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Technological Developments in Small Arms

Implications for International Arms Control Instruments

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INTERPOL Operation Trigger in Europe. © INTERPOL, 2017

Executive summary

Since the adoption of the 2001 United Nations Programme of Action to Prevent, Combat and Eradicate the Illicit Trade in Small Arms and Light Weapons in All its Aspects (PoA) and the 2005 International Instrument to Enable States to Identify and Trace, in a Timely and Reliable Manner, Illicit Small Arms and Light Weapons (ITI), technologies used to design, to manufacture and to control small arms and light weapons (SALW) have evolved. In manufacturing, polymer frames and receivers – first introduced in pistols in 1970 – have become increasingly common, and modular SALW designs are more widely used by both state agencies and civilians. In addition, 3D printing techniques for producing SALW have rapidly developed, profoundly transforming craft production techniques, which used to be largely artisanal, and creating new sources of illicit SALW. All these developments challenge the implementation and continued relevance of the PoA and the ITI as international frameworks for SALW control. At the same time, new technologies offer opportunities to strengthen control and prevent diversion throughout the life cycle of SALW, from manufacture to disposal.

In response, the Fourth Review Conference of the PoA in 2024 established an Open-Ended Technical Expert Group (OETEG). Its mandate is to develop agreed recommendations by consensus to ensure the full and effective implementation of the PoA and the ITI in preventing, combating and eradicating the illicit trade in SALW in the light of developments in the manufacturing, technology and design of SALW, in particular polymer and modular weapons, and SALW produced using 3D printing. It will focus on means of international cooperation and assistance as well as discussing opportunities that arise from new technologies.

This report aims to introduce national representatives to the four primary issues under the OETEG's mandate:

- Polymer frames and receivers
- Modular SALW
- 3D printing of SALW
- Technology to counter diversion of SALW

It summarizes the current state of knowledge, gathered through a series of webinars convened between October 2025 and February 2026, background research and interviews with experts from international organizations, governments, academia, civil society and industry. It explains each of the four issues–outlining the challenges it poses, noting promising approaches to these challenges, and highlighting key considerations for the OETEG.

Polymer frames and receivers

When states agreed the measures under the ITI on marking SALW, they had metal components in mind. Markings directly on polymer frames and receivers, in contrast to markings on metal components, do not meet the ITI requirements that markings need to be durable and, as far as technically possible, recoverable and that their obliteration would make the SALW inoperable. In practice, manufacturers and states have instead developed approaches that apply markings to metal, notably through embedded metal tags or markings on underlying metal components visible through a "window" in the polymer.

Key considerations:

- The OETEG could discuss current marking practices for polymer frames and receivers, including the extent to which applying markings to metal may better support durability, recoverability and tracing.
- It could also explore how best to leverage insights from industry and other relevant actors to address the unique challenges that arise with marking polymer.
- The OETEG could discuss pathways to ensure consistent state efforts to successfully prevent illicit actors from effectively removing marks.

Modular SALW

In contrast to traditional weapons, a modular SALW is designed with interchangeable components that allow for multiple configurations. This creates challenges currently not addressed under the ITI, particularly for marking and record-keeping. It may be less clear which component of a modular weapon should carry the primary marking, and modular weapons and their components can be more complicated to identify and trace.

Key considerations:

- The OETEG could examine measures by states to strengthen the identification of SALW, including modular SALW, for tracing and record-keeping, taking into account different national capacities and practices.

- It could also explore the concrete contribution of international cooperation and assistance to sustainably strengthen national capabilities for SALW identification.
- The OETEG could benefit from states sharing their effective practices for marking modular SALW (including approaches to identifying the primary marking component and other serialized components), as well as their record-keeping practices, database functions and tracing procedures for serialized components, taking into account different needs and capacities.

3D printing of SALW

3D printing of SALW is a form of craft production. Its use for the illicit manufacturing of SALW has rapidly expanded during the past few years. Moreover, SALW manufactured through 3D printing, often in combination with other craft production techniques, have proven that they can be as lethal and sophisticated as industrially manufactured weapons, and their proliferation has been difficult for states to prevent and detect. This poses increasing challenges for states to meet the requirement under the PoA to exercise "effective control" over SALW production. Promising approaches exist to prevent, detect and track 3D printing and other forms of craft production, including through legislation adapted to 3D printing, systematic data collection, targeted training and information-sharing.

Key considerations:

- The OETEG could consider the development of additional guidance, shared understandings or commitments under the PoA and the ITI to support states in addressing challenges posed by the 3D printing of SALW.
- The OETEG could discuss preventive policy measures to address, among other things, the misuse of digital blueprints, dual-use tools and commercially available components for the illicit craft production of SALW.
- It could also discuss which stages of the 3D printing and craft production process offer the most realistic points for intervention, and the capacities, data and partnerships that are needed to detect and disrupt illicit craft production.
- In doing so, the OETEG could consider how international cooperation, assistance and existing information-sharing mechanisms may help states respond to emerging trends and practices in the illicit manufacturing of SALW.

Technology to counter diversion of SALW

New and emerging technologies can be valuable tools to strengthen implementation of the PoA and the ITI and efforts to prevent, detect and counter diversion of SALW. In particular, digital databases are central to effective record-keeping and tracing and are often foundational for the effective use of other technologies. At the same time, despite the availability and potential utility of such technologies, their uptake by states has been uneven and often slow, and their effectiveness depends on implementation being needs-driven and adapted to national contexts.

Key considerations:

- The OETEG could orient discussions around a consideration of states' needs and contexts for successful integration of technologies into counter-diversion efforts.

- It could also explore how to effectively learn from technology use in other industries and fields of application that could be relevant for counter-diversion efforts.
- In doing so, the OETEG could explore how best to leverage different forms of international cooperation around technology for joint counter-diversion efforts by states.

Cross-cutting issues

The challenges of controlling SALW will continue to evolve, driven by developments in the design and manufacture of SALW but also new methods to divert SALW to unauthorized end-users and uses. Contributing to this dynamic is the blurring of traditional boundaries between, on one side, the regulated and legal industry and, on the other, unregulated illicit craft manufacture and targeted efforts by organized criminal groups and other non-state actors to circumvent state controls over SALW. To keep pace, SALW control measures will require continuous improvement and adjustment. The OETEG poses a crucial opportunity for states to consider how to address these wider challenges.

Key considerations:

- The OETEG should take multi-stakeholder approaches, engaging relevant experts from governments, industry, academia and civil society to reach practical solutions. Law enforcement and industry perspectives are particularly important for the issues covered in this report.
- Given that the challenges of technological development will persist beyond the OETEG's current mandate, states should consider whether the OETEG should be maintained after 2028 or a successor mechanism established, in order to ensure that the PoA and the ITI remain up-to-date and that dialogue on technological developments affecting their effective implementation can continue.

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Abbreviations

CAD	Computer-aided design
CNC	Computer numerical control
FPI	Flemish Peace Institute
IFRT	INTERPOL Firearms Reference Table
INTERPOL	International Criminal Police Organization
ITI	International Instrument to Enable States to Identify and Trace, in a Timely and Reliable Manner, Illicit Small Arms and Light Weapons
iARMS	INTERPOL Illicit Arms Records and Tracing Management System
MGE2	Second Open-ended Meeting of Governmental Experts on the Implementation of the Programme of Action to Prevent, Combat and Eradicate the Illicit Trade in Small Arms and Light Weapons in All Its Aspects
MOSAIC	United Nations Modular Small-Arms-Control Implementation Compendium
OETEG	Open-ended Technical Expert Group
PoA	United Nations Programme of Action to Prevent, Combat and Eradicate the Illicit Trade in Small Arms and Light Weapons in All Its Aspects
SALW	Small arms and light weapons

Glossary

The definitions in this glossary draw, where possible, on international instruments, outcome documents and other official documents of the United Nations, with the source provided in parentheses. Where no such official source exists, definitions are based on common usage in the literature and should be regarded as purely informative.

3D PRINTING

Also called additive manufacturing.

A manufacturing process which forms, or prints, a three-dimensional object layer by layer, based on a digital file. 3D-printed SALW are produced partially or entirely using a 3D printer. These include fully 3D-printed SALW and hybrid SALW combining printed and industrial components.

CAD FILES

Computer-aided design files, also sometimes called digital blueprints.

A computer file containing the design of an object to be manufactured in the form of technical drawings and 3D models. 3D printers require a CAD file to manufacture any object, including SALW components.

CNC MACHINING

Computer numerical control machining.

A manufacturing method using computer-controlled tools to cut or mill materials into precision parts. CNC machining can be used to craft produce SALW components.

CRAFT PRODUCTION

A broad category of non-industrial production of SALW, including artisanal, improvised, self-fabricated, workshop-made or privately made weapons, including 3D printing. Craft production ranges from rudimentary handmade SALW to sophisticated weapons integrating industrial parts. Whether craft production is legal or illegal depends on the national regulatory framework (see Manufacture of SALW).

DIVERSION

The movement – either physical, administrative or otherwise – of a weapon, its parts, components or ammunition from the legal to the illicit realm. (MOSAIC Module 01.20)

FIREARMS REFERENCE TABLE

A data set that contains definitive descriptions by which SALW can be identified, including their model, manufacturer and country of manufacture.

The INTERPOL Firearms Reference Table (IFRT) is a global and comprehensive firearms reference table. It is maintained by the Royal Canadian Mounted Police and made available to all INTERPOL member states.

iARMS

INTERPOL Illicit Arms Records and Tracing Management System.

A database and tracing tool developed and managed by INTERPOL that can be used by law enforcement agencies of INTERPOL member states to record and trace illicit SALW, including serialized SALW components.

MANUFACTURE OF SALW

Production of SALW or their components. The PoA requires States to “exercise effective control over the production of SALW”. (PoA, Section II para. 2)

Regulated or lawful manufacture: The manufacture of SALW in compliance with the applicable legal requirements set by the state within which the manufacturing takes place.

