Servicing of GEO Spacecraft for Commercial and Military Customers

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“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
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
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

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

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

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

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

Q3 2011: DirecTV 10 experiences propulsion system problem.

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

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

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

Images from Gunter's Space Page
Commercial satellite anomalies 2012-2013


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

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

May ‘12 – Meteosat 8: Sun sensor issues.


Q2 ‘12 – Echostar VI: Reduced solar array power

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

Images from Gunter’s Space Page

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Breakdown of anomalies by type: 10-year sample

- Solar Array Deployment, 4
- Antenna deployment, 1
- Other SA, 19
- Other internal, 23
- Propulsion, 16
- Other Antenna, 6
- Unknown, 6

Some of these will be addressable using the GEO servicer capabilities

Data compiled by U.S. Naval Research Lab
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
Early lab test: Freeing a solar panel
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
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
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