# NESDIS Ground Enterprise Architecture Services (GEARS)

# Concept of Operations

February 2015

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NESDIS GEARS
CONCEPT OF OPERATIONS
Version 1.0

Prepared By:

Dr. Scott R. Turner
NOAA/NESDIS/OSGS
The Aerospace Corporation

Approved By:

James Holton
Chief Systems Architect
NOAA/NESDIS/OSGS

Approved By:

Steven Grippando
Acting Division Chief, System Engineering Division
NOAA/NESDIS/OSGS

Approved By:

Steven Petersen
Director
NOAA/NESDIS/OSGS

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# Table of Contents

# 1 Introduction

This Concept of Operations (CONOPS) describes how NOAA/NESDIS intends to operate its ground enterprise in the years to come. This CONOPS is written at a high level that is independent of particular systems, as its purpose is to provide a vision of the ground enterprise rather than specific solutions. This CONOPS is a living document that will be updated as the vision of the ground enterprise evolves.

The concepts described in this document, along with the transition roadmap, offer a path towards realizing near-term benefits and optimizing of the ground enterprise for the longer term benefits of operability, maintainability and sustainability in a more cost-effective manner. This CONOPS integrates lessons learned from similar efforts in the National Reconaissance Office and the Air Force Space & Missile Center, as well lessons learned and best practices from other industries and government organizations that have transitioned to integrated enterprise Information Technology systems.

# 2 Vision of the Future Enterprise

Historically, due to partnerships and acquisition strategies, NOAA's missions ended up being developed as stovepipe systems. In the near term OSGS will take ownership of separate ground segments developed to support GOES-R and JPSS; these will join the infrastructure previously fielded to support GOES, POES, and other NESDIS missions. Beyond these near-term deliveries, NESDIS ground will transition to an integrated enterprise that provides cost-effective, secure, agile, and sustainable support for the NESDIS mission. We call this new integrated ground enterprise the "Ground Enterprise Architecture Services" or "GEARS." The sections that follow describe the need for change, the vision for the future and a series of scenarios to provide a working sense of the future ground enterprise.

## 2.1 Justification for Change

NOAA's current ground systems consist of a number of mission stovepipe architectures with 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.

## 2.2 Vision

The vision for GEARS is to provide through focused development, adaptation, and transition in future years a suite of common ground services enabling (1) reduction of mission ground systems costs[1] and (2) accelerated deployment of capabilities.

Reduction of mission ground system costs will be achieved by:

- Eliminating redundant development of common ground system functionality,
- Sharing common but underutilized infrastructure resources across satellite programs, and
- Streamlining ground operations by eliminating redundant operations and embracing automation to require fewer support staff.

[1] It is understood that there will be initial costs to develop and deploy GEARS before cost avoidances can be realized.

Accelerated deployment of new ground system capabilities will be achieved by:

- Eliminating redundant acquisition of common ground system functionality,
- Providing a common hardware and software environment for the development and deployment of new functionality, and
- Implementing business process changes to streamline deployment.

## 2.3 Scope

GEARS is the overarching system of systems provisioned to provide observatory management, product generation and distribution, and archive system services supported by operational, research, development, integration, and test environments that address all NESDIS ground requirements. This includes all ground system related work done by NESDIS personnel (even if externally funded) as well as all work funded by NESDIS (even if done by external personnel such as university faculty or contractors). Some work may be better accomplished – for reasons of cost, business efficiency, security, etc. – on non-GEARS resources. These exceptions will be approved on a case-by-case basis by NESDIS management. Examples of exceptions might include personal laptops or desktops for NESDIS personnel, or development resources shared with foreign nationals who cannot be allowed access to GEARS for security reasons. GEARS will also provide access to non-satellite NOAA data sets maintained under National Center for Environmental Information (NCEI) stewardship in the Enterprise Archive as well as other non-NOAA data as required.

# 3 References

This Concept of Operations provides a high-level overview of GEARS. The documents listed here provide additional insight into GEARS or existing NESDIS policies and procedures that GEARS will implement.

GEARS AS-IS Architecture [TBD]
GEARS Governance Plan, February 2015
GEARS Transition Plan [TBD]
NESDIS IT Security Handbook
NIST SP 800-37 Rev 1, Guide for Applying the Risk Management Framework to Federal Information Systems: A Security Life Cycle Approach, Feb 2010.
NIST SP 800-53 Rev 4, Security and Privacy Controls for Federal Information Systems and Organizations, Apr 2013.
NIST Special Publication (SP) 800-82, Rev 1, Guide to Industrial Control Systems (ICS) Security, April 2013.
NIST SP 800-160, System Security Engineering, Draft, May 2014.
NIST Interagency Report (IR) 7298, Revision 2, *Glossary of Key Information Security Terms,* May 2013.
NOAA Administrative Order 212-15, *Management of Environmental Data and Information*.
NOAA Environmental Data Management Framework.

# 4 Description of the Future Enterprise

The sections that follow will provide a description of the conceptual target architecture and discuss general features of GEARS.

## 4.1 High-Level Conceptual Target Architecture

The high-level conceptual architecture of GEARS is shown in Figure 1 below.

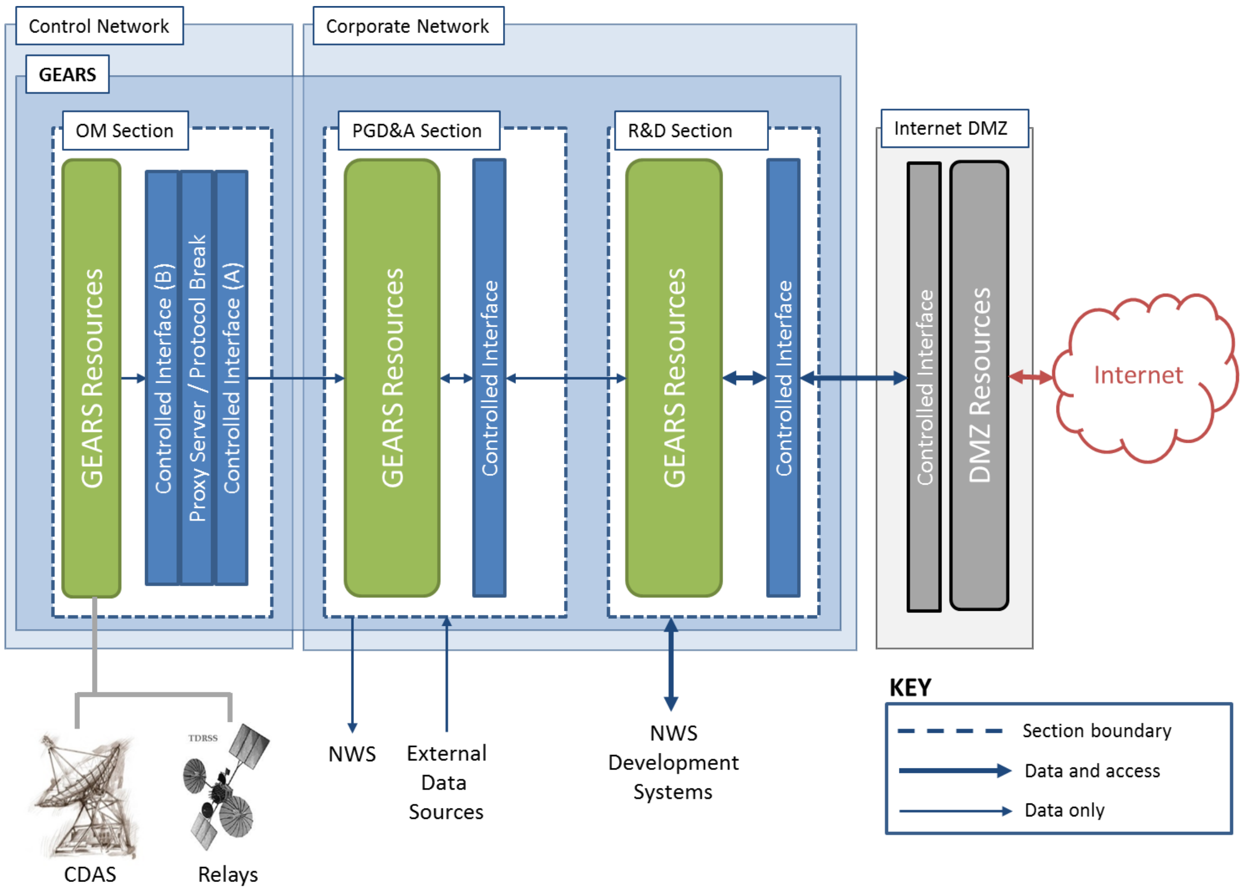


**Figure 1 High-Level Architecture of GEARS**

GEARS comprises three sections: the Observatory Management (OM) section, the Product Generation, Distribution and Archive (PGD&A) section, and the Research & Development (R&D) section. The OM section is hosted on the Control Network, and the PGD&A and R&D sections are hosted on the Corporate Network. The sections have complete physical and logical separation and do not share resources. Sections are interconnected via controlled interfaces. The OM section uses two independent controlled interfaces and a protocol break for greater assurance. Approved data (e.g., satellite data products) may pass between all the sections. GEARS also supports a direct data feed from the OM section to NWS. Data also flows from the OM Section into the R&D Section, and (for public data products) onto resources within the DMZ for distribution across the Internet.

The R&D section may be accessed by approved users (e.g., a STAR researcher) on the Corporate Network or (after proper authentication and using approved tools) by approved users on the Internet (e.g., a University professor using GEARS resources to collaborate with the STAR researcher). The PGD&A section may only be accessed by approved users on the Corporate Network. The OM section may only be accessed by approved users on the Control Network.

Access from GEARS to the Internet is through the Internet DMZ. The Internet DMZ also hosts some GEARS resources that provide Internet interfaces, e.g., a website that provides public access to data products. (For more details about the Internet DMZ, see Section 4.1.4.)

Within each section, GEARS provides an identical common infrastructure, as illustrated in Figure 2 GEARS Infrastructure.

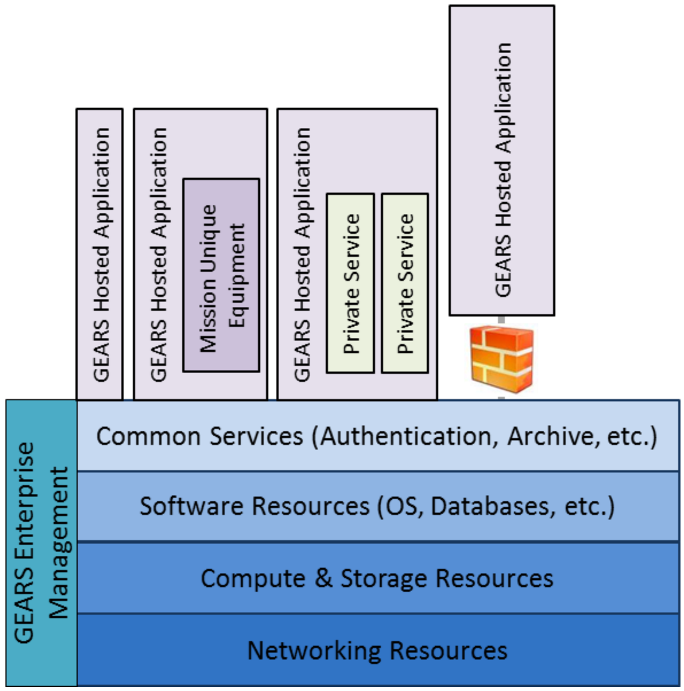


**Figure 2 GEARS Infrastructure**

The GEARS infrastructure provides all hosted applications a complete infrastructure of network resources[2], compute and storage resources, software resources, and GEARS common services. Since this infrastructure is identical across the GEARS sections, migrating applications between sections is simplified. Within each section, the GEARS infrastructure is managed by the GEARS Enterprise Management layer, comprising a suite of processes, applications and operational staff that provides monitoring, reporting and control of the configuration and status of the security, networks, communications, and operational systems (hardware and software).

Hosted upon this shared infrastructure are applications – any NESDIS activity that uses IT resources. Each hosted application may also have its own dedicated software or hardware (Mission Unique Equipment, or MUE) as needed to meet its requirements (see 4.2.4 Shared Infrastructure for more discussion of MUE in GEARS). Applications may also implement their own private services – services that are available only to that application. Applications may also use GEARS services (such as a firewall) to implement additional security controls as necessary to meet their requirements.

[2] Note that the wide area network resources used by GEARS are owned and managed by NOAA Office of the Chief Information Officer (OCIO).

All sections have the capability to partition the GEARS infrastructure into logically or physically separated enclaves. Partitioning permits sections to test, demonstrate and integrate functionality without risking any impact upon the rest of the section. A typical use for this would be to create an Integration & Test enclave within the OM section to receive a software update from the R&D section. After the software update is integrated, tested and accepted within the enclave, it can be moved into the broader OM section.

### 4.1.1 The Observatory Management (OM) Section

The Observatory Management (OM) section is designated for the operational capabilities that interface with satellite assets. It provides access to the CDAS (Command and Data Acquisition Stations), relays, partner ground control networks such as the NASA Integrated Service Network (NISN) and the Deep Space Network (DSN), international partners ground control networks, and other satellite operational assets. It is isolated from the rest of GEARS by a DMZ designed to pass only limited, tightly-controlled data formats (e.g., passing satellite telemetry outwards to the PGD&A section, and required operational data such as orbit predictions inwards). Transfer of other types of software and data (e.g., a software update from the R&D section) uses a manual process with appropriate security controls. The OM section will be handled as a Supervisory Control and Data Acquisition (SCADA) / Industrial Control System (ICS) per NIST 800-82 or its successor.

In addition to observatory management functions, the OM hosts a limited set of product generation functionality. To achieve maximum security for the OM Section, there is no data or control access permitted from outside the OM Section. Data is only allowed to flow out of the OM Section into the PGD&A Section. Therefore, any data product that is intended for re-upload to the satellite for direct downlink (e.g., GOES-R Rebroadcast) must be generated within the OM Section.

The OM section will also provide the capability for end-to-end testing and integration of new satellites and new capabilities without affecting the existing operational capabilities.

### 4.1.2 The Product Generation Distribution & Archive (PGD&A) Section

The Product Generation, Distribution and Archive (PGD&A) section is designated for the generation and distribution of operational products. It receives satellite data from the OM section via the OM section DMZ; it receives other satellite, non-satellite, and ancillary data from the R&D section or the Internet via a controlled interface.

