NOAA/NESDIS
Ground Enterprise Architecture:
Results, Lessons Learned, & Next Steps

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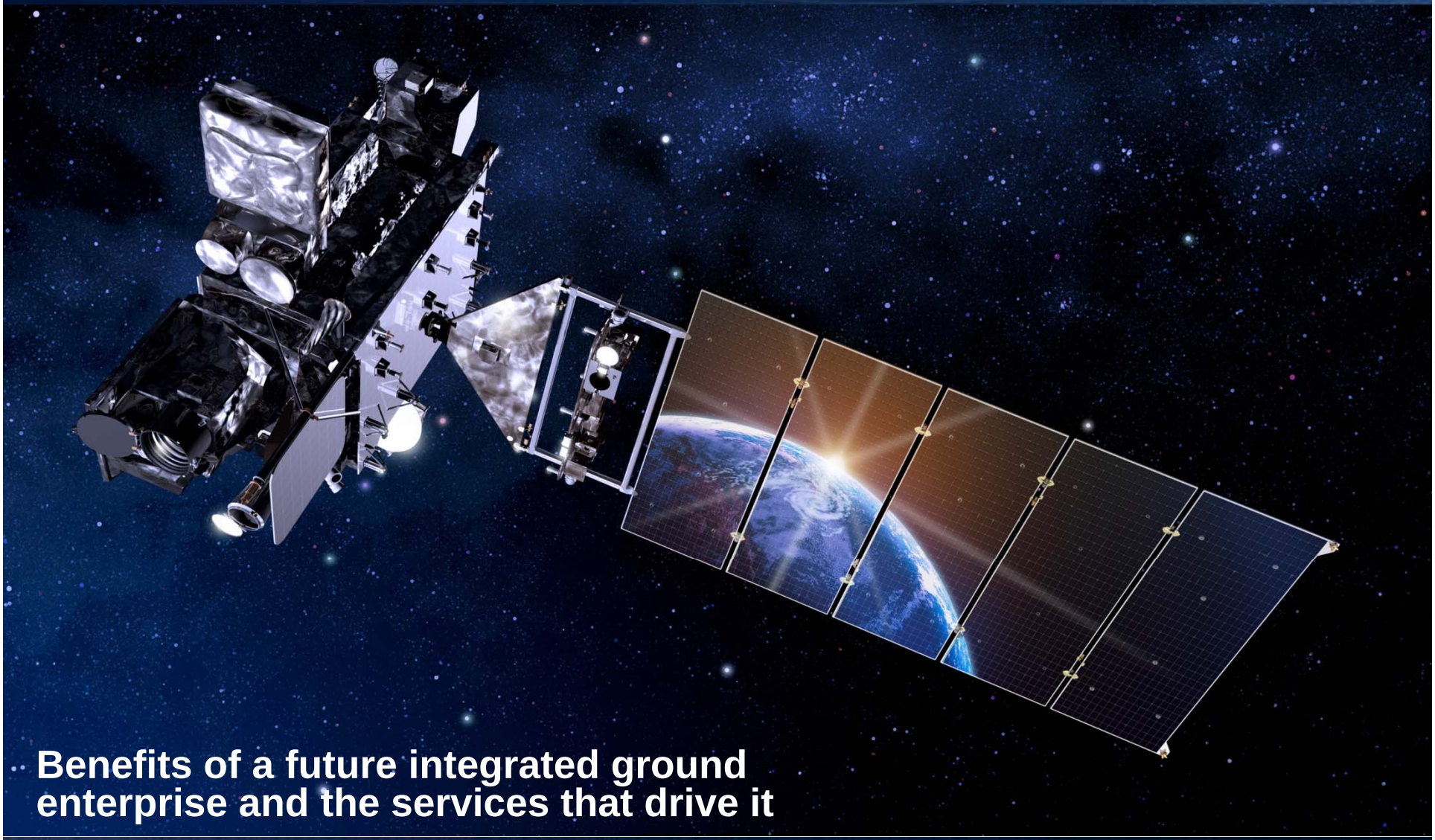
Agenda

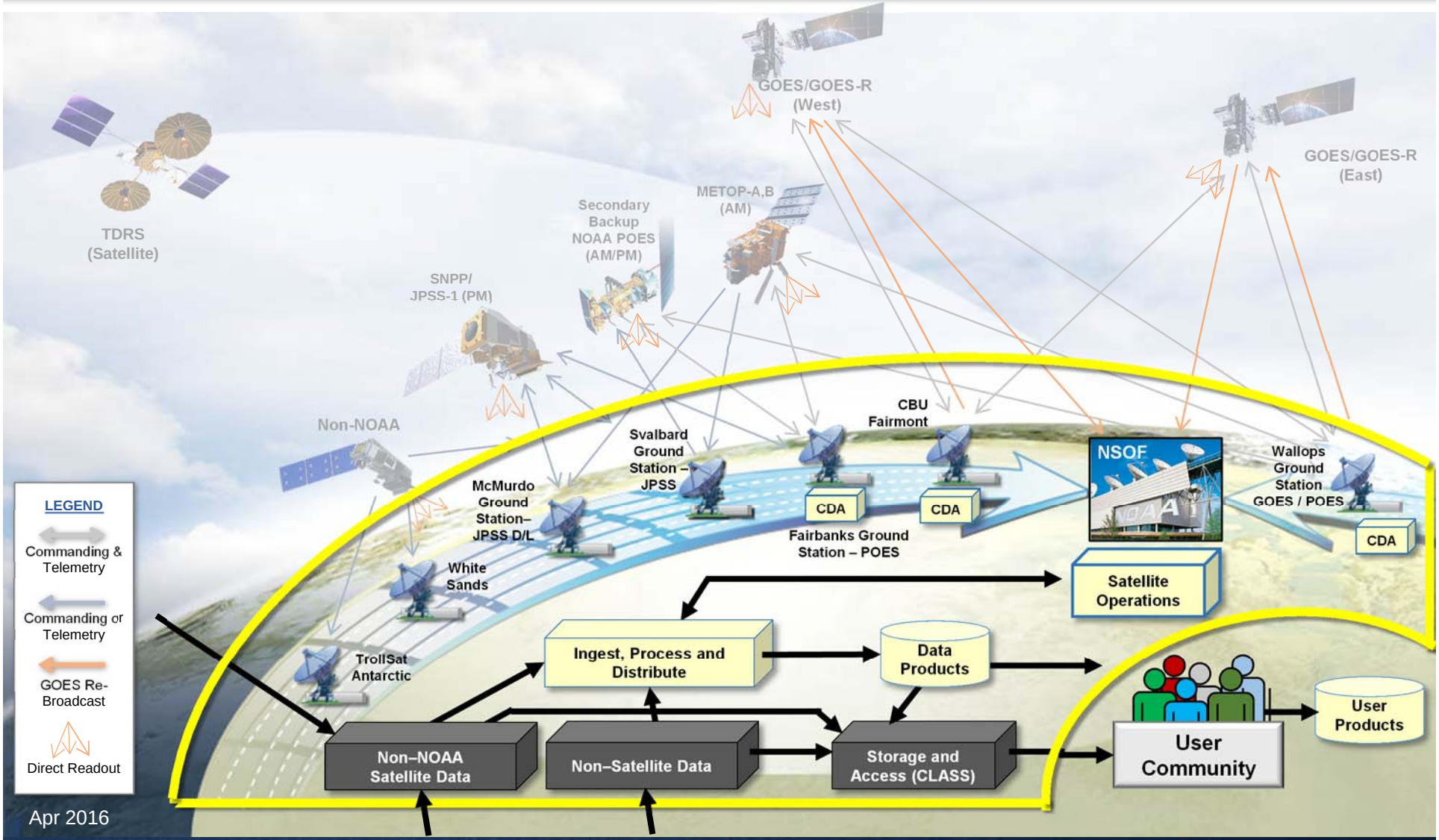
- Introduction the NESDIS Ground Architecture
- Evolving towards an Integrated Ground Enterprise
- Developing the Enterprise Architecture
- Break
- MagicDraw Demonstration
- Transition to Operations
- Wrap-Up

Integrated Ground Enterprise



Benefits of a future integrated ground enterprise and the services that drive it

GEARS Architecture
NESDIS Ground Enterprise



NOAA-Operated Systems are Diverse and Dated

- NOAA operates ground systems supporting nine different satellite constellations
- Most of the designs are dated
- All perform the primary Mission Functions, but there is modest Enterprise Integration between them

Mission	NOAA Operated			Jointly Operated	
	NOAA	DoD/NOAA	NOAA/NASA	NSPO/NOAA/UCAR	NASA/CNES/ESA/ NOAA/EUMETSAT
COSMIC				■	
DSCOVR			■		
GOES			■		
GOES-R	■				
Jason					■
JPSS			■		
POES	■				
SNPP			■		
DMSP		■			

Mission Functions
Mission Operations
Command & Data Acquisition
Mission Data Routing
Data Ingest
Mission Data Pre -Processing
Product Generation
Product Distribution
Archive

Multiple Stand-Alone Systems Performing the Same Mission Functions

Current Mission Functions

Mission Functions*	Description
Mission Operations	Capabilities associated with Mission Management & Flight Operations
Command & Data Acquisition	Capabilities associated with Command Uplink and Telemetry Downlink
Mission Data Routing	Capabilities associated with Ground-Based Mission Data Backhaul
Data Ingest	Capabilities associated with the Receiving & Preparation of Mission Data for Processing
Mission Data Pre - Processing	Capabilities associated with L0, L1, RDR & SDR Processing
Product Generation	Capabilities associated with L2+, & EDR Generation
Product Distribution	Capabilities associated with End-User Data Delivery
Archive	Capabilities associated with Long-Term Data Storage

Information Systems Architecture "as-is" mission functions derived from analyzing existing data flows

Future IGE Services

Flight Operations Support Services
provides engineering and analysis services in support of spacecraft and instrument operations.

Ground Operations Support Services
provides engineering and analysis services in support of ground operations.

Planning & Scheduling Services
provides for the long-term planning and tactical scheduling of operational events.

Common Operating Picture Services
provides a single common display environment of relevant (operational) information for all NGE assets (flight & ground).

Contact Services
manages ground assets and processes in support of both uplink and downlink satellite contact management.

Flight Operations Services
provides real-time support for spacecraft operations.

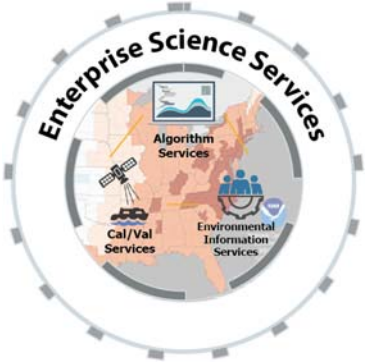
Routing Services
provides ground communications between satellite ground stations and other ground segment facilities.

Space/Ground Communication Services
supports the satellite / ground communications interfaces.

Data Processing Services
prepares incoming data streams (e.g. mission data from satellites, and ancillary product data from external sources) for use in downstream product generation.

Product Generation Services
provides the production services for higher level (L2+, EDR) near-real-time satellite based observation products.

Product User Services
provides a variety of services in support of end –user access to products.



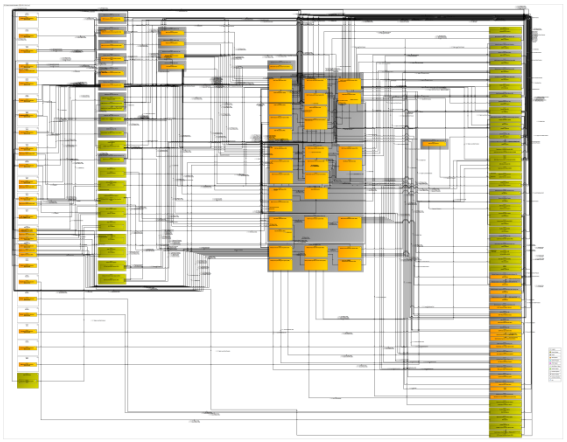
Algorithm Services
provides the capabilities needed for science algorithm development and pre-operational testing.

Cal/Val Services
supports the operational calibration and validation of on-orbit instruments.

Environmental Information Services
provides long-term product user services to support non-operational access to NGE data holdings.

Mapping Existing System-Based Capabilities to Objective IGE Services-Based Capabilities

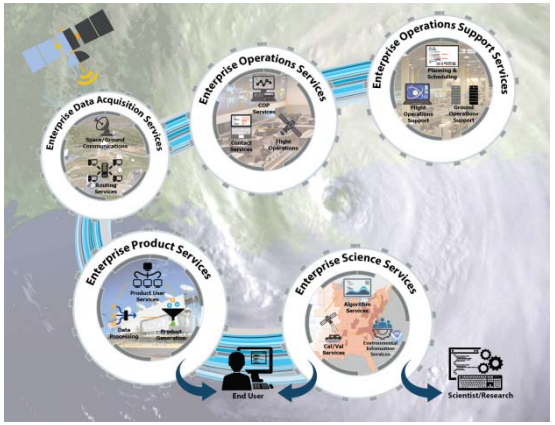
240+ Systems
3 Major Data Centers
5 Ground Stations



29 Missions & 29 Product Sets

	Precip	Imagery	Atm Wnds	SST	HZD Tropic	Snow/Ice Imagery	IR	Sp WX	HZD SO2	Cloud	Snow/Ice MW	HZD Volcano	Aerosols	HZD Fire	Red Bud	MW	Soil Moist	OHC	Veg	O3	OS Wnds Act MW	OS Wnds SAR	GPS RO	Snow/Ice SAR	OS Wnds Pass MW	HZD Oil	Ocean Col.	Lightn'	Sea Level
Threshold	7	6	6	6	5	5	5	5	2	5	5	4	4	4	4	4	4	3	2	2	2	2	2	2	2	1	1	1	1
Objective	4	6	5	4	8	3	2	2	1	2	1	3	2	2	2	1	0	0	2	1	1	1	1	1	0	3	1	0	0
Backup	2	2	2	2	1	2	2	1	1	2	2	2	2	2	1	1	1	0	2	2	0	0	0	0	1	0	1	0	0
JPSS	T	T	T	T	T	T	T		T	T	T	T	T	T	T	T			T	T							O	T	
GOES R Series	T	T	T	T	T	T	T	T		T		T	T	T	T													T	
GOES N Series	T	T	T	T	T	T	T	T		T		T	T	T	T														
DSCOVR		O						T										T											T
Jason																													
METOP	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T	T			T	T	T		T						
DMSP	T					T		T		T	T					T	T								T				
Meteosat SG	O	T	T	T	T							O																	
GCOM-W	T				O						T						T								T				
MTSAT		T	T	T	O		T																						
GPM	T				O						T					T													
Sentinel 1																						T		T	T	T			
RCM																						T		T	O				
Oceansat					O															T									
Cosmic																							T						
Cryosat2-																		T											
SARAL																		T											
SMAP (Radiometer)																	T												
SMOS																	T												
METOP SG	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O			O	O	O		O						
Himawari	O	O	O	O	O	O	O	O		O			O	O	O	O			O										
Meteosat TG	O	O	O	O	O																								
Sentinel 3		O				O																O		O			O		
INSAT		O	O	O	O																								
ADM			O																										
GCOM-C																										O			
POES	B	B	B	B	B	B	B	B		B	B	B	B	B	B	B			B	B									
EOS	B	B	B	B		B	B		B	B	B	B	B	B					B	B							B		
Coriolis																		B							B				

14 Capabilities Supporting 5 Functional Areas

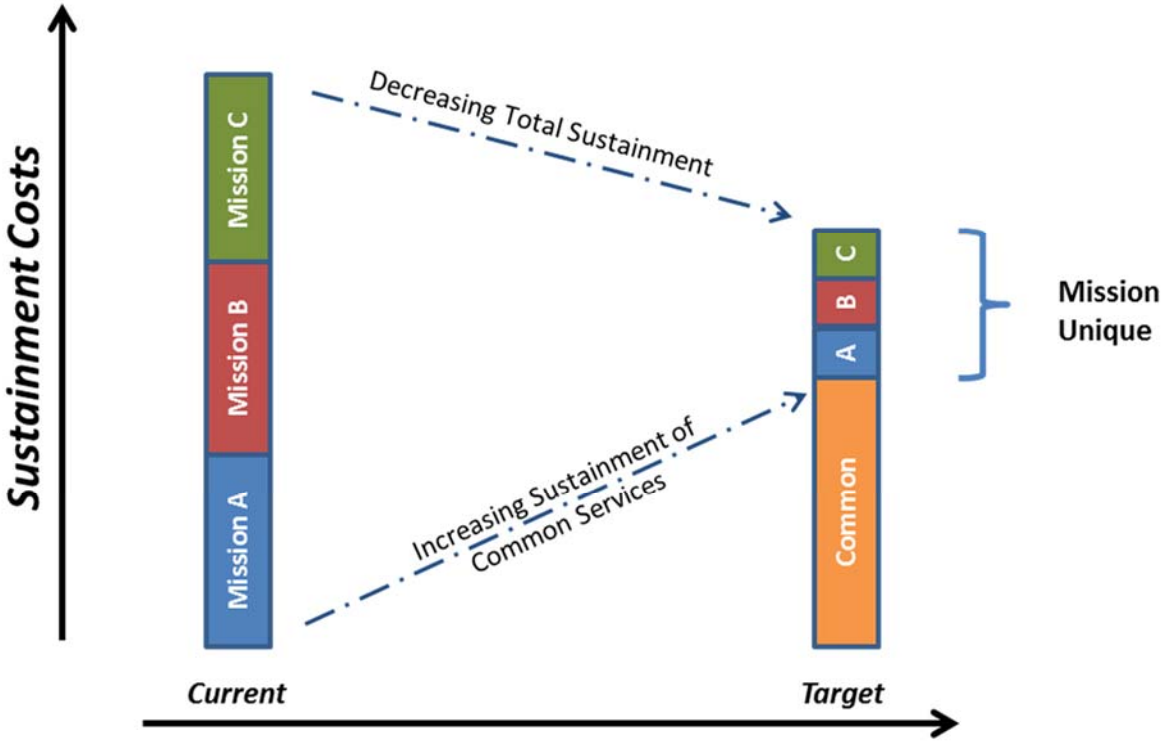


- Existing capability in NESDIS Ground Enterprise has been mapped into sets of services that deliver equivalent functionality
- Shared Services will be implemented to improve flexibility, agility, & cost when the benefits justify the required investment -- this analysis is ongoing now

