

MSIAC Introduction

1st European Technical Days dedicated to chemical compatibility and eco-design of energetic materials and pyrotechnic systems

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Summary

- Introduction
- What is MSIAC?
- A study on PFAS
- How old is your rocket motor?
- The new Challenge of Lithium Batteries – should they be considered as Energetic Materials?



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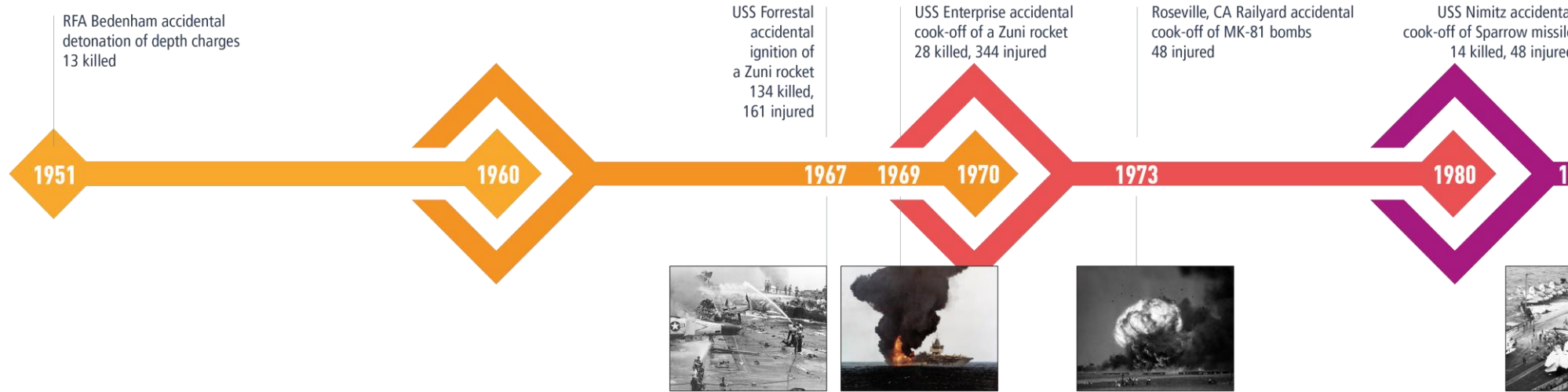
History of MSIAC is linked to history of Insensitive Munitions (IM)

