INFORMATION SYSTEMS

International Interdisciplinary Congress on Space Debris Remediation

- Technical Concepts for Space Debris Remediation -

November 11-12, 2011

Montreal, Canada

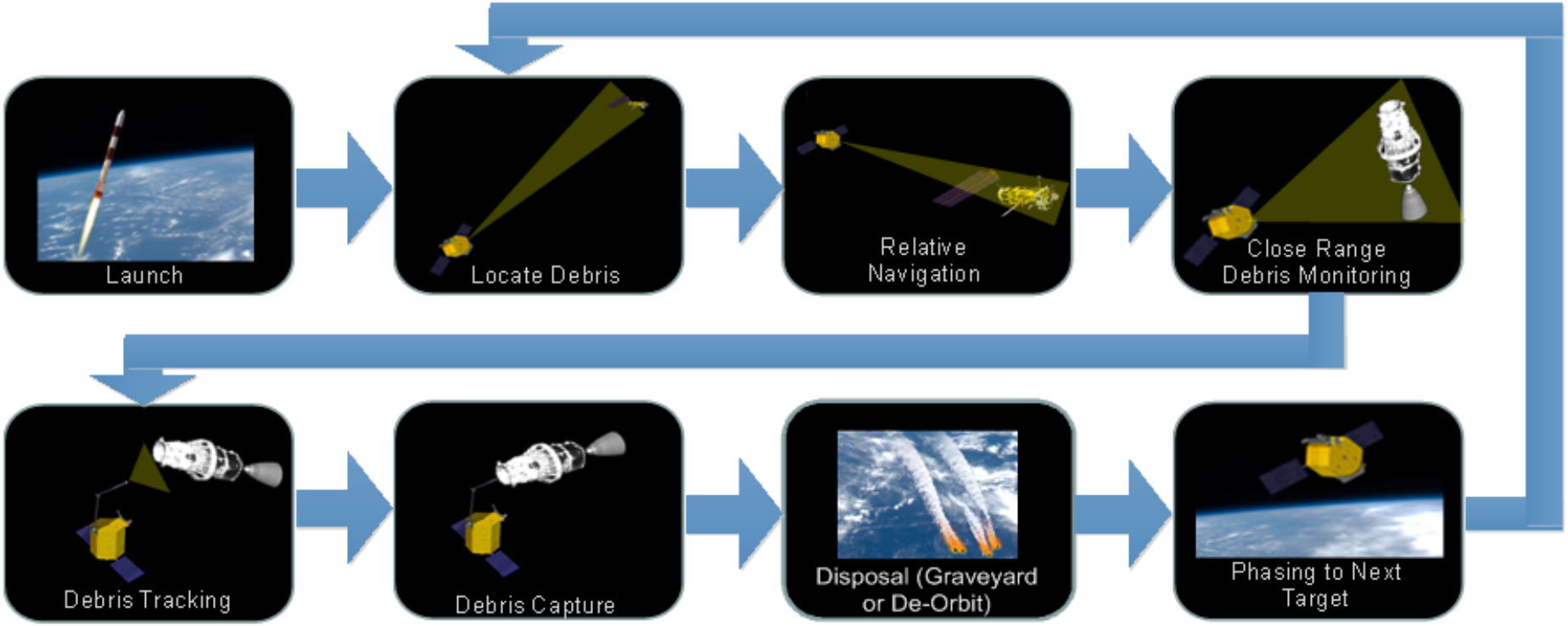
Potential Technical Concepts

METHOD	DESCRIPTION
Foam Ball	Servicer s/c performs prox-ops to close on target. Extensible arm sprays foaming material over target to greatly enhance drag. Target de-orbits due to drag forces
Ion Beam Shepherd	Servicer s/c flys in formation with target & fires ion beam at target to effect momentum change
ROGER	Servicer S/C with either expendable net capture elements or tethered free-flying claws captures targets & tugs them to higher GEO orbits
HybridSail	De-orbiter S/C with docking, detumbling functions. Deploys tether with drag sail attached. Uses both ED forces and enhanced drag to deorbit. S/C consumed
JAXA Small Sat	DeOrbiter S/C with docking, detumbling functions via flexible robotic arms. Deploys tether. Uses ED forces to deorbit. S/C consumed
ElectroDynamic Debris Eliminator	Re-usable de-orbit s/c with docking via capture nets, detumbling functions via unknown means. Deploys tether. Uses ED forces to deorbit. S/C consumed
DR.LEO	De-orbiter S/C with docking, detumbling functions via flexible robotic arms. Controlled deorbit via chemical propulsion. S/C consumed
Ground-based laser	Uses high-powered ground based lasers to ablate surface of debris, thus generating thrust to de-orbit
Solar Sail	Uses solar photon flux as force against large sail to change target momentum. Capture & de-tumbling requires additional mechanisms
Drag sail	Device attaches to target that then extends, by various means, a large sail, parachute or streamer to enhance target LEO atmospheric drag. Target de-orbits due to drag losses. Capture & de-tumbling requires additional mechanisms
Robotic capture	Capture spent asset via robotic manipulator, tow or attach de-orbit module

