THE CIVIL GPS SERVICE

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Abstract

This paper will summarize the efforts which have been made to facilitate the establishment of a Civil GPS Service. Because there is very little definitive information currently available, the paper will highlight some of the activities which have taken place. Those items of interest to the PTTI community will be stressed.

INTRODUCTION TO THE CIVIL GPS SERVICE (CGS)

The Air Force has stated that it will have no resources available for the distribution of data in support of civil users when the GPS system becomes operational. Recognizing that there is a group of civilian users who now get the information they need for planning and for reducing special series of observations from contacts at the GPS Master Control Station (MCS), the Air Force has made a special effort to assist the civilian community in organizing for the time when the present channels of data distribution will be transferred to a single channel within the ORMS (Operational Status and Capability [OPSCAP] Reporting and Management System). The ORMS will be the primary means of distributing GPS data to the military community. It will also be the means by which selected GPS data will be distributed to the the civil community.

In 1986, the Air Force issued a contract to the Applied Research Laboratories of the University of Texas (ARL–UT) to help study the problem. What is presented here is a synopsis of what happened under that study and what has occurred since the study was published [1]. As an outgrowth of that study, the Civil GPS Service (CGS) was established. It has the overall administrative responsibility for providing information and data to the civil community. The Civil GPS Information Center (CGIC) will acquire and disseminate the information.

There is not much which can be said definitively at this time on either the CGS or the CGIC. Plans for both are still in a state of flux. While the Department of Transportation (DoT) has agreed to be the lead Department in establishing the CGS, no Agency within the DoT has yet been tasked with its operation. What will be required of the CGIC is still being discussed.

CGS STEERING COMMITTEE

In December, 1986, after consulting with many members of the GPS user community, one of the first things which ARL–UT did was to recommend the establishment of a Steering Committee for the Civil GPS Service. The charter (Figure 1) for the Steering Committee consisted of 2 main responsibilities. The first was to consider and review the system design of the Civil GPS Information Center, the primary vehicle for the acquisition and distribution of GPS data to the civilian community. The next was to review the administrative structure of the CGS itself. It was thought best that the Steering Committee meet quarterly and that it initially be chaired by someone from the Department

of Defense (DoD). The composition of the initial 18 member Steering Committee was 10 members from either the military or civilians associated with military organizations and 8 representatives from other civilian government agencies, universities and private organizations. Figure 2 outlines the organizations represented by these people.

As the members became more familiar with the concepts involved during the following year, it was thought best to have a chairperson from the civil, rather than from the military community. The committee determined that the Department of Transportation (DoT), as part of its civil radio navigation responsibilities, was best suited to undertake the CGS function. The DoT concurred. During the transition period, the CGS Steering Committee was co–chaired by a representative of DoD and DoT. Early in 1988, the transition was complete and David Scull, Research and Special Projects Administration (RSPA), DoT, was named sole Chairperson of the Steering Committee.

The items discussed under the charter for the Steering Committee were varied (Figure 3). Some of the issues which dealt with the Administrative Structure of the CGS were the concern of the CGS: to interact smoothly with civil GPS users and the Air Force GPS administration; to be an advocate for civil use of GPS; and to deal with liability concerns. In fact, this last issue may turn out to be one of the greatest impediments to be overcome by the CGS.

With regard to the CGIC, the possibility of using an existing GPS data base as an interim, demonstration system was also considered. There were also lively discussions on the impact of GPS Security Policy on the data provided to the CGIC by ORMS. This led to a proposal that Selective Availability not be done to at least one satellite in response to the wishes of the PTTI community. More will be said on this proposal later.

Figure 4, taken from Reference 1, gives a possible depiction of the envisioned CGS. The CGS oversees the CGIC and interacts with GPS Management and the Civilian User Community. The CGIC receives GPS data from the ORMS and distributes it to the Civilian User Community. It will also receive GPS data from any other additional sources that provide it. Because it may not be able to verify or guarantee the accuracy and precision of all this data, the question of liability arose.

An additional consideration is the provision of information to the civil user who has been granted access to the non–degraded signal. This may possibly require another layer in the structure of the CGIC.