- Need for IM arose from horrific accidents of 1960 and 1970s

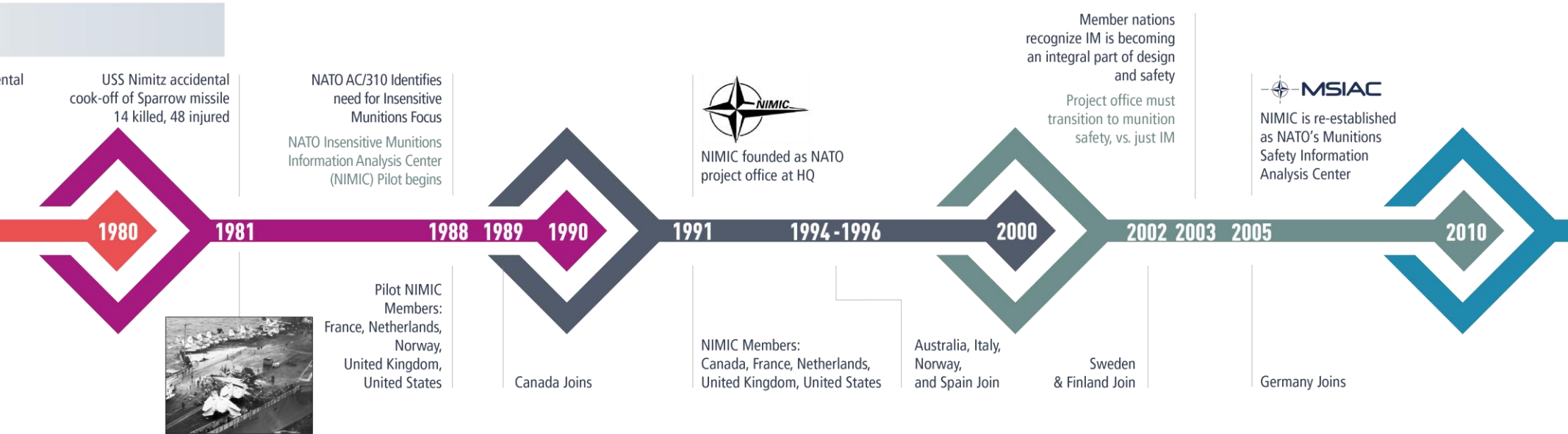


HORRIFIC MUNITION ACCIDENTS

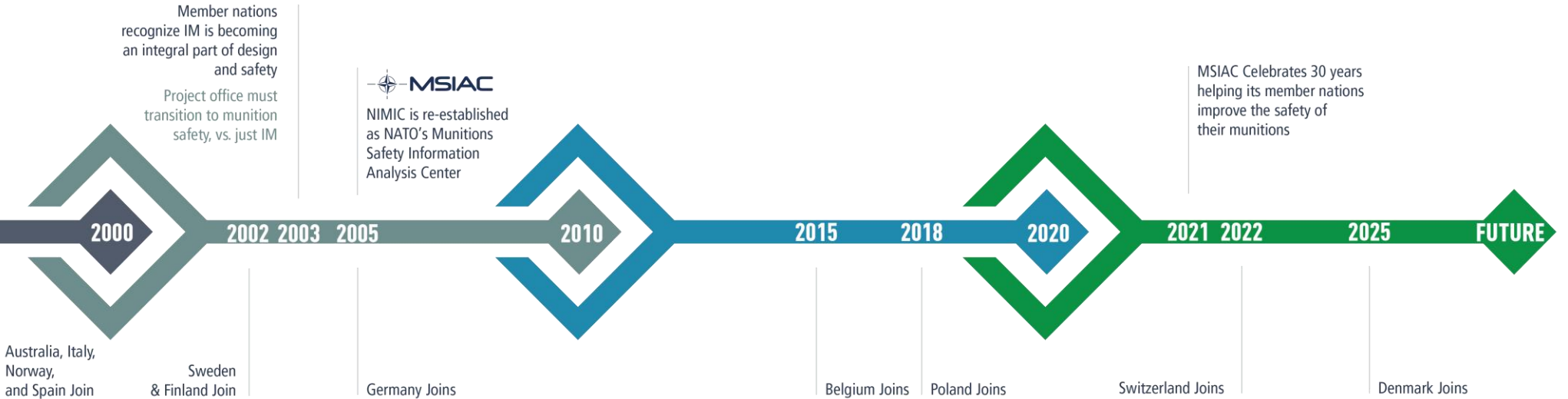
NATIONS RECOGNIZE NEED TO REDUCE DANGER TO OUR OWN FORCES



History



History



Technical Information Analysis Center Focusing on Munitions Safety

- NATO Project Office
- Independently Funded by its Member Nations (16 currently)

Areas of Expertise:

