National Aeronautics and Space Administration

Avionics and Electrical Systems

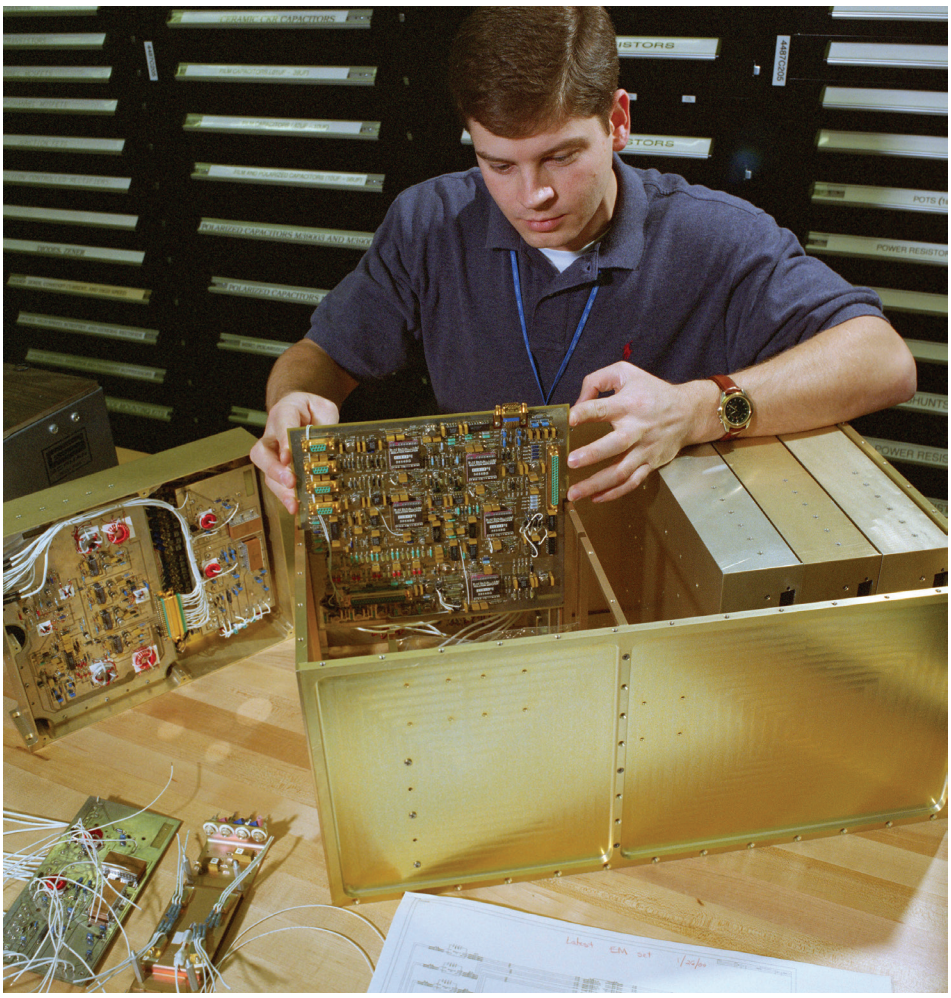
Managing Costs Through Comprehensive Architecture Design

In complex space system development, such as launch vehicles, contractors are responsible for optimizing their portion of the development. This often leads to extensive reworking to resolve disconnects between systems. By managing and/or designing avionics architecture, Marshall contributes to lower cost, reduced schedule complexity, and potentially higher overall system performance.

Marshall has developed avionics systems for key Agency missions such as the Environmental Control and Life Support System aboard the International Space Station (ISS) and continues to do so for the Space Launch System (SLS). The avionics are an integral part of any spacecraft or science instrument, enabling command and control during flight operations.

At-A-Glance

Avionics and electrical systems provide the "nervous system" of launch vehicles and spacecraft, linking diverse systems into a functioning whole. In systems this complex, affordability and stability in the design process are challenges. Government-managed architectures help minimize the number of change orders as systems evolve during design and preserve the incentive to implement a cost-optimized, objectively designed architecture. Marshall can provide both in-house design and independent validation and verification after fabrication of subsystems by industry partners and maintains unique end-to-end system test capabilities.



