The Santa Maria station, also known as “Montes das Flores” (Hill of Flowers), is located on the Portuguese island of Santa Maria, in the Azores. Santa Maria is one of ESA’s first tracking stations with launcher tracking capability, used to receive real-time telemetry from launches from ESA’s Spaceport in Kourou, French Guiana.

Introduction
During any Ariane launch, the reception of vehicle data via telemetry is essential for several reasons, for example to provide information for the launch vehicle specialists and the customers and, of course, flight safety. Overall, more than 1500 parameters are measured from the launch vehicle and recorded throughout the flight.

All these data are received through a specific network of ground stations, historically called ‘the Ariane network’. This is composed of several facilities, fully or partially dedicated to launch vehicle telemetry reception, and developed by the ESA Ariane programmes and operated by the French space agency CNES/Guiana Space Centre (CSG). The Ariane network is...
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Another Element in a European Launcher Tracking Network

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tailored for the most common Ariane trajectory (the geostationary transfer orbit, GTO), therefore its stations are based near the equatorial plane: Gallot station (Kourou), Natal (Brazil), Ascension Island in the South Atlantic Ocean (UK), Libreville (Gabon) and Malindi (Kenya).

For some specific missions, with trajectories other than GTO, additional facilities must be set up. For long ballistic or steady-state flight phases, it is possible to use on-board data recorders to cover the reception ‘holes’ between one ground station and the next. However, for some key phases, for example engine start/shut-off and stages or payload separations, real-time data reception is mandatory. This means that specific receiving facilities must be positioned in the right geographical locations.

One of these ‘exotic’ missions is the launch of ESAs Automated Transfer Vehicle (ATV), such as the flight of Jules Verne that took place in March this year. This type of launch needed an inclined trajectory (about 50 degrees). From the very first Ariane/ATV mission analyses several years ago, it seemed evident that after the loss of signal from the Kourou station, the existing Ariane equatorial network was of no use and that a specific network had to be set up. In the same period, Portugal joined ESA as a Member State, and this opened the discussions to investigate the possibility for setting up a telemetry reception site in the Azores islands, for inclined trajectories such as the ATV ones. The first site surveys were made jointly by ESA and CNES experts in 2003. The Santa Maria Island, the southernmost of the archipelago, turned out to be the best location, even if from a logistical point of view this solution was less easy than the main island of São Miguel. Thanks to a very fruitful cooperation between ESA, CNES and local authorities (the regional government of the Azores and the Town Hall of Vila do Porto), some possible sites were identified on the island. One of these, in the ‘Monte das Flores’ area, 5 km from Vila do Porto, was selected.

Ground Station Build-up
When the ESOC involvement started, the site for the new ground station was already selected, and the infrastructure was prepared to temporarily host a portable containerised station. It consisted of a concrete platform, lighting protection, an access road and connection to the public power supply.

In July 2006, ESA awarded a contract to Carlo Gavazzi Space SpA to develop the new ground station in Santa Maria. The telemetry-receiving system (called the TM kit) had already been developed by the company and was in use at different equatorial ground stations to track Ariane-5 launchers. The new development called for an equipment shelter to house the new installation, and a new antenna system to receive the Ariane-5 telemetry. Indra Espacio S.A. was selected as supplier of the antenna. In addition the contract included the remotely controlled calibration tower equipment.

One key design parameter for the antenna is to autotrack an S-band telemetry signal with a received flux between −109 and −75 dBm/m², and to receive the Ariane-5 telemetry at a data rate of 1 Mb/s. For this a 5.5 m parabolic reflector made of carbon fibre sectors was selected with a newly developed prime focus feed.

Normally, satellites transmit on one frequency and the autotrack systems are also designed for one frequency. The Ariane-5 telemetry is transmitted simultaneously on two different frequencies from two antennas mounted on opposite sides of the spinning rocket. In this way at least one of the frequencies will be seen from the ground station.

This required the development of an ‘autotrack’ system that automatically selects the best signal to steer the antenna during the pass. Autotrack is the capability of an antenna to autonomously follow a target once acquired. This capability is crucial for launcher tracking, because the pointing predictions may not be as accurate as for satellites in well-known orbits.

As an extra option, an X-band feed with a dichroic reflector could be added to have the possibility to use the antenna to receive Earth observation satellite data in X-band. The antenna uses an X-Y mount to avoid problems when following targets at high elevation near zenith. There are still two points that the antenna cannot easily cover, but they are located at the horizon in a direction where the rocket is not expected to appear.

The design also had to consider the possible interference from nearby UMTS transmitters that had been found in radio frequency interference measurements.
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made at Santa Maria. The UMTS frequency was outside the nominal Ariane-5 frequency band, but close enough to cause disturbance if not using input filters for the required attenuation of the UMTS signals (UMTS, or Universal Mobile Telecommunications Service, is a mobile computer and cell phone network standard).

