Ron Hatch: Searching for a Better Way

MELODY WARD LESLIE

As a 20-something math and physics major Ron Hatch didn't like to punch a clock. An attractive job offer from Boeing required that he do so.

His solution: take the other job.

"I'd worked my way through college as an electronics technician tending analog computers on the swing shift at Boeing," Hatch says. "The Boeing offer would have required me to punch the clock for the first year, and I was tired of doing that."

Meanwhile, the Applied Physics Lab at Johns Hopkins did not have a time clock. And they offered a nice position developing navigation and survey algorithms for TRANSIT, the first operational satellite navigation system and the forerunner of GPS.

So, in 1962 the new graduate took that job instead.

And the rest is GNSS history.

Forty-six years later, Hatch has a secure position as one of the foremost developers of GNSS signal processing and application software. The Hatch Filter, a simple and elegant method of eliminating multipath errors, bears his name. He holds more patents than he can count.

And, as director of navigation for NavCom Technology, the company he cofounded and sold to agricultural and construction machinery colossus John Deere, Hatch continues to create novel algorithms that redefine the limits of high accuracy navigation.

HUMAN ENGINEERING

It all began in Oklahoma, where young Ronald R. Hatch first tasted the thrill of competition and realized that he was way ahead of his classmates in math.

He simply had a passion for finding better solutions to problems.

When the Hatch family followed the crops west to Washington state's agricultural cornucopia, the Yakima Valley, their arrival coincided with the opening of a beautifully equipped new high school. Hatch became a founding member of the math club, aptly named The Algorithms.

By his senior year at Seattle Pacific University, the Hatch found himself under pressure to manage the U.S. technology booth at the 1962 Seattle World's Fair. He already had a job that allowed for some studying while on duty, and he wasn't wild about leaving it. However, about 10 of his classmates were being offered part-time jobs at the exhibit—provided he would agree to manage it.

So he said yes.

Shortly thereafter, John Walton, the engineer who had insisted Hatch take the World's Fair job, offered him the

APL position. Hatch and his wife Nancy arrived just as TRANSIT's seven satellites were becoming operational. Walton's assistant supervisor at APL was Tom Stansell.

Once in residence at the Johns Hopkins lab, Hatch says, his mentor Walton and Vern Schwab, mathematician and Fortran programmer, helped him realize that he could make significant contributions in algorithm development.

"It became a challenge to see if I could modify or improve software or hardware to yield a bit more accuracy. The fun of accomplishing that has made my GNSS work very enjoyable over the years."

Back to the Coast

In 1965, Hatch followed Walton to Boeing in Seattle. "My wife and I seized the opportunity to get back to the West Coast," he said.

He worked for Walton in a small group that pursued some unusual projects, among them an unfolding Mylar reflector in space proposed to redirect enough light onto Vietnam to aid in low-light warfare as well as a two-way space communication system.

In 1970 Walton took a position with General Electric in Philadelphia and Tom Stansell, who by then had joined Magnavox and moved west with its commercial TRANSIT business, asked Hatch to join him in southern California. Hatch stayed for 23 years, working in TRANSIT system navigation and surveying software development and in an integrated system for offshore seismic surveying.

Later he transitioned to commercial GPS, developing the first commercial software for GPS surveying using the TI 4100 GPS receiver.

He was working under contract for Geophysical Survey Inc., a subsidiary of Texas Instruments. "GSI could not get the attention of TI engineering personnel, who were too busy with military work, and I could not get access to a GPS receiver; so, it was a match made in heaven," Hatch said.

By 1993 Hatch was in demand as an independent contractor with the Litton Consulting Group, which had

Hatch continues to create novel algorithms that redefine the limits of high accuracy navigation.

been founded by former Magnavox executive Jim Litton. He also consulted with Motorola on a space-borne receiver, with the Federal Aviation Administration on the WAAS/LAAS GPS augmentation systems, and with Northrop on algorithms and flight profiles to maximize navigation accuracy for the targeting of ground objects using SAR (synthetic aperture radar) imagery.

COMPASS POINTS

Engineering Specialties

System engineering and algorithm development with significant software work and limited hardware.

