CSA Activities in On-orbit Robotic Servicing (ORS)

NASA GSFC Int. Workshop on On-Orbit Satellite Servicing
March 24-26, 2010

CSA welcomes this opportunity to better understand future needs, potential missions, and potential collaborations.
On-orbit Heritage – Operational Systems

CSA has delivered 3 state-of-the-art robotic systems for operational use in LEO: the Shuttle Canadarm, the ISS Canadarm2 and the ISS Dextre.
Completed in 2008 the MSS now has the following capabilities:

- Assembly
- Inspection
- Payload handling
- Capture and Berthing
- Cooperative Servicing:
  - EVA Support
- Robotic Servicing:
  - Change-out of On-orbit Replaceable Units (ORUs)

The MSS is also self-serviceable on-orbit, with 6 types of robotically friendly ORUs.
ORS Heritage – Ops Tools & Methods

## Manipulator Performance Evolution

<table>
<thead>
<tr>
<th>Arm</th>
<th>Canadarm (SRMS)</th>
<th>Canadarm2 (SSRMS)</th>
<th>Dextre (SPDM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arm length</td>
<td>15.2 m</td>
<td>16.9 m</td>
<td>3.35 m</td>
</tr>
<tr>
<td>Arm DOF</td>
<td>6</td>
<td>7</td>
<td>7 (each)</td>
</tr>
<tr>
<td>Body DOF</td>
<td>n/a</td>
<td>n/a</td>
<td>1</td>
</tr>
<tr>
<td>Height</td>
<td>n/a</td>
<td>n/a</td>
<td>3.67 m</td>
</tr>
<tr>
<td>Width</td>
<td>n/a</td>
<td>n/a</td>
<td>2.67 m</td>
</tr>
<tr>
<td>Payload</td>
<td>29,000 kg</td>
<td>116,000 kg</td>
<td>600 kg</td>
</tr>
<tr>
<td>Accuracy</td>
<td>± 5.0 cm</td>
<td>± 4.5 cm</td>
<td>± 6 mm</td>
</tr>
<tr>
<td></td>
<td>n/a</td>
<td>± 30 N</td>
<td>± 2.2 N</td>
</tr>
<tr>
<td>Incremental motion accuracy</td>
<td>n/a</td>
<td>n/a</td>
<td>± 2 mm</td>
</tr>
</tbody>
</table>

Canadarm2 and Dextre both have a sense of touch and are capable of automatic accommodation of forces and moments during contact tasks.
Scorecard w.r.t 1980s dream

In addition to ISS and MSS maintenance tasks, Dextre and MSS were also envisioned to be used for:

- providing lighting and CCTV monitoring,
- providing power to a payload or ORU,
- attaching and removing interfaces,
- inspection,
- servicing of attached scientific payloads,
- mating/demating connections,
- removing and installing thermal covers, and
- cleaning surfaces

- ground control
- free flyer capture

Yes
Partially – currently no ISS need
Not yet – tool required
Not possible
New developments!

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Preparing for future On-Orbit Servicing

- Robotics and Automation for Orion (RAO) Concept Study
- Robotic On-Orbit Servicing Module (ROSM) Phase 0 Study
- Orbital Life Extension Vehicle Concept Study

On-Orbit Robotic Servicing is an enabling technology that can benefit from further TRL advancements and cost reductions.
TriDAR DTO

Building on the success of Neptec’s Space Vision System (SVS) for Shuttle and Laser Camera System (LCS) for the inspection boom, TriDAR was successfully demonstrated during STS-128 and will be demonstrated again during STS-131 and potentially STS-133.

TriDAR can be used to guide rendez-vous and docking operations which are essential to future OOS missions.
Dextre – Human scale ORS capability demonstration on-orbit

As Dextre executes its operational mission, each new task performed will yield a gain in knowledge w.r.t. On-orbit Robotic Servicing.
Potential Dextre Tool DTOs

- Blanket Cutter/Pincer Tool
- Multipurpose On-Orbit Stowage for EVA (MOOSE)
- Handrail Clamp
- Wireless Camera
- Generic EVA Connector Handling Tool
- SPDM Under-Actuated Versatile End Effector (SUVEE)
- Laser Camera
Servicing of Future Scientific Satellites

**PAST**
- HST

**Future**
- 2015: JWST
- 2020: SAFIR
- 2025: MUST
- 2030: AT-LAST
- 2035: TPF

Where Does Canada Fit In?
- Laser Camera Systems
- Next Gen. Canadarm
- Serviceable Sub-Systems
- Refueling Tools
- Docking Tools
- Next Gen. ORU Tools

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OOS and Exploration Spin-offs

Past

| ISS - Dextre, SSRMS | Phoenix Lander |

Future

| Marco Polo | ExoMars | Mars Sample Return | Lunar Space Station |

2018

Where Does Canada Fit In?

- Dexterous Manipulators
- Coring Tools
- Vision/ Sensing Systems
- Large Manipulators

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Next Generation Canadarm R&D Project VIDEO (Draft)
Past OOS Flight Missions

Past On-orbit Servicing operational and demonstration OOS missions are all in LEO.
In the future, after ISS demos, we see a need for OOS at GEO and Lagrange point missions.
... with an eventual need for OOS in lunar orbit exploration missions,
Distant-Future Flight Missions

... and a family of potential next generation Observatory class satellite mission clients.
CSA ORS Summary Roadmap
Future Outlook

• The Canadian Space Agency looks forward to using our expertise in robotics and OOS to contribute to International Exploration Servicing Missions

• Based on Canadian expertise in various technologies for OOS and exploration, Canada will be in a position to make infrastructure contributions to international missions

• Canadian contributions may include robotic manipulators, vision systems, surface mobility systems, planetary landing systems and in-situ resource extraction