Artemis

Achievements: first European data relay mission, including first optical intersatellite link; first European operational use of ion propulsion
Launch: 21:58 UT 12 July 2001
Mission end: design life 10 years
Launch vehicle/site: Ariane-510 from ELA-3, Kourou, French Guiana
Launch mass: 3105 kg (550 kg payload, 1538 kg propellant)
Orbit: planned geostationary, above 21.5°E
Principal contractors: Alenia Spazio (prime, thermal control, RF data relay payload), FiatAvio (propulsion), CASA (structure), Officine Galileo (power), Fokker (solar array), Bosch/Alcatel (RD data relay payload elements), Astrium SAS (SILEX), Astrium UK (Electro-bombardment thruster), Astrium GmbH (RF Ion Thruster), Telespazio (ground segment)

ESA's Advanced Relay and Technology Mission Satellite aims to demonstrate new telecommunications techniques, principally for data relay and mobile services. At present, users of Earth observation satellites such as ERS in low orbit must rely on global networks of ground stations to receive their vital data. But, as information requirements and the number of missions grow, this approach is becoming too slow and expensive and sometimes technically unfeasible. Two payloads aboard Artemis will explore data relay directly between satellites, receiving data from low Earth-orbiting satellites and relaying them to Europe: the SILEX laser terminal and the SKDR S/Ka-band terminal.

Europe's Spot-4 and Japan's OICETS satellites will use SILEX; Japan's ADEOS-2 Earth-observation satellite and JEM Space Station module may use SKDR. ESA's own Envisat will be an important user of the Ka-band element.

The L-band payload provides 2-way links between fixed Earth stations and land mobiles in Europe, North Africa and the Near East. This 'L-band Land Mobile' (LLM) payload is fully compatible with the European Mobile System (EMS) payload already developed by ESA and flying aboard Italsat-2. It will be used by Eutelsat.

Artemis was released into a low transfer orbit because of a malfunction in Ariane-5's upper stage: instead of the planned 858x35 853 km, 2°, the under-burn resulted in 590x17 487 km, 2.94°. As scheduled, the solar wings were partially deployed some 2 h after launch and began delivering power while controllers formulated a 4-step recovery strategy:

1. 18-20 July: the Liquid Apogee Engine (LAE) fired during five perigee passes to raise apogee to about 31 000 km.

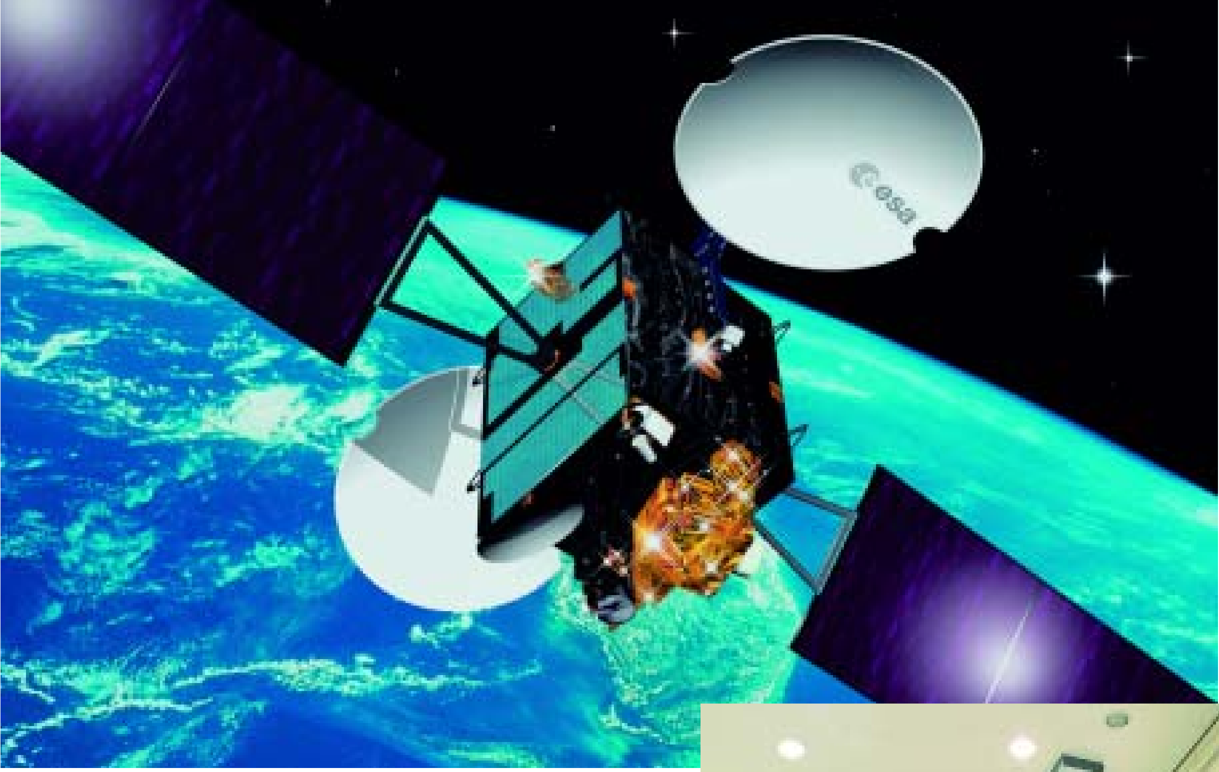
2. 22-24 July: the LAE raised perigee in three burns to produce a circular orbit at about 31 000 km, 0.8°, 20 h. The solar arrays were then fully deployed, as were the two antenna reflectors.

