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PROPOSAL FOR THE REDEFINITION OF UTC: INFLUENCE ON NGA EARTH ORIENTATION PREDICTIONS AND GPS OPERATIONS*

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The Earth-Centered, Earth-Fixed World Geodetic System 1984 (WGS 84) reference frame is realized by the adoption of a self-consistent set of highly-accurate coordinates for the Department of Defense (DoD) Global Positioning System (GPS) Monitor Stations. Over the past several decades, procedures, Interface Control Documents, and operational, configuration-controlled software have been designed for UT1-UTC to be less than 1.0 second. In some cases, automated 'limit checks' have been established on this parameter. The proposed discontinuation of leap seconds and redefinition of UTC will impact these operations. A significant amount of time, effort, and funding will be required for NGA and other organizations to identify and assess all operational software impacted by the change. While the proposal may benefit other communities, a redefinition of UTC and the elimination of leap seconds offer no benefits or improvements to National Geospatial-Intelligence Agency (NGA) or GPS operations.

INTRODUCTION

Over the past several years, an International Telecommunication Union – Radiocommunication Sector (ITU-R) Study Group has been investigating the following three questions:

1. What are the requirements for globally-accepted time scales for use both in navigation/telecommunication systems, and for civil time keeping?
2. What are the present and future requirements for the tolerance limit between UTC and UT1?
3. Does the current leap second procedure satisfy user needs or should an alternative procedure be developed?

The goal of this effort is to make recommendations to the greater ITU and ultimately to the international community as a whole. This paper briefly assesses the effects of changing the definition of UTC on NGA's mission.

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NGA is responsible for maintaining the WGS 84 global geodetic reference frame and other related geophysical models. The WGS 84 Earth-Centered, Earth-Fixed reference frame is realized by the adoption of a self-consistent set of highly-accurate coordinates for the DoD GPS Monitor Station antennas located around the world (Figure 1). These monitor station antennas are attached to the crust of the rotating Earth. The GPS time scale used for all GPS orbit processing is directly tied to UTC (USNO) through well-established, operational processes. The orbit determination process requires transformation between the Earth-Centered, Earth-Fixed reference frame and the Earth-Centered Inertial reference frame and therefore knowledge and accurate prediction of small changes to the Earth's rotation angle (UT1). The quantity UT1-UTC is used in these transformations and will remain an essential bit of information for GPS and other satellite missions requiring high-accuracy orbit determination.

Over the past several decades, procedures, Interface Control Documents (ICD), and operational, configuration-controlled software have been designed to deal with Leap Seconds. In some cases, automated 'limit checks' have been established that test for the UT1-UTC quantify to be less than 1.0 second. The ICD-GPS-211, the ICD between NGA and the GPS Operational Control Segment (OCS), for example, describes such limit checks.

