SAASM on Trial

A Test Regime for Integrated GPS Military Systems

Testing a military-grade GPS receiver by itself is one thing; testing its operation after integration on a platform — vehicle, aircraft, or munition — is something else. It is more of a challenge when the receiver in question incorporates a Selective Availability Anti-Spoof Module (SAASM) for which on-orbit signals have not yet been activated. Staff members of the 746th Test Squadron at Holloman Air Force Base designed and developed a mobile test bed that incorporates a GPS signal simulator and makes realistic performance evaluation of integrated SAASM possible.

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The Selective Availability Anti-Spoof Module (SAASM), which among other things enables decryption of precise GPS satellite signals, is the newest generation of security architecture for all GPS Precise Positioning Service (PPS) users.

Combined with navigation warfare (NavWar) protection technologies, SAASM enhances a combatant commander's ability to use GPS precise position, velocity, and time (PVT) in all environments. The module combines the new capabilities of unclassified black keys, multiple user networks, and extended GPS functions.

Collectively, SAASM extended functions provide the military user with authenticated GPS data necessary for continuous PPS operations without the periodic need to return to base. This affords the warfighter more secure military operations, simplified handling of cryptovariables — the bits that enable PPS operations, and additional operational capabilities, all while preserving GPS's accuracy performance.

In accordance with the Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 6130.01, the 2003 *CJCS Master Positioning, Navigation, and Timing Plan,* DoD system program offices are procuring SAASM-based receivers to replace legacy PPS-security module receivers. Several navigation and weapon platforms with SAASM receivers are now operating in the field. However, due to a test capability gap, many of these SAASM-integrated systems have not been fully exercised at the operational system level to verify their integrated functionality.

This article describes the development of an innovative test bed that performs end-to-end functional tests on weapon systems that have integrated

The Navy's F/A-18 took advantage of the SAASM-ISER's unique test capabilities.

U.S. Navy Photo by Mass Communications Specialist 2nd Class (AW/NAC) Ryan Courtade

SAASM-based receivers within the platform itself.

SAASM Testing: The History

Although this level of integrated platform testing is a recent innovation, we do not mean to suggest that SAASM itself has not been tested. Sandia National Laboratories (SNL) designed and rigorously tested the SAASM architecture using a disciplined and repeatable laboratory test process. This test process included a thorough validation of SAASM's Key Data Processor (KDP), and test results clearly show that the KDP's performance works as advertised within the SAASM design.

Subsequently, SAASM vendors implemented SNL's design into the physical modules that would eventually be integrated into PPS receivers. These modules were then meticulously validated through a series of production tests that include SAASM test vectors — a subset of SNL's validation process that ensured the module produced required outputs in the presence of an extensive list of inputs, guaranteeing correct KDP integration and validating the vendor's implementation of the SAASM architecture.

However, this KDP integration testing is accomplished at the module level and does not guarantee the performance of SAASM integrated into a GPS receiver. Instead, SAASM receivers are tested by their respective vendors and/or by professional GPS test facilities such as the 746th Test Squadron's (746 TS) Navigation Test and Evaluation Laboratory (NavTEL).

Indeed, 746 TS NavTEL personnel, in a cooperative effort with SNL, developed the comprehensive SAASM test scenarios used in SNL's SAASM architecture and KDP validation process, as well as the test vectors used in vendors' facilities to validate the performance of their respective modules. The 746 TS then adapted those test vectors into a receiver test process to validate SAASM-based receivers under simulated functional conditions.

Since then, many other GPS laboratories — primarily members of DoD's GPS Test Center of Expertise and prominent DoD receiver manufacturers — have also implemented the SAASM test vectors into their receiver test processes. However, this robust test capability still does not guarantee the overall performance of larger systems integrated with SAASM-based receivers.

SAASM-ISER fills a critical testing gap and can exercise each of the SAASM extended functions on a fully mission-capable platform at the platform's home station.

As early as 2005 when SAASM-based receivers were earnestly beginning to be fielded, system integrators were quick to identify this test capability gap, but practical options were not readily available. On-orbit SAASM signals were not — and still are not — yet activated. Even once the GPS control segment AEP 5.5 — the software that will enable SAASM signals to be broadcast from space — becomes operational, the right signal conditions for conducting validation testing or end-to-end system performance tests will not occur on a regular schedule, making it difficult for system evaluators to schedule and run tests.

In addition to these limitations, the laboratory capabilities that have exploited the SAASM test vectors are not particularly useful for integrated platform testing, simply because these platforms are generally too large to bring into the laboratories. The only realistic test option seemed to be to broadcast simulated extended function conditions into a large anechoic chamber, which was, for many system integrators, a prohibitively costly option.

