National Aeronautics and Space Administration

Flight Software

Agile Development for the Toughest Missions

Marshall brings a responsive, agile approach to program and project development efforts. The Marshall flight software team performs the complete range of flight software activities, including requirements development and analysis, software processes and planning, design and development, systems integration, and development testing. Marshall also provides the facilities for flight software development and testing and software formal verification through the development and management of test activities.

Marshall was NASA's first field center to achieve CMM Level 3 required for human missions, is an early adopter of UML, uses agile software development techniques, and continually embraces new approaches and tools to be more efficient in software development.

Marshall's expertise in real-time hardware-in-the-loop (HWIL) capabilities complements its software development efforts by enabling the integrated software and avionics hardware systems of launch vehicles to be modeled, simulated, and tested early, before finalizing designs. The modular HWIL approach is easily extensible to multiple types of spacecraft, landers and launch vehicles. Marshall's HWIL capabilities are powerful tools in verifying and validating both development and final designs of integrated hardware and software systems.

At-A-Glance

Flight software is critical to mission success, both in development and execution. For Class A and human missions, it also must meet exceedingly stringent requirements. Marshall's flight software team was the Agency's first to be certified as Capability Maturity Model (CMM) Level 3 (required for Class A and human missions) and an early adopter of agile modular development and industry standards such as Unified Modeling Language (UML). Combining robustness with agility, Marshall has the capability to design flight software for NASA's future flagship science and human exploration missions.

Marshall's Systems Integration Lab conducts HWIL testing to reduce SLS flight software development risk.

Experience from Racks to Rockets

Marshall's flight software development capability integrates hands-on experience in guidance navigation and control, fault management, International Space Station experiments and operational equipment, satellite control systems, and human-rated flight software. This expertise has been applied to a variety of successful missions, including:

Launch Vehicles

- Space Launch System (SLS) Core Stage Command and Control
- Flight imaging launch monitoring real-time system (FILMRS) camera software for SLS
- J-2X Engine
- Ares I Vehicle and Upper Stage Command and Control
- Space Shuttle Main Engine
- Fastrac Engine Ground System

Spacecraft

- FASTSAT
- DARPA Orbital Express
- Advanced Video Guidance Sensor (AVGS)
- GOES Solar X-ray Imager (SXI)

International Space Station

- Materials Science Research Rack (MSRR)
- ECLSS Urine Processor Assembly (UPA)
- Microgravity Science Glovebox (MSG)
- Expedite the Processing of Experiments for Space Station (EXPRESS) Racks

Scientific Instruments on Balloon, Aircraft and Space Platforms

- High-Energy Replicated Optics to Explore the Sun (HEROES)
- Hurricane Imaging Radiometer (HIRAD)
- MMS Magnetospheric Multiscale Dual Ion Sensors
- Mighty Eagle Lander Demonstrator
- Sounding rockets

Testing In-Space Software Performance on Earth

To quickly and effectively meet the needs of any project, Marshall has developed state-of-the-art tools, facilities, and test environments. These facilities support the development, test, integration, and verification of mission-critical human-rated embedded flight software for both small projects and large complex space systems.

Real-Time Hardware-in-the-Loop Integrated Test Laboratories

Marshall is home to two real-time hardware-in-the-loop simulation labs. The Systems Integration Lab (SIL) demonstrates real-time flight control of a launch vehicle, such as SLS, during ascent. The Software Integration and Test Facility (SITF) integrates and tests software specifically for the SLS Core/Upper Stage avionics system. Modular in design, both facilities quickly adapt to changing configurations to accommodate incremental integration and testing and fault injection. The SIL and SITF accommodate a variety of software and avionics configurations and integrated simulations for launch vehicle and spacecraft projects.

Software engineers in the SITF use custom tools like ARTEMIS and MAESTRO to test flight software for various avionics configurations to ensure performance.

