RIGHTTRAC Technology Demonstrator Project : Towards Green and Insensitive Munitions

Sylvie Brochu, DRDC Valcartier

NDIA E2S2 Symposium
Denver (CO)
May 7th, 2009

National Defence Défense nationale

Canada

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
07 MAY 2009		**00-00-2009 to 00-00-2009**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
RIGHTTRAC Technology Demonstrator Project: Towards Green and Insensitive Munitions	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Defence Research & Development Canada Valcartier,2459 de la Bravoure Road,Quebec, Quebec G3J 1X5,**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Presented at the NDIA Environment, Energy Security & Sustainability (E2S2) Symposium & Exhibition held 4-7 May 2009 in Denver, CO. U.S. Government or Federal Rights License

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**28**	

Acknowledgements

Co-authors

- M. Brassard
- S. Thiboutot
- G. Ampleman
- P. Brousseau
- F. Côté
- L.-S. Lussier
- E. Diaz
- V. Tanguay
- I. Poulin

- General Dynamics OTS – Canada
- Biotechnology Research Institute (NRC Canada)
- INRS-ETE (University of Quebec)
- Centre de Recherche Industrielle du Quebec

POC: sylvie.brochu@drdc-rddc.gc.ca

Overview

- Issues in Range and Training Areas (RTAs)
- Revolutionary Insensitive, Green and Healthier Training Technology with Reduced Adverse Contamination (RIGHTTRAC) Concept
  - Fuzing System
  - Main Explosive Charge
  - Gun Propellant
- Conclusions

