MIL–STDS and PTTI
What's Available and What Needs to be Done

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Abstract

The systems developer who needs PTTI capability has relatively little guidance in the form of military standards, particularly for systems using atomic clocks or other sources of very precise time and frequency. This paper will discuss the existing standards, including MIL–STD–188–115, MIL–F–2991(EC), and DOD–STD–1399. These documents were written several years ago and do not always reflect current practice or take advantage of more recent technology improvements. User needs have also changed over the years and some of those needs such as more detailed time codes are not being met. We will summarize what's available and what's good and bad about it.

The second part of the paper will make suggestions about what should be done in the future to promote and facilitate good PTTI design practice. Topics will include clock performance parameters, environmental considerations, time codes, signal isolation and time dissemination.

EXISTING STANDARDS AND THEIR ORIGINS

For years, the annual Frequency Control Symposium and the Precise Time and Time Interval Applications and Planning Meeting have tried to get up–to–date information on timing to the managers and designers. However, some of the key people don't know that they exist and some others don't know that they apply to their programs. Military standards written to alert responsible people to timing issues and to impart some standardization into timing systems have also had only moderate success — partly for the same reasons, but also because of their limited applicability or their inadequacy for some of the newer systems. One way to get the attention of potential precise time and frequency users is to place references to a DOD–STD or a MIL–STD in some of the more general standards, such as those for ships, aircraft, or installations, where integration of the systems should be addressed.

Standardization is not a new issue. The subject was addressed at the PTTI meeting in 1980 in a "Government Planners" session and an "Industry reviews session, in 1981 in a "PTTI Requirements and Specifications" forum, and in 1982 in a panel discussion on "Future Timing Requirements". In 1980, Martin Bloch of FEI reported to the PTTI Meeting that requiring small changes from an otherwise fairly standard product was costing the Government large amounts of money [1]. In 1981, James Bowser reported [2] that "...the planning process for PTTI support is less than a well defined, coordinated process".

About 10 years ago, Dr. Nicholas Yannoni of RADC called a meeting of Air Force PTTI users and found that precise timing devices were far from standardized; some cesium–beam standards, for example, produced only special, non–standard frequencies. The Navy found that each system requiring PTTI usually brought its own standards aboard, so that there was much duplication, but no means of coordination; there was some interest in the Navy for a standardized platform distribution system [3, 4]. In general, timing systems (even those aboard the same platform) had been developed completely independently. This is still a problem, but there has been some effort to resolve it.

MIL–STD–188–115 was developed as a standard for timing and synchronization of tactical and long–haul communications systems. It included some pet projects as well as some useful standardization. As in many committees, there were few specialists on the subject at hand, but it was not too difficult to accept the precedent of DOD–STD–1399–441, which had been drafted earlier by NAVELEX to help standardize Navy platform distribution systems. 1399 had little in the way of dogma, but did list some standard frequencies (100 kHz, 1 MHz and 5 MHz), precision time pulse rates of 1 pulse per second (1 PPS) and 1 pulse per minute (1PPM), and two time codes, each having an on–time feature. One was a 50 b/s, binary–coded–decimal (BCD), dc code giving units and tens of hours, minutes, and seconds once per second. (This time code and the other signals were provided by the Navy's cesium beam specification, MIL–F–28811(EC). The other was Time Code 2137, which gave the same information once per second, but used pulse–width modulation at a 25 PPS rate; the pulses could be either dc or an amplitude–modulated 1000 Hz carrier.

MIL–STD–188–115 adopted a preferred frequency of 5 Mhz (with 5 X 2n MHz acceptable) and a precision timing pulse rate of 1 PPS. It also required a clock either to display time of day (TOD) in hours, minutes, and seconds or to generate a time code with the same information. At first, the 1399 BCD code was considered. The goal for the standard was a minimum interface to allow collocated timing equipment to be shared or pooled. The purpose of the code was simply to resolve the ambiguity of the 1 PPS, although it could be used as a lower–precision, stand–alone time reference. However, there are other aspects of precise timing that might also be crammed into a time code, including the day of the year and a time figure of merit (TFOM). The BCD code was therefore allowed in three versions: the 6–digit (24–bit) TOD format, TOD plus a 3–digit (12–bit) day of year (DOY), and TOD plus DOY plus a 1–digit (4–bit) TFOM.

