frames and receivers, unlike those applied to metal components, fail to meet the ITI requirements that markings be durable, and recoverable to the greatest extent technically feasible. Marking solutions for polymer materials that could meet the ITI requirements are: laser marking or micropercussion (or dot peen stamping). An alternative approach for marking polymer weapons involves the incorporation of a metal insert into the primary plastic component, allowing additional markings to be applied to the metallic surface.

1.2. SALW Design

The broad range of operational requirements faced by armed forces and security agencies has driven the development of modular designs for military-specification rifles. Modern assault rifles can now be built around a central component—typically the upper receiver—to which various interchangeable parts may be attached. That enables different configurations tailored for specific functions or mission requirements. Paragraph 10 of the International Tracing Instrument prescribes the application of a unique marking to essential or structural component of the weapon, such as the frame and/or receiver, and also encourages the marking of other parts of the weapon, such as the barrel and/or slide or cylinder. The design of such configurations may lead to increased risks of misidentification but may contribute to more effective tracing.

Implications for tracing

Increased risk of misidentification: Modular weapons can be fitted with different components, including from other weapons, which means that the marking of those configurations (a) could result in different serial numbers appearing on different parts of the same weapon, and (b) given the possibility to change a weapon's calibre, that change can result in the same serial number being associated with two different calibres.

Improvements in tracing: Some forensic experts argue that a modular weapon with more than one serial number would actually provide more potential clues to better enable a successful trace.

1.3. SALW Production

Additive manufacturing technology, such as three-dimensional (3D) printing, can now be used to manufacture SALW. The printing machine reads the design from a 3D-printable file and lays down successive layers of liquid, powder, paper or sheet material to build the model from a series of cross sections. These layers are joined or automatically fused to create the final shape.

Computer numerical control (CNC) milling technology is a form of *subtractive* manufacturing which enables the manufacture of custom-made SALW with metals. Parts and components are created by removing material from a solid block of metal. Computer-aided design (CAD) software creates digital blueprints (in 2D and 3D), while Computer-aided manufacturing (CAM) software uses the CAD design to generate machine instructions for CNC machinery to physically create the parts and components.

Implications for illicit trade SALW

Risks associated with the use of 3D printing and CNC milling technologies include the production of "ghost guns" which are unmarked and unregistered weapons. That may lead to a lucrative craft production in small-scale illicit weapon manufacturing units leading to illicit sales.

2. Recent Developments in Technology Specifically Applicable to Weapon Marking, Record Keeping and Tracing

2.1. Laser technology for marking

Laser technology can be used for marking a large spectrum of SALW parts and components, including very small parts and components. The surface of such objects is marked through burning by oxidization.

Implications for the implementation of the ITI

However, laser markings can be erased more easily. Obliterated laser engravings are more difficult to recover. Nevertheless, relief polishing and reflected light stereomicroscopy can, in certain cases, successfully reveal obliterated serial numbers originally marked by laser.

2.2. Micro-stamping for marking

Micromarks made by stamping can potentially prevent or reduce illicit trading because such marks are not easily detectable for those wishing to erase them. Moreover, by micromarking the firing pin of a weapon, an imprint can be made on each fired cartridge that could aid forensic evidence collection for criminal investigations.

Implications for marking, record-keeping and tracing

Micro-marking of parts and components may considerably *enhance record-keeping and traceability*. For instance, when applied to the firing pin, microstamping technology makes it possible to identify a firearm solely from a recovered cartridge casing, without requiring physical access to the weapon itself.

2.3. DNA markers and chemical markers

Synthetic DNA markers are artificially engineered molecular identifiers that function like invisible markers. They can be applied to weapon components, ammunition, and packaging. The marks or "tags" carry a unique coded sequence that can be linked to the manufacturer, the production batch, and the consignee.

Chemical markers include a version called "AmTag". The manufacturer of those markers claimed to "use rare earth elements and fluorescent compounds to create an indelible chemical taggant that can be applied to ammunition. The taggant, only visible using UV light, is embedded with a unique chemical 'code' which can be associated with chain of custody data, to render each round fully traceable from the point of manufacture to the last legal custodian."

Implications for marking, record-keeping and tracing

DNA/chemical markers are invisible to the naked eye and thus can act as covert identifiers.

2.4. Microelectronics and Smart Components

Technologies such as barcodes, radio-frequency identification (RFID), and biometric systems—including fingerprint recognition—fall within the broader category of automatic identification and data collection technologies. These technologies are considered useful tools to enhance effective stockpile management and prevent diversion of SALW.

2.4.1. Barcodes

A barcode encodes information in a visual pattern that a machine can read and store.

2.4.2. Radio frequency identification (RFID)

Radio frequency identification technology has two main components: a tag or label, embedded in the weapon, and a separate reader. The data stored on the tags is transmitted to the reader and stored in a database.

2.4.3. Biometric technologies

Biometric technologies use the unique features of an individual as the key to identify an authorized user such as the individual's fingerprint, palm print, voice, face or dynamic grip on a weapon. Thus, the authorized access to a SALW is restricted to a designated individual.

Implications for the implementation of ITI

Automatic identification and data collection technologies are especially well-suited for record-keeping applications in stockpile management, thereby substantially improving stockpile accountability and security. These technologies make it possible to track and document which individual used a specific weapon, as well as when and for how long it was used.

3. New Weapons tracking technologies

A major innovation in tracking conventional arms shipments to prevent diversion has been the introduction of real-time locating systems. These systems enable the monitoring of cargo throughout the entire supply chain. The ability to track shipments of SALW from their point of origin to the consignee or final destination in near real time significantly enhances the security of goods in transit, enables the tracing of diverted shipments, and reduces the risk of diversion.

These new tracking systems depend on the integration of a range of technologies, including tags with or without sensors attached to containers, technologies for the Global Navigation Satellite System (such as GPS, Galileo, GLONASS, and BeiDou), and the Global System for Mobile Communications technology, as well as communication satellites, and software applications such as web-based mapping platforms. In addition, shipping containers may be fitted with container intrusion detection devices or anti-pilferage sensors to enhance cargo security.

Implications for the ITI

Real-time locating systems allow for proactive diversion prevention. Authorities and exporters can monitor SALW transfers in real time and take steps to ensure a diversion will not occur. This increases the capacity of the relevant authorities working with transport agents to intervene during an actual shipment.

In addition, real-time locating systems generate additional data (geolocation, time stamps, possible container breaches) which reinforces the authorities' ability to meet ITI record-keeping obligations.

4. Recommendations

Civil society organisations (CSOs) can raise awareness of new technology risks and opportunities among policymakers and the public through advocacy with officials, parliamentarians, and the media. Such awareness can be achieved by CSOs helping to develop and promote concise guides for policymakers, by lobbying governments, and by organising media and public campaigns. CSO's can also call on States to include technology issues in their State's national reports under the UN PoA and ITI.

The Chair of the First Committee, who was also the President of the fourth Review Conference on the UNPoA, called for CSOs to provide input to the Open-Ended Technical Expert Group (OETEG) on SALW. Research institutes and universities can prepare and send relevant inputs to OETEG.

CSOs may also have the research capacity to hold States and companies accountable if they are in a position to carefully document case studies relating to technological risks, and to make proposals regarding new technologies which have been shown to offer opportunities for stronger SALW controls.

SALW control requires multi-stakeholder collaboration and networking. This can be achieved by convening informal networks to share case studies and develop policy proposals. CSO's may be able to help facilitate constructive dialogue with and between governments, military, and businesses that have developed new technologies.

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