

## Extending Cloud Services Into Space Will Enable The Data-Driven Space Economy

15 February 2024

- For decades, Space has provided a continuum of innovation and global services
  - Rapidly evolving to offer boundless capabilities and opportunity
- NASA established and is incubating a consumption-based services Space economy
  - Cargo and crew transportation
  - Communications, lunar suits and rovers
  - Cloud edge computing services are a natural fit
- Edge computing brings the resources and capabilities of cloud services as close as possible to the sources and users of data in Space

*LEOcloud believes that space is the next domain for cloud edge computing and is vital for the commercial space economy to realize its potential*



*LEOcloud is the Multi-Cloud Infrastructure as a Service (IaaS) provider in LEO, cislunar and beyond*

- Full exploitation of Space-sourced data brought back to Earth for analysis and fusion presents R&D and mission success barriers
  - Security, latency and cost
  - NSR predicts a 14x increase in data volume by 2030, equating to 500 Exabytes of data
- Significant volume of Space-sourced data is never analyzed due to its limited relevance shelf life
- The International Space Station National Lab (ISSNL) has established the market for space-based R&D, and now is experiencing a need for compute resources, that is forecasted to significantly increase
- To realize the greatest benefit from space-sourced data, users require the cloud edge is extended into space
- Cloud service providers are seeking partners for space-hardened technology and managed infrastructure to extend their services into space

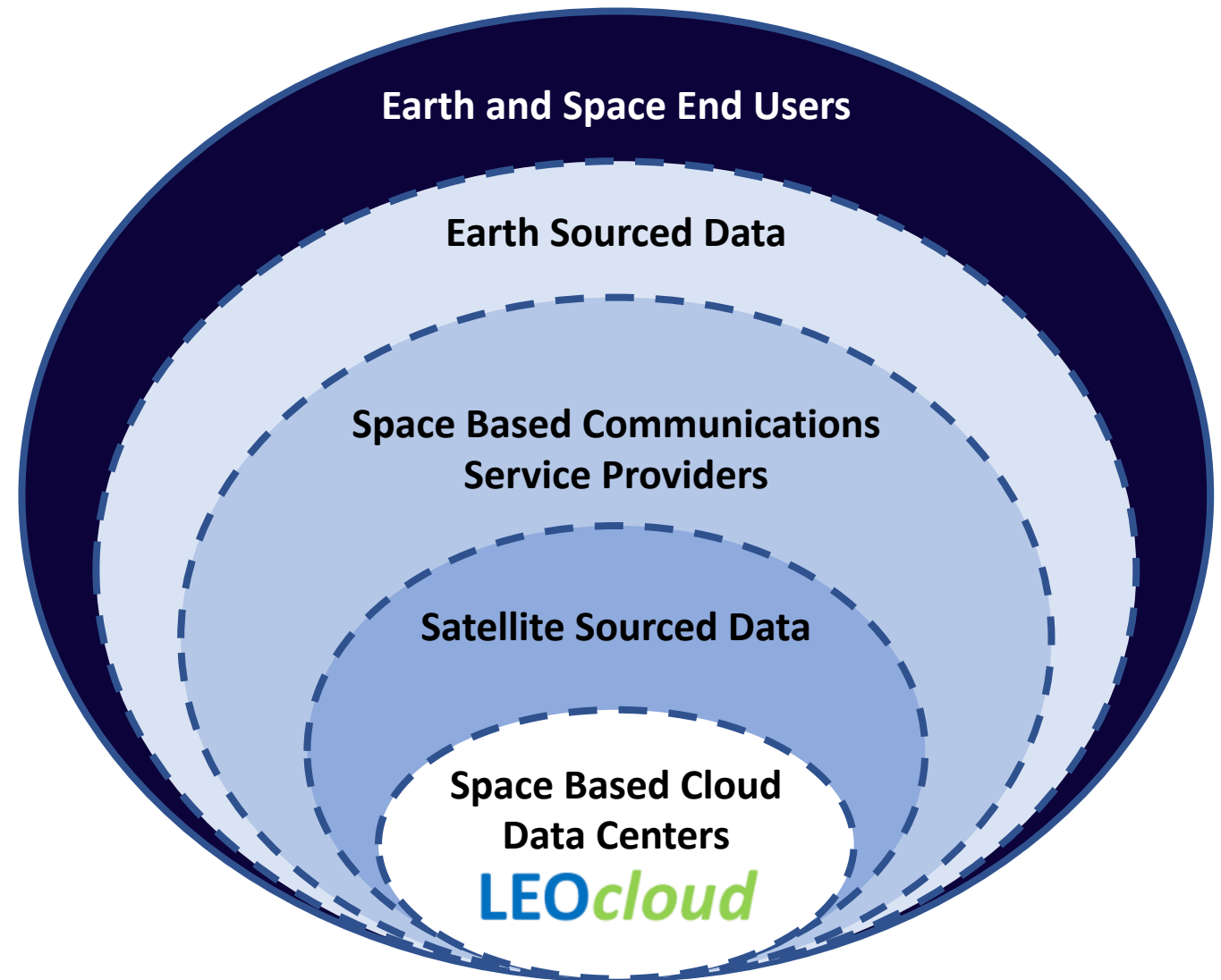
“We need data centers in Space, now”