CGS USER SURVEY

Concurrent with the formation of the Steering Committee, ARL–UT proceeded to prepare a user survey which was issued during the summer of 1987. The survey was an attempt to assess user requirements and determine the methods the civilian community preferred for acquiring and disseminating data. In the Fall, a User Workshop was held in conjunction with the First Technical Symposium of the Satellite Division of the Institute of Navigation at Colorado Springs, CO, to discuss the results.

There were 178 responses to this CGS User Survey. Of them, 55% were from domestic users and 45% from foreign users. Most of those who responded had requirements for some form of GPS data either daily or weekly. Obviously, all those who responded were experienced GPS users. It was impossible to identify and send the survey to probable GPS users even though some groups were identified as potential users.

There seemed to be an equal division among users who required pre–event data, real–time data and those who needed after–the–fact data within a week or two. In response to the question on how the user would prefer to receive needed GPS data, computer modems and publications were the choice of about 50% of the respondents. Machine readable disks and tapes were also desired. There was also a strong interest in voice recordings.

The GPS configuration status, timetables of scheduled events and orbital information were the types of information most frequently requested or needed. There was also a large response for timing information. This was to be expected since the survey was distributed over the U.S. Naval Observatory (USNO) Automatic Data Service (ADS).

CIVIL GPS INFORMATION CENTER (CGIC)

The Civil GPS Information Center will be the primary distribution point for GPS data to the civilian users. Figure 5 highlights some of the points concerning the CGIC which have been discussed by the CGS Steering Committee. The main concerns of the CGS Steering Committee in regard to the CGIC have been whether the CGIC can be self–supporting and the amount of processing or re–formatting of the GPS data that it should do. Unfortunately, nothing definitive can be stated about this very crucial and important aspect of the CGIC. It is a desirous goal of the CGS Steering Committee that the CGIC be able to generate sufficient revenues to be self-supporting. However, in order to be self–supporting, it seems that the CGIC will have to be very responsive to the requirements and needs of the civilian community. Whether this can be done efficiently and in a cost–effective manner is very difficult to estimate at this time. It is almost impossible to factor the question of liability into the estimates.

THE INTERFACE CONTROL DOCUMENT

As stated earlier, the GPS Master Control Station has provided data to the civil community for use in planning and reducing observations. However, once the GPS is operational the Air Force will no longer have the resources necessary to continue this support on a personal basis. Part of the ARL–UT effort was intended to determine what was required to transfer necessary GPS data from the ORMS to a single civil GPS Information Center for further distribution to the civil community. The result of this effort was Vol. III of Ref. 1, entitled The Interface Control Document for the Civil GPS Service Interface to the OPSCAP Reporting and Management System. Figure 6 shows some of the GPS data which was noted as being required by the PTTI community.

The Interface Control Document has been found to be a useful starting point in the determination of requirements. After review of this draft ICD, it is apparent that some revision must still be made. Of immediate concern is that some information stated as a requirement could jeopardize security. Obviously that information could not be provided. The various sub–committee working groups discussed below will attempt to further define actual requirements.

PTTI PROPOSAL

While not yet operational, GPS has become the primary world–wide time distribution system. More and more systems are investing in less expensive GPS timing receivers rather than in expensive clocks. With the implementation of Selective Availability (S/A) which would degrade the GPS navigation transmissions, this cost saving could be negated. This is a cause for concern within both the civil and the military timing communities. Both ephemeris and clock information would be affected.

To minimize the impact, Paul Wheeler of the U.S. Naval Observatory (USNO), at a meeting of the CGS Steering Committee, proposed that no degradation be applied to at least one satellite. By this means then, full timing accuracy would be available at least once per day for global time transfer while not affecting the navigation degradation required by DoD. Later, for redundancy and reliability, it was suggested that a second satellite be left undegraded. This second satellite would be located directly opposite from the first. D. Allan of the National Institute for Standards and Technology

(NIST, formerly NBS) has suggested that one additional satellite with partial degradation be added to this proposal. The partially degraded satellite would prove useful for increasing Common View Time Transfer coverage.

This proposal, with an endorsement by the Oceanographer of the Navy, has been submitted to the Assistant Secretary of Defense (Command, Control, Communications and Intelligence) by USNO in its 1988 Annual Summary of PTTI Requirements and Operations. Since the issue of S/A is one of security, any negative impact on national security must be evaluated. This is currently being done.

