MAINTENANCE AND SURVEILLANCE PROGRAM PLAN

U.S. NUCLEAR REGULATORY COMMISSION

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1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the Maintenance and Surveillance Program Plan (MPP) is to provide direction for the NRC's efforts to assure effective nuclear power plant maintenance and surveillance and to do so in a manner that is consistent with and responsive to the Commission's 1984 Policy and Planning Guidance (NUREG-0885, Issue 3).

The Program Plan describes the problems and issues to be addressed and proposes development of alternative NRC approaches to regulating nuclear utility maintenance activities consistent with the Policy and Planning Guidance. The scope of the Program Plan includes all aspects of maintenance required to carry out a systematic maintenance program. It includes, therefore, as well as conventional maintenance and repair, such things as surveillance and test activities, removal of equipment from service, postmaintenance testing, return to service of equipment following maintenance, maintenance management, administrative control, personnel selection and training, procedures, and technical documentation.

1.2 BACKGROUND

The NRC's current regulatory approach to nuclear power plant maintenance is embodied in requirements for (1) quality assurance (QA) during design, construction, and operation for structures, systems and components to an extent consistent with importance to safety (10 CFR 50, Appendix B), and (2) surveillance requirements to assure that the necessary availability and quality of systems and components is maintained (10 CFR 50.36). Despite these requirements, the NRC's rules and regulations presently provide no clear programmatic treatment of preventive maintenance.

The NRC does not stipulate maintenance requirements for systems and equipment which are not safety related despite the fact that many challenges to safety systems may originate from systems and components which are classified as not safety-related. The principal contribution of maintenance to safety system performance will be addressed as part of the overall approach to maintenance improvement.

Faulty maintenance practices are a principal contributing factor to operating abnormalities. Preliminary estimates indicate that aside from design deficiencies, more than 35% of the nuclear power plant abnormal occurrences reported to Congress since 1975 may be directly attributed to maintenance factors, with the trend towards a worsening maintenance situation as plants age.

Reviews of operating experience show a high frequency of degraded system performance due to both the lack of maintenance (especially preventive maintenance) and improperly performed maintenance, including human error during repair and surveillance testing.

A recent AEOD study concluded that 70% of events involving wrong unit or wrong train were attributable to human error during maintenance (including surveillance and testing). The types of maintenance errors described by Licensee Event Reports (LERs) and the Nuclear Plant Reliability Data System (NPRDS) include such human maintenance errors as: installing electrical connectors incorrectly; mounting equipment (e.g., check valves) backwards or out of alignment; using the wrong parts in equipment repair; removing from service and working on the wrong system or component; misaligning valves after maintenance; and failing to remove lockwire from critical switches after service.

An engineering evaluation of a stuck open isolation check valve on the residual heat removal system at an operating boiling water reactor (BWR) determined that human error during maintenance resulted in the safety problem. The maintenance error was not discovered during post-maintenance testing nor during routine surveillance of control room position indication for the component. The safety significance of the undetected error increased the probability of an interfacing LOCA for the plant. The probability of the LOCA was estimated to be 2×10^{-4} during this period of four months while the error was undetected as compared to a normal estimate of 10^{-7} per reactor year. This is considered to be a substantial reduction in safety margin caused by a maintenance error.

Over the last two to three years, the NRC has initiated several studies demonstrating problems in nuclear power plant maintenance activities. For the most part, studies have been conducted or sponsored by various NRC offices (e.g., Research; Analysis and Evaluation of Operational Data; Nuclear Reactor Regulation) with little or no coordination and no integrating programmatic framework for maintenance issues. To date, this has resulted in a fragmented effort that does not address all the relevant issues and may be duplicative in some respects.

This Maintenance and Surveillance Program Plan is intended to integrate and plan the staff's maintenance activities, and responds directly to 1984 Commission Policy and Planning Guidance (NUREG-0885, Issue 3) directing that the staff develop a plan that "proposes alternative NRC regulatory approaches with respect to maintenance activities" (PPG, Item II.3).

2.0 DESCRIPTION OF THE PROBLEM

2.1 NOMENCLATURE AND DEFINITIONS

The scope of the Program Plan includes the entire maintenance process. Maintenance as a process is defined herein as a function with the objective of preserving the reliability and safety of plant structures, systems and components or restoring that reliability when it is degraded.

