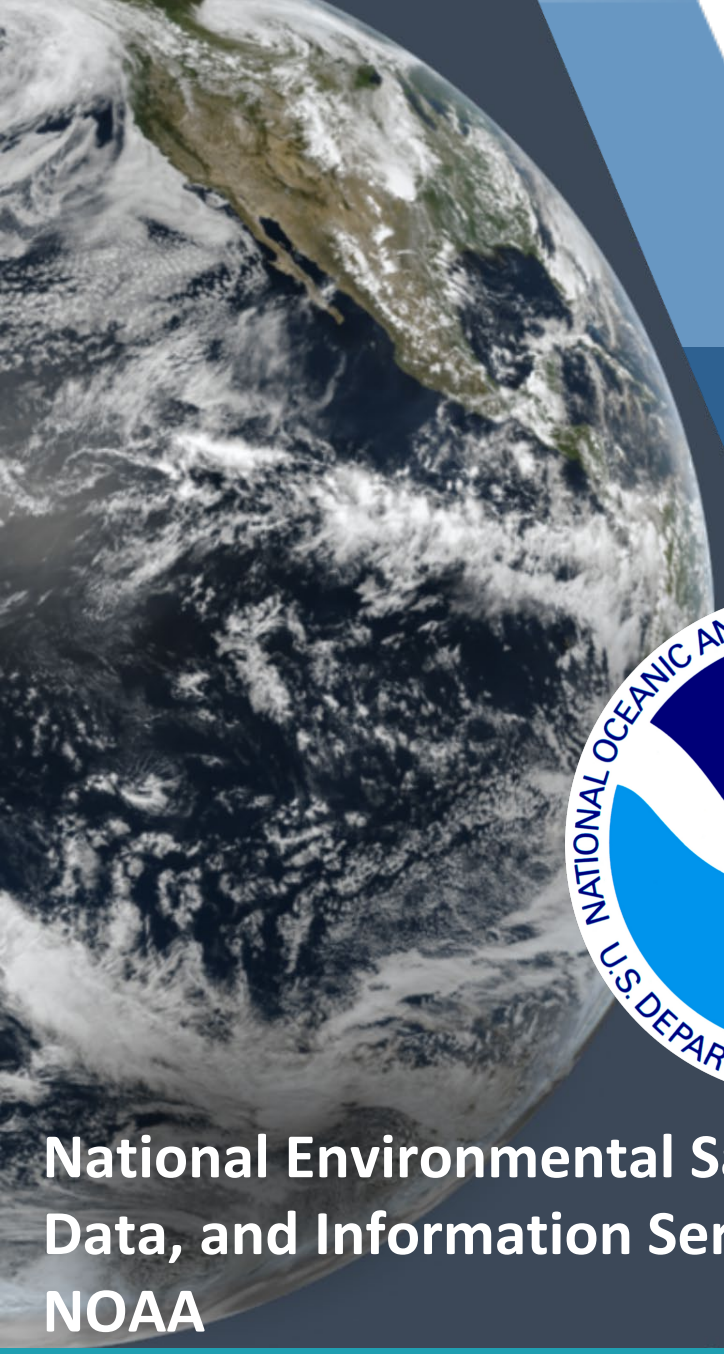


Raad Saleh, Heather Kilcoyne,
Edward Grigsby, Richard G. Marlow

Innovations and Technological Advances in Support of Cost-sustainability of NOAA's Future Ground/Flight System Architectures

National Environmental Satellite, Data, and Information Service, NOAA

GSAW 2024

February 27, 2024, Los Angeles, CA

NESDIS Strategic Objectives

NESDIS Reimagined

1 

Advance terrestrial observational Leadership in geostationary and extended orbits

2 

Advance Space Weather observational Leadership in LEO, GEO, and extended orbits.

3 

Evolve LEO architecture to enterprise system of systems that exploits and deploys new observational capabilities

4 

Develop agile, scalable ground capability to improve efficiency of service deliverables and ingest of data from all sources

