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New Range Design and Mitigation Methods for Sustainable Training

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DRDC | RDDC

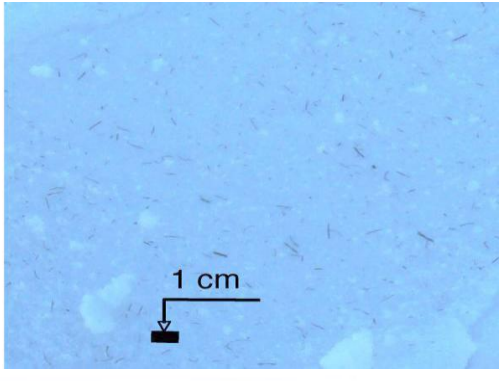
Canada

General Considerations

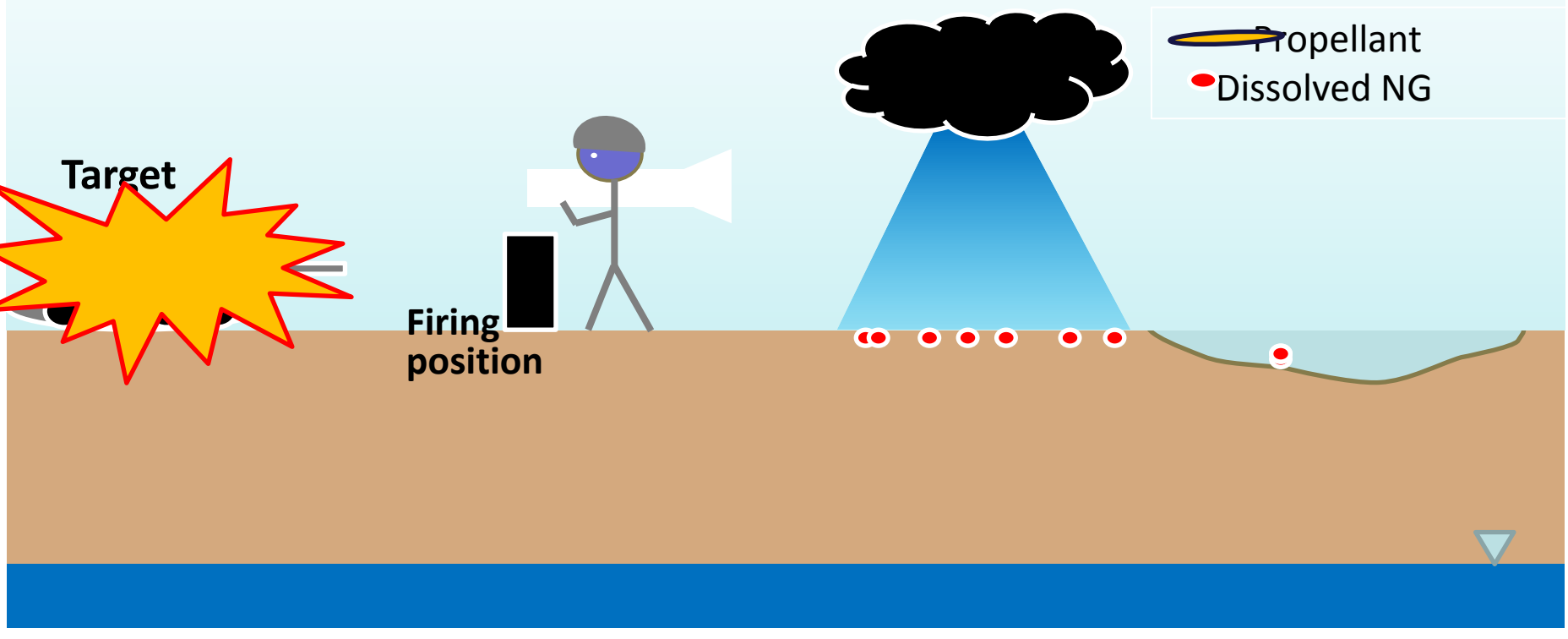
- For explosives and propellant, contamination is found in the first 2.5 cm of top soil (≥95%)
- Propellant residues are imbedded in a NC matrix and are highly resilient contaminants
- HMX has a low water solubility, low mobility and is less toxic than RDX
- RDX is mobile, moves towards SW and GW, low or no adsorption, carcinogenic, mutagenic
- TNT is more water soluble, highly toxic but photodegradable and rapidly transforms to a-DNT that reacts with humic acids, clay and other organic substrates

