DoD and Navy PTTI Report

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Abstract

In addition to its national responsibilities in astronomy and time, the U.S. Naval Observatory (USNO) has also the responsibility for overall DoD PTTI management. This function, originally established by DoD Directive in 1965, has now become part of DoD Instruction 5000.2. This instruction emphasizes the need for a common time reference (the USNO Master Clock), in addition to the need for widest coordination "to ensure worldwide continuity of precision." It also directs the appointment of PTTI managers from DoD Components to assist the DoD manager in the development of the Annual PTTI Requirements Summary, and in coordination of PTTI techniques among the Components. While the PTTI segment of the various electronic systems that use precise time is usually but a small piece of the action, it nevertheless is frequently the most critical one for the precise accomplishment of the mission. This is now generally recognized as one of the lessons of the Gulf War: Accuracy Saves Lives! As a consequence, we see today the emergence of another round of developments that aim at greater accuracy capabilities in the kind of scenario envisioned under the doctrine "From the Sea." The PTTI technology is deeply involved in these developments and this paper gives some examples.

This morning I am going to report on some aspects about the Department of Defense (DoD) Precise Time and Time Interval (PTTI) program: a) the PTTI managers and representatives and who they are; b) some of the actions that came out of last year's PTTI conference; c) a little bit on timing research and development; and finally, d) the importance of the requirements process.

First of all, what are the PTTI managers supposed to do? They are concerned with requirements, inter–operability, and standards. The issue of inter–operability is absolutely vital to the DoD, and not only the DoD but the rest of the nation as well. Concern with this issue is the major role that I see for the PTTI representatives. We cannot have services going off and developing their own systems, i.e., duplication of effort, in today's arena of dwindling resources.

Everything we do, particularly today, as resources become tighter, is tied to the requirements process. Why do we need better clocks? Why do we need ensembles? Why do we need the coordination of time? All has to be tied to DoD operations. If we are going to spend DoD dollars and cents on this program, we have got to be able to bridge the gap about which Dr. Winkler was talking, i.e., of going from the technical and engineering language of the folks that understand the aspects of precise time to the language that the program managers, the people that control the dollars and cents within the DoD, understand and appreciate. They are the ones who can say "Yes, I am willing to spend dollars to get timing down to the hundred picosecond level, down to the one picosecond level because I need it for 'x'." This is absolutely

vital. Finally, the Research and Development Program needs to be coordinated so that it does support the requirement process.

Who are the PTTI representatives and managers? We have two levels essentially. The representatives (Figure 1) are the policy folks. They are at the senior level within their services. They essentially set policy for the DoD. The managers (Figure 2) work the day–to–day issues and problems that come up. These listings of our representatives and managers are current. Commander Dave Markham from SPAWAR has replaced Jay Berkowitz from SPAWAR. These are your points of contact within the DoD. You should know them.

A few words about the workshop from last year. One of the action items that came out of it was to put together a glossary of terms. It is important for newcomers into the field. One of the things that we talked about a little earlier was Father Time. You can take a look around the room and you see that we have a number of folks that can match him in terms of number of years in the program; but there are a lot of folks that are brand new to the program. What is precise time? Many of us have never thought about timing before. All of a sudden they are becoming experts within their areas of responsibility. Certainly, we have a new generation coming on board at the USNO. As a matter of fact, yesterday was the first time I have heard the term "Grandfather Time" in referring to Dr. Winkler.

Environmental versus the stochastic effects in clock technology and also measurement noise versus the actual clock noise is another concern. When we have a problem at the nanosecond level, what are we measuring? Are we really measuring the impacts of the noise? Or are we limited by our measurement systems? What are the environmental impacts? These were areas specifically identified in last year's workshop for additional work.

Next in our list of concerns are the impact of the improved frequency standards, the smart clocks, the 5071 Cesiums which are all remote–steerable. We don't have to have a man in the loop at the site. It can all be done by computer. The impact on having the capability to be able to remotely steer a clock and not have to have a dedicated resource sitting at that site is tremendous. The implications are savings in terms of dollars and cents, and also in our ability to have accurate time at remote sites. On the requirements issue, I'll talk a little bit about that later.

As I mentioned, we have a lot of experienced folks in this room and a lot of new folks. For the new folks there are a number of training opportunities available to us today within the DoD for PTTI, as shown in Figure 3. The annual meetings are excellent grounds to learn what is going on in the community, meet the people who are the community and are the experts, and discuss both the applications as well as the technological advancements. With regard to the Automated Data Service, the bulletin board, if you aren't on that bulletin board, you should be for exchange of information. Service training schools: the one at Lowry will be moving to Kessler since Lowry Air Force Base is closing down; and Ft. Gordon is the Army School in Georgia. There are also many tutorials and seminars of which you need to take advantage. For such an important area within the DoD, it is a very limited training opportunity!

