

A U.S. NAVY PRECISE TIME AND TIME

INTERVAL (PTTI) PROGRAM UPDATE

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ABSTRACT

A review of the Navy's PTTI Program was presented at the Tenth Annual PTTI Applications and Planning Meeting. That review presented a brief history of the Navy's PTTI Program, its management organization, and current and projected requirements, capabilities and Program efforts.

This paper:

- a. Updates those previously identified Navy requirements, capabilities and Program efforts.
- b. Outlines new Program efforts.
- c. Presents overall Program growth since September 1975.
- d. Projects the Navy's areas of concern regarding future PTTI development.

A review of the U.S. Navy's Precise Time and Time Interval (PTTI) Program was presented in November 1978 at the Tenth Annual PTTI Applications and Planning Meeting (1). Since that presentation, the Program's management organization, its basic mission of providing all Navy platforms and their communications, navigation and weapon systems with PTTI information traceable to the U.S. Naval Observatory (NAVOBSY), and its PTTI System Concept, see Figure 1, have all remained essentially unchanged.

This has provided a stable base from which the Program has continued to grow and to respond to the increasing PTTI needs of the Fleet. This growth and response to Fleet needs has resulted in an increasing awareness of and support for the Program by Navy program sponsors, planners, programmers, engineers, support personnel and users.

More specifically, the review at the Tenth Annual PTTI Applications and Planning Meeting reported that the Naval Electronic Systems Command (NAVELEX) had submitted an analysis of the Navy's PTTI requirements to the Chief of Naval Operations (CNO) in November 1978. The review further reported that current, medium and long range Navy platform timing requirements were in the 100 microsecond, the one to ten microsecond, and the 10 nanosecond ranges respectively. With a few exceptions, those values are still valid.

Based on the requirements analysis findings, NAVELEX updated the Navy's PTTI Program Master Plan. CNO subsequently approved the Master Plan in January 1980.

Some of the major Navy PTTI efforts addressed in that Master Plan and reported on at the Tenth Annual PTTI Applications and Planning Meeting include the:

PTTI Maintenance and Calibration Program.

SSN-637 Class Submarine PTTI Platform Distribution System (PDS) Development.

SSN-688 and POSEIDON Class Submarine PTTI PDS Development.

NAVOBSY Master Clock System (MCS) Upgrade.

AN/URQ-23 Frequency-Time Standard.

Global Positioning System (GPS) Time Transfer Unit (TTU).

PTTI Technology Program.

O-1695 Cesium Beam Frequency Standard.

Rubidium Standard Development.

"Standardized" PTTI PDS.

The following is a brief update on each of these efforts covering the past two years.

In 1978, the Naval Electronic Systems Engineering Center (NESEC), Portsmouth was assigned the responsibility of providing maintenance and repair services for all Navy owned atomic standards and providing portable clock trips to numerous Navy installations and Army Defense Satellite Communications System (DSCS) earth terminals under the PTTI Maintenance and Calibration Program. NESEC, Portsmouth has now been formally tasked, as the Technical Manager for PTTI, with providing Field Maintenance Agent (FMA) and Depot Repair Facility services for

Navy owned PTTI equipment including the AN/URQ-23 Frequency-Time Standard and the SG-1157/U Digital Processing Clock. Future projections indicate that NESEC, Portsmouth's responsibilities as the Technical Manager for PTTI will continue to increase and expand.

The automatic, no-break SSN-637 Class Submarine PTTI PDS equipment, see Figure 2, was delivered in 1979 and completed Operational Evaluation (OPEVAL) testing in June 1980. It is currently being considered for Approval for Service Use (ASU).

A direct result of the SSN-637 Class PTTI PDS development effort has been a reduction in scope of the SSN-688 Class PTTI PDS to a manual switch, see Figure 3. Also, current planning is for the POSEIDON class submarines to use the PDS developed under the SSN-688 Class effort. While development was initiated on this PDS at the Naval Ocean Systems Center (NOSC) and the Naval Avionics Center (NAC), reversals and setbacks have necessitated reprogramming actions. A restart effort is now being scheduled.

In July 1980, CNO formally approved the Navy Decision Coordinating Paper (NDCP) for the NAVOBSY MCS Upgrade, see Figure 4. Presently, various component equipments required to upgrade the Data Acquisition System (DAS) of the MCS have been procured and installed. Also, the first of two Environmentally Controlled Monitor Stations (ECMS) have been procured and installed. The first procurement of hydrogen-masers is now scheduled for Fiscal Year (FY) 1982.

The AN/URQ-23 Frequency-Time Standard which will replace the AN/URQ-10A as the Navy's quartz crystal reference standard was granted ASU in August 1979. The first AN/URQ-23 production contract was awarded the following March and the first production units are now being delivered to the Fleet. The next procurement of AN/URQ-23's is scheduled as a competitive, multiyear procurement in FY-82.

