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Flash Memory Summit

Enabling Data Centers in Space

Presenter: **Paul Chopelas, General Manager - Aerospace and Defense**

Agenda

- Space Orbits
- The Ephiphany
- Data Centers in Space
- NAND Flash and MRAM
- Summary Impact
- Q&A

Space : The Key Ingredient in all Space Programs This Decade

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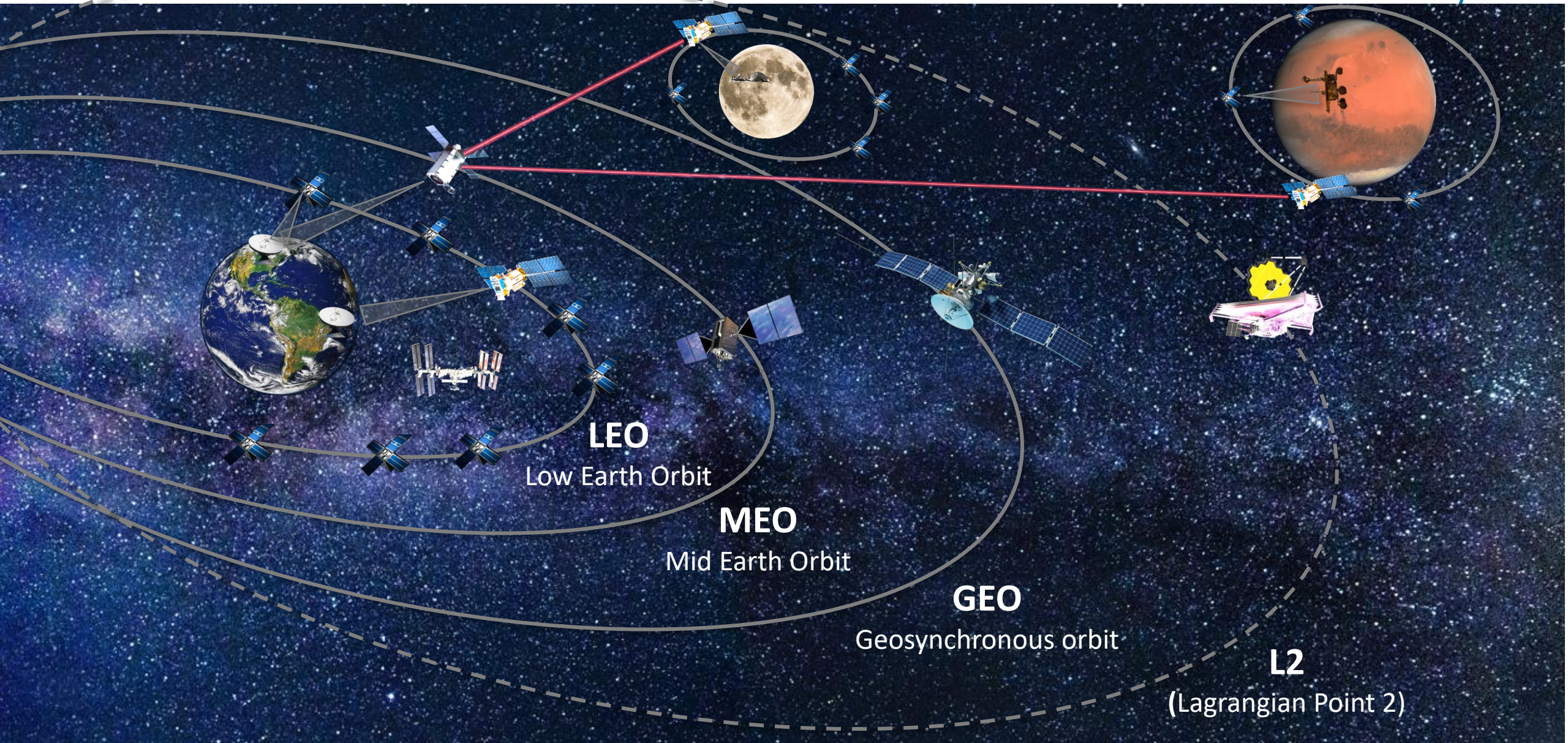
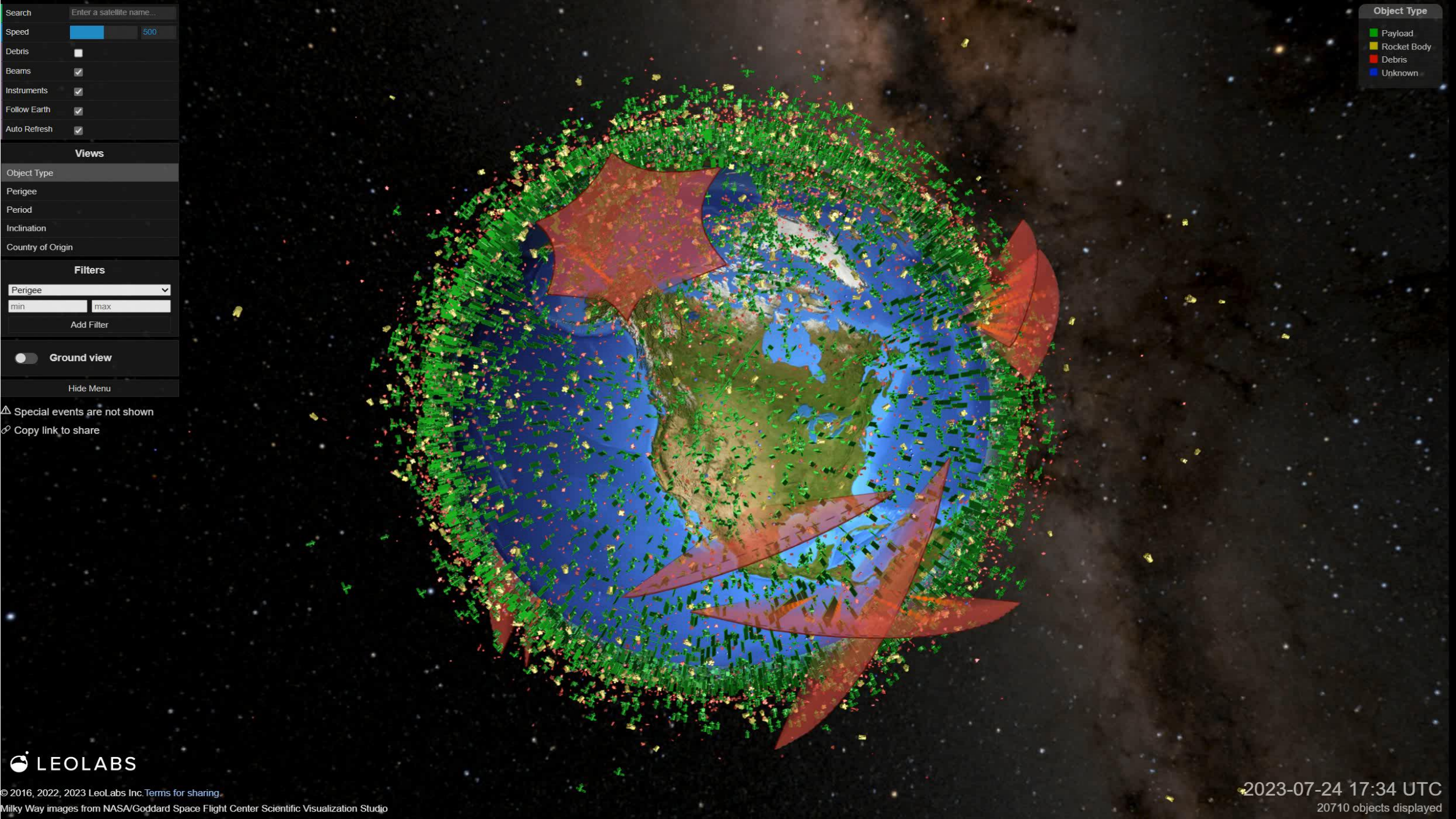


Aerospace: An Epiphany Moment

U.S. strategic military satellites are vulnerable to attack in a future space war and the Pentagon is needs to move to smaller distributed satellites.

