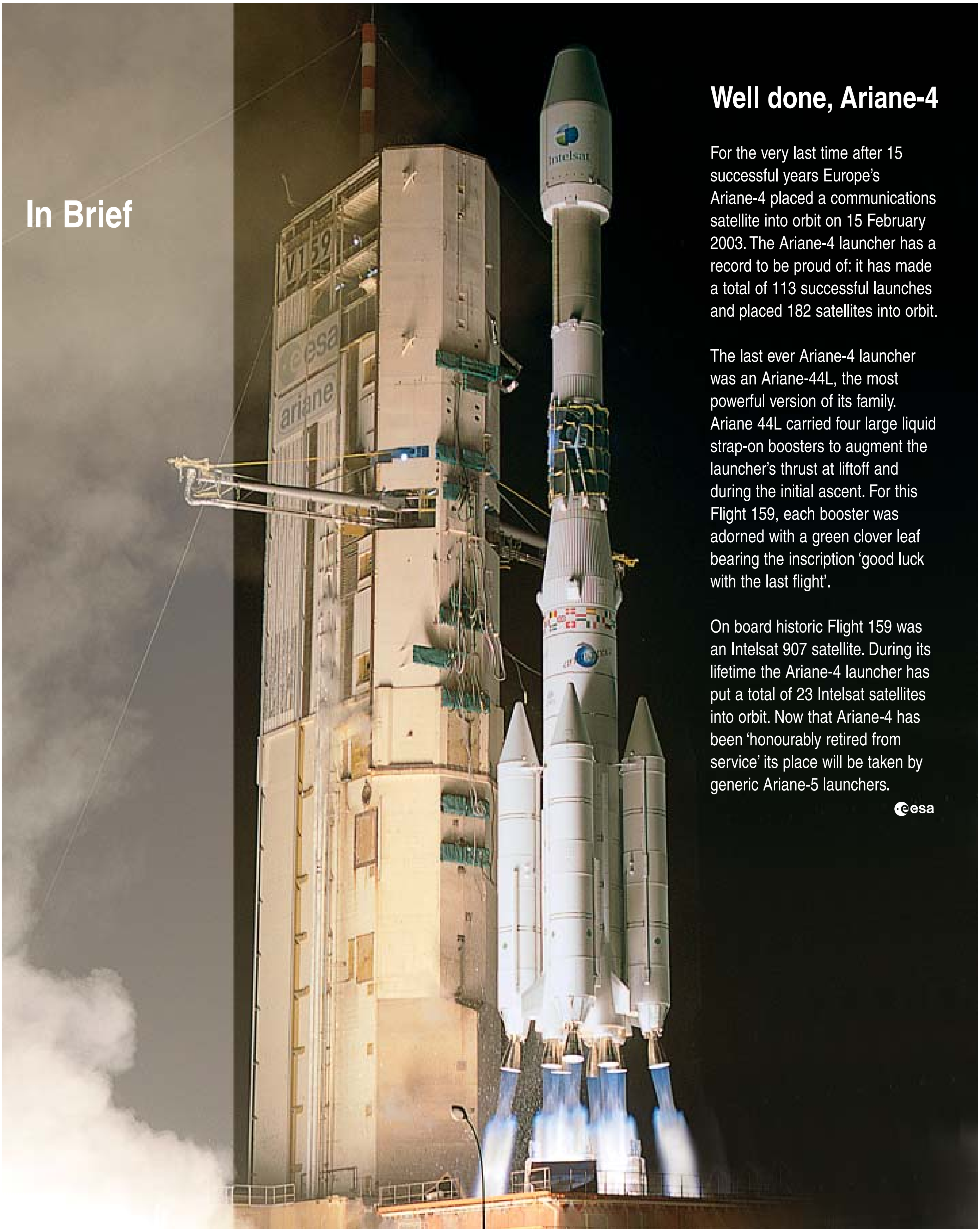


In Brief

Well done, Ariane-4

For the very last time after 15 successful years Europe's Ariane-4 placed a communications satellite into orbit on 15 February 2003. The Ariane-4 launcher has a record to be proud of: it has made a total of 113 successful launches and placed 182 satellites into orbit.

