

SUSTAINING ENERGETIC MATERIALS CAPABILITY FOR THE FUTURE

Antoine E.D.M. van der Heijden¹ and Alexander Paraskos²

¹ Netherlands Organization for Applied Scientific Research (TNO), Dept. Munition Technology, Ypenburgse Boslaan 2, 2496 ZA The Hague, The Netherlands

² US Army DEVCOM AC, Picatinny Arsenal, NJ, USA

Abstract

In light of recent global developments, the supply of energetic materials is critical for maintaining military capability. Many crucial substances are being controlled or banned under REACH (Registration, Evaluation, Authorization, and Restriction of Chemicals, EU) and TSCA (Toxic Substances Control Act, USA) regulations and are therefore becoming harder to obtain or require replacement. Sourcing more environmentally acceptable materials for use in all weapon systems is becoming increasingly important. It is essential to identify and develop cost effective routes to provide sustainable sources of energetic materials (including their precursors) and systems.

This topic is addressed within NATO AVT-418 “*Sustaining Energetic Materials Capability for the Future*”. A preparatory meeting was held at the NATO 56th Panel Business Meeting in Riga, Latvia, in November 2025, and AVT-418 officially started in 2026. Apart from supply chain issues, critical materials and maintenance of existing and future capabilities, other potentially critical issues have been identified such as production capacity, personnel, education & training, processing equipment, lead times, recommendations for updating current STANAGs, specifications of materials and precursors etc. Furthermore, short-term critical energetic materials and components for immediate action will be identified.

With this contribution we aim to raise awareness for this NATO AVT-418 activity among the energetic materials community and invite interested partners from NATO nations, Australia and Japan to join this AVT-418 activity. The output of this activity will be the generation of a collective report to be shared with all participating nations.

1. Introduction

Ensuring a steady supply of energetic materials is essential to sustaining military strength given recent global events. Many chemical substances are being controlled or banned under regulations such as Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH, [1]) in Europe and the Toxic Substances Control Act (TSCA, [2]) in the USA, and some of these substances are also crucial for military applications. Furthermore, the supply of energetic materials and other military-relevant substances is subject to increasingly strict export control regulations to protect national security and economic interests. These substances, fulfilling the specifications on e.g. quality and purity, are therefore becoming harder to source. Changes in components, however, may adversely affect safety and reliability of munition. For these reasons, it is becoming increasingly essential to identify and develop cost effective routes to provide sustainable sources of energetic materials, including their precursors and chemical reagents such as solvents, nitrating agents and catalysts. For a part, this also relates to securing access to critical raw materials which are indispensable for strategic sectors such as renewable energy, aerospace and defence [3].

2. Previous NATO STO activities within AVT

NATO's Applied Vehicle Technology (AVT) panel is part of the NATO Science and Technology Organization (STO) and focuses on advancing military air, land and sea vehicle design and performance through collaborative research. Several NATO STO activities within the AVT panel have addressed aspects of the impact of environmental regulations, availability and quality issues of components built into energetic systems. These activities range from an Exploratory Team (ET) effort (duration of 1 year) to prepare a technical activity proposal for a Research Task Group (RTG, duration of 3 years). Other activities comprise the organization of a Research Workshop (RWS), Research Specialist's Meeting (RSM) or Research Symposium (RSY).

A brief overview of previous AVT-activities related to environmental regulations and critical materials is provided below.

AVT-RTG-293 *“Effect of environmental regulation on energetic systems and the management of critical materials and capability”* [4] (2019-2021): this activity examined

UNCLASSIFIED

present and planned regulations to assess their impact on energetic systems through the EU REACH legislation. The availability of energetic materials and related components is being affected by changes in environmental legislation and those effects across NATO need to be understood. Active research options and programs were reviewed to determine if they provide options for compliance. The Group also attempted to identify critical materials and to define routes for providing equivalent capability. Different national approaches were discussed, and the strengths and weaknesses assessed.

AVT-RTG-311 *“Availability and quality issues with raw materials for rocket propulsion systems and potential consequences for NATO”* (2019-2021): this task group looked into the availability of components for missile systems.

