Space Domain Awareness for Manned GEO Servicing

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TTO Strategic Focus

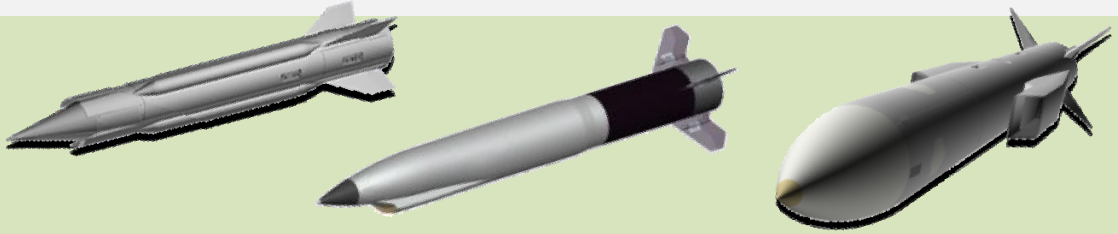
Reach, regain and retain
the tactical advantage of distance
through awareness, access, adaptability and affect

Thrust Areas

Transforming the future of warfighting by pursuing high-risk, high-payoff tactical technology and development of rapid, mobile and responsive combat capability for advanced weapons, platforms and space systems

Advanced Weapon Systems

- Weapons Delivery
- Precision Effects
- Kinetic / Non-Kinetic Effects

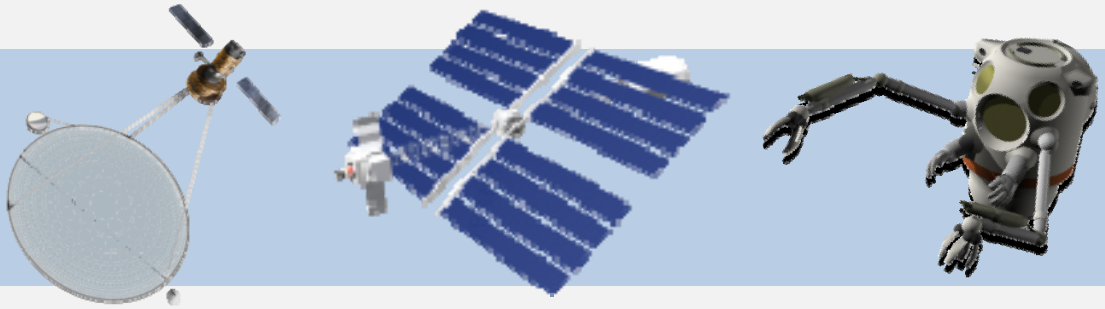


Advanced Platforms

- Unmanned Systems
- X-Planes
- Manned Platforms

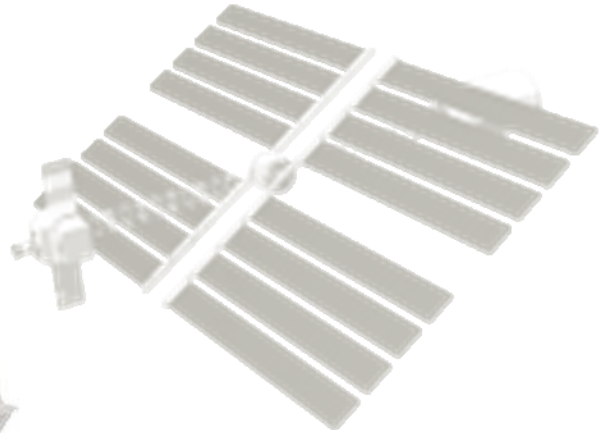
Advanced Space Systems

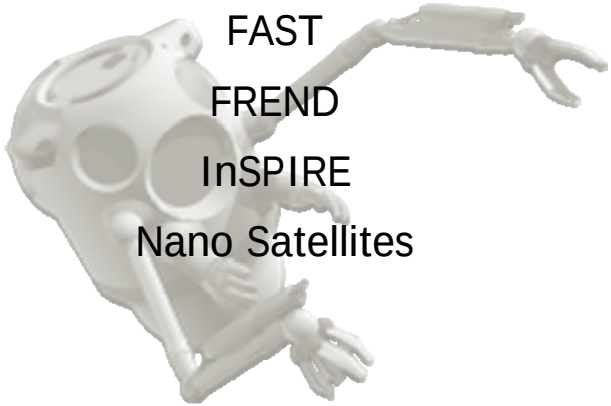
- Stability
- Assured Access
- Resilience



TTO Space Portfolio

Stability Detect, warn, characterize Debris mitigation	**Assured Access** Reliable affordable access robust, competitive domestic industries	**Resilience** Human, robotic initiatives Support against disruption, degradation and destruction
SST	Horizontal Launch	Manned Geo Servicing
SSA Data Fusion	Power Beam Launch	System F6
MAGI		FAST
Rapidly Catalog Space Debris		FREND
Ground–based Geo Imaging		InSPIRE
Novel SSA Sensors		Nano Satellites
Dynamic Sensor Tasking		
Non-Imaging Analysis		
Ultra-WFOV Optics		
MOIRE		
X-TIM		
Catcher's Mitt		
Persistent Comm. for LEO		





Indicates a joint NASA effort

NASA Jump-Starts Space Technology Program

By Debra Werner
Space News Staff Writer
posted: 27 August 2010
10:50 am ET

MOUNTAIN VIEW, Calif. — Senior NASA officials are so eager to jump-start advanced technology efforts that they sought and won congressional approval to devote $36.5 million in 2010 funding to eight high-priority research projects.

Those projects, which include joint efforts with the U.S. Defense Advanced Research Projects Agency (DARPA) to investigate horizontal launch capabilities, in-orbit satellite servicing and power-beam propulsion, are set to begin immediately, said Robert Braun, NASA chief technologist.

The majority of the space agency's new technology initiatives are set to begin in 2011 with the creation of the Space Technology Program. The administration of U.S. President Barack Obama included a request for $572 million to establish the Space Technology Program in NASA's 2011 budget. The program combines many of the space agency's existing research and technology initiatives, such as the Innovative Partnerships Program, with a set of new programs designed to shepherd advanced technology from initial concept studies to flight testing, Braun said Aug. 10 during a visit to the NASA Ames Research Center here.