Unregulated manufacture: Manufacture taking place in the absence of an adequate national legal or regulatory framework. While not illegal under national law, unregulated manufacture can be illicit according to international agreements.

Illicit manufacturing: In the context of the United Nations, this refers to manufacturing of SALW in violation of international agreements or commitments.

Illegal or unlawful manufacture: Manufacture that violates applicable national legal requirements.

MARKING

The application of a unique identifier. Under the ITI, each SALW needs to be marked with a primary marking that includes the name of the manufacturer, the country of manufacture and the serial number as a minimum on a designated component (see Primary marking component). Markings need to be durable and, as far as technically possible, recoverable if obliterated. (ITI paras 7, 8(a), 10)

The ITI recommends that additional components also be marked with secondary markings. (ITI para. 10)

METAL TAG AND WINDOW APPROACHES

Common methods used for marking polymer SALW.

Metal tag: a metal plate embedded into a polymer frame and engraved with required markings.

Window: a cut-out in the polymer that exposes markings applied on an underlying metal component.

MODULAR SALW

A weapon that consists of an essential "control component" to which other "essential modular components" are affixed and can be reconfigured to alter the weapon's functions to suit differing operational contexts. This is achieved primarily through changing calibres (by changing receivers in whole or in part) and by exchanging barrels of differing types. (Report of the United Nations Secretary-General, A/74/187, 2019, para. 78.(e))

PRIMARY MARKING COMPONENT

The designated structural component marked with the primary marking consisting of the main serial number, the name of the manufacturer, and the country of manufacture (see Marking). This is typically the frame or receiver, but several exceptions exist.

RECEIVER, FRAME

An essential component of a weapon which houses its operating parts or components, including the bolt, trigger group and magazine port. Rifles contain a receiver while pistoles contain a frame. (Report of the United Nations Secretary-General, A/74/187, 2019, para. 78.(a))

SERIALIZED COMPONENTS

Any component of a weapon that has been marked with a serial number.

TRACING

The systematic tracking of illicit SALW found or seized on the territory of a state from the point of manufacture or the point of importation through the lines of supply to the point at which they became illicit. (ITI para. 5)

Manufacturing of a pistol in an arms factory. © Adobe Stock, 2023

1. Introduction

Since the turn of the millennium, the landscape of illicit small arms and light weapons (SALW) has evolved significantly. Developments in the design, manufacture and circulation of SALW have made it more difficult to prevent, combat and eradicate the illicit trade in these weapons. Polymer frames and receivers have become increasingly common; modular weapon designs have expanded across military and civilian markets; and the illicit manufacture of SALW using 3D printing and other craft production techniques has developed rapidly. At the same time, diversion patterns and trafficking dynamics have also continued to evolve, including as illicit actors exploit technological innovation and regulatory gaps to circumvent state controls. These developments pose important challenges for the implementation and continued relevance of the 2001 United Nations Programme of Action to Prevent, Combat and Eradicate the Illicit Trade in Small Arms and Light Weapons in All its Aspects (PoA)[1] and the 2005 International Instrument to Enable States to Identify and Trace, in a Timely and Reliable Manner, Illicit Small Arms and Light Weapons (ITI).[2]

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1 United Nations Programme of Action to Prevent, Combat and Eradicate the Illicit Trade in Small Arms and Light Weapons in All its Aspects, 20 July 2001, annexed to United Nations, General Assembly, Report of the United Nations Conference on the Illicit Trade in Small Arms and Light Weapons in All Its Aspects, A/CONF.192/15(SUPP), 9–20 July 2001.

2 International Instrument to Enable States to Identify and Trace, in a Timely and Reliable Manner, Illicit Small Arms and Light Weapons, 8 December 2005, annexed to United Nations, General Assembly, Report of the Open-ended Working Group to Negotiate an International Instrument to Enable States to Identify and Trace, in a Timely and Reliable Manner, Illicit Small Arms and Light Weapons, A/60/88, 27 June 2005.

The measures contained in the PoA and the ITI remain central to SALW control. However, they were negotiated in a context in which certain technological and manufacturing developments were less prominent than they are today. As a result, states are increasingly confronted with questions about how to apply existing commitments effectively in the light of new realities. For example, polymer components raise difficulties for the durability and recoverability of marks; modular SALW complicate identification, record-keeping and tracing; and the growing availability of 3D printing and related craft production techniques challenges states' ability to exercise effective control over the manufacture of SALW. Yet, at the same time, technological developments also present opportunities to strengthen implementation of the PoA and the ITI, including through improved record-keeping, tracing and measures to prevent diversion.

It is in this context that states decided in 2024 to establish an Open-ended Technical Expert Group (OETEG) "to develop agreed recommendations by consensus to ensure the full and effective implementation of the Programme of Action and the International Tracing Instrument . . . in the light of developments in the manufacturing, technology and design of small arms and light weapons".[3] Its two sessions will take place during the PoA Biennial Meetings of States in 2026 and 2028. The OETEG was specifically mandated to address challenges relating to modular weapons, polymer weapons and illicitly produced 3D-printed weapons, which were considered in two Open-ended Meetings of Governmental Experts convened under the PoA (MGE1 and MGE2) and subsequent PoA meetings that have taken place over the past decade.[4] The OETEG is also mandated to examine opportunities that developments in the manufacturing, technology and design of SALW present for strengthening both PoA and ITI implementation and concrete measures for international cooperation and assistance.[5]

This Insight report aims to support national representatives participating in these discussions by providing introductory analysis of four primary issues that may be addressed by the OETEG:

- Polymer frames and receivers
- Modular SALW
- 3D printing of SALW
- Technological developments for countering the diversion of SALW

Sections 2 and 3 focus on the challenges posed by polymer and modular weapons, respectively. Section 4 addresses the issue of 3D printing of SALW. The final section, Section 5, considers opportunities offered by technology for strengthening the effective implementation of the PoA and the ITI, specifically to combat the diversion of SALW. Each chapter provides context for the issue at hand, before exploring promising approaches for strengthening the implementation of the PoA and the ITI and considerations for the OETEG (see also Box 1).

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3 United Nations, General Assembly, Report of the Fourth United Nations Conference to Review Progress Made in the Implementation of the PoA, A/CONF.192/2024/RC/3, 5 July 2024, Annex, para. 174.

4 United Nations, Open-ended Meeting of Governmental Experts on the Implementation of the PoA (MGE1), Chair's Summary, A/66/157, 19 July 2011; United Nations, General Assembly, Second Open-ended Meeting of Governmental Experts on the Implementation of the PoA (MGE2), Chair's Summary, June 2015, https://front.un-arm.org/wp-content/uploads/2018/06/2015-06-17-Chairs_Summary-MGE2.pdf.

5 United Nations, A/CONF.192/2024/RC/3, Annex, paras 174–178.

BOX 1

Overarching considerations for the Open-ended Technical Expert Group

The research conducted for this report highlighted two overarching considerations which may help orient the OETEG's discussion across the different topics of its mandate.

First, given the technical issues on its agenda, the OETEG would benefit from supplementing the participation of relevant experts of national delegations with dialogue with experts from industry, technology companies and specialized organizations. Such multi-stakeholder engagement and collaboration will help the OETEG to find effective and sustainable solutions for PoA and ITI implementation.

Second, SALW design, manufacturing and diversion methods employed by organized criminal groups, terrorists and others seeking to circumvent states' control measures continuously evolve in step with technological developments. As a result, it is worth considering if the OETEG should be maintained after its current mandate expires in 2028, or another mechanism established, to ensure that the PoA and the ITI remain up-to-date and that dialogue on technological developments that affect the effective implementation of the PoA and the ITI can continue.

Sections 2 and 3 are informed by interviews with experts from international organizations, governments, academia, civil society and industry as well as extensive background research. Sections 4 and 5 were developed from the findings of earlier UNIDIR research on, respectively, craft-produced weapons and 3D printing[6] and technology for diversion prevention.[7] In addition, the four sections also reflect inputs made by experts during a series of webinars convened between October 2025 and February 2026.

Given the technical nature of these topics, key terms and technical terminology used in this report are defined in a glossary.

6 Matilde Vecchioni, *Unregulated Production: Examining Craft-Produced Weapons from a Global Perspective* (Geneva: UNIDIR, 2024), https://doi.org/10.37559/CAAP/24/PACAV/08; Matilde Vecchioni and Rueben Dass, "'Do Not Try This at Home!': Current Trends and Developments in Improvised Weapons Production", UNIDIR, 26 November 2025, https://unidir.org/do-not-try-this-at-home-current-trends-and-developments-in-improvised-weapons-production/.

7 Sarah Grand-Clément, "Assessing Technologies to Counter the Diversion of Small Arms and Light Weapons", UNIDIR and Flemish Peace Institute, 2024, https://doi.org/10.37559/CAAP/24/ERC/09; Sarah Grand-Clément and Diederik Cops, "Project D-TECT: Technologies to Counter the Diversion of Small Arms and Light Weapons, and Components of Conventional Weapons", UNIDIR and Flemish Peace Institute, 2023, https://doi.org/10.37559/CAAP/23/ERC/08.

