

CSA-NASA Human Space Flight Cooperation
Steve MacLean
President
Canadian Space Agency

Meeting with the
Review of U.S. Human Space Flight Plans Committee
June 16, 2009





Outline

- Background
 - Overview of the CSA
 - Summary Canada-US Civil Space Cooperation
 - Highlights CSA-NASA HSF Cooperation
- Canada and the Shuttle Program
- Canada and the ISS
- Canadian Astronaut Program
- Exploration and Future Human Space Flight Activities
- Discussion Topics

Annex: Non Human Space Flight Areas of CSA/NASA
Cooperation



The Canadian Space Agency's Mandate

- “...to promote the peaceful use and development of space, to advance the knowledge of space through science and to ensure that space science and technology provide social and economic benefits for Canadians.”

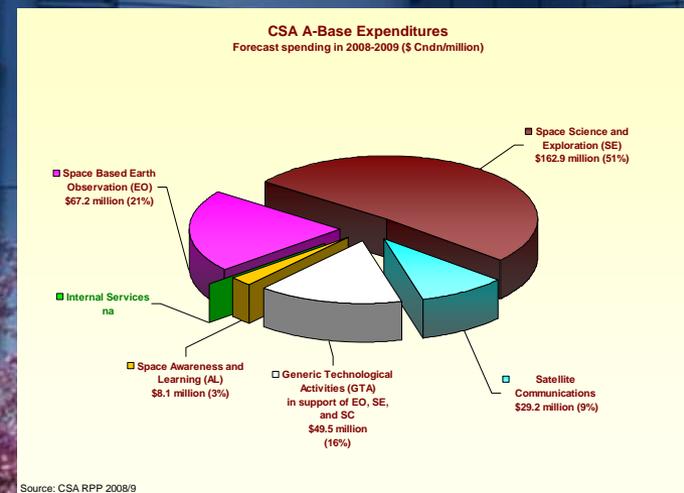
- Annual budget of about \$300M (almost 75% contracted out to industry and academia)

- 600 employees, 240 students annually

- Headquarters: John H. Chapman Space Centre (Longueuil, Quebec)

- Offices in Ottawa, Washington, Paris, Houston

- Testing & Integration Facilities at David Florida Lab, Ottawa



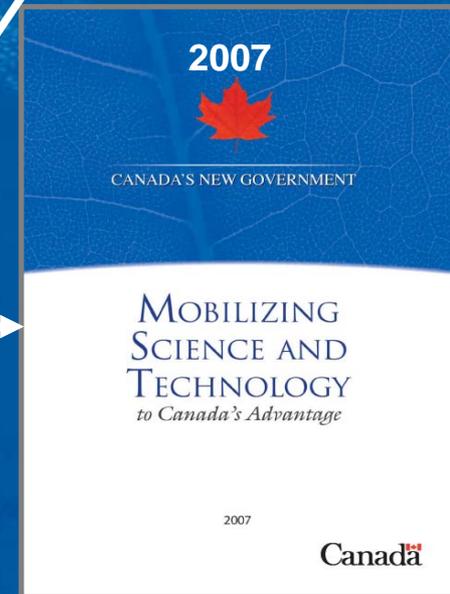
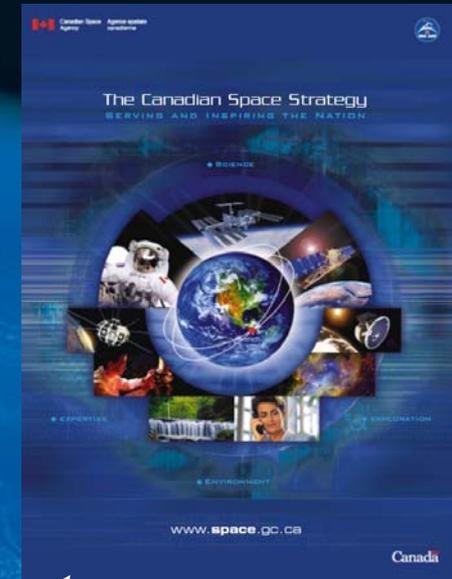
CORE THRUSTS

CORE THRUSTS

- Earth Observation
- Space Science and Exploration
- Satellite Communications
- Space Awareness and Learning

Strategic direction guided by ...

