The ATV Test Platforms

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Introduction

Test platforms will play an important role in ATV's system integration, testing and qualification during development, the launch campaigns in Kourou and mission operations. This includes qualification of the overall ATV system, covering the spacecraft, ground segment and the ISS, and in particular the interfaces between the vehicle and other systems.

An extensive test programme is planned to prepare ESA's Automated Transfer vehicle (ATV) for its debut in 2004 ...

The families of ATV Test Platforms include:

- Software Validation Facilities (SVFs);
- Functional Simulation Facility (FSF);
- Electrical Ground Support Equipment (EGSE);
- Interface Validation Facilities (IVFs).

Software Validation Facilities

The highly demanding mission profile and tight development schedule means that the software is a critical part of the ATV programme. Hence the need for several SVFs with multiple teams working in parallel on the staggered versions of the Flight Application Software (FAS) and the Monitoring and Safety Unit (MSU) software. MSU software is at the highest level of software criticality – its failure would be catastrophic for the mission. It is responsible for the Collision Avoidance Manoeuvre (preventing collision with the ISS) and will take care of the ATV in Survival Mode, when electrical power is at a minimum.

Three SVFs for FAS and one for MSU software are being developed. They will be sited at the Prime Contractor premises in Les Mureaux (F), where EADS-LV is in charge of the overall FAS and MSU software development.

Functional Simulation Facility

The FSF will fully represent ATV's avionics, combining the engineering and flight models. It will simulate the behaviour of onboard equipment during all flight phases, and it will allow switching between software and hardware models. The FSF will also be at EADS-LV in Les Mureaux, close to the building hosting the Ariane-5 simulators.

Interface Verification Facilities

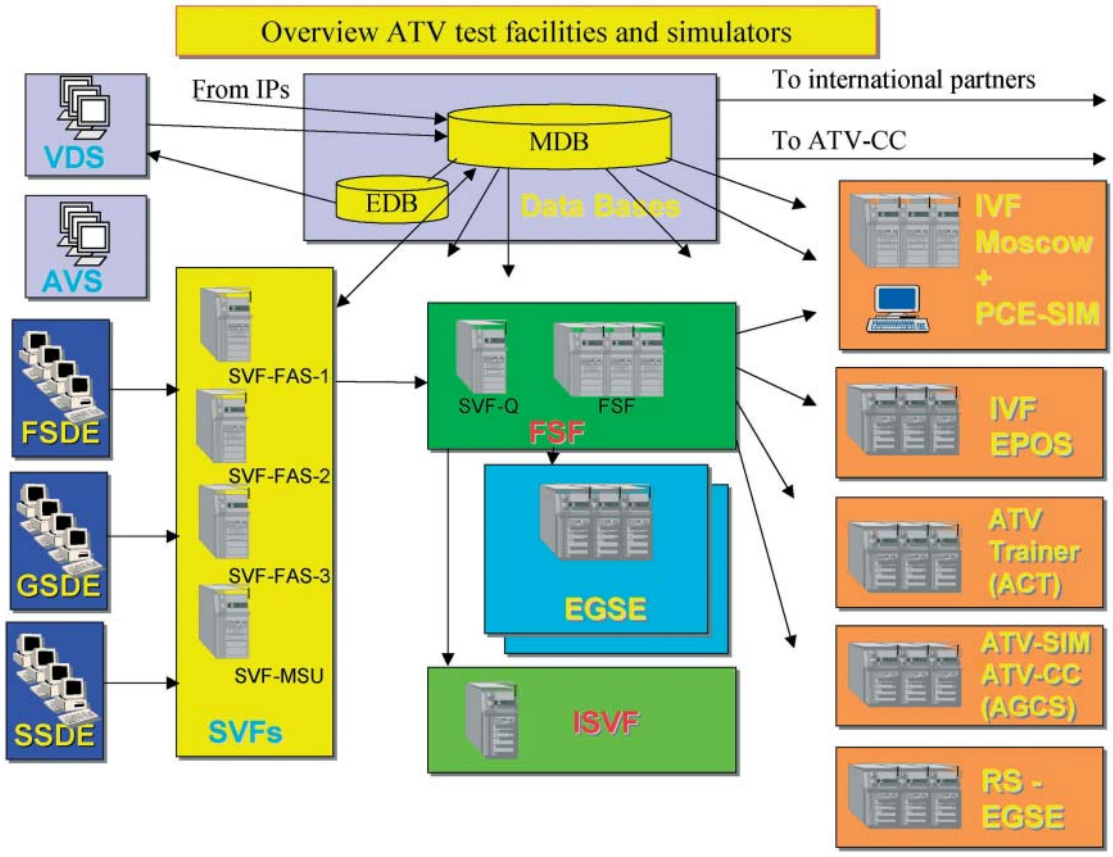
The IVFs will qualify the interfaces between the ATV and ISS. One IVF in Moscow will perform Bilateral Integration & Verification Tests in combination with the ISS Service Module Simulator at the RSC-Energia premises.
A second IVF will be used with the European Proximity Operations Simulator (EPOS) at DLR in Oberpfaffenhofen (D) for verifying equipment and software involved in the last few metres before docking, including the Rendezvous and Docking Sensors.

