Sensor performance Assessment Team (SAT)

NESDIS Ground Enterprise Study NGES

Dr. Raad A. Saleh
NGES Lead
Office of System Architecture and Advanced Planning
NESDIS, NOAA

March 7, 2022

National Environmental Satellite, Data, and Information Service, NOAA

Why NGES

To support the realization of NESDIS Strategic Objective #4: Develop agile, scalable ground capability to improve efficiency of service deliverables and ingest of data from all sources.

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

NGES Architectural Objectives

The Outcomes of NGES:

- Ground Enterprise **target architecture** for 2035-2050 timeframe
- **Capability Roadmaps** to inform decisions for coming decade
- Disciplined, effective and repeatable **decision-making processes**
- **Analytical tools and architectural products** to support ongoing planning
- Integrating NOAA's next-gen data science and ground services with our next-gen space-based Earth observation capabilities

Advancing Data Science and Information Services

TODAY'S GROUND SERVICE

- **Single system data services**
- **Limited computing power**

Data collected & transmitted from single observation system

Delivery to NOAA Users

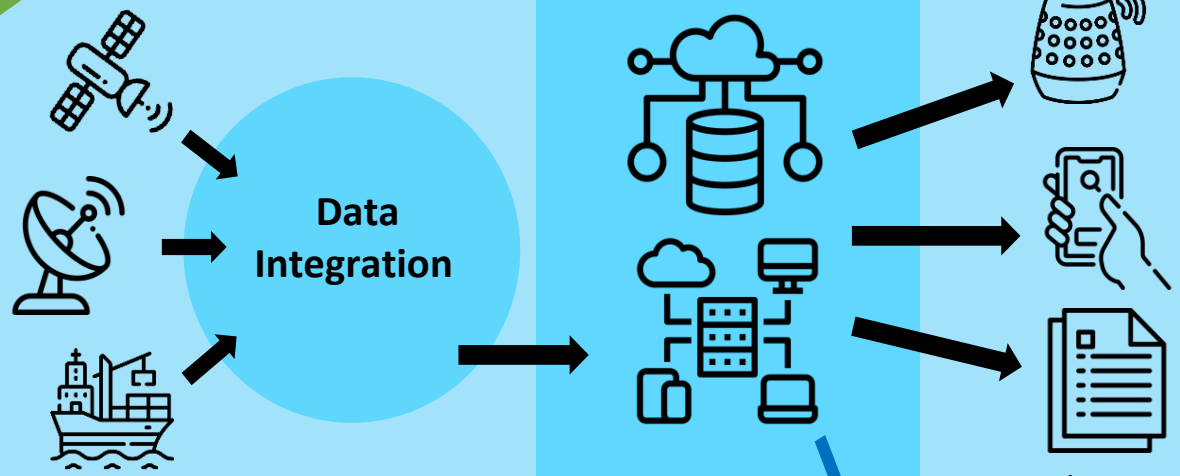
Development of products & services

Forecasts, warnings, watches

Evolving the ground system to meet future observational needs

TOMORROW'S GROUND SERVICE

- **Secure ingest for all data types**
- **Powered by AI, data science**
- **High performance computing capability, cloud-based data storage, stewardship & access**



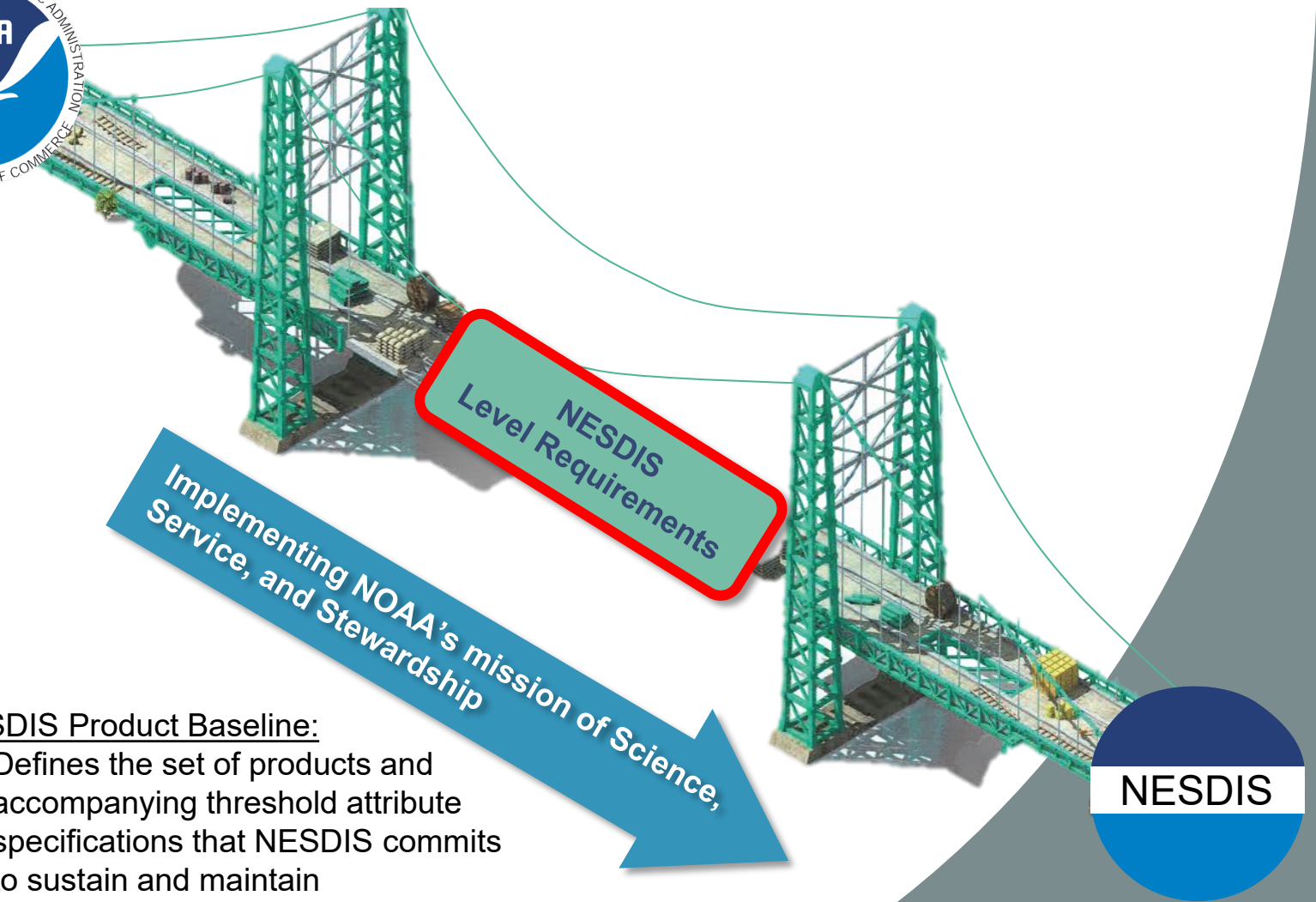
Data collected from multiple sources: International, Commercial, USGS Partners

Cloud-based capabilities

Development of new products & services delivered in new ways to more users

Co-located Earth system data available for ***Data-Driven Science***

NESDIS Level Requirements



NESDIS Product Baseline:

- Defines the set of products and accompanying threshold attribute specifications that NESDIS commits to sustain and maintain

REQ-001
NESDIS will provide environmental data, information, products, services, and reports in the Foundational, Geophysical, and Analytical thematic product areas.