General William Shelton (2014)

Architecture	Fixed Function
Design Cycle	Years
Test & Intg	Years
Launch Cycle	Years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Milky Way images from NASA/Goddard Space Flight Center Scientific Visualization Studio
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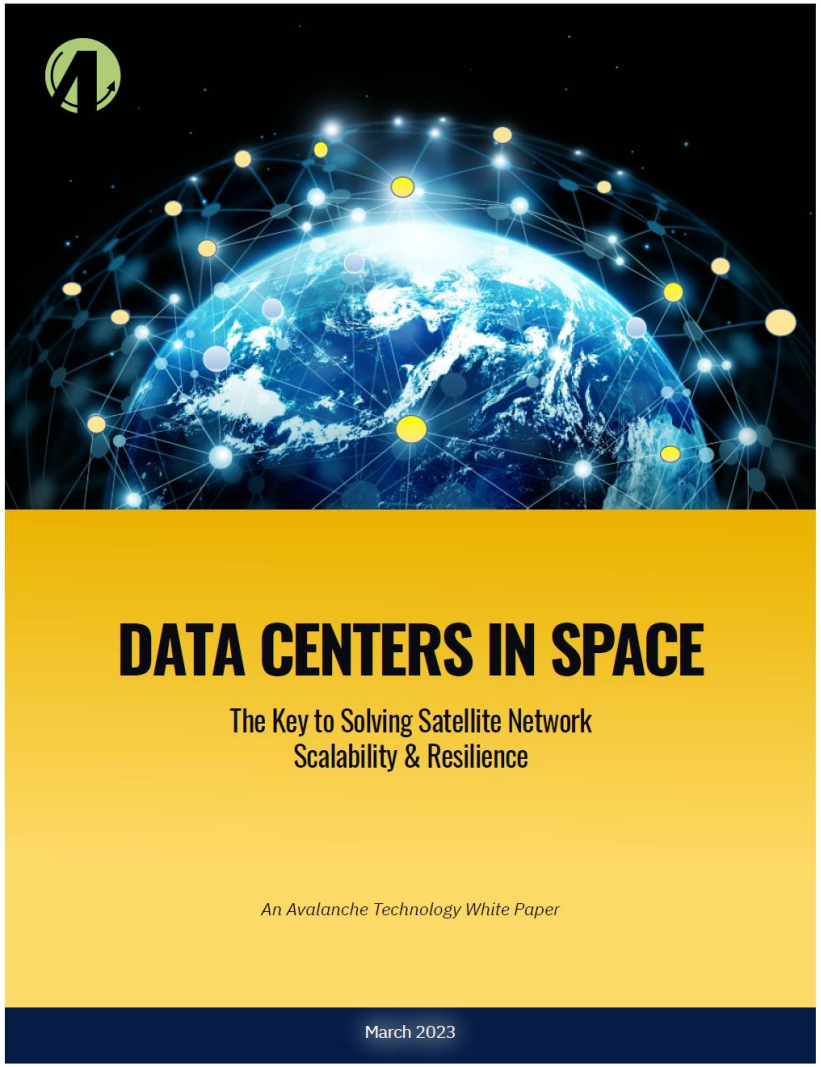
Data Center in Space Campaign (White Paper)



THE EVOLUTION IN SPACE BEGINS IN EARNEST

THIS EVOLUTION OF THE NETWORK toward a more distributed mesh architecture is already beginning to happen as the next generation of Micro satellites are being launched, not just in communication topology, but also distributed intelligence. The resulting impact to the network topology is pictured below in Figure 8.

