THE AEROSPACE CORPORATION

The SnipSat™ Enterprise: Recycling Solar Panels and Other Components from the GEO Disposal Belt to Enhance Space-Cost Effectiveness

Space Power Workshop

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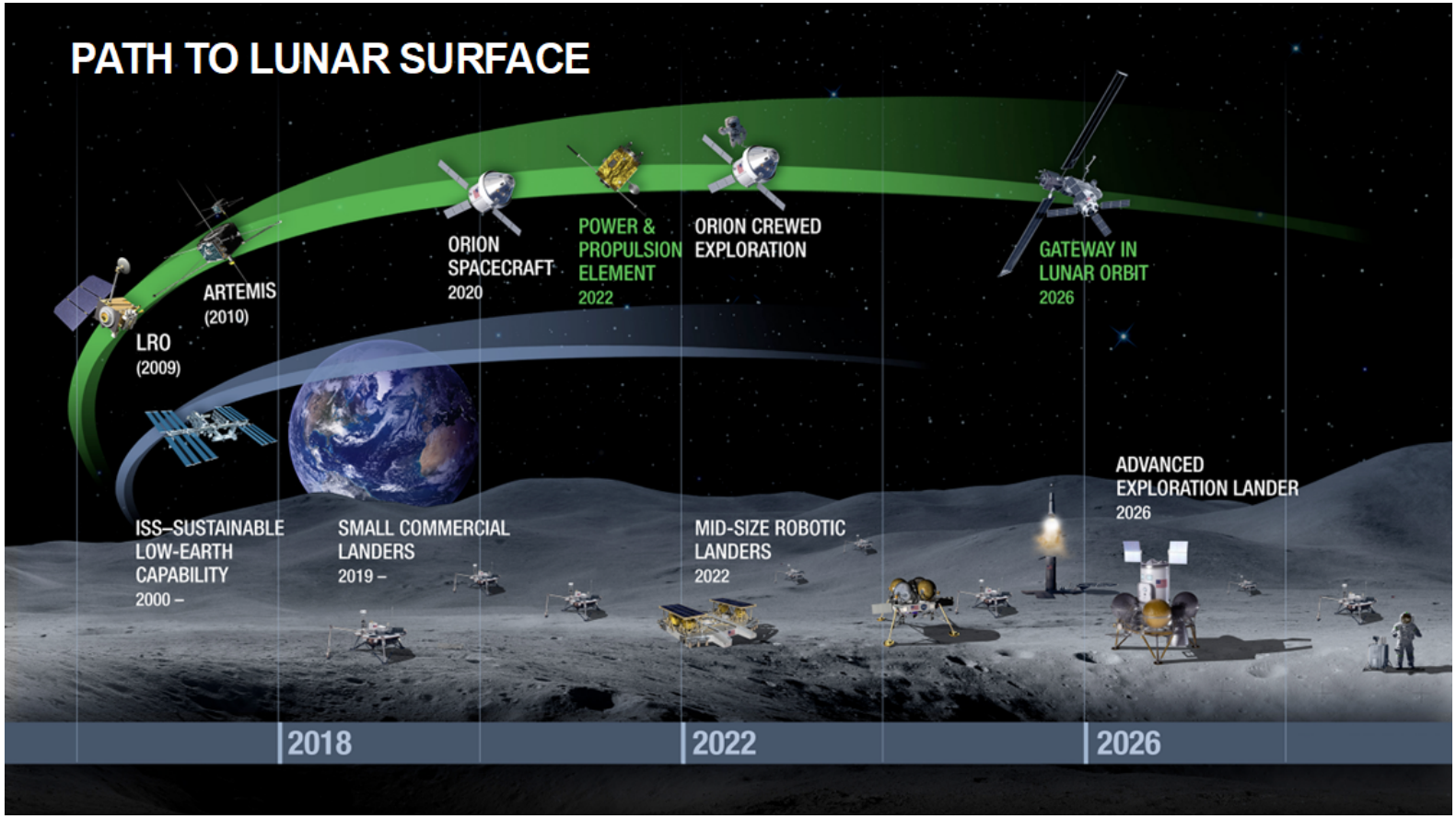
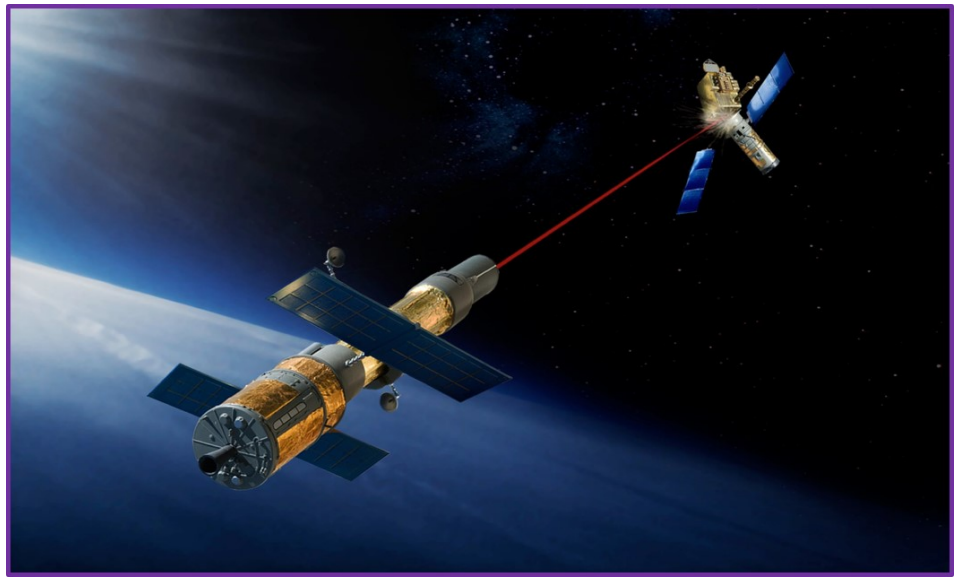
"There's Gold in Them There Orbits"