2. Polymer frames and receivers

2.1 Context

While SALW are traditionally manufactured from steel or aluminium, some SALW incorporate components made of polymers, such as plastic and nylon, often reinforced with fibres from glass, carbon or aramid.[8] Polymers are primarily used for non-pressure bearing components, including the frame or receiver of a SALW; in contrast, they are not a well-suited material for pressure bearing components such as the barrel.[9] Polymer components have become increasingly popular because they are lighter and cheaper to produce than metal components.[10]

Polymer components can pose distinct challenges for tracing SALW that have been diverted and then interdicted, as discussed in several PoA meetings since 2015.[11] Markings made on polymer are far less durable and are far easier to obliterate than those applied to metal, and they are generally less recoverable and, at worst, impossible to recover.[12]

2.2 Promising approaches

Most, if not all, SALW manufacturers appear to have stopped marking on polymer.[13] Instead, it is common practice – and often a national legal requirement – to mark on metal using either a "metal tag" or a "window" approach.[14] These approaches have been recommended by both national and international actors, with the metal tag approach also being included in the final recommendations of MGE2.[15] In practice, neither approach has overcome all of the challenges of tracing weapons with polymer components.

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8 Giacomo Persi Paoli, "From Firearms to Weapon Systems: Challenges and Implications of Modular Design for Marking, Record-Keeping, and Tracing", eds Benjamin King and Glenn McDonald, *Behind the Curve: New Technologies, New Control Challenges*, Occasional Paper no. 32 (Geneva: Small Arms Survey, 2015), https://www.jstor.org/stable/resrep10742.9, p. 7.

9 See, e.g., the discussion of usages of polymers for SALW components in N. R. Jenzen-Jones, "Small Arms and Additive Manufacturing: An Assessment of 3D-Printed Firearms, Components, and Accessories", eds King and McDonald, Behind the Curve, https://www.jstor.org/stable/resrep10742.10.

10 Bonn International Centre for Conflict Studies (BICC), "Glock 17", SALW Guide, https://salw-guide.bicc.de/en/weapon/view/2/glock-17, accessed 13 February 2026.

11 United Nations, MGE2 Chair's Summary, paras 1–3; United Nations, General Assembly, Report of the Third United Nations Conference to Review Progress Made in the Implementation of the PoA, A/CONF.192/2018/RC/3, 6 July 2018, Annex, paras 6–7.

12 United Nations, MGE2 Chair's Summary, paras 1–3; United Nations, General Assembly, Preparatory Committee for the Third United Nations Conference to Review Progress Made in the Implementation of the PoA, "Towards an Effective Marking, Record-keeping and Tracing of Modular and Polymer Firearms", Working paper submitted by Belgium, A/CONF.192/2018/PC/WP.1, 5 March 2018, para. 17; Rachel Bolton-King, Interview by authors, Geneva, 12 February 2026. Some technological advancements have been made for recovering polymer markings. However, these remain available to only few states. Lilian Skokan et al., "The Reconstruction of Serial Numbers in Polymers: Recent Progress, Challenges, and Perspectives", *WIREs Forensic Science*, vol. 5, no. 6 (November 2023): 18–19, https://doi.org/10.1002/wfs2.1495.

13 Frank Grosspietsch, Interview by authors, Geneva, 18 February 2026; Bolton-King, Interview.

14 As recommended in United Nations, A/CONF.192/2018/PC/WP.1, Annex, para. 19. Also Grosspietsch, Interview; Bolton-King, Interview.

15 United Nations, MGE2 Chair's Summary.

Glock 17 with embedded metal tag marked with the weapon's serial number. © Vitaly V. Kuzmin, 2012

SIG Sauer P320 with a window showing the weapon's serial number. © NobuttoO, 2022

With the metal tag approach, a small metal plate is embedded into the polymer component of a SALW and the manufacturing marking is applied to this plate. Removal of the metal tag should destroy part of the frame.[16] Whether this is the case currently varies greatly across SALW manufacturers and models, and there have been several examples where the metal tag has been successfully removed without critically damaging the weapon.[17] Illicit actors have also been known to obliterate the markings on the tag.[18] Anecdotal evidence suggests that markings on metal tags have reduced recoverability, depending on the material of the tag, its thickness and the depth of marking.[19]

Using the window approach, a "window" in the polymer reveals markings made on metal components underneath. This approach has the advantage that markings on the underlying metal structure have greater recoverability if applied according to international good practice.[20] At the same time, marking an internal metal component, rather than the frame or receiver, can further complicate identifying the component that carries the main serial number that is entered into record-keeping systems and used to trace the weapon. This increases the risk of misidentifications, particularly in cases where the weapon is modular (see Section 3).[21]

Another consideration with both metal tags and windows is their size. The ITI "require[s] to the extent possible appropriate simple marking on each imported small arm or light weapon".[22] Ideally, metal tags and windows should be big enough to leave space for additional markings to be applied upon import. The United Nations in its Modular Small-Arms-Control Implementation Compendium (MOSAIC) notes that import markings may be "applied directly to the non-metallic frame" with the caveat that it should be on "a part of the frame that is least likely to suffer from wear and tear during the course of normal operational use" and that the marking is duplicated on "at least one essential metallic component of the weapon".[23]

2.3 Key considerations

1. *Consistent with the MGE2 recommendations, the OETEG could consider alternatives to marking polymer, such as applying markings to a metal tag or window in polymer components*.[24]

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16 United Nations, A/CONF.192/2018/PC/WP.1, Annex, para. 20.

17 Giacomo Persi Paoli, "The Method behind the Mark: A Review of Firearm Marking Technologies", Issue Brief no. 1, Small Arms Survey, February 2010, https://www.smallarmssurvey.org/resource/method-behind-mark-review-firearm-marking-technologies-issue-brief-1; Grosspietsch, Interview; Ivaylo Stefanov, Interview by authors, Geneva, 17 February 2026.

18 Grosspietsch, Interview; Stefanov, Interview.

19 See, e.g., Yeu Uei Bong and R. Kuppuswamy, "Revealing Obliterated Engraved Marks on High Strength Aluminium Alloy (AA7010) Surfaces by Etching Technique", *Forensic Science International*, vol. 195, nos 1–3 (February 2010): 86–92, https://doi.org/10.1016/j.forsciint.2009.11.018; Bolton-King, Interview.

20 See, e.g., Bailey Henwood et al., "An Assessment of a Non-Destructive Magneto-Optical Imaging Technique for the Recovery of Laser Engraved Marks from Steel Plates and Firearm Components", *Science & Justice*, vol. 63, no. 6 (November 2023): 736–42, https://doi.org/10.1016/j.scijus.2023.10.007.

21 Bolton-King, Interview.

22 International Tracing Instrument, A/60/88, Annex, para. 8(b).

23 United Nations, "Marking and Recordkeeping", Modular Small-arms-control Implementation Compendium (MOSAIC) 05.30: 2022(E)V1.2, 2022, https://front.un-arm.org/wp-content/uploads/2022/06/MOSAIC-05.30-2022EV1.2.pdf, Clause 5.3.3.2.

24 United Nations, MGE2 Chair's Summary.

INTERPOL Operation Trigger in Europe. © INTERPOL, 2017

2. *Industry representatives and other practitioners may have valuable insights into the shortcomings of current approaches to marking polymer weapons and new approaches for marking in the future. The OETEG could explore how best to leverage insights from industry and other relevant actors to address the unique challenges that arise with marking polymer components.*
3. *The OETEG could discuss steps that states can take to more effectively prevent the removal of marks. These could include regular review and, where needed, adaptation of marking methods to keep pace with evolving mark-obliteration practices.*

Disassembled AR-15 pattern rifle with lower and upper receiver. © Adobe Stock, 2021

3. Modular SALW

3.1 Context

Traditionally, SALW are manufactured as weapons with one fixed design: a given model has one configuration and its chamber accommodates a single calibre of ammunition. While users can exchange worn or damaged components, such replacements are identical to the original parts. In contrast, a modular SALW contains a core component – typically the upper or lower receiver for rifles or the frame for pistols – and a set of interchangeable modular components.[25] This allows the user to change the weapon's configuration, performance and, at times, calibre and adapt it to different operational scenarios.[26]

Modular weapons were initially developed primarily for military use. Their aim was to be adaptable to field conditions for different purposes and contexts, with the user able to quickly change components such as the barrel and buttstock.[27] Another benefit is the interoperability of replacement components

25 United Nations, General Assembly, "The Illicit Trade in Small Arms and Light Weapons in All Its Aspects and Assistance to States for Curbing the Illicit Traffic in Small Arms and Light Weapons and Collecting Them", Report of the Secretary-General, A/74/187, 17 July 2019, para. 79(e).

26 Persi Paoli, "From Firearms to Weapon Systems". For definitions of these weapon configurations, see, e.g., N. R. Jenzen-Jones (ed.), *ARCS: The ARES Arms & Munitions Classification System*, Version 1.3 (Armament Research Services, July 2022), https://armamentresearch.com/wp-content/uploads/2022/08/The-ARES-Arms-Munitions-Classification-System-ARCS-ver1.3-public-release.pdf.

27 Persi Paoli, "From Firearms to Weapon Systems".

within a weapon family, allowing militaries to reduce the types of spare components kept at hand to repair weapons.[28] Alongside the military market, the civilian market for modular small arms (including assault rifles, hunting rifles and pistols) has expanded significantly over the past decade, particularly in European and North American countries.[29] For some frequently owned modular small arms (e.g., the AR-15 pattern rifle), a market for components has developed in which a wide range of producers offer compatible components, allowing users to assemble or reconfigure weapons.[30] In contrast, components of a "traditional" SALW are produced and sold by one manufacturer.

As discussed in PoA meetings since 2015, including MGE2 and the Fourth Review Conference, modular SALW have the following implications for marking, record-keeping and tracing that are not explicitly covered by either the PoA or the ITI.[31]

Implications for marking

Under the ITI, a "unique marking should be applied to an essential or structural component of the weapon".[32] To implement this provision, it is common practice to designate one component as the "primary marking component" for each SALW model; this is typically the frame or the receiver. The primary marking component is marked at the time of manufacture and carries the main serial number, which is entered into record-keeping systems for inventory management and used to trace the weapon if it has been diverted into the illicit market and then recovered.[33] The ITI recommends also marking the serial number on "other parts of the weapon, such as the barrel and/or slide or cylinder of the weapon".[34] However, limited space means that these might not contain the full serial number. Also, not all states require such additional secondary markings, and they are less consistently recorded.

