THE WSMR TIMING SYSTEM: TOWARD NEW HORIZONS

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Abstract

In 1991, White Sands Missile Range (WSMR) initiated a modernization program for its Range Timing System. The main focus of this modernization program was to develop a system that was highly accurate, easy to maintain, and portable. The logical decision at the time was to develop a system based solely on Global Positioning System (GPS) technology. Since that time, WSMR has changed its philosophy on how GPS would be utilized for the Timing System. This paper will describe WSMR's initial modernization plans for its Range Timing System and how certain events have led to a modification of these plans.

INTRODUCTION

The primary function of the WSMR Timing System is to provide time and time interval information to Range instruments and facilities. At present, the instruments requiring this information receive it in one of three ways: by VHF broadcast, wire line distribution, and (recently) by Global Positioning System (GPS) time and frequency receivers. Much of the equipment used to provide the Timing information in the first two methods is over twenty years old. While this equipment continues to function remarkably well, many of the components required to maintain it are no longer available. Additionally, new requirements placed on the Timing System for site-to-site time correlation have exceeded the technical capabilities of much of this equipment.

To meet these new requirements for time correlation and to replace a significant portion of the aging equipment, WSMR has embarked on a modernization program. This paper will describe the current Range configuration for Timing, the approach WSMR is using for its modernization, and how unexpected events have affected the approach. It should be noted that the modernization program is in its infancy and the approaches explained in this paper may change slightly. Furthermore, two potential enhancements to the chosen approach will be discussed.

CURRENT RANGE CONFIGURATION

RANGE AREA

The majority of the WSMR Timing System is divided into three Range areas (See Figure 1). The Timing System supplies time and time interval information to over 100 instrumentation vans and about 150 fixed locations. Customers include project facilities and Range instrumentation consisting of Telemetry, Radar, Optics, and Computer systems.

To accommodate the variety of customer requirements and yet maintain time correlation among all customer sites, the Timing System produces a standard time signal from its Master Clock. This signal is then distributed to most customer sites using VHF and fixed distribution stations where it is translated into the time format required by the customer.

WSMR MASTER TIME GENERATION SYSTEM

The WSMR Master Time Generation System (at Uncle 2 in the South Range) uses a cesium-beam time standard as its Master Clock. The output of this Clock feeds time code generators that produce the IRIG time codes used for distribution. This System stays within one microsecond of Coordinated Universal Time (UTC) by utilizing Loran C and GPS.

VHF BROADCAST STATIONS

The WSMR Timing System has two VHF broadcast stations that transmit IRIG-B timing. These stations are Uncle 5 in the South Range and Uncle 52 in the North Range. The combination of these two stations provide coverage to 95 percent of the Range area.

FIXED DISTRIBUTION STATIONS

Fixed distribution stations located throughout the Range receive Timing signals from either Uncle 5 or Uncle 52. These stations synchronize their time code generators to this Timing signal and distribute time codes using wire line or cable. Figure 1 illustrates their site locations and their relationship to the Master Station.

MOBILE DISTRIBUTION STATIONS

For areas of WSMR that do not have wire line services available from a fixed distribution station, WSMR Timing provides a mobile distribution service. Currently WSMR Timing has three mobile distribution stations available for on Range support. Each system is capable of generating IRIG time code formats and receiving a synchronizing signal from radio Timing or GPS.

WSMR MOBILE CLOCKS

Timing operates two transportable clock facilities for calibration of the Timing System and validation of GPS receivers. These clocks provide precision on-time pulses for comparison with a pulse generated by the Timing equipment at the customer location. Either the equipment's

time is corrected or the time offset is recorded. Once these calibrations are made, these clocks complete a loop closure by comparing their precision pulses with their synchronization source.

THE INITIAL APPROACH

The initial approach was to develop a Timing System using GPS as the only method of time transfer. GPS time and frequency receivers would be installed in all individual fixed and mobile customer facilities. These GPS receivers would provide the basic time and frequency outputs required for approximately seventy percent of the customers. For customers requiring additional time and time interval information or formats, time code generators synchronized to the GPS signal would be installed and would provide the additional formats. A similar approach would be used at all fixed facilities. Each fixed facility would use a single GPS receiver that had a IRIG-A and IRIG-B serial modulated time code output. These output signals would synchronize all time generation equipment located within the facility. To ensure the GPS receivers were working properly, status information about the GPS receivers would be sent to one of the three service centers (Uncle 2, Uncle 6, or Uncle 25) using the RS-232 port. Once all facilities were supplied with GPS receivers, the VHF broadcast stations would be shut down. The Master Station would remain but its function would change. It would primarily be used to test and validate Timing equipment, distribute Timing signals to local users, and to provide an additional syntonization source for the telecommunications system. The Station would be modernized using GPS capabilities to discipline rubidium standards, and would have time generation equipment synchronized to the GPS signal.

