National Oceanic and Atmospheric Administration
OCIO/HPCC
R&D HPCS
006-48-01-17-01-3804-00
Operational Analysis
2007

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Executive Summary

The R&D HPCS provides the computational resources necessary to support continued advances in the environmental modeling capabilities and addresses other HPC requirements that may arise within NOAA and at other partner agencies. The R&D HPCS includes the HPC systems, complementary storage devices and interconnects, communications hardware interfaces, software, networking equipment, system maintenance, support services, IT security, and necessary infrastructure enhancements.

FY2007 marked the first time that NOAA managed and operated its Research and Development (R&D) High Performance Computing Systems (HPCS) as an integrated system. The program management support for this project is provided by the NOAA Office of the Chief Information Officer. The on site management of the three R&D HPCS subsystems are provided by OAR/ESRL at Boulder, CO., OAR/GFDL at Princeton, NJ., and NWS/NCEP at Gaithersburg, MD.

This report focuses on the operational state of the program as of December 31, 2007, and is based on guidance developed by the Department of Commerce. The Research & Development (R&D) High Performance Computing System (HPCS) project directly facilitates NOAA's Strategic Goals to "Serve Society's Needs for Weather and Water Information" and "Understand climate variability and change to enhance society's ability to plan and respond".
The current project meets established cost, schedule and performance parameters.

This operational analysis (OA) is an annual, in-depth review of the program's performance based on the following:

- Customer Results
- Strategic and Business Results
- Financial Performance
- Innovation

1.0 Customer Results

NOAA's R&D HPCS resources enable scientists to attack long-lead-time problems associated with the physical processes that govern the behavior of the atmosphere and the ocean. Advanced climate models are the only means for distinguishing between natural and forced climate variations, assessing future impacts, and hence providing a capability to adapt to climate change and to explore mitigation strategies. These models are crucial for understanding some of the most critical climate issues of today. Major economic decisions of national importance are being made on issues impacted by climate without being based on the best possible science.

These resources are utilized for a number of shorter-range meteorological research projects, including the development of next generation weather and climate forecast models, National Test Bed, and Satellite Data Assimilation projects. They will also facilitate applied meteorological research and development for purposes of improving and creating short-term warning and weather forecast systems, models, and observing technology.

1.1 Customer Requirements and Costs

The R&D HPCS stake holders include members of the Environmental Modeling Program, High Performance Computing Board, NWS, OAR, researchers (weather and climate), NOAA CIO, AGO, NOAA CFOs, DOC CFO and CIO, NITRB, CITRB, NITRD, and Raytheon.

Funding for the project is provided by OAR and NWS through the Environmental Modeling Program (EMP). The EMP determines the goals that the project is to achieve each year and also determines the HPC allocation that each EMP project will receive. The R&D HPCS project provides EMP a quarterly report that monitors the performance of the HPCS. This contract was competitively awarded in May 2006 and the selected vendor was found to offer the best value to the Government.

1.2 Performance Measures

These measures align with the "Customer Results Measurement Area" of the Performance Reference Model developed by the Federal Enterprise Architecture Program Management Office (FEA-PMO). Table 1 summarizes the performance measures.

Table 1: Customer Results Performance Measure

FEA PRM								
Fiscal Year	**Strategic Goal(s) Supported**	**Measurement Area**	**Measurement Category**	**Measurement Grouping**	**Measurement Indicator**	**Baseline**	**Target**	**Actual Results**
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Customer Results	Timeliness and Responsiveness	Response Time	Response time	Escalation Levels : Level 0 = 1 business hour; Level 1 = 3 business hours; Level 2-3 = priority/issue dependant	These response times are specified in the HPC R&D contract. During first year of the contract the timeliness and effectiveness of escalation process will be monitored and adjustments made as necessary.	The contractor was successful in meeting these response times a majority of the time. The project team tracks help desk tickets on a weekly basis to ensure that the contractor is performing.

2.0 Strategic and Business Results

The R&D HPCS project is meeting its own goals and objectives as well as those of the agency. Program management and controls are in place to ensure the project continues to meet its goals and objectives and monitor how well the R&D HPCS project performs.

