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Defense Weather Program

Meteorological and Oceanographic Support From Continental United States-Based Support Centers
(D-2002-052)

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Acronyms

AFWA	Air Force Weather Agency
COAMPS	Coupled Ocean/Atmosphere Mesoscale Prediction System
C^4I	Command, Control, Communications, Computers, and Intelligence
FNMOC	Fleet Numerical Meteorology and Oceanography Center
METOC	Meteorological and Oceanographic
MM5	Mesoscale Model Version 5
NWP	Numerical Weather Prediction
ORD	Operational Requirements Document

INSPECTOR GENERAL
DEPARTMENT OF DEFENSE
400 ARMY NAVY DRIVE
ARLINGTON, VIRGINIA 22202–4704

February 19, 2002

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY, AND LOGISTICS
ASSISTANT SECRETARY OF THE AIR FORCE (FINANCIAL MANAGEMENT AND COMPTROLLER)
DIRECTOR, JOINT STAFF
NAVAL INSPECTOR GENERAL

SUBJECT: Audit Report on Meteorological and Oceanographic Support From Continental United States-Based Support Centers (Report No. D-2002-052)

We are providing this audit report for review and comment. This report is the sixth in a series about DoD meteorological and oceanographic support services. We considered comments from the Joint Staff, the Navy, and the Air Force when preparing the final report.

DoD Directive 7650.3 requires that all recommendations be resolved promptly. We request that the Navy provide additional comments on Recommendations A.1.a., A.1.b., A.2.a., A.2.b., and B.1.; the Air Force provide additional comments on Recommendations A.1.a., A.1.b., A.2.a., and A.2.b.; and the Director, Joint Staff provide additional comments on Recommendation A.3. We request all comments be provided by April 19, 2002.

We appreciate the courtesies extended to the audit staff. For additional information on this report, please contact Ms. Evelyn R. Klemstine at (703) 604-9172 (DSN 664-9172) (eklemstine@dodig.osd.mil) or Mr. Gary R. Padgett at (703) 604-9632 (DSN 664-9632) (gpadgett@dodig.osd.mil). See Appendix G for the report distribution. The audit team members are listed inside the back cover.

David K. Steensma

David K. Steensma
Acting Assistant Inspector General
for Auditing

Office of the Inspector General, DoD

Report No. D-2002-052 **February 19, 2002**
(Project No. D2000LG-0102.05)

Meteorological and Oceanographic Support From Continental United States-Based Support Centers

Executive Summary

Introduction. This report is the sixth in a series evaluating the effectiveness and efficiency of DoD meteorological and oceanographic (METOC) support provided by the Military Departments to DoD and other governmental agencies.

Background. Chairman of the Joint Chiefs of Staff Instruction 3810.01A, "Meteorological and Oceanographic Operations," February 25, 1998, states that the Chairman of the Joint Chiefs of Staff is responsible for coordinating, evaluating, and integrating operational METOC requirements between the Military Departments. Chairman of the Joint Chiefs of Staff Instruction 3810.01A also requires the Services to assist each other, where feasible, in accomplishing METOC support, including coordinating research and development efforts to avoid duplication and to ensure commonality in the development of METOC capabilities. Joint Publication 3-59, "Joint Doctrine, Tactics, Techniques, and Procedures for Meteorological and Oceanographic Operations," December 22, 1993 (updated March 23, 1999), also requires the Services to collaborate and coordinate METOC services to ensure they support a "one theater, one forecast" concept. The DoD Joint Technical Architecture, "Joint Interoperability and Warrior Support" (version 4.0), April 2, 2001, provides a minimum set of standards that, when implemented, facilitates interoperability during joint operations by mandating interoperability standards for system development. The Navy and the Air Force are the primary providers of METOC support for DoD and U.S. national programs.

Objectives. We evaluated METOC services and support provided by Navy and Air Force regional centers in the continental United States. In addition, we evaluated Navy and Air Force numerical weather prediction (NWP) models and the feasibility of jointly developing METOC acquisition category III and below programs. We also evaluated the management control program as it related to the audit objectives.

Results. The Navy and the Air Force were providing Service-specific, and not overlapping, METOC support from regional centers in the continental United States. In addition, the Air Force Weather reengineered training concept improved the quality of Air Force Weather forecasts and the efficiency of resources (see Appendix B).

The Navy and the Air Force use different Service-specific mesoscale NWP models despite the ability of those models to forecast similar atmospheric conditions. In addition, the Navy and the Air Force are in the process of separately developing

next-generation mesoscale NWP models rather than developing a standard DoD mesoscale model. As a result, the Fleet Numerical Meteorology and Oceanography Center (FNMOC) and the Air Force Weather Agency (AFWA) were not capable of providing adequate and uninterrupted backup for each other, including NWP support, should one center be unable to meet its operational requirements (finding A).

The Navy and the Air Force did not always review and comment on operational requirements documents for METOC acquisition category III and below programs. Specifically, of the 18 Navy and Air Force operational requirements documents for FY 2001 METOC acquisition category III and below programs, valued at $486.9 million, 9, valued at $190.5 million, had not been reviewed by both the Navy and the Air Force for potential joint involvement. As a result, the Navy and the Air Force might be acquiring METOC acquisition category III and below programs that could be supported by existing systems or technology. In addition, the Services might not be deriving benefits that could flow from jointly developing, funding, and managing METOC programs (finding B).

See Appendix A for details on our review of the management control program.

Summary of Recommendations. We recommend the Oceanographer of the Navy and the Air Force Director of Weather implement the initiative "Implement Joint Theater Forecast Consistency" and cooperatively develop the next-generation DoD standard mesoscale NWP model. We recommend the Commanding Officer, FNMOC and the Commander, AFWA develop a viable continuity of operations plan and include all DoD Joint Technical Architecture Command, Control, Communications, Computers, Intelligence (C^4I), Surveillance, and Reconnaissance Domain standards in their existing technical architecture framework. We recommend the Chairman of the Joint Chiefs of Staff revise Joint Publication 3-59 to include doctrine that addresses joint modeling. We recommend the Navy and the Air Force revise their concepts of operations for providing METOC support based on revisions to the joint doctrine. We also recommend the Navy and the Air Force develop procedures for coordinating, reviewing, and commenting on operational requirements documents for METOC acquisition category II and below programs.

Management Comments. The Oceanographer of the Navy agreed with implementing the initiative about joint theater consistency; however, the Air Force Director of Weather nonconcurred, stating that the initiative does not require the Navy and the Air Force to develop a joint mesoscale model. The Oceanographer of the Navy and the Air Force Director of Weather agreed with cooperatively developing the next-generation standard mesoscale model. The Oceanographer of the Navy agreed with the need to develop a viable continuity of operations plan with the Air Force; however, the Air Force Director of Weather disagreed, stating that although there was room for improvement, an effective backup occurs today among AFWA, FNMOC, and the National Weather Service's National Centers for Environmental Prediction. The Oceanographer of the Navy also concurred with including all DoD Joint Technical Architecture C^4I, Surveillance, and Reconnaissance Domain standards in existing technical architecture framework. The Air Force Director of Weather nonconcurred,

stating that its system only provides data into C^4I, Surveillance, and Reconnaissance-related systems; therefore, the Air Force is only required to conform to the rules of data exchange. The Joint Staff disagreed with revising Joint Publication 3-59 to include doctrine that addresses joint modeling, stating that this report mistakenly equates mesoscale NWP modeling processes and products with operational forecasts. The Oceanographer of the Navy concurred with revising Navy guidance to address joint modeling based on revisions to Joint Publication 3-59. The Air Force Director of Weather nonconcurred with revising Air Force guidance to address joint modeling, stating that Joint Publication 3-59 should not address specific solutions, such as joint modeling. The Oceanographer of the Navy and the Air Force Director of Weather agreed with the need to coordinate and review operational requirements documents for METOC acquisition II and below programs. A discussion of management comments on the recommendations is in the Findings section of the report, a discussion of Air Force comments on finding A is in Appendix F, and the complete text is in the Management Comments section.

Audit Response. In an era when transforming the military for the challenges of the 21st century is of paramount importance, we are concerned that the responses to the report do not recognize that the thrust of the report was to promote greater cooperation between the excellent METOC programs in the Navy and Air Force. Greater cooperation can only improve and increase the value of weather forecasts for the warfighter. Although the Navy concurred with the report's recommendations, the Navy did not specify how it would implement the recommendations for "Implement Joint Theater Forecast Consistency" initiative; cooperatively developing the next-generation mesoscale NWP model; developing a viable continuity of operations plan; including all the joint architecture domain standards within their existing technical architecture framework; and revising Navy guidance. We consider the Air Force comments to be partially responsive in regard to cooperatively developing the next-generation mesoscale NWP model, because they do not address a plan for the Navy and the Air Force to jointly develop a next-generation mesoscale NWP model. The Air Force comments were not responsive to the recommendation for "Implement Joint Theater Forecast Consistency" initiative; developing a viable continuity of operations plan; and including all the joint architecture domain standards within existing technical architecture framework. We consider the Joint Staff comments to be nonresponsive in regard to addressing the need for joint modeling in Joint Publication 3-59. The intent of the recommendation was to address the need for joint modeling to support DoD operations in Joint Publication 3-59, not to restrict how joint METOC support is provided. Revision of the Joint Publication 3-59 will result in a requirement for the Navy and the Air Force to revise their implementing guidance.

We request that the Joint Staff, the Navy, and the Air Force provide additional comments on the final report by April 19, 2002.

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Background

Joint Chiefs of Staff Responsibilities. Chairman of the Joint Chiefs of Staff Instruction 3810.01A, "Meteorological and Oceanographic Operations," February 25, 1998, states that the Chairman of the Joint Chiefs of Staff is responsible for coordinating, evaluating, and integrating operational meteorological and oceanographic (METOC) requirements between the Military Departments. In addition, Chairman of the Joint Chiefs of Staff Instruction 3810.01A requires the Services to assist each other, where feasible, in accomplishing METOC support, including coordinating research and development efforts to avoid duplication and to ensure commonality in the development of METOC capabilities.

Military Department Responsibilities. The Navy and the Air Force provide METOC support for Service-specific and joint operations through three-tier organizational structures. The Navy and the Air Force are the primary providers of METOC support for DoD and U.S. national programs. In addition, the Navy and the Air Force also provide METOC support to other Federal agencies and international partners.

Army. The Deputy Chief of Staff for Intelligence is responsible for establishing METOC support policy. The Deputy Chief of Staff for Operations and Plans is responsible for identifying and approving meteorological requirements related to data collection and forecasting; however, the Air Force Director of Weather is responsible for determining how best to meet those requirements. Public Law 253, "National Security Act of 1947," chapter 343, July 26, 1947, assigns the Air Force responsibility for providing METOC support for Army operations. Pursuant to the implementation of the National Security Act of 1947, inter-Service agreements require the Air Force to provide personnel and resources to meet most of the Army's weather requirements.

Navy. The Oceanographer of the Navy is the resource and program sponsor for Navy and Marine Corps METOC activities. The Navy primarily provides METOC services through a three-tier organizational structure corresponding to the three levels of military operations: strategic, operational, and tactical. The Fleet Numerical Meteorology and Oceanography Center (FNMOC) at Monterey, California, is the principal DoD operational processing center for automated global METOC analyses and predictions. FNMOC provides the official DoD global NWP[1] model—the Navy Operational Global Atmospheric Prediction System[2]—and regional models through Navy and joint command, control, communications, computers, and intelligence (C^4I) systems needed to support Navy, Marine Corps, and joint operations abroad or in the continental United States.

[1]NWP is the science of using computers to produce three-dimensional depictions of future atmospheric conditions by solving sets of equations that define how the atmosphere behaves.

[2]The Navy Operational Global Atmospheric Prediction System is the back-up global NWP model for the National Weather Service and the only DoD global model.

Air Force. The Air Force Director of Weather is the resource and program sponsor for Air Force METOC activities. In addition, the Air Force Director of Weather is responsible for coordinating with the Army any operational METOC support and policies related to, or potentially impacting, the Army. The Air Force primarily provides METOC services through a three-tier organizational structure to support the three levels of military operations: strategic, operational, and tactical. The Air Force Weather Agency (AFWA) at Offutt Air Force Base, Nebraska, is the principal strategic center in Air Force Weather. AFWA produces global-scale METOC products and centralized space weather products and services needed to support Army, Air Force, and joint operations. AFWA is responsible for DoD satellite processing; providing regional, theater-scale NWP models and upper-air analyses; providing global visualization products from real-time meteorological databases; and developing and acquiring METOC equipment to meet Army, Air Force, and DoD operational requirements for forces abroad or in the continental United States. In addition, AFWA is responsible for providing all space weather forecasts and analyses that are used by DoD forces to support Service-specific and joint operations.

DoD Joint Technical Architecture. The DoD Joint Technical Architecture, "Joint Interoperability and Warrior Support" (version 4.0), April 2, 2001 (Joint Architecture), provides a minimum set of standards that, when implemented, facilitates the flow of information in support of the warfighter. The Joint Architecture includes content, commonality, format, information processing, information transfer, and security standards. The Joint Architecture:

- provides the foundation for interoperability[3] among all tactical, strategic, and combat systems at the technical architecture level;
- mandates interoperability standards and guidelines for system development and acquisition that will facilitate interoperability during joint operations; and
- communicates to industry the DoD intent to consider open system[4] products and implementation.

The Joint Architecture is required for managing, developing, and acquiring new or improved systems within DoD. In addition, the Joint Architecture is critical to achieving a cost-effective, seamlessly integrated environment that provides interoperability between the Services and across current and future systems.

[3]DoD Directive 4630.5, "Compatibility, Interoperability, and Integration of Command, Control, Communications, and Intelligence Systems," November 12, 1992, defines interoperability as the ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces, and to use the services so exchanged to enable them to operate effectively together. Interoperability is achieved between systems when information or services are exchanged directly and satisfactorily between the system and users. (The Directive was replaced by DoD Directive 4630.5, "Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS)," January 11, 2002.)

[4]An open system is a system that implements sufficient open standards for interfaces, services, and supporting formats to enable properly engineered components to be used across a wide-range of systems with minimal changes; to interoperate with other components on local and remote systems; and to interact with users in a style that facilitates portability.

Objectives

This report is the last in a series evaluating the effectiveness and efficiency of DoD METOC support provided by the Military Departments to DoD and other governmental agencies. The overall objective of this self-initiated series of audits was to evaluate DoD METOC services and support to determine whether the Military Departments were providing the most cost-effective and nonduplicative METOC support to DoD and other governmental agencies. Specifically, we evaluated METOC services and support provided by Navy and Air Force regional centers in the continental United States. In addition, we evaluated Navy and Air Force NWP models and the feasibility of jointly developing METOC acquisition category III and below programs. We also evaluated the management control program as it related to the specific audit objectives. See Appendix A for a discussion of the audit scope and methodology, our review of the management control program, and prior coverage.

Support Initiatives

We evaluated METOC services and support provided by Navy and Air Force regional support centers in the continental United States and determined the Navy and the Air Force were not providing overlapping METOC services and support. The Navy provides operational METOC support for the Atlantic and Pacific Fleets and joint operations from regional centers in the continental United States. The Air Force provides operational METOC support for Army and Air Force units assigned to the Air Mobility Command at Scott Air Force Base, Illinois; the 8th Air Force at Barksdale Air Force Base, Louisiana; the 12th Air Force at Davis-Monthan Air Force Base, Arizona; and the 9th Air Force at Shaw Air Force Base, South Carolina, from regional centers in the continental United States. In addition, we evaluated changes to the Air Force Weather training philosophy that were implemented to improve the quality and quantity of Air Force Weather forecasters. By combining the development of forecasting skills with actual operational support, the reengineered Air Force training concept improved the quality of Air Force Weather forecasts. See Appendix B for a discussion of our review of Service-specific METOC support from the continental United States and the Air Force Weather reengineered training program.

We reviewed an Energy Conservation Forecast Program developed by the Naval Atlantic Meteorology and Oceanography Center in Norfolk, Virginia. The Energy Conservation Forecast Program was designed to provide long-range forecasts to participating military bases with seasonal energy needs to decrease energy use and aid energy buyers in making fuel purchases. As of August 2001, the Naval Atlantic Meteorology and Oceanography Center had a documented reduction of more than $66 million in fuel and energy costs through the program since 1983. See Appendix C for a discussion of our review of the Energy Conservation Forecast Program.

A. Joint Mesoscale Modeling

The Navy and the Air Force use different Service-specific[5] mesoscale[6] NWP models despite the ability of those models to forecast similar atmospheric conditions. In addition, the Navy and the Air Force are in the process of separately developing next-generation mesoscale NWP models rather than developing a standard DoD mesoscale model. The lack of coordination occurred because the Navy and the Air Force did not:

- fully implement the January 13, 1993, Oceanographer of the Navy and Air Force Director of Weather memorandum of agreement, "Navy–Air Force Cooperation Implementation Action Memorandum" (NAVAF Agreement), initiative to "Implement Joint Theater Forecast Consistency";
- develop a mutually agreed-upon continuity of operations plan that includes classified and foreign operations; and
- follow standards to facilitate interoperability and systems[7] integration as defined in the Joint Architecture.

In addition, Joint Publication 3-59, "Joint Doctrine, Tactics, Techniques, and Procedures for Meteorological and Oceanographic Operations," December 22, 1993 (updated March 23, 1999), does not specifically identify joint modeling when addressing a joint concept of operations for providing METOC support during military operations. As a result, FNMOC and AFWA were not capable of providing adequate and uninterrupted backup for each other, including NWP support, should one center be unable to meet its operational requirements.

Service-Specific Mesoscale Modeling

The Navy and the Air Force use different Service-specific mesoscale NWP models despite the ability of those models to forecast similar atmospheric conditions. See Appendix D for a list of atmospheric conditions predicted by both the Navy and Air Force mesoscale NWP models.

[5]Service-specific does not delineate exclusive use by Navy or Air Force; however, within DoD, primary use of the Coupled Ocean/Atmosphere Mesoscale Prediction System is by the Navy and primary use of the Mesoscale Model Version 5 is by the Air Force.

[6]Mesoscale refers to the size of weather systems smaller than synoptic-scale systems but larger than storm-scale systems. Horizontal dimensions generally range from around 50 kilometers to several hundred kilometers across.

[7]A system is an integrated composite of people, products, and processes that provides a capability or meets a stated need or objective.

Navy Mesoscale Modeling. FNMOC provides a high-resolution, real-time mesoscale model that is capable of simulating changes in atmospheric conditions that could affect DoD air, land, and sea operations and weapon systems. The Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) was developed as a replacement model for the Navy Operational Regional Prediction System[8] in 1998 by the Marine Meteorology Division of the Naval Research Laboratory[9] in Monterey, California, to meet an increased need for tactical METOC analyses and forecast products in coastal regions because of the interaction of the atmosphere, the underlying ocean, and nearby land. COAMPS was also needed because the Navy Operational Global Atmospheric Prediction System and conventional METOC observing systems did not provide adequate spatial[10] and temporal[11] resolution to thoroughly process conditions that were actually occurring in or near shore regions. FNMOC uses lateral boundary conditions established by the Navy Operational Global Atmospheric Prediction System output and observations from aircraft, remote sensors, ships, and satellites to generate short-term forecasts (up to 72 hours) for any given region of the earth.

COAMPS is an operational mesoscale NWP model featuring:

- nested,[12] hydrostatic[13] and non-hydrostatic physics;
- explicit moisture physics, including cloud formation and turbulence prediction;
- sea-surface temperature analysis and prediction;
- a coupled ocean and atmosphere integration that describes moisture, heat, and momentum exchanges between the air and sea;
- the ability to forecast embedded aerosols, including dust and smoke, affecting military operations involving electro-optical propagation; and

[8]The Navy Operational Regional Atmospheric Prediction System was developed in 1983 and used operationally by FNMOC until 1998 when COAMPS testing was complete.

[9]The Marine Meteorology Division, Naval Research Laboratory is the only DoD NWP research facility, and the only Navy laboratory, dedicated entirely to meteorological research.

[10]Spatial refers to the distance between model grid points.

[11]Temporal refers to the frequency at which model solutions are calculated.

[12]COAMPS uses multiple nested grids to represent the evolution of environmental conditions over progressively smaller regions of the world with progressively higher spatial resolution requirements.

[13]Hydrostatic is defined as the state of a fluid whose surfaces of constant pressure and constant mass (or density) coincide and are horizontal throughout. Complete balance exists between the force of gravity and the pressure force.

- improved data assimilation, including an automated data quality control, a complete data analysis scheme to provide boundary conditions, an initialization procedure to provide higher quality initial conditions for the forecast, and a prediction system, through a state-of-the-art, three-dimensional variation method.

The Navy uses data from COAMPS to forecast conditions affected by coastal rains, frontal systems, land–sea breezes, terrain-induced winds, and tropical cyclones. FNMOC generally runs the Navy Operational Global Atmospheric Prediction System (81 km resolution) and a COAMPS nested grid (27 km resolution) to support Navy and joint littoral[14] operations (see Appendix E). In addition, FNMOC runs two levels (27 and 9 km resolution) of COAMPS nested grids simultaneously with the Navy Operational Global Atmospheric Prediction System for regions that the Navy considers "high interest" areas. However, if necessary, COAMPS is capable of producing an even finer scale (1 km resolution) nested grid. The Defense Threat Reduction Agency used the finer scale COAMPS model to monitor and predict hazardous dispersion of biological, chemical, and nuclear weapons. Recent advances in remote sensing, data assimilation, and computing capabilities are allowing FNMOC and the Marine Meteorology Division, Naval Research Laboratory to develop a more consistent, full-physics model capable of fully integrating atmosphere and ocean conditions.