Work to be conducted in 2010 includes systems analysis, technology assessment and ground-based testing, Braun said. Continuation of these activities in 2011 will depend on the results of the work completed in 2010 and congressional deliberations, he added.

Congressional deliberations also will determine the overall funding level for the Space Technology Program. While the House appropriations subcommittee supported the president's plan to provide $572 million for the Space Technology Program, the Senate appropriators approved only $[illegible] for the program.

That lower budget level would make it difficult to launch many of the new initiatives designed to bolster space research and technology, Braun said, because funding for several elements of the Space Technology Program that were already in existence will cost approximately $240 million in 2011.

"The thing to realize about the Space Technology Program is that it's not an entirely new program," Braun said. "It includes the Innovative Partnership Programs that were in existence this year and in previous years, Small Business Innovative Research, Small Business Technology Transfer, Commercial Reusable Suborbital Research [and] Centennial Challenges. All these carry forward in 2011 at a budget approaching $240 million."

In addition, he said, new rules that require the space agency to fully account for the cost of its work force will add roughly $60 million to the existing program. "So there's $300 million of content associated with the old programs and the NASA work force in 2011," Braun said. "Unfortunately, if the Space Technology Program is funded at a lower dollar value, a lot of the new program content won't be included. And it is the new programs that folks in industry, academia and the NASA center are very excited about."

The Space Technology Program proposed includes three components: Early Stage Innovation, Game Changing Technology and Cross Cutting Capability Demonstration. The initiative is designed to ensure that sophisticated technology makes its way from the drawing board to NASA missions.

"Frankly, in my history with NASA, this continuous set of technology programs has been missing," Braun said. "There have been past programs focused on innovative ideas. And there have been programs where NASA tried to flight-qualify space system technologies. But I can't remember a time when NASA had a continuous set of technology development programs that would allow us, over time, to take an idea all the way from concept to flight."

As NASA pursues those technology initiatives, the agency is likely to work more closely than ever before with DARPA, Braun said.

Braun and David Neyland, director of DARPA's Tactical Technology Office, identified three areas where "collaborative technology development between NASA and DARPA would have mutual payoffs," according to DARPA spokesman Eric Mazzacone.

Those three research topics include studies of horizontal launch capabilities, servicing of satellites in geosynchronous orbit and power-beam propulsion. "DARPA believes the three studies in which it is engaging with NASA are the first of many to come," Mazzacone wrote in an Aug. 18 e-mail.

For the satellite servicing study, the two agencies will explore ways people could work jointly with robots to maintain and repair satellites, Braun said. The U.S. Department of Defense has "tens of satellites in near-geosynchronous orbit that are approaching the end of their lifecycles," according to Mazzacone. "Identifying a successful approach to extend those lifecycles would save billions of dollars."

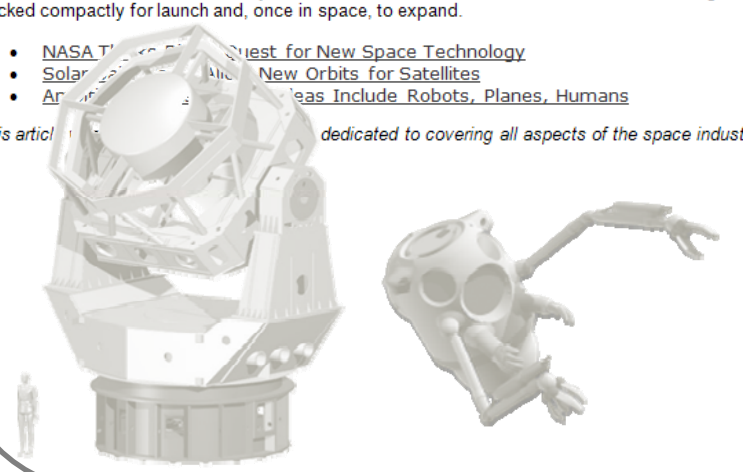
For NASA, this type of research has important implications for exploration missions. "Geosynchronous orbit is interesting for NASA because it's above the Van Allen radiation belts," Braun said. "So from a human physiology perspective, it's a lot like the Moon."

In addition, Braun said, the amount of change in velocity needed to get from low Earth orbit to [illegible] is approximately the same amount needed to get from low Earth orbit to the Moon. "So if we could build to the [illegible] to geosynchronous orbit would be a good start, and maybe even enough, to do an eventual lunar mission," Braun said.

Apart from NASA's collaboration with DARPA, one new technology initiative set to begin immediately involves studies of inflatable aerodynamic decelerators. These decelerators would be designed to be packed compactly for launch and, once in space, to expand.

- NASA T[illegible]uest for New Space Technology
- Solar [illegible] New Orbits for Satellites
- An[illegible]eas Include Robots, Planes, Humans

This articl[illegible] dedicated to covering all aspects of the space industry.



Manned Servicing at Geo

http://www.space.com/news/nasa-jumpstarts-space-technology-program-100827.html

MANNED SERVICING OF GEOSTATIONARY SATELLITES

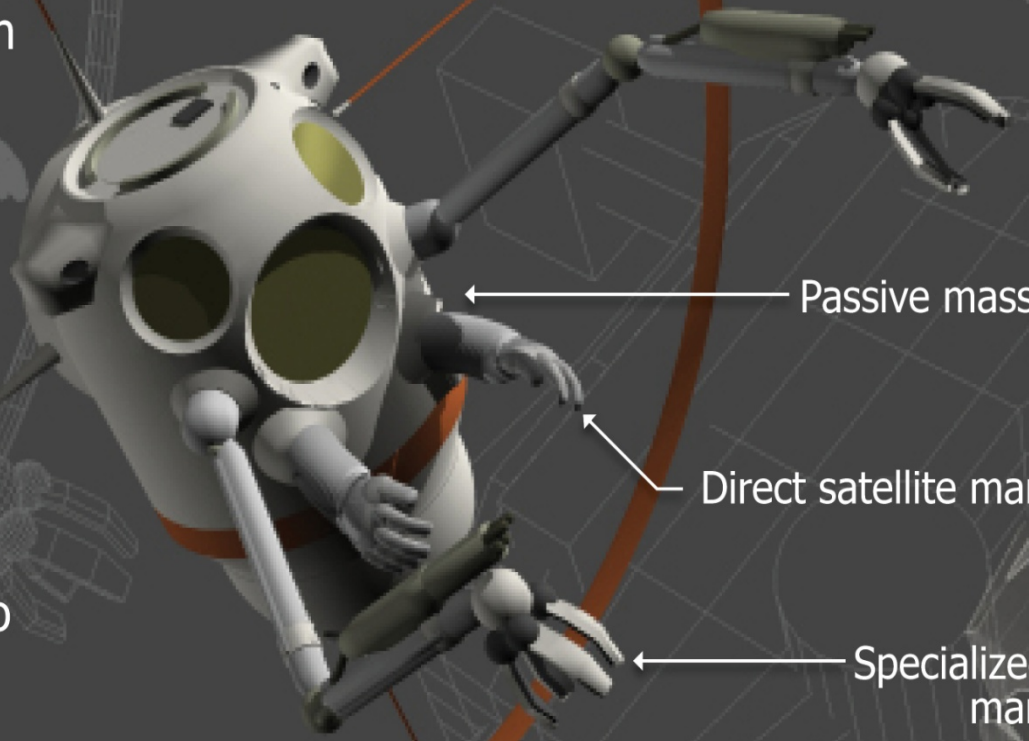
Rendezvous, Refuel, Refurbish, Repair, Reposition (R5)