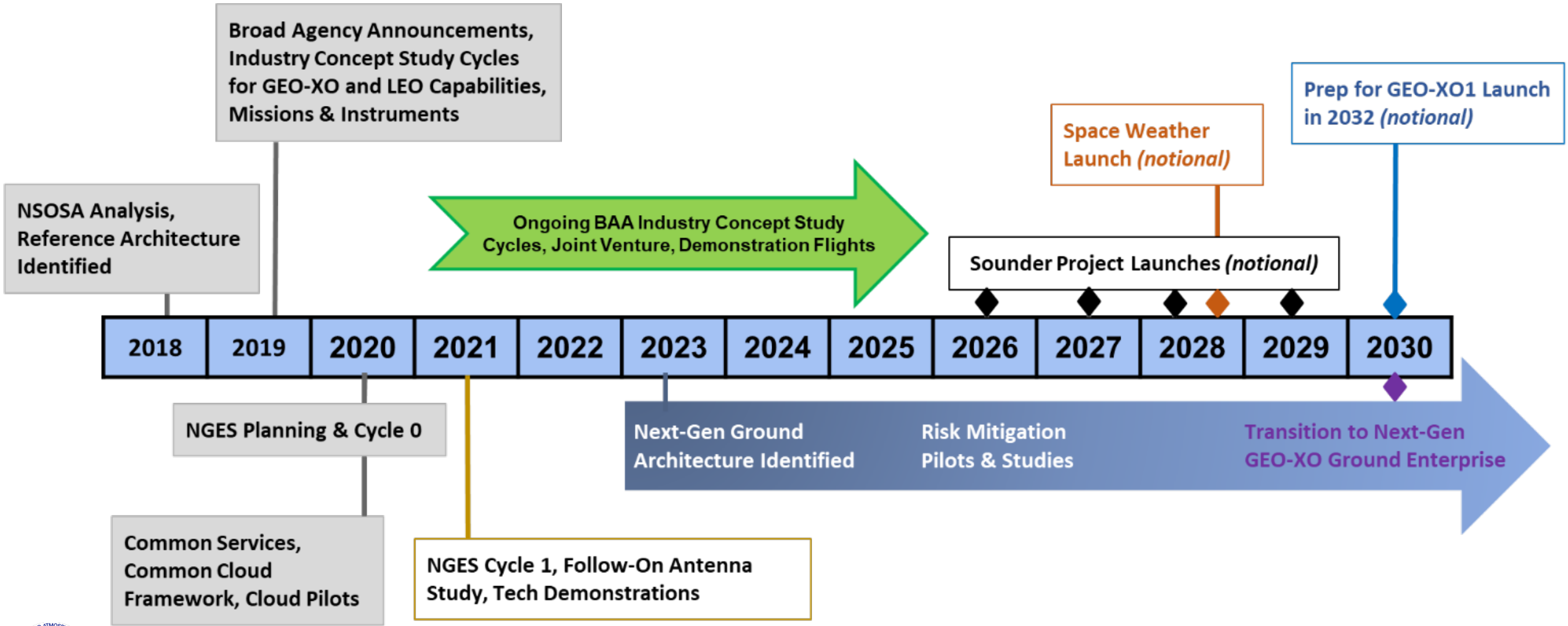
REQ-002
NESDIS will develop, acquire, implement, or operate environmental data sources and systems as needed to fulfill its validated user requirements.

REQ-003
NESDIS will provide secure, timely, and reliable delivery of accurate and high-quality near real-time and retrospective data products and reports to fulfill NOAA's mission.

REQ-004
NESDIS will ensure the quality, accuracy, reliability, preservation, discoverability, and accessibility of the Nation's historical sensor, environmental, and model data archives consisting of data from NOAA, U.S., and global observing systems.

REQ-005
NESDIS will conduct an integrated program of research and technology development in the application of observing systems, data systems, products, and reports to support NOAA's mission.

Strategic Integration and Evolution



Study Methodology

Functions / Goals
NOAA Operational
NOAA Non-Operational)