The PGD&A section also hosts the Product Distribution (PD) capability. This capability is responsible for distributing NESDIS products to the National Weather Service (NWS) and to external customers through resources in the Internet DMZ. The PGD&A section also hosts the Archive capability. This capability is responsible for implementing the NESDIS data archiving requirements.

Note that the interface between the PGD&A section and the R&D section (and Internet) allows only data transfers. No remote access or commanding is permitted from the R&D section (or Internet) into the PGD&A section.

### 4.1.3 The Research & Development Section

The Research & Development (R&D) section is designated for the development of new GEARS capabilities, development of new GEARS-hosted applications, and for research activities. Unlike the other sections, the R&D section allows controlled access both to and from the Internet. This access is controlled using strong authentication (e.g., PKI), encryption (e.g., VPNs) and other security mechanisms to ensure that only properly authorized individuals have access to the R&D section, and that their access is properly restricted. Controlled access to the Internet permits collaboration between NOAA personnel and external persons (such as University faculty) as well as giving R&D section users agile access to Internet resources (e.g., to retrieve satellite data), and permits external developers (contractors) to perform development, integration and test using GEARS resources.

The R&D section replicates the architecture, services and structure of the other sections. This makes it possible to develop applications for all the other sections within the R&D section, and reduces the migration/integration effort to move the developed applications into their deployment section.

#### *4.1.3.1 Development, Integration and Test Support in the R&D Section*

The R&D Section provides hardware (e.g., servers, storage, networks, etc.) and software resources (e.g., compilers, Integrated Development Environments (IDEs), database tools, etc.) for use to develop, integrate and test new GEARS capabilities, or new GEARS-hosted applications. Resources are allocated to development projects as they occur, and reclaimed when the project is finished. These resources will typically be used remotely; developers[3] will connect to the resources over the network. Users will not be allowed to connect to development and test resources until they have met the appropriate security requirements.

Since development success will depend upon the availability of these resources, it will be important for each new development to accurately specify their resource requirements, and for OSGS to fully understand these requirements, so that OSGS can ensure that GEARS will meet these obligations. As the resource requirements for a development change (e.g., when new developers are added to address a schedule slip), the developer will work with OSGS to define and fund the new requirements.

To reduce the risk of integrating new capabilities in the GEARS operational environment, the R&D section has the capability to mimic the other sections as closely as possible[4]. For example, the R&D section offers the same common services as the other sections (although some of these may be modified to work in the R&D section, e.g., by providing test data rather than operational data). This allows developers to integrate and test in an environment that is a close analogue of the eventual operational environment.

The R&D section also has the capability to warehouse the configuration and setup of resources for R&D section projects (see 4.2.16 Warehousing and Restoring), so that the configuration can be recalled if needed later for maintenance or further development. This reduces the cost of ongoing maintenance of GEARS capabilities.

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[3] We use "developer" and "development team" as generic terms for any users or organization developing a system or capability that will be hosted on GEARS. This might be a commercial contractor, a university research team, an internal OSGS team, etc., and their development activities could include writing custom code, acquiring COTS packages, integrating GEARS common services, etc.

[4] Some features of the other sections – such as spacecraft commanding – will be impossible to recreate in the R&D section.

#### *4.1.3.2 Research Support in the R&D Section*
The R&D section also provides resources for the formation of new science and algorithms based upon requirements from the Office of the System Architecture and Advanced Planning (OSAAP). This support is similar to the support for development and test, but specialized towards the types of activities required to refine and create new science algorithms. For example, GEARS might offer a comprehensive library of operational and other data for algorithm testing and other research purposes. As with development and test, resources are allocated to users (scientists) as needed and reclaimed when finished. Users will use the research resources remotely after meeting the required security requirements.

### 4.1.4 The Internet DMZ
The Internet DMZ provides both a controlled interface to all external networks, as well as hosting for GEARS resources that are required to be publicly-accessible. The Internet DMZ may be physically distributed and replicated, but will provide a single external interface to the Internet. The Internet DMZ is managed jointly with the NOAA Office of the Chief Information Officer (OCIO) and the Line Offices (LO) and Mission systems that require an Internet presence. The controlled interface at the NOAA perimeter to the Internet is managed by the NOAA/OCIO as part of the NOAA Trusted Internet Connection (TIC) as well as most of underlying infrastructure that supports GEARS public web pages.

The Internet DMZ controlled interface provides a number of functions. First, it provides user authentication and control for external access to the R&D section. External users of the R&D section must authenticate through the Internet DMZ and establish secure communications before receiving access to the R&D section. The Internet DMZ controlled interface also filters external user interactions with the R&D section to ensure that only allowed protocols and ports are used. Second, the Internet DMZ controlled interface provides secure and reliable data interchange between the Internet and the other sections. It enforces the use of approved protocols (e.g., secure FTP), approved product types (e.g., disallowing the download of executable files) and provides virus scanning and other measures to ensure that data downloaded from the Internet does not contain any security threats.

The Internet DMZ also provides hosting for publicly-accessible GEARS resources. For example, an interface to search and retrieve products could be hosted in the Internet DMZ. Resources within the Internet DMZ are hardened against malicious attack from the Internet, and have limited, controlled interfaces to the other GEARS sections.

## 4.2 General Features of GEARS
This section describes the general features of the architecture and design of GEARS.

These features have been selected for the benefits they provide, but in all cases these benefits are weighed against the cost of implementation and mission requirements (such as data integrity, availability, and timeliness). For example, achieving a “location agnostic” design by moving data recording and buffering away from the downlink equipment (antenna) may require implementing a fast, high bandwidth, high availability, expensive network between the downlink equipment and the Satellite Operations Control Center (SOCC). In this case, the system architects may accept that a portion of the system will be location dependent. So although these features are seen as generally cost-effective, they will not be applied blindly.

### 4.2.1 Enterprise Governance
GEARS is a shared resource that stretches across all of NESDIS. All elements of the NESDIS organization will have critical dependencies upon GEARS, so it is important that it be governed as an enterprise resource, with all stakeholders having a voice in determining policies.

To achieve that, GEARS governance and policy will be decided by the GEARS Governance Board. This board establishes GEARS policies, provides direction, makes cost-benefit trades, and adjudicates user issues in order to achieve an optimized enterprise. The GEARS Governance Board will be co-chaired by the Director of the Office of Satellite Ground Services (OSGS) and the Director of the Office of Satellite & Product Operations (OSPO). Voting members will include representatives from across the enterprise - the Assistant Chief Information Officer – Satellites (OCIO-S), OSAAP, the Center for Satellite Applications and Research (STAR), the National Environmental Center for Information (NCEI), Office of Projects Partnerships and Activities (OPPA), and the NESDIS Satellite Programs. Other stakeholders such as the National Weather Service (NWS), the chair of the NOAA Environmental Data Management Committee (EDMC), the National Marine Fisheries Service (NMFS), the National Ocean Science (NOS), and the Office of Oceanic and Atmospheric Research (OAR) will be encouraged to participate as non-voting members and provide advice and guidance on governance decisions.

The Governance Board will also coordinate and seek guidance and inputs from NOAA boards and working groups such as the NOAA Observing Systems Council (NOSC), the Satellite Products and Services Review Board (SPSRB), the Product Lifecycle Working Group (PLWG), the Science Advisory Board's Environmental Information Services Working Group (EISWG), etc.

After establishing policy, the GEARS Governance Board will delegate decision-making authority to the lowest working levels possible in order to maximize organizational agility. For example, after the GEARS Governance Board establishes the conditions under which an external academic researcher can be given access to GEARS resources in order to collaborate with NESDIS colleagues, the implementation of that policy and the approval process for individual researchers would not require the attention of the Board. Further, the GEARS Governance Board may establish additional boards, working groups, etc. to implement policies that do not require the attention of the higher Board. To enable agile decision making leadership may choose to organize sub-boards and working groups according to 1) Standards and architecture, 2) Operations and maintenance, 3) Future mission capabilities, and 4) IT Security.

#### 4.2.2 Enterprise Management

GEARS is operated and managed to optimize ground IT resources across NESDIS[5]. The GEARS enterprise management capabilities will provide situational awareness (insight into the health and status of GEARS elements) and management capabilities across the ground enterprise. For example, the GEARS enterprise management capabilities will provide insight into the utilization of resources and the capability to shift underutilized resources from one use to another.

GEARS will provide consolidated situational awareness across the GEARS enterprise, including all sections. This includes not only low-level health and status (such as what physical servers are down) but also mission-level insight, such as what data products were produced and distributed, what data products could not be produced, etc. Access to situational awareness will be restricted by user roles – GEARS operators would have access to all situational awareness, while a researcher might see only the status of the server he is currently using. GEARS enterprise management also provides a system inventory of hardware and software items (including specific details such as product versions), and implements NESDIS' configuration management policies.

[5] It is anticipated that OSPO will retain operational responsibility for GEARS as it evolves from its current state (stand-alone elements) into a future capability enabled by new investments and refreshes, with responsibility for sustainment and administration (resource management, scheduling, access approvals) and supervision of Dev and Integration functions delegated to OSGS under a to be determined set of policies and procedures.

GEARS operators and other privileged users will have the capability to manage resources across the ground enterprise[6]. This includes starting and stopping resources and services, assigning resources to tasks, scheduling operations, etc.

GEARS enterprise management will provide all of the technical IT security tools to meet NIST, Department of Commerce (DOC), NOAA and NESDIS IT security requirements.

#### 4.2.3 Enterprise Funding

GEARS will be sustained by OSGS, and the baseline sustainment funding for GEARS will be included in the OSGS budget. As part of the yearly NESDIS budget process, all NESDIS organizations will provide baseline GEARS requirements for the upcoming 5 year budget submission. OSGS will assess the proposed GEARS requirements and estimate the budget required to meet those requirements as well as any other impacts. NESDIS will then adjudicate the submitted requirements and the budget estimates, create approved requirements and fund OSGS as necessary to meet those requirements.

When a new, funded requirement arises that is not included in the yearly GEARS baseline (for example, an unexpected mid-year research grant), the organization with the new requirement will negotiate with OSGS to define the cost of supporting the new requirement for the duration of the requirement, r and then engage NESDIS in a review of the priority and long-term funding needed to support the requirement. If NESDIS decides to support the requirement for the long-term, the organization will transfer funds to OSGS to cover those costs for the year in which it arises.

To support generating a rapid cost estimate for IT infrastructure, e.g., during a proposal development, OSGS will provide a baseline pricing guide for GEARS resources that can be used to quickly develop an accurate estimate of costs. OSGS will also provide technical support to help GEARS users develop cost estimates.

#### 4.2.4 Shared Infrastructure

A basic feature of GEARS is an infrastructure of network, compute, storage and software resources that is shared within the GEARS sections and dynamically managed to meet NESDIS requirements. These resources include everything from ground antennas to computer servers. GEARS-hosted applications have fewer dedicated resources and instead pull the resources they need from a common pool. This feature enables improved efficiency by maximizing resource utilization, improved operational flexibility by enabling allocation of resources where needed when needed, and reduces operations and maintenance costs by standardizing resources across the enterprise.

Resources within GEARS will be sized and actively allocated to meet all mission requirements. For example, resources might be allocated first to generate a product with a short time deadline, and then after that is completed, reallocated to generate a product with a less pressing deadline. GEARS operators will also be able to manually allocate resources to handle unexpected situations, such as a surge request for data products following an unpredicted hurricane landfall event.

[6] To meet security requirements, it may be necessary to manage resources by section rather than across the entire enterprise.

Although most resources will be shared, GEARS will support Mission Unique Equipment (MUE) for programs that cannot meet their requirements using the shared infrastructure. Large amounts of MUE within GEARS will negate many of the benefits of a shared infrastructure, so MUE will be strictly controlled and will require approval on a case-by-case basis by NESDIS management. Requirements that force the use of MUE (such as adopting a satellite communications format that would require custom TT&C equipment) will be discouraged and will require additional justification including a thorough positive cost-benefit analysis before being approved. Generally, if MUE is required it will befunded by the mission and acquired by OSGS for enterprise integration, operations and sustainment.

Another benefit of shared infrastructure is the opportunity to leverage economies of scale, site licenses, and quantity discounts to reduce the cost of acquiring resources. License management at the enterprise level also provides an opportunity for better and more consistent processes, i.e., to renew licenses on time and avoid penalties and/or outages. Additionally in a large, homogenous environment good security hygiene is easier to implement and enforce[7].

#### 4.2.5 Ubiquitous Data Access

Many NESDIS and NOAA activities revolve around data that will be available in GEARS. To facilitate the use of these data (and consequently reduce costs and schedule) the GEARS architecture will provide ubiquitous data access to GEARS users based on appropriate authorization. GEARS will provide a Data Registry for metadata describing all of the available data and how it can be accessed. Documented, standards-based APIs will be provided to access both historical and near-real-time NOAA satellite data, regardless of where the data is stored.

The GEARS data access architecture will be extensible to include data from non-NOAA satellites, data from non-satellite sensors (e.g., in-situ sensors), as well as external data (e.g., data from an international observation mission provided from an external server). The GEARS data access architecture will meet all the data access requirements as defined by NCEI. Since there are cost and other impacts to including data within the GEARS data access architecture, NESDIS management will decide what other data – beyond the NCEI requirements – is included in the GEARS data access architecture. (However, if a GEARS user has a requirement for data that is not included within the GEARS data architecture, he can obtain and maintain that data privately. An example of this is discussed in Section 5.6.)

Fundamentally, GEARS will facilitate access to data and provide access to processing and reprocessing capabilities. The NCEI will remain responsible for the full range of Archival responsibilities as defined in the Open Archival Information System Reference Model Standard (OAIS) documents. However, it is expected that some of those functions will be achieved using GEARS resources and infrastructure (e.g., archival storage may use storage resources provided by GEARS).

[7] Defense Science Board, Cyber Security and Reliability in a Digital Cloud, January 2013.

#### 4.2.6 End-To-End Lifecycle Data Management

Management of NOAA's environment data is an important NESDIS requirement[8] and GEARS will be a critical element of this process. Data management requires an end-to-end process that includes acquisition, quality control, validation, reprocessing, storage, retrieval, dissemination, and long-term preservation activities. To support these activities, GEARS will provide common services for many elements of the process, and all the services that GEARS provides will be compliant with NOAA's data management requirements. Making data management a fundamental feature of GEARS will reduce the cost and effort of managing data, and will promote comprehensive and consistent data management across the enterprise.

The NOAA Environmental Data Management Committee (EDMC) *Data Management Planning Procedural Directive*[9] states that all NOAA environmental data are to be covered by a DM Plan, and provides a Template to be used in creating the Plan.