Modular weapons complicate the designation of the primary marking component for two reasons. First, such weapons contain more components. For instance, the receiver of a modular rifle is split, consisting of an upper receiver and a lower receiver. Second, marked components may be replaced, including with compatible components from a different manufacturer, which might be operating in a different country and therefore under a different national legal regime. There is a risk that the primary marking component and any components marked with secondary markings might differ between manufacturers and between states.[35] In the worst case scenario, this creates loopholes that allow criminals to "mix and

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28 Thomas Held, Bruce Newsome and Matthew W. Lewis, *Commonality in Military Equipment: A Framework to Improve Acquisition Decisions*, Monograph MG-719 (Santa Monica, CA: RAND Corporation, 2008), https://www.rand.org/content/dam/rand/pubs/monographs/2008/RAND_MG719.pdf.

29 Steve Adelmann, "Multi-Caliber Modularity: The Benefits of Modern Rifle Design", *Shooting Illustrated*, 22 May 2018, https://www.shootingillustrated.com/content/multi-caliber-modularity-the-benefits-of-modern-rifle-design/; Mordor Intelligence, "Small Arms Market Size & Share Analysis – Growth, Trends, and Forecast (2025–2031)", https://www.mordorintelligence.com/industry-reports/small-arms-market, accessed 13 February 2026.

30 Bloomberg News, "Deadly New Trade in 'Frankenstein' Guns Enabled by a Gap in US Law", Bloomberg.Com, 14 December 2023, https://www.bloomberg.com/graphics/2023-us-made-gun-exports-frankenstein-gun-parts/.

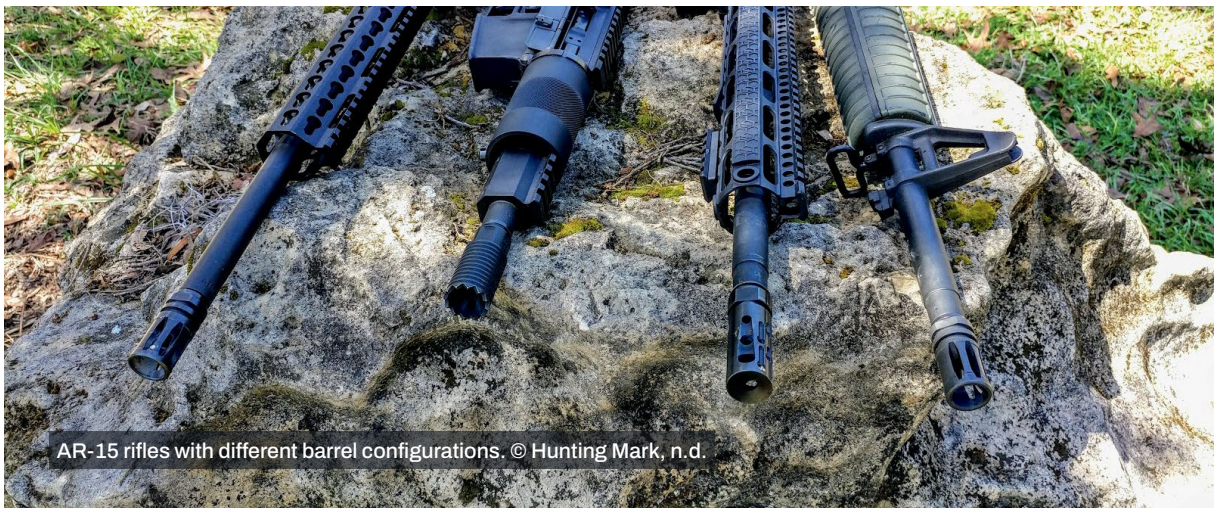
31 United Nations, MGE2 Chair's Summary, paras 11–16; United Nations, A/CONF.192/2024/RC/3, para. 91.

32 International Tracing Instrument, A/60/88, Annex, para. 10.

33 United Nations, MOSAIC 05.30:2022(E)V1.2.

34 International Tracing Instrument, A/60/88, Annex, para. 10.

35 This also depends on whether a national authority designates the components to be marked or whether states delegate this responsibility to the manufacturer.



AR-15 rifles with different barrel configurations. © Hunting Mark, n.d.

match" unmarked components from different states or manufacturers to assemble "ghost guns" – fully functional weapons that are neither marked nor recorded.[36]

Implications for record-keeping

A modular weapon can contain several components with serial numbers (also called serialized components). The manufacturer might mark the components originally fitted to a weapon with the same serial number as on the primary marking component, depending on their marking protocol and national regulations. However, if the user changes components, the weapon will then contain components with mismatched serial numbers.

If an illicit weapon with mismatched serial numbers is recovered, it is difficult to trace the origin and point of diversion of these components. This is only possible if the serial number of each component has been recorded – in addition to the serial number of the primary marking component – and if national record-keeping systems can be searched for these additional serial numbers. Yet, recording all serialized components adds to the workload of national authorities and thus might not be feasible in all national contexts.[37]

Implications for tracing

It can also be hard to correctly identify modular SALW. To successfully trace a weapon, a law enforcement officer should identify, as a minimum, the weapon's manufacturer, model, calibre, serial number and country of manufacture.[38] This is not easy under normal circumstances (see Box 2) and is even more complicated for modular SALW. Two examples of the same modular SALW model can be visually different depending on their configurations, might feature different calibres, and could contain components from different manufacturers or with mismatching serial numbers. This makes misidentification of a modular SALW more likely and decreases the likelihood of successful tracing.

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36 United Nations, Conference of the Parties to the United Nations Convention against Transnational Organized Crime (CTOC), "Implementation of Articles 3 (Use of Terms) and 4 (Scope of Application) of the Firearms Protocol", Background paper prepared by the Secretariat, 24 February 2024, CTOC/COP/WG.6/2023/3, paras 43–48; Bloomberg News, "Deadly New Trade in 'Frankenstein' Guns".

37 Henry Leach, Interview by authors, Geneva, 10 February 2026.

38 United Nations, MOSAIC 05.31:2012(E)V1.0.

BOX 2

Wider challenges of identifying weapons for record-keeping and tracing

Difficulties in correctly identifying a weapon for tracing are not unique to modular weapons. Experts estimate that 20–40 per cent of international trace requests contain an incomplete or incorrect identification of the weapon to be traced, which increases the likelihood that the tracing is unsuccessful.[39] Similarly, records of weapons are frequently incomplete or incorrect.[40]

National officers identifying a weapon for tracing or recording in the national database might misidentify the manufacturer or model. They may also misread or misrecord the serial number, for example by mistaking the letter "I" for the numeral "1" or confusing the serial number with other marked numbers. In addition, they often lack the necessary training to identify counterfeit or craft-produced weapons and components (see Section 4) or counterfeit and falsified markings.[41] Modular weapons further amplify these problems.

At the same time, a frequent lack of willingness to trace and respond to a tracing request is a second key barrier to the successful international tracing of illicit SALW.[42]

3.2 Promising approaches

Interviewed experts noted several promising approaches to identifying, marking, record-keeping and tracing of modular SALW. These expand, in part, on the recommendations of MGE2, which are also applicable to "traditional" SALW.

Marking modular SALW

Promising approaches for marking modular SALW include:

- Using markings that clearly identify the modular nature of the weapon.
- Clearly distinguishing the main serial number on the primary marking component from serial numbers on other serialized components. This can make it easier to distinguish the main serial number from

39 Stefanov, Interview.

40 See, e.g., Her Majesty's Inspectorate of Constabulary (HMIC), *Targeting the Risk: An Inspection of the Efficiency and Effectiveness of Firearms Licensing in Police Forces in England and Wales* (London: HMIC, September 2015), https://nottinghamshire.pcc.police.uk/Document-Library/Public-Information/HMIC-Reports/HMIC-Report-efficiency-and-effectiveness-of-firearms-licensing.pdf, pp. 45–47; Jenni Irish-Qhobosheane, *Gun Licences for Sale: South Africa's Failing Firearms Control*, Policy Brief (Geneva: Global Initiative Against Transnational Organized Crime, November 2020), https://globalinitiative.net/wp-content/uploads/2020/12/Guns-Licenses-for-Sale-South-Africas-failing-firearms-control-GI-TOC.pdf; Queensland Audit Office (QAO), *Regulating Firearms*, Report no. 8:2020–21 (Brisbane: QAO, 2020), https://www.qao.qld.gov.au/sites/default/files/2020-11/Regulating firearms (Report 8—2020–21)_1.pdf.

41 Grosspietsch, Interview.

42 See, e.g., Émile LeBrun and Christelle Rigual, *Monitoring UN Arms Embargoes: Observations from Panels of Experts*, Occasional Paper no. 33 (Geneva: Small Arms Survey, August 2016), https://www.smallarmssurvey.org/sites/default/files/resources/SAS-OP33-UN-Arms-Embargoes.pdf, p. 26.

other, mismatched serial numbers, which is particularly important in record-keeping systems that only record the main serial number. This could be achieved by preceding the serial number on the primary marking component with "(1)" and the markings on other serialized components with "(2)" and subsequent numbers.[43]

- Ensuring that all manufacturers producing components for a model of modular SALW use the same marking protocol (see also Box 3). This protocol would include a common designation of the primary marking component and of which other components should be serialized. Such a marking protocol could be defined by the original state of manufacture in cooperation with the original manufacturer.

Recordkeeping of modular SALW

States and manufacturers could be required to keep records of serialized components of modular SALW.