The TFOM was a new concept, at least to those in the 188–115 working group. It appeared that one normally knew the capabilities of the reference systems that were in use and therefore knew the time errors that could be expected. A clock ensemble might be able to estimate its own inaccuracy, and a GPS receiver might give a worthwhile assessment of accuracy based on signal–to–noise ratios, geometry of the satellites in use, and the consistency of the time solution with more than the minimum number of satellites. However, except for outright failures detected by built–in test equipment, a single clock generally does not know its own accuracy. An estimate might be made from the specified frequency stability, the accuracy of the last time and frequency updates, and the elapsed time since the updates, but inaccuracy can also come from undetected failures or environmental conditions. The TFOM, therefore, might be regarded as a warning, but not as a guarantee, unless there is a solid basis for verifying accuracy. Nevertheless, a TFOM definition was created for 188–115. Using the 1399–441 definition of precise time as 10 ms or better, the largest described error would be "greater than 10 ms or fault". The lower limit used in the TFOM was

1 ns, because technology was pushing such precision (if not accuracy), and the 188–115 TFOM ranked accuracies in decade steps from better than 1 ns to more than 10 ms.

When it was found out how the TFOMs were to be used, it was apparent that the 188–115 TFOM was not all that the users wanted. HAVEQUICK and others were seeking ways to use marginally capable clocks in what could be called a fluid timing hierarchy. The TFOM would be based on a sort of worst–case performance and the accuracy of the last update. Within some ranges of timing uncertainty, the TFOM would describe the uncertainty in increments as small as ten percent.

The interface control document for GPS military user equipment (ICD–GPS–060) was being developed at about the same time as MIL–STD–188–115 and made use of its timing interfaces. It provides for a time display, the full version of the BCD time code (Figure 1), and 1 PPS (Figure 2). It can also accept 1 PPS and the time code for quick acquisition of the GPS satellite signals. Because of its internal design, the user equipment (receiver) could not easily generate an accurate 5 MHz signal, so it does not supply one, but it did accept a 5 MHz input, which it terminated with a 50 Ohm resistor. Besides the 188–115 interface, the GPS user equipment has two other timing interfaces: a HAVEQUICK time code and a MIL–STD–1553 bus interface.

HAVEQUICK is a frequency–hopped communications system used by aircraft and other platforms. The HAVEQUICK time code is gaining in both popularity and content. The most recent version is the third. The MK–XV IFF was working towards a similar code before its development was discontinued, and it might have adopted the HAVEQUICK version. A working group of NATO is currently drafting a precise time and frequency standardization agreement (STANAG 4430) and appears to be leaning towards a HAVEQUICK–type code. The HAVEQUICK code has a nominal 10 μs resolution, although a shorter rise time could improve it.

The MIL–STD–1553 bus is basically a computer interface. GPS–ICD–060 shows it used in conjunction with the 1 PPS precision signal to distribute time.

STANDARDIZATION ISSUES

Standardization is more complex than it first seems. Part of the problem is the wide range of requirements vs. resources. A common standard of **performance**, for example, cannot simultaneously apply to a laboratory and a land–mobile unit. Standards based on current usage in the field could well stifle progress. Part of MIL–STD–188–115, in fact, prescribed performance standards specifically for the long–haul portion of the Defense Communications System. This performance could not be realized in many applications.

In choosing what to standardize, the full effect on all users must be taken into account. Simply selecting a common time scale can have major implications for PTTI: the versions of UTC maintained by different nations may differ by tens of microseconds. (The time scale used by the U.S. military is the version maintained by the U.S. Naval Observatory Master Clock). Within the expert PTTI community, such things can usually be handled rather easily, and they might be ignored by others who need only millisecond accuracy. For operational use at greater accuracies, they must be resolved beforehand, or means must be provided to the operators for dealing with them. Also, the UTC leap seconds can and often do lead to disorder within systems that need precise time only for synchronization. Some systems such as GPS and LORAN C do not observe them; International

Atomic Time might also be considered, but by going to any different time scale, a correction would have to be applied to the time given by the numerous UTC time–dissemination services.

Perhaps the best that can be done now is to standardize an interface that will not limit performance. Clock performance will, of course, continue to be platform–dependent, and each platform will require a clock that can satisfy its most demanding user system. However, a standardized interface that would **support** more demanding uses might still be realized if it does not intrude unnecessarily on system or platform design.

