



Defence Research and  
Development Canada Recherche et développement  
pour la défense Canada

NON-CONTROLLED GOODS

# Gas and Particulate Emissions From Military Activities

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Atmos'fair 2013

September 26<sup>th</sup>



## NOTICE

(U) This document has been reviewed and DOES NOT CONTAIN controlled goods technical data.

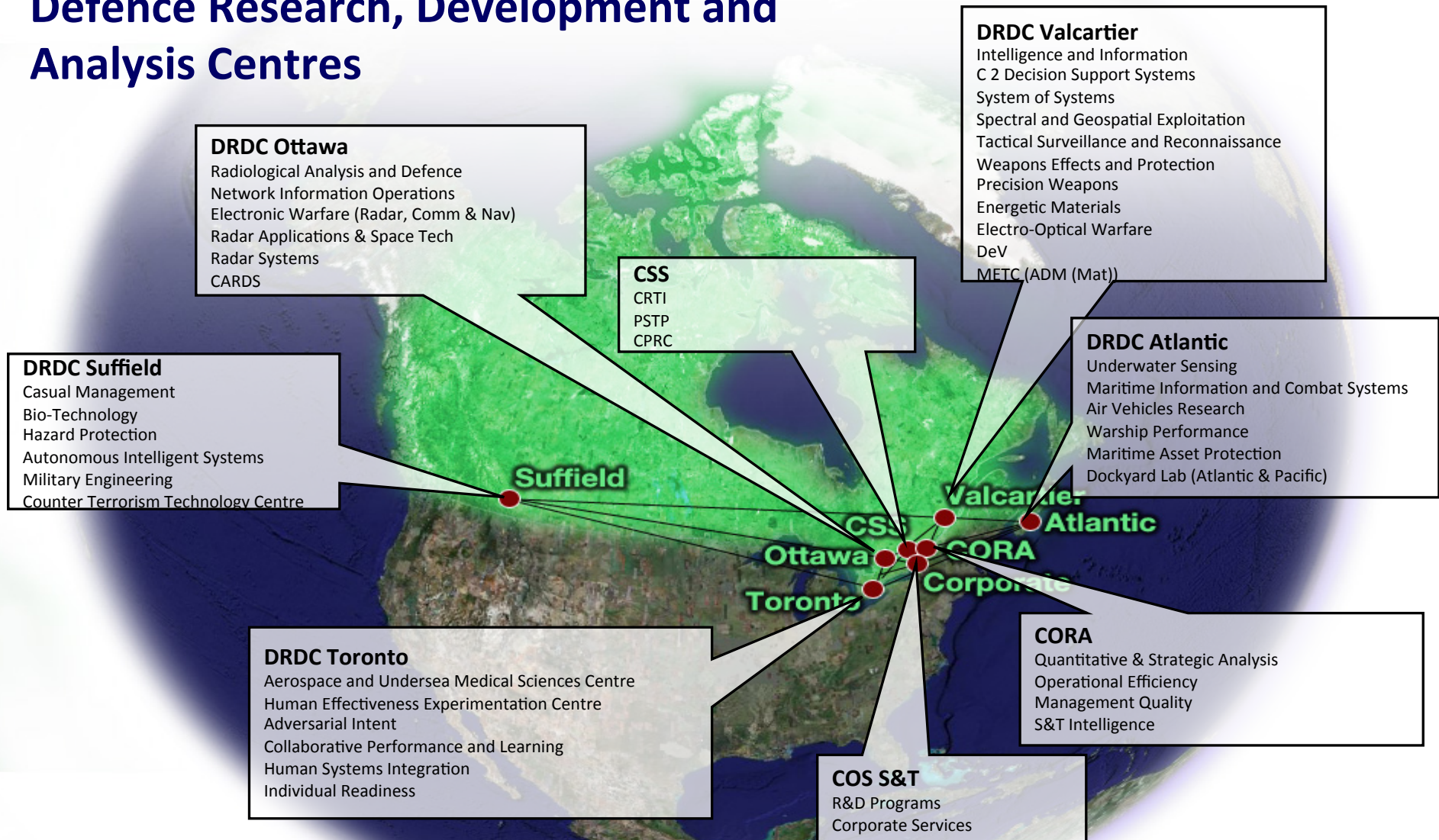
DRDC | RDDC

