

DEPARTMENT OF DEFENSE PRECISE TIME AND TIME
INTERVAL PROGRAM IMPROVEMENT PLAN

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ABSTRACT

Department of Defense Directive 5160.51 assigns the United States Naval Observatory the responsibility for ensuring uniformity in precise time and time interval operations including measurements, the establishment of overall DOD requirements for time and time interval, and the accomplishment of objectives requiring precise time and time interval with minimum cost.

In support of the execution of these responsibilities, the United States Naval Observatory has embarked upon an effort to document the Department of Defense Precise Time and Time Interval's requirements and develop a master plan for overall PTTI program improvements.

This paper presents an overview of the objective, the approach to the problem, the schedule, and a status report, including significant findings relative to organizational relationships, current directives, principal PTTI users, and future requirements as currently identified by the users.

INTRODUCTION

The United States Naval Observatory is assigned the responsibility for precise time and time interval dissemination throughout the Department of Defense (DOD) components. Specifically, it is Department of Defense Directive 5160.51 titled, "Precise Time and Time Interval (PTTI) Standards and Calibration Facilities for Use by Department of Defense Components", that assigns the Naval Observatory the responsibility for insuring: (1) uniformity in precise time and time interval operations including measurements, (2) the establishment of overall DOD requirements for time and time interval, and (3) the accomplishment of objectives requiring precise time and time interval with minimum cost. The first of these responsibilities entails the technical aspects of timekeeping and time dissemination. Despite the rapidly changing systems which seek to exploit the leading edge of

technology, the Naval Observatory staff continues to keep pace in meeting this responsibility. In addition to expanded and improved means of dissemination of time and easier access to time services for the user, the basic equipments and methods of determining precise time are being upgraded. The requirement to upgrade time dissemination systems becomes self-evident through a simple comparison. DOD directive 5160.51 dated August 31, 1971, defines precise time as,---- "a time requirement to within ten milliseconds." Compare this with current user needs of time to within nanoseconds. Not only are operational requirements for time becoming more stringent with respect to accuracy, the number and variety of uses is expanding rapidly. There is a tendency for a new user, faced with a need for precise time, to approach the solution to the problem on a unilateral basis. The pitfalls to such an approach can be counter productive to achieving a fully coordinated PTTI program. Based upon the information available to the manager, a system is designed and an array of equipments is assembled that will meet the requirements. The combination of clocks, frequency dividers, time conversion modems, etc., may be totally unique to that program. This tends to result in a wide variety of non-standard systems which exacerbates the maintenance support problem and training problem. If the manager is one of foresight, he may even anticipate future requirements and design a system whose capabilities far exceed his current specifications for stability, accuracy, or other criteria. Conceivably, the full capability of the system for which the manager paid dearly, may never be fully exploited or required. The synergistic consequences of these factors is an overall PTTI program that is less than cost effective.

In recognition of the dynamic nature of the PTTI program and the influence of the aforementioned factors, the Naval Observatory has initiated an effort to ameliorate the impact of the current processes.

OBJECTIVE

The objective is to achieve improved management of the Department of Defense Precise Time and Time Interval Program in order to provide full coordination of PTTI programs and ensure economies of resources.

Although the Observatory has the lead in the endeavor within the provisions of DOD Directive 5160.51, the support of separate DOD components is engendered through the specific functional responsibilities assigned to those components in the same directive. Under paragraph VI.C., various functional responsibilities are delineated for DOD components and contractors. Of the five subparagraphs spelling out the functions, the first four deal principally with the technical aspects of timekeeping, that is; reference to the USNO master clock, use of portable clocks, etc. Paragraph VI.C.5 and paragraph VI.C.6 cover the management and planning aspects of PTTI. The separate DOD components

are directed to:

"5. Notify the U. S. Naval Observatory of:

- a. Existing and planned PTTI requirements, including information as to accuracy and stability of needs, measurement techniques planned or in operation and continuity of service required of the applicable distribution transmission.
 - b. PTTI (frequency) arrangements between DOD user components and contractors and other Federal Government agencies.
 - c. Scheduled scientific and technical meetings on PTTI (frequency).
6. Consult the Observatory prior to entering into contracts for equipment, research, studies, or services involving PTTI (frequency) in order that maximum use of existing facilities may be assured."