2.1 R&D HPCS Helps to Achieve Strategic Goals

The R&D HPCS supported these NOAA strategic goals:

- Weather and Water – Serves society's needs for weather and water information
- Climate – Understand climate variability and change to enhance society's ability to plan and respond

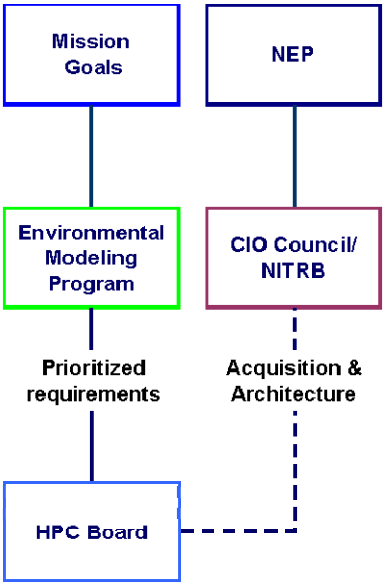
The R&D HPSC supports the following GPRA measures:

GPRA Measures	R&D HPCS Projects
U.S. Seasonal Temperature Skill	
	Climate Test Bed
	Seasonal Climate Model R&D
	Reforecasting R&D
	Regional Analysis
Precipitation Forecast Day 1 Threat Score	
	HMTB
	Joint Center for Data Assimilation
	Next Generation Global Model Development
	Rapid Refresh
Improve Society's ability to plan and respond to climate variability and change using NOAA climate products and information	
	Long-term climate model R&D
	Climate scenarios (analysis and generation)
	Climate model calibration

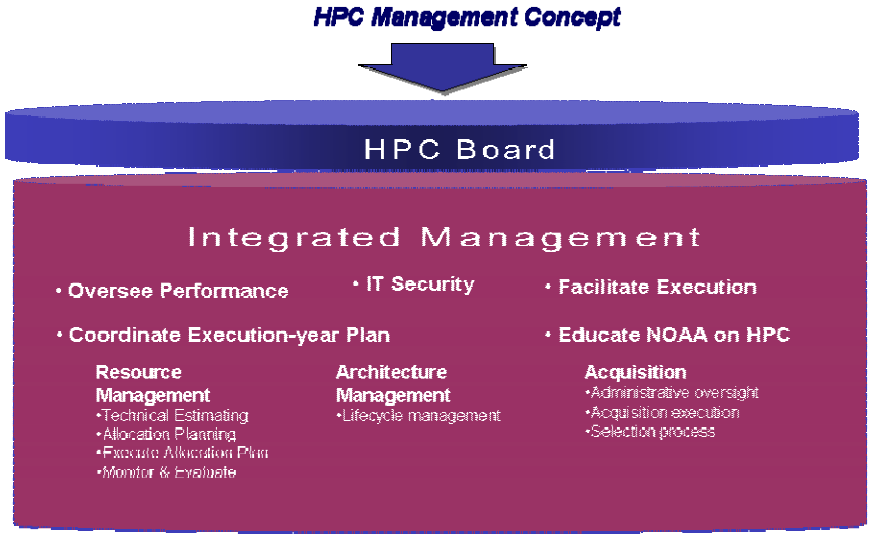
2.2 Business Results

NOA-216-110 “Management and Governance of High Performance Computing” describes how NOAA manages its High Performance Computing resources.

2.2.1 Program Management and Controls



The above diagram depicts how the R&D HPCS is managed. Requirements flow down from the mission goals to the EMP who then prioritizes and provides funding for those requirements and sends to the HPC Board for execution. The HPC Board is responsible for the acquisition and implementation of the appropriate architecture for meeting the EMP requirements. The HPC Board works with the NITRB on IT architecture planning and with the CIO Council on major acquisition issues. Any issues that cannot be resolved by the HPC Board and CIO Council are elevated to the NEP for resolution.



The HPC Board has established an Integrated Management Team (IMT) to manage the day to day operations of the project. The functions that the IMT performs are shown in the above diagram.

2.2.2 Monitoring Cost, Schedule and Performance

Cost – The contract for the R&D HPCS is fixed price. Each year of the contract is executed as a separate option. Funding is provided each year by NWS and OAR. The project also maintains a reserve to fund engineering change proposals or to purchase separate CLIN items. Each month the vendor submits an invoice that is reviewed by the COTR, IMT, and CO prior to making any payment.