His Compass Points

• "It is the glory of God to conceal a matter; to search out a matter is the glory of kings." - *Proverbs 25:2*

• Nancy, my wife of 47 years, our 13 children (ages 19 to 46), and eight grandchildren

His Namesake Equation

The "Hatch Filter" is used to smooth the code measurements so that code multipath noise is reduced. The equation can be written in a number of forms – this is one of the simpler ones:

$$\overline{P}_i = \overline{P}_{i-1} + \frac{1}{\tau}(P_i - L_i - \overline{P}_{i-1})$$

Where:

The subscript i refers to the current time epoch and the subscript $i-1$ refers to the prior epoch of time.

τ is the filter time constant and controls the level of smoothing. If τ is replaced by the value of "i" so that it changes each iteration, the filter becomes an averaging filter.

$\overline{P}$ is the smoothed code measurement.

P is the unsmoothed measurement.

L is the carrier phase measurement after scaling by the wavelength.

Engineering Mentors

John Walton, Tom Stansell, and Jim Litton, the three managers I worked for most of my career.

GNSS Event that Most Signifies That GNSS had "Arrived"

The United States turning off "Selective Availability" on GPS.

Influences of Engineering on His Daily Non-work Life

Studying and writing about alternatives to Einstein's theories of special and general relativity in light of discoveries related to GNSS.

Popular Notion About GNSS That Most Annoys

That it proves Einstein's special relativity.

Favorite Non-GNSS Activities

Reading good books (The Kite Runner is a recent favorite), watching games that have been TIVOed (Angels baseball and UCLA basketball), and attending church with Nancy and with our youngest daughter, when she makes it home from college for the weekend.

The Next Big Thing

When a significant number of satellites are transmitting on three frequencies, I believe that it will become possible to have a "Global RTK" system that does not need closely spaced base stations.

Hatch with NavCom Tech colleague (and son) Ron

The GPS field was wide open in those years and, at times, the source of much amazement. Use of carrier-phase tracking techniques enabled Magnavox to do such things as write a prospective customer's name by moving the receiver (see accompanying figure).

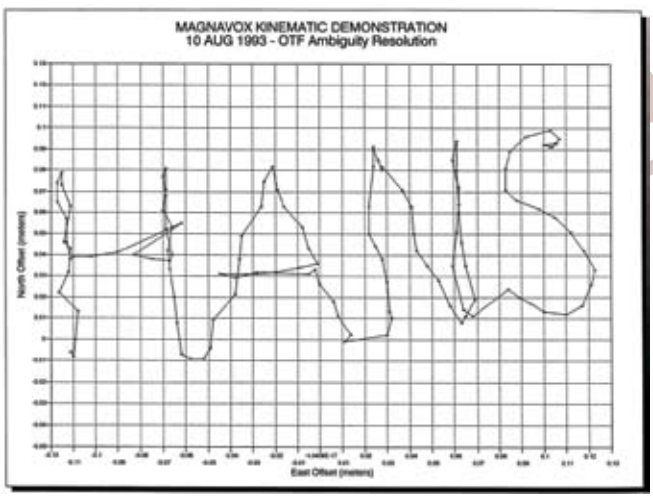
In 1996 Hatch joined Litton as an equal partner in starting NavCom Technology. "The first major win at NavCom was to develop a GPS survey receiver for Sokkia," he said. "It was my first opportunity to participate in receiver design and led to a couple of patents involved with correlator design." Later, the receiver design was modified and applied to agricultural crop yield monitoring systems for Deere.

Within three years, Deere and Company acquired NavCom as a wholly-owned subsidiary.

No article about Hatch would be complete without mentioning NavCom's StarFire Network, a widely available, commercial global satellite-based augmentation system (GSBAS). Such systems provide absolute positioning, meaning they determine location within a space-based reference frame as opposed to determining position relative to some fixed point on the Earth's surface.

Hatch immersed himself in StarFire, which marries NavCom reference stations with the NASA/JPL differential GPS (DGPS) reference stations to create a global, real-time dual frequency positioning network yielding decimeter accuracy.