The degree of detail encompassed in the notification of the observatory is subject to a wide variety of interpretation. Consequently, the perception of PTTI requirements is equally subjected to a wide range of interpretation. Needless to say, a full comprehensive knowledge of the DOD requirements is essential to determining the necessary management actions to improve the overall program. The observatory's initiative can be viewed as a two-pronged approach; each inexorably entwined with the other. In support of the objective, the observatory will conduct a DOD PTTI requirements analysis and concurrently develop a DOD PTTI Improvement Plan.

APPROACH

A three-phased approach is being used for the requirements analysis portion of the task. The three phases are an identification phase, a collection phase and an analysis phase.

Identification Phase

As implied by the title, the purpose of this phase is to identify the users of precise time and time interval. The elements of information being sought to fit the definition of "identification" are somewhat more detailed than simply a name or organization. This effort will endeavor to identify the user by organization, location, points of contact by name and phone number and establish the organizational relationship of the unit with respect to higher and lower echelons of

the appropriate organizational structure. These data will serve to clarify the lines of operational control, administrative processes and logistical support. It will also provide a directory of personnel participating directly in the PTTI program and enhance the flow of information among the participants.

Collection Phase

Having identified the users of PTTI, the next step is to document essential information with respect to their participation in the program. A determination will be made as to the functional use of PTTI (e.g., navigation, communication, calibration, timing/synchronization, etc.), the essential equipment currently on hand and in use; the means whereby these equipments are timed/synchronized (traceable to USNO); and the criteria which define the users requirement in terms such as accuracy, stability, environmental specifications, or other key characteristics. Of equal interest in documenting the equipment is the maintenance policy of each organization. Information will be gained regarding the level of maintenance performed at the site (operational, intermediate or depot), and whether or not it is performed by organizational personnel or under contract support arrangements.

The full scope of information to be collected is not a fixed set at this time. Even early in the collection process, it was found that additional data elements proved most useful in revealing an overall picture of the PTTI program. As an example, the directives issued at various echelons were researched to determine the charter under which various organizations were operating. In some cases, the directives issued within the chain of command, may be useful in revealing the funding lines. Funding information will be essential if recommendations are to be developed regarding cost effective alternatives. Equally as important as documenting the current state-of-the-art is planning for future requirements. Current users will be surveyed to determine their perception of future needs or any problems they may anticipate in meeting their perceived operational requirements in the future. Developmental programs will be reviewed to determine if there may be PTTI requirements which have not yet been explicitly defined. This data on future requirements will provide a baseline for specific areas to be investigated in order to keep pace with refined requirements and broader PTTI applications.

The data collection process will consist of researching documents, interviewing personnel, either by telephone or in person, the circulation of a survey questionnaire, and on-site visits as required.

Analysis Phase

Based upon the information provided by the previous efforts, the

analysis phase will seek to delineate systems methods, systems accuracies, performance requirements, numbers of clocks, maintenance support roles, and inter/intrasystem utilization. Pertinent data elements will be reduced to graphs, charts and/or matrices to present concise, comprehensive summaries from which cogent alternative actions may be derived in support of the improvement plan.

Although it may appear that these three phases are conducted sequentially, in a series fashion, such is not the case. The process is an iterative one in which data derived in one phase may lead back to further investigations in the previous phase which may in turn lead to additional areas of investigation, data collection and analysis.

PTTI Improvement Plan

The customary approach to the development of a plan is being followed for the improvement plan. This entails the development of an outline, the development of a book plan, and finally, the development and publication of the PTTI Improvement Plan. The Book Plan development was scheduled in the early phases of the task in order to provide direction to the data collection and analysis phases. As stated earlier, the improvement plan development will be a concurrent effort which will interact on a real time basis with all three phases of the requirements analysis portion. Proposed management initiative and related recommendations will be firmly supported by clearly defined requirements.

An Executive Summary will be provided as a lead into the Improvement Plan in order to provide a concise overview of the program and recommendations. The succeeding four chapters will describe the characteristics of the PTTI program as it now exists. This will take the form of an introduction/background section; a description of the services available through the U.S. Naval Observatory; a section on users and their related requirements and a section on how those requirements are currently being met and planned improvements matched to potential needs. The next chapter will highlight the critical issues. In essence, this portion will address the shortfalls and problem areas, including cost factors, to the extent that they can be isolated and documented.

The remaining two chapters will provide alternative management actions which, if executed, should result in significant improvements in the PTTI program. Recommendations will be made as to the preferred alternative. The preferred alternative will be expanded in more specific detail with respect to responsibilities, schedule of actions, and any modifications to governing directives required to implement that alternative.