Environmental Impacts of Weapons

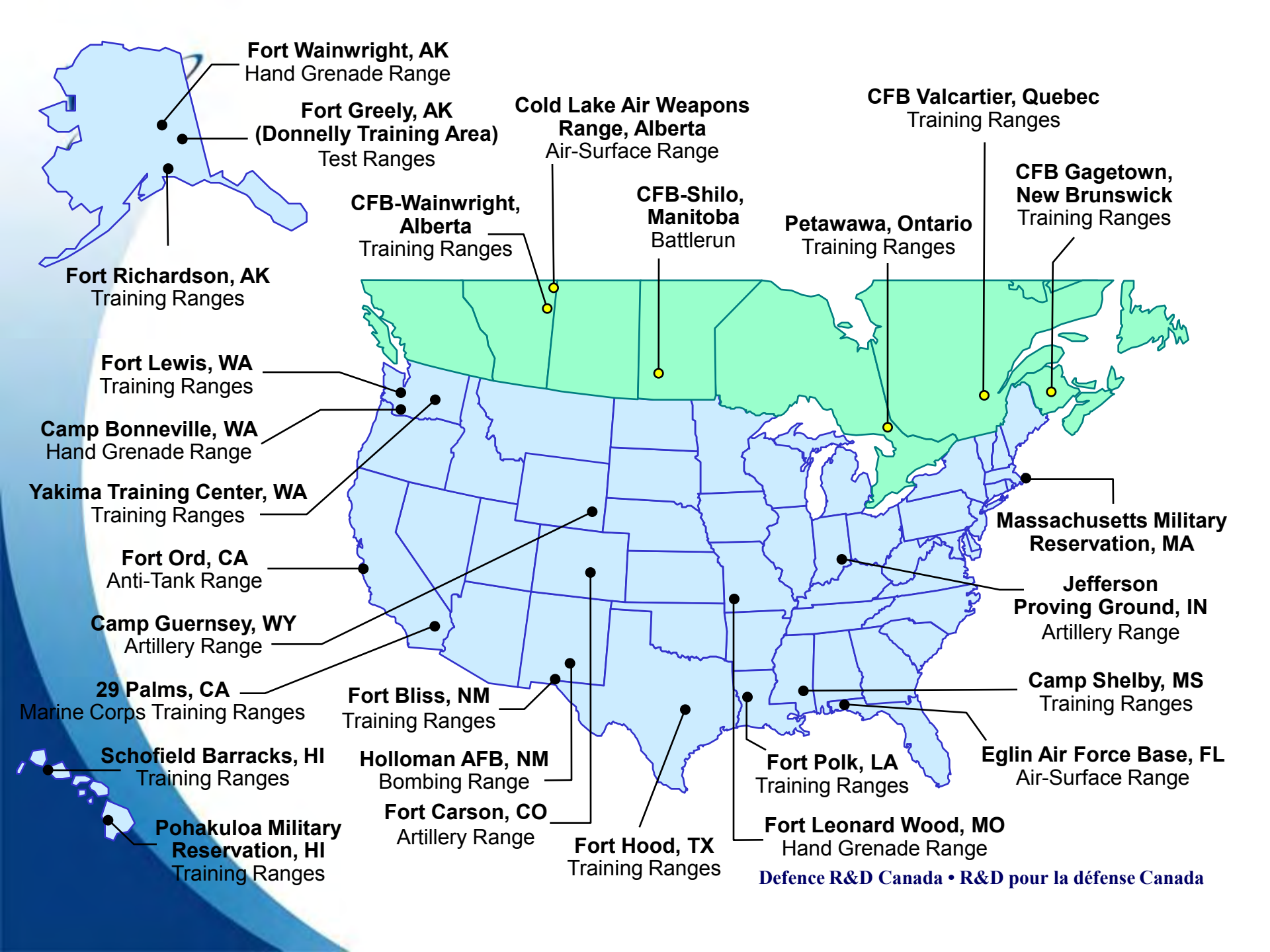
Evaluate Energetic Contamination

Firing Range Source Terms

Apply sound environmental Solutions

Environmental Impacts of Munitions on Training Ranges

- R&D program led by DRDC Valcartier (15y+) (25M+)
- Large international efforts, with USA, Sweden, the Netherlands and the other TTCP countries
- Training impacts
  - Scrutinize operational activities
  - Develop site characterization guidelines (TTCP KTA 4-28, protocol (completed))
  - Understand the complex environmental fate of explosives (ecotoxicology) (TTCP KTA 4-32)


Fort Wainwright, AK
Hand Grenade Range
Fort Greely, AK
(Donnelly Training Area)
Test Ranges
Fort Richardson, AK
Training Ranges
Cold Lake Air Weapons Range, Alberta
Air-Surface Range
CFB-Wainwright, Alberta
Training Ranges
CFB-Shilo, Manitoba
Battlerun
CFB Valcartier, Quebec
Training Ranges
CFB Gagetown, New Brunswick
Training Ranges
Petawawa, Ontario
Training Ranges
Fort Lewis, WA
Training Ranges
Camp Bonneville, WA
Hand Grenade Range
Yakima Training Center, WA
Training Ranges
Fort Ord, CA
Anti-Tank Range
Camp Guernsey, WY
Artillery Range
29 Palms, CA
Marine Corps Training Ranges
Schofield Barracks, HI
Training Ranges
Pohakuloa Military Reservation, HI
Training Ranges
Fort Bliss, NM
Training Ranges
Holloman AFB, NM
Bombing Range
Fort Carson, CO
Artillery Range
Fort Hood, TX
Training Ranges
Fort Polk, LA
Training Ranges
Fort Leonard Wood, MO
Hand Grenade Range
Massachusetts Military Reservation, MA
Jefferson Proving Ground, IN
Artillery Range
Camp Shelby, MS
Training Ranges
Eglin Air Force Base, FL
Air-Surface Range

Issues

Impact Areas

RDX (Most used explosive)

- The most mobile through the soil profile
- Migrates to groundwater and contaminates surrounding areas

Toxic heavy metals (fuze, shell, propellant…)

Firing Positions

- Significant amounts of propellants were detected
- Some of the constituents are **toxic** for the environment and **carcinogenic** for the users. (eg. 2,4-DNT, NG, phthalate derivatives, ethyl centralite, heavy metals, etc.)

