ENTERPRISE GROUND TRANSFORMATION AT NESDIS

Steven R. Petersen
National Oceanic and Atmospheric Administration
steven.petersen@noaa.gov

ABSTRACT

The National Environmental Satellite Data and Information Service (NESDIS) acquires, operates, and sustains geosynchronous and polar weather satellites for the National Oceanic and Atmospheric Administration. These platforms provide key observations for the National Weather Service and a variety of other US users and international partners. Recently NESDIS began activities to transform its ground enterprise from the traditional model of stand-alone systems into an integrated capability that is more flexible, responsive, sustainable, and cost effective. This paper describes results to date, including the Concept of Operations and initial Business Architecture view. It also provides examples of early enterprise activities nearing completion and the underlying service oriented architecture that provides the technical basis for the long-term to-be end state. Finally it illustrates the challenges associated with creating change on an enterprise scale.

BACKGROUND

The National Environmental Satellite Data and Information Service (NESDIS) acquires, operates, and sustains geosynchronous and polar weather satellites for the National Oceanic and Atmospheric Administration[1]. These platforms provide key observations for the National Weather Service and a variety of other US users and international partners. Historically, due to partnerships and acquisition strategies, NOAA's satellite missions were developed as stovepipe systems. In the near term NESDIS will take ownership of separate ground segments developed to support the Geostationary Operational Environmental Satellite Series R (GOES-R)[2] and Joint Polar Satellite System (JPSS)[3]; these will join the infrastructure previously fielded to support legacy Geostationary Operational Environmental Satellite (GOES), Polar Operational Environmental Satellite (POES), and other NESDIS missions. NOAA's stovepipe architectures provide limited sharing of common standards, services or functionality. These systems generally use dedicated component resources crafted to perform solely one mission. While these designs are well-thought out and generally perform their intended functions well, they frequently lack provisions for sharing with other missions that need similar services. This leads to high acquisition costs in the aggregate due to redundant functionality with each new program and high operations and maintenance costs. These costs are particularly important now due to the current Federal budget and policy changes that are affecting NOAA.

ORGANIZATION

In January 2015 NESDIS activated the Office of Satellite Ground Services (OSGS)[4]. OSGS was created to centralize development and sustainment of all NESDIS satellite ground capabilities. To accomplish this objective OSGS is executing three separate but interrelated missions. The first is to sustain NESDIS legacy ground systems. These include the GOES and POES ground systems plus the recently fielded JASON system and elements of infrastructure such as the antennas. The second mission is to assist in the completion and transition to sustainment of the new GOES-R and JPSS ground systems. OSGS provides NOAA civil servants to these satellite program offices.

The third mission is to lead the transition to an Integrated Ground Enterprise (IGE) that offers cost-effective, secure, agile, and sustainable support for the NESDIS mission. The ultimate goal is to never again buy an entire new ground system for future satellite constellations. The remainder of this paper describes how OSGS is executing this third mission. When fully developed the IGE will provide a suite of common ground services enabling (1) reduction of mission ground systems costs and (2) accelerated deployment of capabilities.

Reduction of mission ground system costs will be achieved by 1) Eliminating redundant development of common ground system functionality; 2) Sharing common but underutilized infrastructure resources across satellite programs, and 3) Streamlining ground operations by eliminating redundant operations and embracing automation to require fewer support staff.

Accelerated deployment of new ground system capabilities will be achieved by: 1) Eliminating redundant acquisition of common ground system functionality; 2) Providing a common hardware and software environment for the development and deployment of new functionality, and 3) Implementing business process changes to streamline deployment.

Planning for the transition to the IGE is accomplished through three primary activities: 1) Development of an overarching IGE Concept of Operations[5] (completed); 2) Crafting of an Enterprise Architecture describing the current and to-be IGE states, and a Gap Analysis assessing shortfalls between the two states (in work); and 3) Development of a Transition and Sequencing Plan describing the investments needed for the transformation from the current state to the full IGE (in work)

IGE CONCEPT OF OPERATION AND USE CASES

The IGE Concept of Operations has been completed. It describes the capabilities and attributes that the future Integrated Ground Enterprise (IGE) will possess and illustrates the application of these capabilities and attributes across 12 use cases. Table 1 below describes the capabilities and attributes of the IGE.