Transformation

Today — Future

Objective Enterprise Goal: Employ Common Services and Hardware to Reduce Costs



- Decreasing the amount of mission-unique code reduces overall maintenance cost
- Shared common services reduce time & cost of adding new products and missions
- Adopting common hardware standards enables economies of scale in tech refresh and simpler security hygiene
- Our Infrastructure Reference Model & Application Reference Model establish enterprise standards

Enterprise Summary: Key Take-Aways

- Current ground enterprise elements meet all formal performance requirements; however,
  - Dated stand-alone systems need to be retired or replaced over the next decade
  - Complex GOES-R and JPSS systems are one-off
  - Enterprise is time-consuming and costly to maintain, inefficient to operate, and difficult to expand to support new needs
- Planned future approach meets all existing and envisioned future performance requirements, by
  - Employing shared common services
  - Implementing evolutionary strategy, small pieces at a time while continuing operations
  - Fielding early enterprise elements to demonstrate the value of Common Services
  - Considering Return on Investment – it may not be cost effective to migrate all the functions to shared common services

Evolution Strategy

Identifying investments and determining sequencing

Principles for Ground Evolution Drive the Transition & Sequencing Plan

- **Evolutionary Transformation –** The goal is to transform the Ground Enterprise through incremental improvements consistent with the target architecture, rather than developing the whole solution and migrating existing systems (no “Big-Bang” Transformation)
- **Infrastructure & Support Services First –** Although significant Return on Investment is expected by moving to a common set of IGE Services, these capabilities are built on top of an operational infrastructure and support services
- **Responsiveness to Stakeholders –** Stakeholder participation (e.g., through the NESDIS Ground Enterprise Executive Board and Enterprise Architecture Working Group) guides the transition strategy

Incremental Improvements, Foundation First, Addressing Priority Challenges

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Enterprise Characteristics

Enterprise Characteristic	Description	Benefit
Flight-architecture neutrality	Supports operations across NESDIS missions without consideration of the architecture of the observation instrument or platform (e.g. Common Operating Picture)	Reduced costs to integrate new platforms into Mission Operations
Multi-mission capability	Supports the addition of new data sources within existing data operations (e.g. Enterprise Algorithms)	Faster integration of new sources into Data Operations
Technology commonality	Decreases technology diversity across the enterprise reducing the "IT Footprint" that has to be sustained (e.g. Common Infrastructure Configurations – CIC)	More efficient IT SME utilization and reduced training
Operational efficiency	Supports common processes & process automation and provides efficiency in the operation of NGE (e.g. ECMT, IMMS)	Improved productivity and process consistency across the enterprise

An enterprise approach provides affordable and agile adaptability

Modest Enterprise Integration Today (Shared Infrastructure, Services)

Use of Common Shared Services Supporting More than One Mission:

Service Area	POES	GOES	JASON	GOES-R	JPSS
Mission Operations	No	No	No	No	Yes, SNPP
Command & Control	No	No	No	No	Yes, SNPP
Data Ingest	Yes, POES/GOES Consolidated Ingestor	Yes, POES/GOES Consolidated Ingestor	No	No	Yes, SNPP
Product Generation	No	No	No	No	Some NDE
Product Distribution	Yes, PDA in process	Yes, PDA in process	PDA planned	Some PDA	Some PDA
Product Archive	Yes, CLASS	Yes, CLASS	Yes. CLASS	Yes, CLASS	Yes, CLASS

- PDA, NDE, and CLASS provide Early Enterprise capability to NOAA-Operated Systems
- Remainder of functions are primarily stand-alone

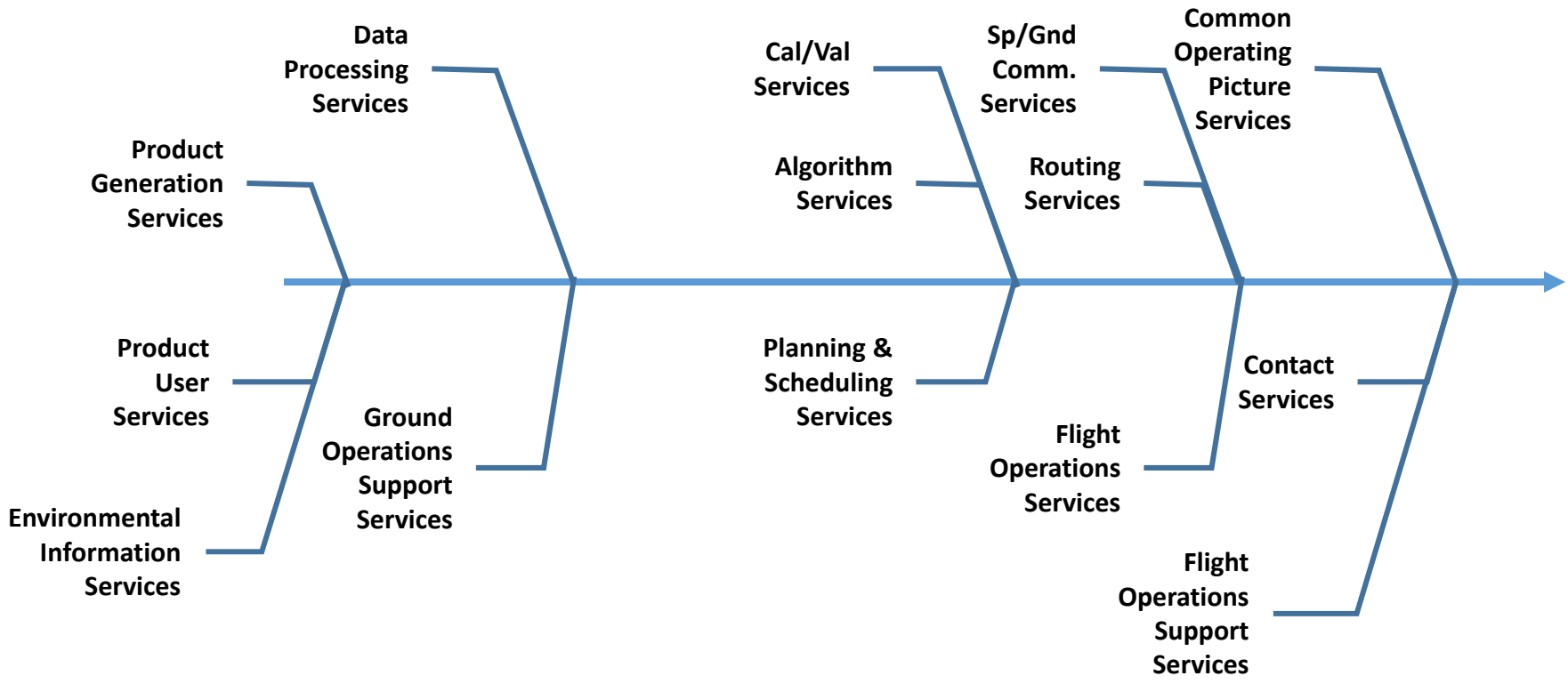
Transition & Sequencing Plan Example: Return on Investment by Function

- Based on the degree to which a given mission function is independent of mission-unique features:
  - Downstream services (i.e., Archive & Distribution) which are independent of the original satellite mission data are ranked ***High***;
  - Spacecraft/Instrument specific services (i.e., Command & Data Acquisition & L1/SDR data processing) are highly dependent on mission specific details and are ranked ***Low***;
  - Services such as Mission Operations, Ingest and Product Generation provide mission specific tailoring of capabilities that are common to all missions and are ranked ***Medium***.

Mission Function	ROI Magnitude
Mission Operations	Medium
Command & Data Acquisition	Low
Mission Data Routing	Medium
Data Ingest	Medium
Mission Data Pre-Processing	Low
Product Generation	Medium
Product Distribution	High
Archive	High

Investment decisions require thorough assessments of alternatives

Capability Roadmap (example)



Notional Roadmap Based on Preliminary Analysis of ROI and Priorities

Architecture Development

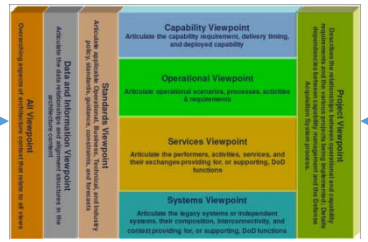
The path to developing an actionable investment strategy

Framework Relationships

TOGAF ADM

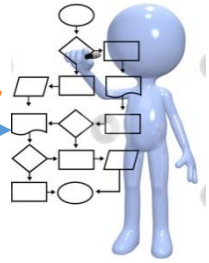
Process

Views

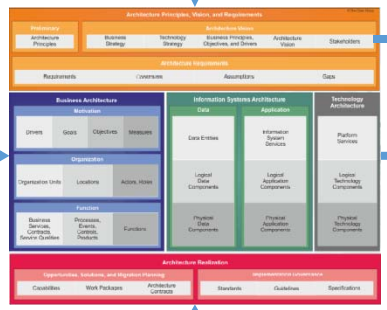


DoDAF

SysML



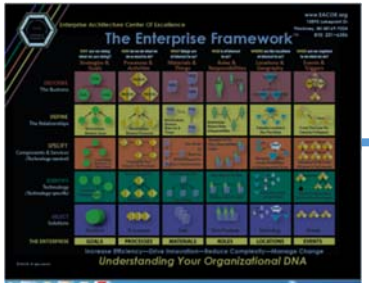
Engineering



TOGAF ACF

Transformation Artifacts

Alignment



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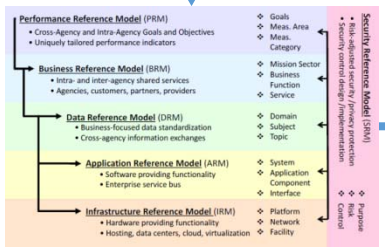
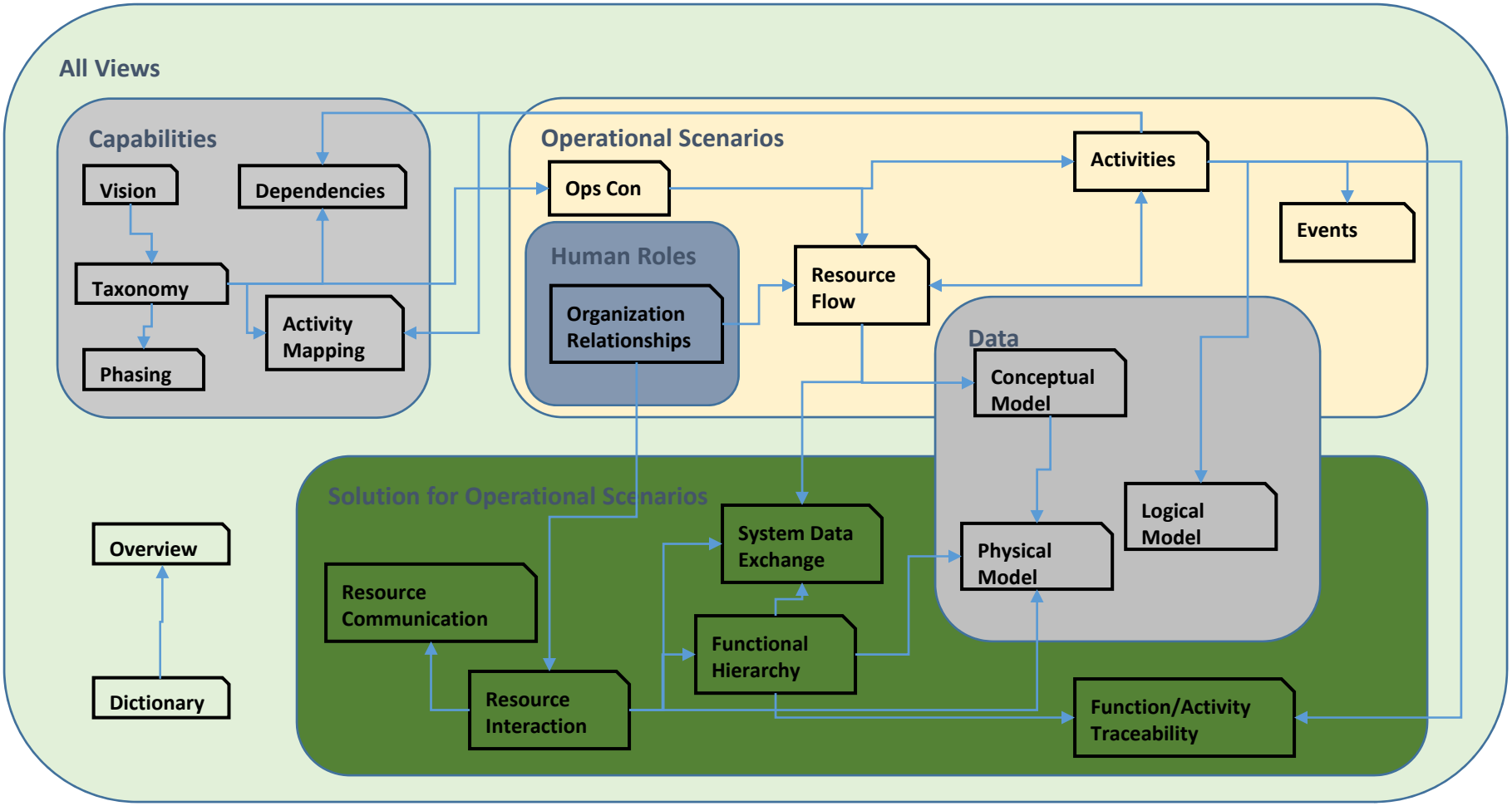
Collection



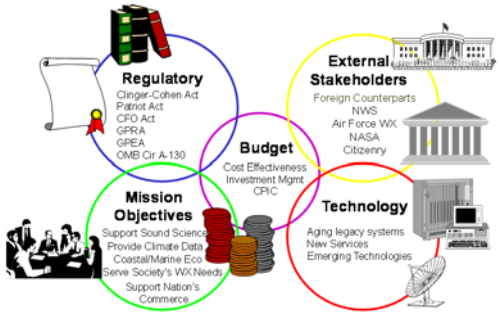
FEA

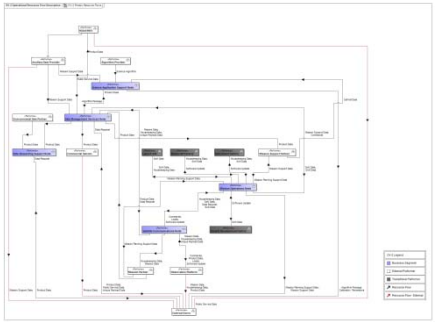
Strategic Planning

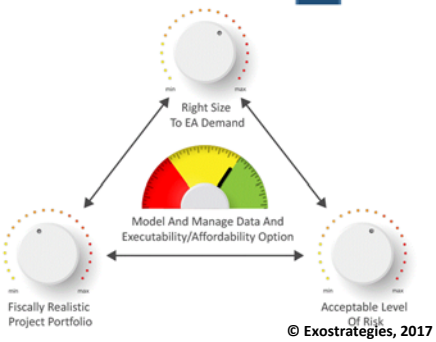
DoDAF View Relationship



OSGS EA Activities







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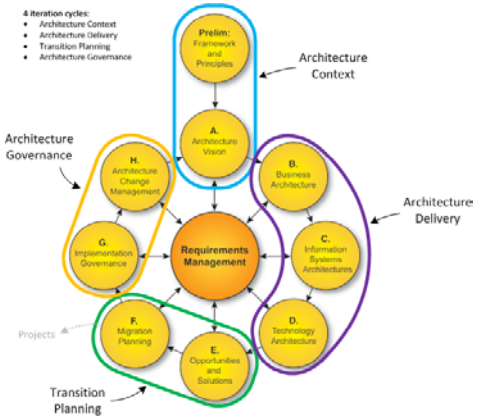

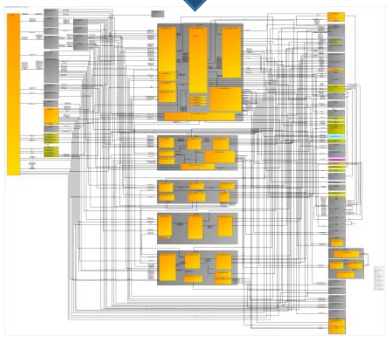

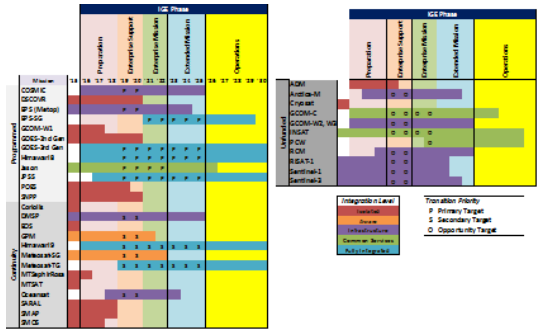

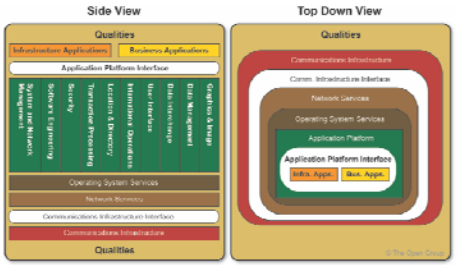

GEARS Architecture
Lessons Learned

- Successes
  - Adoption of a Enterprise-Wide Modeling Framework & Tools
  - Engagement with Stakeholders
  - Right-Team with powerful mix of SE, EA, SME skills
  - Independent external EA process Review / Validation
- Areas For Improvement
  - More detailed understanding / socialization upfront of expected results, use and customer needs
    - Better Management of Stakeholder Expectations
  - Execution Plan was at too high a level to assess progress and manage execution risk
  - Engagement & Outreach Activities began too late to be completed by the end of EA Development project

GEARS Architecture
Challenges/Issues

- From Architecture-to-Implementation
- Culture Change
- Institutionalization of a new Governance Approach
- Operationalization of the Architecture
  - Using & Applying the Architecture to better inform decisions
- Dual/Parallel Operations
  - Integrating the “Old” and the “New”

Always More Cultural than Technical

Role of the EA

Influence Area	Description	Benefit
Organization Roles & Responsibilities	Consolidated representation of NESDIS business services, functions and activities linked to NESDIS organizational elements in an analysis tool	Allows us to understand organizational responsibilities at a consistent level of detail across NESDIS and map that responsibility into supporting systems and (to-be) services.
Common Architecture representation	Consolidated representation of the as-is system architecture in an analysis tools (first time for NESDIS) that identifies the data elements exchanged among them.	Allows us to understand, at a consistent level of detail the NGE as it exists and forms a solid basis to identify and understand the transformations needed to evolve the NGE into an integrated, service-based capability.
Common Representation of Future	Consistent representation of future services that includes data exchanges and interface identification and high-level description that provides a consolidated target, service-based architecture.	Allows for a common understanding of the target capabilities needed as the basis of defining the scope and relationships of implementation projects
Formal Model	Comprehensive modeling tool, grounded in NGE business activities and attached to existing NGE systems and satellite-fly-out schedules	Allows senior leadership to make “better data-driven” decisions regarding changes to the enterprise.