#### 4.2.7 Isolation of Impacts

One risk of a system architecture that shares resources is that there will be negative interactions between users of the shared resources, e.g., an unexpectedly heavy load in one capability resulting in a loss of performance in another capability. GEARS mitigates this risk by providing logical and physical separations between the users of the shared resources. As an example, for virtualized applications[10] GEARS can use hypervisor capabilities to ensure a logical separation between the applications. In some cases, physical separation might be required – as in the case of an antenna that is physically connected to a particular low-noise amplifier. At a higher-level, GEARS also enforces isolation of impacts by use of sections with controlled interfaces.

Isolation of impacts is also useful to mitigate other impacts of a common ground system. For example, high risk events such as launches often incur a "ground system freeze" to mitigate the risk of an untested change to the ground system affecting the high risk event. Freezing the entire ground system can have a very large impact if the ground system is a common ground shared across all missions. Isolation of impacts can be used to mitigate this concern – for example, by freezing only a portion of the ground system, such as the OM section, that has been isolated from the rest of the common ground.

#### 4.2.8 Hardware Agnostic

GEARS supports infrastructure as a service (IaaS). This service model provisions processing, storage, networks, and other fundamental computing resources where the GEARS user is able to deploy and run arbitrary software, which can include operating systems and applications. This approach breaks the dependency between hardware and software, and allows them to be developed and managed independently. The hardware resources (infrastructure) can be monitored, measured and controlled to maximize the return on investment (ROI) to the enterprise. Furthermore, additional capacity and functionality can be added to the infrastructure without impact to the applications (software) that ride upon the infrastructure.

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[8] See NOAA Administrative Order 212-15 Management of Environmental Data and Information and the NOAA Environmental Data Management Framework for more details.

[9] https://www.nosc.noaa.gov/EDMC/PD.DMP.php

[10] *Virtualization* uses a software layer to create a "virtual computer" that acts like a real computer. Software executed on these virtual machines "thinks" it is on a real computer but in fact is separated from the underlying physical resources. The software layer that creates a virtual machine is called a *hypervisor*. Multiple virtual computers can be created on a single real computer. These virtual machines can be kept completely separate from each other by the hypervisor.

For example, Section 5.5 New Data Product Requirement discusses the development of a new data product. The development of a new data product is accomplished by researchers, scientists and developers using GEARS services including virtualized servers. Since the development effort is done in the GEARS environment using GEARS services and standards, the resulting algorithm is not tied to a particular hardware architecture or particular physical servers. The algorithm can be executed anywhere within the GEARS architecture, on any GEARS virtualized server.

#### 4.2.9 Location Agnostic

GEARS is designed to be location agnostic. A location agnostic system is a distributed system where functionality is not tied to particular physical resources, but may be implemented anywhere within the enterprise – and may migrate to new physical locations without impact to the users of that functionality. Users of a location agnostic system do not know and do not care where system functionality is implemented. A location agnostic system provides improved flexibility of resource management and improved continuity of operations (COOP) and failover functionality. However, a location agnostic design will generally require higher-bandwidth and more reliable network capabilities, and may have higher recurring costs.

Some functions are inherently tied to particular physical locations, such as the signal receive capability, which is tied to a physical antenna in a location determined by orbital mechanics, frequency protection and other requirements, or archive redundancy, which requires keeping backup copies of data in a physically separate location. Other functions may be very expensive to make location agnostic (for example, moving data recording and buffering away from the antenna may require implementing a fast, high bandwidth, high availability, expensive network between the downlink equipment and the SOCC). In these cases, the GEARS architects must make a tradeoff between the value of a location-agnostic implementation and the benefits it provides.

#### 4.2.10 Acquisition Approach Agnostic

GEARS employs a range of acquisition approaches for adding additional resources, new capabilities or for applications to be hosted upon GEARS. A new capability or application might be acquired by a competitive acquisition, a sole source contract, by internal development, by transfer for internal development from an academic partner, etc. GEARS provides the flexibility to support all acquisition models, within the boundaries established by the Federal Acquisition Regulations (FAR). This ensures that GEARS and the programs that use GEARS can use the acquisition approach that is most effective for their particular requirements.

Regardless of the acquisition approach, GEARS will provide tools and services to support agile methodologies in the development of new capabilities and applications within GEARS. The use of agile methodologies is key to improving NESDIS business agility, and GEARS will support this throughout the acquisition/development process.

#### 4.2.11 Service-Oriented Approach

GEARS is a service-oriented architecture (SOA). Every IT resource within GEARS is accessible as a service. A "service" is a self-contained, discrete component that provides functionality through well-documented open interfaces. Because each service is discrete and interacts with the rest of the enterprise through defined interfaces, service implementations can be replaced or added with limited impact to the rest of the enterprise. Services are built so that they can be accessed and used across the network, with the intention to make them available across the enterprise regardless of where they are physically hosted. Services can be combined by other software applications to provide the complete functionality of a large software application.

GEARS common services are available to all GEARS-hosted applications and are considered part of GEARS. Common services are included in the GEARS Service Registry and can be used by any GEARS-hosted application. Common services are maintained by GEARS. Common services must meet requirements for documentation, training materials, test suites, interface standards, etc. Common services are selected to save cost and risk across the enterprise. Thus, they will tend to be functions that can be reused in many applications (e.g., a service to read a common Consultative Committee for Space Data Systems (CCSDS) file format) or that are inexpensive to implement (e.g., adopting a service that has already been implemented and tested as a private service).

Any GEARS application or user can make use of any common service with the documented baseline performance and availability. When an application or user requires an enhanced level of performance from a common service, they negotiate a Service Level Agreement (SLA) with OSGS which details how they intend to use the service and provides the information OSGS needs to allocate resources to the service. In return, OSGS guarantees the required level of service and the cost (if any) to the user of the service.

The operator of GEARS continuously monitors the performance of all common services and when actual performance does not maintain a suitable margin above specified baseline performance OSGS will take action to improve the common service performance, e.g., by adding resources, creating a new implementation of a service, etc.

To the extent possible, the same common services will be available in all sections. Having the same services in all sections enables applications to be developed in one section and then transitioned to another section with a minimum of effort. Typically applications will be developed in the R&D section. Some services from the other sections will be impossible to replicate in the R&D section – for example, access to the actual satellite command and control capabilities. For these services, the R&D section will provide simulated equivalents for testing and integration purposes.

Applications hosted on GEARS can also provide their own private services. Private services are specific to a particular application or project and are considered part of the application. These are designed, developed and implemented by the application provider. Private services are not visible or usable outside of that particular application. Private services are a way for applications to develop and use custom services without having to get the service approved and funded for use across GEARS.

By using a service-oriented architecture, GEARS enables service reuse, resulting in lower development and maintenance costs and providing more value once the service is developed and tested. Having reusable services readily available also results in reduced development, test and integration times.

#### 4.2.12 Maximum Reuse of Common Services

In order to reduce overall NESDIS development and maintenance costs, GEARS maximizes the reuse of common services. By a combination of design, investment, requirements, and business management, missions will be incentivized to reuse existing services instead of creating redundant functionality. For example, common services will be well documented in an enterprise registry, with examples, training materials, and test data available to aid in re-use.

Governance and policy will also promote reuse. For example, missions that choose to implement private services that are redundant of existing common services will require a waiver from the GEARS Governance Board, explaining why the additional costs involved are justified by other benefits.

To enable maximum reuse, by policy and contract the Government will own full data rights for all GEARS common services (except for COTS components). This includes the full source code and unlimited rights for reuse of the code at no cost. This policy ensures that the Government will have maximum flexibility to reuse common services without incurring additional costs.

#### 4.2.13 Use of Standards

GEARS resources, interfaces, data and metadata formats use non-proprietary standards, with preference for International or consortium-based standards that have broad deployment and proven success. This helps avoid expensive dependencies on single vendor solutions or upon proprietary standards that are expensive to develop and maintain. This also reduces the cost of infrastructure components by selecting components that have competitive markets – since components use non-proprietary standards, new vendors can compete on an equal footing with established vendors.

Decisions on GEARS standards will be guided by NOAA requirements and recommendations for the use of standards, and GEARS will adopt existing NOAA and NESDIS standards where available. GEARS will adopt or define new standards primarily in areas within GEARS where NOAA or NESDIS standards do not already exist. For example, GEARS might define standard mechanisms for calling GEARS common services.

GEARS standards will be approved by the GEARS Governance Board, with representation from all portions of NESDIS and other GEARS stakeholders (see 4.2.1 Enterprise Governance). There will be a periodic review and update process to keep up with new and evolving standards.

Compliance with the GEARS standards will be required for all systems hosted upon GEARS. The consistent use of the GEARS standards will reduce the integration effort for new systems and capabilities, promote interoperability between systems within GEARS, enable the reuse of common tools, and support data fusion and other cross-mission efforts.

To support consistent utilization of the GEARS standards, GEARS will maintain a library of approved standards with copies or links to sources and make this easily available to GEARS users, developers, and other stakeholders.

The EDMC *Data Documentation Procedural Directive*[11] states that all NOAA environmental data are to be comprehensively documented and establishes a metadata encoding and content standard based on the ISO 19115 family of standards. The EDMC *Data Access Procedural Directive*[12] state that all NOAA environmental data are to be discoverable through the NOAA Data Catalog[13] and accessible to the public, preferably through web services in machine-readable formats, unless a Waiver has been approved by the Line Office Assistant Administrator or designee. This directive also references current recommended standards.

At the inter-agency level, the US Group on Earth Observations (USGEO) Data Management Working Group is adopting a set of core standards for data discovery, access, documentation, and encoding to maximize interoperability of federal observations.

[11] https://www.nosc.noaa.gov/EDMC/PD.DD.php
[12] To be issued March, 2015.
[13] https://data.noaa.gov/

#### 4.2.14 Support for Automation

GEARS will provide workflow automation, rules engines and other automation tools as common services.

Automation provides many benefits, such as greater reliability, faster execution, reduced human errors, and reduced cost. However, automation has risks, and not all functions can (or should) be automated. For these reasons, GEARS supports a full range of functions from fully manual, to operator “in” the loop (an operator is required to manually approve some steps in the automated process), to operator “on” the loop (an operator can interrupt the process if he notices problems), to fully automated. GEARS supports a lifecycle transition for a process from fully manual to fully automated. An example of a process transitioning from fully manual to fully automated is given in 5.10 Automation of a Ground System Function.

#### 4.2.15 Security As Infrastructure

GEARS provides information security as an integral feature of the infrastructure. Most GEARS users will have their security requirements transparently provided by the GEARS infrastructure. For example, GEARS users will not have to run virus scans on their files; this service will be provided by GEARS.

Information security capabilities provided within GEARS will include virus scanning, firewalls, intrusion protection and detection, network filtering, virtual private networks, user authentication, encryption/decryption, access controls, logging and auditing, etc. GEARS will meet NIST security requirements and provide documentation describing common controls implementation to all GEARS users so that they do not have to replicate that work. GEARS will also support Homeland Security Presidential Directive 12 (HSPD-12) requirements.

GEARS uses a “defense in depth/breadth” approach to provide information security across the ground enterprise. Defense in depth/breath uses multiple layers of independent security controls to provide layers and redundancy in the event a security control fails. GEARS tailors the level of security control for each project based upon its risks and criticality.

Security services will be tailored to each user/project based upon security requirements. For example, a collaborative science project in the R&D section between NOAA and university partners might allow external access to the GEARS resources being used; while a source-selection sensitive trade study in the same section might bar external access and restrict access to files based upon user authentication. When a GEARS user or project is established, GEARS will work with the user(s) to understand their security requirements and configure the GEARS security services appropriately to meet those requirements.

#### 4.2.16 Warehousing and Restoring

Warehousing is a function that saves the current state of a user’s profile and resources to storage so that the resources can be freed for other users. Warehoused profiles can be quickly restored when they are needed (i.e., on the order of minutes). Warehousing and restoring is transparent to the user; it is as if they never stopped using GEARS.

For example, a team developing a software application in GEARS might have a profile that included development tools (e.g., a compiler, a revision control tool), a repository of source code, test data, etc. After development is complete and the team is no longer actively using GEARS, the development team's profile is warehoused and the resources (servers, disk space, etc.) that were allocated to the team are released for other uses. If the development team became active again in the future – for example, to develop a new version of the application – the team's profile would be restored and new resources allocated. To the development team it would appear as if they were picking up where they had left off, but in reality GEARS would have benefited in the interim by reusing the resources.

# 5 Illustrative GEARS Scenarios

The sections that follow provide simplified scenarios that illustrate how common NESDIS responsibilities would be achieved using GEARS. These are not intended to be definitive or to imply any particular implementation, but rather to provide an overall context for understanding GEARS. As concrete examples of the vision, these scenarios are intended to:

- Provide a context to better understand the architecture
- Focus on characteristics of GEARS rather than technical implementations
- Explore side effects, consequences, and easily forgotten situations that need to be considered in the target architecture[14]

Obviously, these scenarios cannot capture every aspect of satellite ground system, and they are purposely simplified to focus on the role of GEARS. They are not intended to imply that these tasks are easy or trivial, and shouldn't be taken as a definitive description of these tasks.

## 5.1 Satellite Operations

Our satellite operations scenario takes place in the unified Satellite Operations Control Center (SOCC) in Suitland. One of the key elements of the SOCC in the GEARS era is a unified operations console. The unified operations console provides operators with situational awareness across the GEARS Observatory Management section and a single interface to all the functions of the SOCC. Where possible, the console offers the same interface for common functions, while supporting unique interfaces for unique functions. This common interface enables each satellite operator to flexibly perform any authorized task from a single console. For example, the same interface is used for all satellite commanding. The console also employs principles of user interface design to keep the operator focused and constantly aware of the current context. For example, the console uses prominent titles, colors and other cues to keep the operator cognizant of what satellite he is currently commanding.

Integration with the unified operations console is required for all new satellite programs. Existing legacy programs will be integrated into the unified operations console if a cost-benefit analysis shows an overall long-term benefit; otherwise legacy programs will fly-out using the existing, dedicated consoles.