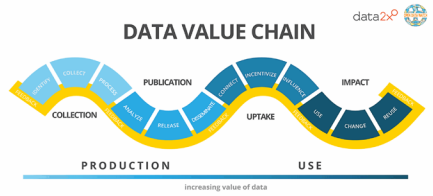
NOAA Leadership Priorities

Strategic & Cost Goals
Ground Mission Value

NGES Study

Results

High-Value Alternative Architectures

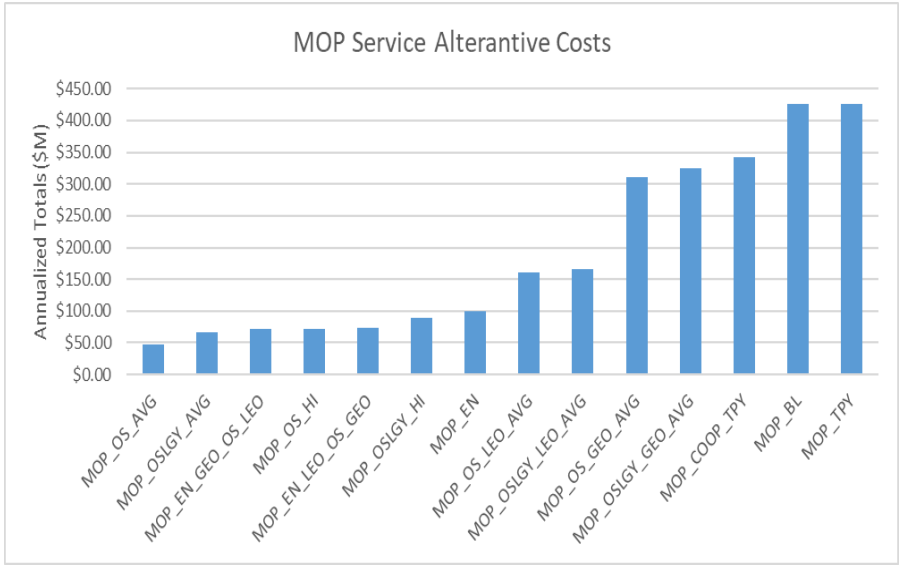


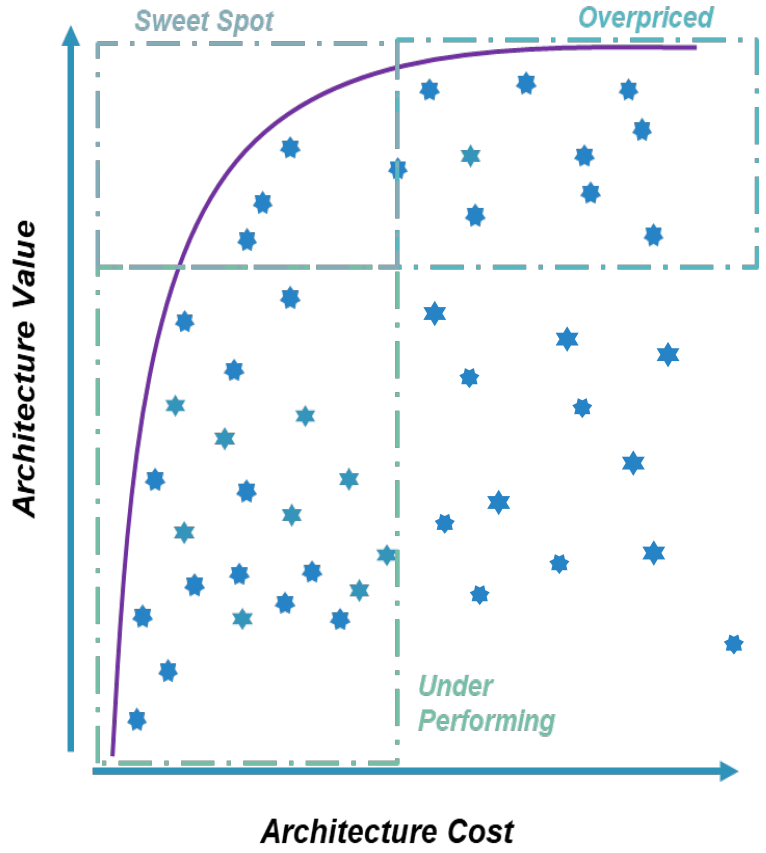
NESDIS Offices and Programs

Enterprise Ground
Software and Hardware capability and capacity

NGES Utility Model

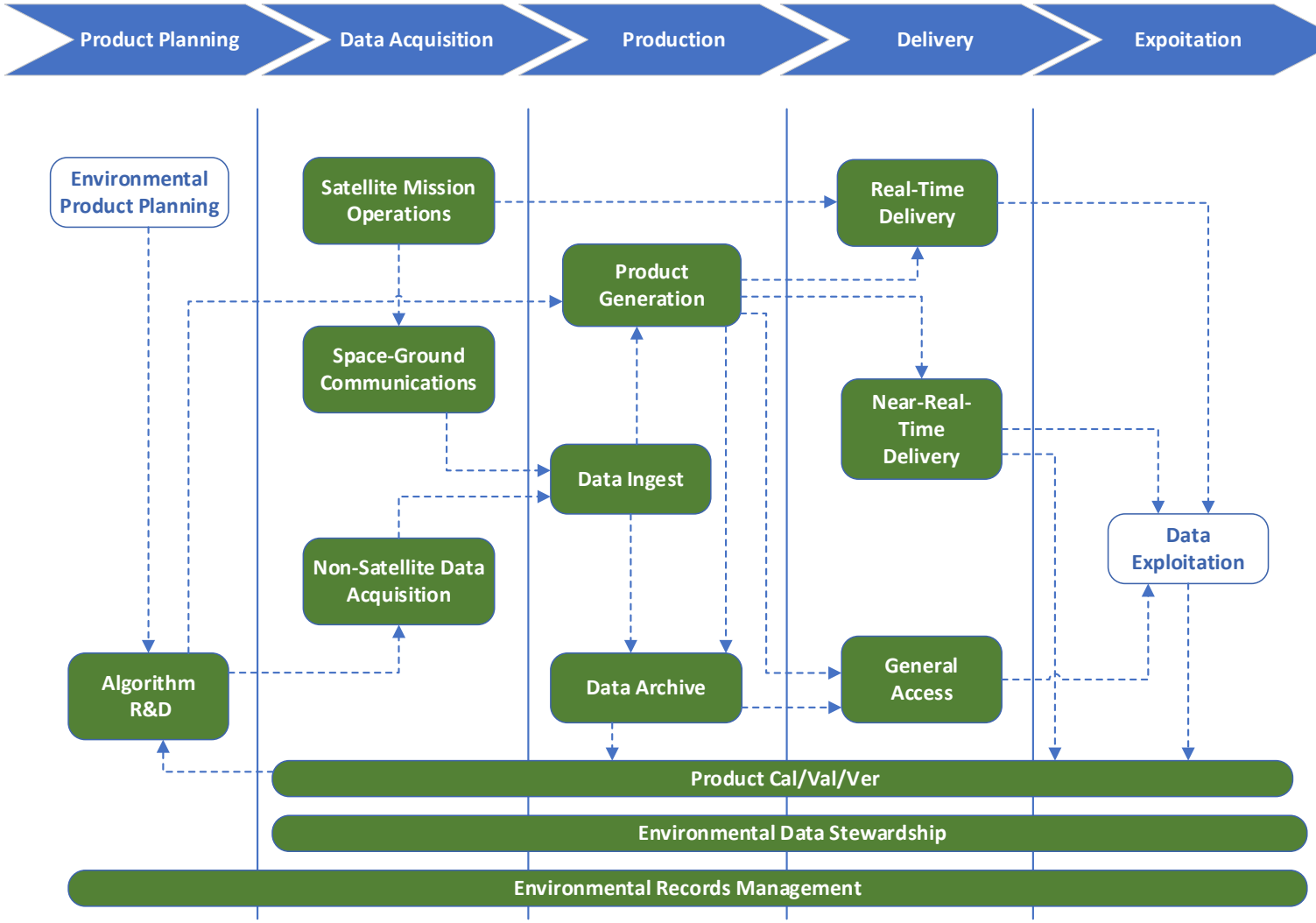
Strategic Objective (Level1)	Attribute (Level 3)	Baseline Assessment	Alt 1: Outsourced Assessment	Alt 5: Enhanced Assessment
Flexible Operations	Operations Portability	R	Y	G
Flexible Operations	Vendor Neutrality	R	Y	G
Adaptable Operations	Scalability / Mission Integration	G	Y	G
Resilient Operations	Degraded Operations (Velocity)	Y	Y	G
Resilient Operations	Degraded Operations (Durability)	R	G	Y
Resilient Operations	Technical Debt	R	G	Y
Resilient Operations	Security Adaptability	Y	R	G
Budgetary Performance	Operational Budget Predictability	R	G	Y