EA Value to NESIDS

- ***Blue Print*** – The EA is the detailed blue print that allows the elements of the NGE to be redesigned, rebuilt or simply upgraded in a coherent manner that ensures when they come back together they will not just retain the vision, but enhance how it is executed.
- ***Acquisition & Funding*** – Acquisition & funding decisions can now be based upon sound, documented architectural analyses, AoAs, CBA/ROI studies, etc. instead of anecdotes and/or simple technology wish lists (the idea of "better-informed" decisions via architectures).
- ***System Engineering Foundation*** – The architecture effort lays a foundation for future Systems Engineering (SE) work starting with
  - A documented enterprise,
  - Enterprise-level requirements, and
  - A sequencing plan for implementation of upcoming initiatives.

Without the EA, the elements of the Enterprise will continue to grow independently, without technical coordination and without the ability to exploit efficiencies.

Wrap-Up

Office of Satellite Ground Systems

https://www.nesdis.noaa.gov/OSGS/index.html

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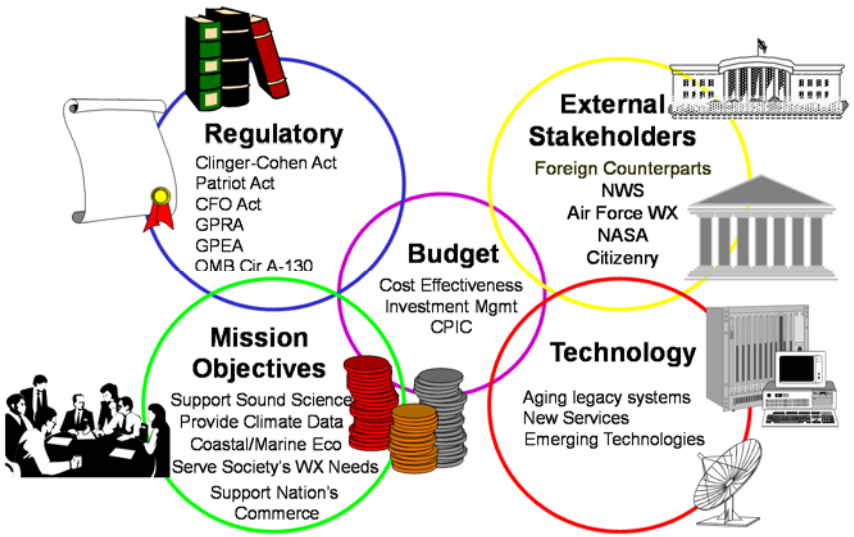
Drivers for EA

- **Governmental Regulations**
- **Alignment with Agency Mission Objectives**
- **Satisfaction of Stakeholder Needs**
- **Affordable Sustainment**
- **Appropriate Technology Leverage**
- **Budgetary Justification**

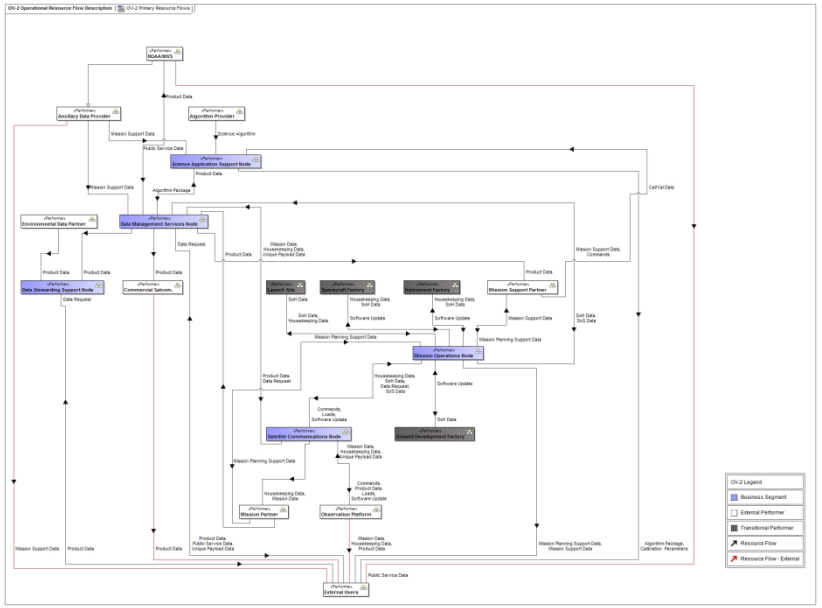
Data Driven Investment Decisions



- Enable a transition plan which results in **no harm to launch** for GOES-R and JPSS 1 & 2.
- **Enable the evolution** of the ground architecture as NESDIS needs change without major architectural changes
- Maximize **acquisition flexibility**
- **Promote interoperability** between observing systems, common ground, and diverse partners.
- Respond to **out-year budget** variability
- Achieve significant **cost avoidance**
- **Define enterprise** ground **services**

Business (What do we do?)

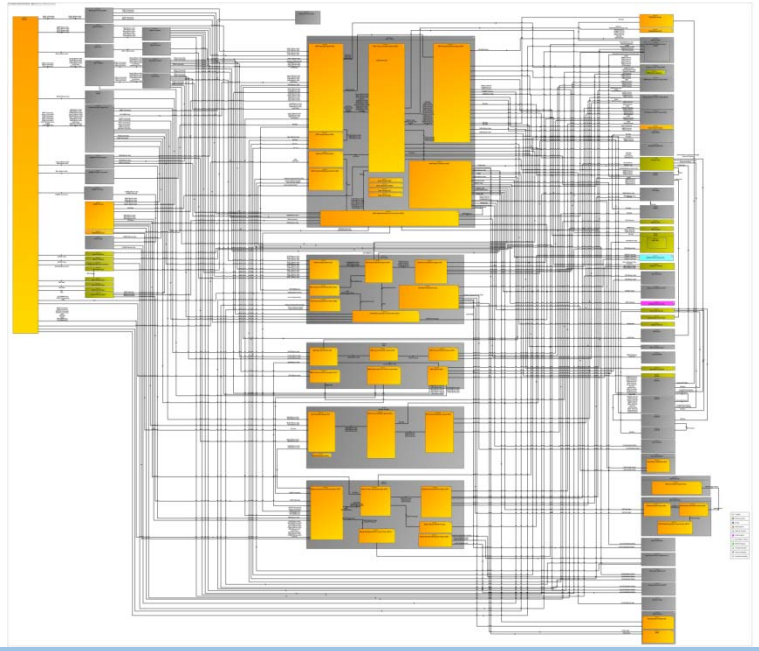
- **Describe the Baseline Business Architecture**
  - Organizational, Functional, Process, Informational & Geographic aspects
- **Develop a Target Business Architecture**
  - Service Strategy
- **Analyze the Gaps between the Baseline & Target**
  - Business Services to carry over
  - Business Services to Eliminate
  - New Business Services



- ***Grounded in Operations***
- ***Underwritten by the Stakeholders***

Information Systems (How do we do it?)

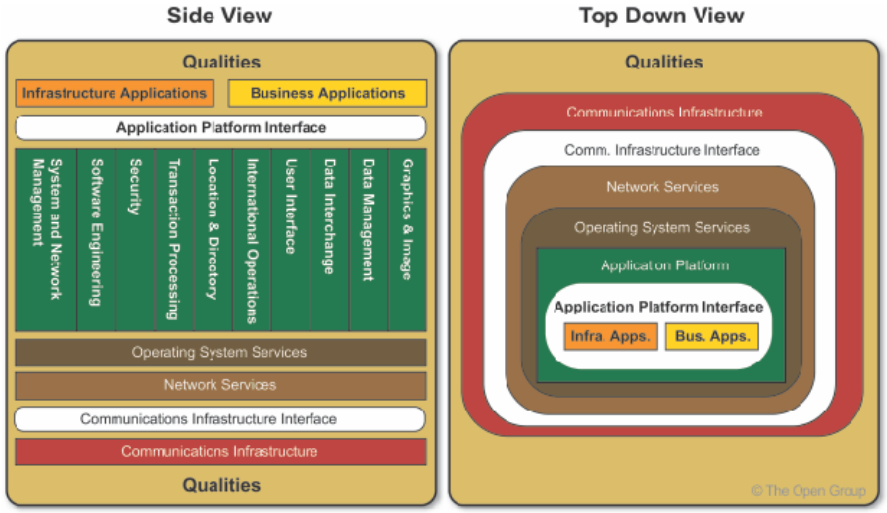
- **Develop architectures covering Data and Application Systems Domain**
- **Addresses Business Processes that are supported by IT**
- **Interfaces of IT-Related process to non-IT related process**



- ***Line-of-Sight – What runs Where***
  - ***Single Repository for All Missions***
- ***Configuration Management***
  - ***Maintainable Source of CM Data***
- ***Trade Study Baseline***
  - ***Consistent Analysis Launch Pad***

Technology (How do we build it?)

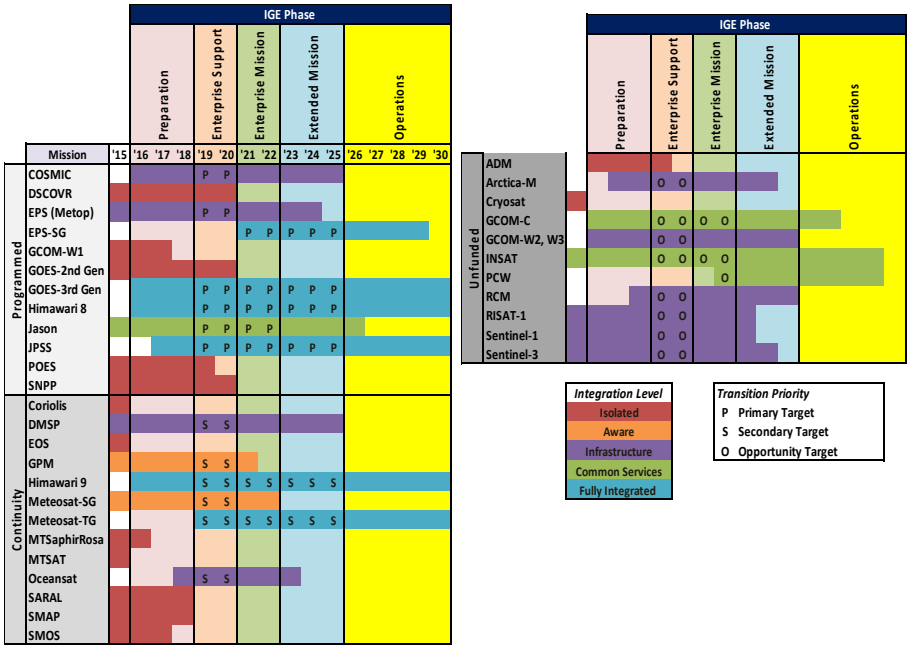
- **Develop a Technology Architecture that supports Business, Data and Application architectures**
- **Forms the basis for the following implementation work**
- **Establishes Building blocks**
  - Functionality
  - Standards
  - Interoperability



- ***Application Portability***
  - ***Services made available in a standard way to applications***
- ***Interoperability***
  - ***Infrastructure Services leveraged in a standard way***
- ***Reduced IT Footprint***
  - ***Simpler to Maintain, Cheaper to Sustain***

Transition Planning (Roadmap for Change)

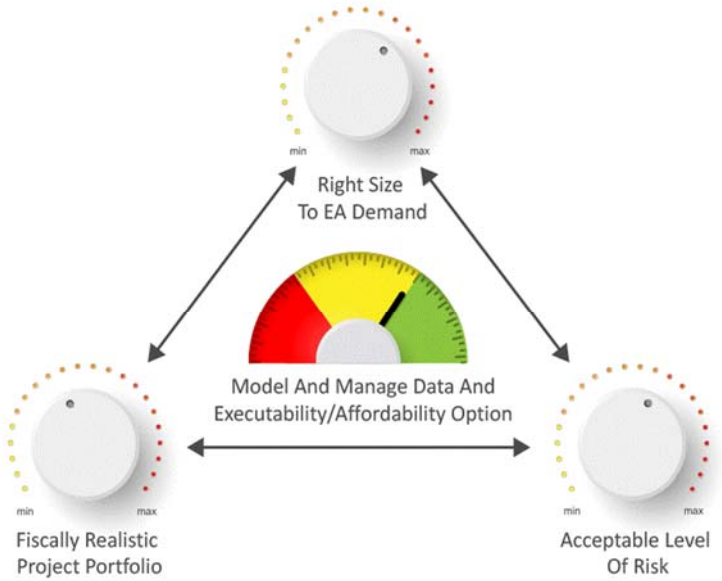
- **Identifies Major Phases**
- **Top Level Projects**
- **Basis for the Implementation Plan**
  - Build/Re-use
  - Dependencies
  - Prioritized Time-Phased Project List
- **Co-existence with Legacy**
  - Multiplicity of User Interfaces
  - Access to Data
  - Connectivity



- ***Manage Investment Portfolio***
- ***Give priority to projects that deliver short-term payoffs***
- ***Create momentum for longer-term projects***

Operational EA (Managing the change)

- **Portfolio Management**
  - Enterprise Perspective
  - Strategic /Continuous Journey
  - Ensuring the Right Projects are selected for Implementation
- **Implementation Governance**
  - Recommendations for each Implementation Project
  - Govern Implementation & Deployment Process
  - Ensure Conformance
- **Establish Architecture Change Management**
  - Continual Monitoring of New Technology
  - Monitoring for Changes in the Business



- ***Choose the right things to do and ensure they get done***
- ***EA Baseline Evolution***

CONOPS Development

- **CONOPS explains the "how" of an enterprise vision**
  - Bridges from the ideal vision to the practical implementation
  - Carefully scoped and specific
- **CONOPS is not a requirements document**
  - But often made available during the acquisition process to provide context
- **CONOPS is not exhaustive**
  - Illustrative, not authoritative
  - But should provide pointers to information outside of its scope
- **CONOPS used to build consensus across the community**
  - An informal requirements elucidation tool

Concept Of Operations Guides Architecture & Implementation

General Attributes

- Enterprise management
  Shared infrastructure Mission isolation
- Hardware agnostic
  Location agnostic
  Acquisition approach agnostic
- Service based architecture
  Common services reuse
  Standards-based
- Automation capable
- Highly secure

Illustrative Use Cases

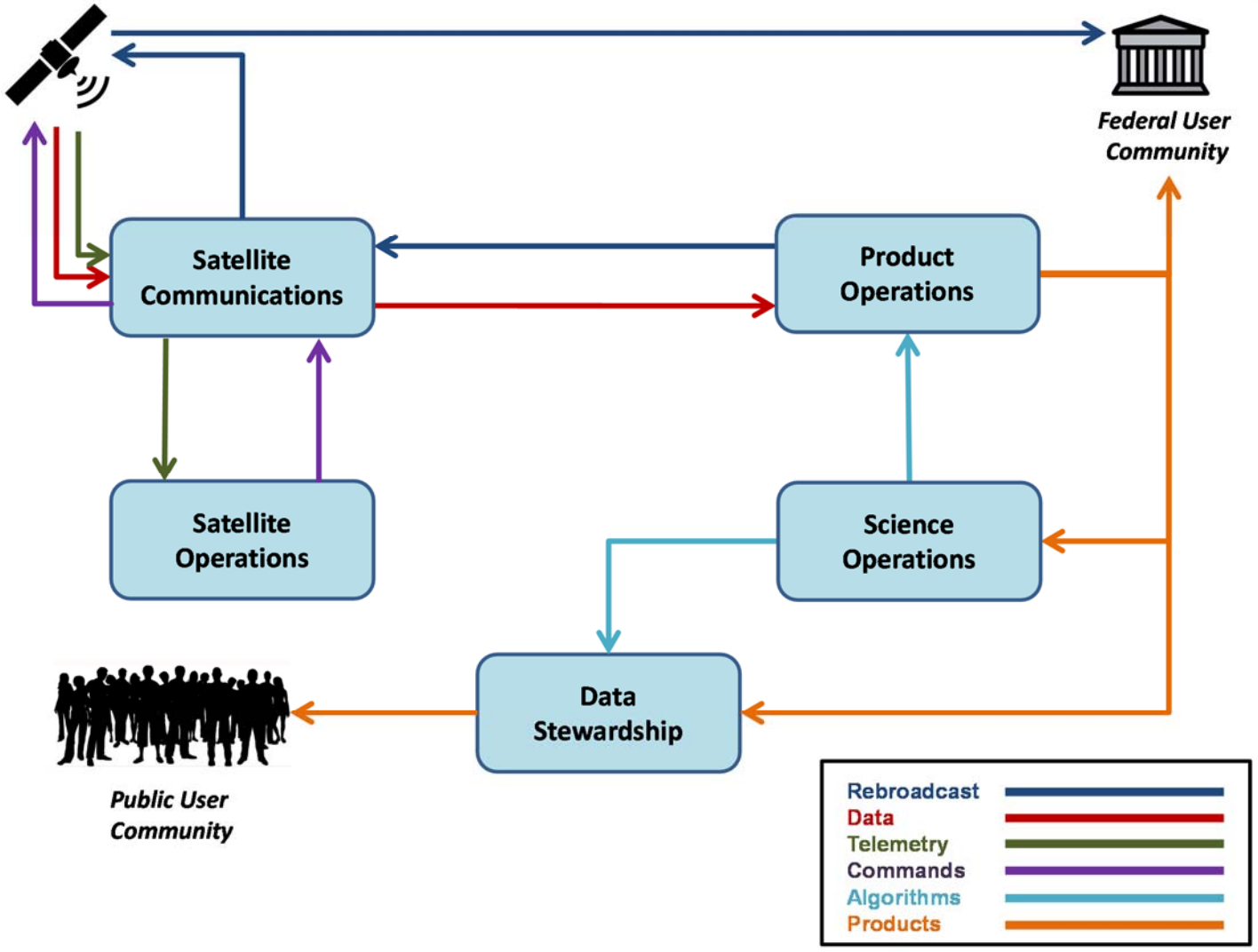
- Day-in-the-Life Satellite Operations
- Integration of a New Satellite Mission
- Integration of an External Data Product
- Adding a Unique Ad-Hoc Query I/F
- Transition of a NASA Research Satellite Mission to NOAA Operations
- New Data Product Requirement
- New Algorithm Development
- Algorithm Sustainment
- Calibration and Validation Support
- Automation of a Ground System Function
- Adding a New Common Capability to GEARS