***New Long Term Space Plan
to be submitted to Government***





Canadian Space Milestones



-  **1959** - 1959 Black Brant I, Canada's first suborbital sounding rocket launched from Churchill Research Range
-  **1962** - NASA launches Alouette -1, an upper atmospheric science satellite, making Canada the third nation in space
-  **1972** - Anik A-1 establishing Canada as the first country with a domestic communications satellite in geostationary orbit
-  **1976** - Launch of Hermes, World's first direct-to-home experimental telecommunications satellite
-  **1981** - Canadarm becomes national icon - launched on the Space Shuttle Columbia
-  **1983** - Selection of Canadian Astronaut Corps: Roberta Bondar, Marc Garneau, Steve MacLean, Ken Money, Bob Thirsk and Bjarni Tryggvason
-  **1984** - Marc Garneau - First Canadian Astronaut in space aboard Challenger Space Shuttle with 10 Canadian science and technology experiments
-  **1992** - Roberta Bondar becomes Canada's first woman to fly in space aboard Discovery Space Shuttle
-  **1992** - Selection of Canadian Astronauts: Chris Hadfield, Julie Payette and Dafydd (Dave) Williams
-  **1995** - Radarsat-1, Canada's first remote sensing satellite launched
-  **1999** - Canada's MOPITT (Measurement of the Ozone Pollution In The Troposphere) sensor launched on NASA's Terra spacecraft
-  **1999** - Canada provides two Fine Error Sensor instruments to NASA to accurately point the Far Ultraviolet Spectroscopic Explorer telescope
-  **2001** - Chris Hadfield installs Canadarm 2 on the International Space Station and becomes first Canadian to conduct a spacewalk
-  **2001** - Launch of Canada's OSIRIS instrument onboard Sweden's third scientific satellite, Odin
-  **2003** - Launch of Canada's space telescope: MOST, and Scisat, an all-Canadian atmospheric science satellite
-  **2004** - Anik F-2, world's largest telecommunications satellites contain three frequencies C, Ku and KA-band
-  **2008** - Dextre, a two-armed robot arrives to assist in the construction and maintenance of the ISS
-  **2008** - Canada's weather station and lidar instrument on NASA's Phoenix lander touch down on Mars and discovers snow in the atmosphere.
-  **2009** - Astronaut Bob Thirsk will become first Canadian to stay and work on the ISS for a long-duration
-  **2010** - Canada's NEOSat space telescope capable of detecting asteroids and space debris will be launched
-  **2013** - Launch of Canada's pointing devices and instrument aboard James Webb Space Telescope
-  **2016** - Launch of ESA ExoMars with Canadian contributions

Canadian Space Milestones

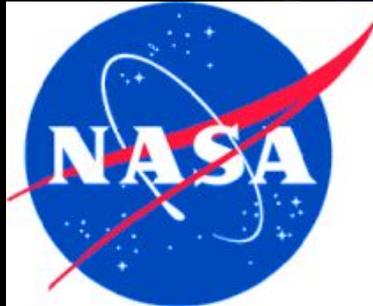
A Strong Industrial Base

Space Robotics, Space Vision Systems, Lidar, Synthetic Aperture Radar, Sat Comms, satellite buses, micro-sats, Sounding Rockets, niche world-class technologies.

MDA Corp, COMDEV, Opetch, Neptec
Magellan Aerospace, Telesat
Plus >200 SMEs
with world-class
niche technologies



Canada's Major Partners in Space



Others include



Canada – United States Civil Space Cooperation: An Overview



- Human Space Flight (Shuttle & ISS)
- Astronaut Corps (Cdn astronauts embedded at JSC)
- Life & Microgravity Science (Shuttle & ISS)
- Earth Science and Observation (Instruments & RADARSAT)
- Astronomy (JWST and Cdn MOST)
- Heliophysics (THEMIS & International Living With a Star)
- Exploration (Mars Phoenix & MSL et al)



- Earth Science & Observation (RADARSAT)

- Ice Monitoring & Cooperation with the Canadian Ice Service (RADARSAT)



- Earth Science & Observation (RADARSAT)

Over Four Decades of Mutually Beneficial Cooperation

HIGHLIGHTS

1961 Alouette-1 makes Canada 3rd nation in Space

1972 Anik-A1 commercial GEO Comms Sat

1976 Hermes

1981 Shuttle's Canadarm

1984 Canada's first astronaut mission on Shuttle

1991 Wind Imaging Interferometer on NASA UARS

1995 RADARSAT-1 (NASA/NOAA launch-for-data)

1999 MOPITT on NASA Terra satellite

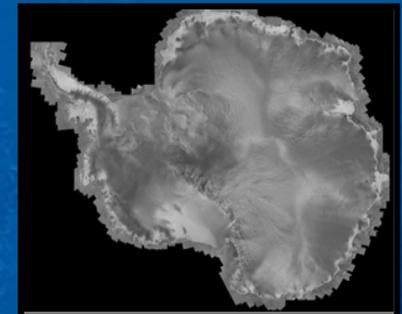
1999 RADARSAT mapping of Antarctica

1999 First Canadian astronaut to ISS

2001 Operations of Canadarm2 on ISS

2008 Mars Phoenix

2009 Canadian astronaut ISS Expedition





Canada - European Space Agency (ESA)

- ESA - 18 ESA Member States
- Canada only non-European Cooperating State (since 1979).
- CSA / ESA - common objectives and priorities
 - Earth observation
 - Satellite communications
 - Human and robotic exploration
- Canada participates in select programs
- Cooperation Agreement - renewal 2009



