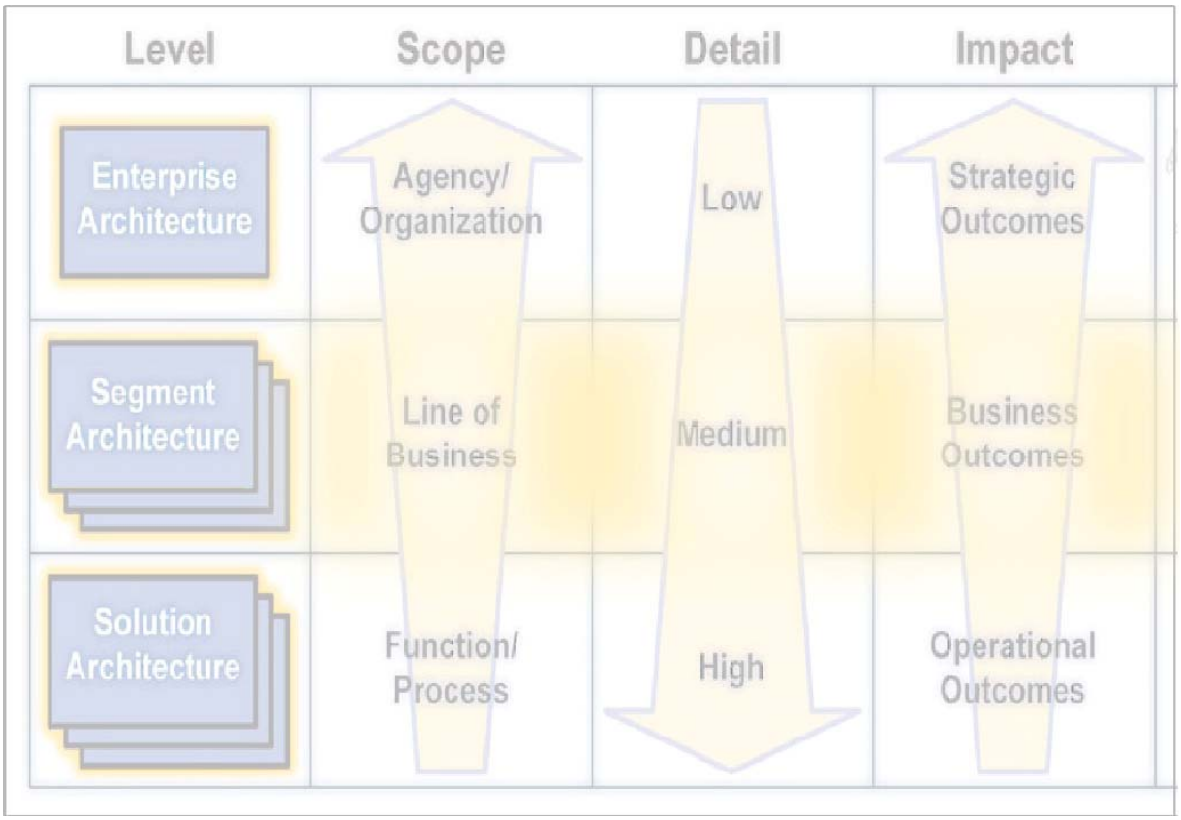
NOAA Observing System Segment Architecture (NOSA)



Department of Commerce
National Oceanic and Atmospheric Administration

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Preface

As per the Office of Management and Budget's request via its annual Enterprise Architecture Update memorandum dated December 22, 2006, it is our pleasure to present the National Oceanic and Atmospheric Administration's (NOAA's) Segment Architecture for the Environmental Observations Enterprise Services Segment, commonly called the NOAA Observing Systems Architecture (NOSA). Global observations taken with systems identified in this segment and the resulting NOAA data and information products provide critical services to U.S. citizens on a daily basis and help policy makers implement sound economic decisions regarding our environment. Indeed, NOAA touches the lives of Americans every day. Our environmental information products are a valuable national and international resource.

This NOSA segment architecture documents the steps NOAA are taking to improve our processes within the overall NOAA enterprise architectural processes. Our observational infrastructure capabilities and expertise contribute to our leadership role in the intergovernmental Group on Earth Observations (GEO). Understanding our global environment requires a global effort, and we have taken steps in the past four years to build partnerships and a global network to share resources, data, and information. Managing observing systems and the resulting data and information on a global scale is being addressed as part of the Global Earth Observation System of Systems (GEOSS), which is being developed by GEO.

In the wake of the 2005 hurricane season and the devastating Indian Ocean tsunami, we must improve our observational and data management processes across NOAA and assist our colleagues in the national and international community. Together we can employ the advances in information technology and worldwide communications to enable timely responses to threats against life and property.

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NOAA Observing System Segment Architecture:
Environmental Observations Enterprise Service

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NOAA Observing System Segment Architecture:
Environmental Observations Enterprise Service

1. Introduction

The National Oceanic and Atmospheric Administration's (NOAA's) environmental observations and resulting products and services satisfy a unique global mission. As NOAA is increasingly asked to answer the Nation's environmental priorities, human ingenuity is needed to ensure that the vast collection of environmental data is used to form a better understanding of the Earth's complex systems.

The 21st century presents complex challenges for NOAA. Every aspect of NOAA's mission—ranging from managing coastal and marine resources to predicting changes in the Earth's environment—faces a new urgency because of intensifying national economic, environmental, and public safety needs. As the new century unfolds, new priorities for NOAA action are emerging in the areas of climate change, freshwater supply, ecosystem management, and homeland security. These challenges are also referred to as strategic change drivers within the context of NOAA's segment architectures.

Additionally, NOAA operates within the rapidly changing Information Age, with new and developing electronic tools and improved methods of applying environmental information to everyday decision making. NOAA of the 21st century must address the needs and opportunities presented by a more globally focused framework, continuing the international work begun in 2003 by the Group on Earth Observation (GEO) System and its U.S. component, USGEO. This requires NOAA's Enterprise Architecture to be integrated with an evolving national and international environmental enterprise architecture.

2. NOAA Segment Identification and Integration

Simply put, *architecture* is a management practice to maximize the contribution of an agency's resources to achieve its mission. As illustrated on the front cover of this document, an agency consists of some number of segments, with each segment composed of a number of solution architectures. The segments are usually defined as *Core Mission Area Segments*, *Enterprise Services Segments*, *and Business Services Segments*. Based on stakeholder input and internal assessments of our mandates and mission, NOAA adopted a business structure of four *Core Mission Area Segments* as represented in Figure 1.

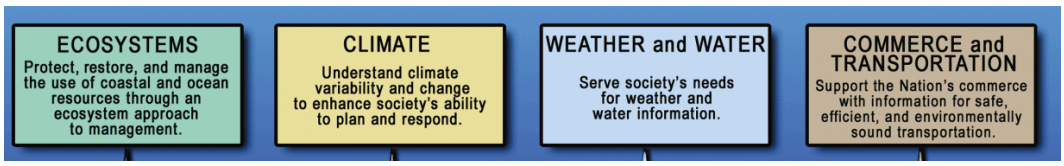

Figure 1. NOAA's Core Mission Area Segments: Called Goals within NOAA.

Each of these four Core Mission Area Segments is composed of sub-segments called *programs*. There are 27 Core Mission Area sub-segment programs and 20 support programs in NOAA that provide one or more *Business or Enterprise* services to the Core Mission Area Segments.

In both the NOAA Strategic Plan and the NOAA Enterprise Architecture (EA) documents, NOAA has articulated its Core Mission Area Segments, its Business Services Segments, and its Enterprise Services Segments. Business services are the foundation mechanisms supporting one or more of the core segments and achieve one or more purposes of the agency. Enterprise services are cross-cutting services that help to achieve the core segment performance objectives. NOAA's enterprise services are consistent with the agency service component model.

NOAA's Core Mission Area, Business Services, and Enterprise Services Segments are illustrated in Figure 2. The four core segments shown across the top of the figure are supported by the Enterprise and Business segments listed down the side of the cube. The Cross-cutting Enterprise Service Segment "Environmental Observations," herein referred to as the NOAA Observing Systems Architecture (NOSA) segment, is the subject of this document.

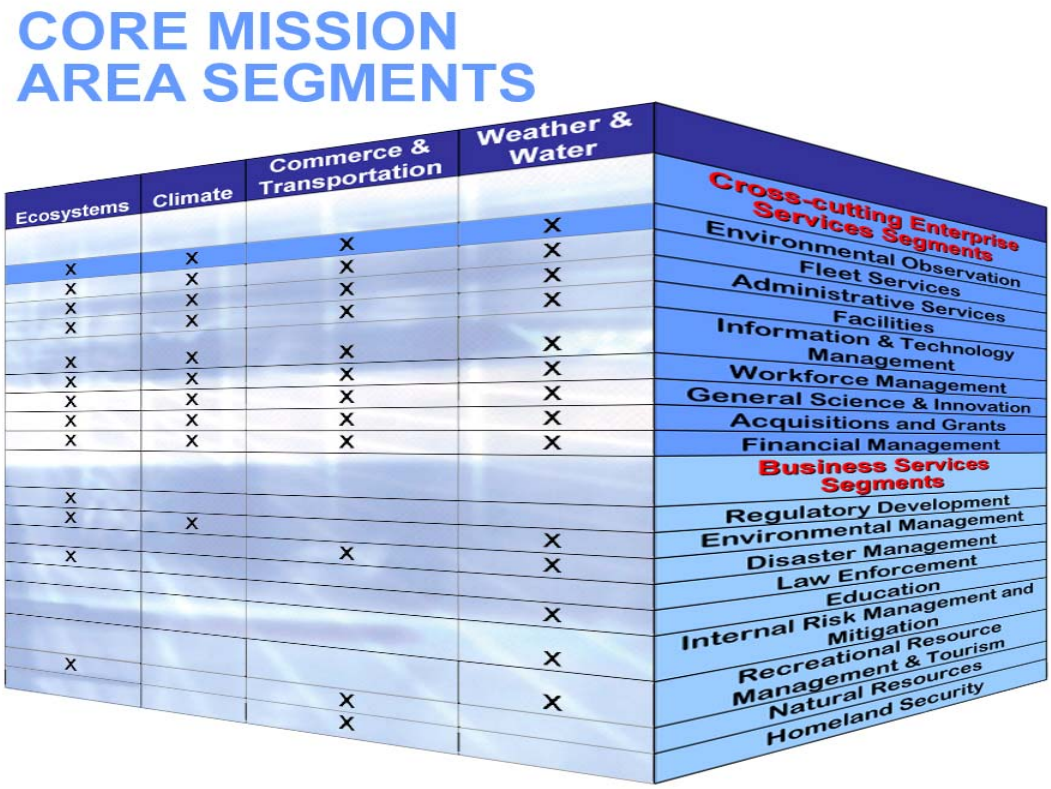

Figure 2. NOAA's Core Mission Area (vertical columns), Business Services, and Enterprise Services (horizontal slices) Segments.

Observations are fundamental to NOAA's mission to describe, understand, and predict the Earth's environment. As a result, NOAA has built a substantial infrastructure over its 37-year history that allows for the collection, analysis, and archiving of global ocean, atmospheric, space, biological, cryospheric, and land surface data. The NOAA Observing System Architecture (NOSA) segment not only supports the four NOAA Core Mission Area Segments, but it is also a key contributor to other Federal agencies such as the Federal Aviation Administration, U.S. Geological Service and the Department of Defense (DoD). In addition, other nations around the globe depend on NOAA's observational capabilities to support their own environmental forecasts and warnings. NOAA also collaborates with other agencies and international organizations to build partnerships to share responsibilities and reduce costs. The NOSA segment is key to meeting NOAA's performance outcomes and satisfying public expectations of NOAA and the Federal Government.

3. Developing the NOAA Environmental Observing Segment Architecture

In the following sections, we will describe and demonstrate the processes NOAA follows in developing, refining, and maintaining the NOSA. We will describe and provide the work products and references used to define the baseline and target architectures as well as the transition strategies to achieve these targets. These work products will document segment level change drivers; describe baseline and target performance and the business, data, services, and technology architecture; and provide an implementation plan to improve performance.

As NOAA developed its core mission, business, and enterprise segments, it recognized the collaboration needed among internal and external business stakeholders, its segment architects, its technologists, and the enterprise architects. NOAA also developed the collaborative business functions and decision-making processes necessary to ensure alignment of the core mission areas and the supporting enterprise and business service segments. Performance and achievement of desired outcomes is the result of all the efforts and activities that take place within NOAA. NOAA's governance structure and processes are articulated in Section 3 of NOAA's Enterprise Architecture document; the components that are relevant to the NOSA segment will be discussed in the following sections.

When the Office of Management and Budget's (OMB's) Federal Enterprise Architecture (FEA) Practice Guidance was released in December 2006, NOAA found the existing process it uses for architecture development—the NOAA Planning, Programming, Budgeting, and Execution System (PPBES)—was aligned with the new FEA Practice Guidance (Section 3 "Developing Segment Architecture"). The NOAA PPBES is also described in detail in the NOAA EA document. The relationship of NOAA's PPBES process to the FEA Guidance graphic "Segment Architecture Development" is shown in Figure 3. The four major steps in the PPBES process, *planning, programming, budgeting,* and *execution* (shaded pink in Figure 3) are closely

aligned to the four steps of segment architecture development and maintenance as identified in the FEA Practice Guidance: *architecture analysis, architecture definition, investment and funding strategy,* and *program management and execution.*

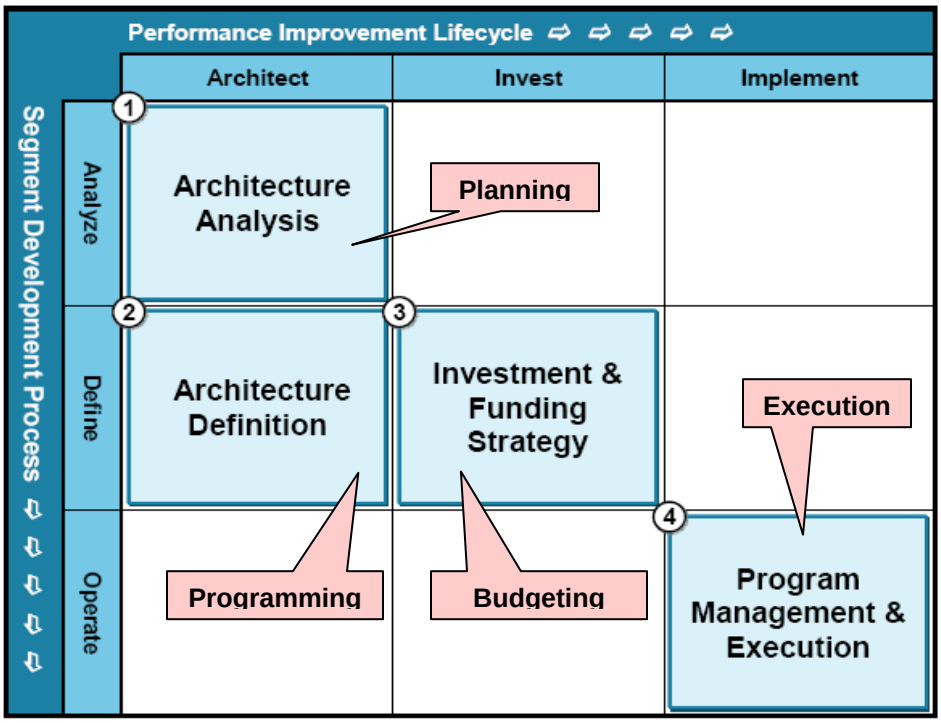

Figure 3. A Crosswalk Comparison of the NOAA PPBES Process (in pink) to the FEA Segment Architecture Development (in blue).

The following sections detail the work processes, the contributors, and the resulting work products generated as part of NOAA's segment architecture development process. For consistency, the sections of this document follow the steps and questions as outlined in the December 2006 FEA Guidance.

3.1 FEA Step #1 Architecture Analysis (NOAA PPBES Planning Step)

In this section we will define the scope of the segment, provide a concise vision for the segment, and relate the vision to NOAA's Strategic Plan. Segment resources, change drivers, and gaps and deficiencies are presented.

3.1.1. What is the scope of the segment?

In defining and refining the scope of the NOSA segment, the NOSA team used a "knowledge modeling"[1] approach; this approach also allowed the

[1] Databases are used to store *structured* data and the *structure* of this data, together with other constraints, can be designed using a variety of techniques, one of which is called **entity-relationship modeling** or ERM or **knowledge modeling**. The end-product of the ERM process is an entity-relationship diagram or

team to gain acceptance among the various stakeholders involved in the process. An Integrated Program Team (IPT) was initially put together, which subsequently became the NOAA Observing Systems Council (NOSC) described further in Section 3.1.2. In order to achieve the performance outcomes associated with NOAA's core mission area segments, NOAA must make observations of the environment covering a wide range of domains. Observing systems used by NOAA (92 of which NOAA owns), currently measure over 500 unique environmental parameters. The mission and vision of the organization and its stakeholders drive the NOSA segment, and each observing system component delivers or provides a unique set of products or services to the business owners and subsequently to the public.

A knowledge model, or entity relationship diagram, was used as the basis for designing analytical systems and processes for capturing and managing the information about the segment entities. The first step was to gather the requirements, and one approach that was used, was to gather the business questions from the stakeholders. A listing of these questions can be found in Appendix A. The approved knowledge model (Figure 4) characterizes architectural elements such as the observing system itself, sensing elements contained within each observing system, environmental parameters measured by these sensing elements, and so on. It also captures information about who owns, operates, supports, funds, and acquires these systems; which NOAA programs (business owners) require the observations and to what accuracy; and the effect these have on their expected outcomes and performance measures. Examining all of the entities relevant to the architecture and defining the relationships among these entities is a complex undertaking requiring input and expertise from all stakeholders and system owners.

ERD. Data or Knowledge modeling requires a graphical notation for representing such data models. An ERD is a type of conceptual data model or semantic data model.

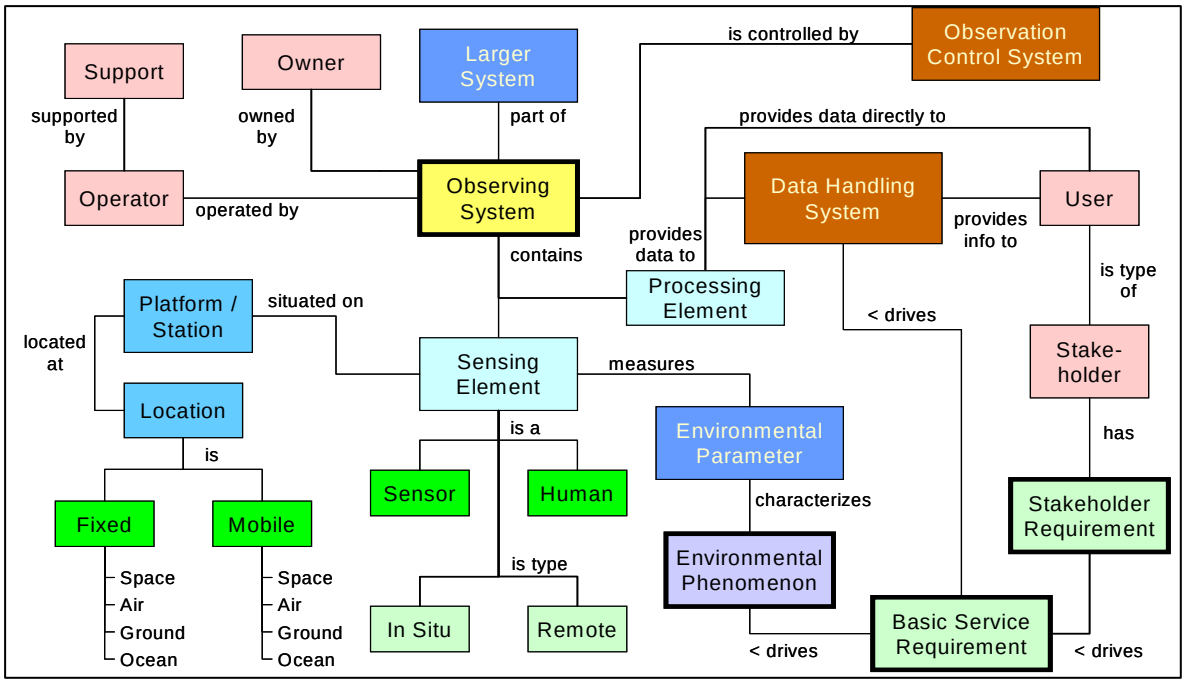

Figure 4. Knowledge Model for the NOSA Segment.

One must recognize that the NOSA segment shown in Figure 4 is a but a component of the larger NOAA enterprise knowledge model (Figure 5). This knowledge model goes beyond the observing components to further delineate the business components of the architecture and the information or data management systems that receive data from the observing systems.

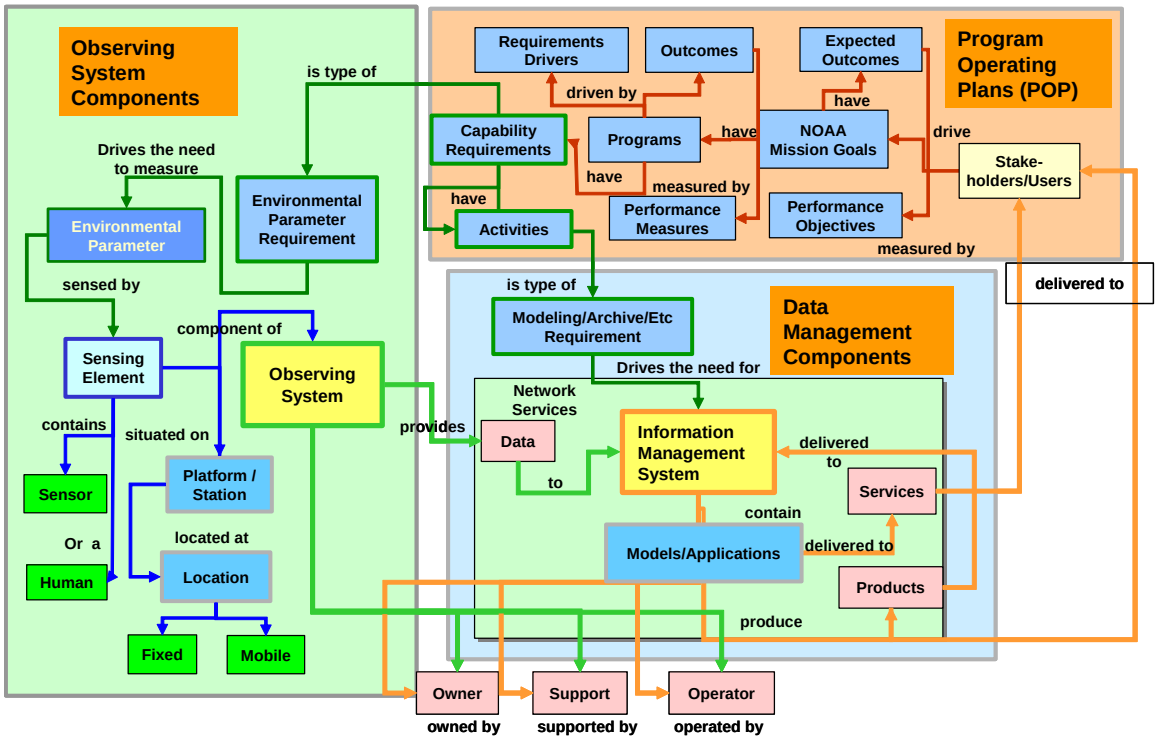

Figure 5. Knowledge Model Representing NOAA's Business, Requirements, Information Management, and Observing System Components.

