OPENING REMARKS

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Ladies and Gentlemen:

It is a pleasure to have this chance to make a few remarks at this, the 41st Annual Precise Time and Time Interval Meeting. This series of PTTI Meetings has provided a valuable forum for participants to share their ideas and demonstrate applications that challenge current capabilities, while stimulating innovative improvements in the contribution of PTTI to the global infrastructure. These meetings have also allowed providers of time and time interval to make system developers aware of the latest improvements and those that are likely to be available in the future.

The PTTI Systems and Applications Meeting is sponsored by the U.S. Naval Observatory, the U.S. Naval Research Laboratory, the NASA Jet Propulsion Laboratory, the Defense Information Systems Agency, and the U.S. Coast Guard Navigation Center to pursue four stated objectives. These are:

1) to disseminate and coordinate PTTI information at the user level,
2) to review present and future PTTI requirements,
3) to inform Government engineers, technicians, and managers of precise time and frequency technology, and
4) to provide an opportunity for an active exchange of new technology.

The sessions outlined in the program of this meeting are well suited to address these objectives, ranging from reports on the latest activities at laboratories from around the world to a preview of the program for the 2030 Meeting.

A quick glance at that program clearly demonstrates that PTTI is an active area of development. The lab reports from approximately a dozen countries show that this development is worldwide and that the requirements for PTTI continue to expand on an international scale. A session on advanced clocks addresses the need for even further improvements in precision as well. This developing technology offers the possibility of unprecedented operational PTTI precision to users. The arrival of these improved clocks now presents a challenge to the providers of time to determine the most appropriate way to make use of a variety of timing sources. The old procedures to combine clock data will need some modernization in order to obtain the optimum capability of those new standards for practical applications. A session on algorithms will address this issue. We can be sure, however, that the providers of time and time interval will be producing cutting-edge precision in the very near future.

This fact, in turn, then presents a renewed opportunity for users and system developers to reassess their applications and seriously ask themselves, "How can we make use of this capability to improve our systems?" "What can we do with sub-nanosecond timing that we couldn't do before?"

We are all well aware of the growing commercial use of satellite navigation in everyday life today. PTTI makes this possible. A session on space clocks provides a forum to address the nature of clocks in space in

the future. These devices will be essential for tomorrow's navigational and communications systems. New systems are being planned now; it is critical that we keep in mind that today's planning should take into account the likely future growth of applications for PTTI. This means that space clock development efforts ongoing today must be approached with the utmost foresight and agility in order to meet increasingly complex and stringent form, fit, accuracy, and precision demands of tomorrow.

Global navigational satellite systems routinely provide extremely accurate positioning and navigational information, but an even greater benefit to users is the timing information that they make available, which enables today's infrastructure. We've long said that PTTI should be considered as a utility comparable to power, water, and energy in their importance to society. It is no surprise, then, that most of the sessions of this meeting are related to various aspects of delivering time and frequency to users.

To meet that need, the growth of Global Navigational Satellite Systems for timing applications continues to accelerate. GPS receivers have, in some cases, replaced precise reference clocks. Their relatively low cost and the demonstrated operational reliability of GPS obviously make this solution attractive. To achieve the most from these receivers, however, requires careful attention to accurate calibration. This is an area that may not have received a lot of attention previously, but this year a session devoted specifically to calibration points out the developing need.

However, concerns still remain regarding users' ability to inter-operate these systems as a result of multiple and possibly inconsistent standards. This situation illustrates the growing need for system designers to consider the requirements for timing accuracy in addition to precision. The growing need for inter-operability demands accurate, as well as precise, PTTI capabilities. It also requires careful consideration of all aspects of standardized reference systems to ensure interoperability.

All of these issues have been recognized in the overall national Positioning, Navigation, and Timing architecture. This process is still in the transition stage, developing the means by which the architecture can be implemented over the next 25 years. PTTI is a critical component of that architecture and this community will be challenged to meet the goals of that plan. Implementing the systems needed to support the anticipated transportation and communications needs of the future will require significant progress in the transfer of PTTI information. These applications and potential threats to our infrastructure will require robust and redundant means to deliver accurate time and frequency to users, particularly in hostile environments. Interoperable networks employing more than one means to transfer PTTI information will likely be the state of the future.

The session dealing with the anticipated program for the PTTI Meeting of 2030 is particularly intriguing. That seems like a date far in the future, but in reality it is "just" 20 years from now. Perhaps we should look back at the program of 20 years ago to see if the attendees of 1990 were able to plan for the PTTI requirements of today. Some of those participants are probably in the room here today. Many of our current capabilities are, no doubt, due to those planners back then. The community must continue to challenge today's system engineers to make use of anticipated developments in PTTI. Rather than asking potential users what their requirements for PTTI are, we need to ask what they might do with 10-picoseond timing or one part in 10^{16} frequency. National and international laboratories must work together to make sure that the world's PTTI needs are met today and that society can make use of what we expect to make available even beyond 2030. I am sure that this and future meetings will continue to address these concerns. But, in addition, I would like to challenge users of time to think creatively about new possibilities that take advantage of our ability to provide time and time interval with improving accuracy. This utility of PTTI will, in the future, provide improvements for us all, and we need to plan now to take advantage of this resource. I'm looking forward to the presentations and discussions.