CURRENT DEVELOPMENTS

Since GPS is a truly global system, the CGS Steering Committee at its November 1988 meeting, invited representatives of several international civil groups to participate in its deliberations. Under consideration for the CGIC is the establishment of international nodal points for the dissemination of GPS data. With this in mind a sub–committee, under the chairmanship of G. Preiss of Norwegian Mapping has been formed to investigate the interest and the requirements of such a node.

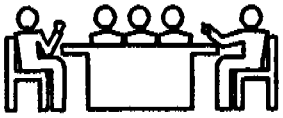
At the same time, a timing sub–committee under the chairmanship of W. Klepczynski, USNO, was formed to further investigate the timing requirements of the civil user. Using the Interface Control Document for the Civil GPS Service described above as a starting point, a refinement of the data items required, the format of the data, the preferred means of dissemination and the frequency/timeliness of distribution will be attempted. Input from the user community is needed. The draft Interface Control Document is available from the Defense Technical Information Center, FDRA, Cameron Station, Alexandria, VA 22304–6145 and from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

In addition, a surveying sub–committee was established under the chairmanship of W. Strange of the National Geodetic Service, NOAA. This group will be concerned with the GPS data requirements of the surveying community.

The effort of defining the Civil GPS Service and the CGIC will continue during the next year. There are several issues that must still be resolved and much work remains to be done.

REFERENCES

1) Tucker, Arnold J., A GPS Information and Data System for the Civil Community, ARL–TR–88–11, Four Volume Set, Vol. I– Requirements of the Civil GPS User, Vol. II–Appendices to Volume I, Vol. III–Interface Control Document, Vol. IV– Synopsis of CGS User Workshop, published by Applied Research Laboratories, University of Texas at Austin, P.O. Box 8029, Austin, TX 78713–8029.



CGS Steering Comm.

CHARTER

- Review System Design of CGIC
- Review Administrative Structure
- Meet Quarterly
- Now Chaired by DoT
- Consider the ability of the CGS to:
  a) be self-supporting;
  b) interact smoothly with DoD; and
  c) be an advocate for civil use of GPS

Figure 1 – Highlights of Items Considered within the Charter of the CGS Steering Committee