For the purposes of this implementation plan, maintenance and surveillance includes (a) diagnostic or periodic testing, surveillance and inspection to determine the condition of structures, systems and components, (b) preventive or corrective actions such as repair, replacement, lubrication, adjustments, or overhaul; and (c) proper removal of equipment from service, restoration to service, and post maintenance testing to assure adequacy of corrective action. Maintenance is performed during all modes of plant operation by plant staff, vendors, or contractors.

It is not the intent of this Maintenance and Surveillance Program Plan to address the technical problem of how to maintain a particular component (e.g., a pump, valve, pipe or steam generator) but rather to consider the programmatic aspects of maintenance.

2.2 PROBLEM AND OBJECTIVES

The Maintenance safety problems[1] and the objectives being addressed by the plan consist of the following:

1. There is indication that needed maintenance is not being accomplished. The objective is to determine the effectiveness of current nuclear power plant maintenance programs, to detect the causes and effects of equipment performance degradation, and to identify corrective action to minimize equipment failures and unavailability.

2. Many failures result from improper maintenance. The objective is to reduce failures from improper maintenance by identifying the fundamental causes of human maintenance errors, by identifying practices which reduce the error rate and which increase the probability of error detection prior to system demand, and to assess the effectiveness of strategies for improved maintenance performance.

3. The interface between maintenance and operations is presently inadequate. The objective is to determine the causes of poor coordination among activities, to assure proper integration of maintenance, operations and other organizational interfaces for maintenance activities which can affect plant safety.

4. The number of maintenance-related challenges to safety systems is excessive. The objective is to determine the causes of the high rate of challenges and improve the effectiveness of nuclear power plant maintenance programs in assuring operability of safety systems.

5. Major portions of occupational radiation exposure (over 75%) and many radiological hazards occur to personnel performing maintenance activities (NUREG-0713). Improved planning and control of maintenance activities may significantly reduce occupational exposure to as much as half of the present exposure. The objective is to assure that by performing preventive and corrective maintenance in a planned and optimized manner, the unnecessary and unanticipated radiological exposure of maintenance personnel will be reduced.

Note: [1] These problems or combination of problems exist at some plants. Other plants appear to have effective, well run maintenance programs.

2.3 SCOPE OF NRC ACTIONS

Two issues will be addressed in deciding on an NRC approach to assure effective maintenance performance.

1. Whether the scope of NRC concern is only with maintenance of safety related structures, systems and components or whether other systems either classified as important to safety or as not safety related are also included.

2. Which of several alternative approaches to address maintenance problems in the U. S. nuclear power industry are to be considered in implementing this Plan. These alternatives are:

   - Develop and implement Policy Statements, regulations or Regulatory Guides,
   - Plant-specific review of utility proposed maintenance programs,
   - Industry self-monitoring through INPO, or other activities (e.g., development of national standards),
   - Continue present programs,
   - Some combination of alternatives.

2.4 TECHNICAL ISSUES

Resolution of several technical issues will be accomplished by a program to provide data and methods for evaluating industry maintenance. These technical issues are:

1. Human Error in the Performance of Maintenance

   Operators and maintenance personnel (in about equal proportion) account for about 2/3 of all human error incidents resulting in LERs. Many maintenance errors have had serious safety consequences. Most of these errors result from poor human factors design of plant equipment, inadequate procedures, and/or insufficient personnel qualifications and training. Although Probabilistic Risk Assessment (PRA) studies have treated human error, it is difficult to quantify the impact of human error in maintenance on risk, and to assess the effect of proposed changes to reduce the incidence of human error in the performance of maintenance. Consequently, there are no currently acceptable criteria for determining the optimum methods for reducing human errors occurring during maintenance activities.

2. Indicators of Maintenance Effectiveness

   Measures of maintenance effectiveness may include indices of the effects of aging, the frequency of reactor scrams or safety system challenges, equipment performance data, SALP ratings, plant housekeeping, reportable human errors in maintenance, and work force man-rem exposure. However, the NRC has not, as yet, identified valid and reliable measures of maintenance effectiveness. It is believed that multiple measures may provide an accurate picture of plant maintenance effectiveness since factors such as management and organization, personnel selection and training, and procedures all affect maintenance performance. There is a need to develop methods of measuring maintenance effectiveness of individual utilities (needed to identify plants with poor maintenance histories) and to compare maintenance performance across the nuclear utility industry as a whole (needed for feedback on effectiveness of regulatory initiatives). Even if NRC elects to rely heavily on INPO programs to upgrade maintenance performance in the industry, a measurement methodology to determine maintenance program improvement or lack of improvement is needed. In addition, means of determining acceptable levels of human error reduction for maintenance activities are needed.