Repair / extend service life of high value satellites

Upgrade / modify missions
Create new capabilities / networks

Provide credible evolution to autonomous servicing

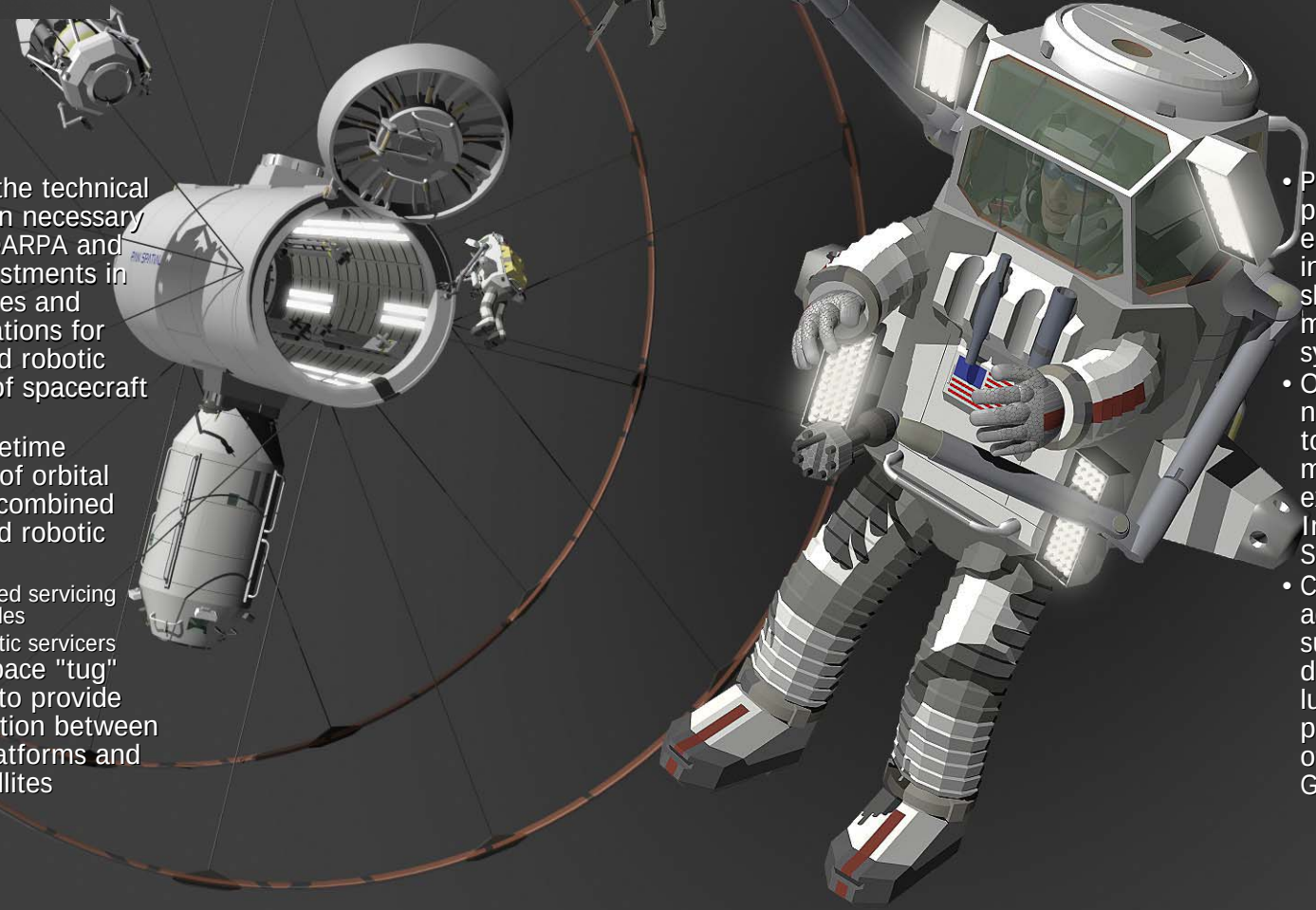
Defer / avoid new satellite launch costs



Enabling Technologies

- Passive mass shielding
- Direct satellite manipulation
- Specialized satellite manipulation
- Active magnetic shielding system

MANNED SERVICING AT GEO



DESCRIPTION

- Generate the technical information necessary to guide DARPA and NASA investments in technologies and demonstrations for human and robotic servicing of spacecraft in GEO
- Enables lifetime extension of orbital assets by combined human and robotic workforce
  - Crewed servicing vehicles
  - Robotic servicers
- Enables space "tug" capability to provide transportation between staging platforms and client satellites

DEFENSE UTILITY

- Provides crew protection from space environment, including passive mass shielding and active magnetic shielding system
- Offers technology for new staging platforms to support servicing or modifications to existing platforms; ex: International Space Station
- Compliments advanced concepts such as earth to GEO direct insertion, a lunar staging platform, or assembly of large structures in GEO

