NOAA High Performance Computing

Strategy and Roadmap

June 25, 2004

Version 1

Acronyms Listing

COMF	Coastal Ocean Modeling Framework
CO - OPS	Center for Operational Oceanographic Products and Services
CIO	Chief Information Officer
CSDL	Coast Survey Development Laboratory
DoD	Department of Defense
DoE	Department of Energy
EMP	Environmental Modeling Program
ESMF	Earth System Modeling Framework
FSL	Forecast Systems Laboratory
FSM	Flexible Modeling System
GFDL	Geophysical Fluid Dynamics Laboratory
GFS	Global Forecast System
GPRA	Government Performance Results Act
HPC	High Performance Computing
IT	Information Technology
NCEP	National Centers for Environmental Prediction
NEC	NOAA Executive Council
NEP	NOAA Executive Panel
NESDIS	National Environmental Satellite, Data, and Information Service
NMFS	National Marine Fisheries Service
NAO	NOAA Administrative Order
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NWS	National Weather Service
OAR	Office of Oceanic and Atmospheric Research
PA & E	Program Analysis and Evaluation
PMWG	Performance Management Working Group
PPBES	Programming, Planning, Budgeting, and Execution System
R & D	Research and Development
SMS	Scalable Modeling System
SON	Statement of Need
SREF	Regional Ensemble
WRF	Weather Research and Forecast Model

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1 Problem Statement

In the fall of 2004, the National Oceanic and Atmospheric Administration (NOAA) High Performance Computing (HPC) program identified five areas of concern that needed to be addressed in order for the program to move forward and become more successful. The HPC program needed to:

- Develop a “holistic” approach to identifying HPC architectural alternatives.
- Establish a consistent process for identifying, prioritizing, and satisfying individual HPC requirements.
- Develop an ability to identify the efficiencies and inter-operabilities of NOAA’s HPC resources.
- Decrease both the time and level of effort required to migrate outputs from research to operational environments.
- Develop a backup strategy to support critical HPC functions.

2 NOAA HPC Goals

The NOAA HPC program has identified two high-level goals to achieve along with corresponding strategies to execute. NOAA must achieve these goals in order for the HPC program to be successful.

2.1 Instill a Strategic “One NOAA” View

- Establish seamless partnerships between offices, labs, centers, and external groups so that NOAA shares HPC resources to cost effectively meet national and NOAA needs.
- Make decisions regarding the use of HPC resources in response to NOAA requirements.
- Build partnerships between the Chief Information Officer (CIO) and programs with a strong customer focus.
- Share HPC resources across programs and line offices.
- Define and articulate a coherent NOAA strategy to drive the HPC program.
- Clearly articulate the vital service NOAA’s HPC program provides to the nation.
- Identify the role of the HPC cyber infrastructure in supporting NOAA’s mission.
- Look for products, solutions, and partnerships outside of NOAA.
- Advocate NOAA HPC requirements to the broader Federal community.

- Show direct support and linkage of HPC resource usage to the NOAA Mission Goals.

2.2 Be effective and efficient

- Identify measures of success so that NOAA HPC can articulate its success to others.
- Define and document the HPC architecture.
- Improve efficiency and effectiveness of allocating financial resources.
- Implement an HPC architecture that ensures the application of appropriate technology to accomplish NOAA's mission.
- Establish an interoperable HPC infrastructure.

3 NOAA HPC Strategic Principles

The NOAA HPC strategic principles guide the HPC Board and HPC practitioners in making consistent decisions in support of NOAA's mission. These overarching principles govern all other principles in HPC architecture, technical functions, and daily operations. The HPC Board has adopted and implemented the following principles:

- All NOAA HPC resources are managed holistically as a corporate asset.
- NOAA HPC decision making process is inclusive, open, consistent, and fair.
- NOAA HPC requirements come with funding through the PPBES.
- NOAA strives for the best return on investment when acquiring HPC resources.
- NOAA HPC uses best practices and does not reinvent the wheel.
- NOAA explores and develops the use of new and innovative HPC technology to advance its mission.
- NOAA leverages external resources when beneficial to its mission.

The strategic principles and their associated rationales and implications can be found in Appendix A of this document.

4 HPC Spiral Methodology

The Roadmap team stressed that making NOAA HPC optimally efficient will take multiple iterations of improvements – a "spiral advance" (see Figure 1.) These iterations should occur in synch with the Programming, Planning, Budgeting, and Execution System (PPBES).

The enormity and complexity involved in making substantive changes to the HPC program requires a consistent and cyclical approach. It is not practical merely to address one problem at a time until that problem has been solved. The spiral approach mitigates risk in complicated problem solving by rapidly solving problems of limited scope. It has two main distinguishing features:

- It is an iterative approach for incrementally refining a system's definition and implementation while decreasing risks.
- It is milestone-driven while ensuring stakeholders' commitment to a feasible and mutually satisfactory system solution.

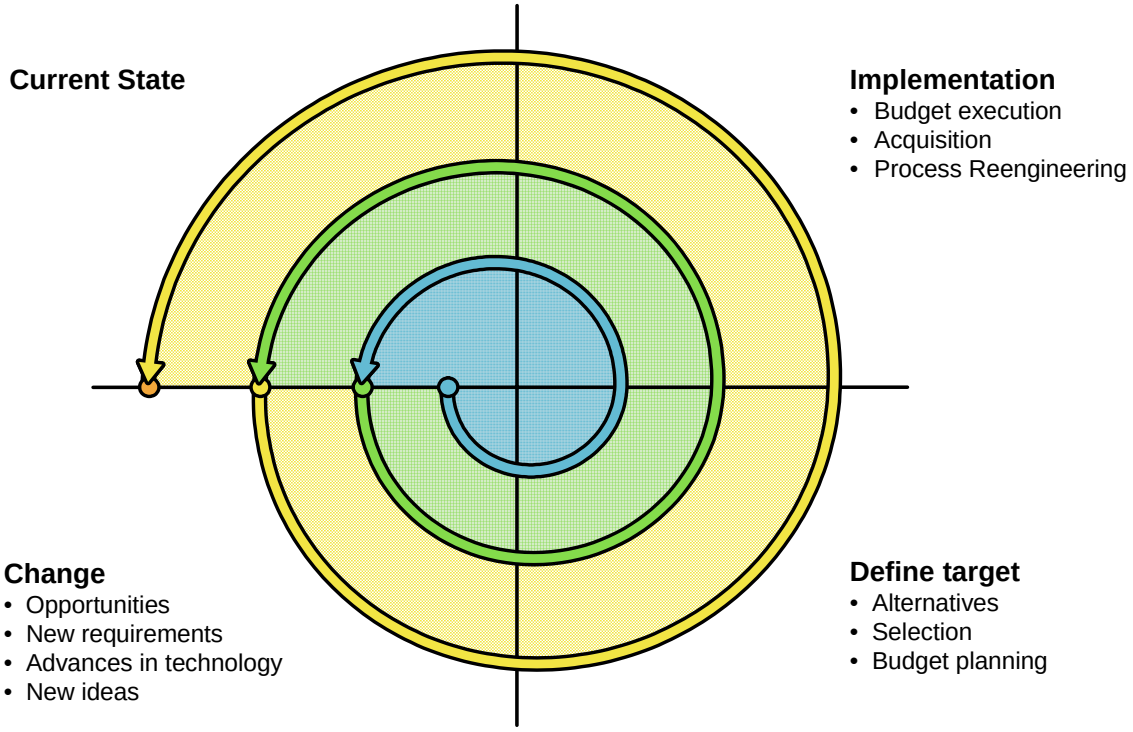


Figure 1: The HPC Strategy is based on a spiral advance.

The HPC Board has completed several activities in the first iteration through the spiral. These were in the areas of:

- Value chain – Developed a line of sight from NOAA Mission Goals to HPC activities, see Appendix B.
- Strategic principles – Developed a set of NOAA HPC strategic principles that guide the HPC Board in making consistent decisions in support of NOAA's mission, see Appendix A.
- Governance – Outlined preliminary governance activities for the NOAA HPC Board and HPC stakeholder activities, see Appendix C.
- Acquisition strategy – Developed an acquisition strategy for NOAA HPC, see Section 5.4 and 7.

- Roadmap – Created a Roadmap to guide the future of NOAA HPC, see Section 7.

Figure 2, below, depicts the initial "Roadmap" the Board followed. The remainder of this document provides more details on the Board's initial findings, HPC strategy, and planned spiral improvement of NOAA's HPC management effectiveness and efficiency.

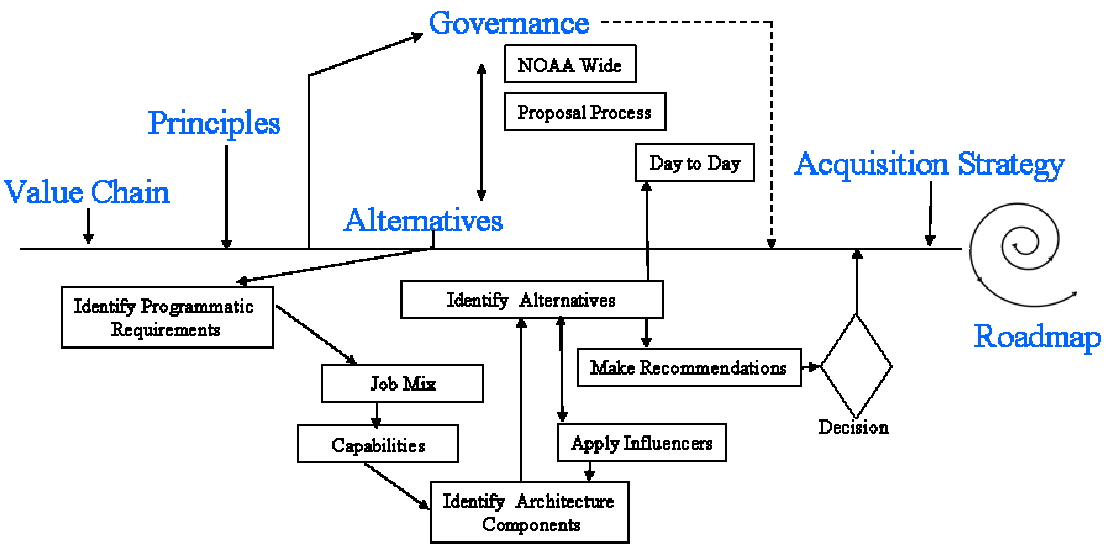


Figure 2: The Board used a simple Roadmap to make its first iteration of developing NOAA's HPC Strategy.

5 HPC Strategies

The Board has settled on four strategies that it will pursue and enhance through spiral development to enable NOAA HPC to achieve its vision. These include:

- Integrated Management
- Requirements Management
- HPC Architecture Management
- Acquisition Strategy

The CIO and HPC Board will use the draft performance measures discussed in Section 6 to manage NOAA HPC and evaluate the effectiveness of the HPC strategies.