3. The Role of Preventive Maintenance in Counteracting Aging and Service Wear Effects

The degradation of operational characteristics and reliability of plant systems with age and service wear needs to be documented and expressed in quantitative terms. The appropriate resolution of the aging issue depends on answers to some basic questions: (a) what aging effects are likely to impair plant safety; (b) what methods of testing, surveillance and inspection will be effective in detecting system degradation due to aging prior to the loss of the safety function; and (c) what is the appropriate mechanism for implementing remedial actions identified from testing, surveillance, and inspection? It is likely that a partial resolution of the aging issue will determine the appropriate role of a preventive and corrective maintenance program in detecting and correcting aging and service wear effects.

Significant technical questions must be resolved to ensure the effectiveness of a preventive maintenance program in enhancing safety. These questions include: (a) what are the components to be maintained, (b) what type of maintenance is to be performed (e.g., replace components, overhaul, etc.), and (c) what is the appropriate schedule for each maintenance action?

4. Management and Organization Impacts On Maintenance Effectiveness

Management practice and organizational structure have an important bearing on organization performance. Proper management of maintenance has been cited as an essential element of an effective maintenance program (NUREG-1000). The NRC currently does not pursue extensive analysis of corrective action for "management" related maintenance problems. There also appears to be insufficient means to document and disseminate lessons learned and to compare maintenance performance in the industry.

5. Maintenance Program Criteria and Standards

Many effective maintenance programs have been identified from practices in other industries such as the FAA and the military. Also, the nuclear industry has begun to document some effective maintenance practices, e.g., EPRI's maintainability guidelines. There is a need to identify acceptable maintenance program standards and criteria for application to plants with poor maintenance histories and for guiding routine NRC inspection.

The national standards organizations, such as ASME, ANS, or ANSI, presently do not have comprehensive standards on maintenance for industry use. Industry self-regulation through such standards could create a common reference for maintenance program development. With such standards, NRC regulatory development activities could focus on approaches such as review guidance, revised inspection modules, or statements of good practices as general guidance documents.

6. The Maintenance and Operations Interface

Safety related systems are sometimes taken out of service or bypassed during surveillance testing and maintenance. Errors in surveillance testing and maintenance have resulted in the wrong equipment being taken out of service or in continued unavailability of equipment following maintenance or testing due to a failure to properly return equipment to service.

The proper integration of maintenance and operations is needed to verify correct performance of activities and reduce human errors. The provision of accurate information for monitoring the status and availability of systems and equipment may reduce operational as well as maintenance errors.

3.0 PLAN FOR PROBLEM RESOLUTION

3.1 MAINTENANCE AND SURVEILLANCE PROGRAM STRATEGY

Resolution of the technical and regulatory issues will be accomplished by a number of projects conducted in phases. In many instances, fundamental work needs to be completed which addresses portions of several issues. For example, a reliable measure of maintenance performance effectiveness is required for the resolution of issues related to management and organization impacts, maintenance criteria and standards, and the maintenance and operations interface.

The relationship of major program elements and functions is shown in Figure 3.1.

The Maintenance and Surveillance Program will be conducted in phases to provide for EDO interim evaluation of results and recommendations prior to initiation of additional activities. The phased approach will also provide the industry an opportunity to take an active role in identifying and proposing solutions to maintenance problems.

The program consists of five phases, as shown in Figure 3.2.

- Phase I Survey and Evaluation of Maintenance Effectiveness
- Phase II Identification of Maintenance Problems and Impact on Safety
- Phase III Identification and Analysis of Alternative Corrective Actions
- Phase IV Develop an Implementation Plan
- Phase V Implementation and Follow-up

The objectives and expected products to aid the EDO evaluation at each phase of the program are as follows:

Phase I: Survey and Evaluation of Maintenance Effectiveness

Objective: to survey current maintenance practices in the nuclear industry and to evaluate their effectiveness.

