Servicing of GEO Spacecraft for Commercial and Military Customers

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COMSTAC Business/Legal Working Group

September 16, 2014

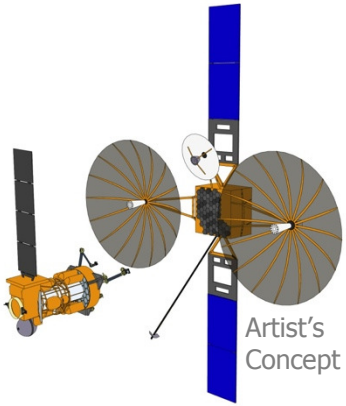
Our program vision

"Communications satellites in geosynchronous orbit, approximately 36,000 kilometers above the Earth, provide vital communication capabilities to Warfighters and others. Today, when a satellite fails, we usually face the expensive prospect of having to launch a brand new replacement. Our program strives to develop and demonstrate technology to robotically service, maintain, and construct satellites in the harsh environment of geosynchronous orbit."

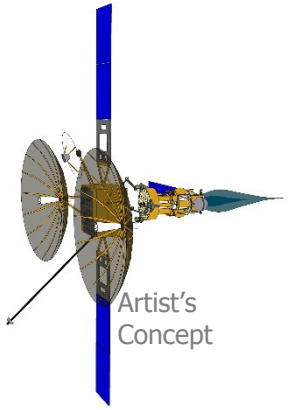
– DARPA Director Arati Prabhakar, March 2014

The DARPA GEO robotic servicing program seeks to revolutionize space reliability, capability and operations

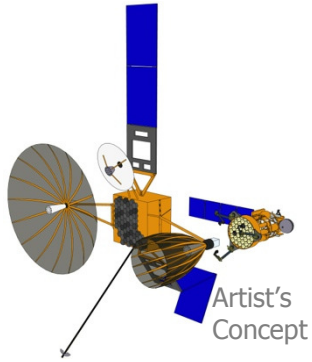
Mission ensemble for a DARPA GEO robotic multi-mission vehicle



- Provide unparalleled **high-resolution images on request** of spacecraft experiencing anomalies
- Inspections would be enabled by a RMMV with a sensor suite and dexterous arms with cameras
  - Stand-off inspections (50m-1km)
  - Close inspections (5m-50m)
  - Docked inspections



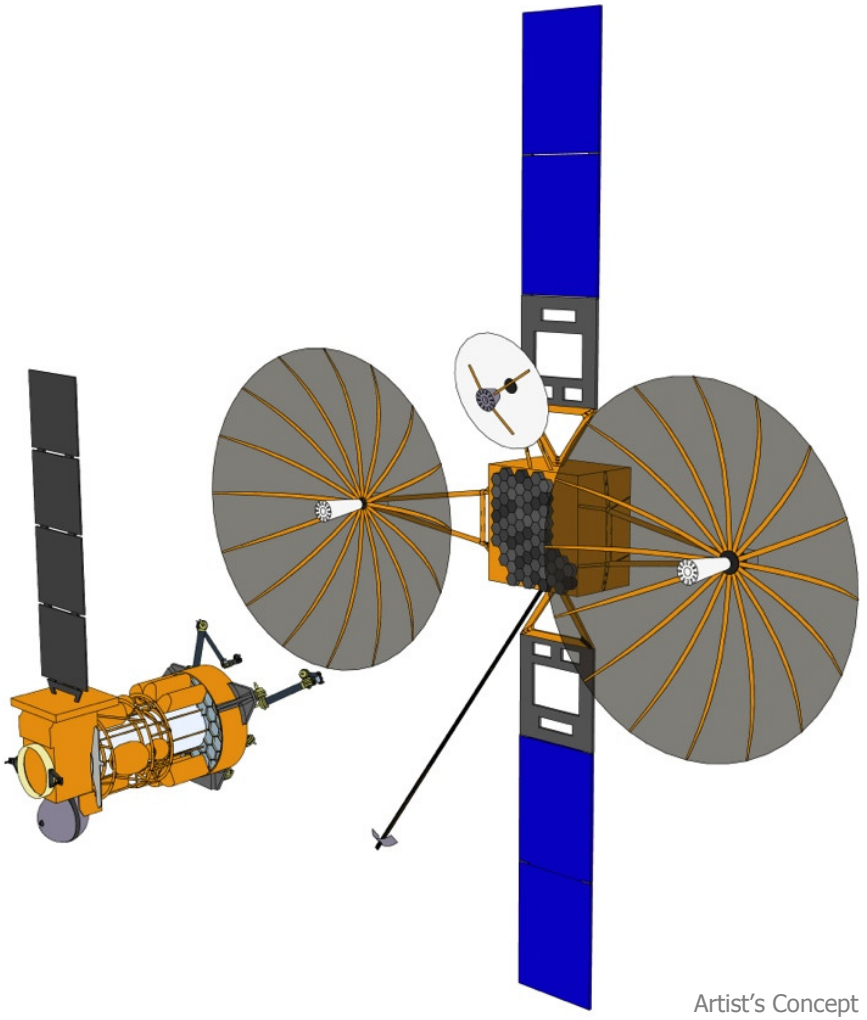
- **Cooperatively move spacecraft in orbit**, recover spacecraft in off-nominal orbits and extend lifetimes through propellant conservation
  - N/S station keeping recovery
  - End-of-Life to GEO graveyard
  - Repositioning within the GEO belt