Details of the supporting rationale contained in the plan will be provided in appendices to the plan. Three levels of detail will be provided: the Executive Summary will provide an overview for decision making; the body of the plan will contain the rationale for the alternatives and recommendations. The backup data will be contained in the appendices.

SCHEDULE

Work on the project was initiated on 18 January 1980. The target date for the completed Requirements Analysis Report and the PTTI Improvement Plan is 27 December 1981. The only major interim milestone is the development of the Book Plan in June 1980. Due to the concurrent and iterative nature of the identification phase, collection phase, analysis phase and plan development, clearly delineated start-stop dates for these activities were not deemed appropriate. However, selected interim goals to be achieved have been identified in the interest of sound program management and are displayed in Figure 1.

STATUS

The identification phase commenced immediately upon initiation of the task. A two-pronged approach was used; a top-down approach and bottom-up approach. The top-down approach began at the policy level in Washington and sought to identify the individuals involved, their job title, code, location, phone numbers and the field agencies or subordinate commands under their purview. The bottom-up approach used the U.S. Naval Observatory distribution list printout for their time services bulletin. The list includes 986 domestic users and 258 foreign users. The listing was separated into categories by Service (USAF, Army, Navy, etc.) or agency. In some cases, the functional area of PTTI in which the user has primary interest may be discerned from the type of time service publications received. Such is not always the case, for there are multiple uses, as well as multiple users of the documents. Here the top-down approach seeks to clarify the functional area of interest by tracking the organizational relationship through the chain of command and the supporting directive system. DOD Directive 5160.51 required each DOD component to issue implementing directives. These, in turn, assigned responsibilities and functional areas to various commands and field activities. The directives have been researched and collected for OSD, JCS, DCA, USAF, USA and USN. To date, a preliminary directory of points of contact in the PTTI arena has been compiled, consisting of approximately sixty persons. In its current format, it lists the personnel by Service or agency, with code, address, phone numbers and any charter or directive associated with their function. Approximately thirty-five of the persons listed have been contacted in search of data. Preliminary initiatives have been made with the Federal

Aviation Administration, Defense Mapping Agency, and certain independent commercial users.

In order to accelerate the data collection process, a survey questionnaire was designed. Using the information gained in the early portion of the identification phase, a distribution list of key recipients was developed. A cover letter signed by the Superintendent of the Observatory, explaining the purpose of the effort and forwarding the questionnaire, was distributed on 7 May 1980. Responses were requested by 4 June 1980. Twenty-five completed questionnaires have been returned. A comparative analysis is now in process comparing data received from interviews and the survey questionnaires with the data required to complete the requirements analysis and fill out the element of the Book Plan. Voids in essential elements of information will be identified. Efforts to fill these voids will begin with local interviews and phone calls and finally, on-site interviews at field activities will be conducted to complete the process. In every case requiring a field visit, a point of contact will be advised in advance either by phone or by letter as to the type of information being sought.

An outline of the Improvement Plan was developed and approved on 23 April 1980. The outline was subsequently expanded into a Book Plan which was approved on 30 June 1980. The Book Plan, which defines the elements of data scheduled for incorporation into the Improvement Plan is now serving as the benchmark in guiding the collection and analysis phases.

A clearer picture of the organizational relationships has begun to evolve. Preliminary diagrams have been drafted in tiered echelons from the policy level down to field activity and users.

Although some minor difficulties have been encountered in translating stated requirements into common terms of reference for easier comparison, and ensuring that all users are identified, the program is currently on schedule with no insurmountable obstacles in view. Although not deemed insurmountable, two areas of investigation which prove more intractable than one would care to have them are those driven by security restrictions and availability of funding details. Every effort is being made to maintain the reports as unclassified in order to enhance their circulation and utility. If need be, a classified appendix may be published to provide supporting data essential to the decision making process.

PRELIMINARY FINDINGS

In the interest of brevity selected highlights of the preliminary findings are presented below in the areas of organizational

relationships, current directives, PTTI users, and future requirements.