The GPS TTU (2) feasibility model was delivered to the NAVOBSY in December 1979 where it is currently completing a one year testing program. Initial findings indicate that its performance is better than the specified 100 nanosecond time transfer capability. A production decision is scheduled for April 1981.

The PTTI Technology Program to investigate (a) time transfer via GPS using laser technology, (b) environmental effects on atomic clocks and (c) high performance standards and advanced timing has gone unfunded for the second year. NAVELEX will continue to pursue this effort by showing the potential impact of these advanced research programs on systems and equipments which are currently scheduled for installation in the Fleet.

Cognizance of the O-1695A/U Cesium Beam Frequency Standard was

scheduled for transfer to the Navy's PTTI Program in FY-79. While responsibility for the maintenance and calibration of the O-1695A/U has now been assumed by the Program, full technical cognizance of the unit has, at the request of the VERDIN Program Manager, not been transferred because of reliability problems associated with the equipment. A transition plan has been developed and will be implemented upon final resolution of those reliability problems.

The development of a rubidium standard for the Navy which was discussed in 1978 is now being held in abeyance. A Preliminary Design and Life Cycle Cost Analysis for the "Standardized" PTTI PDS, see Figure 5, was initiated in late FY-79. The Preliminary Design and Life Cycle Cost Analysis is to develop alternative designs for a modular PTTI PDS comprised of "Standardized" equipments which could be reconfigured to meet the needs of a particular platform, i.e. surface ship, submarine, aircraft or shore installation, and compare the technical, operational and economic advantages and disadvantages of those alternatives. It was decided that it would be premature to initiate the development of a rubidium standard for the Navy prior to the completion of that Preliminary Design and Life Cycle Cost Analysis.

Similarly, final approval for full scale development of the "Standardized" PTTI PDS is being held in abeyance pending the completion of the Preliminary Design and Life Cycle Cost Analysis. The "Standardized" PTTI PDS is the heart of the Navy's PTTI Program. For that reason, NAVELEX is currently attempting to recoup after the failure of the contractor to complete the Preliminary Design and Life Cycle Cost Analysis within cost and schedule constraints and to finish the effort via other alternatives. NESEC, Portsmouth again under the PTTI Technical Manager assignment has taken the lead to insure timely completion of the effort.

New Program efforts have also been kept to a minimum over the past two years for two reasons. First, the PTTI Program Manager made a conscious decision in 1975 to minimize new Fleet, operational equipment developments until the Navy's requirements had been defined and then reasserted that decision in 1978 pending the completion of the Preliminary Design and Life Cycle Cost Analysis. Secondly, there has been a lack of sufficient personnel in the Program office to manage and administer the various Program efforts. Recently, this latter reason has caused NAVELEX to notify its sponsor that it could not accept additional PTTI responsibilities.

Taking this into account, the Program has still taken on new efforts to support immediate Fleet needs. For example, in 1979, NAVELEX procured several TRANSIT Timing Receivers to support NAVOBSY requirements. More recently, NAVELEX procured a clock distribution system to meet an urgent requirement at Naval Communications Station, Japan.

These were relatively small tasks, but, as stated previously, the PTI Program has continued to grow and to support the Fleet. Figure 6 is an updated Program Milestone chart which depicts some of the preceding efforts and reflects that Program growth. Figure 7 provides a funding profile, including RDT&E, OPN and O&MN funds, of the Program from FY-75 to FY-80 which again reflects that Program growth.

Most of this is, however, history. What projections can be made regarding the future?

Broad projections indicate that there will be a continuing increase in the Fleet's need for PTI and that there will be an accompanying increase in the Navy's support for PTI.

Also, while the "Standardized" PTI PDS Preliminary Design and Life Cycle Cost Analysis has not been completed, some specific Navy projections regarding future PTI developments appear feasible.

First, it appears that currently available reference standards combined with both operational and planned PTI dissemination systems, e.g., LORAN-C, TRANSIT and GPS, will be capable of meeting the vast majority of the Navy's projected operational requirements.

Second, there is a need for a properly designed, manual switch combined with an "update and comparison" equipment capable of (a) comparing onboard reference standards with a reference signal from a dissemination system external to the platform as well as with each other, (b) providing an alarm when any one standard drifts beyond a preset limit, and (c) allowing for underway time transfers as required.

Third, there is also a need to reduce the number of reference signals being distributed on board Navy platforms. Currently there are three basic frequencies, 5MHz, 1MHz and 100KHz; two timing pulses, 1PPS and 1PPM; and an untold number of time code signals being distributed. It appears that long range planning should reduce distribution to a single reference frequency and single time code. If necessary, this might be relaxed to include a single timing pulse signal. No decisions have been reached regarding which signals should actually be "standardized" on, but this action alone would reduce the number of cables which must be run, reduce the complexity of the PTI reference signal generation and distribution equipment and notify designers of future Navy communications, navigation and weapons systems of exactly what reference signals will be available on board Navy platforms and to design their systems and equipments accordingly.