- **Assist spacecraft experiencing anomalies**, helping to ensure that missions can be completed at maximum performance
  - Free stuck appendages
  - Supplement attitude control
  - Perform docked inspections

Goal: High-resolution cooperative inspection

- Requirement: unparalleled high-resolution multi-sensor images of spacecraft experiencing anomalies
- Multi-DOF arms will permit imaging of difficult-to-see sites
- Potential benefits:
  - Identify and possibly resolve failures
  - Enable forensics and failure root cause determination
  - Attribute failures to natural environment, engineering or other causes



Artist's Concept

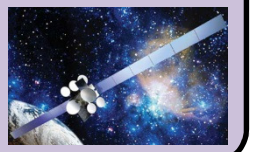
GEO inspection as a commercial resource

- More than 300 spacecraft in GEO provide TV, mobile telephony, data transfer—a $110B market
- Among the causes limiting satellite performance:
  - Solar panel deployment anomaly (complete or partial)
  - Antenna deployment anomaly (complete or partial)
  - Propulsion anomalies
- Insurance claims cover portion of satellite costs but not lost revenue
- Inspection could be the *first step in making decisions* about attempts to correct anomalies
- Could enable future designs to be less exquisite/redundant

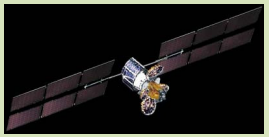
Commercial satellite anomalies 2010-2011

Feb. '10 - IS-4: satellite control processor (SCP) failure. Deemed "unrecoverable".[1]

Q3 2011: DirecTV 10 experiences propulsion system problem.



May 2010: Russian Satellite Communications Co.'s Express-AM1 satellite loses attitude control.



May '11 – Telstar 14R: North solar array fails to deploy.

April 2010

Feb 2010

Feb 2011

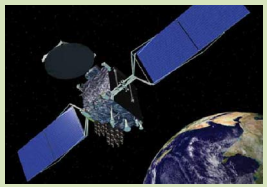
June 2011

Dec 2011

Mar. '10 - AMC-16: partial power loss due to a solar array anomaly. Result is "reduced capacity".

May '11 – Intelsat New Dawn: failed C-band antenna deployment.

Apr. '10 - Galaxy-15: loses control, drifting through the GEO belt and posing a significant interference threat.



2011 - AMC-15: partial power loss due to a solar array anomaly.

Jul. '10 - Insat-4B: loses half its broadcast capability due to a solar array failure.

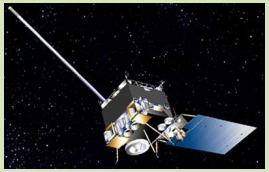
Images from Gunter's Space Page

Commercial satellite anomalies 2012-2013

Jan. '16 – AMC 16: further solar array circuit failure.

Sep. '12, Nov. '12, Jul. '13 – Echostar XII: Further solar array anomalies.

Sep. '12 – GOES 13: increased sensor noise; put into standby mode.

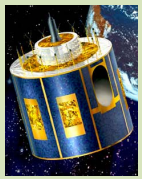


Dec. '12 – Yamal 402: 3rd stage failure; onboard propellant used for final maneuvering

Jan 2012

Jan 2013

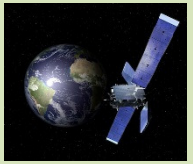
May '12 – Meteosat 8: Sun sensor issues.



Jun. '12 – IS-19: South solar array failed to deploy.

