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My time is NOT your time

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In the 1920s, Rudy Valle had a major hit with his recording of the song "My Time Is Your Time". Life was simpler then. After all, the dispute between the Julian calendar and the Gregorian calendar had been resolved some 200 years before. As mechanical clocks came into widespread use at about the same period, people started scheduling their days by reference to the clock, rather than the sun – hence the term "o'clock" when telling time. Time zones were officially established by international treaty in the 1880s. In the United States, time zone boundaries are designated by the Secretary of Transportation. The dates for daylight savings time are controlled by Congress (daylight seems to be the only thing these legislators can save). Timekeeping in general, as with so many other things, revolved around the sun.

That changed with the arrival of the Atomic Age. Scientists discovered that certain atoms vibrated with amazing consistency. Engineers started developing highly accurate clocks based not on a pendulum, but on these vibrating atoms. They soon discovered that there was a difference between these atomic clocks and the rotation of the Earth on its axis. It seems that, for a variety of reasons that are not germane to this article, the rotation of Earth is slowing down, although not consistently. It takes slightly longer today for the Earth to rotate 360 degrees on its axis (a full solar day) than it took on the same day last year. The difference is so slight that I, for one, did not notice. Mechanical clocks do not detect this slowing either. But atomic clocks do register the difference.

In 1967, before the implications of the slow lengthening of the solar day were fully appreciated, the General Conference on Weights and Measures decided, in the interest of scientific accuracy, to change the definition of the second from "1/86,400 of a mean solar day" to "the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium 133 atom." Soon, it was apparent that the atomic clocks and the Earth were getting out of synchronization. The process of adding leap seconds (generally at the end of various years) commenced in 1972. To date, 22 leap seconds have been added in an attempt to keep the atomic clocks and the Earth in sync.

Why does, or should, the mariner care?

Because life is no longer simple.

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Technologies that mariners have grown to rely on themselves rely on atomic clocks to perform their missions. LORAN-C and especially the Global Positioning System (GPS) utilize atomic clocks to synchronize their highly precise signals. These atomic clocks do not utilize leap seconds. LORAN-C clocks are calibrated to zero-hour on January 1, 1958. There is now a 22 second difference between the LORAN-C clocks and Coordinated Universal Time (UTC). GPS clocks are calibrated to zero-hour on January 6, 1980. There is now a 13 second difference between GPS clocks and UTC. At the speed ships normally travel, 13 seconds or even 22 seconds may not make a significant difference. But, these technologies, particularly GPS, are used for more than just keeping track of the position of ships. In addition, the technologies have become increasingly complex, leading to unintended and unanticipated consequences.

The quest for greater and greater precision has led to greater and greater confusion. There are now multiple time scales in widespread use and most users don't know or advertise which time scale they are utilizing. The most utilized time scale based largely on the Earth's rotation is referred to as Greenwich Mean Time (GMT), but, since 1925, it is actually Universal Time (UT). The basic unit of atomic time is the International System (SI) second (defined above). The atomic time scale based on the SI second is referred to as the International Atomic Time (TAI). The combined rotational-atomic time scale is referred to as the Coordinated Universal Time (UTC), which is the time scale in the widest use today. It combines the familiarity of the rotational time with the accuracy of atomic time. The problem, as discussed above, is the difference between the rotational and atomic times and solution, albeit not fully satisfactory, is the leap second.

When a leap second was added most recently (on December 31, 2003), some GPS receivers malfunctioned – displaying the time as 62:28:15. Another leap second is scheduled to be added on December 31, 2005. Hopefully, GPS receivers will be able to accommodate the event more smoothly this time.

Increasingly, GPS signals are incorporated into electronic navigation systems, automatic identification systems, and other intricate interactive systems. Failure to smoothly accommodate the leap second may lead to unexpected errors arising in some of the outputs of these systems. There is the potential, albeit remote, that an entire system may come down. One is reminded of the predicament of the USS YORKTOWN (CG-48). On September 21, 1997, this Aegis cruiser was in the North Atlantic on a solo cruise. A petty officer in the Engineering Department was placing a routine order for supplies, using the ship's computer system. While doing a simple math problem, he inadvertently inserted a zero as the divisor in an equation. Dividing by zero yields an infinite number. The computer, attempting the calculation as directed, crashed. The crash shut down all electronic, electrical, and propulsion systems on the ship, which became dead in the water for two hours and 45 minutes.

The law of unintended consequences is, by definition, unpredictable and can come to the fore as systems become increasingly complex. A Swedish manufacturer of automatic identification system (AIS) transceivers has become afflicted. The company recently introduced two new models, which utilize UTC time for synchronizing transmissions. Knowing that a leap second would be added at the end of the year, the models were programmed to account for the change. Unfortunately, due apparently to a software mistake, the models now commence their transmissions in the middle of a time slot rather than at the beginning of the time slot. As a result, the transmissions use two time slots, rather than one. This creates the risk that the transmission may not be properly received by other AIS devices. There is also the risk that it will interfere with other AIS transmissions. The company is making software and equipment upgrades available to eliminate the erroneous transmissions, which will self-correct when the leap second takes effect at midnight on December 31, 2005.

The legal consequences of these time problems is still unknown. If the problem is the result of a manufacturing problem caused by the equipment maker and the damages are limited to the piece of equipment itself, warranties (express or implied) will generally allow a purchaser to recover the costs of repair or replacement. Consequential damages, such as damages to equipment with which the failed product interacts, may be recoverable, depending on the circumstances. Recovery of more remote damages, such as a collision that may have been indirectly caused by failure of the equipment, will be difficult as foreseeability becomes harder to demonstrate.

The best course of action is to exercise caution and increased vigilance. As UTC midnight on December 31, 2005 approaches, mariners should check their equipment to ensure that it is operating properly. The equipment should be checked again after the leap second has been inserted in order to ensure that all equipment properly accounted for the leap second and did not malfunction as a result of the insertion. Remember, the problem may arise in the least expected manner. It is much better to avoid problems than to have to deal with their consequences.