Sources of Munitions Residues

- Firing Positions
  - Incomplete combustion of propellants

    15% (84 mm), 3% (9 mm)
  - Open burning of excess propellant

Health Hazards

Environmental Impacts

Sources of Munitions Residues

- Target/Impact Areas
  - Low-order detonations of various ordnance items
  - Unexploded ordnances (UXO) blow-in-place operations
  - Corrosion of surface and subsurface UXO
  - Rupture of UXO items from nearby detonations

Environmental Impacts

Safety Hazards

UXOs in Impact Areas

- Presence of UXOs

Type of fuze/munition	Dud Rate
NATO standard large caliber fuze (105, 155 and 5in):	1-3%
Mortar and grenades fuzes (60-120mm):	3-5%
Medium caliber fuzes (20-60mm):	5-8%
40mm grenades	>10%
Submunition	>20%
Age of munition	
Latest fuze technology:	1-2%
Today's typical fuze:	3-8%
20-year or older munition:	8-10%

Source: US Defense Science Board Task Force on UXO, Nov. 2003

Safety Hazards

Environmental Impacts

Average Canadian Usage of common High Explosive Munitions over the last 7 years

Round	Round/year	HE weight	Total HE	dud rate	HE residues
		g	kg	%	kg/yr
155mm	4558	6950	31678	1	317
105mm (HOW)	24370	2200	53614	1	536
81mm (HE)	6348	857	5440	3	163
60mm (HE)	2848	300	854	3	26
Rocket 66mm HEAT	5674	300	1702	3	51
Grenades HE Frag C13	19399	185	3589	3	108
Total	63197	10792	96878		1200

More than 95% of CF munitions are currently used in training, in domestic operations

180 GL

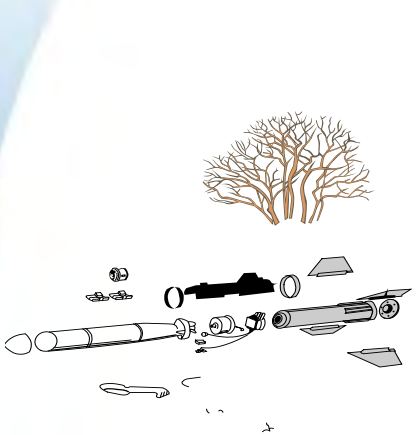
225 000 kg of gun propellant

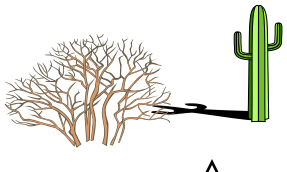
2000-20 000 kg gun propellant residues

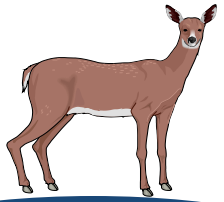
Highly Impacted Sites

- Demolition ranges: EM, NG, 2,4-DNT, heavy metals
- Small arms ranges : Heavy metals, NG, 2,4-DNT
- Grenade ranges: EM and heavy metals
- Antitank ranges: NG, 2,4-DNT, HMX, heavy metals

Environmental Fate of Explosive: Toxicity and Bioavailability







Dissolution

Absorption by Vegetation

Absorption by Wildlife

Interactions with soil

Transport

Degradation

Human Being

Groundwater

Irrigation Drinking Water

National Considerations

- Military readiness is imperative;
- Most of our munitions are fired in RTAs;
- Increased personnel in land force;
- Increased foreign training.