In May 2007, the equipment shelters with the Ariane-5 telemetry kit and the calibration tower equipment were installed at Santa Maria. At the same time the antenna system was assembled and partly tested at the factory in Madrid. Performance tests in the factory were limited since there was no access to a calibration tower and there was a lot of domestic radio interference in the urban area.

In August 2007, the antenna was shipped to Santa Maria for installation and continued testing and commissioning. From October, the station was used for training and preparation by the operations team, in parallel with the final engineering verifications and then the final autotrack tests with an aircraft in January 2008.

**Infrastructure**

Since the plan changed to host the station permanently, the infrastructure needed to be adapted. From the Azores Regional Government, a power plant was supplied, providing fully autonomous electrical power to the station by means of diesel generators and Uninterruptible Power Supplies. The design process was in close collaboration with ESA. Furthermore, a site security system, a fence and a telecom system was installed to adequately support the permanent installation.

Inauguration of the complete ground station took place in January 2008, integrating the station into the ESA Tracking Network.

**Validation**

The majority of the validation tests was done the same as for satellite ground stations. Some of the requirements, however, made extra tests necessary, mainly the tracking and the end-to-end data flow tests. End-to-end data flow tests with the customer took place between the ground station and CSG directly. These tests comprised all aspects of data exchange: extracted launcher telemetry, orbital predictions as well as telemetry recording.

**Autotrack test campaign using an aircraft**

The launcher, as seen from the ground station, appears to have a much higher angular velocity than a satellite. This is mainly because the launcher is much closer when over Santa Maria, around 200 km compared to roughly 800 km for a satellite in a low-Earth orbit.

Obviously testing of the autotrack function was highly desirable, both for the ESOC team as well as for CNES/CSG, but this was not possible using satellites as is normally done for tracking stations. The solution was to downscale the geometry by a factor of about 100 and to replace the target with an aircraft carrying representative transmitters.

The equipment was installed in a 10-seat twin-propeller aircraft, with one antenna in the front window and one in the back, both radiating to the lefthand side on the two different frequencies. For flight regulations, both antennas had to be mounted inside, but the two different locations made it possible to see at least one antenna from the station. This was also a good test case for the frequency diversity function.

The pilots flew exactly along a path, defined by GPS coordinates, at a given speed, simulating both passes of the rocket over the ground station. The test was performed successfully in January 2008, and the results confirmed the theoretical analysis and local measurements already performed earlier. With this, the antenna was fully validated and technically in a state to support the launch.

**Operational Preparation**

The operations performed for launcher tracking are somewhat different than those for satellite tracking, but the preparations for satellite support at ESOC formed a solid baseline for this new type of support. The operations team, composed of the maintenance and operations contractor consortium and the ESOC engineers, underwent an intense training session by CNES at CSG in 2007, to understand the specifics and the elements of operation during a launch support.

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The Santa Maria ground station was part of the Ariane-5 launcher tracking network for the ATV Jules Verne launch. Operational qualification of that whole network was performed in January 2008. The Santa Maria station took part in this, when all the elements occurring during a normal launch countdown and the launch support were exercised. In addition to this, station-dedicated operational and performance tests were performed, as also done for satellite launch supports. This mainly covered contingency situations, which the team had to respond to, also under time constraints.
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Launch campaign
The launch campaign started 10 days
before launch. Now the tests again
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Repetition Générale, which was a
simulation of the full launch countdown
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Launch countdown and launch support
As the support to Ariane-5 for ATV
takes longer than for a normal mission
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minutes later, the Santa Maria station
received the signal of the rocket and
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whole pass went smoothly. The rocket
could even be seen visually during its
thrust phase.

All the other stations also received the
signal flawlessly and the separation of
ATV finally took place over New
Zealand. Half an orbit later, the rocket
was again tracked by Santa Maria.
Again, the new station and its team
worked perfectly. The mission ended
successfully after the debris burn, again
monitored over New Zealand.

Outlook
The Santa Maria station is being
upgraded with X-band (8 GHz band)
receive capability to allow reception of
Earth observation satellite payload data.
For this, a dichroic sub-reflector will be
put in front of the S-band feed, only
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X-band feed located on the main
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The ESA tracking stations network -
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The core ESTRACK network comprises
13 terminals sited at nine stations in six
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The essential task of all ESA tracking
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location, trajectory and velocity of their
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ESTRACK Core Network
Kourou (French Guiana), Maspalomas,
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ESTRACK’s new 35 m stations at New Norcia
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The ESTRACK system also includes
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Additional stations are used in some cases,
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In order to cover the entire length of an
Ariane’s trajectory when launched from
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