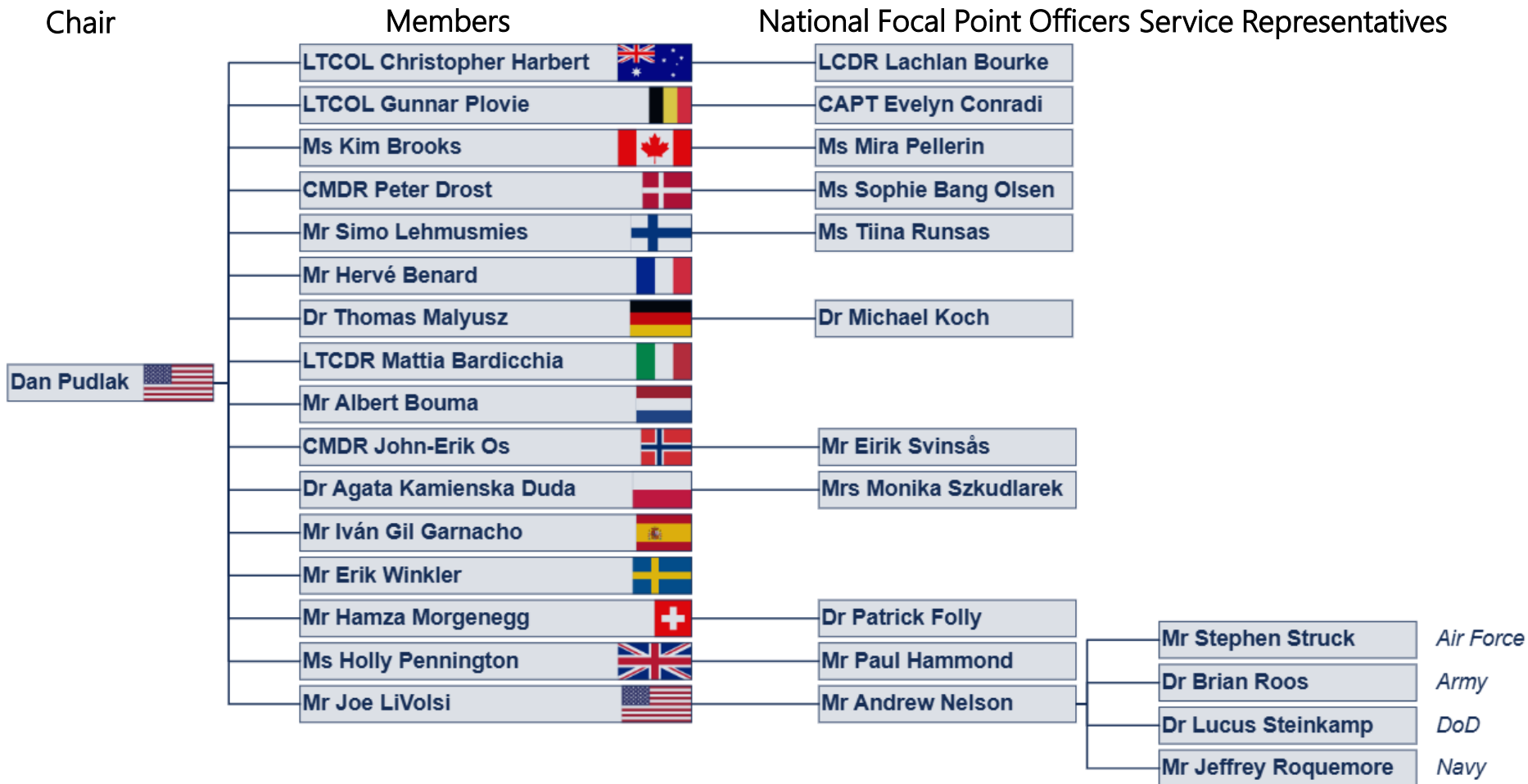
- Warhead Technology
- Propulsion Technology
- Materials Technology
- Energetic Materials
- Munitions Transport and Storage Safety
- Munitions Systems
- E3 on Munitions

Products & Services:

- Technical Questions
- Promotion/participation International Conferences
- Support to NATO WG activities
- Training and Workshops
- Technical Reports
- Repository of Technical Information

Eliminating Safety Risks from Unintended Reactions of Munitions and Energetic Materials throughout their Lifecycle