- Typical cost of launch to GEO orbit ~ $25,000/kg
  - *Gold price is ~40,000/kg*
- Single satellite @ 5,000 kg = $125,000,000 to GEO
  - *Cost to GTO plus boost to GEO*
- 400 satellites in graveyard orbit represent
  - *~$50,000,000,000 of sunk launch costs*
  - *~$100,000,000,000 of sunk total costs*
- The SnipSat Enterprise offers customers opportunity to re-use this investment

Future NASA Lunar Missions Will Require Large Sources of Power



Future National Security Missions Will Require Large Sources of Power

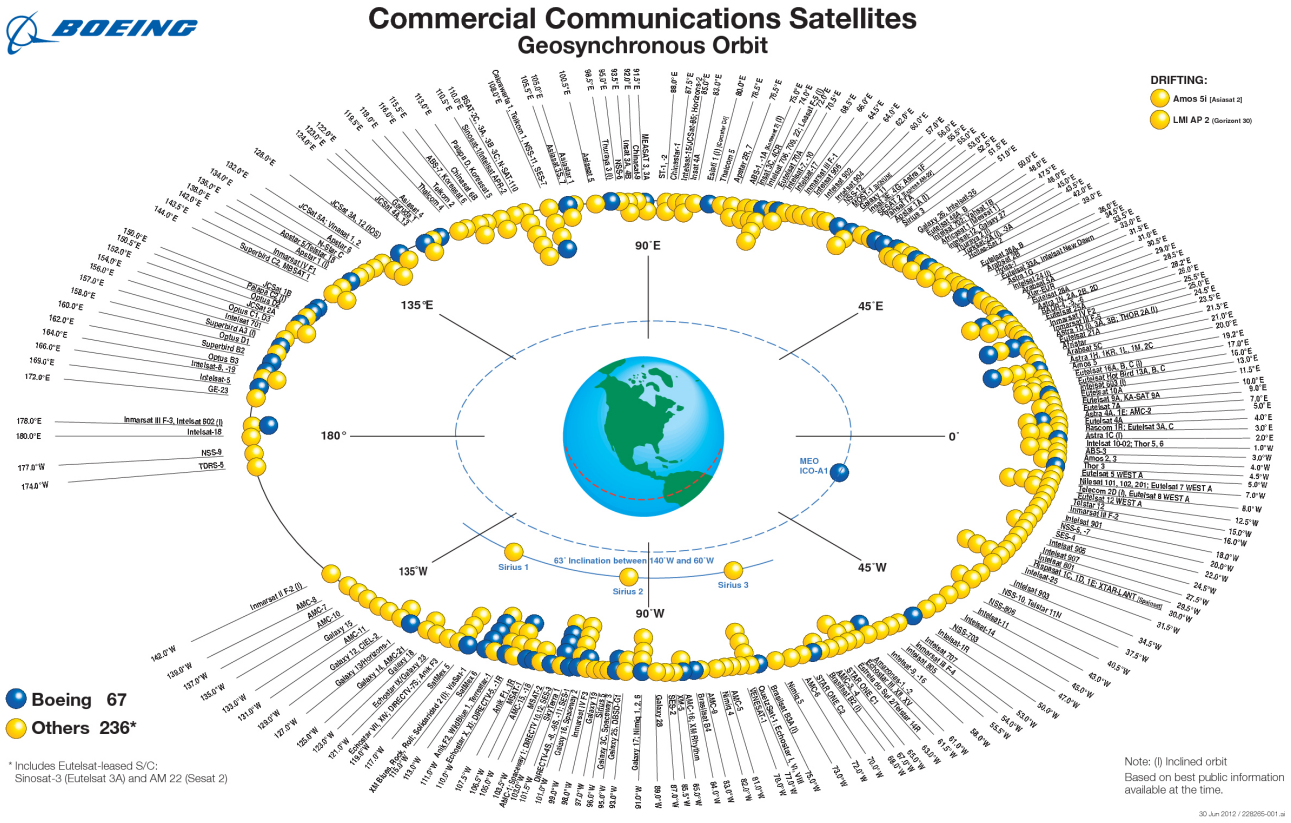


Space as a War-fighting Domain

Lt Gen David "D. T." Thompson, USAF
Col Gregory J. Gagnon, USAF
Maj Christopher W. McLeod, USAF

For the past 70 years, the US Air Force has consistently delivered a war-fighting advantage in support of vital national interests. Our service grew from the vision of early Airmen