ESA-Canada Cooperation Objectives

Policy: Permanent dialogue on respective space policies

– One element of a broader Europe-Canada cooperation in S&T

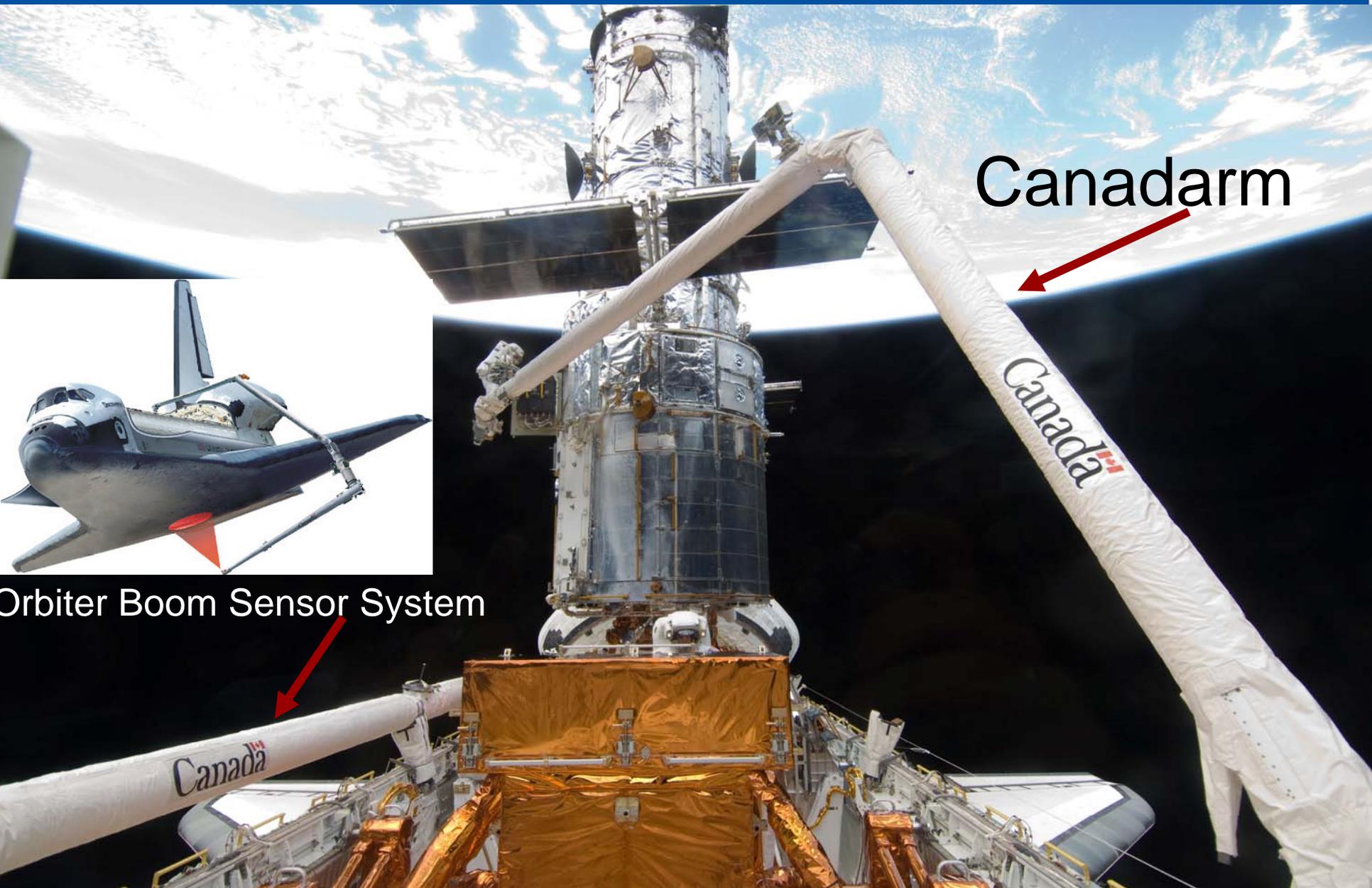
Programmatic: Focus on R&D and demonstration of advanced systems