Identification of modular SALW

To enable the identification of modular SALW:

- Establish and maintain a dedicated unit of national experts who specialize in the identification of SALW. Such units can deliver national training programmes and advise and support other government agencies or units in identifying SALW.
- Share information and effective practices among such expert units as a form of international cooperation.
- Use reference tools to support identification. The INTERPOL Firearms Reference Table (IFRT) provides essential and regularly updated information for identification of SALW, including modular SALW. In addition, states could use the IFRT to develop national firearms reference tables that can be tailored to weapon models in national circulation to support SALW identification by relevant state agencies.

Tracing of modular SALW

To support the tracing of modular SALW and their components:

- Include high-quality photographs of all relevant components and markings in trace requests and in national records of SALW. This can significantly increase the success rate of tracing illicit SALW as photographs allow experts to verify and, if necessary, correct or complete trace requests or national records.[44]
- Trace all serialized components if a weapon contains mismatched serial numbers. The INTERPOL Illicit Arms Records and Tracing Management System (iARMS) contains a new function that supports the tracing of serialized components.

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43 United Nations, MGE2 Chair's Summary, paras 16, 45.

44 See, e.g., N. R. Jenzen-Jones and Matt Schroeder (eds), *An Introductory Guide to the Identification of Small Arms, Light Weapons, and Associated Ammunition* (Geneva: Small Arms Survey, 2018), **https://www.smallarmssurvey.org/resource/documenting-small-arms-and-light-weapons-basic-guide-issue-brief-14**, pp. 277–81.

BOX 3

Blurred lines between regulated and unregulated manufacture

The growing diversity of manufacturers and of production methods is blurring the boundary between regulated and unregulated manufacture of SALW. When the PoA was adopted in 2001, it was assumed that a national government issued a licence to an industrial company authorizing it to produce complete weapons. However, new manufacturers have emerged that specialize in components, including for modular SALW.

Legal classifications can leave certain SALW components outside national frameworks that regulate SALW manufacturing.[45] Partially finished components, including so-called 80 per cent receivers and kits, have been particularly likely to fall into this gap. When this occurs, the manufacturer may not need a manufacturing licence, may not be required to serialize and record these components, or may not apply other controls that would apply to a manufacturer of complete SALW. This creates legal loopholes that can be exploited to produce SALW outside state control.[46]

At the same time, advances in manufacturing technology, including 3D printing, have also made it easier for individuals to fabricate otherwise controlled components outside of state control (see Section 4).

These blurred lines between regulatory categories of manufacture and manufacturer should be taken into account when considering regulatory and operational measures at the national, regional and international levels, including under the PoA and the ITI.

Overall, interviewed experts believed that many tracing-related challenges posed by modular SALW could be addressed:

- If states consistently implement the ITI requirement to "provide prompt, timely and reliable responses to tracing requests made by other States"[47]
- By strengthening states' general capacity to identify, record and trace SALW

3.3 Key considerations

1. *The OETEG could examine measures used by states to strengthen the identification of SALW, including modular SALW, for tracing and record-keeping, taking into account different national capacities and practices.*
2. *The OETEG could explore the concrete contribution of international cooperation and assistance to sustainably strengthen national capabilities for SALW identification. This could include international*

45 See, e.g., United Nations, CTOC/COP/WG.6/2023/3.

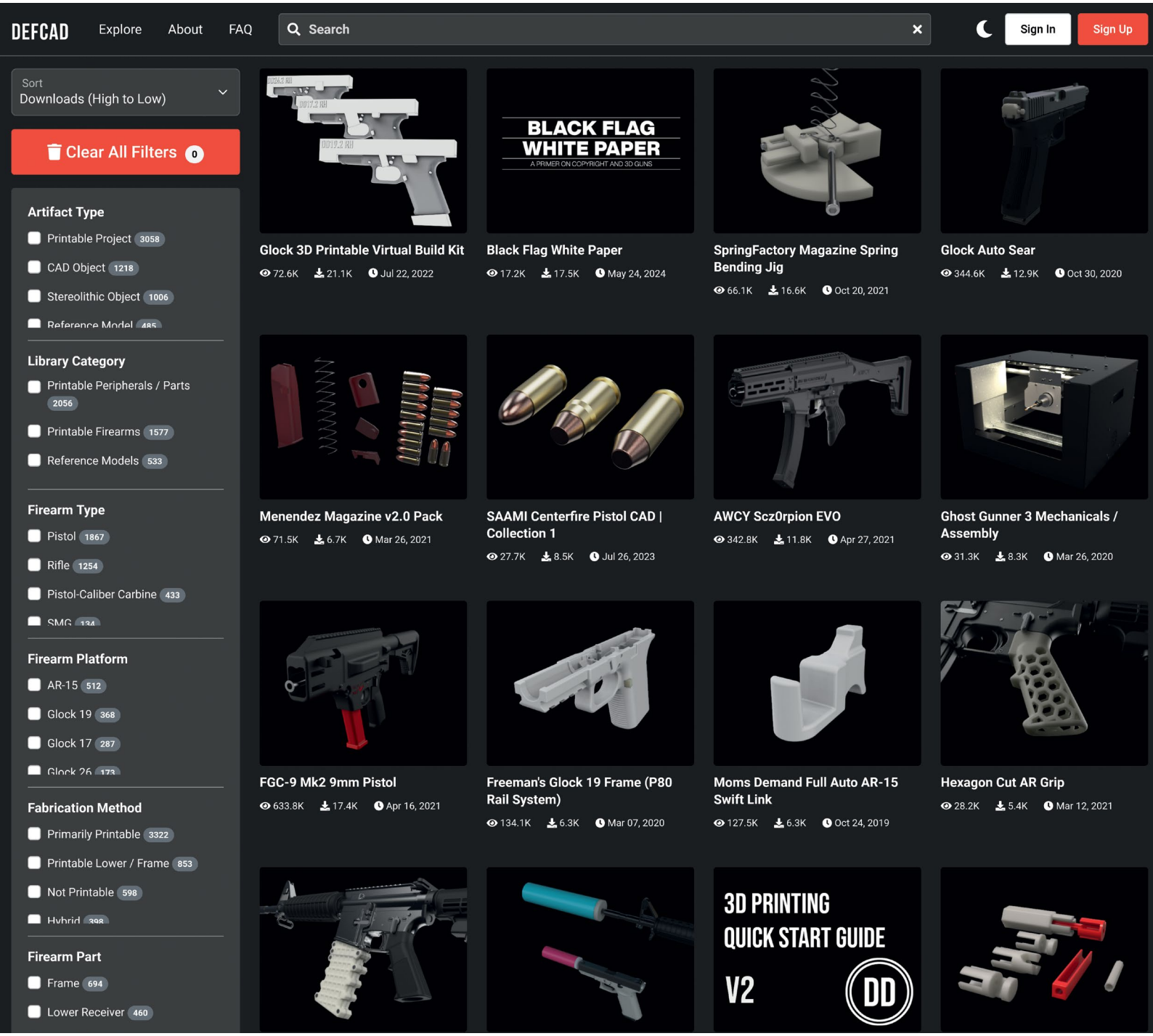
46 See, e.g., United Nations, CTOC/COP/WG.6/2023/3; Bloomberg News, "Deadly New Trade in 'Frankenstein' Guns".

47 International Tracing Instrument, A/60/88, Annex, para. 18.

assistance to develop sustainable national expert units for the identification of SALW, and cooperation to maintain the IFRT and other relevant resources and to share data to support the identification and tracing of SALW.

3. *In the light of the specific challenges of modular SALW and taking into account states' different needs and capacities, the OETEG could benefit from states sharing their effective practices for marking modular SALW (including approaches to identifying the primary marking component and other serialized components) as well as their record-keeping practices, database functions and tracing procedures for serialized components.*

Example of a website distributing knowledge on how to 3D print small arms. © DEFCAD, 2026



4. 3D printing of SALW

4.1 Context

3D printing, also known as additive manufacturing, is a manufacturing process that forms, or prints, a 3D object layer by layer, based on a digital file (often referred to as a blueprint or CAD file).[48] This commercial technology has rapidly evolved and is widely used in several industries – such as construction, medicine and engineering. If used to manufacture SALW, it constitutes a form of craft production (see Box 4).

Over the past decade, the exploitation of 3D-printing technologies for the illicit manufacturing of SALW and their components outside of state control has increased, with documented use of 3D-printed SALW in criminal activity and, more rarely, in conflict settings.[49] These weapons generally fall into two categories (see Box 4):

- Fully 3D-printed SALW, which are primarily composed of 3D-printed components and incorporate only few non-printed elements (e.g. nails, elastic bands)
- Hybrid designs, which combine 3D-printed components and readily available, unregulated components (e.g. pressure-bearing components, including the barrel as well as metal bar stocks, magazines) – resulting in improved durability[50]

3D-printed SALW designs have evolved rapidly, incorporating increasingly sophisticated technical features and higher performance standards (see Figure 1). The available advice and guidance has similarly increased in quality. Recent designs provide an unprecedented level of detailed, step-by-step instructions, which have substantially lowered technical barriers to production.[51] Beyond complete weapons, 3D printing technologies are also increasingly used to manufacture firearm accessories and devices to convert weapons, e.g., to modify a semi-automatic into a fully automatic rifle. These accessories can facilitate the manufacture of craft-produced weapons, make them easier to conceal, and increase their lethality.[52]

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48 Sarah Grand-Clément and Sunniva Selmer Reinertsen, *Additive manufacturing of conventional military equipment and implications for arms control and security: A primer* (UNIDIR, 2026); Rueben Dass, "3D-Printed Firearms: Global Proliferation Trends and Analyses", *Studies in Conflict & Terrorism*, Published online 20 May 2025, https://doi.org/10.1080/1057610X.2025.2477849.

49 Dass, "3D-Printed Firearms"; Stefan Schaufelbühl et al., "The Emergence of 3D-Printed Firearms: An Analysis of Media and Law Enforcement Reports", *Forensic Science International: Synergy*, vol. 8 (2024): 100464, https://doi.org/10.1016/j.fsisyn.2024.100464.