Capability/ Attribute	Description
Enterprise Governance	IGE is a shared resource that must be governed as an enterprise resource; all stakeholders have a voice through a Governance Board.
Enterprise Management	Enterprise management will provide situational awareness (health and status) and the capability to move resources from one use to another.
Enterprise Funding	All using organizations will provide baseline requirements; NESDIS will assess IGE requirements and request the necessary funding.
Shared Infrastructure	An infrastructure of network, compute, storage and software resources are shared and dynamically managed to meet NESDIS requirements.
Ubiquitous Data Access	IGE provides a MetaData Registry describing available data and how to access it. Documented, standards-based APIs enable access.
End-to-End Lifecycle Data Management	Data management includes acquisition, quality control, validation, reprocessing, storage, retrieval, dissemination, and preservation. IGE provides common services for many elements of the process.
Isolation of Impacts	IGE provides separations such as hypervisors between the users of the shared resources, and enforces isolation by controlled interfaces.

Hardware Agnostic	IGE supports infrastructure as a service (IaaS), allowing hardware and software to be developed, allocated, and managed independently.
Location Agnostic	IGE is a distributed system where functionality may be implemented anywhere and migrate to new locations without impact to the users.
Acquisition Approach Agnostic	IGE enables a range of acquisition approaches for adding additional resources, capabilities or applications - through competition, sole source, internal development, or by transfer from an academic partner
Service-Oriented Approach	Every IT resource is accessible as a service. Each service interacts with the enterprise through defined interfaces, so services can be replaced or added with limited impact to the rest of the enterprise.
Maximum Reuse of Common Services	Missions are incentivized to reuse existing services instead of creating redundant functionality, and common services are well documented in an enterprise registry. By policy and contract the Government will own full data rights for all IGE common services (except for COTS).
Use of Standards	IGE resources, interfaces, data and metadata formats use non-proprietary standards that have broad deployment and proven success.
Support for Automation	IGE provides workflow automation for greater reliability, faster execution, reduced human errors, and reduced cost.
Security as Infrastructure	IT security capabilities include virus scanning, firewalls, network filtering, virtual private networks, user authentication, controls, etc.
Warehousing and Restoring	Warehousing saves the a user's profile and resources to storage so that the resources can be freed for other users; later restored easily.

Table 1 – Capabilities and Attributes of the IGE Concept of Operations[6]

In addition to the capabilities and attributes above the Concept of Operations features twelve use cases. These illustrate the benefits of the IGE approach to all the major groups of stakeholders, from application developers to operators to end users. The goal is to socialize the benefits of the IGE and enable all stakeholders to see themselves within the new construct. Table 2 lists the use cases.

Routine Satellite Operations
Integration of a New Satellite Mission
Transition of a NASA Research Satellite Mission to NOAA Operations
Integration of an External Data Source
New Data Product Requirement
New Algorithm Development
Algorithm Sustainment
Calibration and Validation (Cal/Val) Support
Governance of Common Services
Automation of a Ground system Function
Adding a New Common capability to IGE
Reprocessing

Table 2 – Concept of Operations Use Cases[7]

The embrace of modern information technology concepts such as a service oriented architecture and shared resources suggested a layered building block approach shown in Figure 1 below.