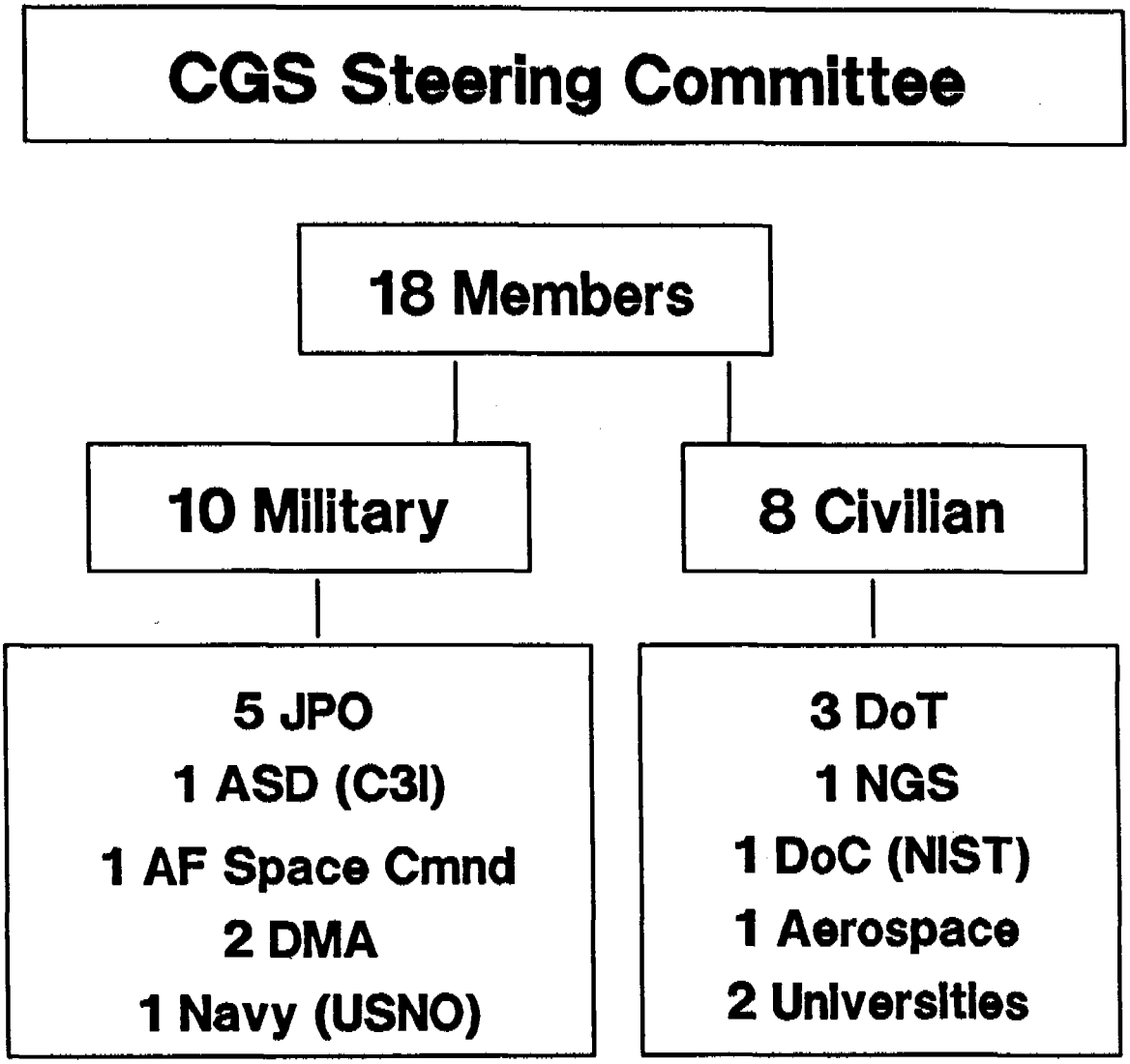


Figure 2 – Initial Composition of the CGS Steering Committee

CGS

Steering

Comm.

TOPICS

- Administrative Structure of CGS
- Interim System
- Liability Considerations
- Impact of GPS Security Policy on GPS
- PTTI Proposal for Undegraded Time

