Spacecraft Robotic Capture Tool

e.Deorbit Symposium

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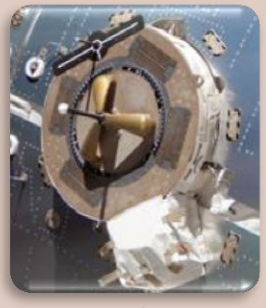
MDA

- MDA is the 7th largest S/C manufacturer in the world (SSL in US - former Loral Space Systems)
- Largest space robotics company in the world (most of US robotics flown to date)
- Largest space company in Canada, mission prime and large system integrator
- Established global supplier to CSA, NASA, ESA, JAXA & RKA as well as US & CDN Defense space programs
- Space robotic technology portfolio spanning manned and unmanned orbital and deep space domains:
  - *Robotic Arms & Sample Handling*
  - *Rovers & Surface Mobility*
  - *Sensors & Science instruments*
  - *Robotic Vision – Cameras & Lidar*
  - *Rendezvous & Prox Ops*
  - *Autonomy, Guidance & Control*
  - *Robotic Interfaces*
  - *Ground Infrastructure*
- Technology applications across multiple terrestrial sectors from medical, mining and nuclear to security, transportation and maritime

MDA Space Products

On-Orbit Servicing

Robotic Manipulators
Robotic Interfaces & Tools
Space Mechanisms
Human-Machine Interfaces

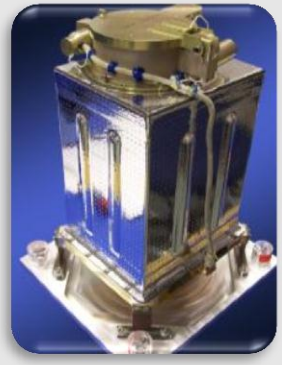


Robotic Manipulators & Interfaces

On-orbit Servicing Solutions

Planetary Exploration

Planetary Robotics
Science Instruments



Mars Phoenix MET

Alpha-Particle
X-Ray Spectrometer

OLA

ExoMars Rover
Locomotion

Deep Space Robotics

Smart Sensors/Autonomy

Space Cameras
Rendezvous/Mapping Lidars
Data Fusion & Processing
Autonomous Navigation

