

On-Orbit Satellite Servicing (OOSS)

On-Orbit Satellite Servicing – Is There A Business Case That Makes Sense



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Lockheed Martin Assessments - OOSS



- Is Market Real and Robust?
- Business Case Viable and Attractive?

On-Orbit Satellite Servicing Markets



Candidate Market Segments

Satellite Rescue	<ul style="list-style-type: none"> • Failure of satellite to achieve desired orbit due to non-catastrophic failure of the LV/Upper Stage or satellite orbit insertion engine resulting in a loss or degraded mission capability.
Satellite Repositioning	<ul style="list-style-type: none"> • Failure of operational asset resulting in loss of orbital positional control but recoverable. • Repositioning of operational space assets in support of: <ul style="list-style-type: none"> – Operationally Responsive Space, – Constellation Management, and – Orbital Slot Management.
Satellite Servicing	<ul style="list-style-type: none"> • Satellite refueling to extend life or reduce initial launch wet mass. • Satellite repair of existing subsystems to restore mission operability or replace failed components where feasible. • Satellite upgrade and/or enhancement (plug-n-play) of next-generation satellite systems (i.e., Hubble Space Telescope).
Flexible Launch	<ul style="list-style-type: none"> • Service vehicle operates as high efficiency, reusable, space-based upper stage that enables: <ul style="list-style-type: none"> – Launch vehicle stepdown, – Increased or multi-manifesting of small satellites, or – Higher payload mass fraction on existing satellite by reducing required on-board propellant requirements. • High delta-V system enables launch site flexibility (assured access to space) • Rideshare of secondary payloads (attached or free-flyers) on periodic service vehicle refueling launches.
Graveyarding	<ul style="list-style-type: none"> • Transfer of end-of-life or failed assets to either a graveyard orbit or to a targeted de-orbit.
Orbital Debris	<ul style="list-style-type: none"> • Capture and transfer of large orbital debris to either a safe orbit or to a targeted de-orbit. • Deployment, servicing, and disposal of capture architecture elements for small and medium sized debris.
Other	<ul style="list-style-type: none"> • Hosted Payloads • Transport to ISS for servicing • On-orbit assembly • Cis-lunar (beyond GEO) transfer stage and servicing architecture

LMSSC Mission Utility Assessment



On-Orbit Services	DoD/IC	USG Civil	Commercial	Foreign Govt.
S&T demo services	Enhancing	na	na	na
On-orbit rescue of stranded SVs	Transformational	Yes	Yes	Yes
Flexible launch				
Enable use of smaller LVs, dual launch, or larger payloads	Enhancing	Yes	Yes	??
Rideshare 2 nd payloads to orbit (Servicer or Resupply)	Enhancing	Yes	na	na
Geographically independent launch	Transformational	Yes	Yes	na
Responsive Space				
Reposition for failures	Transformational	Yes	Yes	Yes
Reposition to opt. coverage	Transformational	Yes	Yes	??
Deploy responsive smallsats	Enhancing	na	na	na
Inspection, Observation				
Space situational awareness	Transformational	Partial	Partial	Partial
Graveyarding				
Routine end of life disposal	Enhancing	Yes	Yes	Yes
Dispose of premature failures	Transformational	Yes	Yes	Yes
Stationkeeping				
Annual contract	Enhancing	Yes	Yes	Yes
End of life extension	Enhancing	Yes	Yes	Yes
On-orbit Servicing				
Transport to ISS for servicing	Transformational	Yes	Yes	??
Emergency crew rescue	Transformational	Yes	Yes	Yes
Emergency deployment assistance	Transformational	Yes	Yes	Yes
Refueling of on-orbit assets	Transformational	Yes	Yes	Yes
ORU replacement/ repair *	Transformational	Yes	Yes	Yes
On-orbit assembly assistance*	Transformational	Yes	Yes	Yes
Salvage abandoned assets*	Transformational	Yes	Yes	Yes
Other Missions				
Debris clean-up payload	Transformational	Yes	Yes	??
Asteroid protection payload	Transformational	Yes	Yes	Yes
Host various 2 nd P/Ls	Enhancing	Yes	Yes	Yes
Insurance Service Contracts	na	na	Yes	na