The 746 TS Solution

The 746th Test Squadron, located at Holloman AFB, New Mexico, responded to this concern of system integrators by developing an innovative test bed called the SAASM Integrated System Evaluator and Reporter (SAASM-ISER). The SAASM-ISER is a mobile laboratory asset that fills the testing gap by performing end-to-end functional tests on weapon systems with integrated SAASM-based receivers within the platform and/or its munitions.

This test resource provides the capability to generate the appropriate GPS signals and collect data from the weapon system platform. It then verifies the fidelity of the SAASM functions and the data transferred from a stand-alone or embedded GPS receiver (EGR) to other system components.

Hence, the SAASM-ISER can provide a real-time functionality assessment of a platform at the receiver, the cockpit, and a weapons pylon, if the system passes GPS information among these subsystems. Additionally, SAASM-ISER provides a means to conduct SAASM anomaly investigation and resolution regardless of on-orbit signal status.

Because the SAASM-ISER is a deployable resource, testing with this

Clockwise: High Mobility Artillery Rocket System (HIMARS)

Preparing to test HIMARS from the 746th Test Squadron's SAASM-ISER °test van

Antenna hood (the green box) over two GPS antennae: one as part of HIMARS, and the other connected to SAASM-ISER's quality control monitor receiver

asset can be accomplished frugally on a platform in its operational configuration at virtually any location.

The SAASM-ISER consists of a multi-channel GPS satellite simulator and control network, a data acquisition system, an antenna hood, a bus interface compatible with RS-422 and MIL-STD 1553, as well as a MIL-STD 1760 connector for the collecting the bit stream which is internally sent to the platform pylon. (See **Figure 1**.)

The GPS simulator is configured to run specific test scenarios in accordance with the SNL profiles. Simulated SAASM signals are broadcast directly to a system under test (SUT) through the antenna hood that is fitted and sealed over a platform's antenna. For applications in which an antenna system does not need to be exercised, the SAASM-ISER can be adapted to inject signals into the SUT directly.

The SAASM-ISER equipment is rack-mountable and can be deployed with a test support van equipped with needed power and environmental (heat/alternating current) control capabilities. If the customer supplies the electrical power, physical security, and environmental support required for the equipment, the SAASM-ISER can be deployed without the support van for additional cost savings.

The Test Bed in Action

Before testing with the SAASM-ISER, the test approach and data collection requirements are first coordinated with a customer to determine the best SAASM scenarios to run, the appropriate scenario sequence, and data collection sources for each test objective. For instance, not every platform passes GPS information internally to a pylon; so, in this case collecting MIL-STD 1760 data would not likely be relevant.

Although the SAASM-ISER can be configured to meet unique customer requirements, the test bed's default configuration can execute the following functions:

- demonstrate, independently, the normal operating functionality of the SAASM-ISER and the baseline performance of the SUT during setup and checkout
- determine the system functionality using the black key and its cryptovariable handling device

Clockwise: The Rack-Mountable SAASM-ISER

The SAASM-ISER support van preparing to SAASM-ISE the HIMARS

SAASM-ISER testing in progress on HIMARS

- determine system performance during simulated extended function conditions
- determine whether or not the system properly outputs and propagates the proper bit stream and information from the GPS receiver to the appropriate parts of the system.

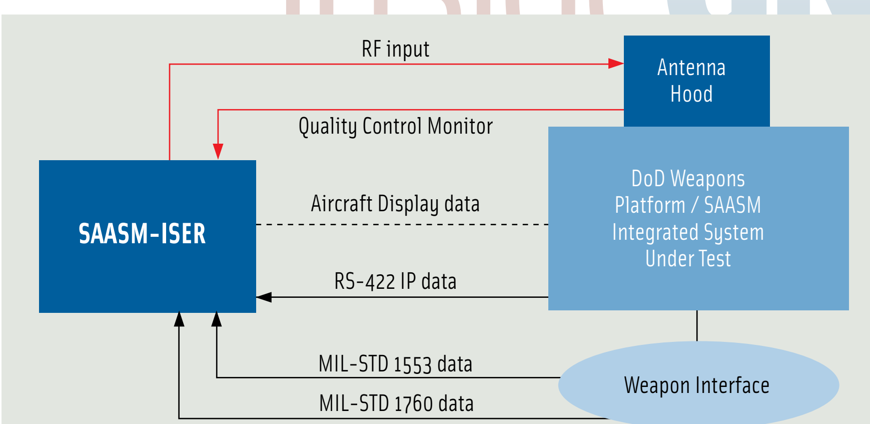

FIGURE 1 SAASM-Integrated System Evaluator and Reporter (SAASM-ISER) test configuration

After an appropriate test approach is agreed upon, selected scenarios are synchronized to the platform test location to be consistent with the platform's inertial navigation system (INS) geoposition and time. The antenna hood is placed over the platform's antenna, minimizing RF leakage with additional shielding if necessary.