One area of greatest need is that of distribution equipment; i.e., a new frequency distribution amplifier and a "time" distribution

amplifier. The AM-2123/U Frequency Distribution Amplifier is a good, reliable amplifier, but it is an old equipment. Modern technology should be able to provide a distribution amplifier with improved reliability characteristics and capable of providing more output channels in the same space as the AM-2123/U. Additionally, the Navy currently does not have an amplifier capable of distributing multiple timing signals, i.e., both time codes and timing pulses, and the need for a "time" distribution amplifier is increasing. Both units should be capable of supplying the multiplicity of reference signals required today, but also be capable ultimately of supplying the "standardized" signals discussed previously.

A final projected need is for reliable PTTI equipment. The "Standardized" PTTI PDS will be driving virtually all of the platform communications, navigation and weapons systems. Loss of a reference standard or failure of a switch could result in system outage or downtime at a critical moment and thereby result in damage to the platform or even a loss of life. Additionally, the Navy and the Nation's taxpayers cannot afford unreliable equipment; e.g., a reference standard which requires a tube replacement in excess of \$10,000 approximately every eighteen months. Reliable equipment is a must if the concept of a "Standardized" PTTI PDS is going to or even should be accepted by the Fleet.

In summary, the Navy's PTTI Program has formed a solid base with the Requirements Analysis and the CNO approved Program Master Plan. It has experienced some setbacks because of personnel shortages, missed delivery schedules, etc. However, the Program is moving forward and providing the Fleet with needed equipment and support.

Hopefully, the next two years will see even greater growth and support both to the Fleet and from Navy sponsors, planners, programmers, engineers, etc. Hopefully, the "Standardized" PTTI PDS Preliminary Design and Life Cycle Cost Analysis will be complete and full scale development of PDS's for candidate platforms will have been initiated.

The Navy PTTI Program office is working to make these hopes become realities.

#### REFERENCES

1. Allen, Ralph T., "A Review of the U.S. Navy's Precise Time and Time Interval (PTTI) Program," Proceedings of the Tenth Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, NASA Technical Memorandum 80250, November 1978.
2. Witherspoon, Jackson T. and Schuchman, Leonard, "A Time Transfer Unit for GPS," Proceedings of the Ninth Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting, NASA Technical Memorandum 78104 March 1978.

