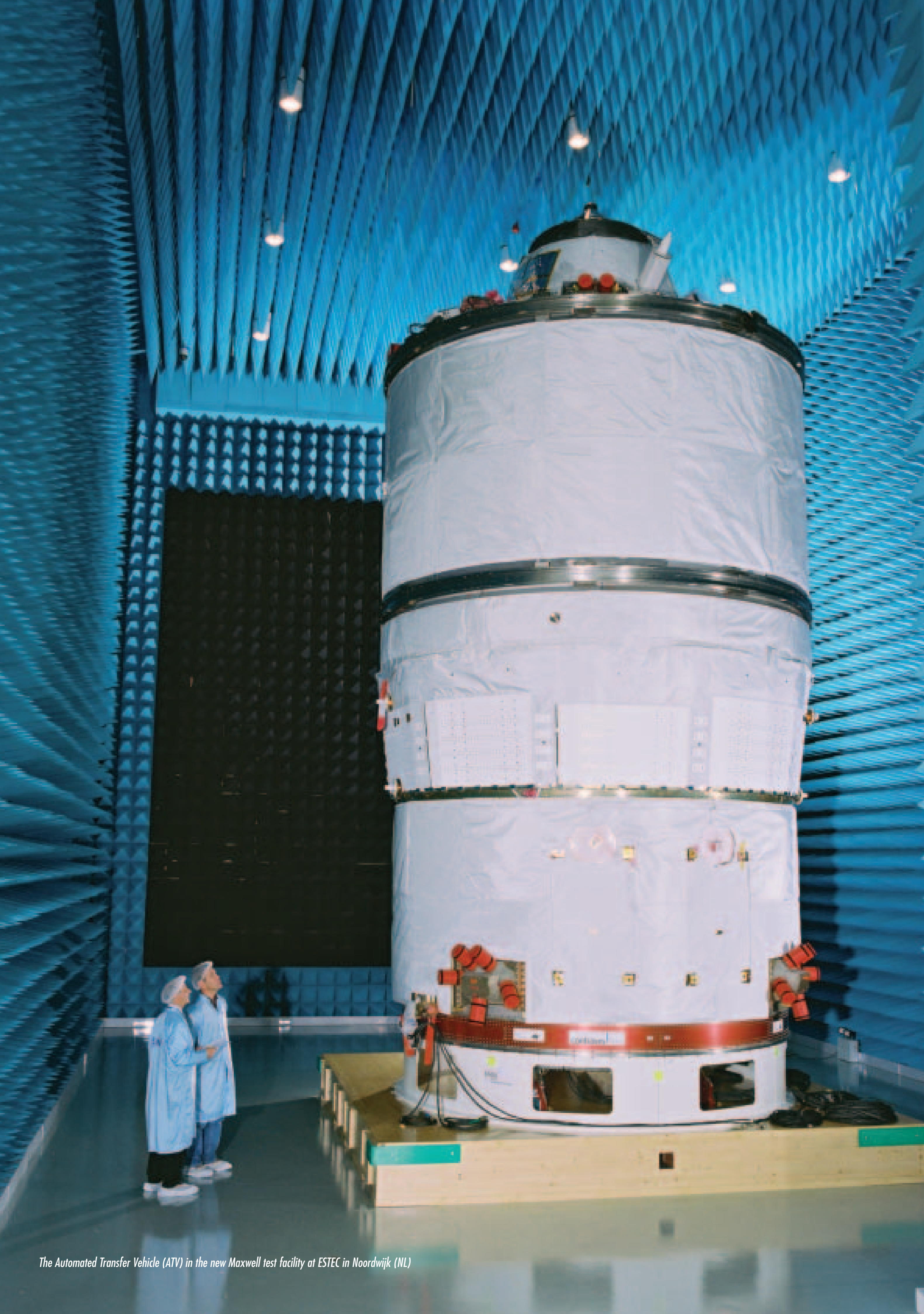

The Automated Transfer Vehicle (ATV) in the new Maxwell test facility at ESTEC in Noordwijk (NL)

‘Maxwell’
– A New State-of-the-Art EMC Test Facility

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Christened “Maxwell’, after James Clerk Maxwell (1831-1879) who unified the physical laws of electricity and magnetism with equations known as ‘Maxwell’s Equations’, the new EMC chamber that has recently come on stream at ESTEC is the perfect facility for testing the electrical and magnetic characteristics of Europe’s largest and most advanced spacecraft payloads. The chamber’s spacious internal dimensions of 14.5 metres x 10.7 metres x 11 metres mean that it can handle the largest satellites compatible with Ariane-5 single-passenger launches.