Assuming that the purposes of standardizing are to permit comparisons of clocks and to facilitate interoperation and time and frequency distribution, the elements specified in MIL–STD–188–115 (a precision timing pulse, a time code and a standard frequency) would seem appropriate, although the specifics of MIL–STD–188—115 might be subject to debate. For example, instead of the precision timing pulse, a precise timing mark might be some feature of the time code that describes when the mark occurred. For that matter, a standard frequency might also be recovered indirectly from the time code or the timing marks, but there is normally a need for clean, accurate standard frequencies in a precisely timed system.

It is a foregone conclusion that not all systems will be able to use the standardized signals and formats *per se*. An array of adapters or converters might be fielded to serve systems that cannot use the standardized interface directly, but the interface should be chosen to serve the great majority of current and future users without conversion.

In designing an interface, it must be considered how signals will be brought to and from it and possibly even what connectors or physical connections will constitute the interface. Because of the great amount of existing equipment and the local nature of most distribution systems, the interface should probably be electrical, even if fiber–optic lines are sometimes used. Since the standard frequency and precision timing signals are analog (as is the time code if its on–time feature is to be used as a time reference), small amounts of interference or noise can degrade them. For precise work, connectors should provide continuity of shielding used on the signal-bearing lines. Multi–pin connectors without individual line shielding should generally be avoided in order to reduce crosstalk and electromagnetic interference (EMI). There are, however, many uses of timing signals that are borderline according to the PTTI definition and for which multiple–conductor cables might suffice.

STANDARD FREQUENCY INTERFACES

Some performance attributes of interest at a standard frequency interface are the sometimes heavily overlapping qualities of frequency stability, spectral purity, single–sideband phase noise, harmonic content (for sine waves), spurious signal content, and jitter. Frequency accuracy is a performance function of the frequency reference, and the standard interface is intended only to preserve accuracy—not to establish it. It is assumed here that the phase of the standard frequency is of no interest to the user, but the constancy of the phase relationship with respect to the precision timing signal might well be consequential. It is probably too much to ask that an absolute phase relationship between the two signals be specified at the interface since they will most likely be distributed on separate lines, and the interpretation of the timing signal may also vary somewhat from user to user. An important relationship for many systems is that the standard frequency and the precision time signal be derived from the same clocking signal; thus, equipment using the standard frequency would not have to be reset occasionally to maintain agreement with the precision time pulse.

The nominal frequency of the signal deserves some consideration. 5 MHz has been used by much military and civilian equipment and is a good compromise frequency for many purposes, although 10 MHz is gaining popularity. At 5 MHz, losses in common coaxial lines are low enough that it can be distributed more than 1000 feet with less than 6 dB loss. At higher frequencies, losses would increase, but at lower frequencies, small amounts of noise or interference would cause larger fractional frequency deviations or jitter. Conceptually, the MIL–STD–188–115 preferred frequency of 5 MHz, with options of 5 MHz X 2n may have some merit, although most existing 5 MHz equipment would require an active frequency divider (and perhaps a filter) if $n > 0$.

A standard frequency signal might be distributed as a sine wave or a pulse chain, such as a square wave. Narrow–band filtering can be used to recover the fundamental frequency of a square wave. However, a sine wave having the same fundamental power as a square wave would cause less EMI. A low–duty–cycle pulse train which could be generated with less power expenditure than a square wave would provide little power at the fundamental frequency, and triggering techniques would likely be employed to recover it; false triggering would be a threat in an impulse–noise environment and could produce very large instability in the recovered signal. The voltage and impedance of the standard frequency signal might be specified, although distribution amplifiers or attenuators can be used to adjust the voltage if the equipment can deliver a clean signal to the interface.

TIME CODE INTERFACES

While MIL–STD–188–115 permits either a time readout or a time code, a time code is more useful if timing information must be distributed around a platform or installation. Other situations that would be best served by a time code include initializing a precise time reference of an aircraft or land mobile platform whose power had been turned off. In these cases, if the mobile unit is then to maintain time autonomously, other information, such as the date and direction of an impending leap second, would be needed. For some automatic equipment, the day of the year and even the year of the century would also be required. For distribution around a platform or installation, a TFOM would not ordinarily be especially useful, except to declare failures detected by built–in test equipment or to warn a lower–level disciplined clock of substandard service being provided to it. If the platform might later use a time reference such as GPS, it may be more convenient for the externally loaded time code and the one provided by the GPS receiver to be in the same format, or at least a compatible format.