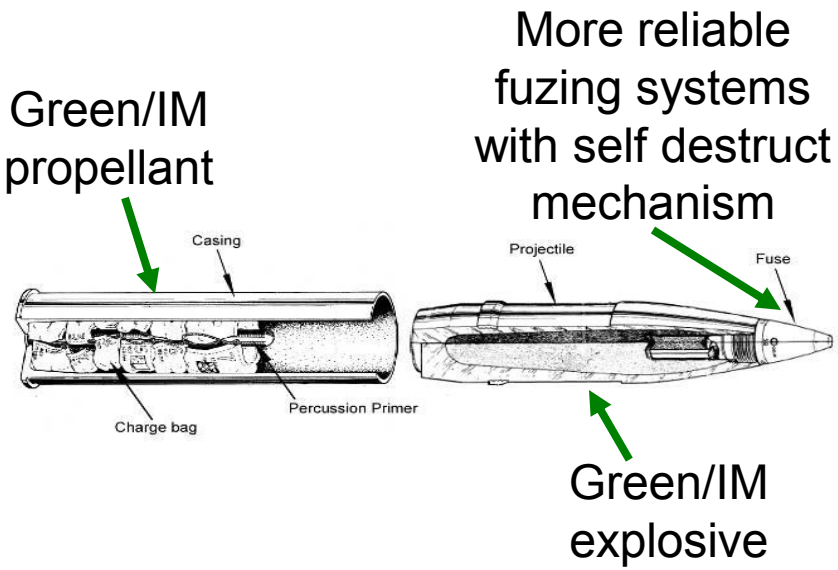
Avoid RDX

Prevention is essential to keep RTAs in operational conditions

Decrease the production of UXO

Avoid the use of toxic and carcinogenic components in gun powders

RIGHTTRAC Concept



Objectives: To demonstrate that Green / IM munitions have better properties than current munitions with the benefit of decreasing the environmental pressure, health hazards, and achieving IM munitions for use in operations.

Technologies:

- Replace toxic and/or environmentally-damageable components of explosive and gun propellant by green, insensitive and recyclable compounds;
- Reduce the dud rate by including a self-destruct mechanism in a fuze
- Technology transferable to other calibers.

IM Tests – Bullet Impact

Current Explosive

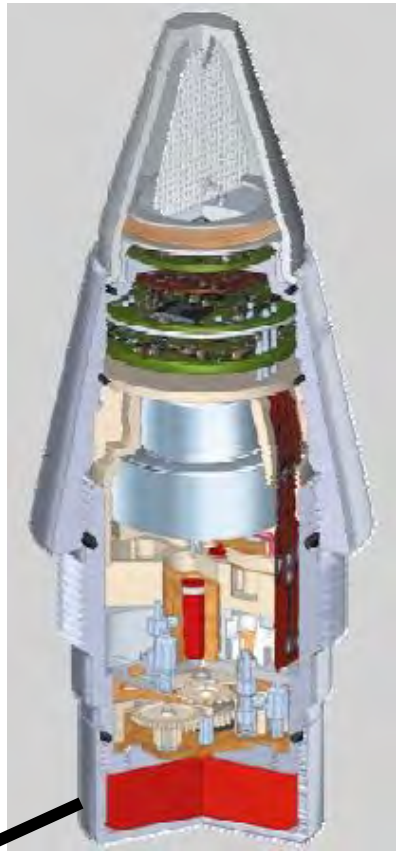
IM Explosive

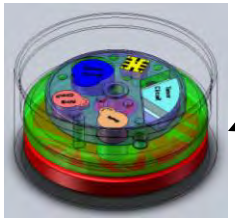
Military Impact

- Reduce safety hazards in training;
- Decrease the need for a regular surface clearance;
- Need for only one type of gun propellant;
  - No more use of 7 different types of bags
  - No burning of excess gun powder
- Sustain military training and maintain CF readiness by decreasing the environmental pressure on RTAs;
- Reduce overall cost of life-cycle management by recycling the components of obsolete rounds into new ammunition;
- Proof of due diligence;
- Reduction of potential law suits by decreasing the adverse impact on the soldier.