Industrial: Opportunities for European and Canadian industries





Canada and the Shuttle



Canadarm



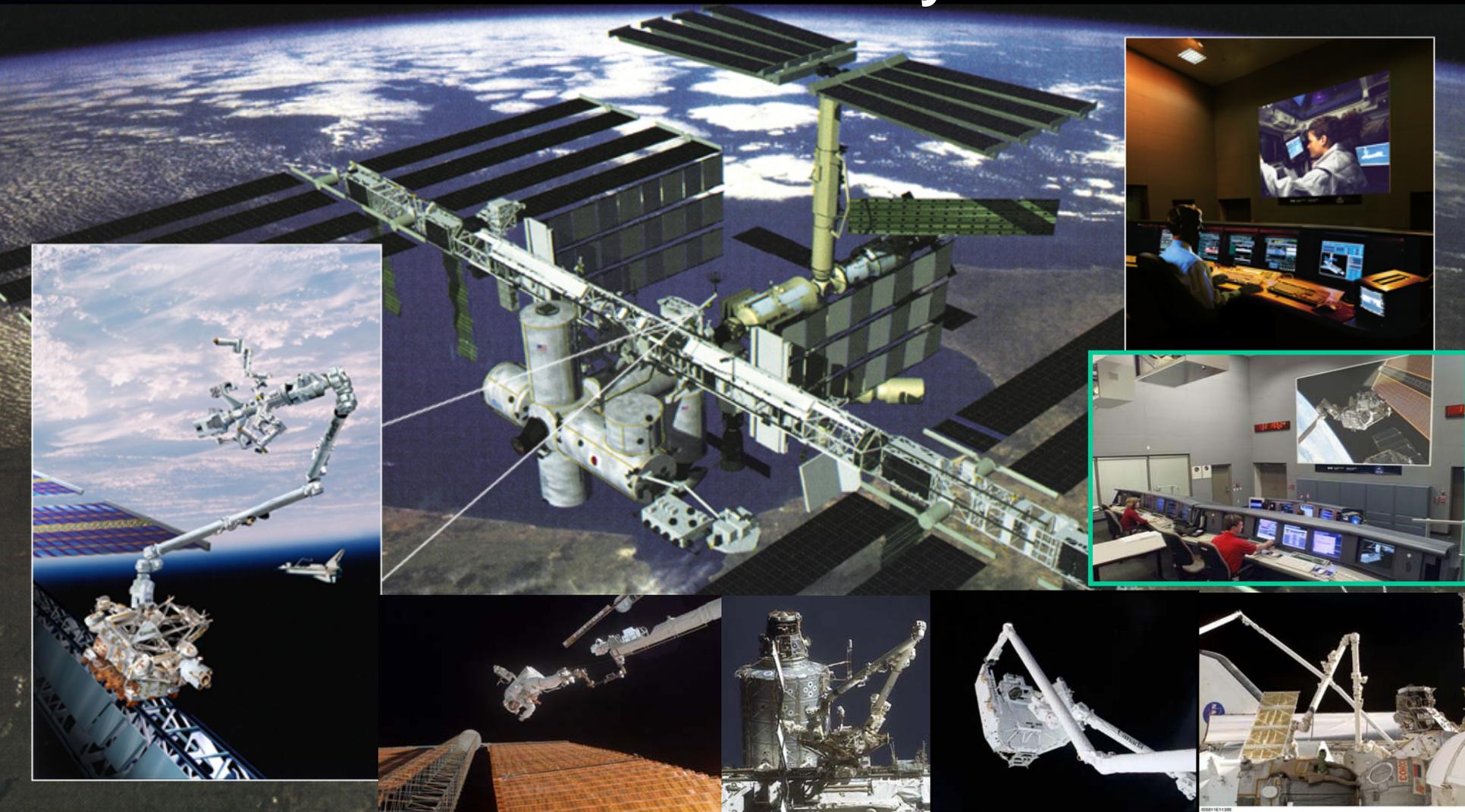
Orbiter Boom Sensor System

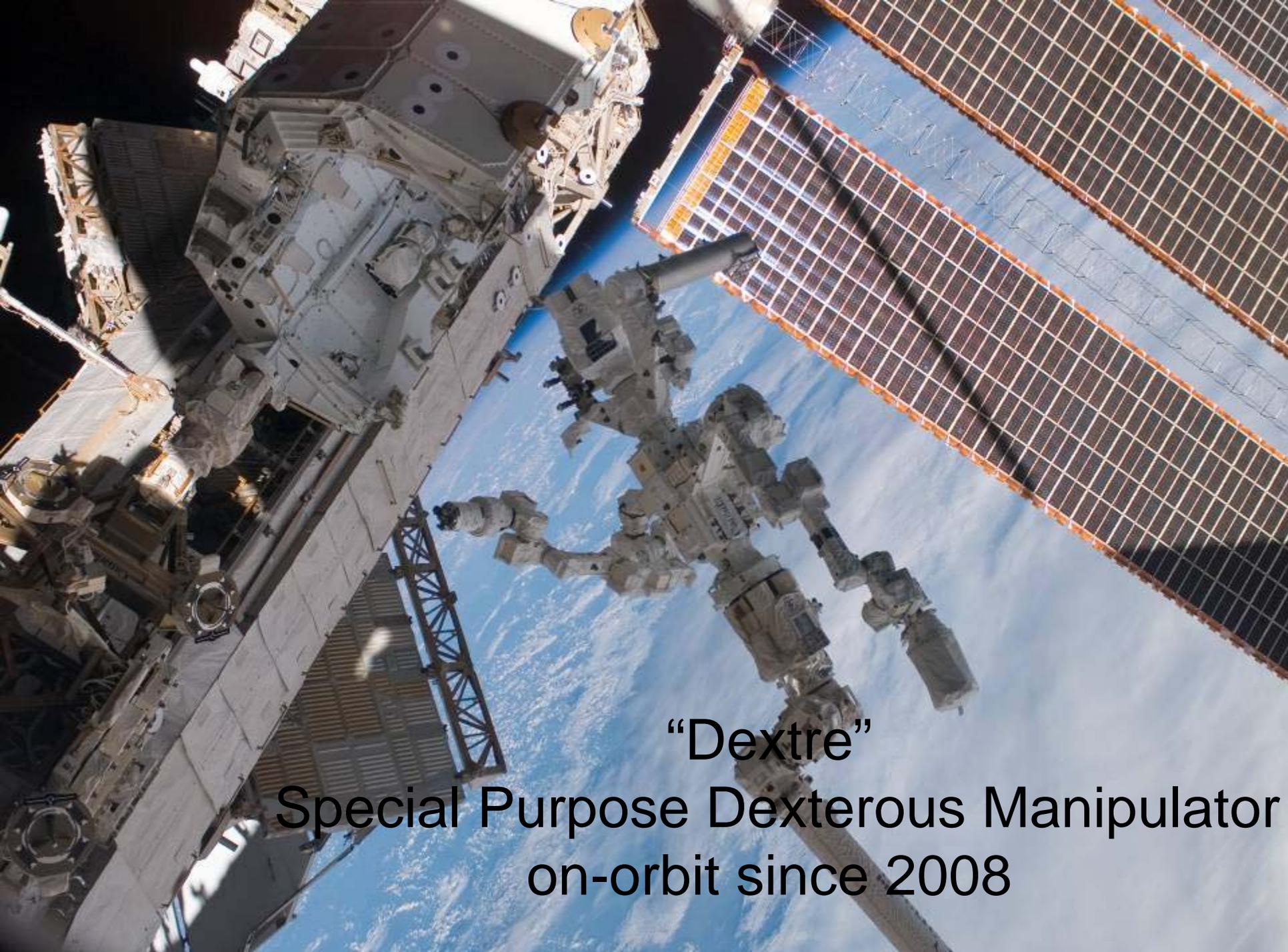


THE INTERNATIONAL SPACE STATION

THE INTERNATIONAL SPACE STATION

The Mobile Servicing System: In-Service On-Orbit for assembly of ISS since 2001





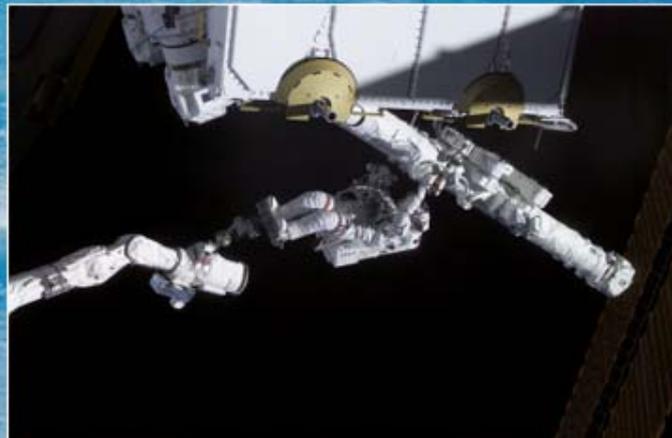
“Dextre”
Special Purpose Dexterous Manipulator
on-orbit since 2008

A WORLD-RENOINED TEAM OF ASTRONAUTS

A WORLD-RENOINED TEAM OF ASTRONAUTS



May 13, 2009
Two Astronauts
added to the Corps



Garneau '84

Bondar '92

MacLean '92

Hadfield '95

Garneau '96

Thirsk '96

Tryggvason '97

Williams '98

Payette '99

Garneau 2000

Hadfield 2001

MacLean 2006