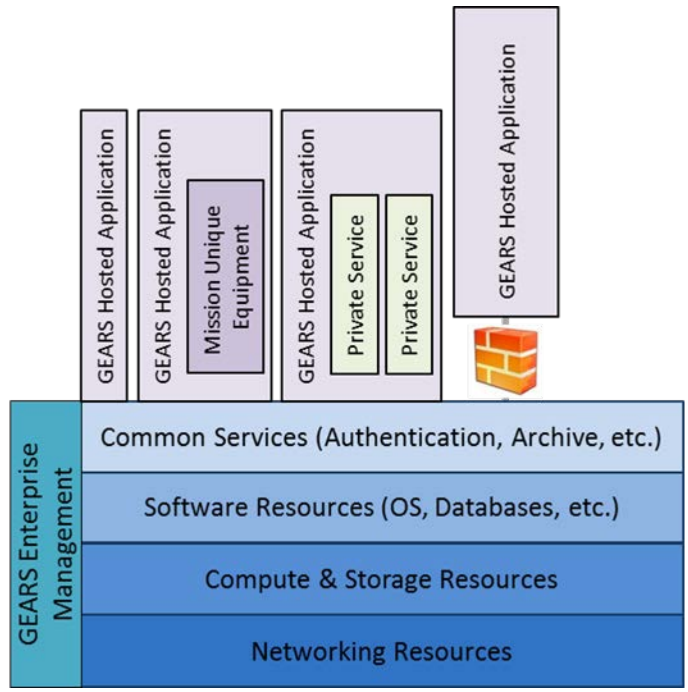

Figure 1 – IGE Infrastructure Approach[8]

Compared to the existing stand-alone approach, the IGE Concept of Operations brings significant impacts to traditional approaches to design, development, sustainment, operations, security, and staffing. Table 3 lists some of these impacts.

Impact	Description
Government Integrator and Infrastructure Provider	In a traditional acquisition a prime contractor provides an end-to-end system, selecting and implementing resources and integrating the system. With IGE the Government provides infrastructure resources and assumes a greater responsibility for integration and performance.
Staffing and Skills	Designing, implementing, operating and maintaining a shared infrastructure requires new staffing and skill sets.
Shared Resources	Since resources are used by many systems across the enterprise, there is a need for redundancy and other mitigations to increase risk.
Security	Capability provisioned across the enterprise reduces the need to implement a redundant set of controls within each application
Satellite Ground System Architecture and Design	Each new satellite ground capability added to IGE becomes an integral part of the overall enterprise architecture. New capabilities must comply with enterprise architecture principles such as being location agnostic, using standards, adhering to open standards, etc.
Mission Acquisition	Missions constitute incremental modifications and additions to the existing ground enterprise, and must be compatible with IGE.

Flight / Ground Integration	IGE provides a defined, documented, and standards-based interface between the flight segment and the ground segment.
Development and Deployment of Ground Functionality	IGE will provide development, test and deployment resources. This avoids costs and speeds development by eliminating delays to acquire resources, provides an environment that mimics operations, provides operational and test data, and common services. This may increase the integration risk, requiring increased integration testing.
Mission Operations	Operators will interact with a common ground operator interface, resulting in lower training costs and improved operations efficiency.
Sustainment	Individual IT resources can be refreshed independent of the systems that use those resources. This enables a dynamic refresh cycle.
Requirements	Level 1 ground requirements will mandate use of IGE.

Table 3 – Impacts of Adopting the IGE Concept of Operations[9]

The IGE Concept of Operations was completed in February 2015. It provides a foundational focus for the Enterprise Architecture activities currently underway.

ENTERPRISE ARCHITECTURE (EA) OVERVIEW

When complete the Enterprise Architecture will provide a comprehensive vision of the capabilities of the IGE end state. This includes descriptions of the mission functions, organizations, data flows, and technologies necessary to achieve the capabilities captured in the Concept of Operations and bounded by the Level 1 requirements. The OSGS EA team is using the TOGAF (The Open Group Architecture Framework)[10] to create three viewpoints of the NESDIS Ground Enterprise (NGE). The Business Architecture[11] is the first viewpoint. The subsequent viewpoints are the Information Systems Architecture (ISA) and the Technology or Technical Architecture (TA). The purpose of the Business Architecture is to describe business needs the NGE must meet versus requirements the NGE system must satisfy or system capabilities the NGE system must provide. The NGE end state is the IGE.