The scope of the NOSA segment includes all currently operating observing systems, all of NOAA's observational requirements, and the capabilities of many of the target observing systems. These data are kept in an EA relational database and knowledgebase[2] called CasaNOSA. All of the entities shown in Figure 5 have multiple attributes, which are stored in the database. NOAA also keeps in the database additional non-NOAA observing systems that NOAA uses to meet some of NOAA's observational requirements.

3.1.2 NOSA Governance

The NOSA segment architecture is overseen by an equivalent body to the FEA's Integrated Program Team (IPT). That NOAA IPT is known as the NOAA Observing Systems Council (NOSC). The entire NOAA enterprise governance and decision making processes are discussed in Chapter 3 of the NOAA EA document, therefore we will only briefly discuss the NOSC IPT here. The NOSC Terms of Reference are published in the *NOAA Business Operations Manual,* and an excerpt of its purpose follows:

Purpose

The Observing System Council is the principal advisory body to the Under Secretary for NOAA's Earth observation and integrated data environment (end-to-end collection, processing, storage, archiving, accessing, and disseminating) activities. It also serves as NOAA's principal coordinating body to the White House Committee on Environment and Natural Resources (CENR) Subcommittee on Earth Observations (USGEO). Specific tasks include:

- Provide recommendations to the NOAA Executive Council (NEC) on observation and data management requirements, architectures, and investments to meet NOAA, national, and international observing needs.
- Oversee the work of the NOSC Staff, providing guidance in the development of the NOAA Integrated Global Earth Observation and Data Management System.

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[2] **Knowledgebases** are designed to allow people to retrieve and use the knowledge they contain. The most important aspect of a knowledgebase is the quality of information it contains. The best knowledgebases have carefully written articles that are kept up to date, an excellent information retrieval system (search engine), and a carefully designed content format and classification structure. They are commonly used to capture explicit knowledge of an organization, including white papers, user manuals, troubleshooting, articles, and others. The primary benefit of such a knowledgebase is to provide a means to discover solutions to problems that have known solutions which can be re-applied by others, less experienced in the problem area.

- Work with local, state, regional, national, and international partners to develop global-to-local environmental and ecological observation and data management systems for comprehensive, continuous monitoring of coupled ocean/earth/ atmosphere/land domains.

The full text of the NOSC Terms of Reference can be found in Appendix B.

The NOSC maintains a website (http://nosc.noaa.gov/) for collaborative purposes and posting meeting minutes, presentations, actions items, documents, system inventories, subcommittee minutes, and reports. The NOSC holds monthly meetings in which projects report status towards achieving their performance goals, proposed new or alternative observation and data management systems are presented, investment recommendations are decided upon and actions items are tracked. All this information is available at the above referenced website.

3.1.3 What are the primary change drivers impacting the segment?

There are several types of change drivers affecting the way NOAA carries out its business. NOAA must, of course, respond to legislative drivers as do other agencies, but NOAA also has environmental drivers that may significantly change the priorities of targets within the segment. Recent environmental drivers such as Hurricane Katrina and the Indonesian tsunami have caused some redirection of resources to fill higher priority gaps in coverage. For instance, NOAA has a warning network that utilizes a set of baseline tsunami buoys for the Pacific and Atlantic Oceans. After the Indonesian tsunami, the timeline for the planned target tsunami buoy network, the Deep-ocean Assessment Reporting of Tsunamis (DART™), was moved up. Similarly, in response to Hurricane Katrina, the NOAA Water Level Network (NWLON) observing system target configuration was moved up within the overall NOAA schedule.

Further, stakeholder requirements change with time, and NOAA addresses this in several ways. NOAA holds stakeholder meetings across the country every year between January and March to gather input on changing needs and priorities. In addition, since NOAA has several direct services to the public, customer feedback is received throughout the year. As an environmental forecast agency, some of the feedback is very direct and reaches NOAA immediately. Some typical stakeholder feedback comments can be found at http://www.ppi.noaa.gov/2007_stakeholder_forum.htm .

Technological drivers can also have a significant impact on the technology used for observing sensors or platforms. For example, the launch of the Department of Defense Global Positioning Satellites (GPS) for improved navigation led to a new way of measuring atmospheric moisture due

to the bending of the GPS signal as it travels through the atmosphere. This second-hand benefit is already showing potential cost avoidance by using the GPS signals vice dedicated sensors and platforms.

3.1.4 What are the current segment systems and resources?

As mentioned earlier the CasaNOSA database houses a complete inventory of the entire NOSA segment and all elements of the NOAA enterprise that relate to this segment. This includes all entities identified in Figures 4 and 5 (performance, business, data, services, and technology).

The actual enterprise data model, or schema, can be seen in Figure 6 on a small scale but the entire data model can be seen in this file.

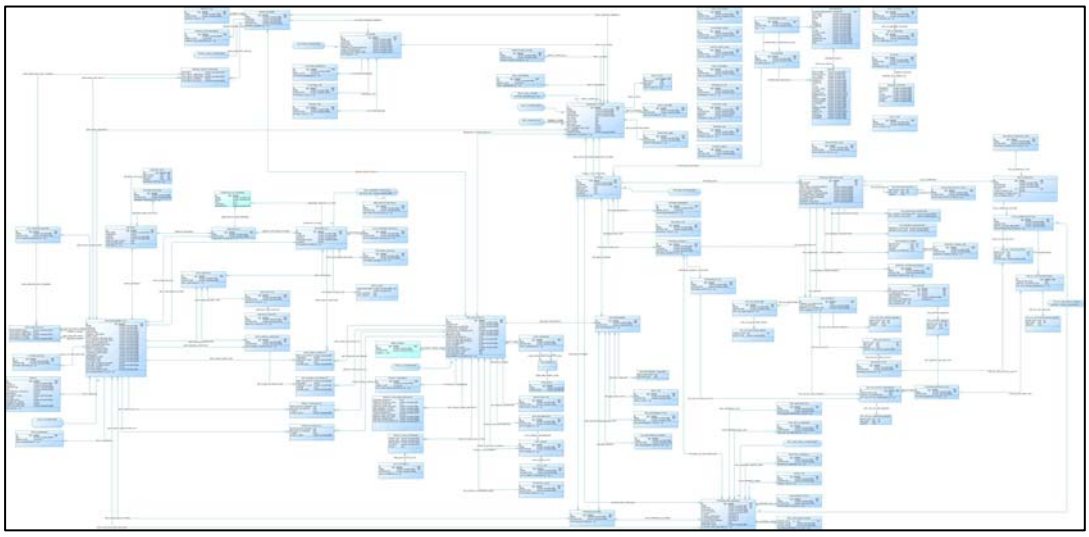


Figure 6. The Entire Enterprise Data Model or Schema.

In addition, the NOSC support team has developed a set of web and desktop client tools with query capability to answer questions about the enterprise. A set of *business questions* gathered from business and technology stakeholders were used as an initial basis for reports (see Appendix A). The output screens of several queries about segment resources are detailed in the following sections.

3.1.4.1 Business Layer Resources

During the annual enterprise architecture update process, each of the 47 NOAA programs provide updated information (including dollar and personnel resources); all of this information is collected via web entry into the EA database. A screen shot of a web based tool used for enterprise information analysis and reporting, found within the CasaNOSA system under “Analysis Tools”, is shown in Figure 7. In this Figure there are three levels of tabs. The first level deals with business information, performance, observing and data management systems, observational

requirements, and observational gaps. The second level tabs change according to the first level tab that is selected. For example, in Figure 7 the user has clicked on, or selected, the first level tab "Program," the second level tab "Capabilities," and the third level tab "Cost data." In this example, the dollar resources currently associated with each capability are presented through FY13. Every dollar associated with each observing system is carried in one or more of these capabilities. Other third level tabs allow the user to view other resources such as Full Time Equivalents (FTE). Output resources and expected milestones are also included in this database.

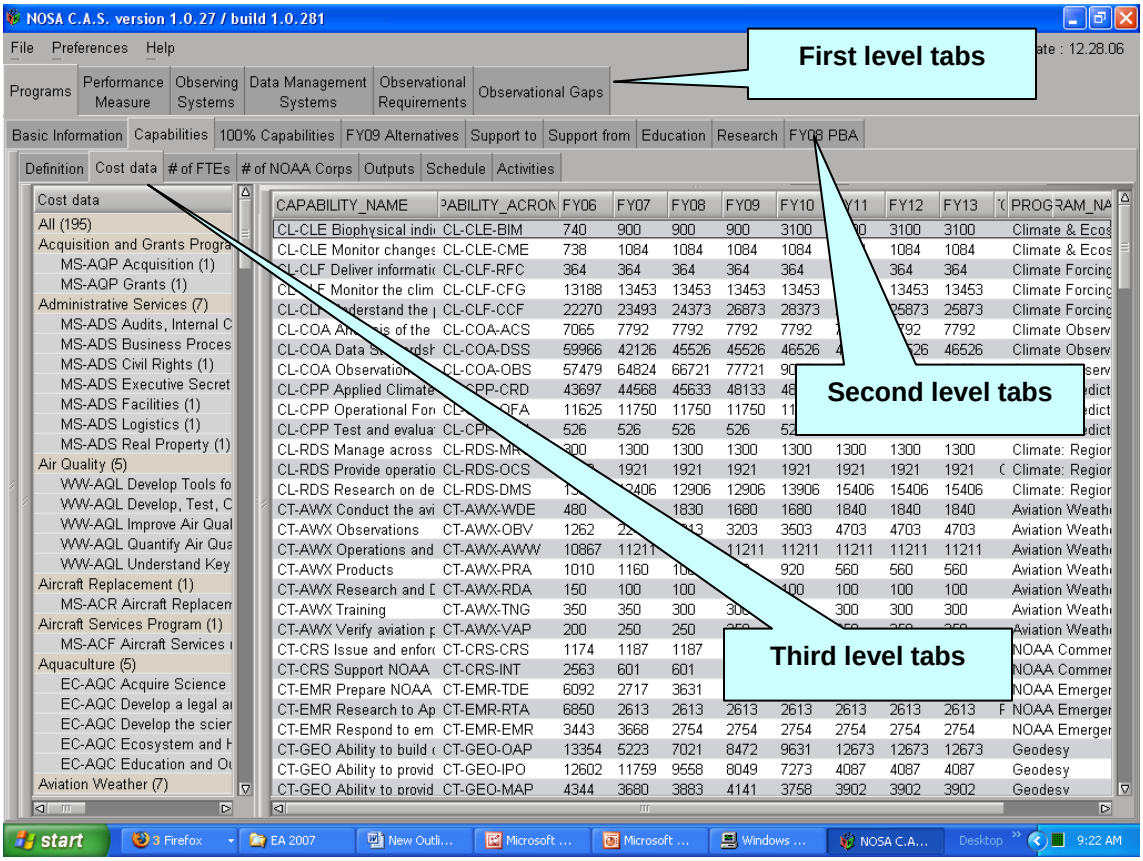


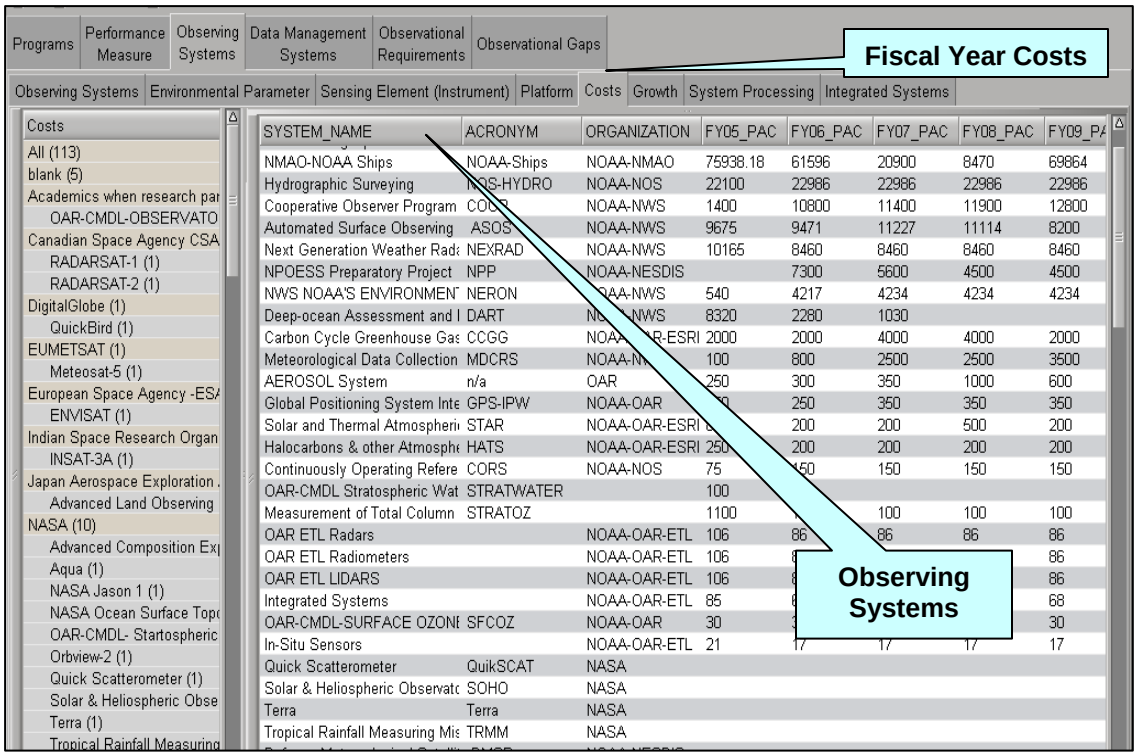
Figure 7. Screenshot of the EA Database Analysis and Reporting Tool, CAS, Illustrating a Listing of NOAA Capabilities and their FY Dollar Resources.

This CasaNOSA EA relational database has been used for the past four fiscal years to capture resource planning and programming information about NOAA's programs, its business and performance data, its observing systems, its data management systems, and its observational requirements. As discussed previously and seen in Figure 7, there are both second and third level tabs covering all current and target resource requirements of these programs. The programs and systems owners also

annually detail alternatives and resources needed to address the 100% required performance or target business outcome.

3.1.4.2 Observing Systems Resources – Technology

Observing system data collection began in 2002 to capture NOAA's baseline observing system segment architecture. The database now includes all of NOAA's observing systems—current and future—and many other non-NOAA observing systems that the NOAA programs use. The database contains resource information as well as information about the instruments or technology aboard the observing systems; the environmental parameters measured by the instruments; the platforms upon which the instruments are located; and various other relevant pieces of information regarding ownership, users, costs, growth, etc. All of the information from the entities in Figure 4 of the NOSA Knowledge Model is collected in the observing system tab. Figure 8 shows budget resource information for several of the 155 systems in the database. Since there is considerably more information that can be queried, reports can be generated and downloaded to the user's desktop.



SYSTEM_NAME	ACRONYM	ORGANIZATION	FY05_PAC	FY06_PAC	FY07_PAC	FY08_PAC	FY09_PA
NMAO-NOAA Ships	NOAA-Ships	NOAA-NMAO	75938.18	61596	20900	8470	69864
Hydrographic Surveying	NOS-HYDRO	NOAA-NOS	22100	22986	22986	22986	22986
Cooperative Observer Program	COOP	NOAA-NWS	1400	10800	11400	11900	12800
Automated Surface Observing	ASOS	NOAA-NWS	9675	9471	11227	11114	8200
Next Generation Weather Rad	NEXRAD	NOAA-NWS	10165	8460	8460	8460	8460
NPOESS Preparatory Project	NPP	NOAA-NESDIS		7300	5600	4500	4500
NWS NOAA'S ENVIRONMENT	NERON	NOAA-NWS	540	4217	4234	4234	4234
Deep-ocean Assessment and I	DART	NOAA-NWS	8320	2280	1030		
Carbon Cycle Greenhouse Gas	CCGG	NOAA-OAR-ESRI	2000	2000	4000	4000	2000
Meteorological Data Collection	MDCRS	NOAA-NWS	100	800	2500	2500	3500
AEROSOL System	n/a	OAR	250	300	350	1000	600
Global Positioning System Inte	GPS-IPW	NOAA-OAR	[illegible]	250	350	350	350
Solar and Thermal Atmospheri	STAR	NOAA-OAR-ESRI	[illegible]	200	200	500	200
Halocarbons & other Atmosphe	HATS	NOAA-OAR-ESRI	250	200	200	200	200
Continuously Operating Refere	CORS	NOAA-NOS	75	150	150	150	150
OAR-CMDL Stratospheric Wat	STRATWATER		100				
Measurement of Total Column	STRATOZ		1100	[illegible]	100	100	100
OAR ETL Radars		NOAA-OAR-ETL	106	86	86	86	86
OAR ETL Radiometers		NOAA-OAR-ETL	106	[illegible]			86
OAR ETL LIDARS		NOAA-OAR-ETL	106	[illegible]			86
Integrated Systems		NOAA-OAR-ETL	85	[illegible]			68
OAR-CMDL-SURFACE OZONE	SFCOZ	NOAA-OAR	30	[illegible]			30
In-Situ Sensors		NOAA-OAR-ETL	21	17	17	17	17
Quick Scatterometer	QuikSCAT	NASA					
Solar & Heliospheric Observato	SOHO	NASA					
Terra	Terra	NASA					
Tropical Rainfall Measuring Mis	TRMM	NASA					

Figure 8. Observing System Tab Illustrating Fiscal Year Resources Associated with Several of the 155 Systems in CasaNOSA.

The NOSA technology is represented in the observing systems tab, the instruments tab, and the platform tab. NOAA shares satellite platform technology with DoD, shipboard technology with the U.S. Coast Guard and the Navy, and uses some surplus aircraft technology from DoD. A current listing of all NOAA observing system resources identified by primary Core Mission Area Segment is represented in Figure 9, including the baseline and many approved target systems.

Weather & Water	Ecosystems	Climate
Atmospheric Integrated Research and Monitoring Network (AIRMoN)	Coastal Change Analysis Program (CCAP)	Air Quality-Climate Field Study Package
Wind Profiling Radars UHF	Commercial Fisheries-Dependent Data (FIS)	Precipitation Profiling Radars
Wind Profiling Radars VHF	Coral Reef Ecosystem Integrated Observing System (CREIOS)	Atmospheric Dispersion Measurement System
Airborne Oceanographic Product (AOP)	Economic Data	INEEL Mesoscale Meteorological Network
Automated Surface Observing System (ASOS)	Ecosystems Surveys	Global Energy and Water Cycle Experiment (GEWEX)
Cooperative Agency Profilers (CAP)	Fish Surveys	Integrated Surface Irradiance Study (ISIS)
Coastal Marine Automated Network (CMAN)	Habitat Assessment	Surface Radiation Budget Network (SURFRAD)
Cooperative Observer Program (COOP)	Recreational Fisheries-Dependent Data (MRFSS)	Regional Atmoshperic Measurement and Analytical Network (RAMAN network)
Deep-Ocean Assesment and Reporting Tsunamis (DART)	National Observer Program (NOP)	AEROSOL
Limited Automated Remote Collector (LARC)	National Status and Trends	Carbon Cycle Greenhouse Gases (CCGG)
IN-SITU SENSORS	National Seafloor Observing System (NSOS)	Hydrocarbon and other Atmospheric Trace Species
INTEGRATED SYSTEMS	Passive Accoustics Observing System (PAOOS)	Observatories (OBOPS)
LIDARS	Protected Resources Surveys	Solar Thermal Atmospheric Radiation Surface Measurements (STAR)
RADARS	Real-Time Environmental Coastal Observation Network (RECON)	Stratospheric Water Vapor
RADIOMETERS	Sociocultural Data Collection	Stratospheric Aerosol
Wind Profiling SODARS	National Marine Sanctuary System-wide Monitoring Program (SWIM)	Stratospheric Ozone
Meteorological Data Collection and Reporting System (MDCRS)	National Estuarine Research Reserve System-Wide Monitoring Program (SWMP)	Surface Ozone (SFCOZ)
MOORED BUOY	**Mission Support**	GPS Integrated Precipitable Water Vapor Sensor
NOAA Environmental Real-Time Observing Network	Defense Meteorological Satellite System (DMSP)	Citizen Weather Observer Prog
Next Generation Radar (NEXRAD)	Geostationary Operational Satellite System (GOES) I/M	Tropical Moored Buoys
National Lightning Detection Network (NLDN) NWS Lightning Data	Geostationary Operational Satellite System (GOES) NOP	Arctic Observing System
Airborne Gamma Radiation Snow Survey Program	Geostationary Operational Satellite System (GOES) R	Argo
NOAA Profiler Network (NPN)	Marine Optical Buoy (MOBY)	Drifting Buoys
Upper Air RAWINSONDE Network	National Polar-orbiting Operational Environmental Satellite System (NPOESS)	Ocean Carbon Networks
Pacific Tsunami Warning Center Sea Level Network (PTWC Network)	NPOESS Preparatory Project (NPP)	Ocean Reference Stations (Long Term Evolution of the Coupled Boundary Layers) (Stratus)
Voluntary Observing Ship Program (VOS)	Jason-2 Ocean Surface Topography Mission (OSTM)	Ships of Opportunity
Commerce & Transportation	Polar Orbiting Environmental Satellite (POES)	Tide Gauges (Global Sea Level Network (GSLN))
Continuously Operating Reference Stations (CORS)	AIRCRAFT	Ionosonde
Hydrographic Surveying (HYDRO)	SHIPS	Fisheries Oceanography Coordinated Investigations
National Current Observation Program (NCOP)		Ocean Acoustic Monitoring
National Water Level Observation Network (NWLON)		Tunable Optical Profiler Aerosol and oZone (TOPAZ)
Physical Oceanographic Real-Time System (PORTS)		US Climate Reference Network (USCRN)
Shoreline		

Figure 9. NOAA's FY07 Observing System Architecture.

3.1.4.3 Data Management Systems Resources

Although not a part of this NOSA segment, the observing systems transmit their observed environmental data to a downstream data or information management system where one or more functions are carried out. The data management tab on the CasaNOSA tool contains information about NOAA's data and information management systems; the software applications and models that run on those systems; the products produced by those applications; the networks over which those products flow; and, as with the observing systems, various relevant pieces of information regarding ownership, users, costs, growth, etc. Figure 10 is

a screenshot of the Data Management Systems applications. Information regarding the application's name, language, lines of code, date developed, date last updated, etc., is available.