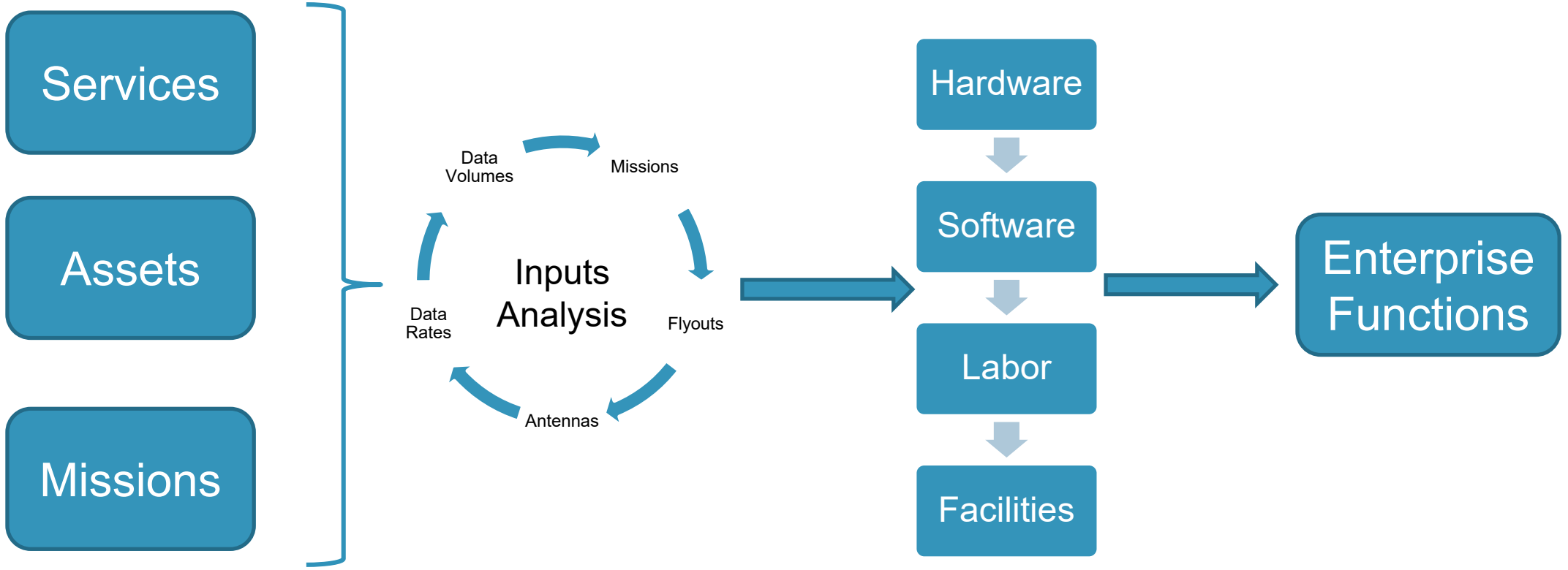
Operational costs are for FY42

NESDIS Value Chain



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

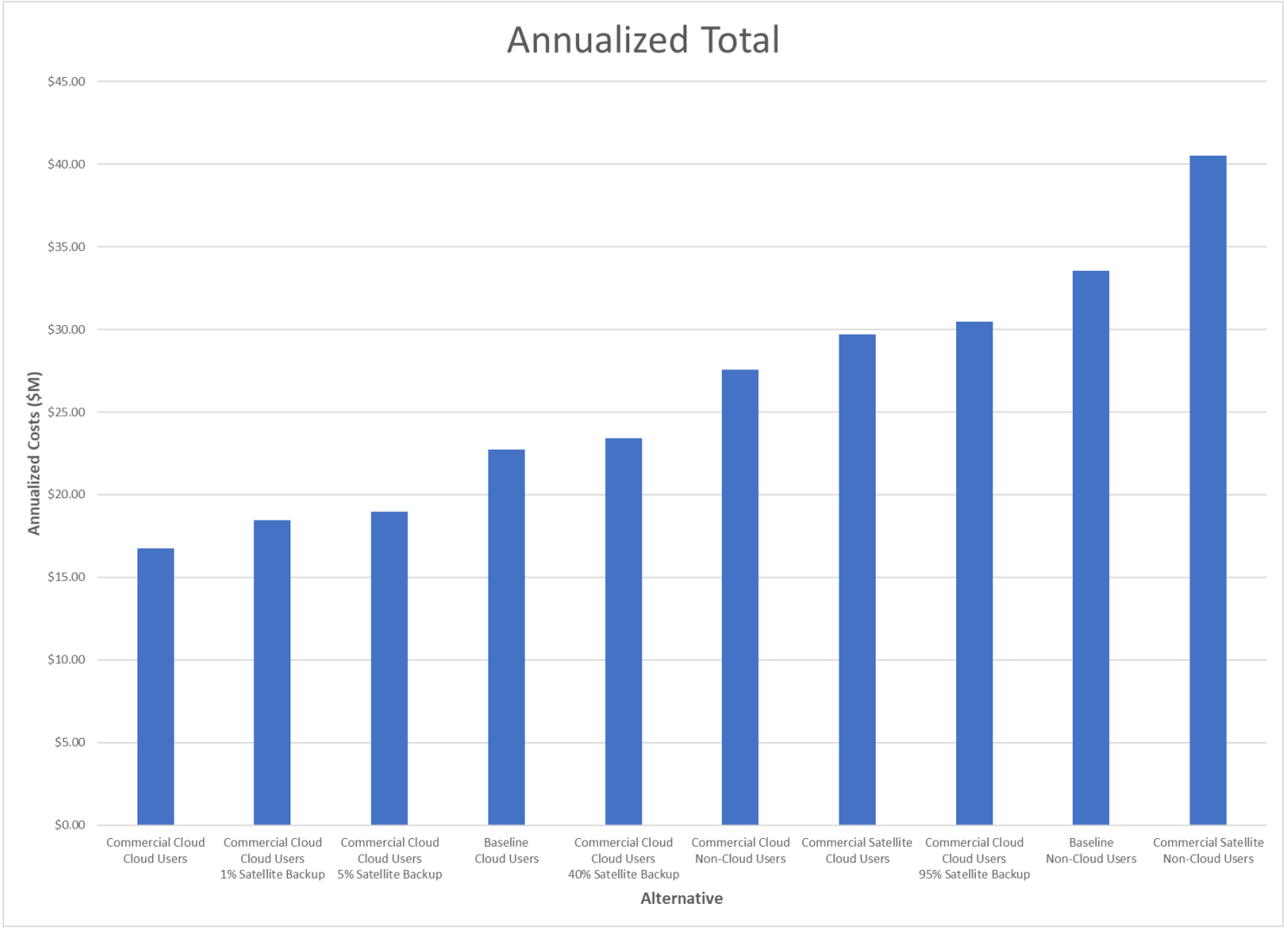
Cost Model


Services
Assets
Missions
Data Volumes
Missions
Data Rates
Inputs Analysis
Flyouts
Antennas
Hardware
Software
Labor
Facilities
Enterprise Functions

Data Delivery (DD)

Data Delivery DD Alternatives Costs

- Commercial Cloud Distribution has a better cost performance than baseline & satellite distribution
- Stakeholder Cloud Adoption is a significant cost driver
- Cost for providing Satellite-based backup is variable
- Optimizing Stakeholder Cloud adoption can make satellite-based backup competitive



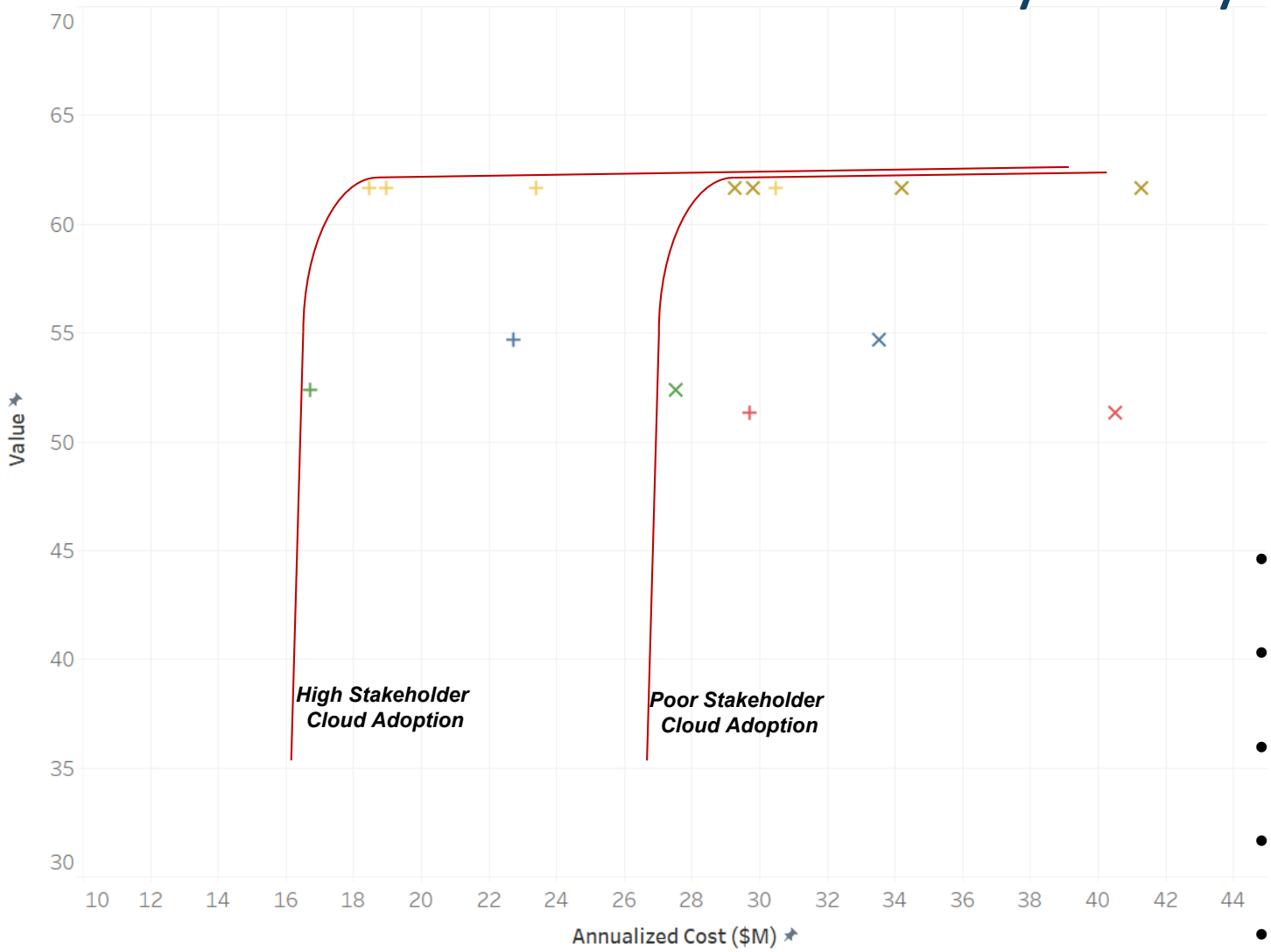
Operational estimates are for FY42

Data Delivery Value Assessment

- Commercial Satellite Broadcast
  - Pros: Spectrum Adaptability; Scalability; Multi-mission; Resilience
  - Cons: Dynamic Data Acquisition; Vendor Neutrality
- Cloud Distribution
  - Pros: Spectrum Adaptability; Budget Predictability; Portability; Technical Debt
  - Cons: Observation Availability; Latency; Vendor Neutrality

Strategic Objective (Level1)	Attribute (Level 3)	Baseline	Cloud Distribution	Commercial Satellite Rebroadcast
Adaptable Operations	Dynamic Data Acquisition	Y	Y	R
Adaptable Operations	RF Spectrum Adaptability	Y	G	G
Adaptable Operations	Scalability / Mission Integration	Y	Y	G
Budgetary Performance	Operational Budget Predictability	Y	G	Y
Enterprise Performance	Observation Availability	Y	R	Y
Enterprise Performance	Latency	Y	R	Y
Flexible Operations	Multi-Mission	Y	Y	G
Flexible Operations	Operations Portability	Y	G	Y
Flexible Operations	Vendor Neutrality	Y	R	R
Resilient Operations	Degraded Operations (Durability, MTBF)	Y	Y	G
Resilient Operations	Degraded Operations (Velocity, MTTR)	Y	Y	Y
Resilient Operations	Security Adaptability	Y	Y	Y
Resilient Operations	Technical Debt	Y	G	G

Data Delivery Utility Analysis



User Cloud Adoption
+ Cloud Users
× Non-Cloud Users

DD
- Baseline: Cloud Users
- Baseline: Non-Cloud Users
- Commercial Cloud: Cloud Users
- Commercial Cloud: Cloud Users: 1% Satellite Backup
- Commercial Cloud: Cloud Users: 5% Satellite Backup
- Commercial Cloud: Cloud Users: 40% Satellite Backup
- Commercial Cloud: Cloud Users: 95% Satellite Backup
- Commercial Cloud: Non-Cloud Users
- Commercial Cloud: Non-Cloud Users: 1% Satellite Backup
- Commercial Cloud: Non-Cloud Users: 5% Satellite Backup
- Commercial Cloud: Non-Cloud Users: 40% Satellite Backup
- Commercial Cloud: Non-Cloud Users: 95% Satellite Backup
- Commercial Satellite: Cloud Users
- Commercial Satellite: Non-Cloud Users

- Cloud adoption for non-operational users impacts all alternatives
- Commercial SatCom is more expensive than baseline & lower value
- Cloud Based distribution outperforms BL on cost, but has lower value
- Satellite Backup to Cloud is potentially cost competitive with baseline and has better value
- Solution Cost depends on stakeholder Cloud adoption