5.1 Integrated Management

Integrated management is the strategy for building and maintaining a strategic one-NOAA view that promotes effective and efficient use of HPC resources. The NOAA CIO plays an active role in planning, establishing, and overseeing the integrated

management. The HPC Board is the primary body responsible for overseeing the implementation of the HPC strategies and their integration into the programs. The Terms of Reference for the HPC Board is in Appendix C of this document.

5.1.1 Refine roles and responsibilities

As part of building the governance structure for HPC, the Board identified initial roles and responsibilities that will help close the gaps and improve the effectiveness and efficiency of HPC's contribution to the NOAA mission. The Board plans to work with other NOAA stakeholders to refine these roles and activities through an iterative and consultative process. The plan calls for the following high-level roles and responsibilities with respect to the requirements process.

5.1.1.1 NOAA CIO

- Sets minimum standards for the integrity, quality and consistency of the requirements analysis

5.1.1.2 NOAA HPC Board

- Supports iterative development of requirements with Goal Teams
- Reviews validated HPC requirements and recommends (as needed) implementation alternatives, including facilitating mission level integration of requirements
- Identifies funding shortfalls and inconsistencies and staff capacity limitations
- Oversees integration of technical requirements and solutions
- Supports innovative solutions to accommodate requirements
- Allocates requirements to the appropriate HPC resource
- Works with the NEP/NEC to resolve any requirements priority issues
- Communicates changes in the NOAA HPC environment
- Facilitates process improvement to promote the collection of well-defined, accurately costed, well-integrated, end to end requirements that can be acted upon and monitored during the budget execution phase
- Ensures that NOAA HPC activities are consistent with NOAA business and program models as well as the Federal Government High-End Computing best practices

5.1.1.3 Program Analysis and Evaluation (PA&E), Programs & Mission Leads

- Develop, prioritize, and validate actionable mission and functional requirements (with awareness of associated capacity and performance requirements)
- Provide adequate program funding for requirements
- Communicate future expectations, strategic thinking, and operational considerations
- Provide guidance on out-year program funding adjustments for HPC

- Clarify and make recommendations regarding inconsistencies between requirements and available funding
- Participate in process improvements to promote the collection of well-defined, accurately costed, well-integrated, end to end requirements that can be acted upon and monitored during the budget execution phase

5.2 Requirements Management

Requirements, as used in this document, are the current and estimated future needs of NOAA's programs for use of the HPC resources to deliver NOAA's mission goals. NOAA's mission requirements drive the management of NOAA's HPC.

5.2.1 Requirements overview

Requirements exist at many levels of detail, starting with the high level, mission requirements, like the capability to predict weather using modeling techniques. These mission requirements can be further detailed to include the lower level functional requirements. For example, in order to predict weather, a particular model might need to be run at some frequency, with a set level of predictive skill, and model output available at a given service level. In turn, the functional requirements drive technical requirements used to estimate the full cost of required hardware, software, communications, and other services to fulfill the mission and functional requirements. In total, the HPC requirements are a portfolio of business needs that are met by HPC resources and drive their upgrade and modification.

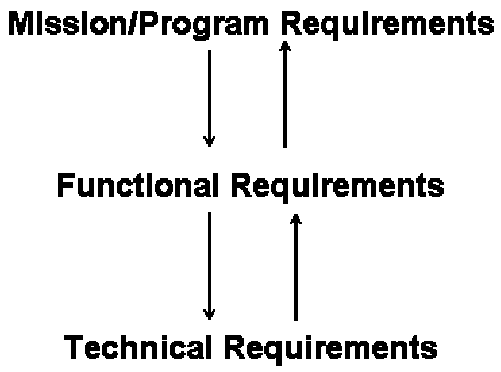


Figure 3: NOAA HPC Requirements Hierarchy

5.2.2 NOAA HPC Program Outcomes

The NOAA HPC program is housed within the Environmental Modeling Program (EMP) and exists to support the EMP outcomes and NOAA's mission outcomes. NOAA HPC assists the Environmental Modeling Program in delivering trusted, timely, accurate environmental assessments and predictions through next-generation models that are:

- *Integrated* – based on a "whole-earth" system and broad range of applications.

- *Interoperable* – linked through architecture, and across multiple, geographically distributed HPC Centers.
- *Driven* - support all NOAA service areas.
- *Accessible* – supported and available to entire community; able to link the nation's science advances to NOAA's mission.

NOAA HPC will support the following NOAA mission outcomes:

- *Weather and Water Outcome:* Enhance weather and water prediction through interdisciplinary modeling, and ability to expand scope of predictions (e.g. air quality, harmful algal bloom, on demand hazards runs.)
- *Climate Outcome:* Improved seasonal to interannual diagnosis and prediction; additional IPCC scenario runs.
- *Ecosystem Outcomes:* New Research and Development (R&D) architecture will make extensibility to Coastal and Ocean ecosystem modeling feasible.
- *Commerce and Transportation:* Extremely high resolution weather and coastal models critical to aviation, roadway transportation, and navigation.

In order to support the mission and functional outcomes above, NOAA HPC must have a strategic process to manage mission and functional requirements that flow from these outcomes. This process must be tightly linked to the supporting technical requirements, in order to achieve NOAA's mission more effectively and efficiently. Strategic planning and efficient use of HPC resources requires coordination between requirements owners and the HPC Board to produce consistent and actionable requirements.

5.2.3 Actionable requirements

An actionable requirement is one that describes the business or mission need such that it can be used to effectively plan and execute. An actionable requirement:

- Defines the business case for meeting the requirement.
- Can be evaluated objectively, i.e. using some quantitative validation method to measure the degree to which the requirement has been met.
- Contains enough detail to allow designers to meet it.
- Allows derivation of meaningful estimates of HPC resource requirements, i.e. capacity and performance.
- Allows for a 'line of sight' from the strategic goal it supports, through the high level requirement's business value to execution of an individual computer job (or series of jobs.)
- Is fully defined through mutual agreement between the requirement owner and the HPC implementer that considers cost, resources, internal priorities, and other relevant considerations.

5.2.4 The Evolution of Requirements at NOAA

Prior to the FY04 budget cycle, each HPC center collected their own requirements, managed them, and implemented them on their respective systems (see Figure 4.) The stove-piped requirements process resulted in a stove-piped HPC architecture, which was effective and efficient when viewed in its piece parts.

Figure 3: NOAA's HPC requirements have been historically

The FY06 PPBES process began the approach of collecting a NOAA-wide set of business requirements through the EMP budget submission. This represented a major shift from organization-centric requirements to mission goal and outcome-based requirements, a major goal of both NOAA management and the HPC Board (see Figure 5.) Further, the HPC Board's analysis of the current requirements and operations confirmed that the current models and applications running on the HPC assets have a direct line of sight to NOAA's mission goals.

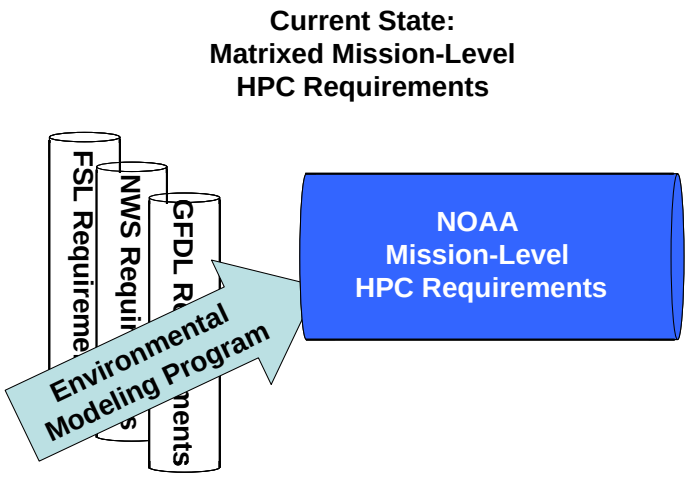


Figure 3: NOAA's current state is a matrixed set of NOAA-wide, mission level, HPC requirements.

5.2.5 Current Requirement Process Gaps

During its review of current requirements and ongoing HPC resource usage, the Board identified important requirements process gaps that it will address through its iterative roadmap activities.

1. The current requirements process manages requirements as a matrixed set of stove-piped requirements rather than as a coherent, NOAA-wide portfolio.
2. Requirements are documented at a high level, but not in ways that make them transparently actionable or allow integration among business lines at the mission level.
3. Requirements documentation does not create a line of sight from a high-level requirement to day-to-day management of HPC resources. Consequently, there is no documentation to fully support NOAA's goal of maximizing the effectiveness and efficiency of HPC resources through oversight and planning.
4. Individual business requirements occasionally lack precision in terms of their incremental improvement over a baseline (tied to the Government Performance Results Act (GPRA) if possible.)

In addition to the above gaps, the Board identified several other needs that should be addressed in the Board's future work:

- Service level agreements at appropriate levels between HPC Providers and HPC Resource consumers (e.g., at the program level between the HPC Board and the program managers, or at the individual level between HPC center management and HPC users.)
- Improved communication between HPC data providers, modelers, and archival partners (within and between organizations) to identify appropriate interfaces and coordination points.

- Better outreach by HPC providers to the broader NOAA community is needed to build technical plans and communicate opportunities.
- Improved support / coordination by information technology (IT) professionals needed in costing and sizing future requirements, including:
    - A capability and supporting infrastructure to execute projects quickly in response to new requirements.
    - An improved methodology to estimate NOAA's applied research requirements.
    - Improvement of the end-to-end planning and coordination, analogous to the new NOAA Administrative Order (NAO) policies for data management.

5.2.6 Requirements roadmap vision

In future PPBES processes, the Board plans to support requirements definition with improved tools and templates that help program staff translate mission requirements in to functional requirements (e.g., the types of models to be run, number of runs, etc.)

In turn, the Board will coordinate technical guidance to translate functional requirements into the technical requirements (e.g., in terms of computing capacity, input/output processing requirements, memory, communications, and storage required.) This will form the basis for the 100% Requirement and required budget. The documentation will also provide the basis for a line of sight from mission level requirement to HPC job mix, including budget linkages, as well as mechanisms to understand the end-to-end linkages among requirements.

The HPC Board will support the goal teams, program managers, and PA&E staff in coherently scoping and documenting NOAA's business requirements. It will also support them in providing technical options for meeting the requirements as well as advice on issues related to budget and requirement tradeoffs or prioritization. The programs are responsible for prioritizing and fully funding their requirements. The Board will review the requirements to ensure that the budgets are sufficient and that the HPC architecture can support the planned activities. Program managers and goal teams manage mission prioritization issues, resolved, if necessary, by the NOAA Executive Council (NEC) or NOAA Executive Panel (NEP) (see Figure 6.)