Williams 2007

Thirsk 2009

Payette 2009



Canadian Astronauts are Integrated into the NASA Corps



- CAPCOM
- CSA Chief Astronaut
- Crew Office Rep Europe



- EVA
- Soyuz FE-1 Trained
- Head Crew Office Robotics



- CAPCOM
- Trained as Soyuz FE-1
- ISS Exp Crew



- Operational Space Medicine – NEEMO 7
- Dir JSC Life Sciences Div
- Surgical Robotics McMaster Univ – March 08



- Micro-gravity Vibration Isolation Technology
- Based at CSA – St-Hubert



- Space Vision System
- CSA President

Canadian ISS Research Priorities

LIFE SCIENCES

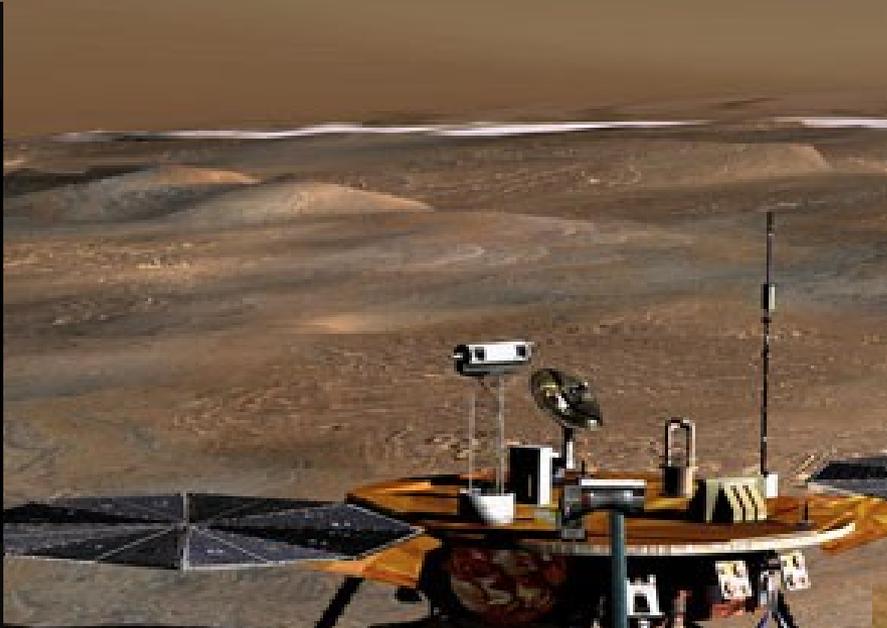
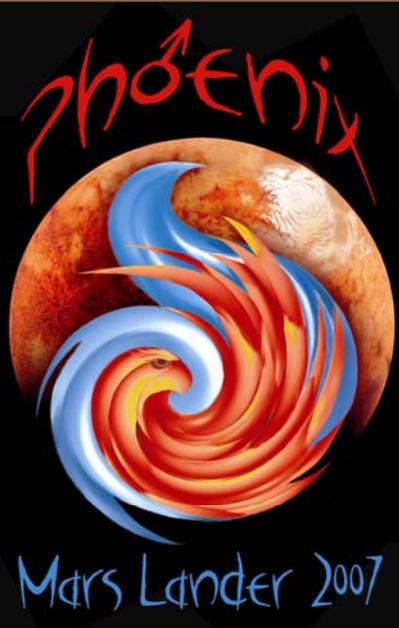
Bone and Muscle Loss
Cardiovascular and Metabolic Science
Radiation
Neuroscience
Isolation and Multi-Cultural Psychology