- 6 month study with NASA
  - To investigate the feasibility, risks and technologies that would have to be matured and demonstrated for human and robotic servicing of spacecraft in geostationary earth orbit (GEO)
  - Met with NASA CTO Bobby Braun, NASA Administrator Charles Bolden, and NASA ARC Director Pete Worden

- FY 2010 Plans:
  - Developed study plan and survey existing relevant work - JUN 2010
  - Select conceptual missions to be developed into point of departure mission studies in next phase of study - SEPT 2010

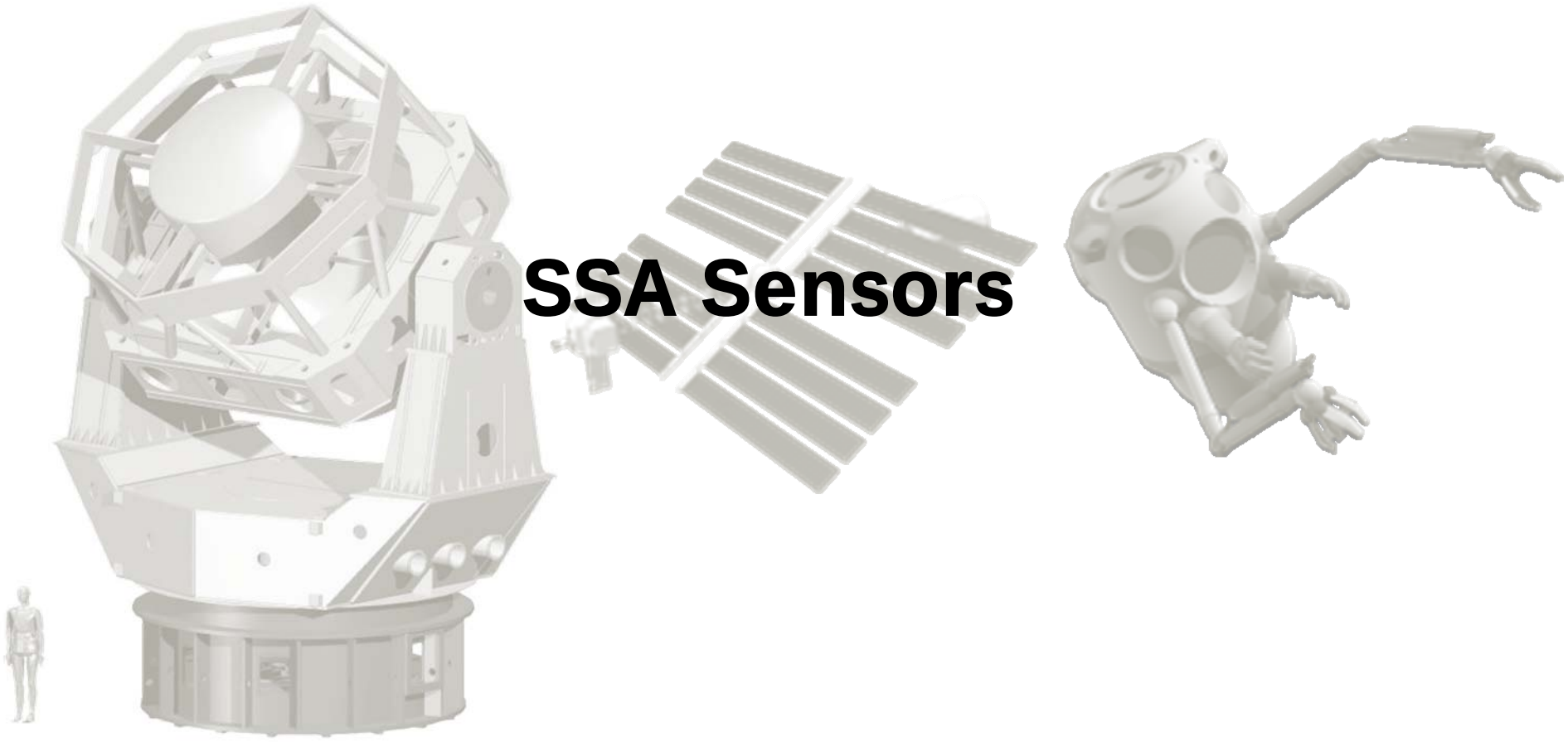
- FY 2011 Plans:
  - Organize and stand up integrated human mission design la for phase III work with multiple NASA Center participation - OCT 2010
  - Create preliminary development plans for each mission, identifying dependencies of other development activities - NO 2010

SDA FOR GEO SERVICING

Robust space domain awareness needed for mission planning

- Precise track of uncontrolled objects
- Object orientation
- Complete knowledge of debris
- Images of object
- Determination of type of repair
- Continuous monitoring during repair

Requires an extensive sensor suite powered by data analysis



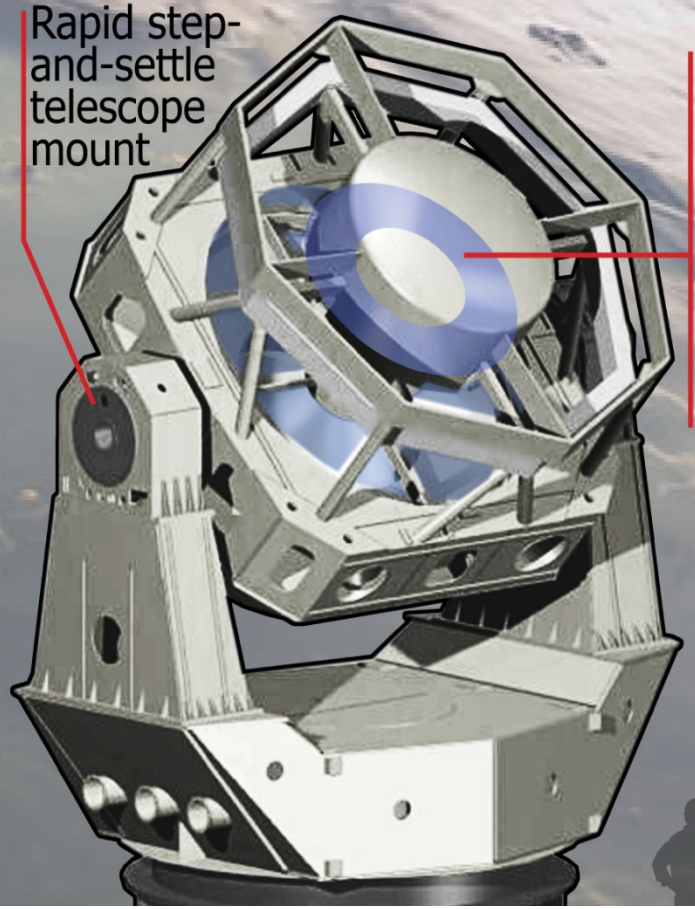
SSA Sensors

DARPA

SST SPACE SURVEILLENCE TELESCOPE

SST will provide over an order of magnitude improvement in search rate and sensitivity, compared to existing Ground-based Electro-Optical Deep Space Surveillance GOEDSS