The last ever Ariane-4 launcher was an Ariane-44L, the most powerful version of its family. Ariane 44L carried four large liquid strap-on boosters to augment the launcher's thrust at liftoff and during the initial ascent. For this Flight 159, each booster was adorned with a green clover leaf bearing the inscription 'good luck with the last flight'.

On board historic Flight 159 was an Intelsat 907 satellite. During its lifetime the Ariane-4 launcher has put a total of 23 Intelsat satellites into orbit. Now that Ariane-4 has been 'honourably retired from service' its place will be taken by generic Ariane-5 launchers.

New DG for ESA:
Jean-Jacques Dordain

Jean-Jacques Dordain will be the next Director General of ESA for a period of four years. He will succeed Mr Antonio Rodotà, whose term of office ends on 30 June this year.

Dordain, born in France in 1946, obtained an engineering degree from the Ecole Centrale in 1968. Before joining ESA in 1986, he held several positions at the Office National d'Etudes et de Recherches Aérospatiales (ONERA) as researcher in the field of propulsion and launch vehicles, coordinator of space activities and as Director of Fundamental Physics. In 1977 he was selected by CNES to be among the first French astronaut candidates.

He joined ESA in May 1986 to be Head of the newly created Space Station and Platforms Promotion and Utilisation Department. He then became Head of the Microgravity and Columbus Utilisation Department, managing about 80 staff and overseeing numerous industrial activities. In 1993 he was appointed Associate Director for Strategy, Planning and International Policy. In May 1999 he was appointed Director of the newly created Directorate of Strategy and Technical Assessment. On 15 February 2001 he took up the post of Director of Launchers.

"I feel very honoured to have been appointed Director General of ESA and welcome this challenging opportunity. I have been working for the European Space Agency in various positions over the years. The current period offers good opportunities for ESA to be even more instrumental in building the future of European citizens and the success of Europe" said Dordain.

Jean-Jacques Dordain is a member of the International Academy of Astronautics and the Académie des Technologies. He has also held professorships at the Ecole Polytechnique and the Ecole Nationale Supérieure des Techniques Avancées.

ESA's new Director General

Arianespace Flight 157 – Inquiry Board submits findings

After a dramatic failure of the new Ariane-5 ECA in the night of 11 to 12 December 2002, an Inquiry Board has established the most probable cause for the failure, examined possible consequences for the baseline Ariane-5 launcher version, and recommended actions to correct the problems that occurred during the Ariane-5 ECA flight 157.

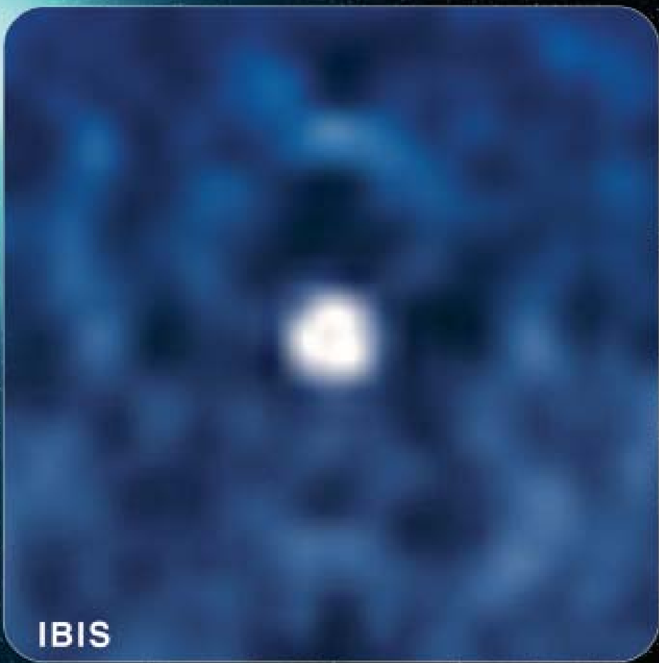
A complete analysis of all measurements recorded during Flight 157 was carried out, along with a review of documentation concerning production, quality and technical records for the Ariane-5 ECA, as well as for all Ariane-5 flights to date. Also reviewed by the Board was the work of production and development teams in Europe. The Board's findings confirm that all preparatory and countdown operations for Flight 157 went normally, as did the flight sequence until the separation of the solid boosters.

