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NEXRAD Software Maintenance

Final Inspection Report No. SED-4559-3-001/February 1993

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Office of Systems Evaluation

UNITED STATES DEPARTMENT OF COMMERCE
The Inspector General
Washington, D.C. 20230

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MEMORANDUM FOR Ray Kammer
Deputy Under Secretary for Oceans and Atmosphere

FROM: Frank DeGeorge

SUBJECT: Inspection Report on NEXRAD Software Maintenance
(Report No. SED-4559-3-001)

This memorandum transmits our final inspection report concerning the maintainability of the NEXRAD software, as well as the ability of the Operational Support Facility to assume software maintenance, configuration management, and distribution responsibilities.

We found that the NEXRAD software, in general, will be maintainable by virtue of prodigious efforts by the NEXRAD Joint Systems Program Office, OSF, and Paramax to improve the quality of the accompanying documentation and to refine the software maintenance training program. We also found that the OSF is making significant progress toward achieving a defined and disciplined software maintenance process.

We have reached agreement with NOAA on implementing all of our recommendations except for (1) limiting the OSF to performing emergency corrections only prior to delivery of the final software by Paramax, and (2) developing a five-year software support plan in order to generate credible OSF software maintenance staffing estimates. The final report reaffirms our recommendations.

We thank NOAA staff for their assistance during this inspection.

Attachment

cc: Dr. Ron Alberty, Director, WSR-88D Operational Support Facility
Robert Brown, NEXRAD Program Manager
Dr. Elbert Friday, Assistant Administrator, National Weather Service
Robert Valone, Director, Systems Program Office

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OFFICE OF INSPECTOR GENERAL
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NEXRAD SOFTWARE MAINTENANCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

EXECUTIVE SUMMARY

Under a tri-agency program, the Departments of Commerce, Defense, and Transportation are acquiring the Next Generation Weather Radar system. Using advanced Doppler technology and improvements in radar software, NEXRAD radars will improve the detection and measurement of storm severity, improve weather warning accuracy, increase warning lead times, and provide automated exchange of digital radar weather data among federal agencies. The NEXRAD system will be installed at a total of 154 sites. The Joint System Program Office is responsible for the acquisition and deployment of NEXRAD systems. Paramax Corporation is the prime contractor for NEXRAD.

The Operational Support Facility in Norman, Oklahoma, will support the installed NEXRAD systems, including maintenance, configuration management, and distribution of the software. The JSPO currently controls the OSF budget and is responsible for ensuring that the OSF is prepared to support NEXRAD when this responsibility is transferred to the National Weather Service.

The purpose of this inspection was to assess the maintainability of the NEXRAD software, as well as the ability of the OSF to assume software maintenance, configuration management, and distribution responsibilities. This inspection was prompted by concerns we raised about deficiencies in Paramax's software development process and their potential impact on the maintainability of the delivered software (see *Final Inspection Report on NEXRAD Software Risks*, Report No. TA-100, August 26, 1991). In addition, software support is a new responsibility for the OSF.

We found that the NEXRAD software, in general, will be maintainable by virtue of prodigious efforts by the JSPO, OSF, and Paramax to improve the quality of the accompanying documentation and to refine the software maintenance training program. However, additional tri-agency efforts are needed to establish credible staffing estimates for OSF software maintenance, to ensure that an effective and disciplined maintenance process is in place, and to control major changes to software algorithms.

Our assessment that the NEXRAD software is maintainable should not be construed as an assertion that the software, consisting of more than 400,000 executable lines of source code, is free from errors. Instead, maintainability means that the condition of the software is such that trained software engineers at the OSF should be able to isolate and correct software errors detected in the fielded NEXRAD systems in a timely manner.

Our major conclusions are as follows:

- **NEXRAD software, documentation, training, and computer resources provide a satisfactory basis for maintenance.** We found that the quality of the code and documentation is adequate to permit the OSF to maintain most of the NEXRAD software without undue effort. Our concerns about maintainability have been mitigated significantly by thorough government review of the software documentation and by reasonable efforts by Paramax to improve it. The improved documentation, coupled with improvements in the contractor-provided software maintenance training program, should generally compensate for the negative effects on maintainability that may be caused by development process deficiencies that existed during the earlier stages of the NEXRAD project. (See page 4.)

- **The OSF needs to conduct more thorough analysis to adequately estimate software maintenance staffing levels.** The OSF has not conducted detailed planning based on an understanding of the quality and quantity of the code and documentation, and on an analysis of the specific work to be performed. Currently, the lack of well-defined tasks for the OSF to perform prior to and following the delivery of the final software by Paramax prevents the reasonable estimation of appropriate staffing levels. (See page 6.)

- **Additional efforts are needed to ensure that the OSF has a disciplined software maintenance process.** The OSF is highly aware of the need for a defined and disciplined software maintenance process, and has many of the necessary plans and controls in place. However, additional efforts are needed to identify problems, deficiencies, and areas for refinement, as well as to ensure that the plans and procedures, when implemented, effectively support maintenance. These efforts include (1) outside review of selected plans and procedures and (2) exercise, by the OSF, of its prospective plans and procedures on a representative set of software problems and enhancements prior to assuming responsibility for software support. (See page 9.)

- **More visibility is needed into NEXRAD algorithm changes.** We are concerned that decisions regarding changes and enhancements to the NEXRAD algorithms, after the OSF assumes its support responsibilities, may not be sufficiently planned and controlled. The OSF should develop an annual plan for modifying and adding algorithms. This plan should be reviewed and approved by the Program Management Committee, a tri-agency organization responsible for decisions involving changes, modifications, and new work which require authority to expend significant OSF resources. (See page 11.)

- **The contractor's obligations under the software warranty are unclear.** The NEXRAD software warranty is written in general terms and requires further interpretation. The JSPO is currently studying the software warranty and plans to

issue guidelines for its own use in determining whether a software problem is covered. However, the JSPO has expressed reluctance to arrive at a general interpretation of the warranty with Paramax and has dealt with warranty issues on a case-by-case basis. We believe that mutual agreement on interpretation by the government and the contractor is necessary to minimize conflict and delays at the time warranty issues arise, to reduce the possibility of the government's inadvertently voiding the warranty, and to allow for the proper planning and administration of warranty work. (See page 11.)

