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U.S. Naval Observatory
Press Release

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U.S. Naval Observatory to Add Leap Second to Clocks

On December 31, 2005 a "leap second" will be added to the world's clocks at 23 hours, 59 minutes and 59 seconds Coordinated Universal Time (UTC). This corresponds to 6:59:59 pm Eastern Standard Time, when the extra second will be inserted at the U.S. Naval Observatory. This marks the 23rd leap second to be added to UTC, a uniform time-scale kept by atomic clocks around the world. Although you normally don't think about it, for most conventional uses the "civil" time you use is based on UTC. At the U.S. Naval Observatory, time is determined by averaging the time signals from cesium beam atomic clocks and hydrogen masers (the last being an improvement over the tried and true cesium clocks for short periods of time).

Man's oldest clock has always been the Earth. We know it's morning when the Sun rises, noon when the Sun is overhead, and evening when the Sun sets. The Earth's accuracy as a clock is good to about one thousandth of a second per day - more than enough accuracy for most people. However, the invention of "atomic" clocks, which operate by measuring the resonant frequency of a given atom (currently Cesium, Hydrogen or Mercury) greatly increased that accuracy, and has led to the capability at the U.S. Naval Observatory of measuring time to accuracies exceeding a billionth of a second per day.

Time measured by the rotation of the Earth is not uniform when compared to the time kept by atomic clocks. In fact, radio telescopes now observe the most distant objects in the universe, known as quasars, to determine the irregularities in the Earth's rotation. This important function is performed continuously by the Naval Observatory in our Very Long Baseline Interferometry program. As a result of these small irregularities, the atomic clocks can get out of sync with the Earth.

In 1972, by international agreement, it was decided to let atomic clocks run independently of the Earth, keep two separate time-scales, and coordinate the two. In order to keep the difference between Earth time and atomic time within nine-tenths of a second as the two scales get out of sync, leap seconds are added to or removed from the atomic time scale. The International Earth Rotation and Reference System Service

(for which the U.S. Naval Observatory provides the Rapid Service and Prediction Product Center) is the organization which monitors the difference in the two time scales and calls for leap seconds to be inserted or removed when necessary. Since 1972 leap seconds have been added at intervals varying from six months to two years. This leap second occurs seven years since the last one. Leap seconds are added because the Earth's rotation tends to slow down. If the Earth were to speed up, a leap second would be removed.

The U.S. Naval Observatory is charged with the responsibility for precise determination and management of time dissemination, and as such provides the Master Clock for the Department of Defense. USNO, together with the National Institute of Standards and Technology (NIST), determines time for the entire nation. Modern electronic navigation and communications systems depend increasingly on precise time and time interval (PTTI). Examples are the ground-based LORAN-C navigation system and the satellite-based Global Positioning System (GPS).

These systems are all based on the travel time of electromagnetic signals: an accuracy of 10 nanoseconds (ten billionths of a second) corresponds to a positional accuracy of about three meters or 10 feet. In fast communications, time synchronization is equally important. All of these systems are referenced to the U.S. Naval Observatory Master Clock.

The present USNO Master Clock is required by the Department of Defense to be accurate to better than a billionth of a second per day. It is based on an ensemble of 60 independently operating cesium-beam atomic clocks and 15 hydrogen maser atomic clocks. These clocks operate in environmentally controlled vaults to ensure their stability. By automatic inter-comparison of all clocks every 100 seconds, a time scale can be computed which is not only reliable but also extremely stable. Its rate does not change by more than about 100 *picoseconds* (0.000 000 000 1 seconds) per day from day to day. On the basis of this computed time scale, a clock reference system is steered to produce clock signals that serve as the U.S. Naval Observatory Master Clock. USNO also operates an Alternate Master Clock, consisting of 12 cesium-beam clocks and three hydrogen masers, located at Schriever Air Force Base in Colorado.

Due to the sheer number of independent clocks maintained by the U.S. Naval Observatory, it is the largest single contributor to the international time scale (UTC), which is computed in Paris, France, at the International Bureau of Weights and Measures. Moreover, its principal role in keeping track of the change in the "Earth clock" (i.e., Earth rotation) and its dissemination of this information as the Rapid Service and Predictions Product Center for the International Earth Rotation and Reference System Service attests to the fact that globally, as well as nationally, the U.S. Naval Observatory remains the leader in precise time.

Information concerning the U.S Naval Observatory, its mission, history, and programs is available from our World Wide Web site at http://www.usno.navy.mil.