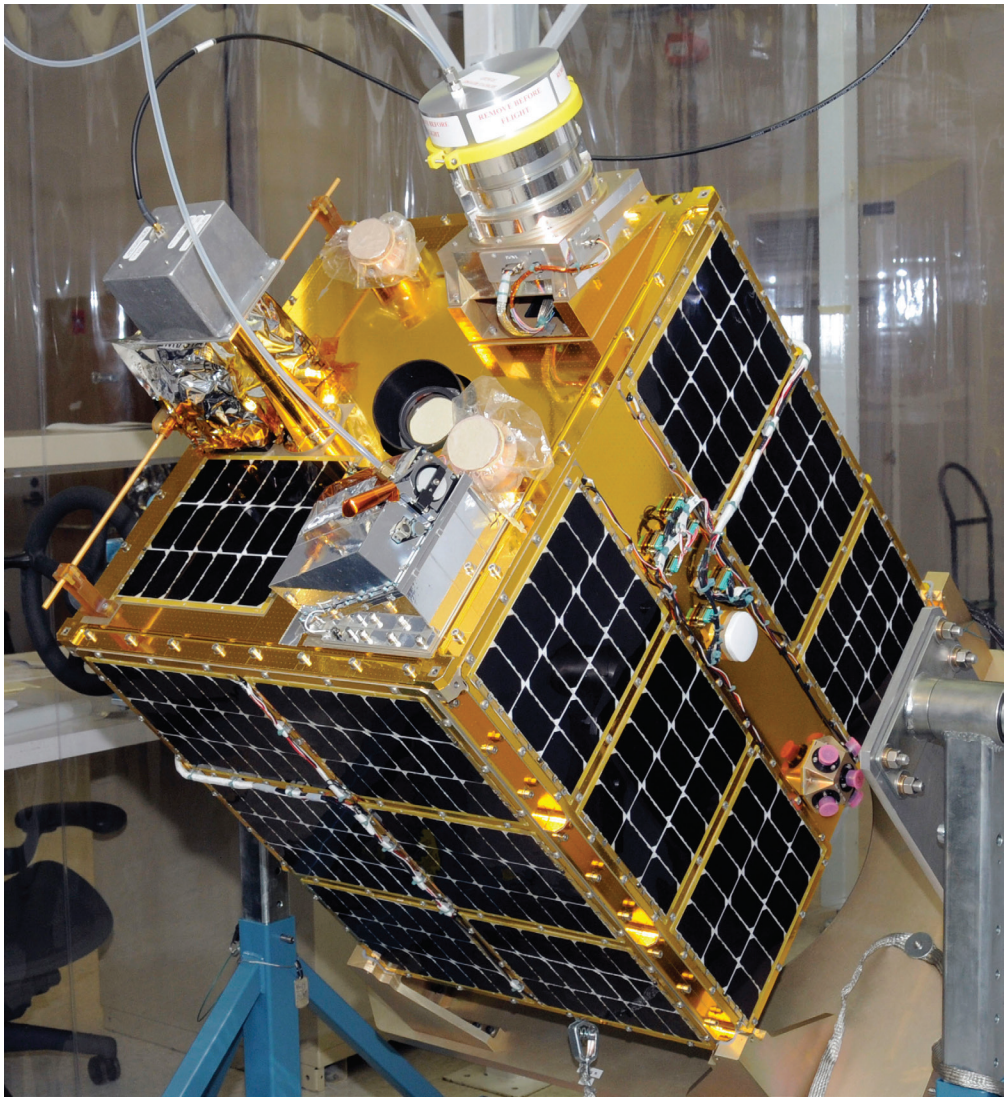
Integration testing with flight hardware is key to reducing cost and maintaining schedule.

FASTSAT Avionics Architecture

Enables Rapid Development and Lowers Mission Costs

For two years, NASA's FASTSAT operated in orbit, conducting six science and technology experiments. FASTSAT used a distributed avionics architecture designed and developed at Marshall with multiple avionics test beds working in parallel to accelerate hardware and software testing. This allowed the team to go from the spacecraft's preliminary design review to final flight hardware in just 12 months. Marshall developed, tested, launched, and operated the ~400-pound microsatellite, using commercial-off-the-shelf hardware, in partnership with the Department of Defense (DOD) Space Test Program (STP), Dynetics, and VCSI.