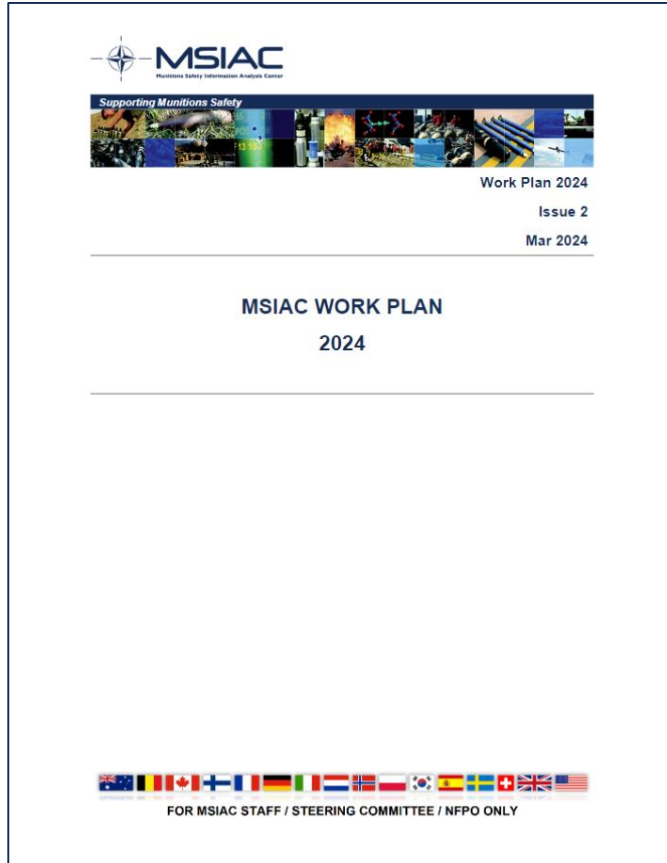
Steering Committee & NFPO



 *Chris Hollands*
PROJECT MANAGER

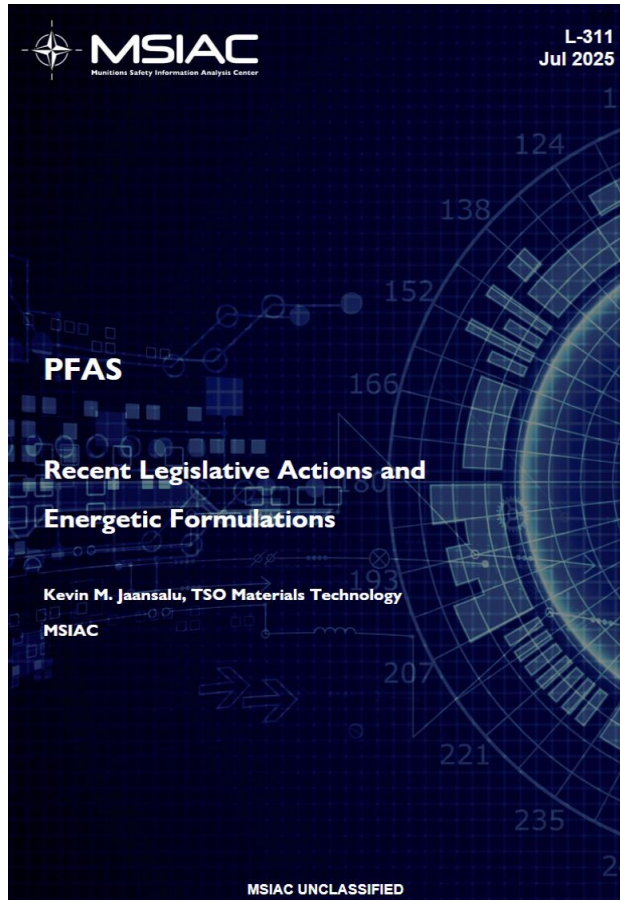


Knowledge & Access to Community of Technical Experts Across our Member Nations



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- PFAS: Per- and polyfluoroalkyl substances
 - Stable molecules : Viton
 - Used in boosters: dimensional stability, reliable performance over time
 - Safe under accident conditions
 - Key technologies for safe and insensitive munitions

BUT...

In 2023, European Chemical Agency (ECHA) received a proposal dossier to ban all substances that meet the following broad definition :

- Any substance that contains at least one fully fluorinated methyl (CF_3 -) or methylene ($-\text{CF}_2$ -) carbon atom (without any H/Cl/Br/I attached to it).

But there is an exception built-in:

- A substance that only contains the following structural elements is excluded from the scope of the proposed restriction:



where $X = -\text{OR}$ or $-\text{NRR}'$ and $X' =$ methyl ($-\text{CH}_3$), methylene ($-\text{CH}_2$ -), an aromatic group, a carbonyl group ($-\text{C}(\text{O})-$), $-\text{OR}''$, $-\text{SR}''$ or $-\text{NR}''\text{R}'''$,

and where $\text{R/R}'/\text{R}''/\text{R}'''$ is a hydrogen ($-\text{H}$), methyl ($-\text{CH}_3$), methylene ($-\text{CH}_2$ -), an aromatic group or a carbonyl group ($-\text{C}(\text{O})-$).