Figure 8 – Evolved Satellite Network, With Layered Comms and Distributed Data Centers

In this picture, shown as green dots, thousands of recently deployed micro satellites in Low Earth Orbit are collecting data and functioning as intelligent IoT nodes with AI engines. They communicate with one another and to the Edge (represented as red dots) using high-speed laser links, as mentioned previously. These newer Edge-based Micro Data Centers in Space can now act as temporary data buffers for the Space-IoT (micro satellites) nodes, given it is impractical to have direct links between each satellite and Earth due to the limited bandwidth RF links to Earth, number of terrestrial base stations and the line-of-sight link time to them.

For simplicity's sake, the picture above shows 6 IoT nodes for every Micro Data Center in Space, which are effectively in their own stationary position relative to one other, while orbiting Earth. Each micro satellite can now become an intelligent AI machine as shown in the block diagram depicted in **Figure 9**, with new capabilities shown in green.

https://go.avalanche-technology.com/datacenters-in-space-whitepaper

Satellite / Constellation Challenges)

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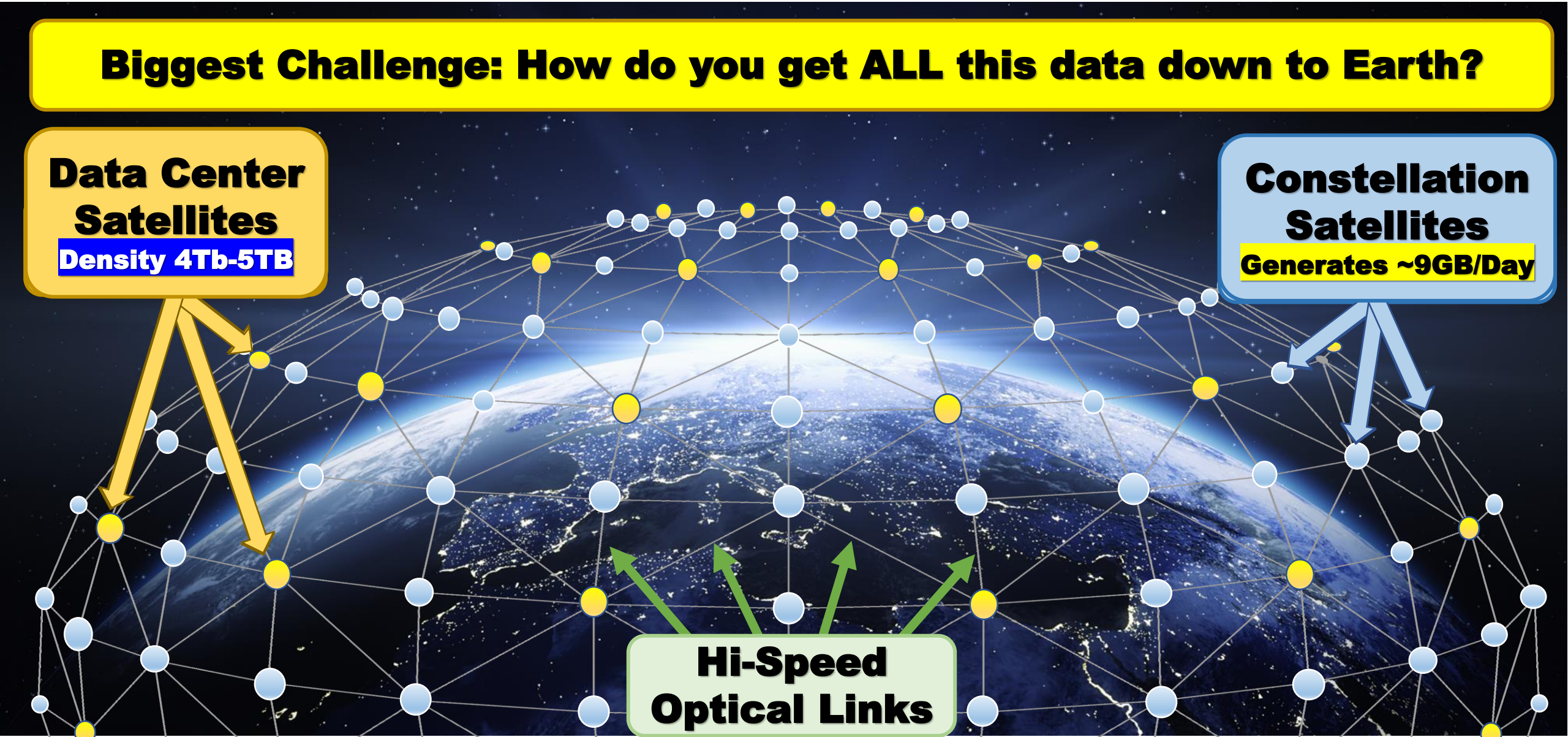