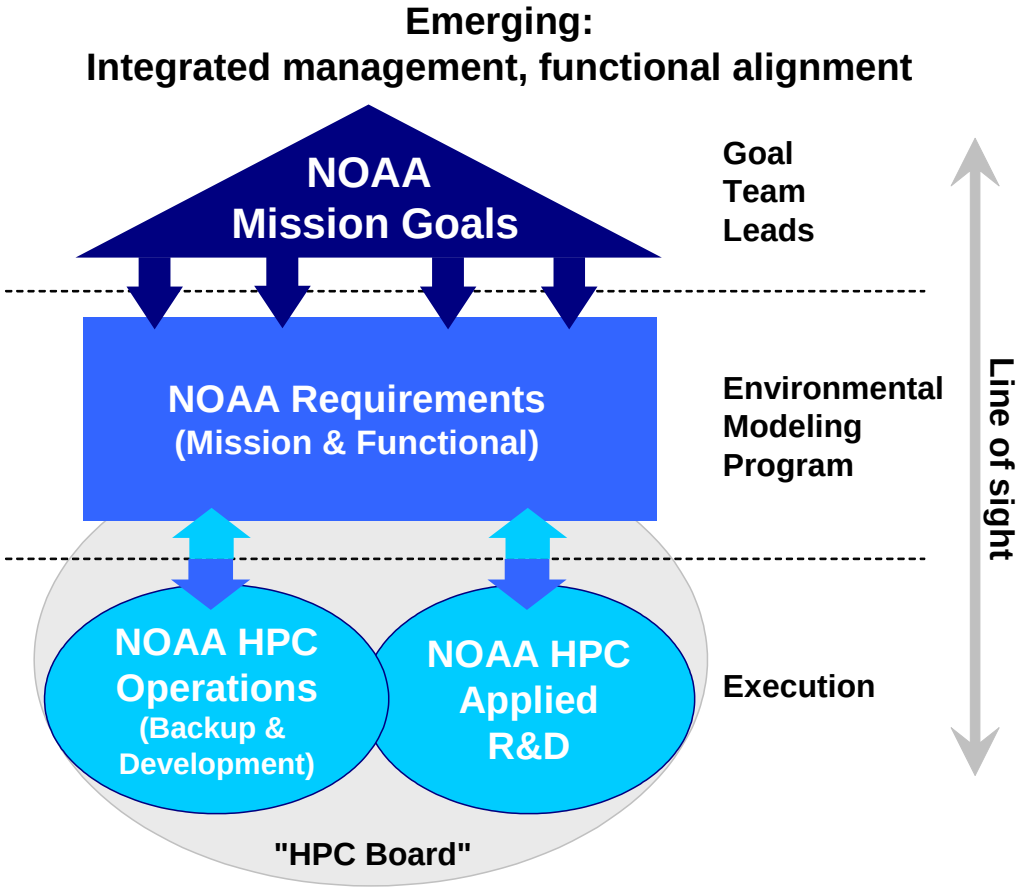


Figure 4: NOAA mission level requirements will be managed day to day according to service level, with oversight by the HPC Board.

5.2.7 Requirements execution and resource management

One of the conclusions drawn from the work of the Board's evaluation team was that a NOAA level HPC resources management process could provide improved technical coordination of the R&D environments. Improved requirements planning, documentation and line of sight will enable more efficient and effective evaluation of the use of HPC resources and will improve technical coordination. The Board plans to establish more effective processes for obtaining management information related to HPC activities to

assist NOAA programs and day-to-day HPC managers in applying priorities transparently.

Mission level requirements already connect to the budget through the PPBES process. One of the next steps is to provide budget visibility into lower level HPC resource allocations.

The Board is not responsible for day-to-day allocation of HPC resources, which is more efficiently and effectively managed at the HPC centers. However, the Board oversees the use of HPC resources and promotes policies to assure that the HPC architecture is used most efficiently. Accordingly, the Board will develop and receive periodic management reports from each HPC center.

Creating this capability will require improvements in the requirements definition and execution processes in order to establish the reporting link between mission level requirements and day-to-day computing jobs. Developing and maintaining the capability to capture and report this valuable management information will require time and additional human, technical, and financial resource inputs.

5.3 HPC Architecture Management

NOAA architecture management is largely driven by NOAA requirements (although new capabilities enabled by more effective and efficient architectures may also inform the strategy.)

5.3.1 Principle-driven: One NOAA

The HPC architecture exists to meet NOAA's approved business requirements. The mission of the Board is to design an architecture that embodies the first HPC Principle:

All NOAA HPC resources are managed holistically as a corporate asset.

Rationale: Managing holistically allows NOAA HPC to best align the use of HPC resources to NOAA's mission and better achieve economies of scale.

Implications:

- There are no HPC planning or allocation constraints based on NOAA organizational structure (no stovepipes.)
- NOAA HPC resources belong to NOAA, not to specific line offices.
- The NOAA HPC Board widely considers multiple NOAA-wide options for meeting specific requirements and selects the option that is in the best interest of NOAA *(Note: this may need revision based upon decisions regarding NOAA HPC management.)*
- The status quo HPC management structure will change.
- NOAA HPC management uses NOAA-wide language when referring to HPC resources.
- HPC related decisions and day-to-day management activities increasingly reflect a NOAA-wide perspective and capability.

5.3.2 Functionally-Driven Architecture (vs. organizationally-based)

In accordance with the first HPC principle, the Board reviewed the existing business requirements and categorized them in functional, rather than organizational terms. The Board identified two distinct functional requirements for HPC:

- Operations
- Applied Research & Development

Operations functions are those that meet a specific and customer-focused product delivery schedule. As such, these do not apply only to the traditional Weather Service operations, but may also apply to certain climate production runs, satellite data processing, and other modeling efforts that meet the expanded definition. The Backup capability exists to support the Operations function due to its mission-critical and time sensitive nature. There will soon be two "operational sites," the main site in Maryland and the physically separated Backup in West Virginia.

Applied Research & Development functions are those that support the improvement of scientific understanding, support initial efforts to improve existing operational models, develop new modeling concepts and products, improve assimilation and evaluation of new observational data, and other activities designed to speed the transfer of applied research to operational use. NOAA's Applied R&D sites are located in Colorado, New Jersey, and Maryland.

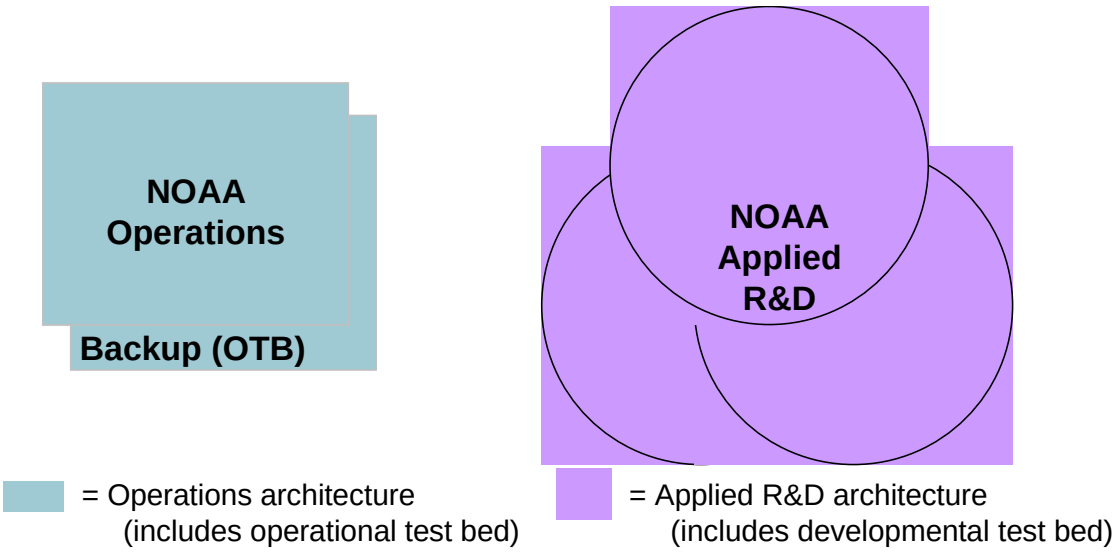


Figure 5: Functional requirements drive two architectures

These architectures will support an Operational Test Bed and Developmental Test Bed, based on the Weather Research and Forecast (WRF) model project. The Developmental Test Bed allows the NOAA R&D community to test code to ensure that it meets interoperability standards. Applied R&D will have technical overlaps enabled by the new one-NOAA architecture, and will probably maintain a heterogeneous architecture that supports external partnering and the use of hardware independent frameworks. For

example, WRF already has several microphysics parameterizations and NOAA is running a DTB for coupled models (and their components) based on the Flexible Modeling System (FMS), prototype models based on the Earth System Modeling Framework (ESMF), and tests of the Forecast Systems Laboratory's (FSL) Scalable Modeling System (SMS) on the Origin platform. In addition, NOS models are being designed within the standardized Coastal Ocean Modeling Framework (COMF).

With the right networking in place, this interoperable Applied R&D system has the potential for improved allocation efficiency due to applications being location independent. The strategy also provides the ability to reprioritize requirements in the event of a system failure and still meet NOAA's highest priority needs.

The Operational Test Bed runs only code that will be run operationally. Using an architecture for the Operational Test Bed that is similar to the eventual operational environment will help speed the transition from R&D to operations. The backup computer in Fairmont is perfect for this purpose because its configuration is nearly identical to the main operational platform.

5.3.3 Architectural efficiency

A critical outcome of this functional architecture is the potential savings that can be achieved by paying for only necessary capabilities. For example, the operations functions must maintain a 99.9% reliability, which costs more than the 96% reliability that Applied R&D requires. By purchasing only the reliability needed for R&D, more processing power may be available for the same dollars than in the current environment. The value of this efficiency will become known during the planned functional acquisition.

5.3.4 Site efficiency

In December 2003, the HPC Board chartered a team including representatives from all NOAA R&D and satellite organizations to evaluate short term opportunities and provide results in March 2004. The team focused on any benefits created by physical consolidation (i.e. reducing the number of HPC sites). The team looked at NOAA resources from a functional point of view, not an organizational view.

The team developed ten site location alternatives and provided cost and other analysis data for each alternative to the HPC Board. The team considered the following elements when developed the cost profiles:

- Facilities
- Local support infrastructure at remote sites
- Communications
- Risk adjustments

The team found that the consolidation costs of increased build out and telecommunications far outweighed the potential overhead cost savings that might result from a smaller number of sites. The study did find significant potential cost savings associated with relocating sites from commercial space to less expensive, government - owned space.

5.4 Acquisition

NOAA's acquisition goal is to achieve ***economies of scale*** in conducting its acquisitions

while providing ***maximum flexibility*** in the resulting contract document.