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NON-CONTROLLED GOODS



# Defence Research, Development and Analysis Centres







# Defence R&D Canada - Valcartier

## *Innovation & Impact*

**Staff**

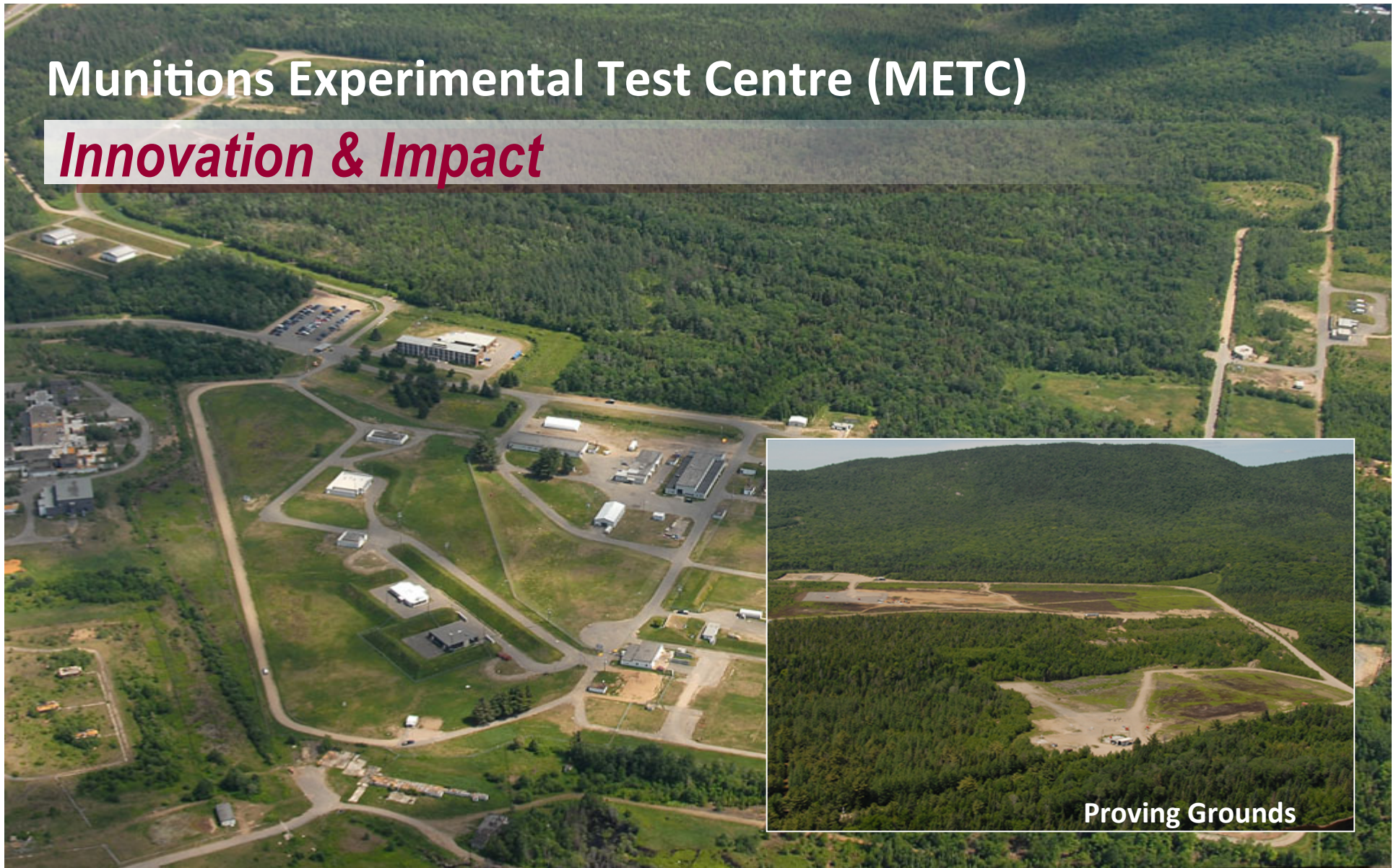
Civilians: 331

Canadian Forces: >20



# Munitions Experimental Test Centre (METC)

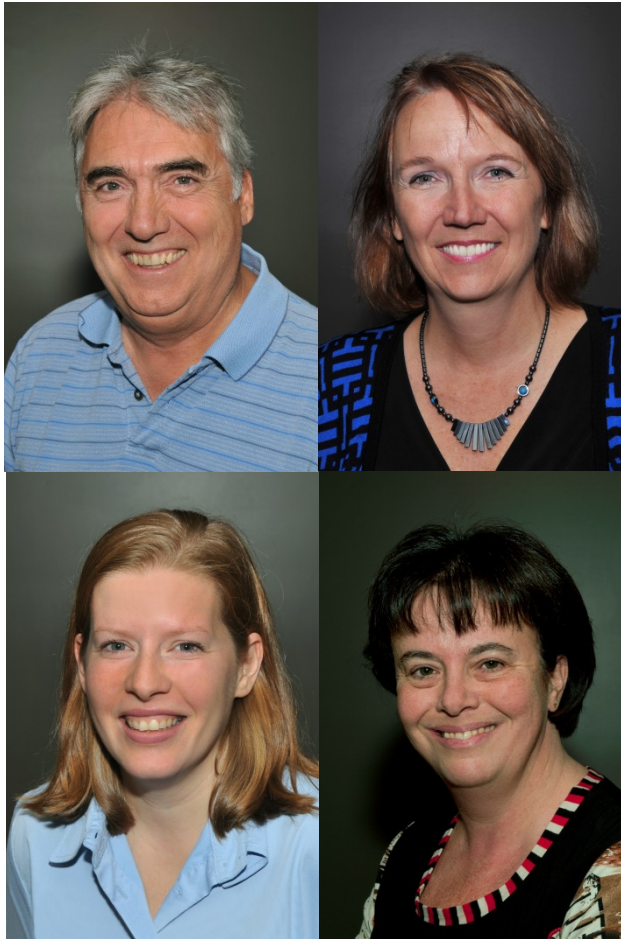
## *Innovation & Impact*



Proving Grounds



## Environmental Project at DRDC Valcartier



- Mission: To sustain the military training and minimize environmental problems.
