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The Global Positioning System has long occupied a central role for imagery applications, such as those used in agriculture and defense to characterize terrain features. And GPS navigation applications are critical, of course, in aviation. However, a general market for the GPS has emerged only recently in personal navigation devices. Remember how cool that first GPS receiver was on the dashboard of a rental car?

The infrastructure for satellite-assisted navigation is poised to grow rapidly within the next four or five years, and the electronics industry is preparing to offer new receivers and services for mass markets, with special emphasis on mobile phones. Electronics Canada, a research and publishing firm, estimates that global value of GPS products will grow to more than US$30 billion in 2008, up from $13 billion in 2003 (http://www.electronics.ca/reports/RFID/gps.html), and Gartner Group analysts predict that almost 40 percent of handsets will support GPS by the end of 2010 (http://www.gartner.com/DisplayDocument?ref=g_blog&id=498745).

"I think there’s a bit of a revolution going on, to be honest with you,” says John Pottle, marketing director for Spirent, a UK-based manufacturer of electronics testing equipment used by GPS and handset manufacturers. "We’re heading from a world where people are aware of this technology to one where people are really using it in their day-to-day life. At Spirent, we believe GNSS [global navigation satellite system] will become the fifth utility and a key part of all our lives, just like electricity or telephone are today.”

Third-generation GPS

Another UK-based company, single-chip wireless device designer CSR, recently invested heavily in the GPS market, purchasing two GPS startups: Swedish firm Nordnav and UK-based Cambridge Positioning Systems. Stuart Strickland, manager of CSR’s GPS business unit, says the satellite navigation market is about to enter its third generation, one marked by mass acceptance, with its concomitant high user expectations and low user expertise.

"The early-generation receivers were used by eccentric niche markets, like hikers and boaters, or special-purpose users very aware of the limitations of the technology,” Strickland says. "These people were willing to point their units at the sky and wait 15 minutes for a signal. Engineering for low power consumption was important, but expectations were low.”

Personal navigation devices represented a breakthrough, Strickland says. Even though the underlying technology was essentially the same as in earlier applications, the power requirements weren’t constrained because the PNDs ran on the alternator in a car or boat. “Consumer expectation was higher,” Strickland explains, “so there was a lot of effort in improving the user interface.” The advances will show up in third-generation systems, he says. “Instead of just taking your device hiking or driving, we’re shifting to a market where people can take this with them everywhere.”

Competition for GPS?

Today, the GPS is the only functional satellite navigational system. Launched and operated by the US government, the GPS became fully operational in 1995. It now consists of 30 satellites, although the
operational number varies according to outages and the available spares in orbit. The satellite
c constellation provides both civilian and military signals. Civilian users receive the standard signal from
the L1 frequency of 1575.42 megahertz, which supplies both coarse and precise radio codes and the
navigational data used to process GPS signals to give the user time, position, and satellite velocity.
Military users receive a precise signal from L1 and also from the L2 frequency of 1227.6 megahertz.

A GPS receiver calculates its position by assimilating information from at least four GPS satellites. By
combining the information, the receiver can estimate its distance from each satellite at a given time,
and then deduce its location in three dimensions. Most handheld GPS receivers are now accurate to
within 20 meters or so. (In 2000, the US Defense Department disabled a technology called Selective
Availability, meant to limit civilian receivers' accuracy to a 100-meter margin (http://gps.faa.gov/FAQ/faq-gps.htm)).

The GPS constellation is undergoing a modernization plan with more powerful GPS III satellites slated
for launch by 2013. The European Union, Russia, and China also plan to launch satellite navigation
systems within the next decade. As the market for satellite navigation grows stronger, industry
observers say these efforts will both augment and compete with GPS. The European project, Galileo,
uses the same communications protocol as GPS—code division multiple access (CDMA)—so it's
interoperable with GPS (http://useu.usmission.gov/Dossiers/Galileo_GPS/Mar2406_Joint_Statement.pdf). However, the
Russian project, Glonass, uses frequency division multiple access (FDMA), which complicates design
decisions for receiver vendors, according to CRS's Strickland.

Galileo delays
Meanwhile, Galileo is suffering significant growing pains, mostly because its core stakeholders can't
agree on scheduling and a business model. Strickland, Pottle, and Glen Gibbons, founder of GPS
information resource Gibbons Media and Research, all remain sanguine about Galileo's long-term
viability. However, they also say the squabbling has caused vendors to scale back their expectations of
Galileo's position vis-a-vis GPS.

"If you had asked me a year ago," Strickland says, "I would have said every GPS receiver sold would
be a combined GPS/Galileo receiver by 2008. That's no longer the case. There will be a lot of GPS-only
receivers."