Comprehensive Set of Use Cases Demonstrate Benefits to Multiple Communities

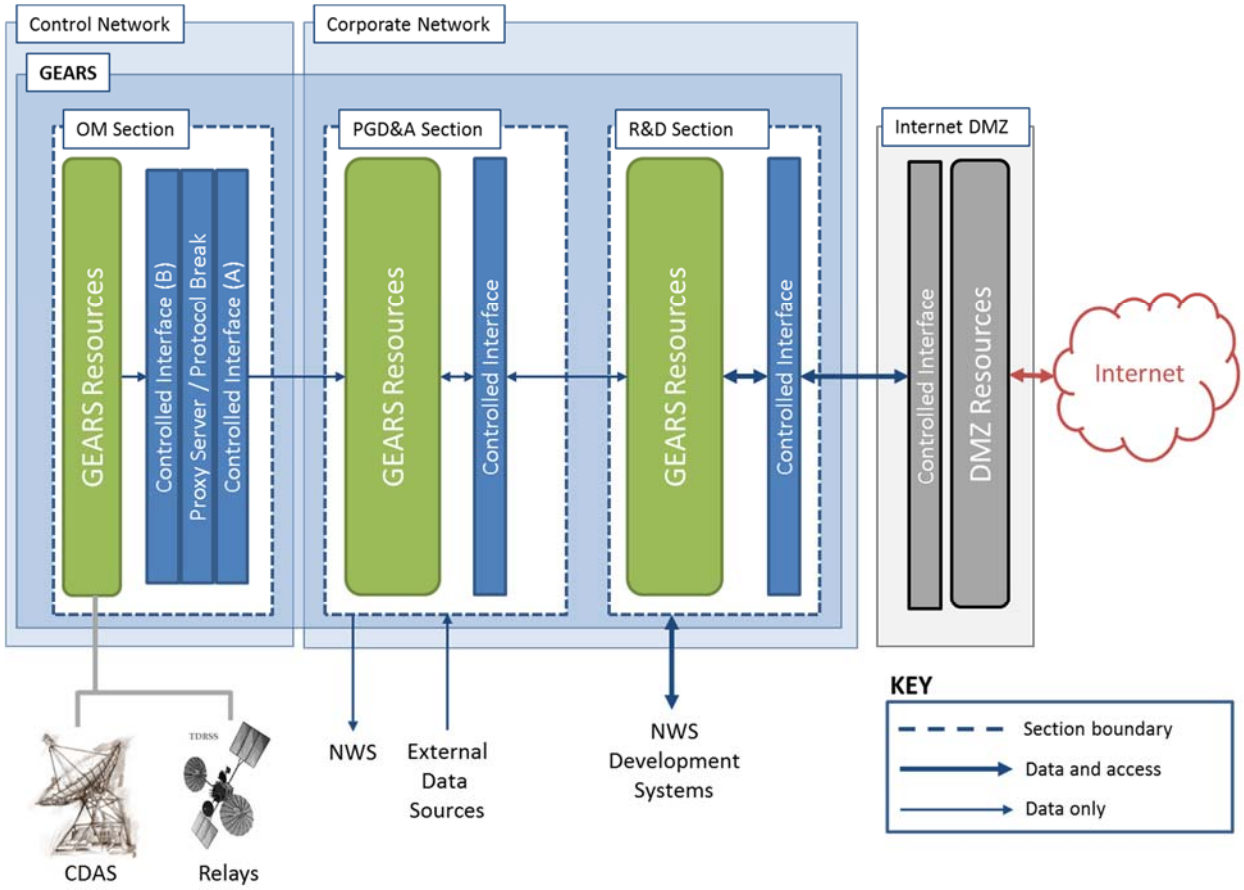
Features of the GEARS CONOPS

- Enterprise Governance
- Enterprise Management
- Enterprise Funding
- Shared Infrastructure
- Ubiquitous Data Access
- End-to-End Lifecycle Data Management
- Isolation of Impacts
- Hardware Agnostic
- Location Agnostic
- Acquisition Approach Agnostic
- Service-Enabled Approach
- Maximum Reuse of Common Services
- Use of Standards
- Support for Automation
- Security as Infrastructure
- Warehousing & Restoring

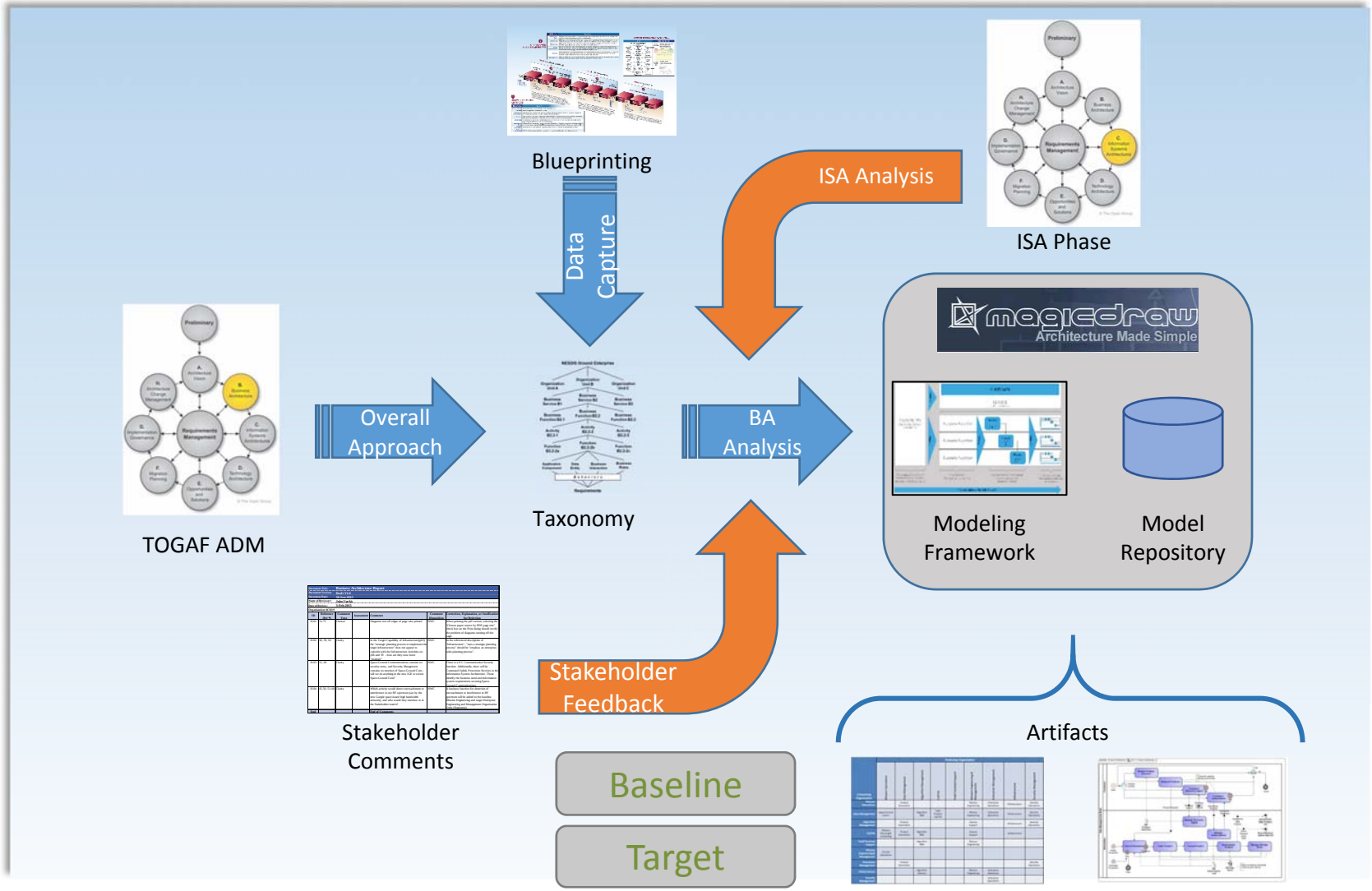
Baseline ConOps



The Target Concept



Business Architecture (BA)
The Approach



Business Architecture (BA)
The Report/Documentation

- **Describe the Baseline (As-Is) Business Architecture**
  - Existing legacy, satellite-ground systems
  - Environmental Satellite Processing and Distribution System (ESPDS)
  - Comprehensive Large Array-data Stewardship System (CLASS)
  - Soon-to-be-operational GOES-R and JPSS ground systems
- **Describe a Target (To-Be) Business Architecture**
  - Considers all elements of the Baseline Business Architecture
  - Target timeframe is considered to be 2022, although the architecture development took a very optimistic view of programmatic constraints (i.e., schedule and funding)
- **Analyze the GAPS between the Baseline and Target Business Architectures**

Business Architecture (BA)
Artifacts – Community Model

Artifact	Description
Organization Catalog	The Organization catalog identifies the organizations that provide services related to the NGE.
Actor Catalog	The Actor catalog provides a descriptive list of NGE actors (i.e., performers).
Stakeholder Catalog	The Stakeholder Catalog lists and characterizes NGE stakeholder interactions with the NGE.
Location Catalog	The Location catalog provides a listing of all locations where the NGE carries out business operations or houses architecturally relevant assets, such as data centers or end-user computing equipment. The Catalog identifies the performer (i.e., organization or system), its geographic location and services that the performer consumes or provides at the specified location.
Service & Activity Catalog	The Service & Activity catalog provides a functional decomposition of the business services, functions and activities in a form that can be filtered, reported on, and queried.
Information Transaction Matrix	The Information Transaction matrix identifies the interfaces between applications and the overall dependencies between applications.
Preliminary Process Catalog	The Preliminary Process catalog identifies the processes that will be modeled during Blueprinting Phase II, Operational Analysis.

Business Architecture (BA)
Artifacts – Operational Analysis

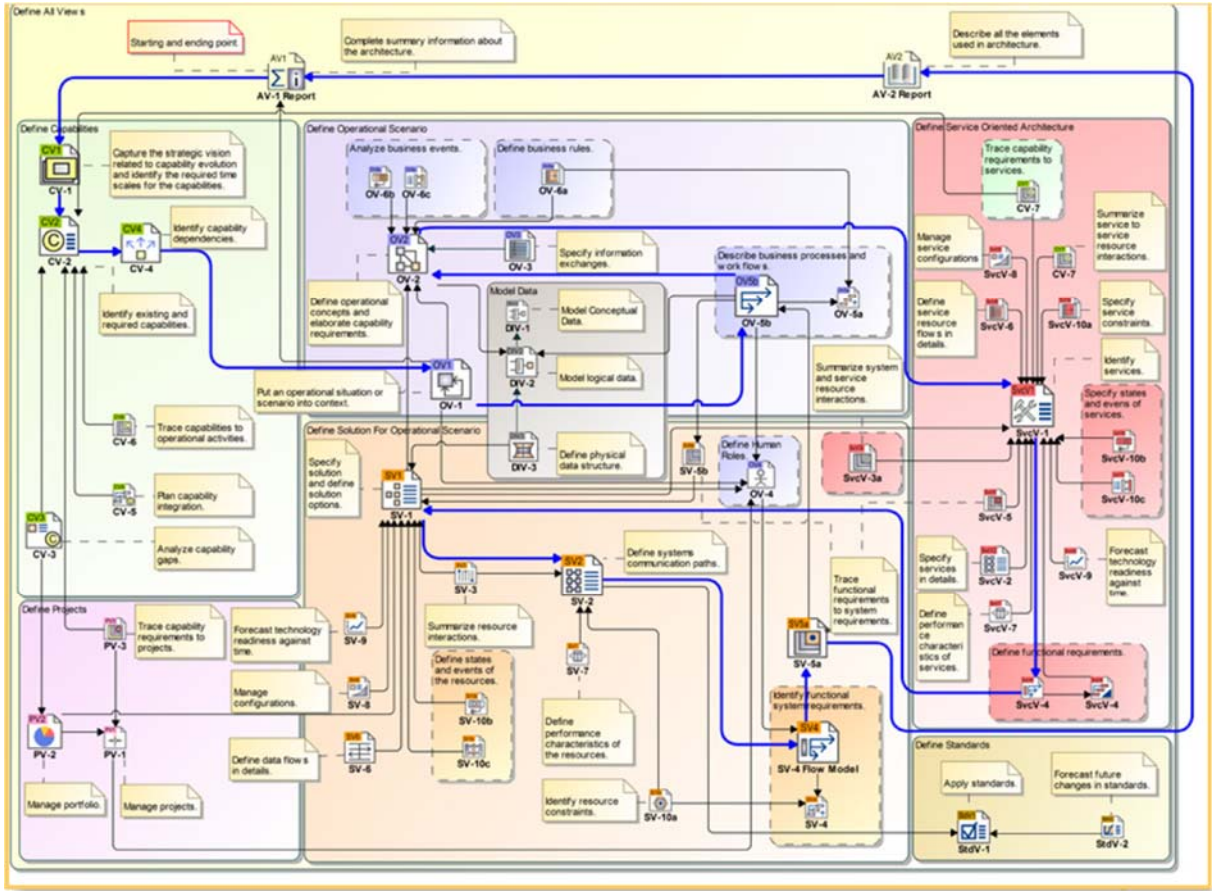
Artifact	Description
Business Footprint Description	The Business Footprint describes links between the business mission, organizational units, business segments, and requirements. It is expressed by a Mission Line of Sight Diagram, a Functional Organization Catalog, a Functional Segment Catalog and a Functional Responsibility Matrix.
Functional Decomposition Diagram	The Functional Decomposition diagram shows the NGE business services and their relationship to the NGE architecture segments.
Business Service Responsibility Matrix	The Business Service Responsibility Matrix identifies the functional organization responsible for the business service and the functional organizations that provide support to the primary
Business Interaction Matrix	The Business Interaction matrix depicts the relationship interactions between NGE business segments in terms of the business services they provide and consume.
Operational Activity Decomposition Diagrams	The Functional Decomposition Diagrams show the decomposition of the baseline segments into business services and functions.
Event Diagram	The Event diagram depicts the relationship between events and process. Certain events - such as arrival of environmental data or a certain point in time (e.g., weekly) - cause work and certain actions need to be undertaken within the Ground Enterprise. These are often referred to as "business events" or simply "events" and are considered as triggers for a process.
Process Flow Diagram	The Process Flow diagrams depict all models and mappings related to the process meta-model entity. They show sequential flow of control between activities and may utilize swim-lane techniques to represent ownership and realization of process steps.