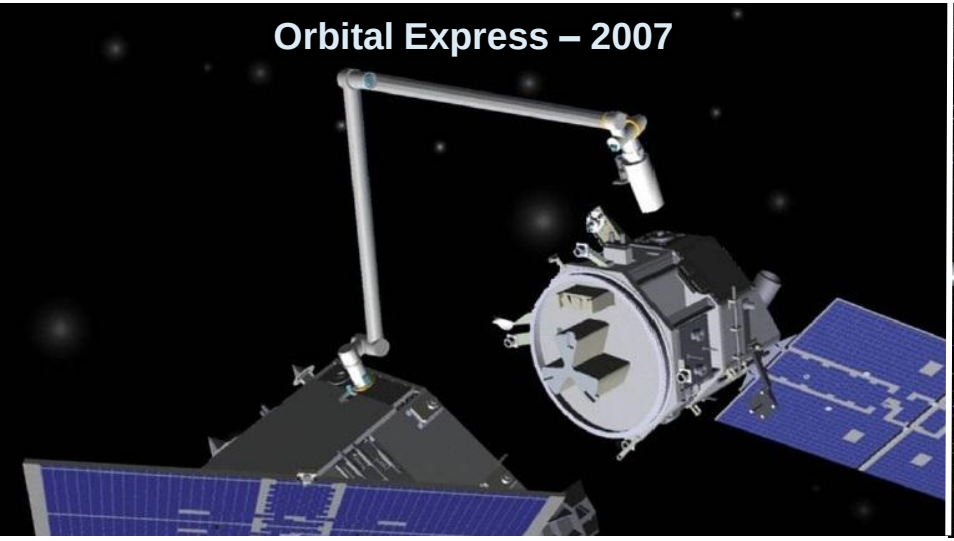
Space Cameras

Rendezvous Lidar

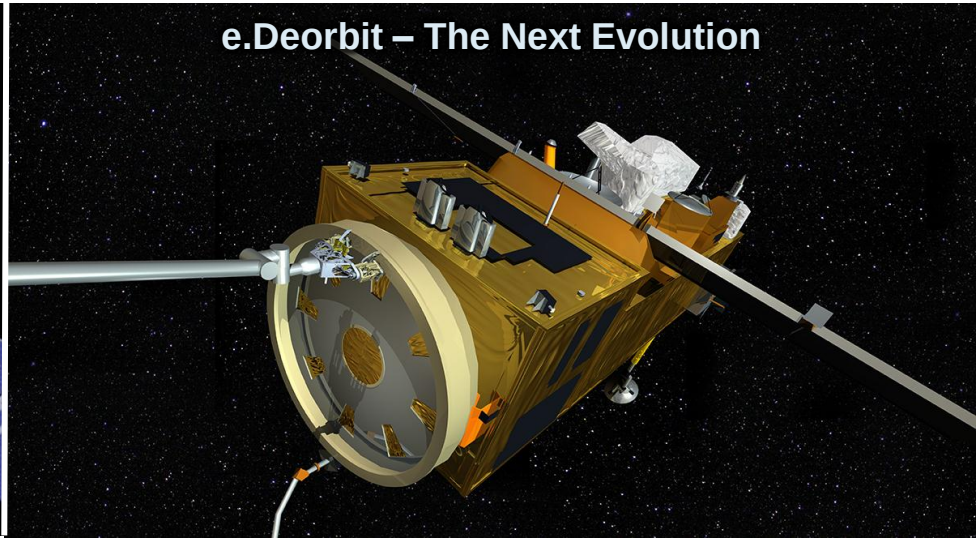
On-Orbit Robotic Capture History…..

Tele-Operated by an On-Board Astronaut

Tele-Operated by an Astronaut, Now also Ground Controlled.
Increasing Level of Automated Response. Captures still Human in the Loop.



Full Autonomous Operation, Failure detection and abort modes.
Still a Prepared Interface (Grapple Fixture / Target)



Full Autonomous Operation, Failure detection and abort modes.
Unprepared interface, uncooperative/tumbling client

Tool Technology Need

- MDA's systems have performed over 40 free-flyer captures on-orbit, and we continue to perform several more each year as we are capturing HTV, Cygnus, and Space-X Dragon on the ISS.

- The challenge with future robotic servicing missions is that the vast majority of objects in existence or currently in development are unprepared
  - Not originally designed for robotic capture and therefore no dedicated grapple point and no target features

- To robotically capture these objects, a rigid and structurally sound feature must be targeted

- The Launch Adapter Ring (LAR) is one of the most attractive interfaces because;
  - They are specifically designed for high loads (launch)
  - They follow a set of standards
  - The profile is well known (although can vary in profile)
  - Sharp edges aid vision system performance
  - Not blanketed or coated
  - Typically found on both rocket bodies and satellites