In addition to the SUT, the SAASM-ISER is also directly connected to a well-characterized SAASM receiver to help ensure that the scenarios are run to a baseline performance level with optimum signal quality.

These baseline functional tests are considered complete when the test platform navigation system shows nominal system performance without any anomalies detected. When the customer and

SAASM and GPS RAIM tests were performed on an operational P-3 using SAASM-ISER.

the 746 TS testers are satisfied that both the SAASM-ISER and the SUT are functioning normally, they are interfaced together for the test profiles.

For the functional SAASM testing, all SAASM-ISER test scenarios are set up for a static position, which allows the SUT's INS to operate in its normal navigation mode. System data are recorded for use in determining navigation performance and system errors, which can be included as part of the report data.

SUT data are acquired from the platform via an RS-422 instrumentation port (IP) and from visual observations/recordings from the platform's navigation central display unit. The RS-422 IP data are recorded on a hard disk on the SAASM-ISER.

Test operators compare the SAASM-ISER end-to-end test checkout data to the pretest baseline data. The quality control monitor receiver power levels are compared to the baseline for any necessary adjustments. Then the test platform's performance is compared to expected values for position, velocity, time, carrier-to-noise density ratio, code, state, and estimated position error figure of merit.

The SAASM-ISER proof of concept and basic capabilities were first demonstrated in May 2005 on the Army High Mobility Artillery Rocket System (HIMARS). During that demonstration, the 746th Test Squadron successfully executed the desired test vectors on a fully integrated and operational weapon system. The test exposed some latent integration issues that the developer was able to correct subsequently.

More recently, the SAASM-ISER has been used to test a variety of platforms, including the Navy's P-3, MH-60S, and F/A-18 (ANAV) aircraft. To accommodate an even more diverse suite of platforms, the SAASM-ISER has since undergone a series of upgrades that include the addition of a controlled reception pattern antenna hood.

Conclusion

The purpose of the SAASM-ISER is to verify the integrated functionality of the SAASM extended functions on operational platforms equipped with SAASM capability. It fills a critical testing gap and can exercise each of the SAASM extended functions on a fully mission-capable platform at the platform's home station.

Using the 746th Test Squadron's SAASM test vector expertise, the SAASM-ISER proves to be a cost-effective risk reducer that verifies technical performance that is nearly impossible to verify otherwise. When used early in a system's integration program, it can reveal and help resolve integrated system deficiencies in a timely fashion or provide a means to duplicate and investigate SAASM anomalies.

Manufacturers

The multi-channel GPS satellite simulator used in the SAASM-ISER is the STR4760 from **Spirent Communications**, Crawley, United Kingdom. The Quality Control Monitor receiver used in the SAASM-ISER is the Defense Advanced GPS Receiver (DAGR) from **Rockwell Collins**, Cedar Rapids, Iowa.

Authors

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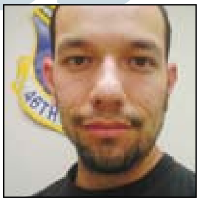
Derek Ruff leads reference systems development at the 746th Test Squadron. He has been involved in all aspects of guidance and navigation testing, from data analysis to test management. Derek also supports the GPS Wing in integrating user equipment onto host platforms.

Angelo Trunzo is currently the director of the GPS Test Center of Expertise (COE), a multi-service consortium of GPS test organizations. Operating out of the 746th Test Squadron at Holloman AFB, New Mexico, he actively participates in several integrated test teams (ITTs), including the GPS Enterprise ITT. Past assignments include design and analysis, environmental testing, and test management that have included the Responsible Test Organization function for the USAF Joint Precision Approach Landing System (JPALS).

Jim Killian is the chief of the GPS Integration and Technical Support section at the 746 TS. He was involved in the design, development, and testing of the SAASM-ISER. He has supported the GPS Wing and system groups in GPS integration upgrade efforts and navigation system testing on numerous platforms.



Andrew Moya is an avionics test manager at the 746th Test Squadron. In addition to managing various GPS, INS, and integrated system tests for the last three years, he has also managed the last several SAASM-ISER tests conducted by the 746th TS. IG