NAND Flash AND MRAM

Challenges of NAND Flash Memory for Space

- Despite its many advantages in space applications, flash memory faces several severe challenges that prevent widespread adoption.[1]
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The space environment also took a particular toll on SBC-1's solid-state disks—out of 20 solid-state disks, 9 failed during the mission. The system had redundant copies of all data, so no data was lost, but the team plans to try different methods to better protect the solid-state disks during the SBC-2 mission.

On the Edge of the Edge: Taking Supercomputing to Space
MAY 7, 2021 • **BY AMELIA WILLIAMSON SMITH, STAFF WRITER**

- MRAM's magnetic structure provides an NVM cell **immune to radiation**
  - Avalanche MRAM traded some density for radiation hardness and very high reliability

Avalanche MRAM Advantages – the Best SWaP for Space

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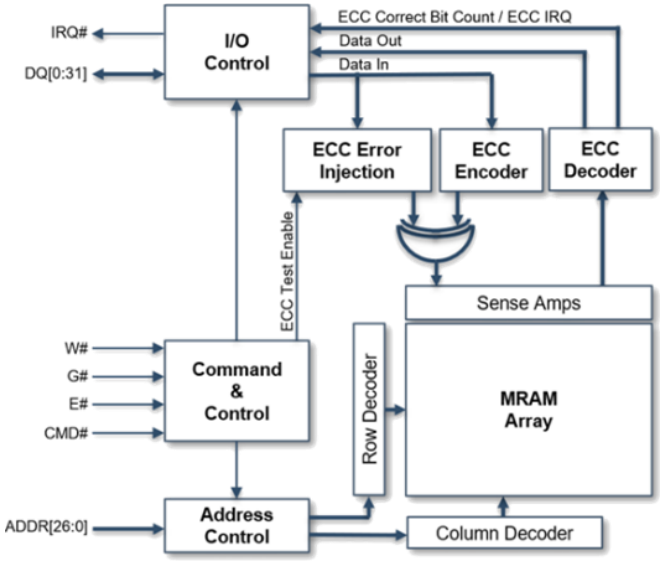
