

**National Oceanic and Atmospheric Administration  
NWS  
Weather and Climate Operational Supercomputer System WCOSS  
Operational Analysis  
2007**

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**Executive Summary**

This report focuses on the operational state of the Weather and Climate Operational Supercomputer System (WCOSS) program as of December 31, 2007, and is based on guidance developed by the Department of Commerce. This annual operational analysis report is a status review in terms of financial performance, customer results and performance measures. It details financial and technical performance against established baselines/requirements and evaluates customer results. The program continues to meet established cost, schedule and performance parameters and directly facilitates NOAA’s strategic goals to “Serve Society’s Needs for Weather and Water Information,” to “Support the Nation’s Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation,” and to “Provide Critical Support for NOAA’s Mission.”

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

The WCOSS program is fully meeting the customer’s needs and the program is delivering the services intended. As described under Performance Measures, this project is exceeding the terms of the contract. Our customers demand on-time product generation and the WCOSS has exceeded NWS requirements while simultaneously support improvements in model accuracy. During 2007, the WCOSS program directly contributed to the NOAA/NWS mission and was critical in supporting the issuance of weather watches and warnings that protect both life and property. The value of this program in terms of lives saved and property protected as well as service to the public mandates a continued need for this investment.

### 1.1 Customer Requirements and Costs

The WCOSS investment interfaces with three NOAA weather data systems as part of its data assimilation activities, and these system interfaces are critical to the modeling and delivery of the suite of operational forecasts that are generated for customers in the weather and climate community: (1) NWSTG, National Weather Service Telecommunications Gateway. The NWSTG shares information with other NWS networks such as the Automated Field Operations & Services (AFOS) network; (2) NEXRAD, Next Generation Weather Radar. NEXRAD is used to warn the public about dangerous weather and its location. Meteorologists can now warn the public to take shelter with more notice than any previous radar. There are 158 operational NEXRAD radar systems deployed throughout the United States and at selected overseas locations. The maximum range of the NEXRAD radar is 250 nautical miles. The NEXRAD network provides significant improvements in severe weather and flash flood warnings, air traffic safety, flow control for air traffic, resource protection at military bases, and management of water, agriculture, forest, and snow removal; and (3) AWIPS, Advanced Weather Interactive Processing System. AWIPS gathers, assimilates, and analyzes vast quantities of data for weather professionals. This powerful data processing system receives a wide variety of meteorological data from Doppler radar, weather satellites, and observation systems, and receives forecasting model data from the WCOSS. The data received is graphically displayed by AWIPS in a geographic weather display.

### 1.2 Performance Measures

The current performance of the system is documented in the table below

<b>Performance Measures</b>			
<b>Indicator</b>	<b>2007 Baseline</b>	<b>Calendar Year 2007</b>	<b>Comments</b>
On-Time Product Generation	99%	99.48%	
System Availability	99%	99.86%	
Time to Switch to Backup System	30 min.	12.75 min	No switch required for four months.

A separate set of Performance Measures were used to evaluate the option to extend the period of performance. The key performance measures were Computational Capability (2.5 times current performance), Computational Capacity (3.7 times current performance) and Input/Output speed (5 times current performance). All these measures were verified by Government personnel. Computational performance was validated using Government provided computational codes.

## **2.0 Strategic and Business Results**

During 2007 significant improvements were made to the following models that run only on WCOSS assets. These models are mission critical and directly contribute to the achievement of NOAA strategic goals. Furthermore, these models are intrinsic to the NCEP business plan.

- Global Forecast System (improved science, improved data assimilation, improved database)
- Short-Range Ensemble Forecast (improved science)
- North American Ensemble Forecast System (improved science, improved database, new products)
- Air Quality Forecast (expanded domain to CONUS)
- Marine Wave Model (improved science, Multi-grid regional model)
- Hurricane Model (improved science)

### **2.1 WCOSS Helps to Achieve Strategic Goals**

NOAA/NWS/NCEP exercised a contract option to extend the current contract with IBM for five years (FY 2007 – FY 2011). This option includes language specific to security enhancements and increased levels of computational performance.

The current investment has boosted the IBM HPC cluster capability with IBM Power5+ processors to 2,368 processors on each system (Primary and Backup). Consequently, the investment will provide a 239% enhancement in sustained performance capability (e.g., an increase of 1.05 teraflops) and a 106% increase in processor capacity, and will alleviate any risks of system saturation and degradation in production generation (e.g., in terms of quality and timeliness of NWS products). The core system configuration previously consisted of tandem (a configuration each for the primary and backup supercomputer system) IBM Power-4 Regatta H clusters with 1,152 processors and a sustained teraflop performance of 0.44 teraflops.