Nature of Munitions Residues Results in Heterogeneous Media

- EM are Crystalline Compounds
- High explosives (TNT, RDX, HMX, PETN, DNAN, NTO, FOX-12, FOX-7)
- Propellants (NC, NG, 2,4-DNT, ADN, AP)
- EM metabolites or impurities (ADNT, MNX, 2,6-DNT)
- Heavy metals (Hg, Pb, Sb, Cd, Sr), radionucleides (Th, U)



Fate and Behaviour



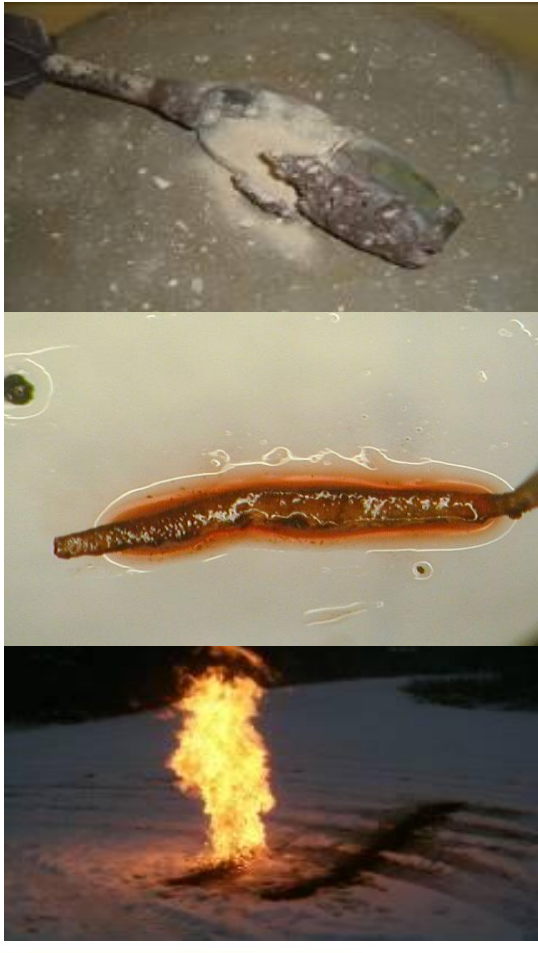
Sources of Munitions Residues in RTAs

Impact Areas

- Corrosion of UXOs
- Rupture of UXOs by detonation
- Low-order detonation
- UXO blow in place
- High order detonation

Firing Points

- Incomplete combustion of gun propellants
- Open burning of excess propellant bags



Many Types of Ranges, Various Impacts

- Artillery ranges
- Impact areas
- Bombing ranges
- Small arms and strafing
- Grenade ranges
- Demolition ranges
- Anti-tank ranges
- Tank ranges

Solutions based on physical measures

Open Burning of Propellants

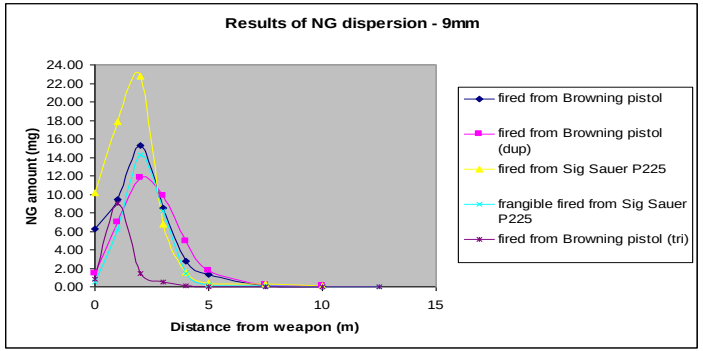
Burning Tables

Portable Burning Table

Small Arms Ranges Results

- Target Impact – stop butts
  - Pb, Sb, Cu, Zn, Sr at levels higher than threshold criteria up to 70,000 mg/kg

- Firing Positions (NG) 250 mg/kg
  - 9 mm (1-4 %)
  - 7.62 mm (1.4 %)
  - 5.56 mm (0.02-0.2 %)
  - 0.5 et 0.338 cal (0.001-0.02 %)