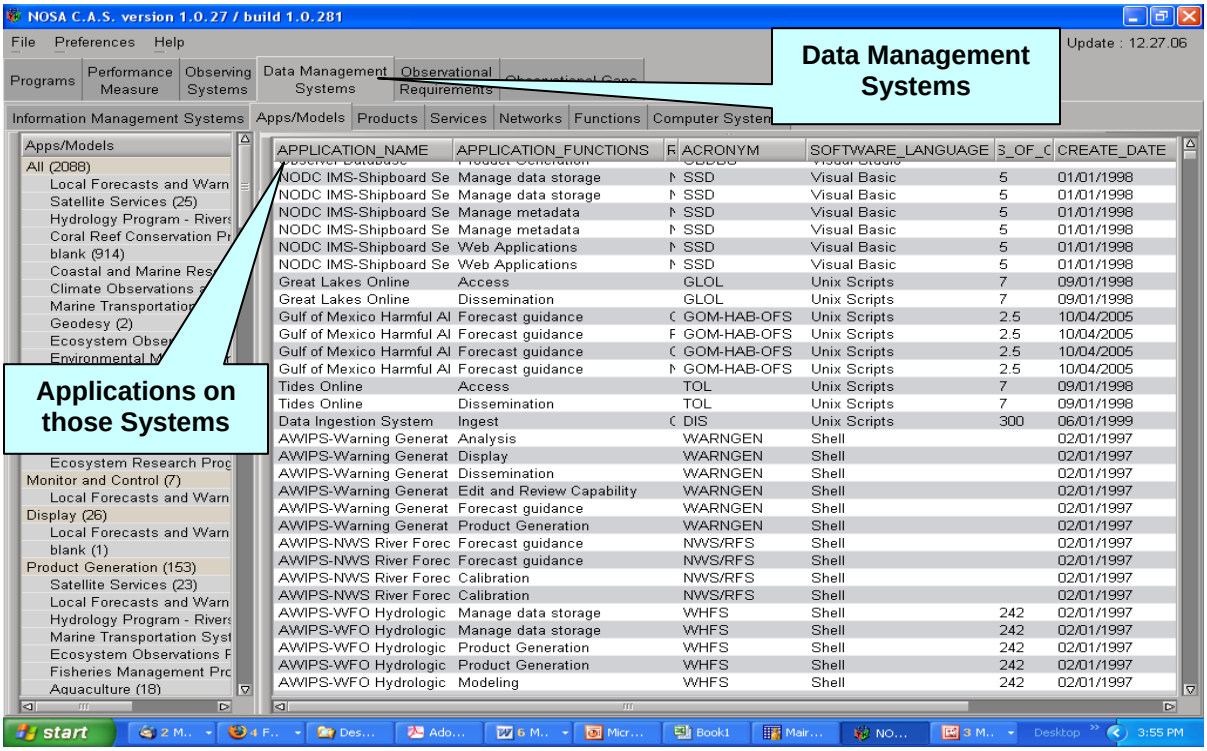


Figure 10. Data Management Systems Applications.

3.1.4.4 Data and Product Architecture and Resource Information

A consistent service provided by NOAA's core mission areas is that of keeping the public informed through the provision of information. The sharing of data through free and open access has been one of NOAA's tenets of since its inception. OMB's Data Reference Model (DRM) 2.0 provides a framework similar to that which NOAA has been using for years. The standardization of data within the areas of data description, data context and data sharing are being followed by NOAA and its international and national partners.

Comprehensive management of data, throughout its life cycle is critical to providing high quality information to all aspects of NOAA's services. As part of the annual update of information on NOAA's observing and data management systems, the NOSC IPT collects a significant amount of information regarding the data transmitted from the observing systems as well as the formats used. Figure 11 is a screenshot of the observing system data characteristics. As shown in the Figure, information regarding data formats, metadata formats, hardcopy or digital output formats, and other data information is available in this tab.

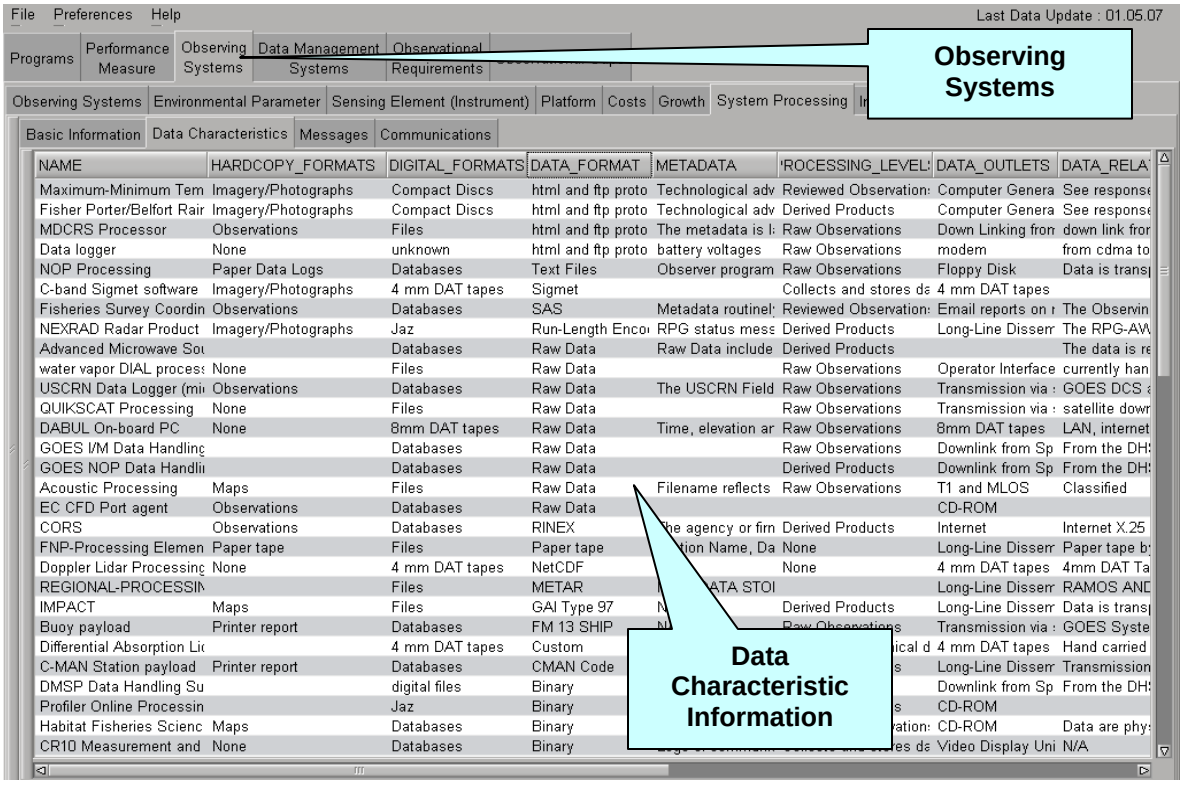


Figure 11. Observing System Data Characteristics.

The data architecture for NOSA has been documented in NOAA's Global Earth Observation Integrated Data Environment (GEO-IDE) Concept of Operations document and the GEO-IDE Implementation Plan. Both of these documents are available at the NOSC website http://nosc.noaa.gov/docs/products.html.

NOAA has been an active leader in several national and international groups, or "communities of interest (COIs)" to establish standards for environmental data observed by the global observing systems. A partial list of some of these COIs follows:

- World Meteorological Organization (WMO) http://www.wmo.ch/
- Committee on Earth Observation Satellites (CEOS) http://www.ceos.org/
- Co-ordination Group for Meteorological Satellites (CGMS) http://www.wmo.ch/pages/prog/sat/CGMS/CGMS_home.html
- Global Change Master Directory (GCMD) http://gcmd.nasa.gov/

As a result of NOAA's work with these COIs, other agencies and countries, there are data description, context and sharing standards in place for international transmission and for use by all members of COIs. Further, to ensure open satellite data exchange, common transmission standards for environmental satellite data are used and agreed to.

The NOSC IPT has recommended the adoption of the GEO-IDE data standards process articulated in the above referenced documents and has recommended the adoption of the following standards.

NOSA IPT Proposed Standards

Version 2.1 – 10/10/06

Discovery-level metadata content standards

All NOAA datasets should be described in sufficient detail that discovery level metadata can be provided in either Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM), ISO 19115 (Geographic Information – Metadata) or Ocean Biogeographic Information System (OBIS) as appropriate, including all mandatory fields. Extensions and additional elements to ISO 19115 proposed by WMO should be included for meteorological data. Any other extensions to ISO 19115 required to characterize NOAA data should be registered with ISO once they have been defined.

Discovery-level keyword lexicon

Beginning with the Global Change Master Directory (GCMD) Parameter Valids, NOAA should agree upon and respect within its service interfaces a standard list of discovery-level keywords that should be used to describe NOAA datasets. Any additional terms needed should be communicated to the GCMD so they can be added to its list of valids.

Discovery-level metadata representation/exchange standard

NOAA data providers and data centers should support the capability to exchange discovery-level metadata in XML compliant with FGDC CSDGM and OBIS as appropriate. It is expected there will be a transition to ISO 19139 over the next few years and centers should adapt as this transition progresses.

Catalogue search protocol specification

NOAA data centers (Data Centers and centers of data) should provide access to their metadata catalogs via a service interface compatible with Geospatial One Stop specifications (currently Z39.50 or OAI-PMH). All data providers in NOAA should also participate in existing discovery mechanisms that are relevant, such as Geospatial One Stop, GCMD for climate, and OBIS for biology.

File transfer protocols

Access to files and Web pages should be provided via FTP and HTTP (This will position NOAA for rapid progress towards a Service-Oriented Architecture [SOA] as standards are adopted and applied.)

Database access methods

All NOAA information management systems that utilize Database Management Systems (DBMS) should support Open Database Connectivity (ODBC) and Java Database Connectivity (JDBC) access to these systems.

API's and Web Services

- OPeNDAP Data Servers should be used to provide access to entire or partial datasets, including aggregations.
- OGC service specifications (Catalog Service for the Web, Web Map Service, Web Feature Service and Web Coverage Service, Simple Features, well-known Text and Binary) should be supported where they are applicable.

Data and Product Format Standards for Delivery

Data/product type	**Recommended Formats**
For publications and text products	
Publications and tables	HTML, PDF
Text products	HTML, ANSI, PDF
For images, charts, graphs, and maps	
Charts, graphs, maps	PNG, PDF, JPEG, GeoTIFF, GML
Images (satellite, radar, etc.)	JPEG, PNG, GeoTIFF, HDF5
For movies, video and animated image loops	
Short/small animations	GIF, JPEG via Java applets
Animations, short image loops	JPEG via Java applets, MPEG4
Movies, long image loops	MPEG4

Note: All standards in the table above are widely-used *de jure* or *de facto* internet standards

For scientific/environmental data	
Tabular data	Delimited ANSI
2-D point/station data (single parameter 2-D or multi parameter 1-D)	Delimited ANSI, netCDF[1,2], HDF5[2], BUFR[3], XML
3-D point/station data, soundings, profiles or time series	netCDF[1,2], HDF5[2], BUFR[3]
Multi-dimensional grids, large arrays	netCDF[1], HDF5[2], GRIB, GeoTIFF(2D only)

1. It is expected there will be a transition to the Common Data Model (netCDF4/HDF5) over the next few years and centers should monitor this activity and adapt as it matures.
2. Standard conventions (i.e. metadata and parameter vocabularies) are required (e.g. Unidata CF).
3. BUFR recommended for meteorological data only.

The above standards cover all aspects of OMB's DRM standardization areas as shown in Figure 12. The goal of all of NOAA's data architecture initiatives is to uniformly describe the data artifacts, resulting in increased opportunities for cross-agency and cross-COI data sharing.

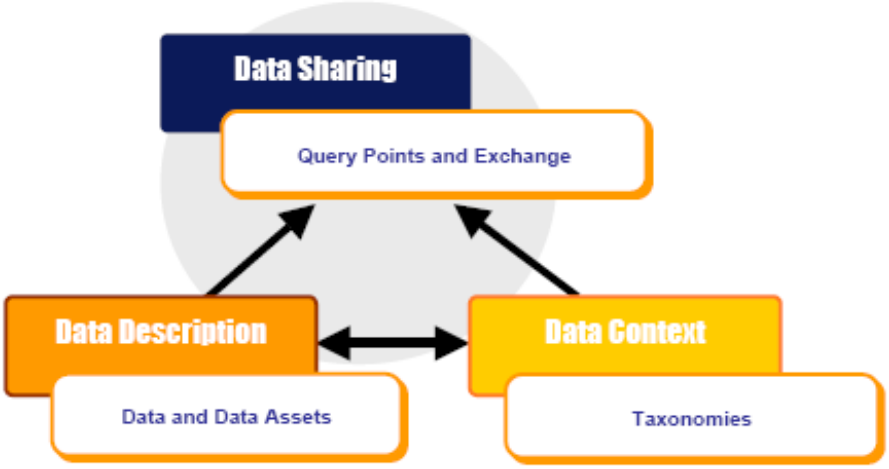


Figure 12. Data Reference Model Standardization Areas

All NOAA data and products go through a similar series of steps between observation, transmission, processing, archiving, and use. The actual divisions in this flow can be defined in many ways. Not all steps may be followed in any particular application, and, in many cases, one or more of the steps will be invisible to a user. The overall chain of events, however, is universal and is represented in Figure 13 below. To improve integration among these steps, standards are needed in two areas:

1) Data/product representation (format) standards
2) Comprehensive metadata and documentation content standards

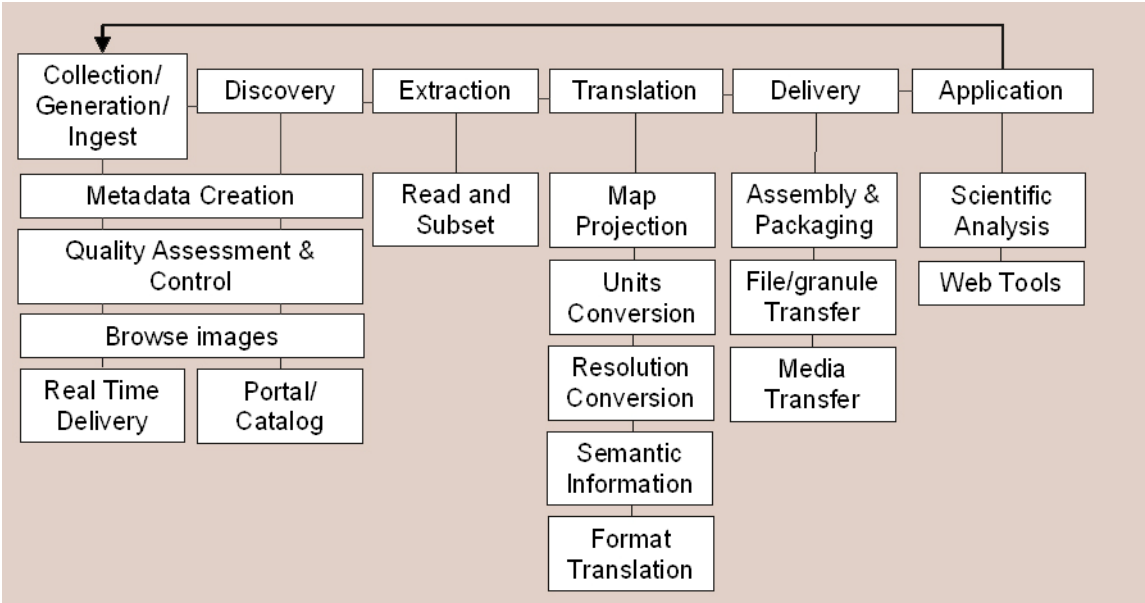


Figure 13. Stages in Data Observation, Discovery, Access, and Use.

The continued review of data needs and architecture improvement is under the purview of the NOSC IPT. The NOSC IPT has placed significant importance on this effort and has formed a subcommittee, the Data Management Committee (DMC), to oversee all data management activities. The two GEO-IDE documents referenced above were created by the DMC. The DMC has its own Terms of Reference and meets monthly.

3.1.4.5 Performance Information and Architecture

On a monthly and quarterly basis, NOAA reports its performance measure information which can be analyzed using the CAS tool. The performance measure tab of CAS contains those measures added by the NOAA programs during the PPBES annual Program Operating Plan (POP) update cycle. POPs are explained within the NOAA EA document. NOAA programs are required to keep their Government Performance Review Act (GPRA) measures updated as per OMB and Program Assessment Rating Tool (PART) requirements.

Figure 14 is a typical CasaNOSA Analysis Tool screenshot of the performance measure information. The three pie charts illustrate the PART state, the type or level, and how well the business unit (NOAA program) is doing in meeting its target performance architecture.

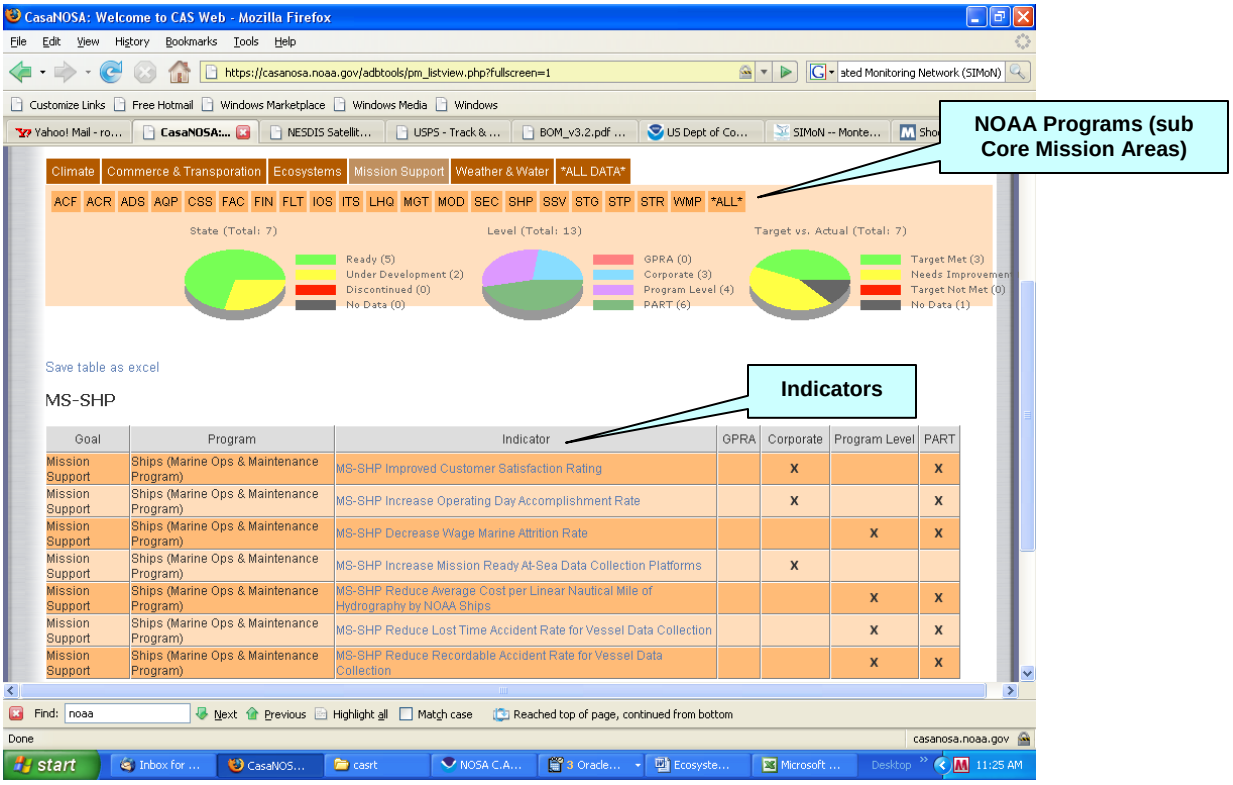


Figure 14. CasaNOSA Analysis Tool Screenshot of Mission Support Goal's Performance Measures.

In addition to this presentation, a user has the option to click on one of the measures and a Trend Analysis with other data will be displayed comparing target performance goals to actual performance. Figure 15 is an example of this trend analysis.

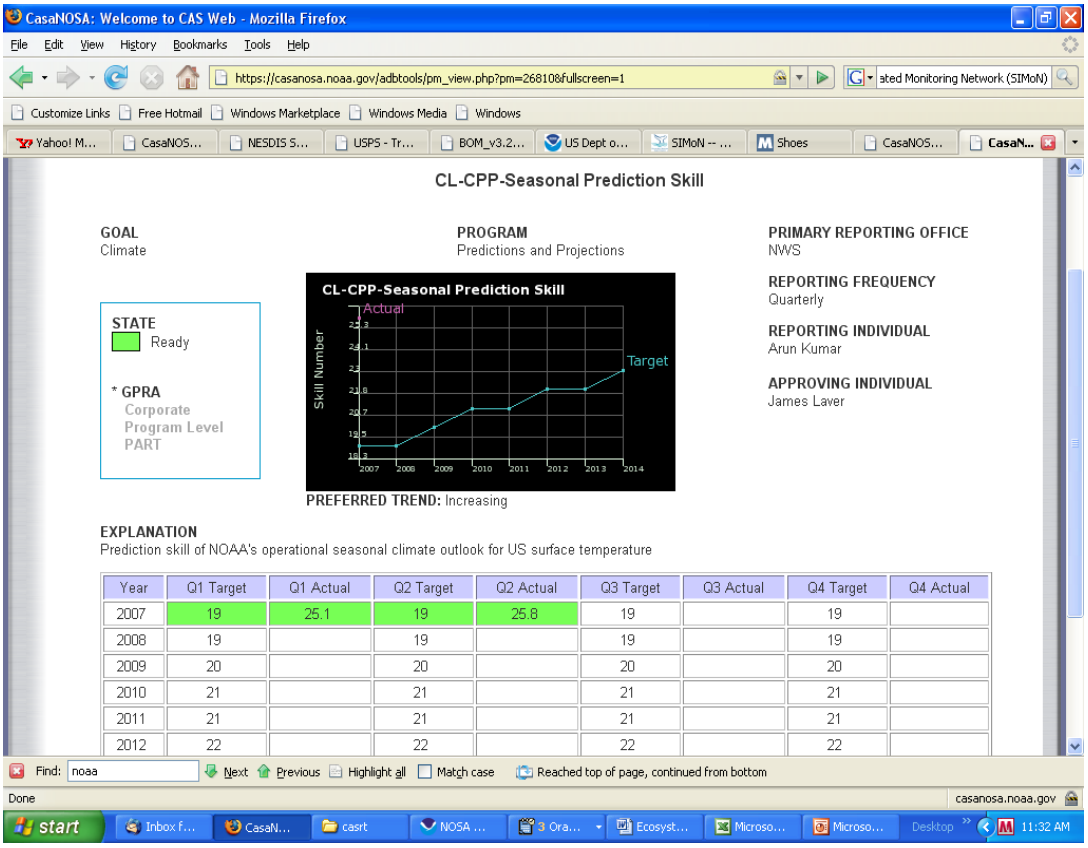


Figure 15. Trend Target and Actual GPRA Performance Measure.

3.1.4.6 Data Collection and Update Cycle Methodology

In order to collect all of the information necessary to populate the database and to keep the information up to date, NOAA requires annual updates of the information as well as updates when significant changes are made. The annual data calls for technology updates are made between February and March and the business updates follow between May and June. Data collected during these periods cover all components of the OMB reference models: performance, business, data, services, and technology. The goal is to collect information in sufficient detail to support the identification of performance improvement opportunities, such as improved service to citizens, improved mission performance, cost savings/avoidance, technology standardization, and improved management and use of the information.

3.1.4.7 Typical Business Query of the Enterprise Database

Figure 16 illustrates a CasaNOSA Analysis Tool query from a core mission area segment owner. The business question from the Marine Weather program is: What are the impacts of the loss of the National Data Buoy Center (NDBC) Moored Buoy observing system on the Marine

Weather program? As shown in Figure 16, the Marine Weather program needs the NDBC Moored Buoy observing system measurements of the indicated wave parameter that affect the Marine Weather Government Performance and Results Act (GPRA) performance measure of "accurate wave height forecasts."