Steve ‘Bucky’ Butow, Director of Space Portfolio, Defense Innovation Unit  
Space Mobility Conference, 2023

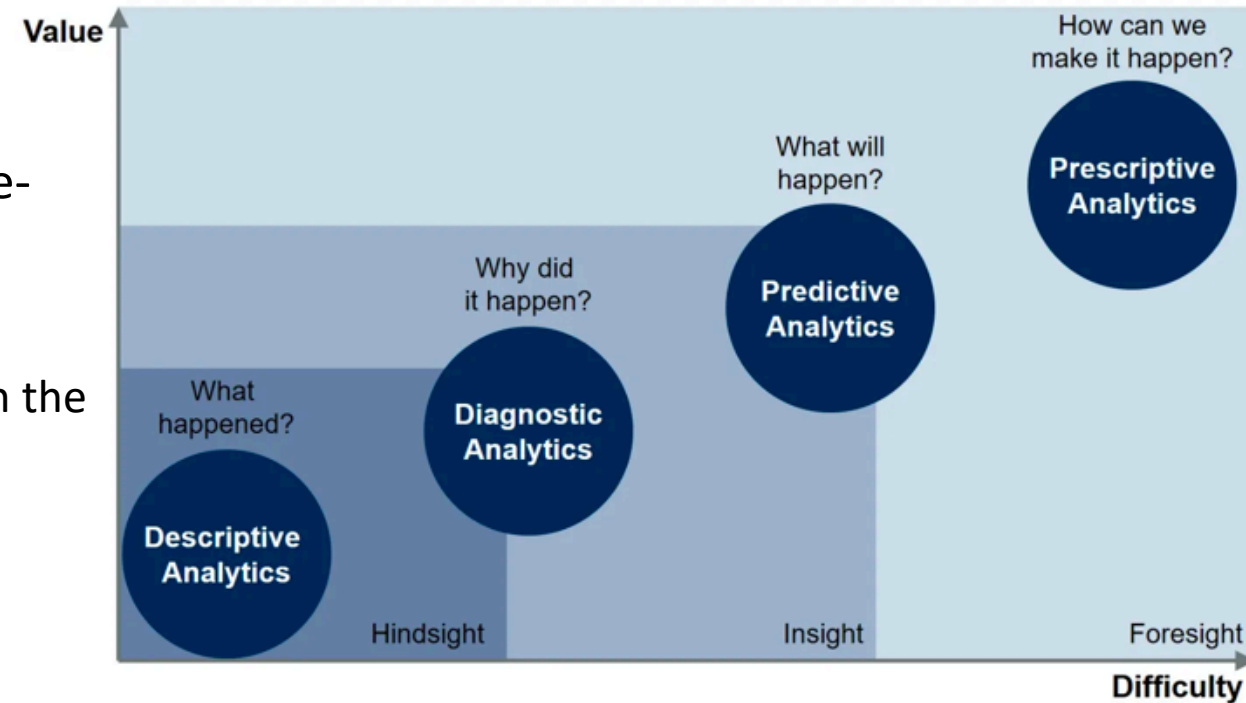
“How does the industry make money?” says Dylan Taylor, founder of Voyager Space Holdings. “It will be mostly on data and predictive analytics. Hardware and launch are just means to an end.”