New Small Arms Green Range

Grenade Ranges Results

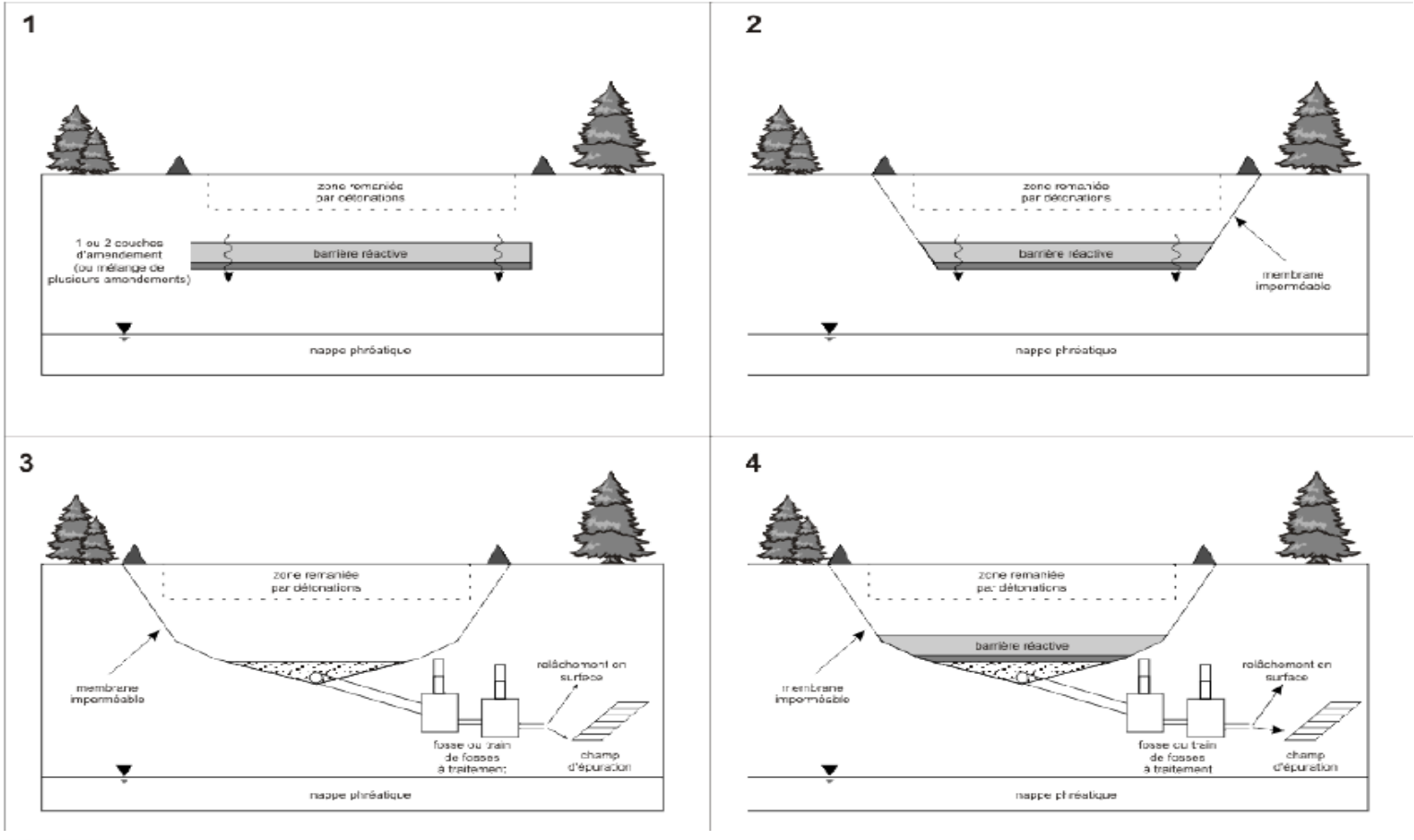
- In front of the bunker from the throwing bay
  - Low levels of RDX and TNT 10 mg/kg
  - Cu, Ni, Zn, Cd, Pb at levels higher than threshold criteria up to 3000 mg/kg and other metals at low levels
- Contamination occurs from UXOs and low orders
- Sub-Surface contamination down to a depth of 30 cm
- Surface water run off brings RDX off site