Information Systems Architecture Objectives

- The objective of the Information Systems Architecture is to describe how the enterprise's information systems architecture will enable the business architecture and the architecture vision

- In Phase B (Business architecture) we defined the way in which the enterprise must be organized and must function. In Phase C - we now identify data, systems and their interactions in order to meet the business architecture expectations. We present the Baseline (As-Is) and Target (To-Be) Information Systems Architectures and identify candidate roadmap components based upon gaps between the Baseline and Target

Information Systems Architecture
UPDM Metamodel

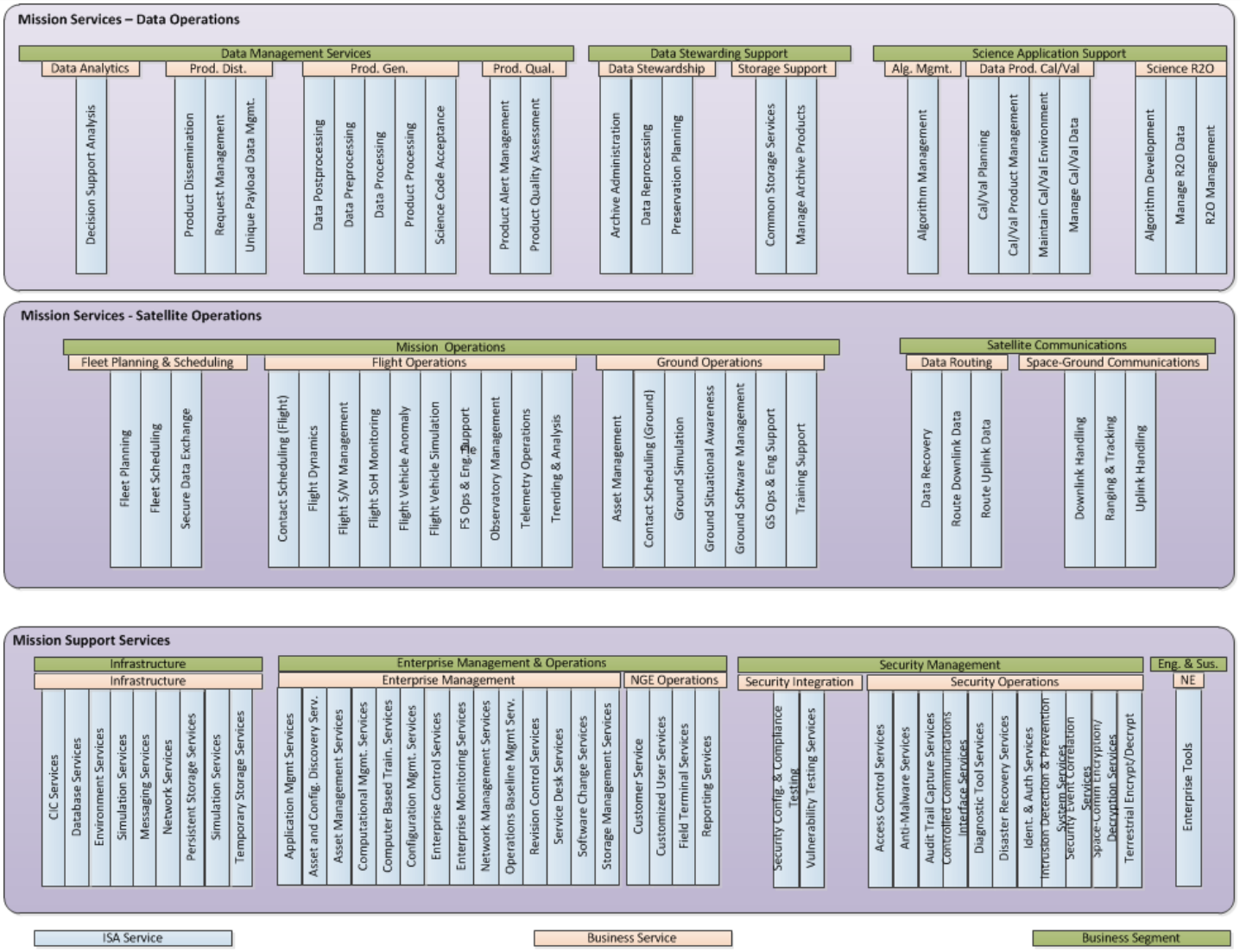


Major Artifact Relationships

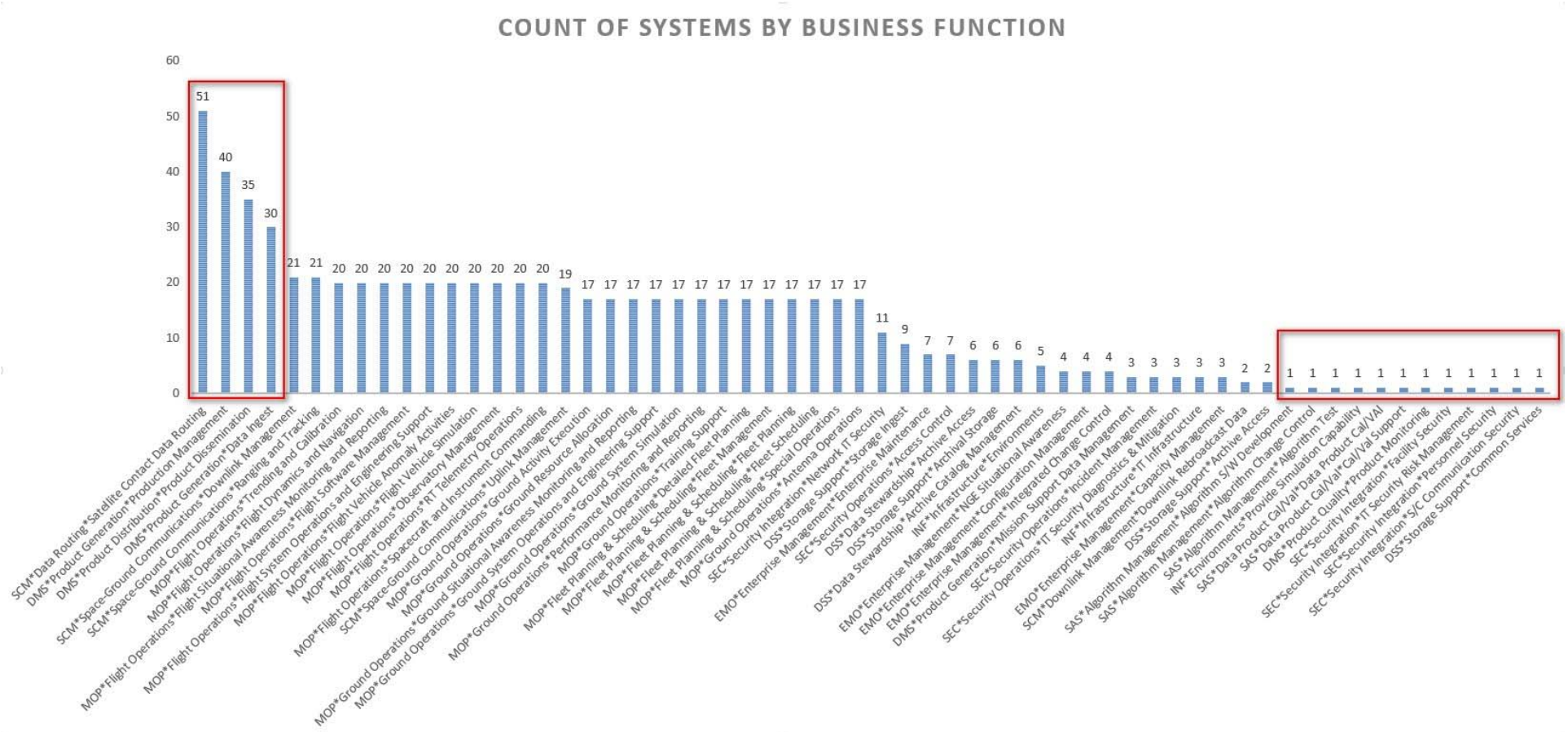
Information Systems Architecture Baseline System Findings

- 152 systems are identified at Level 2
- A useful way to think about the Level-2 systems is as the potential limit to which we can achieve consolidation through IGE
- 59 unique Level-2 Systems inside the NGE Boundary. Each of these systems perform sufficiently different functions that is it not likely that we could further consolidate the functional capability. However, that does not preclude simplification of the long-term system sustainment through implementation of Common Infrastructure, and the use of Common Support Services
- 87 Level-2 Systems outside the NGE Boundary. Although those fall outside the scope of OSGS for consolidation, as we move towards IGE, the degree to which we can implement common interfaces to these externals will determine the ease with which we can maintain these interfaces
- Of the 242 Level-3 Systems identified in the model, 174 (~71%) are considered inside the NGE Boundary. If these could be efficiently consolidated around the 59 unique Level-2 Systems during transition to IGE, a 3 fold reduction in systems diversity potentially achievable.

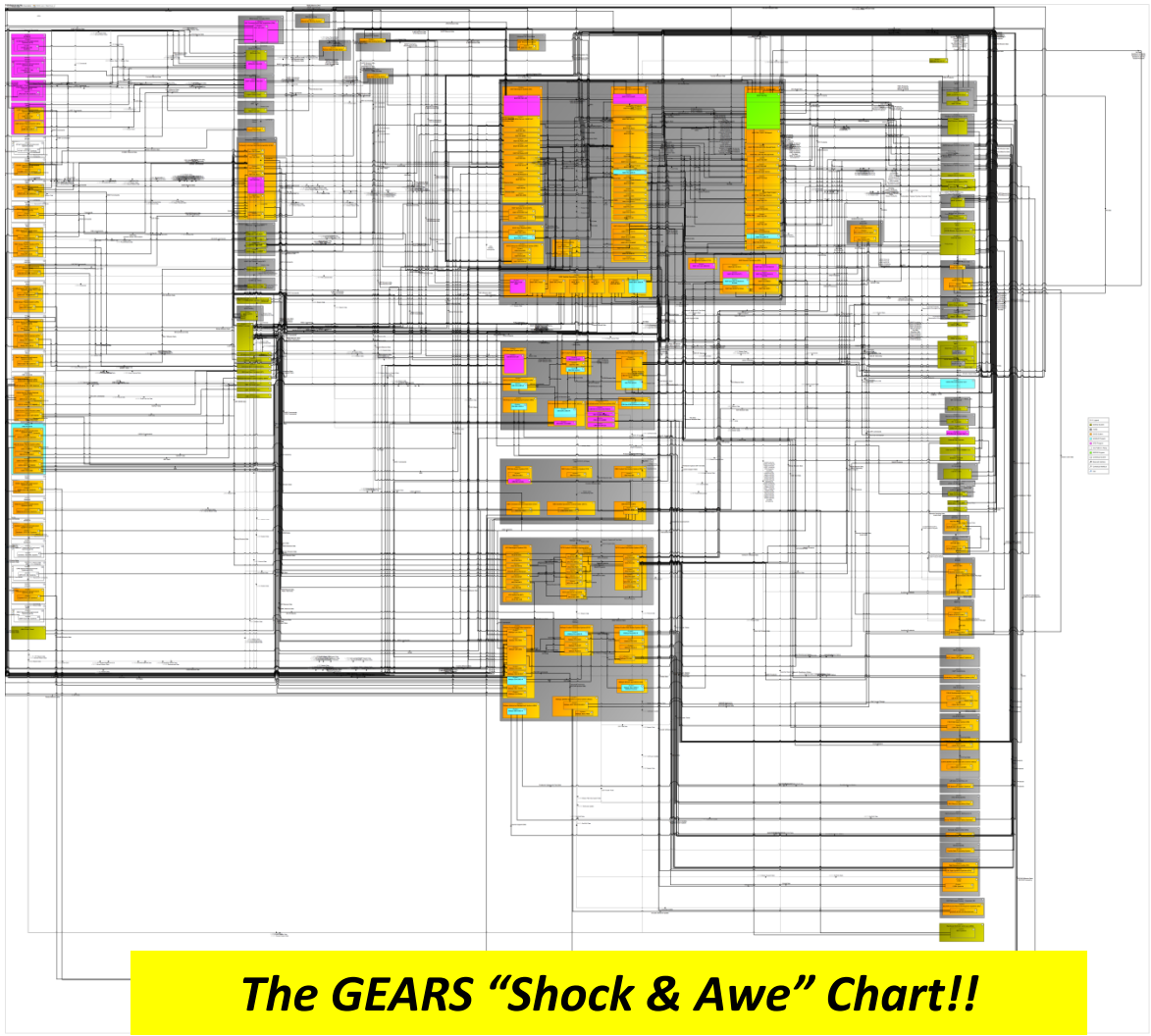
Information Systems Architecture Target Enabled Services



L3 Systems Mapped to Business Functions



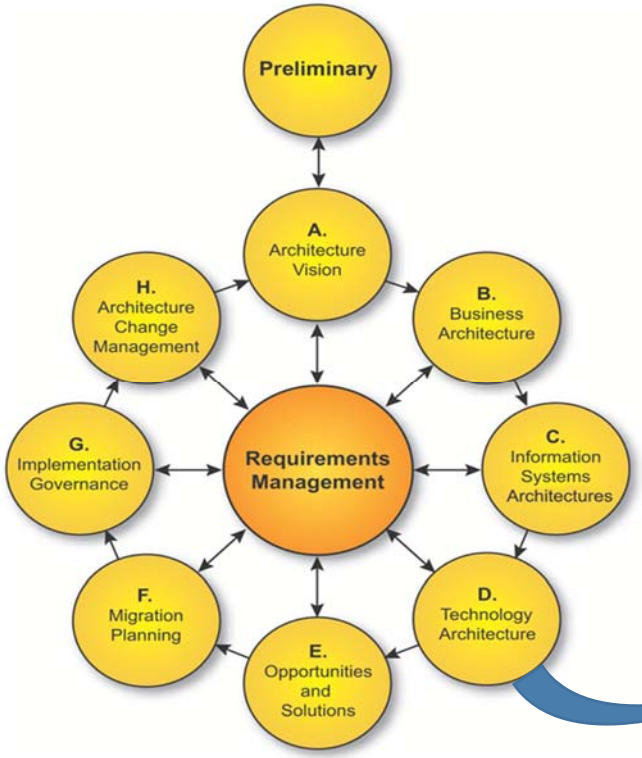
Information Systems Architecture
Level 3 Data Flow



The GEARS "Shock & Awe" Chart!!

Technology Architecture
IRM and ARM

The TOGAF
Architecture Development Method (ADM)



Technology Architecture (TA)

Infrastructure Reference Model (IRM)
- Taxonomy
- Technology Profile

Applications Reference Model (ARM)
- Taxonomy
- Technology Profile

per the FEA, v2.0, 2013
(Federal Enterprise Architecture)

TRM = IRM + ARM

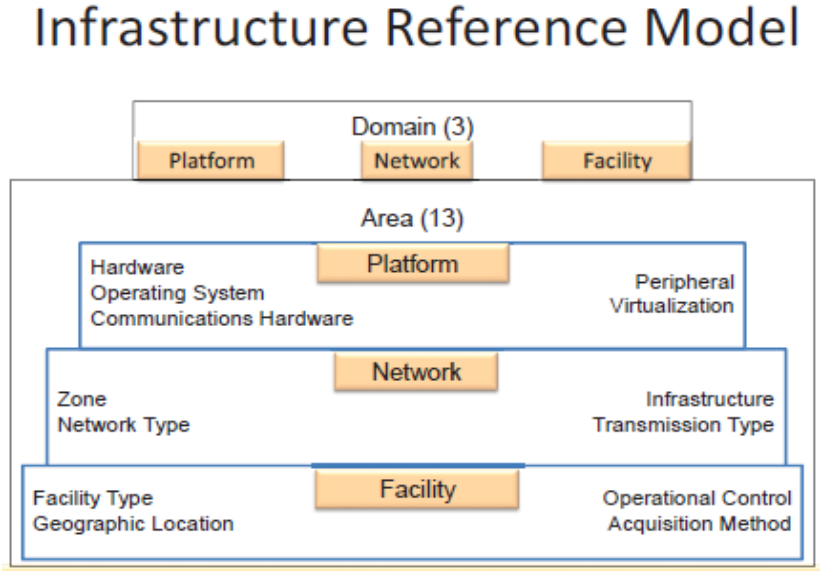
TA = TRM = IRM + ARM

Technology Architecture
What are the Taxonomies?

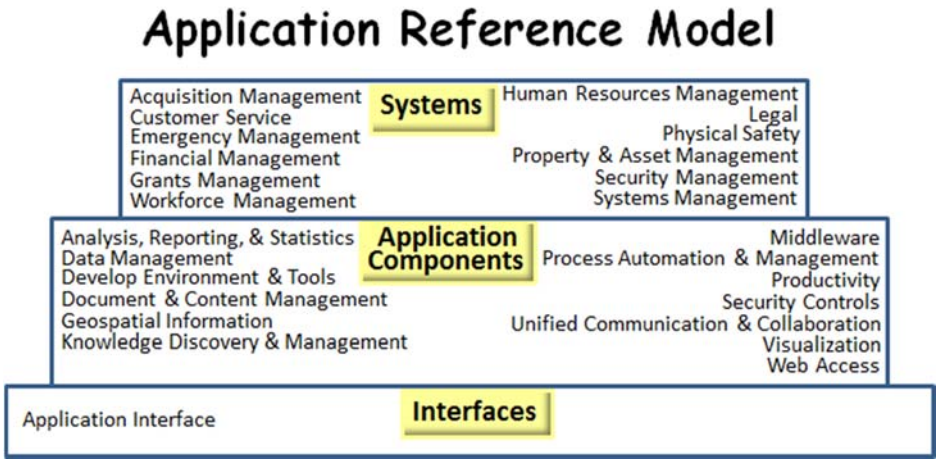
- A categorization scheme for IT assets within the Enterprise
- Identifies & enumerates the HW & SW components of the Enterprise
- A coherent description of the components & conceptual structure of the enterprise's info system, both hardware & software
- When is it needed?
  - During acquisition & engineering milestone decision points
  - Milestone A, B, & C and ORR, PDR, CDR, etc.
- Who uses it?
  - IRMAC, ERB, CIO, Chief Architect, Program Manager, Systems Engineer

Technology Architecture
The Taxonomies

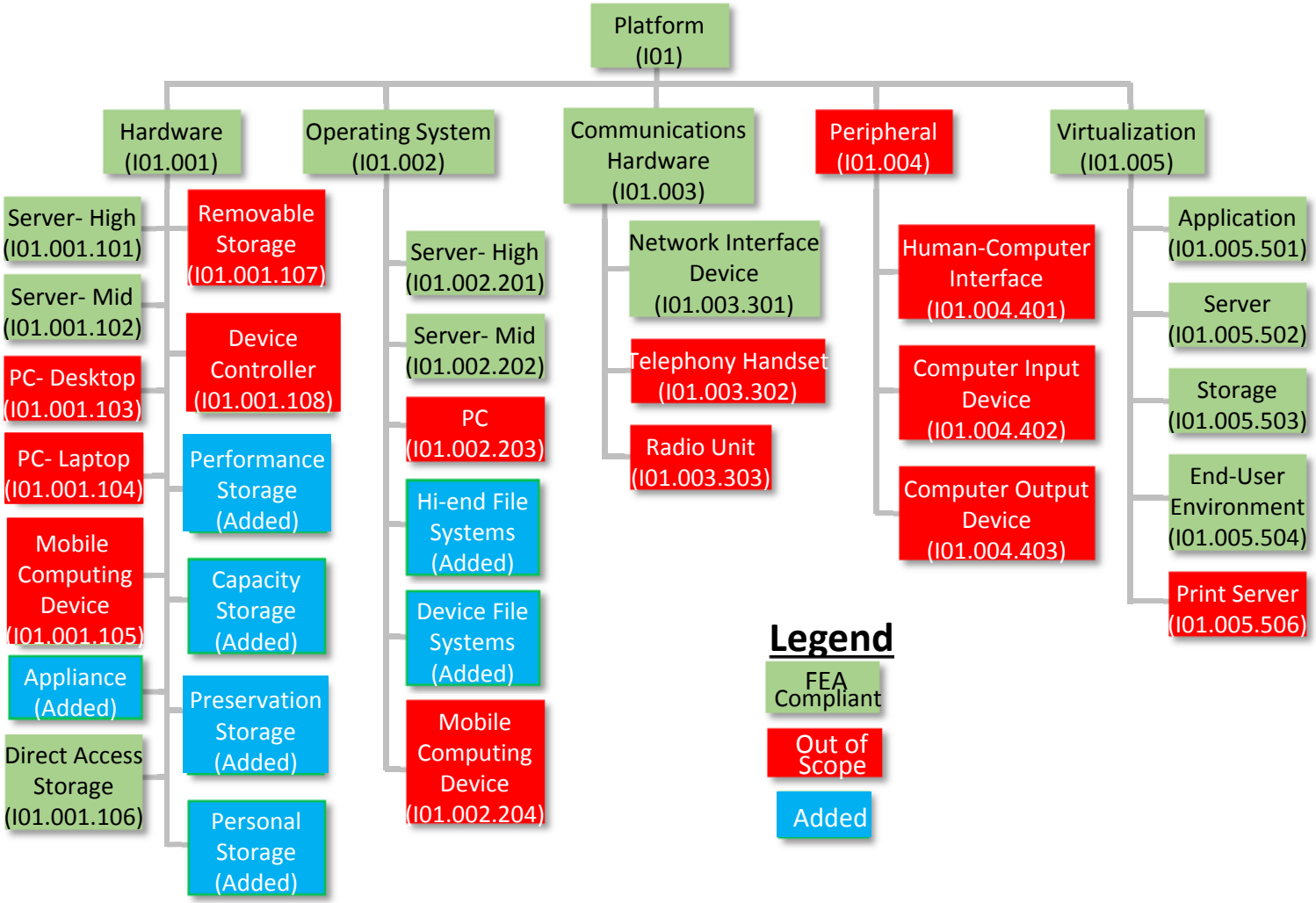
- **IRM**
  - 3 Domains
  - 11 Areas
  - 57 Categories



- **ARM**
  - 3 Domains
  - 39 Areas
  - 186 Categories



Technology Architecture
IRM Platform Taxonomy Example



Technology Architecture
What are the Technology Profiles??