COAMPS provides the high-resolution, globally relocatable, and integrated METOC prediction capability needed to provide seamless METOC support for Navy, Marine Corps, and joint operations. However, the Superintendent, Marine Meteorology Division, Naval Research Laboratory stated that because of rapid advances in science and technology, the Navy planned to support and use COAMPS only for approximately 10 more years. As a result, FNMOC and the Marine Meteorology Division, Naval Research Laboratory, through research and operational testing, are continuously working to implement improvements to COAMPS and to develop an advanced, next-generation mesoscale NWP model that can replace COAMPS by FY 2011.

Air Force Mesoscale Modeling. AFWA provides a high-resolution, real-time mesoscale NWP model that is capable of simulating changes in atmospheric conditions that could affect Army, Air Force, and DoD air, land, and sea operations and weapon systems. In 1974, the weather community—specifically, the Pennsylvania State University and the National Center for Atmospheric Research—cooperatively developed the original version of Mesoscale Model Version 5 (MM5) to meet an increased need for tactical METOC analyses and forecasts. By 1997, AFWA began using the MM5 as a replacement for the Relocatable Window Model. MM5 was designed primarily for research purposes and, through continuous improvements by universities and Government organizations, including AFWA, the original version of MM5 was expanded to include:

- multiple nested grids and global relocation capabilities,

[14]Littoral regions include the area on or near the shore of a body of water.

- hydrostatic and non-hydrostatic physics that allow global- and target-scalability of the model,
- explicit moisture physics, including cloud formation and precipitation,
- multitasking capability on shared- and distributed-memory machines, and
- four-dimensional data-assimilation capabilities.

MM5 uses routine observations, including relative humidity, sea-level pressure, sea-surface temperature, temperature, upper-air and surface reports, and wind direction and speed, to provide variable resolution models needed to support Army and Air Force operations. AFWA generally runs three levels (45, 15, and 5 km resolution) of MM5 nested grids simultaneously to support air and land operations (see Appendix E). However, AFWA is also capable of producing an even finer scale (approximately 1 km resolution) nested grid when required to support a specific mission. Through continuous improvements, MM5 not only has become an advanced NWP model used for research purposes, but also has become vital to meeting Army and Air Force operational forecasting requirements around the world.

MM5 provides the high-resolution and globally relocatable METOC prediction capability needed to provide seamless METOC support for Army, Air Force, and joint operations. However, AFWA personnel stated that because of rapid advances in science and technology, the Air Force planned to support and use MM5 only for approximately 3 more years. During the FY 2000 overall Air Force budget program review, the Air Force Research Laboratory at Hanscom Air Force Base, Massachusetts, did not support atmospheric weather science and technology funding because the Air Force major commands did not identify atmospheric weather research and development as a high priority. As a result, the Air Force Research Laboratory did not receive science and technology funding to support Air Force Weather requirements for atmospheric weather research and development during FY 2001 and was uncertain as to whether atmospheric weather research and development funding would be restored. With a need to leverage other mesoscale modeling research and development efforts, AFWA partnered with the National Center for Atmospheric Research, the National Oceanic and Atmospheric Administration, and a number of collaborating institutions and university scientists to develop a next-generation mesoscale NWP model, the Weather Research and Forecast model,[15] to replace MM5 by FY 2004.

[15]The Weather Research and Forecast model is a development effort jointly undertaken to advance the understanding and prediction of METOC conditions and promote closer ties between operations and research. The Weather Research and Forecast model effort includes reengineering the underlying software architecture to produce a modular, flexible code designed from the outset to provide portable performance across diverse computing architectures.

Next-Generation Mesoscale Modeling

The Navy and the Air Force are in the process of separately developing next-generation mesoscale NWP models rather than developing a standard DoD mesoscale model.

As of January 2002, the Navy and the Air Force were in the process of improving current mesoscale NWP models and developing next-generation mesoscale NWP models; however, neither Service was working with the other to develop a standard DoD mesoscale NWP model. Although Navy personnel stated they were aware of the Weather Research and Forecast model, the Superintendent, Marine Meteorology Division, Naval Research Laboratory[16] stated that the Navy did not expect the Weather Research and Forecast model to initially exceed the capabilities COAMPS already possessed and was also unsure whether the Weather Research and Forecast model would fully integrate atmosphere and ocean conditions. As a result, the Superintendent stated, the Navy planned to continue implementing upgrades to COAMPS and developing an advanced, next-generation mesoscale NWP model.

To support Service-specific operations, the Navy and the Air Force were producing separate mesoscale NWP models that would generally provide coverage for overlapping regions of the world. In addition, the Navy and the Air Force were investing resources for the development of next-generation mesoscale NWP models intended to provide Service-specific support, not facilitate joint support.

Navy and Air Force Cooperative Agreement

The Navy and the Air Force use different mesoscale NWP models and are in the process of separately developing next-generation mesoscale NWP models because they did not fully implement the NAVAF Agreement initiative to "Implement Joint Theater Forecast Consistency."

NAVAF Agreement Initiatives. On January 13, 1993, the Oceanographer of the Navy and the Air Force Director of Weather signed the NAVAF Agreement to evaluate potential areas of cooperation between the Navy and the Air Force and to improve meteorological support problems identified during Operation Desert Storm. The NAVAF Agreement identifies 19 initiatives, including designating a single global model to be used as the DoD global NWP model of choice and consolidating Service-specific mesoscale models. Of the 19 initiatives, 16 were accepted for implementation, 2 were rejected, and 1 was returned for further investigation. As of January 2002, only eight initiatives had been completed.

[16]The Superintendent, Marine Meteorology Division, Naval Research Laboratory and other Naval Research Laboratory scientists are members of the Weather Research and Forecast Model Oversight and Science Board. The board is responsible for budgetary issues, technical evaluations, and the overall progress of the Weather Research and Forecast model.

Designated DoD Global NWP Model. The NAVAF Agreement identifies that a single global NWP model should be used to provide the basis for all DoD forecasts. The NAVAF Agreement recommended that the Navy and the Air Force transition to the Navy Operational Global Atmospheric Prediction System as the DoD standard. The Navy and the Air Force accepted the initiative and, as a result, FNMOC is responsible for producing the official DoD global NWP model. The Navy Operational Global Atmospheric Prediction System ingests classified sources of data observations that are not available to other global NWP models. However, AFWA personnel stated they were not using the Navy Operational Global Atmospheric Prediction System to initiate MM5. Instead, AFWA generally used the National Weather Service global NWP model (Aviation Model) because the National Weather Service was able to provide that global model more frequently (four times a day) than FNMOC (two times a day) and with a higher vertical resolution. As of January 2002, the Navy was in the process of converting the NWP modeling system at FNMOC from a Cray supercomputer to a Silicon Graphics, Incorporated, Origin 3800 multiprocessor server. As a result of the conversion, FNMOC expected to be able to provide the Navy Operational Global Atmospheric Prediction System to AFWA with a higher vertical resolution and four times a day.

Joint Forecast Consistency. The NAVAF Agreement identifies that the Navy and the Air Force should evaluate the types of data and the products required by theater forecasters and determine where those products should be produced. The NAVAF Agreement recommended that the Navy and the Air Force consolidate Service-specific NWP models and provide higher resolution products to ensure they meet the "one theater, one forecast" concept. Recipients of Service-unique NWP models frequently do not have access to, or use, the other Services' NWP models. As a result, Navy and Air Force forecasters may not be effectively and efficiently using other Service models because of unfamiliarity with the NWP model's characteristics and tendencies. Although the Navy and the Air Force accepted the initiative, as of January 2002, FNMOC and AFWA continued to produce separate, Service-specific NWP models rather than using a standard DoD model.

The NAVAF Agreement was designed to provide a framework for a long-term cooperative effort with the goal of identifying ways in which the Navy and the Air Force could provide METOC support with greater efficiency and effectiveness. In a January 16, 2001, memorandum from the Air Force Director of Weather to the Oceanographer of the Navy, "Mutual Objectives in Weather Modeling," the Air Force states that in the spirit of the NAVAF Agreement to improve joint METOC support to the warfighter, the Navy and the Air Force should integrate separate NWP mesoscale models into a single, coupled model that includes atmosphere, ocean, and surface conditions. As of January 2002, the Navy and the Air Force were coordinating that effort and also were planning to address the other accepted NAVAF Agreement initiatives that had not yet been completed.

Establishing a Joint NWP Modeling Center. The Commanding Officer, FNMOC supports a concept paper developed by the staff of the Oceanographer of the Navy, "Establishing a Joint Numerical Weather Prediction Modeling

Center," in which the Navy outlines a proposal to position the DoD METOC modeling community to take advantage of technological advances and achieve the Joint Vision 2020[17] goal of information superiority.[18]

The Navy concept paper also states that with steady budgets and current technology trends, the DoD METOC community should examine the establishment of a joint NWP modeling center and possibly alter some of its organizational and operational concepts. The Navy also states that readiness training will rely on more realistic modeling and simulation efforts of the battlespace environment. For example, DoD and other Federal agencies will be required to rely on more accurate dispersion predictions because of other countries' access to weapons of mass destruction. The concept paper identifies four potential options to provide a single, comprehensive, and coherent representation of the battlespace environment during joint operations and ensures METOC support functions meet the goals of Joint Vision 2020. The Commanding Officer, FNMOC stated that the options identified in the concept paper enhance Navy and Air Force METOC support to the warfighter by providing DoD more ways to consolidate resources and efficiently meet operational requirements.

The Air Force did not agree with or support all the concepts stated in the Navy paper on joint METOC modeling. The Commander, AFWA provided a list of end-state characteristics that should be considered prior to establishing a joint modeling center, including:

- ensuring joint warfighter needs are met while also ensuring the Services are capable of responding to Service-specific operations,
- presenting a logical business decision, both for the end-state and for the cost to achieve the end-state,
- facilitating a unified and consistent forecast for joint operations, and
- exploiting Service-unique METOC capabilities and resources.

However, the Commander, AFWA stated that although joint NWP modeling could be beneficial to providing METOC support for DoD operations, the costs associated with designating a joint NWP modeling center would probably exceed the benefits derived from consolidating NWP modeling responsibilities of FNMOC and AFWA. In addition, the Commander, AFWA stated that by consolidating the separate NWP responsibilities, the Services could potentially inhibit their ability to meet operational requirements.

Other Correspondence on Mesoscale NWP Modeling. In a memorandum from the Oceanographer of the Navy to the Air Force Director of Weather,

[17]Joint Vision 2020 is a conceptual template for how America's military forces will channel the vitality and innovation of their people, and leverage technological opportunities to achieve new levels of effectiveness in joint warfighting.

[18]Information superiority includes the capability to collect, process, and disseminate an uninterrupted flow of information while exploiting or denying an adversary's ability to do the same.

"Navy–Air Force Cooperation: Numerical Prediction," June 5, 1995, the Oceanographer of the Navy states that according to a NAVAF Agreement briefing on December 17, 1993, the Navy and the Air Force approved a regional and theater modeling roadmap that identified COAMPS (then the Navy Operational Regional Atmospheric Prediction System) as the designated DoD mesoscale model. The memorandum also states that the Air Force agreed to use COAMPS, in conjunction with the Air Force Interim Cloud Forecast model, to develop theater forecasts until the Air Force Global Theater Weather Analysis and Prediction Systems was fully operational.[19] When fully operational, the Air Force Global Theater Weather Analysis and Prediction System would use COAMPS to initiate forecasts, including aerosol, cloud, and visibility forecasts.

In response to the June 5, 1995, memorandum, the Air Force Director of Weather replied in a memorandum, "Navy–Air Force Cooperation: Numerical Prediction," July 24, 1995, that although the Air Force was committed to using the best available model for supporting theater operations, the Air Force determined it would cost approximately $3 million to integrate COAMPS fields into the existing Air Force Weather architecture. The memorandum also states that unless the Navy was able to provide additional funding to integrate COAMPS, the Air Force would be unable to follow the agreed-upon theater and operational roadmap.

The Oceanographer of the Navy responded to the July 24, 1995, Air Force memorandum on December 15, 1995, stating that although funding was required to integrate COAMPS fields into the existing Air Force Weather architecture, the approved theater and operational modeling roadmap indicates that after an initial investment of $4.12 million, the Air Force, in subsequent years, could expect to avoid approximately $8.5 million in operational costs. As of January 2002, AFWA had not integrated COAMPS fields into the Air Force Weather architecture and, as a result, had not been able to realize any of the $8.5 million in expected cost avoidance.

The Navy and the Air Force use of Service-specific mesoscale NWP models does not facilitate the ability to provide consistent METOC forecasts during joint operations nor does it support the "one theater, one forecast" concept identified in Joint Publication 3-59. Although nothing precludes having separate mesoscale NWP models, separate models could impede progress toward consistent and efficient METOC support. Separate NWP models may result in different assessments of METOC conditions, preparations for conditions, or operational "go, no go" decisions. Therefore, the Navy and the Air Force should implement the NAVAF Agreement initiative to "Implement Joint Theater Forecast Consistency" by consolidating their separate mesoscale NWP models and develop a standard next-generation DoD mesoscale NWP model.

[19]The Global Theater Weather Analysis and Prediction System is an Air Force-unique system that was designed to improve the accuracy of forecasts in addition to improving spatial and temporal resolution for global and theater forecasts by incorporating modern NWP models.

Continuity of METOC Operations

The Navy and the Air Force are in the process of separately developing next-generation mesoscale NWP models because they did not develop a mutually agreed-upon continuity of operations plan.

METOC Back-Up Capabilities. FNMOC and AFWA were not capable of providing adequate and uninterrupted backup for each other should one center be unable to meet its operational requirements.

METOC Infrastructure at FNMOC and AFWA. FNMOC and AFWA computer infrastructures were Service-specific and could not easily process the other center's mesoscale NWP model without extensive changes to their existing hardware and software. As of October 29, 2001, FNMOC had achieved final operational capability on the Silicon Graphics, Incorporated, Origin 3800 computing system to run the Navy Operational Global Atmospheric Prediction System, COAMPS, and other required models. By FY 2005, FNMOC will have a sustained execution capability of 400 gigaFlops.[20] In comparison, the International Business Machine Scalable Power Parallel system at AFWA allows a sustained execution capability of 625 gigaFlops. However, the Silicon Graphics, Incorporated, Origin 3800 computing system allows FNMOC to process classified and unclassified METOC data concurrently, whereas the International Business Machine Scalable Power Parallel system at AFWA is only capable of processing unclassified METOC data. FNMOC and AFWA also use different methods for storing METOC data.

METOC Products Provided by FNMOC and AFWA. FNMOC and AFWA produce different METOC products to support Service-specific and joint requirements. FNMOC produces a global and a mesoscale NWP model and various specialized models, including the Geophysical Fluid Dynamics Laboratory Tropical Cyclone Model, the Optimum Thermal Interpolation System, and the Wave Action Model, to support Navy and joint requirements for accurate and timely METOC forecasts. The mesoscale NWP model used by FNMOC not only predicts changes in the atmosphere, but also predicts changes in the ocean. AFWA also produces a mesoscale NWP model and various specialized models, including a snow analysis, a real-time cloud analysis, and a land-surface model, to support Army, Air Force, and joint requirements for accurate and timely METOC forecasts. Although FNMOC and AFWA provide unique METOC support for certain classified operations, neither center is currently able to provide support to all classified operations supported by the other center.

METOC Back-Up Support Agreements. FNMOC and AFWA each have memorandums of agreement in place with Federal agencies to provide reciprocal backup for specific functions or NWP models; however, neither FNMOC nor AFWA have viable procedures in place to ensure each center could provide

[20]A gigaFlop is a measurement for rating the speed of microprocessors and is equal to one billion floating-point operations per second.

uninterrupted METOC support to DoD. Joint Publication 3-59 states that the Military Departments must maintain a state of immediate responsiveness to joint operations by:

- identifying training techniques that allow for a seamless transition to joint operations,
- maintaining communication equipment interoperability, and
- planning and maintaining standardized and interoperable equipment.

Although Joint Publication 3-59 identifies FNMOC and AFWA as critical components for the success of joint operations, it does not address operational back-up capabilities should FNMOC or AFWA be unable to meet its operational requirements. Because the Navy and the Air Force have adopted the "train as you're going to fight" methodology, FNMOC and AFWA should have an operationally viable and tested continuity of operations plan in place to ensure they can provide METOC support to DoD forces abroad during peacetime and wartime operations.

Meeting Joint Architecture Requirements

The Navy and the Air Force use different mesoscale NWP models because they did not follow standards to facilitate interoperability and systems integration as defined in the Joint Architecture.

Need for a Joint Architecture. In October 1995, the Deputy Secretary of Defense directed a DoD-wide effort to define and develop a better means and process for ensuring that C^4I capabilities meet warfighter requirements. As a result, the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence) issued a memorandum on November 14, 1995, requiring the Services and other command authorities to develop a set of working standards and establish a single, unifying DoD technical architecture that would ensure all future DoD C^4I acquisitions were joint and interoperable from their inception and give existing systems a baseline to move toward interoperability.

Implementation of the Joint Architecture. On August 22, 1996, the Under Secretary of Defense for Acquisition, Technology, and Logistics (then the Under Secretary of Defense for Acquisition and Technology) and the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence) issued a memorandum, "Implementation of the DoD Technical Architecture," requiring that DoD Components implement the initial version of the Joint Architecture, version 1.0. In addition, DoD Components were required to use the Joint Architecture as the basis for all emerging C^4I systems, system upgrades, and system interfaces and to migrate existing C^4I systems to the applicable Joint Architecture standards, while considering cost, schedule, and performance impacts.

In May 1998, the offices of the Under Secretary of Defense for Acquisition, Technology, and Logistics; the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence); and the Director for Command, Control, Communications, and Computers, Joint Staff agreed to expand the Joint Architecture to include emerging technologies, and, as a result, issued a memorandum, "DoD Joint Technical Architecture Version 2.0," November 30, 1998, that required the Joint Architecture be used for not only C^4I-related systems, but all systems that exchange information electronically, that cross functional or DoD Component boundaries, or that give the warfighter operational capability.

C^4I-Related Systems. The Joint Architecture was designed to provide a foundation for interoperability and to promote applications and data that were independent of their hardware in order to achieve interoperability and systems integration for all C^4I-related systems. Because the infrastructures at FNMOC and AFWA use C^4I-related systems for NWP modeling, they are required to conform to the minimum standards for interoperability and systems integration identified in the Joint Architecture. In addition, METOC support provides an operational capability to the warfighter; therefore, the computer systems that develop NWP models should conform to the Joint Architecture. The Joint Architecture not only identifies minimum standards necessary for interoperability and systems integration, but also identifies additional standards needed for specific groups (domains) of DoD systems. The C^4I, Surveillance, and Reconnaissance Domain consists of integrated systems related to doctrine, procedures, organizational structure, equipment, facilities, and communications. We believe METOC functions are inherent to the C^4I, Surveillance, and Reconnaissance Domain because METOC support involves collecting, processing, integrating, analyzing, evaluating, and interpreting data. The C^4I, Surveillance, and Reconnaissance Domain requires common information modeling and information exchange standards;[21] information processing standards;[22] information security standards;[23] information transfer standards;[24] and human-computer interface standards.[25] In an effort to facilitate interoperability, FNMOC and AFWA developed a common technical architecture framework[26] that addressed information exchange standards. However, FNMOC and AFWA did not incorporate the other C^4I, Surveillance, and Reconnaissance Domain standards in their technical architecture framework.

[21]Information modeling and information exchange standards include the use of standardized activity and data models, data definitions, and formatted messages.

[22]Information processing standards include the use of standardized interfaces for application hardware and software and data formats and instruction-processing specifications required to manipulate data.

[23]Information security standards include the use of standardized security interfaces for systems that exchange, model, process, or transport information.

[24]Information transfer standards include the use of standardized interfaces for end-systems, networks, system management, and transmission media.

[25]Human-computer interface standards include the use standardized user interfaces, style guides, and symbols.

[26]A technical architecture framework provides a set of rules governing the arrangement, interaction, and interdependence of system parts or elements. The purpose of the rules is to ensure that a conformant system satisfies a specified set of requirements.

The lessons learned from conflicts, including Operation Desert Storm, resulted in the Chairman of the Joint Chiefs of Staff establishing goals for new levels of effectiveness in joint warfighting in Joint Vision 2010 and Joint Vision 2020. The Joint Architecture is crucial to achieving the goals of Joint Vision 2020 because it provides DoD systems with the basis for seamless interoperability at the technical architecture level. Although FNMOC and AFWA developed a common technical architecture framework, it only contained information exchange standards. By expanding the existing technical architecture framework between FNMOC and AFWA to include not only information exchange standards, but all C^4I, Surveillance, and Reconnaissance Domain standards, the Navy and the Air Force would meet the intent of the guidance identified in the Joint Architecture for promoting interoperability, portability,[27] and systems integration. In addition, the expanded technical architecture framework between FNMOC and AFWA could help facilitate continuity of operations between the two centers.