who recognized the potential of a new war-fighting domain and exploited emerging technology to make it a reality. We developed the capabilities to gain and maintain air superiority, securing the high ground to protect US forces and defeat adversaries. These advantages were not a given; they were bought with the blood, sacrifice, and ingenuity of American Airmen. In 1982, the Air Force established the Air Force Space Command (AFSPC) to operationalize and normalize space operations, recognizing the intersection of a growing reliance and increased vulnerability of the space domain. More recently, the USAF has led a decades-long effort to exploit space by integrating it into joint war fighting.

The Prospective Sources of Reusable Power

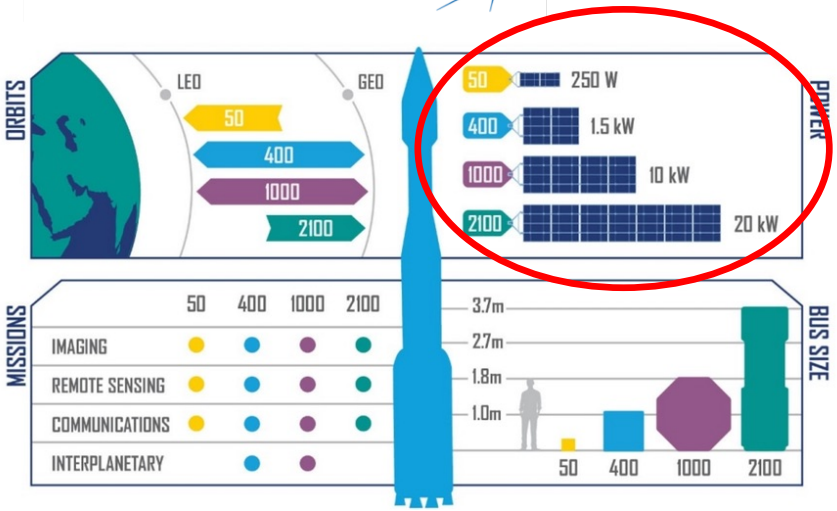


As these satellites retire, they become an source of power for space operations.