5 

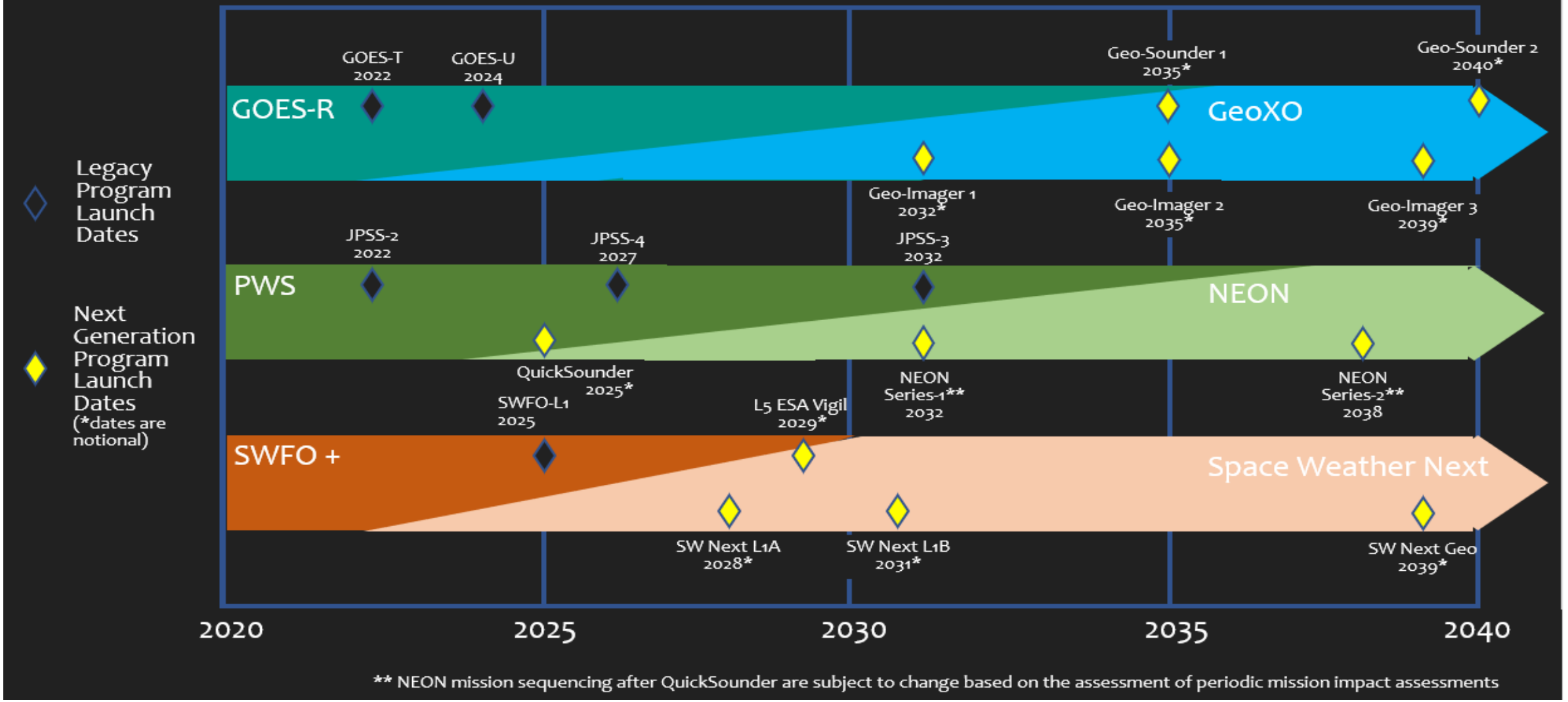
Provide consistent ongoing enterprise-wide user engagement to ensure timely response to user needs

6 

Deliver the best value integrated suite of products and services responsive to user needs

Focus on Establishing the Next Generation Ground Enterprise Architecture 2030-2050