In the past, much information now being asked for in the various time codes was supplied manually. A "universal" time code might be developed, but before doing so, a wider search of time–code needs and practices should be made. Some thought might also be given to adapting an existing code. The 50–bit–per–second BCD code has insufficient room for expansion. The HAVEQUICK code does not give leap–second information, although there seems to be enough room for considerable expansion. The IRIG A, B, and G codes give a time of year at least once per second, but do not give the YOC, TFOM, or leap–second information. The "control" bits available in them might be designated to supply the other information. If the HAVEQUICK or an IRIG code is selected as the standard, any added bits or the use of existing control bits should be standardized; it would be prudent also to leave sufficient room for additional information that might become standardized later. Even so, it would not be surprising if other functions were tacked onto the code just because it is convenient.

PRECISION TIMING SIGNAL INTERFACES

A precision timing signal might be part of a time code, or it could be a separate pulse rate. One pulse per second has been widely used in precise timing; the GPS user equipment ICD, MIL–STD–188–115, and much existing equipment specify a positive 20 us pulse with a rise time of less than 20 ns. This is a reasonable specification for much work, and it doesn't take too much coaxial cable to stretch a shorter rise time to 20 ns or more, anyway. Earlier equipment used a 10 V pulse, but some devices now use transistor–transistor–logic (TTL) output levels. (A TTL 50 Ohm line driver usually delivers about a 3 V pulse).

However, some laboratories and even operational systems are now dealing with single–nanosecond resolution. How different measuring instruments respond to a pulse rise of 20 ns (or more) is then pivotal. Given the difficulty of maintaining a shorter rise time, even if one were generated, a more practical approach may be to standardize on how a pulse is perceived by a user or measurement system. USNO has regularly used a specific voltage threshold in their portable clock measurements. (A 1 V threshold used earlier was later changed to 1.5 V to avoid noise that was present on some systems). But the difference in their practice and how a VSAT two–way time transfer modem or a GPS receiver used in simultaneous viewing would perceive the pulse might differ by a much as, say, 10 ns.

If a measurement standard were to be adopted, it might well include some other features that would improve reproducibility. In some of the current (10 V) pulse–generation specifications, the tolerances of the low and high levels of the pulse are one volt. These are simply undesirable by–products of pulse generation, but they limit flexibility in choosing a threshold. If the measurement system used capacitor coupling (e.g., the circuit of Figure 3), only the dynamic portion of the pulse would be of interest, and the tolerance of the low level would not be a concern. Furthermore, if the pulse rate is once per second, an input circuit time constant might be made small enough to reduce considerably the often experienced effects of ground loops at mains frequencies of 50 or 60 Hz.

A standard input circuit would not be needed by most users. However, if one is specified, it should be able to operate with both the 10 V and the TTL–level 1–pulse–per–second signals. The following specifications might be appropriate:

Input Impedance:

Nominal value: 50 Ohms
VSWR: <1.1 from 20 kHz to 200 MHz
<1.3 below 20 kHz
DC resistance: 50 Ohms ± 10 Ohms

Trigger circuit: Capacitor Input:

Time constant = 100 ± 20 μs
Trigger point: +1 V ± 0.1 V on dynamic rise

The VSWR specification is necessary both to avoid reflections and to set a standard impedance for measuring the pulse. A time constant of 100 μs is large enough to work with pulses of very large rise time (although accuracy would suffer) and small enough to discriminate against 60 Hz signals by almost 30 dB. A strict tolerance on the time constant is not needed unless the pulse rise time is more than 10 μs.

The length of the pulse is not especially critical if the leading edge is used as the reference feature. Only low–accuracy timing systems could use a long pulse to advantage; otherwise, a long pulse is just a waste of energy. A 10 or 20 μs pulse should be adequate for local distribution.

SUMMARY

A standard precise time and time interval interface could make it easier to serve and coordinate precisely timed military systems. Money could be saved; in some cases, by pooling or coordinating platform resources, performance and reliability could be improved. The degree of standardization will undoubtedly be a compromise because of the amount of existing equipment and the wide range of requirements and the technologies available to support them. Just standardizing the types of signals at a standard interface would be a step forward, even if amplifiers, hybrid connectors, or other crutches are sometimes needed.