[14] Alexander, Ian F. and Maiden, Neil. Scenarios, Stories, Use Cases Through the Systems Development Life-Cycle. 2004

At the beginning of each shift, the Satellite Controllers, Aerospace Engineering Technicians and other operation staff gather in a briefing room to meet with the Operations Director and discuss the upcoming shift. The Operations Director uses the mission planning tool to project a schedule of all operations tasking for the day. Since all planning is handled by a common tool, this display shows all satellites and all ground systems activities for the day. Today is typically busy: several overlapping passes for the polar-orbiting satellites, continuous monitoring of the geosynchronous satellites and a network upgrade for one of the SOCC to ground station links. The Operations Director discusses assignments with the operations staff and works out the day's tasking. Most of today's tasking is routine, and the planning system has filled in the appropriate defaults. The discussion focuses on the day's unusual tasking, and as the Operations Director assigns staff and resources to tasks, the planning tool updates the display to show the allocations and notifies the Director of any conflicts. Since the staff uses the same ground system to execute all tasks, they are able to flexibly allocate their effort to work on any satellite for which they are qualified. And since all the operations consoles offer the same functions, they can move to a new console if their assigned console is unavailable due to a problem, scheduled maintenance, etc.

Midway through the morning, the Operations Director takes a call from his counterpart at the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). Due to a communications problem, EUMETSAT failed to download some imagery from a European Ka-band weather satellite, and the EUMETSAT operations director is calling to request that NESDIS download the imagery and forward it to EUMETSAT. Using the mission planning tool, the Operations Director calls up the European satellite's projected orbit and sees that the satellite will be in range of the Fairbanks ground station in about 20 minutes. Tentatively slotting in a contact through Fairbanks, he sees that it will bump a planned JPSS contact, which will be automatically rescheduled through McMurdo with minimal mission impact, primarily latency. He confirms with his EUMETSAT counterpart and commits the schedule change. If the EUMETSAT mission is X-band, such as the METOP series, then Fairbanks has three available X-band antennas to support and conflicts would be minimal and based on spacecraft priorities for the station.

On the SOCC floor, two Satellite Controllers are affected by the change. One Controller receives a notification that she will be managing the newly scheduled contact with the European satellite. She has been qualified for operations on this satellite by cross-training in a simulator, passing a training course, and shadowing a prime operator on previous contacts. She closes her current task – preparing for the upcoming Joint Polar Satellite System (JPSS) contact – and opens the new task. She brings up the Standard Operating Procedure (SOP) for a EUMETSAT support contact and begins executing the procedure.

One of the steps requires her to allocate processing and communication resources for sending the downloaded imagery to EUMETSAT. Using the common health and status monitoring application, she sees that there is sufficient idle capacity in the processing and distribution segment to handle this request, so she schedules those resources. If resources hadn't been available, her request would have triggered a resource allocation conflict. This conflict would be assigned to the Operations Director for resolution – possibly by moving a task to a different time period to free up resources, or by asking operations to temporarily assign additional resources to the processing and distribution segment.

Meanwhile, the second Controller receives a notification that the upcoming JPSS contact has been added to his tasking. He is already tasked with monitoring a Geostationary Operational Environmental Satellite (GOES). GEARS supports a variety of modes for satellite operations, from completely manual to completely automated. Since the GOES is a well-understood satellite with a long history of successful operations, it has progressed to an "operator on the loop" mode of operations where routine tasking is handled automatically by the ground system unless an unexpected event occurs or the operator manually interrupts operations. Operator on the loop mode enables the second Controller to prepare for the JPSS pass while continuing to monitor the GOES satellite for an exception event. If an exception event occurs on the GOES satellite during the critical portion of the JPSS pass – a very unlikely but possible scenario – then he can summon help from other operational staff. Since any console can be used with any satellite, any available staff member would be able to help with minimum disruption. He also has the option to request that a free Controller (or the Operations Director) shadow the GOES satellite during the JPSS pass.

Meanwhile, on the tasking display, the JPSS contact task is blinking red to indicate that it has been assigned to the second Controller but not yet accepted. The second Controller accepts the JPSS contact task and takes up with the preparation from where the other Controller left off. Since both tasks use the same interface and tools, he can do this with minimum disruption to his existing task. He sees that the contact has been re-scheduled for McMurdo and adjusts the tasking accordingly.

Later in the day, a fire alarm triggers in the SOCC, forcing all operational staff to have to exit the building. Since GEARS is distributed across all the NESDIS sites, during this sort of outage the Wallops Island and Fairbanks CDA staff can temporarily assume the responsibilities of the SOCC operators. In this case, the CDA staff use GEARS capabilities to monitor the JPSS pass (taking place at McMurdo) that was scheduled during the network down-time. As it happens, it is a false alarm, and the operations staff returns to the SOCC before the pass commences. Rather than further disrupt operations, the Operations Director chooses to let CDA staff handle the passes and just shadows the passes on her own console. After the pass, the SOCC Controller notifies the CDAs that the emergency is complete and resumes control.

## 5.2 Integration of a New Satellite Mission

In this scenario, we look at the process of integrating a new satellite mission into GEARS. In this case, NESDIS has begun the acquisition of a new generation of polar orbiting weather satellites with instruments that differ significantly from the legacy satellites. To prepare the ground for these new satellites, NESDIS has collaborated with the flight program to define the ground requirements for the new satellites, including capabilities, interfaces, data formats, etc. The new requirements are thoroughly vetted before being approved. Although most ground requirements are met by existing GEARS capabilities, some new capabilities need to be acquired.

NESDIS conducts a competitive acquisition according to DOC and NOAA acquisition processes for the new ground system capabilities. In addition to the usual acquisition documents, the Office of Satellite Ground Services (OSGS) also provides detailed information about GEARS, including the as-built architecture, the registry of available services and infrastructure, the concept of operations, enterprise standards, data/metadata specifications, interface requirements documents and other relevant information. The Request for Proposals (RFP) directs proposers to describe in their RFP responses how they will make use of GEARS and the associated costs.

A wide range of proposals is received, but the winning proposal makes heavy use of GEARS – developing in the GEARS-provided development and test resources, re-using existing services, and hosting the new ground capabilities in the GEARS environment. As a result, the proposal benefits in several of the acquisition assessment areas: It has lower overall cost, lower risk of problems when integrating into the operational environment, and (because it re-uses the standard operator interfaces) high marks for operational usability as judged by OSPO. In one area where the new satellite has very demanding new requirements, the contractor has proposed augmenting GEARS with MUE and explained why that is a cost-effective approach.

Once the acquisition is awarded, OSGS identifies a mission liaison to interface with the Flight Project to ensure successful implementation of the ground-flight and ground-launch interfaces. The ground system development contractor begins working with the GEARS engineers to define in detail how the new mission will use the GEARS capabilities and conform to the established GEARS Interface Control Documents (ICDs). Performance requirements are refined, prototypes and performance testing is performed (in the R&D section of GEARS), and estimates of required GEARS resources are updated. If the new capabilities will require expanding GEARS capacity beyond previously anticipated levels, funds are transferred to the GEARS program office to acquire the new resources to be installed into GEARS. The development contractor also works with the GEARS engineers to define how the mission-unique equipment will be integrated, and to determine a concept of operations, verification and validation, and maintenance requirements for the MUE.

The contractor must also develop some new software capabilities. In most cases, the development will be done using resources from the R&D section of GEARS. As part of the acquisition proposal, the contractor has described the development and test resources that will be required and a schedule for their use. GEARS used these requirements to plan the development and test resources to ensure that the contractor will have the resources required to succeed. After installing the appropriate security controls, the contractor uses these resources remotely by networking into GEARS from their factory. All of the test and development resources are part of GEARS – the contractor networks in only to get access without having to be physically located with the resources. Re-using these development and test resources saves the cost of purchasing them solely for this development, and because the GEARS test and development resources closely mimic the operational resources and provides access to operational and test data, it speeds test and integration.

During test and integration, the resources used are isolated away from all operational equipment. When needed, operational data is delivered using one-way networking to ensure that nothing can leak from the R&D section to the other sections. To reduce integration risk, the R&D section is configured to mimic the capability (but not the capacity) of the other sections as closely as possible.

After passing system test in the R&D section, the capabilities are migrated onto demonstration enclaves in the OM and PGD&A sections. These resources are configured as a protected enclave, where access to operational capabilities is controlled and can be allowed, blocked, or require manual approval. Here the capabilities undergo final integration test and shadow operations to ensure that they work correctly and will not interfere with existing operational capabilities.

## 5.3 Transition of a NASA Research Satellite Mission to NOAA Operations

In this scenario, a NASA research satellite is being transitioned to NOAA. Unlike the previous scenario, this is not a new acquisition but an existing satellite. This satellite was not developed for NOAA, or intended to transition to NOAA operations, but at the end of its budgeted period of research operations it was decided that the science value of its measurements was high and NOAA was selected as the new home for the satellite. NOAA was given a Level 0 requirement to take over satellite operations and to provide the satellite measurements as operational data products.

OSAAP created Level 1 NOAA requirements for providing the measurements using the new satellite and budget has been allocated. The requirements include operations, maintenance and sustainment of the satellite as well as production, distribution and archive of two new products based upon the products NASA is currently producing. The requirements for management of the data were derived per the guidelines set forth in NOAA's NAO 212-15 Procedural Directives and the NEIO data management assessment and approval process.

The satellite uses standard bus and communication protocols, and carries an atmospheric sounder and a space weather instrument. Due to the common services available in GEARS, integration of the new satellite into NESDIS will not require the insertion or acquisition of a new, dedicated ground system. Instead, most of the integration is accomplished by updating the GEARS configuration and composing[15] the existing ground services to handle the new satellite. A small, agile engineering team already on contract is well versed in integration of new satellites into GEARS and is selected to do the integration.

NASA provides the as-built specifications, design and implementation of the satellite as well as the telemetry and test databases they have been using to operate the satellite. These databases are not compatible with the existing GEARS database services, so the satellite team must decide whether to translate the databases into a compatible format, or to develop their own support for the NASA format. Translating the databases will be aided by the use of tools for database translation and validation that are already part of the GEARS common services, and will then give the team access to all GEARS common services, so the team decides to translate the databases.

Since the satellite uses standard bus and communication protocols, no significant changes are required to the common ground services that will receive and process the satellite telemetry. The satellite ephemeris is added to the mission planning system to predict contacts. When this is complete, the satellite operators validate that they can schedule contacts, establish communications with the satellite, display the satellite telemetry, and send commands.

NASA also provides a software-only satellite simulator. The integration team works with NESDIS software engineers to adapt the simulator's interfaces to the standard GEARS interface framework that lets it function as a new common ground service[16]. They register the new simulator in the service registry, and it becomes available as a simulation service for operators to use for training and command verification, and for engineers to use during anomaly resolution.

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[15] Service composition creates a new functionality by combining existing services (and possibly new services). For example, we might produce a new weather product by combing three existing services to read data, perform initial data conditioning and write data with a new service implementing a product algorithm.

[16] "Common ground service" is defined in Section 4.2.11. It means a service that is available throughout the ground system, as opposed to one that is only available to a particular mission.

NASA also provides a set of Standard Operating Procedures (SOPs) and training materials for operating the satellite. To support these SOPs, NASA has developed stored procedures (PROCs) for the existing NASA command & control system. These PROCs must be translated by NESDIS ground engineers for the GEARS command & control services, tested and integrated. Other areas of the SOPs must also be adjusted to conform to GEARS; these changes are made and verified by the NESDIS ground engineers working with the Controllers. The NESDIS ground engineers also investigated whether manual SOPs can be automated using the capabilities of GEARS. NASA also provides initial training to the NESDIS ground engineers and Controllers as part of the transition.

The satellite Controllers begin cross-training on the translated SOPs using the simulator and GEARS. When the simulator is executed, hardware resources are automatically allocated from the pool of available infrastructure resources. Training is streamlined because the new satellite will be operated using the familiar GEARS interfaces and tools.

On the product generation side, NASA has provided two product algorithms. These will be integrated into GEARS by NESDIS software engineers working with NESDIS scientists and using the standard GEARS tools and processes: the GEARS development and test resources in the R&D section, the integration and transition to operations process, etc.

The first algorithm is written in C++ using standard product libraries and interfaces, and has documentation and test procedures. The GEARS development and test resources already include the necessary compilers, libraries and build tools, so the algorithm is quickly recompiled and tested. It works flawlessly and is added to GEARS as a new product generation service.

The second algorithm is in a language that is not supported in GEARS and lacks documentation and test procedures, but does have a large corpus of data that has been processed with the second algorithm while NASA operated the satellite. The NESDIS team evaluates several approaches for transitioning the algorithm to GEARS, including adding the required language and tools to GEARS, running the algorithm on an emulator, or rewriting the algorithm in a GEARS supported language. They determine that the least cost and risk approach is to re-write the algorithm using a supported language.

The rewrite task is executed using development and test resources in the R&D section. Much of the algorithm – data translation and extrapolation routines – is not re-written at all, but replaced with algorithm services that already exist in GEARS. The re-written algorithm is then tested by re-processing old data and comparing the output to the output of the original algorithm. Where the results differ, the NESDIS team finds that the quality of the algorithm is actually improved, since it is now based on common services that are used for many different products and have been carefully optimized.

The new products now transition to operations using standard OSPO processes including validation and verification. As part of the transition to operations, the NESDIS engineers create the required documentation and test procedures for the new implementation.

Per the OSAAP-approved requirements, the new data products are also added to the distribution, archive and catalog of products available to the users.

Both new product services run with acceptable performance on the standard GEARS hardware resources, so no additional hardware has to be purchased or installed.  The SOCC then spends several weeks taking shadow passes while NASA continues to operate the satellite, and producing data products to cross-check against the NASA data products.  After any discovered issues are resolved, command and control of the satellite is switched over to NESDIS and proceeds without issue.

## 5.4 Integration of an External Data Source

In this scenario, it is demonstrated how NOAA user needs are met on a routine and sustained basis by ensuring continuity of data from foreign as well as domestic sources.  The focus in this instance is on integrating ocean color radiometry (OCR) data into GEARS.  However, there are many NESDIS activities that benefit from external data sources.  Another example is a NOAA research scientist collaborating with international partners to exploit data from research satellites such as the Global Precipitation Measurement (GPM) or Soil Moisture Active Passive (SMAP) satellites.

In order to ensure NOAA user requirements for a continuous real-time data stream are met, NESDIS has determined that a “2+1 Model” for Ocean Color is needed.  Specifically there must be two OCR data streams producing data maintained on an operational basis (domestic and/or foreign sources as available), and one data stream developed and maintained on an experimental basis by STAR scientists and ready to be promoted to operations on a short-term basis as needed should one of the primary data sets be lost due to mission failure or other issue.

The principal source of operational OCR data in the JPSS era is from the Visible Infrared Imaging Radiometer Suite (VIIRS).  In this future scenario, the second operational ocean color data stream is provided by EUMETSAT, which not only provides complementary ocean color observations at a different time of day, but also provides capabilities (increased spatial and spectral resolution & coverage) above and beyond what is provided by VIIRS and helps meet unfulfilled NOAA user requirements, particularly in the coastal section.  The “+1” data stream is sourced from Japan.