5.4.1 Economies of Scale

NOAA may achieve economies of scale in several ways, but the underlying theme is consolidation of procurements. Consolidating requirements into fewer acquisitions will help NOAA obtain "more bang for the buck." Consolidating requirements should be viewed as a phased process, starting with consolidating NOAA requirements along functional lines rather than organizationally. Longer term, consolidation might include collaborating with other government agencies to leverage their economies of scale.

NOAA's best current alternative is to consolidate requirements internally and award two contracts broken down by functional area. One contract will cover operations & backup (with an option to include R&D.) A second contract will consolidate NOAA's R&D computing requirements (with an option to include operations.) This maximizes the expected value from consolidation by minimizing schedule risk, reducing bid complexity, and maximizing contract flexibility. Uncoupling time sensitive operational requirements from the R&D acquisition reduces schedule risk. Two contracts also reduce bid complexity, increasing the odds of a positive outcome from the bidding. Finally, the options allow increased flexibility and government leverage during the contract management phase.

A longer-term alternative for achieving economies of scale is to apply the same concepts used in internal consolidation to collaborate with other government agencies in HPC resource acquisitions. Collaborating with agencies such as the Department of Energy (DoE) and Department of Defense (DoD) could result in significant cost benefits to NOAA. The possible downside is NOAA may no longer be in control of the contract vehicle, but rather be a customer of the larger agency. However, should interagency details be negotiated that are favorable to NOAA, the benefits could outweigh the loss of flexibility.

5.4.2 Maximum Flexibility

Another goal of the HPC acquisition strategy is to obtain maximum flexibility in the contract documents. For the most part, NOAA's HPC contracts have failed to include any contract options with which to add additional capability for new, unanticipated requirements. Future NOAA HPC contracts should be broad enough in scope and have sufficient reserve capability (contract ceiling) to accommodate both existing and foreseeable requirements. The ability to provide this contract flexibility starts with properly scoping NOAA's requirements in functional rather than organizational terms.

6 Performance Measures

As part of the overall integrated management of HPC resources, the Board has developed a draft set of performance measures.

6.1 Introduction

The NOAA HPC Board developed draft performance measures in the context of NOAA's Measurement Pyramid, approved by the Performance Management Working Group (PMWG) on 8/6/03 (see Figure 8.)

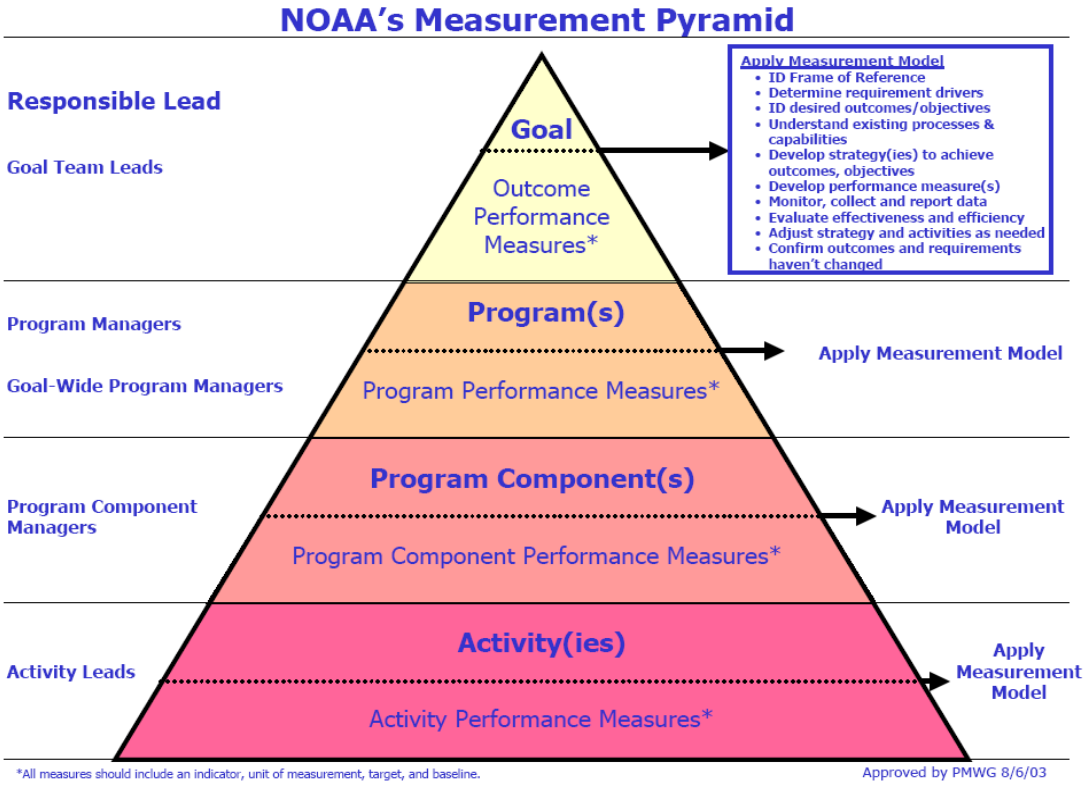


Figure 5: NOAA HPC Board has build performance measures using the NOAA Measurement Pyramid Model

The HPC Program is a Program Component of the Environmental Modeling Program and should be viewed in that frame of reference.

The Environmental Modeling Program performance measures are reproduced and categorized into four types of outcome or output (see Figure 9.)

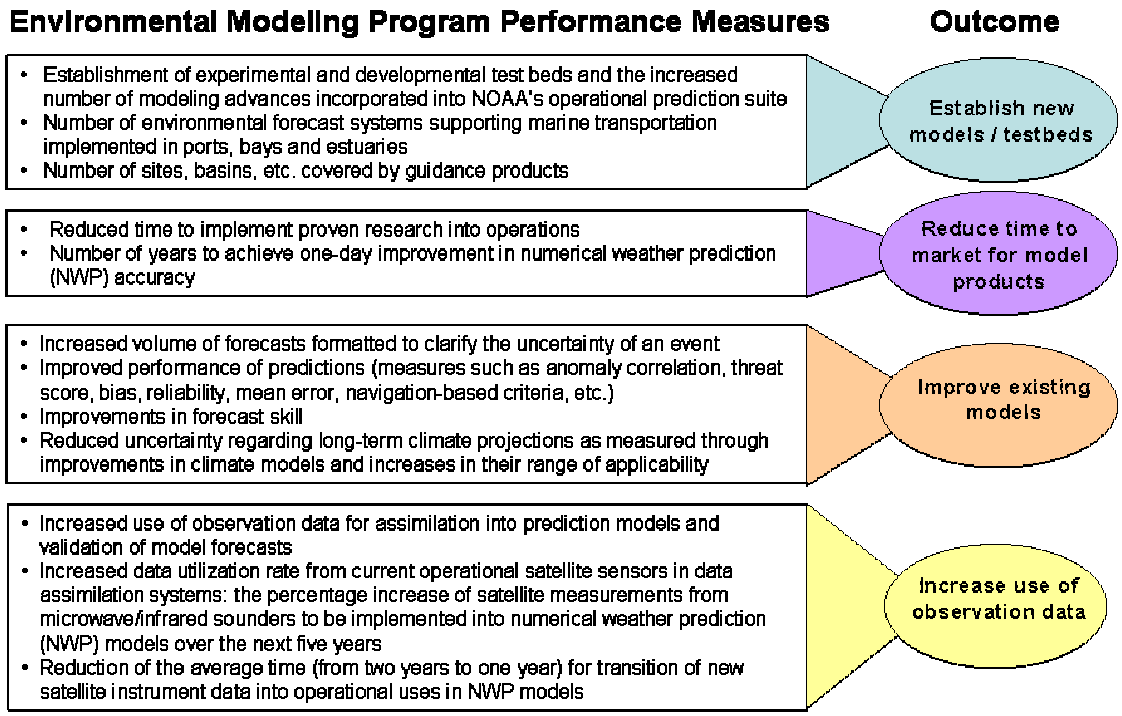


Figure 6: Environmental Modeling Program performance measures aim to achieve four outcomes.

6.2 HPC Performance Linkage to Environmental Modeling

The HPC Board drafted performance measures to track and report Management Effectiveness and Cost Effectiveness outcomes.

- Achieving Management Effectiveness target outcomes will improve the manner in which HPC resources are applied to support the NOAA-wide Environmental Modeling outcomes. This will support increased cost efficiencies, and management of HPC resources to reduce time to market, improve existing models and increase use of observation data.
- Achieving Cost Effectiveness targets will support the EM Program by enabling more EMP outcomes to be pursued for the same inputs. This will provide EMP with greater HPC resources to establish new models/testbeds, reduce time to market and improve existing models.

These relationships are mapped in Figure 10 below.

6.2.1 NOAA HPC Performance Measures

The NOAA HPC Board has initially developed the following performance measures to gauge strategic implementation effectiveness. As part of the next steps in the HPC Roadmap, the Board will validate the performance measures, establish routine collection means and define baseline and target measures. Finally, the Board will implement collection, tracking and reporting mechanisms.

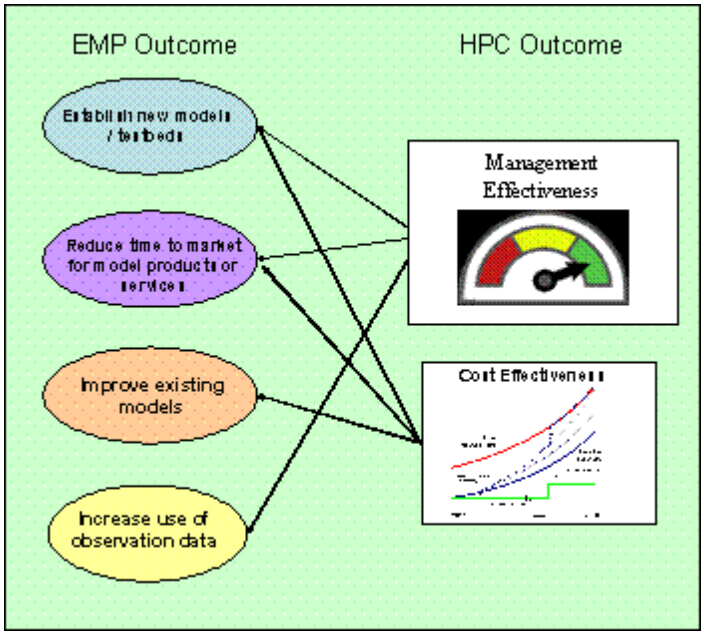


Figure 10: HPC performance measures are designed to support Environmental Modeling outcomes, a key to achieving NOAA's mission.

6.2.1.1 Management Effectiveness

Management Effectiveness measures answer the question, “How well are HPC resources being managed in service of NOAA goals?”