There was a leak in the of the Vulcain 2 nozzles' cooling circuits during this first flight phase, followed by a critical overheating of the nozzle. This resulted in a major imbalance in the thrust of the Vulcain 2 engine due to the nozzle's deterioration, leading to a loss of control over the launcher's trajectory.

In conclusion, the most probable cause of the failure of Flight 157 was the simultaneous occurrence of two factors: the degraded thermal condition of the nozzle due to fissures in the cooling tubes and non-exhaustive definition of the loads to which the Vulcain 2 engine is subjected during flight

The designs of the nozzles on the Ariane 5 Baseline's Vulcain 1 engine and the Vulcain 2 engine for Ariane-5 ECA differ in the shape of the cooling tubes, which form the structure of the nozzle and the technology of the nozzle's stiffeners. After reviewing operating data from the Vulcain 1 engine's 12 successful flights, the Inquiry Board did not identify any weaknesses concerning the functioning and resistance of its nozzle. The Inquiry Board nevertheless requested an exhaustive examination of the behaviour of the Vulcain 1 engine nozzle, including precise modelling to demonstrate the component's correct behaviour during the flight.

It works! First results from Integral



On 25 November 2002, Integral observed a powerful explosion, known as a gamma-ray burst (GRB). For about 20 seconds, a shower of gamma rays bathed the spacecraft and was captured by the gamma-ray imager (IBIS) and the spectrometer (SPI) on-board Integral. This is the first time ever that a gamma-ray burst has been captured using such a powerful gamma-ray camera. Scientists expect about one GRB every month to appear in the direction that the spacecraft happens to be looking. Most GRBs are believed to be the death of an extremely massive star in the distant Universe. According to a second theory, however, GRBs may come from the collision of two neutron stars, which are extremely dense objects. This particular GRB, designated GRB021125, is thought to have been located about 5 thousand million light years away. When they occur, GRBs shine as brightly as hundreds of galaxies each containing millions upon millions of stars.

Integral, launched in October last year from Baikonur in Kazakhstan, is fully operational. Its 'first-light' images – the name astronomers give to initial observations – were presented in Paris in December.

As a first test, Integral observed the Cygnus region of the sky, looking particularly at that enigmatic object, Cygnus X-1. Since the 1960s, we have known this object to be a constant generator of high-energy radiation. Most scientists believe that Cygnus X-1 is the site of a black hole, containing around five times the mass of our Sun and devouring a nearby star. Observing Cygnus X-1, which is relatively close by in our own Galaxy – 'only' 10 000 light years from us – is a very important step towards understanding black holes. This will also help us to understand the monstrous black hole – three million times the mass of our Sun – at the centre of our Galaxy.

During the initial investigations, scientists had a pleasant surprise when Integral captured its first gamma-ray burst. These extraordinary celestial explosions are unpredictable, occurring from random directions about twice a day. Their precise origin is contentious: they could be the result of massive stars collapsing in the distant Universe, or may alternatively be the result of a collision between two neutron stars. Integral promises to provide vital clues for solving this particular celestial mystery.

To study these peculiarities, Integral carries two powerful gamma-ray instruments. It has a camera, or imager, called IBIS and a spectrometer, SPI.

Spectrometers are used to measure the energy of the gamma rays received. Gamma-ray sources are often extremely variable and can fluctuate within minutes or seconds. It is therefore crucial to record data simultaneously in different wavelengths. To achieve this, Integral also carries an X-ray and an optical monitor (JEM-X and OMC). All four instruments will observe the same objects, at the same time. In this way they can capture fleeting events completely. Integral sends the data from all the instruments to the Integral Science Data Centre (ISDC) near Geneva, Switzerland, where they are processed for eventual release to the scientific community.