The operational JPSS OCR algorithms, as part of the unified NOAA Ocean Color (OC) processing system, are hosted in the PGD&A section of GEARS.  VIIRS sensor data are downloaded from the JPSS satellite and data are processed into operational ocean color products with the standard NOAA OC processing system, and distributed and archived as appropriate.

The  EUMETSAT sensor data are processed by the same unified NOAA OC processing system which is hosted in the PGD&A section of GEARS (as for VIIRS).   Both L1 and L2 level EUMETSAT data are imported using a GEARS common service for importing data from a Web interface.  The L1 data from EUMETSAT are obtained for processing by the operational NOAA OC algorithm processing system.  In addition, the EUMETSAT-produced L2 (native EUMETSAT ocean color) products are required by NESDIS (STAR and OSPO) for product monitoring and quality control.  Both data levels are obtained in the SAFE format and require decompression, file renaming, and manipulation of the metadata for compatibility with NESDIS systems, so STAR composes existing GEARS data transformation services to translate from the EUMETSAT format to the NOAA format.  For L1 data, radiances are stored in separate NetCDF datasets.  After some discussion, it is decided that the routine developed by STAR will probably be useful to other users in the future, so it is provided to the GEARS team that maintains the data transformation service to incorporate as a standard functionality in the common service.  Once in GEARS and translated to the NOAA format, the EUMETSAT data are processed into NOAA operational ocean color products with the standard NOAA OC processing system, and distributed and archived as appropriate.

As the "+1" source, the Japanese data stream is regularly acquired and sustained. STAR scientists use the R&D section to modify algorithms within the existing standard (unified) NOAA OC processing system for processing the "+1" Japanese sensor data. Quality assessments on the "+1" data and products are ongoing at the research level. However, full validation for operational use has not been necessary to date.

At this point in the scenario, the operational JPSS satellite suffers a hardware failure, data from the VIIRS sensor are lost, and the next JPSS mission launch is several years away. To maintain the two operational ocean color products, the "+1" OCR data (sourced from Japan) must be promoted to operational status (EUMETSAT + Japan will become the $1^{st}$ and $2^{nd}$ operational streams).

The Japanese data stream now becomes a priority for expedited algorithm work, product validation, and quality monitoring. STAR scientists, working with colleagues from OSPO and OSGS, build workflows to transform the +1 OCR R&D products into operational products and prepare to move them to PGD&A as operational products, reusing many of the same services that were used to process the EUMETSAT and JPSS data streams. The Japanese data also provide capabilities that are complementary to VIIRS but also distinct, providing higher spatial resolution and additional spectral bands not provided by VIIRS and desired by users.

The ocean color team also works with OSGS to determine what impact promoting the Japanese data stream will have upon the GEARS requirements. OSGS then works to ensure that the required resources will be available and to minimize any impact upon other GEARS users.

The R&D section does not have the operational reliability and latency requirements of the PGD&A section, but prioritizing this algorithm mitigates these differences by giving the OCR +1 development high priority for resources. As soon as the NOAA products from the Japanese sensor are determined to satisfy operational requirements, work then begins to migrate the Japanese products from "+1" to $2^{nd}$ operational OCR data stream, from R&D into the PGD&A operational section. This follows a standard migration process involving testing, evaluation and integration. Because the NOAA OCR processing system is sensor agnostic, because the R&D section closely mimics the OM and PGD&A section, and because the STAR, OSPO and OSGS partners work together to facilitate this migration, the migration happens smoothly and quickly. The distribution and archive configuration is also modified so that the EUMETSAT and Japanese sensor-based NOAA products are now the operational products. NOAA users are able to quickly substitute this data stream into their downstream operational products with no break in coverage, having already completed their own product assessments, evaluation and integration activities.

With the failure of VIIRS, both of the NESDIS operational ocean color data streams are now from foreign sources. However, all are run though the standard NOAA ocean color processing system, developed and maintained by STAR and in turn transitioned into operations as part of GEARS. As such, the impact to operational users is minimized. However, without the previous acquisition of these data as part of GEARS and scientific efforts by STAR to ensure they were ready to quickly transition into operations, the impacts to users could have been severe.

## 5.5 New Data Product Requirement

This scenario begins with a STAR scientist conducting basic application research into atmospheric aerosols. She has been conducting this research to fulfill a NESDIS Level 1 requirement to develop new products to improve weather forecasting. She has worked on this task for several years using resources and services allocated from the GEARS R&D section. During that time, she has tested and refined several new data algorithms, and now she has proposed to transition one of her algorithms into operations to create a new product.

STAR forwards this information to the Satellite Products and Services Review Board (SPSRB) for consideration as a new product. In this case, the SPSRB reviews the algorithm and approves a new product requirement. The SPSRB forwards the new product requirement to OSAAP for validation. OSAAP works collaboratively with OPPA Technology, Planning and Integration for Observation (TPIO) and other stakeholders (e.g., STAR, NEIO, OSGS, NWS, OSPO) to validate the new product requirement. In this case, OSAAP approves the new product requirement[17].

OSGS then leads a team including STAR, NEIO, OSPO, and OSAAP to prepare a development plan including an end-to-end project plan, mature cost evaluation, evaluation of impacts, and requirements. OSAAP works with the Chief Financial Officer (CFO) and other offices to determine if funding is available to support this development. In this case, funding is available and OSAAP creates the new product requirements and assigns them and the funding to OSGS for development.

The initial work by the OSGS-led team has created a derived requirement to generate a product which fuses data from two different sensors and uses the fused data to estimate an atmospheric aerosol. Derived requirements have also been created for performance, data format, and so on. With a complete set of derived requirements in hand, OSGS stands up a team of engineers and scientists to implement this requirement.

The development team does a quick, top-level assessment and determines that GEARS has two existing services that might be used to meet the requirement: a data fusion service (“DFS Version 1.0.5”) and an aerosol dispersal algorithm (“AERODISPERSAL Version 1.2.8”). A full analysis of the capabilities of these services to meet the new requirement would take some time, but since both services are already part of GEARS, a prototype can be quickly built and tested. Resources are allocated for development and test, and engineers from the development team use standard development tools to compose the two existing services, write scaffolding code, and produce a prototype to generate the new product.

When the prototype is tested, the development team scientists discover that the prototype product does not meet the mission requirement. The problem is that the existing aerosol simulation algorithm (“AERODISPERSAL Version 1.2.8”) does not have the required accuracy. A new algorithm must be developed and implemented.

The scientists on the development team investigate existing algorithms, study the underlying science, and develop a candidate approach. They create a prototype algorithm in a numerical analysis tool (e.g., Matlab, Mathematica, etc.). After several iterations, they have a new algorithm that produces the required data product. (This process is described in more detail in “5.6 New Algorithm Development.”)

[17] The process for approving a new product described here is notional. The Product Lifecycle Working Group (PLWG) is currently defining this process; GEARS will be compliant with that decision.

However, the performance of this implementation – because it uses a numerical analysis tool – doesn't meet the derived performance requirements.  To improve performance, the development team translates the prototype algorithm into the "C" programming language.   Because the team has followed GEARS guidelines on how to implement new algorithms and services within GEARS and used the provided libraries and tools, the translation to "C" and implementation as a new service is straightforward.

Because this service is only used by this one algorithm, and has not been approved and incorporated into GEARS as a service that is available to all users, it is a private service (see 4.2.11 Service-Oriented Approach).  Private services are only visible to their owners.  This provides a way for GEARS users to develop and use their own services without the overhead of becoming a common service.

Combined with the common ground data fusion service, the aerosol dispersal service is able to produce a product that meets the original OSAAP requirement, and is put into production.  Even though the aerosol dispersal service is in production, it remains a "private" service that is available only to the application creating the new product.  The following scenario looks at how a private service could transition to become a common service.

## 5.6 New Algorithm Development

One step in the previous scenario had scientists researching and implementing a new aerosol dispersal algorithm.  There are several areas where GEARS can support a scientist creating a new algorithm intended for operational use.  One area is to provide access to data for development and test.  Another is to replicate the operational environment during development so that the eventual integration into the operational environment does not require testing & validating new interfaces or capabilities.  In this scenario we look at how GEARS provides this support.

Just as GEARS provides a development and test capabilities for remote use by developers to build new GEARS capabilities, GEARS provides capabilities for remote use by scientists to conduct research.  These capabilities include (1) standards for algorithm control, data inputs, and product output, (2) common research tools such as programming languages, standard algorithmic processing libraries, numerical analysis tools, databases, visualization tools, etc., (3) libraries of sensor data, access to operational data, and testing frameworks.  The purpose of providing these capabilities are to (1) reduce the cost and time to develop new algorithms and (2) reduce the time and risk of integrating new algorithms into the operational environment.  The capabilities offered are determined by the GEARS Governance Board.

In cases where the common tools are not sufficient, researchers can upload and install tools for their own use[18].  The researcher must provide the necessary installation media, licenses, and support.  These tools are private to the user who owns them; other users of GEARS can neither see nor use these tools.  Researchers can also transfer source code, executables and other files from other systems onto the GEARS research resources, e.g., to continue an algorithm development that was begun on another system such as a university research lab.  In all cases where a researcher imports software or data into GEARS, he must comply with the GEARS security requirements.

[18] This only applies to the R&D section.  The other sections are more stringently controlled.  No changes can be made in the other sections without approval.

In the continuation from our scenario above, the lead researcher needs to develop a new aerosol dispersal algorithm based upon the existing basic research.  He uses the documentation provided by GEARS to understand what options GEARS provides for resources such as processing and storage as well as software tools such as compilers and editors.  He selects resources and tools and after approval is allocated these resources in the GEARS R&D section.  This includes both processing and storage resources (e.g., 2 virtual machines running Windows 8.1 and 1TB of disk storage) as well as GEARS-provided software resources (e.g., Subversion 1.8.3 revision control software).

He begins by augmenting the standard GEARS environment with tools he'll need to develop the new algorithm.  This includes a COTS numerical analysis tool and the source code for the previous version of the aerosol dispersal algorithm.  He fills out the security paperwork for the import and is granted permission by GEARS security.  He then arranges for the installation executable for the numerical analysis tool and the source code for the previous version of the aerosol algorithm to be uploaded to his GEARS servers, along with all the ancillary data required.  He provides license information to the GEARS support staff and with their help installs the numerical analysis tool onto his servers.  He also needs to use several data sets from foreign satellites, so he follows the process for uploading external data to GEARS (which involves security approval, virus scans, etc.).

He then begins development of the new aerosol dispersal algorithm.  To test his new algorithm, he makes use of the sensor data library provided in GEARS.  This provides the data needed to test the algorithm against a variety of different sensors.  He also makes use of a GEARS function that allows him to receive sensor data from operational satellites as it is downloaded.

When his algorithm is complete, he works with GEARS engineering to create an automated test suite that runs the algorithm on a variety of test data and compares the results to the existing aerosol dispersal algorithm.

After he is satisfied with the new algorithm, he transfers the implementation and test suite over to the development team.  Working in the GEARS R&D section, the development team will complete the integration and transfer to operations.  In the meantime, the GEARS support staff will warehouse his research environment so that it can be recreated if needed in the future (e.g., to fix or further develop the algorithm).

## 5.7 Algorithm Sustainment

In this scenario, we look at how GEARS could be used to sustain an existing operational algorithm.  We will use the Community Radiative Transfer Model (CRTM) as an example of an existing algorithm.  CRTM is a tool developed by STAR for satellite data assimilation in numerical weather prediction model, GOES-R and JPSS instrument calibration and product developments.  It is also an example of an algorithm with a wide user base, including users outside of NOAA and international users.  Within NOAA it is used both operationally and for research.

CRTM's core modules (e.g. atmospheric transmittance, surface emissivity, cloud scattering look up tables) require updates to incorporate new satellite instruments (e.g. METOP-C Infrared Atmospheric Sounding Interferometer (IASI)) as the new data becomes available.   These updates are challenging because they require extensive data and processing resources.  Data needs include line by line spectroscopy data bases, satellite and conventional data, and mathematical libraries.  For instruments such as METOP-C IASI with thousands of channels, many processors are needed to complete the radiative transfer calculations in a reasonable time.

GEARS provides a number of features to support the CRTM update process. First, GEARS can provide as a service all the required satellite data: the LBL spectroscopy data base, Numerical Weather Prediction (NWP) forecast model outputs from National Centers for Environmental Prediction (NCEP) and European Centre for Medium-Range Weather Forecasts (ECMWF) and radiosonde profile data. As the CRTM scientists acquire new data sets (e.g., for METOP-CIASI) these can be added to GEARS and be available for future use. Second, GEARS can provide on-demand access to a pool of processing resources. When the CRTM scientists need to perform an intensive calculation, they can be dynamically allocated a large number of processors from the GEARS resources. When the calculation is complete (or when the processors are required for some higher priority task) they can be released back to the pool of GEARS resources. Third, GEARS will provide test and integration functions that will streamline the release of a new CRTM version into the NESDIS operational baseline. Fourth, GEARS will provide access to network services (such as a secure FTP repository) that will make distributing a new version of CRTM to the wider community straightforward. Finally, GEARS will provide the ability to warehouse the CRTM development environment so that it can be quickly reconstituted when the next update is required.

## 5.8 Calibration and Validation (Cal/Val) Support

In this scenario, we look at how GEARS supports calibration and validation (Cal/Val) activities.

An integral part of satellite remote sensing is turning instrument measurements into accurate environmental parameters. Proper calibration and validation of instruments ensures high-quality satellite imagery, crucial for forecasts e.g. hurricane tracking and monitoring, ensures that accurate products are generated for assimilation into numerical models for weather forecasts and environmental monitoring, and ensures the integrity of the climate data records from broader satellite instruments. The main challenge faced by scientists supporting cal/val of operational satellite measurements is to get access to real-time operational data for testing and to find qualified match-up reference data for evaluation.

In this scenario the lead investigator of the Cal/Val team is working on validating the aerosol product Environmental Data Records (EDRs) generated by the Visible Infrared Imaging Radiometer Suite (VIIRS)[19]. The aim is to demonstrate that VIIRS produces aerosol EDRs that are within specification and useful to the community. EDR validation is an implicit characterization and validation of the forward model(s) and Sensor Data Records. Therefore, in addition to creating a new algorithm, continuous effort is needed for validating it.