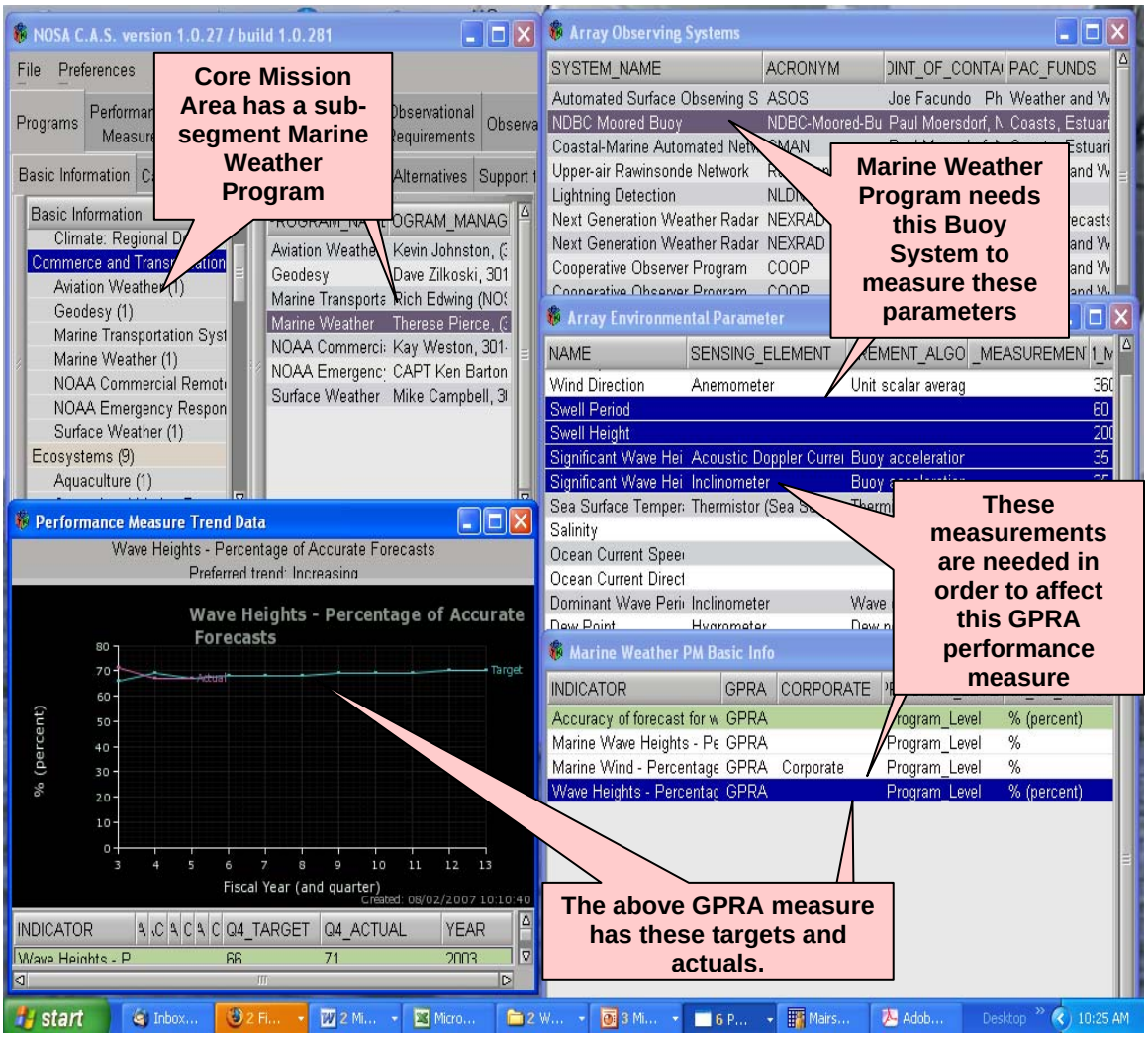


Figure 16. Typical Business Question Query Using CAS Tool.

3.1.5 What are the deficiencies or inhibitors to success with the segment?

One of the first goals of the NOSC IPT is to validate the observational requirements against the performance outcome of the business unit or Core Mission Area Segment owners. Throughout the year the NOSC IPT reviews the baseline architecture capabilities and compares those capabilities against changing observational requirements. Fundamental to the success of any architecture is the degree to which it satisfies the users' needs or requirements. The NOSC IPT has developed a requirements verification and validation process that relies on quantifying techniques to validate requirements.

As part of the NOAA EA database toolset, the NOSC IPT has developed the capability to directly compare observational capabilities against core mission area requirements and measure the size of the gap as well as its priority. The tool used for this analysis, the CasaNOSA Analysis System Requirements Tool (CASRT), has an algorithm that calculates the "relative gap assessed" (RGA) between the requirement and each observing system that measures the required parameter. To determine where best to make investments in observing systems, one needs to determine where the largest and most important observational gaps are located. By matching up NOAA's observational requirements with NOAA and non-NOAA observing systems observational capabilities, one can determine the gaps in our ability to meet those requirements.

The CASRT tool (Figure 17) compares each program's observational requirement (e.g., Ocean Surface Wind Speed) with all of the observing systems capable of measuring ocean surface vector winds. In the Figure, the comparison is made using five attributes: geographic coverage, vertical resolution, horizontal resolution, accuracy, and frequency of coverage. Each observing system's capability is compared with the requirement using these five attributes.

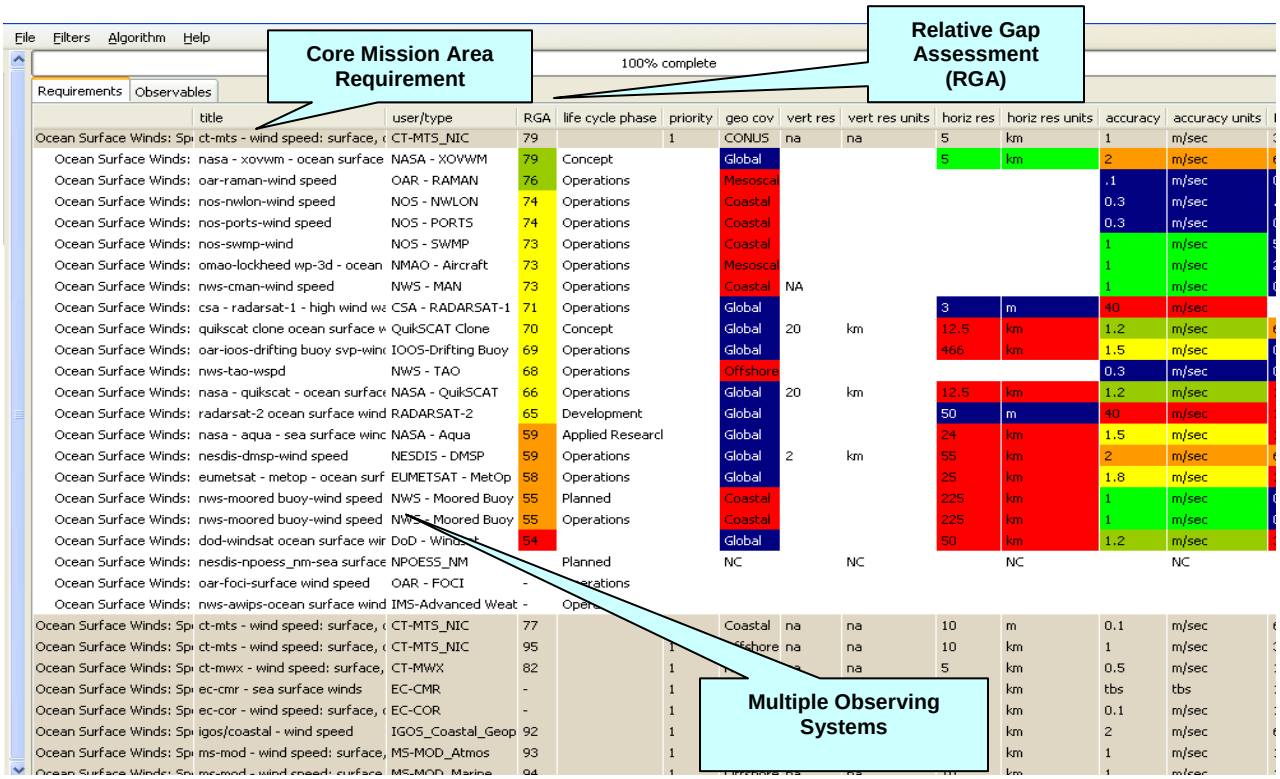


Figure 17. Comparison of Observational Capabilities and Observational Requirements.

Depending on the resulting value (the percentage difference between the capability and the requirement), a color code is assigned: red, yellow, or green. The color code algorithm currently used for horizontal resolution, vertical resolution, accuracy, and frequency is based on the following:

- If the observing system's capability meets or exceeds the requirement, it is colored green.
- If the observing system's capability is between 80%-100% of the requirement, it is colored yellow.
- If the observing system's capability is less than 80% of the requirement, it is colored red.

The observational gap, or RGA value, for each capability is the weighted average of the above values for each available parameter on a scale of 0 to 100 (At present, the weight for each parameter is 1.)

- If the RGA value is less than 90, the observing system does not meet the requirement.

The NOAA Core Mission Area Goals and programs also set priorities based on individual observational requirements, so a prioritized list of the gaps is easily made. Using this listing, the NOSC IPT is able to assess the highest priority mission deficiencies and begin an analysis of alternatives to fill those high priority gaps.

National imperatives for agencies like NOAA can and have led to an imbalance between many valid requirements and the limited resources needed to satisfy them. In addition, NOAA's cutting edge technological needs have also created significant technical gaps. For instance, the ability to remotely sense many ocean parameters is currently not possible. Ocean carbon, which is important to understanding global climate change, is impossible to measure from a remote platform and salinity also poses a significant challenge to measure globally.

3.1.6 What is the vision for the segment?

3.1.6.1 Integrated Conceptual Diagram of NOSA Segment

Figure 18 shows NOAA's high level target architecture. The architecture's goal to integrate observing systems within the five domains, Space-based, Air-based, Land-based, Ocean-based, and Cryosphere-based, is shown in the upper layer of the Figure.

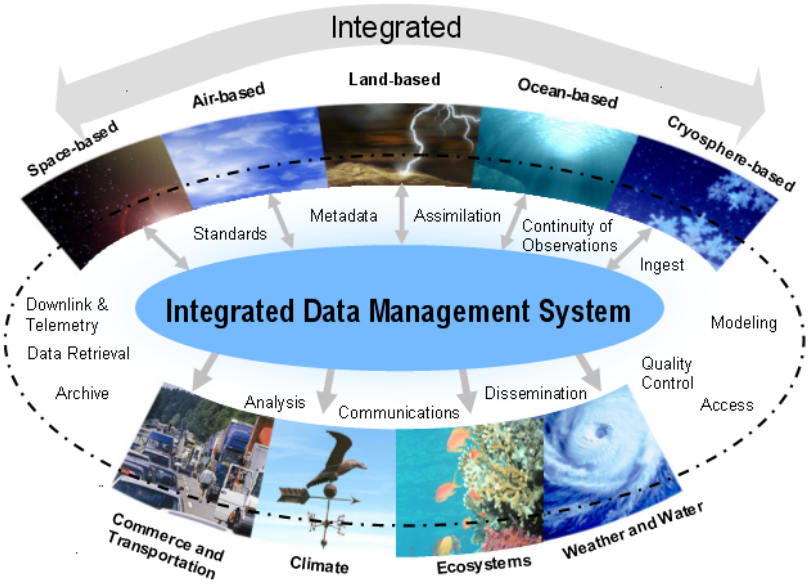


Figure 18. NOAA Approved Target Architecture Conceptual Diagram (OV-1).

3.1.6.2 NOSA Segment Summary Vision

NOAA's current observing system architecture is composed of many different systems covering a wide range of critical environmental information needs. Many of these observing systems were built for a single purpose and consist of limited numbers of sensors connected to different networks using a variety of data formats and dissemination methods. To meet today's ever-growing needs, we must conduct our business using efficient methods. Because the population of the world, currently six billion people, is expected to double over the next 50 years, it is critical that we improve our limited understanding of the complex and interconnected systems of our planet. Understanding our environment and being able to accurately forecast conditions and outcomes both in the near- and long-term will support sustainable economic development and the wise use of the Nation's limited natural resources.

The benefits of integrated systems at the five domains will be enormous. Global coverage of all of the Earth's many subsystems will become, for the first time, a reality.

A VISION For a Target Architecture
Resources can be applied in a more efficient and effective manner to reduce duplication in today's observing systems, improve coverage, and provide networks to disseminate information and knowledge where and when it is needed around the world.

3.2 FEA Step #2 Architectural Definition (NOAA PPBES Programming Step)

Using the Target Architecture Vision, the NOSC IPT has established a deliberate proactive process. This process provides continuous reviews of performance goals necessary to accomplish the core mission areas' expected outcomes; further refines the Target Architecture Vision; and plans the transition strategies necessary to accomplish the vision.

3.2.1 What are the performance goals for the segment?

During the PPBES Programming phase of NOAA's process, each core mission goal lead prepares a five-year plan that includes the target performance metrics necessary for that goal area to accomplish its mission. These plans provide a very detailed roadmap of how the core mission area will structure its plan over the next five years. Plans also contain resource needs and performance targets needed to fully achieve the expected performance outcomes. One component of the plan is called a "Quad Chart" (Figure 19). These charts depict on one page what is necessary for the goal to achieve a specific performance improvement.

GPS-Meteorology (GPS-Met)

PROGRAM ADJUSTMENT

- GOAL: Weather and Water
- PROGRAM: Science, Technology & Infusion, Local Forecasts&Warnings
- CAPABILITY: WWS-OBV R&D&A for Observations; LFW-Observe the Atmosphere
- W&W THEMES: High Impact Events (HIE); Drought & Water Resources
- REQUIREMENT: FY08 PDM—Participate in developing plan for NOAA's Integrated Upper-Air Observing System (GPS-Met integral part of plan). OAR ranks as a high priority transition project.
- DESCRIPTION OF ADJUSTMENT: Transitions GPS-Met from OAR to NWS operations and provides O&M funds for GSP-Met to improve severe weather forecasting and provide an accurate climate record.
- PERFORMANCE MEASURES: Increase number of GPS-Met stations annually; Increase number of products/assessments developed from the GPS-Met data to improve precipitation forecasting.

FUNDING

(FY$ M):	FY'08	FY'09	FY'10	FY'11	FY'12	FY'13
Current Program-WW-WWS	0.00	0.80	0.80	0.60	0.50	0.50
Current Program-WW-LFW	0.00	0.00	0.00	0.00	0.00	0.00
Program Adjustment-WW-WWS	0.00	1.00	0.50	0.00	0.00	0.00
Program Adjustment-WW-LFW	0.00	1.10	1.02	0.78	0.79	0.79
Proposed Program	0.00	2.90	2.32	1.38	1.29	1.29
Input Capacity Change	FY'08	FY'09	FY'10	FY'11	FY'12	FY'13
Comp. (+$M)	0.00	2.10	1.52	0.78	0.79	0.79
Output Capacity Change	FY'08	FY'09	FY'10	FY'11	FY'12	FY'13
GPS-Met Stations	350	500	637	707	777	847
GPS-Met Integrated Precip Water observations per year	5M	7M	11.2M	12.4M	13.6M	14.6M

BENEFITS AND RISKS

Benefits

- Reduces 3-hr relative humidity forecast error by 8-10% improving short term precip forecasting for high impact weather
- Cal/Val corrections for geostationary and polar satellite precip measurements using ground and space-based observations.
- Accurate long-term climate statistics based on GPS observables.
- Receive GPS-Met observations offshore from a variety of platforms including ships, buoys, and oil rigs.
- Expand GPS-Met coverage over North America in collaboration with Canada, Mexico, Central America, Greenland, Iceland
- Plan worldwide IPW coverage by merging AMSU PW (offshore) and international GPS-Met IPW (on-shore).

Risks

- Lack of FY07-08 funding puts GPS-Met R&D and transition preparation on hold.

ACTIVITIES, SCHEDULE & MILESTONES

Activities

- Maintain GPS-Met data acquisition and processing system on a best-effort basis due to lack of funding in FY07 and FY08.
- Advance GPS-met techniques, network and applications.
- Develop NWS OSIP documents for Gate 2 approval

Schedule

- FY09-10: Transition GPS-Met operational system from OAR to NWS operations.
- FY11-13: Expand GPS-Met coverage over North America in collaboration with surrounding regions
- FY09-10: Develop HMT-West tools and implement results
- FY11-13: Develop HMT-East tools and implement results

Milestones

- Complete GPS-Met research to operations by end of FY10
- Complete GPS-Met network of 847 stations by end of FY13

Figure 19. NOAA Quad Chart on GPS-Met.

The NOSC IPT works with the goal leads to develop these Quad Charts for observing system investments. In this GPS-Met example the business owner strongly believes additional observing platforms are needed to meet the goal performance target for precipitation forecast accuracy and timeliness. The NOSC IPT and the goal lead have analyzed several alternative systems and configurations to meet this need and have constructed this "Need Quad."

3.2.2 What are the design alternatives for achieving the performance goals?

The NOSC uses several methods to evaluate or analyze possible observing alternatives to achieving a particular performance goal. These techniques are discussed in the following sections.

3.2.2.1 Program Operating Plan (POP) Alternatives

NOAA's annual planning cycle requires that the business owners reevaluate their requirements against any change drivers; identify and prioritize gaps in their capabilities to achieve their expected outcomes; and offer alternatives to meet those gaps. The NOSC IPT evaluates all of the observing alternatives for architectural compliance and opportunities for integration and then develops investment recommendations for the NOSC to forward to senior NOAA management. An example of a POP alternative write-up submitted by the Climate Core Mission Area Segment during the FY09-13 planning cycle of the PPBES is provided in Figure 20.

Alternative - CL-COA Abrupt Climate Change	Attached Documents [0]
Alternative Type:	Program Increases
Alternative Description:	Monitoring rapid climate changes and surprises in the Arctic and North Atlantic regions will be a high priority due to the potentially catastrophic impacts. Rapid changes are defined as those that occur faster than human or natural systems can adapt or where changes occur more abruptly than the rate of the forcings attributed to the changes. Partnering with the Ecosystem Goal and CLE programs, COA will jointly increase the monitoring of sea ice conditions. COA's strategy includes new reconstructions of Arctic change and variability extending back at least 2,000 years, a highly collaborative effort between NOAA and NSF scientists. Detecting rapid change includes a partnership with European nations to establish real-time monitoring at a few strategic locations for major changes in the N.A. Ocean's heat transport patterns across the entire basin. Models indicate that slowing of the Atlantic circulation from the Arctic to the Tropics will have epic impacts on the Earth's climate.
Background:	Future climate change (due to both natural variability and human influences) may occur so rapidly that it will be difficult for societies and ecosystems to respond. Abrupt climate change can be defined either mechanistically or impacts-based. Mechanistically this would relate to a transition of the climate system into a different state (of temperature and rainfall and other aspects), on a time scale that is faster than the change in the cause. An impacts-based definition would reflect changes in the climate system that is faster than the adaptation time of social- and/or ecosystems (perhaps a few years to a few decades).
Priority:	3
Option - CL-COA Monitor Arctic and North Atlantic	Attached Documents [0]
Option Description:	a. Ocean Observing System: Implement a monitoring capability in the North Atlantic Ocean at selected locations, based on a directed OSE study, to detect changes in circulation patterns between the Arctic and the Tropics that could be used to anticipate a possible rapid climate change. b. Arctic Observations: Accelerate implementation of sea ice & mass balance observations networks. Increase emphasis on the NOAA component of Arctic Ocean sea ice and mass balance observing networks. Partnership between COA-Arctic, CLE, and Ecosystems Goal programs on monitoring to make the best use of limited funds for Arctic Ocean observations. Enhance observations of sea ice thickness and mass balance measurements to complement satellite-based data on sea ice extent and better detect ecosystem and ocean productivity in response to physical changes in the Arctic Ocean environment. c. Paleoclimate reconstructions and related data: Using a combination of paleoclimate data focus on the development of time series with high enough resolution to capture abrupt changes (annual or better) in a variety of temperature or precipitation related indicators. Work with NSF paleoclimate program to secure all federally funded PI data is archived and made available for abrupt climate change and other analyses. This should include adequate metadata, data ontologies, and pertinent information for use by other researchers.
	Provides improved quantitative early warning of observed real changes that could signal potential abrupt climate change, and thus reduce the chance of an otherwise unanticipated or undetected surprise. Accelerate completion of two sub-systems (sea ice and mass balance), part of the larger Arctic Ocean Observing Systems and contributes to completing the larger Global Integrated Ocean Observing System. Increased monitoring of the rate and type of

Figure 20. An Example of a POP Alternative Write-up.

3.2.2.2 Partnership Alternatives

NOAA actively seeks to build on both international and domestic partnerships to achieve its performance goals with less overall cost to the Nation. For example, NOAA negotiated an agreement with the European

Union's EUMETSAT (NOAA European equivalent) that reduces NOAA's polar-orbiting satellite requirement by one-half. NOAA's business owners have a requirement for global coverage every six hours, which requires two satellites in orbit. Because of this partnership, EUMETSAT shares responsibility with NOAA—each organization operating and funding one satellite. This significantly reduces NOAA's observing system costs. Each polar-orbiting satellite can cost in the hundreds of millions of dollars.

Another partnership exists within the U.S. Integrated Ocean Observing System. Several U.S. Agencies, such as NOAA, the U.S. Navy, and the Coast Guard, have ocean observation requirements. In the past there has been considerable data sharing, but typically the observing systems that collect the data were not shared. Over the past five years, NOAA and its partner agencies have developed an agreement to share future observing system investments, thereby reducing overlap and eliminating unnecessary duplication where possible.

Other partnerships have been established with the U.S. citizens who have volunteered their time to make daily temperature and precipitation observations across the United States. The Nation has over 10,000 citizens who make these observations every day. In addition, NOAA has recently begun exploring other partnerships with volunteer groups forming across the country commonly called "MesoNets."

3.2.2.3 Investment Analysis (IA) Alternatives

One of the tools the NOSC IPT uses to evaluate alternatives exploits the Consolidated Observational Requirements Listing (CORL) and observational systems (NOSA) information collected during the annual EA process. The Portfolio Analysis Machine (PALMA™) tool allows the NOSC IPT to provide informed recommendations on observing system investment decisions and to provide the highest priority information to the NOAA Core Mission Areas. The NOSC IPT approved a NOAA-wide portfolio analysis based on a NOAA-wide "value tree." This tree elucidates the relative importance of over 800 mission-critical observing requirements and Core Mission Area programs' evaluations of requirement satisfaction by current or possible future systems.