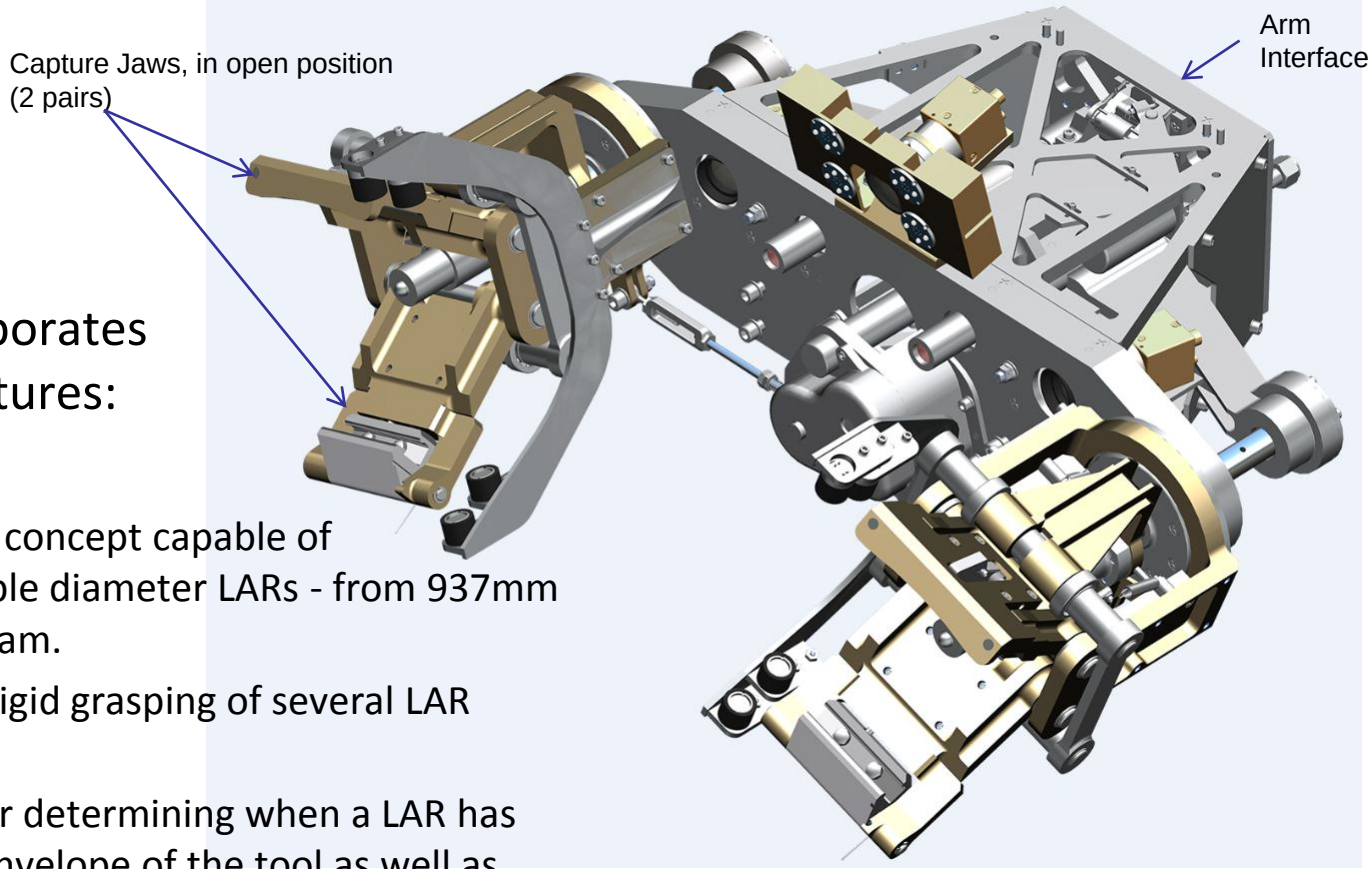
Examples of Launch Adapter Rings

Key Driving Requirements

The main requirements that drive the design of the LAR capture tool:

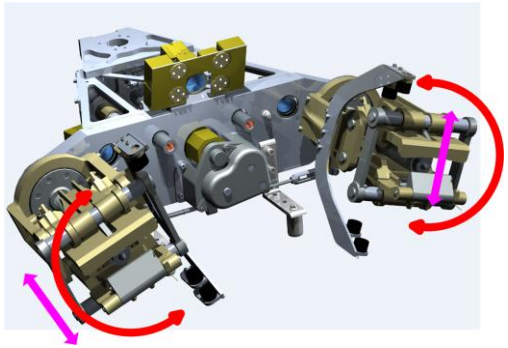
1) LAR Compatibility
   - The ability of the tool to capture multiple styles of LARs
2) Capture Loads
   - The expected loads that the tool must be able to withstand when captured
3) Capture Envelope
   - The misalignments that the tool must be able to allow and still be able to achieve capture
4) Failure Detection and Recovery
   - The tool system must detect a failure or missed capture, and recover
   - Electrical / Sensor Redundancy