More computing power and even machine learning aboard spacecraft would also help the United States keep ahead of emerging threats..., said Col. Russell Teehan, the portfolio architect for the U.S. Space Force’s Space and Missile Systems Center. “Deep-space domain awareness — that’s where we really don’t have time to phone home, process everything, and then send back a point solution,”

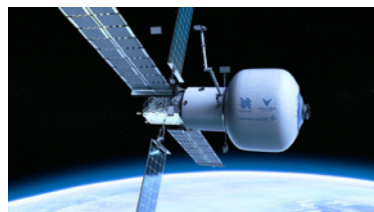
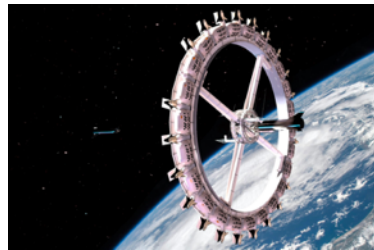
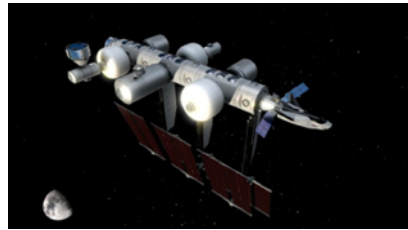
- The commercial Space infrastructure will evolve into an interconnected communications and cloud infrastructure
- As the commercial Space market and infrastructure evolves, space stations have the ability to host scalable, centralized data centers that can ingest large volumes of data from anywhere in Space and Earth
  - Provide the deepest, secure and fastest data fusion results to commercial, military and government customers
  - Provide global (Earth and Space) reach for commercial services



