Ron Beard: The Measure of Time

MELODY WARD LESLIE

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U.S. Air Force photo/Donald S. Branum

The U.S. Naval Observatory Alternate Master Clock in the 2nd Space Operations Squadron's operations center, Schriever AFB, Colorado

GPS clock master Ron Beard dwells in the realm of the nanosecond. That's one billionth of a second, a virtually incomprehensible unit of time even for geeks. But the seamless operation of our cell phones, power grid, banking, and other GNSS-driven technologies depends on that degree of precision.

"For me, being a clock person, clocks are what make GPS work," Beard says. "They provide the ability to measure the range to centimeters, synchronize the satellites, and synchronize your ground assets."

As head of the Naval Research Laboratory's (NRL's) Space Applications Branch and the GPS Clock Development Program in Washington, D.C., Beard oversees advanced technology and development relating to time and frequency, the heart and pulse of GPS.

He is only the second person to hold this position, which he took over from his mentor, Roger Easton, in 1984. If timekeeping is the heartbeat of GPS innovation, Beard must be its cardiologist. A quick summary of his previous roles as a pioneering force in the development of GPS Time:

- key participant in systems analysis and definition of the Navy's first efforts at satellite positioning, the legendary TIMATION Project
- member of the tri-service (Navy/Air Force/Army) team that developed the concept for GPS with the NAVSTAR GPS Joint Program Office (JPO)
- project scientist responsible for developing the satellites that flew the first rubidium and cesium atomic clocks in space, and
- deputy project manager for the Naval Space Surveillance System Modernization Program.

HUMAN ENGINEERING

Hard as it is to imagine GPS without him, the soft-spoken physicist from Amarillo, Texas, easily could have been deployed to wartime service in Vietnam instead, if not for the timely intervention of one of his professors at Louisiana's McNeese State University.

"It was the mid-1960s, and I had been lucky to get an opening in the naval reserve," he says. "I was happily going to school when I got a notice about reporting for active duty."

However, a professor encouraged Beard to apply to officer training school, where he was eventually accepted. After his commissioning in 1968, he was assigned to the Naval Air Systems Command Headquarters as the project officer for satellite navigation. That's how he became involved with the launch of TIMATION, a granddaddy of GPS.

"I've been in the time business ever since," he says.

Synchronicity

No sooner than humans had decided to divide time into discrete units, they began struggling to get clocks tick-tocking in unison.

In particular, before GPS it was tough to synchronize atomic clocks from one continent to another, much less in space. Beard remembers when chief timekeepers carried portable atomic clocks from continent to continent.

"You'd take your 30-to-40–pound atomic clock, buy it a first-class ticket, and fly to France to get the accurate time," he says, referring to visits to the International Bureau of Weights and Measures. "That was one of the things they had to resort to in order to synchronize and compare clocks at different locations."

In contrast, GPS makes it easy to compare clocks anywhere right down to the nanosecond —even in space.

Besides his current role with Precise Time and Time Interval (PTTI) technology for the Department of Defense, Beard also chairs the International Telecommunications Union—Radiocommunications (ITU-R) Working Party 7A, the body responsible for precise time and frequency signal services worldwide.

Previously Beard served as the head of the editorial group preparing a new ITU handbook on satellite time and frequency transfer.

Gaining Seconds

Controversy over leap seconds — and the tricky issues they present for sophisticated systems driven by GPS Time — pushed Beard into the media limelight starting about five years ago during service as special rapporteur for the committee studying the future of the coordinated universal time (UTC) scale.

When it first launched in 1980, GPS time was calibrated to solar time. Since then, however, GPS time has gained slightly more than 14 seconds compared to UTC. (Russia's GLONASS, which does account for leap seconds, has experienced technical problems as a result.)

Research shows that humans can only perceive time down to a millisecond — nine orders of magnitude slower than a nanosecond. So, Beard accepts the fact that most

COMPASS POINTS

Engineering Specialties
Design and operation of navigation satellite systems, space-qualified atomic clocks and related subsystems

His Compass Points
- Carol, his wife of 42 years, " who has always been behind me."
- Son Orson and daughter-in-law Carrie and "three fabulous grandchildren."
- "My love of science."