Figure 8 – Some of the Topics Discussed by the CGS Steering Committee

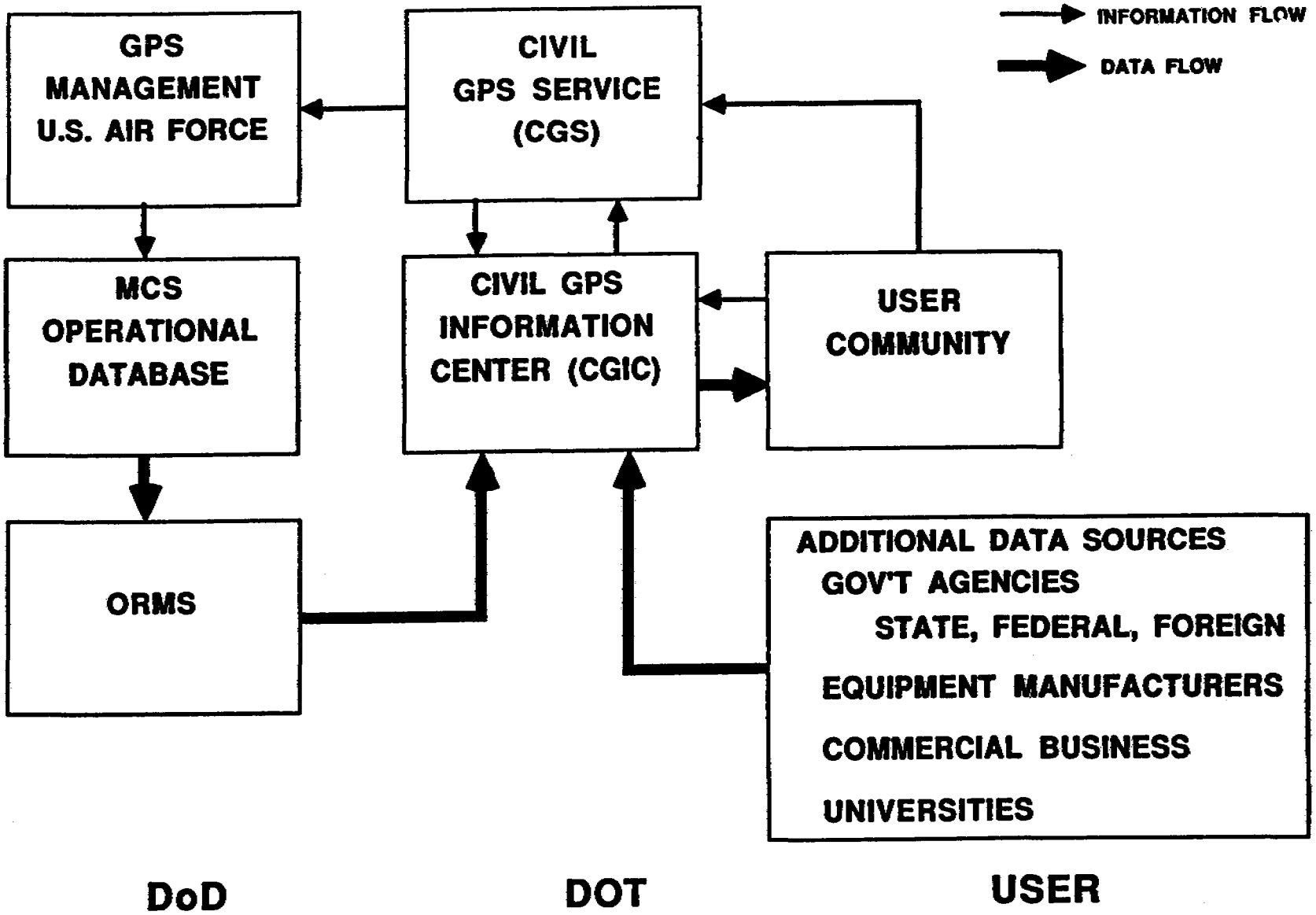
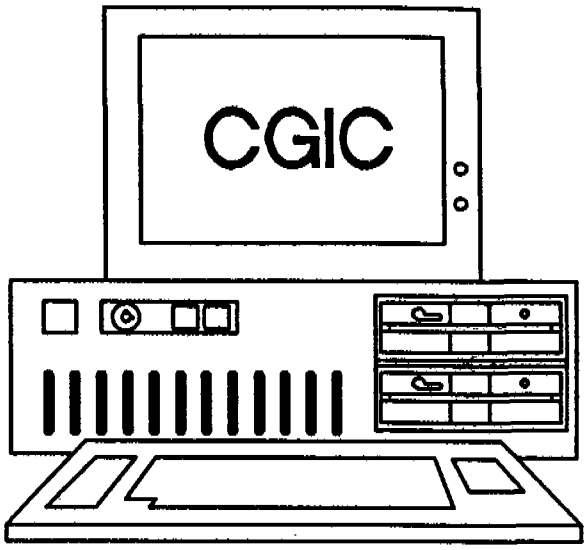


Figure 4 – One Possible Way to Depict the Interaction of the CGS with the Civilian User Community and the Air Force

CIVIL GPS INFORMATION CENTER



* Controlled by CGS
* Stores and Formats Data
* Data Distribution Point to the Users
* Receives GPS Nav Status Info from Operational Status and Capability (OPSCAP) Reporting and Management System (ORMS)