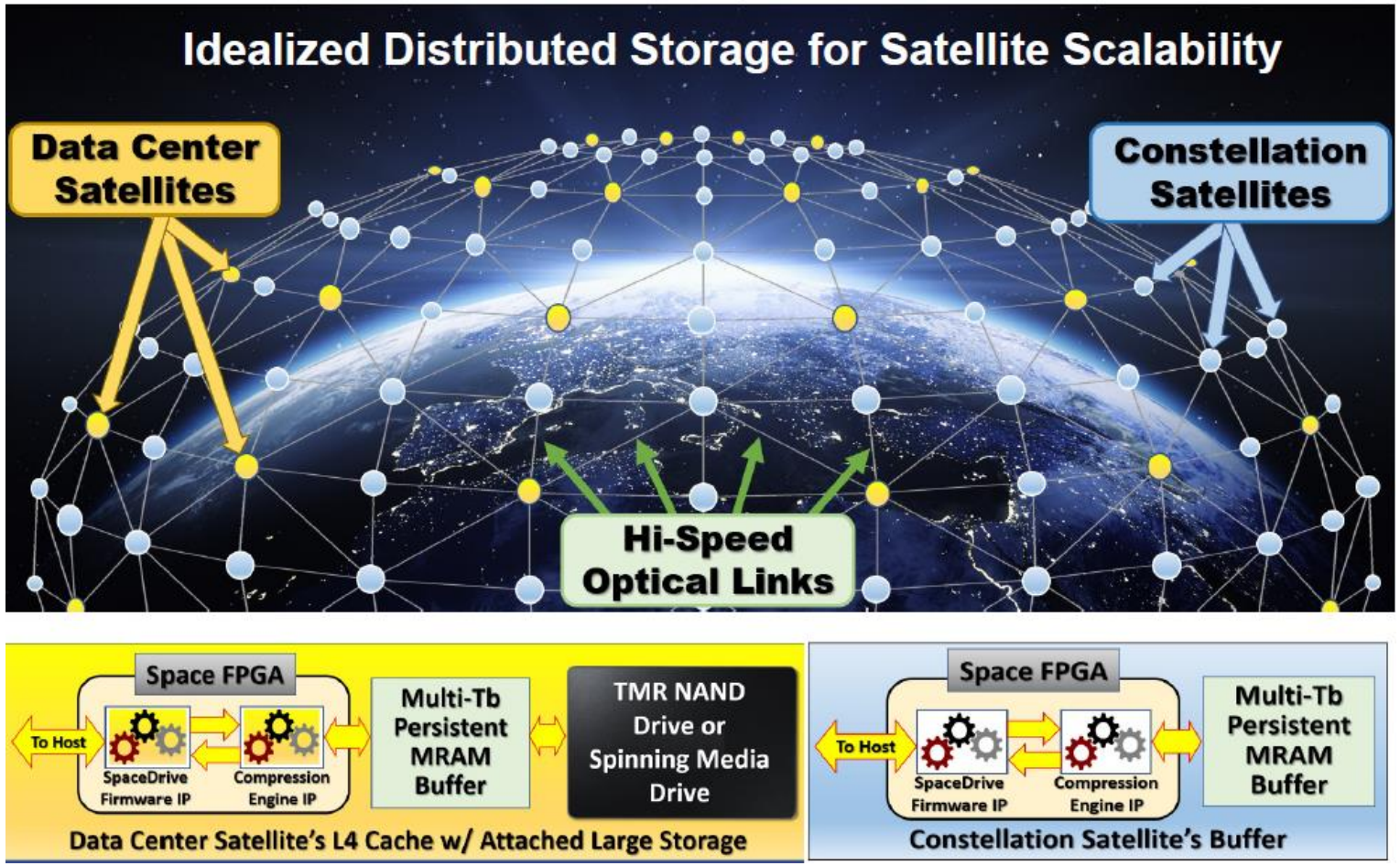
- MRAM's magnetic structure provides an NVM cell **immune to radiation**
  - CMOS circuitry protected by RHBD techniques
- **Innovations in cell, circuit & device architecture** over Flash & early MRAM
  - Designed as persistent SRAM – simplifies memory design
  - Higher endurance (10^{16}) than NAND or NOR Flash - simplifies system sw
  - No Shielding Required
- Designed for the **Highest Reliability** with embedded multibit ECC
- **Low Power, Unified Memory Architecture**
- **Best SWaP profile of any Space/RH NV Memory available**



What Does All This Mean to our Satellite Network Data Problem?



- Improved Network Scalability
- Mission Adaptability in Orbit
- Distributed Intelligence & Storage
  - Improved Mission Range
  - Enhanced Network Resilience
  - Satellites More Resilient to Threats in Real Time

Thank You!

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