3. software will be created and loaded for orbit-raising by the ion engines.

4. from late September 2001 for several months, the ion engines will raise the orbit to achieve GEO. Spacecraft commissioning then requires 2 months.

Artemis also carries a transponder providing part of the European Geostationary Navigation Overlay Service (EGNOS) for enhancing the GPS/Glonass navigation satellite constellations.

Artemis is the first ESA satellite to fly electric propulsion technology operationally: UK and German xenon ion thrusters will control the north-south drift in geostationary orbit. The attractions of this technology are its high specific impulse (3000 s) and

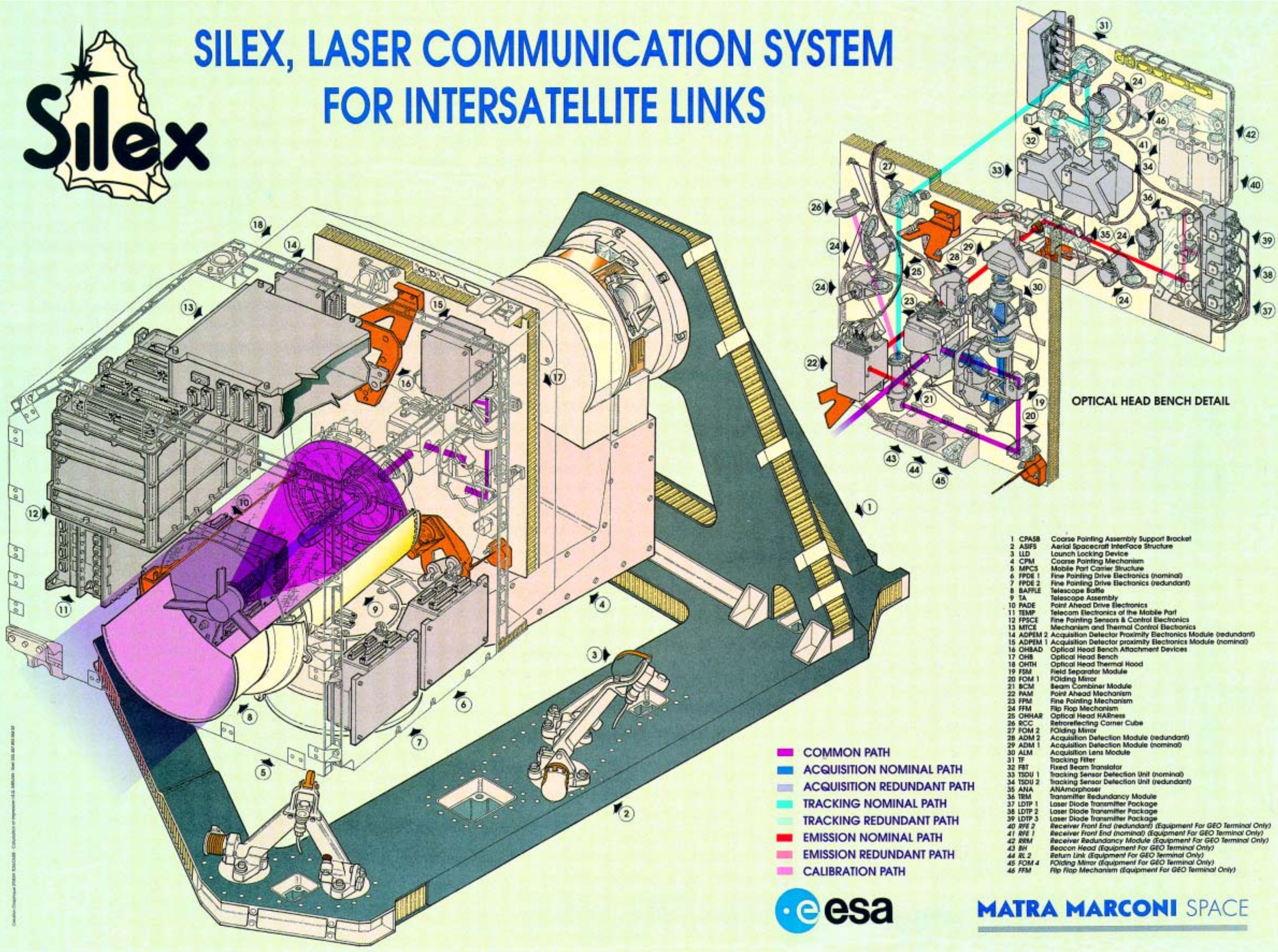


Artemis is dominated by the two 2.85 m-diameter reflectors for inter-orbit links and the LLM payload.

Above: unpacking the Flight Model after its arrival at ESTEC to begin systems-level testing in July 1998. The SILEX terminal is at bottom right; the telescope is pointing down. Above it is the Ku-band feeder link for the LLM land mobile package. At top left is the Ka-band feeder for the SKDR and SILEX packages.

Above left: the Flight Model bus at ESTEC, showing the Large Apogee Engine. Above it are two ion thruster nozzles.

Left: vibration testing of the Artemis Structural Model in launch configuration at ESTEC in December 1996. One of the ion thruster packages can be seen at bottom left.



low thrust (about 20 mN) in contrast with chemical propulsion. For Artemis, the result is a mass saving of about 60 kg. Launch problems mean that the ion thrusters are being used unexpectedly to achieve GEO (see box p.166).