Estimate of Available Power in Orbit

Typical GEO satellites start life with >10 kW, end with >7 kW. Upon retirement, the 400+ satellites presently in GEO would offer >2.5 megawatts of harvestable power.

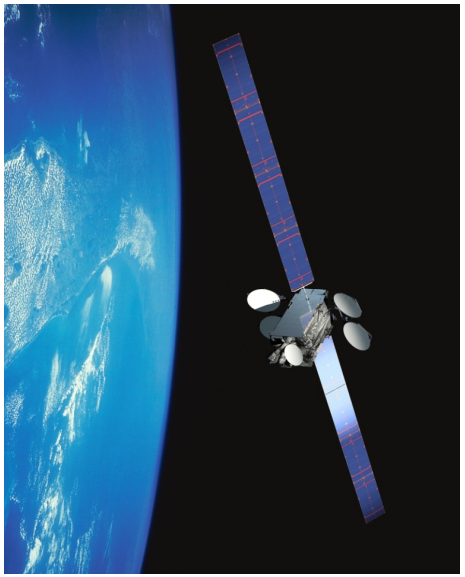
LOCKHEED MARTIN



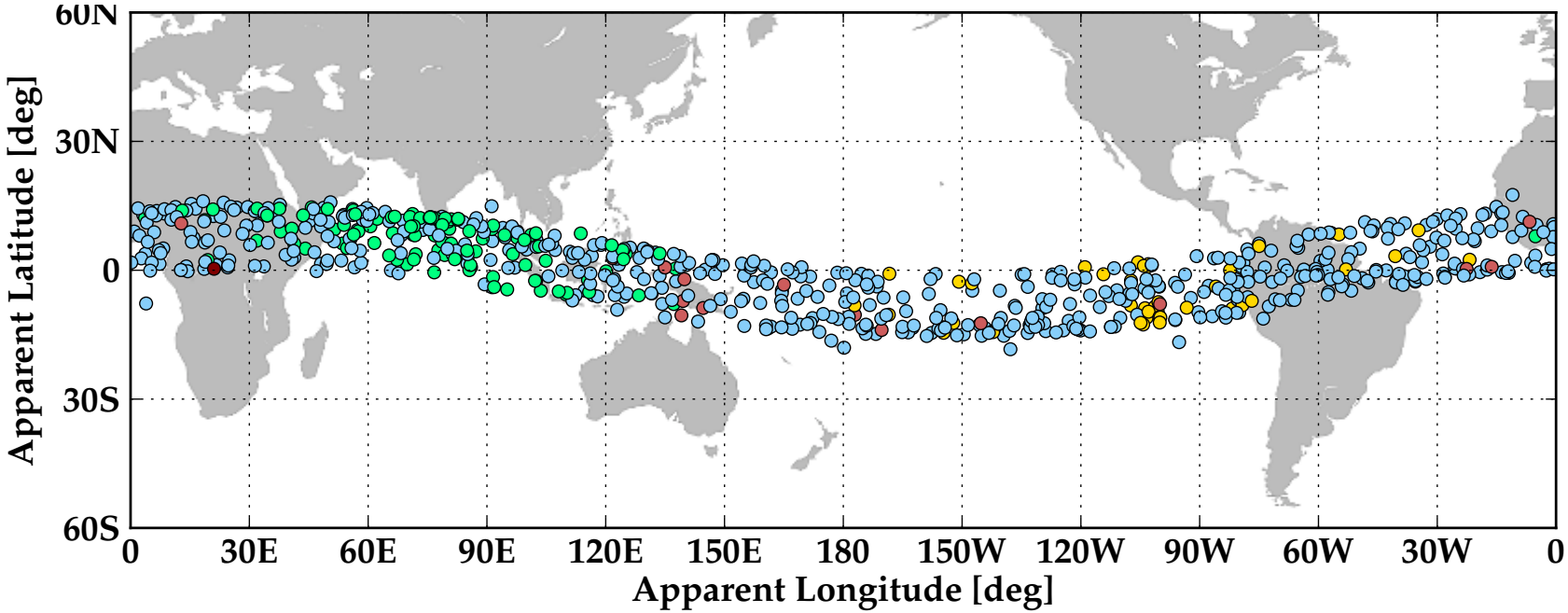
https://spacenews.com/lockheed-martin-unveils-new-satellite-bus-lineup/