40 mm Grenade Range

- Dud rate 0-5% and low order detonations results in RDX spread by OD or partial detonation, safety issue for clearance of the range
- Thin metal may corrode exposing RDX content

Retractable Roof

Green Grenade Range with Underlying Membranes



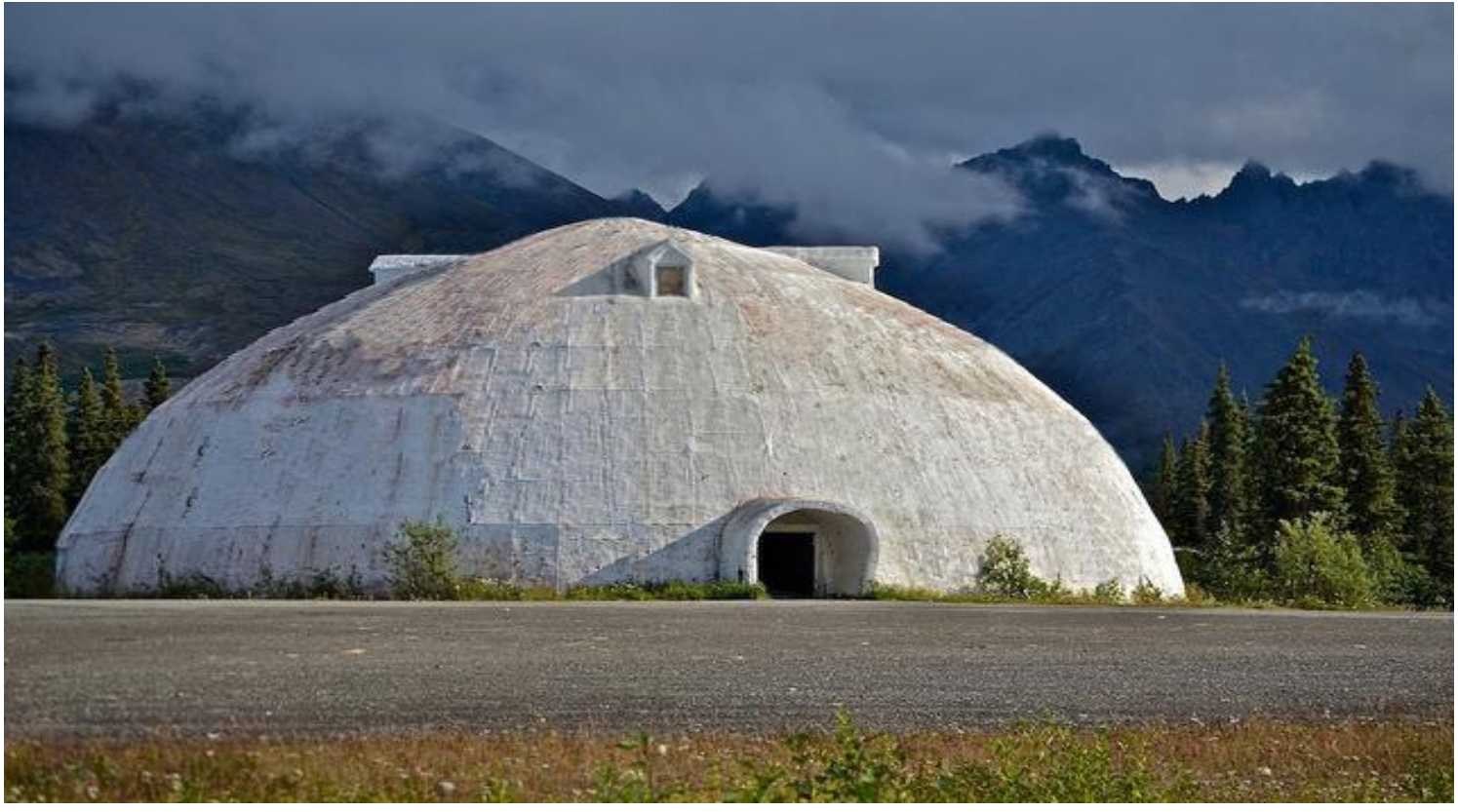
Rifle Grenade Range (40 mm)