"We have been optimising the instruments' performance to produce the best overall science," says Arvind Parmar, Integral Project Manager at ESA. "These images and spectra prove that Integral can certainly do the job it was designed to do, and more, which is to unlock some of the secrets of the high-energy Universe".

Integral's primary mission will last for two years, but it is carrying enough fuel to continue for five years, all being well.

Workshop on Trajectory Design and Optimisation

One of the most challenging aspects of designing a mission is the definition of the trajectory. Not only do you need a good knowledge of celestial mechanics (where the stars and planets are at any time, and how they are moving relative to one another), but you also need to perform some very complex analysis. This requires specialised mathematical software tools, plus some means of optimising the results, to ensure not just that you reach your target destination, but also that you take the best route. There are a variety of software tools available nowadays, some commercially produced and some custom designed (e.g. by NASA).

In October 2002, the ESA Advanced Concepts Team organised a Workshop on Trajectory Design and Optimisation. A number of specialists were invited to take part, some to present the state of the art in trajectory design, and others to speak about optimisation techniques that are used in other fields but not yet in space. The contributors came from Russia and the USA as well as Europe.

During discussions at the Workshop, it became clear that different specialists have their own opinions and preferences as to the optimal tools and solutions.

One interesting aspect of the workshop was seeing how different countries had evolved different methodologies: for example, computing resources in Russia were rather limited in the past, and this meant they traditionally leaned towards an approach that was less demanding in terms of processing power. However, this limit no longer applies; in fact, the computational power available in modern computers worldwide is so great, and still increasing so fast, that much more complex analyses can be performed now than was possible in the past.

As well as informing the attendees, the Workshop highlighted some potential areas of research and development that may be interesting for ESA in future.

The ESA Advanced Concepts Team (ACT)

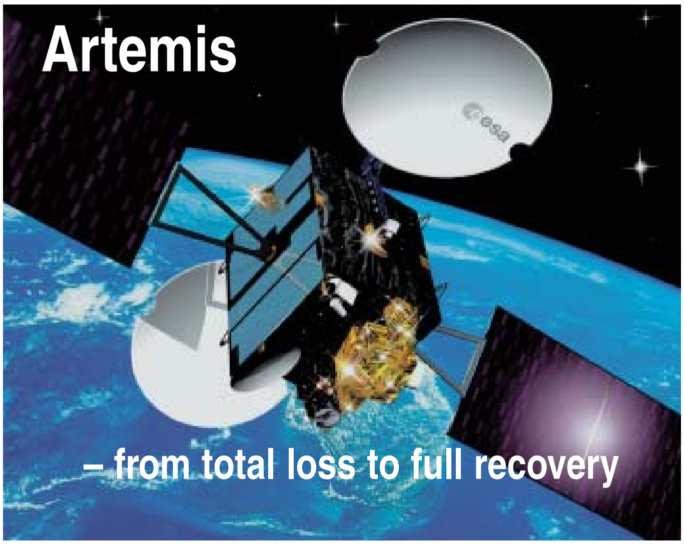
The Advanced Concepts Team is a group of scientific, technical and engineering Research Fellows (ESA's post-doc programme) working at the European Space Research and Technology Centre (ESTEC), in Noordwijk, Netherlands.

Based on strong links with academic research centres, ACT members carry out research work on leading edge concepts and emerging technologies for which both space systems engineering competence and specific theoretical knowledge are required.

The ACT is intended to provide quick and sound in-house expertise in various advanced research topics, to bridge the gap with universities all over Europe, and to develop innovative methods and approaches to problems of space exploration. In this respect, critical open-mindedness, scientific curiosity and interdisciplinary teamwork are the essential pillars of the ACT philosophy.

Current research topics comprise:
- Advanced Mission Analysis
- Advanced Space Power and Energy
- Biomimicry on Space Systems
- Near Earth Objects – Analysis of Threat
- Planetary Protection

To ensure it is always at the forefront of current thinking, the ACT occasionally organises workshops and conferences.



