

ROADMAP OOS & SATELLITE SERVICING

DETAILS

TOPIC	TIMEFRAME (as of 2004)		
	<i>Sub Topic</i> 0-5 Years	5-10 Years	10-20 Years
GENERAL	Paving the way for OOS Grass-roots private sector	Paving the way for OOS Grass-roots private sector More complex missions Decreasing cost Trade for programs and advocacy	Focus on increasing mission availability, flexibility and efficiency. 3 classes of space infrastructure elements: <ul style="list-style-type: none"> • Non-cooperative • Partly cooperative • Fully cooperative Corresponding OOS will be available to all classes.

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BUSINESS DEVELOPMENT	<p>Generating economic benefits from on-orbit servicing</p> <p>OOS is an emerging business that needs to establish its credibility through demonstration/operational missions.</p> <p>The first operational mission will likely be the Hubble Servicing Mission.</p> <p>The space community will start to consider OOS as part of future programs.</p>	<p>Entrepreneurial/commercial successes.</p> <p>Link to private equity</p>	<p>OOS will evolve as an integral part of space industry and business landscape.</p>
OOS Service Providers	<p>Companies focused on providing end-to-end on-orbit servicing. For example:</p> <p>Astrokeys</p> <p>Boeing</p> <p>EADS</p> <p>Geo-Ring</p> <p>Kayser-Threde</p> <p>Lockeed Martin</p> <p>MDA</p> <p>Orbital Recovery</p> <p>In the next five years the OOS</p>	<p>Achieve a portfolio of viable solutions in all service classes: motion, observation & manipulation.</p> <p>Several providers will have established themselves in the market and will extend their range of services.</p> <p>New players and concepts will enter the field.</p>	<p>Offer and market a portfolio of viable solutions in all service classes: motion, observation & manipulation.</p> <p>Competitive providers will have established themselves in the market.</p> <p>Some will specialize and focus on niche or simple services while others will offer more complex servicing tasks.</p>

	<p>providers will establish themselves in the market place by defining their business plan. The main focus for applications will be flight demonstration missions to reduce the risks and convince potential customers. The support of space agencies will be required.</p>		
<p><i>Manufacturers</i></p>	<p>Companies part of the on- orbit servicing chain of supply: satellite manufacturers, space robotics companies, sub-systems and components providers. For example:</p> <p>MD-Robotics EADS Kayser-Threde</p> <p>In the next five years, only the space automation & robotic companies will invest in OOS development as a way to generate new business.</p>	<p>The traditional space industry will take position w.r.t. OOS.</p> <p>New players will enter the field.</p>	<p>Manufacturing & launch of new satellites suitable for OSS.</p> <p>Servicing infrastructure will a new business stream (dedicated servicers, logistic elements, launches etc.).</p>

<p><i>Insurance</i></p>	<p>The insurance sector will investigate the benefits of OOS in response to discussion with OOS providers. At this point, the insurance sector is not convinced that OOS is a solution.</p>	<p>Achievement of insurance industry acceptance for OOS. Have insurance industry encourage participation and serviceability. Insurance industry will develop detailed know-how and understanding (risks, policies, processes etc.).</p>	<p>OSS related insurance products will create a new business stream. OOS will become part of the overall risk mitigation of space missions.</p>
<p><i>Others</i></p>	<p>Others include the satellite operators, the financial community, military and other public bodies. Military will continue their investment in OOS through demonstration missions. The others will start to investigate if OOS could improve their missions.</p>	<p>Professional know-how and processes will develop in finance, legal, regulatory etc.. Military will perform demonstrational & operational missions. Military will develop new procurement models to implement operational OOS.</p>	<p>Professional know-how and processes will develop in finance, legal, regulatory etc.. Military will perform demonstrational & operational missions.</p>

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DEMONSTRATION MISSIONS	<p>Missions for which the main objective is to demonstrate and verify the capabilities of on-orbit servicing.</p> <p>The level of complexity of the mission will increase from rendez-vous without contact to capturing and docking of non-cooperative satellites.</p> <p>Manipulations, refuelling and component exchange will be done only for satellites/spacecrafts designed to be serviceable (e.g. Hubble, Orbital Express).</p>		
DART (2004)	<p>Autonomous rendezvous demonstration without contact</p> <p>Advanced Video Guidance Sensor</p>	<p>Assessment of mission results and lessons learned</p>	
Orbital Express (2007)	<p>Demonstration mission by DARPA to demonstrate autonomous capture and docking, autonomous servicing and refuelling of satellite.</p>		
ROKVISS	<p>Robot Component Verification to space-qualify DLR robot joints, tele- presence and</p>		

(2005)	automated modes (scripted commands).		
TECSAS (2008)	Demonstration mission led by DLR to demonstrate an end-to-end servicing mission with a non-cooperative satellite (rendezvous, capture, motion control, deorbiting through teleoperation and autonomous modes)		
XSS 11 (2005)	Demonstration of proximity operation (no contact) using Lidar		
Smart 1 (2005)	Japanese mission led by NICT to demonstrate		
Proof of Concept		<p>Continuous preparation of next generation demonstrations.</p> <p>Universally applicable services (e.g. for any satellite, planetary missions).</p> <p>More complex com sat servicing.</p> <p>Refueling tech-demo using standardized Interface.</p> <p>Repeated rendezvous and non-cooperative satellite capture.</p> <p>ORU exchange.</p> <p>Repair.</p>	<p>Continuous preparation of next generation demonstrations.</p> <p>Universally applicable services (e.g. for any satellite, planetary and disaster prevention missions).</p> <p>More complex com sat servicing.</p> <p>Repair.</p> <p>Modular design.</p> <p>Next generation service vehicles and their utilisation.</p> <p>Systems autonomy & on board "intelligence"</p>

