RECOMMENDATION ITU-R TF.767-1

USE OF THE GLOBAL POSITIONING SYSTEM (GPS) AND THE GLOBAL NAVIGATION SATELLITE SYSTEM (GLONASS) FOR HIGH-ACCURACY TIME TRANSFER

(Question ITU-R 152-1/7)

(1992-1998)

The ITU Radiocommunication Assembly,

considering

a) the need for operational time transfer and comparison at the highest possible accuracy levels over intercontinental distances;

b) the demonstrated capabilities of satellite techniques for providing time transfer accuracies at levels of less than 100 ns;

c) the advantages offered by the Global Positioning System (GPS) in terms of current availability of multiple satellites, the system of 24 satellites providing continuous global coverage for time transfers, and the strong commitment to monitoring and control of the system. The precisely known relationship between GPS system time and UTC, the use of on-board atomic standards, and the availability of numerous commercial sources for GPS timing receivers;

d) the extensive favourable experience gained from the wide use of GPS satellites for time transfer over many years;

e) the establishment of a Civil GPS Service Interface Committee to provide information and liaison between the GPS system and civil users;

f) the technical capabilities to intentionally degrade the accuracy of the GPS signals that are available to general civil users through the use of selective availability (SA) and anti-spoofing (AS) techniques (see Annex 1);

g) the demonstrated technical feasibility of at least partially compensating for the adverse effects on time-transfer accuracy related to selective availability and anti-spoofing procedures by use of the GPS common-view technique, averaging the received timing signals over one or more days, using a weighted average across several satellites, or use of delayed precise satellite position information;

h) that the Global Navigation Satellite System (GLONASS) is a comparable system to GPS and is anticipated to have similar important utility,

recommends

1 that the use of GPS and GLONASS satellites for time transfer and comparison be seriously considered, particularly in those applications requiring global coverage and accuracy levels of about 1 µs or less;

2 that the GPS and GLONASS common-view time-transfer technique be seriously considered for applications requiring accuracies in the range of 10-100 ns; that by using this technique time stabilities and accuracies can be further enhanced by:

– applying a weighted average across several satellites;

– using a codeless receiver to measure and compensate for the satellite signal's delay through the ionosphere;

– applying corrections using precise satellite ephemeris data;

– determining accurate (1 m) coordinates for the receiver antennas;

3 that in an environment where selective availability and/or anti-spoofing measures are activated users requiring the best possible accuracy should compensate as far as is possible for the intentional degradation by applying the following techniques:

– exact (within 1 s of the same start and stop times) common view to cancel SA satellite clock modulation;

– averaging the received signals across all available satellites and over several days;

– applying later corrections using delayed precise satellite ephemeris data.

ANNEX 1

Intentional degradation on GPS signals

The GPS has been designed with the ability to intentionally degrade the GPS signal that is available to general civil users. The degradation is called "selective availability" (SA). In addition to SA, there is also anti-spoofing (AS). A set of encryption keys is required to remove the effects of AS and SA.

The activation of AS will make the GPS precise positioning service (PPS) inaccessible to those without the appropriate keys. The PPS gives the full accuracy of the GPS. The clear access (C/A) 1.023 MHz code will remain available for all users and provides the standard positioning service (SPS). With SA on, the SPS still provides access to GPS, UTC (USNO (United States Naval Observatory)), or UTC time, but the time modulation causes peak-to-peak uncertainty of several hundred nanoseconds. The SPS has stated (2σ) uncertainty in two dimensions of 100 m for position and 340 ns for time. With one-day averaging 100 ns uncertainty have been obtained, and with three-day averaging 50 ns uncertainty have been obtained. A stable reference clock is necessary to realize these accuracies.

Most of the international timing centres have adopted the GPS common-view method as the best operational means for time transfer. The coordinates of the GPS antennas at timing centres are now known to better than 1 m.

The Consultative Committee for the Definition of the Second (CCDS) has set up a special Task Group to study systematic effects in GPS timing equipment (mainly receivers). Various kinds of biases and temperature dependencies have been discovered; work continues in this area.

Several steps have been taken to assist civil users in obtaining information about GPS. For example, a Civil GPS Service Interface Committee (CGSIC) has been established. Within the CGSIC is a timing sub-committee. This sub-committee services the Bureau international des poids et mesures (BIPM), international timing centres, and industry (telecommunications, power companies, etc.). The CGSIC provides:

– general and specific GPS information;

– an operating bulletin board serviced by the United States Coast Guard; and

– information regarding techniques and research and development efforts.

To further assist GPS users, weekly or monthly bulletins are available from the following organizations: BIPM, the National Institute of Standards and Technology (NIST) and USNO. In addition, World Wide Web access is available at BIPM, NIST and USNO. All three organizations have personnel who can answer many of the detailed questions civil users may have regarding GPS.