FIGURE 3.1 TECHNICAL AND REGULATORY PROGRAM STRATEGY

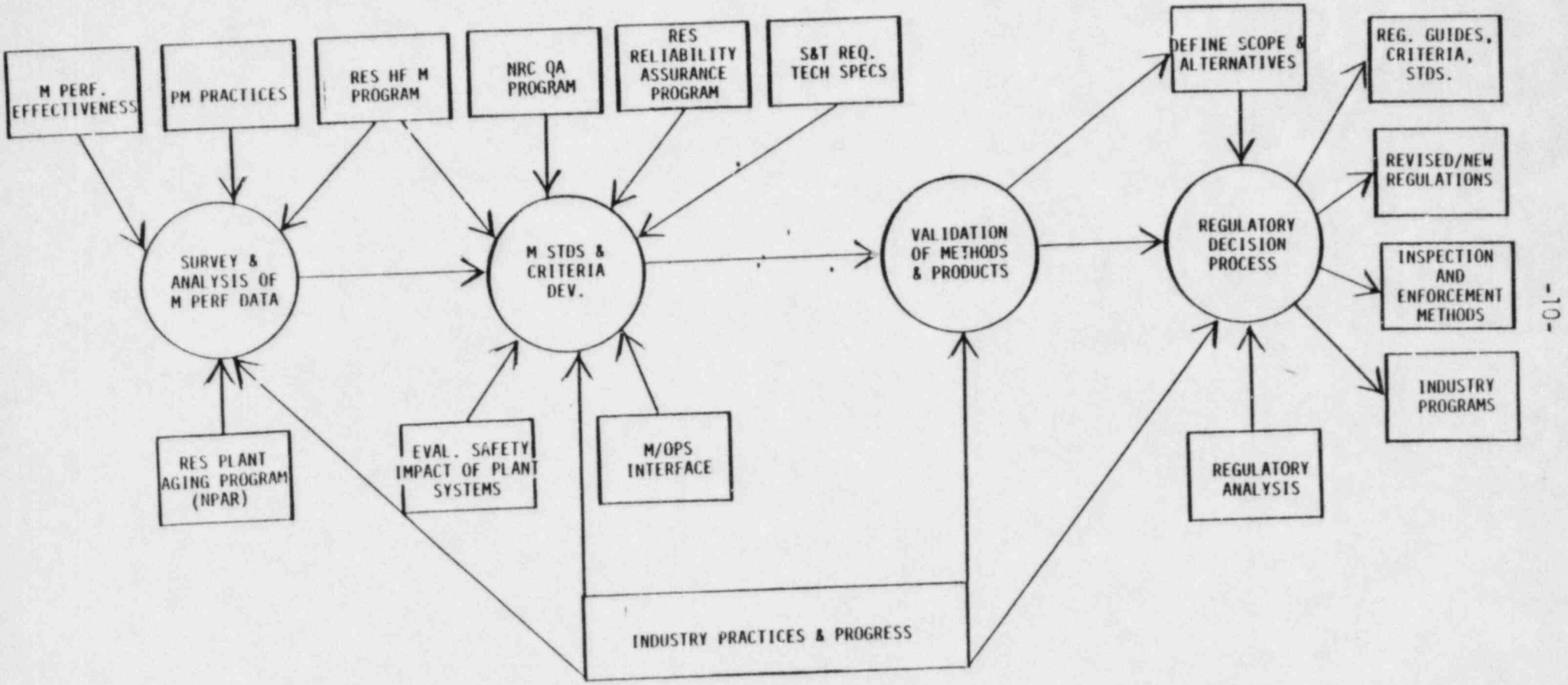
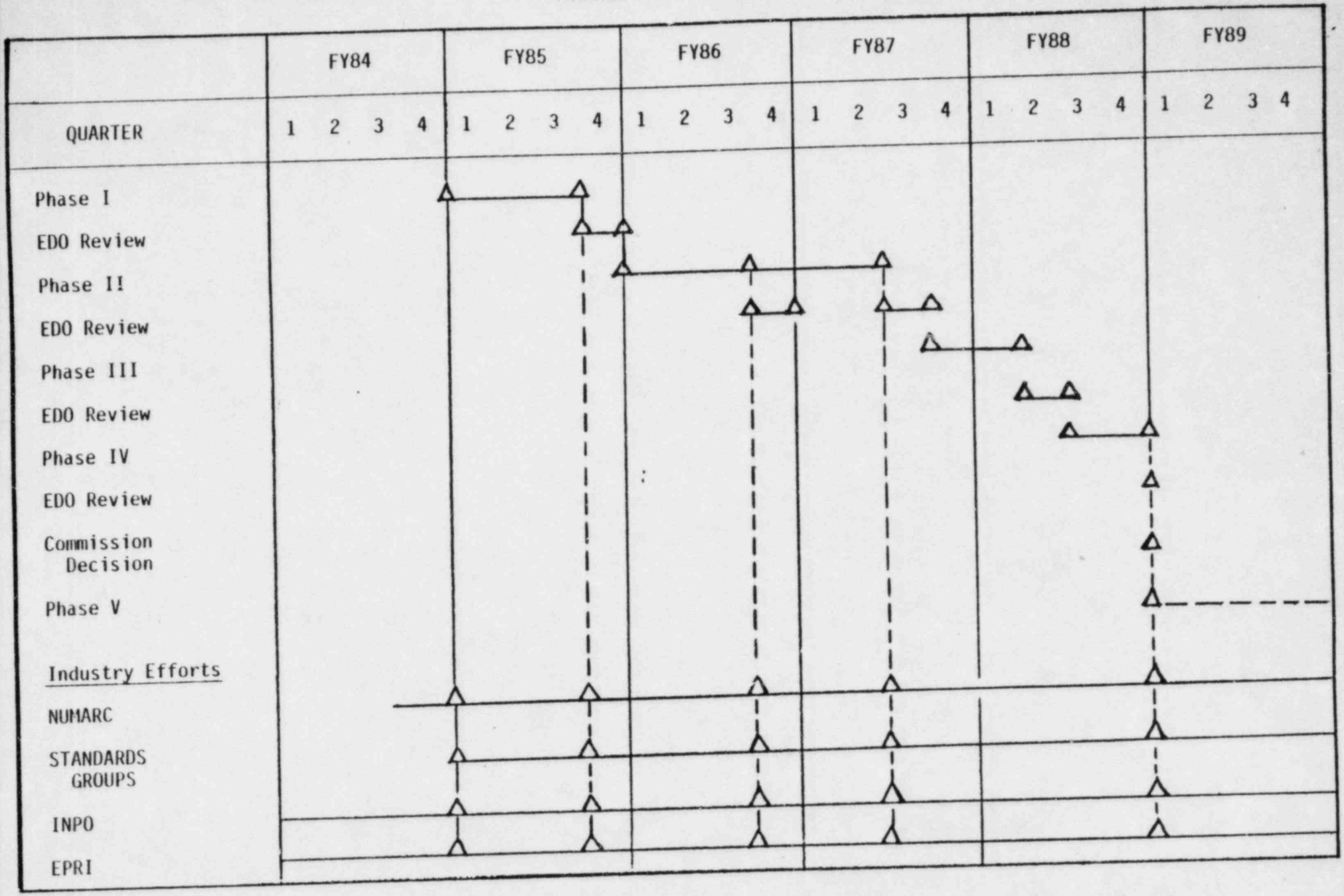