NOAA Value Tree

Breakout of Climate Goal,
Climate Observations and Analysis - Oceans (COA-Oceans) Program

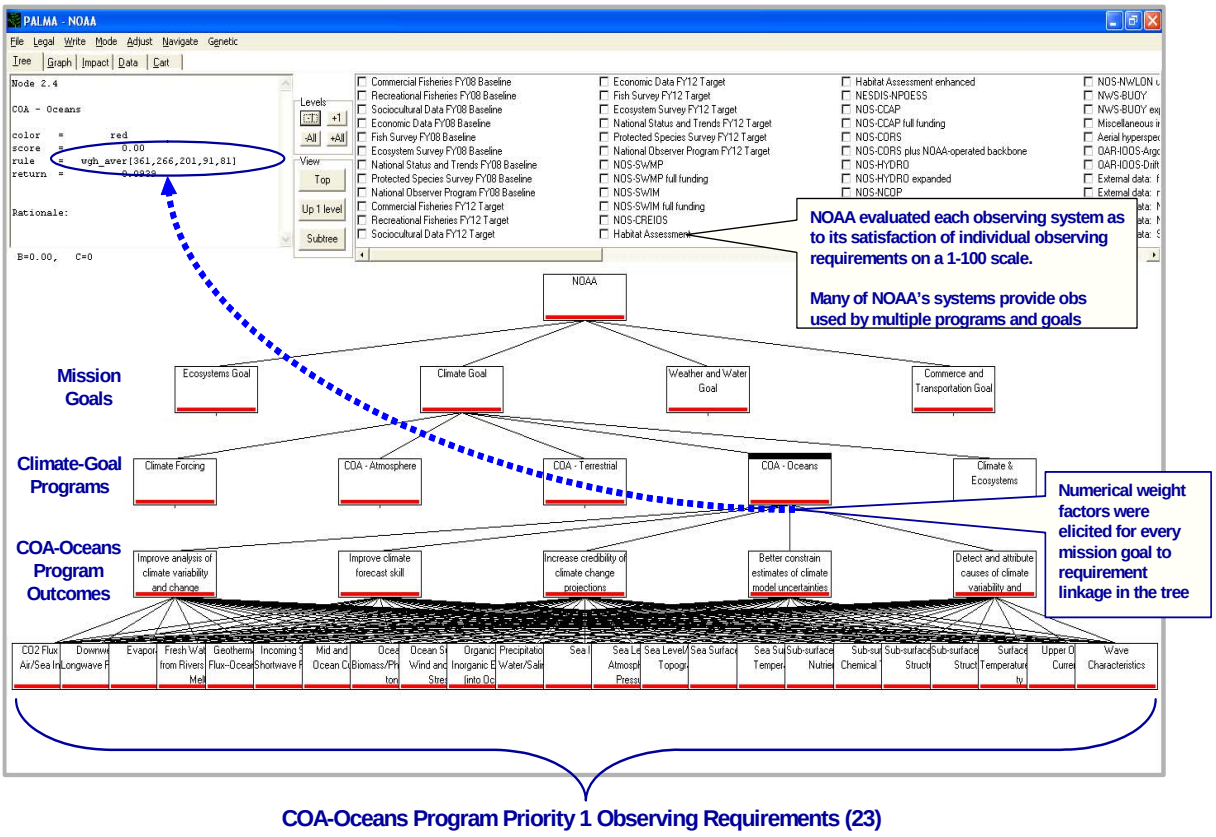


Figure 21. PALMA™ Value Tree for the Climate Core Mission Area Program, Observations, and Analysis.

The result of this analysis is a set of alternatives along what is called the *efficient frontier* as seen in Figure 22. Each point on the efficient frontier curve represents a different combination or portfolio of current or potential future observing systems that provides the highest overall satisfaction of NOAA's prioritized requirements at different budget constraints (X axis). NOAA's approximate planned expenditure for observing (excluding GOES-R) in FY08 is represented by the dashed blue line.

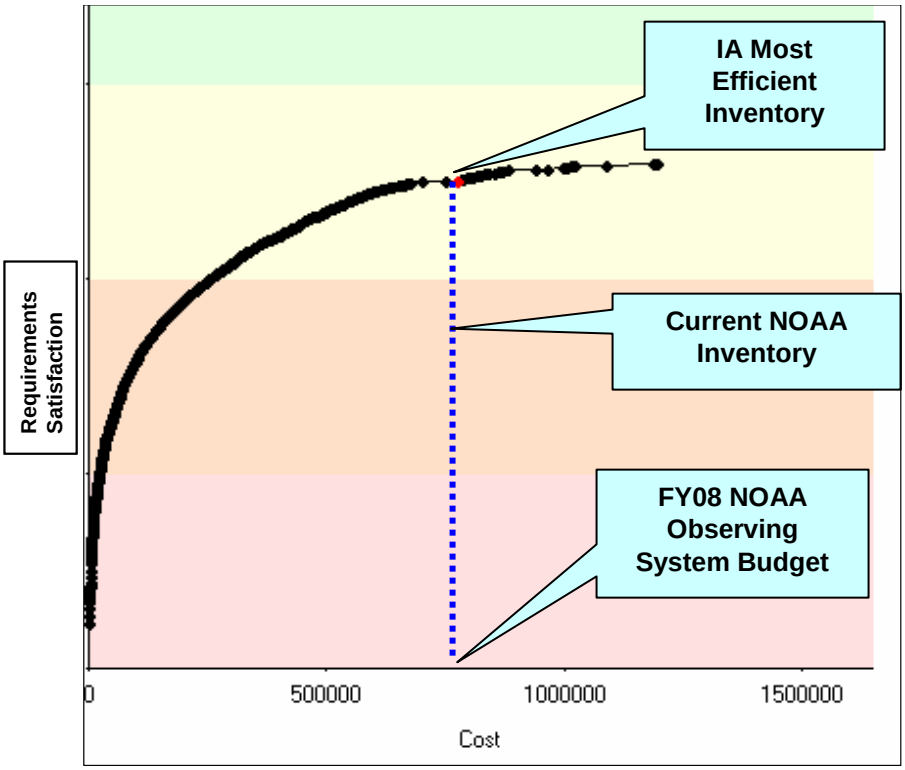


Figure 22. FY08 NOAA Efficient Frontier.

The red dot on the curve thus represents the mix of systems that best satisfies NOAA's requirements, given the data and portfolio analysis assumptions. The "Current Inventory Point" is the level of requirements satisfaction of NOAA's baseline observing system inventory. The total satisfaction score (Y axis) understates total satisfaction of NOAA requirements because the NOAA portfolio model in its current implementation does not reflect the contributions of multiple systems to individual requirements. The portfolio analysis tool can also model additive interactions between systems, subject to the availability of data on the type and extent of these interactions. Also, many of NOAA's requirements are stringent and cannot be satisfied by any combination of current, planned, or proposed systems.

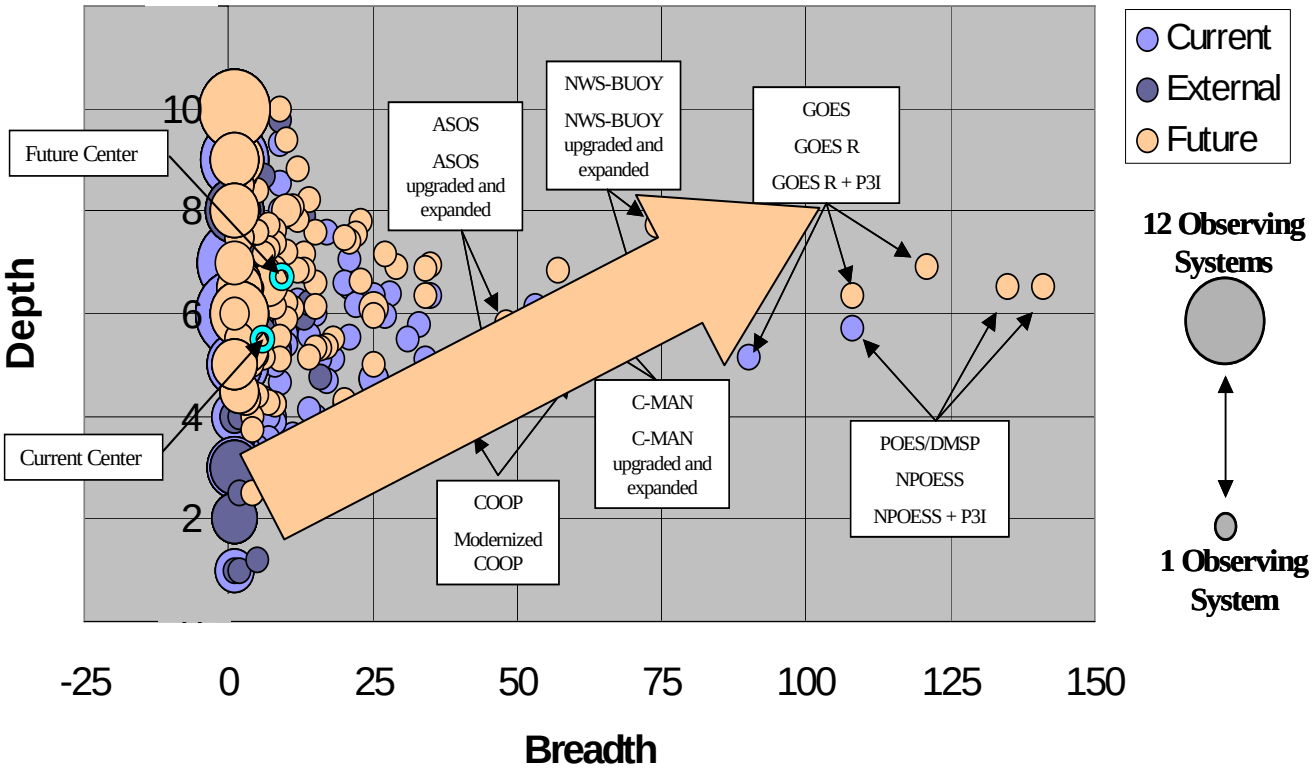
The NOSC has made a number of recommendations over the past three budget cycles to NOAA's Program Analysis and Evaluation (PA&E) group based on this analysis. For example, data from the Investment Analysis (IA) on the relative importance of different observing requirements was used to evaluate options for restructuring the GOES-R satellite acquisition.

3.2.2.4 Breadth and Depth Alternative Analysis

The Breadth and Depth Alternative Analysis investigates the breadth and depth of NOAA's observing systems to support the development of strategic observing investment recommendations. The breadth value for an observing system represents the number of Priority-1 observational requirements that the observing system measures. The depth value of the observing system represents the average contribution made by the observing system toward meeting one or more Priority-1 requirements. A depth value of ten indicates an extremely valuable contribution; a depth value of one indicates a negligible contribution.

Figure 23 displays the breadth and depth of current, future, and external observing systems either used or proposed by NOAA. The Figure depicts specific results from the analysis, including expansions to current systems (for instance, adding more buoys to the National Weather Service-Buoy System) and upgrades to current systems (for instance, adding the ability to measure a new environmental parameter that is not measured by the current system) that can contribute to increased depth and/or breadth. The size of each bubble indicates the number of observing systems within each particular breadth/depth pairing. Current systems appear in light blue; future systems are in tan. External systems, indicated in dark blue, are non-NOAA systems that contribute to meeting NOAA observation requirements. The large arrow depicts the direction in which NOAA wants to move—owning, operating, and/or funding integrated observing systems that have maximum depth and breadth values.

Figure 23. Breadth and Depth of NOAA's Observing Systems.



The preponderance of systems, both current and future, is located on the left side of the chart. Systems that have very high depths tend to have low breadths—they are special purpose systems. Most of NOAA's current and future observing systems measure fewer than 15 environmental parameters. The chart also shows that there are relatively few systems with high breadth scores and those observing systems tend to have lower than average depths. The high-breadth systems called out in the chart include NOAA satellites, the NWS-Buoy system, and the Cooperative Observing Program. GOES-R, for example, has a higher breadth score and a higher depth score than the current GOES, since it will measure parameters that the current GOES systems do not; it will also do a better job measuring parameters. GOES-R with the enhanced Planned Program Product Improvement (P3I) observing capability has even higher breadth and depth scores than GOES-R without the P3I.

The indicated centers for the current and the future observing systems correspond to the average of the breadth and depth scores of all NOAA observing systems. If NOAA fields the future systems, the average breadth and depth score will increase; on average, future observing systems will measure more environmental parameters and do a better job measuring those environmental parameters.

3.2.2.5. Overall Observing System Portfolio Analysis.

In the previous sections we have explained the various analytical components that go into the NOSC IPT alternative analysis process. In this section we will explain how all those components fit together to yield the final prioritized, recommended alternatives listing. The NOSC IPT follows a structured 'waterfall type' process (Figure 24) to capture and prioritize observational requirements, analyze observational gaps, and generate solutions or solutions sets.

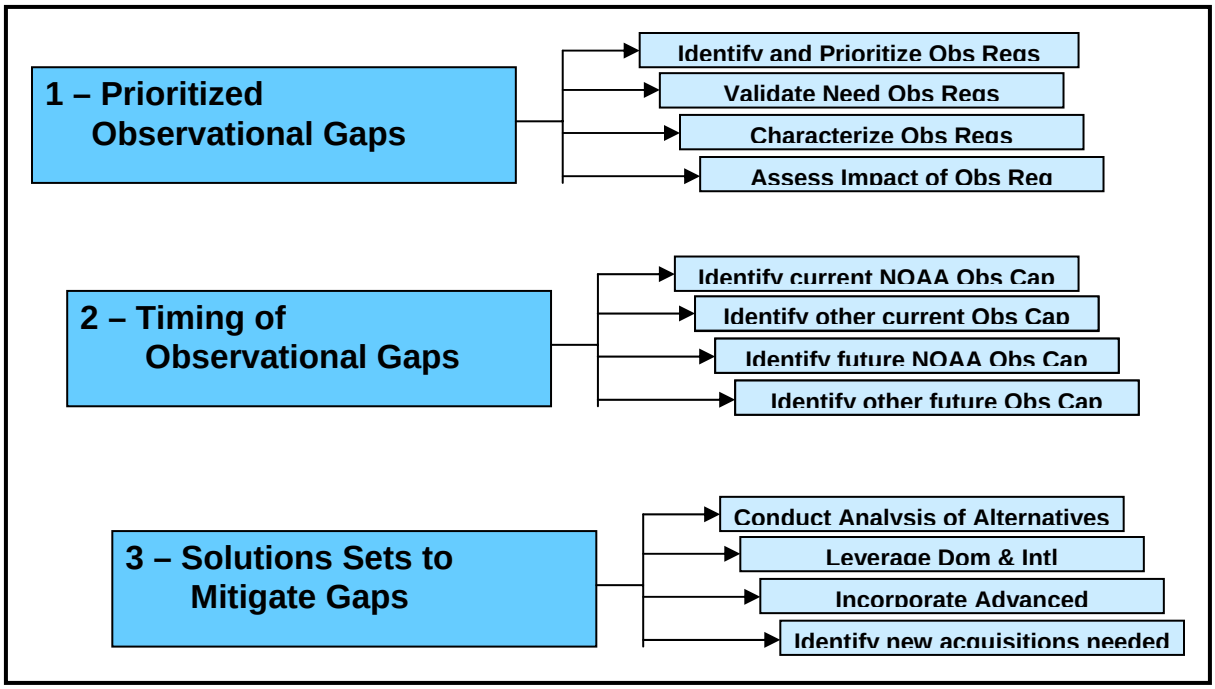


Figure 24. The NOSC IPT 'Waterfall Type' Process.

The NOSC IPT maintained Consolidated Observational Requirements List (CORL) database identifies observations needed for NOAA sub-segment programs to accomplish their missions across the domains of space, the atmosphere, land, and oceans, irrespective of possible observing system solutions. This database is the foundation for the development of NOAA's Integrated Observing System Architecture, and helps focus observing system acquisition, research and technology initiatives on high-priority user requirements.

A key component of NOSC IPT's quantitative, repeatable and traceable decision analysis capability are methods for evaluating the relative importance or contribution of NOAA organizational components and observing requirements to NOAA's mission performance as described in Section 3.2.2.3. These evaluations are necessary in order to quantify the relative utility of alternative investments, and to provide a quantitative basis for decisions aimed at improving the overall cost-effectiveness of NOAA's observing architecture. The IPT uses two complementary methods to arrive at these values (also called requirement weights); a mission-to-requirement value tree, and the Analytic Hierarchy Process/Pair-wise comparison method for estimating the weights for each link in the value tree shown in previous section (Figure 21).

As part of the analysis toolset, the NOSC IPT has also developed the capability to directly compare observational capabilities captured in the NOSA database against observational requirements captured in the

CORL and measure the gaps between capabilities and requirements. The resulting relative gap assessment (RGA) scores are also a measure of the performance of observation capabilities (both internal and external to NOAA). The CasaNOSA Analysis Requirements Tool (CASRT) is the tool developed for this analysis. To determine where best to make investments in observing systems, one needs to determine where the largest and most important observational gaps are located. By matching up NOAA's observational requirements with NOAA and non-NOAA observing systems observational capabilities (current, future and conceptual) and combining these RGA scores with the requirement weights generated from the value tree/pair-wise comparison process, one can determine gaps in our ability to meet those requirements, the extent to which different observing system options (both current and proposed) can fill these gaps, and the relative utility to NOAA of each observing alternative.

A screenshot of CASRT (Figure 25) shows several NOAA programs' observational requirement (e.g., water vapor profiles as tan rows) with all of the observing systems (white rows) capable of measuring water vapor profiles. A comparison is made using five attributes: geographic coverage, vertical resolution, horizontal resolution, accuracy, and frequency of coverage and a numeric value is calculated for each attribute pair. The performance of each observing system is calculated with respect to each attribute, these calculations are mapped to a utility curve, and the individual utility values are averaged to yield the 'relative gap assessment' (RGA) score.

RGA scores for each observing system capability are on a scale of 0-100 where 90 represents full satisfaction of the threshold CORL requirement. Scores that are less than 90 indicate that a gap exists between the system capability and the requirement. Depending on the resulting value, a color code is assigned: red, orange, yellow, green (full satisfaction) and blue (exceeds threshold requirement).

These RGA scores are used to calculate NOAA-wide utility scores for each alternative by first identifying a best operational observing capability that is expected to be available during the service period of the alternative in question. If a best operational capability exists, the difference between that RGA score and the subject alternative's RGA score is calculated and these differential (or incremental) utilities are summed across all of the requirements for which there is a positive incremental value and a requirement weight is available. In some cases, there is no expectation of continuity of capability absent the alternative, and the alternative receives the full value of its RGA score(s).

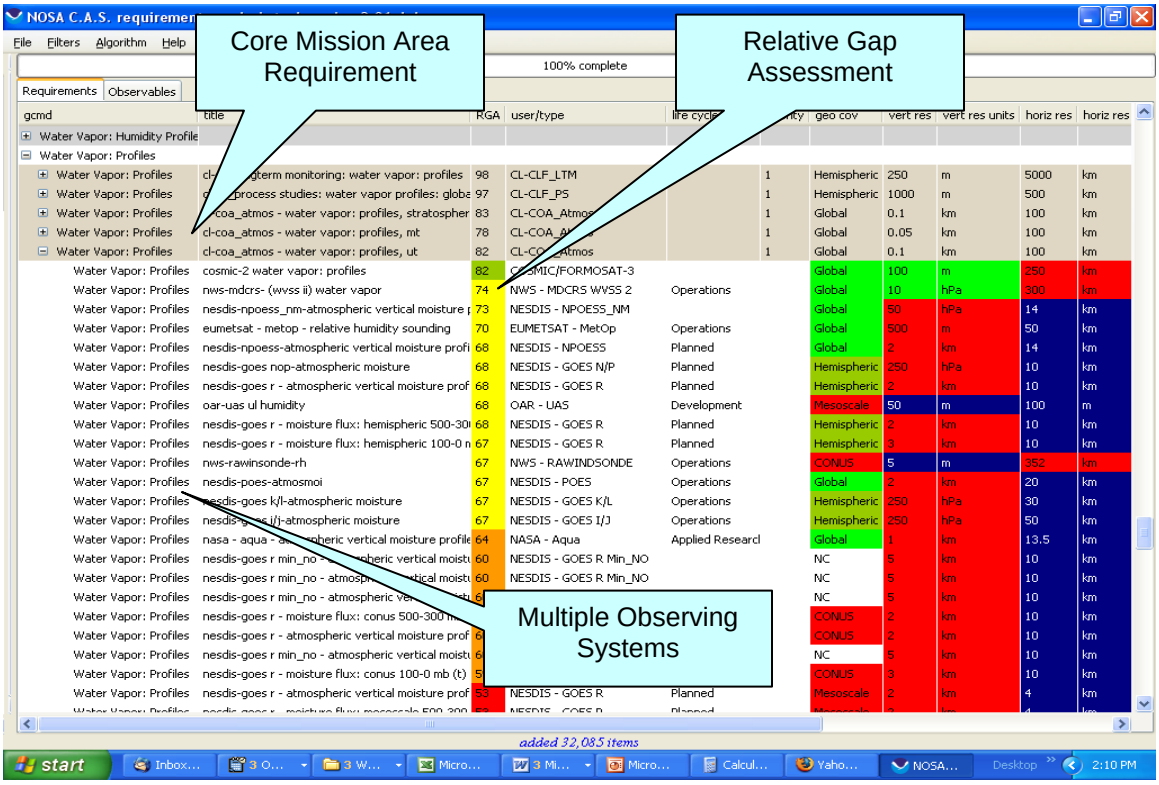


Figure 25. A screenshot of the CasaNOSA Analysis System Requirements Tool (CASRT) illustrating how NOAA requirements for a particular parameter (tan rows) are compared with observing systems measuring that parameter (water vapor).

Risk Assessment

The next step in the analysis process is the assessment of risk for each alternative. All observing system investments inherently involve some risk that the technology will not perform as expected or that sensors or systems will be damaged or destroyed during deployment or while in service. The NOSC IPT investment prioritization framework includes an approach that quantifies the potential impact of technical risk. This risk assessment approach, which is still under development and testing, is based on a technology maturity scale established by DoD for assessing candidate technologies. The risk assessment approach also includes a factor that represents the approximate risk inherent in deploying observing systems in different media (e.g. space, ocean, airborne, surface), or on different kinds of platforms or missions.

Technical Risk = Technology Maturity * Deployment Risk

Thus a typical NOSC IPT risk factor calculation might be:

Technical risk of deploying a proven technology in space: If maturity risk = 0.9 and space deployment risk = 0.8, then the IPT risk factor would be 0.9 * 0.8 = 0.72. In the NOSC approach, the estimated utility of this alternative is multiplied by this technical risk factor reducing utility of the alternative to 72 percent of the non-risk adjusted utility value.

Cost Analysis

In determining the cost for each observing system alternative, the NOSC IPT gathers cost information from a number of sources. The NOAA core mission area Goal leads were asked to provide Points of Contact (POCs) for each observing system alternative and many of these POCs were able to provide costs. The NOSC IPT staff also gathered cost information from the NOAA Line Office "Integrated Priority Lists", the FY10-14 Program Operating Plans (POPs) and the Strategic Investment papers. The cost information gathered was in many cases not "total costs to complete" or "life cycle" costs, but the cost information did include both capital investment and O&M costs. In most cases, costs were gathered for a number of years ranging from four (4) to ten (10). To normalize costs the NOSC IPT staff divided the total multi-year costs by the number of years to yield an "average annualized cost."

Prioritization Algorithm

The Prioritization Algorithm used by the NOSC IPT puts all of these components together to arrive at an overall prioritization score for each observing system alternative that reflects their utility to NOAA (sum of incremental improvements in requirement satisfaction), technical risks, and cost—both total cost and annualized over the number of years included in each alternative's cost figures. The Annualized Priority Score (APS) is probably the most accurate overall indication of relative cost-effectiveness of the alternatives assessed, because of the substantial range in service years represented in the cost estimates for the alternatives.

Annualized Priority Score =
(Sum of Incremental Utility across All Requirements **X**
Combined Maturity and Deployment Risk Factor **X** 100) ÷
(Total Cost/Service Years)

Results of the FY10-14 NOSC IPT analysis process can be found in the 5.0 Results Section, Table No. 4.

3.2.3 What is the target architecture for the segment?

NOAA's concept of a target architecture is seen in three views: a conceptual architecture, a logical architecture, and the resulting physical architecture. This matrix view, presented in NOAA's Enterprise Architecture document, is shown in Figure 26. The three horizontal layers represent the

three architectural views, and the vertical columns represent NOAA's five framework views and their conceptual, logical, and physical attributes.