Fuzing System

- Development of a self-destruct capability to current artillery fuzing system in case of a failure of the primary fuze:
  - Operator handling
  - Soft impacts
  - Age-related failures
- Implementation in the existing C32A1 multi-options fuze artilley (MOFA) and/or the point detonating mechanical (PDM) 739.
- Reduce the actual live fire dud rate from approximately 5% overall to less than 1%;





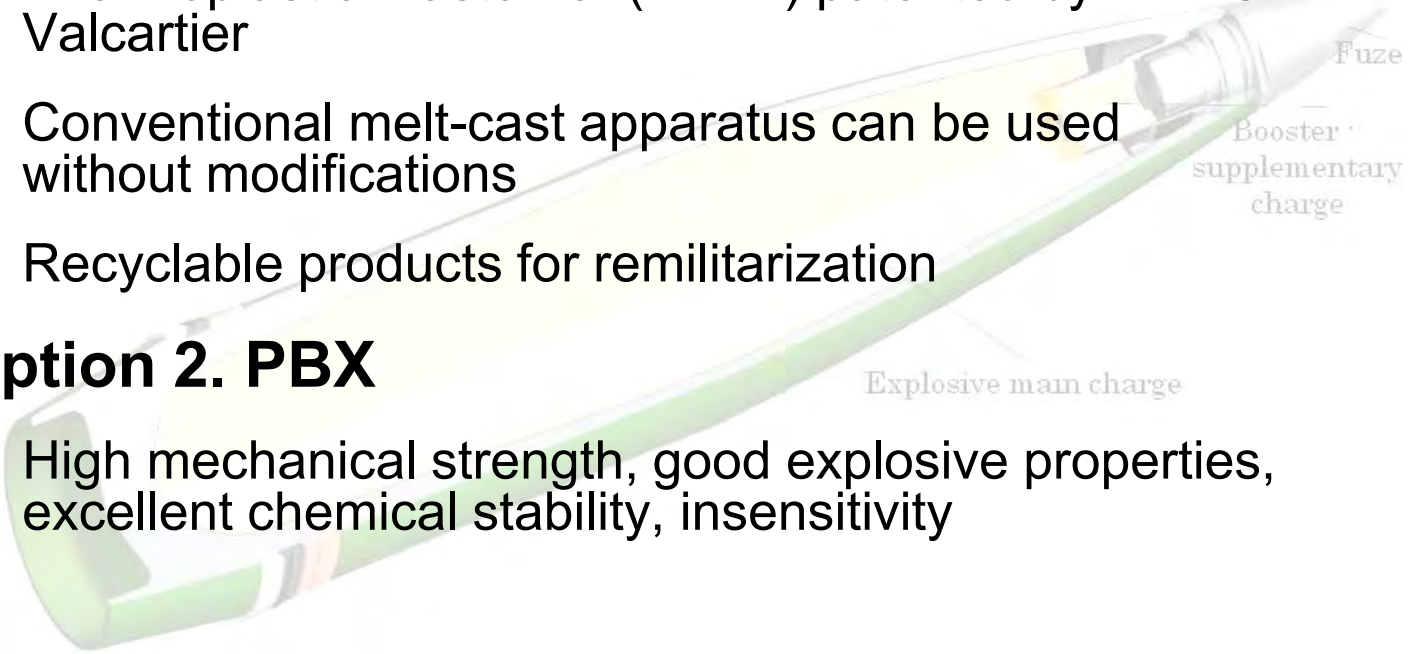
Explosive Main Charge

Option 1. Green/IM Explosive (GIM)

- Mix of melt-cast explosives with an Energetic Thermoplastic Elastomer (ETPE) patented by DRDC Valcartier
- Conventional melt-cast apparatus can be used without modifications
- Recyclable products for remilitarization

Option 2. PBX

- High mechanical strength, good explosive properties, excellent chemical stability, insensitivity



RDX Substitute

Water Solubility (mg/L)	
RDX	HMX
42	5.0

EPA Lifetime Health Advisory for Drinking Water (μg/L)	
RDX	HMX
2	400

- HMX less soluble than RDX
- HMX less toxic than RDX
- Factor of 1000!
- Other energetic materials could also be appropriate but at this point in time, HMX is our best bet!