NESDIS Plans for Future Satellites

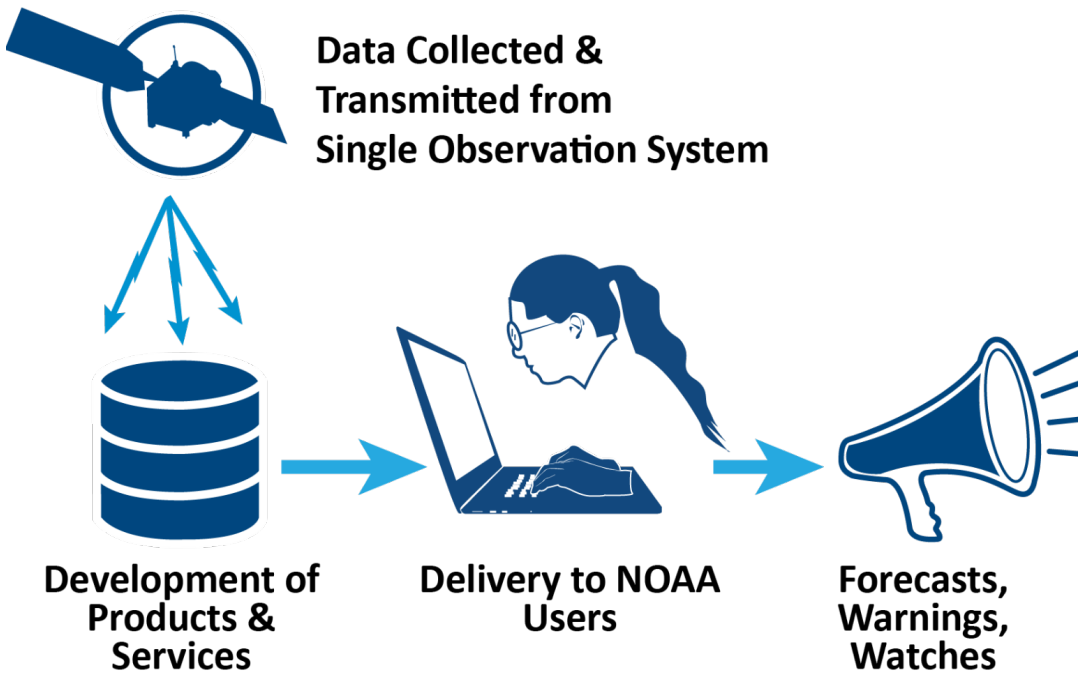


Source: Dr. Volz, CEOS Agency Report: NOAA, 2023

Motivation for Common Services

TODAY'S GROUND SERVICE

- Single system data services
- Limited computing power



The **NESDIS Ground Enterprise (NGE)** has been comprised of a disparate set of systems across offices

- Separate approaches support operations, science, and archive
- Duplicative functions and data from system-specific standards

The **NGE in its current form is unsustainable.** We will overrun our IT sustainment budgets with the current approach, and we need to support observations from new, non-NOAA sources.

Motivation for Common Services

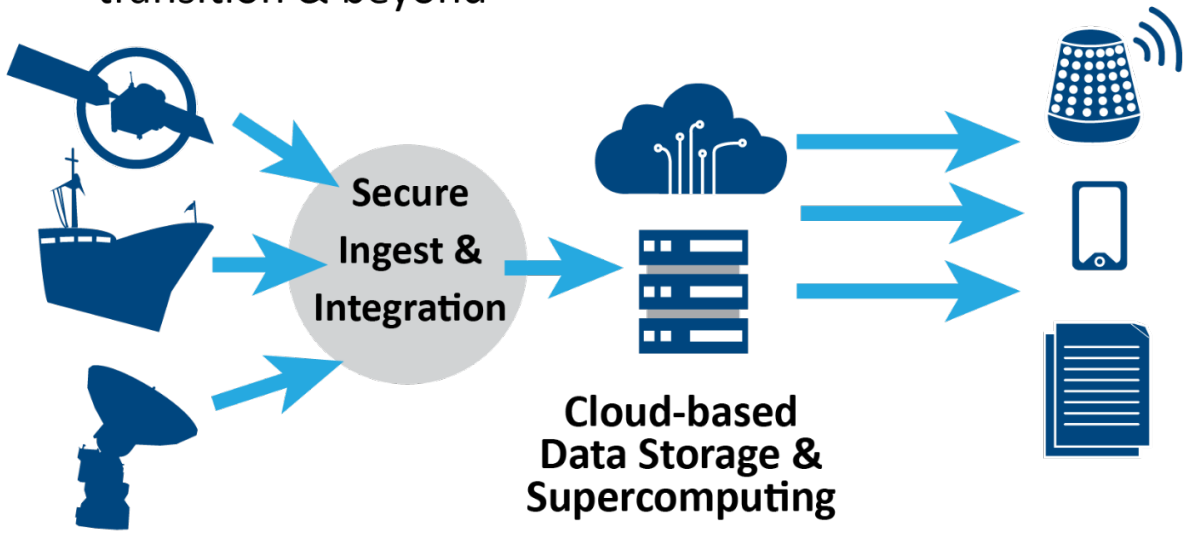
With the NGE implemented as a set of disparate systems and hence unsustainable, **NESDIS is therefore transforming its business operations approach** to accommodate growing data volumes and diverse sources of data

- Suite of services will enable access to and use of environmental data from a variety of sources

We are using a service-based enterprise commercial cloud solution based on industry best practices

TOMORROW'S GROUND SERVICE

- Secure ingest for all data types
- Powered by AI, data science
- Super-computing capability though cloud transition & beyond