Degree of Mission Support

Indicator – Percent of “NOAA 100% Requirement” being met (see Figure 11.)

Unit of Measure – Processing Capacity

Baseline – TBD

Target – TBD

Strategic Linkage

Indicator – % of HPC job resources with line of sight through requirements to NOAA’s mission

Unit of Measure – Cost of HPC jobs with linkage / Cost of HPC

Baseline – TBD %

Target – 100%

Customer satisfaction

Indicator – Satisfaction of HPC system users

Unit of Measure – User response on a scale of 1-5 on key parameters of satisfaction.

Baseline – TBD

Target – TBD

Indicator – Satisfaction of new or small HPC system users

Unit of Measure – User response on a scale of 1-5 on key parameters of satisfaction, including: level of effort required to begin using HPC (for first-time users); and ease of use to meet a relatively small, new requirement

Baseline – TBD

Target – TBD

Indicator – Satisfaction of HPC product consumers

Unit of Measure – Consumer response on a scale of 1-5 on key parameters of satisfaction

Baseline – TBD

Target – TBD

Indicator – Satisfaction of HPC procurement customers with flexibility and responsiveness of NOAA contract vehicle(s).

Unit of Measure – User response on a scale of 1-5 on key parameters of satisfaction

Baseline – TBD

Target – TBD

Code Portability

Indicator – % of codes that have been run on multiple platforms within past year (increasing potential for cross-platform scheduling efficiency.)

Unit of Measure – Code packages that have run on multiple platforms within the past 12 months

Baseline – TBD

Target – TBD

Software development efficiencies

Indicator – Number of modeling frameworks

Unit of Measure – Modeling framework

Baseline – TBD

Target – TBD

Value of external partnerships

Indicator – The number of external partners whose energy leveraged in support of NOAA's mission accomplishment through use of HPC resources.

Unit of Measure – Number of users of NOAA HPC, working on NOAA's problems, who are not employed directly by NOAA.

Baseline – TBD

Target – TBD

6.2.1.2 Cost Effectiveness

Cost effectiveness measures answer the question, "How efficiently is the HPC asset being provisioned and managed?"

Cost effectiveness

Indicator – Cost to meet 100% Requirement

Unit of Measure – Dollars

Baseline – Current HPC Budget (based on Moore's Law curve)

Target – TBD

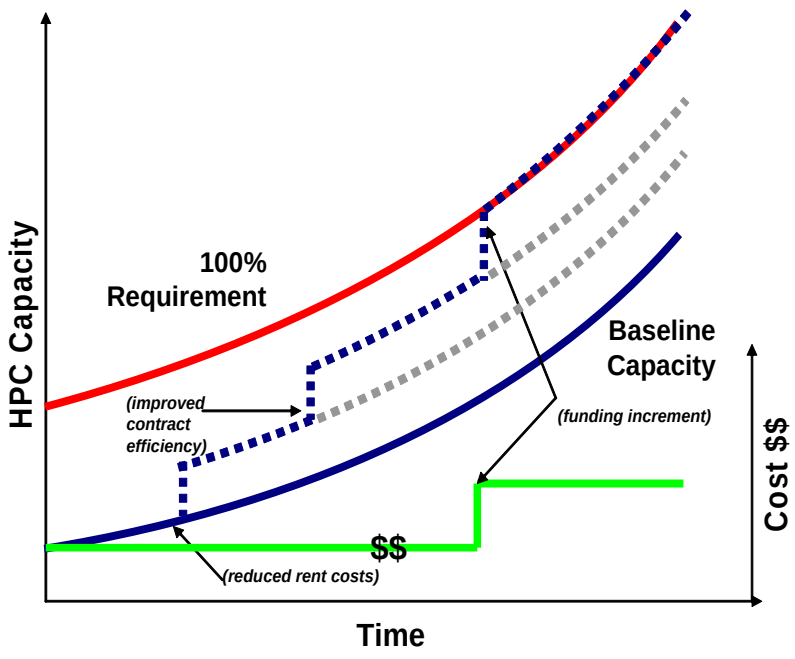


Figure 11: The NOAA Cost Effectiveness Model shows how improved management and technical efficiencies help reduce the size of the funding increment necessary to achieve the 100% requirement.

7 HPC Roadmap 2004-2010

Below is a draft HPC Roadmap with four lanes, each of which reflects the major milestones of each strategy over the next six years.

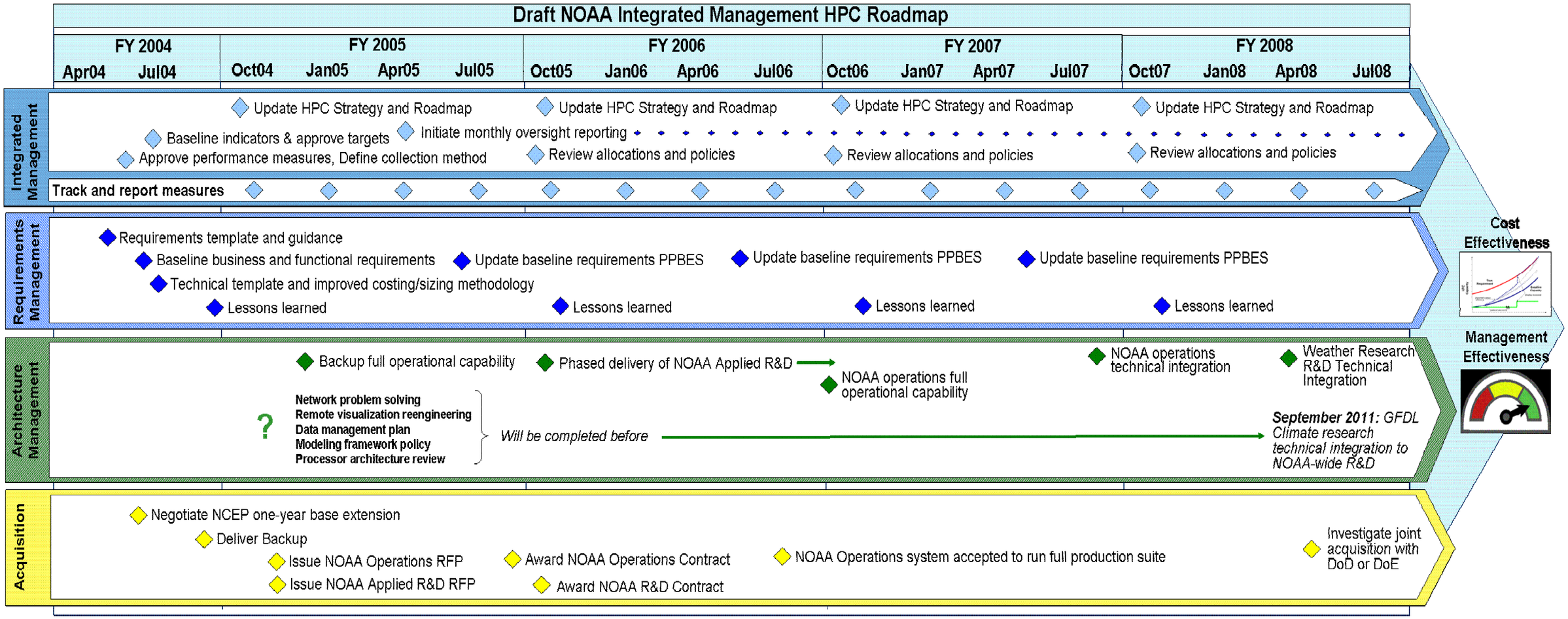
The Integrated Management lane contains activities relating to the oversight of NOAA HPC. The HPC Board will review monthly reports concerning HPC resource allocation and other management areas. It will also assess the effectiveness of these reports and its policies on an annual basis and modify its activities according to the lessons learned. The programs using HPC resources will be responsible for tracking and reporting a set of performance measures. The specifics of what measures will be reported and to whom will be defined by the end of September 2004.

The Requirements Management lane lists the major milestones necessary to define a requirements management process. NOAA will baseline its requirements and annually refresh this baseline using a requirements management process improved through lessons learned.

The Architecture Management lane lists a set of possible issues to address by September 2011 in order to achieve the full technical integration of the NOAA-wide R&D architecture. These activities include:

- Network problem solving: determine how best to connect and provide greater interoperability of the NOAA-wide R&D architecture from a network perspective, given the currently prohibitive costs of network buildout from some of NOAA's sites.
- Remote visualization reengineering: explore new data management processes to support remote visualization in order to promote greater interoperability. Remote visualization would allow physical separation of scientists from HPC assets while minimizing telecommunications costs and fully supporting scientific efforts.
- Data management plan: assess what HPC data is used by who and determine how to move, store, and archive only necessary data to appropriate parties. Identify future HPC requirements that the NOAA data centers may have.
- Modeling framework policy: create and encourage the use of a modeling policy that will support interoperability across the NOAA -wide R&D architecture and faciliate the quicker transfer of models from research to operations.
- Processor architecture review: understand and assess the relative utility of vector versus scalar architectures with respect to meeting NOAA's mission requirements, partnering options, and other operational and strategic considerations.
- Satellite data processing: with the expected volume increase in satellite data examine the role that HPC architectures might play in the processing of satellite data.

The Acquisition lane provides high-level milestones for the consolidation of NOAA HPC contracts in to R&D and Operations vehicles.


Draft NOAA Integrated Management HPC Roadmap
FY 2004
Apr04
Jul04
FY 2005
Oct04
Jan05
Apr05
Jul05
FY 2006
Oct05
Jan06
Apr06
Jul06
FY 2007
Oct06
Jan07
Apr07
Jul07
FY 2008
Oct07
Jan08
Apr08
Jul08
Integrated Management
Update HPC Strategy and Roadmap
Update HPC Strategy and Roadmap
Update HPC Strategy and Roadmap
Update HPC Strategy and Roadmap
Baseline indicators & approve targets
Initiate monthly oversight reporting
Approve performance measures, Define collection method
Review allocations and policies
Review allocations and policies
Review allocations and policies
Track and report measures
Requirements Management
Requirements template and guidance
Baseline business and functional requirements
Update baseline requirements PPBES
Update baseline requirements PPBES
Update baseline requirements PPBES
Technical template and improved costing/sizing methodology
Lessons learned
Lessons learned
Lessons learned
Lessons learned
Cost Effectiveness
Management Effectiveness
Architecture Management
Backup full operational capability
Phased delivery of NOAA Applied R&D
NOAA operations full operational capability
NOAA operations technical integration
Weather Research R&D Technical Integration
?
Network problem solving
Remote visualization reengineering
Data management plan
Modeling framework policy
Processor architecture review
Will be completed before
September 2011: GFDL Climate research technical integration to NOAA-wide R&D
Acquisition
Negotiate NCEP one-year base extension
Deliver Backup
Issue NOAA Operations RFP
Issue NOAA Applied R&D RFP
Award NOAA Operations Contract
Award NOAA R&D Contract
NOAA Operations system accepted to run full production suite
Investigate joint acquisition with DoD or DoE

Appendix A: Strategic Principles

Purpose

The NOAA HPC strategic principles guide the HPC Board in making consistent decisions in support of NOAA's mission. These overarching principles govern all other principles in HPC architecture, technical functions, and daily operations. For purposes of this document, HPC resources are defined as the systems funded by the Environmental Modeling program and which currently reside in Boulder, Colorado, Princeton, New Jersey, and Gaithersburg, Maryland.