MICROGRAVITY SCIENCE

Fluid science
Materials science
Biotechnology
G-jitter

**SPACE LIFE SCIENCES AND
MICROGRAVITY RESEARCH**

Mars Exploration Cooperation



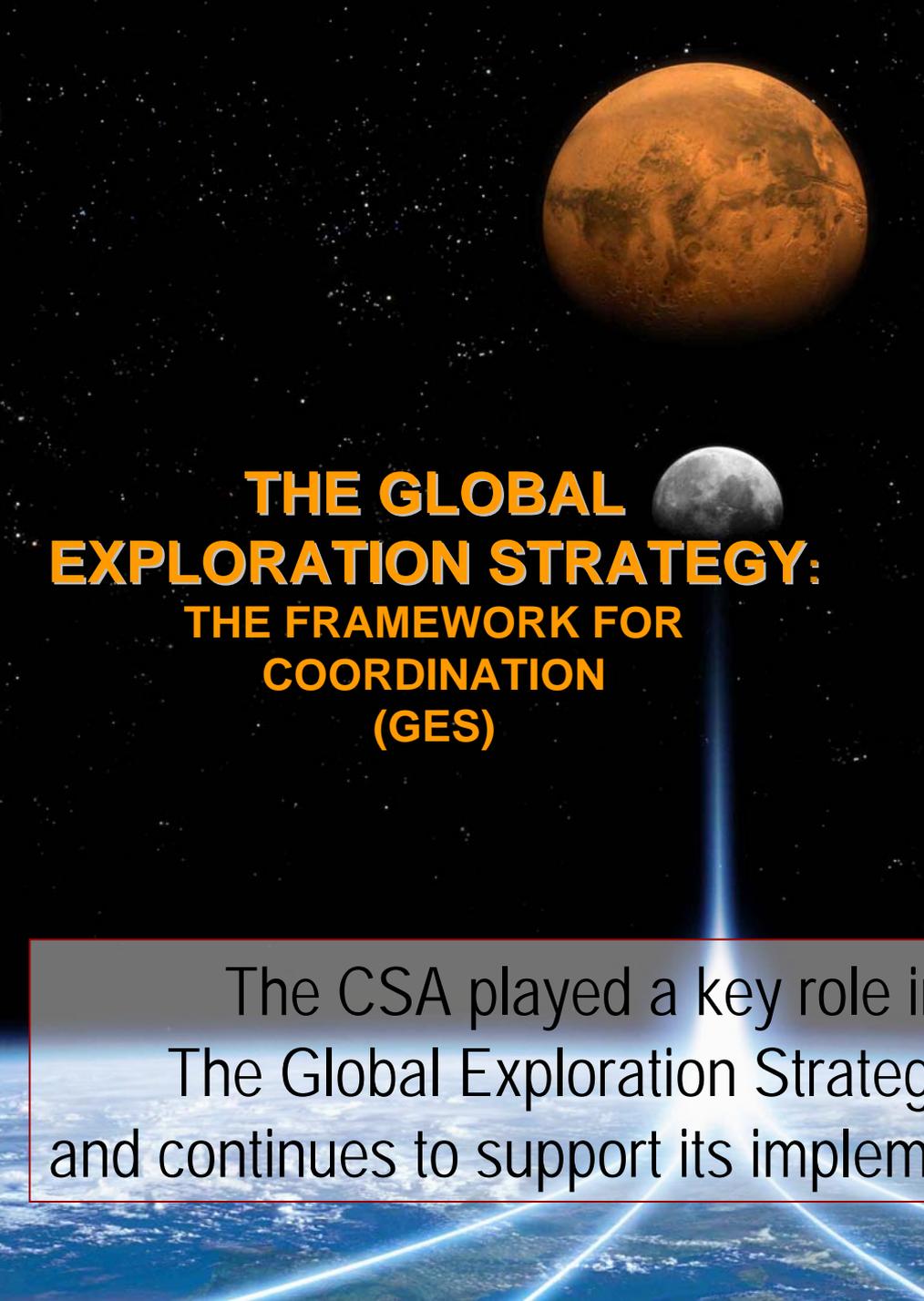
ExoMars



MSL

Canadian Alpha Particle X-ray Spectrometer

Canadian Meteorological Station Instrument



THE GLOBAL EXPLORATION STRATEGY: THE FRAMEWORK FOR COORDINATION (GES)



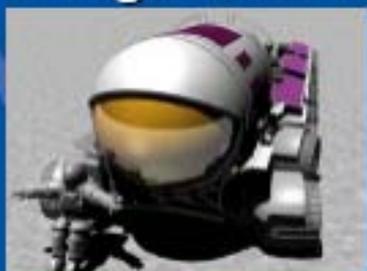
INTERNATIONAL SPACE EXPLORATION COORDINATION GROUP (ISECG)

The CSA played a key role in the development of The Global Exploration Strategy framework document and continues to support its implementation through the ISECG



Long-Term Exploration Goals

- Participation in human Lunar exploration
 - ◆ Through surface infrastructure
 - ◆ Through precursor missions
 - ◆ Through astronaut flights



- Scientific Exploration of Mars
 - ◆ Through unmanned Mars Sample Return
 - ◆ Through precursor missions



- Supported through CSA Exploration Core Program



CSA Criteria for Lunar Infrastructure Contribution(s)

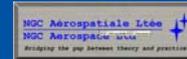
- Smart, multi-use investment
- Visible and uniquely Canadian
- Required, and required early in the sequence of missions
- Welcome by international partners

Exploration Core Program for studies and prototyping for potential Moon-Mars contributions, initiated in 2007

Exploration Core Program Phase 1

18 Concept Studies Completed

- Canadian Moon mobility system
- Other potential infrastructure contributions
- Concepts for science contribution to Mars missions
- Science instruments for surface operation on the moon
- ISRU package
 - Drill, excavation and processing
- Vision systems
- Robotic arms for rover/lander
- On-orbit servicing systems
 - Manipulator - docking system
- Exploration communication infrastructure
- Medical autonomy