What is EMC?

Electromagnetic Compatibility (EMC) is defined as: ‘the ability of equipment to operate safely within a defined electromagnetic environment without causing or suffering unacceptable degradation as a result of electromagnetic interference’. EMC testing is therefore an integral part of any spacecraft's pre-launch qualification and verification programme, along with mechanical and thermal testing, and similarly requires dedicated facilities to achieve the appropriate levels of accuracy.

The EMC verification process can be separated into two broad categories of activities:
- Electromagnetic immunity and radiated susceptibility testing: to verify the ability of a device to tolerate disturbances.
- Radiated emissions testing: to characterise the level of disturbance generated by the device.

The Causes and Effects of Electromagnetic Interference

Electromagnetic Interference (EMI) can be either mission-dependent or intrinsically related to undesirable interaction between the various systems onboard the spacecraft, and therefore include, for example:
- electrical static discharge due to space-environment interactions
- intra-system common mode phenomena
- transients due to the switching on and off heavy electrical loads
- spurious radio frequencies in receiver bandwidths (so-called ‘intermodulation’).

The consequences of EMI-related disturbances are generally nuisances affecting the mission or reducing the efficiency of some spacecraft functions. They may also translate into irreversible loss of operational capability, with an impact on scientific and programmatic yields. The main effects are:
- temporary or permanent telemetry interruption/corruption
- noisy scientific data, or channel outages on telecommunications satellites
- accidental tripping of safety devices, spurious commands, electronic resets (e.g. clocks), spacecraft switching into safe mode
- damage to or loss of power supplies.

The most extreme consequence is total loss of the spacecraft.

The new Maxwell test chamber

Spacecraft EMC Testing

Spacecraft EMC tests are performed throughout the successive phases of the project to verify that the requirements applicable from equipment level all the way up to system level have been properly implemented. The testing is carried out inside a dedicated facility known as an EMC chamber, sometimes referred to as an 'anechoic' (i.e. reflection-free) chamber. It shields the spacecraft's receivers from outside transmitters, such as local TV broadcast stations and mobile telephones.

Reciprocally, the chamber allows the satellite's transmitters (e.g. the communications system) to transmit their signals just as they would in space. This verification covers both normal and critical mission phases to ensure that the satellite electronics will function exactly as they should.

The New 'Maxwell' Facility

The limited volume of the previous EMC chamber at ESTEC had meant that, for several years, it was no longer compatible with the size of current space projects. Some projects had therefore used the antenna compact payload test range instead, but this chamber required significant reconfiguration for EMC testing and was not optimised for this type of test. Some projects built dismountable anechoic corner structures to perform radio-frequency auto-compatibility measurements, but installing and dismounting them was laborious, they generated a storage problem when not in use, and were still not optimised for EMC testing.