Probably the most controversial element will be the time code. Several different time codes may be needed to serve different types of users. Modulated–carrier time codes, for example, are still needed for instrumentation recorders that cannot record DC signals and might also be used in voice–frequency circuits. DC codes are easier to generate and use in most other local applications. The MIL–STD–1553 code could be used to interface with computers, although for precise work, a precision timing pulse is also needed.

The content of a code would depend on where the basic information would be injected into the timing hierarchy. For example, will leap–second, day of year, or year of century information be injected manually? If so, where? If TFOMs are used, there should be a standard method of determining them or at least evaluating the confidence that should be placed on them. Used indiscriminately, TFOMs can cause large reliability problems. For the purpose of standardization, a coarse TFOM such as provided in MIL–STD–188–115, or even just a warning flag, might be adequate. The coarseness actually may be advantageous, because it would tend to discourage its use for selecting a reference based on minor and meaningless TFOM differences. Space might be reserved in the code for user–defined TFOMs or other user–specific information; if it is, the type of user should also be identified so that other user types would not be confused by the information.

Finally, the question of applicability should be resolved. The interface could be required of each clock brought aboard by each platform system. (A clock for these purposes would contain its own oscillator and therefore be able to operate autonomously for some period of time). The whole picture changes if those responsible for platform design and integration also take responsibility for providing the precise time and frequency services needed by all precisely timed systems. (Such a philosophy was adopted from the start in the SSN–688 class of submarines and likely some other platforms). This approach is the one with the greatest potential for success.

REFERENCES:

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[3] R. Allen; *"The Navy's Stnadardized Precise Time and Time Interval Platform Distribution System"*. Proc. 36th Annual Symposium on Frequency Control; 1982.

[4] J. Murray; *"Platform Distribution System Specifications"*. Proc. 37th Annual Symposium on Frequency Control; 1983.

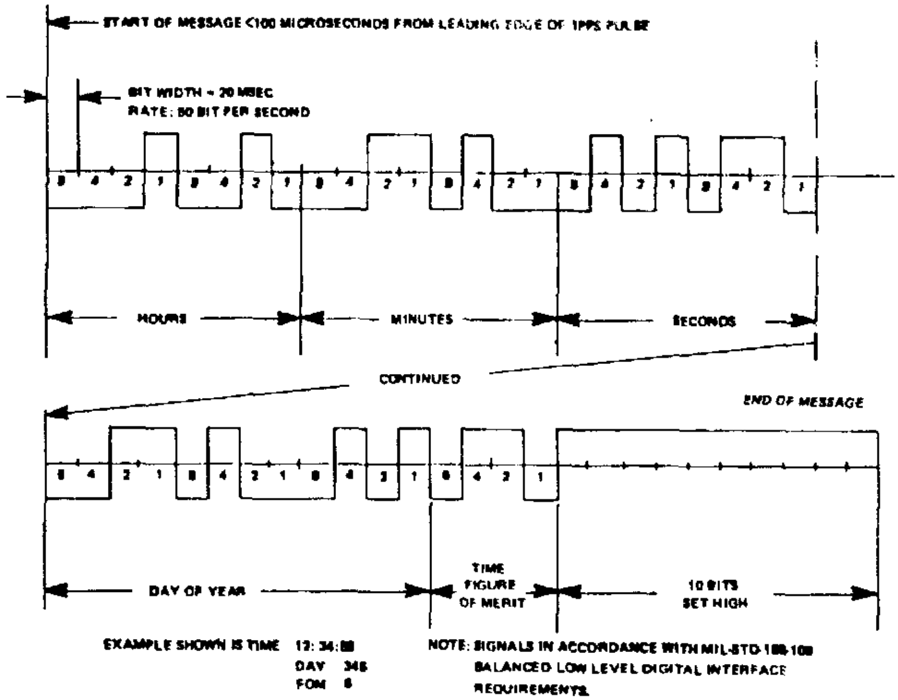
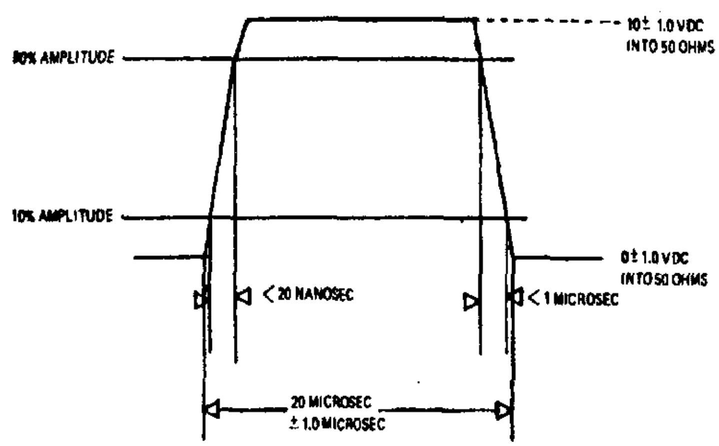
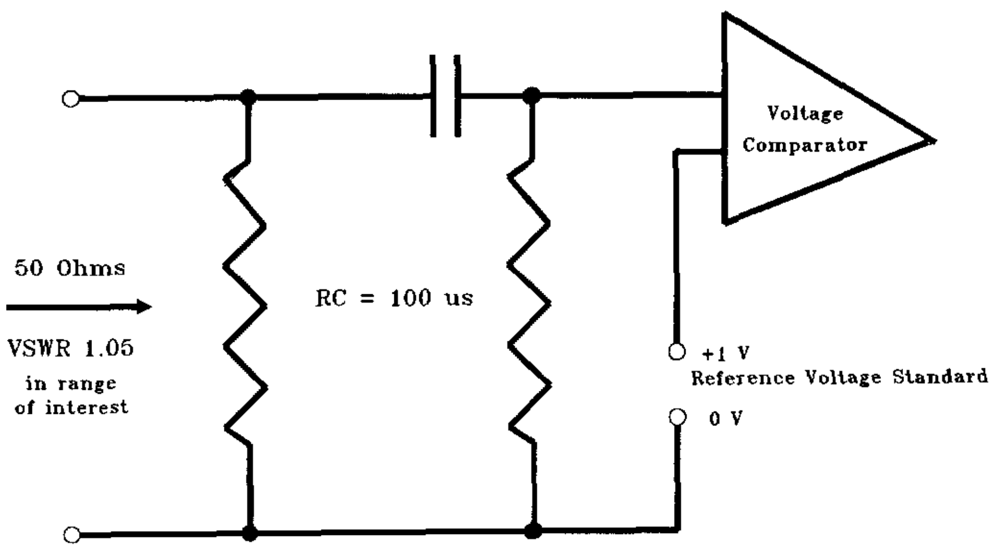


