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Astronaut Guy S. Gardner, Major USAF
Subject: Overview of Space Shuttle and Future Pay Loads

FOREWORD

These proceedings contain the papers accepted by the Technical Program Committee for the 13th Annual Precise Time and Time Interval Applications and Planning Meeting. In addition, these proceedings include the discussions following the presentations. There were 200 registered attendees; of this number 17 were from 9 foreign countries.

The objective of the meeting was to provide an opportunity for the program planners to meet those who are engaged in research and development and to keep abreast of the state-of-the-art of the technological development. At the same time, it provided an opportunity for the engineers and scientists to meet the program planners and to learn what technology can be applied. This objective is clearly reflected by the title of the meeting. While the intent of the meeting was designed for logical evolution of technology and program development, it has not been easy, indeed, to reduce it into practice.

Since the first meeting, held informally at the U.S. Naval Observatory in 1969, we have had 12 years of experience and growth. As we reach the tender age of the teens, we begin to find support from the sponsors as well as from the participants. It will always remain a challenge to us all and, in particular, to those who have the responsibility of managing and steering the meetings to achieve our stated goals.

The Executive Committee has been fortunate in attracting new and able leaders to organize and plan the meetings. Their rewards are reflected by the increasing number, and the continuing support of the sponsors. On behalf of the Executive Committee, I want to recognize the excellent effort of the Technical Program Committee and the Session Chairmen for their leadership and contributions to make this meeting a success. Finally, I want to express our appreciation to the host for 1981, the Naval Research Laboratory, the many people behind the scene, and the secretaries, whose support was vital to conduct the meeting smoothly.

Andrew R. Chi
General Chairman

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CALL TO SESSION

Mr. Andrew Chi
General Chairman
NASA Goddard Space Flight Center

CHAIRMAN CHI: It is my pleasant duty to officially open this Thirteenth Annual Precise Time and Time Interval Applications and Planning Meeting.

In retrospect, it is indeed a record for us to have had 12 meetings in the past dozen years. As we reach adolescence, we cannot help but look forward to the future, toward maturity, and to look backward with pride and appreciation for our accomplishments and for the generous support of our sponsors. And especially those who contribute so much of their time and resources to foster our growth.

Although the number 13 is ominously associated with omen by some who are superstitious, it is really a number associated with growth. Like the number of the moons around the Jupiter, it was always 13 until 1979, when the Voyagers I and II flew by the planet and discovered that there are now at least 16.

I propose that we continue to grow and to strive toward our objectives. Who knows from this year on, we may, like JPL, someday reach the stars like Canis Major. It is certainly appropriate for us to dream along these lines from this year, the year of the Canine, according to the Chinese calendar.

I would like to use this opportunity to welcome our two new sponsors, the United States Army Electronics Technology and Devices Laboratory of Fort Monmouth, New Jersey; and the United States Air Force Research and Development Command of the Rome Air Development Center, Hanscom Air Force Base, Massachusetts.

It is again my pleasure to introduce to your our host, the Assoicate Director of Research of the Naval Research Laboratory, Dr. Bruce Wald who will give us the welcome remarks.

WELCOME ADDRESS

Dr. Bruce Wald
Associate Director of Research
Naval Research Laboratory

DR. WALD: For those of you who are paying too much attention to the program, and not enough to the person who spoke, I am not Alan Berman. Alan, unfortunately has a boss and the Chief of Naval Research called him away on very short notice to attend an O & R retreat this morning.

Unfortunately, I have a boss, too, and he asked me to come here and substitute for him. But I am not at all disappointed that he asked me to do it, because it has occurred to me from time to time "isn't it too bad that I am not alive at the time that the fundamental breakthroughs in science are being made", that I could not have been alive at the time of Newton, or Galileo.

But if we take a historical perspective, this is the century of time. In many respects the 18th Century was the century in which precision in the measurement of mass first had its impact. I am thinking of the classical chemists, the name of Lavoisier comes to mind because he was also the executive secretary to the French Commissions on Weights and Measures, and he also improved gun powder so his science would have some military relevance.

But by the use of the chemical balance, he really reversed the concepts of the time on which were elements and which were compounds, which were the ores and which were the names of metals. He did this with precision in mass.

I think the 19th Century was the century of precision in length and in angular measurement. This not only had tremendous economic impact in the industrial revolution, interchangeable machinery, mass production, but it also had great scientific impact in spectroscopy in which precision in measurement in length and small changes and little fine spectra, things that could not be measured before, provided the clues that are helping to unlock some fairly fundamental questions on the nature of matter.