Audience

The target audience for these principles is NOAA senior management, the Department of Commerce CIO, Congress, and the Office of Management and Budget. All HPC related personnel are expected to be fully informed on and in compliance with these strategic principles.

HPC Strategic Principles

1. All NOAA HPC resources are managed holistically as a corporate asset.

Rationale: Managing holistically allows NOAA HPC to best align the use of HPC resources to NOAA's mission and better achieve economies of scale.

Implications:

- There are no HPC planning or allocation constraints based on NOAA organizational structure (no stovepipes).
- NOAA HPC resources belong to NOAA, not to specific line offices.
- The NOAA HPC Board widely considers multiple NOAA-wide options for meeting specific requirements and selects the option that is in the best interest of NOAA *(Note: this may need revision based upon decisions regarding NOAA HPC management).*
- The status quo HPC management structure will change.
- NOAA HPC management uses NOAA-wide language when referring to HPC resources.
- HPC related decisions and day-to-day management activities increasingly reflect a NOAA-wide perspective and capability.

2. NOAA HPC decision making process is inclusive, open, consistent, and fair.

Rationale: Open and transparent processes build trust and foster cooperation among existing and perspective HPC managers and users which is required to facilitate change in NOAA's current processes.

Implications:

- The HPC Board documents tradeoffs and decisions made.
- The HPC Board has established decision-making processes and consistently applies them.
- Definition of fair does not mean no impact, it means following a solid process and considering the corporate view.

3. NOAA HPC requirements come with funding through the Mission Goal teams and from other sources approved by NOAA senior management.

Rationale: The NOAA HPC Board focuses on valid, approved, and funded requirements. NOAA leadership is focused on achieving the NOAA mission and its corresponding strategic goals; NOAA HPC exists to support these efforts. Successfully meeting the mission and strategic goals requires NOAA resources be strictly focused on the agency mission and goals. All HPC activities should, therefore, be clearly connected to and in support of the NOAA mission.

Implications:

- Accepting requirements from these sources through approved processes ensures that the requirements have been properly vetted and validated and that funding is available to support them.
- The HPC Board does not prioritize or "approve" HPC requirements. When requirements cannot be met the HPC Board works closely with requirement owners to determine the best solution to meeting them. When no resolution can be achieved requirements are met in the priority order of those initiatives the requirements support; this priority order is established by NOAA senior leadership.

4. NOAA strives for the best return on investment when acquiring HPC resources.

Rationale: There are finite resources available to support NOAA HPC requirements. These resources must be maximized in order to provide the highest benefit to NOAA's mission. Striving for the best return on investment supports the Government getting the best value and cost-effectively achieving NOAA's mission.

Implications:

- NOAA HPC leverages funding opportunities to optimize NOAA HPC resources in compliance with the HPC architecture.
- NOAA examines a wide range of acquisition strategies to determine the most cost-effective vehicle to acquire HPC resources. This includes considering the implications of selecting such options as:
    - Leasing vs. buying
    - Government vs. contractor facilities
    - Single vs. multiple NOAA contracts for HPC resources.
- NOAA HPC conducts appropriate market research to determine the most cost-effective acquisition strategy.
- While assessing options, NOAA HPC completes a cost/benefit analysis for each alternative. This analysis considers all costs associated with meeting the requirement, including communications.

5. NOAA HPC uses best practices and does not reinvent the wheel.

Rationale: The Board continuously evaluates and takes advantage of the best practices in the larger HPC community, academia, industry, and other agencies.

Implications:

- NOAA HPC considers existing resources and processes in light of applicable best practices.
- The HPC Board supports activities that demonstrate industry best practices tailored appropriately for NOAA.
- The HPC Board supports activities that reflect a consideration of, and connection to, NOAA's existing resources and processes.
- NOAA will consider code portability when making application design decisions.

6. NOAA explores and develops the use of new and innovative HPC technology to advance its mission.

Rationale: NOAA's mission can be most effectively accomplished by taking maximum advantage of advances in computer science. Past examples of such improvements include the development of massively parallel computing using commodity hardware; new efforts include the effective use of grid computing. Experience has shown that emerging computer science methods applied to development can result in improving, by a factor of two or more, the price/performance ratio of NOAA's research and operations.

Implications:

- Advanced computing changes so rapidly that an explicit effort to adapt these changes for NOAA's use can easily pay for it in lowered costs.
- NOAA HPC is explicit about matching the appropriate technology with appropriate activity (e.g. operational activities require less risky technologies than research).

- The risk associated with using a particular technology is explicitly acknowledged as part of HPC cost/benefit analyses.

7. NOAA leverages external resources when beneficial to its mission.

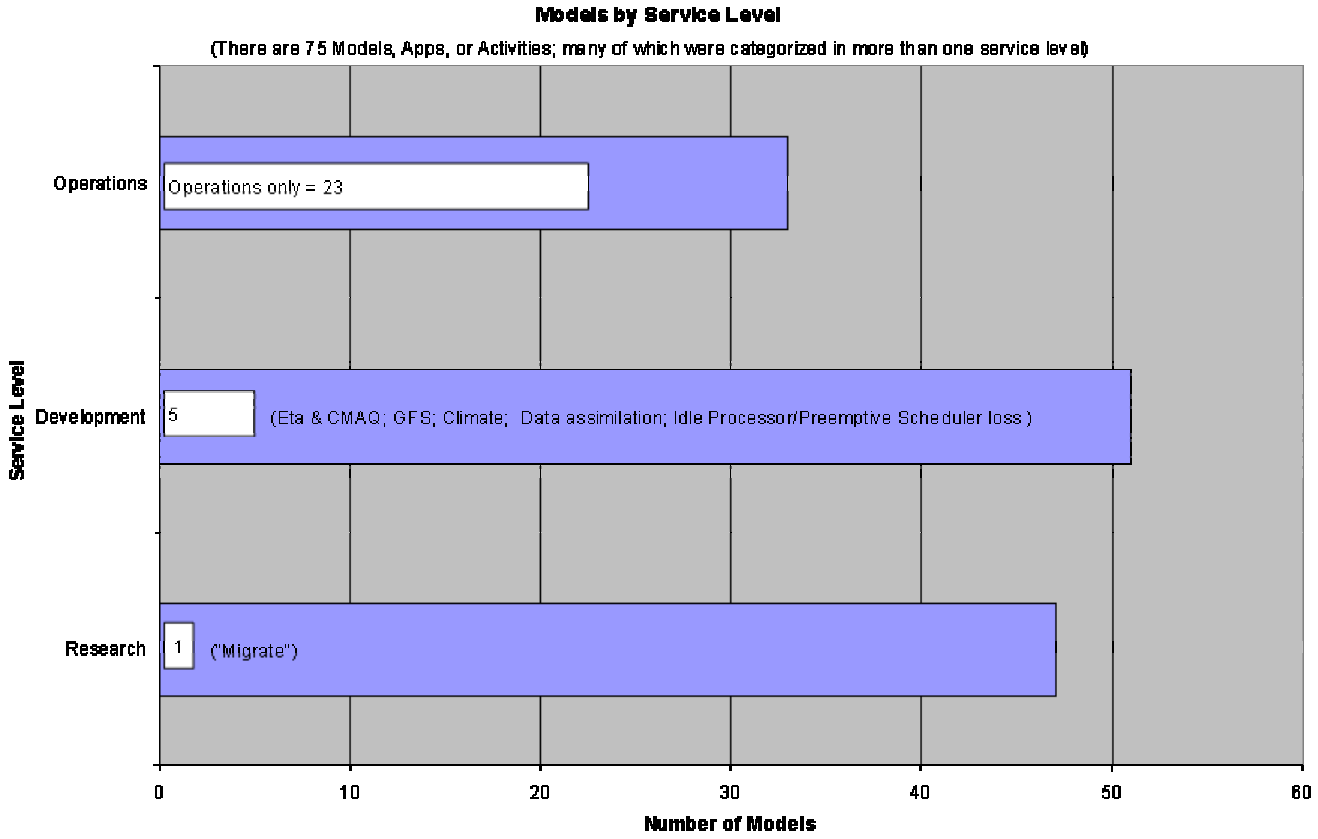
Rationale: At times, it is more efficient or effective to work with external organizations to achieve stated objectives. Many organizations use high-end computing and can serve as research and operational partners, sharing resources and/or data as necessary.

Implications:

- When building a list of alternatives for meeting a requirement, the HPC Board considers how external organizations could support NOAA.
- The NOAA HPC Board actively pursues partnerships with external organizations that could provide an opportunity to access resources and/or data at minimal cost.

Appendix B: Value Chain

The Value Chain analysis included 75 models, applications, or activities and did not include some system administration software. Only 29 models were categorized as only one of the service levels (operations, development, and research). Therefore, more careful analysis is still needed to understand which models or applications require 96% versus 99% system availability. The chart below reflects the distribution of NOAA models across service levels.