Gun Propellant System

- Highly plasticized single base propellant (DNT, DBP and DPA free)
  Green compliance** = **High**; **IM compliance** = **Low

- Modified triple base propellant incorporating TEGDN as plasticizer instead of NG
  Green compliance** = **High**; **IM compliance** = **High

- Modified HELOVA
  (Nitramine-based propellant with ETPE (Energetic ThermoPlastic Elastomer) and energetic plasticizer)
  Green compliance** = **Medium**; **IM compliance** = **Very High

- Propellant combining nitrocellulose and ETPE
  Green compliance** = **High**; **IM compliance** = **Very High

Demonstrations

- Candidate technologies selected based on:
  - Environment (30%) (environmental fate, bioavailability, air emissions and recyclability)
  - IM (25%) (bullet impact, fragmentation impact, slow cook-off, fast cook-off, sympathetic detonation and shaped charge jet)
  - Technical feasibility (20%)
  - Cost (15%)
  - Performance (10%) (**must be at least as good** as in-service ammunition)

- Before any tests are done, the requirement for an environmental assessment, as defined by the *Canadian Environmental Assessment Act*, will be reviewed
- Demonstrations will be conducted initially as sub-system bench tests at METC and/or contractor's site
- Final demonstrations under real firing conditions using 105-mm artillery ammunition in Suffield

Conclusions

- We are trying to demonstrate a green and IM 105-mm round
  - To ease the environmental pressure on the Canadian Forces RTAs
- We are working on:
  - The fuze (to reach a near-zero dud rate)
  - The gun propellant (to incorporate less toxic ingredients that will also increase IM)
  - The explosive (to replace RDX – move to HMX, and add a binder that will reduce the bioavailability and increase IM)
- Life-cycle cost of current ammo vs green ammo

Questions?

Comments?


DEFENCE
R&D
DÉFENSE

Environmental fate of TNT

- Rapidly degraded to DNT in soil
- Not bioavailable, because strongly bound to the organic content of the soil
- Seldom detected in groundwater, to the contrary of RDX
- Very little solubilization observed after more than one year of underwater exposure of TNT samples in Swedish lakes
- Octol-contaminated legacy sites: High levels of HMX in surface soil (up to 5000 mg/kg), but no TNT detected in the soil or the groundwater
- Open detonations studies of Comp B-filled munitions:
  - RDX detected
  - No TNT detected (possibly transformed to dimers in the detonation process)

Conclusion

- Even if TNT is toxic, it is not bioavailable in most of the environmental conditions.

Other Sub-Systems

- Booster:
  - Not a new ingredient
  - Ensure that the IM explosive is efficiently ignited by the booster
- Need of a supplementary charge?
- Primer:
  - Not a new ingredient
  - Ensure that the IM gun propellant is efficiently ignited by the primer

Exploitation Strategy

- Exploitation Strategy planning has identified **5 beneficiary communities**:
  - ADM(IE)/DGE
  - ADM(Mat)/DGLEPM
  - User Community (CLS,CAS,CMS,CEFCOM)
  - Industry
  - Allied Nations
- **Exploitable Results** for these communities:
  - Self-destruct Fuze (probably **most rapidly exploitable** aspect of project)
  - Green/IM/Recyclable Explosive
  - Green/IM/Recyclable Propellant
  - 105mm Prototype
  - Validation of Test methods for Environmental Fate
  - Development and validation of Test methods for Air Residues
  - Development and Validation of IM Test Methods
  - Life Cycle Costs Assessment Methodology
- **Exploitation Plan**: Will be developed with Exploitation Manager (DAEME 8), during 1st year of Implementation