The Marshall-defined avionics architecture reduced costs and the risk of time-consuming redesigns during subsystem integration. Working with industry partner Dynetics, Marshall's top-level architecture governed each component of the avionics system, ensuring compatibility and adequate power and signal resources for the operation of all six of FASTSAT's experiments. On-board storage for flight data was also critical, as the average contacts with ground stations were only a few minutes long. Even within these limitations, the mission delivered 17 GB of data from orbit, while receiving thousands of lines of code to update the flight computer and instrumentation during the mission, optimizing the scientific and technology development value of the flight.



FASTSAT's distributed architecture led to a very rapid development schedule.

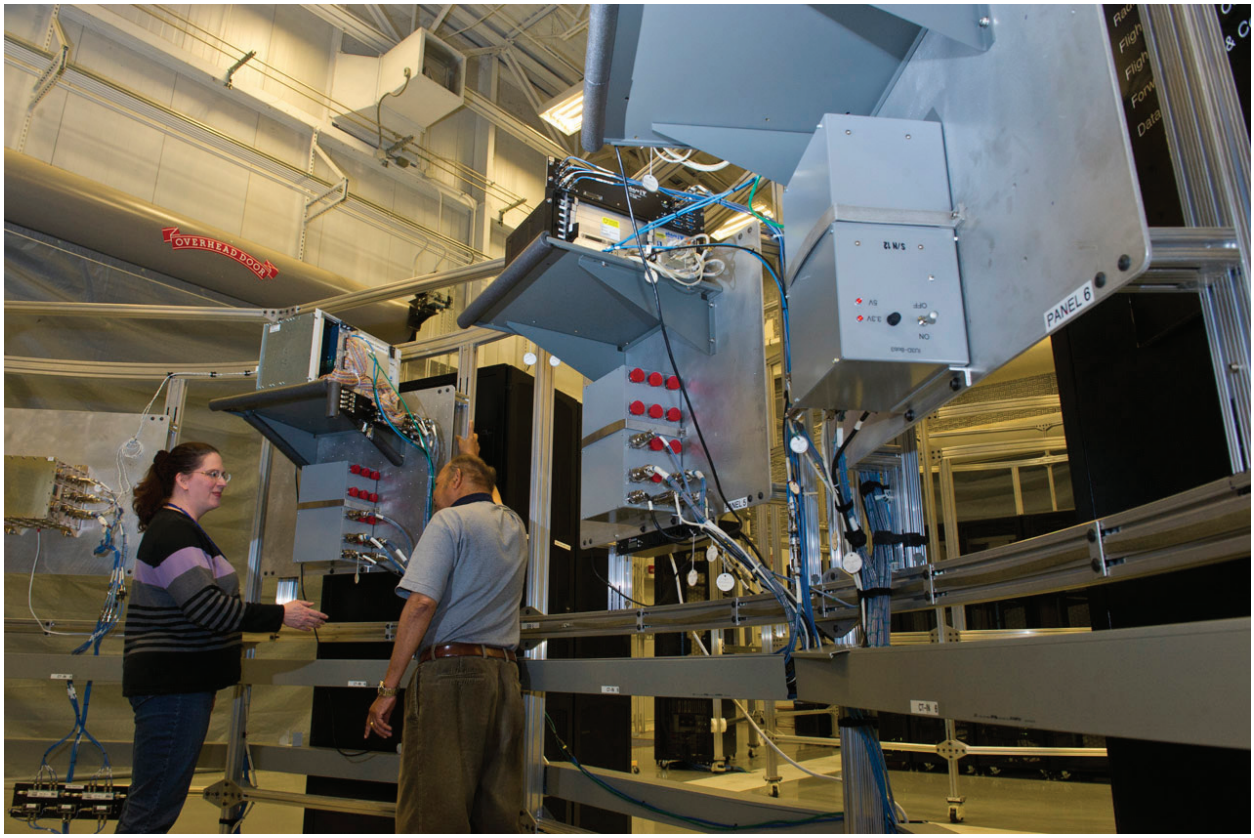
Marshall's avionics capability enabled the launch vehicles of the past, including Apollo and shuttle, and progressed to the design and development of many scientific payloads that flew on shuttle scientific missions. More recently, Marshall has expanded its knowledge base into the design, development, and test of many of the electrical components that make up the Environmental Control and Life Support System (ECLSS) and the Material Science Research Rack (MSRR) in service on the ISS. Marshall has also supported missions from the large Hubble Space Telescope and Chandra X-ray Observatory to the more recent and much smaller Fast, Affordable, Science and Technology Satellite (FASTSAT) as well as instruments on the Tropical Rainfall Measuring Mission (TRMM) and the Geostationary Operational Environments Satellites (GOES). In support of SLS, Marshall has not only overall avionics architecture definition and oversight responsibilities but also in-house design work such as the cameras and video controllers to be attached to the Core Stage and Interim Cryogenic Propulsion System (ICPS).