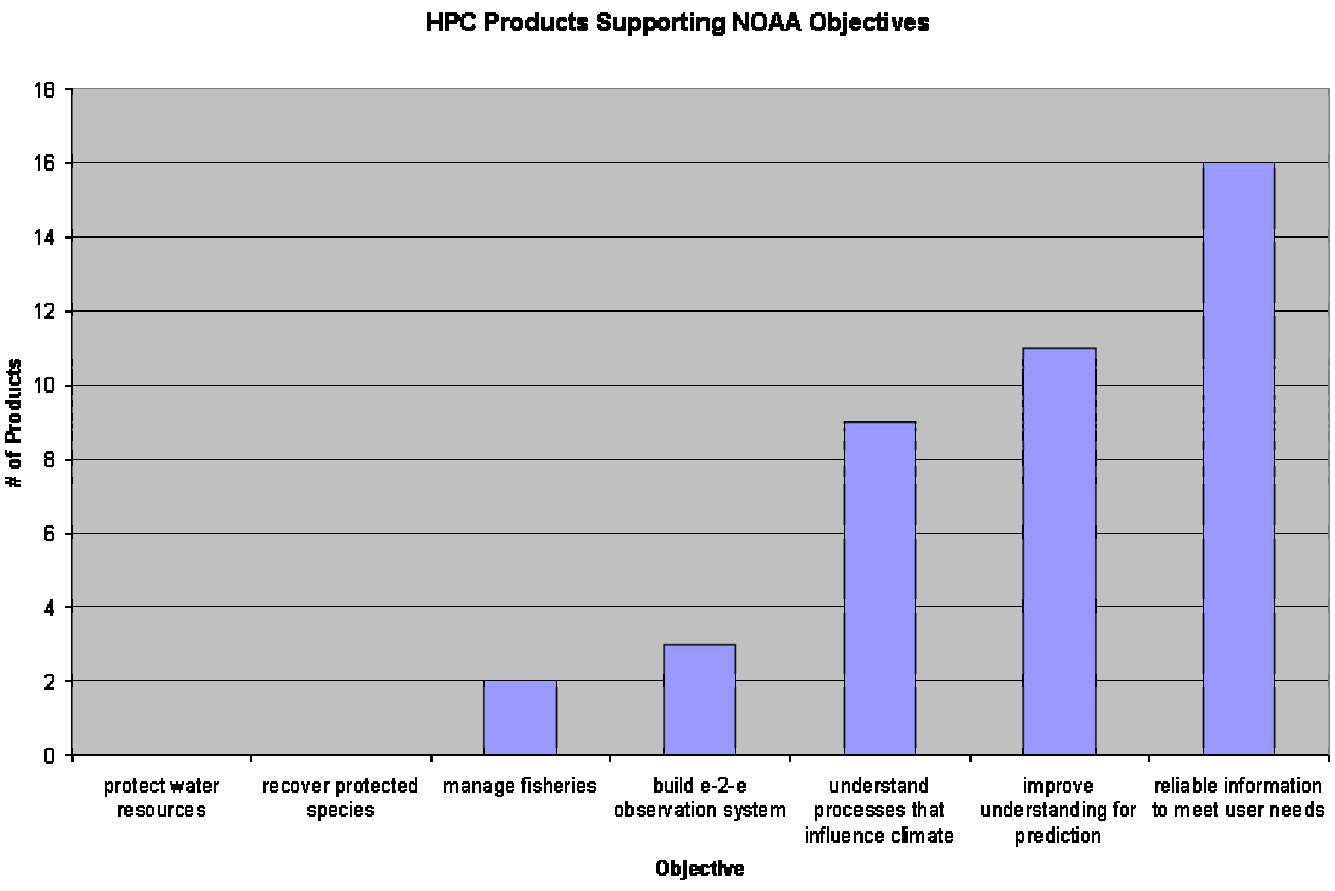


Models appear to account for the vast majority of NOAA's HPC capacity. The majority of the HPC resources appear to be fully utilized, with the exception of one platform being decommissioned in Fiscal Year 2004 of which approximately 35% is utilized.

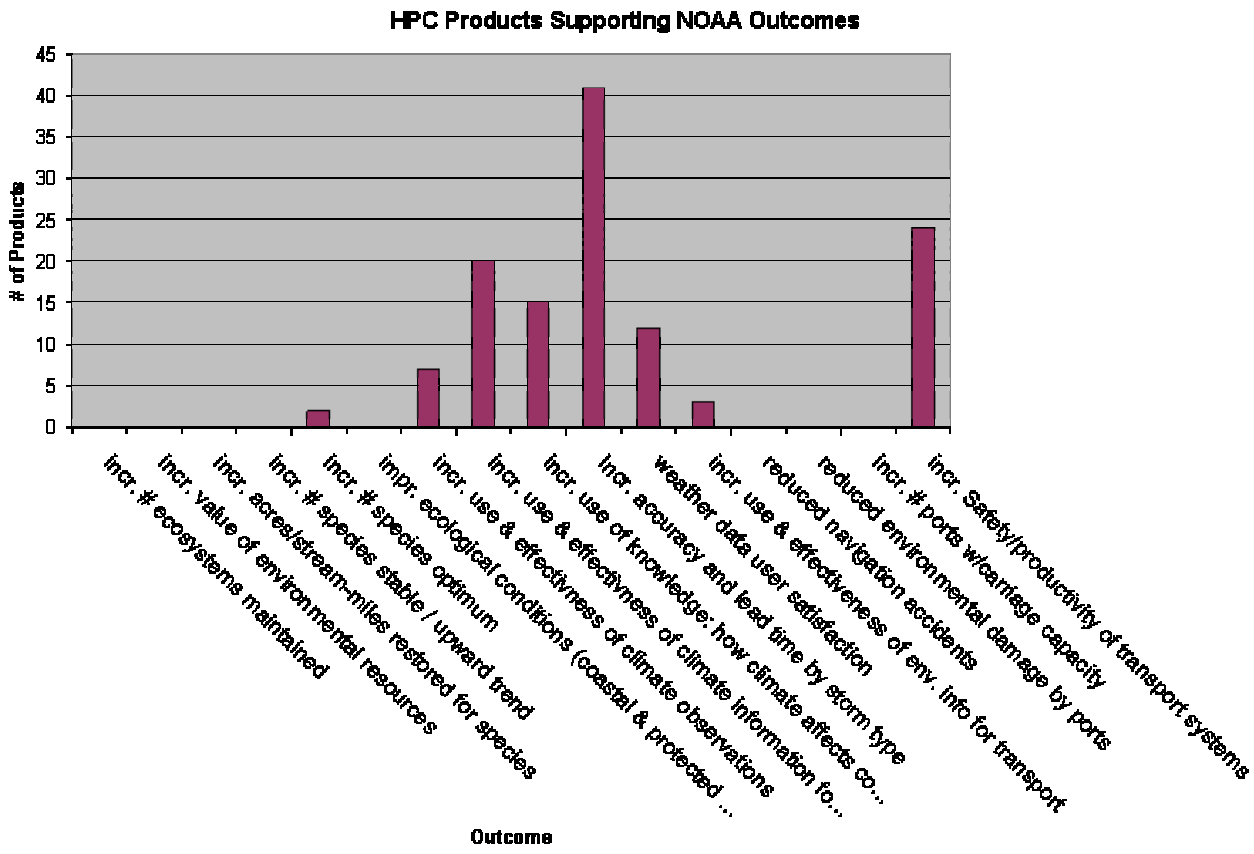
The models generated 61 unique service types (e.g., fire weather, sea ice simulation, population analysis of marine species, public forecasts, and hurricane forecasts). Several services were provided by more than one model (e.g., Water management forecasts were generated by Mesoscale (Eta), Global Ensemble, Regional Ensembles

(SREF), Global Forecast System (GFS)). If each model output is considered a separate service, there are 97 services.

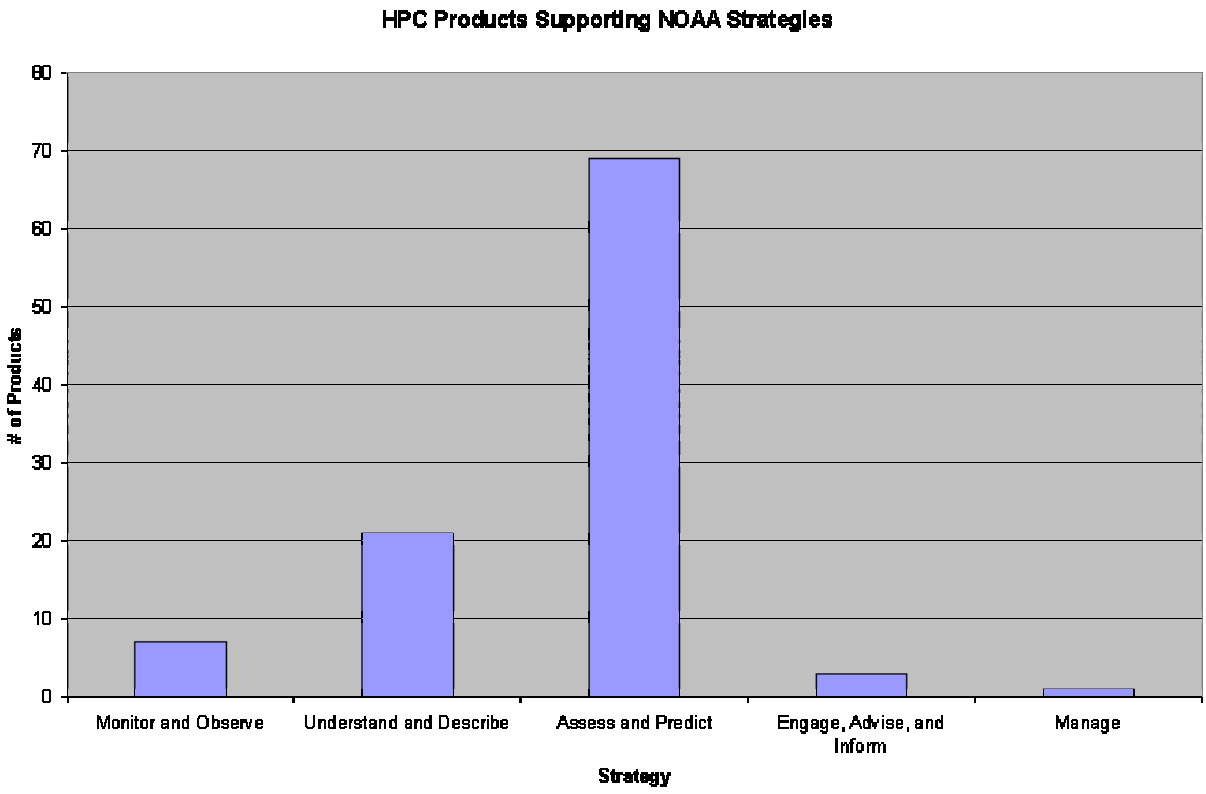
The chart below shows how the HPC products support NOAA's objectives.



The chart below reflects that NOAA HPC supports outcomes for each mission goal.



As demonstrated below, NOAA HPC is focused on the “Assess and Predict” strategy.



The chart below shows the high-level attributes of the NOAA HPC platforms by organization.

Org.	Platform Name	No. Processors	Memory (GB)	Speed (GHz)	IO Processors	IO Memory (GB)	IO Speed (GHz)
FSL	Linux Cluster (iA32)/HPT	1490	745	2.2	32	64	2.2
	Linux Cluster (EV68)/HP	280	210	0.833	8	16	0.67
GFDL	AC (SGI Origin 3900)	192	192	0.6			
	Atipa Linux Cluster	32	128	2			
	HSMS/HFS (SGI Origin 3800)	128	128	0.6			
	LSC (SGI Origin 3800/39...)	2432	2432	0.6			
NCEP	CCS - eServer p690/IBM	1408	1408	1.3	128	256	1.3
NESDIS SATEPS							
	Linux Platforms (Dell 4400/4600 running Red Hat)	approx 370	appox 925	2.8 max			
	IBM SPs	24 nodes	96	0.395			
	SGI Origin 2000s	36	3.228	.256-.758			
	SSEC Desktop Ingestors	20	1.6	most @ 0.5			
CEMSCS							
IPD	Amhdal Enterprise Server	4	1	80MIPS			
	Cray J90	8	128MB	100MFLOPS			
IPD	IBM RS6000 SP/2	8	1.5	332MHz			
	IBM P660	10	20	750MHz			
IPD	SUN E4500	12	10	336MHz			
	SGI Origin 3800	64	16	400MHz			
	SGI Origin 3400	32	8	400MHz			
	SGI Origin 3200	2	1	400MHz			
IPD	Dell PowerEdge 2650	12	40	2.2			

Appendix C: Terms of Reference - NOAA High Performance Computing (HPC) Board

Purpose:

Ensure HPC resources best support NOAA's mission and goals.

