TIME TRANSFER - TERRESTRIAL

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ABSTRACT

Terrestrial time transfer techniques include the transport of portable clocks, hard lines, and numerous radio systems. The radio techniques can be further broken down into complete and partial time systems. A complete system (e.g. WWV, WWVH, CHU, etc.) provides (nearly) all the information needed to set a clock. If one considers completeness even for automatic systems, then one needs the year (Alt. MJD) and some knowledge of the location of the receiver relative to the transmitter. Partial time transfer systems (e.g. Loran C) can provide impressive time synchronization accuracies but some coarse measure of time (e.g. 10 ms for Loran C) must be available by some other means in order to make full use of the potential timing accuracy of the partial system. Of course, many of these systems were designed for other purposes than precise time transfer; still they are extremely valuable to the PTTI community. Time transfer techniques can also be characterized by accuracy, precision, geographic coverage, carrier frequency, format, reliability, precision and accuracy as broadcast, propogation effects, equipment cost, and even operator cost (e.g. labor intensive systems).

The high frequency (HF) services such as WWV and CHU broadcast in the range from a few megahertz to a few ten's of megahertz providing timing accuracies of about a millisecond. While designed primarily for voice communication, some form of computer readable time code is available from several of the world's HF stations. For years, portable atomic clocks have provided the most accurate time transfer although the satellite system known as the Global Positioning System (GPS) is now providing impressive results. In the recent past the Loran C system has been the mainstay of world time coordination, providing time comparison precisions of a microsecond or better. Loran C transmits pulses of 100 KHz at precise intervals (traceable to the U.S.Naval Obsevatory). The precise time transfer of Loran C depends on the ground wave arriving at the receiver before any skywave signal. The ionosphere, which reflects the skywave back to the ground, constantly changes and makes the skywave signal quite variable as compared to the ground wave. The ground wave signal is especially stable over water and sub-microsecond precisions are readily obtained.

The Annual Report of the International Time Bureau contains a great deal of information on the standard time and frequency services available.