	Business/Service Processes	Information	Applications	Observing Technology	Infrastructure Technology
Conceptual Vision & Strategy - Goals/Objectives - Definitions - Principles	- Vision, Goals, Programs - Performance Objectives - Mission - Work Principles	- Types & Standards - Information Principles	- Types and Standards - Principles - Goals	- Technology Strategy - Principles	- Technology Strategy - Technology
Logical Architecture - Relationships - Organization or Service Area	- Business Functional Model - Process Flow - Program/LO Relationship	- Data Model - Information Needs	- Architecture - Information Flows	- Technology Architectures - Logical Target	- Technology Architectures - Logical Structures
Physical Infrastructure - Design - Implementation	- Process Task/ Activity - Organization/Line Offices - Performance Measures - Partnerships	- Data types - Formats - Forms/Reports - Data Access - Governance - Outputs	- Modules - System Exchanges - Languages	- Platforms - Instruments -Comms	- Platforms - Comms - Protocols - Operating Systems - Performance Metrics

Consistent intra-dimensional view of the forest down through the trees

Intra and inter-dimensional views of how the parts relate to one another

Figure 26. NOAA's Enterprise Working Framework.

3.2.3.1 Target Conceptual and Logical NOSA Segment Architecture

NOAA's Target Architectural Vision was presented in Section 3.1.5 of this document and is again presented below in Figure 27. As described in the Conceptual Vision & Strategy layer in Figure 26, NOAA has adopted a set of principals and a technology strategy to work toward the target architecture. This is one of the first steps in defining the scope to the segment architecture as detailed in Section 3.1.1. The technology strategy adopted by NOAA is an integrated view of observing systems in five domains: space, ocean, atmosphere, land, and cryosphere. To assist in making it clear as to what NOAA means by integration, it has adopted the following definitions:

- ***Observing System*** **–** A collection of one or more sensing elements (human and/or instrument) that reside on fixed or mobile platforms. They directly or indirectly measure environmental parameters on a defined basis meeting data user objectives.
- ***Integrated Observing System*** **–** A planned, organized, and structured system of interoperable earth observing systems, which, when networked, provide an expanded range of capabilities satisfying user

information and product needs. An integrated observing system holds common goals and adopts common solutions to achieve them.

This target logical view is represented in the upper portion of Figure 27. The target goal is to increase the breath and depth of the observing systems within each of these five domains and reduce the number of systems and provide the most efficient (improved business requirements satisfaction) and cost effective architectural investment recommendations for NOAA. For instance, the ocean-based domain currently contains 25 observing systems. The NOSC IPT's goal is to reduce this number through careful analysis as was demonstrated in the previous alternatives analysis section. NOAA's goal is to increase the breadth and depth of its observing systems as was shown in the previous section.

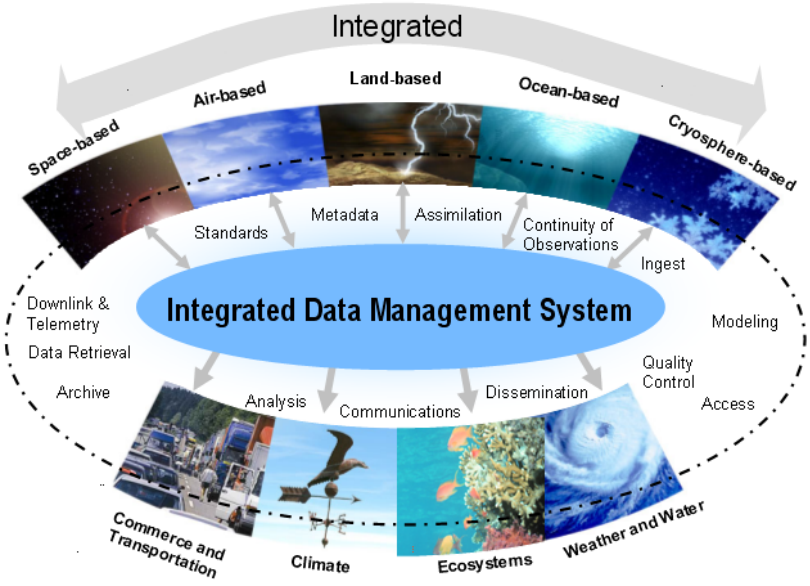


Figure 27. NOAA Approved Target Architecture Conceptual Diagram.

For its conceptual target architecture, NOAA has adopted a set of principles and a set of criteria that are used to determine compliance for its observing systems architecture as identified in the following table. All new systems are evaluated against this set of principles. All future observing system solution architecture alternatives must address these principles as the solution is developed.

Target Architecture Principles	Checklist Criteria
• Utility – Focus on societal benefits – Focus on user requirements – Archive data and make accessible to users & partners	• What validated requirements does this system satisfy? • Where will the data and metadata be archived? • What is the user interface process that will ensure timely access to and retrieval of the data?
• Interoperability – Adopt and implement common standards – Establish common requirements with partners – Develop data model (includes metadata) – Share data in a full and open manner*	• What data and metadata standards are being used for this system? • Is the data format designed for use by the maximum number of users? • Can existing capabilities or external capabilities satisfy the observation requirement without making this investment?
• Flexibility – Leverage research and technology – Adopt and implement common standards – Investigate solutions that are agile and adaptable	• What is the plan, schedule and cost for transitioning this prototype or research capability to operations? • Can the new system be easily added and quickly integrated into the architecture?
• Sustainability – Build on existing systems – Leverage research and technology	• What existing system is being modified? • What Research Plan objectives does this system support? • Is there a long term sustainment plan for this system?
• Affordability – Effectively use non-NOAA systems – Invest in systems that best satisfy requirements	• Has an Analysis of Alternatives (AoA) and Cost & Operational Effectiveness Analysis (COEA) been performed? • Is the system cost within budget, even if it requires tradeoffs?

Table 1. NOSC IPT's Observing System Architecture Principles.

3.2.3.2 Pathway to the Target Physical NOSA Segment Architecture

Once the set of principles and a strategy were adopted, the pathway toward a target physical architecture began. This pathway began with the baseline architecture. In 2002 NOAA completed its first baseline observing system architecture which comprised 99 observing systems, located on over 23,000 platforms, measuring over 500 observation parameters. Since that time, we have annually updated our baseline observing system architecture and inventory. We now have NOSC IPT oversight of these systems; an observing requirements collection process in place; and an established NOAA Research to Applications Policy. The baseline inventory now consists of 92 systems, located on over 30,000 platforms, measuring over 800 observation parameters. The decrease in systems from 99 to 92 is due to the steps and governance discussed in Section 3.1.2 of this document and the NOAA EA. The annual, iterative,

NOSC IPT focused review and analysis process is represented in Figure 28.

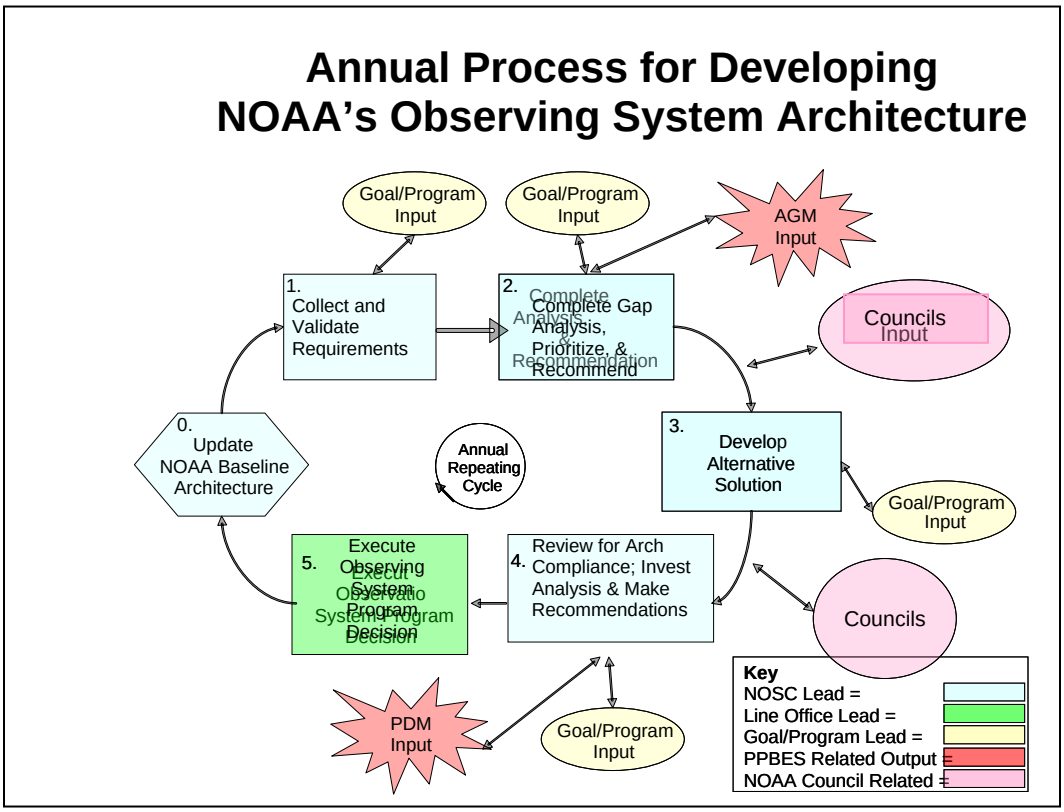


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Figure 28. The NOSC IPT Focused Review and Analysis Process.

This six step annual process leads to an investment recommendation and a set of decisions to refine the baseline, near-term, and target architectures. In steps 0 and 1, the baseline technical inventory, the currently programmed target, and the observational requirements are collected and validated using business performance outcomes. These steps were articulated in the Architecture Analysis sections of this document. In steps 2 and 3, the NOSC staff works with the NOAA Goals and programs to validate business performance gaps, analyze alternatives, and make recommendations to the programs as well as to senior management. These alternative analysis techniques were also discussed in previous sections of this document. Once the agency head identifies the project priority of the initiative and resources are allocated, the project management and review steps using processes articulated in later sections begin.

On an annual basis, with a conceptual strategy and principles in mind and the approved target logical architectural vision, the NOSC IPT in its continued analysis and iterations moves closer to the target physical architecture. For the past two years, we have been using a "first guess"

target architecture that has matured as we developed the total process, leading NOAA to the target architecture (see Figure 29).

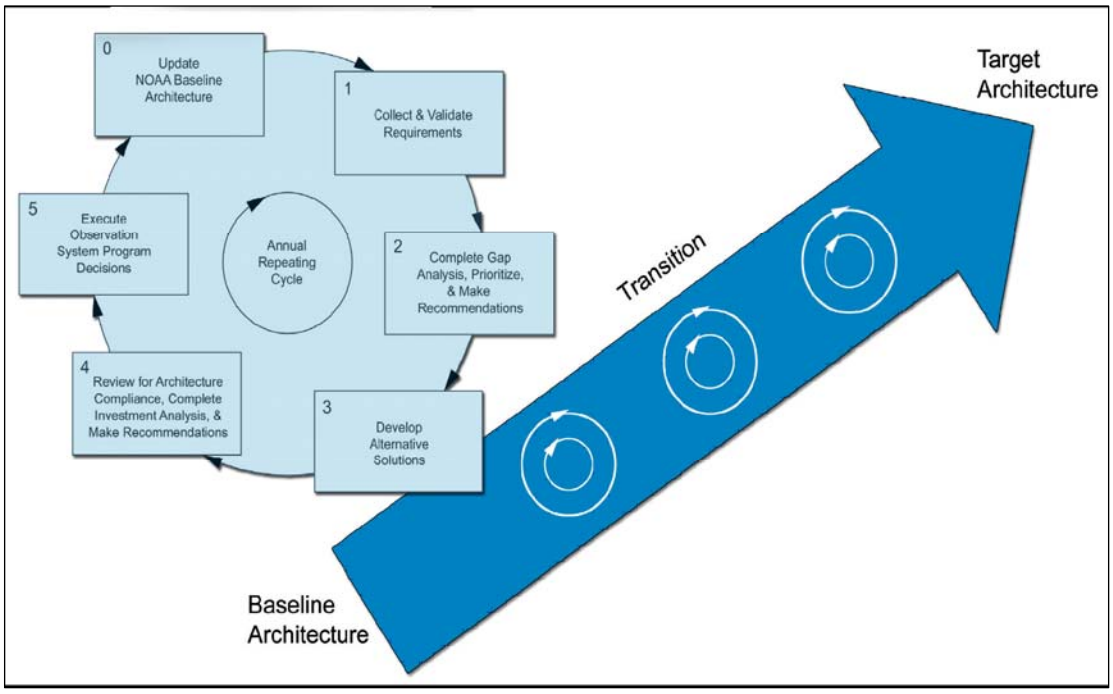

Figure 29. NOAA Pathway to the Target Observing Systems Segment Architecture.

The large blue arrow in Figure 29 represents a multiyear refinement of NOAA's architecture. Using the annual review and analysis process (see Figure 28), the NOSC IPT reviews all of NOAA's business outcome performance goals; assists the programs and Goals in prioritizing their requirements; works with them in analyzing alternatives; and then makes investment recommendations.

One way to identify the target architecture is to look at the Efficient Frontier (see Figure 22). Barring other considerations, the target architecture should be the intersection of the available budget and the efficient frontier. Given the assumptions leading to the Investment Analysis, that intersection is the most efficient target architecture. However, at the present time, there are other considerations that we have not yet built into the Investment Analysis system such as dependence among observing systems. For instance, a satellite measuring sea surface temperature needs some number of *in situ* observing platforms also measuring sea surface temperature to calibrate and validate its data. We are refining our Investment Analysis techniques to consider these dependencies properly.

NOAA now has a firm grasp on the conceptual, logical, and physical target architectures for the next 10 years; however, trying to identify all of the physical components for an integrated segment architecture 10-25 years in the future is difficult at best.

A component of the ocean-based target domain is represented in Figure 30. This physical architecture timeline runs from 2003 through 2016. The 2003-2008 period is the baseline and the affordable programmed budget. The 2009-2016 period is the target needed to accomplish the business derived performance goals of the Core Mission Area Segments.

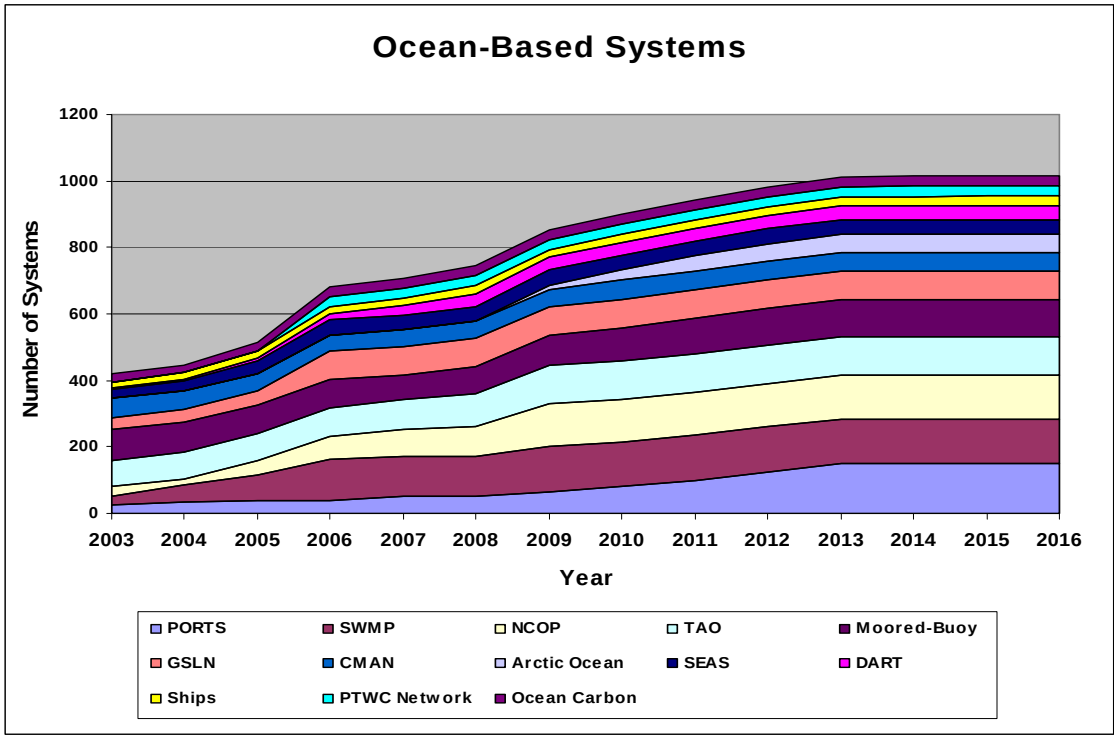

Figure 30. The Partial Target Ocean-based Domain of the NOSA Segment Architecture.

The target physical architecture for the space-based segment is shown in Figure 31. As was discussed Section 3.2.2.2, this Figure shows that NOAA has many partnerships with other organizations allowing a significant number of NOAA Core Mission Area observational requirements to be met by other organizations' assets, thereby significantly reducing NOAA's overall investment.

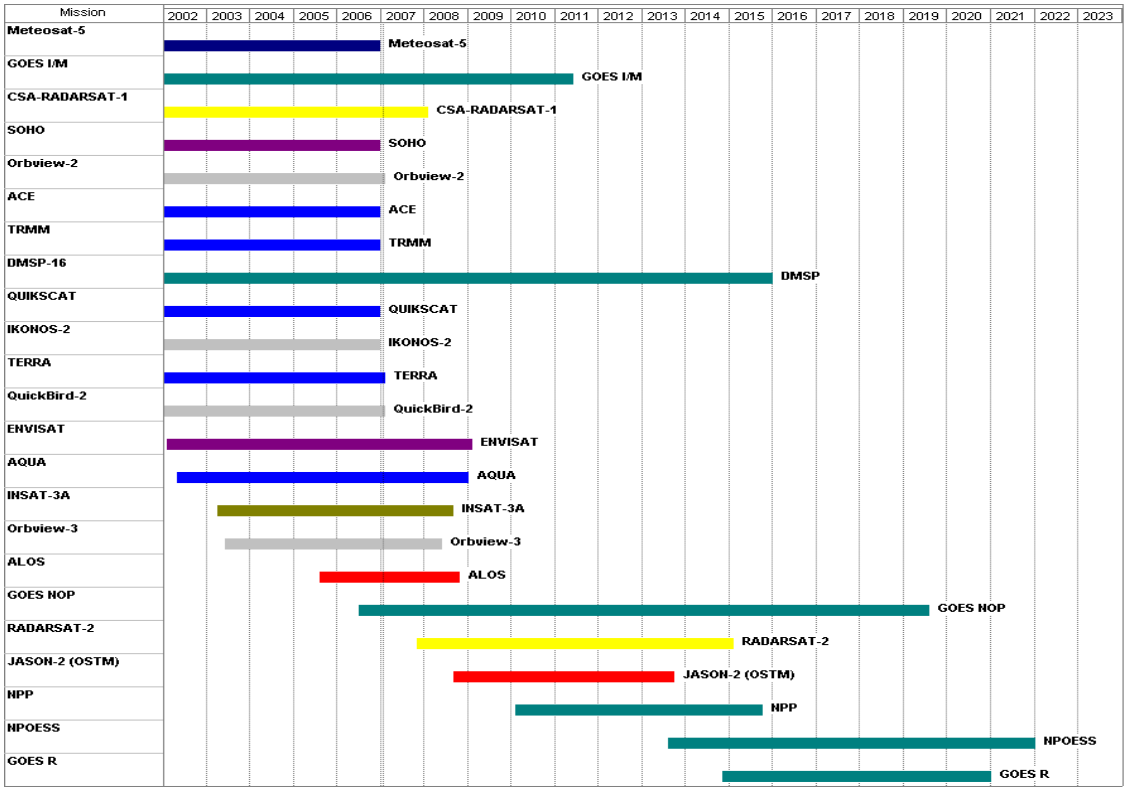

Figure 31. The Target Physical Space-based of the NOSA Segment Architecture.

The partial target physical architecture for the air-based segment is shown in Figure 32.

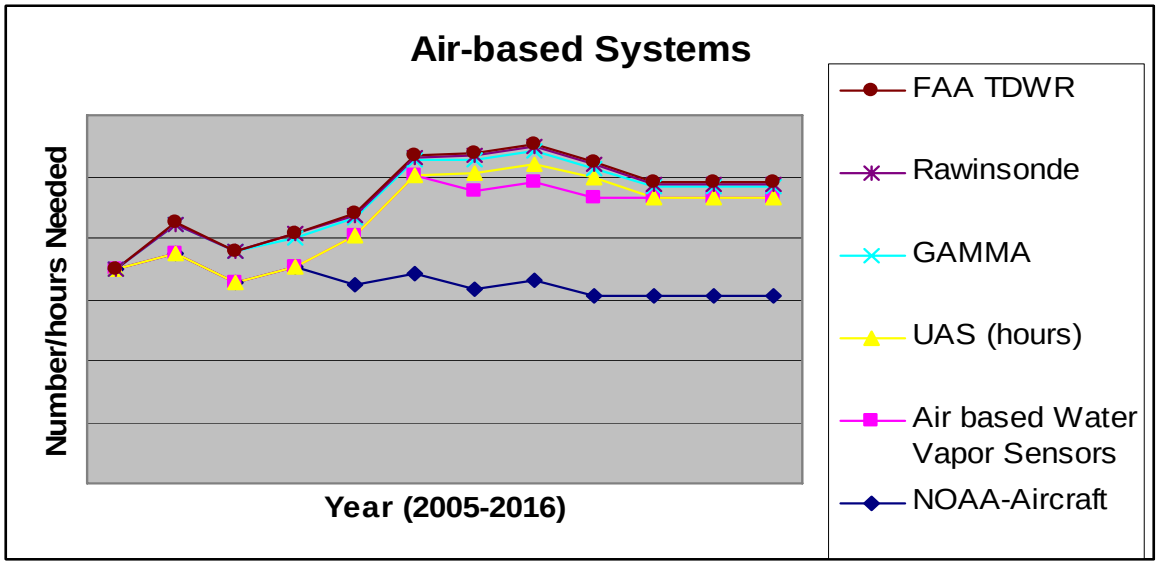

Figure 32. The Partial Target Air-based Domain of the NOSA Segment Architecture.

The partial target physical architecture for the land-based segment is shown in Figure 33.

