Honda Aircraft Company develops a fully automated Advanced Systems Integration Test Facility to get its new business jet into the air in record time.

First Flight in Real Time

Honda Aircraft Company in 2008 laid the foundation for a world-class simulation and test facility for its HondaJet at the company's R&D facility in Greensboro, North Carolina. This Advanced Systems Integration Test Facility (ASITF) is Honda's core facility for developing, validating and verifying engineering systems. After a rigorous evaluation of different hardware-in-the-loop (HIL) vendors on the market, Honda Aircraft selected dSPACE HIL systems to provide real-time simulation capability. In the following months, dSPACE developed a new HIL interconnection architecture that lets Honda Aircraft fully test its interfaces for avionics and full authority digital engine control (FADEC), either through closed-loop simulation or point-to-point breakout and analysis. The HondaJet team accomplished the first successful flight of the HondaJet ASITF on October 9, 2009, approximately 14 months before the actual maiden flight of the first FAA-conforming HondaJet – a critical milestone for the program and a significant step toward the first flight of a conforming aircraft.

Research Phase

Honda began its research in aviation in the late 1980s, so its engineers now have more than 20 years of experience in researching and developing advanced aerospace technologies. The initial design for the HondaJet was sketched in 1997 by Michimasa Fujino, who is now President and CEO of Honda Aircraft Company. Only a year later, research and configuration design for the HondaJet began, giving the jet its characteristic engine mount design, the Over-The-Wing Engine Mount (OTWEM) configuration. >>

The test lab including the iron bird (left) and the three dSPACE HIL simulators (center).

Many more milestones have followed:

- *2003:* First flight of the proof-of-concept HondaJet
- *2005:* World debut of the HondaJet at EAA AirVenture, Oshkosh
- *2010:* Maiden flight of the first FAA-conforming HondaJet
- *2012:* Start of HondaJet production
- *2013:* FAA Type Inspection Authorization for the HondaJet, clearing the way for FAA pilots to begin on-board testing
- *2014:* Initial flight of the first production HondaJet

The HondaJet combines many technological innovations of aviation design. Its characteristic Over-The-Wing Engine Mount configuration, for example, dramatically improves aircraft performance and fuel efficiency by significantly reducing aerodynamic drag. This original airframe design also reduces the noise of aircraft flying overhead and allows for a more spacious cabin and greater cargo capacity. The HondaJet is powered by two highly fuel-efficient GE Honda HF120 turbofan jet engines.

Advanced Systems Integration Test Facility (ASITF)

The HondaJet ASITF consists of two major elements: the aircraft test facility and the Real-time Test and Simulation System (RTSS). Its development was led by Masa Hirvonen, Senior Manager of Systems Integration. At the ASITF, actual aircraft system hardware and software is set up in a spatially representative manner and connected with actual aircraft cable harnesses. The RTSS simulates the avionics systems, the environment and aerodynamics. It is supported by dSPACE real-time hardware and I/O that runs Honda-developed, high-fidelity 6-DOF (degrees of freedom) aerodynamics models and real-time Simulink engine models. Additional simulation capabilities were integrated to provide real-time simulation of navigation RF data, including GPS and VOR/ILS (VHF omnidirectional radio range/instrument landing system) signals. The HondaJet ASITF also includes an electronic control loading system (ECLS) that is integrated with a fully representative primary flight control system (PFCS). The avionics configuration for the HondaJet is based on the integrated Garmin G3000™ avionics suite with two touchscreen controllers.

"Test automation and traceability from test execution all the way back to the system requirements are the keys to efficient, repeatable, and fully traceable test operations for systems development and integration. Being able to implement these key features has given us a significant advantage over many other aircraft programs."

Masa Hirvonen, Senior Manager Systems Integration, Honda Aircraft Company

"The hardware and software tools provided by dSPACE have allowed us to quickly implement the advanced simulation and test capabilities needed for the HondaJet program. The open and expandable architecture lets us develop and expand the test facility to meet our growing needs. Without the exceptional tools, service, and support that dSPACE provides, our small team would not have been able to accomplish the things we have."