METOC Concept of Operations

The Navy and the Air Force use different mesoscale NWP models and are in the process of separately developing next-generation mesoscale NWP models because Joint Publication 3-59 does not specifically identify joint modeling when addressing a joint concept of operations for providing METOC support during military operations.

Joint METOC Guidance. Joint Publication 3-59 assigns roles and responsibilities to the Services for providing effective and efficient METOC support during joint operations. The Chairman of the Joint Chiefs of Staff developed Joint Publication 3-59 to prescribe doctrine and procedures for providing accurate, reliable, and timely METOC support during military operations. In addition, Joint Publication 3-59 requires the Services to collaborate and coordinate METOC services to ensure they support a "one theater, one forecast" concept. Although mesoscale NWP modeling is a critical element to providing METOC support for Service-specific and joint operations, modeling is not addressed in the joint guidance.

Navy METOC Concept of Operations. The Navy developed a Service-specific concept of operations for providing METOC services that was designed to support the joint tactics, techniques, and procedures identified in Joint Publication 3-59. Naval Meteorology and Oceanography Command "Concept of Operations," October 22, 1996, identifies a fundamental Navy METOC support concept: ensure customer needs are met by providing the right information to the right people at the right time. The concept of operations defines roles and responsibilities for strategic, operational, and tactical METOC support. As a strategic center, FNMOC provides comprehensive forecasts and various global and regional METOC products to regional and tactical METOC

[27]Portability is defined as the ease with which a body of data, component, or system can be transferred from one hardware or software environment to another.

organizations to use as a baseline for developing tailored products to meet warfighter requirements for specific missions and weapon systems. As of January 2002, the Navy was in the process of updating its METOC concept of operations. The updated concept of operations will be developed to meet the expected operational architecture described under the Navy's anticipated "network-centric operational concept"[28] and to ensure all Navy METOC providers are knowledgeable in the Navy's five closely related disciplines: astrometry, hydrography, meteorology, oceanography, and precise time.

Air Force METOC Concept of Operations. The Air Force developed a Service-specific concept of operations for providing METOC services that was designed to support the joint tactics, techniques, and procedures identified in Joint Publication 3-59. U.S. Air Force Program Action Directive 97-10, "Reengineering Actions for Air Force Weather," December 1, 1997, directs the end-to-end restructuring of Air Force Weather to integrate Air Force Weather into joint operations and enable Air Force Weather to provide products and services that meet specific operator needs. Air Force Instruction 15-128, "Aerospace Weather Operations—Roles and Responsibilities," November 3, 2000, and Air Force Manual 15-129, "Aerospace Weather Operations—Processes and Procedures," November 8, 2000, define the Air Force METOC concept of operations.[29] Air Force Instruction 15-128 requires the Air Force to provide high quality, mission-tailored meteorological and space weather observations, forecasts, and services to Army, Air Force, and other Government agencies. As the principal Air Force strategic weather center, AFWA collects, analyzes, forecasts, and disseminates global METOC products to regional Air Force operational weather squadrons. Operational weather squadrons tailor those global METOC products using METOC products indigenous to the operating area to ensure that they meet minimum operational requirements identified by Army and Air Force tactical units operating within the squadron's assigned area of responsibility. Tactical units (Combat Weather Teams) use the forecasts generated by the operational weather squadrons to determine the impact METOC conditions have on specific missions and weapon systems.

Although Joint Publication 3-59 prescribes joint tactics, techniques, and procedures, it does not address joint modeling. Because the Navy and the Air Force developed their Service-specific concepts of operations for providing METOC support based on the guidance provided in Joint Publication 3-59, neither Service addressed joint modeling. Because modeling is a critical element to providing accurate and reliable METOC support, the issue should be addressed in Joint Publication 3-59 and in the Navy and Air Force METOC concepts of operations.

[28]A network-centric operational concept is designed to promote rapid access to information, whether it is environmental, logistical, or tactical, as a warfighting asset or weapon system.

[29]In November 2000, Air Force Instruction 15-128 and Air Force Manual 15-129 replaced "Concept of Operations for Reengineered Air Force Weather," April 20, 1998.

Uninterrupted METOC Support

The Navy and the Air Force have reduced assurance that FNMOC and AFWA could provide uninterrupted METOC services, including NWP support, should one center be unable to meet its operational requirements. On April 17, 2001, the Commanding Officer, FNMOC issued a memorandum, "Recent Navy–Air Force Meetings," to the Commander, AFWA, stating that there is a need for a formal operational back-up plan between the two NWP modeling centers. The memorandum also states that although there are work-arounds in place, FNMOC and AFWA are vulnerable because they have no assurance that they can provide uninterrupted, quality support to DoD forces should one center not be able to meet its requirements. As of January 2002, FNMOC and AFWA had not developed a joint continuity of operations plan.

Summary

Chairman of the Joint Chiefs of Staff Instruction 3810.01A states that the Services should ensure commonality in the development of METOC capabilities. Because NWP models provide the foundation for forecasting METOC conditions that affect military operations, the models provide a critical METOC capability. The Navy and the Air Force should jointly develop a next-generation standard mesoscale NWP model that is designed to provide DoD with a single METOC forecast. A standard DoD mesoscale NWP model could increase interoperability, improve overall model accuracy, achieve common data transfers, and facilitate operational back-up capabilities between FNMOC and AWFA. In addition to developing a standard DoD mesoscale NWP model, FNMOC and AFWA should develop and test a continuity of operations plan that identifies processes and procedures to ensure DoD receives uninterrupted, high quality METOC support should one center not be able to meet its operational requirements.

Recommendations, Management Comments, and Audit Response

A.1. We recommend the Oceanographer of the Navy and the Air Force Director of Weather:

a. Implement the initiative "Implement Joint Theater Forecast Consistency" to ensure the Navy and the Air Force meet the "one theater, one forecast" concept by providing consistent and high-resolution mesoscale numerical weather prediction support for joint operations.

Navy Comments. The Deputy Assistant Secretary of the Navy (Environment), in coordination with the Oceanographer of the Navy, concurred, stating that the Navy should pursue Joint Theater Consistency. The Navy also stated that using Internet Relay Chat[30] has provided a valuable tool for improving communication among theater forecasters as a step toward consistency.

Air Force Comments. The Deputy Chief of Staff for Air and Space Operations, in coordination with the Air Force Director of Weather, nonconcurred, stating that the NAVAF Agreement does not require the Navy and the Air Force to develop a joint mesoscale model. The Air Force stated that the Navy and the Air Force concept of operations at FNMOC and AFWA only propose a common regional (theater-scale) model with each Service using a higher resolution mesoscale model to support Service-specific missions, not a joint mesoscale model. In addition, the Air Force stated that in 1992, they envisioned that the regional model would be different than the higher resolution mesoscale model. The Air Force also stated that because COAMPS and MM5 provide lower resolution products, both models are used by the Navy and the Air Force to provide regional and mesoscale forecasts that meet Service-specific mission requirements. The Air Force also encouraged the Navy to join in the Weather Research and Forecast Model.

Joint Staff Comments. Although not required to comment, the Director, Joint Staff disagreed with the recommendation, stating that consolidating separate mesoscale NWP models will not ensure that the Services fully promote joint METOC support and will not facilitate the Services' ability to provide consistent METOC forecasts during Service-unique or joint forecasts.

Audit Response. We consider the Navy comments to be partially responsive and the Air Force comments to be nonresponsive to the intent of the recommendation. Although the Navy concurred with the recommendation, actions taken or planned to implement joint theater consistency were not addressed. The Air Force stated that the initiative to "Implement Joint Theater Forecast Consistency" does not require the Navy and the Air Force to develop a joint mesoscale model; however, the initiative requires the Navy and the Air

[30]Internet Relay Chat is a collaborative tool used by the Navy and the Air Force to discuss METOC forecasting issues.

Force to evaluate products developed by mesoscale models that are required by forecasters and determine where those products should be developed to ensure they aid in providing consistent joint theater forecasts. The intent of the recommendation was for the Services to optimize attributes from each Service's mesoscale model to aid in providing a consistent joint theater forecast. The Navy and the Air Force can leverage the benefits of each other's separate mesoscale NWP models by jointly incorporating the benefits into a single mesoscale NWP model that would provide consistent joint METOC data used by forecasters. The Navy has recognized Internet Relay Chat as a valuable tool in improving communication between Navy and Air Force theater forecasters and which has resulted in greater theater forecast consistency. However, without jointly addressing all available options, including a joint mesoscale NWP model or other tools, such as the Internet Relay Chat, the Air Force cannot effectively complete the initiative to "Implement Joint Theater Forecast Consistency." We request that the Navy and the Air Force provide additional comments detailing actions taken or planned to implement the "Implement Joint Theater Forecast Consistency" initiative and provide additional comments in response to the final report.

b. Promote joint meteorological and oceanographic support by cooperatively developing the next-generation standard mesoscale numerical weather prediction model to replace existing Service-specific models.

Navy Comments. The Deputy Assistant Secretary of the Navy (Environment), in coordination with the Oceanographer of the Navy, concurred, stating that the Navy supported the development of a standard next generation mesoscale model, provided it exceeds the capabilities of COAMPS.

Air Force Comments. The Deputy Chief of Staff for Air and Space Operations, in coordination with the Air Force Director of Weather, concurred, stating that the complexity of science and technology for model and analysis systems has outgrown the single-agency development methodology. The Air Force stated that AFWA, the National Weather Service, and other organizations are in the process of developing the Weather Research and Forecast model as the next-generation mesoscale model.

Joint Staff Comments. Although not required to comment, the Director, Joint Staff agreed with the recommendation, stating that a consolidated effort by the Services, coupled with the civilian research METOC communities, should reduce the inefficiencies associated with single-Service or single-agency model development.

Audit Response. Although the Navy and the Air Force concurred with the recommendation, we consider their comments to be partially responsive to the intent of the recommendation. The Navy and the Air Force comments recognize the need to cooperatively develop a next-generation standard mesescale. The Navy will continue to use and enhance COAMPS for mesoscale modeling until a next-generation mesoscale model is developed that exceeds the capabilities of COAMPS. The Air Force has chosen to jointly develop the Weather Research and Forecast model with the National Weather Service. However, the Navy only participates in the effort to develop the Weather Research and Forecast model as a member of the program oversight board. The

intent of the recommendation was for the Navy and the Air Force to jointly develop a next-generation mesoscale model that would reduce the inefficiencies associated with single-Service model development. We request that the Navy and the Air Force provide details on actions taken or planned to cooperatively develop a next-generation standard mesoscale NWP model and provide additional comments in response to the final report.

A.2. We recommend the Commanding Officer, Fleet Numerical Meteorology and Oceanography Center and the Commander, Air Force Weather Agency:

a. Develop a viable continuity of operations plan that identifies processes and procedures to ensure the Navy and the Air Force are capable of providing meteorological and oceanographic services, including numerical weather prediction support, for classified and foreign operations should one center be unable to meet its operational requirements.

Navy Comments. The Deputy Assistant Secretary of the Navy (Environment), in coordination with the Oceanographer of the Navy, concurred on developing a viable continuity of operations plan. In addition, the Navy stated that it is in the process of testing an operational back-up plan for NWP modeling with the National Weather Service.

Air Force Comments. The Deputy Chief of Staff for Air and Space Operations, in coordination with the Air Force Director of Weather, nonconcurred, stating that although there was room for improvement, an effective backup occurs today among FNMOC, AFWA, and the National Weather Service's National Centers for Environmental Prediction. In addition, the Air Force stated that migration to a community NWP model would facilitate greater opportunities for backup among all of the DoD and civilian centers. However, the primary need is for backup of the METOC data and not the model itself.

Joint Staff Comments. Although not required to comment, the Director, Joint Staff disagreed with the recommendation, stating that the Services are responsible for organizing, training, equipping, and providing METOC forces and support for Service and joint operations. A Service-unique back-up capability is inherent to that responsibility. There is no title 10 requirement for either Service to perform the other's mission in a back-up role.

Audit Response. We consider the Navy comments to be partially responsive and the Air Force comments to be nonresponsive to the intent of the recommendation. Although the Navy concurred with the recommendation, actions taken or planned to develop a continuity of operations plan between the Navy and the Air Force were not addressed. Also, the Air Force stated that effective backup exists between FNMOC, AFWA, and the National Weather Service. However, a formalized continuity of operations plan does not exist between and FNMOC and AFWA to ensure uninterrupted METOC support within DoD. Because FNMOC and AFWA provide unique METOC support for classified and unclassified DoD operations, an operationally viable and tested continuity of operations plan should be developed. Also, considering that the Navy and the Air Force have adopted a "train as you're going to fight"

methodology, the Air Force must assume that the availability of unclassified data, such as that from the National Weather Service and the National Center for Environmental Prediction, may be insufficient to support a worldwide DoD mission. The intent of our recommendation was to have an established continuity of operations plan in place that addresses each center's responsibilities and procedures that would be implemented should a failure at one of the centers occur. We request that the Navy provide additional comments detailing actions taken or planned to implement the recommendation. We request that the Air Force reevaluate its position on developing a viable continuity of operations plan with the Navy and provide additional comments in response to the final report.

b. Include all DoD Joint Technical Architecture Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance Domain standards in their existing technical architecture framework to promote interoperability and portability, ensure systems integration, and facilitate continuity of operations between the two numerical weather prediction centers.

Navy Comments. The Deputy Assistant Secretary of the Navy (Environment), in coordination with the Oceanographer of the Navy, concurred, stating that the Navy has renamed the Joint METOC Configuration Control Board to the Joint METOC Interoperability Improvement Board and has increased the scope of the Joint METOC Interoperability Improvement Board to address potential interoperability issues between FNMOC and AFWA.

Air Force Comments. The Deputy Chief of Staff for Air and Space Operations, in coordination with the Air Force Director of Weather, nonconcurred, stating that systems that only provide data into C^4I, Surveillance, and Reconnaissance-related systems (the mesoscale modeling systems at FNMOC and AFWA), but interface with them in no other way, are only required to conform to the rules of data exchange. The Air Force also stated that categorizing the modeling systems at FNMOC and AFWA as C^4I, Surveillance, and Reconnaissance-related systems is inappropriate and misinterprets the intent of the Joint Architecture.

Joint Staff Comments. The Director, Joint Staff agreed with the recommendation, stating that all efforts to improve interoperability between the Service METOC communities are welcomed as long as the efforts are consistent with title 10.

Audit Response. We consider the Navy comments to be partially responsive and the Air Force comments to be nonresponsive to the intent of the recommendation. Although the Navy concurred with the recommendation, the actions taken by the Navy do not address the intent of the recommendation to improve interoperability between Navy and Air Force METOC communities. The Air Force stated that FNMOC and AFWA modeling systems are governed only by data exchange requirements. We believe that METOC functions are inherent to the C^4I, Surveillance, and Reconnaissance Domain because METOC support involves collecting, processing, integrating, analyzing, evaluating, and interpreting data. In a memorandum, "DoD Joint Technical Architecture Version 2.0," November 30, 1998, the Joint Architecture standards were

expanded to include all systems that exchange information electronically, that cross functional boundaries or DoD Component boundaries, or that give the warfighter operational capability. METOC support provides an operational capability to the warfighter; therefore, we believe the computer systems that develop NWP models should conform to all applicable Joint Architecture standards and not just the data exchange standard. The intent of the recommendation was to improve interoperability between Navy and Air Force METOC communities. We request that the Navy provide additional comments detailing actions taken or planned that are responsive to the recommendation. We request that the Air Force reconsider its position and provide additional comments on the final report.

A.3. We recommend the Chairman of the Joint Chiefs of Staff revise Joint Publication 3-59, "Joint Doctrine, Tactics, Techniques, and Procedures for Meteorological and Oceanographic Operations," March 23, 1999, to include doctrine that addresses joint modeling in relation to supporting the "one theater, one forecast" concept.

Joint Staff Comments. The Director, Joint Staff nonconcurred, stating that the report mistakenly equates mesoscale NWP modeling processes and products with operational, theater-level forecasts. The Joint Staff stated that the report erroneously assumes that METOC doctrinal tenant of "one theater, one forecast" is dependent upon that single component of the forecast process. Also, the Joint Staff stated that the lack of a joint mesoscale model was not due to the failure of joint doctrine to identify joint NWP modeling when addressing a joint concept of operations, as stated in the report.

Navy Comments. The Deputy Assistant Secretary of the Navy (Environment), in coordination with the Oceanographer of the Navy, agreed, and stated that the Navy supports the concept of joint modeling.

Air Force Comments. The Deputy Chief of Staff for Air and Space Operations, in coordination with the Air Force Director of Weather, disagreed with the recommendation, stating that the report erroneously assumes the METOC doctrine of "one theater, one forecast" is dependent on data derived from mesoscale models. Also, the Air Force stated that as NWP models become more sophisticated and accurate in the future, a more dominate role of NWP output might be appropriate in Joint Publication 3-59.

Audit Response. We consider the Joint Staff comments to be nonresponsive to the intent of the recommendation. Although the Joint Staff nonconcurred with addressing joint modeling in Joint Publication 3-59, the Navy agreed with the need to address the concept of joint modeling. In addition, the Air Force stated that as NWP models become more sophisticated and accurate in the future, addressing joint modeling in Joint Publication 3-59 may be appropriate. A National Research Council report[31] states that the complexity of science and technology for model and analysis systems has outgrown the single-agency

[31]Source: Board of Atmospheric Sciences and Climate, Commission on Geosciences, Environment, and Resources, National Research Council, "From Research to Operations in Weather Satellites and Numerical Weather Prediction—Crossing the Valley of Death" (Washington, D.C.: National Academy Press, 2000).

development methodology. The report states that no single agency is capable of internally developing upgrades required to continue improving models at the current pace and that each agency should identify resources necessary to ensure active collaboration in research and development. We realize that NWP modeling is one element used in the process to develop a forecast. However, because the Navy and the Air Force agreed with the need to jointly develop a next-generation mesoscale NWP model, we believe that joint modeling should be addressed in Joint Publication 3-59 because it is a critical element to providing accurate and reliable METOC support. The Navy and the Air Force developed their Service-specific concepts of operations for providing METOC support based on guidance provided in Joint Publication 3-59. The intent of the recommendation was to address the need for joint modeling to support DoD operations in Joint Publication 3-59, not to restrict how joint METOC support is provided. We continue to believe it would be beneficial to DoD if the Joint Staff would address joint modeling in its concept of operations for providing joint METOC support. We request that the Joint Staff reconsider its position and provide additional comments on the final report.

A.4. We recommend the Commander, Naval Meteorology and Oceanography Command, revise the Naval Meteorology and Oceanography Command "Concept of Operations," October 22, 1996, to address joint modeling based on the revisions to Joint Publication 3-59 as a result of Recommendation A.3.

A.5. We recommend the Air Force Director of Weather revise Air Force Instruction 15-128, "Aerospace Weather Operations—Roles and Responsibilities," November 3, 2000, and Air Force Manual 15-129, "Aerospace Weather Operations—Processes and Procedures," November 8, 2000, to address joint modeling based on the revisions to Joint Publication 3-59 as a result of Recommendation A.3.

Navy Comments. The Deputy Assistant Secretary of the Navy (Environment), in coordination with the Oceanographer of the Navy, concurred, stating that the Navy supports the concept of joint modeling and is willing to discuss the establishment of a Joint Modeling Center.

Air Force Comments. The Deputy Chief of Staff for Air and Space Operations, in coordination with the Air Force Director of Weather, nonconcurred, stating that Joint Publication 3-59 should not address specific solutions, such as joint modeling.

Joint Staff Comments. Although not required to comment, the Director, Joint Staff disagreed with the recommendation, based on the same comments provided for Recommendation A.3.

Audit Response. Although the Navy concurred, we consider the comments partially responsive because the Navy did not address modifying the Navy's concept of operations when Joint Publication 3-59 is revised. We consider the Air Force comments to be nonresponsive to the intent of the recommendation. Although the Air Force disagreed with updating its concept of operations for providing METOC support to address joint modeling, it recognized the need to jointly develop a next-generation mesoscale model. Because the future of NWP

modeling appears to be moving from a single-agency approach to joint development, including the concept of joint modeling in the Air Force concept of operations for providing METOC support could define how it will address the issue when supporting Service-specific and joint operations. The intent of the recommendation was to address the significance of joint modeling in meeting current and future DoD requirements. We believe it would be beneficial if the Navy and the Air Force would address joint modeling in their concepts of operations for providing METOC support for Service-specific and joint operations. However, the issue will be resolved through resolution of Recommendation A.3., that was addressed to the Joint Staff, so additional comments are not requested.

B. Coordination and Review of Meteorological and Oceanographic Acquisition Category III and Below Program Requirements

The Navy and the Air Force did not always review and comment on operational requirements documents (ORDs)[32] for METOC acquisition category III and below[33] programs. Specifically, of the 18 Navy and Air Force ORDs for FY 2001 METOC acquisition category III and below programs, valued at $486.9 million, 9, valued at $190.5 million, had not been reviewed by both the Navy and the Air Force for potential joint involvement. The ORDs were not being properly reviewed because the Navy and the Air Force did not have procedures for coordinating, reviewing, and commenting on ORDs for METOC acquisition category III and below programs. As a result, the Navy and the Air Force might be acquiring METOC acquisition category III and below programs that could be supported by existing systems or technology. In addition, the Services might not be deriving benefits that could flow from jointly developing, funding, and managing METOC programs.