Let's talk a little bit about our Research and Development Program, the exploratory 6.2 and 6.3 work. In Figure 4, you can see the correlation between the exploratory work that we are doing to improve clock accuracy and stability as well as to improve the models. With regard

to new prediction models for polar motion, we are taking a look at using GPS instead of the VLBI radiotelescopes that we are using today. GPS may be able to help us in some of the polar motion studies.

Time transfer improvement; especially, two–way satellite time transfer, you will hear a considerable amount about that later on today. The improvements that we can make in GPS will given help the proliferation of GPS receivers that is coming on line today. The key question is just how accurate can we transfer time through GPS; how precise can we be? Similarly this leads to the advanced research and development that you see in Figure 4.

The preceding speaker talked a little bit about progress in PTTI. In Figure 5, we see that in about every ten years, there is an order of magnitude of increase in our capability to provide precise time. The devices we have used have really been tied to those order of magnitude increases. I have "ion storage device" up there for the year 2003, to get down to the hundred ps. That is a guess; I don't know what the next hardware piece is going to be; you folks are the experts in that. Can we use cesium? Will it continue throughout? It is largely driven by this question mark that you see right here and that is, "What is the requirement? Who is the user out there? What do they need? Why do they need it?" And then, "How can we provide it? Is 2003 good enough? Do we need to be at the hundred ps level in ten years or do we need to be there next year or the year after?" That is part of the requirements process. And that needs work.

Time distribution: LORAN–C is being phased out as a DoD navigation system; however it is very vital to time transfer. GPS and GPS common–view capabilities get us down to ten and five nanosecond range, with two–way satellite transfer, we are rapidly approaching a one nanosecond capability. I am not certain that we are there yet with reliability and universal applications, but we are rapidly getting there. Certainly, GPS is again critical to our ability to distribute time and ties right in to the requirements.

I would like to conclude with a discussion of the requirements. Our requirements in navigation, communications, time systems, and targeting systems within the DoD have been well defined for a number of years. But they have been well defined in terms that in the past have not been scrutinized as closely as they are going to be. As we approach the next budgeting, planning and programming process within the DoD, it is going to become absolutely critical that we articulate what our timing requirements are and how that translates into the operation of the master clock at the USNO, the time reference stations that we have throughout the DoD and throughout the world. How do we get that time information into the hands of the operator and to the operating systems that need that timing information?

I was very impressed yesterday when I got a chance to see some of the hardware demonstrations, particularly in the area of communications and navigation. For those of you who did not see the hardware yesterday, make sure you get a good look at some of the capabilities of the hardware, the dollar and cents involved in procuring that hardware. It runs a considerable range. If a ms is good enough, you can buy a three hundred dollar GPS receiver today. If you need ps capability, then you need a much more sophisticated piece of hardware. We also need to do the research and development to give us that capability. And as PTTI DoD manager, I have to be able to stand up in front of DoD and say I need this much money to conduct this

kind of research and development to produce this sort of a master clock by this year in order to satisfy those DoD requirements. And that is really what the bottom line is in terms of the DoD: what is my operational requirement, when do we need to get there, and how do we get there?

When I talk about the DoD, it also reflects our national interest. Very quickly, our national interest in communications, particularly in high data rates, as we get into data exchange and data processing, is the future of the world. And I think that there is a lot of work that we do behind the scenes in precise time that is going to become much more visible to the world of telecommunications here in the near term.

That is a summary of where we are within the DoD and within the Navy. Thank you.

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Information and Training in PTTI

★ **Two Annual Meetings**

- ➡ PTTI Applications & Planning Meeting (Dec)
- ➡ Symposium on Frequency Control (June)

★ **Automated Data Service**

★ **Training**

- ➡ Service Training Schools (Lowry AFB, Ft. Gordon)
- ➡ Tutorials (USNO, ARL)
- ➡ Seminars (NIST and Commercial Sources)