- Concrete traps could be adapted to this exercise
- Membranes (large area must be covered)
- BIP with shaped charges

Demolition Ranges Results

- Multi-contamination by explosives, propellant and heavy metal
  - RDX is the main contaminant - from C4 OD
  - Levels up to 100 mg/kg in OD pits
  - Levels vary from non detected to 25 mg/kg in cratering, wood cutting and concrete cutting.
  - In groundwater, RDX up to 400 ppb in Petawawa

Concrete Bunker



Anti-Tank Ranges Soil Results

- Target Positions
  - HMX around targets up to 7000 mg/kg
  - TNT detected low 20-400 mg/kg
  - Heavy metals up to 15000 mg/kg
  - RDX rarely detected
  - Perchlorate higher than drinking value

Anti-Tank Ranges firing positions

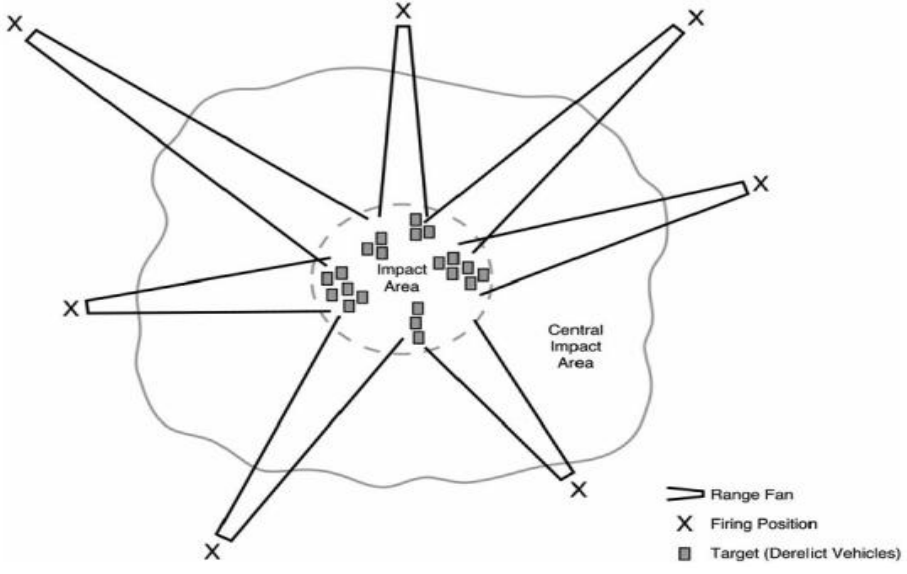
- Firing positions
  - NG detected up to 1000-17000 mg/kg
  - NG presence in front (20 m) and behind FP (30 m)
  - 84 mm Carl Gustav: Arnhem 14 % w/w
  - 66 mm – M72 : Liri 0.2%

Anti-tank Firing Positions Solutions

- Lime Application (chemical)
- Soil Burning (chemical)
- Membrane with filtering system
- Permanent Roof

Seismic Acoustic UXO Detection

- Seismic/ acoustic detectors to differentiate between high order, low order and DUD and give GPS Localization
- Target impact area: explosives residues near low orders or cracked UXO (up to % level), heavy metals around targets up to 5000 mg/kg



Artillery Target Positions Sampling

- Look for low order and cracked UXOs

Solutions Based on Chemical Measures

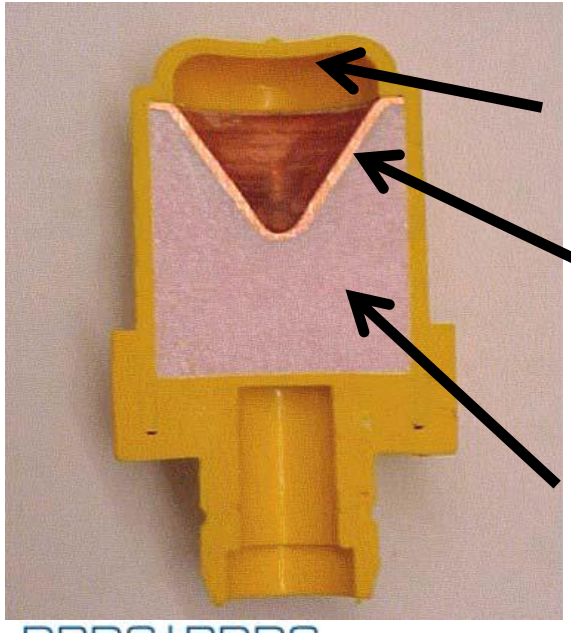
Chemical Solutions

- Alkaline Hydrolysis by lime application
- Soil Burning
- Shaped charges
- Green demolition blocks
- Green weapons : small arms, 40 mm grenades, shoulder-type weapons, modular charges
- RIGHTTRAC