Exploration Core Program Phase 2

Industry Studies and Prototyping Underway 1/2

Canadian Federal Stimulus Budget 2009
provided an additional
“\$110m over three years for the Canadian Space
Agency to contribute to the development of
terrestrial prototypes for space robotic vehicles,
such as the Mars Lander and Lunar Rover, and
the further development of other technologies
and space robotics”



Exploration Core Program Phase 2

Examples Industry Studies and Prototyping Underway

2/2

- Human Sized Rovers for Lunar Mission:
 - Technologies and Prototypes
- *In-Situ* Resource Utilization (ISRU) Technology
- Canadian Science Lander for the International Lunar Network
- On-Orbit Servicing Robotic Technology (follow-on to Canadarm)
- Cdn Science Instruments for Mars Science Orbiter
- Technologies and Science Instruments for Mars Sample Return Precursor Missions
- Technology and Science Instrument contributions to Japan/JAXA Selene-2





Discussion Topics 1/4

- Shuttle Retirement:
 - Impacts MSS logistics and R&O philosophy
i.e. Orbital Replacement Unit (ORU) concept
 - All large MSS ORU spares must be pre-positioned
on ISS to ensure availability of the MSS
 - ISS research affected due to down-mass limitations,
will require adjustments to Canadian research plans





Discussion Topics 2/4

- ISS Operations Post 2016:
 - CSA intends to continue to meet its MSS responsibilities
 - CSA expects its ISS utilization and astronaut flight opportunity rights to be fulfilled as anticipated
 - CSA intends to continue to use ISS as a research and technology development facility





Discussion Topics 3/4

- Next Generation Space Transportation Systems:
 - US obligated (ISS IGA/MOUs) to provide ISS transportation
 - CSA supports concept of separating crew and cargo
 - To ensure minimum further impact on CSA's ISS utilization and operations we encourage the US to minimize "the gap".





Discussion Topics 4/4

- Future Human Space Exploration:
 - Canadian next Long Term Space Plan in process
 - Canada continues to strongly support the framework articulated in The Global Exploration Strategy
 - Canada's overarching exploration goals are;
 - Long-Term ISS Utilization and Crew Opportunities
 - Canadian presence on the Moon
 - Mars samples in Canadian laboratories
 - To achieve these goals Canada is developing terrestrial prototypes and technologies for:
 - Lunar Rover and lunar precursor robotics missions, to support extended human presence on the Moon
 - Mars Sample Return and precursor missions
 - There are opportunities to maximize the ISS and a Lunar outpost lessons for Mars missions
 - The CSA has a technology Research, Development and Prototyping Exploration Core program underway designed to mature technologies for Canadian contributions to Moon and Mars exploration





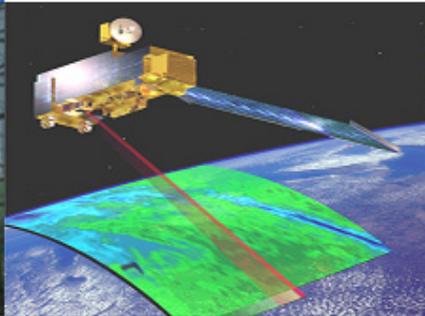
ANNEX

Non Human Space Flight Areas of CSA/NASA Cooperation



Monitoring the Health of our Planet from Space

- Monitoring natural disasters
- Ice movement
- Managing our natural resources
- Improved weather forecasting
- Antarctic mapping mission
- Joint AOs for: New Orleans Subsidence (ongoing), Hurricane Research (in prep), Geo-hazards (future), Cryosphere (future)



EARTH OBSERVATION

- RADARSAT-1 Twelve + Years of Cooperation
- RADARSAT-2 Launched Dec '07/Operations May '08
- RADARSAT- Constellation Cooperation with NASA/NOAA/USGS Under Discussion



Cooperation in Earth Observation

RADARSAT-1

- Launch for data arrangement with NASA and NOAA
- Nov 1995 to May 2008
- Data for U.S. National Ice Service
- Data for NASA, NOAA and USGS research
- 1999 first mapping of Antarctica



RADARSAT-2

- Public-Private-Partnership
- Some data sharing between Cdn and US Ice Services
- Opportunities for joint research

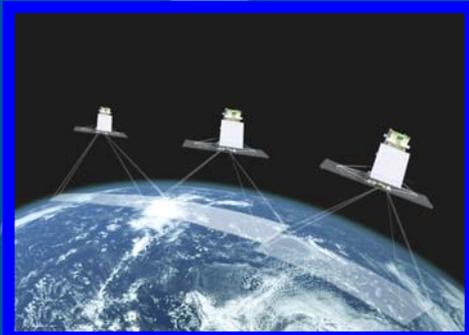
RADARSAT-CONSTELLATION

- Development underway
- Preliminary discussions for cooperation with NASA, NOAA and USGS