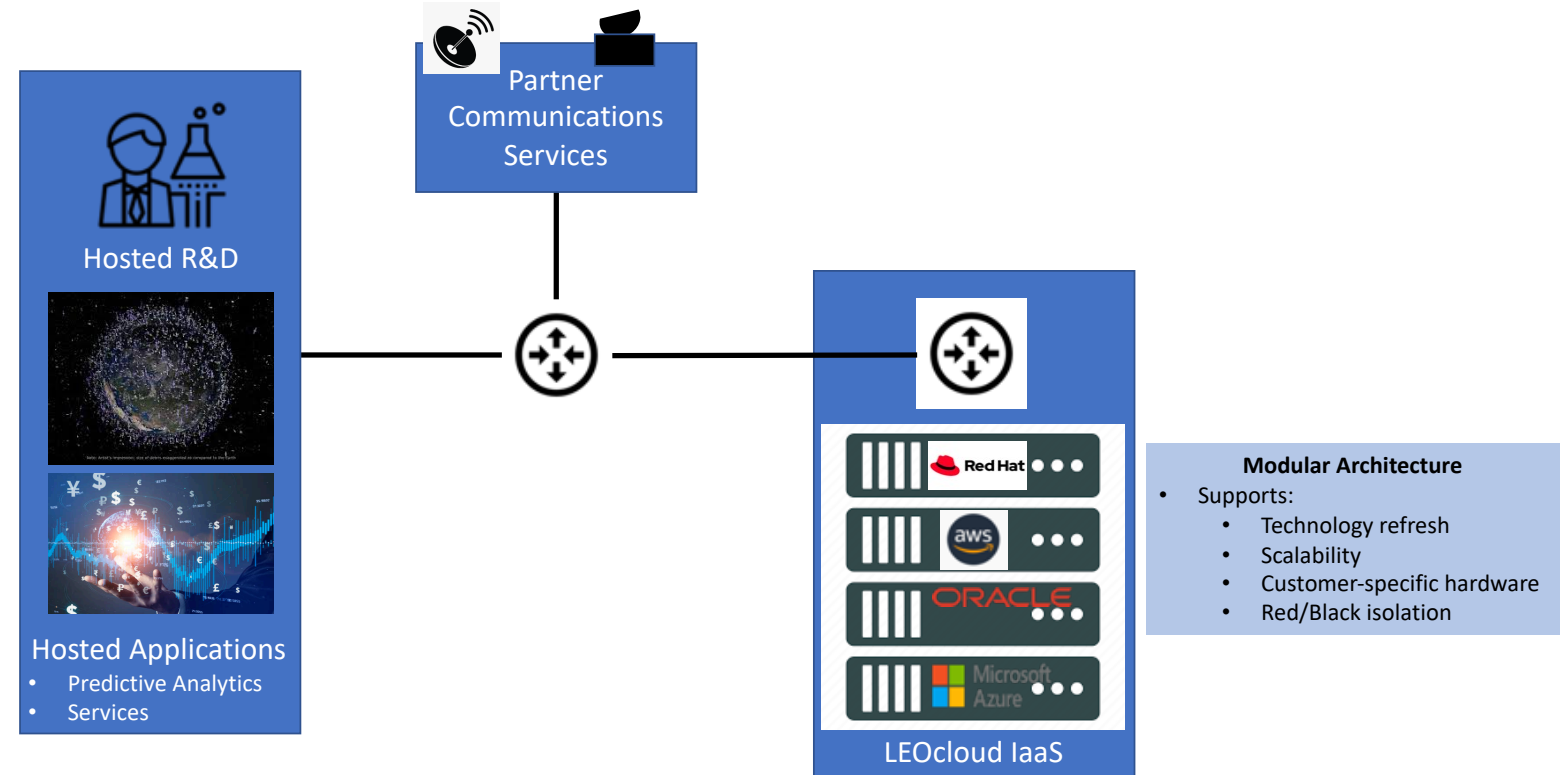
- Extending multi-cloud services into Space will address the need and urgency for information at the speed of relevance
- Artificial Intelligence will play a vital role in the new space economy
  - Space Situational Awareness
  - Space weather forecasting
  - Medical treatment
- Inside The Terrestrial Loop (ITTL)<sup>TM</sup> paradigm shift is required in order to realize the maximum value of Space-sourced data
  - Today, significant volume of Space-sourced data is not analyzed due to it's limited shelf-life relevance
  - In the future AI will cross a threshold where astronauts in the loop will not be needed
- Generative AI
  - Large language models
  - Natural text and spoken language processing
- Architecture
  - A hybrid distributed edge and centralized data center architecture will evolve in Space
- Software Factory Model- Applications are developed and tested in a terrestrial cloud environment, then seamlessly moved to a Space-based cloud region







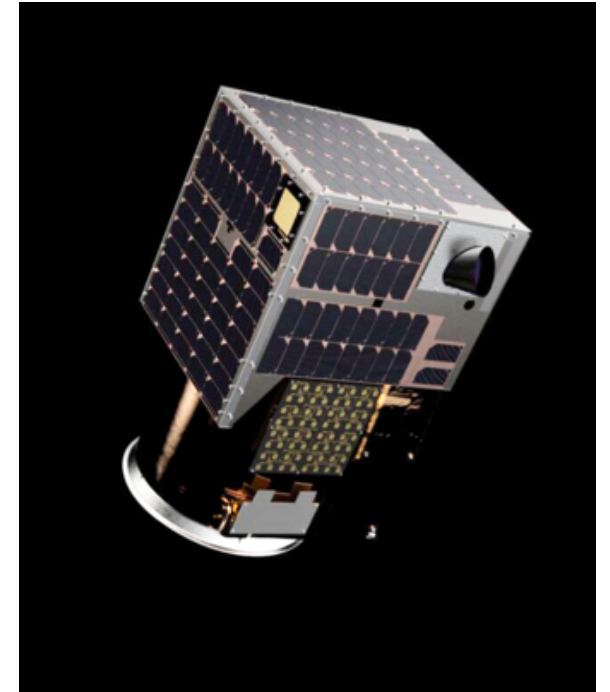
- Data center for government, military and commercial users
  - Support highly iterative research and deep data fusion
- Centralized space-based command center for customers, satellites and constellations
- Extension of terrestrial virtual private clouds for seamless R&D collaboration with colleagues on Earth
- Host commercial services
- Support CSS facility operations