50 G. Hays et al., *Desktop Firearms: Emergent Small Arms Craft Production Technologies* (Armament Research Services, March 2020), https://armamentresearch.com/wp-content/uploads/2020/03/ARES-Research-Report-8-Desktop-Firearms.pdf, p. 13.

51 Yannick Veilleux-Lepage and Zoltán Füredi, "Beyond the FGC-9: How the Urutau Redefines the Global 3D-Printed Firearm Movement", Global Network on Extremism and Technology, 8 January 2025, https://gnet-research.org/2025/01/08/beyond-the-fgc-9-how-the-urutau-redefines-the-global-3d-printed-firearm-movement/.

52 Stefan Schaufelbühl, "Click, Print, Shoot, Investigate: Identifying and Navigating Investigative Challenges of 3D-Printed Firearms", Doctoral thesis, University of Lausanne, 2025, https://serval.unil.ch/resource/serval:BIB_5904A4A9811B.P003/REF.pdf, pp. 30–32.

BOX 4

Craft production of SALW

While the OETEG mandate only explicitly includes "illicit 3D printing", in practice, 3D printing intersects with other craft production techniques. For example, this is the case when 3D-printed components are combined with metal components milled using a computer numerical control (CNC) machine to produce a functional small arm. In addition, these different types of craft production pose the same types of regulatory and operational challenges to states as 3D printing. Therefore, while this section focuses on 3D printing in line with the OETEG mandate, it contextualizes 3D printing as a craft production technique.[53]

There is no universally agreed definition of craft-produced SALW. Craft production is an umbrella term that encompasses a wide spectrum of non-industrially produced small arms and light weapons "including artisanal, improvised, home-made, workshop-made, self-fabricated, or privately made weapons".[54] The wide-spread existence and changing dynamics of craft production have far-reaching implications for SALW control, making their prevention, detection and traceability harder. Craft producers can range from individuals attempting small-scale production to organized groups attempting to produce large quantities of craft weapons. These weapons have proven that they can be as lethal and as sophisticated as industrially manufactured arms. For these reasons, developing a shared understanding of what craft-produced SALW are and how to effectively control and regulate them is essential for effective arms control efforts.

The degree to which craft-produced SALW incorporate industrially manufactured components varies. Three broad categories can be distinguished:

- **No reliance on craft-produced components.** This category includes arms that are developed or assembled entirely using industrially produced components. This is generally termed modification, conversion or reactivation of small arms.
- **Mixture of craft-produced and industrial components.** This category refers to SALW with a combination of components fabricated by the craft producer and commercially available industrial components (that might or might not be regulated, depending on relevant legislation). Such craft-produced SALW range from the least sophisticated examples to largely 3D-printed designs.[55]
- **Complete reliance on craft-produced components.** This category refers to SALW that entirely use components fabricated by the craft producer, circumventing state oversight. This can include rudimentary firearms – artisanally produced using metal pipes, wood or other available materials – as well as hybrid or fully 3D-printed firearms.

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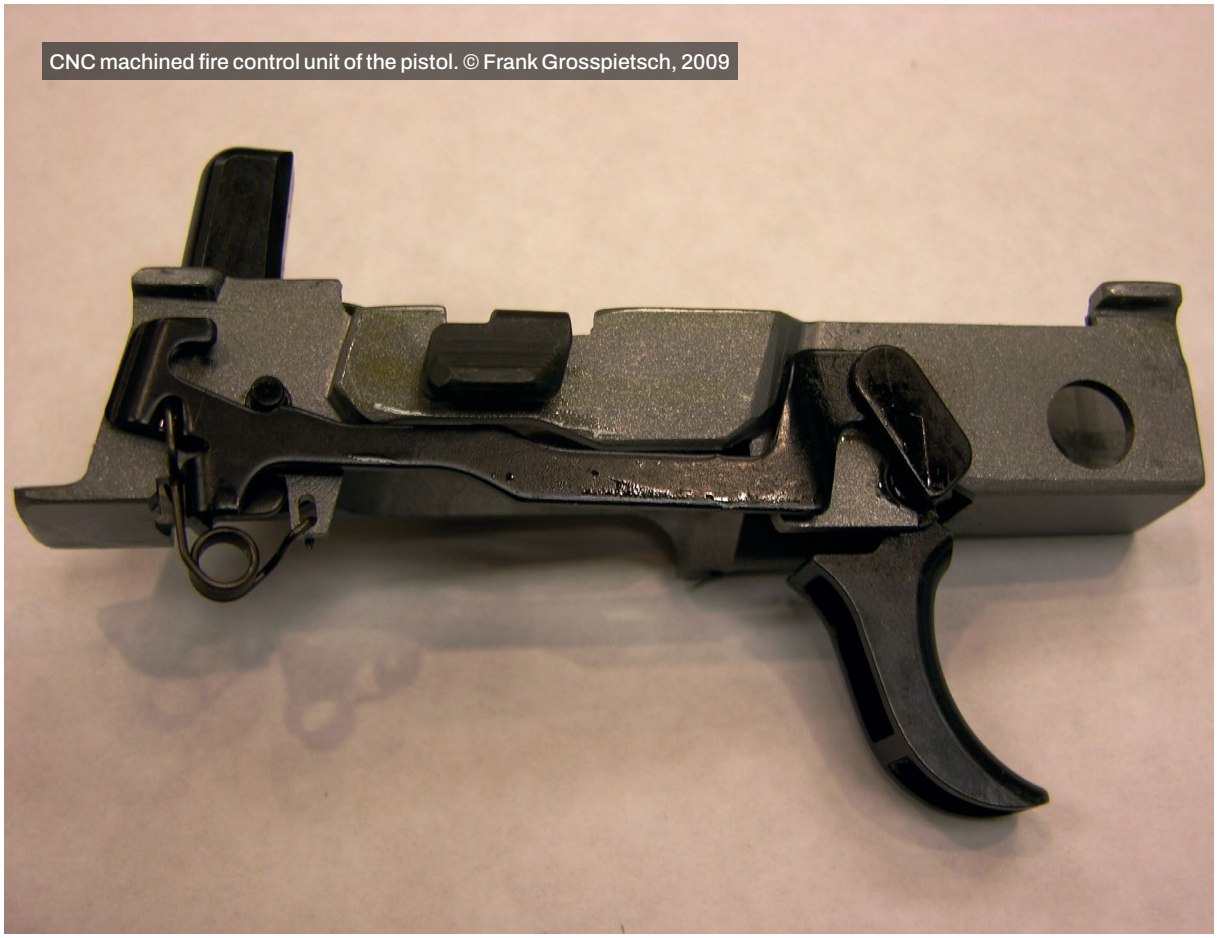
53 See, e.g., United Nations, A/CONF.192/2024/RC/3, Annex, para. 85; United Nations, General Assembly, Fourth United Nations Conference to Review Progress Made in the Implementation of the PoA, "The Craft Manufacturing of Small Arms and Light Weapons", Working Paper Submitted by France, 2024, https://docs-library.unoda.org/Programme_of_Action_on_Small_Arms_and_Light_Weapons_-Review_Conference_(2024)/WP_Craft_manufacturing_EN.pdf.

54 Vecchioni, *Unregulated Production*.

55 Hays et al., *Desktop Firearms*, p. 13.

Craft produced SIG Sauer P250 pistol. © Frank Grosspietsch, 2009



CNC machined fire control unit of the pistol. © Frank Grosspietsch, 2009

Note: This illegal craft weapon was assembled from unregulated SIG Sauer P250 components without markings and a craft produced fire control unit. The weapon has no markings (ghost gun) and was recovered at the crime scene of a homicide.

FIGURE 1

Evolution of 3D-printed SALW designs

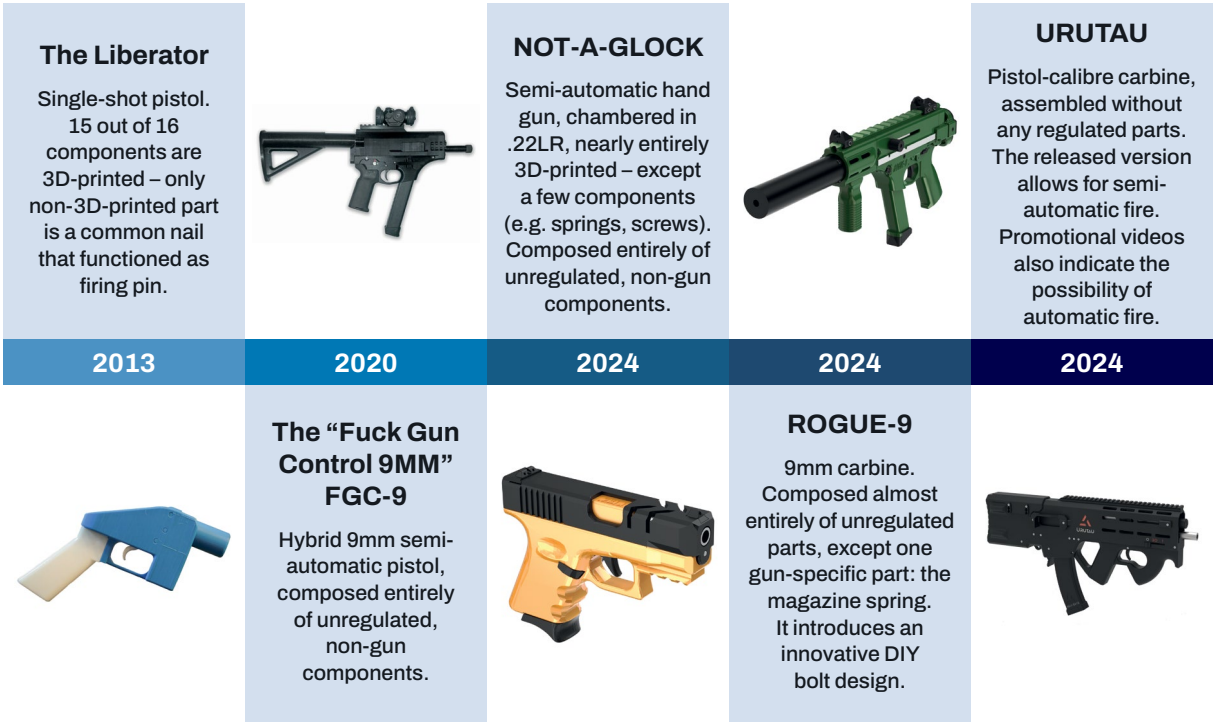


Image credits: The Liberator – © Vvzvlad, 2013; The "Fuck Gun Control 9MM" FGC-9 – © JStark1809 / Deterrence Dispensed, 2021; NOT-A-GLOCK – © DEFCAD n.d.; ROGUE-9 – © DEFCAD n.d.; URUTAU – © Black Lotus Coalition / Joseph the parrot / Rsmith28, 2024.