Operational estimates are for FY42

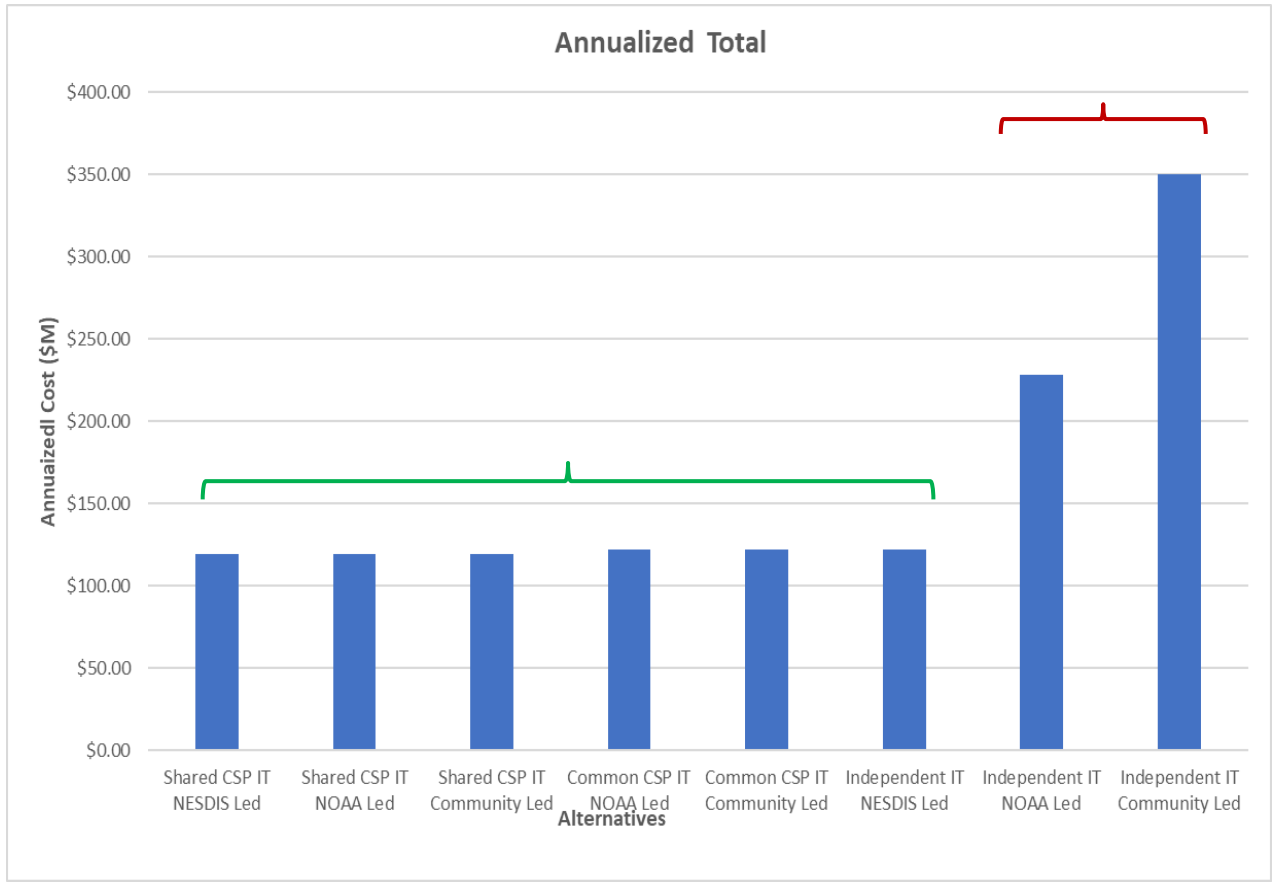
Data Delivery Analysis Insights

- Migration to Cloud based delivery has significant cost benefits
- Providing backup to Cloud based delivery for high availability products provide best utility
- Stakeholder Cloud adoption is key to managing operational costs

Algorithm Operations (AO)

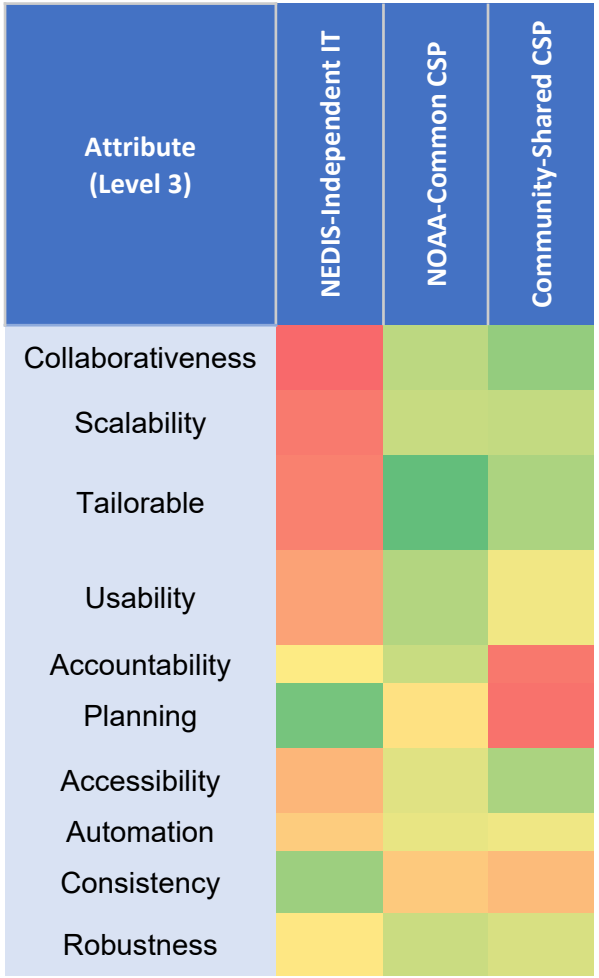
Algorithm Operations Alternatives Cost

- Independent IT infrastructure incurs egress costs for supporting broader science community engagement
- All other architectures are relatively independent of cost



