OPENING REMARKS

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JAY OAKS (U.S. Naval Research Laboratory): Welcome to the 35th Annual Precise Time and Time Interval (PTTI) Systems and Applications Meeting. It is my privilege to start the meeting. We have this morning an old friend who used to work at NRL, the Scientific Director of the Naval Observatory, Dr. Ken Johnston, to give the opening remarks.

KEN JOHNSTON: Good morning. I am very happy that Jay didn't tell you stories on me; Jay and I have been associated for the last 30 years or so. He didn't tell you about any of my trials and tribulations in time transfer. I am not going to get to that story either, but we both think the other person did it, and you can talk to us at the cocktail party about how we transferred time at the nanosecond level, after the other person knew the other one's answer. It is always good to know the answer to a complex problem.

I am pleased to make the opening remarks for the 35th Annual PTTI Systems and Applications Meeting. Capt. Gillard, our Superintendent of the Naval Observatory, expresses his regrets for not being able to attend the meeting. My presentation uses much of the material he prepared for the meeting. I modified this presentation and allowed Dr. Dennis McCarthy, the Director of the Time Directorate at the USNO, to review it. He removed most of my excellent material. So this presentation is about 75% Capt. Gillard and 25% Dr. Johnston. In fact, when I saw Dr. McCarthy this morning, he said that the whole presentation is questionable. That gives one a lot of confidence in opening the meeting.

Let's talk about the outlook for PTTI. The Navy and the Department of Defense (DoD) have a great need for PTTI. However, Captain Gillard's outlook is based on his 18-month experience in detailed timing applications. I go way farther back. I attended my first timing meeting in 1972. At that time, I had a need for precise time at the microsecond level for synchronizing Very Long Baseline Interferometer (VLBI) arrays. This was for the study of the special structure of black holes and celestial masers due to OH and H_2O. So you can see that PTTI has more applications than just those in the military.

But when we talk about the meeting today, things have changed little over the past 35 years. The meeting itself has the same objectives that it did 35 years ago. That is:

1) To disseminate and coordinate PTTI information at the user level. This is very important. This meeting brings together the users of timing systems.
2) To exchange information on how well their systems work and give us some improved PTTI for operations.
3) To review present and future PTTI requirements. We have many, many timing requirements for DoD and also in the commercial sector.
4) To inform government engineers, technicians, and managers of precise time and frequency technology and its problems. We know that there are no problems with timing. Right, Dennis?
5) To provide an opportunity for an active exchange of technology associated with PTTI.

So these are the major purposes of these meetings that we have had for the past 35 years or so.

The USNO, together with NRL, the Air Force Office of Scientific Research, the Defense Information Systems Agency, and the Coast Guard, sponsor these meetings because PTTI plays a key role in almost all military operations.

These operations are pretty straightforward. We have operations in communications. We want to synchronize our communications so we can talk to one another. We want detection and tracking using disparate intelligence, surveillance, and reconnaissance assets. This is using many different sensors, making sure that timing those sensors is all the same so that we can avoid ambiguities in our target selection. Really, what we are talking about many times here is precise positioning of different things on the surface, in the air, or in space.

In addition, the DoD has put a great emphasis in the last few years on transformation. This is a magic word among DoD people. If you are asking for money from DoD, you should use transformation many, many times. One of the big transformations here is using network-centric operations, that is, to actually have everybody on the same time. This is extremely important in any kind of operations that we have. It allows each participant, whether on a ship, aircraft, vehicle, or a person to be a node in that network, synchronizing everybody together with a common time. We know that the whole is going to be greater than the sum of its parts. This requires coordination between the nodes and we need a common, absolute time, temporal reference frame for the whole network.

For that, precise time is fundamental for the interoperability of these nodes. When you have interoperability, you want to use all of your assets in any kind of operation. This goes for DoD as well as for the UPS truck delivery system. You want all your trucks delivering packages; you want them all synchronized to get maximum efficiency for your operations.

So there is a common thread here of the use of time for many, many different applications.

Let's talk about precision. This is one of the things, as far as I'm concerned, where we want to have very good time. We need excellent time. The question today is that it is fairly easy to get time via GPS at a fixed location and get it at the 10-nanosecond accuracy. It is available now, but who is using it? One of the problems we have in DoD, and we are going towards using it, is the use of GPS for precise locations. But we look at many, many DoD systems, at the systems themselves, and although we give them very good time, they are limited in their accuracy and position location. This is due to the fact that the electronics are not up to snuff.