Guidance

The Joint Staff, the Navy, and the Air Force have guidance that addresses the requirements generation process for acquisition category II and below programs. The Joint Staff guidance includes the development and coordination of program ORDs. Although the guidance addresses acquisition category II and below programs, our review only included Navy and Air Force ORDs for METOC acquisition category III and below programs, which are also covered by the Joint Staff and Service guidance.

Joint Guidance. Chairman of the Joint Chiefs of Staff Instruction 3170.01B, "Requirements Generation System," April 15, 2001, establishes policies and procedures for developing and processing ORDs. In addition, Chairman of the Joint Chiefs of Staff Instruction 3170.01B:

- authorizes the Services to validate all acquisition category II and below program ORDs;

[32]An operational requirements document is a document that contains operational performance requirements for a proposed concept or system.

[33]Acquisition category III and below are non-major programs for which the milestone decision authority is designated by the Component acquisition executive and is assigned at the lowest appropriate level.

- requires the Services to eliminate duplication through effective cooperation and coordination when developing ORDs by coordinating all ORDs with other DoD Components before validation to ensure that the ORDs cannot be supported by existing systems or technology; and

- requires that, during the coordination process, DoD Components reviewing an ORD identify and appropriately comment on whether the program has potential for joint involvement.

Chairman of the Joint Chiefs of Staff Instruction 3170.01B also requires DoD Components to designate whether the program is considered to be one of the following.

- An independent program[34] that does not require further correspondence between the Service initiating the ORD and the DoD Component reviewing the ORD.

- A joint interest program[35] that does not require further correspondence between the Service initiating the ORD and the DoD Component reviewing the ORD.

- A joint program[36] that requires further comments and resolution between the Service initiating the ORD and the DoD Component reviewing the ORD.

Navy Guidance. Secretary of the Navy Instruction 5000.2B, "Implementation of Mandatory Procedures for Major and Non-Major Defense Acquisition Programs and Major and Non-Major Information Technology Acquisition Programs," December 6, 1996, prescribes procedures for developing and processing Navy ORDs. The Navy Instruction requires the Chief of Naval Operations to validate and approve acquisition category II and below program ORDs. In addition, the Navy Instruction identifies procedures for developing non-acquisition programs. A non-acquisition program is an effort that does not directly result in the acquisition of equipment or a system for operational deployment. An ORD is not required for a non-acquisition program. The Navy Instruction requires the Chief of Naval Operations to manage all research and development non-acquisition programs.

[34]An independent program designator indicates that the DoD Component reviewing the ORD considers the program to provide no potential benefits for joint development.

[35]A joint interest program designator indicates that the DoD Component reviewing the ORD considers joint management of the program to be inappropriate, but identifies that a potential exists for other Service use.

[36]A joint program designator indicates that the DoD Component reviewing the ORD considers the program to provide potential benefits for joint development, funding, and management.

Air Force Guidance. Air Force Instruction 10-601, "Mission Needs and Operational Requirements Guidance and Procedures," August 13, 1999, prescribes procedures for developing and processing Air Force ORDs. The Air Force Instruction requires the Chief of Staff of the Air Force to validate and approve ORDs for acquisition category II and below programs.

Navy and Air Force Review of METOC ORDs

The Navy and the Air Force did not always review and comment on ORDs for METOC acquisition category III and below programs. Specifically, of the 18 Navy and Air Force ORDs for FY 2001 METOC acquisition category III and below programs, valued at $486.9 million, 9, valued at $190.5 million, were not reviewed by both the Navy and the Air Force for potential joint involvement. Chairman of the Joint Chiefs of Staff Instruction 3170.01B requires the Services to eliminate duplication through effective coordination of ORDs to ensure that the Services do not acquire acquisition category II and below programs that could be supported by existing systems or technology. In addition, the Services might derive benefits that could flow from jointly developing, funding, and managing METOC programs.

Navy Review of Air Force METOC ORDs. We reviewed 14 Air Force FY 2001 METOC acquisition category III and below programs being acquired by the Combat Air Force Command and Control System Program Office to determine whether the Navy had reviewed the ORDs. The Navy had provided comments on 7 of the 14 ORDs. Table 1 shows the results of the Navy's review of the seven Air Force METOC program ORDs.

Table 1. Navy Review of Air Force ORDs

Air Force METOC Programs	Navy Comments	Program Value (in millions)
Air Force Combat Climatology Center Replacement	Joint Interest	$3.8
Cloud Depiction and Forecast System—II	Joint Interest	20.9
Forecast System—21st Century	Joint Interest	65.9
New Tactical Forecast System	Joint Interest	2.5
Observing System—21 Century	Joint Interest	75.9
Space Weather Analysis and Forecast System	Joint Interest	34.9
Tactical Weather Radar	Joint Interest	22.8
Total		**$226.7**

Of the seven Air Force ORDs reviewed by the Navy, the Navy had recommended all seven programs be designated as joint interest. Because Chairman of the Joint Chiefs of Staff Instruction 3170.01B does not require further correspondence for program ORDs designated as "joint interest," no further correspondence between the two Services existed. Table 2 shows the seven Air Force ORDs for METOC programs that the Navy did not review.

Table 2. Air Force ORDs Not Reviewed by the Navy

Air Force METOC Programs	Navy Comments	Program Value (in millions)
Automated Weather Distribution System	No record of review	$2.2
Global Theater Weather Analysis and Prediction System	No record of review	17.8
Reengineered Enterprise Infrastructure Program	No record of review	68.9
Small Tactical Terminal	No record of review	46.1
Tactical Meteorological	No record of review	1.0
War Weather	No record of review	14.7
Weather Information Processing System Upgrade	No record of review	2.8
Total		**$153.5**

Of the seven Air Force ORDs not reviewed by the Navy, officials in the Office of the Deputy Chief of Naval Operations (Resources, Requirements, and Assessments) stated that those ORDs had not been received by the office for review and comment. However, the Air Force Requirements Division stated that all seven ORDs had been submitted to the Office of the Deputy Chief of Naval Operations (Resources, Requirements, and Assessments) for review and comment.

Air Force Review of Navy METOC ORDs. We reviewed 14 Navy METOC acquisition category III and below programs being acquired by the Meteorology and Oceanography Systems Program Office, Space and Naval Warfare Systems Command to determine whether the Air Force had reviewed the ORDs. Out of the 14 Navy METOC programs, only 4 had ORDs. The Navy had not developed ORDs for the remaining 10 programs because they were considered non-acquisition programs. Secretary of the Navy Instruction 5000.2B does not require non-acquisition programs to be coordinated or reviewed by other DoD Components. Therefore, those 10 programs did not undergo a joint Service review. Out of the four Navy ORDs, the Air Force had provided comments on two. Table 3 shows the results of the Air Force's review of those two Navy ORDs.

Table 3. Air Force Review of Navy ORDs

Navy METOC Programs	Air Force Comments	Program Value (in millions)
Supplemental Weather Radar	Joint Program	$4.6
Tactical Environmental Support System	Joint Interest	65.1
Total		**$69.7**

Of the two Navy ORDs reviewed by the Air Force, the Air Force had recommended that one program be designated as joint interest and the other be designated as joint. The Navy agreed with the Air Force recommendation for the Supplemental Weather Radar program to be designated a joint program. As a result, the contract that the Meteorology and Oceanography Systems Program Office, Space and Naval Warfare Systems Command negotiated for the program allows the Air Force to purchase weather radars.

Table 4 shows the two Navy ORDs for METOC programs that the Air Force did not review.

Table 4. Navy ORDs Not Reviewed by the Air Force

Navy METOC Programs	Air Force Comments	Program Value (in millions)
AN/SMQ—11 Satellite Receiver Processor	No record of review	$13.6
Shipboard METOC Observing System—Replacement	No record of review	23.4
Total		**$37.0**

Navy officials stated that they had submitted the two ORDs for review and comment to other DoD Components; however, the Air Force Requirements Division stated it had not received the ORDs for review and comment.

Procedures for Reviewing and Commenting on ORDs

The Navy and the Air Force did not have procedures for coordinating, reviewing, and commenting on ORDs for acquisition category II and below programs. Although Secretary of the Navy Instruction 5000.2B and Air Force Instruction 10-601 prescribe procedures for the development, validation, and approval of acquisition category II and below program ORDs, those instructions do not address coordinating acquisition category II and below ORDs with other DoD Components. In addition, the Navy and the Air Force instructions do not

establish timeframes for other DoD Component reviews of acquisition category II and below program ORDs or define procedures for reviewing and commenting on the ORDs to determine whether a program could be supported by existing systems or technology or whether a program was a candidate for joint involvement.

Review of Navy and Air Force ORDs to Eliminate Duplication

The Navy and the Air Force might be acquiring METOC systems for acquisition category III and below programs that could be supported by existing systems or technology. In addition, the Services might not be deriving benefits that could flow from jointly developing, funding, and managing METOC programs. For example, the Air Force ORD for the "Observing System—21st Century Program," August 27, 1999, states that the Army and Air Force have a direct need for knowing the actual environmental conditions that will be encountered in order to correctly launch missions, ensure precise weapons delivery, and protect warfighting assets. The Observing System—21st Century program is expected to consist of five separate systems: a fixed-based observing system; a deployable observing system; a remote expendable observing system; a manual observing system; and an upper-air observing system. Officials from the Combat Air Force Command and the Control System Program Office stated that the Observing System—21st Century program is integral to the Air Force Weather reengineering plan because it improves the ability of the Air Force to provide tailored information describing the operational impact on air, ground, and space operations.

The Observing System—21st Century program represents the next-generation solution to requirements for METOC observing systems in all operational environments. The Air Force ORD for the system states that it "will be able to meet battlespace environmental observing requirements (e.g., soil moisture and temperature, illumination), not found in today's equipment. These requirements include, but are not limited to, battlespace atmospheric profiles for the employment of precision-guided munitions [and] terrain conditions affecting maneuver of equipment and personnel." Officials from the Meteorology and Oceanography Systems Program Office, Space and Naval Warfare Systems Command stated that the Navy was aware of the Air Force Observing System—21st Century program; however, they had not reviewed or commented on the ORD. We provided the program office with a copy of the Air Force Observing System—21st Century ORD. After reviewing the ORD, the program office indicated that the Navy could have potential uses for the deployable and upper-air observing components of the Observing System—21st Century program. DoD Components might derive potential benefits by jointly developing, funding, and managing the two components of the program, valued at $75.9 million.

Conclusion

Chairman of the Joint Chiefs of Staff Instruction 3170.01B requires the Services to eliminate duplication through effective coordination and cooperation. Although the Navy and the Air Force developed guidance addressing the development and processing of ORDs, specific guidance regarding coordinating and reviewing ORDs for joint involvement is not addressed in the Service-specific guidance. The Chairman of the Joint Chiefs of Staff Instruction 3170.01B also gives DoD Components the authority to validate and approve Service-generated ORDs for acquisition category II and below programs. As a result of the Navy and the Air Force authority to approve and validate ORDs for acquisition category II and below programs without ensuring that the ORDs have been effectively coordinated and commented on by other DoD Components, the Navy and the Air Force increase the risk of developing duplicate METOC equipment or technology.

Recommendations, Management Comments, and Audit Response

B.1. We recommend the Assistant Secretary of the Navy (Research, Development and Acquisition) revise Secretary of the Navy Instruction 5000.2B, "Implementation of Mandatory Procedures for Major and Non-Major Defense Acquisition Programs and Major and Non-Major Information Technology Acquisition Programs," December 6, 1996, to include procedures for meteorological and oceanographic acquisition category II and below programs that address:

a. Coordinating operational requirements documents with other DoD Components.

b. Establishing timeframes for other DoD Component reviews of program operational requirements documents.

c. Prescribing procedures for reviewing and commenting on operational requirements documents to determine whether a program could be supported by existing systems or technology or whether the program is a candidate for joint involvement.

Navy Comments. The Deputy Assistant Secretary of the Navy (Environment), in coordination with the Oceanographer of the Navy, concurred with the need to coordinate review and comment on any METOC-related ORDs by DoD METOC components.

Audit Response. We consider the Navy comments to be partially responsive to the intent of the recommendation. Although the Navy concurred with the recommendation, the Navy did not specifically address revising Secretary of the Navy Instruction 5000.2B. We request that the Navy provide additional comments in response to the final report.

B.2. We recommend the Air Force Deputy Chief of Staff for Air and Space Operations revise Air Force Instruction 10-601, "Mission Needs and Operational Requirements Guidance and Procedures," August 13, 1999, to include procedures for meteorological and oceanographic acquisition category II and below programs that address:

a. Coordinating operational requirements documents with other DoD Components.

b. Establishing timeframes for other DoD Component reviews of program operational requirements documents.

c. Prescribing procedures for reviewing and commenting on operational requirements documents to determine whether a program could be supported by existing systems or technology or whether the program is a candidate for joint involvement.

Air Force Comments. The Deputy Chief of Staff for Air and Space Operations concurred, stating that such a review is mandated by a Chairman of the Joint Chiefs of Staff instruction and that Air Force Instruction 10-601 is being updated.

Appendix A. Audit Process

Scope

We reviewed and evaluated whether DoD, Joint Staff, and Military Department METOC-related guidance and memorandums issued from July 1947 through April 2001 were adequate to ensure that the Military Departments provided METOC support efficiently and effectively. Specifically, we reviewed Public Law 253, chapter 343, July 26, 1947; the Joint Architecture; Joint Vision 2010, July 1996; Joint Vision 2020; the NAVAF Agreement; the "Naval Meteorology and Oceanography Command Strategic Plan," May 1997; the Naval Meteorology and Oceanography Command "Concept of Operations," October 22, 1996; the Strategy for Research and Development, "A Roadmap to a Vision of Operational Oceanography," September 2000; the "Air Force Weather Strategic Plan," June 28, 2000; the Air Force Program Action Directive 97-10, "Reengineering Actions for Air Force Weather," December 1, 1997; and a FNMOC and AFWA inter-Service memorandum, "Recent NAVAF Meetings," April 17, 2001. We reviewed the processes used by the Military Departments to generate requirements and develop or acquire new METOC technology and equipment. We also reviewed 18 Navy and Air Force ORDs for METOC acquisition category III and below programs that were developed and approved from August 1990 through June 2001. We evaluated interagency and inter-Service agreements and memorandums to determine the methods used by the Military Departments to collect, process, and disseminate METOC information and products. In addition, we reviewed METOC products and operations at the Navy regional METOC centers and Air Force operational weather squadrons in the continental United States.

High-Risk Area. The General Accounting Office has identified several high-risk areas in DoD. This report provides coverage of the DoD Systems Modernization high-risk area.

Methodology

We analyzed FNMOC and AFWA mission responsibilities to support the warfighter and reviewed Navy and Air Force METOC acquisition processes by:

- conducting interviews with personnel from the offices of the Commander in Chief, U.S. Joint Forces Command; the Commander in Chief, U.S. Central Command; the Commander in Chief, U.S. Transportation Command; the Director, Defense Research and Engineering (Science and Technology); the Defense Modeling and Simulation Organization; the Oceanographer of the Navy; the Deputy

Chief of Naval Operations (Resources, Requirements, and Assessments); the Air Force Director of Weather; the Air Force Directorate of Operational Requirements; and the Joint Staff;

- visiting FNMOC; the Marine Meteorology Division, Naval Research Laboratory; the Meteorology and Oceanography Systems Program Office, Space and Naval Warfare Systems Command; the Naval Atlantic Meteorology and Oceanography Center at Norfolk; the Naval Pacific Meteorology and Oceanography Center at San Diego; the Navy Technical Training Unit at Keesler Air Force Base, Mississippi; AFWA; the Air Combat Command Directorate of Weather at Langley Air Force Base, Virginia; the Air Mobility Command Directorate of Weather at Scott Air Force Base, Illinois; the Combat Air Force Command and Control System Program Office at Hanscom Air Force Base, Massachusetts; the 15th Operational Weather Squadron at Scott Air Force Base, Illinois; the 26th Operational Weather Squadron at Barksdale Air Force Base, Louisiana; the 28th Operational Weather Squadron at Shaw Air Force Base, South Carolina; and the 335th Training Squadron at Keesler Air Force Base, Mississippi;

- evaluating the Navy and the Air Force coordination process for jointly producing and distributing METOC information;

- reviewing the Services' acquisition, coordination, and requirements generation processes for METOC acquisition category III and below programs that collect, process, and disseminate information;

- identifying NWP models produced at FNMOC and AFWA that are needed to generate forecasts to support Army, Navy, Air Force, and joint operations;

- reviewing the Military Departments' METOC training programs to determine the effect Air Force Weather reengineering had on joint METOC training; and

- reviewing Navy and Air Force regional support centers in the continental United States (the Naval Atlantic Meteorology and Oceanography Center at Norfolk, Virginia; the Naval Pacific Meteorology and Oceanography Center at San Diego, California; the 15th Operational Weather Squadron at Scott Air Force Base, Illinois; the 26th Operational Weather Squadron at Barksdale Air Force Base, Louisiana; and the 28th Operational Weather Squadron at Shaw Air Force Base, South Carolina) to determine whether the centers were providing overlapping METOC services and support.

Use of Technical Assistance. The Office of the Inspector General, DoD, Audit Followup and Technical Support Directorate, Technical Assessment Division reviewed computer operating systems, communication systems, NWP modeling procedures, and system interfaces for feasibility in developing a standard DoD mesoscale NWP model or a joint NWP modeling center within DoD.

Audit Type, Dates, and Standards. We performed the program audit from April 2001 through January 2002 in accordance with generally accepted government auditing standards. We did not use computer-processed data to perform this audit.

Contacts During the Audit. We visited or contacted individuals and organizations within DoD. Further details are available on request.

Management Control Program Review

DoD Directive 5010.38, "Management Control Program," August 26, 1996, and DoD Instruction 5010.40, "Management Control Program Procedures," August 28, 1996, require DoD organizations to implement a comprehensive system of management controls that provides reasonable assurance programs are operating as intended and to evaluate the adequacy of the controls.

Scope of Review of the Management Control Program. We reviewed the adequacy of the Military Departments' management controls related to METOC support in the continental United States. Specifically, we reviewed Navy and Air Force NWP modeling activities at FNMOC and AWFA. We also reviewed management's self-evaluation applicable to providing uninterrupted METOC support to the warfighter.

Adequacy of Management Controls. We identified a material management control weakness within the Navy and the Air Force as defined by DoD Instruction 5010.40. FNMOC and AFWA did not establish or test a formalized continuity of operations plan to ensure DoD forces were provided uninterrupted quality METOC services and support. Without formalized and tested operational backup within DoD, FNMOC and AFWA might not adequately accomplish their mission of providing the warfighter with accurate, timely, and reliable METOC services and support. DoD Instruction 5010.40 defines control weaknesses as material when the weakness impairs fulfillment of essential missions or operations. Recommendation A.2.a., if implemented, will ensure FNMOC and AFWA are able to provide adequate and continuous METOC support. A copy of the final report will be sent to the senior official in charge of management controls in the Offices of the Oceanographer of the Navy and the Air Force Director of Weather.

Adequacy of Management's Self-Evaluation. The Oceanographer of the Navy and the Air Force Director of Weather did not identify operational back-up capabilities for providing uninterrupted METOC support as an assessable unit because FNMOC and AWFA did not develop a mutually agreed-upon continuity of operations plan. Therefore, the Oceanographer of the Navy and the Air Force Director of Weather did not identify or report the material management control weakness identified by the audit.

Prior Coverage

During the last 5 years, the following reports have been issued that are relevant to this report. Unclassified Inspector General, DoD, reports can be accessed over the Internet at http://www.dodig.osd.mil/audit/reports.

Inspector General, DoD

Inspector General, DoD, Report No. D-2001-157, "Global Command and Control System—Meteorological and Oceanographic Application," July 11, 2001

Inspector General, DoD, Report No. D-2001-152, "Meteorological and Oceanographic Support in the European Theater," June 28, 2001

Inspector General, DoD, Report No. D-2001-151, "Meteorological and Oceanographic Support in the Pacific Theater," June 28, 2001

Inspector General, DoD, Report No. D-2001-133, "Deliberate Planning for Meteorological and Oceanographic Operations (U)," June 1, 2001

Inspector General, DoD, Report No. D-2001-121, "Use of the DoD Joint Technical Architecture in the Acquisition Process," May 14, 2001

Inspector General, DoD, Report No. D-2001-018, "Management and Oversight of the DoD Weather Program," December 14, 2000

Inspector General, DoD, Report No. 98-023, "Implementation of the DoD Joint Technical Architecture," November 18, 1997

Appendix B. Meteorological and Oceanographic Support and Training

We evaluated METOC services and support provided by Navy and Air Force regional support centers in the continental United States and determined the Navy and the Air Force were not providing overlapping METOC services and support. In addition, we evaluated changes to the Air Force Weather training philosophy that were implemented to improve the quality and quantity of Air Force Weather forecasters.