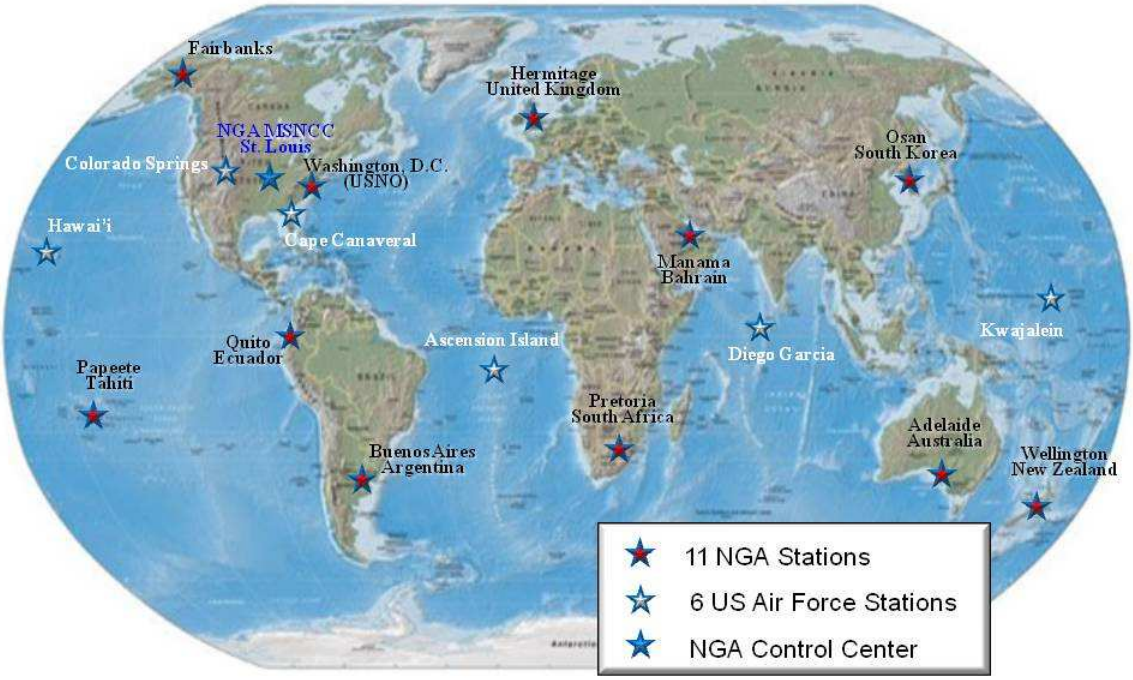

Figure 1. DoD GPS Monitor Station Network.

NGA OPERATIONAL SUPPORT

The NGA GPS Network Control Center supplies 24/7 real-time support to the U.S. Air Force 2nd Space Operations Squadron's (USAF 2SOP's) GPS operations. This support is a collaborative effort between NGA and the USAF that includes the sharing of data, anomaly resolution, and collaboration on GPS performance monitoring. NGA's GPS tracking data directly improve GPS broadcast accuracies and integrity monitoring. NGA also routinely generates its own precise

(post-fit) GPS ephemerides in support of world-wide geodetic surveying and quality control for GPS operations.

Daily Earth Orientation Parameter (EOP) predictions and post-fit estimates, generated using USNO's daily EOP solutions, are used in earth-fixed to inertial reference frame transformations. The required accuracy of these EOP predictions are documented in the Interface Control Document ICD-GPS-211 and shown in Table 1. Currently, ICD-GPS-211 between NGA and the USAF 2SOPS indicates that the UT1-UTC parameter is to be maintained to less than 1.0 second. This ICD will soon be replaced by ICD-GPS-811. This ICD defines the requirements for data transfer between NGA and the USAF's Next Generation Operational Control Segment known as 'OCX'. This new interface treats the UT1-UTC parameter in a similar fashion. Because this parameter is now limited to 1.0 second or less the automated 'Limit Checks' have been established in code to assure compliance with current and future ICDs. Therefore, the handling of the leap second has been 'institutionalized' within procedures, software, and documentation.

Table 1. ICD-GPS-211D Accuracy Requirements for EOP predictions*

Predictions (days)	Polar Motion X & Y (mas)	UT1-UTC (ms)
1	3	3
7	7	5
14	10	7

*One standard deviation measured over any 1-year period

EFFECT ON GPS OPERATIONS

As indicated earlier, the ICDs state requirements for the transfer of data between NGA, GPS OCS, and other satellite operations. Replacing the current definition of UTC with a continuous time scale will require the modification of these documents. It will also require the identification, modification, testing, and validation of operational software to allow UT1-UTC to grow beyond the current 1.0 second limit.

While eliminating this 'sanity check' may seem trivial, changes to the code, documentation and execution of thorough testing will require resources and in some cases, contract modifications. The costs and time needed for the initial investigation and subsequently to make the required changes to the operational software are unknown at this time, but they are expected to be significant. Furthermore, considering that this possible redefinition of UTC and the elimination of the leap second offer no benefits to NGA GPS operations and GPS users, pursuit of such a fundamental change appears to be an inefficient use of limited resources.

CONCLUSION

DoD GPS Monitor Stations, the 'starting point' for all GPS Positioning, Navigation and Timing (PNT) are located on the rotating Earth and will be for the foreseeable future. Therefore, a regular source of UT1-UTC predictions will continue to be needed for NGA, GPS, and other DoD satellite operations.

The proposed discontinuation of leap seconds and redefinition of UTC will impact the operational software and automated transfer of Earth Orientation Prediction Parameters between NGA, the GPS OCS, and other DoD organizations. A significant amount of time, effort, and funding

will be required for NGA and other organizations to identify and assess all operational software that references, tests for, or applies the UT1-UTC parameter in high-accuracy orbit determination processes. The costs and time needed for the required changes to the operational software and ICDs are unknown at this time, but they are expected to be significant.

While the proposal to re-define UTC may offer benefits to other communities, a redefinition of UTC and the resulting elimination of leap seconds offer no benefit or improvement to NGA or GPS operations. Our recommendation, therefore, would be to maintain the current definition of UTC.

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