FIGURE 3.2 PROGRAM PHASES



Note: Human Factors Projects to be accomplished in each phase are shown in Figure 3.3.

Expected products:

- Description of current industry practices in maintenance and surveillance
- Preliminary objective indicators of maintenance performance effectiveness
- Methods for NRC use in assessment of plant maintenance effectiveness
- Staff assessment of industry progress in self-improvement
- Industry standards committees initiate maintenance standards development activities

Phase II: Identification of Maintenance Problems and Impact on Safety

Objective: to identify distinct maintenance problem areas and determine their impact on plant safety

Expected products:

- Definition of the scope of NRC concern and prioritization of individual maintenance problems
- Technical information to determine the contribution to risk and necessary corrective actions
- Validated indicators of maintenance effectiveness related to plant safety
- Assessment techniques for NRC use in determining plant maintenance effectiveness
- Recommendations for endorsement of good maintenance practices
- Draft industry standards for maintenance

Phase III: Identification and Analysis of Alternative Corrective Actions

Objective: to identify and analyze the alternative regulatory strategies to ensure maintenance effectiveness and achieve safety and health benefits

Expected products:

- Identification of appropriate regulatory strategies
- Regulatory analysis of alternatives, including value/impact assessment
- Recommendations for appropriate NRC action
- Industry standards for maintenance

Phase IV: Develop an Implementation Plan

Objective: to develop an implementation plan for appropriate NRC and industry action

Expected products:

- Modified existing or appropriate new industry and/or NRC guidance or regulations concerning maintenance
- Description of the recommended method of implementation of corrective action for maintenance problems
- Regulatory decision
- Nationally endorsed industry maintenance standards

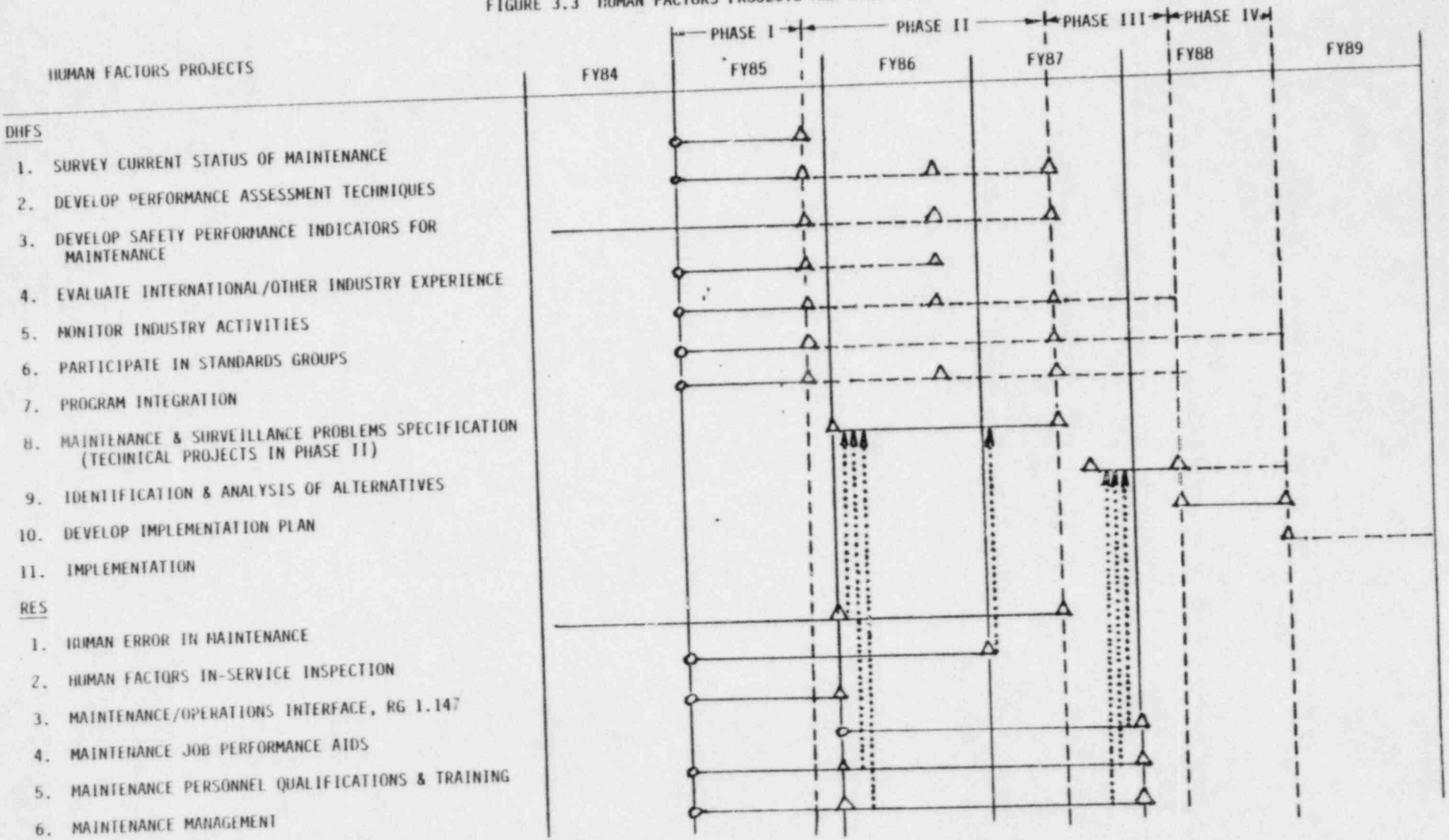
Phase V: Implementation

Objective: to implement appropriate NRC action for maintenance and to follow up and assess the safety impact of corrective action in industry.