Debris Removal Mission Concept

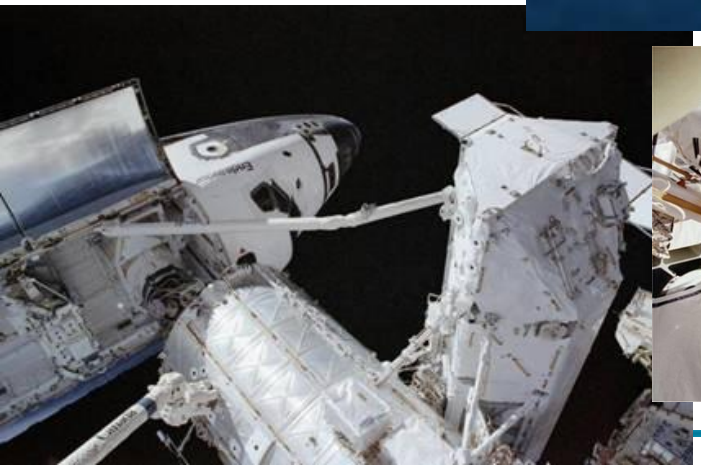
- For a mission to remove 5 large intact objects per year
- Reside in same orbital slot
  - Initial review shows there are sufficient candidates in same orbital slot to achieve goal
- Ideally, same capture interface, same de-orbit strategy

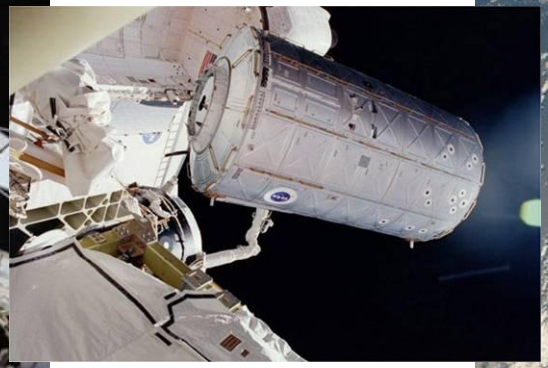
Potential Mission Concept



TECHNOLOGY READINESS

25 Years of Robotic Operations on Shuttle / Station





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Are robotics ready for Prime Time Space Missions?

- in orbit construction
- asset maintenance and life extension
- debris removal/disposal

Yes, the fundamentals are in place…

Technological and Operational Foundation for On-Orbit Operations and Servicing is Mature

Evolving from direct local control to remote Earth based control, Shuttle and ISS experience provides foundation for the design and execution of future Orbit Operations and Servicing Missions

- We know what works for robots and operators
- We know how to recover from unexpected events
- We have realistic expectations for the future

91 Shuttle Missions with Robotic Operations

9 years of ISS robotic assembly and support operations

HTV Capture

ISS026E021164


ISS DL 1
ISS DL 2
ISS DL 3
ISS DL 4


ISS026E021032

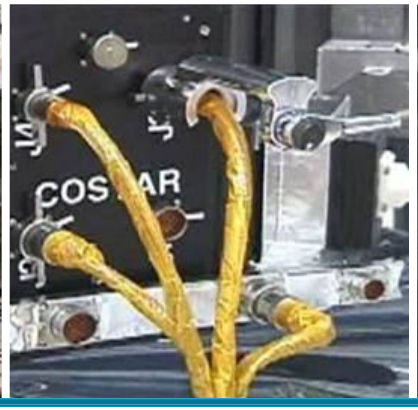
ISS026E024076

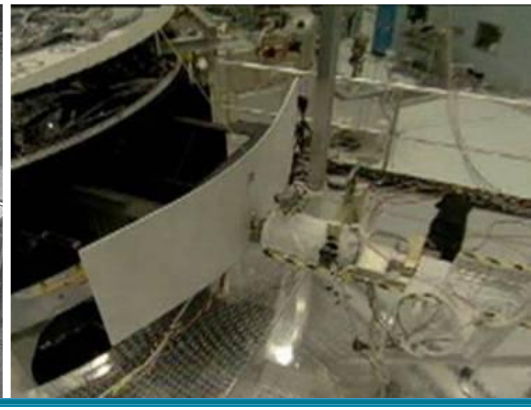
Autonomous Servicing of Prepared Clients has been Demonstrated