Responsibilities:

The NOAA HPC Board will:

- Provide corporate leadership.
- Achieve operational and organizational efficiencies for HPC.
- Develop and coordinate policy.
- Establish the integrated NOAA HPC requirements and architecture.
- Make decisions regarding the use of HPC resources in response to NOAA requirements.
- Look for products and solutions outside of NOAA.
- Build partnerships between the CIO and programs with strong customer focus.
- Advocate NOAA HPC requirements to the broader Federal community.

Membership:

Chair: Carl Staton, 301-713-9600 X170, Carl.Staton@noaa.gov

Members:

Frank Aikman	*National Ocean Service (NOS), Chief, Marine Modeling and Analysis Programs Coast Survey Development Laboratory (CSDL)*
Kevin Cooley	*National Weather Serivce, NWS, National Centers for Environmental Prediction (NCEP)*
Brian Gross	*Oceanic and Atmospheric Research (OAR), Deputy Director of the Geophysical Fluid Dynamics Laboratory (GFDL)*
Nancy Huang	*OAR CIO*
Sandy MacDonald	*OAR, Director of the Forecast Systems Laboratory (FSL)*
Mike Matson	*National Environmental Satellite, Data, and Information Service (NESDIS), Satellite Services*
Fred Toepfer	*NWS, NCEP*
Bill Turnbull	*NOAA Deputy CIO, HPC Project Deputy Senior Sponsor*
Larry Tyminski	*NMFS, Chief Information Officer*

Mark Vincent	*NOS, Center for Operational Oceanographic Products and Services (CO-OPS)*
Bill Voitk	*NOAA Procurement, Contracting Officer*

Contact person: Mike Kane, 301 713 3575 mike.kane@noaa.gov

Committees that report to this Board:

The HPC Board may establish, as mutually agreed and on and ad hoc basis, special temporary working groups to investigate specific areas of interest, cooperation and coordination and to report at subsequent Board meetings. The Board may establish, as mutually agreed upon, standing working groups where an ad hoc status is deemed insufficient.

Roles and Responsibilities:

It is the responsibility of the members to:

- Notify the Chair of a change in status with regard to participation on the Board.
- Make resources available to support Board's outcomes

Meeting Frequency:

The HPC Board will convene semimonthly or when called for by the Chair.

Decision Making Process:

HPC Board decisions will be accomplished by consensus (i.e., no individual votes thumbs down on an issue). The Chair will strive for consensus on every issue. The Chair maintains 51% of the vote; therefore the final decision is made by the Chair when consensus is not achieved.

Charter:

The NOAA HPC Board was created to satisfy the community desire to achieve improvements in the enterprise utilization of NOAA's HPC resources.

Some of the requirements that led to the Board's creation include a need for:

- Mutual support for backup and recovery.
- Procurement of new HPC resources.
- Sharing of HPC resources across programs.
- Fostering collaboration.
- Improving customer service.
- Strengthening NOAA's participation and presence in Government and private sector HPC forums and groups.
- Establishing a common HPC infrastructure.

HPC TOR Addendum

1.0 Governance Overview

The NOAA HPC governance strategy outlines the ***process*** and ***management framework*** that NOAA will use in its strategic management and decision making process for High Performance Computing. The HPC Board will follow the guidance agreed upon in its Terms of Reference regarding specific roles, responsibility and decision-making.

One of the principles objectives of the Board is to think corporately regarding a wide array of strategic, management, technical and contractual issues involved with applying finite HPC resources to meet NOAA's mission. This includes handling changes to the governance strategy itself. NOAA HPC governance is an on-going multi-level core management activity that ensures the business activities are aligned with market forces and NOAA mission goals.

2.0 Strategic Principles

The HPC Board has developed a set of strategic principles that delineate the context and objectives of the board across all NOAA mission goals. The Board will refer to these principles and use them in developing a strategic agenda.

3.0 Operating Rules and Procedures

The HPC Board shall operate under the following rules and procedures:

3.1 Process

3.1.1 The HPC Board shall consider a wide range of influencing factors in defining its agenda, deliberations, and tactical thinking. These factors include, but are not limited to the following list:

- Requirements
- Asset Management
- Budget
- Planning
- Acquisition / Contractual Obligations
- Resource utilization
- Criteria for Success/measures
- Political landscapes

3.2 Meetings

Meetings will be called by the Chair who will preside over the HPCB. Meetings shall be announced at least 4 weeks in advance.

3.3 Agenda

It is the responsibility of the Chair to prepare and distribute the agenda at least 2 weeks before the meeting. Any Board member can request that an item be place on the agenda at the discretion of the Chair.

3.4 Review Materials

Review materials shall be distributed two weeks in advance of meetings. All members are expected to review materials and come to the meeting prepared for deliberations.

3.5 Attendance

Members should normally participate in person, but may participate via video or audio calls. Alternates should be able to speak for the primary member at meetings (with the prior permission of the Chair).

3.6 Invited Guests

Guests may be invited to participate in some meetings. They may be invited to give presentations or lead a discussion in their area of expertise.

3.7 Minutes

It is the responsibility of the Chair to prepare accurate and timely minutes to be distributed and ratified by all HPCB members. Minutes should accurately reflect discussions, agreements, decisions, and action items from Board meetings.

4.0 Strategic Alliances/ Linkages

4.1 PA & E

The Program Analysis and Evaluation Office in NOAA plays a vital role in formulating and validating requirements for NOAA. In addition this group plays a pivotal role in making recommendations regarding programmatic budget execution.

The significance of the PA & E's role in the undertakings of the Board should not be understated. An open exchange of information is essential to communicate the Boards strategic agenda, short term objectives, and current limitations. The Chair will be the primary interface between the Board and the PA&E Office. The expectations of the PA&E Office are noted below:

- Provides validated, funded NOAA wide requirements for HPC
- Provides guidance on out-year program funding adjustments for HPC

- Clarifies and makes recommendations regarding inconsistencies between requirements and available funding
- Provide direction on out-year program funding adjustments for HPC
- Participates in process improvements to promote the collection of well-defined, accurately costed, well-integrated, end to end requirements that can be acted upon and monitored during the budget execution phase.

The HPCB's role with respect to the Mission Goals is as follows:

- Reviews validated HPC requirements and makes recommendations (as needed) regarding implementation alternatives
- Identifies funding shortfalls and inconsistencies
- Facilitates process improvement to promote the collection of well-defined, accurately costed, well-integrated, end to end requirements that can be acted upon and monitored during the budget execution phase.
- Communicates to PA&E staff capacity limits and evolutionary changes in the HPC environment
- Provide innovative solutions to accommodate requirements

4.2 NEP and NEC

The NOAA Executive Panel and the NOAA Executive Committee are executive level decision making groups for NOAA. Decisions in NOAA should be made at the lowest practical level. The nature or implications of some decisions require the issues be presented to NOAA's executive leadership for their consideration. The NEP serves as the final forum ensuring that issues, programs, and briefings are condensed into understandable terms and recommendations for decisions before presentation to the NEP.

The Chair is the liaison between the Board and the NEP. In that role the Chair typically brings forward informational or decision briefings that result from deliberations of the Board.

4.3 Mission Goal Teams

The mission goal Team Leads provide leadership and coordinate across NOAA regarding mission requirements. They assist in updating the Strategic Plan and provide the vision, strategy and outcome measures for the goal. The Teams leads serve as the principle coordinating body to ensure a consistent NOAA message to external partners and stakeholders.

With respect to the HPCB, the Mission Goals Teams provides the following services / roles:

- Propose revision to program structure based on goal needs
- Review existing and generate new Statements of Need (SON)
- Represent Goal to higher management authorities
- Communicate to HPCB future expectations, strategic thinking, and operational considerations

The HPCB's role with respect to the Mission Goals is as follows:

- Coordinate with Mission goals team lead to ensure a shared understanding exists for priorities and operations
- Consult with Mission Goal Teams to assist with annual PPBES process & planning
- Conduct periodic joint planning and review sessions

4.4 Enterprise Architecture

The HPCB and NOAA's Enterprise Architect will work in tandem to ensure that the NOAA's High Performance Computing environment and its Enterprise Architecture are closely integrated. The NOAA Architect will serve as a consultant to the HPCB to ensure that:

- HPC architecture fulfills and meets the expectations for Federal Enterprise Architecture and NOAA senior leadership
- Where feasible, NOAA wide standards are employed
- Recommend improved efficiencies by leveraging the NOAA-wide architecture. The NOAA HPC Board will provide timely updates to the NOAA Architect with respect to decisions affecting the current or planned HPC architecture.

4.5 Acquisition Office

The NOAA Acquisitions Office is a sitting member of the HCHB and as such assists the HPCB in: leveraging industry best practices by facilitating dialogues with industry leaders; devising flexible acquisition strategies; and advising the Board regarding the FAR, and contractual obligations.

4.6 CIO Council

The NOAA CIO Council acts as an adjunct advisory group to the HCHB. The CIO's will provide feedback on proposed program adjustments via the NITRB, NOAA's Capital Planning and investment control group.

5.0 Requirements

5.1 Assumptions

Requirements for NOAA HPC will be governed by current capabilities as defined and approved in the annual Program Decision Memorandum. Program adjustments that are not included in that guidance are not approved nor funded.

5.2 Baseline requirements

The current year baseline of HPC requirements are contained within the Environmental Modeling program. The baseline requirements for HPC are those contained within the PDM for FY06. Any additions, deletions or other changes to those requirements for out years are required to be handled and vetted thru the PPBES business process.

6.0 NOAA Executive Decision Process

6.1 Overview

NOAA's Executive Decision process is a tiered structure wherein significant issues are identified, discussed, decided or framed for decision at the next higher level.

6.2 HPC Decisions

Any HPC decision that is deemed beyond the scope of responsibility of the HPC Board must be elevated to the NEP and in some cases to the NEC. It is the responsibility of the HPC Chair to staff and prepare informational or decision briefings for the NEP and NEC. This process should be followed to obtain approval for significant NOAA HPC issues.