Schedule – Each week a project status meeting is held with the contractor, IMT, and CO. Monthly Project Management Reviews are held with the contractor, IMT, and CO. Plans, schedule, and milestones are discussed at both meetings. In addition the COTR and PM meet on a weekly basis with the Raytheon PM to discuss issues, plans, and schedule. An annual review meeting is also held to review the past year and discuss the plans and schedule for the upcoming year.

Performance – The R&D HPCS is tracked on a weekly and monthly basis. Each week the vendor reports to the Government the following metrics: System utilization, system uptime, archive availability, numbers of help desk tickets (opened, closed, and carried over), and the health of the various system components. Each month the vendor provides a detailed summary of system availability, number of SLTs produced, and data availability. Each quarter the IMT provides a status report to the EMP that includes many of the information provided by the vendor along with metrics describing how the EMP allocations are being met.

2.3 Reviews

On October 16, 2007 the NITRB conducted a Post Implementation Review of the R&D HPCS project. The project was rated as “Green” overall by the NITRB.

On November 28, 2007 the CITRB conducted a Post Implementation Review of the R&D HPCS project. The project was rated as "Green" overall by the NITRB.

In June and October of 2007 the R&D HPCS PM provided status briefings to the HPC Board.

2.4 Security

The R&D HPC system is accredited under requirements spelled out in NOA 212-13 (08/06/90) and are based on OMB and NIST guidance. System Security Plans, Risk Assessments, and Contingency Plans were certified and approved for the R&D HPCS in March 2007. Management, operational, and technical security controls are adequate to ensure the confidentiality, integrity and availability of information.

The R&D HPCS C&A was completed and approved on March 30, 2007

2.5 Performance Measures

The performance measures in Table 2 show the contribution that the R&D HPCS project's performance made with respect to Strategic and Business Results.

Table 2: Business Results Performance Measures

FEA PRM								
Fiscal Year	**Strategic Goal(s) Supported**	**Measurement Area**	**Measurement Category**	**Measurement Grouping**	**Measurement Indicator**	**Baseline**	**Target**	**Actual Results**
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Mission and Business Results	Environmental Management	Environmental Monitoring and Forecasting	Concurrent execution of atmospheric models on the NOAA R&D HPCS	Atmospheric models run on the NOAA operational HPCS	Atmospheric models (NMM, WRF-EM, GFS) to run concurrently on the NOAA R&D HPCS	All running on the NOAA Boulder HPCS supporting research projects.
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Mission and Business Results	Environmental Management	Environmental Monitoring and Forecasting	Implement at least one new or updated component into the Earth System Model	Uncertainty in climate model projections remains higher than desirable	Decrease uncertainty in climate system processes and long-term climate projections measured through improvements in Earth System models	Completely new atmospheric physics and land models complement increased resolution in all Earth System Model components in the model being developed for the IPCC Fifth Assessment Report.
2007	3.1 Advance understanding and predict changes in the	Mission and Business Results	Environmental Management	Environmental Monitoring and Forecasting	Decadal predictive skill in North America surface	Quantification of climate model validation is insufficient	Measure predictive skill to validate the reduction of	Techniques for assimilating ocean observations into

	Earth's environment to meet America's economic, social, and environmental needs.				temperature		uncertainty in climate models	a coupled model to develop initial conditions for decadal prediction can replicate significant features of the ocean's circulation
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Mission and Business Results	Environmental Management	Environmental Monitoring and Forecasting	Perform enhanced climate scenarios designed to address specific decision issues regarding climate change	Perform climate model scenarios with current physics-only climate models, as resources permit.	Simulate 7800 equivalent model years to clarify natural systems uptake of carbon and to provide climate information for assessment report	Over 8000 equivalent model years of climate and Earth System model integrations have been completed
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Mission and Business Results	Environmental Management	Environmental Monitoring and Forecasting	Provide focused assessment reports based on climate scenarios	Contribute research findings to National and International climate assessments	Publish assessment report on a key climate impacts topic, incorporating climate scenario results	A draft of CCSP SAP 3.2 is complete and is currently under NRC review.
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Mission and Business Results	Environmental Management	Environmental Monitoring and Forecasting	20 km resolution RUC Hybcst code performance	Existing performance	2x increase	1.8x performance increase.
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Mission and Business Results	Environmental Management	Environmental Monitoring and Forecasting	Improved 3 Day Precipitation Forecasts (%Accuracy, model capability)	17% (forecast precipitation accuracy)	19% (forecast precipitation accuracy)	19%
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Mission and Business Results	Environmental Management	Environmental Monitoring and Forecasting	Leverage high performance computing in other federal agencies to accelerate meeting mission goals	NOAA climate models run almost exclusively on NOAA HPC platforms	Port new atmoshperic and high resolution coupled climate models to DOE HPC platforms	This port is complete, and a number of validation experiments and control integrations are underway
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Mission and Business Results	Environmental Management	Environmental Monitoring and Forecasting	Improved 1 day precipitation forecasts (% accuracy model capability)	30% (forecast precipitation accuracy)	32% (forecast accuracy)	31%