While a phased approach to the Program is envisioned, it is anticipated that activities will span more than one phase of the Program as preliminary results and methods are refined and validated. Use and review of interim results from planned multi-year activities will allow for the assessment of progress toward major milestones.

Coordination with other NRC offices will be necessary to utilize results of planned and ongoing activities related to maintenance, surveillance, and the impact on safety. Related human factors projects are shown in Figure 3.3, emphasizing milestones and their anticipated integration into the maintenance and surveillance program. Vertical arrows on Figure 3.3 show where research results will be utilized. Interim products of planned activities will provide data to evaluate the safety impact of maintenance problems and improvement strategies during Phase II.

FIGURE 3.3 HUMAN FACTORS PROJECTS AND MILESTONES



Note: Vertical arrows indicate where research products or results will be utilized.

Related ongoing and planned projects have been identified which may provide technical data and other products useful to Phase II of the maintenance and surveillance program. A listing of related projects in NRC offices and industry organizations is given in Table 3.1.

Although sufficient detail is known to initiate Phase I, detailed milestones and interfaces have not been identified for all related NRC and industry programs. Specific project details are being coordinated with other offices and may result in the need for changes or modifications to project schedules to provide interim products as appropriate.

Major programmatic responsibilities for NRR include projects to measure maintenance performance, assessment of industry developments and scoping NRC activities, with DHFS having lead responsibility. These projects are related to DHFS activities concerning maintenance indicators, assessment methods, personnel qualifications, and foreign experience in maintenance.

Coordination with IE is necessary for projects related to the evaluation of importance to safety issues and QA program impact on maintenance standards and criteria development. Participation of Regional staff with NRR staff to evaluate licensee maintenance performance and monitor industry programs is envisioned.

Coordination with RES will provide support for program elements to investigate the maintenance/operations interface, to determine maintenance pesonnel qualifications from a review of surveillance and Technical Specification requirements. DRAO will coordinate ongoing and planned activities to support these program elements. The Nuclear Plant Aging Research of RES/DET will provide information related to the role of maintenance in counteracting the effects of plant aging and make recommendations as appropriate for criteria and standards development.

AEOD will support IE and NRR review of licensee operating experience related to maintenance. LER data will be an important source for measurement of maintenance performance effectiveness.

TABLE 3.1 RELATED PROGRAMS [1]

	Responsible Organization
NRC	
Quality Assurance Program, R.G. 1.33	IE/DQASIP
Systems Important to Safety	IE/DQASIP
Safety Implications of Control Systems (USI A-47)	DST/GIB
Comprehensive Reevaluation of Standard Technical Specifications	RES/DRAO
Surveillance and Test Requirements (ECCS Outage Criteria)	RES/DRAO
Nuclear Plant Aging Research	RES/DET
Effectiveness of Industry ALARA Programs	NRR/DSI
Equipment Qualification - R.G. 1.89	NRR/DE
Reliability Research	RES/DRAO
Improving Quality	IE/DQASIP
Training Rule - Section 306 Waste Act	NRR/DHFS
Industry	
Maintenance Activities Coordination	NUMARC
Standards	ANS, ASME, IEEE
Plant Evaluations	INPO
NPRDS, SEE-IN	INPO
Maintenance Superintendent's Workshops	INPO
Good Practices	INPO
Accreditation of Training	INPO
Maintainability Guidelines	EPRI
Technical Specifications	EPRI
Reliability Centered Maintenance	EPRI

[1] Not identified in Figure 3.3

3.2 INTERACTIONS W ΓH OUTSIDE ORGANIZATIONS

Interactions with outside organizations will be conducted in order to assess the acceptability of industry initiatives and activities to achieve the objectives of the maintenance program. A number of outside organizations have expressed interest in nuclear power plant maintenance and are concerned in various aspects of maintenance operations. The Program Plan is designed to assess the significance of the contribution of these organizations and to utilize their activities to complement the NRC efforts. The primary coordination point is currently with NUMARC. Through NUMARC and direct NRC contacts, the following organizations are expected to play major roles in a national program for improving maintenance in the nuclear industry.

