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Integrating SAASM GPS and Inertial Navigation: What to Know

Conquering Complexity®

At any moment, a mission could be threatened — with potentially severe consequences — because of jamming and spoofing aimed at global navigation satellite systems. The U.S. government's mandate that any military GPS system receiver be equipped with a Selective Availability Anti-Spoofing Module (SAASM) microchip helps manage the risk. In the field, however, integration between SAASM, GPS and inertial navigation systems (INS) doesn't always work as planned. For manufacturers new to navigation or SAASM, or even for larger companies, knowing the steep integration challenges and considering turnkey solutions can save time and expense and ensure secure operations.

Top SAASM-Based GPS and INS Integration Challenges

Even the most sophisticated and experienced design engineers tend to underestimate the complexity of integrating SAASM-based GPS into an INS for unmanned vehicle systems or manned portables such as target locators. From creating a robust, real-world algorithm to making micro-electromechanical parts fit while avoiding magnetic interference, successful integration begins with a knowledge of the challenges.

1 ACQUIRING RESTRICTED SAASM CIRCUIT BOARDS

The ITAR-controlled, non-commercial SAASM GPS microchips are capable of decrypting high-precision GPS locations from encrypted satellite communications — which is why purchasing the technology is highly restricted to manufacturers with the right clearance. A government system tracks where every SAASM chip goes, what products they're in and who is using these products. Notably, the chip isn't mounted on a circuit board. While that may not seem significant, most generic board manufacturers and suppliers don't have the security clearance to work with SAASM.

SAASM compliance requires significant time for authorization

Developers and manufacturers must have a military STARS account, a Communications Security (COMSEC) account, a Key Data Processor Loading and Installation Facility (KLIF) account and undergo a Navstar GPS Joint Program Office (JPO) design-review process. They must also provide various forms of proof about their ownership and ensure their facility has security clearance issued by the Defense Security Service.

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It's no wonder that experts in time and frequency instrumentation warn that "the process to acquire SAASM-compliant receivers requires significant time for authorization."[1] They recommend that "makers of such equipment first have a government security structure in place."[2]

"The challenge for companies is that while they can open up the phone book and find 10 contractors to make a circuit board, they won't find any who can integrate a SAASM chip into the board," explains Mike Bagley, Senior Product Manager at Sparton NavEx.

2 CREATING AN ALGORITHM THAT SYNCHRONIZES

Even advanced military GPS systems produce errors. They may not send data fast enough or update data when expected. They may send bad data or appear to be "missing" for a period. Most commonly, the signal bounces off a building or part of the terrain (multi-mapping) and produces an error. GPS usually provides accurate information independent of time, but may be subject to these outages or interference. In contrast, inertial technology provides good position and velocity data in the short term, but has a tendency to drift.

For full, continuous navigation capability in a GPS-denied environment, synchronization between the two systems is critical. The navigation algorithm needs to take into account that the SAASM-based GPS is not running at the same speed as the inertial — or a sort of cognitive dissonance between the two will occur.

"Having stale information is risky," says Bagley. "It's important to know when each sensor reading comes in relative to other readings. But even knowing GPS data is two seconds older than sensor data isn't enough. You need to teach the device that something has changed and how to determine which sensor is wrong. Developing the navigation algorithm is more complex than many expect."

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Mike Bagley
Senior Product Manager, Sparton NavEx

[1] Holm, Ron. "Why convert to a SAASM-based global positioning system?" *Military Embedded Systems*. October 2005. http://mil-embedded.com

[2] Callaghan, Steve and Fruehauf, Hugo. "SAASM and Direct P(Y) Signal Acquisition." *GPS World*. http://archive.is/xeRH

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Customized Sensor Data Checklist

For maximum performance and flexibility, make sure your SAASM GPS/INS design includes the ability to:

- Write and execute custom, user-defined applications
- Provide full access to all adjustable parameters
- Directly interface with real-time sensor data
- Create custom computations for your applications
- Modify startup commands

Sparton NavEx INS-20, an INS system that integrates SAASM GPS, includes the advanced NorthTek™ customizable programming environment.

3 LEVERAGING ADDITIONAL SENSORS

Ideally, the SAASM-based GPS and INS operate as a unified navigation system, able to add on additional sensors and integrate with additional sensor inputs to enhance location accuracy even further. The challenge is in developing an algorithm that can pick up several sources of motional information so that you can catch errors and have one source of data compensate for another.

"You need to not only ensure agreement between the inertials and the GPS sensor, but to track the data from any additional sensors," says Bagley. "Many companies will use a static filter that depends on things being correct. We use a dynamic filter in our system to provide balancing between sensors that's essential for changing conditions."

With input from additional, external sensors such as odometers, pedometers and celestial navigation — that are likely already in the platform — the whole is greater than the sum of its parts for getting accurate data. With additional sensor input, developers might even find they need fewer components, such as additional inertial measurement units (IMUs) containing accelerometers and gyros.