Organizational Relationships

There are two distinct lines of staff cognizance in PTTI, the logistics side and the operational side. In most cases, the responsibilities for PTTI shift to the logistics staff at the policy level. The bulk of the documentation is written in terms of metrology and calibration responsibilities for technical laboratories or similar support units in the field. In general, these lines of responsibility through the logistic side are easily traceable. The logisticians are tasked with specific responsibilities to maintain set standards, and provide support to operational users. The operational side of the problem does not lend itself to easy traceability. It has been difficult to pinpoint the central controlling agency for operational requirements within the various organizational structures. It appears at first blush that a variety of research agencies, usually resident at the same location with a metrology/calibration facility will develop operational requirements and resolve their needs in coordination with the resident experts. As currently documented the technical or logistics side of the chain is very responsive to the users' needs and the interchange of services and information is free-flowing and continuous. However, as additional support services are required from a higher support echelon (such as the Naval Observatory), the requirement flows up through the technical chain on the logistics side of the staff. Again, the system works by virtue of the nature of the participants. However, this system places the Observatory in a reactive mode--responding to needs from the field on an "as required" basis. Ideally, the operational requirements should be centrally coordinated for each agency. The central coordinator would express these requirements to the U.S. Naval Observatory personnel who, in execution of their charter as DOD PTTI Manager, would assist in defining the system to meet the requirements. Then through the logistics side of the staff, the USNO would insure that the necessary dissemination system and proper support equipments were available to execute the PTTI support. This process would place the USNO in the requirements determination loop and insure a more cost effective, coordinated program.

PTTI requirements which transcend the bounds of single Service of single agency applications are generally addressed by committees. In some cases, the committees are formed to address specific issues and representation is established to insure that all interested parties participate. There are two standing committees which provide a forum for addressing joint requirements. The MUSIC MAN COMMITTEE and the JOINT TECHNICAL COORDINATING GROUP for METROLOGY and CALIBRATION (JTCC-METCAL). Based upon the representation on these committees, it appears that the MUSIC MAN COMMITTEE is best suited for addressing

the operational aspects of the problem and the JTCG-METCAL is technically oriented.

There are exceptions to the general description of the interaction of operational agencies and logistic agencies as previously described. Two notable exceptions are the GPS/NAVSTAR program and the SATCOM/DCA program. These two programs have been the beneficiaries of long arduous planning and inter-agency activity. However, in spite of such coordination at the top level, the results of the survey questionnaire reveal that some participants in the PTTI program are somewhat tentative as to the precise impact the program may have on their "modus operandi".

Current Directives

Two items of interest were revealed in tracing through the directives which govern PTTI programs in the Department of Defense. First, the assignment of responsibilities in implementing directives generally substantiates the heavy influence of the technical/logistic participants in structuring the character of the program. In instances where operational staffs are tasked with responsibilities, they are usually stated in terms of verifying the compatibility of design and specifications rather than explicit responsibilities for stating and processing requirements. The second item is tracing directives to a common reference. Some implementing directives cannot be traced back to DOD Directive 5150.61, although other DOD Directives may be referenced.

PTTI Users

Preliminary findings with respect to PTTI users reveals that the laboratories, research organizations, and test ranges are best able to document their function, equipments, current operating procedures, and identify future requirements. There appears to be a significant community of beneficiaries of PTTI who tend to accept the services provided without full awareness of the impact on their program of how, by whom, and at what cost the services are made available. The investigation and full documentation of this community's PTTI programs portends to be the most difficult aspect of the task. Consequently, it will be the objective of detailed scrutiny in the iterative identification and data collection processes. Some of the PTTI users who responded to the survey questionnaires left some unanswered questions. A few indicated that they had no "next higher" echelon of command and no subordinate commands. Some provided no further time or calibration service beyond their own use, an acceptable though unlikely situation, except for a research facility. In some instances it was indicated in the survey that the time maintained on-site was not traceable to the USNO, yet the method whereby the time was maintained provides for such

traceability. Current requirements were generally implicit in the description of the users function and the capabilities of the equipments in use. Further investigation is warranted to insure the most economical and efficient use of resources.

Future Requirements

Future requirements have been expressed in a variety of characteristics desired. These include: cost, stability, accuracy, vibrational loading, G-loading, temperature sensitivity, power requirements, size, and accessibility. A number of these characteristics were described in quantified terms and others in general terms. For example, the lease cost item desired was to be less than \$100 per unit. Stability requirements have been submitted at the refined end of 4×10^{-12} /sec and $1 \times 10^{-11}/4$ hours. Accuracy statements range from "extreme" to a quantified value of 100 nanoseconds. Every effort will be made to quantify requirements to provide a common means of comparison and evaluation.