ECHA's Initial Overview of PFAS Applications

PFAS manufacture	Textile, upholstery, leather, apparel and carpets (TULAC)	Food contact materials and packaging	Metal plating and manufacture of metal products
Consumer mixtures	Cosmetics	Ski wax	Applications of fluorinated gases
Medical devices	Transport	Electronics and semiconductors	Energy sector
Construction products	Lubricants	Petroleum and mining	Waste stage PFAS applications
Laboratory equipment & filtration	Plant protection products and biocides	Chemical industry	Firefighting foam
Medicinal products	Plastics (other than packaging) and rubber/elastomer production (including flame retardants)	Pyrotechnics	Personal care products other than cosmetics
Fracking (currently hardly applicable in EEA)	Immersion cooling (currently hardly applicable in EEA)	Defence industry	Printing inks
Cement industry	Professional cleaning and polishing	Other niche applications	Uses (yet) unknown

- Sufficiently broad definition to capture most fluoroelastomers in the European Market
- Chemical industry, pyrotechnics and defence industry were not examined
- 32 different applications defined but only 16 were actually examined

- Green uses are researched in detail
- Blue uses are researched in general
- Orange uses not researched in detail
- Purple use: Separate restriction proposal

- Many responses made involving defence, energetic materials in particular, some are non-public
- For fluoroelastomers, “*..there have been no previous regulatory alerts and therefore no substitution dynamic exists. ... There is currently no research that has led to alternatives.*” – SFEPA
- ASD argued that the scope of the ban was disproportionate and non-manageable for the sector
- EDA argued that the administrative burden may be substantial (and disproportionate), especially for smaller nations

- Has revised the background document in response to contributions received
- Identified an additional eight application sectors:
 - Printing, sealing, machinery, other medical, military, explosives, technical textiles, and broader industrial uses
- No exceptions, will provide derogations for 12 years for some applications
 - Political mechanisms to extend exist
 - 18 months to implement + 12 years to remove → 13.5 years

PFAS (Viton, Kel-F) used as a binder in many pressed explosive formulations (found 70 times in MSIAC EMC)

- High solids loading (especially for binder content of ~5%),
→ Very high performance
- Homogeneous throughout (relative)
- Further shaped to fine tolerances
- High temperature and radiation stability (space applications)
- Very stable decomposition temperature above that of the explosive

- Insensitive Munitions
 - Pressed explosives have Good strength and higher tolerances
 - Better performance and more consistent performance (booster, shaped charge)
 - Historically, boosters had high sensitivity -> tetryl, PETN, fine RDX
 - Problem in accident or enemy action : IM response influenced by the weakest link / developing safe boosters is a critical technology for safety
- MTV Flares
 - Magnesium is the fuel; Teflon, Viton binder as oxidizers
 - Several accidents have occurred involving their manufacture



If there was something to replace it, one would think that it would have happened

- PFAS is a key ingredient in energetic formulations
 - Critical for IM technologies
- Use in synthesis / formulation / manufacturing processes not examined but likely critical
- Different approaches in different jurisdictions
- A ban is coming in Europe, bans are already in place in different sectors
 - Effects already seen in the clothing sector

 MSIAC Limited report: L-311 PFAS Recent Legislative Actions and Energetic Formulations

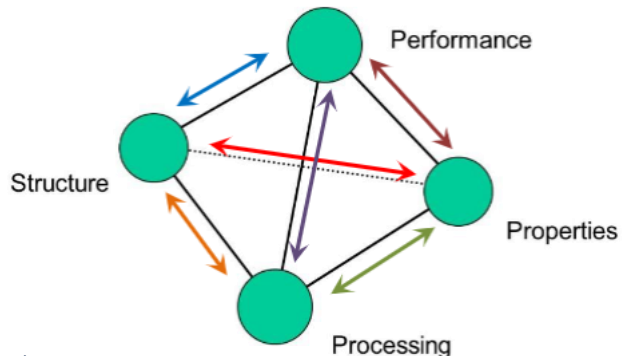
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- Numerous MSIAC reports in the past six years on ageing of munitions and energetic materials
 - L-217: Ageing of Munition Materials
 - L-281: Lifing Approaches and Ageing Algorithms
 - L-286: Thermomechanical Fatigue: An Introduction
 - L-294: The Effect of Ageing on IM Response
 - L-307: Lifing Considerations of Composite Propellant Rocket Motors