RADARSAT Constellation Mission



MARITIME SURVEILLANCE

Ice and iceberg monitoring
Marine winds
Oil pollution monitoring
Ship detection

DISASTER MANAGEMENT

Mitigation
Warning
Response
Recovery and assessment

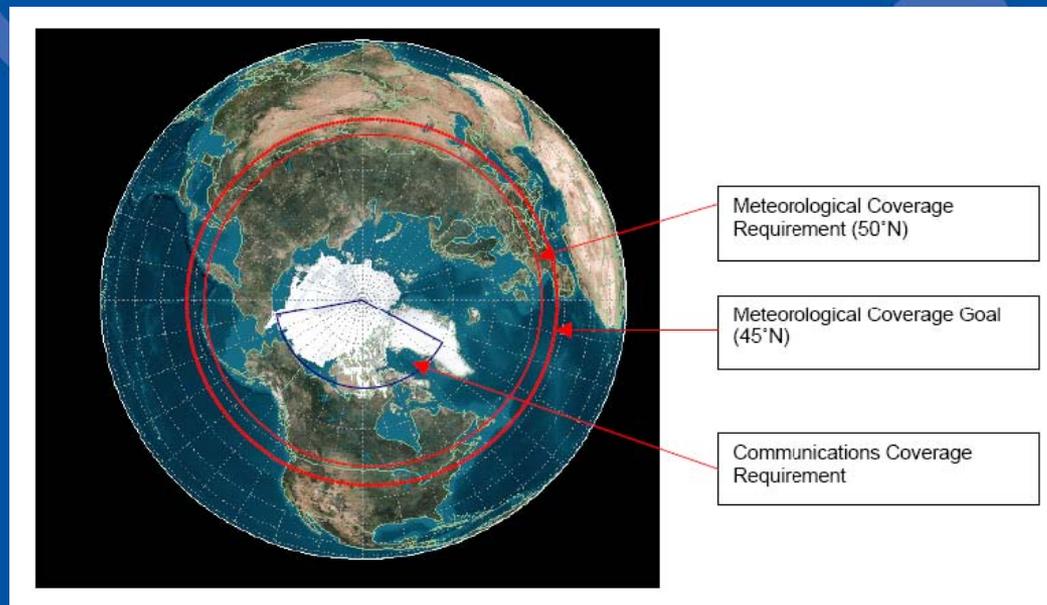
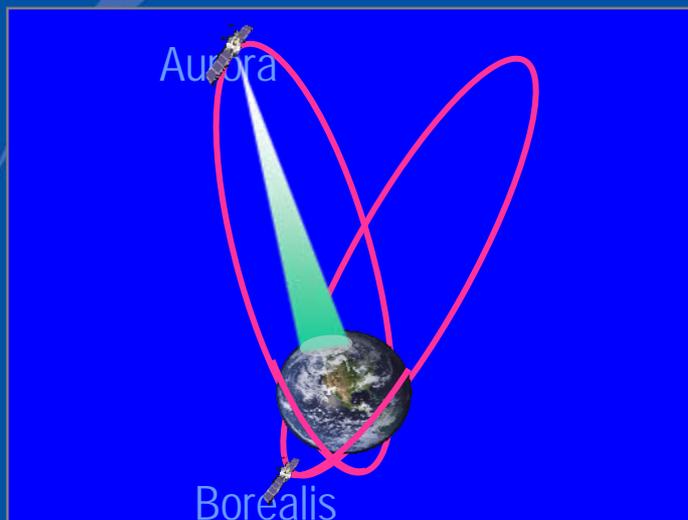
ECOSYSTEM MONITORING

Forestry
Wildlife habitat
Agriculture
Wetlands
Coastal change

- Follow on to the RADARSAT-2 program
- Evolution toward wider operational use and higher reliability
- Provides increased coverage with daily revisit of Canada and daily access to 90% of the world
- Canadian Government owned and operated

- Three satellites with a potential of six
- Minimum daily coverage of Canadian waters and regular land coverage
- Data analyzed in near real time for operational applications
- 4-day Coherent Change Detection using SAR interferometry in between satellites
- Dual polarization data capability, with experimental quad pol

Polar Communications & Weather Mission (PCW) In Phase A



- Reliable 24/7 communications in the high latitudes (North of 70°)
- High temporal/spatial resolution meteorological data for the Earth disk area above 50° N
- Cooperation and Data Sharing discussions underway with NOAA

MOPITT (Cdn instrument contribution)

NASA Terra since 1999 – CO in Troposphere

Scisat (Cdn Small Sat)

NASA (3rd Party Mission) launch in 2003 – Ozone layer

Cloudsat (Cdn technology & science contribution)

Launch Oct 2005 – Cloud structure in 3D

US “Earth Science Decadal Missions”

Cooperation in future NASA missions under discussion
e.g. SMAP, ICESat-II, DESDynI, HypIRI, ACE

Atmospheric Science Mission

Cooperation TBD

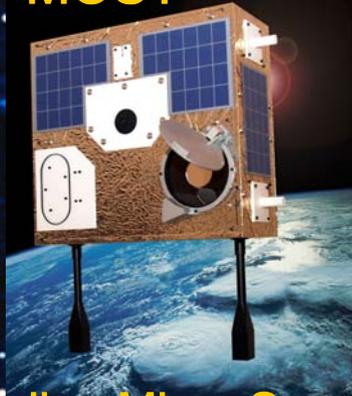
AIR, ATMOSPHERE AND CLIMATE CHANGE

SPACE SCIENCE & EXPLORATION

SPACE SCIENCE & EXPLORATION

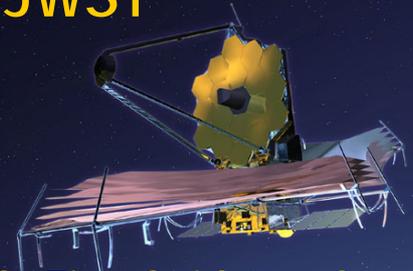
Astronomy and Heliophysics

MOST



Canadian Micro Space Telescope: 2003

JWST



Cdn Fine Guidance Sensor

International
Living With
a Star



CSA ORBITALS w/NASA MORE TBD

- CSA ePOP on CSA CASSIOPE