The Business Architecture encompasses the mission and mission support ground capabilities that exist, or will soon exist, in NESDIS today. This includes the legacy satellite ground segments, early enterprise elements like the Environmental Satellite Processing and Distribution System (ESPDS), the Comprehensive Large Array-data Stewardship System (CLASS), and the soon-to-be-operational GOES-R and JPSS ground systems.

The Business Architecture consists of the Baseline (As-Is) and Target (To-Be) viewpoints and a preliminary Gap Analysis identifying the differences between them. The Baseline (As-Is) Business Architecture describes business capabilities that exist as of the end of Fiscal Year 2015. The Target (To-Be) Business Architecture describes desired IGE business capabilities in the 2022 timeframe. It is these differences between the current timeframe and the target timeframe that represent candidate initiatives for migrating from today's stand-alone systems-based environment to a service-oriented architecture in the future. Figure 2 below illustrates IGE operations in the target timeframe.

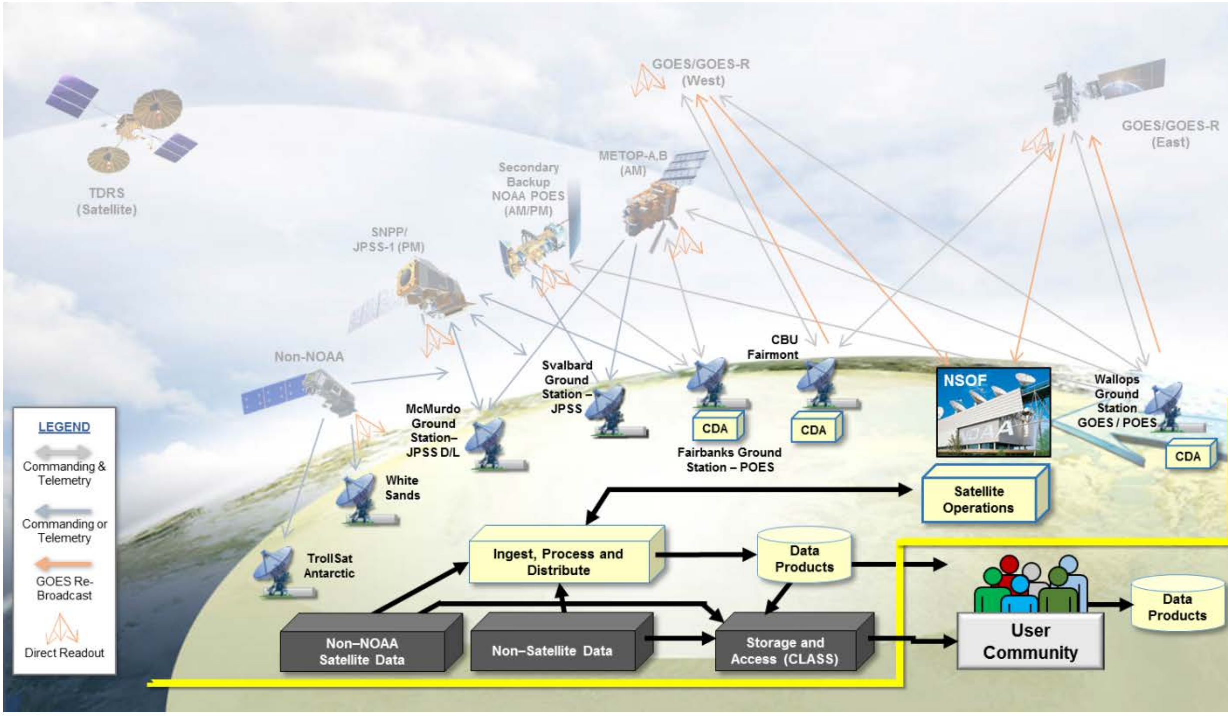

Figure 2 – The NESDIS Ground Enterprise[12]

ANALYSIS APPROACH: TOGAF ARCHITECTURE DEVELOPMENT METHOD (ADM)