1. Standards Organizations

The ASME Committee on Operations and Maintenance and the ANS Operations Committee have been conducting a dialogue within the last few years on the need for a national standard on maintenance for nuclear power plants. A working relationship will be conducted with these organizations by NRC representatives on the committees and by periodic presentations on NRC activities to the committee meetings. If a national standard on maintenance becomes available within a reasonable period of time, it will be considered for inclusion in the regulatory alternatives.

2. Institute of Nuclear Power Operations

The Institute of Nuclear Power Operations (INPO) is involved in a number of activities that are closely related to the subject of the Maintenance Program Plan. The following INPO programs are considered: (a) INPO's periodic plant evaluations address issues in maintenance. The Program Plan will assess the effectiveness of the plant evaluations and will consider it as one of the regulatory alternatives concerning industry self-monitoring; (b) INPO has developed qualification guidelines for mechanics, electricians and instrumentation/control technicians. The implementation of these guidelines will be followed; (c) INPO has conducted a number of workshops for maintenance superintendents. NRC participation and observation of the workshops will be continued; (d) INPO is in the process of documenting and disseminating information on good industry practices. INPO good practice activities on maintenance will be followed within the Implementation Plan; (e) INPO's Accreditation Program for Training includes maintenance personnel. Training accreditation is being evaluated by NRR; the results will be monitored as part of the planned maintenance activities.

3. Department of Energy

The Department of Energy (DOE) has developed a method to assess the performance of maintenance for nuclear reactors within the Management Oversight and Risk Tree (MORT) program. The method has been used for DOE reactors, and is in the process of being validated with a number of Scandinavian nuclear power plants. The applicability of the DOE assessment method for NRC use will be evaluated within this program.

4. Electric Power Research Institute

The Electric Power Research Institute (EPRI) has been conducting a large number of research studies related to maintenance. Some of the EPRI programs, such as the development of a preventive maintenance guide (EPRI Report NP-3416) or the maintainability guidelines (EPRI Report NP-2360) are directly related to some elements of the Program Plan. The results of the EPRI research studies will be utilized in the program and NRC personnel will participate in and contribute to EPRI maintenance workshops.

5. American Nuclear Insurers, Inc.

The American Nuclear Insurers, Inc. (ANI) considers plant maintenance as one factor for developing an overall plant assessment. The ANI method and past experience will be reviewed and utilized within the program in the development of performance measurement techniques.

6. Vendor Maintenance Programs

The maintenance guidelines, maintenance program recommendations, and maintenance services available from the vendors of nuclear power plants will be evaluated and utilized in the program.

7. Maintenance Activities Outside the Nuclear Industry

The U. S. military, the NASA and the Federal Aviation Administration (FAA) have well-established and successful maintenance programs. The technical, organizational and regulatory aspects of these maintenance activities will be included in the program by direct exchange of information, documentation, and data between the above organizations and the NRC staff.

8. Foreign Countries Maintenance Programs

The staff plans to continue its exchange of maintenance program information with the Japanese and to initiate information exchange with the French, German, Swedish and Canadian Governments.

4.0 RESOURCES

Major program resource requirements for human factors projects only are shown in Table 4.1 for NRR and RES. For FY 1985, NRR's budget includes projects to survey maintenance performance, develop assessment techniques, develop objective maintenance indicators related to safety, and to evaluate other industry and international nuclear experience in maintenance. NRR/DHFS will also provide resources necessary to integrate the results of projects and programs in other offices with the activities of the Maintenance and Surveillance Program.

RES resources will be used for projects related to the qualifications of maintenance personnel, management of maintenance, human error in maintenance, job performance aids, and in-service inspection.

Resources for other related ongoing projects (e.g., IE's QA initiatives) have been budgeted separately. Incremental resources needed to assure program coordination are anticipated to be small and will likely be accomplished through minor program reduction by the responsible organizations. Additional resources, if necessary, will be identified during development of the detailed Division Level Plan.

TABLE 4.1 SUMMARY RESOURCE REQUIREMENTS

	FY 1985		FY 1986		FY 1987	
	PSY	$K	PSY	$K	PSY	$K
NRR/DHFS	4.4	950	6.2	1025	6.0	1075
RES/DRAO		750		950		950