Figure 5 – Areas of Concern for the Civil GPS Information Center

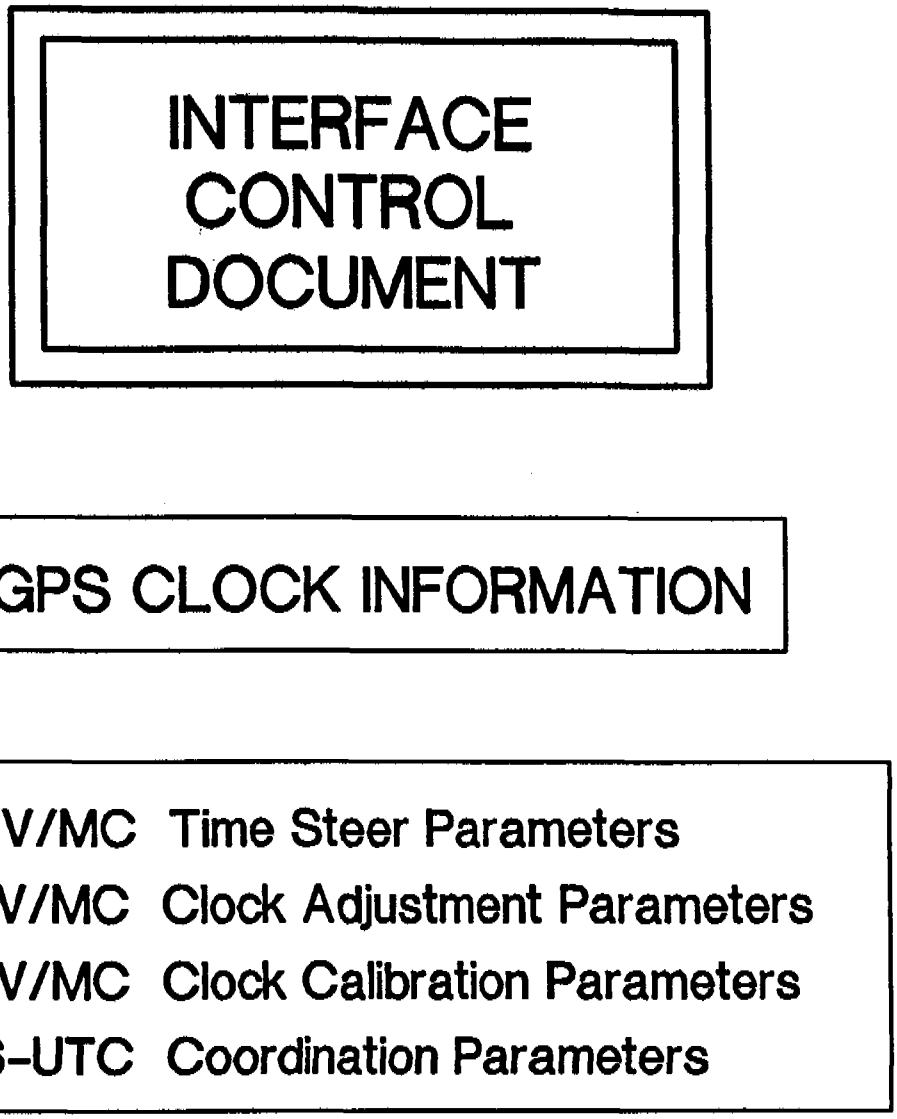


Figure 6 – GPS Clock Information in the Draft Interface control Document Which is of Use to the PTTI Community

UNIDENTIFIED QUESTIONER, Not into the microphone...

DR. KLEPCZYNSKI: I am sorry that John Scull is not here. No, there is no official list of users. There is a list of the people that respond to the survey, and that forms the user list as such.

UNIDENTIFIED QUESTIONER, Not into the microphone...

DR. KLEPCZYNSKI: We plan to become active as soon as possible, probably in the next two or three months. The plans are that the selective availability will be enabled as soon as the Block II satellites are launched. The satellites that are currently flying will not be affected by selective availability. They should still be around for another two or three years. We have to get our foot in the door and make our wishes know before the policy becomes firm and cannot be changed. We feel that, if it can be done in the next two or three months, it will still be possible to influence the policy–making decision.

JIM SEMLER, INTERSTATE ELECTRONICS: One of the things that has been mentioned is changing the GPS orbital parameters—increasing the orbital altitude. This has a certain effect in that you no longer get a repeating ground track, which is useful in doing common–view tracks from day–to–day. I wonder if there has been any consideration of those effects.

DR. KLEPCZYNSKI: That is correct. In fact, that is the proposal from the Joint Program Office. GPS has three sets of four satellites, and if the satellites are increased in altitude by another 50 kilometers, the current periodicity will change. Consequently, the geometry with respect to the earth will be changing from day–to–day. That is why three sets of four satellites were chosen. As the geometry over the earth changed, they would switch to another set. The decision to lift the satellites another 50 kilometers in orbit, to my understanding, is still not definite yet. There are still some things to be ironed out because there are certain technical questions within the satellites themselves as to how they will be affected by this rise of another 50 kilometers. So that is not 100% firm yet.

DR. KLEPCZYNSKI: Please let it be known what the problems might be. This is a very important question.

DR. GERARD LACHAPELLE, UNIVERSITY OF CALGARY, CANADA: I am quite concerned with the ionospheric effect because if there is only one or two satellites which are not implemented with selective availability, it means, that for time transfer, we will not have the same capability to decrease the effect of the ionosphere by observing any satellite in view. That will put, in my opinion, a severe restriction on the capability to perform time transfer. Do you have any comments on that?