Capability Domains: Satellite, Science and Data Operations

Satellite Operations	**Space-Ground Communications (SCM)** • Ground Station Operations • Mission Data Backhaul **Satellite Mission Operations (MOP)** • Mission Planning • Real-time Satellite Operations • Trending & Platform Management
Science Operations	**Algorithm Operations (AO)** • Algorithm R&D • Product Cal/Val/Ver **Environmental Information Operations (EIO)** • Environmental Data Stewardship • Environmental Records Management
Data Operations	**Product Operations (PO)** • Data Ingest • Product Generation • Data Archive **Data Delivery (DD)** • Real Time Data Delivery • Near-Real Time Data Delivery • General Access

Satellite Operations Requires Further Strategic Evolution & Innovation to meet 2030+ Satellite Constellation Needs

Dimensions of Cost-Sustainability

Evolution of the NESDIS Ground Enterprise can NOT be realized **solely** by new and innovative technologies, but more so how the new technology will provision NESDIS business services and impact its structural practices in a sustainable cost-effective way.

Specific Dimensions	Asset Location	Asset Ownership	Security Model	Operational Control	Capability Provisioning Model	Acquisition Model	Operational Mode
Current Approach	NOAA Facility	NOAA Owned	NOAA Owned	NOAA Operated	Mission-Centric	Systems	Data Driven (Push)
Radical Alternative	Non-NOAA Facility	3rd Party	External Owned	Outsourced Operations	Enterprise	Services	User Driven (Pull)
Enterprise Architecture Alternative	Transfer of Capital Investment Responsibility	Transfer of Sustainment Responsibility	Hybrid Approach	Transfer of Operations Responsibility	Transfer of Development Responsibility	Reallocation of Budget (Development to Operations)	Realignment of Operational Priorities

Mission Operations Value Assessment

- Business Dimensions should be analyzed individually based on allowable Programmatic Risk
- **More** Risk Tolerant Missions allow for Radical or Emerging Business Alternatives
  - Commercial Ground Systems, Outsourced Capabilities
  - Potentially reduces Costs and allows further assessment to lower risk
- **Less** Risk Tolerance points to integration of mature solutions
  - Incorporation of Ground Station as a Service, Cloud Services, etc.
  - Focus on maintaining critical operations
- As Radical Alternatives mature, a transition could occur to incorporate that functionality into the Enterprise

Attribute	Current NOAA Approach	Radical Alternative	Enhanced NOAA Alternative
Timeliness of Implementation	R	G	Y
Scalability of Missions	G	Y	G
Availability (Performance)	Y	Y	G
IT Security	Y	Y	G
Budgetary Performance	R	G	Y

Targeted Use of Emerging Satellite Operations Alternatives

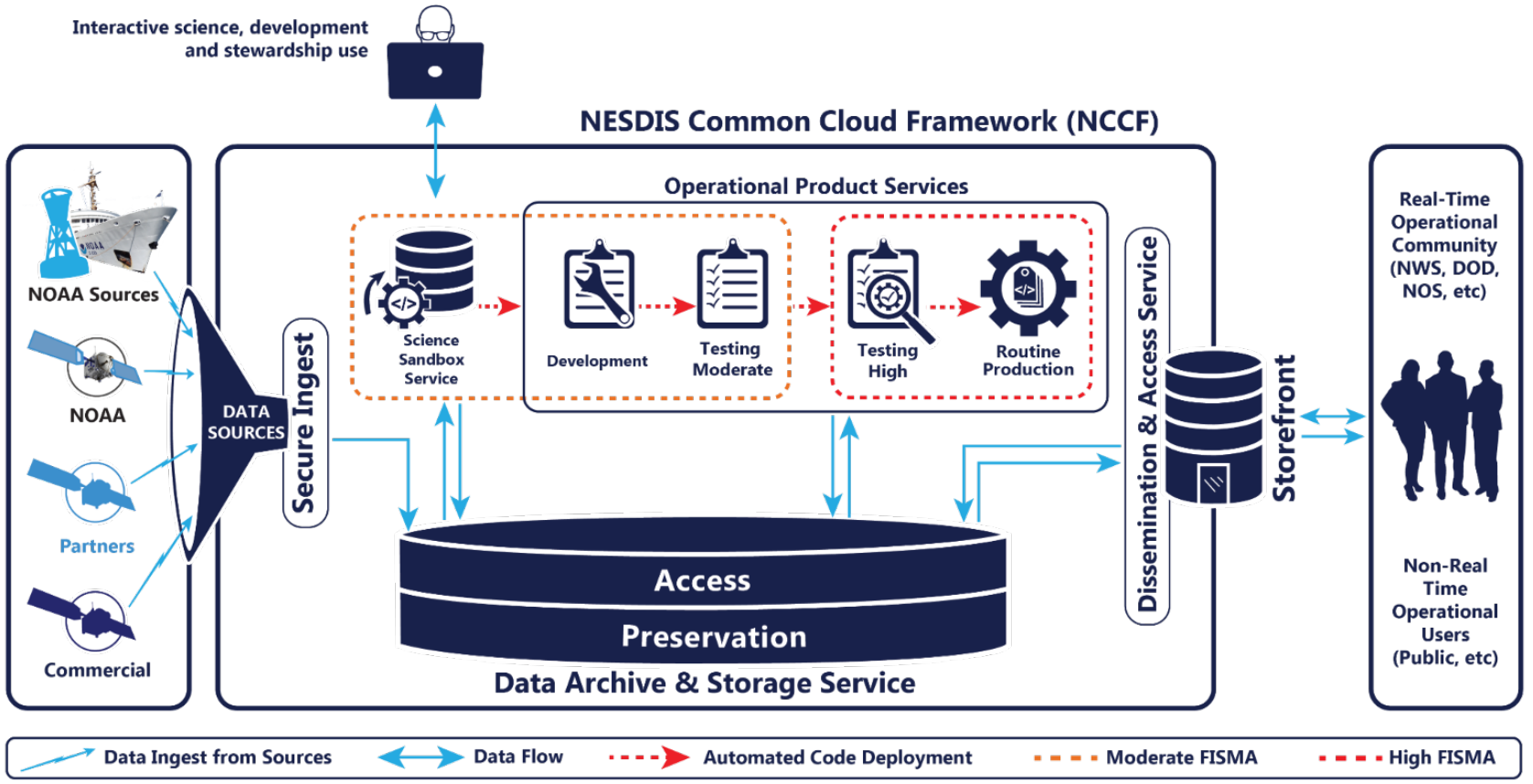
Incorporation of Alternatives into NESDIS Enterprise Architecture

