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OF THE SEVENTH ANNUAL
PRECISE TIME AND TIME INTERVAL
(PTTI)
APPLICATIONS AND PLANNING MEETING

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December 2-4, 1975

Sponsored by

Naval Electronic Systems Command
NASA Goddard Space Flight Center
Naval Observatory
Naval Research Laboratory
Defense Communications Agency

Prepared by
GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland 20771

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Dr. William B. Lenoir, NASA Astronaut
Subject: The Space Shuttle Program

CALL TO SESSION

Dr. Harris A. Stover, DCA

WELCOME ADDRESS

Dr. John F. Clark, GSFC

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FOREWORD

The Proceedings contain the papers presented at the Seventh Annual Precise Time and Time Interval (PTTI) Applications and Planning Meeting and the edited record of the discussion period following each paper.

This Meeting provided a forum to promote more effective, efficient, economical and skillful applications of PTTI technology to the many problem areas to which PTTI offers solutions. Specifically the purpose of the meeting is to:

a. Disseminate, coordinate, and exchange practical information associated with precise time and frequency;

b. Acquaint systems engineers, technicians and managers with precise time and frequency technology and its applications;

c. Review present and future requirements for PTTI.

Attendees come from various U.S. Government agencies, private industry and foreign countries to present papers and participate in the meeting in a mutual interchange of information. Papers were presented relative to frequency and time services; frequency and time devices; clock synchronization techniques and PTTI applications to navigation, communications, position location, and interferometry.

These Proceedings, taken together with those of prior meetings provide a good cross-section of the status of PTTI technology and its applications.

Many people contributed to the success of this year's Meeting. On behalf of the Executive Committee, I want to acknowledge the Session Chairmen, Speakers, and Authors, members of the Technical Program Committee and Editorial Committee, and the many others who gave freely of their time.

Additional copies of the 1972, 1973, 1974 and 1975 Proceedings can be obtained by sending $5.00 for each copy desired to:

S. C. Wardrip
Code 814
Goddard Space Flight Center
Greenbelt, Maryland 20771
or Telephone (301) 982-6587

Harris A. Stover
General Chairman

CALL TO SESSION

Dr. Harris Stover
Defense Communication Agency

DR. STOVER: I am Harris Stover from the Defense Communications Agency, and it is my pleasure to call to session this Seventh Annual Precise Time, Time Interval Applications and Planning Meeting.

A purpose of the meeting is the exchange of information that will enable us to make better use of PTTI. I think that the Technical Program Committee, under Dr. Reder, has selected an excellent set of papers to initiate that exchange of information. However, we would also like to have your participation in the discussion periods.

I would like to remind you that the sessions are being recorded, so that the discussion periods can appear in the printed proceedings. It would be helpful if you could provide a written report of your contributions to the discussion sessions that would help the editorial committee.

Again this year, we have quite a large foreign participation at this meeting, and that should increase the breadth of the information exchange. It is my pleasure to call on Dr. John F. Clark, the Director of the Goddard Space Flight Center, for the welcoming address.

WELCOME ADDRESS

Dr. John F. Clark
Goddard Space Flight Center

DR. CLARK: Some repeat performances are enjoyable. This is certainly one of them. I had the pleasure of welcoming you and encouraging your efforts in 1973 when you last did us the honor of convening at Goddard. I know it's trite to say that it seems like yesterday. And I mention it, of course, only because of your professional interest in the passage of time. However, have you noticed as you grow older that the earth is actually increasing its speed around the sun?

Coupled with that is the other phenomenon, that there aren't enough hours in the day anymore. I would hope that this group could do something about these problems, for the need is great.

It is a pleasure to welcome you back. This will mark the third time that we have hosted a PTTI Meeting. I am in better condition now than when we met in 1973 when I welcomed you after being up most of the night before working with the pictures of Mars which were just coming in from the Mariner flight. The pace has been heavy since that historic event. Many of you have been intimately involved with the scientific, applications, and manned spacecraft launched in the past two years. After the Skylab series, we had a successful joint flight with the Russians. When the Space Shuttle provides the opportunity to resume manned flight (beginning in the 1980s) it will complete the merger of manned flight and scientific efforts.

If the spacecraft which NASA will launch for non-NASA organizations is considered, the pace of the space program in the interim between now and the era of the shuttle will be extremely active. The Delta launch vehicle alone, for example, will be flying at a rate of more than once per month for the next two years. Some of NASA's launches in the interim should be of special interest to your community, such as the Tracking and Data Relay Satellites, the High Energy Astronomy Observatories, and the Laser Geodynamics Satellite (LAGEOS).

Woven through all this activity will be the binding thread of the precision frequency and time community. Many of the scientific measurements that have been made and the information that has been collected could not have been properly interpreted and correlated without precise frequency and time sources. The scientific community as a whole is grateful for what you as a group have been able to achieve in your various laboratories.

We presently have on the drafting table the design for a frequency measurements and standards laboratory which we hope to start constructing within the next several months. This facility, which will be one of the finest magnetically shielded and environmentally controlled measurement and test laboratories in the country, will house our primary hydrogen maser frequency standards. We hope to achieve parts in ten to the fifteenth long term frequency stability measurements over 100 days and longer.

The laboratory will also be used to verify the accuracy (to parts in ten to the fourteenth) of primary frequency standards and the precision of calibration of hydrogen masers for long periods of time.

This laboratory is being constructed here at Goddard as a separate structure in a remote location. For those who know the center's geography, it will be beyond our network test and training facility. Its location and design are such that there will be a minimum of shock and vibration. We anticipate construction to be finished by the end of CY 76.

In addition to our NASA commitments to support our various internal programs, we will continue our hydrogen maser support to the scientific community such as those in the fields of VLBI, radio astronomy, geodesy and red shift and relatively measurements areas.

In the precise timing area we presently rely on terrestrial radio transmissions and portable clock trips to achieve ±25 microsecond global clock synchronization at our network tracking stations.

Our future programs will have to do much better. For example, in the geodetic measurements required for the LAGEOS satellite experiments, we will have a need for $\nearrow$ or - 1 microsecond world wide clock synchronization. LAGEOS is one of the scientific satellites in the Earth and Ocean Physics Application Program.

A laser tracking network of 8 stations is being brought into existence. It will be portable, with each station housed in a trailer. We will be able to move the trailers to various sites for precise geodetic work. We are building the new timing system needed for precision work with this network. Some proof-of-concept experiments on the world wide satellite time transfer techniques have just been completed. Goddard and NRL worked with the Royal Greenwich Observatory, the Radio Research Laboratory in Tokyo, the U.S. Naval Observatory, and the Australian Division of the National Map Facility at Orroral Valley, Australia. We used the Navy's Navigational Technology Satellite (NTS-1) for these experiments, with encouraging results.

Among our guests today from the Navy is Rear Admiral Julian Lake who heads up the U.S. Naval Electronic Systems Command; Dr. H. Q. North, the Associate Director of Research, the Naval Research Laboratory, and Dr. K. Aa Strand, Scientific Director U.S. Naval Observatory. And I see from the program that many of you are from abroad, and that makes this meeting very valuable. There are few other meetings that I know of which bring together so many scientists and engineers from around the world who work in the PTTI field. Goddard is proud to be a charter member of this community and we look forward to continued cooperation with each of you.

On behalf of NASA, the U.S. Naval Observatory and the U.S. Naval Electronic Systems Command, the three sponsoring agencies, I extend a special welcome to those of you from other countries. Your attendance here attests to the importance of this meeting.

I'll be seeing you at some of the sessions during your three days here, and at the banquet tomorrow night. I wish you a very successful meeting.