- **Government plans to make software changes may impair the warranty and interfere with contractor efforts.** Prior to the delivery of the final software by Paramax, the OSF may make corrections to the interim software in the event that errors are found that impair the operational mission of the system. In some instances, we would expect corrections to be covered under the software warranty. However, there is, as yet, no interpretation of the warranty. In addition, a government change to the NEXRAD software could affect Paramax's performance and schedule under the NEXRAD contract. (See page 12.)

Our recommendations begin on page 14.

A copy of NOAA's written response is attached. Through NOAA's response and our subsequent discussions, we have reached agreement on implementing all recommendations except those dealing with limiting the OSF to production of emergency releases only prior to delivery of the final NEXRAD software by Paramax and development of a five-year support plan on which to base staffing estimates. We reaffirmed our recommendations.

INTRODUCTION

Under a tri-agency program, the Departments of Commerce, Defense, and Transportation are acquiring the Next Generation Weather Radar system. Using advanced Doppler technology and improvements in radar software, NEXRAD radars will improve the detection and measurement of storm severity, improve weather warning accuracy, increase warning lead times, and provide automated exchange of digital radar weather data among federal agencies. The NEXRAD system will be installed at a total of 154 sites. The Joint System Program Office is responsible for the acquisition and deployment of NEXRAD systems. This office reports to the NOAA Systems Program Office, which is responsible for integrating the various National Weather Service modernization programs. Paramax Corporation is the prime contractor for NEXRAD.

The Operational Support Facility in Norman, Oklahoma, will support the installed NEXRAD systems, including maintenance, configuration management, and distribution of the software. The JSPO currently controls the OSF budget and is responsible for ensuring that the OSF is prepared to support NEXRAD when this responsibility is transferred to the National Weather Service. The OSF formally reports to the NWS Deputy Assistant Administrator for Modernization, and will ultimately be managed by the NWS Office of Systems Operations.

In order for the OSF to fulfill its critical software support responsibilities, the JSPO will need to ensure that OSF staffing levels are properly assessed, training requirements are identified and satisfied, the necessary computer resources are made available, and plans and procedures for performing the various software maintenance and support tasks are in place in a timely fashion.

PURPOSE AND SCOPE

The purpose of this inspection was to assess the maintainability of the NEXRAD software, as well as the ability of the OSF to assume software maintenance, configuration management, and distribution responsibilities. This inspection was prompted by concerns we raised about deficiencies in Paramax's software development process and their potential impact on the maintainability of the delivered software (see *Final Inspection Report on NEXRAD Software Risks*, Report No. TA-100, August 26, 1991). In addition, software support is a new responsibility for the OSF.

We reviewed selected NEXRAD software components and associated documentation to determine the level of maintainability. We also examined the plans and procedures that are being developed to determine whether the OSF will have a well-defined and disciplined software maintenance process in place, and we reviewed training, staffing, and resource requirements and plans to determine whether the OSF will be prepared to assume software maintenance responsibility.

This report is based on discussions with representatives of the NEXRAD JSPO and the OSF. It is also based on a review and analysis of the following documents:

- Computer Program Product Specifications for Computer Program Configuration Items 01 (Radar Data Acquisition Status and Control Program), 02 (Signal Processing Program), and 28 (Performance Analysis and Data Reduction Program) prepared by Paramax
- Computer Program Development Plan (Contract Data Requirements List Items 503 and 607) prepared by Paramax
- Software Management Plan prepared by the NEXRAD Computer Resources Working Group
- Computer Resources Management Plan prepared by the NEXRAD Computer Resources Working Group
- Integrated Logistics Support Plan prepared by the Joint System Program Office
- Requirements Initiative NA-WW-91-55-02 for the Operational Support Facility
- NEXRAD Responsibility Transfer Plan

We also reviewed briefing materials, internal documentation, and correspondence provided to us during a visit to the OSF. Finally, we examined selected government review comments on Computer Program Product Specifications, along with examples of Paramax's comment resolutions, and draft Paramax Program Support Library documentation.

Currently, 14 NEXRAD systems have been delivered. Delivery of the final system is scheduled for April 1996. Fielded systems incorporate software providing a specific set of functions referred to as **builds**. The initially fielded systems incorporate software build 5.1f. As further required functions are added to the software and certain known errors are corrected, new builds are placed in the field. At present, new systems are being fielded with software build 5.1g. This build is intended to provide the functions and performance sufficient for commissioning.[1] The NEXRAD production contract calls for two final builds, 6 and 7, which are scheduled for delivery in 1993 and 1994, respectively. We reviewed Build 5.1f software and associated documentation for this inspection.

Since inspections are designed for quick corrective action by agency managers, they generally do not include the detailed analysis associated with management audits. Our work

[1]A system is used on a test basis prior to commissioning. At commissioning, it becomes the official operational system.

was conducted in accordance with the *Interim Standards for Inspections* issued by the President's Council for Integrity and Efficiency, as adapted by the Department of Commerce.

BACKGROUND

This section establishes a common understanding of software maintainability, maintenance, configuration management, and distribution functions as they relate to this inspection report. It also describes the key documentation necessary for maintaining the NEXRAD software. Definitions of terms used in this report are presented in the glossary.

Software maintainability pertains to the ease of finding and correcting errors. Since software maintenance comprises 60%-70% of the total life-cycle cost of software systems, maintainability is an extremely important software quality factor.[2]

Software maintenance is the performance of those activities required to keep a software system operational and responsive after it is accepted and placed into production. Software maintenance consists of activities which result in changes to the originally accepted product set. These changes result from modifications to accommodate corrections, insertions, deletions, extensions, and enhancements.

In general, there are three types of software maintenance: corrective, adaptive, and perfective. Corrective maintenance pertains to changes made as a result of detecting actual errors in the system. The second type, adaptive maintenance, consists of modifications to accommodate changes in the environment in which a software system operates. Examples include modifications to handle newly installed hardware devices, a new version of the operating system, new file structures and data formats, and modifications in policies and rules. The third type, perfective maintenance, involves changes, insertions, deletions, modifications, extensions, and enhancements made to accommodate evolving and possibly expanding user needs. Examples of perfective maintenance are addition of a new precipitation model, modification of an existing hail algorithm to improve its accuracy, and enhancements to improve the user interface to the system.