Benjamin Hager, Real-time Control Design and Simulation Engineer, Honda Aircraft Company

Other real parts used in the integration system include the flap actuation system (FAS), fuel quantity system (FQS), automatic flight control system (AFCS), nose wheel steering system (NWSS), and electrical power system (EPS). These individual components combine the abilities of an engineering simulator, an integration test facility, and an iron bird in a single facility.

Setting up the Test System

dSPACE Inc. supplied the RTSS, which provides the advanced test interface, test automation and high-fidelity simulation abilities. It essentially comprises three full-size HIL racks: two racks for avionics interfaces (RTSS1 and RTSS2) and one for the aircraft engines (Engine HIL for FADEC interfaces). The RTSS systems use six DS1006 Processor Boards in five expansion boxes and have the following I/O and communication support:

- 820 channels of discrete I/O (inputs and outputs)
- 180 channels of ARINC429 (90 TX, 90 RX)
- 240 channels of analog I/O (inputs and outputs)
- Multiple serial data bus interfaces
- Ethernet interfaces (UDP and TCP/IP)

The RTSS uses a special signal breakout interface system that enables system testing and simulation in four operation modes:

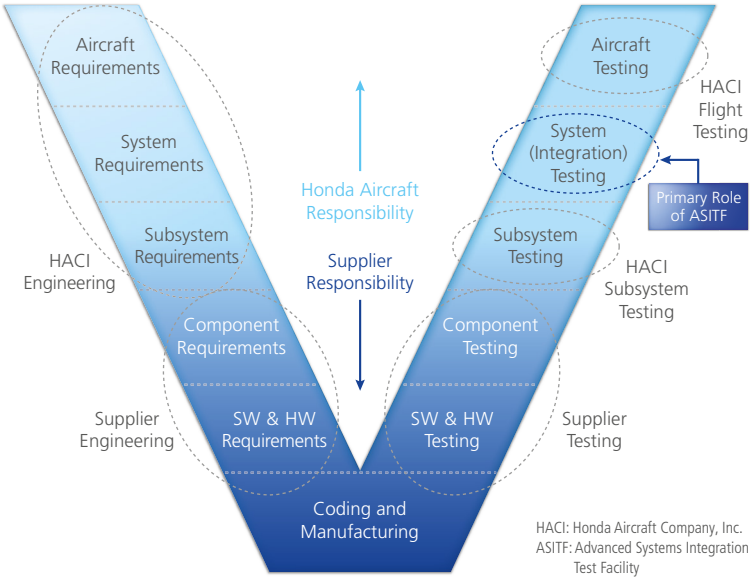
1. Manual testing (traditional system break-out)
2. Computer-assisted testing (using ControlDesk®)
3. Automated testing (using AutomationDesk)
4. Pilot-in-the-loop testing (including iron-bird capability)

The RTSS uses a harness interconnect and break-out box (BoB) system with which the signals can be either sent straight through, broken out for analysis, bypassed for simulation, or connected directly for iron-bird testing.

System Simulation Control and Interfaces

The core of the RTSS system is a high-fidelity 6-DOF aircraft simulation model that is integrated with engine simulation models and various aircraft system test interfaces. The model is spread across the multiprocessor system to allow for full-bandwidth model control and parallelization of ARINC message >>

Benjamin Hager, Real-time Control Design and Simulation Engineer at Honda Aircraft Company, operates the test system using dSPACE ControlDesk equipped with avionics instruments (Primary Flight Display) and dSPACE AutomationDesk.