Complementary supercomputer infrastructure includes storage devices and interconnects, communications hardware interfaces, software (operating system, file system, and compilers), networking equipment, system maintenance, support services, and necessary infrastructure enhancements

### **2.2 Business Results**

Some of the qualitative benefits generated by this investment from various climate and weather models include the following: (1) Global Model: model guidance used by the commercial airlines sector facilitates navigational planning and reduces fuel consumption for international flights. (2) Eta Model: The Eta model is the primary guidance used for short-range basic North American weather, severe weather forecasting, regional forecasts and domestic aviation forecasts. (3) Hurricane Model: this model contributes to the forecasts of hurricane tracking and intensity and is the primary modeling tool used by the National Hurricane Center (NHC) forecasters. The guidance provided by this model helps reduce the costs associated with evacuations, estimated to be approximately \$1 million per mile of evacuated area. As the fidelity

and accuracy of this operational model is improved with more advanced computational resources, the NHC forecasters are able to reduce the size of the warning area used for posting hurricane evacuations. (5) Nested Threats WRF Model: This model will replace the current Year-Round Threats Model and will provide detailed guidance for small-scale severe weather, high winds and heavy precipitation, particularly where topography is important. An additional performance measure will be added in the future. This model will also be used to provide the meteorological input at a very fine scale to support the incident meteorologists and Fire Behavior Analysts to project the spread of fire through environments with structures. (6) Year-Round Threats Model: This model is composed of runs of the GFDL hurricane model whenever there are tropical cyclones threatening and of runs of various fixed and selectable nested Meso domains at all other times throughout the year. (7) Climate Model: This model represents a group of models based upon the Global Model coupled to the Ocean Model and land surface model. It is used to develop the NWS's seasonal outlooks and is directly responsible for the U.S. Seasonal Temperature performance measure. (8) WRF /RUC: This model is an enhanced Rapid Update Cycle (RUC) model and provides guidance to the domestic aviation sector. This model provides guidance to the commercial airline sector for route planning (e.g., storm tracking, jet stream effects) thereby helping to reduce fuel consumption costs on domestic flights.

### **2.2.1 Program Management and Controls**

### **2.2.2 Monitoring Cost, Schedule and Performance**

Cost – This is a fixed price contract. The COTR monitors monthly invoices to ensure they correspond to the baseline. Contract modifications are reviewed by the COTR, Program Manager and Contracting Officer prior to implementation and weekly during routine status meetings.

Schedule – This contract provides the principal supercomputing resource for the National Weather Service and as such it is in operational mode 7X24X365. Service delivery is non-stop except during planned upgrades or unscheduled outages. Daily operational status meetings are conducted at NCEP/NCO and attended by Government and IBM personnel engaged in Production Suite support. Weekly status meetings are conducted by NCEP/NCO with participation by NCEP, IBM, facility managers and others (such as communications support personnel) as required.

Performance – CCS program status (cost, schedule and performance) is summarized on monthly Quad charts. Performance-based measurements such as on-time product generation, system reliability and run time variability are verified daily. Computational speed, numerical reproducibility and Input/Output performance are verified quarterly via benchmark tests. Additionally, the NCEP High Performance Computing Allocation Board meets on a quarterly basis to review the requests for and allocations of the operational high performance supercomputing resources to ensure efficient use of those resources.

## **2.3 Reviews**

Annual contingency testing and FISMA self assessment were completed in September 2007.

## **2.4 Security**

The WCOSS system is accredited under requirements spelled out in DOC Information Technology (IT) security program (06/30/05) that are based on OMB and NIST guidance. System Security Plans, Risk Assessments, and Contingency Plans were certified and approved

for WCOSS program in August 2005. A recertification effort is ongoing with an estimated completion date of 02/15/2008. Annual contingency testing and FISMA self assessment were completed September 2007. Management, operational, and technical security controls are adequate to ensure the confidentiality, integrity and availability of information.

## 2.5 Performance Measures

The current performance of the system is documented in the table below

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	Service Quality	Accuracy of Service or Product Delivered	1-day Precipitation Forecast threat score: the forecast accuracy of this score is critical for flood and snowfall planning purposes as well as for agricultural planning.	29	Increase forecast accuracy to a score of 28	29
2007	3.1 Advance understanding and predict changes in the Earth's environment to meet America's economic, social, and environmental needs.	Customer Results	Service Quality	Accuracy of Service or Product Delivered	Seasonal Heidke Temperature skill score: a categorical climatology skill score that measures the improvement in accuracy over the reference forecast.	18	Improve skill score to 19	28.7
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	48-Hour Hurricane Tracking Forecast: this is a critical forecast that gauges the accuracy of the hurricane storm track over a 2-day period and is used by the public and emergency management agencies for evacuation and planning purposes.	Track error of 142 nautical miles	Improve track error to 126 nautical miles	TBD
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	Cycle Time and Resource Time	Timeliness	On-time generation of forecast products: measures the percentage of the time that weather and climate forecasts produced as scheduled, to be available to the weather and climate community.	99.66%	Improve to 99.92%	99.63%
2007	3.1 Advance understanding and predict changes in the Earth's environment to	Technology	Reliability and Availability	Availability	Supercomputing System Availability: a critical measure of the uptime for the	99.0%	Maintain 99.0% availability	99.87%

	meet America's economic, social, and environmental needs.				supercomputer assets used to run and generate the climate and weather forecasting models.			
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	Reliability	Automatic Switch-over time to backup system: in an event of a failure of the primary computer this is a business continuity testing measure that gauges the amount of time necessary to revert all operational forecasts over to the back up supercomputer	30 minute cut-over to full operational backup	Maintain 30 minute cut-over	13 minutes