Software configuration management is the process by which software changes are controlled. This process applies to the development phase of a software project as well as to the maintenance phase. Software configuration management ensures that all software change requests are handled accurately and completely; resulting products satisfy specified requirements; key software maintenance considerations, responsibilities, and requirements are identified; and the processing of software change requests is facilitated. Software

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[2]W. Osborne, "Reports on Computer Science and Technology," NBS Special Publication 500-130, October 1985 in David H. Longstreet, ed., *Software Maintenance and Computers,* (Los Alamitos: IEEE Computer Society Press, 1990) p. 4.

configuration management ensures that all appropriate design, product, and test documentation is updated to reflect changes made to the software. When a software build comes under configuration management it is considered a **baseline.**

The software distribution responsibility to be assumed by the OSF will entail providing each operational NEXRAD site with the magnetic media containing the latest version of the operational software.

The NEXRAD software consists of a set of computer programs that provide the functions necessary to meet the processing and performance requirements set forth in the NEXRAD Technical Requirements specification. One or more computer programs comprise a computer program configuration item. Each configuration item consists of smaller elements referred to as computer program components, which in turn consist of modules. Together, the modules and computer program components of a configuration item satisfy a defined set of system requirements. Each configuration item has an associated Computer Program Product Specification (also referred to as the C-5 specification). This documentation is the primary source of information describing the structure of the configuration item, and it thus provides the principal information for maintaining the software. The C-5 specifications contain graphical and textual information, as well as source code listings, data cross-references, database references, and tables describing processing interactions for the computer program components and modules that constitute the various NEXRAD configuration items.

OBSERVATIONS AND CONCLUSIONS

I. NEXRAD software, documentation, training, and computer resources provide a satisfactory basis for maintenance.

A. Code Quality Adequate

The quality of the code and the associated documentation is the key factor determining the cost and effort required for software maintenance. We therefore reviewed the C-5 specifications for three representative Computer Program Configuration Items. As described above, the C-5 specifications provide the source code, which allows the assessment of the quality of the software itself, as well as the descriptive information needed to understand and maintain the code.

In general, we found that the code follows the standards specified in Paramax's Computer Program Development Plan, and these standards are adequate to provide maintainable software. We also assessed maintainability by examining such characteristics as modularity, variable localization, coupling, and control flow complexity. Overall, we found that the NEXRAD software is reasonably well structured. As can be expected of any large software system, we found code segments that are poorly structured and difficult to understand. However, we believe

that from a code quality perspective, most of the NEXRAD software will be maintainable without undue effort.

B. *Software Documentation Improved*

We also found that the format and content of the C-5 specifications are now suitable for supporting the OSF's software maintenance responsibilities. This is due, in large measure, to prodigious efforts made by JSPO and OSF software personnel to thoroughly review and comment on early versions of the specifications delivered by Paramax. It is also attributable to the corrective actions taken by Paramax to accommodate the government's review comments. We believe that the overall quality of the C-5 specifications has been significantly improved as a result of the combined JSPO and OSF review process and that the specifications will generally be adequate to allow the OSF software engineering staff to maintain the software.

C. *Software Maintenance Training Restructured*

Also contributing to the ability of the OSF to maintain the software are the improvements to the contractor-provided software maintenance and configuration management training. The JSPO and OSF found the initial software maintenance course provided during an earlier phase of the NEXRAD production contract to be deficient and were concerned that the subsequent course also would not meet their needs. As a consequence, JSPO reached agreement with Paramax to modify the training to better address OSF requirements. Modifications include shortening and focusing the software maintenance course, using vendor-provided courses for special topics (e.g., operating system internals, device drivers, graphics), and providing an on-site software specialist from Paramax for six months prior to and six months after the software maintenance course.

In addition, Paramax specialists will conduct informal one-week courses at the OSF for each of the seven software functional areas of NEXRAD. These one-week courses will afford the OSF staff an opportunity to probe the software to depths that could not have been attained during the formal maintenance course. For example, the staff could use this opportunity to understand in detail the interaction of time-critical software components, get clarification of any source code that is not well documented or is particularly difficult to understand, and gain insight into how to add new algorithms to the system.

With respect to configuration management, the JSPO has arranged for Paramax to provide the OSF staff with formal training in the use of the automated Program Support Library, which will be the primary tool used for software configuration management. The Program Support Library will facilitate software version control, configuration change request processing, and automatic generation of operational programs based on a controlled source code configuration.

D. *Computer Resources Provided*

The OSF has identified the appropriate computer hardware and software necessary to fulfill its software maintenance, configuration management, and distribution responsibilities, and the JSPO is acquiring these items in a timely manner. Because NEXRAD uses a proprietary computer system (Concurrent) for which limited commercial software tools are available, Paramax has developed a number of software support and testing tools for its own use in developing and testing the NEXRAD software. Such tools include stand-alone calibration software for the Radar Data Acquisition processor and debuggers (i.e., tools for finding and correcting coding errors). Although these tools were developed using NEXRAD contract funding, they are not formal deliverables under the contract, and they therefore do not have the associated user documentation. Certain of these tools are useful to the OSF, but because of budget constraints, the JSPO is reluctant to task Paramax to document and formally deliver them. Paramax, however, has agreed to provide the source code for some of these tools and to cover their use in the software maintenance training course.

We expressed serious concern in our *Final Inspection Report on NEXRAD Software Risks*, Report No. TA-100, that the lack of a disciplined software development process by Paramax would have an adverse effect on the maintainability of the software. This concern has been mitigated significantly by the thorough review of the software documentation by the government and by reasonable efforts by Paramax to improve it. The improved documentation, coupled with the restructured software maintenance training program, should generally compensate for the negative effects on maintainability that may be caused by development process deficiencies that existed during the earlier stages of the NEXRAD project.

Our assessment that the NEXRAD software is maintainable by virtue of the relative quality of the code itself, the accompanying C-5 specifications, and the planned training program should not be construed in any way as an assertion that the software, consisting of more than 400,000 executable lines of source code, is free from errors. Instead, maintainability means that the condition of the software is such that trained software engineers at the OSF should be able to isolate and correct software errors detected in the fielded NEXRAD systems in a timely manner.

II. The OSF needs to conduct more thorough analysis to adequately estimate software maintenance staffing levels.

The OSF Software Engineering Section will be responsible for all system, support, test, and operational software associated with the NEXRAD system. This broad spectrum of responsibility warrants careful planning to ensure that staffing levels are sufficient for

effective execution of the various tasks that will be assigned, but are not excessive. Although the JSPO and OSF have made estimates of staffing needs in the past, detailed planning based on an analysis of the specific work to be performed has not been conducted. Consequently, the OSF lacks credible staffing estimates.