BOEING

*The Boeing 702MP high-bandwidth bus/platform design uses **two solar arrays with Gallium Arsenide triple junction solar cells to provide 15 kW of power.***

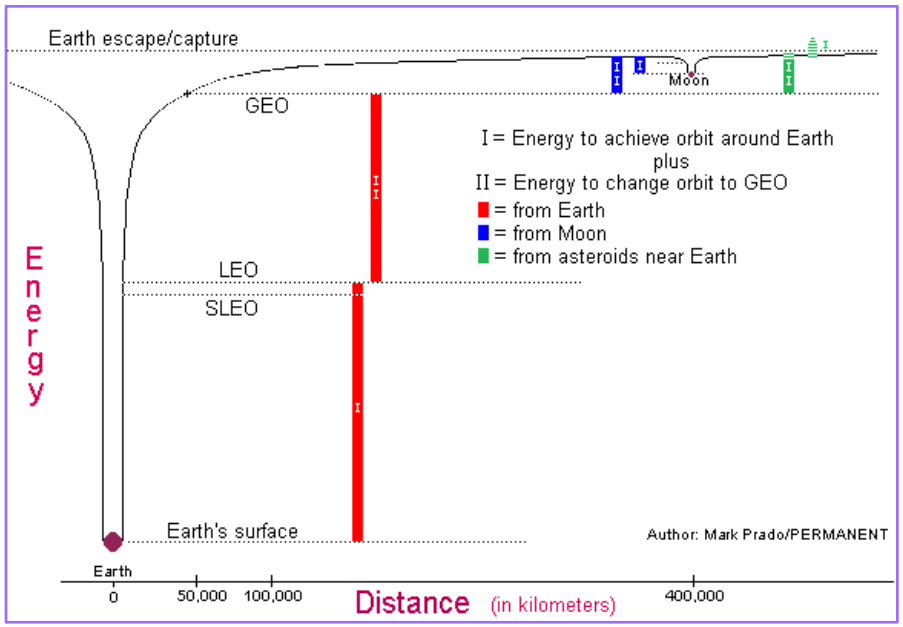


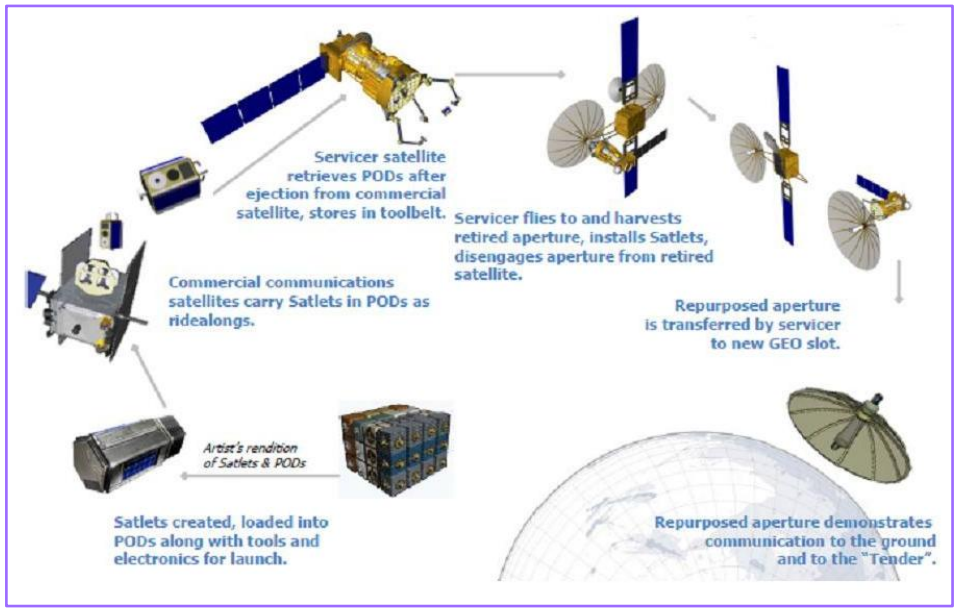
Longitude/latitude distribution of the 745 GEO debris on 01 March 2014