- A living document that delineates the specific technologies, standards, specifications, and/or policies for each category identified in the taxonomy
- Identification & promotion of proven industry standards & technologies to increase interoperability
- The primary resource for determining the status of each technology, standard, specification, and policy
  - Emerging
  - Preferred
  - Permitted
  - Prohibited
  - Sunset/Grandfathered
  - Retired
- Identifies the permitted items within the Enterprise
- Used:
  - During acquisition & engineering milestone decision points
  - Milestone A, B, & C and ORR, PDR, CDR, etc.

Technology Architecture
Technology Profile Example

28. Hardware and Software				
	IEEE 802.1Q-2014	Standard	Mandatory	IEEE Standard for Local and metropolitan area networks--Bridges and Bridged Networks
	IEEE 802.1X:2010	Standard	Mandatory	Local and Metropolitan Area Networks - Port Based Network Access Control
	IEEE 802.3-2012	Standard	Mandatory	IEEE 802.3-2012, IEEE Standard for Information technology - Specific Requirements, Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications
	IEEE Std 802.1AE	Standard	Mandatory	IEEE Standard for Local and Metropolitan Area Networks -- Media Access Control (MAC) Security
	IETF Standard 5 (RFC 791, 950, 919, 922, 792 and 1112)	Standard	Mandatory	Internet Protocol
	IETF Standard 3/RFC 1122/RFC 1123	Standard		Requirements for Internet Host

Technology Architecture
Whose Standards

- NIST (National Institute of Standards & Technology)
- IEEE (Institute of Electrical & Electronics Engineers)
- ISO (International Organization for Standardization)
- IEC (International Electrotechnical Commission)
- FIPS (Federal Information Processing Standards)
- ANSI (American National Standards Institute)
- IETF (Internet Engineering Task Force)
- MIL-STD (DOD Defense Standardization Program(DSP))
- And, other nationally & internationally accepted organizations and governing bodies

Transition & Sequencing Plan
The Roadmap

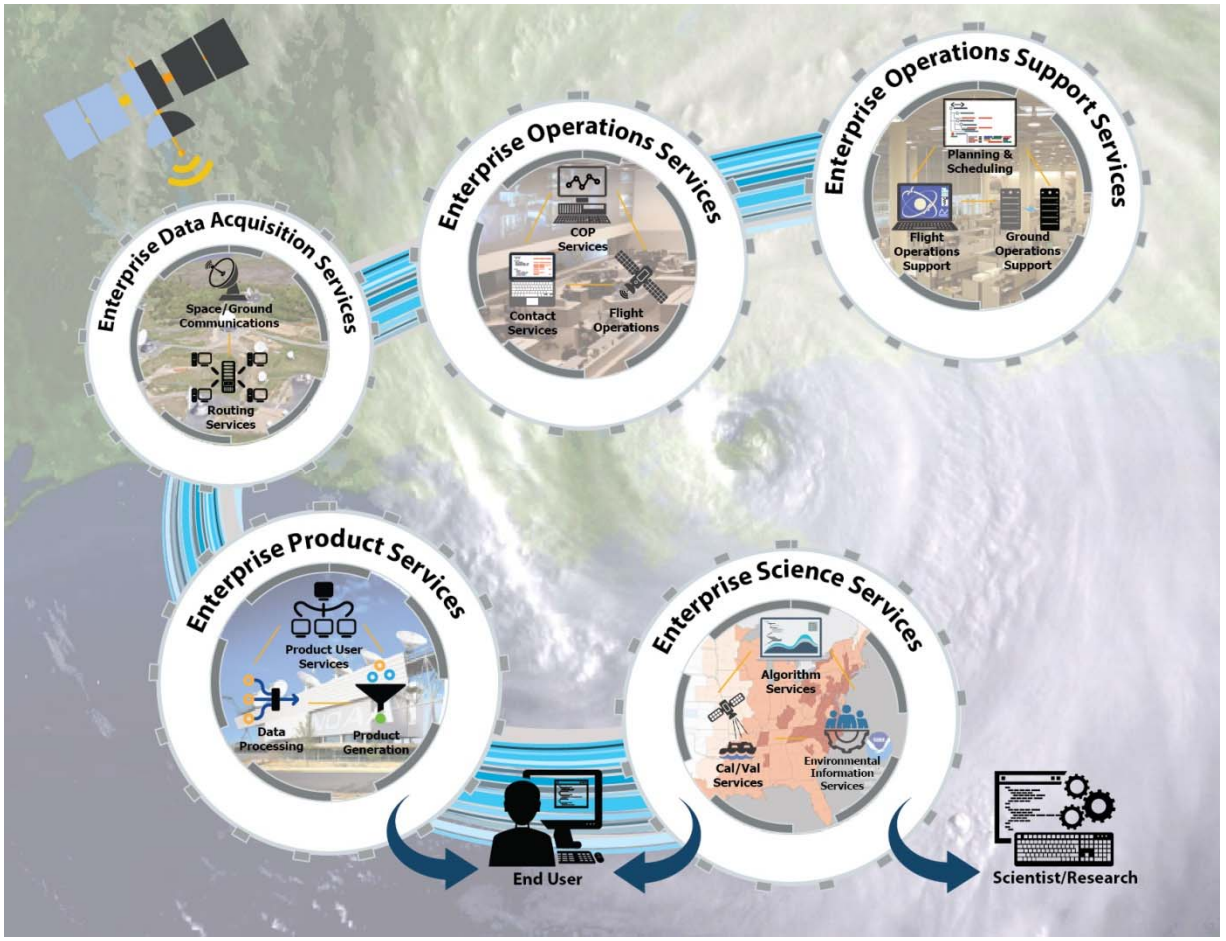
- **Purpose**
  - Establishes a strategic roadmap for achieving the IGE
  - Focus is on the transformation of the current systems-based enterprise to a services-based enterprise by affecting incremental change within the current operational, sustainment and development constraints
- **Scope**
  - Encompasses the breadth of sustainment and capability improvement activities for the NESDIS Ground Enterprise
- **Intended Use**
  - Basis for generating project tasks, schedules, and sequencing of individual efforts
  - Used as a tool, it facilitates taking the architectural artifact from an Enterprise perspective to realize practical implementation projects

Transition & Sequencing Plan Value

- **Enterprise Architecture Model**
  - Line-of-sight from Baseline “as-is” Systems to Target “to-be” Services
    - Complete mapping of NGE capability as we transition from stovepipe systems to common operational services (Verifiable)
  - Integrated with Mission Flyout, Science 5yr Plan & NESDIS Strategic Plan
    - Complete alignment with Satellite and Data Operations business needs (Verifiable)
  - 1st Time NESDIS SME/operational knowledge has been formally captured in a maintainable fashion
- **Investment Model**
  - Investment Strategy Analysis Tool
    - Enables NESDIS to understand the sequencing impact of different transition strategies and scenarios
  - Integrated with common ROI estimation model
    - Provides consistent budgetary and ROI analysis across the Enterprise
  - Integrated with the EA Model
    - Provides a direct line-of-sight from investment strategy to impacted systems and services sequencing

Capability Strategy

- ***Identifies Capabilities around related services***
- ***Groups 14 Capabilities around 5 major business behaviors***
- ***Links every Target Service to an Capability***

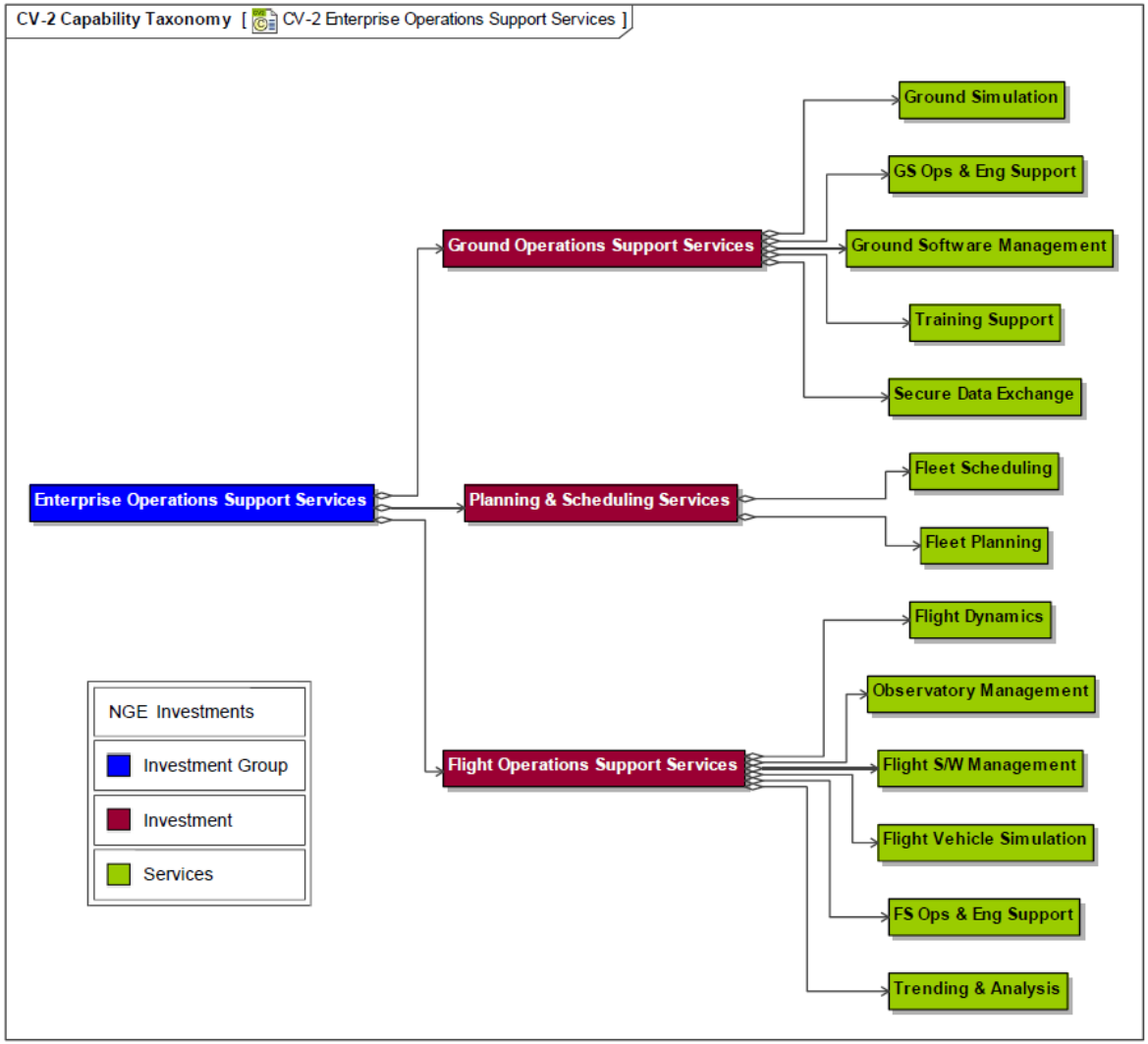


Enterprise Operations Support Services

Flight Operations Support Services - provides engineering and analysis services in support of spacecraft and instrument operations.

Ground Operations Support Services - provides engineering and analysis services in support of ground operations.

Planning & Scheduling Services - provides for the long-term planning and tactical scheduling of operational events, such as orbit maneuvers, satellite contacts, and observation campaigns.

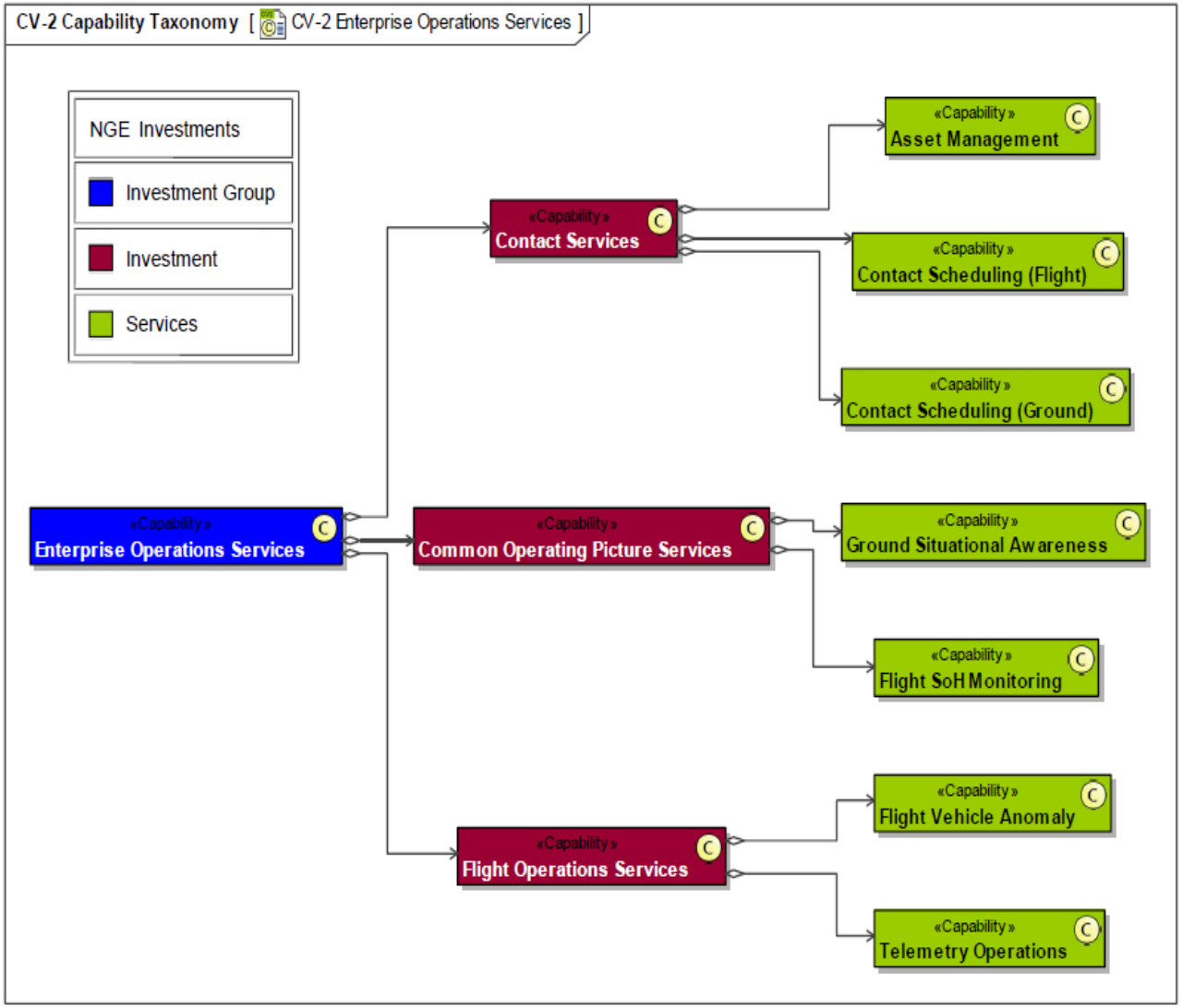


Enterprise Operations Services

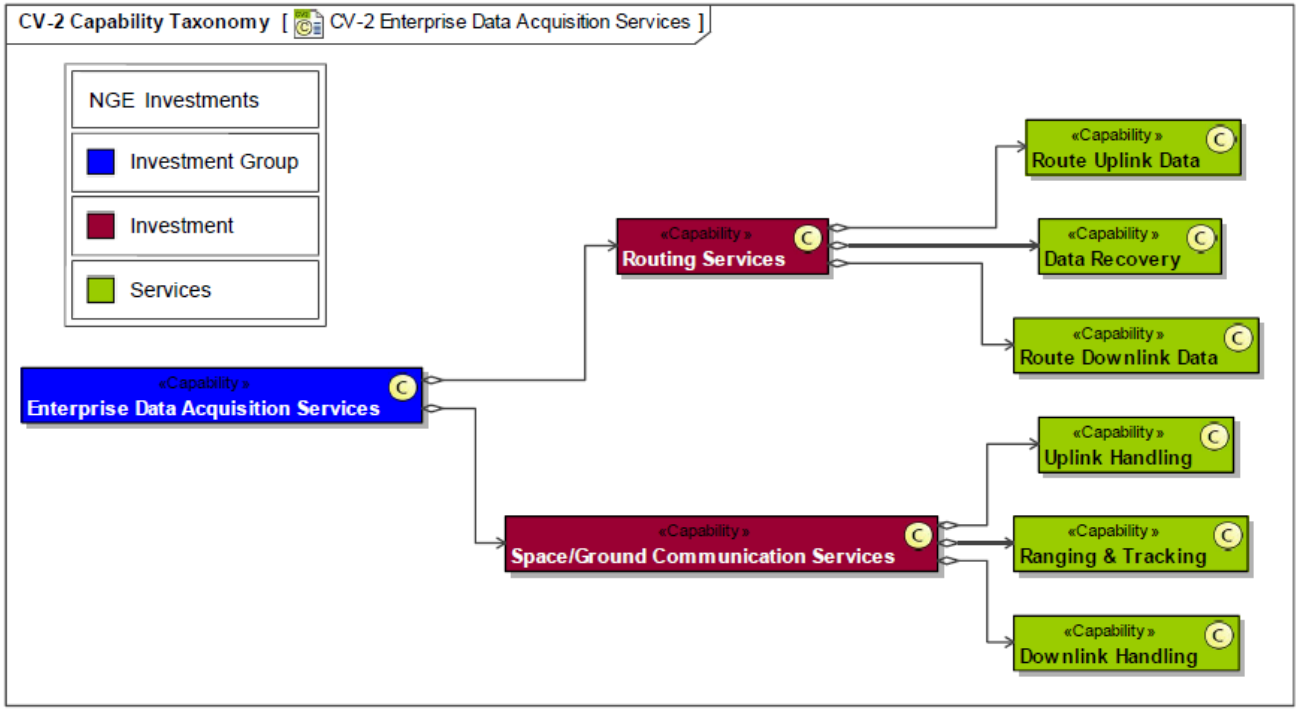
Common Operating Picture Services - provides a single common display environment of relevant (operational) information for all NGE assets (flight & ground).