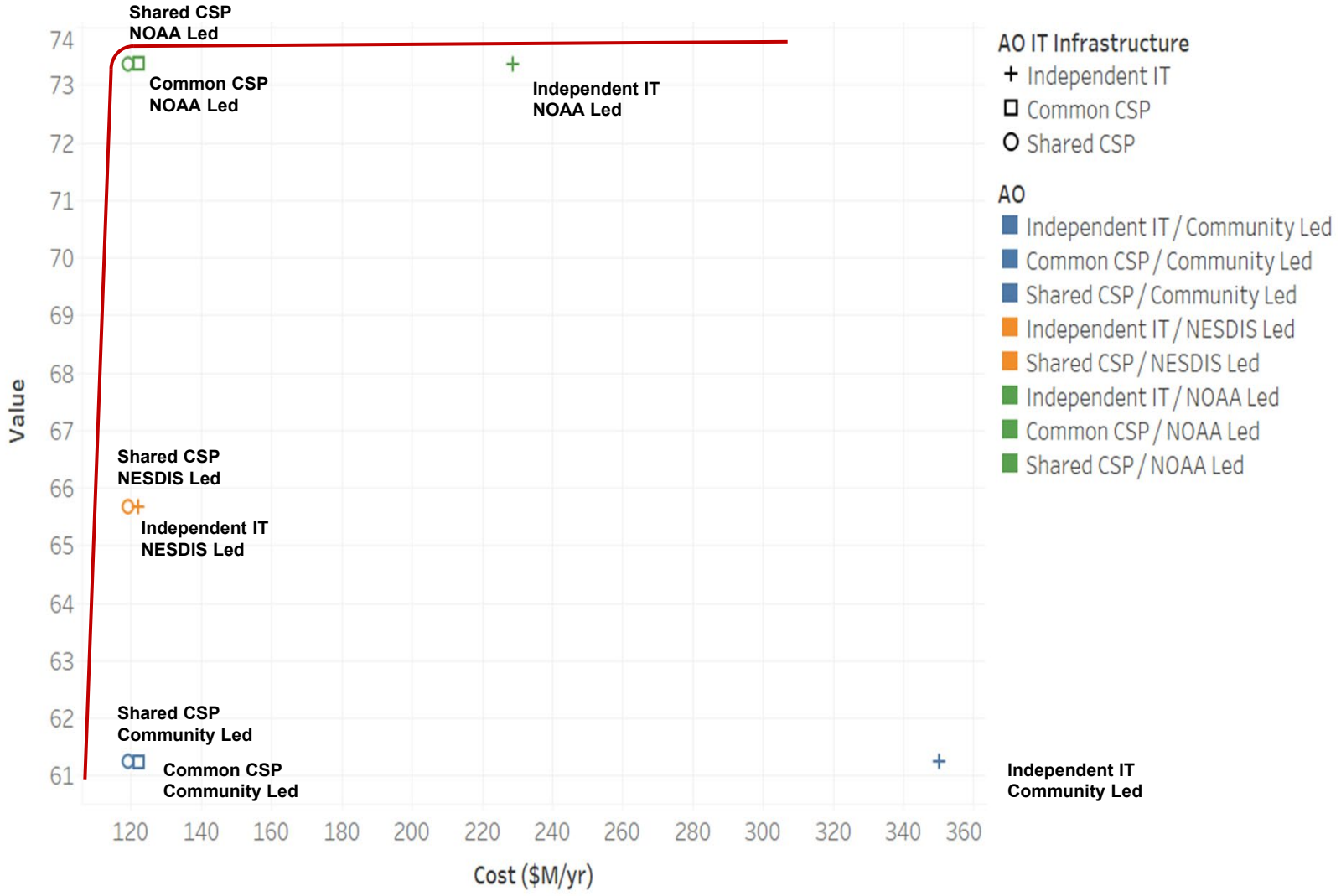
Operational estimates are for FY42

Algorithm Operations Value Assessment



- NOAA Led Science is preferred
  - Balance between
    - Collaboration provided by broader community engagement
    - Control provided by a NESDIS Led Science and
- Federal IT infrastructure is preferred
  - Enhances
    - Adaptability of Common CSP
    - Robustness and accessibility of larger deployment base

Algorithm Operations Utility Analysis



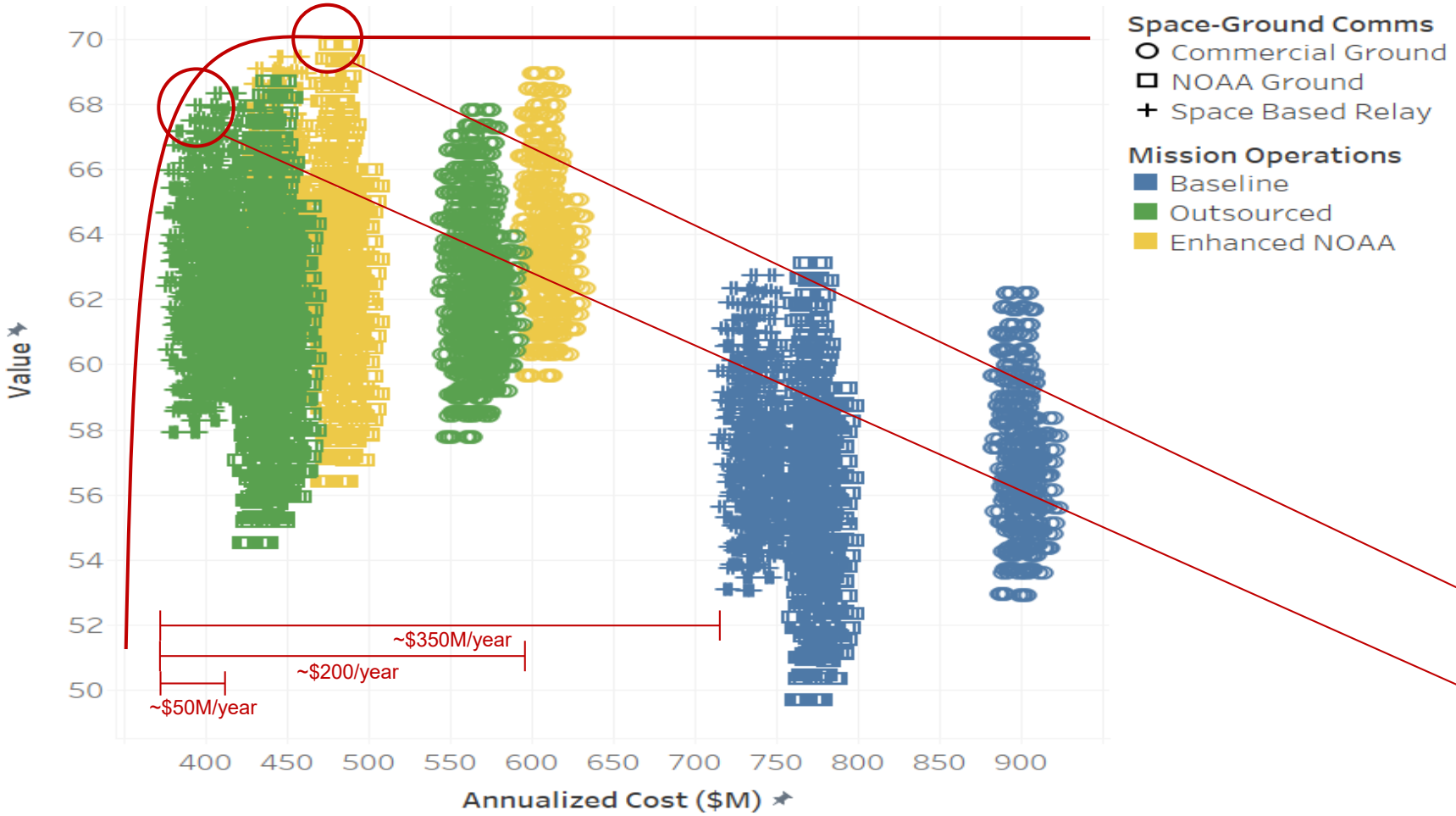
- The Common CSP approach when combined with a NOAA led science business approach prides the optimum utility
- Extending to a shared CSP infrastructure has marginal additional costs benefits
- Regressing to an Independent IT infrastructure has no significant benefits and potentially significant cost risk

Operational estimates are for FY42

Algorithm Operations Analysis Insights

- The current path of migrating NESDIS IT infrastructure services for Environment Science R&D to at a Cloud infrastructure is validated
- Extending this approach to Common CSP solution accessible NOAA-wide provides the optimal utility to the enterprise
- Although extending further into a Shared CSP environment does not add significant benefit to NESDIS it may have enhanced benefits for the R&D community

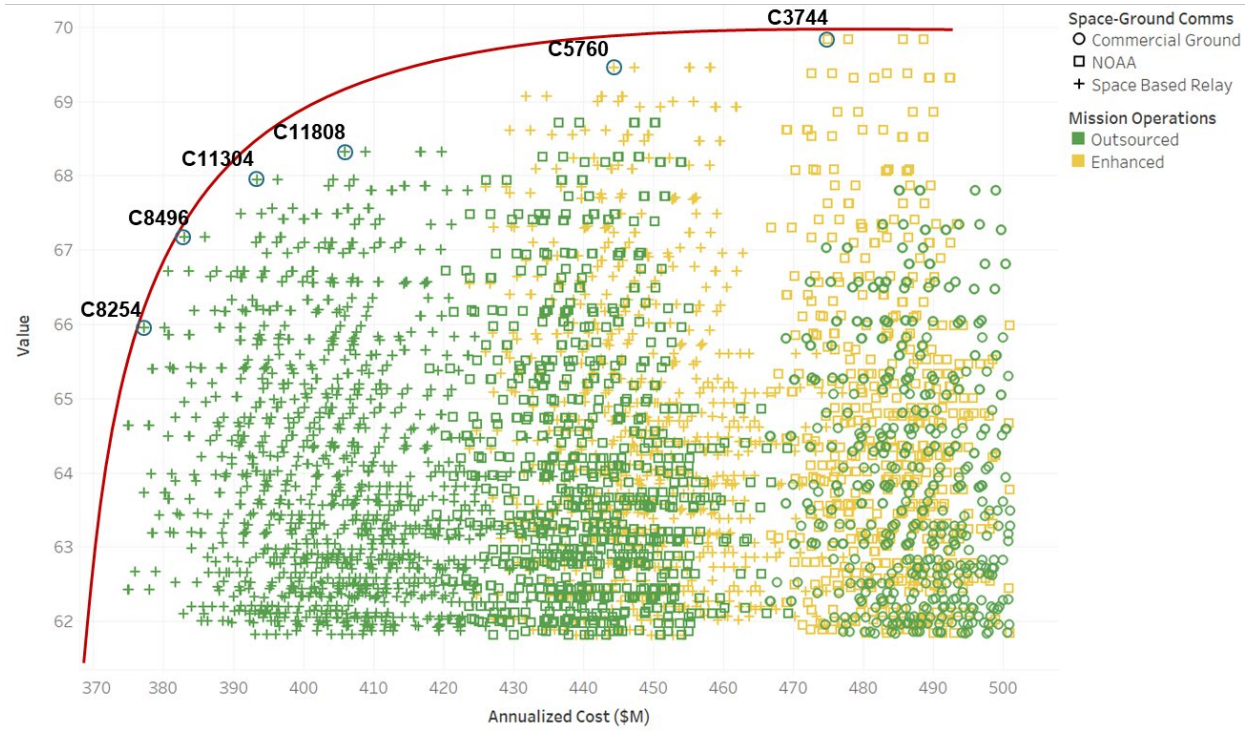
Integrated Analysis



- Each Symbol represents a complete solution
  - All 6 Functions
- Mission Operations has the greatest impact on cost
- Space-Ground Coms has next greatest impacts
- All Other functions have significantly less impact
- Optimal Utility is found between:
  - Enhanced NOAA Ops using NOAA Ground Stations, and
  - Outsourced Mission Ops using Space Based Relay