LAR Capture Tool Overview



The MDA design incorporates the following main features:

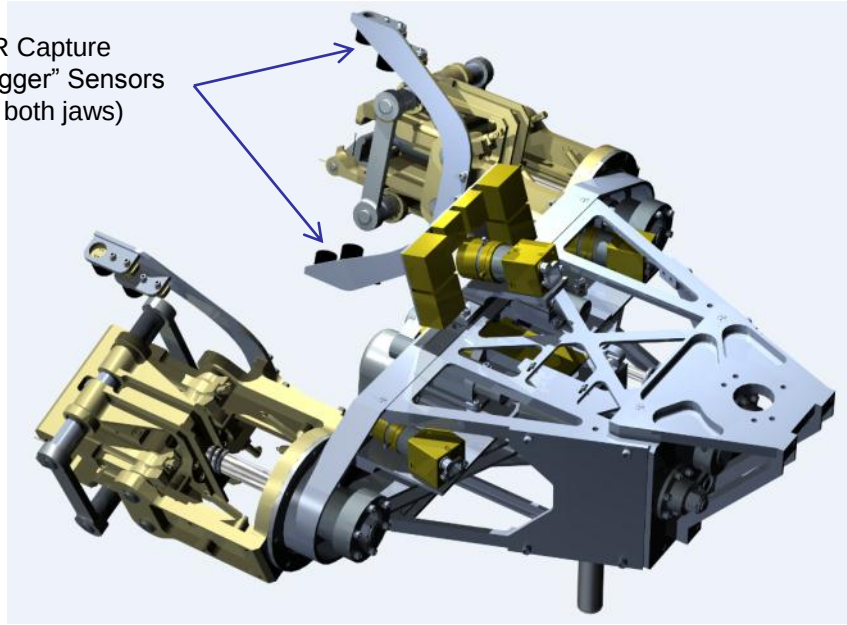
- Dual latch mechanism concept capable of accommodating variable diameter LARs - from 937mm diameter a straight beam.
- Adaptive Jaw tips for rigid grasping of several LAR profiles (optional).
- Contactless sensors for determining when a LAR has entered the capture envelope of the tool as well as detecting a successful or failed capture attempt
- A two stage capture operation consisting of a fast acting (<0.5 second) soft capture and a slower (≥ 15 seconds) operation to seat and rigidize the LAR in the tool
- A single motor drive to perform the capture operation.

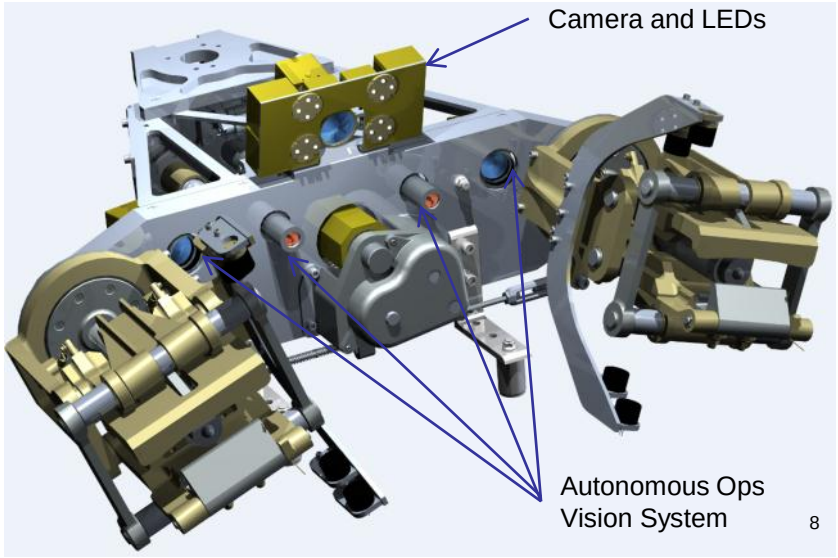


LAR Capture Tool Overview

The MDA design incorporates the following main features:

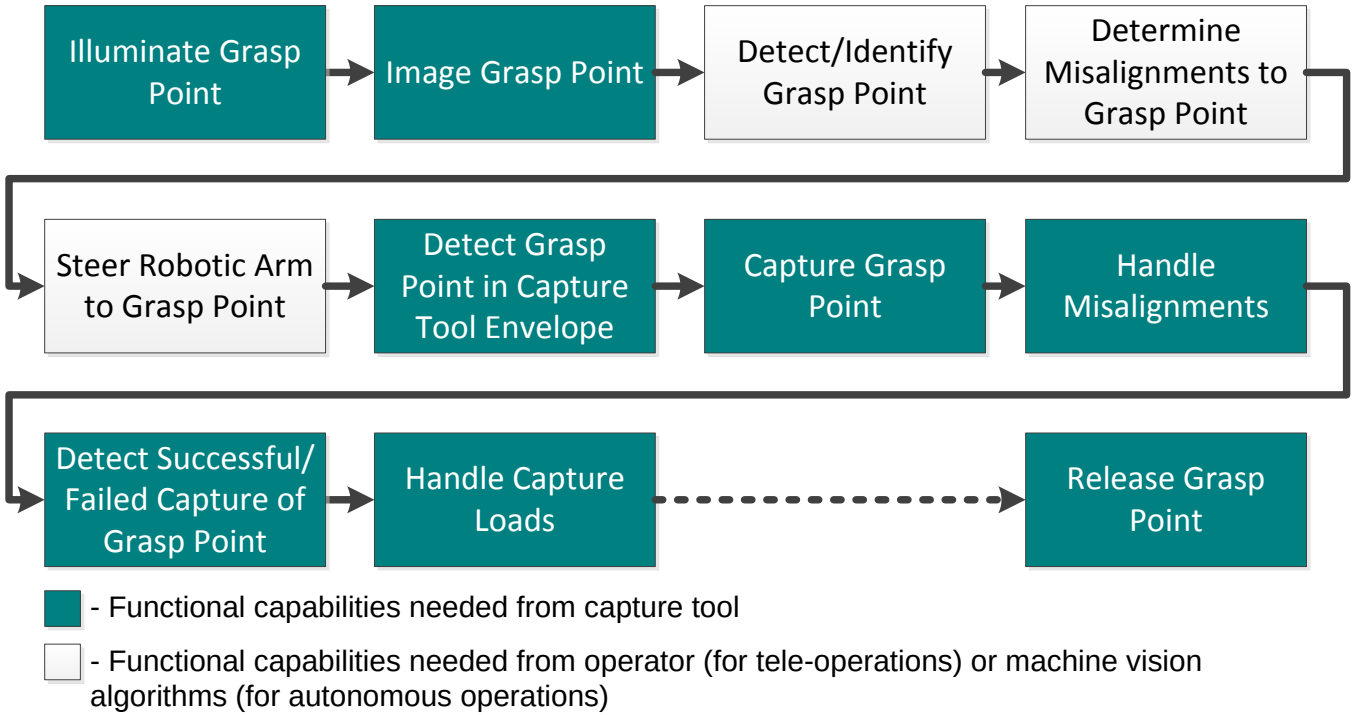
- Releasable, resettable
- Failure Mitigation: Dual-Wound motors, redundant sensors
- Compatible with arm capability and ops
- Camera with LED lights for situational awareness and human-in-the-loop operations
- Vision system for future autonomous operations
- Patent Pending