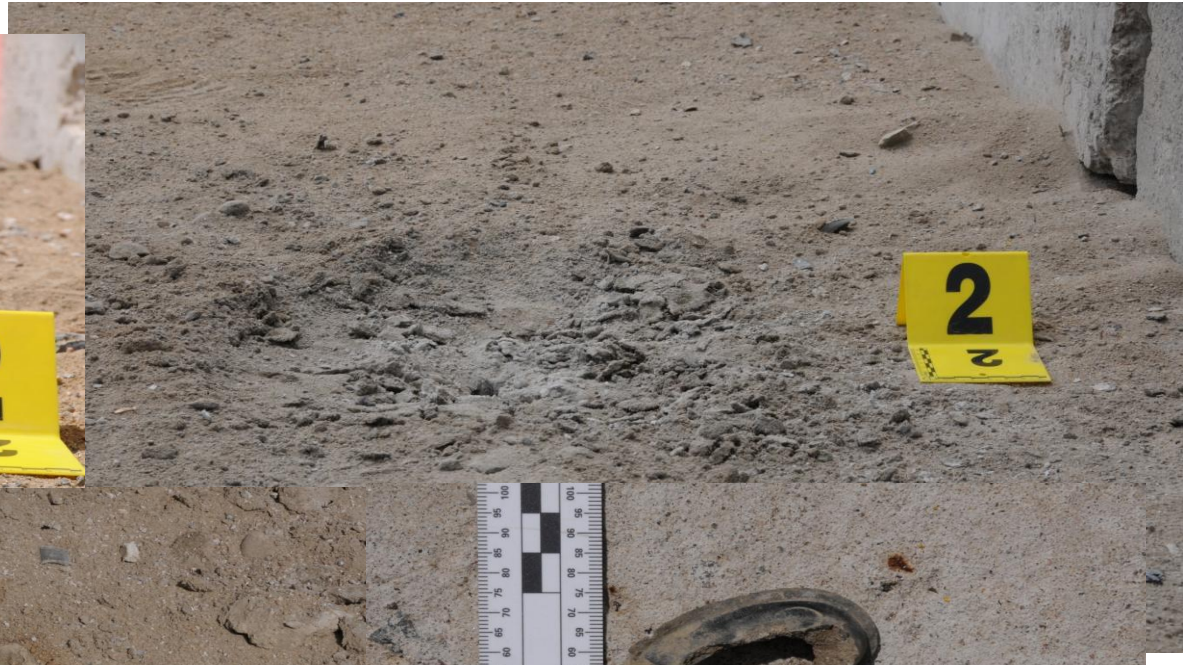
In-Situ Soil Burning

Shaped Charges

- Used for explosive ordnance disposal (UXOs, mines and IEDs)
- Prefilled shaped charge
- Copper liner to convert to a jet



High Order : 40 mm



Green Demolition Blocks

- Still need malleable explosives for cuttings
- Replacement of RDX by HMX in a formulation similar to C4
- Commercial NM-92 contains HMX and is similar to C4
- Commercial DM-12 contains PETN, can replace C4
- Work will be done to evaluate both blocks

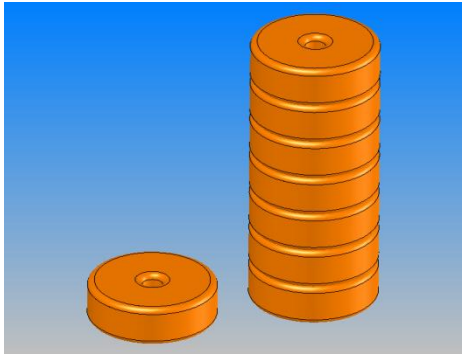
Greener Weapon

- Small Arms Tungsten vs steel/copper, tighter barrels led to erosion, metal fever. Canada will look at developing greener primer and propellants not bullets
- 40 mm grenade filled with pressed HMX would solve issues related to RDX but would cost more
- Shoulder-type weapons may benefit from re-design of the combustion chamber
- 105 mm propellant modular charges are under development to avoid burning excess of propellants
- RIGHTTRAC TDP demonstrates greener weapon