- Important event
  - The closure of the Massachusetts Military Reservation (MMR).
- Canadian initiatives and strength
  - Hydrogeology

## What we know ?



Low-order



Low-order



Cracked UXO

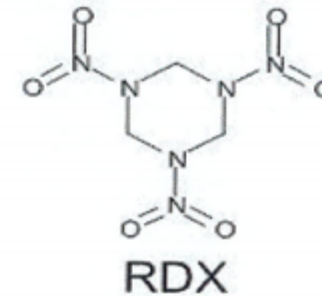
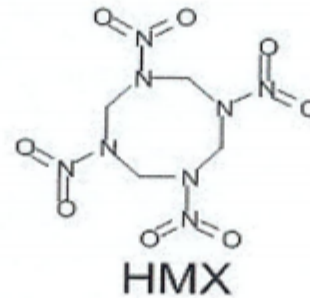
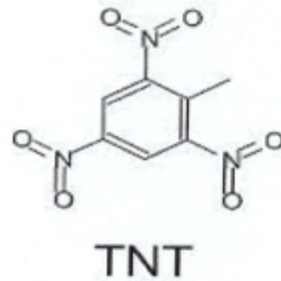


Low-order

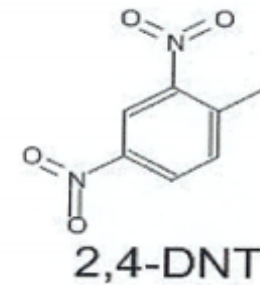
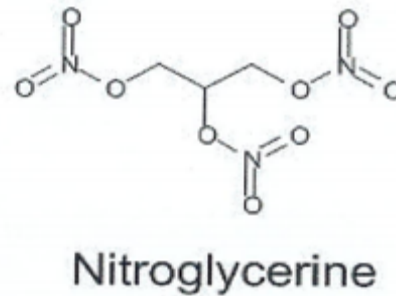