Evolution of cost-sustainable flight/ground operations is realized by:

- Incorporating New, Breakthrough, and Disruptive Technologies
- Adoption of Enterprise Common Services and use of cloud-based Enterprise infrastructure
- Establishing Strong Capability Engineering to streamline end-to-end operations from detector to user, based on an Enterprise framework
  - Changing all Requirements Development to to deliver user-centric end products
  - Instituting a mechanism to continuously evaluate all Requirements to ensure they remain relevant and effective

A Data-Centric Enterprise Cloud Vision for NESDIS

- The NESDIS Common Cloud Framework (NCCF) provides a new concept of operations - to consolidate its operational workloads around centralized data, enable innovative science, and enhance data discovery
- Benefits of the NCCF include:
  - Consolidated and improved access to NOAA data holdings
  - Innovative science potential with AI/ML tools and centralized data
  - Faster research to operations transition for code updates
  - Improved system performance through automation and cloud redundancy
  - Increased traceability of cost and data use



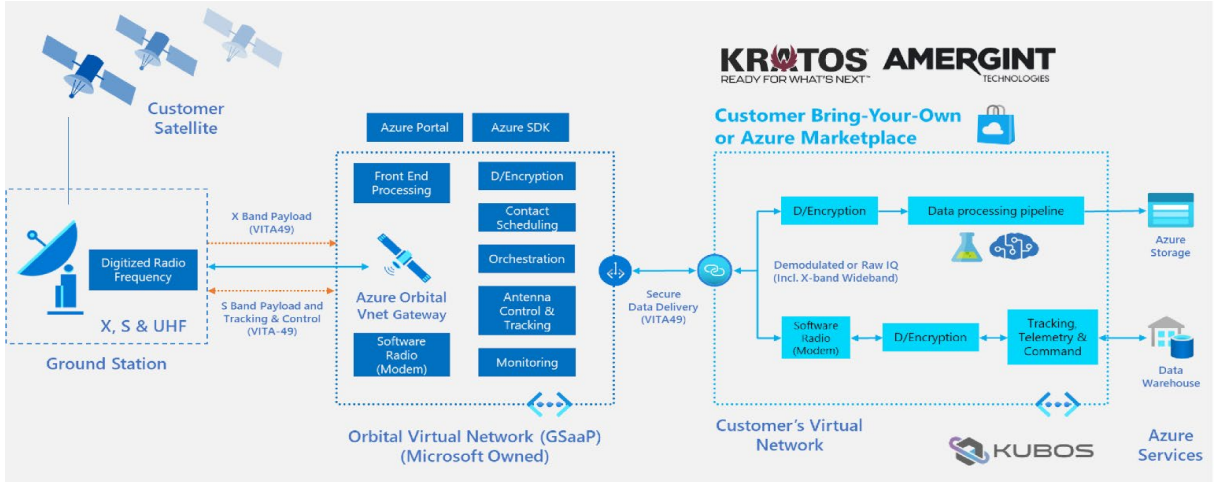
NCCF is a flexible, scalable, highly available and secure suite of cloud services to provide environmental data and science operations functionality