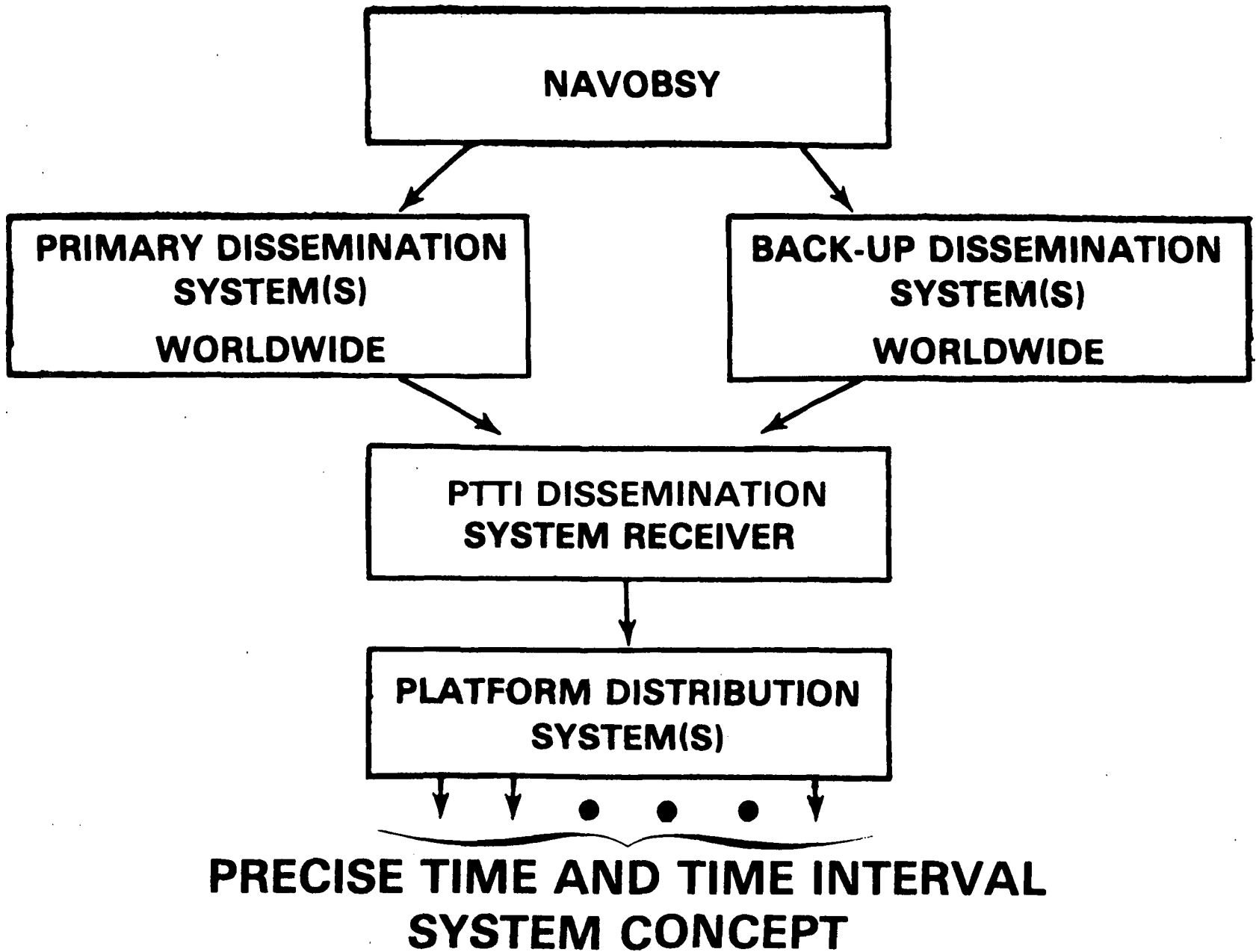