(d) Longitude/latitude distribution of debris population (18:00:00 Zulu).

Harvesting Solar Panels and Other Components from GEO Disposal



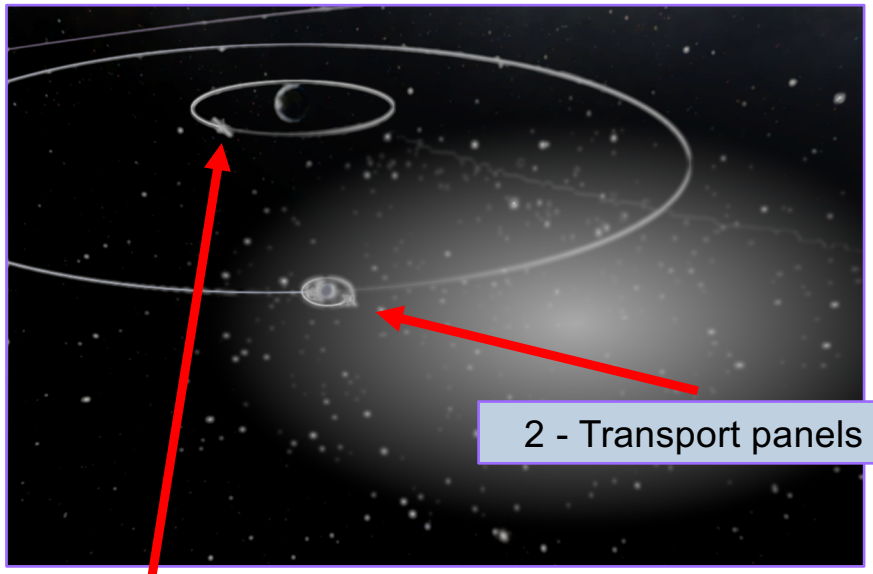


We take advantage of the "sunk energy cost" of satellites in the disposal orbit

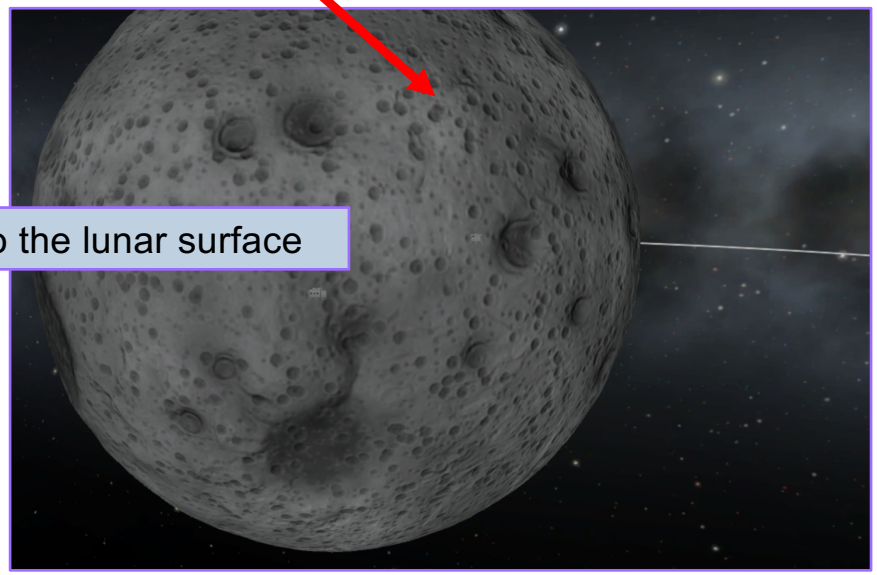
DARPA/Phoenix and other initiatives have developed needed technologies for in-space repair and construction.