Autonomous, rapid uncued search, detection, and tracking of dim objects (>18 Mv) in deep space




Telescope Mount Gimbal (TMG)


Enclosure at White Sands Missile Range

Background earth image ISS020EO47807 courtesy NASA-JSC Gateway to Astronaut Photography of Earth; http://earth.jsc.nasa.gov/sseop

Intensity Correlation Imagery for Imaging of Geostationary Objects (ICI)

Description

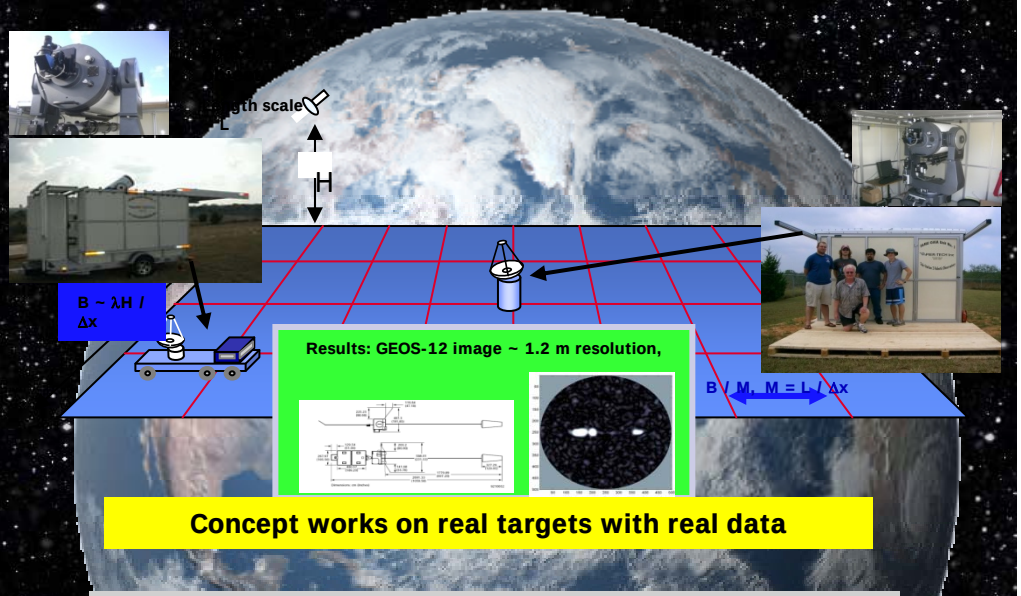
- Use low-quality (non-imaging) apertures to collect intensity measurements at various baselines
- Correlate simultaneous intensity fluctuations between two or more apertures
- Use phase retrieval algorithms along with a priori information (i.e. black background) to extract phase information from the mutual coherence function and recreate an image in post processing

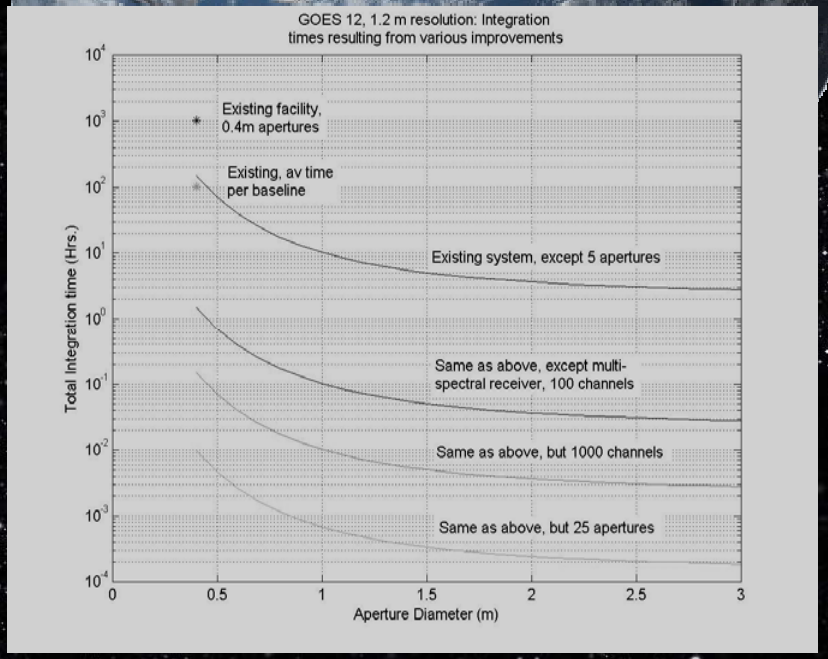
Defense Utility

- High resolution imaging of resident space objects (RSO) in GEO to:
- Characterize RSO attributes and capabilities
- Identify operational attributes and nominal behaviors
- Identify and analyze changes in physical attributes, operational behavior or perceived control
- Establish and maintain object identity, ownership and control

Program Status

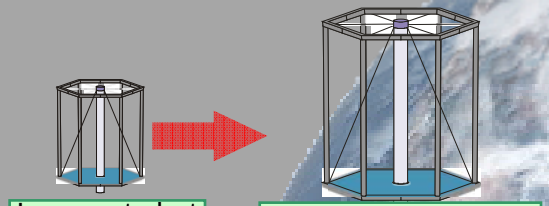
- Study; 9 month effort which ends in FY2011
- FY 2010 Plans:
- Initial investigation into ranging requirements for inverse polarimetric synthetic aperture LADAR
- Object radiometry
- Multi-spectral ICI detector
- SNR and detector options
- Long baseline experiments
- FY 2011 Plans:
- Phase retrieval





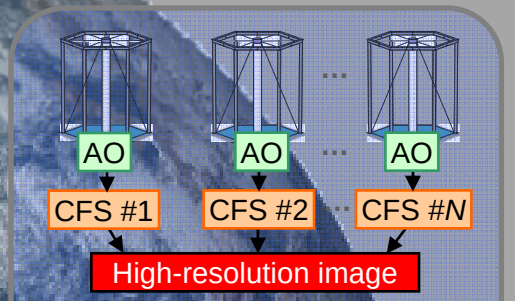
High-Resolution Imaging with Sparse Array of Low-Resolution Adaptive Telescopes for Space Surveillance Applications - SSA

STATUS QUO



Increasing resolution of space objects/ debris imaging for SSA requires building giant and extremely expensive systems.