Regional METOC Support From the Continental United States

We reviewed operational support provided by the two Navy regional METOC centers located in the continental United States, the Naval Atlantic Meteorology and Oceanography Center in Norfolk, Virginia, and the Naval Pacific Meteorology and Oceanography Center in San Diego, California. In addition, we reviewed operational support provided by three of the four Air Force operational weather squadrons located in the continental United States, the 15th Operational Weather Squadron at Scott Air Force Base, Illinois; the 26th Operational Weather Squadron at Barksdale Air Force Base, Louisiana; and the 28th Operational Weather Squadron at Shaw Air Force Base, South Carolina. We did not visit the 25th Operational Weather Squadron at Davis Monthan Air Force Base, Arizona.

Navy Regional Support Centers in the Continental United States. The Navy provides operational METOC support for the Atlantic and Pacific Fleets and joint operations from regional centers in the continental United States. The Naval Atlantic Meteorology and Oceanography Center provides the Commander in Chief, Second Fleet with aviation and energy conservation forecasts, en route weather support for ships, high-wind warnings, optimum track ship routing services,[1] and the effects of METOC conditions on operations and weapon systems. In addition, the Naval Atlantic Meteorology and Oceanography Center provides specialized METOC support for the North Atlantic Treaty Organization. The Naval Pacific Meteorology and Oceanography Center provides the Commander in Chief, Third Fleet with high-wind warnings, optimum track ship routing services, en route weather support for ships, aviation forecasts, and the effects of METOC conditions on operations. The Naval Pacific Meteorology and Oceanography Center also serves as the Navy

[1]Optimum track ship routing is a Navy advisory service designed to minimize en route time and fuel consumption while ensuring minimal risk from damage caused by tropical storms, high seas, and sea ice.

developmental test site for METOC systems. In addition, both centers provide direct mobile environmental team support to ships not permanently assigned an Operational Aerography Division.[2]

Air Force Operational Weather Squadrons in the Continental United States. The Air Force provides operational METOC support for units assigned to the Air Mobility Command and Air Combat Command (the 8th Air Force and the 9th Air Force) from regional centers in the continental United States. The 15th Operational Weather Squadron provides the Commander in Chief, U.S. Transportation Command with air refueling, drop zone, landing zone, and transient aircraft forecasts; flight weather briefs; and terminal aerodrome forecasts[3] for Army, Air Force, and joint operations. The 15th Operational Weather Squadron provides operational forecasts to support worldwide military airlift missions. In addition, the 15th Operational Weather Squadron provides tailored local area forecasts to Army and Air Force units assigned to bases in the northeastern United States. The 26th Operational Weather Squadron provides the Commanders in Chief, U.S. Joint Forces Command and U.S. Strategic Command with air refueling, drop zone, landing zone, and transient aircraft forecasts; flight weather briefs; and terminal aerodrome forecasts for Army, Air Force, and joint operations. In addition, the 26th Operational Weather Squadron provides local area forecasts to Army and Air Force units assigned to bases in the south-central United States. The 28th Operational Weather Squadron provides the Commander in Chief, U.S. Central Command with air refueling, drop zone, landing zone, and transient aircraft forecasts; flight weather briefs; and terminal aerodrome forecasts for Army, Air Force, and joint operations. In addition, the 28th Operational Weather Squadron provides local area forecasts to Army and Air Force units assigned to bases in the southeastern United States. The operational weather squadrons serve as the primary links between AFWA and the tactical weather units that are responsible for providing mission-specific METOC support.

Operational METOC Support. The Navy and the Air Force provide METOC support from regional centers located in the continental United States. The Navy regional METOC centers provide tailored services and support to meet operational requirements of the Atlantic and Pacific Fleets. The Air Force operational weather squadrons provide tailored forecasts for numbered Air Force units and unified commanders operating in specific regions abroad or in the continental United States. The Navy and Air Force continental United States-based regional centers provide specialized METOC support for air, land, and sea operations abroad and for DoD forces operating in the continental United States. Because Navy and Air Force regional centers provide METOC support for separate areas of responsibility and unique operational requirements, it does not appear that the Navy and the Air Force were providing overlapping METOC support from the five continental United States-based regional centers reviewed.

[2]Operational Aerography Divisions are assigned to ships and provide on-scene METOC services to ensure operational safety and optimal use of Navy weapon systems.

[3]Terminal aerodrome forecasts are concise statements of expected meteorological conditions at an airfield during a specified period (usually 24 hours).

Reengineered Air Force Training Concept

We reviewed the reengineered Air Force Weather training concept to determine whether changes to the program would affect joint METOC support.

Background. Following Operation Desert Storm, Air Force Weather was unable to meet requirements for accurate and timely weather support. From 1995 through 1997, the Air Force Weather program conducted several standard evaluations on various weather functions and determined that 33 percent of the units inspected failed to meet established standards. The Air Force did not meet established standards because a lack of skilled senior forecasters created a serious experience deficit that, in part, contributed to the production of unsatisfactory weather products and because the forecaster training program did not adequately prepare forecasters for the tasks they would encounter "in the field." The original Air Force Weather training program required students to attend a 18-week Weather Apprentice Course at Keesler Air Force Base that was designed to teach the basic meteorological skills students would need to become observers. Once the initial training assignment was completed, the observers were assigned to Combat Weather Teams and were assigned responsibilities that they were not adequately trained to perform. Because of a high operational tempo, the Combat Weather Teams did not provide an adequate source of on-the-job training. In addition, the Combat Weather Teams had a shortage of senior forecasters and, as a result, were not able to adequately mentor and supervise the newly assigned Air Force Weather personnel. After completing their first assignment, students that chose to continue their military careers were then required to attend a 22-week advanced Weather Forecaster Course at Keesler Air Force Base where they learned detailed meteorological forecasting skills.

Reengineered Air Force Training Program. Air Force Weather reengineering was designed to take advantage of developments in technology and to focus Air Force Weather functions toward a common goal. The "Air Force Weather Strategic Plan," August 1, 1997 (updated June 28, 2000), states that one of the goals of Air Force Weather reengineering is to "revolutionize training—create a continuous, efficient, and effective training process to build a premier combat weather force focused on operations." Program Action Directive 97-10 "Reengineering Actions for Air Force Weather," December 1, 1997, was designed to enhance mission focus and improve Air Force Weather capabilities by providing meteorological services through an improved operational and organizational structure by transferring routine, 24-hour forecasting, aviation briefings, and selected meteorological advisory and warning responsibilities from tactical units to operational weather squadrons.[4] The Air Force Weather Strategic Plan states that Air Force Weather reengineering occurred because of decreased personnel resources and experience levels at weather stations,

[4]An operational weather squadron is responsible for tailoring regional forecasts and using products indigenous to the operating area to provide fine-scale meteorological forecasts needed for base resource protection, flight operations, and operational decisionmaking.

different support structures required to provide meteorological services in peacetime and wartime, inadequate training, and less-than-optimal organizational career paths.

To reengineer Air Force METOC training, the Air Force designed a majority of its training mission at operational weather squadrons. The training curriculum for the operational weather squadrons was developed to assist forecaster apprentices and recent Introductory Skills Course graduates in designing weather briefings based on real-world situations. The classrooms were designed to parallel the operation watch floor at the operational weather squadrons. By training in an operational environment, the students are able to observe decisionmaking skills needed to forecast METOC conditions and, through daily evaluations, gain confidence to become proficient and successful while actually contributing to products produced by the operational weather squadron. In addition, Air Force Weather training enables the students to see the impact forecasts have on daily Air Force operations.

Use of Contract Trainers. The Air Force Weather reengineering concept employs professional training contractors from the Science Applications International Corporation because of a lack of experienced, senior Air Force Weather forecasters. Contract trainers assigned to operational weather squadrons were required to develop and teach basic forecasting courses in conjunction with the Air Force Weather personnel assigned to the operational weather squadron. The contract trainers not only provide experienced educational support, but also provide continuity of operations because active duty Air Force personnel typically rotate every 2 years but the contract trainers are permanently assigned to the operational weather squadrons. Until the number of experienced forecasters increases, the Air Force Weather community will continue to use contract trainers to accomplish the reengineered weather training mission.

Benefits of Reengineered Training. Under the reengineered Air Force training program, students are expected to learn forecasting skills quicker than they did in a traditional classroom setting. Additionally, forecaster apprentices are contributing to the daily operations much sooner than they were able to before reengineering. By combining the development of forecasting skills with actual operational support, the reengineered training concept improves the quality of Air Force Weather forecasts and the efficiency of human resources, thereby meeting the intent of the Air Force Weather Strategic Plan.

Appendix C. Navy Energy Conservation Forecast Program

We reviewed an Energy Conservation Forecast Program developed by the Naval Atlantic Meteorology and Oceanography Center in Norfolk, Virginia, to determine whether the benefits derived from the program could benefit not only the Navy, but also other Military Departments.

Background. In September 1983, the Naval Atlantic Meteorology and Oceanography Center established an Energy Conservation Forecast Program to aid base engineers in planning and decisionmaking regarding the use of energy resources. The Energy Conservation Forecast Program was designed to provide long-range forecasts to participating military bases with seasonal energy needs to decrease energy use and aid energy buyers in making fuel purchases. By projecting the estimated timeframe when temperatures are expected to change, energy planners can economize the amount of money spent on climate control by turning the heat or air conditioning on at the appropriate time, rather than turning it on too early or turning it off too late. In January 2001, the Commander in Chief, U.S. Atlantic Fleet reemphasized the need to conserve energy. He directed all subordinate commands, by March 1, 2001, to participate in the Energy Conservation Forecast Program because it standardized criteria, maximized savings, and improved the process for making energy-related decisions throughout the Atlantic Fleet.

Energy Conservation Forecasting Program. The Naval Atlantic Meteorology and Oceanography Center uses long-range weather forecasts, climatological data, and specific customer profiles to develop energy conservation action recommendations that are tailored to specific locations and geographic regions. DoD Instruction 4170.10, "Energy Management Policy," August 1991, requires DoD to minimize the amount of energy used, and its cost, while meeting operational mission support requirements and providing quality working and living conditions for DoD personnel and dependents. In addition, DoD Instruction 4170.10 states that DoD Components are responsible for ensuring that all cost-effective actions are taken to eliminate energy waste; for improving energy use efficiency; and for implementing measures to reduce energy costs. The Energy Conservation Forecast Program enables customers to save fuel and money by optimizing energy resources and making informed energy management decisions. Since the program began, the Naval Atlantic Meteorology and Oceanography Center has provided energy conservation forecasts at no cost to its customers. As of August 2001, the Naval Atlantic Meteorology and Oceanography Center was using four METOC personnel at an annual cost of $310,000 to provide forecasts to 131 customers, including various Coast Guard and Army installations.* As of August 2001, the Naval Atlantic

*A similar service provided by the National Weather Service or other commercial providers costs an average $5,000 to $7,000 per location.

Meteorology and Oceanography Center had documented a reduction of more than $66 million in fuel and energy costs through the Energy Conservation Forecast Program since 1983.

Use of the Energy Conservation Forecast Program Service. Program managers from the Naval Atlantic Meteorology and Oceanography Center provided briefings on the program to Navy and DoD program offices responsible for managing energy use and installations in an effort to offer energy conservation forecasts to all of DoD. In May 2001, the Commanding Officer, Naval Atlantic Meteorology and Oceanography Center and the Energy Conservation Forecast Program Manager provided a status review to the Office of the Deputy Assistant Secretary of the Navy (Installations and Facilities). As a result, the Office of the Deputy Assistant Secretary of the Navy (Installations and Facilities) planned to direct all Navy and Marine Corps installations in the continental United States to use the Energy Conservation Forecast Program.

In July 2001, the Commanding Officer, Naval Atlantic Meteorology and Oceanography Center and the Energy Conservation Forecast Program Manager met with the Office of the Deputy Under Secretary of Defense for Installations (Housing and Energy) to discuss the potential benefits of using the program. As a result of the July 2001 meeting, the Office of the Deputy Under Secretary of Defense for Installations (Housing and Energy) directed the Naval Atlantic Meteorology and Oceanography Center to coordinate and brief the appropriate energy offices within each Military Department on the Energy Conservation Forecast Program. In addition, the Office of the Deputy Assistant Secretary of the Navy (Installations and Facilities) directed the Naval Atlantic Meteorology and Oceanography Center to provide a briefing on the program to energy officials within the Army and the Air Force. However, the Office of the Deputy Under Secretary of Defense for Installations (Housing and Energy) did not offer additional support or resources to the Naval Atlantic Meteorology and Oceanography Center should other customers subscribe to the Energy Conservation Forecast Program.

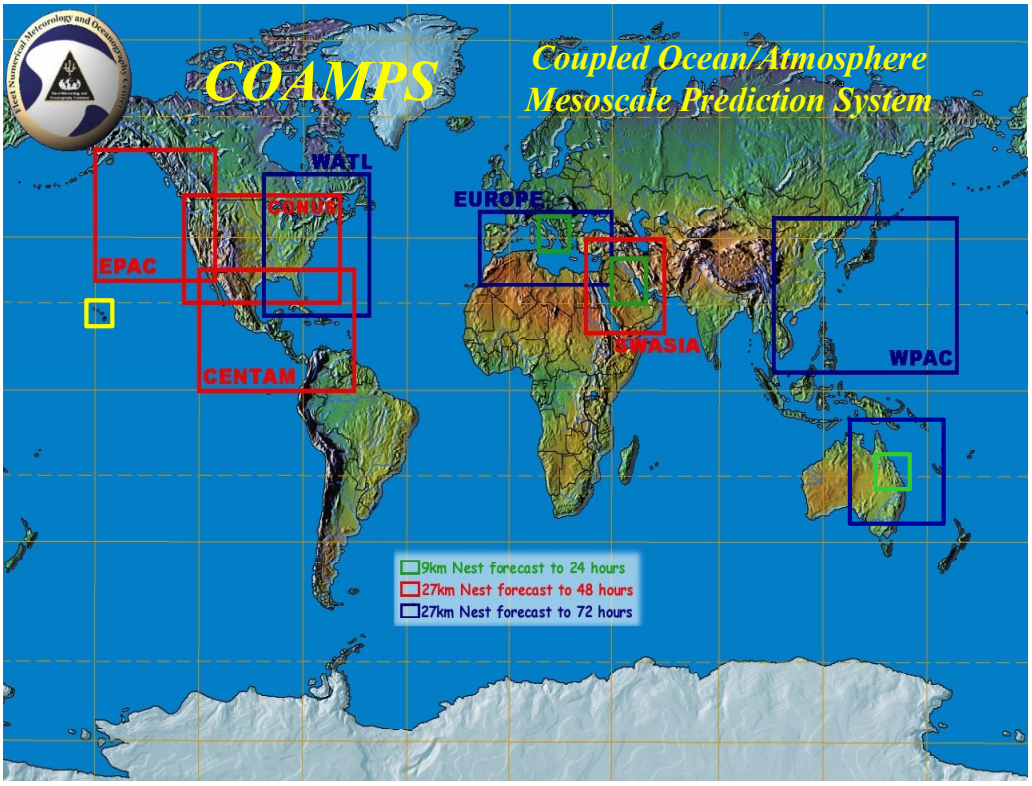
Appendix D. Meteorological and Oceanographic Conditions Predicted by Navy and Air Force Mesoscale Models

The following is a partial list of METOC conditions predicted by both COAMPS and MM5 mesoscale NWP models.

- Dew point depression
- Pressure
- Relative humidity
- Sea state (when coupled to an ocean model)
- Soil moisture (when coupled to a land-surface model)
- Soil temperature (when coupled to a land-surface model)
- Sea-surface temperature (when coupled to an ocean model)
- Temperature
- Upper-air pressure
- Wind direction
- Wind speed

Appendix E. Navy and Air Force Mesoscale Numerical Weather Prediction Model Coverage

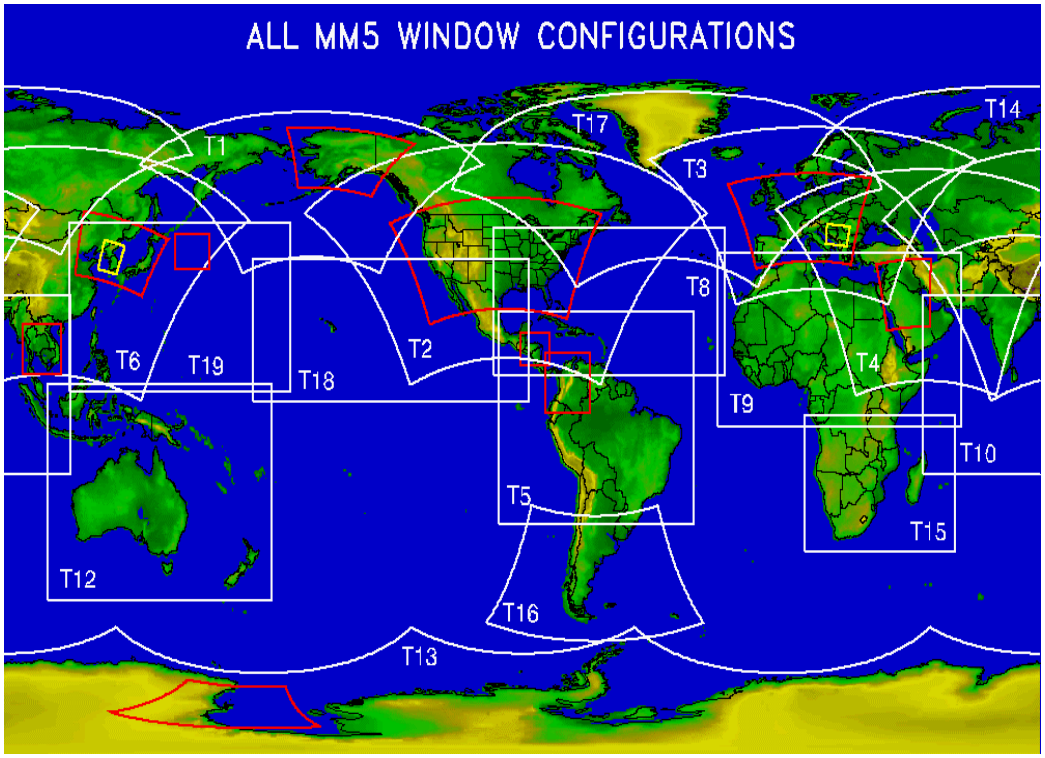
As of August 2001, the following worldwide geographic areas were supported by globally relocatable Navy COAMPS nested grids.



The fine-scale (9 and 27 km resolution) nested grids are not the only areas where Navy METOC support is provided. FNMOC disseminates the fine-scale COAMPS nested grids to Navy regional METOC centers. The Navy regional centers are capable of running mesoscale NWP models on the Distributed Atmospheric Modeling Prediction System* using COAMPS data to further generate theater forecasts for their specific areas of responsibility, thereby reducing the number of fine-scale nested grids produced by FNMOC.

*The Distributed Atmospheric Modeling Prediction System is a Navy system that allows regional centers to integrate high-resolution data and on-scene observations into global and regional models produced by FNMOC to support tactical warfighters.

As of August 2001, the following worldwide geographic areas were supported by globally relocatable Air Force MM5 nested grids.



White boxes (boxes containing a “T”) are 45 km resolution
Red boxes (mid-size boxes) are 15 km resolution
Yellow boxes (smallest boxes) are 5 km resolution

Appendix F. Air Force Comments on the Finding and Audit Response

This appendix addresses comments provided by the Air Force Deputy Chief of Staff for Air and Space Operations on the draft report concerning finding A. See the Management Comments section of the report for the full text of the Air Force comments.

Joint Forecast Consistency

Air Force Comments. The Air Force stated that forecasters are more likely to use models they have tuned, such as MM5, to meet Service-specific missions and to provide the best possible information to support Army and Air Force flight operations. The report conclusions imply that a forecaster should always be limited to a single model. The Air Force uses multiple models in formulating forecasts because doing so provides the greatest insight into the range of possible future meteorological conditions. The answer to a lack of familiarity with a source of information is to increase that familiarity rather than ignoring it. In addition, the report shows a continued lack of understanding of Air Force Weather reengineering because the Operational Weather Squadron–Combat Weather Team construct does not intend to provide raw model data down to the lowest levels. The Operational Weather Squadron provides the Combat Weather Team warfighter-focused products that already incorporate NWP inputs so the team can tailor the support to individual missions and operations.

Audit Response. We disagree with the Air Force statements that the report conclusions imply that a forecaster should always be limited to a single model and that the report shows a lack of understanding of Air Force Weather reengineering. The intent of that section of finding A is to have the Navy and the Air Force implement the accepted NAVAF Agreement initiative to "Implement Joint Theater Forecast Consistency" by consolidating their separate mesoscale NWP models and developing a standard next-generation DoD mesoscale NWP model. The NAVAF Agreement initiative states that the Navy and the Air Force should evaluate the types of data and the products required by theater forecasters and determine at which DoD center those products should be developed. We believe the use of Service-specific mesoscale NWP models by the Navy and the Air Force does not facilitate the ability of the Services to provide consistent METOC forecasts during joint operations and does not support the "one theater, one forecast" concept identified in Joint Publication 3-59.

Joint Modeling

Air Force Comments. The Air Force stated that the report's assertion that a lack of a common NWP model hinders consistency in forecasting for operations is incorrect. The NWP output is only one of a number of factors leading to a forecast and is not necessarily always the primary determining factor. There is no proof that adopting a single model means that the model will be the best one under all conditions and locations. In addition, models have unique strengths and weaknesses that can actually improve forecasting capabilities when used in concert.