Operational estimates are for FY42

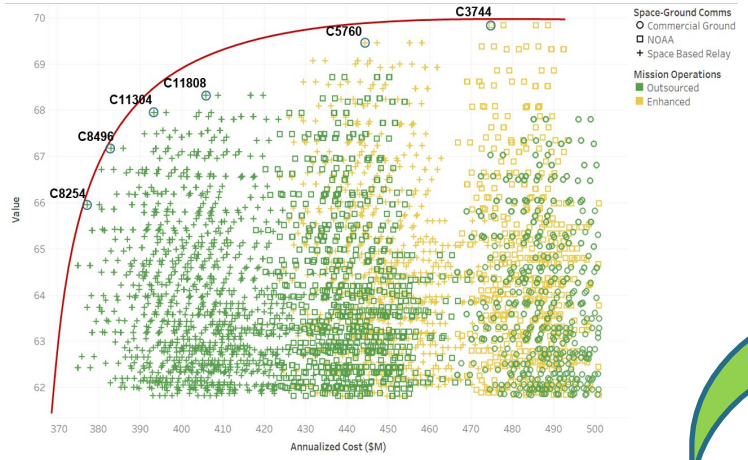
Sample of Highly Valued Solutions



Combo	8254	8496	11304	11808	5760	3744
Cost ($M/yr)	$375	$383	$393	$406	$444	$475
Value	65	67	68	68	70	70
Flexibility						
Adaptability						
Budget						
Performance						
Resiliency						
Space/Ground Coms	Space Based Relay	Space Based Relay	Space Based Relay	Spaced Based Relay for LEO Next Gen NOAA for GEO & SWO	Spaced Based Relay for LEO Next Gen NOAA for GEO & SWO	Next Gen NOAA
Mission Ops	Outsourced	Outsourced	Outsourced NSOSA Missions Only	Outsourced NSOSA Missions Only	Enhanced NOAA Operations NSOSA Missions Only	Enhanced NOAA Operations NSOSA Missions Only
Product Ops	On-demand	On-demand	On-demand	On-demand	On-demand	On-demand
Data delivery	Cloud High Stakeholder Adoption	Cloud High Stakeholder Adoption 5% Rebroadcast	Cloud High Stakeholder Adoption 5% Rebroadcast	Cloud High Stakeholder Adoption 5% Rebroadcast	Cloud High Stakeholder Adoption 5% Rebroadcast	Cloud High Stakeholder Adoption 5% Rebroadcast
Algorithm Operations	Shared CSP NOAA Led Science	Shared CSP NOAA Led Science	Shared CSP NOAA Led Science	Shared CSP NOAA Led Science	Shared CSP NOAA Led Science	Shared CSP NOAA Led Science
Environmental Information	L0, L1, L2 Single Copy	L0 & L1 2nd Copy	L0 & L1 2nd Copy	L0 & L1 2nd Copy	L0 & L1 2nd Copy	L0 & L1 2nd Copy

Operational estimates are for FY42

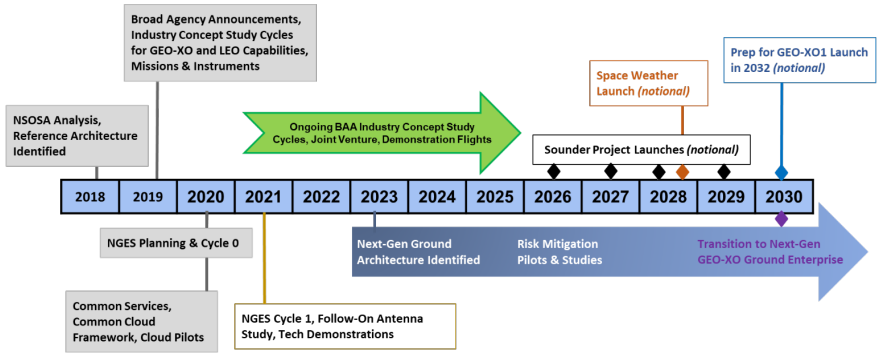
Capability Development Cycle



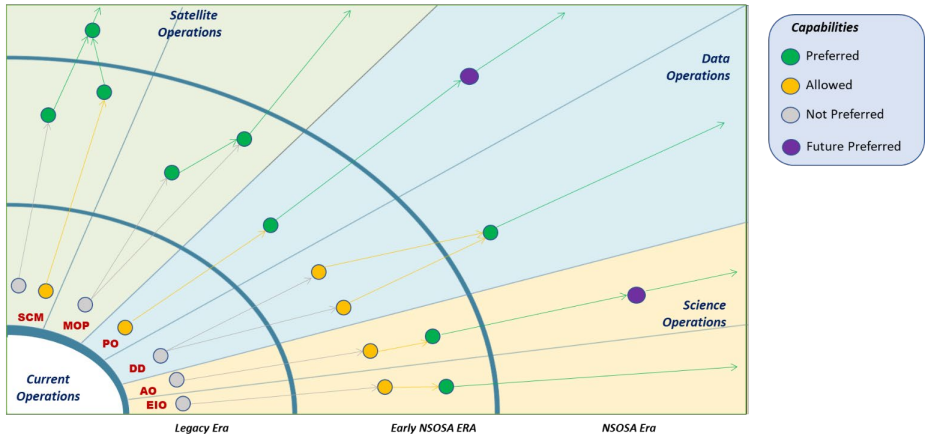
Alternative Analysis

Combo	8254	8496	11304	11808	5760	3744
Cost ($M/yr)	$375	$383	$393	$406	$444	$475
Value	65	67	68	68	70	70
Flexibility						
Adaptability						
Budget						
Performance						
Resiliency						
Space/Ground Coms	Space Based Relay	Space Based Relay	Space Based Relay	Spaced Based Relay for LEO Next Gen NOAA for GEO & SWO	Spaced Based Relay for LEO Next Gen NOAA for GEO & SWO	Next Gen NOAA
Mission Ops	Outsourced	Outsourced	Outsourced NSOSA Missions Only	Outsourced NSOSA Missions Only	Enhanced NOAA Operations NSOSA Missions Only	Enhanced NOAA Operations NSOSA Missions Only
Product Ops	On-demand	On-demand	On-demand	On-demand	On-demand	On-demand
Data delivery	Cloud High Stakeholder Adoption	Cloud High Stakeholder Adoption 5% Rebroadcast	Cloud High Stakeholder Adoption 5% Rebroadcast	Cloud High Stakeholder Adoption 5% Rebroadcast	Cloud High Stakeholder Adoption 5% Rebroadcast	Cloud High Stakeholder Adoption 5% Rebroadcast
Algorithm Operations	Shared CSP NOAA Led Science	Shared CSP NOAA Led Science	Shared CSP NOAA Led Science	Shared CSP NOAA Led Science	Shared CSP NOAA Led Science	Shared CSP NOAA Led Science
Environmental Information	L0, L1, L2 Single Copy	L0 & L1 2nd Copy	L0 & L1 2nd Copy	L0 & L1 2nd Copy	L0 & L1 2nd Copy	L0 & L1 2nd Copy