Cloud Based Satellite Operations - A Case Study

- NOAA entered into a CRADA to demonstrate Microsoft Azure Orbital Commercial Command, Control and Communication (C3) Capabilities on July 13, 2021; completed on April 7, 2022
  - NOAA-18 was selected to support any POES CRADAs due to its minimal risk to ongoing POES Operations and Technical Capabilities (e.g., unencrypted commanding, zero propellant).
  - Azure Orbital utilized its Quincy Washington Microsoft Ground Station and West Coast Azure Cloud Environment
  - Azure partnered with KUBOS to utilize their MajorTom Command and Control (C2) services; Services Available on the Azure Marketplace
- As a demonstration, Azure successfully used NOAA OCIO's enterprise ICAM and ERAV VPN isolation capabilities

Demonstrated viability for Rapidly Deployed Cloud Based Command and Control Services

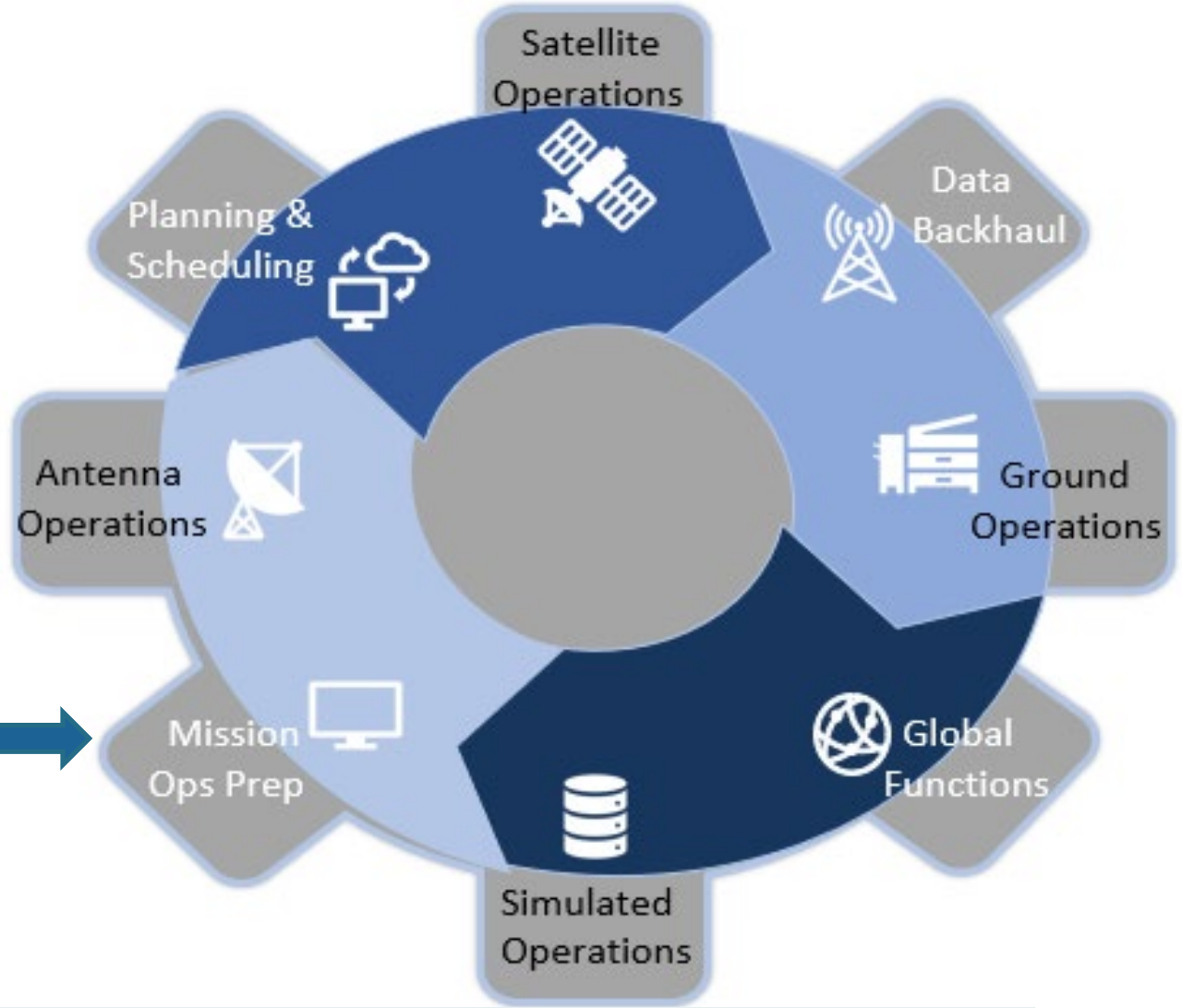
CRADA Scope		
Objective 1	Demonstrate the ability to support mission control	August 2021 ✓
Objective 2	Demonstrate RF Uplink and Downlink Compatibility with NOAA-18	January 2022 ✓
Objective 3	Demonstrate the ability to conduct mission operations	April 2022 ✓