• Adaptive optics (AO) complexity and cost increase quadratically with size



An array of small (existing) synchronized telescopes with complex field sensors (CFSs) provides data to dramatically enhance resolution for SSA

• Moreover, the optical field can be compensated locally at each telescope using low-order and simple adaptive optics

MAIN ACHIEVEMENT:

High-resolution imaging system providing an image quality superior to that of any of the telescopes in the array with no need to build new systems

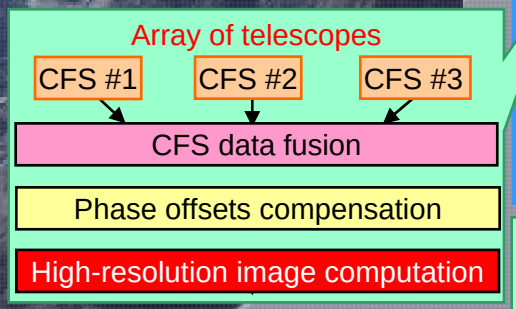
HOW IT WORKS:

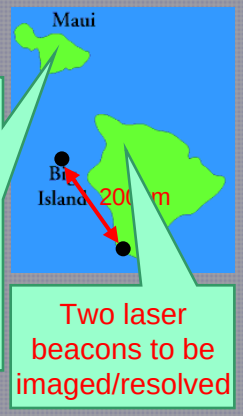
Major operational steps:

1. **Time-synchronized measurements of complex fields from each telescope are sent to a central digital processing unit (CDPU)**
2. **All local measurements are fused into a large-scale digital complex field**
3. **Piston-phase differences (offsets) between telescopes are compensated digitally, a step called *phase-locking* (PL)**
4. **Finally, a high-resolution image is computed digitally from the large-scale complex-field**

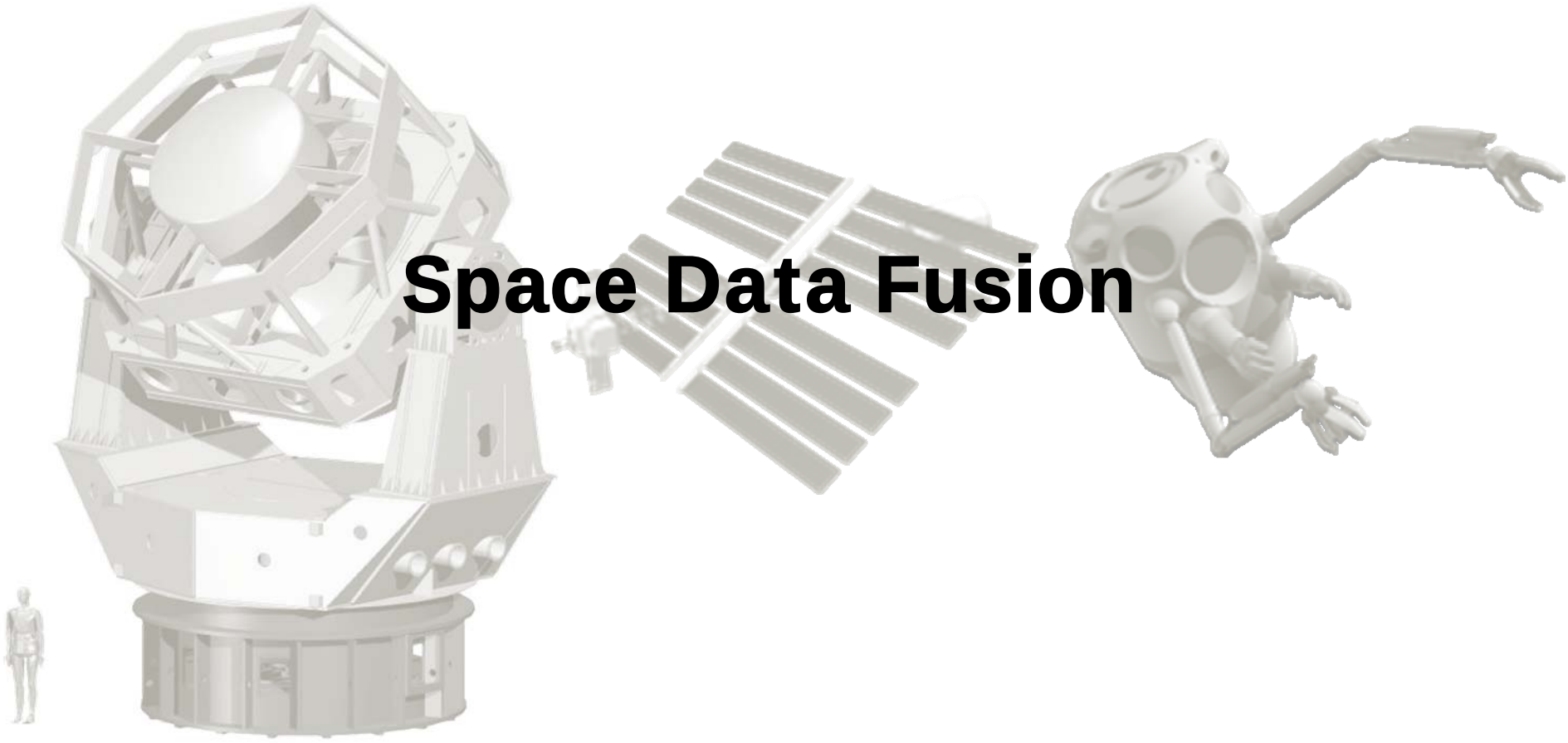
ASSUMPTIONS AND LIMITATIONS:

- **Object of interest should be isoplanatic**





NEW INSIGHTS



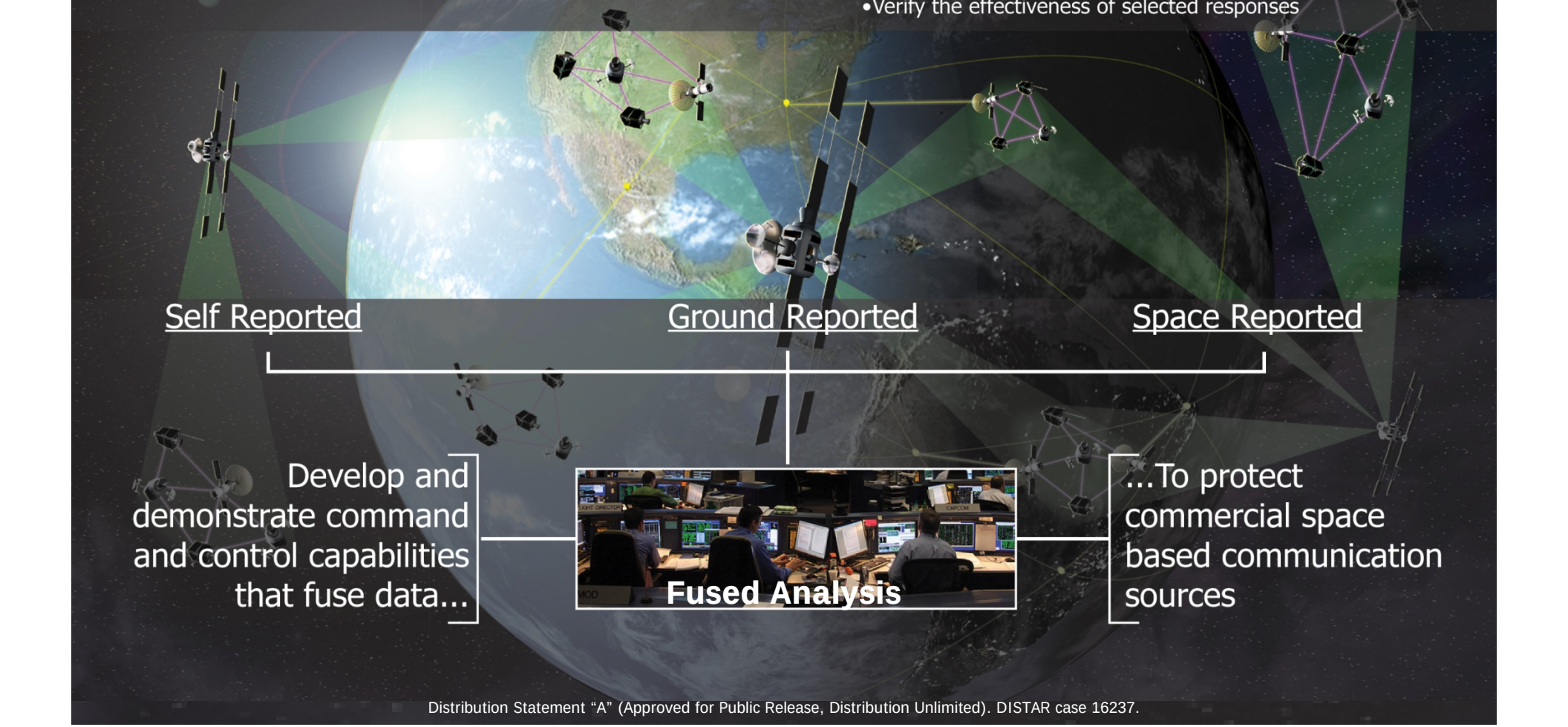
Space Data Fusion

DARPA

SSA SPACE SITUATIONAL AWARENESS DATA FUSION

Correlates data to rapidly:

- Identify anomalies and threat activities
- Propose mitigating countermeasures
- Verify the effectiveness of selected responses