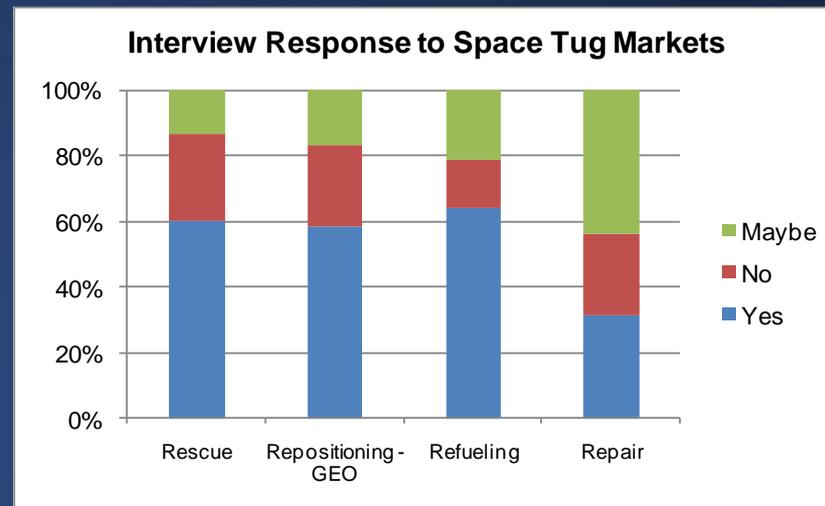
* - Requires target SV to have appropriate capabilities incorporated into their designs

Customer Reaction to Servicing Capability

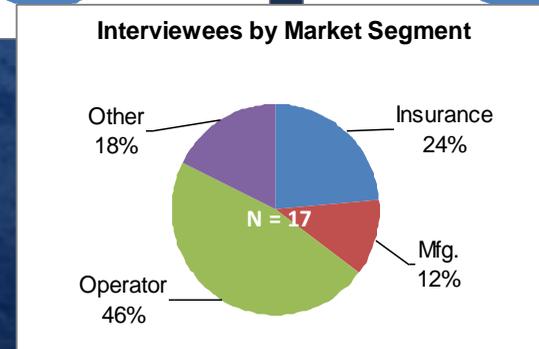
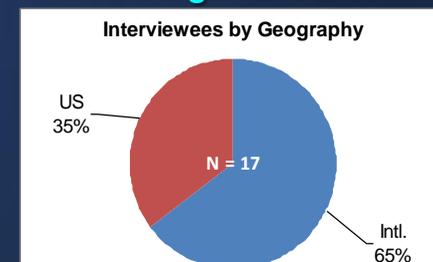
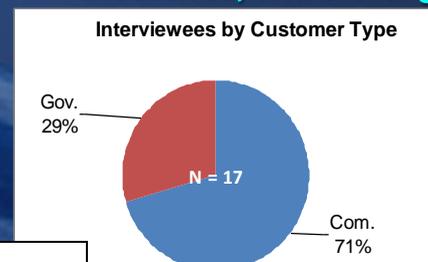
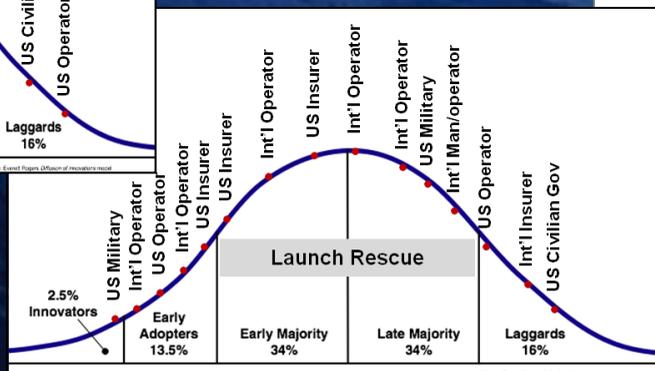
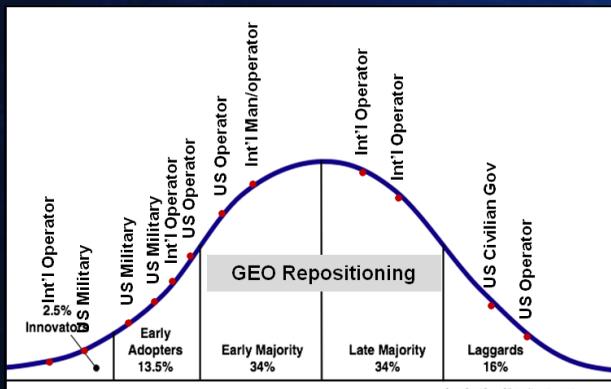


Survey of Users offered several insights:

1. Desire for bundled products and services with satellite manufactures was greater than expected and timing was sooner than anticipated.
2. Launch rescue, life extension, and orbit/slot maintenance were clear market opportunities.
3. Market size is moderate – large, with growth rates in line with traditional space market sectors.
4. Adoption rates were positive.
5. Successful on-orbit demonstrations required.