The present Software Engineering Section consists of seven software engineers who have extensive experience in the maintenance and development of complex software systems, including systems dealing with meteorological applications. These engineers have become familiar with the NEXRAD software as a result of attending the initial software maintenance training course presented by Paramax, reviewing C-5 specifications, and investigating reported software problems. The staff also includes two former Paramax software engineers having experience with software development for two of the three major components of the system, Radar Product Generation and Principal User Processor. This staff should provide an excellent foundation for building a capable software maintenance team at the OSF. Ultimately, the JSPO and OSF plan for this organization to be supplemented by support contractor personnel.

The OSF provided results of two separate analyses of staffing requirements for the Software Engineering Section. These analyses used different methods, yet arrived at similar estimates (41 and 47 staff government and support contractor personnel). These estimates were significantly higher than the estimate of 20 personnel, which is contained in the Integrated Logistics Support Plan prepared by the JSPO.

While these estimates were useful as initial attempts at quantifying staffing levels, none was based on a specific plan for maintaining the NEXRAD software. Estimates should now reflect what is known about the quality and quantity of code and documentation, and the known software problems for which the OSF will be responsible. In addition, the JSPO plans to have Paramax provide 10 additional software support personnel on-site at the OSF for a period of two years beginning in early 1993, and this will affect near-term staffing requirements. At this point, however, there are no plans for how these software personnel will be used.

OSF staffing was considered at a meeting of JSPO and OSF representatives on July 1 and July 2, 1992. At that meeting, primarily as a result of the disparity between OSF and JSPO staffing estimates, the JSPO recommended holding OSF Software Engineering Section staffing to the current level until a determination could be made concerning the possibility of having an Air Force Communications Management Engineering Team apply its models to provide an additional independent estimate of staffing requirements. A decision was subsequently made at the July 1992 NEXRAD Program Council meeting not to request an

Air Force staffing estimate.[3] Instead, the NWS Deputy Assistant Administrator for Modernization, who is a member of the NEXRAD Program Council, agreed to study the staffing needs of the OSF and report any resource problems at the NEXRAD Program Council meeting to be held in November 1992.

Currently, the lack of well-defined software support tasks prior to and after delivery of the final software by Paramax prevents the OSF, JSPO, NWS, the Air Force, or any other organization from reasonably estimating appropriate staffing levels. In fact, the lack of clearly defined software maintenance tasking for the OSF was a consideration for not having an Air Force team perform an analysis of OSF staffing requirements. Although having on-site support from Paramax can be highly beneficial, the appropriate level of effort is problematic without well-defined responsibilities for either the OSF or Paramax. It is also essential that the expected presence of Paramax software engineers at the OSF for two years does not cause the OSF to become overly dependent upon Paramax for subsequent software maintenance.

As a basis for determining staffing for software maintenance, the OSF should develop a five-year software support plan that explicitly identifies all known software problems that the OSF will be required to resolve and their priority, and any planned NEXRAD algorithm modifications or additions. The completed support plan should contain staffing estimates for all identified tasks and thereby serve as the vehicle for justifying OSF Software Engineering Section staffing requirements. The plan also should serve as a basis for determining the number of Paramax software engineers that can be productively used on-site at the OSF for the planned two-year period.

For the initial period following delivery of the final NEXRAD software, the plan should be concerned primarily with corrective measures related to software problems rather than with algorithm enhancements or development, and it should consider the effort required to deal with software problems reported from the field. The OSF Hotline Assistance Requests related to software problems provide a reasonable indication of the types and relative frequencies of software problems that might be reported by the operational sites.

Finally, the staffing plan should be based on the use of government staff wherever possible and should provide a rationale for the proposed mix of government personnel and support contractors. The plan should explicitly define a course of action for transitioning from Paramax support.

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[3]The NEXRAD Program Council provides overall policy guidance for the NEXRAD program and approves higher authority decisions. Voting members are senior officials of the three agencies acquiring NEXRAD.

In our opinion, on-site Paramax staff could assist the OSF staff in the following areas:

- Defining site adaptation data and developing automated procedures for handling these data
- Helping the OSF understand existing software to support development and maintenance of background map data
- Providing guidance and documentation for the use of Paramax-developed test and support software for which no formal documentation exists
- Resolving existing software problems
- Correcting deficiencies in the C-5 specifications
- Providing assistance in planning for and transitioning to future releases of the Concurrent OS/32 operating system

III. Additional efforts are needed to ensure that the OSF has a disciplined software maintenance process.

A stable, disciplined software development process improves a software organization's ability to achieve its development and maintenance goals and to increase productivity. Such a process depends on having fundamental controls in place for software project planning and management, tracking and oversight, configuration management, quality assurance, requirements management, and contractor or subcontractor management.[4] These controls should be clearly documented, well understood by software maintenance managers and staff, and used for both routine and emergency tasks. We found that the OSF is highly aware of the need for a defined and disciplined software maintenance process. The OSF, in conjunction with the JSPO, has many of the necessary plans and controls in place and intends to develop others that are needed. However, we believe that additional steps are necessary to help ensure, before the OSF formally assumes its maintenance responsibilities, that its plans and controls are effective.

Currently, two top-level management plans, the Software Management Plan and Computer Resources Management Plan, are being revised by the OSF to accommodate technical and contractual changes that have occurred since their approval. The Software Management Plan describes the overall software maintenance strategy and functional activities needed to support the NEXRAD software. The Computer Resources Management Plan describes the

[4]Charles V. Weber et al., *Key Practices of the Capability Maturity Model*, CMU/SEI-91-TR-25 (Pittsburgh: Software Engineering Institute, 1991) pp. L2-1—L2-84.

computer resources required by the OSF to maintain the NEXRAD software. The revised plans will be reviewed by the NEXRAD Computer Resources Working Group and submitted to the NEXRAD Program Council for approval. The Computer Resources Working Group is a tri-agency group responsible for updating the NEXRAD software maintenance philosophy. Members include representatives of the JSPO, OSF, NWS Office of Systems Operations, Air Force, and FAA.

In addition to these plans, the OSF is working on a Configuration Management Plan, Software Quality Assurance Plan, and Software Development Procedures, which will provide additional detail and guidance for the OSF's software support mission. The OSF Director has formal approval authority for these plans, but no external review is planned for these three documents. In order to ensure uniform quality of OSF software products, the OSF will require support contractor personnel to adhere to the same standards and procedures followed by OSF software engineers.