Note: This timeline is illustrative, not exhaustive.

The PoA requires that states exercise "effective control over the production" of SALW.[56] Yet, 3D-printed SALW have several implications for the PoA and the ITI in particular because the established controls were not designed to address 3D printing or craft production and their specific challenges. As far back as 2008, Cameroon and Ghana raised for the first time the need for better understanding of local illicit manufacturing and related challenges;[57] other states have followed suit. Starting from 2015, PoA meeting outcomes, including the outcome of MGE2, have highlighted concerns regarding 3D printing.[58]

Regulatory implications

Under the PoA, states commit to controlling SALW production and to criminalizing their illicit manufacture, possession, stockpiling and trade.[59] Existing national legal and regulatory frameworks largely address

56 United Nations Programme of Action, A/CONF.192/15(SUPP), Annex, Section II, para. 2.

57 Silvia Cattaneo and Sarah Parker, *Implementing the United Nations Programme of Action on Small Arms and Light Weapons: Analysis of the National Reports Submitted by States from 2002 to 2008* (Geneva: UNIDIR, 2008), https://unidir.org/wp-content/uploads/2023/05/Implementing_the_UN_Programme_of_action_on_SALW-2008.pdf.

58 United Nations, MGE2 Chair's Summary.

59 United Nations Programme of Action, A/CONF.192/15(SUPP), Annex.

Seizure during Operation Trigger IX, Chile. © INTERPOL, 2023.

industrial manufacturing and licensed production, and cover unlicensed craft manufacturing only implicitly, as a form of illicit manufacturing. However, 3D printing and other craft production tools and techniques are not solely intended for SALW production and can therefore be difficult to regulate (see Box 4).

In addition, current legislation in many states aims at punishing craft production, including 3D printing, after it has taken place but may have had limited success as a preventative approach.[60] For example, one common approach is to prosecute the illicit manufacture, possession and use of craft-produced weapons. The lack of a preventative approach can also limit states' capabilities to anticipate technological adaptation.

Operational implications

In accordance with PoA and ITI commitments, states agreed to take action against groups and individuals engaged in the illegal manufacturing of SALW and to cooperate in marking, tracing and record-keeping.[61] The decentralized and non-industrial nature of 3D-printed and otherwise craft-produced SALW poses significant challenges to identification, tracing and record-keeping. This complicates law enforcement efforts to investigate sources of supply and users of such SALW. Such weapons frequently lack standardized markings, may present deliberately misleading identifiers, or may closely replicate commercially manufactured firearms, including copying the same markings from such weapons. These characteristics undermine conventional tracing and classification methods. Moreover, the incorporation of polymer components further complicates detection and forensic analysis, reducing the effectiveness of traditional inspection and scanning tools (see Section 2).

60 Vecchioni and Dass, "'Do Not Try This at Home!'"

61 International Tracing Instrument, A/60/88, Annex, Section II, para. 3.

BOX 5

Knowledge transfers and the proliferation of 3D printing of SALW

Knowledge transfer is a critical enabler of 3D-printed SALW. 3D printers, CNC machines and CAD software were developed for legitimate civilian and industrial purposes and are widely available on the commercial market. Because of their wide-ranging legitimate uses, it is difficult to restrict their sale or use without disproportionately affecting lawful economic activity. One key area that could lend itself to state intervention to prevent illicit 3D printing of SALW is therefore the transfer of knowledge on how to use such tools to craft produce SALW. Such knowledge has been spreading rapidly in recent years. Increasingly precise and detailed guidance is easily accessible online. Knowledge exchanges on 3D printing of SALW occurs largely through open-source and mainstream online channels (e.g. X, Reddit, Odysee), with encrypted or Dark Web platforms playing a less prominent role.[62]

4.2 Promising approaches

PoA outcome documents have not yet provided recommendations to states on how to address the use and rapid evolution of 3D printing of SALW and other methods to craft produce SALW. Nevertheless, engagements with national and independent experts have highlighted a range of promising approaches to control and prevent the illicit proliferation of 3D-printed SALW.[63]

Preventive policy measures

Several states have updated their legislation with provisions specifically targeted at addressing and preventing 3D printing and other craft production of SALW.[64] Legal and regulatory frameworks include the criminalization of the possession, distribution or use of digital blueprints intended for weapons production,[65] as well as transfer controls on both physical and intangible technology (see Box 5). Measures also exist on related challenges, such as the conversion of blank-firing weapons.

Operational responses

Each stage in the craft production process presents opportunities for operational measures to counter illicit SALW manufacturing and proliferation. These include:

- The systematic collection and analysis of data and information relating to craft production and 3D printing of SALW. This could range from knowledge on developments in materials, tools and manufacturing technologies to identifying and monitoring individuals and networks involved in illicit manufacturing and the circulation of technical guidance and know-how.

62 Vecchioni and Dass, "'Do Not Try This at Home!'".

63 See, e.g., Vecchioni, *Unregulated Production*; Vecchioni and Dass, "'Do Not Try This at Home!'"; United Nations, "The Craft Manufacturing of Small Arms and Light Weapons", Working Paper Submitted by France.

64 Dass, "3D-Printed Firearms".

65 United Nations, MGE2 Chair's Summary.

- Sensitization and training for law enforcement officers on how to detect and trace craft-produced SALW.
- Government outreach and awareness-raising about the potential misuse of relevant tools and facilities (e.g. 3D printers) for the illicit production of SALW. This could extend to state authorities (e.g. law enforcement and border authorities), postal and shipping services, social media platforms, manufacturers of 3D printers, educational establishments, and relevant civil society actors.[66]
- Development of digital defence mechanisms and built-in tools that can prevent the usage of software, 3D printers and CNC machines to manufacture weapon components.

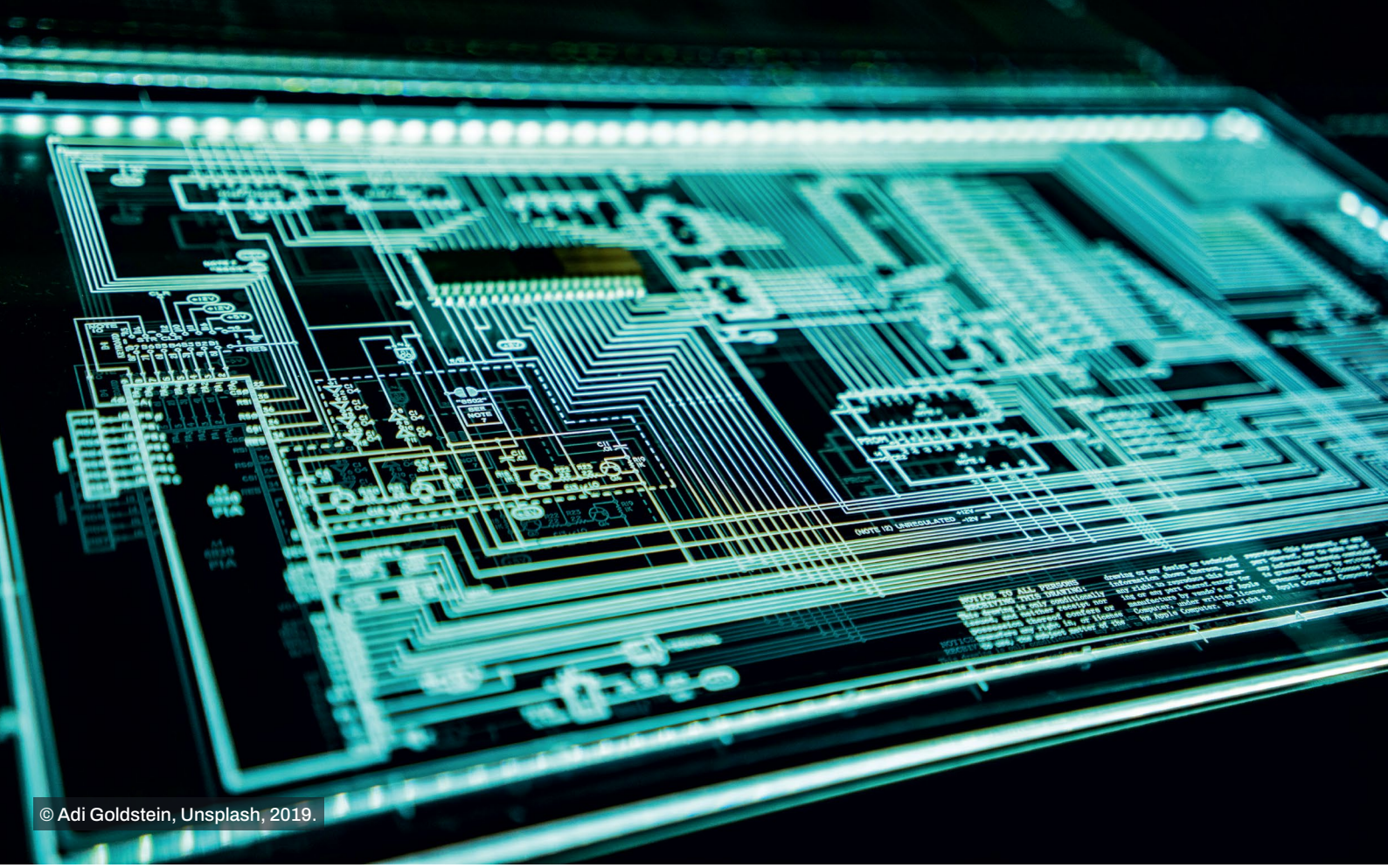
Information-sharing

States could use existing national and international cooperation mechanisms, including those under INTERPOL, to share relevant data (e.g., on seizures) to ensure that they are working with up-to-date data to inform operations.