In the process of seeking answers to questions initially proposed for data collection, there appears to be a higher ratio of new questions than answers to old questions. In a program as dynamic and complex as the Precise Time and Time Interval program, one should reasonably anticipate such results in the early portion of the investigations. Hopefully, the crossover point will occur soon, wherein the number of answers neatly matches the questions at hand and no vital area which may influence the selection of viable alternatives remains unexplored. Needless to say, it is a challenging task, but one that should prove to be rewarding and beneficial to the PTTI community as a whole.

DOD PTTI SCHEDULE

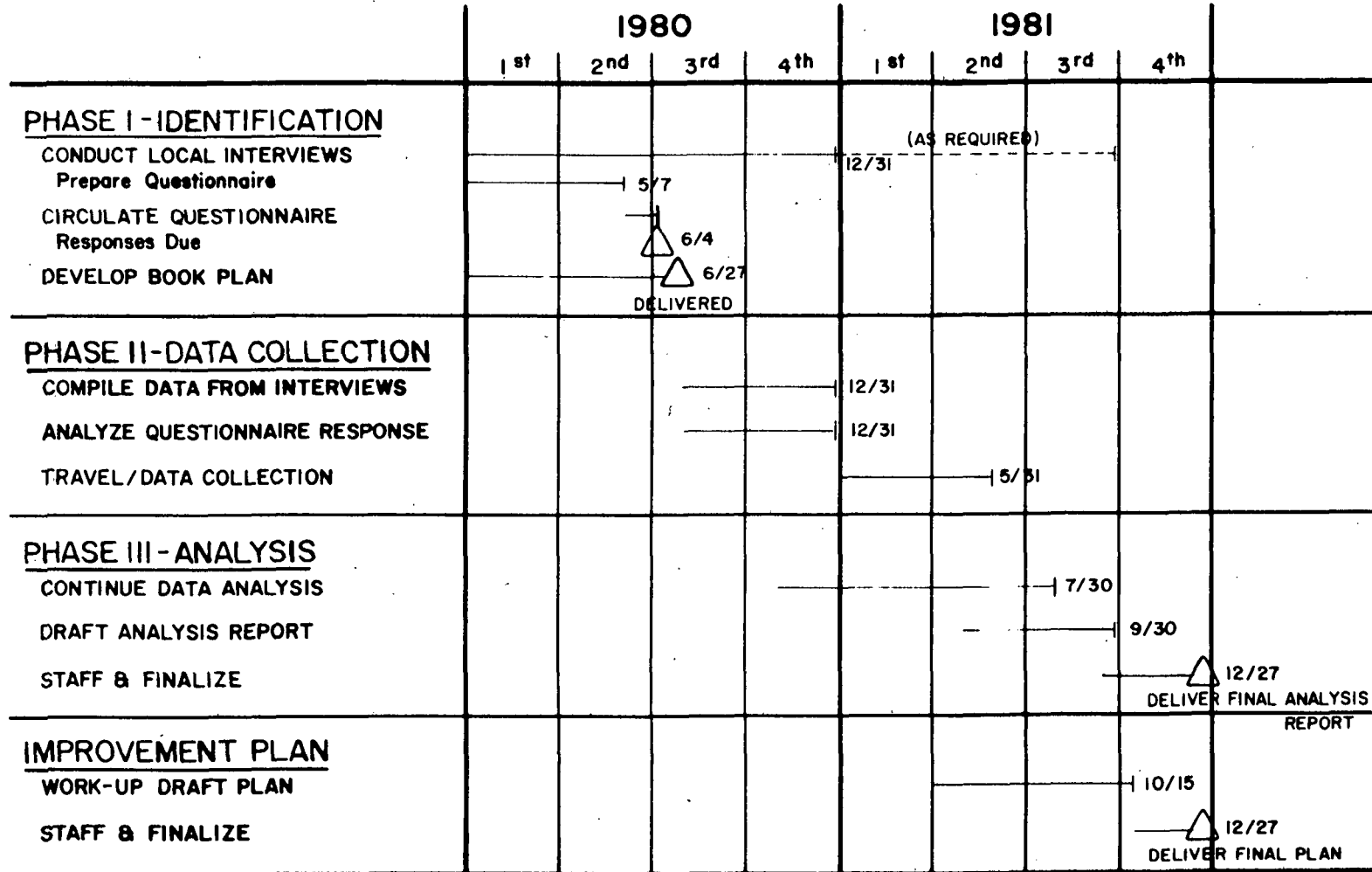


FIGURE 1