



Responsive Space for the Canadian Forces (AIAA-RS-5-2007-3004)

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Defence Research and
Development Canada

Recherche et développement
pour la défense Canada



Persistent Wide-Area Coverage





Persistent Global Coverage





Current CF Space Paradigm

- Canada has a fundamental requirement for space assets to support its defence commitments
 - Intelligence and surveillance
 - Communications
 - Navigation
 - Meteorological
 - Search and rescue
- Currently, this space support:
 - Does not consist of indigenous defence space assets
 - Depends on high-levels of cooperation between DND and DoD
 - Depends on the commercial sector



Proposing a New Paradigm

- Increasingly capable small and micro satellites can provide the CF with:
 - Indigenous and low cost C4ISR space assets
 - Capabilities, from space, on a small platform, where it makes the most sense to do so
- DRDC's Space Systems Group has established a responsive space effort to:
 - Assess and, where feasible, develop and demonstrate a responsive and indigenous DND space capability
 - Influence Canada's defence space strategy
 - Contribute to allied collaborative space partnership



Defining Responsive for the CF

Multi-Mission Micro/Small Bus: Generic busses designed to provide low-cost access to space.

Scope: Focused on one mission.

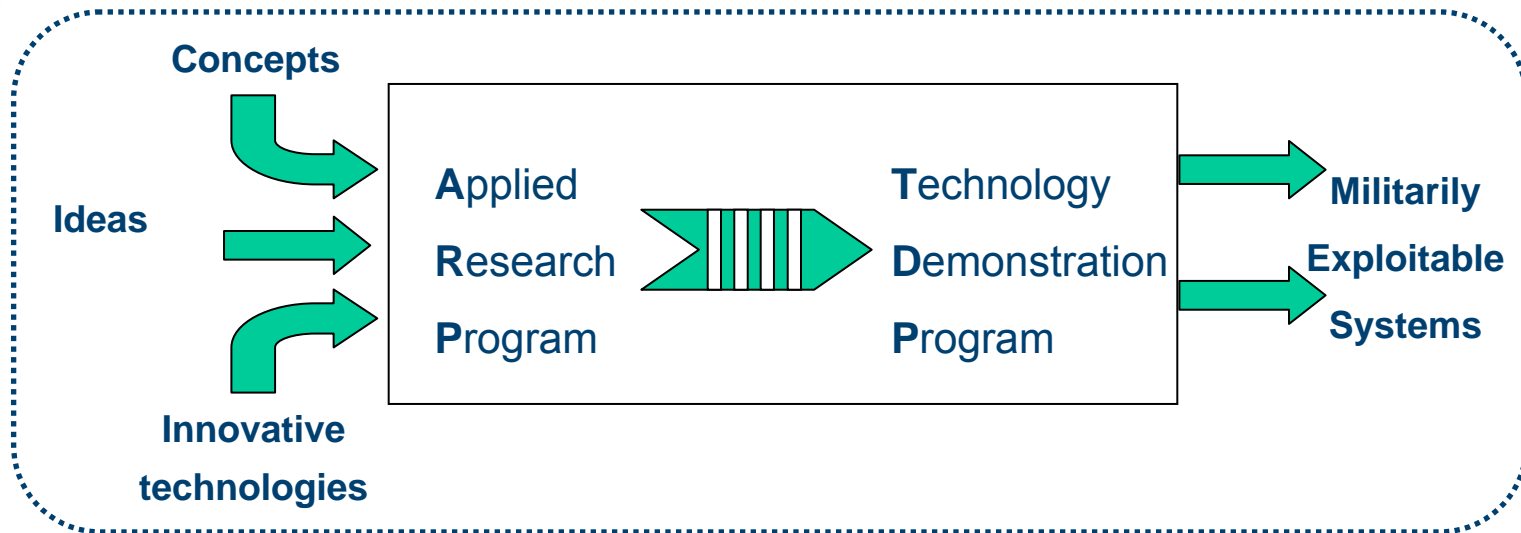
Time: 2 to 5 years from requirements definition to operations.

Cost: \$15M to \$30M (CAD) per platform with launch.

Implementation Process: Expediting the system life-cycle.