AVT-RWS-364 *“Environmental regulation on energetic systems and its impact on critical munitions materials and capability”* (2022): the previous activities of AVT-293 (see above) highlighted many of the issues including materials which are critical for capability. To continue the discussion on these issues, a Research Workshop was organized intended to explore these topics through broad-based discussion and review. This included reviewing regulations and future developments (REACH etc.) across NATO and partners, identifying short-term critical materials for immediate action, assessing existing research activities for options complying with planned regulation.

AVT-ET-243 *“Critical energetic materials development of sustainability”* (2024): an Exploratory Team was initiated to prepare for a new Research Task Group with the aim of directing further work to solving the problems. This effort resulted in **AVT-RTG-418** *“Sustaining energetic materials capability for the future”* (2026-2028).

3. Critical Materials

As mentioned above, legislations like REACH, TSCA, export control, etc. may heavily impact military applications. As an example, lead-based primary explosives like lead styphnate and lead azide, but also several di-isocyanates typically used for the curing of hydroxy-terminated polybutadiene (HTPB) polymers are restricted substances under REACH, implying that manufacture, placing on the market or use of these substances (on their own, in a mixture or in an article) is limited or banned in the EU. Finding alternative solutions to replace restricted

UNCLASSIFIED

DISTRIBUTION STATEMENT A: Approved for public release: distribution unlimited

UNCLASSIFIED

or banned substances is generally a lengthy process, involving research on lab-scale to identify and screen suitable alternatives, followed by development, optimization and testing of formulations and finally scale-up of the most promising solution. When changing components in a munition article, a requalification is required to demonstrate its Safety and Suitability for Service (S3). This involves rigorous testing to prove the munition is safe to handle and performs reliably in its intended operational environments throughout its lifecycle.

4. Supply Chain Issues

The collective security and industrial resilience depend on a secure and reliable supply of energetic materials, which is essential for our defense capabilities. In addition to the regulatory impacts to critical materials (as discussed above), there are other issues which can impede a reliable and secure supply chain. The origin of sourcing for precursors and associated processing materials, critical dependence on a limited number of external suppliers for essential raw materials and processing, potential shortages and changes in economics during times of conflict, as well as the ability to meet potential surge demand as stockpiles are depleted are all relevant topics. Minimizing reliance on materials susceptible to export restrictions or geopolitical manipulation is critical for ensuring manufacturing continuity.

5. Activities AVT-418

Apart from supply chain issues, critical materials and maintenance of existing and future capabilities, other potentially critical issues have been identified such as production capacity, personnel, education & training, processing equipment, lead times, recommendations for updating current STANAGs, specifications of materials and precursors etc. Furthermore, short-term critical energetic materials and components for immediate action will be identified.

UNCLASSIFIED

DISTRIBUTION STATEMENT A: Approved for public release: distribution unlimited

UNCLASSIFIED

6. Conclusions and way forward

The continued supply of energetic materials, which is crucial for military capability, is under significant pressure due to increasingly strict environmental regulations like REACH and TSCA, which are restricting or banning essential substances. This regulatory pressure, combined with fragile global supply chains dependent on limited external suppliers, presents challenges with regard to sourcing of critical components for munitions. To address this, the NATO Science and Technology Organization AVT-418 3-year research task group activity, “*Sustaining Energetic Materials Capability for the Future*” has been initiated. This group aims to identify and develop sustainable, cost-effective sources for energetic materials, tackle supply chain vulnerabilities, and address related issues such as production capacity, personnel training, and updating military standards. This document serves as a call to action for interested partners from NATO nations, Australia, and Japan to join this collaborative effort.

7. References

- [1] Registration, Evaluation, Authorization, and Restriction of Chemicals (REACH), https://environment.ec.europa.eu/topics/chemicals/reach-regulation_en (accessed 4 May 2026)
- [2] Toxic Substances Control Act (TSCA), <https://www.epa.gov/laws-regulations/summary-toxic-substances-control-act> (accessed 4 May 2026)
- [3] EU Critical Raw Materials Act, https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials/critical-raw-materials-act_en (accessed 4 May 2026)
- [4] NATO 2021 Highlights, Science & Technology Organization, https://www.nato.int/content/dam/nato/legacy-wcm/media_pdf/2022/4/pdf/2021-NATO-STO-Highlights-web.pdf (accessed 4 May 2026)

UNCLASSIFIED

DISTRIBUTION STATEMENT A: Approved for public release: distribution unlimited