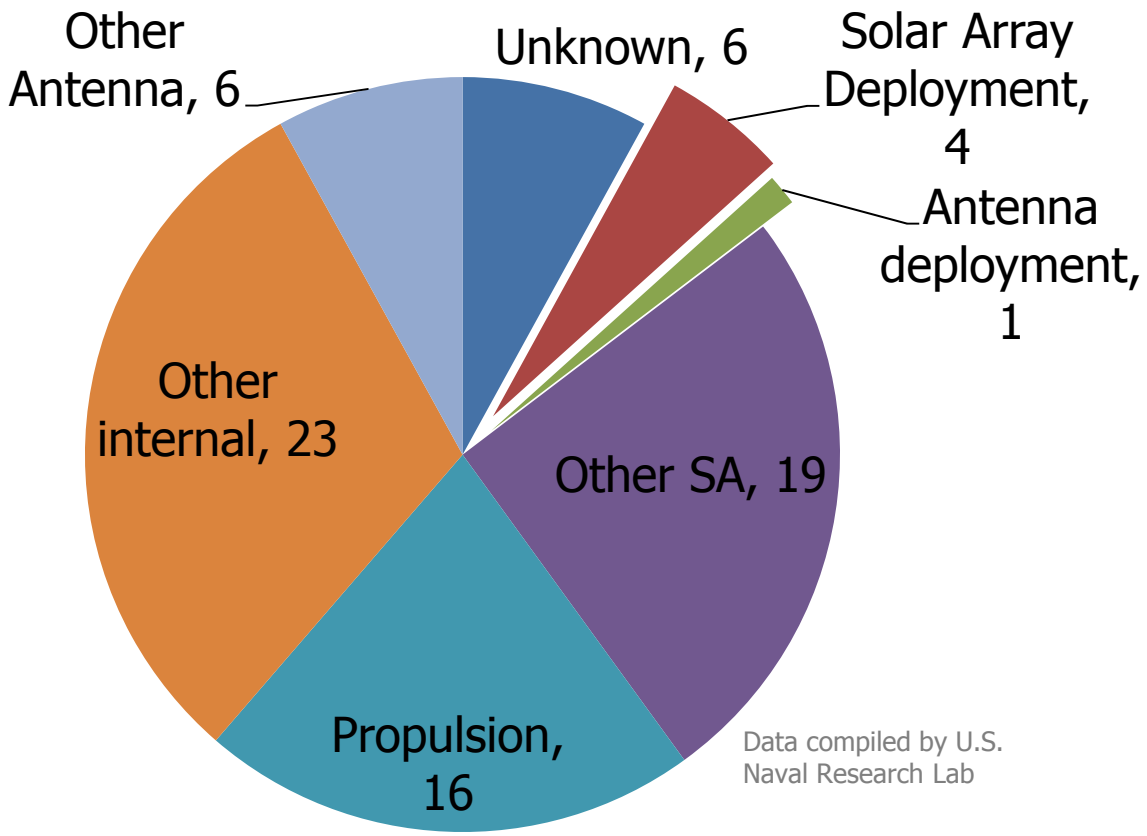
Q2 '12 – Echostar VI: Reduced solar array power

Apr. '14 – Amazonas 4A: Unspecified power subsystem anomaly.



Images from Gunter's Space Page

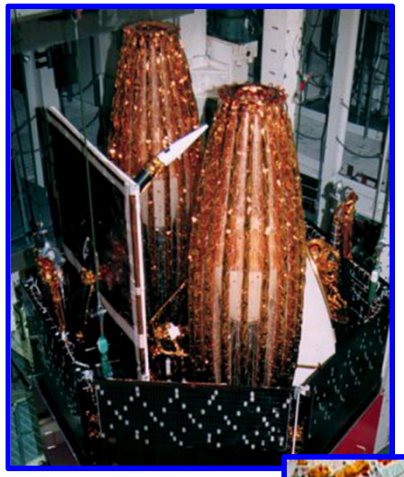
Breakdown of anomalies by type: 10-year sample