Audit Response. We recognize that an operational forecast is developed using more than the output from an NWP model and that several others factors, such as the mathematical and physical relationship between METOC data derived from the occurrence of weather on the earth's surface, upper-air, and oceanographic observations, contribute to the development of a operational forecast. However, we believe that the development of a joint DoD NWP model would aid in forecasts that are provided in support of joint operations. Futher, reducing those variances within the forecasts will aid the Joint METOC Officer in making more timely decisions in support of the warfighter.

Appendix G. Report Distribution

Office of the Secretary of Defense

Under Secretary of Defense for Acquisition, Technology, and Logistics
  Director, Defense Research and Engineering
Under Secretary of Defense (Comptroller)
  Deputy Chief Financial Officer
  Deputy Comptroller (Program/Budget)
Assistant Secretary of Defense (Command, Control, Communications, and Intelligence)

Joint Staff

Director, Joint Staff

Department of the Army

Deputy Chief of Staff for Intelligence
Auditor General, Department of the Army

Department of the Navy

Naval Inspector General
Auditor General, Department of the Navy
Oceanographer of the Navy
Commander, Naval Meteorology and Oceanography Command
  Commanding Officer, Fleet Numerical Meteorology and Oceanography Center
  Commanding Officer, Naval Atlantic Meteorology and Oceanography Center
  Commanding Officer, Naval Pacific Meteorology and Oceanography Center, San Diego
Program Manager, Meteorological and Oceanographic Systems, Space and Naval Warfare Systems Command
Superintendent, Marine Meteorology Division, Naval Research Laboratory

Department of the Air Force

Assistant Secretary of the Air Force (Financial Management and Comptroller)
Auditor General, Department of the Air Force
Director of Weather
  Commander, Air Force Weather Agency
  Commander, 15th Operational Weather Squadron
  Commander, 26th Operational Weather Squadron
  Commander, 28th Operational Weather Squadron
Commander, Combat Air Force Command and Control System Program Office

Unified Commands

Commander in Chief, U.S. European Command
Commander in Chief, U.S. Pacific Command
Commander in Chief, U.S. Joint Forces Command
Commander in Chief, U.S. Southern Command
Commander in Chief, U.S. Central Command
Commander in Chief, U.S. Space Command
Commander in Chief, U.S. Special Operations Command
Commander in Chief, U.S. Transportation Command
Commander in Chief, U.S. Strategic Command

Other Defense Organizations

Director, Defense Information Systems Agency

Non-Defense Federal Organization

Office of Management and Budget

Congressional Committees and Subcommittees, Chairman and Ranking Minority Member

Senate Committee on Appropriations
Senate Subcommittee on Defense, Committee on Appropriations
Senate Committee on Armed Services
Senate Committee on Governmental Affairs
House Committee on Appropriations
House Subcommittee on Defense, Committee on Appropriations
House Committee on Armed Services
House Committee on Government Reform
House Subcommittee on Government Efficiency, Financial Management, and Intergovernmental Relations, Committee on Government Reform
House Subcommittee on National Security, Veterans Affairs, and International Relations, Committee on Government Reform
House Subcommittee on Technology and Procurement Policy, Committee on Government Reform

Joint Staff Comments

THE JOINT STAFF
WASHINGTON, DC

Reply ZIP Code:
20318-0300

DJSM-0925-01
11 December 2001

MEMORANDUM FOR THE INSPECTOR GENERAL, DEPARTMENT OF DEFENSE

Subject: Draft Audit Report Meteorological and Oceanographic (METOC) Support from Continental United States-Based Support Centers Project No. D2000LG-0102.05

1. Thank you for the opportunity to comment on the draft audit report.[1] The enclosed comments are provided for your consideration.

2. The Joint Staff point of contact is Lieutenant Colonel Bob LaFebre, J-3, 695-0581.

JOHN P. ABIZAID
Lieutenant General, USA
Director, Joint Staff

Enclosure

Reference:
1 Draft Audit Report D2000LG-0102.05, 2 October 2001, " Meteorological and Oceanographic Support from Continental United States-Based Support Centers"

Final Report
Reference

ENCLOSURE

COMMENTS ON METEOROLOGICAL AND OCEANOGRAPHIC (METOC) SUPPORT FROM CONTINENTAL UNITED STATES-BASED SUPPORT CENTERS

Page 18

1. Page 17, subparagraph A1a. Nonconcur in this recommendation.

REASON: The report erroneously assumes numerical weather prediction (NWP) products equate to operational forecasts. In general, theater METOC forecasts result from an understanding of the inter-dependent mathematical and physical relationship between METOC data derived from surface, upper-air, and oceanographic observations and the occurrence of "weather" on the earth's surface. These relationships, when studied on a global-, meso-, and microscale from a multi-model perspective, in tandem with satellite information, local rules-of-thumb, climatology, and the laws of physics that govern atmospheric and oceanographic motion, facilitate the formulation of theater METOC forecasts. NWP products are but one component in the spectrum of operational forecast development. As such, consistent METOC forecasts are in no way dependent upon a single NWP model's output. Therefore, consolidating separate mesoscale NWP models will not ensure the Services fully promote joint METOC support and will not facilitate the Services' ability to provide consistent METOC forecasts during Service-unique and/or joint operations as stated in the report.

Page 19

2. Page 17, subparagraph A1b. Concur with comment.

REASON: A consolidated effort by the Services, coupled with the civilian operational and research METOC communities, should reduce the inefficiencies associated with single-Service or single-agency model development. However, modern weather prediction successes depend on the ability of the forecaster to exploit model output from multiple NWP models vice a single model. In fact, current state-of-the-art research has shown that a multi-model ensemble-type forecast scenario can more accurately predict weather and seasonal climate change than either a single model or non-ensemble multi-model forecasts. The Services should take great care in this effort to ensure the prediction benefits associated with multiple models, each with differing strengths, are not lost in the development of a single model.

Page 20

3. Page 17, subparagraph A2a. Nonconcur.

REASON: The Services are responsible for organizing, training, equipping, and providing METOC forces/support for Service and joint operations. Within limited budgetary constraints, it is the Service's responsibility to ensure its centers meet operational requirements. A Service-unique backup capability is inherent to this responsibility. There

Enclosure

ENCLOSURE

is no title 10 requirement for either Service to accept and/or perform the other's mission in a backup role.

4. Page 18, subparagraph A.2b. Concur with comment. Page 21

REASON: All efforts to improve interoperability between the Service METOC communities, consistent with title 10 responsibilities, are welcome.

5. Page 18, paragraph A3. Nonconcur. Page 22

REASON: The report consistently and mistakenly equates mesoscale NWP modeling processes and products with operational, theater-level forecasts. Specifically, the report overestimates the significance of mesoscale NWP modeling when stating that mesoscale NWP is a critical element to providing METOC support for Service-specific and joint operations. The report erroneously assumes the METOC doctrinal tenant of "one theater, one forecast" is dependent upon this single component of the forecast process. Furthermore, the lack of a joint mesoscale model (vice Service-unique models) is not due to the failure of joint doctrine to identify joint NWP modeling when addressing a joint concept of operations as stated in the report. There is no cause-and-effect relationship between the existence of a single mesoscale model and the application of METOC forecast principles within joint/Service military doctrine. As previously noted, theater METOC forecasts result from an understanding of the interdependent mathematical and physical relationship between METOC data derived from surface, upper-air, and oceanographic observations and the occurrence of "weather" on the earth's surface. These relationships, when studied on a global-, meso-, and microscale from a multimodel perspective, in tandem with satellite information, local rules-of-thumb, climatology, and the laws of physics that govern atmospheric and oceanographic motion, facilitate the formulation of theater METOC forecasts. Current and historical precedent of modern military and civilian operational METOC centers, and state-of-the-art operational research efforts, support a multi-model forecast regimen.

6. Page 18, paragraph A4. Nonconcur. Page 23

REASON: Same as noted in paragraph 5 above.

7. Page 18, paragraph A5. Nonconcur. Page 23

REASON: Same as noted in paragraph 5 above.

Final Report
Reference

ENCLOSURE

Page 31

8. Page 25, paragraph B1. Comment: This recommendation is directed at the Navy. The Joint Staff offers no comment.

Page 32

9. Page 25, paragraph B2. Comment: This recommendation is directed at the Air Force. The Joint Staff offers no comment.

Department of the Navy Comments

DEPARTMENT OF THE NAVY
OFFICE OF THE ASSISTANT SECRETARY
(INSTALLATIONS AND ENVIRONMENT)
1000 NAVY PENTAGON
WASHINGTON, D.C. 20350-1000

DEC 10 2001

MEMORANDUM FOR DEPARTMENT OF DEFENSE ASSISTANT INSPECTOR GENERAL FOR AUDITING

Subj: DOD IG DRAFT AUDIT REPORT D2000lg-0102.05

Ref: (a) DoD IG Final Report D-2001-151, Meteorological and Oceanographic Support in the CONUS Theater; 28 June 2001

a. In response to reference (a), we concur with the subject report and comments 1a-f.

My point of contact is CDR Paul Stewart at 703-588-6674.

Donald R. Schregardus
Deputy Assistant Secretary of the Navy
(Environment)

DEPARTMENT OF THE NAVY
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
2000 NAVY PENTAGON
WASHINGTON, D.C. 20350-2000

IN REPLY REFER TO
5410
Ser N096/1U570771
30 Nov 01

From: Chief of Naval Operations (N096)
To: Assistant Inspector General for Auditing
Office of the Inspector General, Department of Defense
Via: Assistant Secretary of the Navy (Installation and Environment)

Subj: DOD IG DRAFT AUDIT REPORT, METEOROLOGICAL AND OCEANOGRAPHIC SUPPORT FROM CONTINENTAL UNITED STATES-BASED SUPPORT CENTERS (PROJECT NO. D2000LG-0102.05)

Ref: (a) DOD IG Project NO. D2000LG-0102.05, Meteorological and Oceanographic Support from Continental United States-Based Support Centers of 2 Oct 01

1. In response to the recommendations in reference (a), the following comments are provided:

a. Concur with Recommendation A.1.a that Joint Theater Consistency should be pursued. IRC Chat has provided an extremely valuable tool in improving communication among theater forecasters as a step toward that consistency.

b. Concur with Recommendation A.1.b in that we support development of a standard next generation mesoscale numerical weather prediction model. However, we want to ensure that the next generation model will significantly exceed the capabilities of the current Navy model.

c. Concur with Recommendation A.2.a on the development of a viable continuity of operations plan. We are currently testing operational backup for numerical weather modeling with the National Weather Service.

d. With regards to Recommendation A.2.b, we have invigorated and renamed the Joint METOC Configuration Control Board to the Joint METOC Interoperability Improvement Board (JMIIB), which has broadened their scope to address this recommendation.

e. Concur with Recommendations A3 and A4. We support the concept of joint modeling and are willing to discuss establishment of a Joint Modeling Center.

Subj: DOD IG DRAFT AUDIT REPORT, METEOROLOGICAL AND OCEANOGRAPHIC SUPPORT FROM CONTINENTAL UNITED STATES-BASED SUPPORT CENTERS (PROJECT NO. D2000LG-0102.05)

f. Concur with Recommendation B.1 on the need to coordinate review and comment on any METOC related operational requirements documents by DoD METOC components.

2. If you have questions, please contact me at (202) 762-1020 or my Action Officer, LCDR John Mykyta at (202) 762-0261.

R. D. WEST
Oceanographer of the Navy

Copy to:
NAVIG
CNO (N00, N09)
USAF/XOW
COMNAVMETOCCOM

Department of the Air Force Comments

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC

7 DEC 2001

MEMORANDUM FOR ASSISTANT INSPECTOR GENERAL FOR AUDITING
OFFICE OF THE INSPECTOR GENERAL
DEPARTMENT OF DEFENSE

FROM: HQ USAF/XO
1630 Air Force Pentagon
Washington, DC 20330-1630

SUBJECT: Draft DoD IG Report, Project No. D2000LG-0102.05, Meteorological and Oceanographic Support from Continental United States-Based Support Centers, 2 October 2001

The Air Force has reviewed the subject draft audit report. The Air Force concurs with comment on Recommendations A.1.b and B.2 and non-concurs with Recommendations A.1.a, A.2.a, A.2.b, A.3, and A.5. Attachment 2 contains additional specific comments on the recommendations and Attachment 2 contains comments on the report text.

We are discouraged that an audit to assess efficiencies did not recognize the significant return on defense investment we have achieved by leveraging the community-based MM5 weather forecasting model and the future potential return from leveraging the next-generation Weather Research and Forecast community model. We have provided information on the benefits of our approach in Attachment 1.

We concur with your recommendation to support joint development of the next-generation model to promote joint support. In the future, we envision a forecaster in the loop, smartly adjusting the best forecast model output available to form the basis for warfighter-focused, mission-tailored joint support across the operations area. We look forward to bringing the best support possible to the joint warfighter.

This memo is a coordinated Air Force and Army position.

CHARLES F. WALD, Lt Gen, USAF
Deputy Chief of Staff
Air and Space Operations

Attachments:
1. Framework for Effective Numerical Weather Prediction
2. AF Position on Recommendations
3. Specific Comments
4. AF/XOW Memo, Mutual Objectives in Weather Modeling, 16 Jan 01

cc:

ASD(C3I)	OAIG-AFU	Dep Asst SecNav (Env & Safety)	
DAMI	CNO(N096)	SAF/IGI	SAF/SX
SAF/AG	SAF/FM	SAF/LLR	SAF/PA

Framework for Effective
Air Force Weather Numerical Weather Prediction (NWP)

Our top characteristics are based on operational concerns. Of these, specific model attributes usually play a minor role. For example, radiation schemes are common to all present-day numerical weather prediction models, and the basic physics is well understood (meaning similar in all models). Therefore, for our purposes, that characteristic does not distinguish one model from another. We can describe our rationale for using MM5 today, and the Weather Research and Forecast (WRF) model in the future, in six categories.

Mission-Tailored Support: We require the capability to tailor our support for missions ranging from ground operations, paradrops, aerial refueling, delivery of precision-guided munitions, to high-altitude intelligence, surveillance, and reconnaissance (ISR) and optical turbulence forecasting in support of the Airborne Laser Program. MM5 gives us the flexibility to rapidly begin contingency windows, designed for those operations and locations, while also enabling us to obtain and integrate new physics options to improve the quality of support. Using MM5, we produce mesoscale forecasts for over 65 windows each day, and cover all land masses and military air routes. This includes contingency windows that can be activated within minutes, as well as moving 15 km windows that focus on tropical storms.

Cost-effective Modeling: AFW cannot afford to develop and maintain its own unique regional/mesoscale weather model. For example, AFW has recently streamlined its structure, eliminating duplication of effort at centralized facilities. The result--the AF now relies primarily on low-cost/high-payoff strategic partnerships with national laboratories, universities, and other R&D organizations. Our operational model is leveraged from the world's most widely used community mesoscale model---MM5. The model baseline is maintained at the National Center for Atmospheric Research (NCAR), minimizing software lifecycle costs for the military. NCAR is able to leverage scientific improvements made by the worldwide research and development community--AFWA receives continuously upgraded model versions for minimal cost. For example, we needed an arctic physics package to support DoD operations in Antarctica and Alaska. The Byrd Polar Research Center (BPRC) at Ohio State University (OSU) developed an arctic physics package based on the MM5 mesoscale model. AFWA is incorporating that research via their partnership with NCAR – a great example of the type of leveraging that is possible in a community-modeling environment. Because of this leveraging we operate with much lower costs (especially in personnel) when compared to centers developing and maintain their own models.

Robust Performance: Our service base extends far beyond the Air Force, and these customers cannot accept missing or degraded forecasts that arise from unstable modeling processes. And, since MM5 is parallelized, we can easily accelerate performance by adding more processing nodes. Parallelization also provides the framework for fault tolerance that permits on-the-fly load redistribution from disabled nodes, should they go down. Our GTWAPS modeling system, centered on MM5, has maintained a 99.97% up-time.

Attachment 1 (1 of 2)

High Quality: This characteristic is largely based on the composite effects of the model physics mentioned in the above questions (model initialization - ability to use best-available background analyses), boundary layer physics options, cumulus convection schemes, radiation schemes, grid nesting flexibility (to the order of 1 km for both model grid spacing and associated terrain), and surface coupling (ocean and land), similar to COAMPS). MM5 is the standard model at most universities and has been exhaustively tested and improved, as proven by hundreds of refereed journal articles (395 of which are listed on the MM5 home page). A few of the contributing partners are: the national NWP centers, NCAR, AF Research Lab, Army Research Lab (ARL), University Partnering for Operational Support (UPOS), AF Institute of Technology and universities, and the national labs.

Integrated with other Models within the Modeling System: As briefed during the DoD IG visit in June, models run at AFWA share data and output fields. This integration helps achieve forecast consistency and eliminates duplication of effort. Our primary models are MM5 for NWP forecasts, LSM for land surface model analysis, RTNEPH/CDFS-II for real-time cloud analyses, ADVCLD/HRCP for cloud forecasts, SNODEP for snow analyses, and SFCTMP for global temperature analyses. This interwoven data fabric is unique to AFWA! In fact, none of the components can be removed from AFWA without degradation to AF-unique mission support.

Future Growth Potential: Our operational NWP system must be postured to migrate towards next-generation physics and computer architectures. The future of mesoscale weather modeling lies with the Weather Research and Forecast (WRF) model. This next-generation community model will merge operational requirements of AFWA and the National Centers for Environmental Prediction (NCEP) with research requirements of NCAR, National Weather Service (NWS), and the university community into single model framework. Through this approach, the AF will reap tremendous cost savings compared to the R&D costs of independently developing our own model. One additional benefit of partnering on the science is that our common NWP model and similar architecture makes possible cooperative processing arrangements that will reduce duplication of operational forecast efforts by the partnering forecast centers.

WRF software is designed for parallel supercomputing on any open system, ensuring optimal flexibility, modularity, portability, system performance, and long-term maintainability. The software design allows multiple model dynamics and physics within a single software framework. This allows users to implement different configurations of the model to meet their different requirements. Different plug-compatible configurations will provide simple, cost-effective mechanisms for ensemble forecasting within a single software framework. WRF will also deliver a cutting-edge data assimilation system employing 3D and 4D variational techniques. WRF is essential to achieve Operational Requirements Document and Mission Needs Statement requirements for precision targeting, effective operations, flight safety, and resource protection. We also see WRF as the NWP cornerstone for the new administration's National Missile Defense.

Attachment 1 (2 of 2)

Meteorological and Oceanographic Support from CONUS-Based Support Centers

Air Force Position on Recommendations

Recommendation A.1. We recommend the Oceanographer of the Navy and the Air Force Director of Weather:

a. Implement the initiative "Implement Joint Theater Consistency" to ensure the Navy and the Air Force meet the "one theater, one forecast" concept by providing consistent and high-resolution mesoscale numerical weather prediction support for joint operations.

AF Position: Non-concur.

Rationale: We fully support the "one theater, one forecast" doctrinal tenet described in JP 3-59 and implemented for recent operations including Operations Allied Force and Enduring Freedom. However, the report incorrectly concludes that the operation of separate models at AFWA and FNMOC is in violation of the NAVAF item "Implement Joint Theater Consistency." Nothing in this agreement states that the AF and Navy would develop a joint mesoscale model. The CONOPS proposed a common regional (theater-scale) model, while each Service would use a higher resolution mesoscale model that could be employed over areas of interest for each Service. In 1992, we envisioned that the regional/theater-scale model would be different from the higher resolution mesoscale model. Instead, both MM5 and COAMPS are now run at lower resolution to provide a theater-scale forecast and are run at higher resolution to provide additional forecast capabilities in Service areas of interest. Additionally, MM5 has been optimized for AF and Army operations, contributing to improved performance at all resolutions. These low-resolution runs of MM5 and COAMPS turned out to be of much better quality than the regional models run by the centers at the time, which contributed to the change in concept of operations by both centers. Therefore, the NAVAF agreement has proceeded with unanimity over the last several years--our modeling capabilities were combined for global models only and both Services agreed that each required the capability to run their own mesoscale models optimized for different regimes and missions. Additionally, the report consistently and mistakenly equates today's mesoscale NWP modeling processes and products with complete operational, theater-level forecasts. Mesoscale models are but one source of information that contributes to the formulation of a joint or Service-specific forecast. The report erroneously assumes the METOC doctrinal tenet of "one theater, one forecast" is dependent upon this single component of the forecast process. As we look to models of the future, we see benefit in optimizing the attributes of the next-generation model for specific regimes and missions. To this end, we've encouraged the Navy to join the Weather Research and Forecast model development effort (see Atch 4). We also see future computing and communications capabilities that can make creating "one theater, one forecast" much easier, but implementing the NAVAF initiative referred to in this recommendation will not accomplish this.

Attachment 2 (1 of 4)

Final Report
Reference

b. Promote joint meteorological and oceanographic support by cooperatively developing the next-generation standard mesoscale numerical weather prediction model to replace existing Service-specific models.

AF Position: Concur, with comment.
Rationale: A 2000 report by the National Research Council stated that the complexity of science and technology for model and analysis systems has outgrown the single agency development methodology. AFWA, the National Weather Service, and many others have chosen to join the national, community-wide Weather Research and Forecast (WRF) model effort to develop the next-generation mesoscale model rather than attempt to go it alone. We are encouraged to see the recent Naval Research Lab participation in the WRF program oversight board and their growing support of WRF goals.