Figure 1. BCD Time Code



THE LEADING (POSITIVE GOING) EDGE OF THIS PULSE INDICATES ONE SECOND ROLLOVER.

Figure 2 One Pulse per Second Output



Example of Standard 1PPS Input Circuit
Figure 3.

QUESTIONS AND ANSWERS

G. Winkler, USNO: I think your excellent paper has raised several points. First the identification of the second and the problem of identification of the year. Many systems and our own operations with the observatory identify the second through the MJD plus six decimals. That is a very convenient way, strictly decimal and very easy to convert into any other format. After all, the calendar is well defined in advance and I think it avoids all these problems of the year change and the century and what have you. Second point, in the DSCS there is no reason what so ever why the DSCS came up without the same standards with the same procedures as LORAN and GPS and that is simply to ignore the leap second within the system. The problem is that we have difficulty in getting everybody together because DSCS is operated through the services with a more or less loose supervision by (?) and the problem is purely one of coordination, but my recommendation would be to do exactly the same thing as what we do in LORAN. That is have no interruption what so ever and a coherence in the electrical system, but do things through a table of coherence or a table of offset. After all OMEGA, LORAN, GPS and all of these systems do that and they avoid the problems of resetting modems and things like that. That would be my recommendation. The last point I wanted to make is to talk and clarify the situation with the UPC reference. That has come home very convincingly during the last meeting which in fact Dr. Beard has organized with the NATO representatives. That is really the only one way to do that and that is for GPS through the observatory reference. To produce as close a predicted value of UTC BIPM as we can make, because there is no better way to do it. The BIPM values; they come one or two months in arrears and we have to have a real time reference. The only way to avoid endless disputes and confusion is to adopt that policy and we have adopted that policy. There is only one difficulty and that is the annual terms, which exist in practically every operation when it goes to that kind of a precision to nanoseconds instead of long term time keeping. But I believe that problem will go away with the installation of a great number of the new cesium clocks into the system, the international system. They are much less sensitive to time, to temperature fluctuations and that will eliminate, I hope a great deal of that annual term. Until that happens the price that you pay are more frequent small frequency changes in the observatory time scale. These frequency changes are in the order of one or two parts in ten to the fourteen and they come practically every month. Whenever a new bulletin from the BIPM arrives we have to change our prediction. This, I think will go away as time goes on and we have a much better international system. Some discussion about what can be done, in that regard, by including better methods to make international time comparisons including some recommendations by the GPS Standardization Group, as we had yesterday. Considering a slight change maybe in the way (?) is implemented by BIPM. All of that will be discussed in a meeting next March. We will be very much interested to get some additional inputs concerning this questions.