- Enables customer's research data to be processed local to their research
- Deliver results from ISS facility to customer
  - Versus transporting high volume raw data to a terrestrial data center
- Seamless delivery to customer's terrestrial cloud environment
- Benefits include latency, security, reduced transport costs and availability



- Enables customer's data to be processed on board SDS satellites
- Deliver results from satellite to customer
  - Versus transporting high volume raw data to a terrestrial data center
- Seamless delivery to customer's terrestrial cloud environment
- Benefits include latency, security, reduced transport costs and availability
- Processing high volume data is a net power consumption reduction versus transmitting it to a terrestrial network
- Supports roadmap to high performance, centralized cloud compute services in LEO for satellite constellations



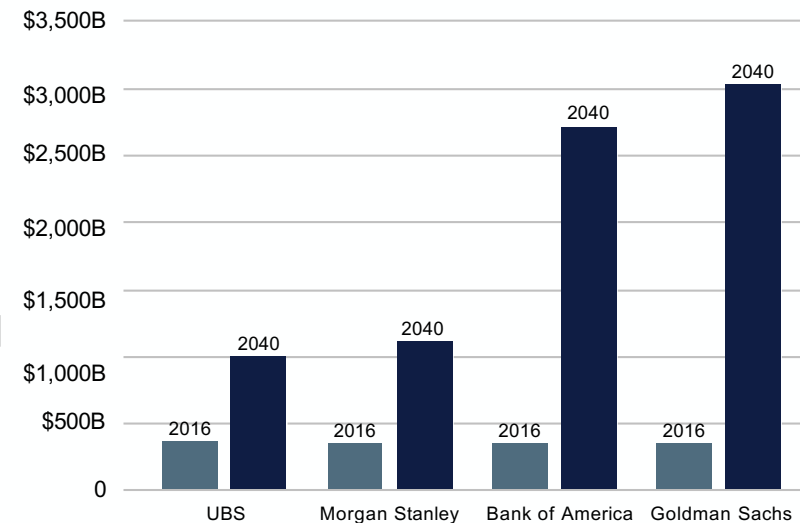


- Purpose built, dedicated facilities in LEO and lunar regions
- Inside-The-Terrestrial-Loop (ITTL) cloud edge computing services will be integral to the warfighter's advantage
  - Convert data from many sources to actionable insight without dragging it back to Earth
- Can be non-human rated
- Networked for redundancy, scalability and resiliency
- Supports technology refresh
- Lower cost than a full service station
- Supports multiple communications services options



- Commercial, government and military end users are driving the demand for Space-sourced data
- The benefits of microgravity is driving the demand for data intensive Space-based R&D
  - R&D has been hosted on the International Space Station National Lab (ISSNL) for 10 years
  - Future: Commercial Space Stations and R&D facilities
- DoD multi-\$B JADC2 and JWCC programs require deep data fusion to enable decision dominance at the speed of relevance

Space Economy Market Size Projections



## Addressable Use Cases For Commercial, Government and Military Customers

- Cybersecurity
- Deep Data Fusion
- Disaster Recovery
- Energy Grid
- Global Services
- Planetary Network Orchestration
- R&D
- Space Situational Awareness
- Space Weather
- Surveillance

Analytics and High-Performing Computing is estimated to be a \$4B segment of the global space economy, which is estimated to grow to \$18B by 2030.