# Contaminants

## Impact area



# Firing positions



# Metals and perchlorate

## Air Emission from Live-Firing (2006-2010)

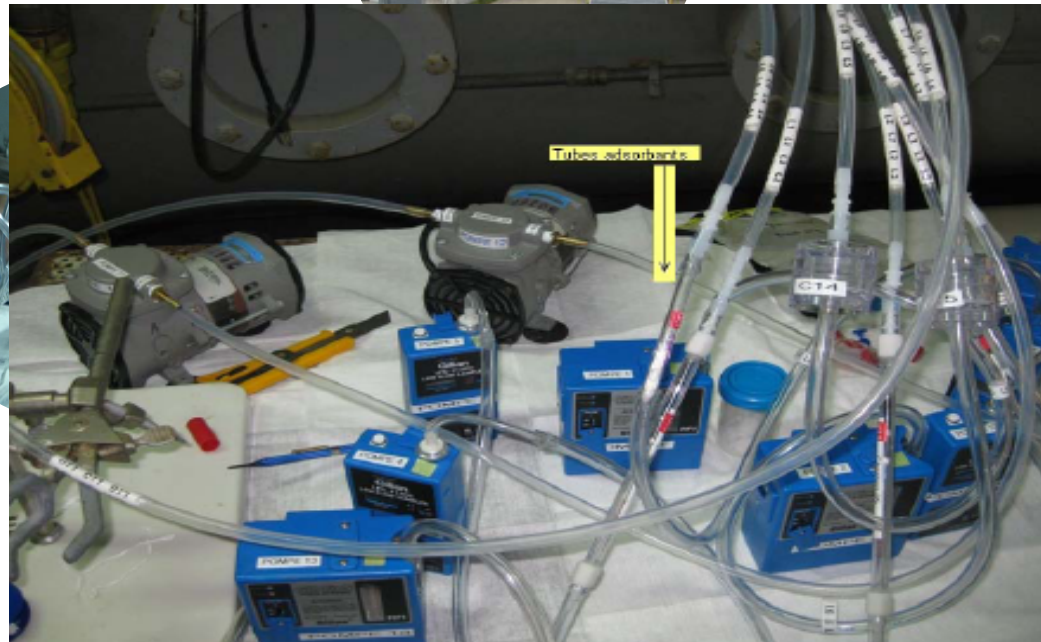




## Live-Firing monitoring : outdoor set-up



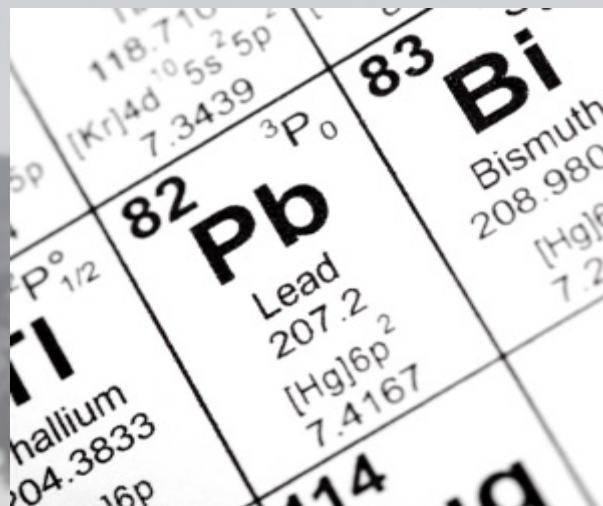
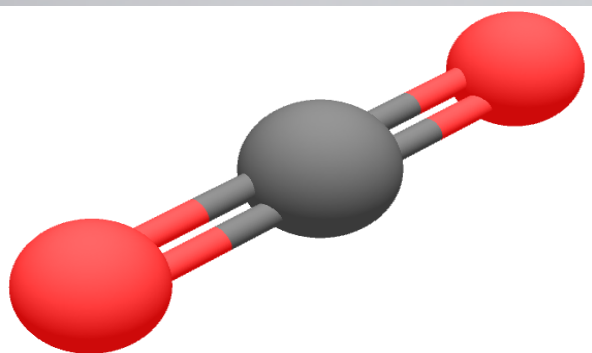
## Indoor set-up





## Gun Propellant: Live-firing and demilitarization (open burning)





A close-up photograph of a portion of the periodic table, specifically focusing on the elements Lead (Pb) and Bismuth (Bi). The table is printed on a white background with black text. The element Lead (Pb) is highlighted in the center, with its atomic number 82 and atomic weight 207.2. To its right is Bismuth (Bi) with atomic number 83 and atomic weight 208.980. To the left of Lead is Thallium (Tl) with atomic number 81 and atomic weight 204.3833. The table also includes some isotopic information and electron configurations.