NOAA Completes Cloud-Based Satellite Operations Testing with Microsoft | NESDIS

Commercial Services Evolution

- The Commercial Services IPT is an **OCS led initiative** formed to:
  - Investigate the commercial sector's ability to support **OCS' establishment of a NESDIS cloud-based common services enterprise ground system**
  - Evaluate suitability for adoption of **enterprise aligned** commercial capabilities into OSGS provided common services
  - Identify a common set of approaches to incorporate **core NESDIS Satellite Communications and Mission Operations (SCM/MOP) capabilities** into the NESDIS Common Cloud Framework (NCCF)



Tailored Market Research in service of NESDIS Tactical and Strategic Objectives

Commercial Service Evolution - Activities Overview

- **Phased Array Antennas (PAA) - L3Harris Phased Array CRADA (Completed 12/31/23)**
  - Completed in situ field testing of phased array capabilities against NESDIS mission sets at FCDAS

Enterprise on-ramp considerations
- PAA Technology advancement is emerging and fluid
  - USSF awarded $1.4B in FY22 to Blue Halo for development
- Disruptive technology and/or industry-funded efforts may significantly drive down costs
- NESDIS should continue to monitor advances and conduct market research
  - NESDIS needs high TRL functionality for X/Ka-band downlink

Technology attributes
- Emerging TRL
- Current capabilities are limited (L/S-band)
- Scalable and extensible to new missions
- Strong LEO business case - GEO/SW unproven
- Reduced hardware footprint
- SDR integrated with PAA in some designs

- **Cloud Based Mission Operations (MOP) - POES Extended Life Acquisition (Commercial Contract ongoing through 2026)**
  - **EASI –** JPSS antenna Scheduling and Mission Management development ongoing in FY24
  - **MOP Business Case - Developed** and briefed in FY24

Enterprise onramp considerations
- High TRL
- Number one NGES study recommendation
- Next step in NESDIS roadmap progression

Technology attributes
- POES EL is underway FY22 – FY25
- Cloud-based, virtual platform solutions and hybrid approaches
- Interoperable across AWS and MS Azure Cloud Service Providers (CSPs)
- Modular, flexible, scalable architecture
- Primarily LEO w/ some applicability to GEO and SWFO

Commercial Service Evolution - Activities Overview

Cloud Based Software Defined Radios (SDR) - Broad Agency Announcement (BAA) FY24

- Vendor conducted demonstrations of cloud-based software defined radio (SDR) capabilities
- Assess feasibility for incorporation into NCCF in support of NESDIS enterprise aligned common service objectives

Enterprise on-ramp considerations

- Cybersecurity implementation evaluation underway by ACIO-S
  - Radios historically considered an appliance
  - NIST has recently circulated draft guidance
  - USSF cybersecurity testing conducted by OSPO/ACIO-S
- Differences in cloud-based versus virtual hardware need to be evaluated

Technology attributes

- Mature TRL
- Interoperable with AWS and MS Azure Cloud Service Providers (CSPs)
- Modular, flexible, scalable architecture
- Support LEO, GEO, SWO – extensible to new missions
- Reduces hardware footprint and associated OM&S costs

Space Based Data Relays (SBDR) - SAE Ground BAA FY24

- Market Research for rapidly emerging commercial SBDR capabilities
- Multiple awards for FY24 vendor studies and demonstrations