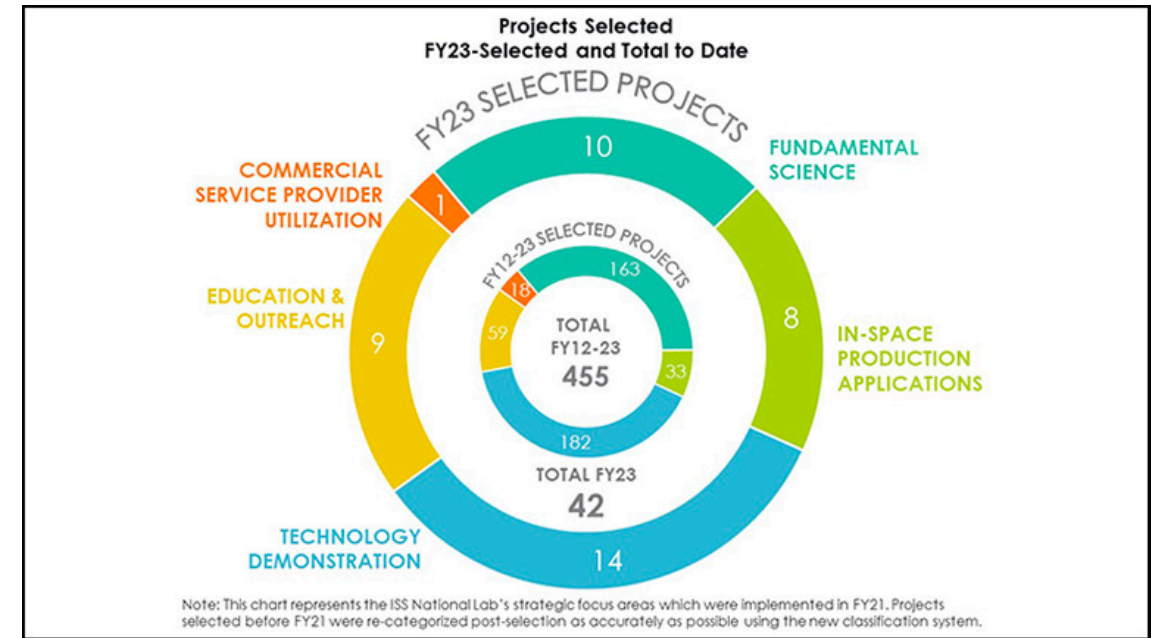
Morgan Stanley Research

• Areas of R&D That Benefit From Microgravity

- Human Research
- Biology and Biotechnology
- Technology
- Physical Science
- Earth and Space Science
- Education

• 2023 ISSNL Activity

- 113 payloads delivered
- Greater than 80% were from commercial entities
- 70% were new-to-Space users
- Multi-year R&D projects have steadily increased since 2010
- Research institutions that used ISSNL include Notre Dame, Clemson, Arizona State, MIT, Georgia Tech
- ISSNL investor network expanded to more than 300 members, with \$2.1B cumulative funding raised by startups post ISSNL research
  - 1,317 cumulative startup - investor introductions



- ISSNL provides a market opportunity indicator for the commercial and government R&D addressable markets
- Additional opportunity exists for military R&D which is an unaddressed market on ISSNL
- NASA forecasts a demand of 200 science payloads to be hosted on commercial space stations in 2030

Sources:

- 1) Forecasting Future NASA Demand in Low-Earth Orbit: Revision Two – Quantifying Demand, June 7, 2019
- 2) ISS NL Annual Report for Fiscal Year 2023