The TOGAF ADM is the result of continuous contributions from a large number of architecture practitioners. It describes a method for developing and managing the lifecycle of an enterprise architecture, and forms the core of TOGAF. Figure 3 below illustrates the nine phases of the ADM. They are:

- Preliminary Phase
- Architecture Vision Phase (A)
- Business Architecture Phase (B)
- Information Systems Architecture Phase (C)
- Technology Architecture Phase (D)
- Opportunities and Solutions Phase (E)
- Migration Planning Phase (F)
- Implementation Governance Phase (G)
- Architecture Change Management Phase (H)

Figure 3 – TOGAF Method[13]

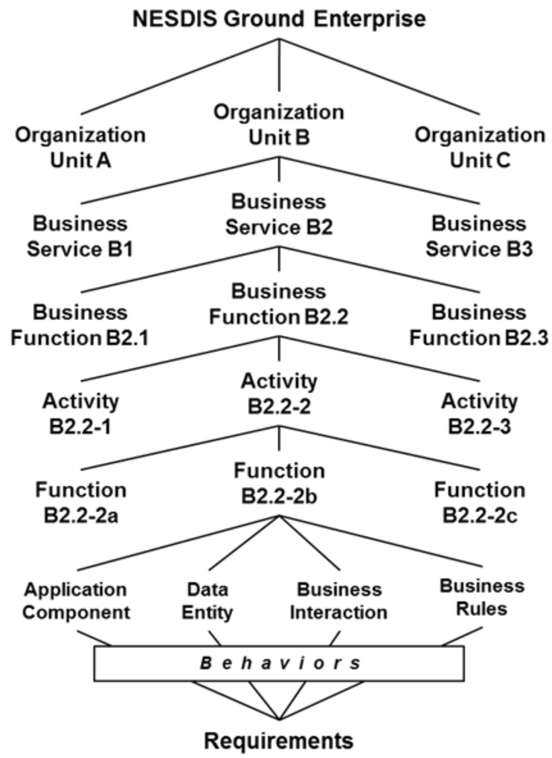

Figure 4 – Enterprise Blueprinting[14]

Enterprise Blueprinting is an established methodology developed to systematically describe business functions and associated applications, data, interfaces, and rules. It accurately, completely and consistently elucidates IT application requirements and is based on over 30 years of pragmatic systems engineering applied to many businesses and business disciplines. The OSGS EA Team tailored Enterprise Blueprinting to merge it with The Open Group Architecture Framework (TOGAF).

As illustrated in Figure 4, Enterprise Blueprinting decomposes the Ground Enterprise into organization units, business services, business functions, activities and functions. The behavior of applications, data, interfaces and business rules describe each function and lead to an accurate elucidation of requirements. To ensure completeness, Enterprise Blueprinting includes analysis of mission objectives using Mission Threads and Capability Vignettes. The OSGS EA Team has adapted the Business Process Model and Notation (BPMN) capabilities available in the NESDIS architecture modeling tool, MagicDraw[15], to create a series of BPMN process flows. In addition to housing the artifacts created during the architecture analysis MagicDraw can be integrated with the DOORS requirements management tool, enabling traceability and linkages between architecture and requirements.

Enterprise Blueprinting has three phases. The OSGS EA Team has completed Phase One, Community Analysis, and Phase Two, Operations Analysis, in the development of the IDE business architectures. Phase Three, Systems Analysis will be done in conjunction with OSGS system engineering during the TOGAF ISA phase.

BUSINESS ARCHITECTURE ARTIFACTS

Examples of artifacts produced for the Target Business Architecture are shown below. The Mission Line of Sight Diagram[16], Figure 5 below, depicts the relationship of the IGE mission needs, as specified in the requirements applicable to the baseline architecture from the Level 1 Requirements Document, to the NOAA, NESDIS and OSGS missions. The Functional Decomposition Diagram, Figure 6, identifies the IGE business capabilities and their relationship to the types of organization that provide the capability.

Figure 5 – NESDIS Mission Line of Sight

Figure 6 – Target Business Architecture Functional Decomposition[17]

There are four groupings shown in the diagram – one for capabilities that are provided by international organizations, one for capabilities provided by United States Government organizations, one for capabilities provided by NOAA, and for capabilities provided by NGE.