Something that we need to do at the meeting here is to educate people to ask what kind of time they need, and how good can we get time? So when these systems are actually built, you will actually use the proper time to its ultimate and make the system operate in its proper area.

In 2013, which is my guess, what we want to do is use picosecond time instead of 10 picoseconds. With the development of fountains and other devices, this is what people are going in to say about optimum frequencies for standards. This is not that far-fetched. What would you use it for? Well, one of the things that we would certainly use it for is for space operations. The space operations with dilute synthetic apertures could look down or look up. Looking down, they could be use for some military operations and geodesy. Looking up, they could be used for astronomical applications.

So in the future, there are many, many applications here with picosecond timing. This is the reason that the DoD sponsors this meeting as well as NASA. NASA sees a future need for precise timing in space for their operations.

When we talk about DoD, what are some of the gaps that Capt. Gillard sees as a military person? What he is looking for is #1) more accurate realization of UTC. I am sure if you hear from the BIPM, they will say, "What is this person talking about?" What he's talking about is more accurate realization in real time of UTC. He wants the time now for his operations. He cannot afford to wait until some time in the future to say, "Okay, the time was accurate on this day to a nanosecond or so."

He wants #2) a common, absolute time standard among all participants, both DoD and others. We know we have almost absolute time standards; look at GPS. We do have BIPM. But again, it is in real time that he wants it for both DoD and others, because he is looking at using both DoD and commercial systems.

Another focus area that he has is #3) better dissemination to the end user. Right now, we are using GPS. We are getting very good time dissemination, but we think we could do better. One of the main problems that we have with GPS is calibration. Every time I discuss calibration with the people at the Observatory, there are always a few nanoseconds running around the room, so to speak. Although we always do everything to 100 picoseconds or 10 picoseconds, I put my finger on it and say, "That is great precision you have there; what is the real accuracy?" This is more difficult than you think it is, to actually get the accuracy down to a nanosecond.

And finally, we have #4) mitigation of vulnerability studies. He sees that we have GPS. It is a single point of failure. What happens if GPS goes away and you are dependent on 10-nanosecond timing globally. Where do you go? One could say that you have two-way satellite time transfer, but that is very limited in the number of stations that you can have. The nice thing about GPS is that it is broadcast over a wide region, it is globally available, and that is what is really needed.

This is what we have right now; we have GPS in space for use of time. But in the future, what I see – maybe in 2013, maybe 2020, a vision statement – are satellites in space with precise clocks on them and clocks on the surface here; and these all go together to make a common time reference. That is something for the future – which we almost have now.

What topics do we have at this meeting? We have commercial timing dissemination and performance. These are some of the commercial vendors that we see here today and who will be giving small talks this morning. In addition, we can view their equipment in the room next to us. We have, I think, over 20 different vendors. This shows real progress in actually developing commercial devices that we can all use in our timing laboratories.

We have talks on Standards Laboratory Reports. If you want to find out what the different timing laboratories are doing worldwide, we have many reports here for you that are going to be given.

We have different topics again that are very interesting. Satellite time transfer: we will talk a little bit about GPS and Galileo. We will talk about algorithms, timing systems, and measurement technology as well as military systems and advanced clocks.

I think we have on the order of 48 audio papers to be given and we have 16 papers in the poster session. So that is a lot of material to absorb in the next 3 days.

In addition to these papers, which I think are very good, we have working groups: one on the future of UTC, one on PTTI needs, and one on calibration issues. These are the very topical topics that we do need to discuss and go forward with. So there is a lot of information at this meeting, as I said, in just a short 3-day period.

So what are we going to do at this meeting? This is a slide Captain Gillard put in here. We are going to educate and advocate. We are going to listen for opportunities to fill needs, innovate, attack all facets of timing error budget, share lessons and technology, and cooperate in R&D. This is the major part of what we are getting done at this meeting. It is very, very important.

We have a large number of papers here. The large number of papers shows the viability of this whole area, that there are a lot of very interesting things going on. After 35 years, this topic is still interesting and gets an old guy like me, who comes here, to learn new things.

With that, let me wish you a very successful meeting, and thank you very much!