**JADC2**  
Joint All Domain  
Command & Control

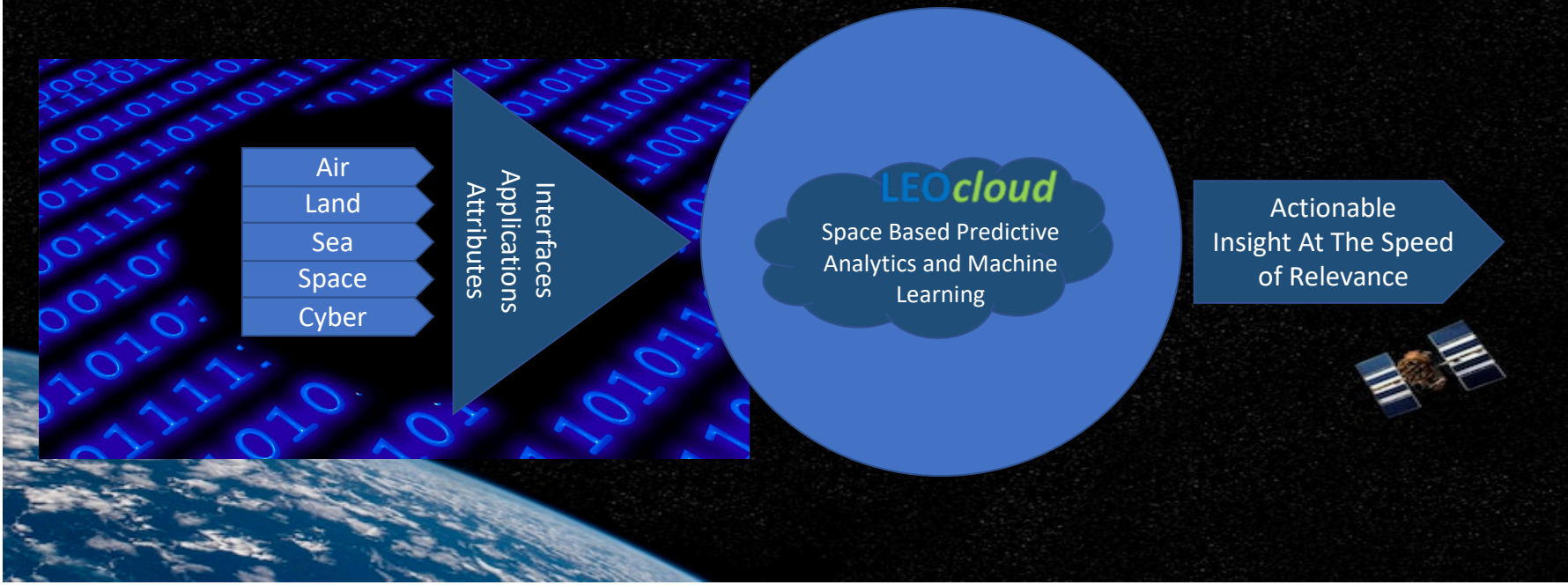


**JWCC**  
Joint Warfighter  
Cloud Capability



**UDL**  
Unified Data Library

## LEOcloud Enables Decision Dominance At The Speed of Relevance For The Warfighter



### Space Command Leader Sees AI Tech Deployments as Mission Critical

“There are at least three ways that I think we will be using artificial intelligence in the future from a U.S. Space Force and Space Command perspective.”

- The first mission case, he said, is “space domain awareness” that involves getting a handle on the vast “volume of space that we need to observe and understand.”
- Gen. Shaw said a second AI mission case comes from the expected proliferation of platforms in space that will be smaller in size than today’s satellites and operating autonomously.
- The third mission case, the general said, involves integrated operations of space-based and terrestrial domains that are contributing to space operations and space flight.

*Lt. Gen. John Shaw, deputy commander of the U.S. Space Command*

JADC2- Joint All Domain Command & Control - <https://www.defense.gov/News/Releases/Release/Article/2970094/dod-announces-release-of-jadc2-implementation-plan/>

JWCC – Joint Warfighter Cloud Capability (formerly JEDI) - <https://www.defense.gov/News/News-Stories/Article/Article/3243483/departments-names-vendors-to-provide-joint-warfighting-cloud-capability/>

UDL – Unified Data Library - <https://www.af.mil/News/Article-Display/Article/1928041/afspc-rolls-out-new-enterprise-data-strategy/>

- Agriculture: crop monitoring
- Forestry: forestry planning and prevention of illegal logging
- Fishing: prevention of illegal fishing
- Energy: pipeline and right-of-way monitoring
- Asset Management and Insurance: infrastructure integrity monitoring
- Financial services
- Land use: infrastructure planning and monitoring of building activity
- Sea traffic: iceberg monitoring, oil spills detection, vessel tracking
- Security: coastal traffic monitoring
- Disaster response: fast response to natural catastrophes

*Data Marketplace in space, combined with cloud-based compute will “enable a competitive advantage for service providers”*

- Incentivizes commercial space industry
- Enables immediate interaction
- Allows for immediate payment
- Enables anonymous data acquisition
- Provides market insight for future investment
- Reduces the cost to engage from millions to pennies
- Inclusive to all sectors (commercial, government, academic, allied)
- Allows the government to take advantage of the global commercial space industry



**LEOcloud**

# *Space Edge Cloud Services*

*Enabling Cloud Services In Space*