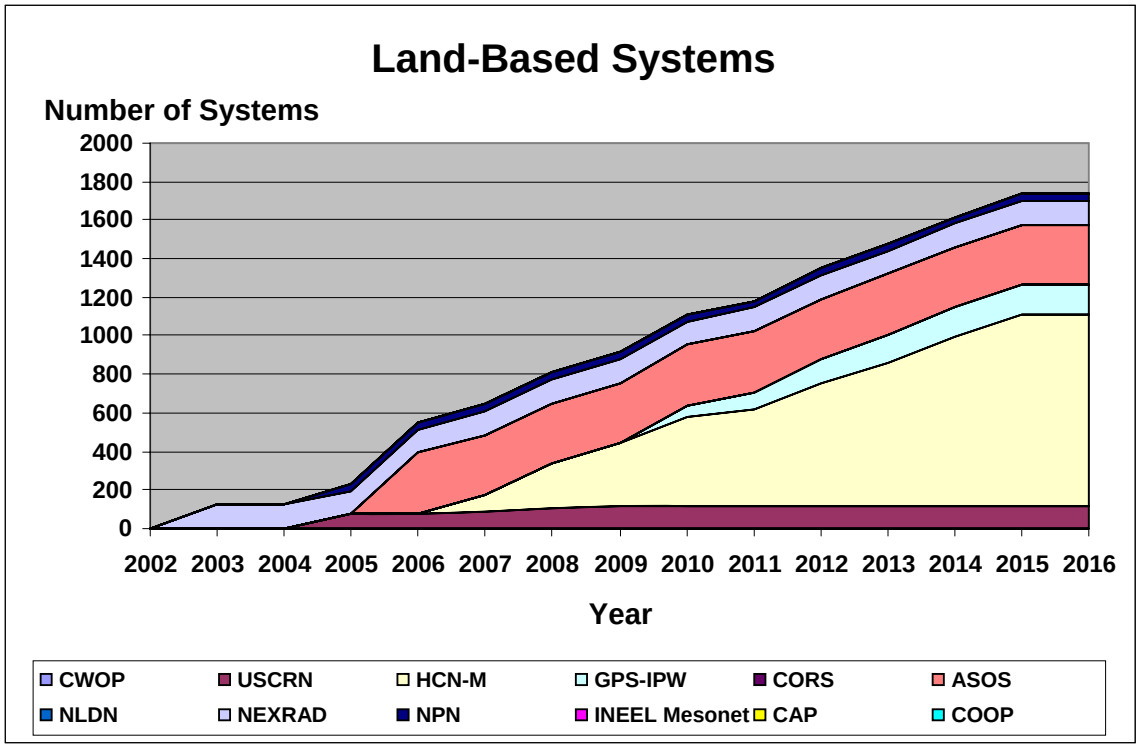

Figure 33. The Partial Target Land-based Domain of the NOSA Segment Architecture.

3.2.4 What projects are required to achieve the target architecture and in what order should they be executed? - Transition Strategies

As discussed in Section 3.2.2.1, the NOAA programs and Core Mission Area Segments, with the assistance and review of the NOSC IPT, identify in their annual planning documents a prioritized listing of gaps in their capabilities to achieve expected performance outcomes. These plans also detail alternatives to fill the gaps. As shown in the six step analysis process (see Figure 28), the NOSC IPT carefully reviews these alternatives and independent analyses and then provides a set of target recommendations to NOAA senior leadership. As discussed in 3.2.2.5 The NOSC IPT analyses these alternatives and provides a prioritized listing of utility to NOAA for each of the alternatives found in the following Results Section (Table 4).

Through the NOAA governance and decision-making process identified in the NOAA EA, this information is evaluated by the NOAA PA&E Office along with all other agency needs. A draft NOAA program is then presented for internal NOAA review followed by the agency head issuing an Program Decision Memorandum (PDM) each January. The PDM lists all NOAA-approved new or enhanced projects to achieve the target architecture. For new projects this step would be followed by the preparation of OMB 300s for each project.

The agency head also annually releases a Major Projects list each year encompassing all projects that must follow a NOAA Administrative Order regarding the management and oversight of the projects. These projects constitute the annually updated target and transition strategy to achieve that target. These major projects have a set of templates they must follow as the project progresses. Table 2 below lists the major projects for which the NOSC IPT has purview.

Project	Rational for Major Project	Oversight Council	Project Manager	Target Domain
NPOESS Satellite	• Large project with interagency partners and funding obligations • Planned funding:$1.8B (all years)	NEP/NEC PMC NOSC	Dan Stockton	Space
Fisheries Survey Vessels 5,6,7	• Large requirement: $189M (FY07-11) • Planned funding: $1M	Fleet Council with NOSC	Joseph Bohr	Ocean
GOES-R Satellite	• Large project • DOC will also review • Planned funding: $2.3B (FY07-11)	NEP/NEC PMC NOSC	Greg Mandt	Space
Hydrographic program including HYDRO observing system	• Large program • Significant execution restrictions • Planned funding: ~ $245M (FY07-11)	Ocean Council and NOSC	Rich Edwing	Ocean
Tsunami Warning System including DART™ observing system	• Extremely high visibility • Current program has significant funding but clear identification of sources lacking • Planned funding: ~$200M (FY07-11)	NOSC	David Green	Ocean
Unmanned Aerial Systems	• High visibility • Cross NOAA effort • Planned funding: $56M (FY07-11)	Research and NOSC	Marty Ralph	Air
NOAA's Historical Climate Network Modernization (HCN-M)	• Large requirement: ~$190M (cost to complete) • Programmatic definition lacking • Effectiveness of National Integrated Drought Information Systems dependent on HCN-M • Planned funding: (FY07-11)	NOSC	Bruce Giza	Land

Table 2. NOAA's Major Projects for which the NOSC IPT has Purview.

3.3 FEA Step #3 - Investment and Funding Strategy for NOSA Segment (NOAA PPBES Budgeting Step)

3.3.1 What is the funding strategy for the projects?

As stated in previous sections, the annual PPBES process lays out the funding for all of NOAA's 47 programs at the beginning of each year. After

approval within NOAA, the funding strategy follows the same agency, OMB, and Congressional timelines and processes as other Federal agencies.

In addition, and as discussed in Section 3.2.2, there are also partnership funding strategies that have led to significant cost avoidance for NOAA, such as NOAA's partnership with EUMETSAT for shared operations of polar-orbiting satellites. EUMETSAT has also acted as a backup for NOAA satellites in cases where the NOAA suite of satellites has been at risk. NOAA also has partnerships with DoD for environmental satellites, which have also led to reduced costs. NOAA and DoD share the same satellite platform thereby significantly reducing the cost to the Nation. In addition, NOAA has partnerships with FAA in the funding and deployment of Next Generation Radar (NEXRAD) and Automated Surface Observing System (ASOS) observing systems, again leading to significant cost avoidance.

NOAA also has very strong ties to the citizens of the Nation with over 10,000 U.S. citizens providing environmental observations to NOAA on a daily basis, 365 days per year. Using a conservative estimate of one hour a day of voluntary time, valued at the new minimum wage of $7.25/hour, NOAA enjoys a $26M per year cost avoidance through this Cooperative Observer Program.

In recent years NOAA has also begun to establish relationships with local observing networks springing up across the United States and internationally. This too should lead to improved performance with little to no additional cost.

Recapitalization Plan - The NOAA Administrator, noting the difficulty with the up-and-down fiscal nature of major observing system projects, requested that NOAA develop multiyear satellite, fleet and aircraft recapitalization plans. The intent is to have a fairly stable observing system segment budget and do a better job of planning NOAA's observing requirements to match this budget. The original request was for 10 years, however it has been recognized that the satellite recapitalization plan must cover at least two generations of operational satellites to effectively describe the long-term impacts. Since each generation of new operational satellites takes about 10 years to design and build, and is then operated for 15-20 years, the plan requires at least 40 years of foresight in order to understand the budgetary and technology insertion impacts over two generations of systems. The recapitalization team has developed a 20-year profile that was briefed to NOAA senior management in late 2007. The goal is to develop a 20-year plan consistent with the program strategy that also (1) provides a vision for future technology insertion from NASA, our scientific and developmental partner for future observing capabilities, and others, and (2) provides opportunities for new missions and capabilities to enhance our environmental monitoring capabilities. The budget profile will also conform to the general

guidance to develop a “satellites line” similar to the “ships budget line” used by the U.S. Navy.

3.4 FEA Step #4 - Program Management Plan and Execute Projects (NOAA PPBES Execution Step)

3.4.1 How do we use available resources to achieve target performances goals?

NOAA has a strong requirements-based approach to managing and monitoring performance of programs and projects that will be discussed in detail in following sections. NOAA is following Federal guidance that mandates efficient and effective use of resources tied to an agency’s mission, goals, outcomes, and objectives. The Federal Acquisition Streamlining Act of 1994, Title V, requires agencies to establish measurable cost, schedule, and performance goals for all major acquisition programs. The OMB Circular A-11 requires new investments to be justified on the basis of addressing shortfalls and projects to demonstrate satisfactory progress toward cost, schedule, and performance goals.

The PPBES provides an annual review and assessment of the progress toward implementing NOAA’s mission. The progress of selected solutions toward eliminating performance shortfalls is evaluated, and changes in scope and direction are proposed, as appropriate. Major projects (i.e., those that require significant resources and have high risk and external visibility) require more periodic and thorough corporate reviews and assessments than the annual PPBES; these will follow additional guidelines to ensure common application of the requirements management policy across NOAA.

3.4.1.1 Project Management

All projects (major and non-major) will have a designated project manager. The project manager is responsible for translating mission requirements into a project that will ensure a satisfactory solution. Mission requirements for an existing project should not change during the course of project execution; if new requirements emerge, they will be validated as specified in NOAA Administrative Order 216-108. The project manager shall establish and maintain a process to manage change throughout the project’s life cycle. The project manager is responsible for preparing documentation to support the continuous and systematic review of progress as it relates to Key Decision Points (KDPs) and mission requirements.

3.4.1.2 Software Development Lifecycle (SDLC)

NOAA spends millions of dollars each year on the acquisition, design, development, implementation, and maintenance of observing systems vital to its mission. The need for safe, secure, and reliable system

solutions is heightened by the increasing dependence on the downstream computer systems and technology to provide services and develop products, administer daily activities, and perform short- and long-term management functions. There is also a need to ensure privacy and security when developing observing systems.

NOAA needs a systematic and uniform methodology for information systems development, and this carries over to many observing systems as well. Using SDLC ensures that systems developed by NOAA not only meet its mission objectives, but also meet information technology (IT) mission objectives; are compliant with the current and planned IT Architecture; and are easy to maintain and cost-effective to enhance. Sound life cycle management practices include planning and evaluation in each phase of the information system life cycle. The appropriate level of planning and evaluation is commensurate with the cost of the system, the stability and maturity of the technology under consideration, the clarity of the user requirements, the stability of the program, and other user requirements and security considerations.

3.4.1.3 Key Decision Point (KDP) Reviews

Reviews will be conducted at the end of each project phase to ensure that project deliverables continue to meet valid mission requirements. A KDP represents the completion of a project phase and is commonly marked by a review of significant deliverables and project performance. KDP reviews determine whether a project should proceed to the next stage. During the review, mission requirements will be confirmed, and the project's ability to progress within the defined scope will be assessed. If appropriate, multiple KDP reviews for a major project may be combined into one review. A listing of KDP topics to be addressed in these reviews can be found in Table 3.

KDP 1	**Needs Identification and Definition**
	• What is the need? – Description • What are our existing capabilities and what is the gap? • Where did this need come from? How well is it documented? • Who are key customers and stakeholders? • How does need link to the NOAA mission and strategic plan and other validated requirements? • Benefits and performance impacts of meeting this need?
KDP 2	**Solution Alternatives Identification**
	• How will alternatives for meeting requirement be investigated? • What alternatives were evaluated, developed, and analyzed? • How were alternatives evaluated? • Provide cost/benefit analysis of alternatives • Cost, Schedule, Performance • How much will alternative investigation, development, and analysis cost? • What is proposed solution? Success criteria? • What is the Concept of Operations? • Identify risks and mitigations • Was solution coordinated internal and external to NOAA? • Is this solution compliant with NOAA policies and standards? • How will solution impact current programs?
KDP 3	**Solution Selection**
	• Investment Strategy • Life Cycle Cost Estimates • User Impact Assessments • Tradeoff Analyses • Investment Budgets
KDP 4	**Acquisition/Implementation Approval**
	• Cost • Schedule • Performance • Configuration Management

Table 3. Key Decision Points (KDP) and the Information Required to Pass Each Point.

3.4.1.4 Project Management Plans

Major and non-major projects required to achieve the target architecture are managed using proven project management methods and tools. Project Management Plans are prepared to define the project organizational structure, responsibilities and authorities, planning and

acquisition strategy, risk management, and project execution and control strategy. A sample table of contents from one of NOAA's non-major projects, the Critical Infrastructure Protection (CIP) Project Management Plan (PMP), can be found in Appendix C.

3.4.1.5 Earned Value Management (EVM)

Department of Commerce policy mandates the use of Earned Value Management techniques in the management of the DME portion of all Department major IT projects, and these techniques must be part of an EVMS that meets the criteria specified in the Electronic Industries Alliance standard, "ANSI/EIA-748, Earned Value Management Systems," including the requirement to conduct a monthly assessment of cost and schedule performance. Project performances for major projects and other significant developmental activities are measured using appropriately tailored EVMS. Examples of major development activities implementing EVMS are the Critical Infrastructure Protection (CIP), Comprehensive Large Array-data Stewardship System (CLASS), National Polar-orbiting Operational Environmental Satellite System (NPOESS), and NPOESS Data Exploitation projects. For large developmental activities with contract values over $50M, such as the NPOESS project, the EVMS must be certified to meet the above referenced ANSI/EIA standard.

Resource-loaded project schedules are used to determine time-phased Planned Values, which comprise the Performance Measurement Baselines. Performance (Earned Value) is evaluated using objective measurements, usually based on discrete schedule activity progress. Actual Costs are compared with Earned Value to determine Cost Variances. Earned Value is compared with Planned Value to determine Schedule Variances. Variances exceeding predetermined thresholds are analyzed to identify root causes, and corrective actions are taken when appropriate. Earned Value reports, including variance analyses and Estimates at Completion, are prepared on a periodic basis, usually monthly. A typical Earned Value chart is shown in Figure 34. The chart is from a developmental activity to extend the service life of geostationary satellites.

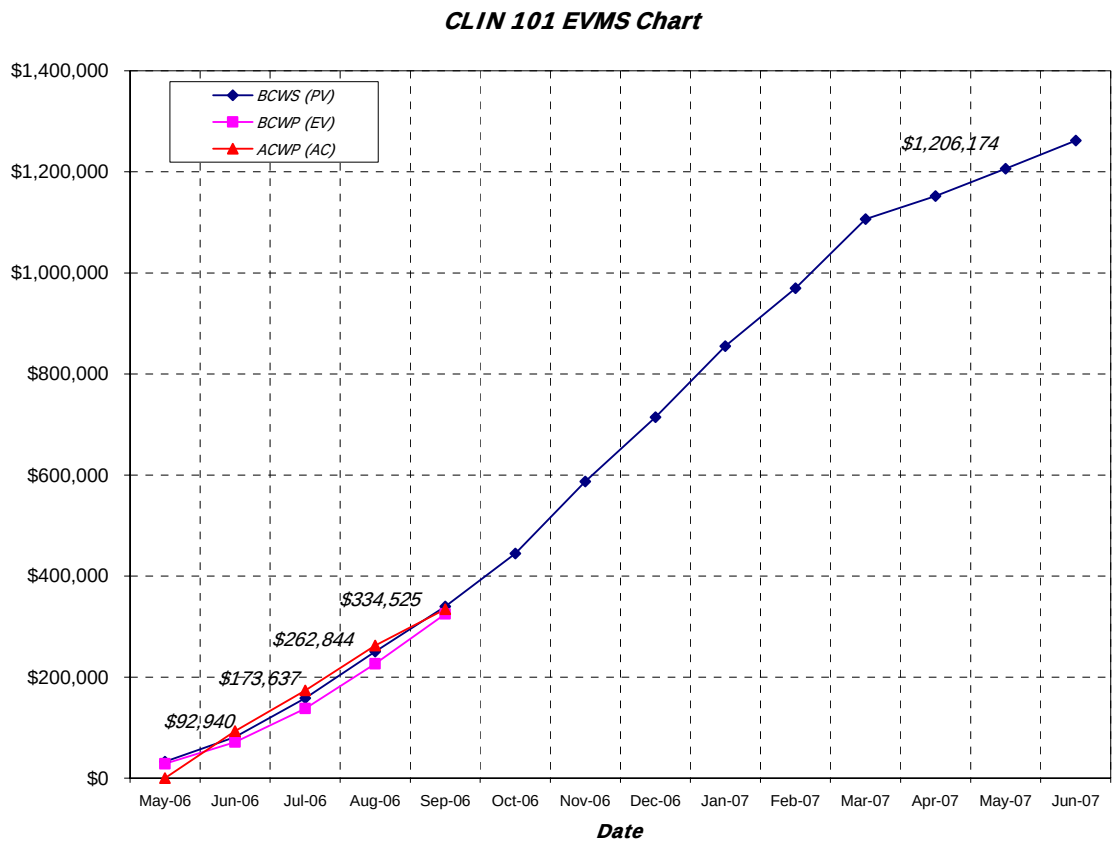

Figure 34. Earned Value Chart for Extended GOES High Inclination Mission (XGOHI).

Cost and schedule variances and performance indices are also displayed graphically in reports so that adverse trends are readily apparent. EVMS is used to identify performance issues so that causes can be identified and corrective actions taken early, thus increasing the probability of completing the projects within their cost and schedule baselines.

3.4.2 What is the nature of individual solutions to implement the target segment architecture and achieve performance goals?

The processes used to identify individual solutions within the NOSA segment are represented by the evolving baseline and target observing system solutions as discussed in previous sections and as represented in Figure 35. A complete listing and description of each solution can be found at http://nosc.noaa.gov/docs/products/strategic.pdf.

Weather & Water	Ecosystems	Climate
Atmospheric Integrated Research and Monitoring Network (AIRMoN)	Coastal Change Analysis Program (CCAP)	Air Quality-Climate Field Study Package
Wind Profiling Radars UHF	Commercial Fisheries-Dependent Data (FIS)	Precipitation Profiling Radars
Wind Profiling Radars VHF	Coral Reef Ecosystem Integrated Observing System (CREIOS)	Atmospheric Dispersion Measurement System
Airborne Oceanographic Product (AOP)	Economic Data	INEEL Mesoscale Meteorological Network
Automated Surface Observing System (ASOS)	Ecosystems Surveys	Global Energy and Water Cycle Experiment (GEWEX)
Cooperative Agency Profilers (CAP)	Fish Surveys	Integrated Surface Irradiance Study (ISIS)
Coastal Marine Automated Network (CMAN)	Habitat Assessment	Surface Radiation Budget Network (SURFRAD)
Cooperative Observer Program (COOP)	Recreational Fisheries-Dependent Data (MRFSS)	Regional Atmoshperic Measurement and Analytical Network (RAMAN network)
Deep-Ocean Assesment and Reporting Tsunamis (DART)	National Observer Program (NOP)	AEROSOL
Limited Automated Remote Collector (LARC)	National Status and Trends	Carbon Cycle Greenhouse Gases (CCGG)
IN-SITU SENSORS	National Seafloor Observing System (NSOS)	Hydrocarbon and other Atmospheric Trace Species
INTEGRATED SYSTEMS	Passive Accoustics Observing System (PAOOS)	Observatories (OBOPS)
LIDARS	Protected Resources Surveys	Solar Thermal Atmospheric Radiation Surface Measurements (STAR)
RADARS	Real-Time Environmental Coastal Observation Network (RECON)	Stratospheric Water Vapor
RADIOMETERS	Sociocultural Data Collection	Stratospheric Aerosol
Wind Profiling SODARS	National Marine Sanctuary System-wide Monitoring Program (SWIM)	Stratospheric Ozone
Meteorological Data Collection and Reporting System (MDCRS)	National Estuarine Research Reserve System-Wide Monitoring Program (SWMP)	Surface Ozone (SFCOZ)
MOORED BUOY	**Mission Support**	GPS Integrated Precipitable Water Vapor Sensor
NOAA Environmental Real-Time Observing Network	Defense Meteorological Satellite System (DMSP)	Citizen Weather Observer Prog
Next Generation Radar (NEXRAD)	Geostationary Operational Satellite System (GOES) I/M	Tropical Moored Buoys
National Lightning Detection Network (NLDN) NWS Lightning Data	Geostationary Operational Satellite System (GOES) NOP	Arctic Observing System
Airborne Gamma Radiation Snow Survey Program	Geostationary Operational Satellite System (GOES) R	Argo
NOAA Profiler Network (NPN)	Marine Optical Buoy (MOBY)	Drifting Buoys
Upper Air RAWINSONDE Network	National Polar-orbiting Operational Environmental Satellite System (NPOESS)	Ocean Carbon Networks
Pacific Tsunami Warning Center Sea Level Network (PTWC Network)	NPOESS Preparatory Project (NPP)	Ocean Reference Stations (Long Term Evolution of the Coupled Boundary Layers) (Stratus)
Voluntary Observing Ship Program (VOS)	Jason-2 Ocean Surface Topography Mission (OSTM)	Ships of Opportunity
Commerce & Transportation	Polar Orbiting Environmental Satellite (POES)	Tide Gauges (Global Sea Level Network (GSLN))
Continuously Operating Reference Stations (CORS)	AIRCRAFT	Ionosonde
Hydrographic Surveying (HYDRO)	SHIPS	Fisheries Oceanography Coordinated Investigations
National Current Observation Program (NCOP)		Ocean Acoustic Monitoring
National Water Level Observation Network (NWLON)		Tunable Optical Profiler Aerosol and oZone (TOPAZ)
Physical Oceanographic Real-Time System (PORTS)		US Climate Reference Network (USCRN)
Shoreline		

Figure 35. NOAA's Observing System Segment Architecture Solution Systems.

3.4.3 How well are we progressing toward achieving target performance goals?

As discussed in Sections 3.1.4.5 and 3.2.1, NOAA collects all core mission, business and enterprise segment performance measures on a quarterly basis (at a minimum) and reports them throughout the chain of command. Quarterly Core Mission Area sub-segment reviews, including performance metrics, are given by all 47 programs.

As with any complex and diverse organization with 92 observing systems under review, some exceed expectations and others do not live up to expectations. However, with regular review, problem areas are identified quickly, and improvement plans are prepared.

4. NOSA Segment Architecture Maintenance

4.1 What are the new or revised change drivers for the segment?

As discussed in Section 3.1.3, there are several types of change drivers affecting the way NOAA carries out its business. Of course, like most other agencies, NOAA must respond to legislative drivers, but NOAA also has

environmental drivers that may significantly change the priorities of targets within the segment. Recent environmental drivers such as Hurricane Katrina and the Indonesian tsunami have caused some redirection of resources to fill higher priority gaps in coverage. For instance, NOAA has a warning network that utilitzes a set of baseline tsunami buoys for the Pacific and Atlantic Oceans. After the Indonesian tsunami, the timeline for the planned target tsunami buoy network, the Deep-ocean Assessment Reporting of Tsunamis (DART™), was moved up. In response to Hurricane Katrina, a similar initiative has occurred with the NOAA Water Level Network (NWLON) observing system. Recent or on-the-horizon legislative drivers possibly impacting this segment often deal with fishery dependent stakeholder representation; the ones resulting from the tsunami and the hurricanes and the global climate change issue may result in legislative mandates.

Further, stakeholder requirements change with time and NOAA addresses this in several ways. NOAA holds stakeholder meetings across the country every year between January and March to gather input on its changing needs and priorities. Since NOAA has several direct services to the citizen, we receive customer feedback throughout the year. Being an environmental forecast agency (weather forecasts, etc.) some of the feedback is very direct and reaches us immediately! Some typical stakeholder feedback comments can be found at: http://www.ppi.noaa.gov/2007_stakeholder_forum.htm

There are also technological drivers that can have a significant impact on the technology used for observing sensors or platforms. For instance, the launch of the Department of Defense Global Positioning Satellites (GPS) for improved navigation led to a new way of measuring atmospheric moisture due to the bending of the GPS signal as it travels through the atmosphere. This second-hand benefit is already showing potential cost avoidance by using the GPS signals versus other sensors and platforms.

4.2 What is the impact of new change drivers on segment architecture work products?

- The Indonesian tsunami resulted in additional DART™ buoys and associated network components.
- Hurricane Katrina resulted in additional and strengthened NWLON sites.
- The launch of the GPS satellites has resulted in collaborative efforts with the Department of Interior to jointly improve the CORS observing system for atmospheric moisture.
- Technological developmental problems with both the new GOES-R and NPOESS satellites have resulted in the elimination of some instruments and capability on those satellites.
- The global communities' recognition of the importance of climate change has resulted in an analysis of observing system alternatives to measure 'essential climate variables'.