|   |   |  |
|---|---|--|
| 81<br><b>Tl</b><br>Thallium<br>204.3833<br>[Kr]4d <sup>10</sup> 5s <sup>2</sup> 5p <sup>3</sup> | 82<br><b>Pb</b><br>Lead<br>207.2<br>[Hg]6p <sup>2</sup><br>7.4167 | 83<br><b>Bi</b><br>Bismuth<br>208.980<br>[Hg]6p <sup>3</sup><br>7.29 |
|---|---|--|

VOC

SVOC





## Analysed compounds

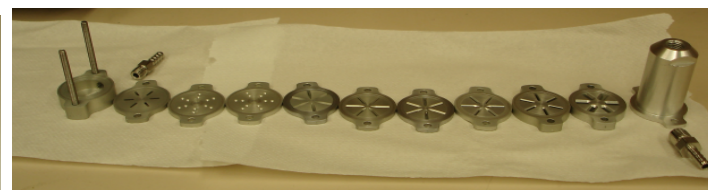
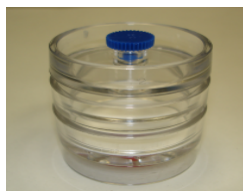
- $\text{H}_2\text{O}$ ,  $\text{CO}$ ,  $\text{CO}_2$ ,  $\text{CH}_4$ ,  
 $\text{NH}_3$ ,  $\text{N}_2\text{O}$ ,  $\text{SO}_2$ ,  $\text{NO}_2$ ,  
 $\text{H}_2\text{S}$  and  $\text{Hg}$



- VOC

- SVOC

- Inorganic particles



## Sampling media and analytical methods

| Compounds   | Sampling Media   | Analytical Methods |
|---|--|--------------------|
| Combustion gases                                    | Tedlar bags (interrupted):<br>Outdoor: 20 L, 5 L/min<br>Muffler : 60 L, 23 L/min | FTIR               |
| VOC (EPA)   | Carbotrap 300<br>(continued) (0.2 L/min)   | GC-MS              |
| SVOC (EPA)  | Carbotrap 300<br>(continued) (0.2 L/min)   | GC-MS              |
| Organic particles<br>(explosives residues)          | Supelco orbo-402 Tenax   | HPLC -MS (or UV)   |
| Inorganic particles<br>(derived from NIOSH<br>0500) | Filters (outdoor : 2.5 L/<br>min; Muffler : 2L/min)<br>Cascade impactor          | ICP-AES            |



## Results of live-firing testing

- Oxygen content
  - Outdoor : 20.9% and indoor : 20.5%
- Indoor set-up
  - Gases : 10 to 1000 x more concentrated
  - Solid particles : 10 x
    - Easier to determine compounds

## Main combustion gases

| Combustion gases        | Muffler | Outdoor set-up<br>in front of the<br>fun |
|-------------------------|---------|--|
| O <sub>2</sub> (%)      | 20.5    | 20.9                                     |
| CO (ppm)                | 5000    | 50                                       |
| CO <sub>2</sub> (ppm)   | 1800    | 500                                      |
| CH <sub>4</sub> (ppm)   | 100     | 9  |
| NH <sub>3</sub> (ppm)   | 70      | < 3                                      |
| SO <sub>2</sub> (ppm)   | 40      | < 5                                      |
| NO <sub>2</sub> (ppm)   | < 3     | < 3                                      |
| H <sub>2</sub> S (ppm)  | 1.2     | 0.06                                     |
| Hg (mg/m <sup>3</sup> ) | 0.04    | 0.09                                     |



## Main VOCs and SVOCs

| Compounds            | Muffler<br>( $\mu\text{g}/\text{m}^3$ ) | Outdoor set-up in<br>front of the gun<br>( $\mu\text{g}/\text{m}^3$ ) |
|----------------------|---|---|
| Benzene              | 1600                                    | 40  |
| Toluene              | 50                                      | 10  |
| Styrene              | 12                                      | 0.8   |
| Benzonitrile         | 17                                      | 1.6   |
| Naphtalene           | 22                                      | 0.8   |
| Phenanthrene         | 12                                      | n.d.  |
| Carbazole            | 22                                      | n.d.  |
| Di-n-butyl phthalate | 36                                      | n.d.  |

