

A wireframe globe of the Earth is shown in a light purple color. A bright purple starburst representing a satellite is positioned above the globe, with a beam of light extending from it towards the top of the globe.

Micro-GEOs:
An Emerging Small Satellite Bus Class

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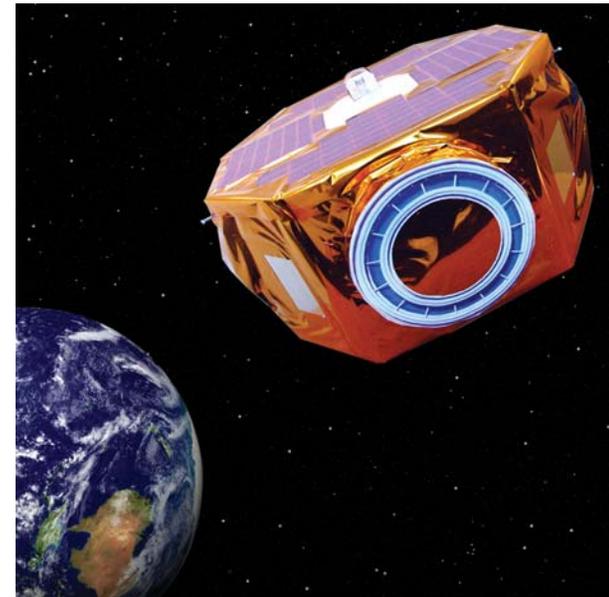
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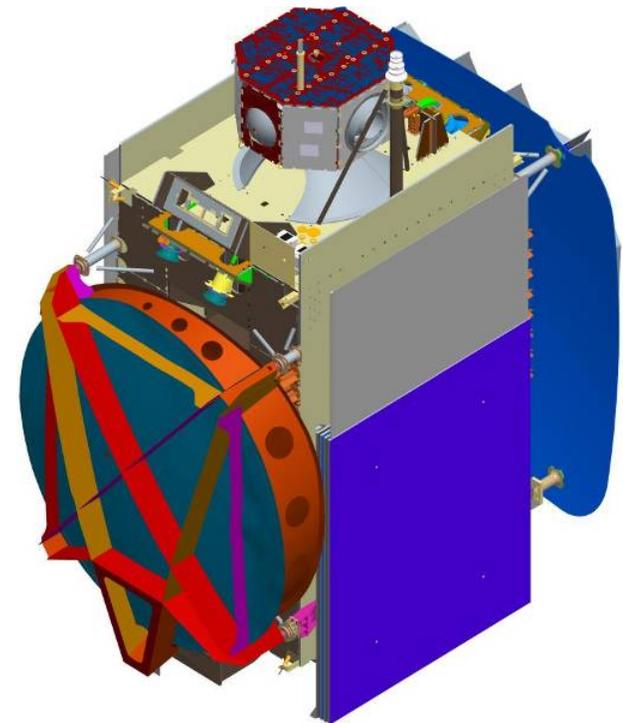
- For the last several decades, microsattellites have been limited primarily to LEO orbits
- Access to space has limited opportunities in higher orbits
- Mission need is strong
 - Opportunities to fulfill that need are growing
- Definitions:
 - “Micro”: Consider spacecraft mass up to 200-300kg
 - “GEO”: Broad array of high-energy orbits from 5 to 9 Earth radii (not strictly bounded)

- Micro-GEOs are appealing for the same reasons Micro-LEOs are appealing
- Science
 - Single instruments missions (e.g., augment/replace instrument on large GEO satellite)
 - Instruments requiring high orbits (e.g. energetic neutral atom imaging)
- Fractionated / cluster / constellation
 - DARPA's F6 concept
 - Large baseline apertures
- Defense
 - Space situational awareness
- Technology demonstration
 - Applies to both civil and national security space

- Geosynchronous transfer orbit (GTO) launches
 - High availability—average of more than one launch per month
 - Ariane has provided secondary opportunities for many years
 - AeroAstro SPORT™ vehicle designed to maneuver from GTO to LEO
 - May also raise orbit from GTO to GEO
- IBEX example
 - NASA SMEX mission (fall 2008 launch)
 - 105 kg wet mass
 - Pegasus launch to 200km circular orbit
 - STAR 27 solid rocket motor raises the apogee to 50 RE (319,000 km or more than 80% of the distance to the moon)
 - On-board propulsion raises perigee
 - 3,000 m/s total delta-V, *double* that required to raise orbit from GTO to GEO



- GEO launches
 - This is the ideal approach, but launches to GEO are uncommon
- GEO rideshare
 - Secondary satellite mounted to GEO spacecraft on nadir deck
 - Secondary satellite separated after injection into GEO but before insertion into GEO slot
 - Benefits to commercial GEO spacecraft owner
 - Modest additional revenue
 - Up-front cash
 - Cost drivers
 - Management and integration cost
 - Marginal launch cost
 - Shortened mission duration due to additional fuel expenditures during orbit raising from GTO to GEO
 - Increased insurance due to added risk
 - Additional information available in “Micro & Nanosatellite Launch Capabilities from the Star Bus GEO Commercial Communications Platform,” an alternate paper in Session IX



- GEO Hosted Payload
 - Orbital and its GEO customers have been evaluating hosting payloads on the GEO platform
 - Also use available space on the nadir deck
 - Advantage
 - Lowest cost option since the GEO spacecraft provides bus functionality
 - Disadvantages
 - Only one orbit option; some ability to select orbital slot
 - High probability of mission compatibility issues
 - Pointing accuracy and stability; availability of fields of view
 - Cleanliness
 - Electrical interfaces, EMI/EMC
 - Data processing resources
 - Increased risk to primary communications mission





- Micro-GEOs bear more resemblance to LEO spacecraft than GEO spacecraft
 - Diversity of missions, payloads
 - Diversity of orbits
- Micro-GEO is a bus class, not a bus design
 - Product lines are likely to emerge
 - Spacecraft will be significantly tailored to mission needs as is common in LEO spacecraft products

- GEO / high energy orbits pose some different design challenges than LEO
- Radiation environment
 - Total dose is much higher than LEO missions
 - Many low-cost LEO components are not designed for this environment
- Power
 - Eclipses are much longer (82 minutes vs. 35 minutes)
 - Sun time is greater (94% vs. 65%)
- Guidance, Navigation, and Control
 - GPS receivers are not available
 - Magnetic field is not viable for attitude control or momentum dumping
 - Propulsion system (or other method of momentum dumping) is required
- Communications
 - Much greater distance drives larger apertures and/or lower data rates

Conclusion



- Progress in access to space for secondary payloads to high-energy orbits heralds a new frontier for small spacecraft
 - GEO ride-shares are an appealing new option
- Micro-GEOs are adaptable to a broad range of missions
- Spacecraft will more closely resemble LEO designs, but some modifications will be necessary