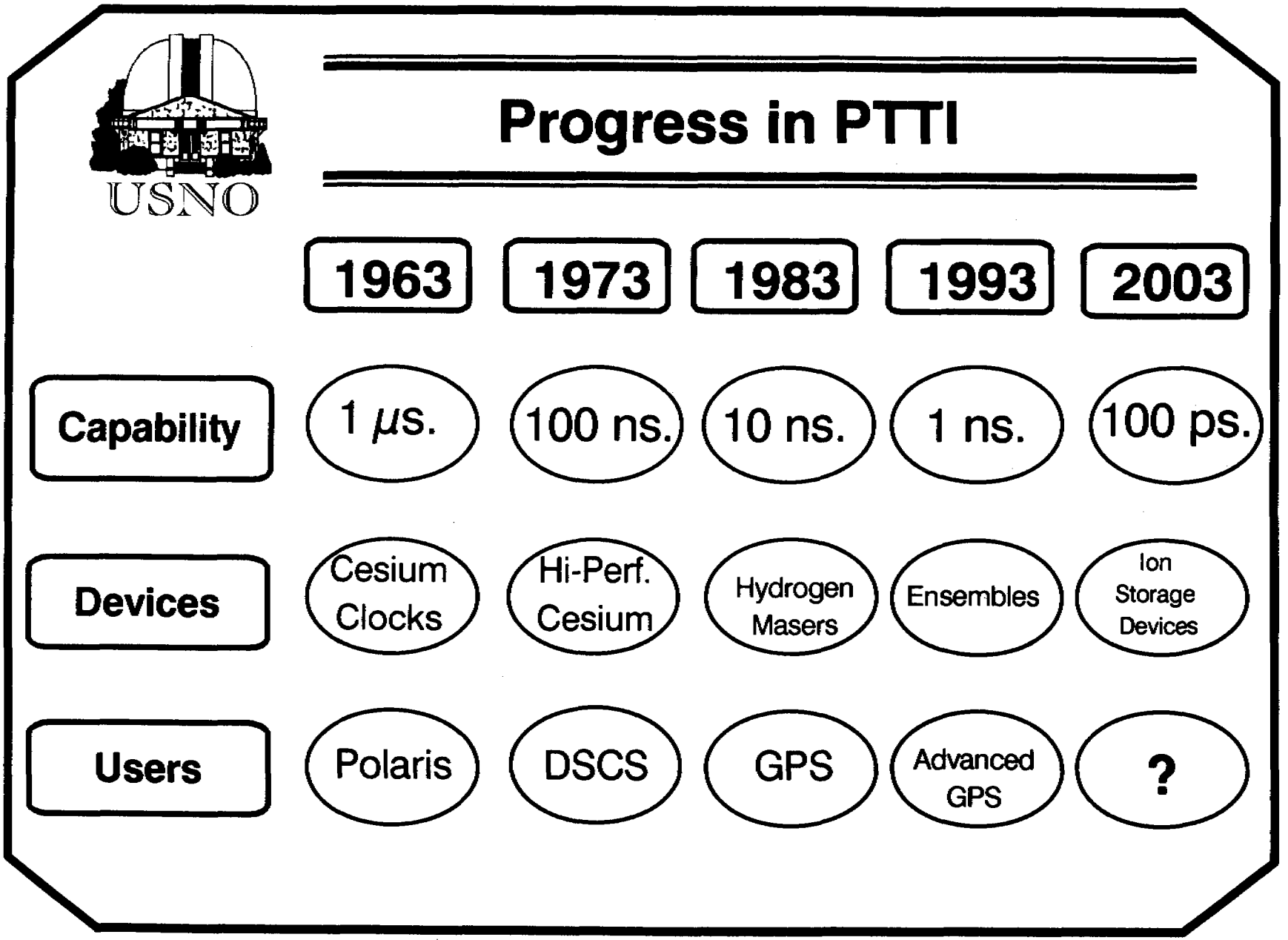
PTTI Development Program

★ Exploratory (6.2)

- ➡ Improved Clock Accuracy & Stability
- ➡ Improved Algorithms & Statistical Models
- ➡ New Prediction Models for Polar Motion
- ➡ Time Transfer Improvement
  - Two-Way Sat. Time Transfer
  - Laser Techniques
  - Increased GPS Accuracy

★ Advanced (6.3)

- ➡ Master Clock Upgrade
- ➡ Time Transfer
- ➡ VLBI for Earth Orientation
  - Polar Motion Studies


USNO
Progress in PTTI
1963
1973
1983
1993
2003
Capability
1 μs.
100 ns.
10 ns.
1 ns.
100 ps.
Devices
Cesium Clocks
Hi-Perf. Cesium
Hydrogen Masers
Ensembles
Ion Storage Devices
Users
Polaris
DSCS
GPS
Advanced GPS
?

QUESTIONS AND ANSWERS

Pat Romanowski, Allen Osborne Associates: I have one question for the last speaker. That is whether or not you tie your time back into UTC and the broadcast over – I believe it's WWV.

Howard Hopkins: As far as I understand it, the time that we get through the USNO is UTC time. I am not sure what they do, however, at the PMEL level. I know that they receive time off the GPS and I assume that they correct their cesium clocks for that. But beyond that I just can't tell you any more.

Christine Hackman, NIST: I have a question for the first speaker. You made some mention of a bulletin board that we all should be on. How do you access it?

Richard Blumberg: The bulletin board is at the USNO; it is called "Automated Data Services." I will ask for some help from Dr. Winkler as to the details of how you access it.

Dr. Winkler, USNO: In every *Series IV*, which comes out weekly, there are instructions to do that on Page Two. The telephone numbers are also there. The bulletin board is accessible on three telephone numbers with any modem speed up to 14.5 kilobytes per second. It is available also on Internet. That information is widely distributed. We have asked for a password to access it, simply because for a while we have been inundated with inquiries and tests coming from all kinds of people. That is why we had to restrict access to the bona fide PTTI user. But there is no problem for anybody here to get that.