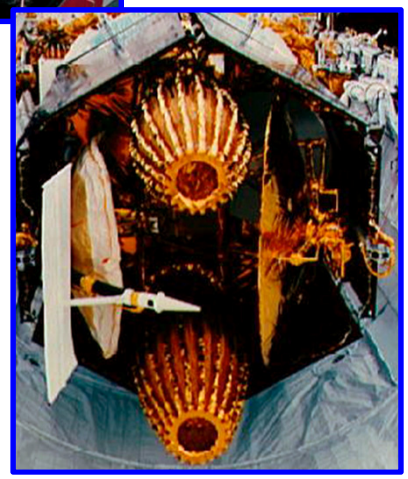


Some of these will be addressable using the GEO servicer capabilities

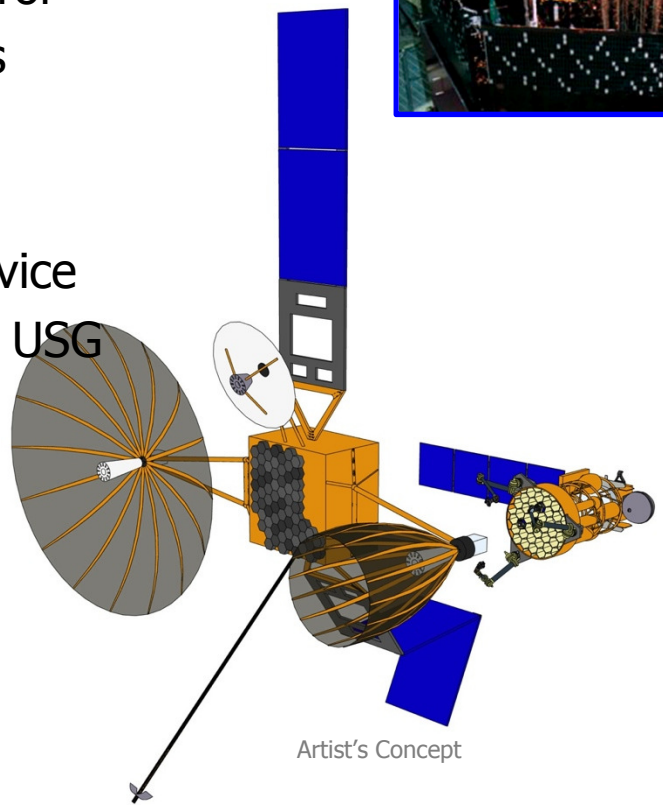
Goal: Anomaly resolution

- A GEO robotic multi-mission vehicle would assist spacecraft experiencing anomalies, helping ensure mission completion
  - Free stuck appendages
  - Supplemental attitude control
  - Perform docked inspections
- Potential benefits:
  - Increased fleet resilience
  - Episodic but high-value service
  - Of particular importance to USG self-insured spacecraft