Recommendation A.2. We recommend the Commanding Officer, Fleet Numerical Meteorology and Oceanography Center, and the Commander, Air Force Weather Agency:

a. Develop a viable continuity of operations plan that identifies processes and procedures to ensure the Navy and the Air Force are capable of providing meteorological and oceanographic services, including numerical weather prediction support, for classified and foreign operations should one center be unable to meet its operational requirements.

AF Position: Non-concur.
Rationale: We agree there is room for improvement in this area, and agree with the intent of this item. However, effective backup occurs today among AFWA, FNMOC, and the National Weather Service's National Centers for Environmental Prediction (NCEP). Migration to a community model (such as WRF) would facilitate greater opportunities for backup among all of the DoD and civilian centers, but the primary backup need is the data and not the model itself. Historically, failures of these unique center processes are extremely rare. Any attempt at 100% backup, especially "immediate backup," of each DoD center's unique processes would necessitate redundant capabilities and require significant additional resources that could be more effectively applied elsewhere. The AF has structured weather operations to use a multitude of different inputs, such as the National Weather Service's AVN global model and the Navy's NOGAPS model, to initialize our model runs and we encourage our Operational Weather Squadrons and Combat Weather Teams to use the best source and model available for a specific requirement. This provides flexibility and a backup capability far better than being tied to a single source or model.

Revised

b. Include all DoD Joint Technical Architecture Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance Domain standards in their existing technical architecture framework to promote interoperability and portability, ensure systems integration, and facilitate continuity of operations between the two numerical weather prediction centers.

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AF Position: Non-concur.
Rationale: AFWA and FNMOC modeling systems produce METOC data that is imported into C4ISR systems. Systems that only provide data into C4ISR systems, but interact with them in no other way (such as the mesoscale modeling systems at AFWA and FNMOC), are governed by the rules on data exchange standards. The only requirement is that the model output data be shared. Therefore categorizing the AFWA and FNMOC mesoscale modeling systems as C4ISR-related systems is inappropriate and misinterprets a basic tenet of the JTA.

Recommendation A.3. We recommend the Chairman of the Joint Chiefs of Staff revise Joint Publication 3-59, "Joint Doctrine, Tactics, Techniques, and Procedures for Meteorological and Oceanographic Operations," March 23, 1999, to include doctrine that addresses joint modeling in relation to supporting the "one theater, one forecast" concept.

AF Position: Non-concur.
Rationale: We fully support the "one theater, one forecast" doctrinal tenet described in JP 3-59. However, the report consistently and mistakenly equates today's mesoscale NWP modeling processes and products with complete operational, theater-level forecasts. Mesoscale models are but one source of information that contributes to the formulation of a joint or Service-specific forecast. The report erroneously assumes the METOC doctrinal tenet of "one theater, one forecast" is dependent upon this single component of the forecast process. JP 3-59 should not dictate a particular model/product, and since no model is perfect in all conditions and for all purposes, we need enough flexibility to allow for selection of the right model/product, for the situation at hand. As NWP models become more sophisticated and accurate in the future, a more dominant role for NWP output might be appropriate in JP 3-59, but we do not believe specifically identifying joint modeling in JP 3-59 is appropriate at this time. JP 3-59 covers overarching principles and METOC component responsibilities. Doctrinally, the Joint Staff does not pick solutions such as joint modeling. Per JP 3-59, it is the responsibility of the joint METOC officer (JMO) to provide one theater/one forecast in the most effective means possible. As such, the JMO/Joint Meteorological Forecast Unit should pick the solution for the current situation (to include service-unique needs, meteorological scenario, etc). We have prepared a draft of a new JP 3-59 and are starting the coordination process with the Services. This revision is required due to our reengineering effort and leveraging National Weather Service capability to achieve economies and efficiencies, but modeling specifications in JP 3-59 are not necessary.

Recommendation A.4. (Addressed to Navy only.)
AF Position: No comment.

Recommendation A.5. We recommend the Air Force Director of Weather revise Air Force Instruction 15-128, "Aerospace Weather Operations - Roles and Responsibilities," November 3, 2000, and Air Force Manual 15-129, "Aerospace Weather Operations - Processes and Procedures," November 8, 2000, to address joint modeling based on the revisions to Joint Publication 3-59 as a result of Recommendation A.3.

AF Position: Non-concur.
Rationale: See position on Recommendation A.3 above.

Recommendation B.1. (Addressed to Navy only.)
AF Position: No comment.

Recommendation B.2. We recommend the Air Force Deputy Chief of Staff for Air and Space Operations review Air Force Instruction 10-601, "Mission Needs and Operational Requirements Guidance and Procedures," August 13, 1999, to include procedures for meteorological and oceanographic acquisition category II and below programs that address:

a. Coordinating operational requirements documents with other DoD Components.

b. Establishing timeframes for other DoD Component reviews of program operational requirements documents.

c. Prescribing procedures for reviewing and commenting on operational requirements to determine whether a program could be supported by existing systems or technology or whether the program is a candidate for joint involvement.

AF Position: Concur, with comment.
Rationale: The AF/XO OPR for AFI 10-601 concurs with the recommendation. This review is now already mandated by CJCS instruction and an updated AFI 10-601 is in coordination. However, the AF does not plan to single out METOC programs with specific wording. Further, we anticipate using the NAVAF vehicle to coordinate joint acquisition when it makes sense to do so.

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Final Report
Reference

Meteorological and Oceanographic Support from CONUS-Based Support Centers

Audit Report Analysis and Specific Comments

Air Force Response to Draft Report

Page i, Executive Summary, Background, para 2, and Page 1, Background, Navy: "...FNMOC is the principal DoD operational processing center for automated global METOC analyses and predictions."
Comment: This statement is factually incorrect. There are many automated analysis and forecast processes at FNMOC, the Naval Oceanographic Office, and AFWA. The principal function that occurs at FNMOC (which was given up by the AF as part of the NAVAF agreements) is global METOC Numerical Weather Prediction (NWP). Other automated global METOC analyses and forecasts are produced at AFWA and not at FNMOC, such as the Snow Depth (SNODEP), Surface Temperature (SFCTMP), Agricultural Meteorology (AGRMET), and cloud analysis/forecast models. This statement should be changed to state that FNMOC is "the principal DoD operational processing center for automated global METOC Numerical Weather Prediction (NWP) analyses and predictions."

Revised

Page 3, Support Initiatives, Para 1: "The Air Force provides operational METOC support for units assigned to the Air Mobility Command at Scott Air Force Base, Illinois; the 8th Air Force at Barksdale Air Force Base, Louisiana; and the 9th Air Force at Shaw Air Force Base, South Carolina, from regional centers in the continental United States."
Comment: One of our four CONUS regional centers was omitted (25th Operational Weather Squadron [OWS], Davis-Monthan AFB, AZ), the paragraph ignores OWS support to Army units and operations throughout the US, and it fails to recognize the full scope of overseas, combatant command support performed by the OWSs. The document also fails to recognize that the Air Force provides space weather support for all of DoD through AFWA products.

Revised

Section A: Joint Mesoscale Modeling

Page 4, Joint Mesoscale Modeling, para 1: "The Navy and the Air Force use different Service-specific mesoscale NWP models despite the ability to forecast similar atmospheric conditions."
Comment: This is factually incorrect. The Air Force has not developed nor do we maintain a service-specific (i.e., Air Force unique) mesoscale model. AFWA leveraged MM5, an off-the-shelf mesoscale model run by more users than any other mesoscale model in the world. The version of the model run at AFWA is available to any researcher or operational user and is not unique to the Air Force. The Air Force accomplished this at dramatically lower cost compared to development of a unique model. Also, given the large number of worldwide users of MM5 who feed back improvements into the official MM5 baseline, AFWA is able to continuously upgrade this capability at minimal cost.

Revised

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Note: The document repeats the error in describing AFWA's implementation of MM5, an off-the-shelf community model, as a "service specific model" in numerous other places throughout the document. We comment only for this occurrence to minimize the length of this response.

Revised

Page 4, Joint Mesoscale Modeling, para 1: "In addition, the Navy and Air Force are in the process of separately developing next-generation mesoscale NWP models rather than developing a standard DoD mesoscale model."
Comment: This is factually incorrect. The AF is not independently developing a next-generation mesoscale NWP model, but is instead participating in a large interagency effort that includes the National Weather Service (NWS), National Center for Atmospheric Research (NCAR), the NOAA Forecast Systems Lab, as well as other government agencies and universities. The AF is leveraging a modest investment in the Weather Research and Forecasting (WRF) model to obtain a state-of-the-art capability benefiting from a wide developer and user base.

Page 4, Joint Mesoscale Modeling, para 1, bullet 1: "The lack of coordination occurred because the Navy and the Air Force did not fully implement the Jan 13, 1993 ...NAVAF initiative 'Joint Theater Consistency'".
Comment: This is factually incorrect. Nothing in this agreement states that the AF and Navy would develop a joint mesoscale model. The CONOPS proposed a common regional (theater-scale) model, while each Service would use a higher resolution mesoscale model that could be employed over areas of interest for each Service. In 1992, we envisioned that the regional/theater-scale model would be different from the higher resolution mesoscale model. Instead, both MM5 and COAMPS are now run at lower resolution to provide a theater-scale forecast and are run at higher resolution to provide additional forecast capabilities in Service areas of interest. Additionally, MM5 has been optimized for AF and Army operations, contributing to improved performance at all resolutions. These low-resolution runs of MM5 and COAMPS turned out to be of much better quality than the regional models run by the centers at the time, which contributed to the change in CONOPS by both centers. Therefore the NAVAF agreement has proceeded with unanimity over the last several years--our modeling capabilities were combined for a global-scale model only (used to initialize our mesoscale model) and both Services agreed that each required the capability to run their own mesoscale models.

Page 4, Joint Mesoscale Modeling, para 1, bullet 3: "The lack of coordination occurred because the Navy and the Air Force did not follow standards to facilitate interoperability and systems integration as defined in the Joint Architecture."
Comment: This is factually incorrect. Running different mesoscale models in no way violates any aspect of the Joint Architecture. The mesoscale models are themselves not joint systems, and have no requirement to be run on joint systems. As for MM5 and COAMPS software run at AFWA and FNMOC, respectively, there is no requirement to run that software on any other DoD systems, and as such there is no violation of the JTA. However the output data and products derived from that data are required on other DoD systems. AFWA and FNMOC have worked together to provide standard data exchange formats, and have made great strides in working together to further such interoperability under a NAVAF working group on data standards. We have been exchanging data according to JTA standards for years. Furthermore, AFWA and FNMOC are meeting all minimum requirements for JTA data exchange based on our

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backup data exchange agreements. AFWA and FNMOC do not have a joint requirement to duplicate running each other's models and therefore don't have a JTA systems requirement. The requirement is only that the data be exchanged directly and satisfactorily. This is stated by DoDD 4630.5 which, as quoted on page 2 of the audit report, "defines interoperability as the ability of systems, units, or forces to provide services to accept services from other systems, units, or forces, and to use the services so exchanged to enable them to operate effectively together. Interoperability is achieved between systems when information or services are exchanged directly and satisfactorily between the systems and users." Having said this, we do however see value in migrating to a common mesoscale model if it meets or exceeds the requirements for support to our AF, Army, and DoD customers.

Page 4, Joint Mesoscale Modeling, para 2: "In addition, JP 3-59....does not specifically identify joint modeling when addressing a joint CONOPS for providing METOC support during military operations. As a result, FNMOC and AFWA were not capable of providing adequate and immediate backup for each other..."
Comment: This is factually incorrect in several ways. First, joint modeling is not addressed in JP 3-59 because it should not be addressed in such a doctrinal document. Secondly, the fact that AFWA and FNMOC have independent mesoscale models is not in any way an impediment to providing backup. For example, FNMOC provides backup to NWS in global modeling, even though FNMOC runs the NOGAPS model and the NWS runs the AVN model. Similarly, AFWA provides mesoscale model backup to NWS, even though AFWA runs MM5 and NWS runs the Eta model. Both of these were successfully exercised when NWS/NCEP suffered a catastrophic fire in their production facility in 1999. Thirdly, the report erroneously establishes a cause and effect relationship in its conclusion that the absence of guidance on joint modeling in JP 3-59 results in the lack of a backup capability.

Footnote 6

Page 4, Footnote 5, 2nd sentence: "Horizontal dimensions generally range from around 50 miles to several hundred miles."
Comment: Change miles to kilometers to make this a correct statement. Also suggest adding the word "across" at the end of the sentence for clarity.

Revised

Revised

Page 4-5, Service Specific Mesoscale Modeling, Navy Mesoscale Modeling, para 1: Describes COAMPS as "a model that is capable of simulating changes in atmospheric conditions that could affect Navy, Marine Corps, and DoD air, land, and sea operations and weapons systems." and **Page 6, Service Specific Mesoscale Modeling, Air Force Mesoscale Modeling, para 1:** Describes MM5 as "a model that is capable of simulating changes in atmospheric conditions that could affect Army, Air Force, and DoD air and land operations and weapons systems."
Comment: The omission of sea operations and weapons systems from the MM5 description misleadingly implies MM5 is not useful over water. Because both models use comparable physics and simulate the same atmospheric conditions, they are both well suited to support all phases of operations. Both models are capable of forecasting all the atmospheric conditions listed in the report. In the case of tropical storms in the Pacific, verification performed at the Naval Research Lab (NRL) has shown that MM5 exceeded all regional/mesoscale models in forecast accuracy this year in the Pacific for times other than at 24 hours, and at 72 hours was the most accurate of any forecast. Clearly, MM5 is capable of supporting operations over water.

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Page 6, Air Force Mesoscale Modeling.
Comment: The section on Air Force Mesoscale Modeling is incomplete and does not accurately provide information for comparative purposes. Replace with the following:

Air Force Mesoscale Modeling. AFWA provides a high-resolution, real-time mesoscale forecasts and data using MM5, an NWP model that is capable of simulating changes in atmospheric conditions that affect Army, Air Force, and DoD air, land, and sea operations or weapon systems. MM5 is the Fifth-Generation NCAR / Penn State Mesoscale Model and is the latest in a series developed from a mesoscale model used by Dr. Rick Anthes at Penn State in the early 1970s that was later documented by Anthes and Warner (1978). Since that time, it has undergone many changes designed to broaden its usage. These include (i) a multiple-nest capability, (ii) nonhydrostatic dynamics, which allows the model to be used at a few-kilometer scale, (iii) multitasking capability on shared- and distributed-memory machines, (iv) a four-dimensional data-assimilation capability, and (v) more physics options. MM5 is a community mesoscale model and is continuously improved by contributions from users at many universities and government laboratories. It is a limited-area, nonhydrostatic, terrain-following sigma-coordinate model designed to predict mesoscale and regional-scale atmospheric circulation. Through an extensive collaboration between U.S. national laboratories, universities and the Air Force Weather Agency, MM5 has grown into the most widely used community mesoscale model including such features as:

- Multiple, fully 2-way nested, moveable grids with rapid global relocation capability;
- Hydrostatic and non-hydrostatic dynamics that allows the model to scale from global down to target-scale;
- Explicit moisture physics, including cloud formation and precipitation;
- Two-way coupling with both land and ocean models that describes moisture, heat, and momentum exchanges between air and sea;
- Operational across multiple supercomputer platforms, including vector machines and shared and distributed memory processor machines;
- Processes data on three separate grids (Polar stereographic, Lambert conformal, or Mercator). This ensures stable model runs for theaters at the poles, straddling the equator, or anywhere between;
- Uses variable resolution terrain elevation, land use, soil type, deep soil temperature, vegetation fraction, and land-water mask datasets (the new global 30 sec terrain data may be obtained from NIMA or USGS);
- Uses multi-variate optimum interpolation (MVOI) for operational data assimilation and is now being tested with a state-of-the-art 3- and 4-dimensional variational data assimilation capability providing superior forecast initialization. Advanced data assimilation

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processes include spatial and temporal quality control. Background fields and lateral boundary conditions can be obtained from either global analyses such as AVN or NOGAPS, or can be ingested from regional fields from previous MM5 forecast runs;

- The Air Force processes a wide variety of observation types. MVOI currently has the capability to use upper air observations (rawinsonde, dropsonde, and pilot balloon (PIBAL), surface observations (aviation routine, Airways, synoptic, ship, buoys, and drifting buoys), aircraft observations (pilot reports, automated sensor data, and weather reconnaissance data), polar-orbiting satellite temperature and moisture sounding data and cloud drift winds from geostationary satellites, surface mesonet observations, NOAA satellite vertical sounding data, and microwave imager sea surface wind observations. QuikSCAT Seawinds, microwave imager precipitable water, and satellite radiances will be incorporated into the 3-Dimensional Variational Analysis (3DVAR) model planned for implementation in 2002.

Revised

- AFWA generally runs four resolutions of MM5 grids simultaneously to support air and land operations: 45, 15, 5 and 1.67km resolution grids (See Appendix D). The 1.67 km nests are run on an "as needed" basis when mission support dictates. Sub-kilometer runs are possible, but lack adequate input observational density to be feasible. AFWA uses MM5 to support a wide variety of current warfighter missions, including resource protection, precision-guided munitions, cloud forecasts for Predator missions over Bosnia, and more. DTRA also uses MM5 data via a server at AFWA to provide predictions of the dispersion of nuclear, radiological, chemical, and biological hazards. AFWA also uses MM5 to help design future weapon system such as the Airborne Laser.

- Although MM5 is an advanced mesoscale numerical weather prediction model, AFWA's participation in the community modeling effort has opened a gateway to the next-generation modeling physics—WRF, the Weather Research and Forecasting model. An initial operational capability of WRF will be available by 2004.

Page 8, Next Generation Mesoscale Modeling, para 2: States that "the Navy and the Air Force were investing resources to separately develop next-generation mesoscale NWP models intended to provide Service-specific support, not facilitate joint support".
Comment: The Air Force has chosen not to participate in a DoD-only development program but rather a community-wide development effort (WRF) to leverage a modest taxpayer dollar investment to obtain a state-of-the-art mesoscale model at a fraction of the cost of a "go it alone" effort. With benefits of continual community-wide research and development, the AF intends to leverage a continuing small investment to maintain this state-of-the-art capability throughout its lifecycle, providing a several-fold return on investment compared to a DoD-only maintenance and upgrade effort. These are the same advantages currently accrued by the AF and Army use of the MM5 model. The creation of a joint theater forecast from whatever is the best source of forecast information for that time and place can provide the basis for Service-specific applications from a common picture that will facilitate joint support.

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Page 8, NAVAF Cooperative Agreement, para 1: "The Navy and AF use different mesoscale models and are in the process of separately developing next-generation mesoscale NWP models because they did not fully implement the NAVAF Agreement initiative to 'Implement Joint Theater Consistency'".
Comment: This is factually incorrect. As described above, this initiative recognized from the beginning the need for each center to be able to run a mesoscale model. While we speculated that COAMPS might be the solution for both centers in the future, we did not adopt it for several reasons. COAMPS development proceeded more slowly than originally thought and the availability of the MM5 community model with its large worldwide user base provided much greater opportunities for partnering and leveraging improvements.

Page 8, NAVAF Agreement Initiatives: "As of August 2001, only seven (out of the original 19 initiatives from 1992) had been completed."
Comment: The implication that little has been done with NAVAF over the last 9 years is incorrect. Great strides have been made in several of these areas due to the hard work of people at AFWA, CNMOC and FNMOC. The result has been greatly improved cooperation and interoperability compared to 1992 when NAVAF began.

Also the number of completed items stated in the report is factually incorrect. The actual number of issues from the 1992 agreement was 18; two of the original 19 items were combined almost immediately to give 18 items that have been worked and tracked. Of those 18 items, 8 have been completed (92-1, 92-4, 92-6, 92-7, 92-9, 92-12, 92-13, and 92-17) with only routine, ongoing associated work still occurring on some. Of the remaining 10 items (92-2, 92-3, 92-5, 92-8, 92-10, 92-11, 92-14, 92-15, 92-16, and 92-18), significant progress has been made on most since 1992, although the issues have not been completely resolved. This is reflected in a joint NAVAF status update provided to the DoD IG. We also provided these comments to the auditors in response to the report on management and oversight and several other reports. Many of these items were general topic areas that involved several tasks. So while many of the original tasks in those categories were completed long ago, other tasks are still being worked and some new tasks have been added, keeping the general category open. For example, on Item 92-3 (CONOPS for Joint Theater Support), Joint Pub 3-59 was published in 1999, a significant accomplishment. However since then we have added tasks to perform an update to the document, which is the open item from this original category opened back in 1992. Therefore the implication that no progress was made because the topic areas still remain open is factually incorrect.

Revised

Page 8-9, NAVAF, Designated DoD Global NWP Model: States that NOGAPS is the single DoD global NWP model that "should be used to provide the basis for all DoD forecasts". Also stated that AFWA was not using NOGAPS "to initiate MM5" and was using AVN from NWS because AVN was available 4 times per day, vice NOGAPS which was only available twice per day.
Comment: This is misleading and contains several factual inaccuracies. First, the AF uses the best information available to support the warfighter. The AVN is available with higher vertical resolution, arrives earlier and permits MM5 products to reach the warfighter sooner, and produces more accurate MM5 output in some areas of the world. When NOGAPS or any other model is the better input, we use it. Also, there is not one product that is or should be the "basis for all DoD forecasts." We purposely structured our processes to enable us to use a variety of

Revised

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inputs, seeking out the best in a particular region for a desired result. No single model is optimized for all regions and all missions. Through a document search we found that this section was taken from a previous NAVAF report but was misinterpreted. The AF simply agreed to replace AFWA's global model with FNMOC's global model to gain economies and efficiencies. To conclude that the NAVAF agreement means NOGAPS should be used to initialize all of AFWA's MM5 model runs, or that future mesoscale models would be initialized only with NOGAPS, is simplistic and does not provide the best weather support to the warfighter.