I think the 20th Century has been the century of time. When historians a few hundred years from now look back at the 20th Century they may think that the effect of this revolution about time may be just as profound. But in order to check that thesis, I went last night looking for as current -- well, not as current, but as important a book as I could find on perspective of science around the turn of the century.

What I found is Carl Pearson's Grammar of Science, First Edition, 1892, in which he discusses the problem of time. He spends a chapter, and I think what he is saying is despite all the triumphs of observational astronomy, that time is purely a psychological concept, because after all there is no real standard and there is no way of telling the tidal friction hasn't slowed down the planets. If the number of days in the year are changed we don't know if the days are getting shorter or the year is getting longer. And that time is purely a psychological concept.

I wish I could have Carl Pearson attending this conference and hearing some of the things that have been done by the percise time, not only in the engineering sense, but the things that have been made possible in communications and navigation, and the fundamental physics sense for improving our understanding about the fabric of space.

So, perhaps in the future people will look back on the 20th Century and say that the revolution in time was as important as the one in the 18th Century on mass, and in the 19th Century on length.

But since I can't have Carl Pearson here, I am going to listen with interest, as long as I can this morning, on behalf of the Commanding Officer and the Director of Research, I want to welcome you to NRL. I want to say as an institution, we are proud to have been the sponsor of the early conferences and to have so many distinguished colleagues and sister organizations cosponsor them. And we are looking forward to a very productive meeting.

OPENING COMMENTS

Dr. John McElroy
Deputy Director
NASA Goddard Space Flight Center

DR. McELROY: I am really delighted to have this opportunity to welcome you here to this 13th Conference. I was fortunate enough to attend the one last year, and my own assoication with the conference goes back from colleagues of mine who have participated in this over many years.

If you look back over the past dozen or so years, at this conference as measured in many respects, we have seen numerous, extremely exciting breakthroughs which have been brought forth here. And I think if you look back over the conference proceedings you can get a tremendous measure of the dynamic nature of this subject and its technology.

In the beginning, when the meeting was originally sponsored by the Naval Observatory and NRL, and the Naval Electronics Systems Command, it was known as the PTTI - Strategic Planning Meeting. Later on that was shortened to simply the Planning Meeting. And in about 1975 it took on this current title, reflecting both the planning nature, as well as the achievement nature of the meeting.

If the number of sponsors is any measure of interest, obviously you have been highly successful. Certainly starting off with just the three, we have gradually expanded the sponsorship up to the present number listed on the brochure, with some nine sponsors being currently listed.

I notice that Fort Monmouth is now here, as one of the sponsors. I will try not to hold any grudges against Fort Monmouth -- some more than 25 years ago, I had the experience of going through the radar school there, and later served under a lieutenant who had learned very well the first rule of leadership, which is namely when faced with a difficult problem, to tell the sergeant to get that radar up on top of that mountain.

I came to appreciate transportable in a way in which I have never since -- I have never quite not been able to react to the word "transportable" since my experience at Monmouth.

But, perhaps, those of you who go back that far will remember that there was a precision time interval measurement system in the old "Tipsy Dog" called a mercury delay line, which took a phenomenal amount of period to settle down.

If I look back over the years of achievement of the group here, basically, I see that you have advanced the state-of-the-art a decade-per-decade. We keep increasing, and increasing the frequency stability of our standards and thereby the scientific and technical payoff that we can get from those standards.

And I look forward to hearing the results of the most recent measurements that have been made and the most recent developments. You have paralleled the NASA program, going back to Apollo 11 when we were talking about 10 to the minus 12 and 10 to the minus 13th, and gradually moving up to 10 to the minus 14th, 10 to the minus 15th these days.

So, with a little bit of luck, another decade will see at least another decade of improvement and with a little bit of luck, all of us will still be here to share in some of the excitement.

So, I welcome you to the conference, Goddard intends to keep right on sponsoring it. We think it is a highly productive exercise.

Thank you.

OPENING COMMENTS

Dr. Gernot Winkler
Director, Time Service Division
United States Naval Observatory

Dr. WINKLER: It is not quite correct that I was the founder on the PTTI Strategic Planning Meeting in 1969. Back in that year the Observatory was faced with the responsibility of coordinating the overall DoD PTTI operations, but with practically no way of finding out what is going on and no way of influencing these. And so somebody in my group, I think it was Nick Acrivos, who has since retired, had a terrific idea, why don't we call a conference. And that is how it all started.