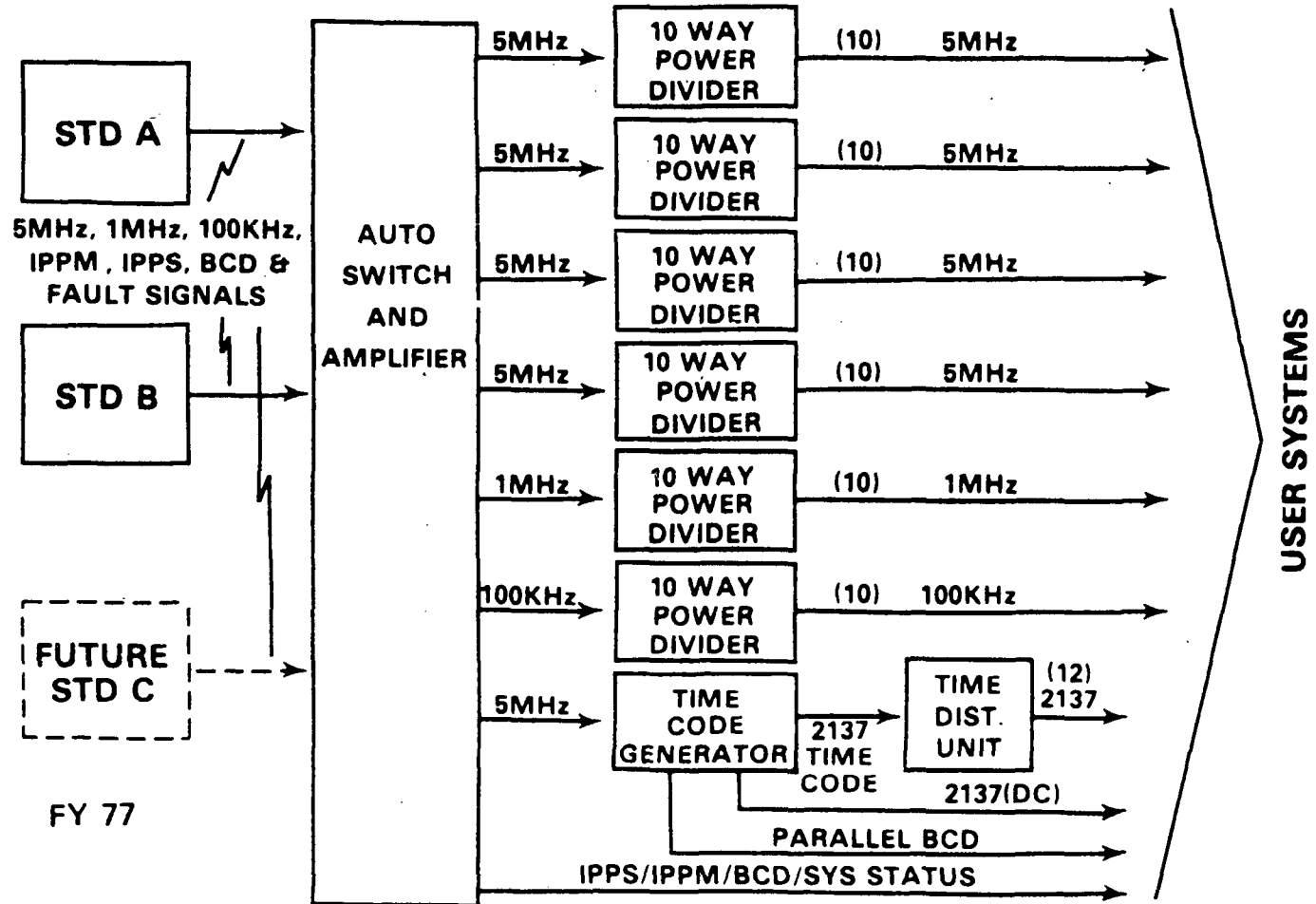