# Particulate matter

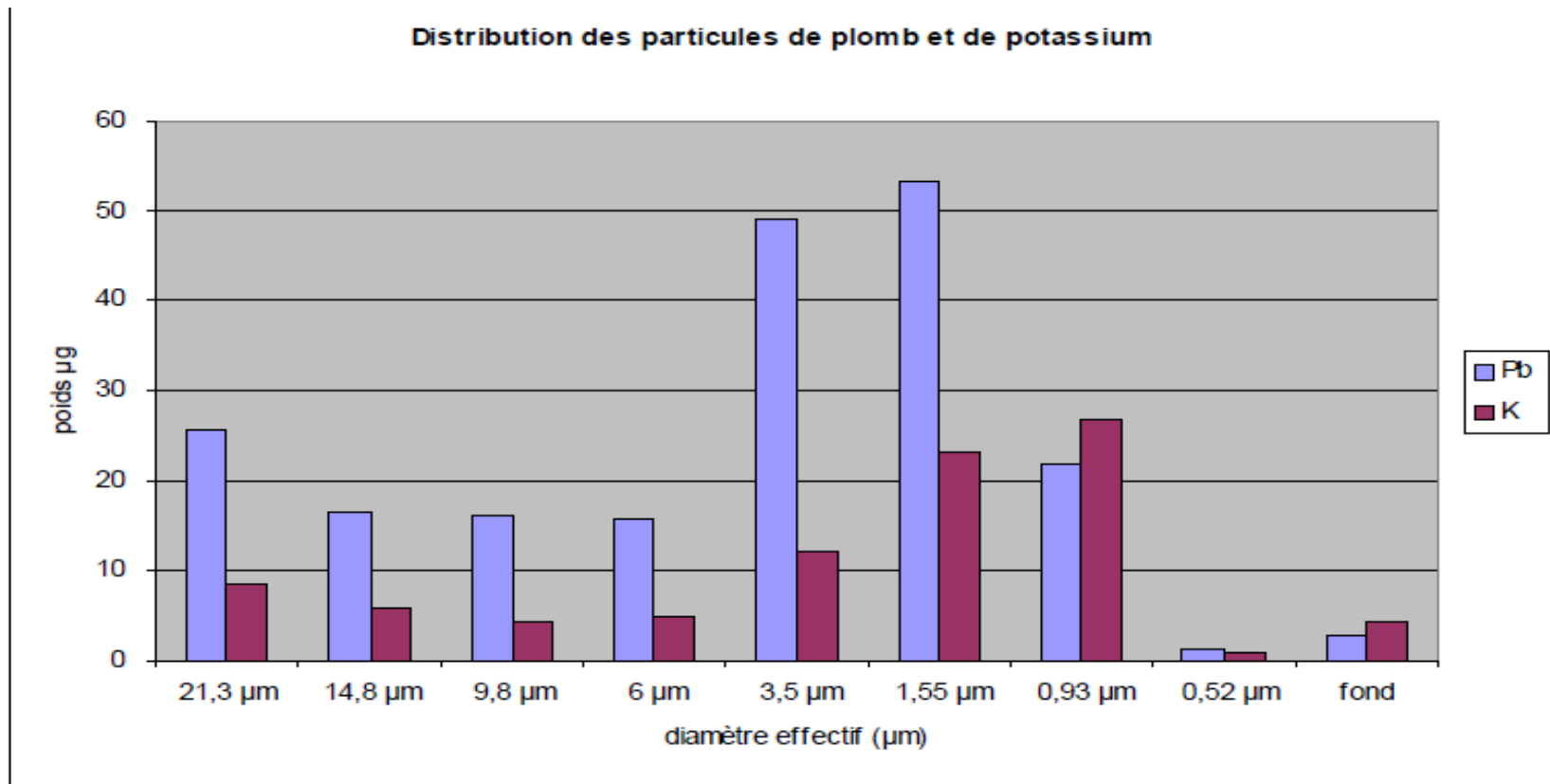
- Mean amounts of particles

- Indoor : 160-210 mg/m<sup>3</sup>
- Outdoor: 240-300 µg/m<sup>3</sup>

- Cascade impactor

- Mean diameter (all particles) : 0.93 µm
- Distribution mainly between 0.52 and 1.55 µm

## Particles size distribution for Pb and K





## Conclusions: Live-firing testing

- The muffler has a lot of advantages;
- This set-up allows the measurement of the relative toxicities of new formulations;
- The number of bags has an influence on the results.