We believe that the OSF will have a reasonably well-defined and controlled process in place for maintaining the NEXRAD software. However, because the complete set of plans and procedures was not available for review at the time of our inspection, we cannot be certain that all the necessary planning and control issues will be addressed. Areas that frequently pose problems for new software organizations include (1) estimating costs and schedules for software maintenance tasks, (2) establishing rigorous test procedures, (3) establishing effective procedures for interfacing with the system engineering, system test, and configuration management organizations, (4) controlling requirements, and (5) managing contractors or subcontractors.

It is essential that the plans and procedures, when implemented, effectively support maintenance, are well understood by software maintenance personnel, are used routinely, and are not abandoned in emergency situations. Therefore, as a means of identifying any problems with the plans, as well as areas for refinement, the Computer Resources Working Group should review the complete set of plans and procedures, and provide feedback to the OSF. Particular attention should be provided by the Office of Systems Operations in this review both because of its experience in maintaining other NWS software systems and because this office eventually will have management responsibility for the OSF.

Finally, the OSF should exercise its prospective plans and procedures on a representative set of software problems and enhancements prior to assuming responsibility for software support. This software maintenance exercise will identify weaknesses with the plans and procedures, as well as train staff in their use. Plans and procedures should be tested on emergency, urgent, and routine problems and should cover the maintenance life cycle from identification of a problem or requirement to release of a corrected or enhanced baseline. Special attention should be paid to the areas indicated above as potential problems for new organizations. The lessons learned should be used to identify problems or deficiencies in the plans and procedures and make refinements.

IV. More visibility is needed into NEXRAD algorithm changes.

Although the OSF intends to modify existing algorithms and add new ones, we found no documented plans identifying such algorithms and the prospective changes to them. Such planning is essential for the OSF to estimate its staffing requirements. In addition, we are concerned that decisions regarding algorithm changes after the OSF assumes its support responsibilities may not be sufficiently controlled. Substantial changes to the NEXRAD algorithms should not be made until the system is stable, and all three agencies should clearly understand and agree to any proposed changes.

The OSF's draft Configuration Management Plan provides for OSF approval of any system changes under $1 million. According to the plan, major engineering changes of over $1 million have to be approved by the Program Management Committee. This tri-agency committee, subordinate to the NEXRAD Program Council, will be responsible for decisions involving changes, modifications, and new work which require authority to expend significant OSF resources. It will also review OSF activities, monitor staffing and funding, and act as a high level configuration control board.[5]

We are concerned that the threshold of $1 million will not adequately control software modifications since significant changes can be made for well under this amount. Moreover, algorithm changes and additions should not take place in a piecemeal fashion and should not be made without the explicit understanding and consent of the participating agencies. To address these issues, the OSF should develop an annual plan for modifying and adding algorithms. The plan should cover algorithms for hydrology, meteorology, and signal processing. It should present the rationale, technical approach, and cost and schedule estimates for the proposed changes and additions. The Program Management Committee should review and approve this plan.

V. The contractor's obligations under the software warranty are unclear.

Section H of the NEXRAD production contract, *Special Contract Requirements,* states that all delivered software and any associated documentation shall be free of defects and fully compliant with contract requirements for a period of 60 months after contract award. This 60-month period will end in December 1992. In addition, Section H specifies that all software changes and any associated documentation provided by Paramax and delivered to the government shall be fully compliant with the performance requirements of the NEXRAD Technical Requirements specification and the authenticated (approved) development and product specifications (the C-5 specifications) for a period of one year following acceptance of that change by the government.

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[5]The NEXRAD Computer Resources Working Group, *NEXRAD Software Management Plan,* December 15, 1989, p. 2-2.

For the time periods mentioned above, Paramax is required to correct, at no cost to the government, all applicable software errors and provide corrected software and updated documentation within 120 days of problem notification by the government. The contract also states that the software warranty becomes null and void only for those modules that are modified by the government. Correspondingly, Section H states that if a software failure occurs during the warranty period which can be attributed to a government software modification, Paramax shall be entitled to an equitable adjustment in the contract price for all corrections required due to the government modification.

In practice, in a large software system such as NEXRAD, it is virtually impossible for the delivered software to be free of all defects, and it may not be practical to require the contractor to correct lower priority defects. In addition, how the warranty actually would be applied to software changes is unclear. The JSPO is currently studying the software warranty and plans to issue guidelines for its own use in determining whether a software problem is covered by the warranty. However, the JSPO has expressed reluctance to arrive at a general interpretation of the warranty with Paramax and has dealt with warranty issues on a case-by-case basis. We believe that mutual agreement on the interpretation by the government and the contractor is necessary to minimize conflict and delays at the time warranty issues arise, to reduce the possibility of the government's inadvertently voiding the warranty, and to allow for the proper planning and administration of warranty work. At this time, it is not clear what corrections the warranty covers, how a determination would be made that a software failure is attributable to a modification made by the government, and what the value is of preserving the software warranty.

VI. Government plans to make software changes may impair the warranty and interfere with contractor efforts.

A. Incomplete Emergency Release Procedures

As discussed previously, the OSF's maintenance role prior to the delivery of the final software build by Paramax has not been clearly established. One function that has been considered is that of making corrections to the software in the event that serious errors are found after delivery and acceptance of interim builds. Serious errors are those which impair the operational mission of the system and for which there are no known workarounds. Corrected software provided to the sites under these circumstances is termed an **emergency release**. In some instances, we would expect emergency releases to be covered under the software warranty. In other instances, particularly after December 1992 when major parts of the warranty expire, it may be necessary for the OSF to make corrections on an emergency basis to keep systems operational.

The NEXRAD Computer Resources Working Group met in August 1992 to define procedures governing emergency releases by the OSF. The working group distributed

a draft document entitled, "Emergency Release Interim Procedures," to be used as guidance by the JSPO and the OSF until detailed procedures can be incorporated into the Software Management Plan and the Configuration Management Plan. The interim procedures task the JSPO Configuration Control Board, a tri-agency board chaired by the NEXRAD program manager, to determine which reported software problems qualify for inclusion in an emergency release. In evaluating a problem for inclusion in an emergency release, the Configuration Control Board will need to determine whether the problem is covered by the software warranty and whether the OSF or Paramax should be responsible for correcting the problem. In order to make this determination, the board needs to be provided with an interpretation of the warranty and guidance on its application. The effective development and application of emergency release procedures will be hampered until the warranty implications have been resolved.

The JSPO and OSF are aware that any modifications made to fielded software by the OSF to accommodate an emergency release must be communicated to Paramax so that the modifications can be incorporated into Paramax's evolving build. However, procedures for doing this have not been established either.