At that time, if I may use this opportunity to make a comment about it, we had actually two conferences one for discussion and review of progress to provide an overview of the state-of-the-art for our managers. But we also had a second part where a smaller group met, where plans were discussed.

I think we have lost the second part, but the Executive Committee and the Conference Committee have come up with something which I think should serve the same purpose. I am very curious to see how this will work out.

My main concern, as I look back over these years, is that in order to be successful, we must have audience participation. We must hear from you, who are much closer to the actual needs of the area, we must hear from you what is needed, how could things be improved.

So I am asking you during this conference to do your very best by asking questions and by giving your opinions. This is one of very few conferences which records and prints at least the more important comments. I think they are only slightly edited. And from many users I have been told that this is one of the better features of the proceedings, that we get the comments afterwards, so they are not just made and forgotten, but they are somehow documented.

So, please participate.

OPENING COMMENTS

Rear Admiral J. B. Mooney, Jr.
Director of the Naval Oceanographic Division
Office of the Chief of Naval Operations

REAR ADMIRAL J. B. MOONEY, JR.: Being in a new position of oceanographer of the Navy has some pluses and minuses, and one of the pluses is that I am expected to give short greetings to important assemblies, such as this, without inadvertently shaking the foundations upon which these meetings were founded.

My responsibilities as oceanographer include resource sponsorship for the Naval Observatory and the precise time and time interval coordination.

It is a pleasure for me to work very, very closely with these folks at the Naval Observatory, the timekeepers of the nation, and also folks who have many other illustrious achievements over the more than 150 years.

I think it is appropriate that the various efforts now the responsibility of the oceanographer of the Navy conducted from the shared location of the Observatory. Our predecessor started out together in 1830 and now we are back together, and the old things that were done at the depot with charts and instruments are now coordinated and consolidated at the Observatory where we have meteorology, oceanography, MC&G and time and astronomy, all at the same place.

I am pleased to know that your conference this year is placing emphasis on tasking requirements, and planning and management PTTI activities. Precise time and time interval play an essential role in naval operations. However, the clear articulation of requirements is a problem for us because we need to have them defined so that we can properly document our resource needs.

I hope that you will find Mr. Bowser's paper on DoD PTTI requirements to be a contribution to our planning for our future needs. The study conducted by Automation Industries, also addresses DoD PTTI management problems. It is already being used to generate a revised DoD directive on precise time.

A significant event will take place at the Observatory commencing in 1982, and we will begin procurement of hydrogen masers for upgrading the Naval Observatory master clock system.

All four of the PTTI sponsors in the Navy have been involved in the upgrade of this master clock, NAVELEX, NRL and the Naval Observatory, and my own division, 952.

The purpose of this meeting is to help all of us managers make better use of our time and to manage our PTTI activities.

I hope that our objectives for these meetings are realized and our bonds of communication are strengthened by sharing the common challenges and achievements. I will be with you sometime this morning and I hope to join with you at various times throughout the time that you are here.

Thank you for coming.

OPENING COMMENTS

Rear Admiral C. J. Moore
Deputy Commander
Naval Electronic Systems Command

REAR ADMIRAL C. J. MOORE: Good morning, ladies and gentlemen.

It is a great pleasure that I welcome you on behalf of the Naval Electronic Systems Command to the 13th Annual Precise Time and Time Interval Applications and Planning Meeting.

As you have heard, and as many of you already knew, NAVELEX engineers have been associated with this meeting from its inception in the late 1960s. The system we have provided to the fleet, the systems we are providing to the fleet and the systems that we will provide to the fleet tomorrow demand the best time and frequency precision we can achieve, both on a global and on a local level.

Command, control, communications and intelligence systems and the ability of a fleet to wage a successful electronic battle are intimately tied to cesium clocks dispersed throughout the fleet and synchronized to permit a rapid real time interference-free flow of tactical data and command decisions.

Today we have to be satisfied with atomic frequency standards which precisions of a few parts in 10^{11} and time synchronization to 100 nanoseconds, this only on a local level.

Through joint planning meetings, such as this, we hope to develop ideas and techniques that will allow the fleet to have rugged frequency standards with much greater long-term stability and with global time synchronization to 100 nanoseconds.