Based on interviews with 17 organizations, including 8 satellite operators, 4 insurance executives, and 5 U.S. government organizations.

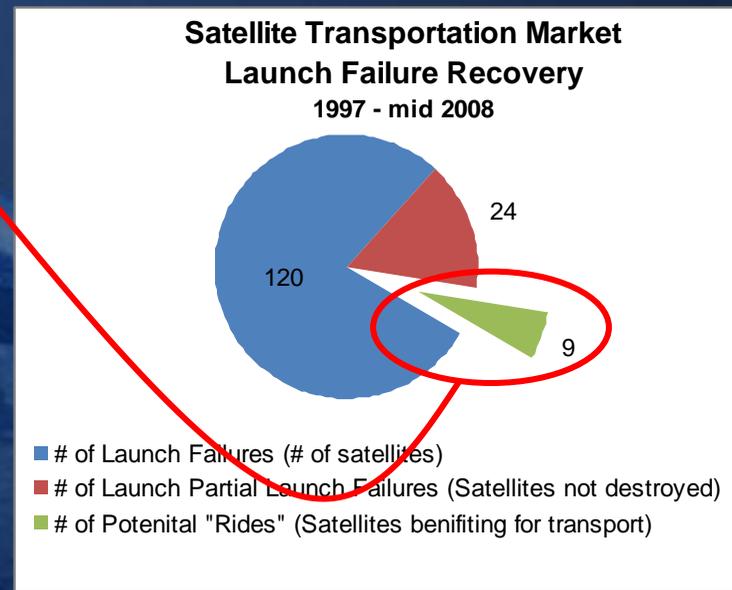
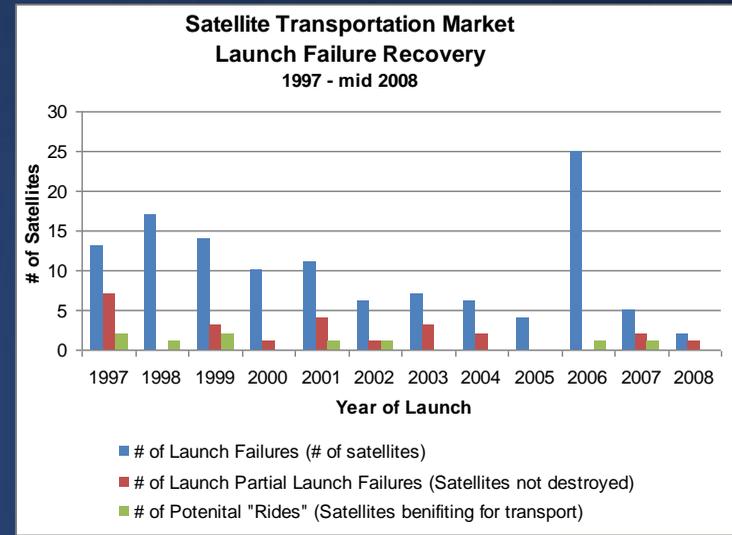


History Supports Need & Value



Satellite Rescue

Launch Year	Payload	Orbit Type	Value (US\$ 2008)	% Loss	\$ Lost	Notes
1997	IRS 1D	LEO	\$83,054,032	10%	\$8,305,403	Use fuel to obtain final orbit
1997	AsiaSat 3	GEO	\$138,423,387	100%	\$138,423,387	Total Loss
1998	COMET S 1	GEO	\$503,968,642	20%	\$100,793,728	Incorrect orbit
1999	DSP 19	GEO	\$234,859,173	100%	\$234,859,173	Total Loss
1999	Milstar F3	GEO	\$1,043,818,547	100%	\$1,043,818,547	Total Loss
2001	Gsat 1	GEO	\$329,418	20%	\$65,884	Incorrect Orbit
2002	Astra 1K	GEO	\$334,334,643	100%	\$334,334,643	Total Loss
2006	ArabSat 4A	GEO	\$189,964,754	100%	\$189,964,754	Total Loss
2007	NRO L-30	LEO	\$721,000,000	20%	\$144,200,000	Incorrect Orbit
Total			\$3,249,752,596		\$2,194,765,519	



If revenue represents 50% of loss value, ~\$1.1B over 10 years is achievable based solely on replacement.