Self Reported

Ground Reported

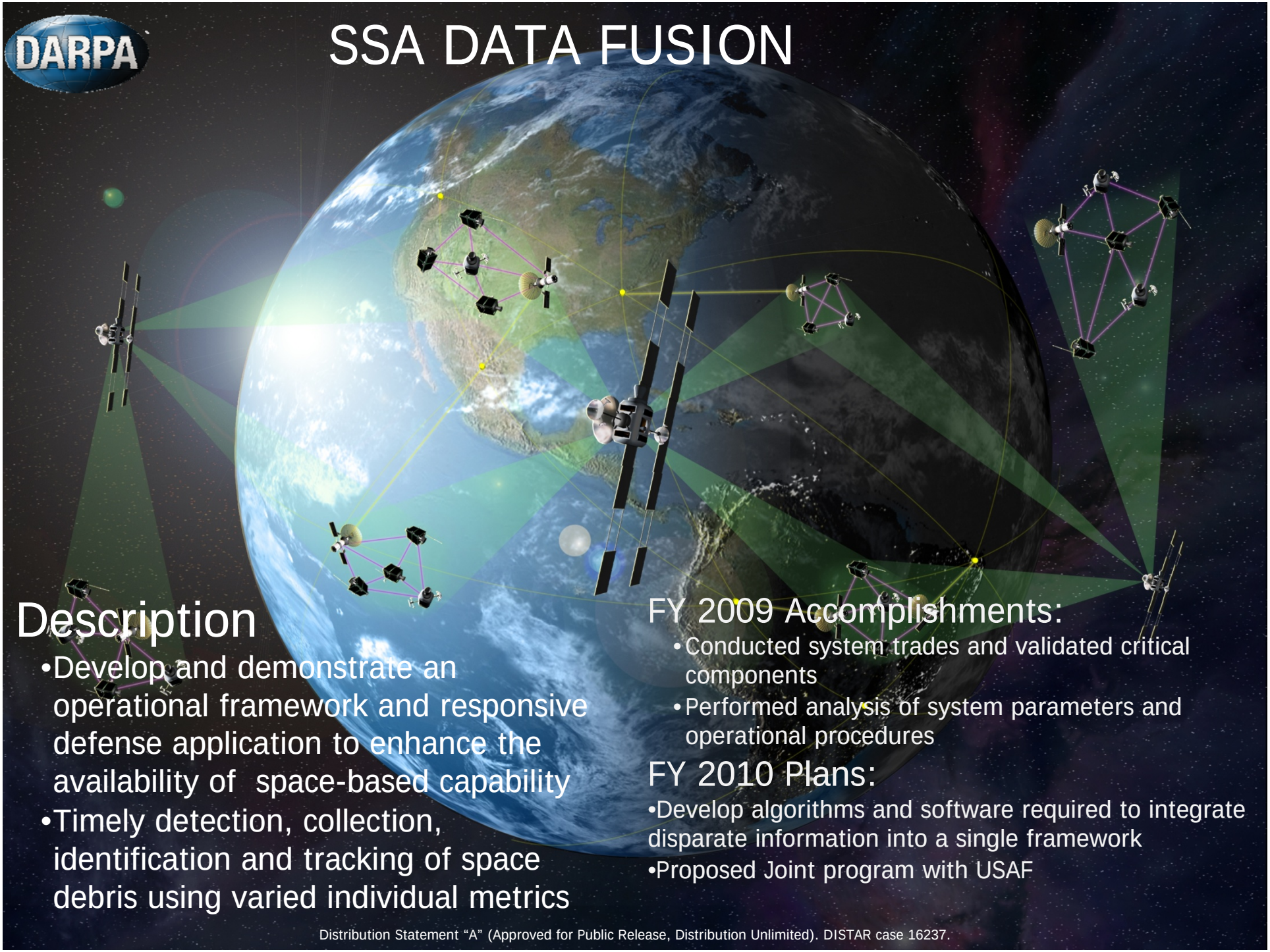
Space Reported

Develop and demonstrate command and control capabilities that fuse data...

Fused Analysis

...To protect commercial space based communication sources

SSA DATA FUSION



Description

- Develop and demonstrate an operational framework and responsive defense application to enhance the availability of space-based capability
- Timely detection, collection, identification and tracking of space debris using varied individual metrics

FY 2009 Accomplishments:

- Conducted system trades and validated critical components
- Performed analysis of system parameters and operational procedures

FY 2010 Plans:

- Develop algorithms and software required to integrate disparate information into a single framework
- Proposed Joint program with USAF

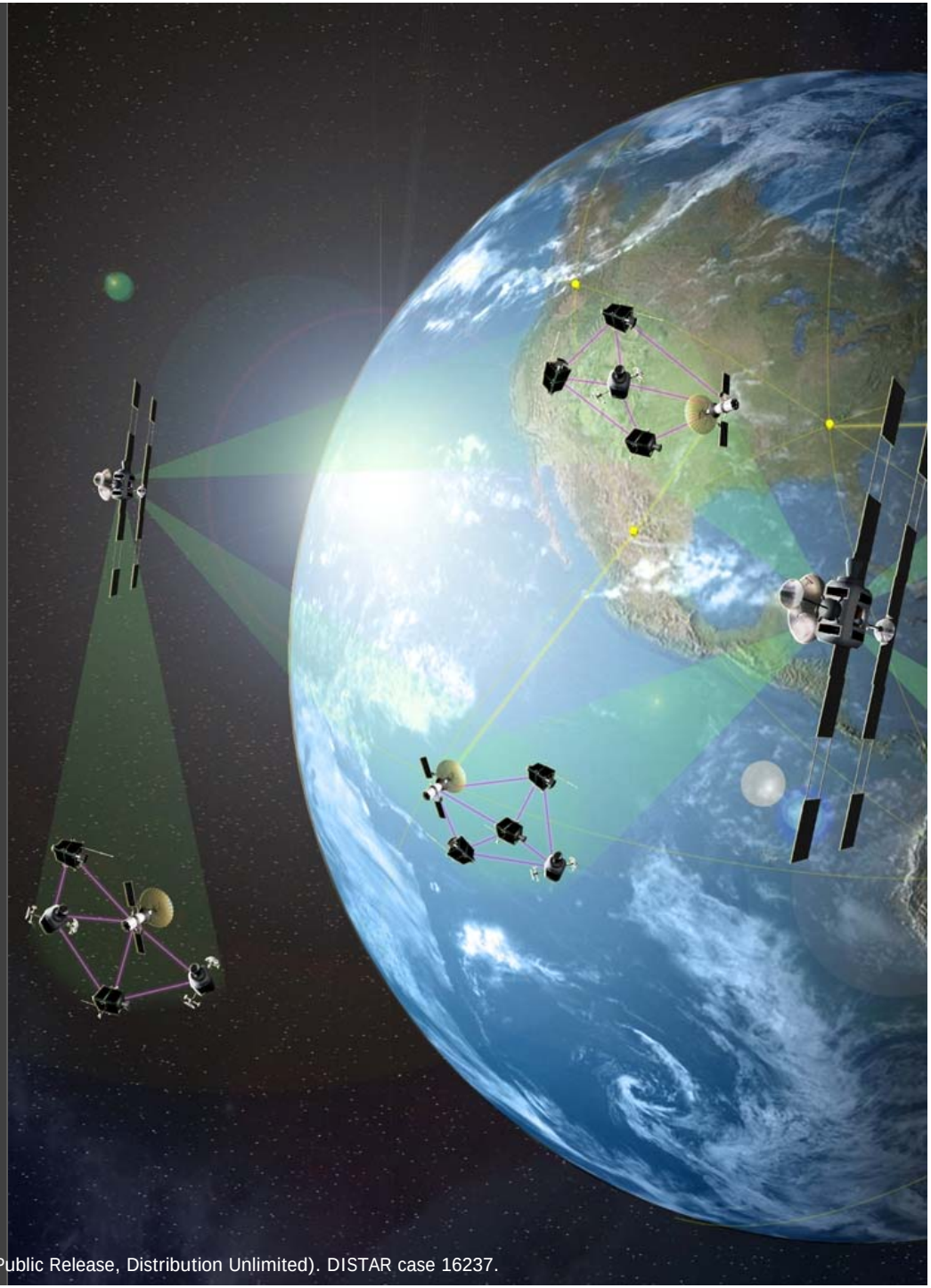
FUTURE DIRECTION

Complete SST Demonstration

Begin Ground-based GEO imaging program

Develop data fusion tools:

- Rapid track and catalogue of break-ups
- Dynamic sensor tasking/data analysis
- Non-imaging characterization



www.darpa.mil