Favorite Equation
"The one I seem to use the most is Range = speed of light × time interval. The time interval is measured between the clock in space and the one of the ground. The whole GNSS infrastructure is built and designed to support this equation."

GNSS "Aha" Moment
"The pivotal moment was when I was assigned to NAVAIR, Washington, D.C."

First Significant GNSS Achievement
Beard developed Navigation Technology Satellite One (NTS-1) and NTS-2, which flew the first rubidium and cesium atomic clocks in space, while working as a project scientist during the early years of GPS development (1973-79)

GNSS Mentor
GPS pioneer Roger Easton, TIMATION System concept inventor and former branch head at of the U.S. Naval Research Laboratory.

Influences of Engineering Outside Work
"Engineering and science is something that becomes part of the way you think and the things you do. You can't turn it off after hours. Repairing things around the house, building things, and reading all tend to technical themes."

Favorite Non-GNSS Activity
"I collect and repair fountain pens. The ones from the 1940s and 1950s are the best."

What's Next
"The re-definition of the UTC Time scale – a major step in establishing common ground for GNSS that could become a common time scale among the [various GNSS] systems."

Beard's coordinates:
Approximate Position (ITRF)
X coordinate (m): 1117249.15762
Y coordinate (m): -4848758.67469
Z coordinate (m): 3976821.16656
Latitude (N is +): +38.491471
Longitude (E is): -077.012785
Elevation (m,ellips.): -26.010

people, including members of the GNSS community, have trouble believing that our solar-based timekeeping system isn't good enough.

"The fact that it's so subtle makes people think that it's not important, but there is potential for major problems," Beard says.

For example?

"Airlines set flight paths by GPS, but air traffic controllers are on traditional solar-based time," Beard says.

If something does go wrong, tracing the problem to a timing issue can prove difficult.

"Timing problems are the hardest to identify and to document," Beard explains. "Often they're perceived as operator error. The challenge is getting people to realize that if cell phones don't work, it could be the fact that the time is off or that the units are not synchronized because they're not running at the same rate."

Things seem okay so far, but Beard's job is to anticipate future needs, such as the interface between GPS-driven technologies and other applications or systems that are being controlled by clocks geared to solar-based time scales.

In that role, he leads the effort to gain consensus for adopting a more precise international timekeeping system that will depart from the tradition of tying time to the earth's rotation on its axis as it circles the sun.

Counting Atoms
Leap seconds are used to compensate for changes in the earth's rotation, which has — very gradually — been slowing down for millions of years. However, Beard reports that introducing leap seconds into the data streams of space age timekeeping systems has become increasingly difficult.

"If you have to adjust . . . the time, it becomes very complex as to when and how and who it would affect," Beard says.

Although he is a master of clocks that count atoms rather than ticking off seconds, Beard hasn't lost his love of old-school instruments. His personal timepiece is an electronic Seiko pocket watch that he purchased in the 1970s, and he's also an avid collector of antique fountain pens.

Ron Beard and his wife Carol in Geneva

In fact, he still takes notes with a Shaeffer Snorkel, the same fountain pen with which he wrote TIMATION programs in the era before word processors.

"I scribbled pages and pages, and ball point pens just killed my hands," he says. "That's when I became enamored with fountain pens and the technology that makes them work."

Looking ahead, Beard sees the science of timekeeping as fundamental to innovation in interplanetary communications. As ever-more-stable clocks are invented to withstand interstellar stresses, they will lead to new technologies having unforeseeable capabilities here on Earth.

And Beard will be right in the thick of it.

"So much of what GPS has done was absolutely unforeseen," he says. "It appears in places that you never would have expected. It's been such a quiet revolution of going from great difficulty in knowing what time it was or where you were, to just picking up your cell phone. It took a lot to get here." IG

Human Engineering is a regular feature that highlights some of the personalities behind the technologies, products, and programs of the GNSS community. We welcome readers' recommendations for future profiles. Contact Glen Gibbons, <glen@insidegnss.com>.