B. Dual Software Baseline Risks

In addition, issues arise as a result of two software baselines being worked on at the same time. Changes made by the OSF to Build 5.1g while Paramax is developing Build 6 will subsequently have to be incorporated into Build 6. Similarly, changes made by the OSF to Build 6 after it is operational and while Paramax is developing Build 7 will subsequently have to be incorporated into Build 7. Problems can arise if the OSF makes a modification that changes the behavior of the operational or developing baseline in unintended ways, or if the changes made by Paramax to the developing baseline affect the behavior of modifications made by the OSF to the operational baseline. Problems will occur if a modification is incorrect or introduces errors; problems can also occur even if a modification is valid and correct. A government change that has unintended consequences for an evolving baseline could affect Paramax's performance and schedule under the NEXRAD production contract.

While it may be appropriate or necessary for the OSF to issue emergency software releases to the sites while the NEXRAD production contract is still underway, this should not be done without mutual agreement of the government and contractor regarding the interpretation of the warranty, an understanding of the risks, and effective procedures for both parties to identify and track modifications to the software baselines. In addition, although the OSF may wish to make non-emergency software modifications in order to gain experience with the NEXRAD software and to have corrections ready to incorporate after delivery of the final software by Paramax, these modifications should not be distributed to the field while Paramax is developing

a follow-on baseline. Finally, the OSF will need to track modifications made by Paramax so that their potential impact on its non-emergency changes can be evaluated.

RECOMMENDATIONS

NOAA's response indicates agreement with all of our recommendations. However, the responses regarding recommendations #2, #3, and #4 do not indicate how these recommendations will be implemented. As a result, we held discussions with a JSPO representative to further clarify NOAA's intent. A summary of these discussions is provided with recommendations #2, #3, and #4 below since a formal written response was not requested.

We recommend that the Deputy Under Secretary for Oceans and Atmosphere:

Recommendation #1

Direct the JSPO to seek agreement with Paramax on the interpretation of the NEXRAD software warranty.

Recommendation #2

Direct the JSPO and NWS to limit changes to the NEXRAD operational software by the OSF to emergency corrections only until delivery of the final software under the NEXRAD production contract. Such emergency corrections should be consistent with the software warranty.

Summary of Discussions With JSPO

NOAA's written response describes the steps that are being taken to develop effective procedures for the OSF's preparation and distribution of emergency software releases, but does not explicitly agree to limit the OSF to providing only emergency software releases to sites prior to delivery of the final NEXRAD software product, build 7, by Paramax. The JSPO has indicated its desire to limit the OSF to providing only emergency software releases prior to delivery of build 7, but noted that the three agencies would like to be able to request the OSF to provide other than an emergency release to accommodate inclusion of tri-agency approved enhancements. However, since build 5.1h will provide the functional basis for commissioning NEXRAD radars, the JSPO indicated that the likelihood of a tri-agency request to provide a non-emergency release prior to delivery of build 7 is very small.

We believe that once the NEXRAD software is acceptable for commissioning, there is no need to provide any enhancements prior to delivery of build 7, and we continue to recommend that NOAA restrict the OSF to providing emergency software releases only prior

to delivery of build 7. Such restriction would limit the amount of software version control and distribution required of the OSF and would allow it to focus on the high priority tasks of developing and refining its software maintenance process and correcting existing software problems.

Recommendation #3

Direct the OSF to develop a five-year software support plan. This plan should determine the work that the OSF Software Engineering Section needs to perform in order to be prepared to assume full maintenance responsibility and to make necessary emergency corrections prior to delivery of the final software under the NEXRAD production contract. It should also identify the software maintenance tasks that will need to be accomplished after delivery of the final NEXRAD software.

Summary of Discussions With JSPO

NOAA's response indicates that The MITRE Corporation is currently involved in developing staffing estimates for the OSF and includes a brief description of MITRE's effort to do this, along with its current effort to help the OSF develop and refine a software maintenance process. The response does not, however, address development of the recommended five-year software support plan and does not indicate that MITRE's staffing estimates or the process development effort will be based on clearly identified software maintenance tasks to be accomplished by the OSF both prior to and subsequent to delivery of build 7. We believe that to be credible, estimates of OSF staffing levels and development of an effective software maintenance process must be based on a plan that sets forth the specific tasks to be performed.

Recommendation #4

Recommend to the NEXRAD Program Council that the OSF develop an annual plan for modifying and adding algorithms.

Summary of Discussions With JSPO

NOAA's response to this recommendation describes a process whereby the three agencies will be able to access an OSF-maintained data base containing information about changes to algorithms and addition of new algorithms, but does not indicate agreement with our recommendation to have the OSF prepare an annual plan for modifying and adding algorithms. As a result of subsequent discussions, the JSPO has agreed to comply with this recommendation by requesting the OSF Applications Branch to prepare an annual plan which would identify Engineering Change Proposals related to algorithm modification or addition that have been approved by the OSF Configuration Control Board or the Program Management Committee as appropriate. The plan would also serve as input to the OSF's

annual release plan which will undergo tri-agency review. The OSF will provide details about the annual release plan in the revised Software Management Plan.

Recommendation #5

Direct the NEXRAD Computer Resources Working Group to review the OSF Configuration Management Plan, Software Quality Assurance Plan, and Software Development Procedures and provide feedback to the OSF. Direct the NWS Office of Systems Operations to perform, as part of the review effort, an in-depth assessment of these plans and provide feedback through the Computer Resources Working Group.

Recommendation #6

Direct the OSF to exercise its prospective plans and procedures on a representative set of software problems and enhancements prior to assuming responsibility for software support and to use the lessons learned from this software maintenance exercise to identify problems or deficiencies in the plans and procedures and make refinements.

Recommendation #7

Direct the JSPO to obtain from Paramax the source code for any undocumented test and support software tools developed on the NEXRAD contract for which the OSF identifies a need.

GLOSSARY

Algorithm. A set of well-defined rules for the solution of a problem in a finite number of steps.

Authenticated specification. A specification which the government has determined is correct. After a specification is authenticated, it becomes part of the system baseline, and changes must be accomplished through formal change control procedures. (See **baseline.**)

Baseline. As used in this report, software and associated technical documentation that defines the evolving or approved software product and serves as the basis for further development. An approved baseline can be changed only through formal change control procedures. (See **software configuration management.**)

Build. An operational version of a software system that incorporates a specified subset of the capabilities that the final product will provide.