Representative Mission

Supply Power for the Lunar Base



3 – Use electrical power and lunar materials to produce fuel for further solar array transfer



2 - Transport panels to the lunar surface

1 - Collect solar panels from satellites in the Graveyard Orbit

Trades analysis needed to compare this approach with alternative power supply options

The SnipSat™ Enterprise

- Over 400 large communication satellites will populate the GEO graveyard orbit after their commercially useful life - a resource of over 2MW of electrical power.
- We propose to apply government and commercial advances to create an architecture and CONOPS that:
  - *Harvests components such as solar arrays in the GEO graveyard orbit*
  - *Collects and stores these components in an accessible depot*
  - *Makes them easily available for repair, enhancement of existing satellites*
  - *Allows in-orbit assembly for flights beyond GEO (moon, gateway Mars, etc.)*

Public-private partnerships provide advantages to government agencies by leveraging commercial efficiencies and innovation while sharing risk with the private sector in exchange for profits linked to performance.

Benefits include lower cost power systems, reduced launch weight of new systems, and reduced graveyard collision risk.

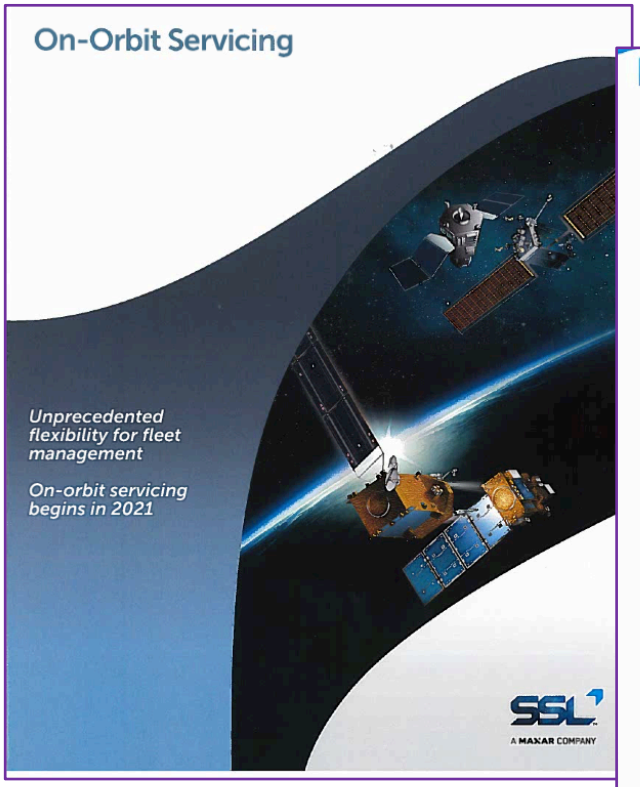
SnipSat™ Enterprise Elements

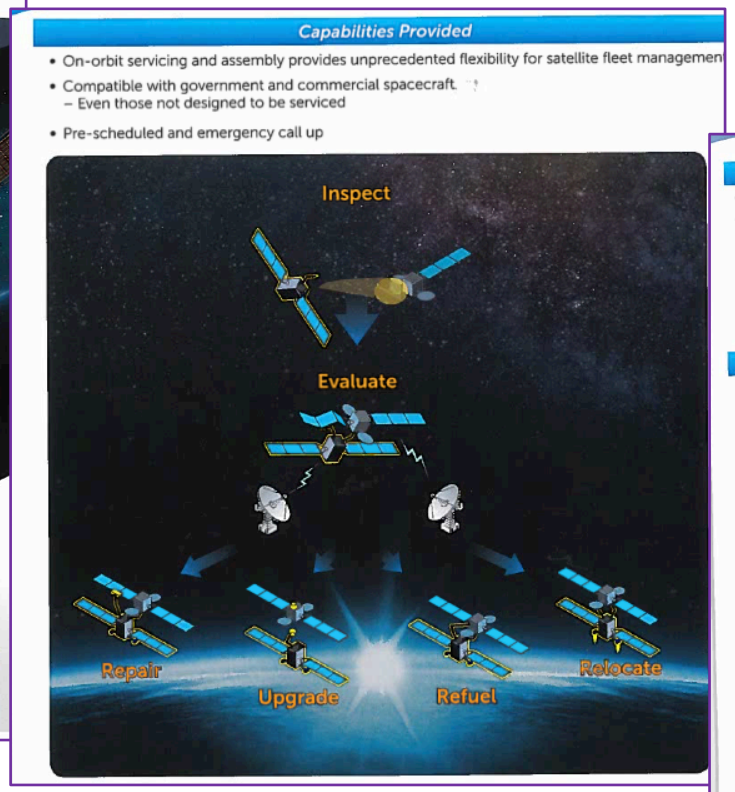
- A public-private partnership that designs, deploys and operates the SnipSat system.
  - *"SnipSat Harvesters" that remove components from satellites in the GEO graveyard orbit.*
  - *"SnipSat Depots" that collect and store the harvested components for future use.*