- How do Energetic Materials age?
 - Ageing is both simple and complex
 - Service life of munitions in service up to 20/30 years
 - The rate of ageing is strongly dependent upon the Life Cycle Environment Profile (LCEP)
 - Ageing capability: analysis of the chemical reactions occurring as a function of time and temperature
 - Artificial acceleration by heating an item at an elevated temperature for a period of time following the Arrhenius law.



$$t_E(T_E) = A e^{\left(-\frac{E_a}{R}\left(\frac{1}{T_E}\right)\right)} \quad \text{and} \quad t_T(T_T) = A e^{\left(-\frac{E_a}{R}\left(\frac{1}{T_T}\right)\right)}$$

Higher temperature \neq saving time

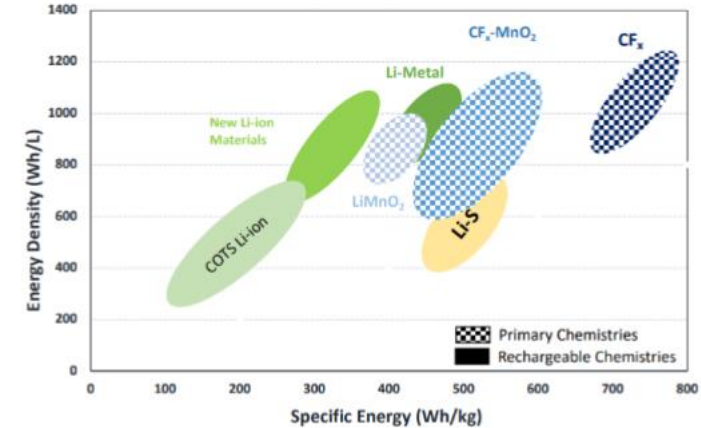
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- Batteries have been in munitions for years
- Widespread use of large capacity lithium batteries for Loitering Munitions (LM) systems since 2022
- Rapid growth in interest among NATO and partner nations
- Questions on standardization and regulatory efforts vs. existing storage and transportation regulations

- **Primary** (i.e. non-rechargeable) : single used cells
 - **Active Primary** : ready for discharge / self discharge / limited lifespan
 - **Reserve Primary** : needs to be “activated” / isolation between electrolyte and the rest of the cell / longer lifespan
- **Secondary** (i.e. rechargeable) : commonly called “lithium-ion”



➔ Primary : higher energy density and specific energy

Secondary : ability to recharge / much more encountered

- Failure induced by :
 - Undetected manufacturing defects
 - Thermal abuse
 - Mechanical abuse
 - Electrical abuse



Lithium-thionyl chloride battery – penetration by a nail – explosion 5 min after the fire started



Effect of the TNT eq of an electric vehicle battery explosion on surrounding facilities (BS&A / Fondation Maïf)



Li-ion cells failure due to abuse

Lithium Battery Hazards

- Explosion of a garage in Izegem, Belgium (Oct, 11, 2025):
 - Hybrid car exploded while charging
 - Rear wall of a building blasted
 - Broken windows around the building
 - No victim
 - 8 inhabitants relocated

[Link to article](#)



- Higher demand for Loitering Munitions
 - Widespread use of secondary Li-ion batteries even in non-reusable/recoverable LM systems
 - Trade-off between unit cost and range/endurance
- Different configurations (with primary or secondary Li Battery)
 1. Integrated, non-removable
 2. Removable but all in the same container
 3. Removable stored separately



- UN system does classify Dangerous Good upon the expected consequence, should be the DG involved in some credible accident.
 - Class 1 : Explosives (based on the response to predefined threat environment)
 - Class 9 : Miscellaneous Dangerous Substances and Articles (based on what they are with no further consideration)
- It does not consider the probability of such event to occur -> Risk that the DG themselves act as the initiating event is mitigated in general
- Lithium Batteries are unique in this sense as they may undergo “spontaneous” thermal runaway due to undetected design flaw or abuse
- No specific consideration has been given to the potential logistic requirements for storage and transportation of DG Class 1 alongside lithium batteries.
- Within the last 3 years, this issue has become important, but changes takes time in UN committees and reviews.
- Solution : “bottom up” approach from military regulations?



Cooperation and coherence with allied nations will be the key for future interoperability