Table 3: Process & Activities and Technology Performance Measures

FEA PRM								
Fiscal Year	**Strategic Goal(s) Supported**	**Measurement Area**	**Measurement Category**	**Measurement Grouping**	**Measurement Indicator**	**Baseline**	**Target**	**Actual Results**
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Processes and Activities	Management and Innovation	Innovation and Improvement	Implementation of Integrated Management	Initial Integrated Management processes in place	Refined and more complete processes to be defined and implemented during FY07.	Resource allocation process successfully implemented. Process for collecting quarterly metrics implemented.
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Processes and Activities	Productivity and Efficiency	Productivity	Benchmark suites	63,073 benchmark suites	167,484 accumulated benchmark suites	167,052 delivered.
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Technology	Effectiveness	IT Contribution to Process, Customer, or Mission	Performance increase (X)	3.1X level of performance over current baseline offered at initial delivery	Successful acceptance of replacement system for ESRL that meets availability and enhanced Benchmark Performance requirements	3.28X level of performance delivered
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Technology	Effectiveness	IT Contribution to Process, Customer, or Mission	Performance increase (X)	1.76X level of performance over current baseline offered at initial delivery	Successful acceptance of replacement systems for GFDL that meets contracted availability and enhanced Benchmark Performance requirements	1.98x level of peformance was delivered
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Technology	Effectiveness	IT Contribution to Process, Customer, or Mission	Performance Increase (X)	2.93X level of performance over current baseline offered at initial delivery	Successful acceptance of replacement system for NCEP that meets contracted availability and enhanced benchmark performance requirements	3.13X level of performance was delivered.
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Technology	Efficiency	Accessibility	% of data availability	99%	At the discretion of the Government the Vendor will either deliver additional equipment to make up for any loss of availability below 99% or the Government will reduce its monthly lease	99%

FEA PRM

Fiscal Year	Strategic Goal(s) Supported	Measurement Area	Measurement Category	Measurement Grouping	Measurement Indicator	Baseline	Target	Actual Results
							payment by the % of time that the data was unavailable.	
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Technology	Information and Data	Data Storage	Terabytes (TB) of storage	127 TB	Upgrade in FY07 to 830 TB of disk space	847 TB was delivered.
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Technology	Reliability and Availability	Availability	% of system available	97%	Vendor will deliver additional equipment to make up for any loss of availability below 97% or the Government will reduce its monthly lease payment by the % of time that the system was unavailable.	94% was achieved due to the late delivery of the system in Boulder and the numerical reproducibility problems encountered with the Princeton system.

SLT is a measure of how much work the Government is obtaining from the system (i.e. the expected amount of science that the Government plans to accomplish). In FY07 the planned number of SLTs was 167,484. The actual number of SLTs delivered was 167,052, a variance of 432 SLTs. As consideration for this variance the Government obtained 512 additional processing cores from the R&D HPCS support vendor. The Government has also submitted a proposal to the vendor for additional consideration due, at this time the vendor is reviewing the Government's proposal and the Government is awaiting the vendor's response.

The planned availability for the R&D HPCS is 97%. The actual availability of the R&D HPCS in 2007 was 94%. This 3% variance was due to a number of factors. The equipment delivery and acceptance testing of the sub-system at Boulder took almost 7 months more than planned. The sub-system at Princeton experienced numerical-reproducibility problems. Both of these problems impacted the ability of the users to make productive use of these two sub-systems. The Government is in discussions with the vendor for consideration due for this shortfall in availability.

The planned data availability of the R&D HPCS is 99%. The actual data availability of the R&D HPCS in 2007 was 99%.