  - *"SnipSat Servicers" that deliver fuel, spares, technology refresh and power to enhance orbital assets*
- Aerospace Mission Assurance analyzes operational missions, maintains the component data base and safeguards intellectual property.
- The business case is based upon lower customer costs, lower mission risks, shortened timelines.

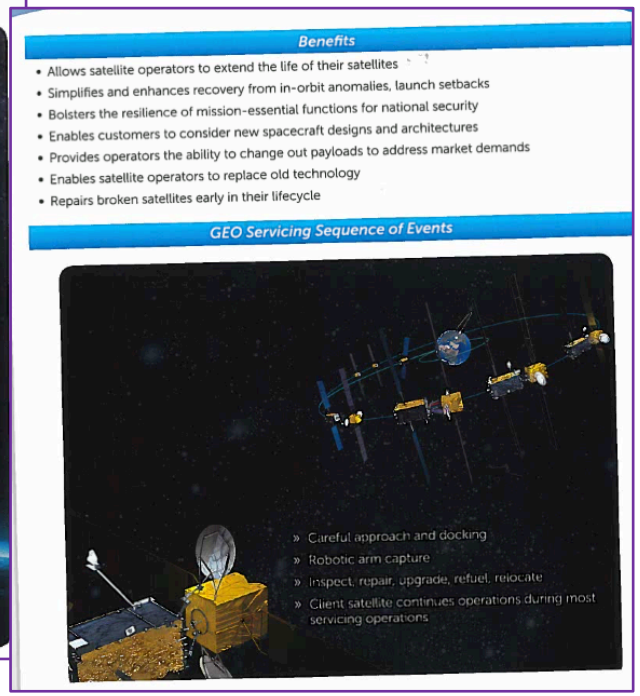
Solar panels are our first target to harvest, transfer and store and reuse.

SnipSat™ Builds on Industry Work

Flight-Proving Relevant Technologies







SnipSat™ Enterprise Customer Benefits

- Repair s/c in Geo orbit by installing components or refueling from the Depot to extend mission lifetime.
- Assemble large s/c at the Depot for flights beyond GEO
  - *Moon, Gateway, Mars, etc.*
  - *In-space assembly allows construction of s/c shapes and sizes not compatible with Earth-launch fairing constraints.*
- Weight reduction permits customers to use smaller, cheaper launch vehicles

Starting with solar arrays the enterprise grows to provide many services

SnipSat™ Enterprise

Summary

- The SnipSat™ Enterprise is an attractive business
  - *Public-Private partnership*
  - *SPEC-OTA prototyping*
  - *Aerospace Mission Assurance*
- Technologies are reaching high enough TRL to design the system
  - *Starting with Solar Power Reuse*
- Timeline of design, development and deployment is 5-10 years
  - *Use of concurrent NASA and DARPA funded programs*
  - *Leverage ongoing commercial initiatives*
- Business case, technology challenges and risks need analysis by government and industry