Figure 1

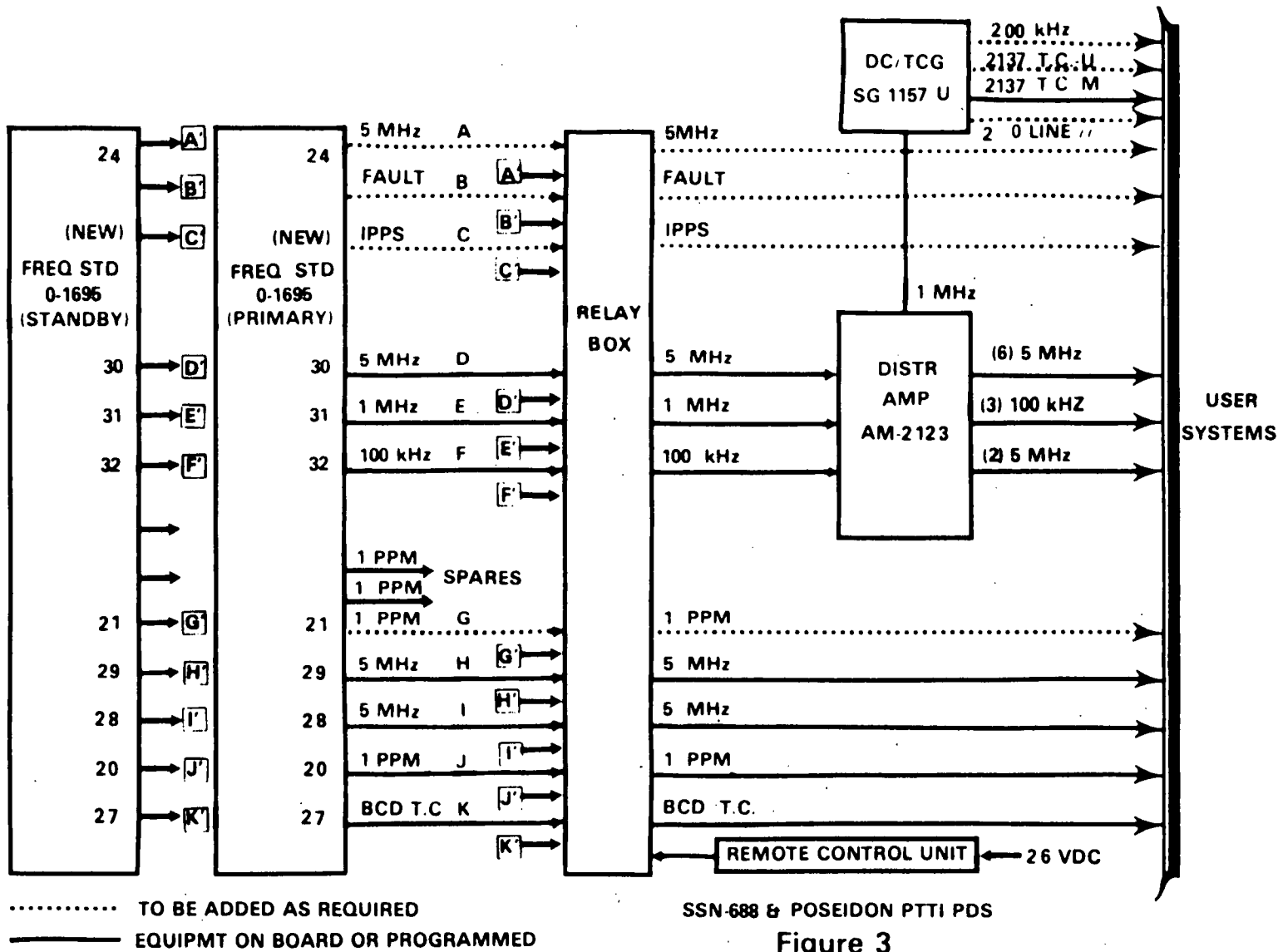


# SIMPLIFIED DIAGRAM OF SSN-637 CLASS PTTI PDS



FY 77

Figure 2