4.3 Key considerations

1. *The OETEG could consider the development of additional guidance, shared understandings or commitments under the PoA and the ITI to support states in addressing challenges posed by the 3D printing of SALW.*
2. *The OETEG could discuss preventive policy measures taken by states to prevent craft production of SALW, including 3D printing, such as preventing the misuse of digital blueprints and of commercially available 3D printers, feedstock and components. Such measures should also take into account legitimate civilian applications.*
3. *The OETEG could discuss which stages of the 3D printing and craft production process offer the most realistic points for countering illicit craft production and the required capacities, data and partnerships for detection and disruption.*
4. *The OETEG could consider the role that international cooperation and assistance can play in preventing the craft production of SALW. This might include sharing information on sources of supply of knowledge and materials and on new production techniques and equipment, and effective countermeasures. Channels for this cooperation could include INTERPOL and also PoA meetings.*

66 United Nations, MGE2 Chair's Summary.



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5. Technology to counter diversion of SALW

5.1 Context

The diversion of SALW to unauthorized end users and end uses poses a significant threat to societies around the globe. Diversion can occur at any stage in a weapon's life cycle. Counter-diversion efforts should therefore be a continuous process throughout the whole transfer chain. While new and emerging technologies have changed diversion dynamics, they can also support counter-diversion efforts: before diversion happens (prevention), while it happens (detection) and after it has occurred (identification). These technologies can serve critical functions, such as facilitating tracking and tracing of SALW, improving record-keeping, and providing easier methods for item identification.

In the context of the PoA, states have repeatedly called attention to the importance of taking advantage of the opportunities of new technologies, including technologies to counter SALW diversion.[67] There has been discussion during PoA meetings of states on technology transfers and on international cooperation and assistance to increase the use of technology to strengthen national SALW controls and

67 United Nations, General Assembly, Report of the Seventh Biennial Meeting of States to Consider the Implementation of the PoA, A/CONF.192/BMS/2021/1, 11 August 2021.

counter the diversion and trafficking of SALW. There already exist certain technologies – both designed explicitly for arms control and designed for different, but related, applications – that are mature enough to be implemented in counter-diversion systems. Despite the interest of states and the availability of such technologies, their overall uptake in the SALW control domain has been mixed and slow compared to other sectors.[68]

5.2 Opportunities of technology in counter-diversion

There is no "one size fits all" technology to enhance counter-diversion efforts. It is critical to take a needs-driven and context-sensitive approach to applying technology to counter diversion. A methodical approach to technology integration can help the OETEG begin to consider which technologies to examine for different counter-diversion contexts.

To aid this process, UNIDIR in collaboration with the Flemish Peace Institute (FPI) developed a framework that states can use to identify and assess possible counter-diversion technologies.[69] It begins by assessing the state's needs, followed by developing an understanding of which technologies could meet those needs and then analysing the implementation context to see if this is an appropriate solution

A key component of this work entailed an assessment of technologies that could be used to counter diversion at different stages in the SALW life cycle (see Figure 2).[70] This non-exhaustive list of technologies could serve as a useful starting point for deliberations within the OETEG.

In consultations with SALW experts to develop the assessment framework, several key lessons emerged that could be useful for the OETEG:

- It is important to understand how diversion is occurring before determining which technology or combination of technologies could help to counter diversion in this context.
- Technological integration should be responsive to the systems that are already in place. For example, if existing structures are available to share diversion-related information among relevant agencies, technology could be used to make these communication channels faster or more secure, rather than attempting to restructure or duplicate them.
- Many practices and technologies that can be used to counter SALW diversion are commonplace in other industries and applications. Industry actors have implemented various technologies to strengthen the integrity and security of supply chains of commercial goods or warehouse management. For example, item-identification technologies (e.g., chemical encoding) are already in use to detect counterfeit goods such as electronics. Experiences from other sectors may help states better understand the advantages and disadvantages of certain technologies for countering diversion.
- Depending on the context, the most effective counter-diversion measure may not always require highly sophisticated technologies and may, in fact, not be technological at all.

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68 Grand-Clément and Cops, "Project D-TECT".

69 Grand-Clément and Cops, "Project D-TECT".

70 Grand-Clément, "Assessing Technologies to Counter the Diversion of Small Arms and Light Weapons".

FIGURE 2

Longlist of counter-diversion technologies and their purposes

Technology	POTENTIAL PURPOSES								
	Accountability	Tracking and tracing	Item-level identification	Inventory and storage	Anti-tampering	Identification and certification	(End-use) monitoring	Data capture / recording	Data analysis
2D Codes	✓	✓	✓	✓					
Chemical encoding	✓	✓	✓	✓					
DNA coding	✓	✓	✓	✓					
Document authentication						✓			
Electronic seals (e-seals)					✓				
GNSS and mobile tracking		✓							
Near-field communication (NFC)	✓	✓	✓			✓			
Radio-frequency identification (RFID)	✓	✓	✓	✓		✓			
Sensors						✓	✓	✓	
Internet of Things							✓	✓	
Distributed Ledger Technology (DLT)		✓			✓			✓	
Big data analysis									✓
Natural Language Processing (NLP)									✓
Computer vision									✓

BOX 6

The centrality of digital record-keeping

Record-keeping is a fundamental building block of SALW control, especially for countering diversion and SALW tracing, and is a requirement of the ITI.[71] Record-keeping practices need not be highly technical or sophisticated, but a digitized, centralized data repository can be an effective tool for counter-diversion efforts.

Record-keeping technologies can serve numerous counter-diversion functions, such as stockpile monitoring. For example, the Organization of American States (OAS) identified that many of its member states had large weapon stockpiles that were inventoried either on paper or through disparate Excel files. In response, it developed inventory-control software (Software for Control of Arms and Munition, SAM), using open-source coding, to be locally deployed by its member states. Use of this software has allowed improved stockpile management, movement tracking and monitoring of diversion risks across the region.[72]

Robust record-keeping and data can also help identify patterns of diversion. For example, Conflict Armament Research (CAR) maintains iTrace, a dynamic database of verified information that provides unique field data on diversion cases, actors, routes and patterns. This information can be integrated into national systems for transfer control assessments. Maintaining and consulting such information can help states take effective measures to prevent future diversion.

Maintaining centralized and searchable databases on SALW provides a strong basis for effective counter-diversion efforts across the SALW life cycle.

- Technology can support counter-diversion efforts at the national, regional or international level and can foster joint responses by states. For example, shared databases of diversion incidences at the regional level can help relevant states improve their diversion risk assessments.
- Many of the possible useful technologies for counter-diversion rely on digital record-keeping (see Box 6).

The OETEG should take into account the potential barriers that may be encountered when trying to implement and sustain the use of technologies to counter SALW diversion. A technology may have cost, skill, regulatory or infrastructural requirements that may make it more or less appropriate for a specific context. For example, if a state wanted to implement technology to improve tracking and tracing in a context without reliable digital infrastructure or with poor signal, a global navigation satellite system (GNSS) may not be an appropriate solution unless the state could reasonably overcome this infrastructural barrier. Figure 3 indicates which of the technologies identified for counter-diversion have the highest and lowest barriers to implementation, based on UNIDIR and FPI's findings.

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71 International Tracing Instrument, A/60/88, Annex, para. 11.

72 Pier Angelli De Luca, "OAS: Communication and Information Sharing Tools – Use of Technology to Counter Diversion of SALW", Presentation at the webinar New and Emerging Technologies to Help Counter Diversion, Geneva, 10 February 2026. https://youtu.be/Zn8_yPfoTIE?si=wb0ucYhRJ1CUGgRt

FIGURE 3

Technologies assessed as facing the highest and the lowest barriers to implementation, by stage of counter-diversion

PRE-EXPORT STAGE	
Highest barriers to implementation	Lowest barriers to implementation
GNSS and mobile tracking	2D codes
DNA coding	Document authentication
DLT	E-seals
TRANSFER STAGE	
Highest barriers to implementation	Lowest barriers to implementation
DNA coding	Document authentication
DLT	2D codes
Computer vision	RFID
Chemical encoding	–
POST-DELIVERY STAGE	
Highest barriers to implementation	Lowest barriers to implementation
DNA coding	Document authentication
GNSS and mobile tracking	E-seals
IoT	2D codes
Big data analysis	NFC

5.3 Key considerations

1. *The OETEG could consider how to assist states in determining not only technology assistance needs, but also the requirements for the successful integration of a particular technology into national counter-diversion efforts.*
2. *The OETEG could explore how best to leverage different forms of international cooperation around technology for joint counter-diversion efforts by states at the bilateral, regional and international levels.*
3. *The OETEG could provide a platform for sharing experiences and lessons learned from using technology to counter diversion of SALW. In addition, it could be expanded to enable learning from other sectors that use technology for similar functions.*

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