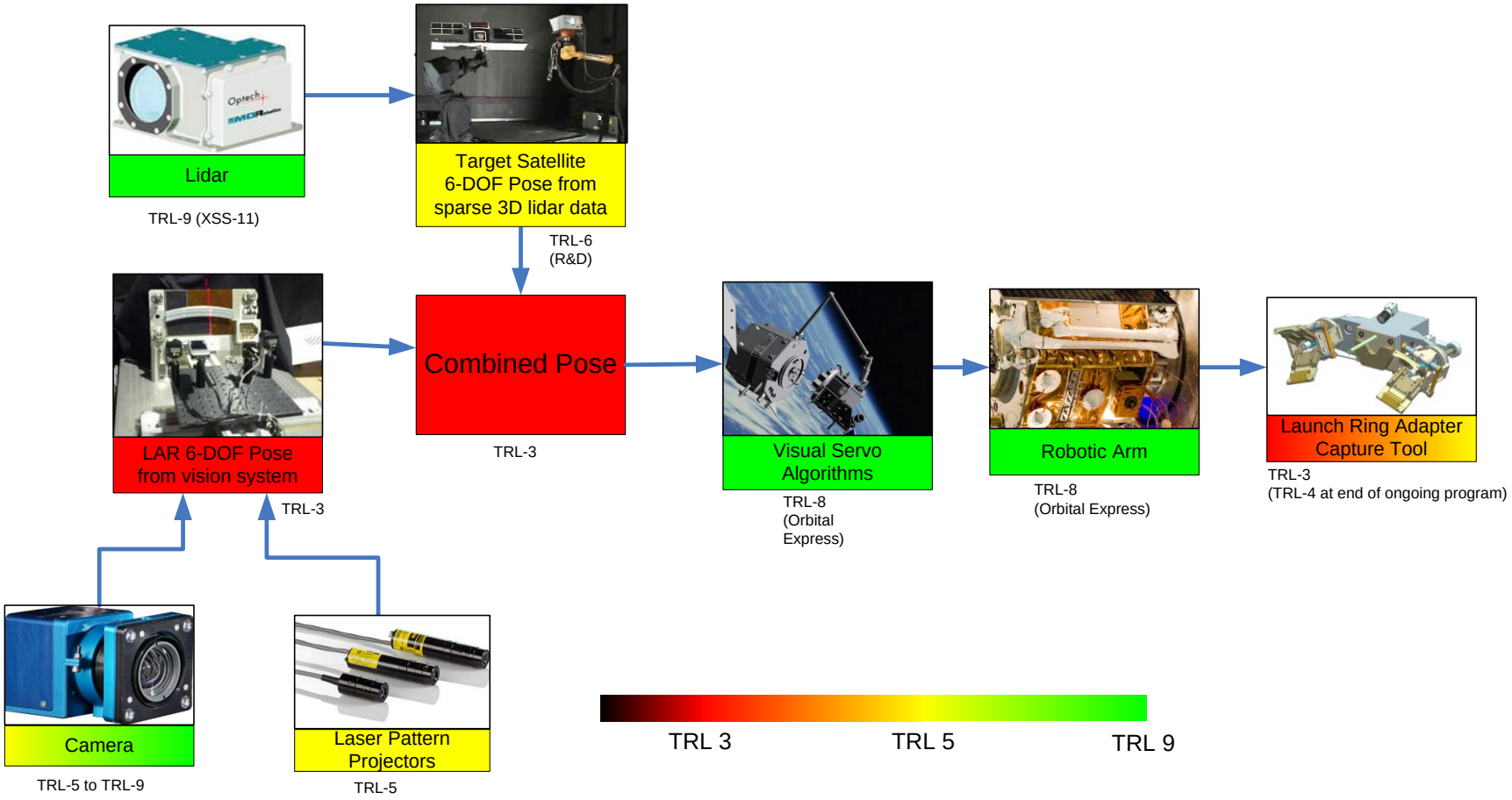
Tool Functional Flow of Operation

- Identified in this figure are the high-level functions that the Launch Adapter Ring Capture Tool must provide as well as the functions that an arm operator (or machine vision system) must perform to support the tracking and alignment of the capture tool to the grasp point.



LAR Capture Tool Technology Roadmap

- Ongoing development program with Canadian Space Agency
- Prototype tool is currently in production
- Testing planned for this summer
- Expect TRL4 by August 2014.
- Next step is advancement of the LAR vision system from TRL-3 to 4, expected to begin this Autumn.



….. And the Envisat Capture !