Page 9, NAVAF, Joint Forecast Consistency, para 1: States that "Recipients of Service-unique mesoscale NWP models frequently do not have access to, or use, the other Service's NWP models. As a result, Navy and Air Force forecasters may not be effectively and efficiently using other Service NWP models because of an unfamiliarity with the model's characteristics and tendencies. Although the Navy and the Air Force accepted the initiative, as of August 2001, FNMOC and AFWA continued to produce separate, Service-specific mesoscale NWP models rather than using a standard DoD mesoscale NWP model."
Comment: A reasonable person would expect the Services to more often use the models they have tuned to meet Service-specific missions, such as COAMPS coupling with the ocean surface to support maritime forces and MM5's coupled Land Surface Model to provide the best possible information to support Army and low-level AF flight operations. We use multiple models, including indigenous models, to find the best to meet warfighter requirements at the time. The report's conclusions imply that a forecaster should always be limited to a single model. In reality, AF forecasters use multiple models (when available) in formulating their forecasts because it provides the greatest insight into the range of possible future meteorological conditions. A check of secure network web pages today shows that both AF and Navy METOC providers are closely linked on their web pages used by deployed combat weather teams throughout the contingency areas of operations. The answer to a lack of familiarity with a source of information is to increase that familiarity rather than ignoring it. AFWA posts to its web site details about the model itself, how AFWA deploys the model for various theaters around the world, the strengths and weaknesses of the model and real-time verification statistics on MM5's performance against both global and mesoscale models. Additionally, the report shows a continued lack of understanding of AFW reengineering because the Operational Weather Squadron - Combat Weather Team (CWT) construct does not intend to provide raw model data down to the lowest levels. The OWS provides warfighter-focused products already incorporating NWP inputs to the CWT so they can tailor the support to individual missions and operations. We stand ready to explain the AF Weather Reengineering concept of operations to the audit team.

Revised

Page 9, Establishing a Joint NWP Modeling Center, first sentence: "In an undated, unsigned position paper…."
Comment: Undated, unsigned position papers are not considered official Service positions and should not be the basis for IG evaluations.

Pages 10-11, Other Correspondence on Mesoscale NWP Modeling: The section lists correspondence from 1995 that illustrates an apparent disagreement as to the scope and content of the mesoscale models agreement in 1993. In particular, it cites a Dec 95 letter which made an

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unsubstantiated claim that, had COAMPS been adopted by AFWA, $8.5 million in savings could be realized.
Comment: While the report correctly identifies an earlier disagreement, it fails to cite more recent NAVAF documents that reflect that the issue has been resolved amicably, whereby both Services now recognize FNMOC as the DoD Global NWP Center, and that both center's have a requirement for their own mesoscale modeling capability. The assertion that $8.5 million could have been saved had AFWA adopted COAMPS has no factual basis and far exceeds any amount expended to leverage MM5. Finally, the last paragraph of this section repeats the incorrect statement that more than one mesoscale model is a detriment to joint operations and violates the "one theater, one forecast" principle outlined in JP 3-59 (see previous comments).

Page 11, para 4: "The Navy and the Air Force use of Service-specific mesoscale NWP models does not facilitate the ability to provide consistent METOC forecasts during joint operations nor does it support the "one theater, one forecast" concept identified in Joint Pub 3-59. Separate models could impede progress toward consistent and efficient METOC support. Separate NWP models may result in different assessments of METOC conditions, preparations for conditions, or operational "go, no go" decisions."
Comment: The assertion that a lack of a common NWP model hinders consistency in forecasting for operations is incorrect. Joint Pub 3-59 designed an intricate system to ensure one theater-one forecast is in effect through designation of the JMO and JMFU and creation of the Joint Operations Area Forecast (JOAF). NWP output is only one of a number of factors leading to a forecast and is not necessarily always the primary determining factor. Also, there is no proof that adopting a single model means that model will be the best one under all conditions and locations. Models have unique strengths and weaknesses which can actually improve forecasting capabilities when used in concert. Forecasters who are unfamiliar with model strengths and weaknesses is a training issue, not proper rationale for discarding a model.

Page 11, Continuity of METOC Operations, para 1: States that the Services use separate models and are separately developing new models "because they did not develop a mutually agreed-upon continuity of operations plan."
Comment: This is an erroneous cause and effect statement; the reason the Services use separate models has nothing to do with the lack of a continuity of operations plan.

Page 12
Revised

Page 11, Continuity of METOC Operations, METOC Back-up Capabilities: "FNMOC and AFWA were not capable of providing adequate and immediate backup for each other should one center be unable to meet its operational requirements."
Comment: Backup occurs today with both AFWA and FNMOC backing up the National Weather Service's National Center for Environmental Prediction (NCEP) with AFWA's MM5 as backup to NCEP's Eta mesoscale model and FNMOC's NOGAPS backup of NCEP's AVN global model. Although the primary backup need is the data and not the model itself, migration to a community model (such as the Weather Research and Forecasting [WRF] model) would facilitate greater opportunities for backup among all of the DoD and civilian centers. This should be pursued if the Navy is convinced of the accuracy and benefits of the WRF model. Any attempt at 100% backup, especially "immediate backup," of each DoD center's unique processes would necessitate redundant capabilities and require significant additional resources that would be more effectively applied elsewhere.

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Revised

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delete

Page 12, METOC Products Provided by FNMOC and AFWA, last sentence: "Although FNMOC and AFWA provide unique METOC support for certain classified operations, neither center is currently able to provide support to classified operations supported by the other center."

Revised

Comment: This last sentence is not true. For terrestrial operations, both centers would be able to provide support to classified operations supported by the other center via many products.

Revised

Page 13, Meeting Joint Architecture Requirements, para 1: "The Navy and AF use different mesoscale NWP models and are in the process of separately developing next-generation mesoscale NWP models because they did not follow standards to facilitate interoperability and systems integration as defined in the Joint Architecture."

Comment: This is factually incorrect. The conclusion that these models, which have no requirements to run on any DoD non-weather systems, violate the JTA is incorrect and disagrees with established doctrine for interoperability. An example of this is the maps produced by NIMA. The requirement is for the map data to be interoperable with and used by C4ISR systems, but there is no requirement for the NIMA software that actually produced those maps to run on the C4ISR or other systems. The same is true for the center-specific software at AFWA and FNMOC. The JTA requires C4ISR systems to be capable of using the model data, but there is no requirement for these systems to be interoperable with the AFWA and FNMOC systems that created the model data. Nor is there any requirement that the software/hardware at AFWA and FNMOC be interoperable with each other. Again, the key is exchange of data, not the software/hardware that produces it. Finally, the report repeats the pattern of stating erroneous cause and effect relationships--AFWA and FNMOC running different models has nothing to do with the JTA.

Pages 13-14, Meeting Joint Architecture Requirements. The subsection entitled C4I-Related Systems states "Because the infrastructures at FNMOC and AFWA use C4I-related systems for NWP modeling, they are required to conform to the minimal standards for interoperability and system integration identified in the Joint Architecture. In addition, METOC support provides an operational capability to the warfighter; therefore, the computer systems that develop NWP models should conform to the Joint Architecture. ...We believe METOC functions are inherent to the C4ISR Domain because METOC support involves collecting, processing, integrating, analyzing and interpreting data. The C4ISR Domain requires common information modeling and information exchange standards", as well as other assorted standards. It also states "FNMOC and AFWA developed a common technical architecture framework that addressed information exchange standards" but "did not incorporate the other C4ISR Domain standards in their technical architecture framework." Finally, this section concludes by stating "by expanding the existing technical architecture framework between FNMOC and AFWA to include not only information exchange standards, but all C4ISR Domain standards, the Navy and AF would meet the intent of the Joint Architecture guidance..."

Comment: This is factually incorrect. AFWA and FNMOC modeling systems produce METOC data that is imported into C4ISR systems. Systems that only provide data into C4ISR systems, but interact with them in no other way (such as the mesoscale modeling systems at AFWA and FNMOC), are governed by the rules on data exchange standards. The only requirement is that the model output data be shared. Therefore categorizing the AFWA and

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FNMOC mesoscale modeling systems as C4ISR-related systems is inappropriate and misinterprets a basic tenet of the JTA.

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Revised

Page 13, para 3, METOC Back-Up Support Agreements.
Comment: We do not agree that the agreements in place with Federal agencies cover backup only for specific functions for only the continental US. Amongst our backup support, AFWA backs up the Joint Typhoon Warning Center (JTWC), the Washington Volcanic Ash Advisory Center (VAAC), and the Space Environment Center (SEC). JTWC's area is well outside of CONUS, VAAC extends beyond CONUS, and SEC is worldwide. AFWA has a draft continuity of operations plan involving several organizations beyond FNMOC that are viable options for continuity of AFWA operations for DoD forces. Many of the options listed in the draft have been tested in real time. In addition, FNMOC and AFWA exist separately to satisfy unique requirements of respective Service weapon systems (per Title 10). Due to our different missions, we see use of Navy data and products (which we currently receive) as a partial answer. We are currently sending MM5 data to the Navy for their use. Also, our products and data are available to the Navy via the Joint AF-Army Weather Information Network web site and FTP file transfers. We do not disagree that continuity of operations needs to be considered by both FNMOC and AFWA, but a one for one backup of each for the other is not an efficient or effective use of limited resources

Page 15

Page 14, last sentence of first paragraph: "... AFWA did not incorporate the other Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance Domain standards in their technical architecture framework."
Comment: This statement is factually incorrect. AFWA did incorporate C4ISR domain standards in the Air Force Weather Architecture and the AF Weather Weapon System (AFWWS) Requirements Document Version 2.4. The AFW Architecture does reflect the minimum set of standards required to support the warfighter for data exchange as stated in the JTA.

Page 15, METOC Concept of Operations, para 1: "The Navy and Air Force use different mesoscale NWP models and are in the process of separately developing next-generation mesoscale NWP models because JP 3-59 does not specifically identify joint modeling when addressing a joint concept of operations for providing METOC support during military operations."
Comment: This is a false cause and effect relationship. The need for both centers to run a model was based on requirements and technical realities (as previously explained), neither of which violated any doctrine from JP 3-59. Per JP 3-59, its scope is to cover the tactics, techniques, and procedures for the planning and execution of METOC and space environmental operations. Specifically, it covers organization, METOC principles, and METOC operations. Per JP 3-59, principles cover timeliness, accuracy, relevance, unity of effort, readiness, and effectiveness. Effectiveness "should be based on the successful and effective use of METOC information." As such, it should not dictate one particular model/product, but allow for selection of the right model/product, for the situation at hand. We do not believe specifically identifying joint modeling in JP 3-59 is appropriate. JP 3-59 covers overarching principles and METOC component responsibilities. Doctrinally, JCS does not pick solutions such as joint modeling. Per JP 3-59, it is the responsibility of the joint METOC officer (JMO) to provide one theater/one

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forecast in the most effective means possible. As such, the JMO/Joint Meteorological Forecast Unit should pick the solution, for the current situation (to include service-unique needs, meteorological scenario, etc). Further restrictions in JP 3-59 are not necessary.

Revised

Page 16, Air Force METOC Concept of Operations, line 17: "...AFWA collects, analyzes, forecasts, and disseminates global METOC products to regional Air Force operational weather squadrons."
Comment: Does not include digital database support to Army or space weather support to all of DoD. Recommend changing the sentence to read "...AFWA collects, analyzes, forecasts, and disseminates global METOC and space weather products to regional Air Force operational weather squadrons and provides a 4-dimensional forecast digital database (MM5-Lite) for each Army Major Command to use to produce weather effects tactical decision aids."

Page 16, METOC Concept of Operations, last para: "Because modeling is a critical element to providing accurate and reliable METOC support, the issue should be addressed in JP 3-59 and the Navy and Air Force METOC concepts of operations."
Comment: The report consistently and mistakenly equates mesoscale NWP modeling processes and products with operational, theater-level forecasts. Mesoscale models are but one source of information that contributes to the formulation of a joint or Service-specific forecast. The report erroneously assumes the METOC doctrinal tenet of "one theater, one forecast" is dependent upon this single component of the forecast process.

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Page 16, Uninterrupted METOC Support: FNMOC and AFWA have limited assurance that either "could provide uninterrupted METOC services, including NWP support, should one center be unable to meet its operational requirements."
Comment: This is correct. However, the only way that *immediate* backup can occur is to maintain completely redundant systems duplicated at both centers, consuming significant resources better applied elsewhere. For example, a requirement for AFWA to provide immediate backup to NOGAPS is not cost effective given the readily available National Weather Service global model. For mesoscale models, as stated earlier, the data is what's most important and not that the models are not identical.

Section B: Coordination and Review of ACAT-III and Below METOC Program Requirements

Page 28

Page 22, Table 2: AF ORDs Not Reviewed by the Navy.
Comment: Table is factually incorrect. Reengineered Enterprise Infrastructure Program, Tactical Meteorological, War Weather, and Weather Information Processing System Upgrade projects did not require an ORD. Tactical Meteorological and Weather Information Processing System Upgrade were modification efforts of existing capabilities. Reengineered Enterprise Infrastructure Program and War Weather are covered by the Centralized Aerospace Weather Capability and Forecasting System-21st Century ORDs, respectively. After removing these programs from the table, the total dollar amount is $142.0M instead of $229.4M.

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Page 22, para 2, line 5: "The Navy had not developed ORDs for the remaining 10 programs because they were considered non-acquisition programs."
Comment: The report should state what a non-acquisition program is in the Navy, which will allow for comparing programs between the Air Force and the Navy. It may be that there are Air Force programs that if the Navy definition of a "non-acquisition program" is applied that would also be considered non-acquisition programs.

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Appendix B: Meteorological and Oceanographic Support and Training

Page 32, Appendix B. Para 2, Air Force Operational Weather Squadrons in the Continental United States.
Comment: As written, this paragraph omits any mention of 25 OWS' responsibilities for the Western CONUS region AOR and fails to fully describe CONUS OWS command relationships and roles and responsibilities for furnishing operational-level METOC products and services. Rewrite as follows:

"The Air Force activated four Operational Weather Squadrons (OWS) to furnish operational-level METOC support to all Air Force, Army and Reserve Forces based within the Continental United States. Each of these four regional centers is assigned a geographical Area of Responsibility (AOR) and is responsible for furnishing their supported customers with terminal forecast and resources protection forecasts; transient aircrew and Reserve force flight weather briefings; and fine-scale, regional graphics depicting weather parameters critical to operations. The 15 OWS is located at Scott AFB, IL, aligned under Air Mobility Command and provides operational-level METOC products and services for the North Central Region of the Continental United States. The 15 OWS is also responsible for providing operational-level METOC support for worldwide airlift and refueling missions controlled by Air Mobility Command's Tanker Airlift Control Center. The other three Continental United States regional OWSs are aligned under Air Combat Command's three numbered air forces. The 28 OWS is located at Shaw AFB, SC and aligned under Ninth Air Force and the 609th Air Operations Group. The 28 OWS' responsibilities include supplying operational-level METOC products and services for customers located in the Southeast region of the Continental United States. The 28 OWS is also responsible for providing operational-level METOC support to Air Force and Army forces based in the Southwest Asia AOR due to Ninth Air Force's role as the air component to US CENTRAL COMMAND (CENTCOM). The 26 OWS is located at Barksdale AFB, LA and aligned under Eighth Air Force and the 608th Air Operations Group. The 26 OWS is responsible for furnishing operational-level weather products and services to the South Central region of the Continental United States. The 26 OWS is also tasked to provide operational-level METOC support to a large portion of the US Strategic Command (USSTRATCOM), Air Force Information Operations and Army and Air Force units operating in the US Joint Forces Command (JFCOM) AOR. The 25 OWS is located at Davis-Monthan AFB, AZ and aligned under Twelfth Air Force and the 612th Air Operations Group. The 25 OWS is responsible for producing operational-level METOC products and services for the Western Region of the Continental United States. The 25 OWS also produces operational-level METOC support to Air Force and Army units operating in Central and South America due to Twelfth Air Forces role as the air component to US Southern Command (USSOUTHCOM)."

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Page 34, Appendix B, Paragraph 2.
Comment: As written, the existing paragraph omits important details concerning the reasoning and methodology used to restructure and optimize training and career progression for Air Force Weather enlisted and officer personnel. Recommend this paragraph be revised to read as follows:

"To correct these problems, Air Force Weather restructured its METOC training programs to improve its training capabilities and optimize officer and enlisted career progression. One of the main objectives of this restructured program is to shift the bulk of the workload for training new officer and enlisted career field accessions from frequently task saturated, undermanned base and post weather stations to regional OWSs. Under this structure, officer and enlisted forecasters begin their careers by attending an in-residence Initial Skills Course administered at Keesler AFB by Air Education Training Command. After graduating from these courses, officer and enlisted forecaster trainees are typically sent to a regional OWS to obtain required proficiency training in METOC information systems and forecasting techniques and upgrade their skill levels. Upon arrival, each OWS trainee is enrolled in a comprehensive training program consisting of a mix of classroom instruction, performance-based on-the-job training (OJT), correspondence courses and various types of distance learning. In most instances, trainees will be initially assigned to OWSs for a period of at least 24 months to ensure they have ample opportunity to complete all of their required OWS qualification and skill-level upgrade training before they depart to attend Air Force Weather's new 12-week Combat Weather Team (CWT) Operations. Upon completion of this course, trainees will typically be assigned to a base or post CWT to become fully proficient in providing METOC products and services for a wide variety of different types of tactical-level air and land operations. The combined effects shifting the bulk of the training workload away from base and post weather stations and instituting robust training programs at regional OWSs is expected to result in a marked improvement to the overall quality of Air Force Weather training and significantly boost the average experience levels of CWTs."

Page 40
Revised

Page 34, Appendix B, Paragraph 3, line 2.
Comment: This is not the correct name for SAIC. Change "... Science Applied Industries Corporation ..." to "... Science Applications International Corporation ...."

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DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON, DC

16 January 2001

MEMORANDUM FOR OCEANOGRAPHER OF THE NAVY N096
ATTENTION: RADM WEST

FROM: AF/XOW

SUBJECT: Mutual Objectives in Weather Modeling

Air Force Weather has embraced the concept of leveraging the efforts of the entire weather community to improve our ability to forecast. By doing so, we've seen significant benefits to include:

a. More bang for the buck -- the MM5 community model is documentable as the model of choice in several sets of circumstances -- the resources expended to achieve this performance are less than any single entity would have had to expend if they "went it alone."

b. Timely enhancements -- we are already running a coupled land-atmosphere model in beta and expect IOC of a coupled model that includes soil types, vegetation types, snow depth, soil moisture, "greenness," accumulated precipitation, etc., to improve our ability to predict atmospheric changes. We'll be declaring IOC in a few weeks.

c. Economies and efficiencies in that we can apply our limited resources to solve other challenges that enable better support to warfighters.

In the spirit of NAVAF and our ongoing effort to improve joint METOC support to warfighters, we'd like to create a small team to explore the possibility of integrating Navy modeling efforts into a single coupled model -- an atmospheric model coupled with land surface AND oceans. Your release of COAMPS is a great step that could be incorporated into such an effort. By working toward a common modeling solution, we envision the benefits listed above for everybody.

We would, of course, need to preserve Service capability to tailor products and meet mission requirements we've already agreed to work separately. These include: Navy NOGAPS for the global synoptic model - COAMPS to feed the ocean part of the model, Navy oceanography, Air Force mesoscale modeling for theater METOC support and discrete Air Force support to NIMA for certain National Missions, etc. -- a division of labor already codified through NAVAF and similar initiatives. By taking such an approach, we maintain the ability to perform unique Service responsibilities, yet have the potential to achieve the benefits of a "virtual" consolidation of our modeling efforts.

By coupling the oceans to the land and atmosphere model, we should be able to improve the comprehensive overall model accuracy, achieve common data transfer, standardize

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interoperable formats and achieve the one theater, one forecast, one model, one worldwide effort. To that end, Air Force XOW would welcome the opportunity to advocate inclusion of the Navy in the next round of modeling efforts.

If you agree this idea has merit, we could form an investigation team to look into how we would implement such an effort. We could form our team and begin those efforts immediately. My point of contact is Col Web Tileston, (703) 614-7410. We look forward to working together with you in this effort.

DAVID L. JOHNSON, Brig Gen, USAF
Director of Weather
DCS/Air and Space Operations

cc:
AF/XO

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Audit Team Members

The Readiness and Logistics Support Directorate, Office of the Assistant Inspector General for Auditing, DoD, prepared this report. Personnel of the Office of the Inspector General, DoD, who contributed to the report are listed below.

Shelton R. Young
Evelyn R. Klemstine
Gary R. Padgett
Sean J. Keaney
Captain Gregory W. Lewis, U.S. Marine Corps
Frank J. Kelly