Specialized Software Tools for Simulation and Testing

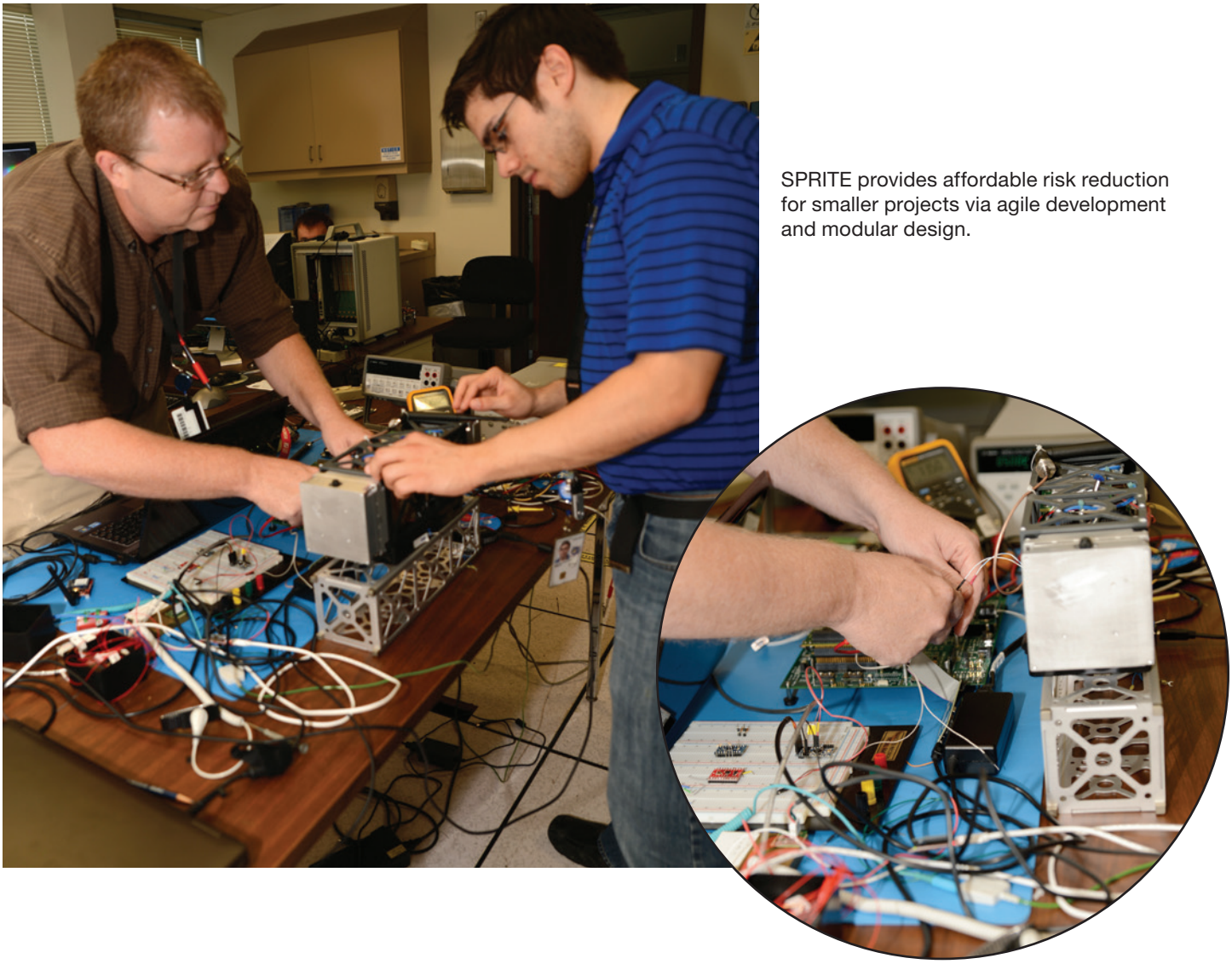
Both the SIL and SITF are equipped with Marshall's highly specialized software tools, ARTEMIS and MAESTRO.

- A Real-Time Environment for Modeling, Integration, and Simulation (ARTEMIS) is a suite of models, simulations, and hardware interfaces used for simulating avionics hardware/software through all phases of mission from pre-launch through orbit insertion. It includes core simulation, subsystem models, component models, and input/output hardware to communicate with flight-like avionics.
- The Managed Automation Environment for Simulation, Test, and Real-Time Operations (MAESTRO) is an automated laboratory management tool that configures and controls test operations. MAESTRO sets up a test configuration and executes and monitors test scenarios based on that test configuration, and it archives test products for later retrieval and analysis.

ARTEMIS and MAESTRO are integrated to create real-time launch vehicle simulations for the SLS. The integrated system allows early requirements validation in addition to verification and validation activities before and during hardware development. The modular design supports multiple test configurations across all Marshall HWIL facilities. Marshall is working on open-source versions of ARTEMIS and MAESTRO to support a low-cost generic framework for simulation capabilities.

Small Projects Rapid Integration and Test Environment (SPRITE)

SPRITE is a modular HWIL test facility that provides rapid development, integration, and testing capabilities of flight software for small projects. SPRITE focuses on efficient processes and modular design to support rapid prototyping, integration, testing and verification of small projects at an affordable cost. In addition, Marshall is developing the Low Cost Software Platform (LocSwap), a spinoff from SPRITE, as an open-source tool for industry.



SPRITE provides affordable risk reduction for smaller projects via agile development and modular design.

Fast, First Release of SLS Software

NASA engineers working on the new Space Launch System delivered the first release of flight software in May 2013, three weeks ahead of schedule, by using the Boeing-provided test bed flight computers. As the SLS program pursues its aggressive schedule toward a first flight in 2018, flight software development is a critical aspect of the integrated system, requiring the highest standards and robustness of Class A and human missions.

Availability of this test bed platform early in the engineering development phase allowed Marshall to reduce technical and schedule risk to help the program meet development milestones, as well as to allow more time for Marshall programmers to continue development of what will be the most capable flight software in the history of spaceflight.

Key objectives for this initial flight software delivery included implementation of key flight software infrastructure functionality and the ability to communicate across the vehicle's flight-critical data busses. This flight software release will support Boeing's Avionics Integration Laboratory testing, as well as future planned Michoud Assembly Facility testing. Additional functionality will be added to each release to support the progress in test and integration phases.

Fine-tuning of the software is underway, and ultimately it will be installed at Marshall's Software Integration Test Facility and tested with other electrical hardware and software. The SLS team will run a variety of simulations to evaluate how the vehicle will perform in space.

Flight software development is one of the more technically challenging aspects of any complex space system and frequently one of the top schedule risks.

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