RESULTS OF THE BUSINESS ARCHITECTURE ANALYSIS

The Business Architecture development effort and the associated Gap Analysis discovered potential near-term and long-term investment opportunities on the path to transitioning to the desired end-state of the 2022 Target Enterprise Architecture. This includes new capabilities, existing mission-specific capabilities that should be combined and applied enterprise wide, and existing capabilities that should be enhanced and applied across the enterprise. The following is a list of the candidate, business process migration opportunities ascertained during the development of the NGE Business Architecture:[18]

Infrastructure – Investment in enterprise infrastructure capabilities migrates mission-specific capabilities to the enterprise with attendant savings in acquisition, maintenance and sustainment.

Algorithm R&D – Investment in enterprise algorithm research and development capabilities consolidates mission-focused algorithm sustainment and maintenance activities into an enterprise capability that supports algorithm research, development, deployment, maintenance and sustainment with savings in the time from research to operations and significant reduction in the number of algorithm versions that need to be supported.

Product Generation – Investment in enterprise product generation capabilities consolidates mission-focused product generation into an enterprise-wide product generation capability. It is expected the enterprise capability will be built on enterprise infrastructure services, thereby achieving savings in COTS licensing, system sustainment and maintenance.

Enterprise Engineering – Investment in enterprise engineering capabilities consolidates mission-focused management activities into enterprise engineering services providing enterprise-level tools and processes for configuration management, requirements management, acquisition management, facility management, quality management and risk management with savings in engineering, licensing and system sustainment and maintenance.

These opportunities will be thoroughly assessed in conjunction with the ISA analysis to be completed in upcoming months. As the Enterprise Architecture work continues, early investments in enterprise capabilities are already maturing within OSGS.

EARLY ENTERPRISE ELEMENTS

Before the Concept of Operations was drafted NESDIS leadership recognized two early opportunities to apply an enterprise approach to existing needs. OSGS now leads development of two systems, the Environmental Satellite Processing and Distribution System (ESPDS) and the Comprehensive Large Array-data Stewardship System (CLASS) that embody the enterprise principles described above.

The Environmental Satellite Processing and Distribution System (ESPDS)[19] is being developed by the Solers Corp under a contract awarded in August 2010. It modernizes the existing Environmental Satellite Processing Center (ESPC), operated by the NESDIS Office of Satellite and Product Operations, with an enterprise solution that meets some of the needs of legacy, GOES-R, S-NPP/JPSS, and GCOM-W satellite programs, with scalability to support future environmental satellites. It includes modernization of the Product Generation (PG), Product Distribution (PD), and Infrastructure segments of the ESPC (with Ingest as a potential future modernization), and provides environmental satellite data and services to a growing user community including the NOAA Line Offices (NWS, NMFS, NOS, NIC, NESDIS, etc.), DoD (AFWA, NAVO, etc.), and other U.S. and international users (government, universities, foreign partners, etc.). ESPDS provides a scalable and secure infrastructure as a foundational building block upon which all other system functions and services reside. It leverages common infrastructure and processing services, reducing redundancy and costs while simplifying operations, maintenance, monitoring, and security.

The ESPDS User Portal provides user self-service subscription and search capabilities across all NESDIS products, eliminating labor required with the current manual subscription method. Approved users can manage their data access details (product customization, selection and transfer method) and exercise greater data discovery (via the online catalog). Enterprise Shared Storage reduces transfers of data, reducing resource requirements and improving reliability. ESPDS is built on a Service-Oriented Architecture (SOA) that provides the following benefits: 1) Extensibility: The loose coupling of services allows the ability to add new functionality to the system without impacting the existing capabilities; 2) Reusability: ESPDS services will be usable for future integration, benefitting future government systems; 3) Modularity: ESPDS services can be upgraded and replaced easily.