# Conclusion

- Future testing in November 2013
  - Comparison between new formulations and usual ones

TODAY



TOMORROW

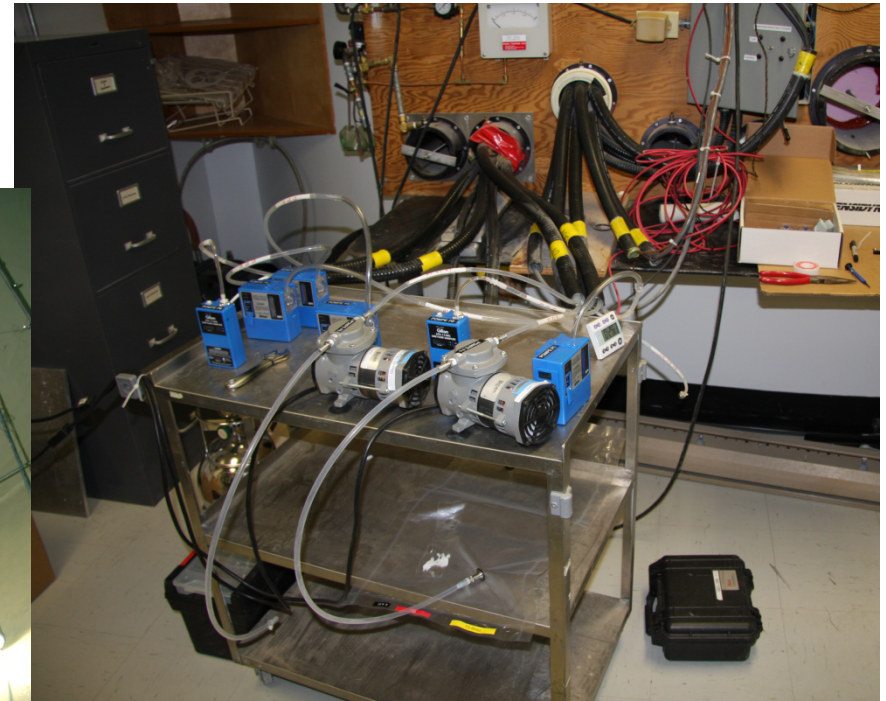


## Air emission monitoring from demilitarization activities





## Demilitarization Set-up

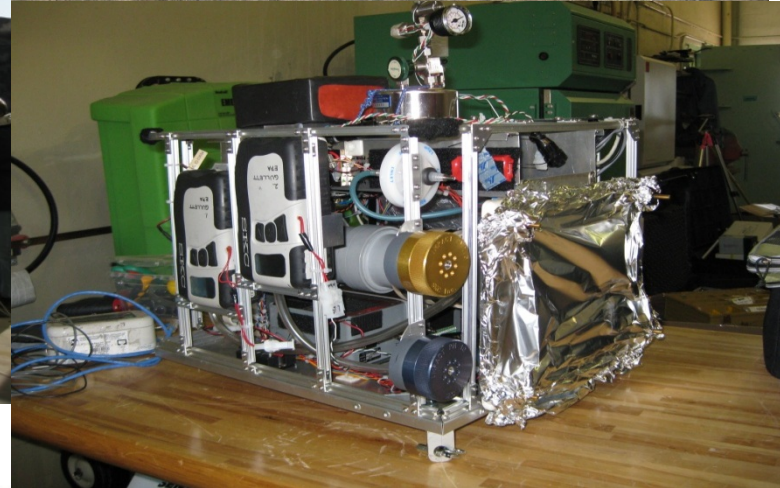


## Results : air emission from demilitarization activities

- Three types of gun propellant formulations : 76, 105 and 155 mm
  - 105-mm propelling bags #5, 6 and 7
- Two distances from the ground: 1.5 and 9 m
- EPA Method : TO-15 and TO-17 (thermic desorption) and solvent desorption tubes method (GC-MS)
- Thermic desorption: 10 to 100 more sensitive than with solvent
  - Solvent desorption better for concentrated compounds
- Comparison between Live-firing and demilitarization open burning
  - More efficient combustion for demilitarization process
    - CO and CH<sub>4</sub>
    - CO<sub>2</sub>



## Collaborative project with US EPA- Emission factors for demilitarization activities





Question ?



# DRDC | RDDC

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FOR CANADA'S DEFENCE AND SECURITY

**SCIENCE, TECHNOLOGIE ET SAVOIR**  
POUR LA DÉFENSE ET LA SÉCURITÉ DU CANADA