Lost revenue/mission capability not factored but could be significant.

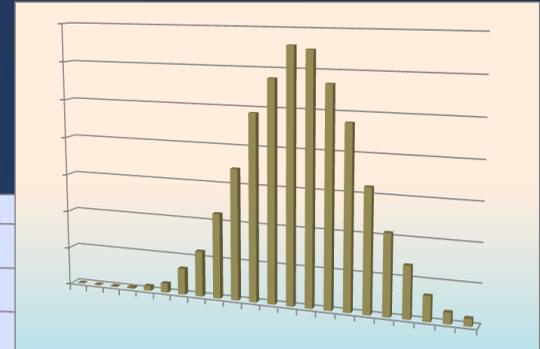
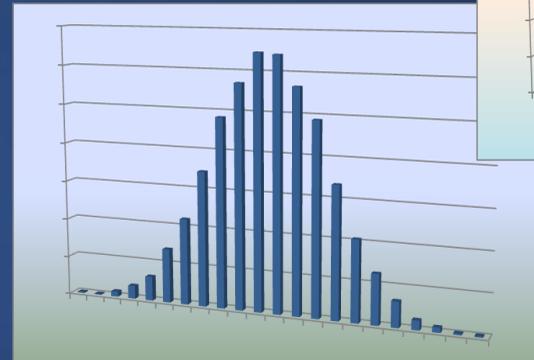
Source – LMSSC Funded Study

Is There a Commercial Business Case?



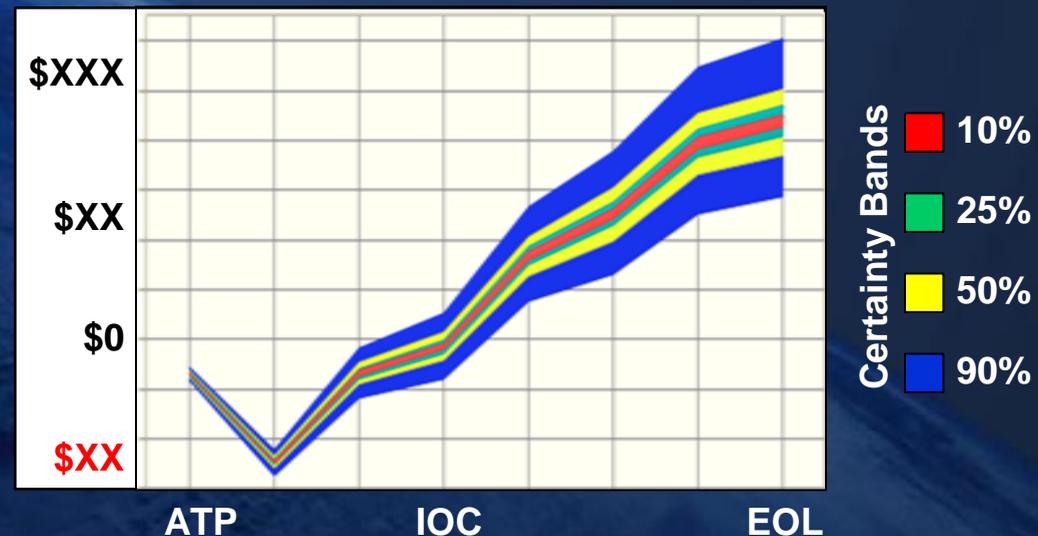
- Standard business case analyses do not adequately capture risks and returns
- Statistical model required to address new markets
 - Servicing architecture
 - Development costs
 - Operating costs
 - Market size & timing
 - Market value
 - Financing options
 - Contractual agreements
- Sensitivity analyses & off-nominal market conditions are quickly analyzed

Non-Recurring & Recurring Costs



Market Size & Market Value

Representative Net Present Value (or Cash Flow)



Summary



- **On-Orbit Satellite Servicing market is medium – large and diverse**
- **User community interest is relatively strong, but**
 - **Technical feasibility must be demonstrated, even for early adopters,**
 - **Value proposition must be well defined and measurable to potential customers, and**
 - **Customer interest is highly dependent on structure of servicing business model**
- **Under the right conditions, OOSS business case is attractive**

Thank You