# U. S. NAVAL OBSERVATORY MASTER CLOCK SYSTEM

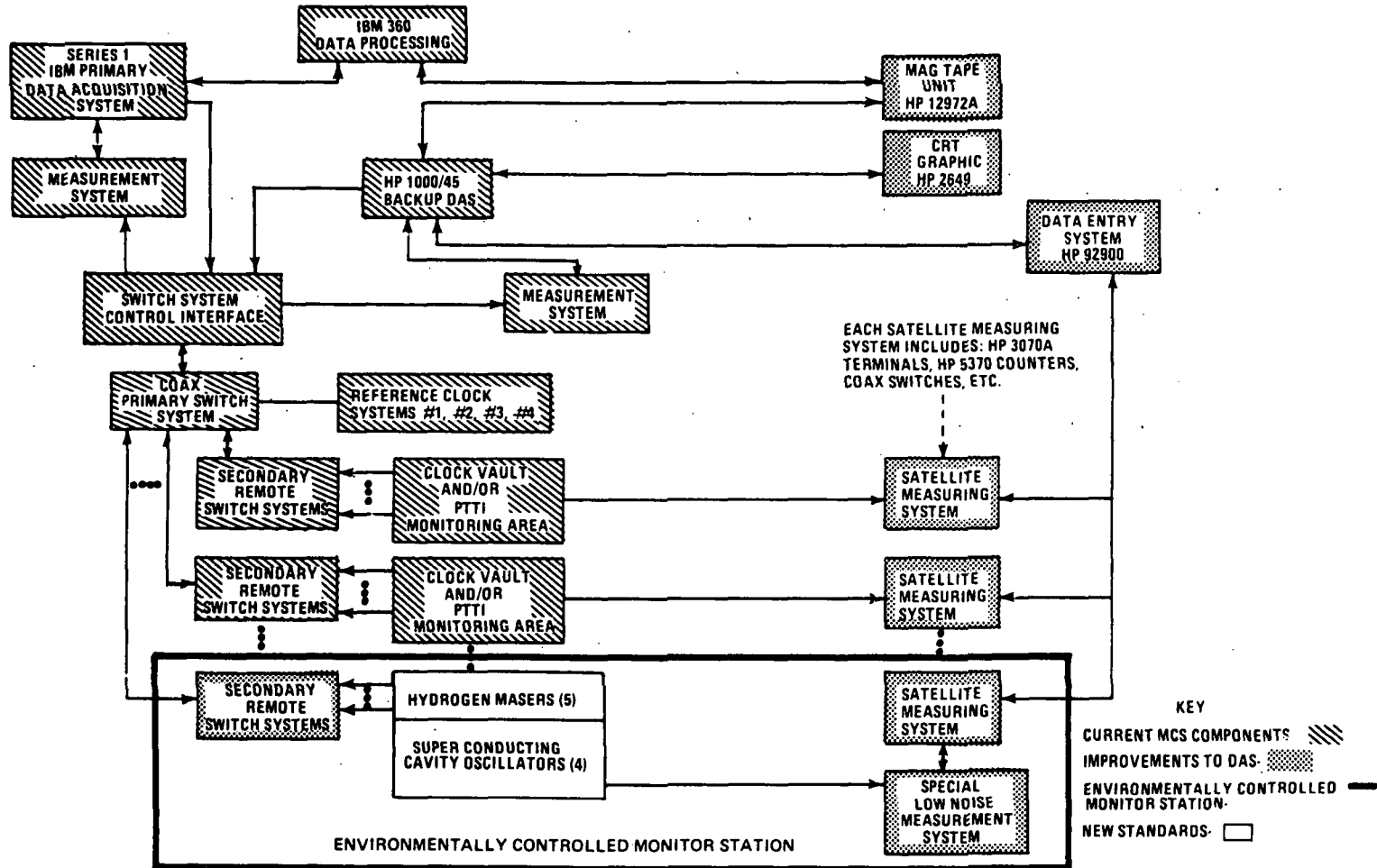
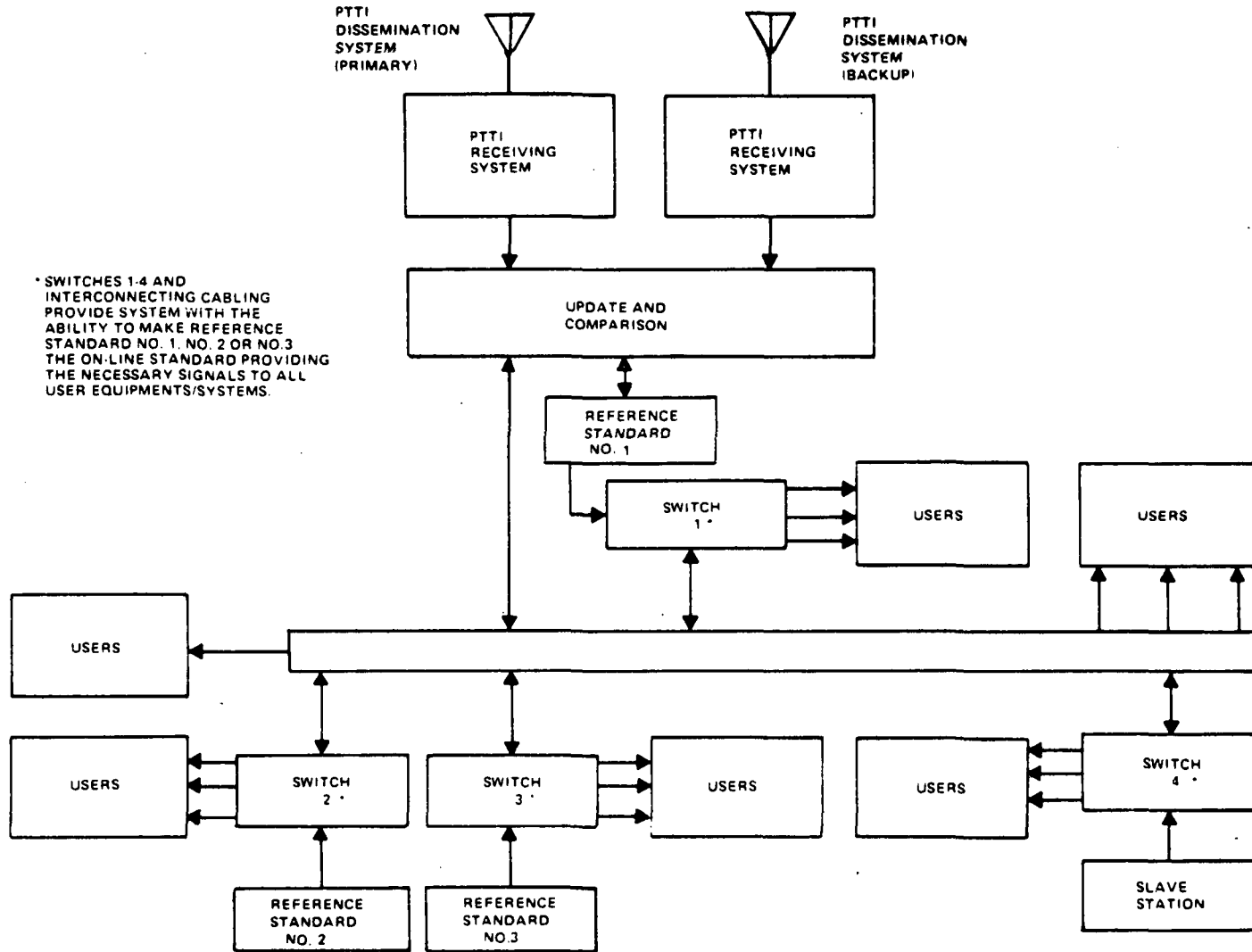