Recommendation Solutions

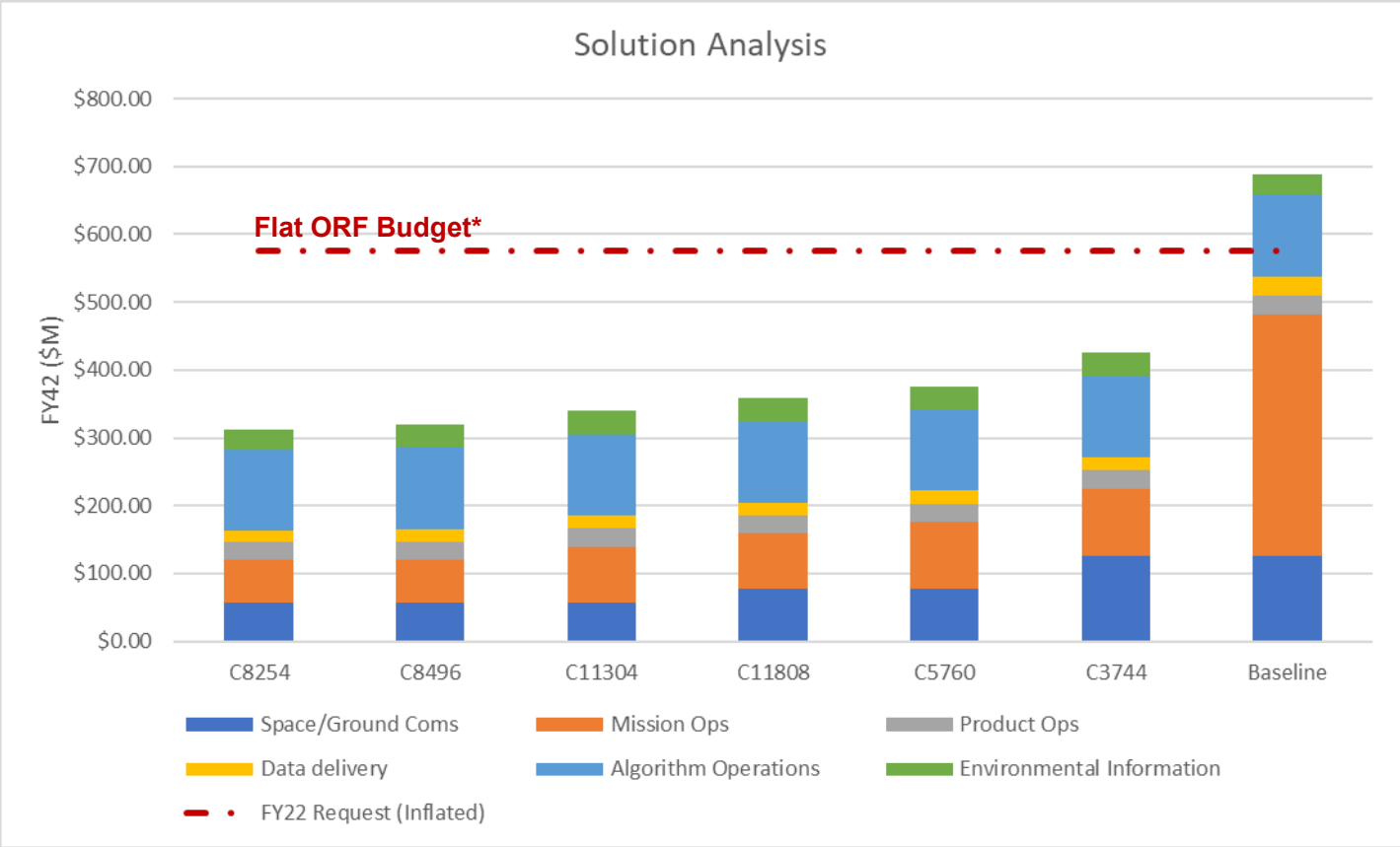


Integration into the Ground Enterprise



Strategic Roadmaps

Solution Cost Comparison



*ORF Includes OSPO, STAR & NCEI

Mission Cadence in NSOSA era will drive costs to exceed current spending levels

- ORF increases from 17% to 21% of Budget

Most alternatives considered can reduce O&M costs to below current spending

- ORF ranges from 9% - 13% of budget
- $160M/yr-$230M/yr (FY22 $'s) cost avoidance over Baseline

Operational estimates are for FY42

Cycle 2 Objectives

Cycle 2 will focus on three primary objectives. The first is determining tactical activities that are most relevant to existing and proposed flight programs. The second is to define and understand the most efficient structural alignment between flight and ground segments. Finally, the third is to refine and expand the results of Cycle 1 to further define the future end-state ground architecture.

Cycle 2 Plan

- Cycle 1 focused on developing solutions in the individual functional areas expressed by the most favorable future enterprise architectures
- Cycle 2 develops actionable capabilities roadmap to realize these future solutions
- Cycle 2 develops transformational business practices

Cycle 2 Plan

- ***Tactical – Infrastructure Transformation***
  - ***Focus on realizing the integrated ground enterprise to meet upcoming mission needs***
  - ***Emphasis on Assured Operations & Collaborative Science***

- ***Strategic – Business Transformation***
  - ***Focused on preparing NESDIS services for an expanded NOAA public service mission***
  - ***Emphasis on Flexible Operations & Open Science***

Cycle 2 Strategy

Tactical

- **Assured Operations**
- **Common Services**
- **Collaborative Science**
  - Collaborative Science SW Development (LO's & CI's)
  - Line Office Services (Product Development, Cal/Val, Exploitation)

Cycle 2 Strategy

Strategic

- **Flexible Operations**
- **Open Science**
  - Provider of operational environmental data across the Fed government
  - Science Community products services where NESDIS has a compliance and certification role
  - Transnational collaborative science environment

Guidance for Future Ground Development

- Current NESDIS operational services are not future proofed
  - Operational costs are projected to become a larger fraction of the NESDIS budget
  - NESDIS will need to change its business practices going forward in order to achieve affordable adaptability and resilience
- Adoption of new practices could significantly improve performance
  - Increased use of commercial services (Cloud, Ground Stations, & Comms)
  - Transitioning to demand-driven product services
- Coordination of technology deployment is key to success
  - Use of common services across the mission portfolios
  - Coordinate of migration to compatible services across the NOAA Line Offices XX

Summary

The NGES study is integral to the NESDIS Reimagine Strategic Objectives.

The NGES is aligned with the NSOSA vision to provide an integrated, adaptable and affordable enterprise for Space & Ground operations.

The NGES aims at providing a set of Ground Enterprise Capability Portfolio management & decision support products & processes.

Cycle 2 of NGES provides specifically defined tactical, structural, and strategic analyses that expand beyond the Cycles 0 and 1 goals.

Thank You

NGES POC

Raad A. Saleh, Ph.D.
NGES Lead, Office of System Architecture and Advanced Planning
National Environmental Satellite, Data, and Information Service, NOAA
1335 East West Highway, SSMC1
Silver Spring MD 20910
Mobile: (301) 215-0417
Email: Raad.Saleh@noaa.gov

Backup Slides

Basis of Cycle 2 Plan

- Exec Council Feedback
- Direction from OSAAP Leadership
- Offices and Programs
- Cycle 1 Results
- NGES Team

Cycle 2 Plan

- Tactical
- Structural
- Strategic

Cycle 2 Plan
Tactical

- NGES will provide guidance to flight programs
  - Reduce risk or mature technologies that will move each program toward the future enterprise ground solution

- Define demonstration and pilot projects that would support near-term strategic planning
  - Pilots will be independent of the flight programs
  - Used to reduce risk and enhance understanding of new capabilities
  - Provide a mechanism for establishing the future ground architecture.

Cycle 2 Plan

Structural

- NGES will determine and evaluate one or more NESDIS organizational structures
  - establish the most effective demarcation between flight programs and the enterprise ground
- NGES will develop alternatives for obtaining data and developing products from non-NOAA, non-commercial data
  - Understanding of the most appropriate decision-making process for obtaining those datasets

Cycle 2 Plan

Strategic

- The NGES will continue to update alternatives and refine the analysis of the future NESDIS ground enterprise architecture.
  - continuation of Cycle 1 with the inclusion of a holistic view of all ground system functions rather than considering them piecemeal

Cycle 2 Strategy

- **Tactical Focus– Integration with SIP (FY23-27)**

  - Theme: Infrastructure Transformation
    - "Assured operations through commercial partnerships"
    - "Enabling collaborative science"

  - Approach
    - Describe how individual Offices/Programs contribute
    - Near-term studies and BAA contracts
    - Address technology implications of proposed solutions

Cycle 2 Strategy

- **Strategic Focus– Transformation for the Future (FY35-50)**
  - Theme: Business Transformation
    - "Flexible Operations in a changing data provider landscape"
    - "Empowering Open Science"
  - Approach
    - Establish how potential future solutions cope with radical changes (both Push & Pull)