Anti-Tank 84 mm versus 66 mm

Large and Medium Calibre Sustainable Ammunition: Modular Charges for 105-mm

- 4-year project
- LG1 and C3 guns
- One bag
- The main challenge !

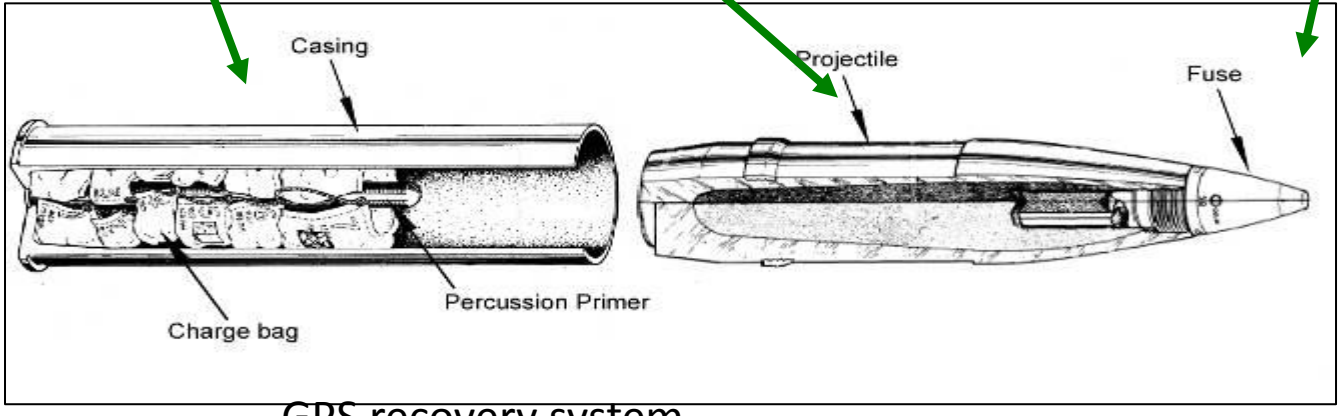


TDP RIGHTTRAC

Insensitive green

propellant and explosive

Secondary fuze



GPS recovery system

Development of Potential Solutions

Mainly by three options

- Design of green weapons without toxic components; need long development timeframe, costly but leads to sustainable solutions.
- Physical protection such as bullet catchers, burning tables, concrete traps, liners and membranes to catch water for further chemical treatment, etc
- Mitigation, destruction or transformation to benign materials by chemical treatment such as lime application, biopile, oxydation, etc

Hand Grenade Range Solutions

- Concrete traps
- Construction of a retractable roof
- Combination of retractable roof and stop berms on each side with or without underneath membranes
- Development of a grenade based on HMX formulations
- Use of membranes beneath the impact area and way around to cover projected materials
- New BIP procedures with shaped charges

Demolition Range Solutions

- Water collection using reactive or non reactive membranes followed by treatment (might be costly over time, will need analyses and surveillance)
- New procedures for demolitions using alternatives to C4 block (PETN, HMX based, shaped charge), relatively cheap, could be obtained quickly and may represent an immediate alternative before identifying a permanent solution
- Construction of a building to contain all the residues during the detonation, zero impact on the environment since it is closed, no need to implement new procedures for demo but more expensive
- Relocation on better geological formations to avoid RDX migration, soil decontamination

Conclusions

- EM found in ranges result mostly from the firing, low orders and from the UXOs and their destruction using C4 blocks
- Re-design of the weapon to make it green is feasible but is time consuming and costly
- Solutions are presently sought after to mitigate the impacts such as bullet traps, burning tables, new range designs, new ways of training and new procedures of destructions
- Designing ranges to solve the issues may represent the best long term solutions.
- Discussions among users, scientists and stakeholders is critical to identify the best solutions to sustain the training

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