In the late afternoon of Friday 31 January, a final trim manoeuvre nudged Artemis into its assigned position in geostationary orbit, completing a remarkable satellite recovery operation which has lasted 18 months.

Due to a malfunction in its upper stage, Ariane-5 had left the telecommunications satellite in a lower than intended elliptical orbit. A team of ESA and industry specialists responded vigorously with a series of innovative control procedures to rescue the spacecraft. Daring manoeuvres were executed and these proved not only very successful but also highly efficient. Using almost all of the available chemical propellant, Artemis managed to reach a circular orbit at an altitude of 31 000 km only a few days after launch.

Since then, the rescue efforts have continued unabated using the four ion engines mounted on the satellite redundantly in pairs. These novel engines, instead of conventional chemical combustion engines, use ionised Xenon gas. They were originally designed only to control the satellite's inclination by generating thrust perpendicular to the orbital plane. The rescue operation, however, required thrust to be generated in the orbital plane to push the satellite to final geostationary orbit. This could be realised by rotating the satellite in the orbital plane by 90 degrees with respect to its nominal orientation.

The Artemis recovery team

Taking optimum advantage of the spacecraft flight configuration, new strategies were developed not just to raise altitude but also to counter the natural increase in orbital inclination. To implement those new strategies, new onboard control modes, a new station network and new flight control procedures had to be put in place.

The new concept for steering the ion propulsion engines included entirely new control modes never before used on a telecommunication spacecraft, as well as new telecommand and telemetry and other data-handling interface functions. In all, about 20% of the original spacecraft control software had to be modified. Thanks to the reprogrammable onboard control concept, these modifications could be loaded by uplinking to the satellite software 'patches' amounting in total to 15 000 words, the largest reprogramming of flight software ever done on a telecommunications satellite.

By the end of December 2001 work on the new software had been completed, and it was subsequently validated using the spacecraft simulator as testbed. Artemis – through dogged operation of its ion engines with their modest thrust of only 15 milli-Newton – climbed at an average of 15 km per day.

After the new attitude control mode was commissioned in February 2002, and the ion engines started to expand the orbit with an almost imperceptible thrust, the workload was gruelling and almost every week brought new problems to be solved. Although generally minor, these anomalies needed investigation and sometimes resulted in an interruption in effective thrusting, slowing progress.

With these difficulties behind them, the operators turned their attention to planning for the process of station acquisition in the geostationary orbit and initial operations on station.

At altitudes only a few hundred kilometres below the geostationary ring, it takes several weeks for the satellite to drift once around the Earth. It is therefore important to avoid overshoot by tuning the drift rate to arrive at the designated station longitude (21.5 deg. East) just as the geostationary altitude is reached.

These orbital adjustments were made using small chemical propellant thrusters, activated for the first time since launch. The first thrust was performed successfully in December and two more in January, slowing the drift rate to a few degrees per day as the satellite made its last pass over Europe to arrive at its working position in geostationary orbit.

When the last manoeuvre was performed on 31 January it was an emotional moment. From the attitude control mode which had sustained the ion thrusting for so long, the satellite was turned to point to Earth for normal operations. Ground controllers were able to stand down the network of ground stations around the world that had helped in commanding the satellite.

Now on station, Artemis will function as originally planned.

The satellite can be made available to serve its first users: SPOT-4, Envisat, EGNOS and Eutelsat/Telespazio. A preparatory test will also be made with NASDA's Earth observation mission ADEOS-II. Other users planning to use Artemis in the future include ESA's Automated Transfer Vehicle and Columbus elements of the International Space Station.

Not only has Artemis clocked up a number of unique first-time applications during its recovery – first optical inter-orbit satellite link; first major reprogramming of a telecommunications satellite; first orbital transfer to geostationary orbit using ion propulsion; longest ever operational drift orbit – but it will also provide the promotional opportunity and stimulus for future European data relay services. Hence there is a promising future for this incredible mission!