ESPDS will be fielded at the primary and backup ESPC sites. The primary ESPC site is the NOAA Satellite Operations Facility (NSOF) in Suitland, MD; the future ESPC backup site is the Consolidated Back Up (CBU) facility in Fairmont, WV. The program is on-track to provide distribution of some GOES-R products following its launch in 1Q17. ESPDS will also generate products and distribute data from the JPSS satellites, with the first launch scheduled for 2Q17.

The Comprehensive Large Array-data Stewardship System (CLASS)[20] development contract was awarded to DGP, a joint venture between DB Consulting (8a) and Global Science & Technology Inc., in March 2008. CLASS was developed to support long-term, secure storage of NOAA-approved data, information, and metadata, and to enable access to these holdings through both human and machine-to-machine interfaces. Capabilities are provided in 3 primary functional areas as defined by the Open Archive Information System Reference Model (OAIS-RM): 1) Ingest - mechanisms by which data, information, and metadata are transferred to and organized within the storage system; 2) Archival Storage - common enterprise means for data, information, and metadata to be stored by the system and the capability to refresh, migrate, transform, update, and otherwise manage these holdings as part of the preservation process; 3) Access - common enterprise access capability enabling users to identify, find, and retrieve the data and information of particular interest to the user.

As an enterprise solution, CLASS is anticipated to reduce cost growth associated with storing environmental datasets by consolidating stove-pipe, legacy archival storage systems and relieving data owners of archival storage-related system development and operations issues. CLASS is not intended to support near-real-time or mission-critical product delivery. CLASS consists of two full replicated storage nodes hosted by NOAA's National Centers for Environmental Information (NCEI) located at Asheville NC and Boulder CO. Receipt nodes at located at the NOAA Satellite Operations Facility (NSOF) in Suitland , MD, and the Consolidated Backup Facility (CBU) at Fairmont, WV. The current capacity of the CLASS system is 20 PB, with projected growth to 53 PB by 2020. CLASS is an evolving operational system currently supporting the following users:

- NOAA Polar-orbiting Operational Environmental Satellites (POES)
- US Department of Defense (DoD) polar orbiting satellites
- NOAA Geostationary Operational Environmental Satellites (GOES)
- Canadian Space Agency's Synthetic Aperture Radar Satellites (Radarsat)
- European Meteorological Operational Satellite (MetOp) Program
- Ocean Surface Topography Mission (OSTM) Jason-2 and Jason-3

CLASS development is forecast to be completed in 2017.

MANAGING CHANGE

This paper has addressed the technical and programmatic activities necessary to chart the transition from stand-alone to integrated ground systems. The good news is that the technologies to accomplish this transformation already exist and have been successfully applied to similarly complex problems in other industries – there is no unobtainium. The biggest challenges associated with this transformation are cultural. Team members across the spectrum of ground enterprise jobs have been successful for many years doing things the traditional way. Now we are asking them to recognize that the traditional way is no longer scalable or affordable, and to adopt new roles, job definitions, and tools. The transformation is about change management.

The OSGS leadership team is investing significant time and effort socializing the benefits and opportunities enabled by an integrated enterprise. The team sought and gained agreement from all the other NESDIS organizations on the Concept of Operations described above. It facilitated formation of a Ground Enterprise Executive Board[21] co-chaired by the Directors of OSGS and Operations and attended by all the other Directors. It meets every 8 weeks, facilitating communication and decision-making at the Director level. At the working level the Enterprise Architecture Working Group meets frequently, providing a forum for all NESDIS organizations to review and vector the architecture artifacts before they are finalized. The OSGS team is also looking hard for opportunities for early wins that illustrate the benefits of enterprise thinking on a non-threatening scale. Likewise the team seeks to implement the change initiatives flowing from the Transition and Sequencing Plan in small, digestible increments. The strategy is to employ multiple small, evolutionary changes that produce a revolutionary result.