J. Levine, NIST: I would like to endorse Dr. Winkler's recommendations very strongly; in particular two of his recommendations. (1). That time be given in terms of Modified Julian Day number in seconds which we use as well; it is a very useful system. I think that's an extremely good idea. (2) Endorse very strongly is the idea of using UTC BIPM. There is a difficulty of course as you pointed out with predicting it. We have the same difficulties and we have steering of a few parts in ten to the fourteenth every month as well. I think in the long run using UTC BIPM allows international coordination that allows for hand over among different standards laboratories. I think, I agree with you there are problems now and this is a goal we ought to move towards; because it will facilitate international coordination.

G. Winkler: The reaction to the first thing, and that, is for an electronic system such as the DSCS to avoid the leap second by simply continuing coherently and leave that change to the interface between your electronic system and the clock on the wall. We do this with the table of coincidences as in the case of LORAN and through the GPS minus UTC correction which is another navigation message of GPS.

Comment: I am not clear when you say GPS has no leap second. I did an experiment in which the satellite message has knowledge ..

J. White, NRL: They broadcast the correction; there are multiple time scales broadcast by GPS.

G. Winkler: What we mean is the system, the electronics go on uninterrupted. There is no step, no resetting. Everything is done through the information change. What you do is you change the information in the navigation message, you change from 7 seconds to 8 during the next leap second. That is much easier to accomplish than to reset the whole system; reset clocks. In a case of the DSCS, what is being done and what has to be done right now is at some convenient time when the system, in other words, the star or whatever communication arrangement you have, when they have the calibration period then they can reset their modems to the new time 10 second period. I think this is a great inconvenience and should be avoided.

Question: What GPS documents also have the algorithms that tell you how GPS receivers should handle and ...

J. White: Yes, absolutely that is all in there. The GPS time itself does not have the leap seconds in it, they broadcast the leap second corrections to generate UTC.

Question: What is your recommendation on Figure of Merit?

J. White: I do not have a recommendation on Figure of Merit. I point out that Figure of Merit is something a lot of people want, that I do not think is handled well at the moment.

Comment: At the last ICD060, our agency was helpful in writing it up, and want everyone to know, if they have any recommendation on that ICD, there is a (?) process, a working group meeting and that has not occurred for that ICD for awhile. If you have recommendations for GPS changes, they should be submitted through JAPO and put in for future ICD meetings to determine whether or not these changes will be considered or approved; and that is rare.

G. Petit, BIPM: If the leap second is really a problem, why not think of removing this leap second, at least until we can introduce leap powers for example. Anyone who wants to know precisely the rotation of the earth, why not stop thinking of removing the leap second.

G. Winkler, USNO: I agree with you, in fact, when the leap second thing was brought up in 1967, the first proposal was to do it every leap day. However many seconds will be required at that moment, usually three or four, but that would require the tolerance limit to be extended from nine tenths or one second to more than ten seconds. There was a tremendous resistance to that and I do not know if that would be possible today. That is a subject that CCDS should address in the next March meeting.

J. Cecil, NUWC: I am the current chairman of the Range Commander Council Telecommunications Group Timing Committee. We are the ones that established these IRIG standards. I do not have a question, but I would just like to make the comment that when we go out and interrogate other DoD ranges to ask them, or inquire about upgrading these standards, we have a great deal of difficulty getting responses in a lot of cases. We would like to see that changed, so I can see your point in a lot of comments on what you would had to say.

Ron Beard, NRL: One comment on the leap second consideration in the NATO arena, which I am the U.S. representative on a working group. They are considering recommending adding a field for dissemination of leap second information through the standardized interface. So that is one approach around that. I think the significant point that has not been raised this morning through Joe's rather good paper is where is the interface? Is it between a clock and a local reference system? Is it in the field between system units? Exactly where is the interface that can be standardized. This is a problem we run into in the NATO arena. It is something that needs to be considered.