As with the previous scenario, the Cal/Val team begins by requesting and being allocated GEARS resources in the R&D section, including processing, storage and software resources. These resources are then customized by the addition of any calibration and validation tools, reference data, ancillary data, etc. needed by the Cal/Val team to perform the calibration/validation.

The processing chain for the VIIRS instrument processes the Raw Data Records (RDRs) to create Sensor Data Records (SDRs), which are subsequently processed into Environmental Data Records (EDRs). To perform calibration and validation of the EDRs, the Cal/Val team requires access to the intermediate RDRs and SDRs. The GEARS research resources include a service to capture and store the RDRs, SDRs and EDRs as they are received and processed. For this effort, the Cal/Val team uses this service to capture and store snapshots of VIIRS data. They then analyze the VIIRS data records to calibrate and validate the instrument. This process may take some weeks and involve interacting with the algorithm development team (also working on GEARS) to refine and modify the algorithm.

[19] This is an illustrative example of a class of activities. There are many other activities, e.g., routine monitoring of EDRs, that are equally critical to NESDIS.

Calibration and validation is an ongoing but intermittent activity.  When the current activity finishes, GEARS warehouses the Cal/Val teams resources and configuration, so that when the next cal/val activity begins, they can be quickly restored and be ready for immediate use.

## 5.9 Governance of Common Services

In this scenario, we look at how a common service – for example, the new aerosol dispersal service created in the previous scenario – is governed throughout its lifecycle.  A common service is available to any application in GEARS, and is maintained by GEARS.  (See Section 4.2.11 for a detailed comparison of private versus common services.)

In the example from 5.6 New Algorithm Development, there is an existing common service for aerosol dispersal ("AERODISPERSAL Version 1.2.8").  This is part of the enterprise specification and is registered in the enterprise service registry for discovery and reuse (as happened above).  Since this is a common service, any application within GEARS can use it with baseline performance.  If an application requires greater performance, they negotiate a Service Level Agreement with OSGS which details how they intend to use the service and provides the information OSGS needs to allocate resources to the service.

However, the "AERODISPERSAL Version 1.2.8" service did not have the required accuracy, so the development team had to develop a new aerosol dispersal that could meet their accuracy requirements.  Since they developed the new functionality for their own use, it was a private service.  After some time testing and using the new private service, the science team determined that it represented a significant improvement over the existing common aerosol dispersal service ("AERODISPERSAL Version 1.2.8"), and proposes to the GEARS Governance Board that the new private service should be offered as a common ground service.  The GEARS Governance Board accepted this recommendation.

The new aerosol dispersal service is then turned over to OSGS for incorporation into the suite of common ground services.  To be common ground service in GEARS, a service must meet a number of requirements not required of a private service.  It must have documented interfaces, performance specifications and algorithms.  It must be implemented in a supported language and use approved libraries.  It must have an automated build process and be under configuration management.  The intellectual property rights of the service allowing it to be used in the enterprise must be established.  When all the conditions are met, the service can become a common ground service within GEARS.  The documentation is published in the appropriate locations, the service is hosted in GEARS, and the service is added to the enterprise service registry.

In cases such as this one, where the new service is an upgrade or change to an existing service, the new service is given a new version number (e.g., "AERODISPERSAL Version 1.3.0").  Users of the existing version are notified of the new version and given information on how the new version differs from the previous version and how long the old version will continue to be supported and available.  The old version is marked "Deprecated" in the documentation and service registry so that new applications will not be able to use the old version without a waiver.  (This avoids creating new dependencies on obsolete services.)

Generally, the enterprise will try to transition existing applications to new service versions as they become available. In some cases, it may make fiscal sense for the enterprise to continue to support older service versions instead of incurring the cost to transition existing applications to a new service. Missions that use an older versions of a service can also choose to incorporate the older version as a private service (supported by the mission and not by the enterprise) rather than transition to the new version of the service.

## 5.10 Automation of a Ground System Function

In this scenario we discuss how a ground system function in GEARS can transition from fully manual to fully automated. In this scenario we use the quality management for a new data product as a typical candidate for automation.

Initially, quality management for the new data product is a fully manual process. A NESDIS analyst who is familiar with the new data product and an expert in the underlying science is responsible for sampling the data product outputs and performing quality control. Initially, this is a vague task, and the analyst uses his technical expertise to refine a better understanding of the quality issues with this particular data product. At first he examines all aspects of the data product – he looks at the size of the product, the accuracy and fidelity of the measurements, cross-checks the data product against reference products, and many other types of analysis. Over time, he identifies several focus areas where quality issues arise. One of these issues is sudden drift error in the measurement sensor. When this happens, the sensor must be re-calibrated. Until that can be done, the data product must be corrected with an additional post-processing step using parameters provided by the analyst and inserted into product distribution. Initially, this is an entirely manual process.

After some months, the analyst and the rest of the data product team decide that the sudden drift error detection and correction process has matured to the point where it has become a candidate for automation.

The first step in the automation process is to create an "operator in the loop" GEARS ground process. An operator-in-the-loop process is automated but requires operator approval within the automated process. Requiring approval enables the operator to confirm that each step in the automation has succeeded before continuing to the next step, and gives him an opportunity to apply manual corrections as necessary. GEARS provides several capabilities to support the creation of "operator in the loop" processes. The first is a workflow automation service that permits a user to create a new workflow process by compositing existing GEARS services. The second is a user confirmation process that can be inserted into the workflow to create operator decision points.

The analyst uses the workflow automation service to create a workflow with several steps. The first step uses a numerical computing language to compare the data product to a reference product, and derive a drift measurement. If this drift measurement is small, then nothing more is done. However, if the drift is large – indicating a sudden drift event – then the workflow automation will trigger post-processing on the data product. The first step in the post-processing is to use the output of the first step to calculate the correction parameters. After this step, the analyst inserts a decision point that will notify him of the sudden drift event processing and give him a chance to correct the parameters if necessary. The last step in the process is to apply the correction using the parameters. Finally, the analyst uses the GEARS workflow capabilities to attach this process at the end of the production process for the data product. Every time the data product is produced, this process will be run.

Initially, the new sudden drift correction process is run as a private service for the quality analyst. It is not visible to other GEARS users and doesn't make any changes to the data product archives. This provides an opportunity to verify that the process is running correctly. In this case, the analyst is notified by the process every time it is run. He verifies the correction parameters (fixing them if necessary) and manually inserting the corrected data product after the process is complete.

After several months of successful experience with the "operator in the loop" process, and after having fixed some problems in the process, the data product team decides to put the process into operations. In operations, the process will be run by a GEARS operator, so the data product team must create Standard Operating Procedures (SOPs) that explain to the operator how to run the process. In this case, the SOP tells the operator to approve the process if the correction parameter has a value between 0.0 and 1.0. Any value above that is suspect, and in that case the SOP instructs the operator to stop the process and contact the data product team. In operational mode, the process will also automatically replace the original data product with the corrected data product in product distribution.

After a year of operational experience, a GEARS operations review shows that the data product team has only been contacted twice for an out-of-range parameter value. They meet with the data product team to suggest that the process be fully automated, with the data product team receiving an automated email if the correction parameter is out-of-range. The data product team approves the change, and the process is fully automated by removing the decision point from the workflow and replacing it with a step to send email.

## 5.11 Adding a New Common Capability to GEARS

In this scenario we discuss how new common capabilities – things like tools, data sets, etc. – are added to GEARS.

Our scenario begins with two GEARS users talking over lunch. The first user mentions that he uses "FindBugs" from the University of Maryland[20] to help find bugs in his Java code. The second researcher says that he has used it as well, and wishes that it was available as a common tool in GEARS. The first user thinks that's a great idea and agrees to suggest it to GEARS. The process for suggesting a new common capability is straightforward. The user fills in a form on the GEARS Help Desk website describing the desired capability, its purpose, what types of users would be expected to use it, etc.

The submitted form is forwarded to GEARS technical support for assessment and to provide feedback to the user. For example, some capabilities may already exist and the user can be pointed toward the existing capability. Or a suggested capability may violate a policy. If the initial assessment indicates that providing the capability will be useful to GEARS users, then a more detailed assessment is performed. This purpose of this task is to assess the costs, benefits and risks of providing the capability as part of the GEARS common capabilities.

In this case, the proposed capability passes the initial assessment and is given a more detailed analysis. GEARS technical support investigates FindBugs and learns that it is open source and developed by US citizens. They find that the tool has already been approved for use in GEARS, find that a number of users have installed it as a private tool. GEARS technical support concludes that it will be inexpensive to provide the capability, create little risk, and would benefit all Java developers using GEARS.

[20] http://findbugs.sourceforge.net/

The proposed new capability along with the assessment is then forwarded to the GEARS Governance Board for consideration. In addition to deciding whether or not to offer the capability, the Governance Board also determines the level of support to provide. The level of support is determined on a case-by-case basis anywhere from "as is" – no GEARS technical support at all – up to "full support" – where GEARS assumes full operations and maintenance of the capability.

In this case, the Governance Board approves adding the capability on an "as is" basis. This means the new tool will be available for any GEARS user to use without restriction, but without any support from GEARS.

The Governance Board also considers a second request – to add the water vapor products from the latest Metop satellite to the GEARS library of available data products. This request must be approved by the Governance Board because adding a new product to the official GEARS library of available data products requires a commitment to provide the resources and budget to support that product. To make this decision, the Board will need to understand the lifetime of the product, how it will be supported, what customers will use the product, and other information. To help the Board assess this request, GEARS technical support has estimated the costs to import these data (including obtaining the data, virus scanning, uploading, etc.), the cost of any additional storage required, the costs of distributing the data to its customers, and so on. In this case the Board approves the request to add the Metop water vapor products to the GEARS library, but determines that the available budget only supports updating these products monthly instead of the requested weekly updates.

## 5.12 Reprocessing

In this scenario we discuss how the GEARS architecture would enable reprocessing of archived data. Reprocessing is a key functionality for operational products such as Ocean Color, Climate Data Records (CDRs), for calibration/validation activities, and for any product when significant quality enhancements or algorithm improvements are developed. Routine operational data production at OSPO is largely intended to meet the low-latency timeliness requirements of the NWS. Reprocessing enables NESDIS to produce higher quality products when accuracy instead of low latency is the driving requirement.

However, there are several difficulties with reprocessing in the current NESDIS ground architecture. First, the legacy ground systems are not generally designed to flexibly apply available resources to secondary tasks such as reprocessing. Even if POES resources are idle between passes, they cannot be applied to reprocessing without significant effort. Second, the legacy ground systems are operational resources, so making even temporary modifications to them to support reprocessing (e.g., temporarily substituting a new algorithm) creates significant risk to meeting NOAA's operational requirements. Current NOAA reprocessing takes place ad hoc within cal/val groups, science groups and at universities who have separate, highly tailored systems that are designed for very high throughput instead of low latency and high dependability requirements. Since these groups are distinct, they cannot easily share their compute resources and cannot realize any economies of scale, limiting the pace of progress.

The GEARS architecture incorporates a number of features that address these difficulties.

First, the GEARS architecture is hardware agnostic and provides a common environment for all GEARS users. This means that a GEARS functionality (such as data processing) is not tied to a particular set of hardware or even to a GEARS section. This means that reprocessing a data product can run on any GEARS resource, not just ones dedicated to a particular mission.

Second, the GEARS enterprise management is specifically designed to be able to flexibly and responsively allocate resources between GEARS tasks.  This permits tasks with relaxed timelines (such as reprocessing) to opportunistically make use of any available GEARS resources.

Third, the GEARS architecture provides several mechanisms for isolation of impacts.  This means that reprocessing campaigns can be executed without concern that they might impact the operational data processing.  Combined with the ubiquitous data access that GEARS provides, reprocessing can even be executed in the R&D Section to provide greater separation from the operational data processing and to take advantage of available resources in that section of the architecture.

Finally, GEARS provides warehousing and restoring capabilities.  Even before processing the data, organizing a reprocessing campaign with the proper data sources, algorithms, configuration parameters, etc., can be a significant effort.  In GEARS, once a reprocessing campaign has been defined, that configuration can be warehoused and saved for future re-use, saving time and effort for future reprocessing campaigns.

To see how these capabilities come together in a reprocessing campaign, let's suppose that NESDIS scientists within STAR have been analyzing archived S-NPP data and have developed new calibration tables from recently collected in situ data that corrects for biases in the Ocean Color products. The corrected, higher quality algorithms will be used to resolve inter-seasonal changes in Atlantic waters for fisheries assessments. A decision is made to reprocess the archived S-NPP data to produce a new corrected Ocean Color CDR.

The STAR scientists work with S-NPP mission support in the R&D Section of GEARS to develop a reprocessing workflow.  This involves ordering original S-NPP data (RDRs) through the GEARS data services, processing the RDRs into Ocean Color CDRs using the new calibration coefficients on GEARS processing resources, validating the new CDRs, and then submitting the CDRs to NCEI for archive and distribution.  The reprocessing team makes several test runs of the reprocessing workflow and validates the new products.

Once the workflow is validated, the reprocessing campaign is approved.  In this case, the reprocessing team has decided to run the campaign using idle GEARS resources, and negotiated this with GEARS management.  Although it may take longer to complete the campaign, using idle resources reduces the overall enterprise cost of the campaign.  If time was a priority and budget was available, the reprocessing team could negotiate with GEARS to make dedicated resources available for reprocessing.  This might cost more (e.g., GEARS might have to purchase additional processing resources) or have other impacts (e.g., other GEARS tasks would have to be delayed).

The reprocessing team uses the GEARS enterprise management services to schedule the reprocessing workflow to run on any idle resources in the R&D Section of GEARS.  For the next several days, the workflow run at low priority in the R&D Section and about 20% of the archived S-NPP data is reprocessed.

At this point, a significant integration & test effort begins in the R&D Section and few resources are available to run the reprocessing workflow.  The reprocessing team proposes to move the reprocessing campaign into the PGD&A Section, and the move is approved.  This move is achieved by warehousing the reprocessing workflow in the R&D Section and restoring it in the PGD&A Section.  And because the PGD&A Section offers the same common services and standards as the R&D Section, the transferred workflow works immediately in the new environment.

Once in the PGD&A Section, GEARS enterprise management services are again used to schedule the reprocessing workflow to run on any idle resources. Within a week the campaign is finished, and the reprocessing workflow is again warehoused. If there is a need for an additional reprocessing campaign in the future, the workflow can be restored for use as a starting point for the new campaign.