DRDC's Responsive Space Effort



- **The effort exploits DRDC's current R&D programs:**
 - Space R&D proposals must compete against all other R&D concepts and ideas for ARP and TDP funding
- **The effort has enjoyed a good amount of success in the last four years, most notably with the approval of:**
 - NEOSSat tech demo mission
 - M3MSat tech demo mission



DRDC / CSA Collaboration



- **Near Earth Object Surveillance Satellite (NEOSSat):**
 - Surveillance of space mission
 - First joint DRDC/CSA (Canadian Space Agency) mission
 - Launch: circa late 2009
 - Lifetime: 2 years with a goal of 3
 - Total cost: \$11.5M CAD
- **Maritime Monitoring and Messaging Microsatellite (M3MSat):**
 - Maritime surveillance mission
 - Second joint DRDC/CSA mission
 - Launch: circa 2010
 - Lifetime: 2 years with a goal of 3
 - Total cost: \$12M CAD



NEOSSat Overview

NEOSSat Missions

Near Earth Object Surveillance Satellite (NEOSSat)

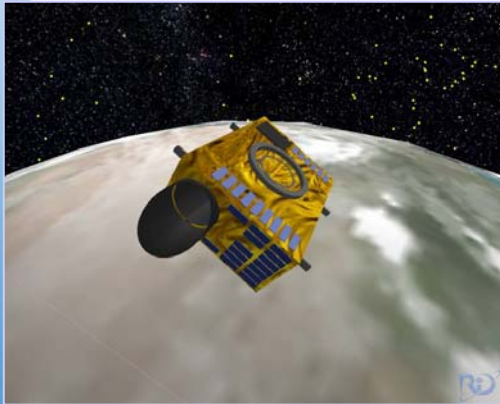
Near Earth Space
Surveillance



High-Earth Orbit Surveillance
System



1st flight - Multi-Mission
Microsatellite Bus



Aten-class asteroid detection

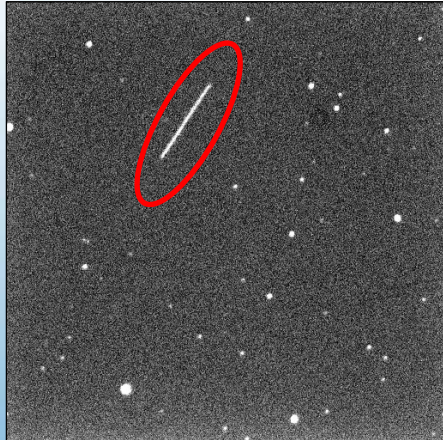
→ NESS

Obtain metric space surveillance data

→ HEOSS



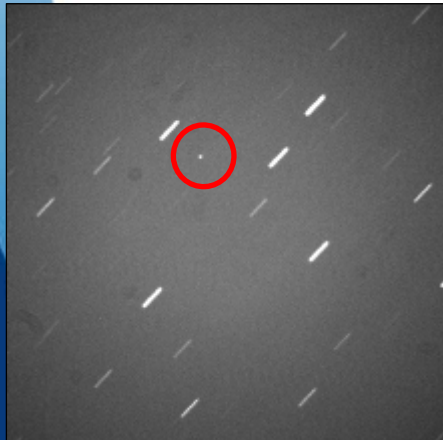
NEOSSat Mission Requirements



An example of a SSM observation.

HEOSS Mission Requirements

- Locate GEO RSO to within $\pm 500\text{m}$ (3 arcsecond)
- Sensitivity to GEO RSO with brightness down to 14 magnitude in Sidereal Stare mode (SSM)
- Experimental Track Rate Mode (TRM) up to 60 arcseconds per second



An example of a TRM observation.

NESS Mission Requirements

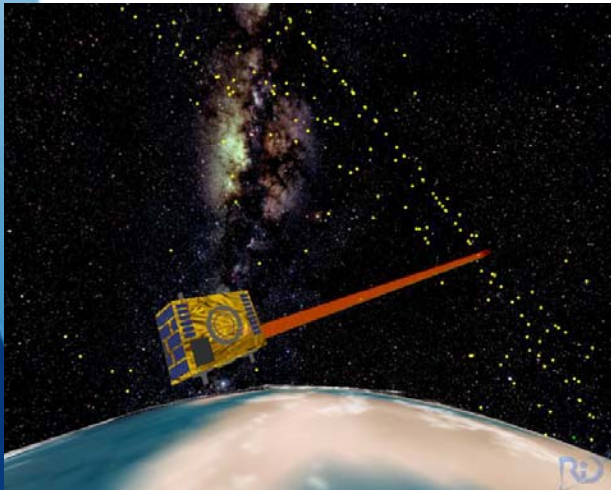
- Detect 50% of Aten-class asteroids greater than 1 km during mission life
- Sensitivity down to 19.5 magnitude for 100 seconds exposures
- Observe in sunward direction (up to 45° in ecliptic longitude)



