in-Space Assembled Telescopes (iSAT) Study

Key Design Features of iSAT		Derived Benefits	Relative Challenges/Drawbacks
Modularized Flight Elements	**Relative Cost Impact**	- Enables scheduling flexibility and helps avoids a single critical path during AIT to avoid large ground marching army when there are anomalies and late deliveries. - Reduces or eliminates AIT end-to-end system performance testing. - Modularization enables easier access to anomalous components for repair or replacement during I&T. - The degree of modularization can be tailored to simplify the assembly depending on the telescope and available LV fairing sizes. - Distributes and competes module development work across NASA and industrial base to the most cost-effective vendors and facilities. - Enhances potential domestic and international partnerships. - Reduces need for new and unique ground test facilities. - Encapsulates complexity (simplifies design and isolates functionality). - Enables less risky in-space servicing. - As number of instances of a module increases, cost per module decreases. - Reduces spacecraft cost and schedule since no complex integration of large deployment mechanisms (support sturcture is smaller and simpler)..	- Will require greater SE and V&V involvement earlier in project phases. - More modules and parts to design, build, assemble, performance test, and flight qualify, each with multiple interfaces (however, there is expected to be many instances o same system with the same interfaces).
	Relative Risk Impact	- Enable testing of the partially assembled observatory in situ to verify performance and validate modeling enabling subsequent corrections with later module deliveries. - Smart modules can communicate error modes. - Faults and anomalies can be more readily contained and not propagated. - Levels vendor schedule issues when one has technical challenges or over-subscribed.	- Modularization and its multiple interfaces (latches, rails, more connectors) mean higher risk. - More modules mean increased management challenges due to widely distributed participants (but may result in lower cost due to competed vendors). - If there is a common design flaw in a few modules all may have to be modified.
Multiple Launches	**Relative Cost Impact**	- Liberates conventional single-launch mass and volume constraints that drive schedule and cost. - Eliminates dependence on new LV cost and schedule development risks while fully leveraging lower-cost commercial LV capabilities.	- Planned use of multiple launch vehicles along with their smart upper stage cargo delivery vehicles may increase launch costs for the mission. - Assembly of observatory in space requires much longer duration of vehicle control compared to a single complex deployment complete in short duration.
	Relative Risk Impact	- Mitigates the risks associated with a single LV or deployment anomaly (Launch failure need not be mission failure). - Reduces programmatic risk of depending on a specific LV, can have a variety of possible LV to use if a single vendor has a failure or over-subscribed.	- The use of multiple LVs increases the risk of a launch failure and adds schedule to recuperate lost payload (but it would only be a fraction of the total cost).
Relaxed Mass and Volume Constraints	**Relative Cost Impact**	- Relaxes system mass and volume design requirements simplifying overall system configuration. - Diminishes cost and schedule impacts from major hardware re-design changes and iterations. - Decouples operational environment from launch environment resulting in reduced interface ruggedization and lighter structures. - Enables new technology on-ramps in space that cannot be easily tested at 1 g or safely survive launch in an integrated state. - Offers the use of current SOA technology decreasing the need for new technology development. - Offers instrument builders opportunities to reduce the need to lightweight and reduce volume in order to reduce cost and schedule.	- Thermal blind mate/demate interfaces don't yet exist.
	Relative Risk Impact	- Enables architectures that eliminate complex autonomous deployments.	
	Relative Science Impact	- Reduces volume constraints allowing for optical layouts with fewer reflections and hence greater throughput, operational efficiency, and greater science yield. - Enables more observatory instruments that single LVs may not have mass or volume capacity to carry. - Since telescope is no longer constrained by fairing dimensions the telescope can be slower allowing for more separation between field points at the focal plane and less crowding of instrument pick-offs. This also results in better wavefront error performance and ultimately science yield and can therefore result in flying more instruments.	
In-Space Assembly and Servicing of Flight Elements	**Relative Cost Impact**	- Leverages the decades of NASA human spaceflight, robotic assembly, and servicing experience to the benefit of NASA SMD. - More readily enables programs to tailor flight element developments to a prescribed fixed and/or flattened funding profile. - With increased life times, can amortize system costs over a longer period of time and number of missions (science per dollar increases). - Represents an architecture that enables common module development and interfaces benefiting many SMD mission areas. - Enables opportunity to use Class C and D components for a Class A mission reducing cost. - Servicing and servicer is enabled.	- Likely extended Phase A and B due to need for clear interfaces, V&V and integration plans, fault mode recovery plans understood earlier. - Hardware/software for robotic and RPO operations the current paradigm doesn't require will increase cost of iSA. - Fewer anomaly resolution options when assembling in space compared to ground and they will cost much more to fix. - Robotic arms and autonomy software development will require characterization testbeds demonstrating assembly and assembly sequences. - Novel applications of space robotics may require significant new operations and technology developments: e.g., more complex multiple acquisition, rendezvous, and docking capabilities. - Ground Data Systems will have to be altered to include robotic assembly. - Space AI&T is a new engineering development for in-space telescope assembly.
	Relative Risk Impact	- Enhances recovery from flight system failures and anomalies. - Enables ORU sparing and upgrading strategies for redundancy and new technology on-ramps. - Enhances contingency planning and options to mitigate flight element risks.	- Contamination concerns during assembly and servicing.
	Relative Science Impact	- Extends the operational lifetime of observatories for multiple decades through repair, replace, and refueling (extent of serviceability will be greater with an iSAT compare to a single LV observatory that is serviceable). - Enhances capability to more rapidly respond to new science questions through the replacement of payload instruments. - Enables missions (telescope sizes and masses) that aren't feasible from a single launch. - Enables evolvable telescopes so that science can be conducted early in the assembly and apertures can grow.	- Must ensure that traveling robotic arms do not damage the observatory nor impact performance.