# 6 GEARS Transition Approach

The transition from the existing legacy architecture to GEARS will be incremental. Each increment will add a limited set of GEARS capabilities to the NESDIS ground enterprise, until the entire GEARS architecture has been achieved. Increments will also add capacity as required to meet the enterprise requirements. The As-Is Architecture document describes the NESDIS ground architecture at the start of the GEARS. In short this view includes the legacy infrastructure (POES, GOES, and elements of the partner programs that NESDIS participates in) and the soon-to-be-delivered ground segements supporting GOES-R and JPSS.

The content and sequence of the capabilities added in each increment will be driven by priorities established by OSGS management in collaboration with stakeholders, by return on investment (ROI) principles, and by engineering constraints. OSGS management will establish overall priorities for the GEARS capabilities based on Governance Board guidance, and OSGS will then implement these capabilities to maximize ROI within technical, budget and other constraints. For example, suppose that OSGS management made Product Generation capabilities the highest priority. OSGS might analyze the requirements for providing Product Generation capabilities and structure those into a series of increments, beginning with basic server and network capabilities and building through libraries of product generation software. Initial increments might deliver only small amounts of capacity and capability, gradually building as more programs make use of the new capabilities. Over time, legacy capabilities will be retired and GEARS capabilities will grow, as illustrated in Figure 3.

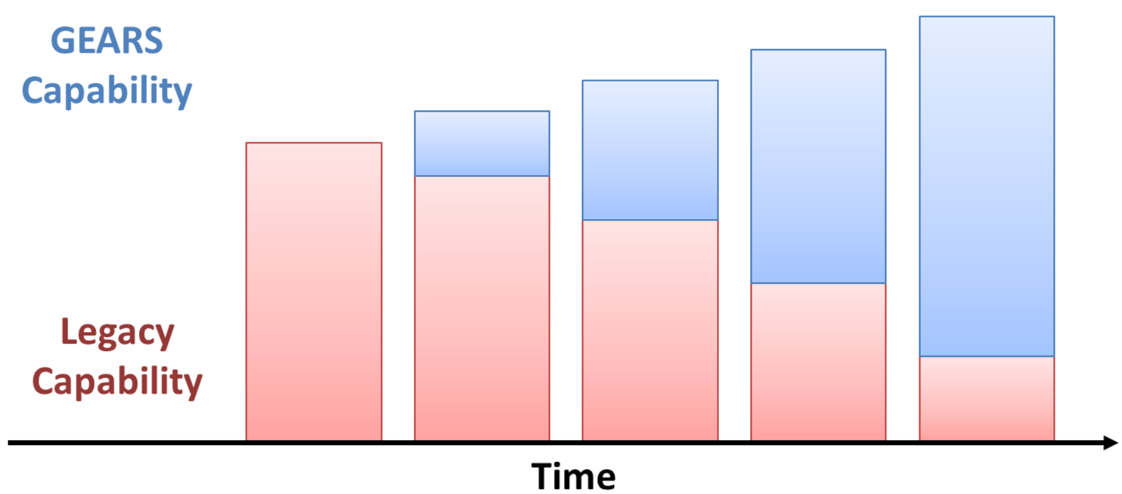


**Figure 3 Incremental Transition from Legacy to GEARS Capabilities**

As the capabilities of the GEARS architecture become operational, their use will become mandatory for new NESDIS programs. For example, after the Product Generation capabilities are mature, new programs will be required to use these capabilities for product generation (rather than create their own product generation stovepipes).

Legacy systems will transition to GEARS only if a careful analysis shows a significant ROI. In some cases, the cost of re-implementing a legacy capability using the new GEARS architecture will not create enough cost avoidance to justify the expense and risk of transitioning to a new architecture. Similarly, it may make sense for a follow-on to an existing program to re-use the legacy systems rather than transition to GEARS.
However, for some long-term programs, the expense of transitioning the program's legacy systems to GEARS may be justified. There may also be cases where NESDIS management directs programs to transition systems to the new capabilities for other reasons (e.g., for increased COOP capabilities). The cost of transitioning a legacy system onto GEARS would be budgeted and allocated by NESDIS. More details about transition can be found in the GEARS Transition Plan.

When the transition is complete, the GEARS architecture will be complete and operational alongside the residual legacy capabilities. Over time, new systems will be implemented within the GEARS architecture and legacy systems will be transitioned into GEARS or retired, until the entire NESDIS enterprise is operational upon the GEARS architecture. This gradual evolution of the enterprise is shown in Figure 4.

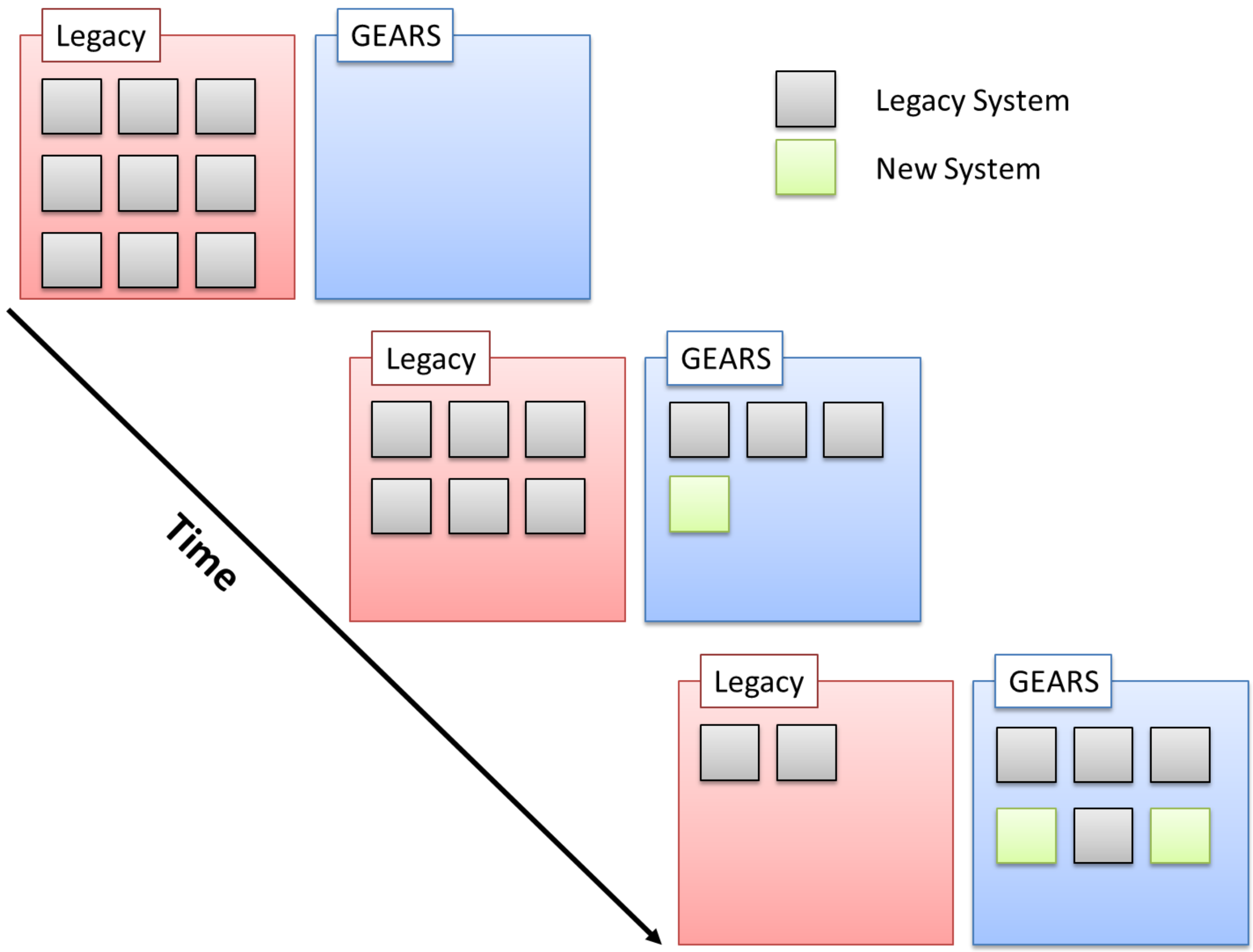


**Figure 4 Enterprise Transition from Legacy Systems to GEARS Systems over Time**

# 7 Impacts of GEARS

GEARS represents a new approach for the business of ground systems within NESDIS, and this has impacts throughout the organization. The following sections discuss (in no particular order) some of the more significant impacts.

## 7.1 Government as Integrator and Infrastructure Provider

In the traditional model of acquisition, the Government acquires an end-to-end system from a prime contractor. The prime contractor has the complete responsibility to select and implement hardware and software resources, integrate the system and meet functional and performance requirements. In contrast, in the GEARS model the Government dictates and provides infrastructure resources and consequently assumes a greater responsibility for integration and meeting end-to-end system requirements.

For example, in the GEARS model many acquisitions will be hosted upon the GEARS infrastructure. In this model of acquisition, the GEARS infrastructure will be treated as Government Furnished Equipment (GFE) and the developer cannot be held responsible if the GFE is not provided as promised or does not perform as promised. Likewise, the developer will rely on integrating with and using various common services, tools and other resources of the GEARS environment. Since the developer does not control these resources, he cannot be held entirely responsible for end-to-end integration of his deliveries with these resources.

GEARS provides several mitigations for this impact. First, the GEARS resources will be fully documented and available to developers during the acquisition process so that they can accurately assess the capabilities of the resources and the integration effort required to use them. Part of this documentation will be an archive of "lessons learned" about working with the GEARS environment compiled from previous acquisitions. Another part will be detailed service specifications (including performance) to enable accurate modeling and design of systems that will use the GEARS services. Second, GEARS will provide technical support to the developer throughout the acquisition, development, test and integration of new systems to answer questions not covered by the GEARS documentation, resolve issues, and otherwise mitigate the technical risks. Third, GEARS is designed so that the R&D section can be configured for a user to mimic the OM and PGD&A section as closely as possible. Mirroring the OM and PGD&A section in the R&D section enables developers to perform early integration in the R&D section and reduces the risks of problems when moving to the OM and PGD&A section.

The Government acting as an infrastructure provider also raises an acquisition impact. Developers may mis-estimate the performance, cost or effort involved in using the GEARS resources. This impact will be increased if the documentation provided during the acquisition process is not accurate and up-to-date.

For example, a developer may assume that he can use a GEARS common service to perform a vital function in the system. If he discovers during development that the service does not have the necessary performance or functionality, that may cause additional costs – for example, the developer might have to implement his own version of the service.

The primary mitigation for this impact is to provide accurate documentation of GEARS, its capabilities and performance[21]. Management may also track unexpected costs for GEARS development efforts to identify particular areas where costs are being incurred so that specific mitigations can be created for those areas.

[21] For legal, security, or other reasons, access to portions of the GEARS documentation may be limited, e.g., to parties that have accepted a non-disclosure agreement (NDA).

## 7.2 Impacts to Staffing & Skills

Successfully executing the GEARS vision will require changes to staffing and skill sets across the NESDIS organization. In particular, designing, implementing, operating and maintaining a shared infrastructure introduces new tasks and challenges to the NESDIS organization, and staffing and skills will need to evolve along with these changes.

The initial mitigation to this impact has been the reorganization of NESDIS to an organizational structure that better addresses these challenges, including the creation of new organizational units to focus on issues such as enterprise architecture. In the longer term, hiring and training will also be used to acquire and develop the necessary skill sets.

## 7.3 Impacts of Shared Resources

GEARS creates a layer of shared resources across the ground enterprise. This includes both hardware resources such as computer servers, storage arrays and networks as well as software resources such as common services. Unlike traditional systems, where a resource is only used by a single system, these GEARS resources are used by many systems across the enterprise. As a result, there is a potentially greater impact from problems within these shared resources. Instead of impacting a single system, they may impact multiple systems. This is particularly true of security vulnerabilities. Because the infrastructure is (generally) homogenous, if one resource has a vulnerability, then all similar resources may have the same vulnerability. For this reason, a shared infrastructure may also be a more tempting target for hackers.

There are several mitigations that can be used to reduce the impact of relying on a shared resource. First, GEARS can approve dedicated, physically isolated resources for critical applications (such as satellite command & control). Second, GEARS can employ redundancy (such as multiple network paths or “Redundant Arrays of Independent Disks” (RAID) for data storage) and other technical mitigations to increase the reliability and availability of the shared resources. Third, GEARS will implement additional testing when modifying existing GEARS resources to specifically identify impacts to GEARS-hosted systems.

Security vulnerabilities have an additional mitigation: Because the infrastructure is largely homogenous, applying patches and other security controls can be largely automated. This leads to more consistent and timely security hygiene, which may reduce the risk of a security problem.

## 7.4 Impacts to Security

With traditional standalone, stove-piped systems, each system was responsible for meeting its end-to-end security requirements. In the GEARS era, GEARS will provide a security framework for GEARS-hosted systems. By adopting this framework and following the GEARS standards, many security requirements will be met automatically or with little effort. For example, GEARS will provide compute resources with virus checking, firewalls and other security tools already installed and operational, eliminating the need for users to meet those requirements. In general, the security approach for GEARS will be for the host (GEARS) to meet security requirements on behalf of all its tenants (the GEARS-hosted systems) to eliminate the redundant effort of each system meeting the security requirements individually.

The GEARS security approach will require robust and collaborative communication between NESDIS organizations, particularly between OSGS and the CIO.

Missions that implement systems which do not follow the GEARS security framework (e.g., by requiring MUE, or by customizing the GEARS-provided resources) will incur the cost of meeting any additional security requirements and provide appropriate documentation.

## 7.5 Impacts to Satellite Ground System Architecture and Design

In GEARS, each new satellite ground capability added to GEARS becomes an integral part of the overall enterprise architecture. This means that new capabilities can no longer be architected and designed independently ("stove-piped"). They must comply with the overall enterprise architecture. This has several impacts to the process of design and architecture.

First, new satellite ground system capabilities must meet the architecture principles of the overall enterprise (see 4.2 General Features of ). For example, new satellite ground capabilities must avoid creating duplicative services, be location agnostic, use non-proprietary standards, adhere to standard, open interfaces in the enterprise, etc. To achieve this, the satellite ground capability acquisition process includes compliance with the enterprise architecture, governance and policies as a requirement. OSGS will also coordinate with the NOAA Chief Architect and the NESDIS Chief Architect to ensure that the GEARS architecture is compliant with the higher levels of the enterprise architecture.

Second, new satellite ground capability acquisition proposals will be evaluated for how well they will integrate with the overall enterprise architecture and how they will contribute to the future enterprise.

## 7.6 Impacts to Mission Acquisition

In the GEARS enterprise, mission acquisition changes in significant ways. Section 5.2 illustrates some of these changes.