StarFire has become the basis for Deere's automatic path-following AutoTrac system, which literally places GNSS in the driver's seat. Although NavCom is now part of the Intelligent Mobile Equipment Technology (IMET) group within Deere, it still maintains significant business outside the parent company.



Name spelled out by a computer program tracking the real-time movement of a GPS receiver. Scale on horizontal and vertical axes is in centimeters, producing an almost one-to-one s cale on an 8.5x11-inch sheet of paper.

Piles of Patents (With One Exception)

Hatch won his first patent in 1986 for developing a means of automatically calibrating a magnetic compass using data obtained while turning the host vehicle in a complete circle.

Ironically, he doesn't hold a patent on his famous code minus carrier smoothing algorithm (the eponymous Hatch Filter) because Magnavox patent lawyers told him it wasn't patentable.

Hatch's coordinates:
Latitude = 33º 50' 28.171" N
Longitude = 118º 20' 37.027" W
Height above WGS ellipsoid = 9.11 m

"I knew they were wrong," he says good-naturedly. "I'm just as glad it wasn't patented because almost everyone uses it for GPS receivers."

Hatch co-invented another technique, unique to Deere, that is marketed as RTK-Extend. The service compensates for interruptions in data transfer between receivers by combining StarFire global DGPS in both the system's real-time kinematic (RTK) reference receivers and user equipment to compensate for loss of line-of-sight due to such obstacles as trees or rolling hills.

Users can continue to navigate with almost no degradation in accuracy for 15 minutes or more. When RTK communication is re-established, it resumes with virtually no apparent change in accuracy.

Finally, the first of his two most recent patents issued in 2007, describes a method used in many of NavCom's receivers for high-rate position computation. The other is for a moving base RTK solution that allows for the computation of the relative position of two moving GPS receivers.

With a NavCom Technology working group, from left to right: Jonathan Esche, Yuki Zhang, Hatch, Yiqun Chen, and JP Genta.

An Independent Thinker

As a hobby, Hatch enjoys studying and writing about alternatives to Einstein's theories of special and general relativity.

"My knowledge of GPS clock phenomena has contributed significantly to my thinking in this area," he says. "I see things out there saying I'm a heretic. It helps if you're pretty confident you're correct."

His favorite "relativistic" equation is one he developed in his soon-to-be-published paper, "A New Theory of Gravity." A simplified version of this new equation for the force of gravity on mass, m, looks like this:

$$F = \frac{d}{dr}\left(e^{-\frac{GM}{rc^2}}\right)mc^2 = \frac{GMm}{r^2}\left(e^{-\frac{GM}{rc^2}}\right)$$

The exponential value in the parentheses is the gravitational scale factor (Hatch used the symbol s for this value in the paper), which among other things scales the frequency of clocks in the GPS system. He claims it also scales the rest mass energy. This scale factor differs only very slightly from Einstein's gravitational scale factor of

$$\sqrt{1-\frac{2GM}{rc^2}}$$

"Both scale factors differ only very slightly from the value of one for ordinary gravitational fields," Hatch says. "Thus, Newton's inverse square law is a very good approximation. What this equation shows is that the gravitational force arises from the spatial gradient of the rest mass energy."

Always Looking Ahead

At age 69, Hatch still has new, proprietary projects in the works. He anticipates a new project or two may be introduced towards the end of 2008 and "more important things may be a couple of years off."

Meanwhile John Deere is developing completely autonomous tractors so that humans won't need to expose themselves to harsh environments. Even though he knows the technology from the inside out, Hatch found himself marveling at the magic of GNSS when the prototype he was riding automatically turned itself around at the end of a crop row.

"They drive a straighter row than a human can," he said, "I would never have guessed that agriculture would be one of the biggest applications for high accuracy GPS."

With Galileo on the horizon and the prospect of three frequencies, Hatch looks forward to solving new kinds of problems. "The fact that they're changing the system keeps it interesting," he says, referring to modernization of GPS and the emergence of other GNSS systems.

True to form, he's already obtained a related patent. 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.

InsideGNSS