Contact Services - manages ground assets and processes in support of both uplink and downlink satellite contact management.

Flight Operations Services - provides real-time support for spacecraft operations



Enterprise Data Acquisition Services



Routing Services **- provides ground communications between satellite ground stations and other ground segment facilities.**

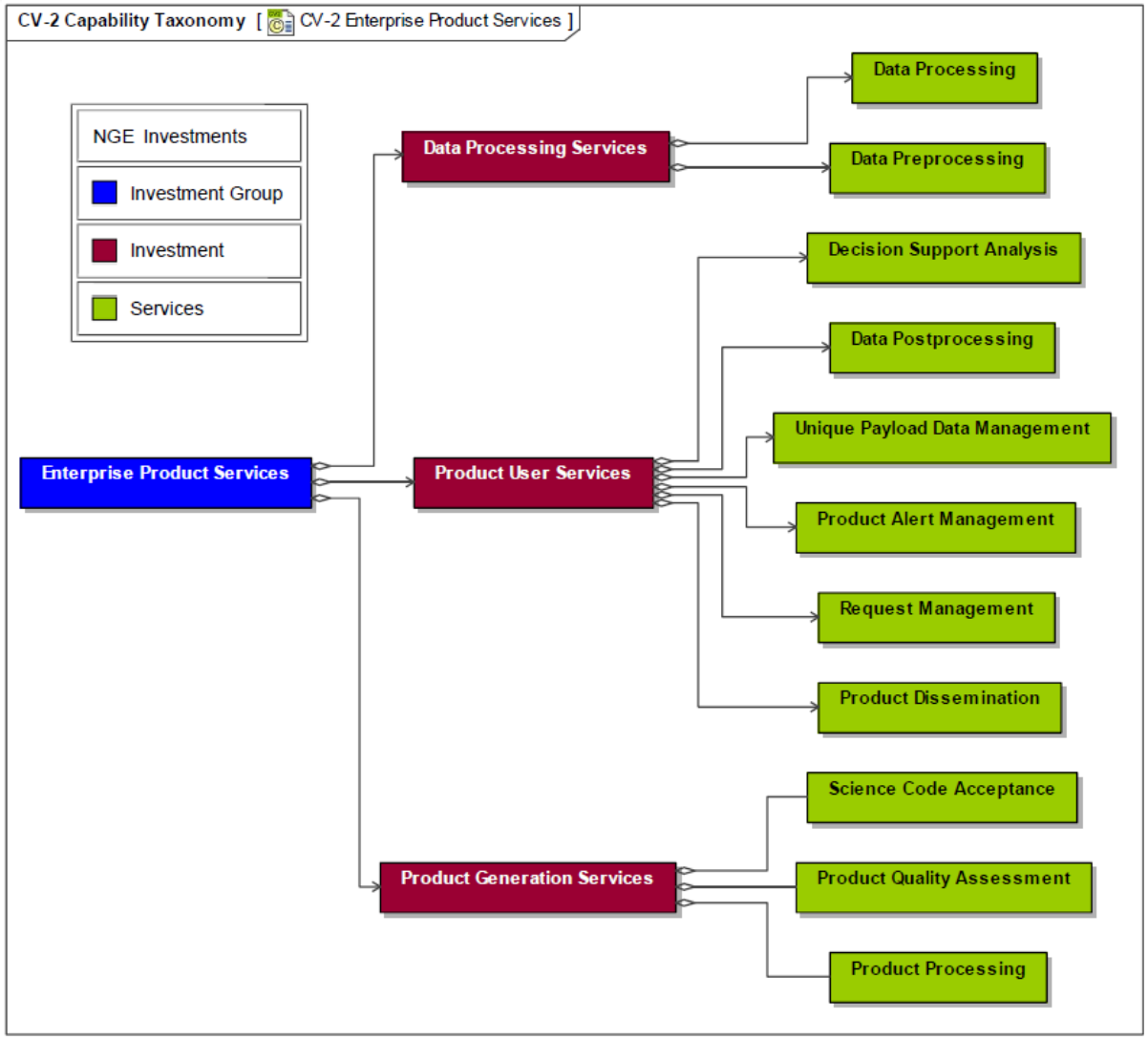
Space/Ground Communication Services **- Supports the satellite / ground communications interfaces.**

Enterprise Product Services

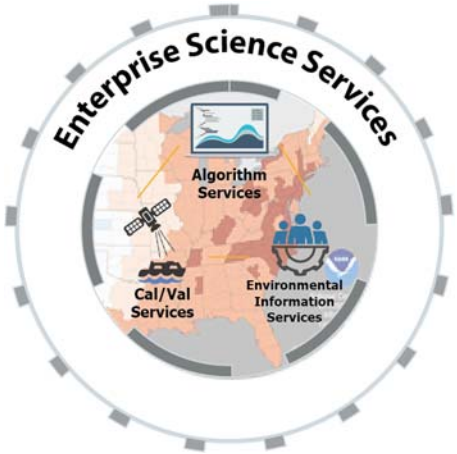
Data Processing Services **- prepares incoming data streams (e.g. mission data from satellites, and ancillary product data from external sources) for use in downstream product generation.**

Product Generation Services **- provides the production services for higher level (L2+, EDR) near-real-time satellite based observation products.**

Product User Services **- provides a variety of services in support of end – user access to products.**



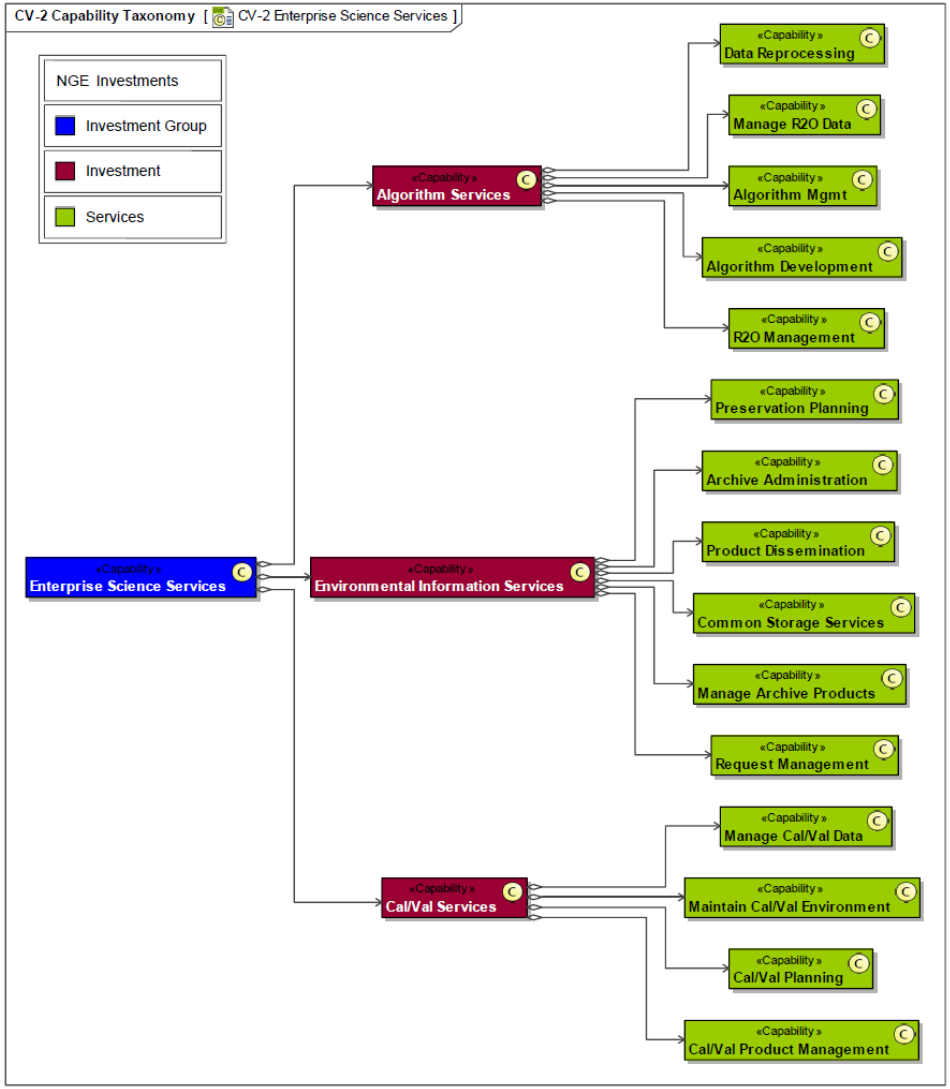
Enterprise Science Services



Algorithm Services **- provides the capabilities needed for science algorithm development and pre-operational testing.**

Cal/Val Services **- Supports the operational calibration and validation of on-orbit instruments.**

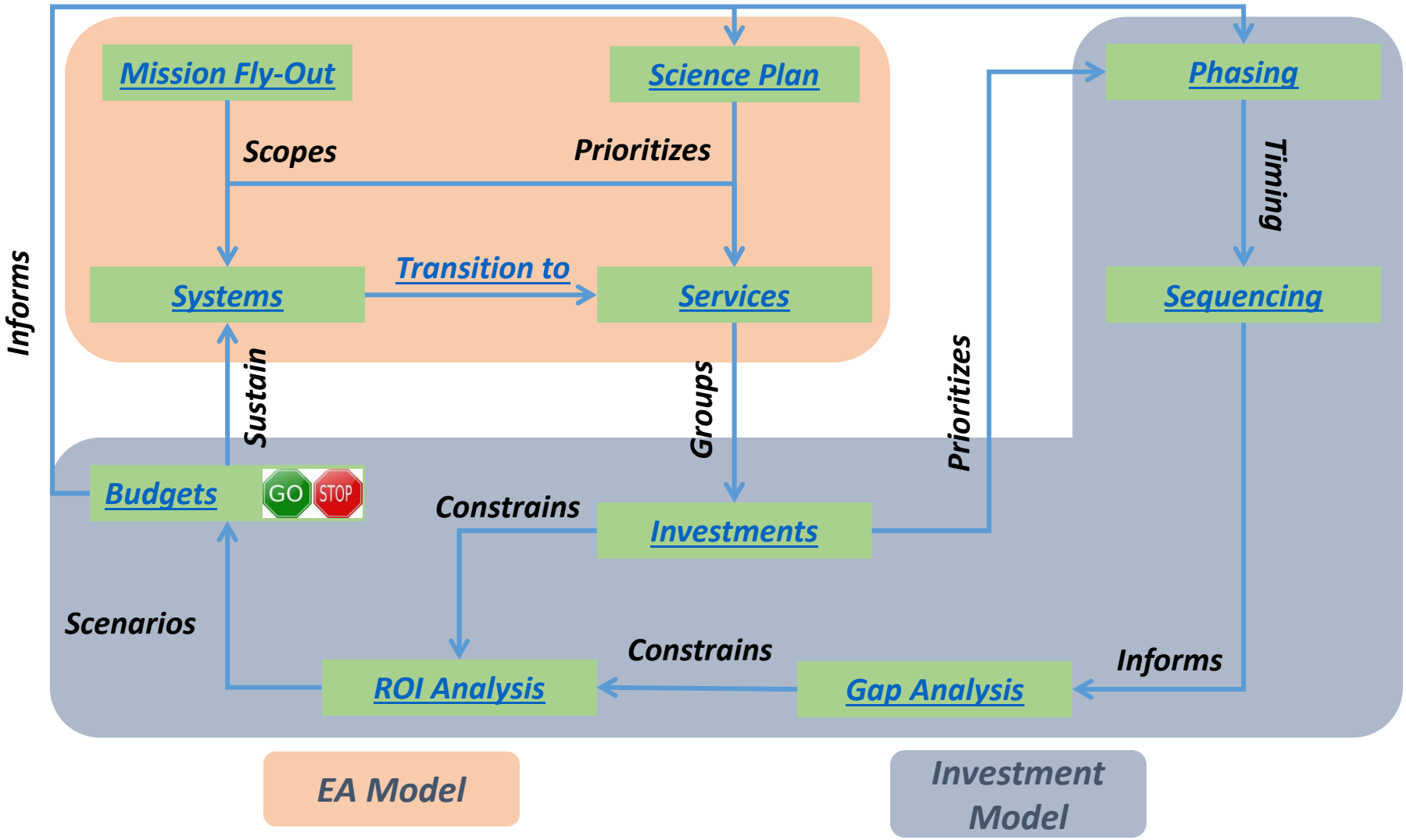
Environmental Information **Services provides long-term product user services to support non-operational access to NGE data holdings**



Engineering Trade Studies

- Disposition for 50% of the Baseline Systems is straightforward:
  - Either there mission end-of-life is soon and so they are "***Sustained in Place***", or
  - They mission extends well beyond the transition to IGE and they are "***Fully Integrated***" into the IGE
- However, for the other 50% mission end-of-life is anticipated to be within 1 tech refresh cycle. These are designated as "***Partially Integrated***":
  - Each system needs to be assessed on its own merits
  - The degree to which these are integrated into the IGE is dependent on the investment needed to transform to IGE, and the return realized by that transformation
- This requires a consistent ROI Modeling approach

Developing an Integrated Transition Analysis



Investment Phasing

Enterprise Initative Group	Enterprise Initiative	Services	2019	2020	2021	2022	2023	2024	2025	2026	2027
Enterprise Data Relay Services	Routing Services	Data Recovery									
	Routing Services	Route Downlink Data									
	Routing Services	Route Uplink Data									
	Sp/Gnd Comm Services	Downlink Handling									
	Sp/Gnd Comm Services	Ranging & Tracking									
	Sp/Gnd Comm Services	Uplink Handling									
Enterprise Operations Services	Common Operating Picture Services	Flight SoH Monitoring									
	Common Operating Picture Services	Ground Situational Awareness									
	Contact Services	Contact Scheduling (Flight)									
	Contact Services	Contact Scheduling (Ground)									
	Flight Operations Services	Flight Vehicle Anomaly									
	Flight Operations Services	Telemetry Operations									
Enterprise Operations Support Services	Flight Operations Support Services	Flight Dynamics									
	Flight Operations Support Services	Flight S/W Management									
	Flight Operations Support Services	Flight Vehicle Simulation									
	Flight Operations Support Services	FS Ops & Eng Support									
	Flight Operations Support Services	Observatory Management									
	Flight Operations Support Services	Trending & Analysis									
	Ground Operations Support Services	Ground Simulation									
	Ground Operations Support Services	GS Ops & Eng Support									
	Ground Operations Support Services	Secure Data Exchange									
	Ground Operations Support Services	Training Support									
	Planning & Scheduling Services	Fleet Planning									
	Planning & Scheduling Services	Fleet Scheduling									
Enterprise Product Services	Data Processing Services	Data Preprocessing									
	Data Processing Services	Data Processing									
	Product Generation Services	Product Processing									
	Product Generation Services	Product Quality Assessment									
	Product Generation Services	Science Code Acceptance									
	Product User Services	Data Postprocessing									
	Product User Services	Decision Support Analysis									
	Product User Services	Product Dissemination									
	Product User Services	Request Management									
	Product User Services	Unique Payload Data Management									
Enterprise Science Services	Algorithm Services	Algorithm Development									
	Algorithm Services	Algorithm Management									
	Cal/Val Services	Cal/Val Planning									
	Cal/Val Services	Cal/Val Product Management									
	Cal/Val Services	Maintain Cal/Val Environment									
	Cal/Val Services	Manage Cal/Val Data									
	Environmental Information Services	Common Storage Services									
	Environmental Information Services	Manage Archive Products									

- Provides the timelines for development & deployment of services grouped by Investment