- Key Servicing Functions Demonstrated in LEO for remote servicing missions
- Autonomous vehicle capture
- Autonomous Computer and Battery exchange
- Autonomous fluid transfer
- Streamlined operations approach
- Candidate servicing interface standard

Demonstrated Strategies for Clients designed to Non-Robotic Standards using Remote Operator Supervision

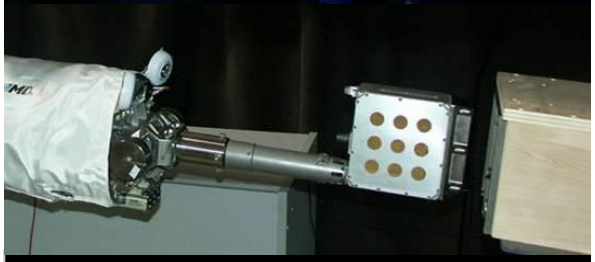
- GSFC and MDA demonstration of dexterous robotics with HST HiFi mockup in 2004-2005
- Combines the best of automation with human cognitive skill and judgment
- Planned robotic compatibility can be non-invasive to a client
- If a technician can do it, a robot can do it



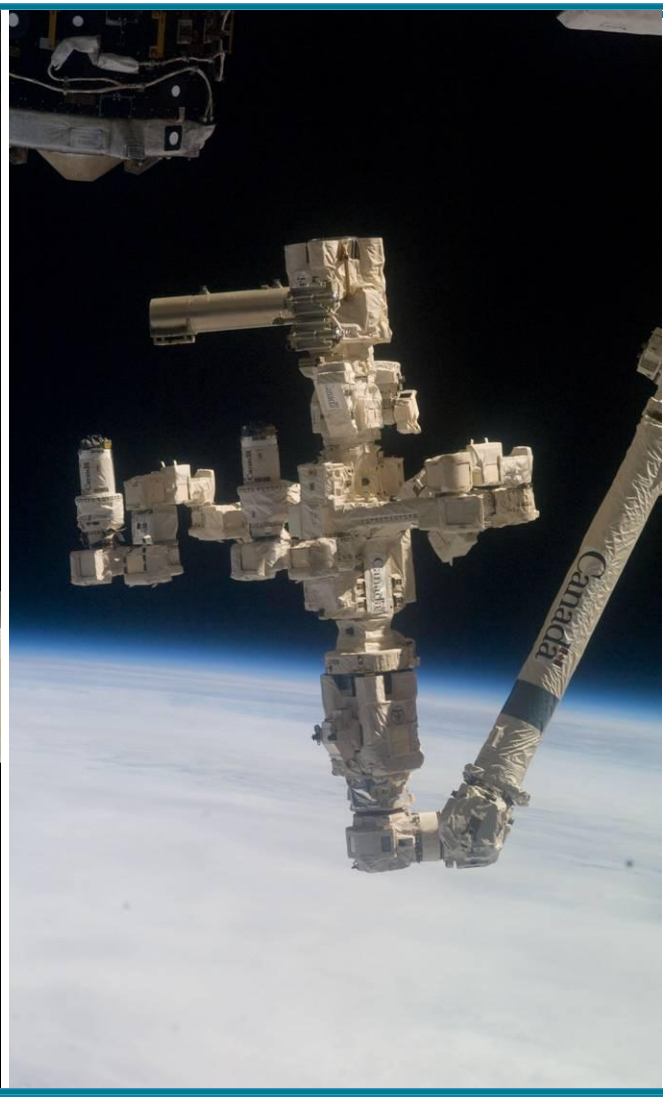


On-orbit Test bed for Advanced Servicing Missions

Dextre on ISS – will continue to perform ground controlled, dexterous servicing tasks and demonstrations adding to our operational experience and imagination



Practicing ‘what-ifs’ in the lab with the 1g compatible SPDM-GT for the RPCM changeout



CONCLUSION

Debris Removal

Robotic technologies are sufficiently mature for large object capture and disposal in GEO or LEO

Large or small tumbling object in SSO, LEO or GEO can be autonomously captured and berthed by grapple arm, then moved to graveyard or deorbited

- This task employs the same capabilities used for assembly and servicing
- Autonomous capture and berthing demonstrated by Orbital Express
- Guided deorbit demonstrated by Compton Gamma Ray Observatory and Mir