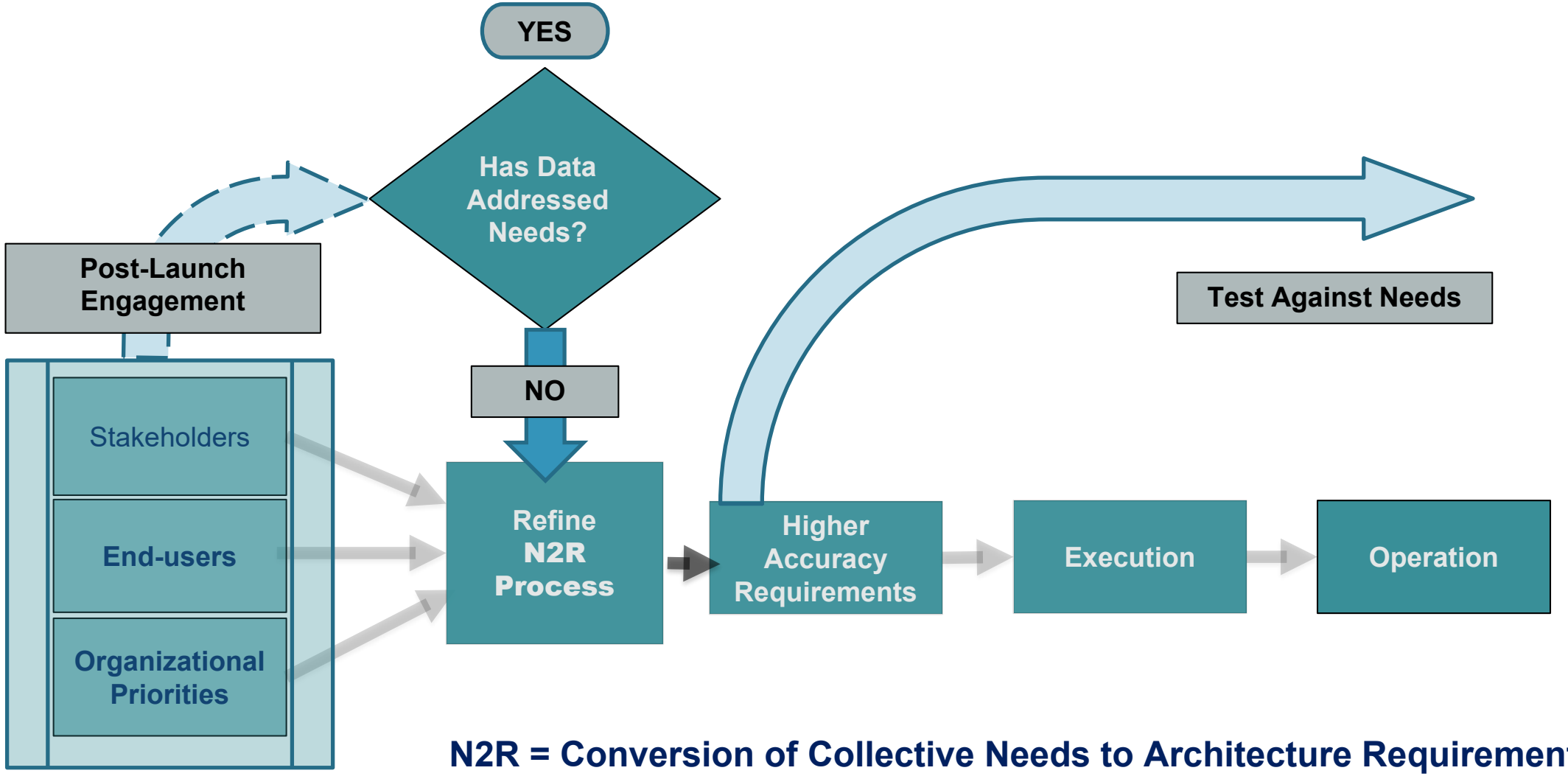
Enterprise on-ramp considerations

- Rapidly emerging commercial utilization
- Interoperability and Orchestration
- Mesh network – many to many – untethered to ground stations
- TDRSS – NASA targeting commercial service replacement by 2030

Technology attributes

- Maturing TRL
- Space Development Agency (SDA) OISL open standards for interoperability
- High-rate data, low latency (real time), increased security
- Modular, flexible, scalable architecture
- Reduced NTIA spectrum compliance

Needs-Based Iterative Refinement of Requirements



N2R = Conversion of Collective Needs to Architecture Requirements

Conclusions

- Today's siloed NESDIS Ground Systems must strategically evolve to meet the needs of the forecasted satellite constellations that will meet future NESDIS data needs
- Emerging technologies allow for a consolidated Enterprise Architecture that will meet most cross-constellation business requirements
- Satellite Operations Alternatives will be analyzed in a Programmatic Risk Based Manner
- Change to the processes and culture are in work to evolve to an Enterprise Architecture that enables NESDIS strategic objectives and future operational needs through 2030-2050