Electrical Ground Support Equipment

The EGSE will be used to qualify all the ATV spacecraft (Astrium GmbH, Bremen) and check them out during the launch campaigns (Kourou). The first ATV qualification will be done at ESTEC.

Generic Design

The Test Platforms are designed for ATV's development phase but will continue to be used for the production phase. They derive from the unique Generic Test Platform concept,



Overview of the ATV test facilities and simulators.
Acronyms for the figure and article are:
ACT: ATV Crew Trainer
AGCS: ATV Ground Control Simulator
ATV: Automated Transfer Vehicle
ATV-CC: ATV Control Centre
AVS: Algorithm Validation Simulators
CCSDS: Consultative Committee for Space Data Systems
CGS: Columbus Ground System
COTS: commercial of the shelf
DLR: Deutschen Zentrum für Luft- und Raumfahrt
EADS-LV: European Aeronautic Defence and Space Company – Launch Vehicles
EDB: Engineering Database
EGSE: Electrical Ground Support Equipment
EPOS: European Proximity Operations Simulator
EPS: Electric Power System
FAS: Flight Application Software
FEE: Front-End Equipment
FSDE: Flight Software Development Environment
FSF: Functional Simulation Facility
FTC: Fault-Tolerant Computer
GNC: Guidance, Navigation & Control
GPS: Global Positioning System
GSDE: Ground Software Development Environment
ISS: International Space Station
ISVF: Independent Software Verification Facility
IVF: Interface Verification Facility
MSU: Monitoring and Safety Unit
PCE: Proximity Communication Equipment
PCI: Peripheral Component Interconnect
RF: radio frequency
RS: Russian Segment
RSC-E: Rocket and Space Corporation Energia
SMAS: Service Module Avionics Simulator
SPT: Synchronous Packet Transfer
SSDE: Simulation Software Development Environment
SVF: Software Verification Facility
TDRSS: Tracking and Data Relay Satellite System
VDM: Videometer
VDS: Vehicle Definition System
VME: Versatile Module Eurocard

consisting of: Database; Simulator; Test Supervisor; Front-End Equipment (FEE) interfacing with the product under test.

Databases

The heart of each platform is the ATV Mission Database. Copies are installed at the different test locations from the Master Mission Database, which describes the flight and test equipment. The MDB concept relies on Astrium GmbH's Columbus Ground System (CGS), and ensures full Configuration Control not only for the platforms but also for the tests themselves. The Test Results Database stores all the data produced during a test session for later analysis and replay.

Simulator

Apart from the EGSE, all the test facilities have a Simulator. Based on a Silicon Graphics quad-processor computer running Fokker Space's Eurosim simulation kernel, the Simulator runs real-time models of those elements not physically present during the test. It also allows the simulation of errors.