TOWARDS THE FUTURE

OSGS is driving the development of a future Integrated Ground Enterprise that offers numerous advantages over the traditional stand-alone approach to system development and operation. Activities to realize the desired end state are well underway, including completion of a Concept of Operations and initiation of Enterprise Architecture analyses. Complementing these activities, OSGS is fielding pioneering enterprise product generation, distribution, and archive systems that are on-track to support upcoming satellite launches. Supporting all these endeavors is a communication and outreach approach designed to address the challenges of change management.

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[1] "About NESDIS – NOAA's Satellite and Information Service". *NESDIS.NOAA.gov*. National Oceanic and Atmospheric Administration. 29 Feb 2016. Web. 24 Mar 2016.
[2] "GOES-R Ground Segment Overview". GOES-R.gov. GOES-R Series Program Office. Web. 24 Mar 2016.
[3] "About JPSS – JPSS Ground System". JPSS.NOAA.gov. National Oceanic and Atmospheric Administration. Web. 24 Mar 2016.
[4] "NESDIS. Offices. NOAA OSGS – Office of Satellite Ground services". NESDIS.NOAA.gov. National Oceanic and Atmospheric Administration. Web. 24 Mar 2016.
[5] United States. Department of Commerce. National Oceanic and Atmospheric Administration. National Environmental Satellite Data and Information Service. Office of Satellite Ground Services. NESDIS Ground Enterprise Architecture Services (GEARS) Concept of Operations. Silver Spring, MD: NOAA. N.p.: Office of Satellite Ground Services, Feb 2015. Print.
[6] Ibid., pp 11-20.
[7] Ibid., pp 20-37.
[8] Ibid., p 8.
[9] Ibid., pp 39-45.
[10] "TOGAF Version 9.1". OpenGroup.org. The Open Group. 2013. Web. 24 Mar 2016.
[11] "TOGAF 9.1. Part II: Architecture Development Method. Phase B: Business Architecture." OpenGroup.org. The Open Group. 1999-2011. Web. 24 Mar 2016.

[12] "NESDIS. Offices. NOAA OSGS – Office of Satellite Ground services. About OSGS". NESDIS.NOAA.gov. National Oceanic and Atmospheric Administration. Web. 24 Mar 2016.
[13] "TOGAF 9.1. Part II: Architecture Development Method. Introduction to the ADM." OpenGroup.org. The Open Group. 1999-2011. Web. 24 Mar 2016.
[14] United States. Department of Commerce. National Oceanic and Atmospheric Administration. National Environmental Satellite Data and Information Service. Office of Satellite Ground Services. NESDIS Ground Enterprise Architecture Services (GEARS) Enterprise Architecture (EA) Plan. Silver Spring, MD: NOAA. N.p.: Office of Satellite Ground Services, 12 Feb 2015. Print.
[15] "NoMagic. Products. MagicDraw". NoMagic.com. No Magic. 2016. Web.
[16] "NESDIS. Offices. NOAA OSGS – Office of Satellite Ground services. About OSGS". NESDIS.NOAA.gov. National Oceanic and Atmospheric Administration. Web. 24 Mar 2016. 24 Mar 2016.
[17] United States. Department of Commerce. National Oceanic and Atmospheric Administration. National Environmental Satellite Data and Information Service. Office of Satellite Ground Services. Draft NESDIS Ground Enterprise Architecture Services (GEARS) Transition & Sequencing Plan: A Migration Strategy for the NESDIS Ground Enterprise (NGE). Page B-2. Silver Spring, MD: NOAA. N.p.: Office of Satellite Ground Services, December 2015. Print.
[18] Ibid., pp E7 – E12.
[19] "NESDIS. Offices. NOAA OSGS – Office of Satellite Ground services. Sustain." NESDIS.NOAA.gov. National Oceanic and Atmospheric Administration. Web. 24 Mar 2016.
[20] Ibid.
[21] United States. Department of Commerce. National Oceanic and Atmospheric Administration. National Environmental Satellite Data and Information Service. Office of Satellite Ground Services. NESDIS Ground Enterprise Executive Board Charter. Version 1.0. Silver Spring, MD: NOAA. N.p.: Office of Satellite Ground Services, January 2016. Print.