NEOSSat Phase A Results

NEOSSat Bus:

- High precision attitude determination and control:
 - Pointing stability < 0.5 arcsecond for 100-second exposures (1σ)
- Orbit positional knowledge of ± 50 m (1σ)
- Timing accuracy and precision of 1 millisecond (relative to UTC)



NEOSSat Instrument:

- 15 cm passive on-axis optical telescope
- Stray-light suppression system
- Image acquisition rate: 288 images per day with a goal of 460
- No-onboard data processing



M3MSat Project Overview

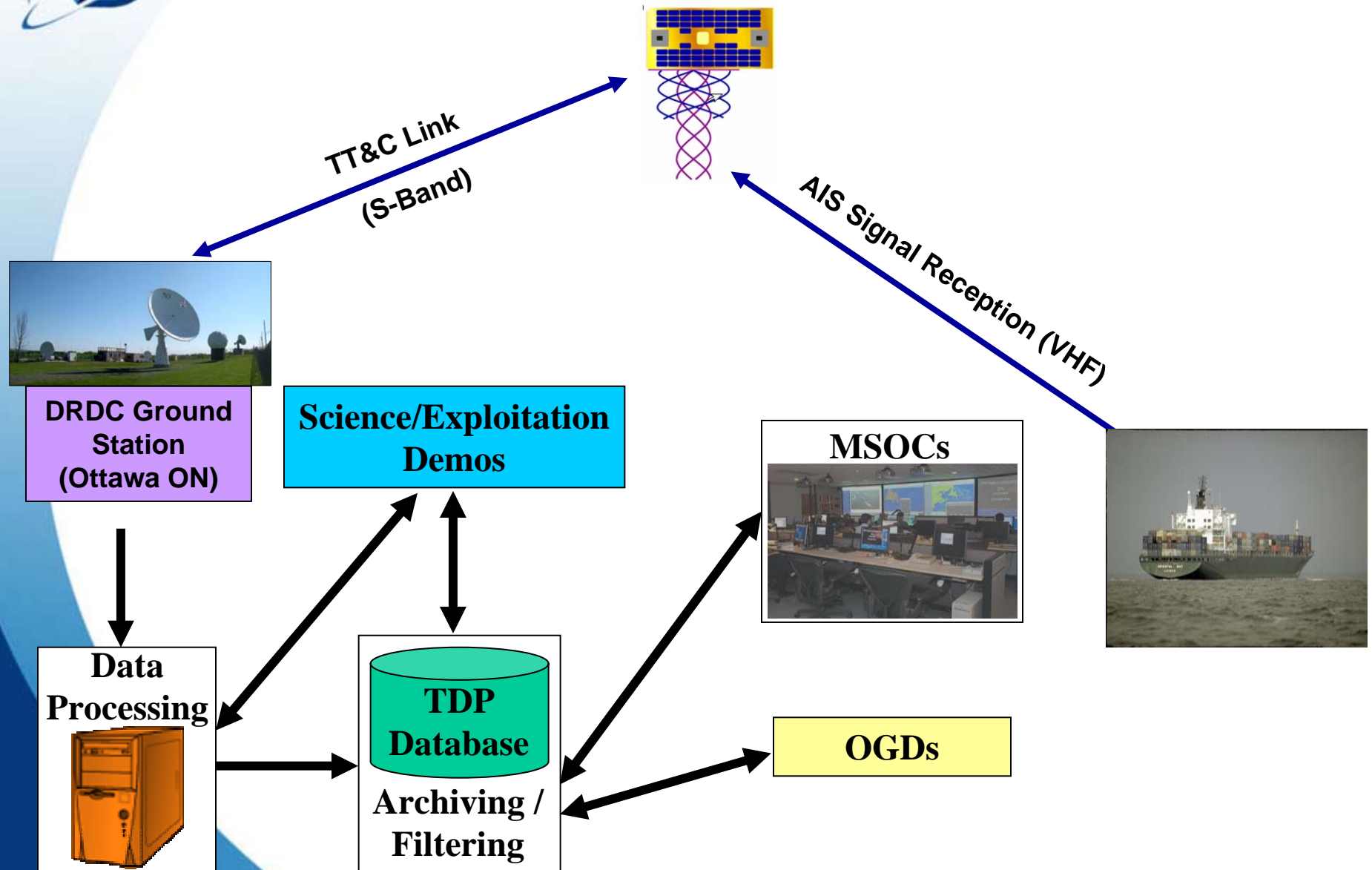
- **M3MSat:**
 - Will employ a complex AIS receiver for maritime surveillance
- **AIS Summary:**
 - **Automatic Identification System**
 - International Maritime Organization (IMO) decree, implemented through the Safety of Life at Sea (SOLAS) convention.
 - Ship information includes (but not limited to):