Development

Deployment Phase I

Deployment Phase II

Deployment Phase III

- Subjective Alignment based on Stakeholder Consensus

40+ Phased Service Deployments

System Sequencing

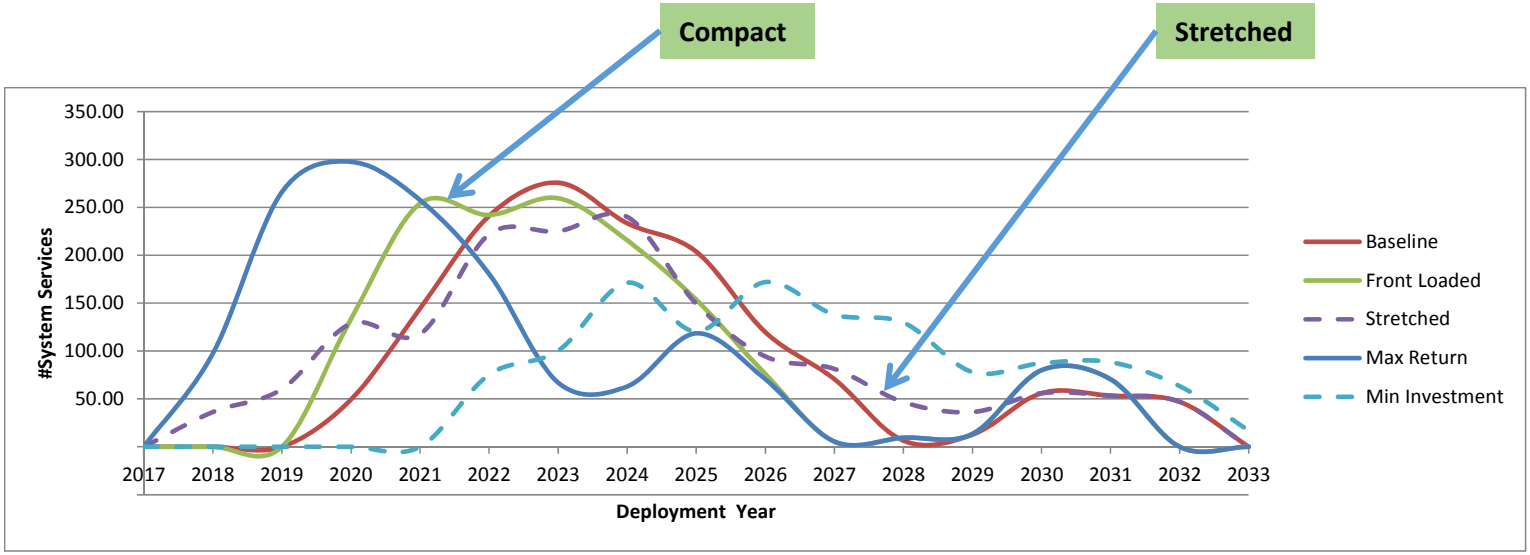
- Specific Transition Sequencing for each System

Enterprise Initiative	Systems	Satellites	Sustainment Goal	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Product Generation Services	NSOF PGS DCS	GOES-R	Partially Integrate		F	F	F	F	F	F	F	F	F	F	F			
Product Generation Services	NSOF PGS GOES-R	GOES-R	Partially Integrate		F	F	F	F	F	F	F	F	F	F	F			
Product Generation Services	NSOF PGS HRIT	GOES-R	Partially Integrate		F	F	F	F	F	F	F	F	F	F	F			
Product Generation Services	NSOF PGS Jason	Jason	Partially Integrate	F	F	F	F	F	F	F	F	F	F	F	F			
Product Generation Services	NSOF PGS POLAR	Jason	Partially Integrate	F	F	F	F	F	F	F	F	F	F	F	F			
Product Generation Services	NSOF PGS VAP	Jason	Partially Integrate	F	F	F	F	F	F	F	F	F	F	F	F			
Product Generation Services	NSOF CVS CGS-GRAVITE	JPSS-1	Partially Integrate			F	F	F	F	F	F	F	F					
Product Generation Services	NSOF PGS CGS-IDP	JPSS-1	Partially Integrate			F	F	F	F	F	F	F	F					
Product Generation Services	NSOF PGS NDE	JPSS-1	Partially Integrate			F	F	F	F	F	F	F	F					
Product Generation Services	NSOF PGS DCS	GOES-S	Fully Integrate				F	F	F	F	F	F	F	F	F	F	F	F
Product Generation Services	NSOF PGS GOES-R	GOES-S	Fully Integrate				F	F	F	F	F	F	F	F	F	F	F	F
Product Generation Services	NSOF PGS HRIT	GOES-S	Fully Integrate				F	F	F	F	F	F	F	F	F	F	F	F
Product Generation Services	NSOF CVS CGS-GRAVITE	JPSS-2	Fully Integrate							F	F	F	F	F	F	F	F	
Product Generation Services	NSOF PGS CGS-IDP	JPSS-2	Fully Integrate							F	F	F	F	F	F	F	F	
Product Generation Services	NSOF PGS NDE	JPSS-2	Fully Integrate							F	F	F	F	F	F	F	F	
				Sustain				*Partial Integration*						*Fully Integrated*				
				Dev.		Deploy I				Deploy II					Deploy III			

980+ System Sequencing Elements

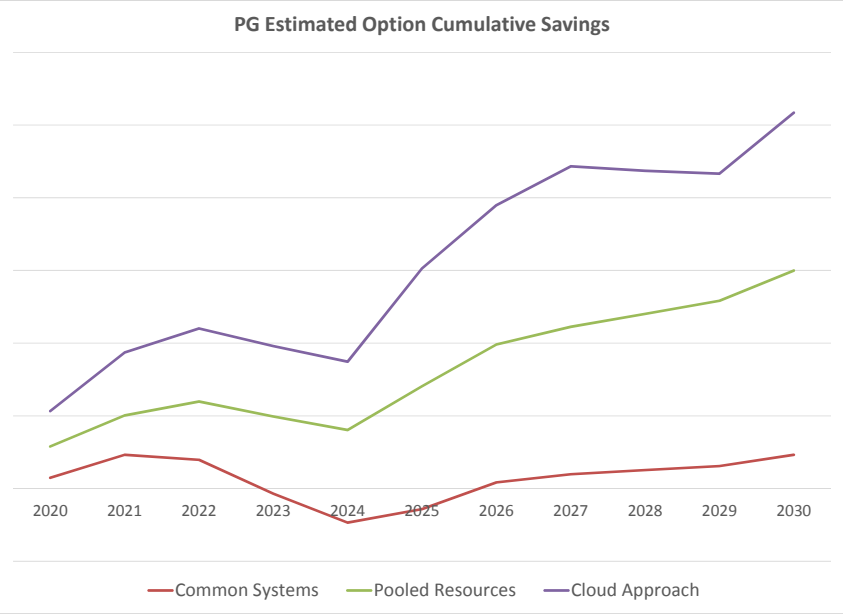
Alternatives

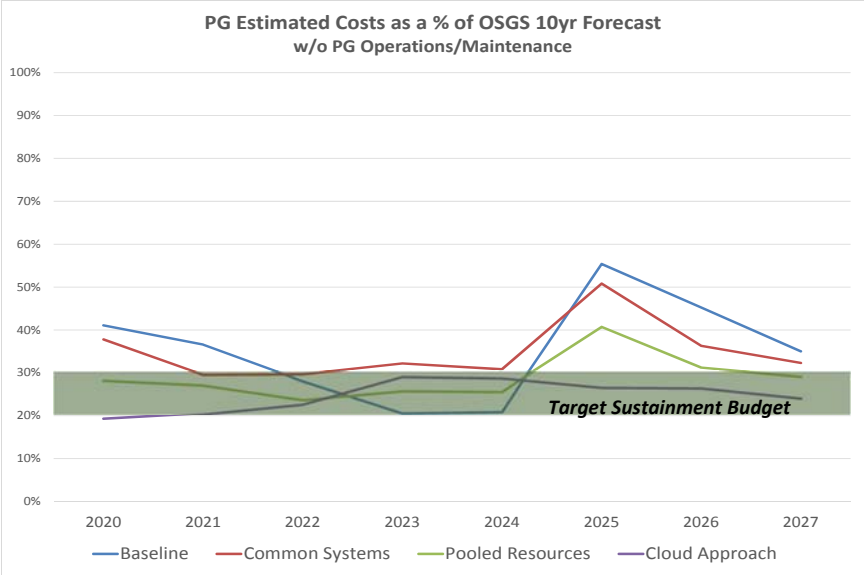
Enterprise Initative Group	Enterprise Initiative	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Enterprise Data Acquisition Services	Routing Services																												
	Sp/Gnd Comm Services																												
Enterprise Operations Services	Common Operating Picture Services																												
	Contact Services																												
	Flight Operations Services																												
Enterprise Operations Support Services	Flight Operations Support Services																												
	Ground Operations Support Services																												
	Planning & Scheduling Services																												
Enterprise Product Services	Data Processing Services																												
	Product Generation Services																												
	Product User Services																												
Enterprise Science Services	Algorithm Services																												
	Cal/Val Services																												
	Environmental Information Services																												



Higher-Level Product Generation

- A cyclic technical refresh strategy for the PG deployed systems for the GOES, JPSS and legacy missions will require significantly more budget resources than previously assumed.
- Significant cost saving should be possible by going to a common suite of core COTS hardware (inclusive of operating system).

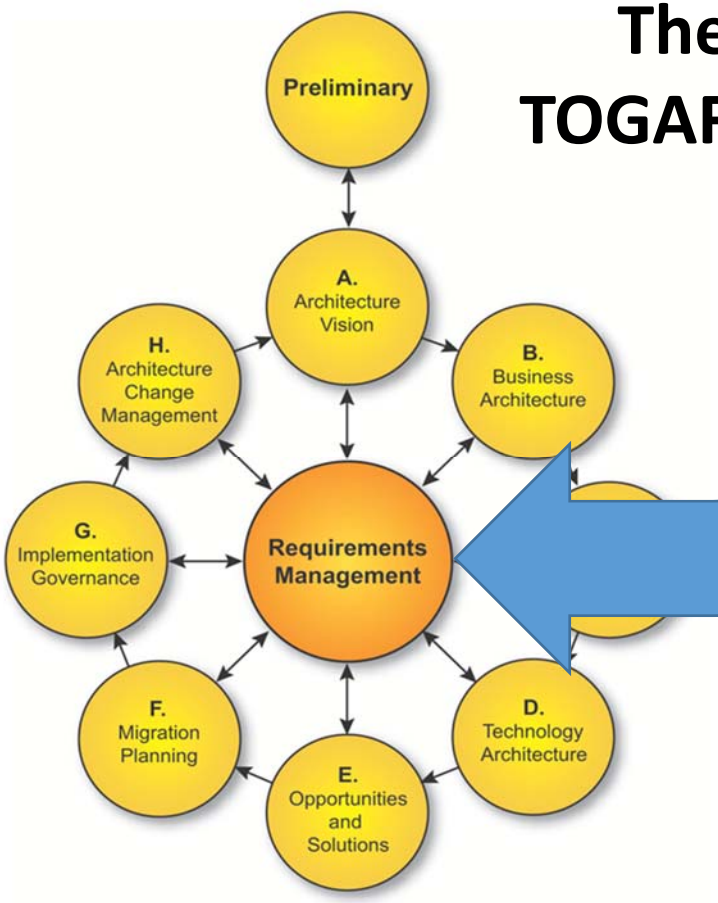




- Additional cost savings should be possible if NESDIS pooled candidate PG functions onto a shared suite of COTS HW and SW at NSOF and CBU.
- Moving the PG compute and data requirements to an outside Cloud Service provider removed the challenge of cyclic technical refresh

NGE Requirements

Requirements
The Heart of the
TOGAF Methodology!!!



NESDIS Strategic Plan

NGE L1 Requirements

NGE L2 Requirements

Individual System Requirements

NGE Requirements

- **15 Approved Level 1 Requirements**
  - *NESDIS GROUND ENTERPRISE (NGE) Level 1 Requirements Document*
- **155 Level 2 Requirements**
  - Completed review within EA team
  - Provided to GART for review at 6/29 meeting
  - Completed review by the EA Working Group

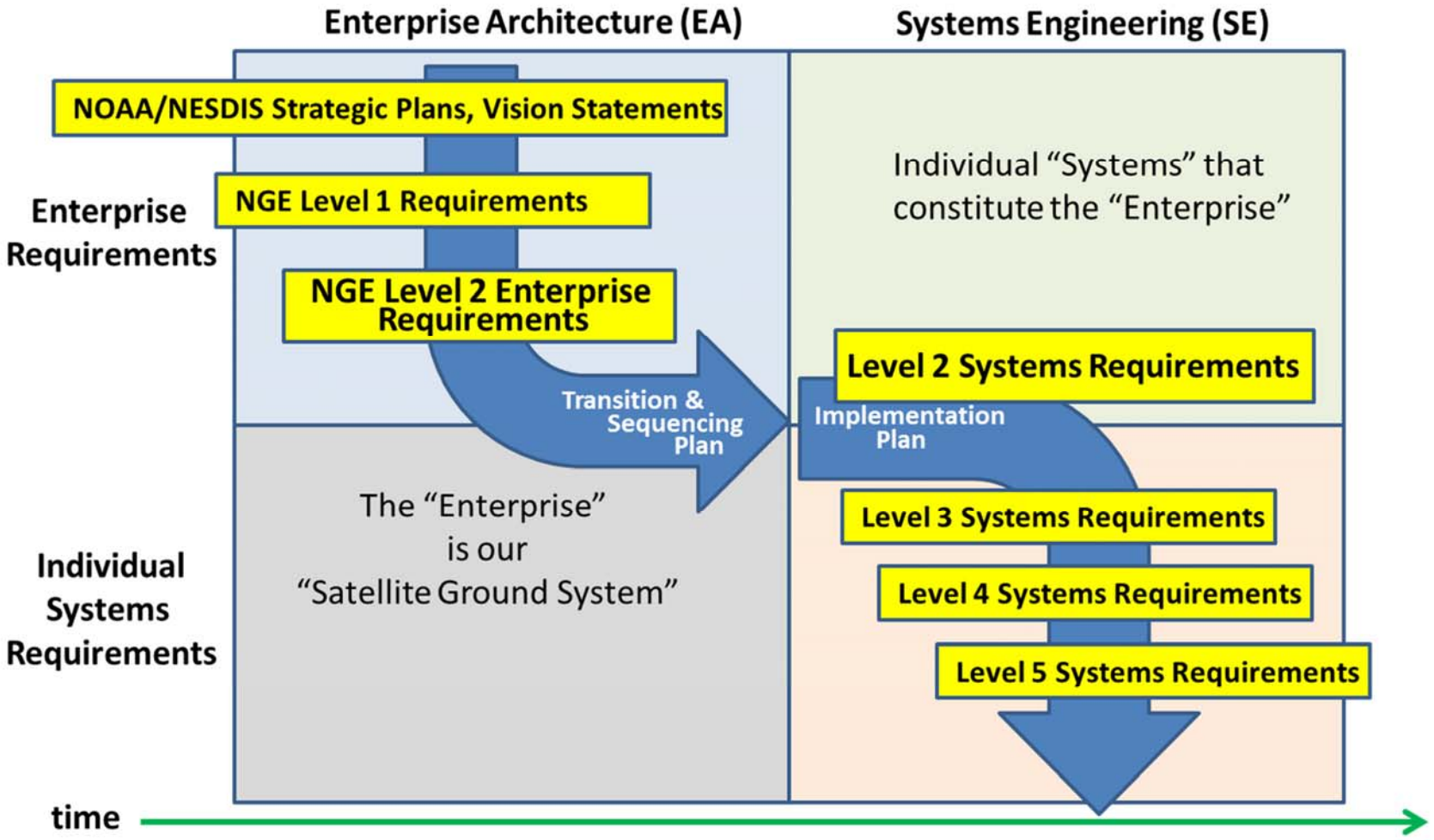
Enterprise L2 Requirements

- **Defines the NGE functionality and qualities**
  - "The NGE shall receive satellite telemetry." [functionality]
  - "The NGE shall be extensible to support additional missions." [quality]
- **Mission scope will be defined via effectivities**
  - An effectivity defines when a requirement is in effect for a particular mission
- **Performance defined in mission-specific specifications**
  - "The NGE shall meet all mission-specific performance specifications, including timelines, availability, and latency."
  - "The NGE shall provide each GOES-R L1b Space Weather End-Product to GAS within 15 seconds of its receipt at NSOF via GRB."

NGE Requirements
Sample Requirement

ID	Text	Rationale	L1RD	BA Mapping
1	**Enterprise Requirements**	These requirements apply broadly across the entirety of NGE. They are primarily qualities or attributes of the enterprise rather than specific functionalities.		
1.1	The NGE shall use open standards.	Open standards promotes interoperability across the enterprise.	4.1	NGE Engineering & Sustainment Node
1.2	The NGE shall be extensible to support additional missions.	An NGE goal is to "never buy another ground system". NGE should be capable of supporting new missions without requiring the acquisition of a new, separate ground system.	4.1	NGE Engineering & Sustainment Node
1.3	The NGE shall provide service-based interfaces to all functions and data.	Providing service-based interfaces enables reuse and achieving new requirements by creating new workflows of existing functionality.	4.1	NGE Engineering & Sustainment Node

Requirements Traceability EA-to-SE



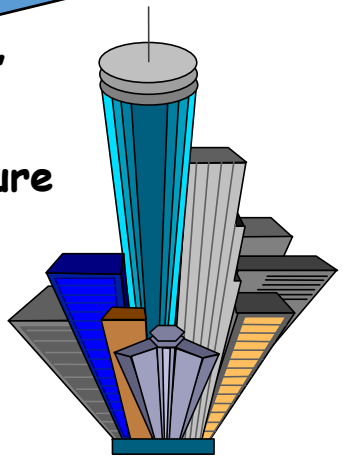
Towards Systems Engineering
Transition & Implementation

Transition

"As-Is"
Baseline
Architecture

Architect

"To-Be"
Target
Architecture



Build

Implementation

- System Architecture/System Requirements
- Concept Studies and Trades
- Implementation Planning
- Annual Budgeting of Initiatives
- System Development, Test/Eval/Acceptance

"Never Buy Another Stand Alone Ground System Again"

GEARS Transition
iSEE