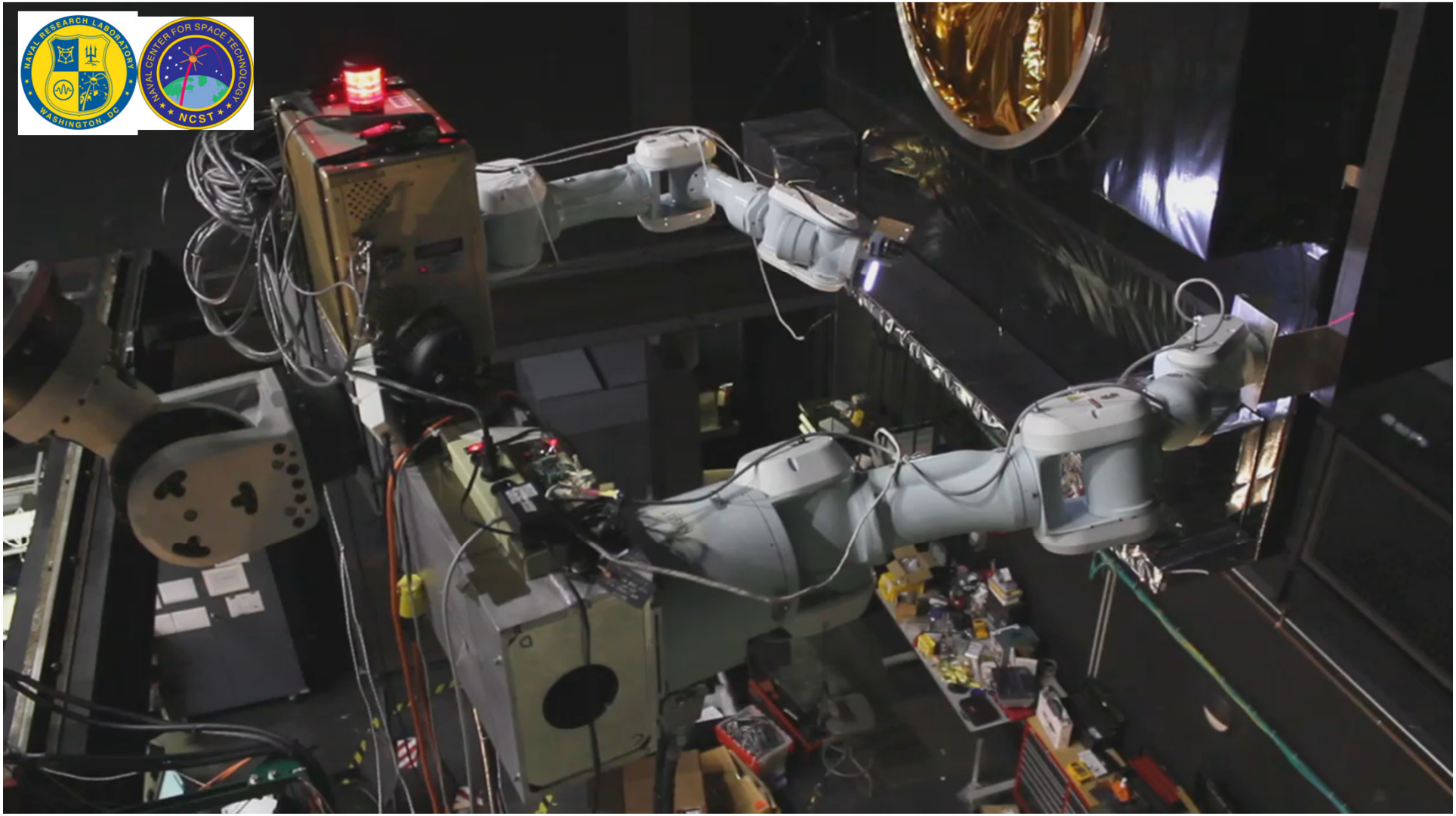


NASA Images



Artist's Concept

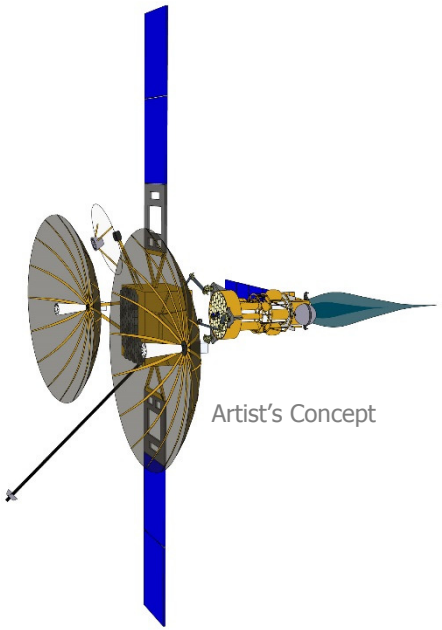
Early lab test: Freeing a solar panel



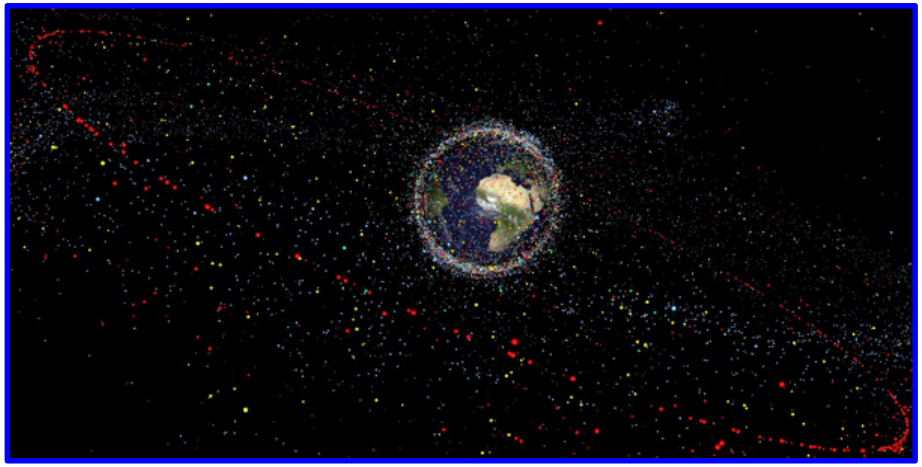
U.S. Naval Research Lab

Goal: Orbit modification assistance

- A GEO robotic multi-mission vehicle would provide assistance to move spacecraft in orbit, recover spacecraft in off-nominal orbits and manage space traffic
  - N/S station keeping recovery
  - End-of-Life to GEO graveyard
  - Repositioning within the GEO belt—manage slots
  - Propulsion anomalies
- Potential benefits:
  - Economic benefits of deferred disposal and correction of propulsion anomalies
  - Can assist with recovery from avoidance maneuvers
  - Future capability: repositioning of navigation hazards



Artist's Concept



www.spaceflightnow.com

Summary

- The DARPA robotic GEO servicer program seeks to provide new capabilities for robustness and productivity of GEO satellite fleets
- GEO servicing operations have both potential commercial and national value
- We are exploring innovative ways to implement the capability in partnership with industry

www.darpa.mil