Test Supervisor

The pool of computers, workstations and printers devoted to providing a man-machine interface to the test operator is the Test Supervisor. It also hosts the Mission Database and runs the automatic procedures controlling the test sequence. The Test Supervisor software is based on the latest version of CGS with Oracle 8 as the database manager.

Front-End Equipment

There is a set of front-ends in charge of the direct interaction with the product under test. All of them interface with the Test Supervisor via a LAN connection. However, their interface with the Simulator depends on their particular nature, and the most time-critical ones (GNC, power drive, rendezvous) use Reflective

Memory. There are different versions depending on the test facility; the most important ones are described below.

MIL-1553B FEE
The MILFEE is in charged of managing the onboard busses, whether internal or linking to the ISS. It can perform as Bus Controller, as a Remote Terminal or simply spy on the data traffic. Its architecture is VME-based and interfaces the simulator through a VME-to-PCI bridge. It can also inject errors at different levels: MILBUS, SPT or CCSDS protocols.

Electric Power System (EPS) FEE
The EPS FEE takes care of all electrical power matters, including:
- providing power to the ATV via the ground interface or the ISS;
- simulating the ATV Power Control and Distribution Units;
- simulating the ATV electric loads. This function requires a Reflective Memory interface with the simulator;
- simulating both the ATV rechargeable and non-rechargeable batteries;
- simulating the ATV solar arrays;
- trickle-charging the batteries of the ATV flight model.

Fault-Tolerant Computer (FTC) FEE
The FTC FEE allows the analysis of communication between the different layers of the ATV main computer. It also allows analysis and interaction with the software under test by using Aonix commercial-off-the-shelf tools.

Telemetry/Telecommand & RF FEE
The Telemetry and Telecommand FEE provides the digital signal processing, monitoring and control functions required to process the ATV commands and telemetry. It also provides a set of non-modulated interfaces to the spacecraft. The Radio Frequency FEE allows the verification of the ATV radio link using Spread Spectrum Technology both for the Proximity Link (ATV-ISS) and for the NASA TDRSS link.

Guidance, Navigation and Control FEE
Consists of the:
- Global Positioning System (GPS) FEE providing electrical stimulation;
- Star Tracker FEE providing optical stimulation;
- Sun Sensor Optical FEE providing dynamic or optical stimulation;
- Dry Tuned Gyroscope FEE providing electrical stimulation;
- Accelerometer FEE providing electrical and mechanical stimulation.

They interface the simulator via Reflective Memory. In particular, the GPS FEE will be used for testing the ATV GPS receiver and also when the ISS GPS receiver is present during simulations of the ATV-ISS relative GPS navigation capability.

Rendezvous FEE
Consists of the :
- telegoniometer FEE providing electrical stimulation and optical/static/dynamic stimulation;
- videometer FEE, providing electrical and optical simulation.

The telegoniometers provide ATV-ISS range and ATV line-of-sight during the final approach of the rendezvous phase from 500 m to 50 m. The videometers provide ATV-ISS range, ATV line-of-sight and relative attitude during the final approach from 50 m to docking.

User Interface Simulator FEE
This FEE provides an analogue/digital monitoring and stimulating interface with the flight equipment. It simulates and acquires signals on all types of hard-wired ATV equipment interfaces, both internal to the ATV and those between ATV and ISS. It includes electrical stimulation of the MSU, simulating the Sun Sensor when absent.

Service Module Avionics Simulator FEE
The SMAS acts as the FEE for the ATV Russian System. It will be provided by RSC-Energia to simulate ISS power- and data-busses as well as the wired interface with the Russian equipment control, docking and propellant systems that are integrated within the ATV.

Conclusion

The ATV Test Facilities are a complete and coherent set of tools devoted to qualifying the ATV system, equipment and interfaces. Developments from previous ESA programmes have been used in their design. Their common architecture is allowing incremental construction and great synergy between them, thereby simplifying the test logic. ■