## 2.6 Other

## 3.0 Financial Performance

### 3.1 Current Performance vs. Baseline

The WCOSS financial performance for calendar 2007 shows no variance, lease costs followed the contractual baseline (extended by Modification 21) exactly. The WCOSS lease packages hardware, software, maintenance, support (including on-site personnel, training and travel) costs under a single invoice.

Performance for the months January through December was tracked against Contract Modification 21 (aka TCP 9) which extended the Period of Performance by five years (2007 through 2011) and specified the total fixed price in each year of the contract.

In addition to lease costs, NCEP spent an additional \$95,346.00 with IBM to augment the system's communications interface and support 10GB/s speeds, consistent with NCEP's wide area network. All funds were derived from NCEP's PAC fund budget.

### 3.2 Performance Measures

The IT capital investment for the WCOSS centers on redundant supercomputer systems. The system procurements will follow the general approach and guidelines established by the Department of Commerce (DOC) Consolidated Operations (CONOPS) process. This methodology is intended to improve the acquisition process between the Government and contractor community, and aims to achieve economies of scale through consolidation of system requirements and fewer acquisitions. With respect to CPIC process, NOAA NWS/NCEP WCOSS is a steady state project with periodic technology refreshment (e.g., maintenance costs) required to improve capability and satisfy increasing computational requirements. Since the supercomputer assets are comprised of commercial off-the-shelf (COTS) equipment that is delivered and installed according to contract specifications within short timeframes (days or

weeks), there is no development phase. The contract specifies guaranteed delivery at a firm fixed price and therefore there is no risk of cost over-runs.

A monthly quad chart, prepared by the COTR, has been reported to NOAA/NWS senior level management describing the ongoing status of schedule and cost performance as well as identifying issues and project risks.

### **3.3 Cost Benefit Analysis**

### **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.

This project is authorized by the NOAA Chief Information Office (CIO), the Assistant Administrator for Weather Services, and has been reviewed by the DOC IT Review Board (CITRB). It is identified as a requirement for the National Centers for Environmental Prediction (NCEP), the organization tasked with the oversight and operation of state-of-the-art high performance computing systems that execute environmental models to meet the nation's requirements for weather and climate forecast information. The acquisition of the primary and backup high performance computing systems undertaken by this project requires a Delegation of Procurement Authority (DPA) from the DOC.

### **4.0 Innovation to Meet Future Customer Needs**

During 2007 NCEP completed an upgraded supercomputing system from its contractor, IBM. This new Power5+ system provided NCEP staff with three times the computational performance of the preceding system, an IBM Power4+ system, propelling NCEP from numbers 167 and 168 to numbers 36 and 37 on the Top 500 Supercomputers (<http://www.top500.org/list/>). In quantitative terms, NCEP systems went from supplying 14 Tflops each to 15.5 Tflops each (where Tflop is trillion of operations/second). Along with the increase in computational performance the contractor delivered a balanced system with increased memory, I/O bandwidth and disk storage. This upgrade positions NCEP to meet the needs of the next generation models with increased spatial and temporal resolution and to increase the number of ensemble members. These improvements are designed to provide our customers with improved weather forecast products (including enhanced precipitation and Air Quality forecasts) on a daily basis.

### **4.1 Number and Types of Users**

NCEP manages access to operational supercomputing environments. Currently, about 125 users have access to the primary machine to manage and monitor the daily operational suite of products that are made available for weather forecasting. About 360 users have access to the backup supercomputing environment that aside from being used as the failover environment for the primary supercomputer, is used by NCEP community of modeling developers and its collaboration extended community as a testbed for products destined to become operational.

## 4.2 Other

### 4.3 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.

Project to Address Challenge: **Keeping pace with EMP modeling requirements.**

The WCOSS is the cornerstone of NWS numerical weather prediction and particular attention is paid to program execution. Therefore, no significant adjustment of plans was required during 2007 but a critical change in new system installation order was supported by the contractor, IBM. To provide the most flexibility during facility work at the Backup System site in Fairmont, WV.

In addition, to benefit NCEP's research and development activities, supported under the NOAA R&D HPCS program, IBM delivered significant computational components to the Gaithersburg facility, well ahead of the scheduled R&D HPCS delivery. Once the R&D HPCS system was delivered, these components were removed and used to complete the Backup System. The actions by the contractor preserved NCEP's R&D computational resources that were at risk due to delays in the NOAA R&D HPCS program.