Some of these projects require direct hands-on development and/or testing of the hardware, while others involve insight into and analytical integration of work performed by one or more prime contractors. In order to meet the Agency's needs in this area, Marshall has developed a rich set of avionics resources including state-of-the-art facilities and tools and broad disciplinary expertise in all aspects of avionics and electrical systems design, development, testing, and integration.

Unique Test Capabilities Ensure System Performance

Integrated Avionics Test Facility (IATF)

The IATF is an integrated hardware-in-the-loop laboratory that combines digital computer models, software, and avionics hardware to demonstrate real-time flight control of the Space Launch System during its flight. Avionics hardware is mounted in an approximation of its flight configuration, using the same cables and connectors that will be used in the final launch vehicle. The electronics architecture in the facility can be rapidly reconfigured as the avionics design for SLS matures, using a modular system of avionics boxes and other hardware to provide a complete representation of the SLS avionics system with the capability to simulate error conditions for trouble-shooting and validation of the system.



The IATF tests avionics in flight configuration to ensure system performance.

MSFC EMI Test Facility

The MSFC EMI Test Facility provides a comprehensive range of electromagnetic environmental effects testing services to a wide variety of customers. It has distinct capabilities in electrostatic discharge (ESD) and electromagnetic interference (EMI). A unique capability of the facility is its ability to assess lightning indirect effects. Sensitive spacecraft avionics and electrical systems can be damaged or destroyed by nearby lightning strikes during pad operations or ascent of the launch vehicle.

EEE Parts Physical Analysis

A unique specialty the EEE Parts team provides is the expertise and equipment to perform EEE parts physical analysis to determine the cause of EEE parts and assembly failures. Nanofocus real-time radiography, X-ray Fluorescence, 3D-CT (Computed Tomography), and Environmental Scanning Electron Microscopy and Optical Microscopy are just a few of the cutting-edge non-destructive techniques available.

End-To-End Avionics Discipline Expertise

Marshall's avionics and electrical systems capability is represented by several teams, each focused around a particular set of disciplines.

The Sensors, Data Systems, and Control Electronics team performs research, design, and development of electronic circuits and systems. Testing and evaluation is conducted in a variety of laboratories ranging from basic electronics to audio and sensor characterization chambers. These facilities support a variety of customers in the development of experiments to control instrumentation for propulsion elements on space vehicles.

The Radio Frequency Systems team analyzes RF systems for both communication and range safety for launch vehicles and satellites. The RF team also has expertise with Global Positioning Satellite (GPS) systems, including a GPS simulator, which also supports the GN&C Hardware team.

The **Electrical Integration team** designs and integrates avionics systems and hardware for spacecraft, payloads, and their associated electrical ground support equipment.

The Electrical Power Branch runs the gamut from research through test and evaluation of flight and ground electrical power subsystems (EPS). The team provides power electronics design, development, test, and analysis, circuit simulation, power quality compliance, and solar arrays, as well as design of custom electromagnetic and isolation transformers and inducers.

The E3 team provides engineering and requirements development and tailoring in electromagnetic compatibility; electrostatic discharge (ESD); electrical bonding; and lightning protection and test services for electromagnetic interference, power quality, ESD, and lightning indirect effects.

The Parts, Packaging & Fabrication team provides electro-mechanical design, analysis and assembly of space flight and ground hardware. Engineering capabilities include mechanical design, printed wiring board design, thermal analysis, EEE parts selection assistance, parts screening, and design support. In addition, this branch provides EEE Parts Obsolescence Management — a unique capability within NASA to manage electronic parts for a program that has become obsolete.

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George C. Marshall Space Flight Center
Huntsville, AL 35812
www.nasa.gov/marshall

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