The delay in Galileo has alarmed officials at the highest levels of the European Commission. As the
impasse continued through March, Jacques Barrot, EC vice president of transport, issued a letter
demanding that the project's private-sector partners streamline their organization by 10 May
(http://www.euractiv.com/29/images/Barrot_Galileo_tcm29-162520.doc). If progress on getting
Galileo operational doesn't improve, he also says it might be time to seek an alternative organizational
scheme.

"I consider that the delay so far accumulated and the absence of any sign of progress on the
negotiation of the concession contract must now be considered as risk for the delivery of the project in
the timeline that we envisaged," Barrot wrote. "Moreover, we have to fear significant cost increases
which could go well beyond the foreseen budget."

Unless the private partners respond by 10 May, Barrot said he would begin exploring alternatives for
delivering the project: "I do not exclude that we may have to revisit some fundamental aspects of our
earlier assumptions and approach. A number of options are available for such alternatives and I would
not want to exclude any of them at this stage."

Gibbons says he expects the Galileo project partners to eventually work out their issues because the
technology is compelling. The new satellites will not only complement existing GPS technology but
improve it. "Galileo should be broadcasting a modern signal well ahead of GPS III," Gibbons says.
"That signal will be so much better than the old one, and that'll be real good for cell phones."
Spirent’s Pottle also sees Galileo’s benefits overcoming vendor reservations about developing dual-capability GPS/Galileo equipment. When you add GPS to Galileo, he says, “you get twice as much signal and consequently better performance in tricky areas, particularly in cities, where you have buildings blocking signals. I don’t think people see the lack of Galileo as a barrier—it will be a bonus when it comes in for better accuracy and performance.”

**Meanwhile, back on Earth ...**
The profound changes in satellite navigation’s celestial infrastructure will be matched by technological changes in the earthbound receivers as single-function devices give way to multiuse phones, media players, and PDAs.

“Devices that have existed in personal navigation devices and receivers have largely been system-on-chip [SoC] architectures,” CSR’s Strickland says. “When we go to devices intended to do many different things, they have a lot of shared common resources. CSR is looking—and probably many companies will look—at ways to identify common resources to support GPS in ways that bring GPS-specific hardware and software to a market-sustainable cost point.”

Gibbons contends that mass introduction probably won’t occur until GPS-specific hardware and software costs drop about 20 percent from the estimated $5 to $7 per unit it does currently. According to Strickland, the costs need to be low enough for vendors to include them in the low-cost subsidized phones they offer in introductory plans. Vendors will have to weigh the performance and integration advantages of SoC architectures versus the lower cost of more software-based designs.

“As GPS enters higher-volume markets, where cost per unit is more important than the initial development costs, it’s inevitable to lead to more software architectures. It’s bound to happen, a condition for GPS getting onto all the handsets. If it doesn’t happen, GPS will be niche-marketed to just high-end handsets.”

Those next-generation handsets will also have to combine GPS technology with terrestrial technologies that calculate a phone’s position relative to mobile carriers’ network facilities. These technologies offer location-based services in spots the GPS can’t easily reach, such as indoors. Furthermore, they can guarantee a level of accuracy in an amount of time that cell-based users expect. The broader user demographic won’t be willing to wait a minute on location, Strickland says. “And cell-based technologies are accurate within 50 to 100 meters, as good as GPS indoor accuracy would be.”

**A solar flare and you’re lost**
The extra satellites promised with Galileo (and Glonass to some extent, especially if its operators switch to CDMA technology) might prove beneficial in the next concentration of maximum solar flare activity in 2011 and 2012.

A Cornell University graduate student, Alessandro Cerrutti, accidentally discovered that solar flares of about 8,700 solar flux units (SFUs) caused GPS receivers to record between 40 and 50 percent signal loss during a brief solar burst in September 2005 (http://www.news.cornell.edu/stories/Sept06/solar.flares.gps.TO.html). At the time, Cerrutti and his colleagues estimated that a projected 80,000 SFU burst would cause 90 percent degradation for several hours. On 6 December 2006, however, a 1 million SFU burst completely wiped out signals on the Cornell equipment for 10 minutes, and Paul Kintner, head of Cornell’s GPS Laboratory, said, “Some of the most robust receivers got down to tracking just four satellites, and that is the absolute minimum necessary to get a reading.”

Kintner says more signals—and more powerful ones—might help mitigate potential outages. The concern is critical for agencies such as the Federal Aviation Administration. While GPS outages probably won’t mean life or death for the average motorist staring at a blank navigation screen, aviation safety will mandate more research before the solar maximum hits.
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