In line with these future goals, I would like to mention two things that are happening around the Naval Electronic Systems Command in PTTI. First, my director, which is the Command Control Communications and Intelligence Systems and Technology Director, has assumed responsibility for supporting research and exploratory developments at the Naval Observatory starting in FY 82.

Hopefully, we can improve the financial support of the Naval Observatory's PTTI R&D efforts.

Second, our Navy PTTI manager, which is PME-110, has recently established plans of action and milestones leading to the development of the next generation of Navy cesium beam frequency standards and a time distribution amplifier, both of which are slated for production in the FY 86 and 87 timeframe.

This cesium beam standard we intend to militarize, so that it will have long-term stability to satisfy the needs which I mentioned earlier.

Again, let me say that it is a pleasure to be here and for NAVELEX to support this effort.

Thank you.

OPENING COMMENTS

Captain Raymond A. Vohden
Superintendent of the Naval Observatory

CAPTAIN VOHDEN: Good morning. As Superintendent of the United States Naval Observatory, it is gratifying to see so many of you here today. The Naval Observatory was the sponsor and originator of the first Annual PTTI Conference 13 years ago. And, as the Superintendent of the Observatory, it is a real pleasure to welcome the Army Electronics Technology and Devices Laboratory and the Air Force Rome Air Development Center, as the eighth and ninth sponsors of this annual meeting.

I consider this a very significant event because it is the first time that all three services have joined in sponsorship of a PTTI meeting. I hope this is the forerunner of greater participation by the Army and Air Force in future PTTI meetings, and that eventually your services will have an even more active role in the sponsorship of these annual conferences.

In February 1965, the Department of Defense delegated responsibility to the Naval Observatory for PTTI. On 28 April 1969, the first PTTI conference was held at the Observatory. The purpose of that conference was to reveal if we were meeting all the requirements and to determine what we could do better than we were doing then.

Four specific goals were set, the first one was to establish a sound working relationship between the Observatory and each DoD component, contractor and other interested agencies. The second was to review existing PTTI requirements and examine possible future requirements. The third was to provide advice and guidance to all PTTI users. The fourth was to promote and establish the means for maintaining operational uniformity of PTTI functions.

In review, it appears that the PTTI conferences have been very successful in accomplishing the original purpose and goals. It must be credited with providing the major means to accomplish technical coordination.

Without the conference we would find the PTTI area in much worse shape than it actually is. If then the conference has been at least reasonably successfully, can anything be done to improve it further?

The answer which I received to this question is that several steps could be taken. One step is that today you will find a major effort to solicit audience participation in what has been called from the beginning a strategic planning meeting.

Secondly, we should increase our efforts to bring higher-level managers from the various agencies to this conference. If they are too busy to attend, at least attempt to better inform them about time.

The importance of PTTI, as evidenced by this large gathering of distinguished scientists from government and industry, from the four corners of the world, is probably not well understood by many higher-level management officials.

Consequently, they are not aware of how important our discussions are for their own operations and management decisions. And this unawareness is probably the main reason why the Observatory, as the DoD PTTI manager, frequently does not receive pertinent information and requirements on time, and sometimes not at all.

I suggest that you give this matter your thoughts and bring forth any suggestions you may have at a later time.

Fortunately, the Observatory is now in the process of getting the DoD PTTI instruction revised, which, if approved, will require PTTI coordination within the agencies and services. This new effort can now be justified on the basis of an extensive analysis of the overall PTTI requirements, which is near its completion.

I trust that you will be interested in hearing more about this effort, which will be the subject of the first session.

One final note is that the Naval Observatory, located on Massachusetts Avenue, Northwest, Washington is well worth a visit for those of you who may not have been there already. Besides being a place of considerable scientific interest, it is a rather pleasant place to visit.

A tour of the Naval Observatory is scheduled for 8:00 o'clock this evening. I am sure you will find the tour a very interesting and worthwhile experience.

I wish you full success at this important conference.

OPENING COMMENTS

Dr. Richard L. Sydnor, Chairman
Technical Program Committee
Jet Propulsion Laboratory

DR. SYDNOR: As you already heard, we have a slightly different kind of session this first session, we would like to have everybody participate. There are questions raised in the program, you can read them on the program and discuss them during coffeebreak, and we will be back for a discussion later on.

The first chairman is Harris Stover, from Defense Communications Agency, and he will introduce the first session.

Thank you.