- The Iraq war and the increased use and reduced cost of Unmanned Aerial Vehicles (UAV) has led to the possible increased use of UAVs to address NOAA's observational requirements.
- The Internet and the proliferation of home meteorological instruments has led to a new set of voluntary observers and a new and very inexpensive observing capability in NOAA called the Citizen Weather Observing Program (CWOP).

5. Results

5.1 NOSC IPT Investment Recommendations and their Impact on Cost, Schedule, and Performance.

The goal of the NOSC IPT is to provide oversight to all NOAA observing systems activities and to develop investment recommendations for the NOSC to provide to senior NOAA leadership. These recommendations are designed to help NOAA leaders make sound observing system investment decisions that further the overall core mission area's (NOAA Mission Goals) performance objectives. As has been shown in previous sections, the NOSC IPT analyzes alternatives against requirements throughout the year, working with the core mission areas to understand their performance objectives. The NOSC IPT has provided investment recommendations and observations to the core mission area Goal leads and the NOAA Program Analysis, and Evaluation Office (PA&E) to use in their evaluation of NOAA's overall annual investment strategy and in further development of the NOAA Administrator's PDM.

In the recently completed annual NOSC IPT cycle, there were 19 recommendations made for the planning period of FY10-14 totaling nearly $4.9B (Table 4).

Focus Areas	Alternatives	Sum of Incremental Utility Across Requirements	Combined Maturity & Deployment Risk Factor	Risk-adjusted Incremental Utility	Estimated Cost ($M)	Service Years	Annualized costs ($M)	Risk Adjusted Incremental Utility ÷ Annualized costs X 100
Climate and Hurricanes	MDCRS WVSS2	736	0.77	563	43	7	6	9272
Climate	SEBN	270	0.86	231	27	9	3	7849
Hurricanes	Phased Array Radar	150	0.76	114	10	5	2	5709
Hurricanes	ASOS Enhanced	178	0.86	152	15	5	3	5248
Climate	Carbon Tracking OS	503	0.81	407	42	5	8	4873
Hurricanes	Tail Doppler Radar	36	0.81	29	4	5	1	3615

Space Weather	**CME Data Buy**	176	0.64	113	25	5	5	2253
Climate	**Jason3**	763	0.72	549	177	5	35	1552
Climate	**AK CRN**	50	0.81	41	14	5	3	1406
Space Weather	**Solar Wind Data Buy**	567	0.64	363	114	5	29	1257
Hurricanes	**NEXRAD Dual Polarization**	65	0.86	55	50	10	5	1110
Hurricanes	**FAA TDWR data acq.**	10	0.86	9	5	5	1	950
Climate	**Radarsat 2-3**	69	0.64	44	23	4	6	767
Hurricanes	**Shoreline Mapping**	129	0.81	104	73	5	15	718
Hurricanes and Climate	**COSMIC2**	236	0.72	170	158	5	32	539
Climate and Hurricanes	**UAS**	40	0.56	22	24	5	5	458
Hurricanes	**XOVW**	628	0.64	402	2038	10	204	197
Hurricanes	**QuikSCAT clone**	328	0.64	210	2026	10	203	104

Table 4. Ranked Listing of Analyzed Observing System Alternatives for the FY10-14 Planning Period.

An example of how the above investment recommendations (Table 4) are evaluated is provided in the following text.

The observing system alternative MDCRS WVSS2 listed in the above Table 4 refers to the Meteorological Data Collection and Reporting System (MDCRS) which has been designed to support improved weather forecasting, particularly for upper-air wind and severe weather. This observing system is composed of a small instrument package placed on participating national and international commercial aircraft. The system collects and organizes up to 28,000 real-time, automated position and weather reports per day. These data are forwarded to the NOAA's National Centers for Environmental Prediction where it is used as input in predictive weather models and subsequently by the climate community. Water vapor profile information which is of critical importance to the forecast community is currently not available. The MDCRS Water Vapor Sensing System (MDCRS WVSS2) alternative in the above Table 4 is an instrument enhancement to this MDCRS system which will provide the much needed water vapor profiles.

The current baseline observing system used to collect water vapor profiles is the National Weather Service (NWS) Upper-air Observations Program comprised of 92 Radiosonde stations in North America and the Pacific islands and 10 stations in the Caribbean. The global radiosonde network nominally includes

about 900 upper-air stations, of which about two-thirds make observations twice daily. The network is predominantly land-based and favors the Northern Hemisphere. Efforts to reduce operating costs have led to station closures and reduced observing schedules in some parts of the former Soviet Union and elsewhere. Nominally these radiosondes cost approximately $130 each.

In order to provide the same benefit as the MDCRS WVSS2 alternative, the national and international meteorological community would need to launch an additional 26,000 radiosondes per day and this would still not provide adequate oceanic coverage. The approximate cost of these 26,000 reports per day would be $3.4M/day or $1.2B/year. Obviously the $6M/year cost of the MDCRS WVSS2 observing system alternative is the more cost effective solution.

In the current (FY08) President's Budget, 48 investment recommendations were made by the NOSC IPT of which 39 were adopted and articulated in the NOAA Administrator's PDM. Table 5 is an example of NOSC IPT recommendations and the resulting NOAA Administrator Decisions for FY08-12.

Core Mission Area	Proposed Alternative Solution	Cost in $	NOSC Recommendation	PDM	Comments on PDM Items
Climate	National Integrated Drought Information System (NIDIS)	$9.6M	The NOSC supports this investment. This investment leads to integration of systems and supports a high priority goal	Examine feasibility of establishing NOAA NIDIS team in FY06 and establish NIDIS Operations Office within NOAA under direction of Climate	PDM item is consistent with NOSC recommendation
Climate	Integrated Ocean Observing System (IOOS) and Above Core Item #2 – Arctic Ocean Observing Systems (AOOS)	$(6.5M) for IOOS, $45.4M for Arctic Ocean Component	Overall, the proposed program adjustment seems reasonable—essentially a one-time reduction in a planned ramp-up of funding for Climate IOOS. Relative to other programs, the Climate Observations and Analysis—Oceans subprogram appears to be relatively close to achieving its stated 100 percent observing requirements. From a NOAA-wide perspective, there are investment opportunities in other programs that would generate greater improvement in requirements satisfaction than would be achieved by fully funding Climate IOOS in FY2008	In coordination with the NOSC and domestic and international partners, identify options to meet global climate observing requirements	PDM item is consistent with NOSC recommendation
W&W	NERON	$19.5M	The NOSC will re-assess NERON as an investment option in the FY2009 cycle based on the new program definition and plan.	Provide additional definition for the NERON project, including cost, schedule and performance information for use in the FY08 budget development.	PDM item is consistent with NOSC recommendation
C&T	Within Core Program Adjustment: Aviation Weather – Water Vapor	$(0.2M)	Recommend that Aviation Weather and Commerce and Transportation publicize this enhancement more broadly so that other programs with requirements for water vapor	Provide additional definition for the NERON project, including cost, schedule and performance information for use in the FY08 budget development.	PDM item is consistent with NOSC recommendation

	Sensors		profile data (e.g., Climate Observing and Analysis, Local Forecast and Warning (LFW), Hydrology (HYD), Climate Forcing (CLF)) can assess whether it helps them. Concur with proposed adjustment		

Table 5. Example of NOSC IPT Investment Recommendations and Resulting NOAA Administrator Decisions for FY08-12.

- These annual recommendations can be found on the NOSC IPT website at http://nosc.noaa.gov/docs/products.html.

The following Table 6 contains several examples of actual recommendations made by the NOSC IPT (found in the above documents) and their resulting cost avoidance impact on NOAA budget decisions.

Core Mission Area	Gap in Core Mission Area's ability to provide services	Alternative Solution Proposed and Cost $	NOSC Recommendation	Agency decision	Potential Cost Avoidance
Weather & Water, Space Weather	Aging NASA STEREO satellite's CME instrument is only current source of data which is crucial for geomagnetic and solar radiation storm warnings	GOES-R formulation studies estimated a cost of $40.2M for flight sensor.	NOSC analysis yielded a recommended lower-cost commercial data-buy alternative at $9M	Data-buy alternative proposed at five year cost of $8.1M	$32M.
Weather & Water, Space Weather	Aging NASA ACE satellite is only current source of solar wind data which is crucial for geomagnetic storm warnings	$222M mission proposed in FY07 Program Plan	NOSC recommended partnership with NASA through 2013 using DSCOVR satellite and a lower-cost data buy alternative	Solar Wind alternative proposed at $25.5M	$197M

Table 6. Several NOSC Recommendations Resulting in Cost Avoidance.

There are also partnership funding strategies that have led to significant cost avoidance for NOAA, such as NOAA's partnership with EUMETSAT for shared operations of polar-orbiting satellites. EUMETSAT has also acted as a backup for NOAA satellites in cases where the NOAA suite of satellites has been at risk. NOAA also has partnerships with DoD for environmental satellites, which have also led to reduced costs. NOAA and DoD share the same satellite platform thereby significantly reducing the cost to the Nation. In addition, NOAA has partnerships with FAA in the funding and deployment of Next Generation Radar (NEXRAD) and Automated Surface Observing System (ASOS) observing systems, again leading to significant cost avoidance.

NOAA also has very strong ties to the citizens of the Nation with over 10,000 U.S. citizens providing environmental observations to NOAA on a

daily basis, 365 days per year. Using a conservative estimate of one hour a day of voluntary time, valued at the new minimum wage of $7.25/hour, NOAA enjoys a $26M per year cost avoidance through this Cooperative Observer Program.

5.2 Calendar of Activities, Actions, Artifacts, and Work Products

Table 7 presents the annual calendar of actions being taken by NOAA and the Environment Observations segment and the resulting artifacts. Each NOAA step in the process is compared to the FEA performance lifecycle in this Table.

FEA Performance Lifecycle Step	NOAA EA PPBES step	Date	Action Taken	Deliverables/Artifacts
Architect	Planning	January	Program Decision Memorandum (PDM) published. New target architecture developed based on new drivers and fiscal reality resulting from President's Budget	PDM
Architect	Planning	February	Hold stakeholder meetings across the US	Stakeholder comments, meeting minutes. Identification of new change drivers and stakeholders http://www.ppi.noaa.gov/2007_stakeholder_forum.htm
Architect	Planning	February	Update conceptual ERD-Knowledge Model	New Knowledge Model –ERD
Architect	Planning	February	Issue data calls to update observing system architecture database. Identify new or revised requirements	Updated baseline database information available for subsequent planning.
Architect	Planning	February	Issue data calls to update information management system architecture database	Updated database Information Management System information available for subsequent planning.
Architect	Planning	February	Issue data calls to update observational requirements database	Updated database Requirements information available for subsequent planning.
Architect	Planning	February	Hold training sessions for observing, information mgmt system and observational requirements owners on web entry of requested data call information.	Training manuals, CasaNOSA User's Manual
Architect	Planning	March	Annual Planning Phase begins	Memorandums and instructions
Architect	Planning	March	Annual Guidance Memo (AGM) Issued	AGM
Architect	Planning	March	NOAA Program (business) Charters updated to reflect changing business drivers	45 Program Charters with mission requirements validated. Keyed to legislative drivers.
Architect	Planning	March	PART training for selected programs	Training manuals http://www.whitehouse.gov/omb/part/index.html

FEA Performance Lifecycle Step	NOAA EA PPBES step	Date	Action Taken	Deliverables/Artifacts
Architect	Planning	March	Brief Science Advisory Board (stakeholder) on AGM	Briefing materials and stakeholder feedback
Architect	Planning	March	Release Planning Guidance Memo #1, includes preliminary guidance for developing Program Operating Plans (POPs)	Memorandums and instructions
Architect	Planning	March	Updated Business Operations Manual (BOM) Posted	Business Operations Manual
Architect	Planning	April	Updated observing, information management and observational requirements information due	Updated information in database
Architect	Planning	April	Annual update to baseline observing and information management architectures complete	Published updated baseline architecture available
Architect	Planning	April	Architecture Analysis and Reporting tools available for planning	CasaNOSA Analysis System (CAS) tool available for planning
Architect	Planning	April	Final web based data entry forms for POPs are user tested	Web forms and User Manual
Architect	Planning	April	Release Planning Guidance Memo #3	Memorandums and instructions
Architect	Planning	April	Goal leads (business owners) issue guidance to Program Managers for POP preparation	Goal guidance materials
Architect	Planning	April	Release Planning Guidance Memo #3,	Memorandums and instructions
Architect	Planning	April	Final User Manual completed and training materials completed	User's Manual and Training documents
Architect	Planning	April	Release IT Strategic Plan	IT Strategic Plan
Architect	Planning	May	Train NOAA staff on POP preparation	Training course

FEA Performance Lifecycle Step	NOAA EA PPBES step	Date	Action Taken	Deliverables/Artifacts
Architect	Planning	May - June	Prepare POPs	POPs
Architect	Planning	May	Strategic Portfolio Analysis Guidance	Memorandums and instructions
Architect	Planning	June	POP preparation continues	
Architect	Planning	July	POPs completed	Example POP
Architect	Planning	July	NOAA review POPs (business and segments)	NOSC review of observing needs and POP alternatives to meet these needs
Architect	Planning	August	NOAA-wide analysis of POPs for business needs, priorities, following guidance, impacts	NOSC analysis and recommendations
Architect	Planning	August	Councils and Goals review segment architecture vision	Visual segment vision prepared
Architect	Planning	August	Goal leads prepare Strategic Portfolio Analyses	Presentations
Architect	Planning	September	Councils and PA&E review and comment of SPAs	Analysis reports
Invest	Programming	September	Release of Programming Guidance with fiscal targets	Guidance memo
Invest	Programming	September	Draft Business Cases	Draft OMB 300s

FEA Performance Lifecycle Step	NOAA EA PPBES step	Date	Action Taken	Deliverables/Artifacts
Invest	Programming	October	Goals prepare Program Plans	Program Plans
Invest	Programming	November	Program Plans review by Councils, PPI and PA&E	Review comments and reports
Invest	Programming	December	PA&E prepares NOAA Program based on their analysis and all of the Council input	Program Briefs
Invest	Programming	December	PA&E presents NOAA Program to NOAA	Program
Invest	Programming	January	NOAA Administrator submits NOAA Program Decision Memorandum	NOAA Program Decision Memorandum
Invest	Budgeting	February	Budget Released to Congress	Budget
Invest	Budgeting	February	NOAA Administrator briefs stakeholders on budget	Presentations
Invest	Budgeting	February	Budget Guidance based on PDM	Memorandums and instructions
Invest	Budgeting	March	Line Office Budget Reviews complete	
Invest	Budgeting	April	Budget briefing to CFOs and Goals	Presentations and Reports
Invest	Budgeting	April	Begin preparing E300s	
Invest	Budgeting	April	Brief NOAA Administrator on Budget	Presentations
Invest	Budgeting	April	Budget production	Budget
Invest	Budgeting	April	Project managers prepare project plans	Project plans
Invest	Budgeting	May	Issue Budget Decision Memo	Memorandums and instructions
Invest	Budgeting	June	NOAA briefs DOC on budget	Presentations and Budget
Invest	Budgeting	June	NOAA receives House and Senate Marks	Congressional Budget Marks
Implement	Execution	August	Prepare spending plans	Internal spending plans
Implement	Execution	September	Major Project list prepared	Major Projects list
Implement	Execution	September	Annual Operating Plan Guidance issued	
Implement	Execution	September	Prepare Annual Operating Plans	Annual Operating Plans
Implement	Execution	throughout year	Project management plans prepared throughout the year	Project management plans as Identified in segment architecture
Implement	Execution	throughout year	Observing system projects report status via Key Decision Point briefings (KDPs)	KDP briefings

FEA Performance Lifecycle Step	NOAA EA PPBES step	Date	Action Taken	Deliverables/Artifacts
Implement	Execution	throughout year	Quarterly status reports to the NOSC	Status reports
Implement	Planning	throughout year	New technologies and new possible partnerships are presented to the NOSC	presentations and reports
Implement	Execution	throughout year	NOSC staff work with Goals/Programs to evaluate requirements against current and target capabilities	Working sessions and better, more integrated planning

Table 7. NOAA Annual Calendar of Steps Aligned with the FEA Performance Lifecycle.

6. Summary

In this document, we have demonstrated that the NOSA enterprise services segment architecture was developed using a well thought out and organized set of processes that identified and captured strategic and tactical drivers. These processes also trigger the further development and maintenance of the NOSA segment architecture. We have detailed these drivers, provided examples, and provided work products validating these efforts.

We have also shown how NOAA has implemented a common architectural framework for EA and how it has identified its Core Mission Area, Business Services, and Enterprise Service Segment Architectures. NOAA subsequently developed the NOSA segment, maintained this segment, and validated these efforts through its architectural work products/artifacts. We have also shown how the NOSA segment is compliant with the OMB reference models.

We have demonstrated our repeatable process for both internal and external stakeholder collaboration. We have also detailed the repeatable process the NOSC IPT uses for segment architecture development and maintenance and have provided work products detailing meeting presentations, KDP briefings, investment recommendations, meeting minutes, and other work products, many of which are available on the NOSC IPT website.

We have demonstrated in detail the overall NOAA governance process in the NOAA EA document and further described the NOSC IPT relevant governance components in this segment architecture document.

We have implemented and demonstrated the governance and management processes to review and approve solution architectures within the NOSA segment

architecture and shown how the NOSC IPT reconciles its decisions, recommendations, and work products with the NOAA and Department EA.

We have demonstrated the annual, quarterly, and monthly communications and outreach strategies used to educate business stakeholders on the value of the NOSA segment architecture as an element of NOAA's implementation of the FEA Performance Improvement Lifecycle process.

In order to use the enterprise-wide data collected, we have developed an enterprise database, knowledgebase and a set of desktop tools that all segment stakeholders may use to answer business, data, performance or technology questions. We have shown how this information is being used throughout the year to impact architectural decisions.

NOAA believes that when it comes to a model for FEA's Performance Improvement Lifecycle, the NOSA enterprise service segment is probably one of the most mature in the Federal Government. We have demonstrated a continual improvement over the years with considerable cost avoidance, and the segment component of the overall EA PPBES process has had a significant impact on the way NOAA conducts its business.

Appendix A - Business and Technology Questions

Data Management Purpose: Types of business/mission related queries:

- List and sort all data management systems by formats used? Metadata used? Access methodologies? Where are products archived? Expected growth of data, communications, and CPU.
- What are the O&M costs of all of NOAA's data processing systems? Communications lines? Web servers?
- Which NOAA programs have identified a gap in their data management capabilities? What is the gap and what is the cost?
- What are the current network components of NOAA's data management systems?
- Show me all components and personnel of any OMB 300 business case.
- Display all product generation systems owned by a particular office, goal, or program.
- What data management systems are supporting the requirement driver: Disaster Relief and Emergency Assistance Act?
- How much is NOAA spending on data assimilation?
- What products are supporting any of NOAA's performance objectives?
- What data management systems are associated with each NOAA strategic goal or expected outcome or program performance measure?
- Display the NOAA locations that have operational web servers.

IT Purpose: Types of IT business/mission related queries:

- What is the current C3 architecture for NOAA's geostationary satellites?
- Show me all IT components and personnel of any OMB 300 business case.
- Display all product generation systems owned by a particular office.
- Display all communications lines between Boulder and Washington, DC, and their recurring costs.
- What IT systems are supporting the requirement driver: Disaster Relief and Emergency Assistance Act?
- How much is NOAA spending on helpdesks, software maintenance, or web server support?
- What data processing systems are associated with each NOAA strategic goal or expected outcome or performance measure?
- What IT systems are addressing the Business Reference Model 'Environmental Management'?
- Display the geographic coverage of NOAA's communications lines.
- Display the NOAA locations that have operational web servers.
- Provide an Excel spreadsheet of all of NOAA's Technical Reference Model service areas.
- What are the O&M costs of all of NOAA's data processing systems?

Appendix B - NOSC Terms of Reference

Purpose

The Observing System Council is the principal advisory body to the Under Secretary for NOAA's Earth observation and integrated data environment (end-to-end collection, processing, storage, archiving, accessing, and disseminating) activities. It also serves as NOAA's principal coordinating body to the White House Committee on Environment and Natural Resources (CENR) Subcommittee on Earth Observations (USGEO). Specific tasks include:

- Provide recommendations to the NOAA Executive Council (NEC) on observation and data management requirements, architectures, and investments to meet NOAA, national, and international observing needs.
- Oversee the work of the NOSC Staff, providing guidance in the development of the NOAA Integrated Global Earth Observation and Data Management System.
- Work with local, state, regional, national, and international partners to develop global-to-local environmental and ecological observation and data management systems for comprehensive, continuous monitoring of coupled ocean/earth/ atmosphere/land domains.

Membership

Co-Chairs: NOAA Satellite and Information Services Assistant Administrator
NOAA Weather Services Assistant Administrator

Executive Secretariat and Contact Person: NOSC Staff

Principals

Senior representatives from NOAA:

Chief Financial Officer (CFO)
Chief Information Officer (CIO)
National Environmental Satellite, Data, and Information Service (NESDIS)
NOAA Office of Marine and Aviation Operations (NMAO)
National Marine Fisheries Service (NMFS)
National Ocean Service (NOS)
National Weather Service (NWS)
Office of Oceanic and Atmospheric Research (OAR)
Program Analysis and Evaluation (PA&E)
Program Planning and Integration (PPI)
NOAA GEOSS Integration Manager

Non-Voting Members

NOAA Mission Goal Leads:
- Climate
- Commerce and Transportation
- Ecosystems
- Water and Weather

NOAA Mission Sub-Goal Leads
- Fleet Services
- Leadership and Corporate Services
- Homeland Security
- Modeling and Observing Infrastructure
- Satellite

Advisor

Director, NOSC Staff

Committees/Teams/Working Groups

The Council may form committees, teams or working groups (WG) to achieve specific tasks. Such committees/teams/WG may include persons who are not Members of the Council, but the Council will seek to include a Council Member on all committees. The NOSC may designate either standing or ad hoc committees/teams/WG. Committees in turn may establish teams or WGs. An example of a standing committee is the Data Management Committee (DMC).

Committees will use the same decision making process followed by the Council. The Council may terminate committees/teams/WG at it discretion.

Roles and Responsibilities

Council

- Participate in the planning and programming phases of the annual PPBES cycle to foster a NOAA Program that advances NOAA's efforts in efficiently and effectively developing an integrated global earth observation and data management system
- Provide corporate oversight of the NOSC Staff
- Establish observation and data management system investment policy
- Review observation and data management systems requirements
- Identify gaps between NOAA observation and data management requirements and capabilities
- Review architecture alternatives
- Analyze architecture alternatives and risks

- Recommend acquisition of appropriate observation and data management systems to meet NOAA, national, and international observing architecture requirements
- Maintain cognizance over NOAA observation and data management systems activities while coordinating NOAA participation in national and international Earth observation efforts (e.g., US Group on Earth Observations (USGEO))

Members

- Attend council meetings
- Identify line office points of contact for interaction with the NOSC Staff

Meeting Frequency: Meetings are held at least monthly.

Decision Making Process

Decisions will normally be reached by consensus. The Co-Chairs will strive for consensus on every issue, but maintain 51% of the vote. Therefore, the Co-Chairs make the final decision when consensus is not achieved.

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Appendix C - An Example Project Plan Table of Contents

Critical Infrastructure Protection (CIP)
Project Management Plan (PMP)

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