Figure 4



\* SWITCHES 1-4 AND INTERCONNECTING CABLING PROVIDE SYSTEM WITH THE ABILITY TO MAKE REFERENCE STANDARD NO. 1, NO. 2 OR NO.3 THE ON-LINE STANDARD PROVIDING THE NECESSARY SIGNALS TO ALL USER EQUIPMENTS/SYSTEMS.

PTTI PLATFORM DISTRIBUTION SYSTEM CONCEPT

Figure 5

# MAJOR PTTI PROGRAM MILESTONES

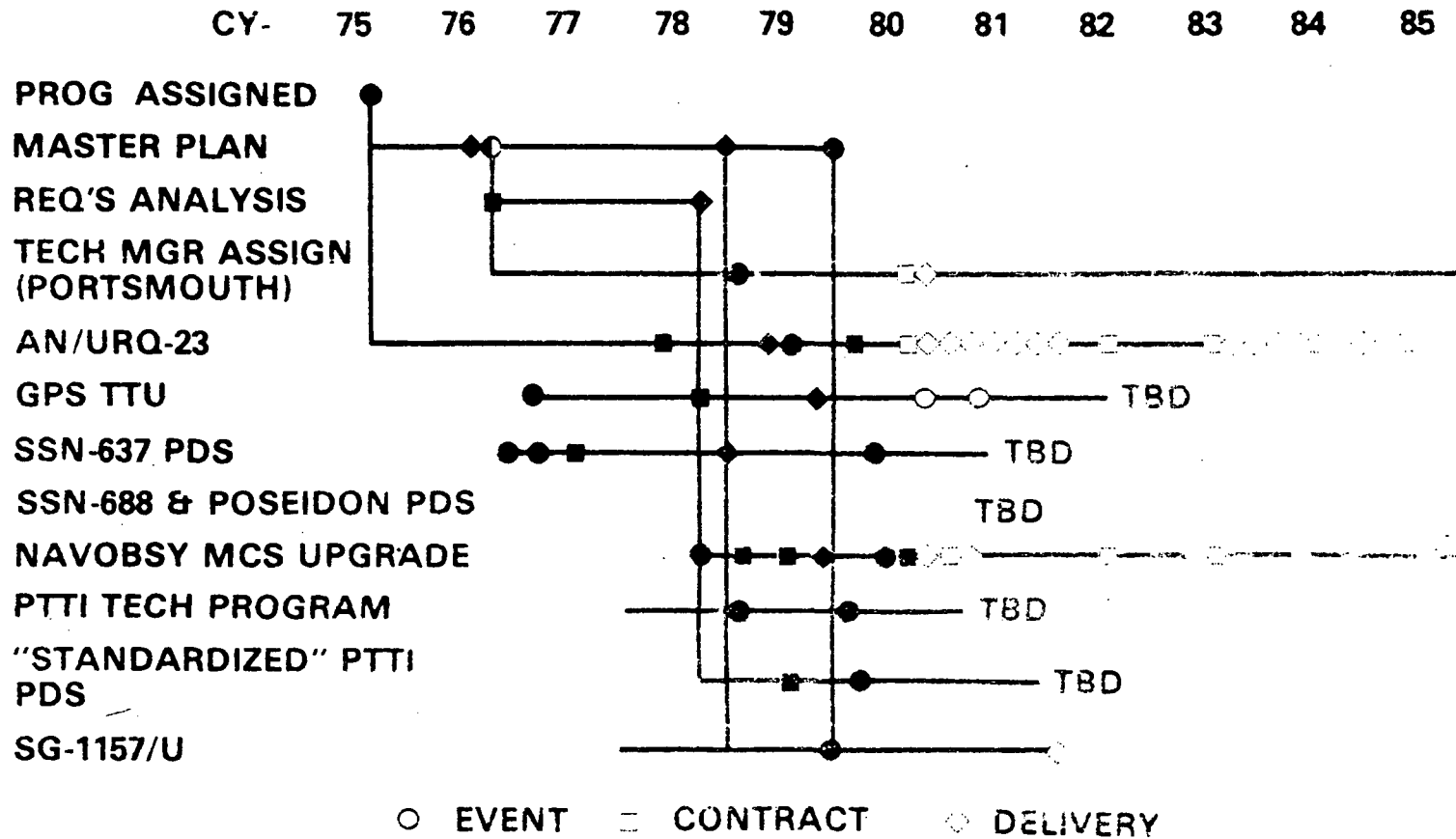


Figure 6

# PTTI FUNDING PROFILE

DOLLARS IN MILLIONS

140

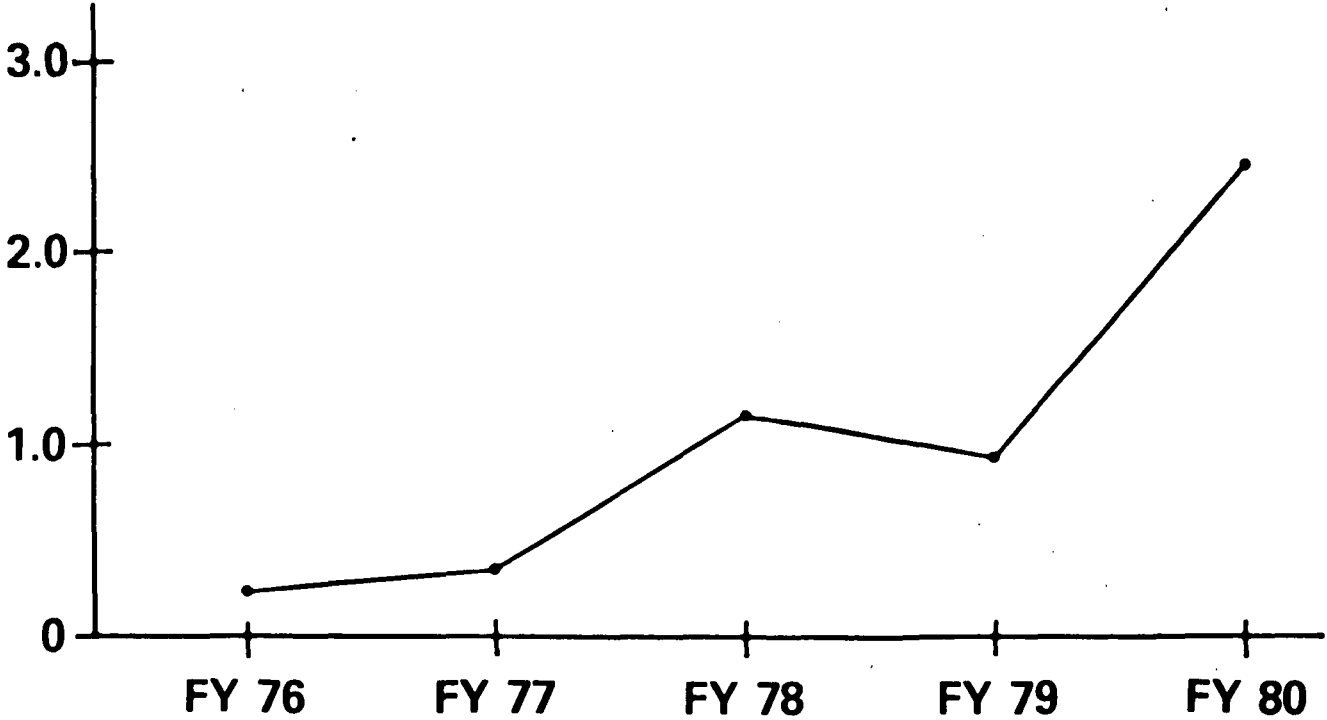


Figure 7