Another measure that is used for this investment to gauge customer satisfaction involves measuring how much actual work is being performed by the users of the R&D HPCS. The Environmental Modeling Program (EMP) allocated 18 projects to the R&D HPCS for FY2007.) EMP also specifies the % of each sub-system that is allocated to each of these 18 projects. In FY 07 the 18 projects were able to utilize 87% of their R&D HPCS allocation.

The 13% variance was in part attributed to the problems with two of the sub-systems as described above.

3.0 Financial Performance

3.1 Current Performance vs. Baseline

FY07 R&D HPCS Contract Costs	
Base (Fixed Price)	**$20M**
Reserve	**$1.28M**
Total	**$21.28M**

The contract was fully funded in FY07 there was no cost variance.

The equipment delivery and acceptance testing of the sub-system at Boulder took almost 7 months more than planned. The contractor received and responded to a "Cure Notice" that was sent by the Contracting Officer. The Contractor was able to complete the items listed in the "Cure Notice" as planned. The Government is in discussions with the vendor for consideration due for this delay in schedule and performance.

3.2 Performance Measures

This is fixed price contract that includes a schedule of costs broken out by month and contract year. The vendor invoices the Government on a monthly basis. Invoices are checked against the contract cost schedule to verify that they match and the contract performance measures (SLT, System Availability, and Data Availability. This cost baseline was established at contract award. It is only adjusted when the Government modifies the contract to add more work or when making purchases from the CLINS.

3.3 Cost Benefit Analysis

The cost benefit analysis was performed during the acquisition process. Prior to exercising the yearly option the IMT in conjunction with the HPC Board makes the decision on whether or not to exercise the next contract year based on the contractor's performance.

3.4 Financial Performance Review

Financial performance is typically subjected to a periodic review for reasonableness and cost efficiency. Monthly budget reviews are held with the program manager, CORs and contract managers to ensure contracts are within cost and on schedule. Monthly reports from contractors are required to ensure the Government has the information it needs to evaluate cost performance. A detailed review of work and priorities is undertaken if cost is significantly above base lined values. Also, any necessary corrective actions are also identified and implemented.

4.0 Innovation to Meet Future Customer Needs

The following improvements and activities have been implemented in FY2007 to better meet customer needs, make better use of technology, and lower operating costs:

- Implemented a common scheduler (SGE) at two sites
- Increasing network capacity between R&D sites
- Have implemented a software improvement, text replication, that provides overall performance gains, some jobs see performance gains of 25% or more
- Have implemented a software version upgrade of a commonly used tool (NETCDF) which provides performance gains of up to 19% for some data intensive jobs
- "Parallelized" the ensemble transform code, leading to more than a 20 fold reduction in the wallclock time for this processing step
- "Parallelized" the change-resolution program in the Global Weather Forecast Model which resulted in a reduction of the runtime from 230 seconds to 41 seconds
- Restructured the queues of one sub-system which has resulted in a significant increase in system utilization (close to 100%)
- Obtained CPU hours at Oak Ridge (DOE) to develop surge computing concept
- Completed porting new atmospheric and high resolution coupled climate models to DoE HPC platforms
- Received an additional 500,000 CPU-hours on NASA's Columbia system in May to continue on-going projects on data assimilation and high-resolution atmospheric modeling
- Received 2 million hours from DoE INCITE program for climate

4.1 Number and Types of Users

NOAA's requirements for the use of R&D HPCS far exceed the existing capacity.

Managing the existing R&D HPCS more efficiently will help to mitigate a small portion of this gap. Partnering with other Federal Agencies to utilize their HPC resources also aids in closing the gap somewhat. Advances in technology (Moore's Law) also help. The case needs to be better made both within NOAA management, to OMB, and Congress that additional funding is needed to increase both the capacity and capability of NOAA's HPC in order to better meet the needs of the Nation.

4.2 Funding Levels

Recent trends in government spending indicate that agencies should not expect significant increases in their budgets. This, coupled with the requirement to accommodate more users and incorporate evolving technology, will force the program to find efficiencies and to do more with the same amount of resources.

This is fixed priced contract and the impact of continuing resolutions ends up forcing the contractor to work at risk until funding is received. A recent example occurred at the start of FY08; the vendor decided that they could no longer afford to pay the power costs at one of our sites which caused a major scramble to identify funds with which to pay these costs during the CR.