This was the initial approach taken for modernizing the WSMR Timing System. This approach seemed to satisfy most users and the promoters of GPS technology. The general consensus was: if GPS receivers were installed everywhere, the Timing signal would be more accurate, calibrations of Timing equipment would be eliminated, and modernizing the Timing system would be relatively easy to implement. Then personnel within the Timing System started asking the following questions: "Could GPS be disrupted and what mechanisms could be put in place if a disruption occurred?" And "Does the hardware that is going to be purchased have external synchronization capability?" Well, at first these question were for most part ignored. Or the standard answer was "GPS will always be available and, if for some reason it wasn't, the internal clocks will have the ability to flywheel with very low drift rates.". Then it happened! GPS receivers in the North Range would not lock up during several hours in the day. "How could this be? This is GPS equipment, GPS is always available; it must be faulty equipment." However, when the equipment was tested in Central or South range, the GPS equipment worked perfectly. Finally, after some investigation, it was discovered that methods for jamming GPS equipment were being tested in the northern part of the Range. Concurrently, other incidents of loss of lock were traced to interference from legally operating instruments on the Range. It now was time to listen to the questions asked above, come up with solutions, and to implement a modified approach.

THE MODIFIED APPROACH

The GPS jamming tests and interference incidents provided the incentive necessary to take a second look at how the Timing System would be modernized. The first area reviewed was the mobile instrumentation systems. WSMR's mobile instrumentation systems support a large number of missions at many locations. Often one mobile may be required to support at more than one location in a day. Moving from one location to another requires removing power; GPS interference in the new site area could prevent attaining lock and, hence, knowing what time it is. A secondary source for time information would, therefore, be beneficial to these systems. In some fixed facilities, time and time information requirements are less critical and the equipment can be left on. In these, a secondary means of providing Timing information is not necessary because the internal oscillators have very low drift rates and can flywheel during periods of GPS interference. However, a benefit of a secondary source would be the ability to compare the time information received from the secondary with that generated from a GPS input signal. This would provide some additional assurance of the validity of the site's time information.

It was decided to include a secondary source for time information in the modernization of the WSMR Timing System. It was further decided to use the existing VHF broadcast system as a secondary source for synchronization. To accommodate the concept of dual sources at any site, it was decided to have a time generation device that could receive GPS, receive VHF, or accept a wire line IRIG signal. This would provide flexibility to users and would enhance Timing availability. The design for the new Master Station was modified as well. The new design would use GPS to initialize the time generation components and then to function as an independent reference (for comparison with cesium standards). By using GPS as a reference instead of the synchronizing source, the System would still maintain UTC traceability and yet be able to operate independently of the GPS source (since the VHF system uses the Master Station's serial modulated IRIG-B output for its broadcasts.

At this point it is necessary to explain some of the reasons for choosing the VHF system as the secondary time transfer method. The most obvious of reasons was the availability of existing equipment that could be used. The existence of this hardware provided a quick solution to a concern that required immediate attention (interference with GPS). The VHF broadcast system provides coverage to 95 percent of the Range. It transmits a serial modulated IRIG-B format that can be used to achieve Timing accuracies of 10 microseconds or less if the general location of the receiver site be known. Also there are currently available modular VHF receivers that could easily be used in the time generation device described above. Although the VHF system does not have as good site to site time correlation capability as GPS, it could be used as the only source for time transfer for the majority of the missions at WSMR. Finally, the VHF system at WSMR has been a reliable source for time transfer for years.

POSSIBLE FUTURE ENHANCEMENTS

Significant upgrades of the WSMR Timing System have only occurred at widely spaced, irregular intervals. Since there is no reason to expect this situation to change, the current modernization

has to carry the System quite some time into the future. The modernization must be able to accommodate advances in technology and unexpected changes in political (and budgetary) priorities.

GLONASS One area considered was the use of the GLONASS network. The existence of another, independent, source of reference time is attractive. Since low-cost commercial GLONASS receivers did not appear to be imminent in the U.S. market, this feature was not incorporated into the initial implementation. However, the Master Clock configuration is flexible enough to allow for incorporating this additional reference in the future. Also, since many of the GPS receivers in the new System will be plug-in modules, there is the potential for supplementing these with new combined GPS/GLONASS receiver modules, should that capability emerge in the U.S. market.

Precise Positioning System (PPS) Use of the PPS portion of GPS offers the potential for increasing the accuracy of received Timing. There is a significant cost difference, however, between an approved PPS receiver and a commercial GPS Timing receiver. Evaluation of current and potential requirements (or even desires) for Timing accuracy to WSMR customer facilities reveals very few in the accuracy range that PPS serves; so the investment required to provide PPS capability to the whole Timing System would not be prudent. The Master Clock will be provided with PPS capability, however; also, several PPS receivers will probably be obtained to accommodate the rare customer who might have a requirement. WSMR would not be able to meet a requirement for a large number of sites to be within 100 or fewer nanoseconds (with S/A enabled) under the current approach.

CONCLUSION

GPS offers the Timing System the capability of providing customers Timing accuracy of 300 nanoseconds, or better, referenced to UTC. WSMR will use this capability whenever and wherever it can be used to enhance the Timing System. In those cases where GPS cannot be used, the VHF system will continue to be a reliable second source.