		<p>Modular design.</p> <p>Dexterous end-effector /manipulator.</p> <p>ISS platform / exposed facility.</p> <p>Next generation service vehicles and their utilisation (Robonaut etc.)</p> <p>Debris removal</p> <p>Systems autonomy & on board "intelligence"</p>	"intelligence"
<i>Design of Serviceable Assets</i>			<p>Modular design of spacecraft.</p> <p>Build-in ability to upgrade spacecraft (satcom cluster, unmanned GEO station)</p>
<i>Enabling Measures for Operational Missions</i>			<p>Space Qualification & Demonstration of industrial subsystems, components and ORU's etc.</p>

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OPERATIONAL MISSIONS	Missions that are responding to a need expressed by a customer.	Missions that are responding to a need expressed by a customer.	OOS will be established as part of operational missions.
Shuttle Inspection (2005)	<p>The shuttle inspection will allow in-situ inspection of the shuttle tiles for damage.</p> <p>Technologies to be used:</p> <p>Manipulator</p> <p>3D vision system for tile crack detection</p>	Assessment of mission results and lessons learned	
ISS Construction & Maintenance (on-going)	<p>The construction and the maintenance of the ISS will continue with the Canadarm II. The maintenance will reach a new level of sophistication with the launch of DEXTRE in 2006.</p> <p>The launches of ERA and JEMS will allow the manipulations og experimental payload.</p> <p>Products required:</p> <p>3D vision system for tile crack detection</p>	Assessment of mission results and lessons learned	
ATV (2005)	<p>Automated Transfer Vehicle developed by ESA.</p> <p><i>Human supervised direct</i></p>	Assessment of mission results and lessons learned	

	<i>docking to the ISS.</i>		
HTV (2006)	H-IIA Transfer Vehicle developed by JAXA. <i>The HTV will fly autonomously to the ISS and will be captured by the Canadarm 2 to be docked to the ISS.</i>	Assessment of mission results and lessons learned	
CX-OLEV (2007)	Orbital Life Extension Vehicle. Demonstration of docking, attitude control and displacement of satellite to different orbits.	Assessment of mission results and lessons learned	
Hubble Servicing (2008)	The Hubble Servicing Mission is aiming at providing a de-orbit capability, power supply renewal, bus component replacement and payload instrument upgrade.	Assessment of mission results and lessons learned	
Concept Studies	New concept studies will establish the requirements for OOS for EO, Satcom and Exploration.	New concept studies will establish the requirements for OOS And OOA (on-orbit assembly).	
Design		Co-operative design of target, e.g. power re-supply (power module connecting to umbilical) Interfaces OTS modularity	Co-operative space infrastructure Optimization of first generation OOS design
New		Nano-Sat Inspector	?

<i>Extension of demonstrated OOS capabilities</i>		Different orbits Further space assets	Further extension
<i>Military Applications</i>		First operations	OOS as part of military projects
<i>Space Debris</i>			Controlled De-orbiting Disposal to graveyard orbit Other orbital clean-up processes
<i>Routine OOS</i>			Sophisticated Comsat Servicing Refueling ORU exchange Components and Subsystems of large/high- value satellites

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CONCOMITANT ACTIVITIES	<p>Activities beyond the technical development to create the proper environment for the development of on- orbit servicing.</p> <p>We could expect a series of developments that will impact OOS.</p>	<p>Activities beyond the technical development to create the proper environment for the development of on- orbit servicing.</p> <p>We could expect a series of developments that will impact OOS.</p>	<p>Proper environment established for OOS & OOA.</p>
Legal & Regulatory	<p>In the next five years, we could expect regulations and laws that will have impact on OOS (e.g. orbit cleanup for GEO and controlled re-entry of large LEO spacecrafts).</p>	<p>Endorsement of first order legal and regulatory standards for: OOS (OOA)</p>	<p>Implementation of legal and regulatory framework for OOS & OOA Debris management of small micro-nano-satellites.</p>
Political	<p>We should create an appropriate political environment by setting-up an international inter-agency working group on OOS.</p> <p>We should foster interaction between military and civilian applications of OOS.</p>	<p>International inter- agency working group on OOS and OOA established.</p> <p>Interaction between military and civilian OOS.</p>	<p>International inter- agency working group on OOS and OOA activities.</p> <p>Military and civilian OOS collaboration.</p>
Processes	<p><i>OOS will be seen as a stepping-stone towards space exploration.</i></p>	<p>OOS and OOA become integral elements of future mission planning in areas like: Telecommunication systems Operations</p>	<p>OOS and OOA become integral elements of future mission planing and missions.</p>

		Space exploration Etc.	
<i>Cultural</i>	We could expect case studies to evaluate the impact of OOS on space activities in general	Appreciation of reference studies and demonstration mission. Lessons learned from other sectors (e.g. automotive, IT, infrastructure, logistics etc.) Consideration of OOS and OOA in areas like: Technical (design etc.) Organizational (structure and set-up) Business Processes	Acceptance and recognition of OOS and OOA as assets of space infrastructure Established OOS and OOA communities
<i>Standardization & Modularized Concepts</i>	Standard development for the satellite manufacturers to improve their efficiency: e.g. modular design and standard components and interfaces. We will see an effort in the standardization that could have some impact on OOS.	Standard development for the satellite manufacturers to improve their efficiency: e.g. modular design and standard components and interfaces. Introduction of first generation standards on element level.	Standards for spacecraft design and manufacturing covering all system levels. Creation and implementation of modular design principles.
<i>Disaster Prevention/Mitigation</i>			NEO trajectory correction maneuvers. Armageddon!