C-5 specification. A document that describes the design of a software system and includes system architecture, control logic, data structures, input/output formats, interface descriptions, and algorithms. A C-5 specification is also referred to as a computer program product specification.

Commissioning. With respect to NEXRAD, commissioning is the orderly process to ascertain that a NEXRAD site can provide all its products and services using the WSR-88D system as its primary source of information.

Computer program configuration item. An aggregation of software that is designated by the government for software configuration management. (See **software configuration management.**)

Configuration control board. A committee responsible for the systematic evaluation and approval or disapproval of proposed changes to the approved functional or physical characteristics of hardware or software.

Control flow complexity. The degree to which the sequence of operations performed during execution of a computer program can be understood and verified.

Coupling. The manner and degree of interdependence between software modules.

Debugger. Tool for finding and correcting software errors.

Emergency release. A software system that is distributed to NEXRAD sites to correct serious errors that impair the operational mission of the system and for which there are no workarounds. (See **workaround.**)

Modularity. The degree to which a computer program is composed of discrete components such that a change to one component has minimal impact on other components.

Software configuration management. A discipline by which technical and administrative direction and surveillance are applied to (a) identify and document the characteristics of the software, (b) control changes to those characteristics, and (c) record and report on change processing and implementation status.

Software maintainability. The ease with which a software system can be modified to correct faults, improve performance, or adapt to a changed environment.

Software maintenance. The performance of those activities required to keep a software system operational and responsive after it is accepted and placed into production.

Variable localization. The practice of declaring variables or data structures and limiting their scope to those software modules that require access to them.

Workaround. A process that permits an identified problem to be avoided, or its effects nullified, by introducing new operational procedures or modifying existing ones.

ACRONYMS

FAA	Federal Aviation Administration
JSPO	Joint System Program Office
NEXRAD	Next Generation Weather Radar
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OSF	Operational Support Facility

ATTACHMENT

UNITED STATES DEPARTMENT OF COMMERCE
The Deputy Under Secretary for
Oceans and Atmosphere
Washington, D.C. 20230

JAN 5 1993

MEMORANDUM FOR: Frank DeGeorge
Inspector General

FROM: Ray Kammer

SUBJECT: OIG Draft Inspection Report on NEXRAD Software Maintenance (Report No. SED-4559-XXX)

We agree with the recommendations contained in the subject draft report. Attached are our specific comments in that regard.

Attachment.

Response to OIG Draft Inspection Report
NEXRAD Software Maintenance

Response to Observations and Conclusions:

I. NEXRAD software, documentation, training, and computer resources provide a satisfactory basis for maintenance.

We agree with the conclusions stated in this section. In general, the code follows the required standards, and most code will be maintainable without undue effort. The software documentation has improved markedly since the early versions and is adequate to allow the OSF software engineering staff to maintain the software.

The software maintenance training will provide for a formal training course and an informal forum that allows specific aspects of the software maintenance requirements to be addressed in the detail required by the individual maintainers. It will also provide opportunities for specific questions and problems to be addressed, after the OSF personnel gain post-training experience, by the on-site Paramax software specialist.

We are continuing to work with the OSF and Paramax to identify and acquire additional computer resources. The OSF test system and Software Development System (SDS) are currently in place and being used by the OSF staff. A SUN file server with multiple workstations is planned for delivery by Paramax in the near future. We are currently planning the work to be loaded onto the SUN and analyzing the SUN system capacity to handle this workload.

Paramax has generated several software maintenance tools that were not a result of specific NTR requirements. We are working with the OSF and Paramax to identify the need for these or additional tools that may be useful. Paramax has already delivered the source code for several of these tools. As part of the final delivery of software from Paramax, the JSPO will request Paramax to provide any additional tools, test sets, etc., that were generated under contract funds which have not been previously provided.

II. The OSF needs to conduct more thorough analysis to adequately estimate software maintenance staffing levels.

MITRE Corporation is currently working with the OSF to estimate the OSF's required software maintenance staffing levels. A study was initiated during November to gather information. Once the data is acquired, an appropriate staffing model will be identified, the data run through it, and an independent estimate

of required staffing levels determined. The current schedule calls for data gathering to be completed early in December 1992, preliminary data of required staffing estimates to be available by the end of the year, a JSPO/OSF/OSO analysis of the data in January 1993, and recommendation to the Program Management Committee (PMC) in February 1993. This information will be provided to the NEXRAD Program Council (NPC) for their consideration during their March/April 1993 meeting.

The estimate provided by the MITRE task will provide a raw number of personnel and will not address the mix of Government and contractor personnel. The OSF has recently hired two additional software engineers (bringing the number to nine) and has plans to hire two more in the near future. Titan Corporation currently has five software engineers assigned to OSF software maintenance support. The Government currently has two people supporting software configuration management (CM) and system generation (including map backgrounds) with one planned hire in the near future. There are two Titan personnel assigned to support these tasks. There are currently two Government Software Quality Assurance (SQA) engineers with one additional person starting in the middle of December 1992. Under the Interim Contractor Support (ICS) of the NEXRAD contract with Paramax, there are three software engineers supporting the OSF (both software engineering and CM) until February 1993.

The JSPO is currently in the process of modifying the NEXRAD contract to provide ten Paramax software engineers to the OSF for two years. The purpose of these engineers is to provide the OSF with training and support for specific tasks required to maintain the NEXRAD systems. The number of engineers was determined by the different areas in need of this support (e.g., signal processing, configuration management, map background generation). The time-frame was determined to allow the OSF to gain a reasonable amount of experience after the final Paramax delivery, i.e., Build 7.0.

Upon further refinement of OSF maintenance plans, the optimum number of support personnel may change. There is enough flexibility in the Titan support contract and the planned Paramax contract modification to allow the Government to react to any needed changes in staffing levels or durations.

III. <u>Additional efforts are needed to ensure that the OSF has a disciplined software maintenance process.</u>

We agree that a stable, disciplined software development process is paramount for the OSF to do their job of maintaining the NEXRAD system. As stated, the OSF is updating the Software Management Plan (SMP) and the Computer Resources Management Plan (CRMP). The NEXRAD Computer Resources Working Group (NCRWG) is

scheduled to meet in January 1993 to finalize the plans for NPC approval. These are high level plans, more policy than procedure. The OSF is also updating their Configuration Management Plan, Software Quality Assurance Plan, and Software Development Procedures. There is currently no requirement for these lower level plans to be reviewed by any outside organization. We agree that these plans should be reviewed by the Office of Systems Operations (OSO) because of both their management responsibility and their experience in the area of software maintenance. They should also receive appropriate review by the agencies. The NCRWG may be the appropriate group to review these plans, but it is not currently in that group's charter. The subject will be placed on the agenda for discussion during the January meeting. It will be suggested to the NCRWG that the SMP be updated to include provisions for both OSO and agency review of all appropriate OSF plans and procedures.