4 COMPENSATING FOR MAGNETIC INTERFERENCE

Digital magnetic compasses in an INS require a complex and often cumbersome in-field calibration process. This calibration is often performed improperly, incompletely or sometimes not at all, resulting in diminished sensor performance and poor overall accuracy in targeting and other applications. However, field calibrations are vital to account for changes in the magnetic signature of the system platform. This signature can change over time due to variables including installation of new batteries. When integrating SAASM GPS and INS, engineers must develop a calibration mode that effectively collects and processes calibration measurements.

"Targeting isn't like working within a large vehicle with room for componentry; everything is driven by size, weight and power. And when you start putting things close together, impact increases. That's why we developed a 3D, real-time calibration model — an atypical but important feature in digital compasses."

Jeff Cavins, PhD
Engineering Manager, Sparton NavEx

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5 MANAGING INTERNAL RESOURCES AND SCALE

With SAASM GPS and INS systems, even engineers with deep industry knowledge may not have the navigation skill set or history of "lessons learned" to perform integration efficiently and successfully while still keeping timelines and schedules under control.

"The 'what ifs' and the unknowns don't show up in a lab or textbook," says Bagley. "It requires having seen specific scenarios many times before — a sort of 'tribal knowledge,' if you will."

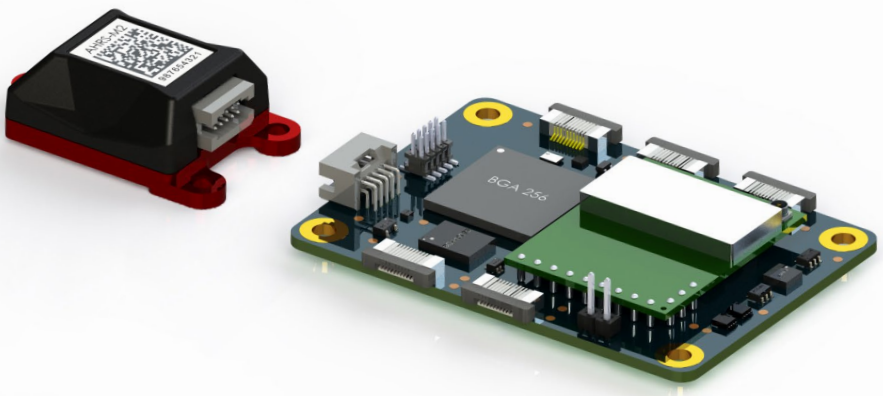
Even larger companies might find themselves scaling up to bring on additional navigational expertise.

"Whether they work in robotics or imaging, the in-house team's highly specialized knowledge may not extend to other areas such as navigation," says Cavins. "Periods of development and trial and error can mean long man years and the possibility of running short on contract funding."

A Blended Turnkey Solution

For many developers and manufacturers, the best, most efficient approach for managing the challenges of integrating SAASM GPS into a navigation system is a turnkey, ready-made package. Sparton NavEx INS-20, for example, integrates SAASM GPS with a MEMS-based inertial navigation system. The first in its class, INS-20 provides fully compliant SAASM GPS security with an onboard SAASM receiver. The system integrates the SAASM GPS input with sensor input from the Sparton NavEx AHRS-M2 system.

With a turnkey, properly integrated system, developers can bypass the software, accuracy and security/clearance challenges. They'll have a compact, versatile low-power solution that provides full self-location and navigation capability including latitude, longitude, altitude, heading, pitch, roll and velocity.



INS-20 Feature Set with AdaptNav™ algorithm:

- **Selective Availability Anti-Spoofing Module (SAASM)**
- **Rockwell Collins microGRAM™ SAASM GPS coupled to Sparton NavEx AHRS-M2 through AdaptNav™ algorithm**
- **Sparton AdaptCal™ 3D provides continuous, in-field calibration**
- **User-programmable sensor customization via Sparton NavEx NorthTek™ Forth interpreter**
- **Ability to add additional external sensors such as pedometers, odometers**
- **Improved GPS tracking with position data output rate of 100 Hz**
- **Static heading accuracy of 0.2° RMS**
- **Small form factor of 31g for the combined system**
- **Low power consumption of 1W**
- **Full 360° rollover capability using quaternions or rotation matrix**

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Conclusion

Most industry insiders would agree — there's no silver bullet when it comes to achieving precision navigation. The challenge becomes more complex when developers and manufacturers take on integration of highly restricted SAASM-based GPS into an INS. The good news is that with a blended, turnkey SAASM GPS and INS package, backed by a robust algorithm and other advanced capabilities, manufacturers can enter the military market or expand an existing portfolio without spending significant time or investing in the talent required for successful integration and high performance.

About Sparton NavEx

Sparton is a worldwide leader in the development and production of undersea warfare devices and inertial sensor systems. The Company designs and manufactures sonobuoys for the U.S. Navy and MEMS-based inertial systems for defense and commercial applications. Sparton delivers low power, low cost, robust sensor solutions for military, aerospace, industrial and commercial applications. The Company has a full line of solutions to meet the challenges and requirements of diverse and demanding markets. For more information, visit SpartonNavEx.com.

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