The development process for the HondaJet program follows the V-cycle. The dSPACE simulators are mainly used during the system integration testing phase.

and I/O throughput. The closed-loop simulation executed in the RTSS can be used to fly the ASITF 'aircraft' in real time. The Real-time Engine Model (RTEM) simulation connects to real FADEC hardware so the HF-120 turbofan engine can be simulated closed-loop. Real-time GPS and VOR/ILS simulations (RF signals) provide navigation data during the piloted missions. The pilot-in-the-loop mode uses the interface and animation abilities of the visual system to provide direct flight simulation interaction. This out-of-the-window visual system is key for pilot-in-the-loop testing. Honda Aircraft engineers worked with the ControlDesk-programmable user interfaces to create quick access interfaces for the most important aircraft subsystems, making testing easier. The engineers used the related API to build extensions for ControlDesk that allow for calibration trim, provide interfaces for the real-time model, and make test setups easy to prepare. dSPACE test automation blocks from the Appl-Tools Solution are used to help manage the complexity of I/O interfacing and usage. By automating the layouting and model creation from ARINC labels, using the myriad of messages in the system became much simpler. Signal definitions are now taken from the models, and Python scripts use XML to auto-map the signals to HondaJet custom instrument configurations. Interface control definitions (ICDs) are used to manage all system interface signals, which are used to work with signals within the models and RTSS system. All software used with the RTSS is managed and controlled in IBM® Rational® ClearCase®, and IBM Rational ClearQuest® is used for internal issue and change tracking.

Development According to V-Cycle

Honda uses the established V-cycle for systems development and defines the responsibilities of customer and supplier via subsystems

"Our Advanced Systems Integration Test Facility is a powerful tool that continues to support the development and certification program for the HondaJet. The ASITF lets us evaluate the entire system integration, which increases aircraft safety and ultimately helps us develop an advanced light jet that will exceed our customers' expectations and bring them lasting joy."

Michimasa Fujino, President and CEO of Honda Aircraft Company.

and systems development methodologies. The core responsibility of the ASITF is system integration and validation, as shown in the following diagram. The ASITF mission is defined by the following tasks and responsibilities:

- Hardware-in-the-loop (HIL) test facility, including iron-bird capability
- Integration tests of aircraft subsystems
- Functional tests of aircraft systems
- Pilot-in-the-loop (PIL) tests
- Flight test, production and fleet support

Automated Test Runs

Automated test scripts written with dSPACE AutomationDesk let the HondaJet ASITF team perform 'lights-out testing'. This means that the team can test flight control and avionics systems around the clock, at night and on weekends, with minimal supervision. "This ability lets the Honda Aircraft team conduct more thorough and in-depth testing at the ASITF, while keeping track of requirements traceability," says Jace Allen, Lead Technical Specialist at dSPACE, Inc. Honda Aircraft uses IBM Rational DOORS® to write requirement specifications and test plans. Specific requirements are linked to test cases within DOORS, and dSPACE Connect&Sync links HondaJet test cases to AutomationDesk tests and projects. The test results can re-imported into the DOORS document after test cases are run in AutomationDesk. This integration gives Honda Aircraft traceability in their test process, allowing them to directly connect requirements to current test results. Honda Aircraft is considering to expand this traceability to help extend the testing capability with an integrated test management using dSPACE SYNECT® Test Management. ■

By kind permission of Honda Aircraft Company, Inc.

Watch the first production HondaJet take to the sky: www.dspace.com/go/dMag_20152_HJET

Summary of the HondaJet Project

Honda Aircraft Company set up a world-class simulation and test facility for the HondaJet. This Advanced Systems Integration Test Facility (ASITF) is the core facility for engineering systems development, validation, and verification. By using tools like dSPACE simulators and the test automation software dSPACE AutomationDesk, Honda Aircraft is able to test all of its flight control and avionics systems. The engineers at Honda Aircraft are convinced that hardware and software tools provided by dSPACE were an important contribution to verifying and validating avionics reliably and efficiently. With dSPACE tools, the developers were able to use the following test methods:

- Manual testing
- Computer-assisted testing using dSPACE ControlDesk
- Automated testing using dSPACE AutomationDesk
- Pilot-in-the-loop testing (including iron-bird capability)