DR. KLEPCZYNSKI: Yes, as a mater of fact, since there are no more questions and we have ten more minutes scheduled, I might ask Myron Moranian to show a few slides on the effect of the modeled ionosphere corrections vs. the measured ionosphere corrections. At the observatory we have two dual–frequency timing receivers which are used both in Washington and in Florida. We have been tracking and doing observations with these two. We have some preliminary data which, if Myron would come up and show and discuss, will show you the effect of the ionosphere. If I may steal Myron's message, the improperly modeled ionosphere can give errors on the order of at least ten nanoseconds or so. While this is not a large amount, it can still be significant. For a lot of users, that may not be too bad.

Myron Moranian showed the slides in question at this point.

JOHN KLOBUCHAR, AIR FORCE GEOPHYSICS LABORATORY: I would like to first ask a question and then make a couple of comments. What are you using for an ionospheric

model?

DR. KLEPCZYNSKI: The model transmitted by the satellites.

MR. KLOBUCHAR: I know a little bit about that and I must caution you that that model is advertised as a 50% RMS model. Anyone who tries to use it for more than that does so at his own peril. Secondly, any attempt to use daily values, or even more often values of solar flux does that at his own peril also. Numerous studies have been made of the ionosphere in which it is shown that the short term correlation of the total electron content, or time delay if you will, does not correlate very well with the day–to–day values of solar flux. The original decision to use the five–day running mean of solar flux in that model and the Master Control Facility had some unfortunate start–up problems and some recurring problems, but that is probably the "best" way to do it anybody that wants to get better than about 50 or 60% RMS should come and listen to my talk tomorrow after lunch.

DR. KLEPCZYNSKI: We have a comment here from Dr. Winkler.

DR. WINKLER: Dr. Klobuchar, what is your estimation of the correlation for the same moment for geographically distant locations? That is the problem that you have in common view.

DR. KLOBUCHAR: Yes. For the correlation to do you any good, it has to be very high. If the correlation is 0.7, that only explains 28% of the residuals. A correlation distance of deviations from monthly average at two stations, for instance, I know the time delay at Washington due to the ionosphere and I call up a colleague in Boulder and I say to David Allan "Hey, it is ten percent higher than normal today", it isn't going to ten percent higher in Boulder. The correlation distance is of the order of 1500 kilometers or so for that 0.7, and it is less, of course, for correlation that is higher.

DR. KLEPCZYNSKI: It seems extremely fortuitous that the measured ionospheric corrections are agreeing with the model at this point in time because of the low solar activity at this point.

DR. LACHAPELLE, UNIVERSITY OF CALGARY, CANADA: In northern Canada, with selective availability and one frequency we could have errors as high as 100 nanoseconds in time transfer. If we didn't have selective availability we could watch many satellites continuously, some towards the south and somewhat decrease that. With selective availability would give us a problem. Another problem is that under strong auroral conditions we would have loss of phase lock on the carrier. This has already been seen at some times in the north. It has a very strong correlation with magnetic storms. This will have a severe effect on GPS navigation and time transfer as well.

DR. Klepczynski: That is an interesting observation. I guess that another observation is that the difference between the measured time delays and the model will be a function of time that varies throughout the year, and also a function of solar activity.

DAVID ALLAN, NIST: It is probably worth mentioning that there are code–free ionospheric calibrator receivers being made. One exists at the Paris Observatory and the accuracy of that one seems to be extremely good, on the order of a nanosecond or so. In the future we can anticipate, for the civil user, a code–less type of receiver for calibrating the ionosphere.

DR. KLEPCZYNSKI: We will hear about that receiver two papers from now.

DR. WINKLER, ASSN.: It is clear that, in the best of all worlds, we would have all satellites unchanged. For the moment it is clear also that the best way to kill any proposal is to make it unreasonable. That is a technique that is used over and over again in political circles. If you don't like a proposal, improve it so that it becomes unacceptable. I think that we have the same situation in our proposal to make two satellites undegraded. Of

course, it would be better to have three, or four, or five undegraded, but that is the best way to make it unacceptable and we would have no relief whatsoever. I think that a little bit is better than nothing at the moment. In the present situation it is my firm belief that the only chance that you have is, at most, two undegraded satellites. The question then is "How is this going to affect your operations?" I can only repeat Dr. Klepczynski's request to let us know your opinions about that.