One significant impact is to add enterprise-level requirements to the mission acquisition. Instead of viewing a mission as the acquisition of new, independent capabilities, missions are now viewed as incremental modifications and additions to the existing ground enterprise capabilities. New missions will be required to be compatible with GEARS. Instead of controlling most aspects of the end-to-end-system design, proposers will be provided with extensive, detailed documentation of GEARS and will propose how they will use the GEARS capabilities. This new acquisition approach will require that NESDIS provide greater technical support to proposers to help them better understand GEARS.

There is a corresponding change in the acquisition assessment criteria. Instead of assessing the cost, risk and impact of a new mission in isolation, it is now assessed for its cost, risk and impact to the overall ground enterprise. A low cost proposal for a new mission that breaks the enterprise architecture may be rejected in favor of a higher cost proposal that integrates well with the enterprise. For example, a standalone system with lower initial costs might be rejected in favor of a system with higher initial cost (from integrating with the enterprise architecture) that offers enterprise benefits, such as a lower lifecycle cost or increased enterprise capability.

Another significant impact is that for competitive acquisitions, NESDIS will have to provide comprehensive documentation of the GEARS environment and processes to enable proposers to assess how to best use GEARS and accurately estimate costs. And when a proposal is selected, it will create an obligation for GEARS to provide resources and services as detailed in the proposal. In effect, the acquisition becomes a joint effort between the system developer and GEARS.

## 7.7 Impacts to Flight / Ground Integration

In the "traditional" acquisition model, a single prime contractor is responsible for delivering both the space and ground functionality for a new mission, and has full responsibility for the flight/ground integration. In some recent missions (e.g., GOES-R), NOAA has acquired the flight and ground segments separately, and has taken on the flight/ground integration responsibility. With GEARS, the approach will be different.

The GEARS architecture provides a defined, documented, and standards-based interface between the flight segment and the ground segment. New flight systems must integrate to a defined interface owned and controlled by NESDIS/OSGS. GEARS will provide support and tools for flight/ground integration (e.g., tools for monitoring the flight/ground Application Programming Interfaces (APIs), standard test scenarios, etc.) that will be available to aid integration. In addition, OSGS will designate an integration lead for each new mission with the responsibility to coordinate integration between the flight and ground segments.

## 7.8 Impacts to Development and Deployment of Ground Functionality

In the GEARS enterprise, development and deployment of ground functionality changes in significant ways. Section 5.2 illustrates some of these changes.

One significant change is that GEARS will provide development, test and deployment resources to developers. Instead of purchasing development and test resources and deploying them to their factories, developers will use common resources provided by NESDIS. This avoids costs and speeds development and deployment by (1) eliminating the cost and time to acquire resources, (2) providing an environment that closely mimics the operational environment, (3) providing access to operational and test data, and (4) providing common services. This requires NESDIS to implement a robust planning process to ensure that development, test and deployment resources are available to developers as required by their schedules; it also shifts risk onto NESDIS if those resources are not available.

Accessing these resources will require developers to obtain network connectivity to GEARS and to implement the required security controls. At the conclusion of a development effort, the resources can be released for re-use in future developments. In addition, multiple developers will be involved in the development, integration and test of a new mission. Developers for common services changed and/or used by the new mission will work with the developers of mission unique services, the mission system engineers and OSGS system engineers to fully integrate the new mission into the enterprise.

Another significant change is the process of integration of new capabilities into the operational system. Integration risk for stove piped systems is minimized because they typically have only a few, simple interfaces to external systems. In contrast, new capabilities in GEARS will have critical dependencies on common ground services and resources, and will have interactions with other parts of GEARS. This reduces the lifecycle costs for new missions by eliminating development effort, but may increase the integration risk. Some of this risk will be mitigated by providing improved integration tools in the R&D section as described above. However, the primary mitigation will be increased enterprise integration testing. Testing the integration of the new capabilities into the enterprise will be more difficult and time-consuming than in today's enterprise.

## 7.9 Impacts to Mission Operations

This section discusses changes to mission operations under the GEARS enterprise. Section 5.1 illustrates some of these changes.

The primary difference is that operators for new missions will interact with a single, common ground operator interface. While interfaces and tasks will vary between satellite systems, there will be a unified, shared approach across all satellite operations. The common operator interface will result in lower operator training costs, and improved operations efficiency.

And since GEARS is (largely) location agnostic, there will be no dependency between location and tasking. Most ground system tasks will be executable from any ground system location (and in many cases, from anywhere that network access is available). Tasking independence will improve efficiency by allowing control (operations) of tasks to shift to locations where there is staff available, and provide improved availability and disaster recovery.

## 7.10 Impacts to Sustainment

In a traditional satellite program, the ground system is typically acquired with a known lifetime and an expectation that the mission requirements will be generally unchanged across the system lifetime. Required technology refreshes can be planned up-front based upon projected technology cycles. This sustainment approach works well for systems with short lifetimes, but less well for systems with longer lifetimes, or systems that are extended beyond their original lifetimes.

In GEARS, resources are independent of functionality. There is no stand-alone “system” with fixed requirements and a known lifetime. There are still some fixed, dedicated resources, but there is also a large pool of shared resources that are dynamically allocated to meet changing requirements. This enables a more dynamic sustainment approach.

In this approach, technology refresh is tied to IT resources rather than systems. Individual IT resources or classes of resources can be refreshed independent of the systems that use those resources. This enables a dynamic cycle of capacity management and technology refresh that can quickly leverage changes in technology to achieve benefits across the enterprise. For example, if a cheaper, faster storage technology becomes available, it can be quickly integrated into GEARS without impact to the hosted systems or the rest of GEARS. On a smaller scale, a failing computer server can be replaced or upgraded without requiring all GEARS computer servers to be upgraded at the same time.

Of course, it may still be beneficial to do large scale recapitalizations across GEARS. For example, there may be cost and other benefits from having all computer servers within GEARS be the same brand and model. The GEARS architecture does not preclude large scale recapitalizations when they make sense; it just enables recapitalizations that are independent of system stovepipes.

Another impact of the elimination of mission stovepipes is that sustainment responsibility for GEARS, including the applications that operate within it and the IT resources that are shared across it, is discharged in whole by OSGS. Sustainment funding takes care of common infrastructure (the resources that are shared across the enterprise) and mission-unique resources (the resources unique to a particular mission). For example, this includes product generation algorithms, and the servers, networks and storage that the algorithms use.

## 7.11 Impacts to Requirements

One of the goals of GEARS is to consolidate and standardize ground system requirements at an enterprise level. The traditional approach of delegating the development of ground requirements to the individual acquisition programs makes it difficult to optimize across the enterprise. The individual programs do not have the scope to make the necessary trade-offs at an enterprise level, and are therefore optimized for their particular needs at a given decision point in their life cycle. In the GEARS era, the process whereby requirements are flowed down to the ground system will be revised to enable enterprise-level ground system solutions to be provided to the programs. This revision process is not yet complete, but this section describes some of the impacts and implications of the new requirements process.

OSAAP will be responsible for the defining and allocating level 0/1 requirements to set the starting conditions for program formulation (i.e. facilitate and coordinate pre-formulation trades that start the next generation of Programs). The process will include input from the Satellite Programs, OSGS, NCEI, OSPO, STAR, and CIO to ensure all elements of the life-cycle (including flight, ground, data products and algorithms, information assurance, operations, archive, data stewardship and preservation services) are captured.

OSAAP will define, as a level 1 requirement to the programs, that ground functionality be acquired through OSGS. OSGS will collaborate with the flight program to define the derived requirements for new ground functionality, including capabilities, interfaces, data formats, etc. It is expected that OSGS will have its own enterprise budget line item (which OSAAP plays a role in validating) to develop and sustain the common ground services. Should there be mission unique requirements not available in the registry of common ground services, OSGS will work closely with the programs to properly integrate the new requirements, including identifying the resources needed to deliver them. The following paragraphs provide some examples to illustrate the concept.

Example 1: This example concerns a NESDIS requirement such as providing GEARS-wide software licensing configuration management. OSAAP (in conjunction with CIO) would flow this requirement down to OSGS for implementation. OSGS will in turn be responsible for deriving Level 2/3 requirements from the Level 1 requirements, and implementing those requirements. OSGS will work with other NESDIS offices to derive L2/3 requirements to provide the services.

Example 2: In this example, OSGS receives a L1 requirement from OSAAP to support the ground network requirements for a new satellite mission. OSGS elaborates this requirement and derives a L2 requirement for increased network bandwidth between the Wallops Command and Data Acquisition Station (WCDAS) and the Satellite Operations Control Center (SOCC). Since network provisioning is the responsibility of the OCIO, OSGS would work with OCIO to allocate that requirement to CIO for planning and implementation.

Example 3: Suppose that OSAAP allocates a L1 requirement to STAR to develop a new ocean surface temperature product, outside of the Programs environment. To do this, STAR may require a research environment including data processing and data storage resources, access to satellite data test sets, software licenses, and so on. Since OSGS has the responsibility to provide IT infrastructure for NESDIS activities, these derived requirements would then be allocated by STAR to OSGS for planning and implementation in GEARS.

Example 4: As part of the requirements process, OSGS will have the responsibility to provision subject matter expertise for ground systems technical support to other organizations and programs to help them best utilize the enterprise IT infrastructure. For example, OSGS would work with a satellite acquisition program as part of their systems engineering team to help them understand the capabilities of GEARS and how they could best be utilized integrated into the program environment. To implement the command & control function, as an example, OSGS will provide information about the existing command & control services, and help the acquisition program contractor use the GEARS development environment to create command sequences, scripts and user screens for the existing services.

Example 5: In this example, NOAA decides to begin archiving and distributing mission data products from an international observing program. When this policy decision is final, OSAAP creates L1 requirements for collecting, archiving and distributing products from the international program. In creating these requirements, OSAAP collaborates with NCEI and other stakeholders for subject matter expertise. The final requirements are then allocated to NCEI for implementation. NCEI uses their expertise in data management to derive L2 requirements, including the GEARS resources that will be needed for the collecting, archive and distribution of the mission data products.

# 8 Summary

This Concept of Operations (CONOPS) provides (1) a high-level overview of the GEARS concept, (2) detailed discussion of unique GEARS features, (3) scenarios to illustrate how GEARS will impact the business of NESDIS, and (4) a discussion of the impacts of GEARS to NESDIS. Taken together, this CONOPS should provide the reader with a clear and concrete understanding of the GEARS vision.

# A. Acronym List

| Acronym | Expansion |
|---|---|
| **API** | Application Programming Interface |
| **CCSDS** | Consultative Committee for Space Data Systems |
| **CDAS** | Command and Data Acquisition Stations |
| **CFO** | Chief Financial Officer |
| **Conops** | Concept of Operations |
| **COOP** | Continuity of Operations |
| **COTS** | Commercial Off The Shelf |
| **CRTM** | Community Radiative Transfer Model |
| **DOC** | Department of Commerce |
| **DMZ** | De-Militarized Zone |
| **DSN** | Deep Space Network |
| **ECMWF** | European Centre for Medium-Range Weather Forecasts |
| **EDMC** | Environmental Data Management Committee |
| **EDR** | Environmental Data Record |
| **EISWG** | Environmental Information Services Working Group |
| **EUMETSAT** | European Organisation for the Exploitation of Meteorological Satellites |
| **FAR** | Federal Acquisition Regulations |
| **FIPS** | Federal Information Processing Standards |
| **GEARS** | Ground Enterprise Architecture System |
| **GFE** | Government Furnished Equipment |
| **GOES** | Geostationary Operational Environmental Satellite |
| **GPM** | Global Precipitation Measurement |
| **I & T** | Integration and Test |
| **IaaS** | Infrastructure as a Service |
| **IASI** | Infrared Atmospheric Sounding Interferometer |
| **ICD** | Interface Control Document |
| **ICS** | Industrial Control System |
| **IDE** | Integrated Development Environment |
| **IT** | Information Technology |
| **JPSS** | Joint Polar Satellite System |
| **LEO** | Low Earth Orbit |
| **METOP** | Three polar orbiting meteorological satellites operated by EUMETSAT. |
| **MUE** | Mission Unique Equipment |
| **NASA** | National Aeronautical and Space Administration |
| **NCEI** | National Center for Environmental Information |
| **NCEP** | National Centers for Environmental Prediction |
| **NDA** | Non-Disclosure Agreement |
| **NESDIS** | National Environmental Satellite, Data, and Information Service |

| | |
|---|---|
| **NISN** | NASA Integrated Service Network |
| **NIST** | National Institute of Standards and Technology |
| **NOAA** | National Oceanic and Atmospheric Administration |
| **NOSC** | NOAA Observing Systems Council |
| **NWP** | Numerical Weather Prediction |
| **NWS** | National Weather Service |
| **OAIS** | Open Archival Information System |
| **OC** | Ocean Color |
| **OCIO** | Office of the Chief Information Officer |
| **OCR** | Ocean Color Radiometry |
| **OM** | Observatory Management |
| **OPPA** | Office of Projects Partnerships and Activities |
| **OSAAP** | Office of the System Architecture and Advanced Planning |
| **OSGS** | Office of Satellite and Ground Services |
| **OSPO** | Office of Satellite & Product Operations |
| **PD** | Product Distribution |
| **PGD&A** | Product Generation, Distribution and Archive |
| **PKI** | Public Key Infrastructure |
| **PLWG** | Product Lifecycle Working Group |
| **PM** | Product Management |
| **POES** | Polar Operational Environmental Satellite |
| **PROC** | Stored Procedure |
| **R&D** | Research and Development |
| **RAID** | Redundant Arrays of Independent Disks |
| **RDR** | Raw Data Records |
| **RFP** | Request for Proposals |
| **ROI** | Return On Investment |
| **SCADA** | Supervisory Control and Data Acquisition |
| **SDR** | Sensor Data Record |
| **SLA** | Service Level Agreement |
| **SOA** | Service-Oriented Architecture |
| **SMAP** | Soil Moisture Active Passive |
| **SOCC** | Satellite Operations Control Center |
| **SOP** | Standard Operating Procedure |
| **SPSRB** | Satellite Products and Services Review Board |
| **STAR** | Center for Satellite Applications and Research |
| **TIC** | Trusted Internet Connection |
| **TPIO** | Technology, Planning and Integration for Observation |
| **UI** | User Interface |
| **VIIRS** | Visible Infrared Imaging Radiometer Suite |
| **VPN** | Virtual Private Network |

| | |
|---|---|
| **WCDAS** | Wallops Command and Data Acquisition Station |