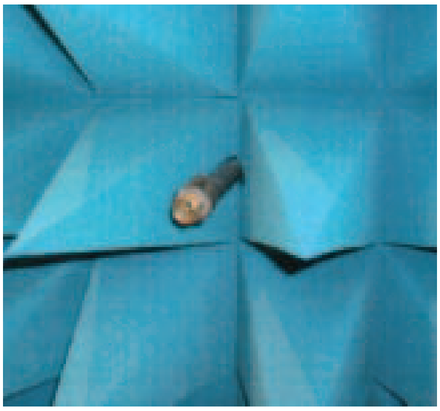
To overcome these problems, an existing verification support area in the ESTEC Test Centre has been used to erect a large EMC chamber, together with a dedicated control room, a room for customer-supplied electrical ground-support equipment, and the requisite hardware storage areas. The new facility provides an extremely clean electromagnetic environment, with outstanding shielding and attenuation of up to 40 GHz. Specially designed air-cooled high-power dissipation walls make it possible to test the latest high-power telecommunications satellites with local dissipation capabilities of up to 3 W/cm^2. An especially large door (11m high x 6m wide) provides direct access from the Test Centre's integration area to the chamber for Ariane-5 single-passenger sized satellites, transported on a non-conductive 5 m x 5 m air-cushion pallet with an SWL of 15 tonnes, which glides over an anti-static epoxy-coated floor. High-cleanliness absorbers line the ceiling, floor and doors, and state-of-the-art fire detection and suppression systems ensure a safe testing environment for the priceless flight-model satellites.

To achieve the best possible electromagnetic screening performance, the whole chamber (which is a Faraday cage) has been insulated from its supporting structure by means of high-mechanical-strength epoxy isolators and connected to a dedicated clean-earth grounding system. The latter was specially built by sinking a 150 m deep pit in the ground outside the building. A 100 m-long copper electrode was then inserted into this pit (achieving just a 0.2 ohm resistance). Last but not least, an over-voltage protection system was instwalled between the grounding facility and the building to provide lightning protection.

To provide access for signal cables between the test chamber and the integration area, EGSE (Electrical Ground Support Equipment) and control rooms, feedthrough panels have been installed in the walls. Blank panels can easily be machined and fitted with appropriate feedthrough connectors, according to customer requirements, and installed before a particular test is carried out.

The radio-frequency absorbers on the walls of the chamber are of paramount importance in terms of the chamber's final performance, as their role is to prevent radio-frequency waves from reflecting on the Faraday screening and thereby to

Fire-resistance testing of the carbon-loaded foam pyramids at TNO in Delft (NL)



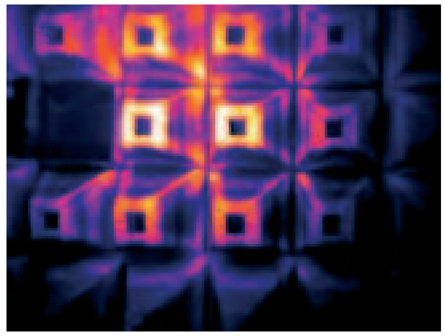
One of the many fire-extinguisher nozzles in the new chamber

simulate an infinite environment around the spacecraft. The fire-retardant, resistive carbon-loaded foam pyramids (meeting clean-room class-100 000 conditions) are mounted on supporting rails on the walls and glued to the ceiling and doors. The absorbers are manufactured using Nomex substrate honeycomb panels, providing air-circulation channels within their structure for improved cooling. When high-power tests are performed, an additional forced air-cooling system can be turned on for local areas. This system injects compressed air into the tips and edges of the absorbers to increase the dissipation capabilities of the cones.

During such high-power tests, the temperature of the walls can be monitored in real time using an infrared camera and displayed on monitors in the control and EGSE rooms. High-sensitivity detectors provide an early warning to the ESTEC central security desk should any two of the sensors reach their first alarm level. At the second threshold, the chamber's doors will close automatically, and after 30 seconds a fire-extinguishing gas (Inergen) will be released into the chamber through 15 nozzles located on the sidewalls and ceiling, reducing the oxygen level to less than 12% within 2 minutes and sustaining that level for over 20 minutes.

Conclusion

With the completion and inauguration of the Maxwell facility, ESA/ESTEC has complemented its unique suite of environmental test facilities – thermal vacuum (LSS), acoustic (LEAF), and mechanical vibration (Hydra) – with a state-of-the art EMC facility, thereby catering for all of the qualification test needs for Ariane-5 single-passenger-class payloads. The first major customer to use the new EMC facility, in Autumn 2004, was the first flight model of the European Automated Transfer Vehicle (ATV), called 'Jules Verne'.



Thermal imaging of the new chamber's high-power-dissipation absorber cones during a power-dissipation test