Several activities are occurring to test, review, and improve the OSF's software development process. As part of the Build 5.1h software release, the OSF will develop and run independent tests (engineering and operational) to determine that the corrections have been properly implemented and the build is acceptable for release to the field. They will build releases for two field sites, including applications software, operating systems, and map backgrounds, send those to the field along with releases for two other sites that were built by Paramax and delivered to the OSF, and run beta tests to ensure the stability of the release. The OSF is responsible for coordinating and accomplishing these tasks. Once the effort is completed, it will be assessed and can be used as a baseline for improving the process.

During November 1992, the Software Engineering Institute (SEI) presented an overview of the work they have done to identify software development process and implement continuing assessment and improvement programs. This information was well-received by the OSF staff and planning is taking place to implement a long term improvement plan at the OSF. SEI, OSF, MITRE, JSPO, and System Program Office personnel (SPO) will meet to develop a software development process improvement plan to be implemented at the OSF. This plan will cover process identification, process assessment, and continuing process improvement. The information gained from the Build 5.1h effort will be factored in, as well as the plans that the OSF has already developed. The plan is still in its early phases, but one aspect that has been talked about is having the OSF build a release implementing a subset of the Configuration Change Requests (CCR) that have already been identified by Paramax as a software maintenance exercise and following that up with a Software Process Assessment (SPA). The current schedule calls for a briefing to management (OSF, OSO, JSPO, agency focal points) to outline strategy (occurred 12/10/92) with the goal of presenting a more detailed plan in February 1993 to provide an estimate of resource requirements

(i.e., the time required of the software engineers to be dedicated to software development process improvement). The understanding and commitment by management, and the dedication of necessary resources by them, will allow the software development process to be an aid to the OSF in performing their job.

IV. <u>More visibility is needed into NEXRAD algorithm changes.</u>

We agree that more visibility is needed into NEXRAD algorithm changes, determining what and when changes are made. Along those lines, the OSF has agreed to make the detailed status of CCR's available to the agencies on a regular basis through access to the OSF database. Any proposed changes to algorithms will be documented by the Applications Branch of the OSF and submitted to configuration management for inclusion in the database and review by the OSF Configuration Control Board (CCB). In addition, it was agreed at the Program Management Committee (PMC) organizational meeting that any change to the system that has an estimated cost of greater than $200,000 (development and installation) or an estimated development effort of greater than 1000 hours will be presented to the PMC for approval. The Configuration Management Plan has been updated to change the $1 million threshold to the agreed to criteria.

V. <u>The contractor's obligations under the software warranty are unclear.</u>

The initial 5 year software warranty has expired; the one year warranty on the incremental software provided with each subsequent release is currently active on Build 5.1g. With the acceptance of Build 6.0, the Government will have one year of software warranty coverage for all differences in software since Build 5.1g, a significant portion of the system. Several known minor software deficiencies, itemized in the contract, are the responsibility of the OSF to correct. These errors will not be covered by the warranty.

Paramax did generate the fixes required by Build 5.1h under the software warranty (i.e., no charge to the Government), however, charges were still incurred by the Government because we required that the fixes be delivered sooner than the allowed 120 days. This acceleration was required in order to meet the initial commissioning schedule of the National Weather Service. If a serious error is detected in the fielded systems and determined to be covered by the software warranty, it is possible that the Government will determine that the corrections are required sooner than the 120 days, in which case the Government would be responsible for some costs.

After delivery of Build 6.0 to the Government, it is probable that the OSF will begin making corrections to the software in order to address the needs of the agencies in the most cost effective and timely manner. The Build 7.0 changes (system redundancy functionality) should be very separable from the remainder of the system, so it will be more cost effective for the OSF to take those changes and incorporate them into the OSF's baseline, rather than incorporate the varied OSF changes into the Paramax Build 7.0 baseline.

It is in the best interest of the Government to continue the software warranty. The cost has already been paid, and with the major portion of the warranty ended, the Government would probably not be due a very significant rebate. By maintaining the warranty, the expertise of original software developers, i.e., Paramax system and software engineers, would still be available to support the correction. This would provide a significant advantage in expediting a quality correction. The acceleration would cost the Government additional money, but the overall cost to implement the correction would be less than if the work was put completely on the OSF. The technical and schedule risks of making the correction would also be less.

Prior to the acceptance of Build 6.0, the JSPO will meet with Paramax to agree on procedures for identifying deficiencies that fall under the software warranty provisions of Build 6.0, develop a methodology that will allow the OSF and Paramax to work together to design and implement the corrections, and determine criteria for identifying all additional costs that the Government may be responsible for.

VI. Government plans to make software changes may impair the warranty and interfere with contractor efforts.

With the generation and delivery of Build 5.1h by Paramax, it is no longer anticipated that the OSF will make any changes to the NEXRAD software prior to the acceptance of Build 6.0. Because of this, it is no longer necessary to continue the effort to approve the "Emergency Release Interim Procedures." The NCRWG will ensure the SMP contains appropriate guidance for issuance of emergency releases by the OSF, taking into account the current plans for Build 6.0 and Build 7.0. The OSF Configuration Management Plan will contain the detailed Emergency Release Procedures. These will be reviewed by the agencies as part of the review of the OSF Configuration Management Plan, as specified by the SMP (see III, above).

The SMP is being updated to address the control of dual software baselines, including multiple fielded baselines, emergency releases, and development baselines, both Paramax and OSF. The

OSF Configuration Management Plan will be updated as necessary to contain the necessary detailed procedures.

Response to Recommendations:

Recommendation #1

We agree with this recommendation. See V, above.

Recommendation #2

We agree with this recommendation. See V and VI, above.

Recommendation #3

We agree with this recommendation. See II, above.

Recommendation #4

We agree with this recommendation. See IV, above.

Recommendation #5

We agree with this recommendation. See III, above.

Recommendation #6

We agree with this recommendation. See III, above.

Recommendation #7

We agree with this recommendation. See I, above.