<i>MMSI</i>	<i>Position heading</i>
<i>Time</i>	<i>Course speed</i>
<i>Rate of Turn</i>	<i>Cargo</i>

- VHF maritime band with GPS
- Reports generated approx every 6 sec (depending on speed)



M3MSat Mission Concept

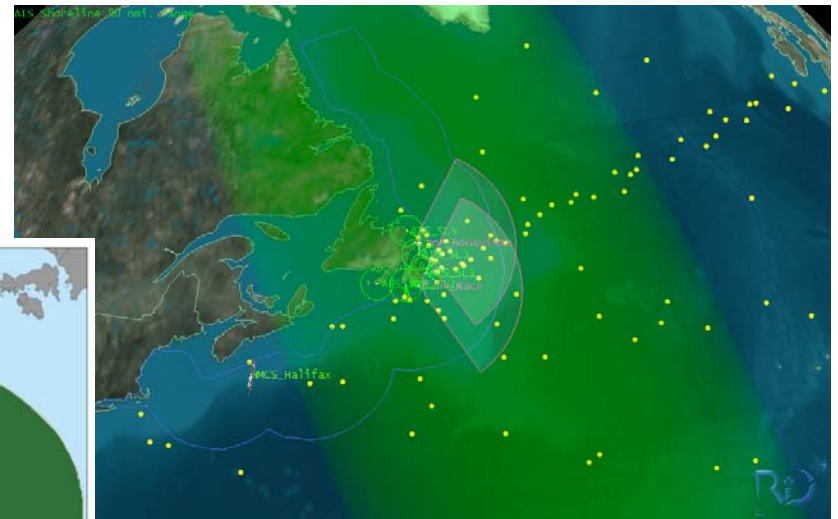




M3MSat Benefits to CF

Defence of North America and Public Security

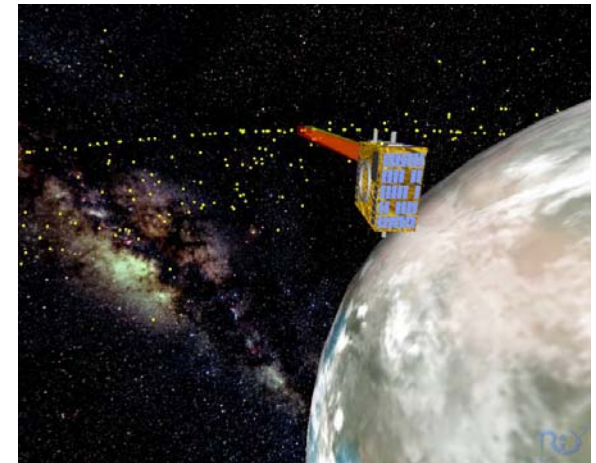
- Will contribute to wide area surveillance coverage of maritime approaches to Canadian territorial waters
- Current deficiency in middle & outer zone coverage (50-1000nm)
- UNCLASSIFIED ISR capability
 - Broad access
 - Allow data sharing





Future Direction

- Gain acceptance of responsive space through demonstration:
 - Continually seek new opportunities/missions for small/micro satellites
- Improve the “non-responsive” implementation processes:
 - From requirements definition to operations phase
 - Acquisition processes
- Influence future revision of the Canadian defence space strategy
- Leverage resources to establish networks and constellations (i.e. DMC constellation)
 - Not necessarily coordinated constellations!
 - Coordinated data distribution and sensor suites
 - Increased persistence, minimal resources per country



Defence R&D Canada

***is the national authority for providing Science
and Technology (S&T) leadership
in the advancement and maintenance of
Canada's defence capabilities***