Artemis also differs from the traditional approach by combining onboard data handling and AOCS into a centralised processing architecture.

Satellite configuration: classical box-shaped 3-axis bus derived from Italsat and other European predecessors. 25 m span across solar wings. Primary structure of central cylinder (aluminium honeycomb skinned by carbon fibre), main platform, propulsion platform and four shear panels. The secondary structure is principally the N/S radiators, E/W panels and Earth-facing panel. The central propulsion module houses the propellant tanks, LAE, pressurant tanks and RCS pipes. E panel: L-band antenna/feed. W panel: IOL antenna. N/S panels: host most of the electronic components requiring heat dissipation. Earth panel: other antennas and AOCS sensors.

Attitude/orbit control: Earth/Sun sensors & gyros for attitude determination, reaction wheels for

Artemis Communication Payload

Semiconductor Laser Intersatellite Link Experiment (SILEX)

SILEX is the world's first civil laser-based intersatellite data relay system. The transmitter terminal on Spot-4 in LEO will beam data at 50 Mbit/s (bit error rate $<10^{-6}$) to the receiver on Artemis for relay via the feeder link to Spot's Earth station near Toulouse, France. Japan's OICETS satellite will also be used in experiments (including 2 Mbit/s from ground via Artemis to OICETS). Each terminal has a 25 cm-diameter telescope mounted on a coarse pointing mechanism; pointing accuracy 0.8 mrad. Optical power source: 830 nm GaAlAs semiconductor laser diode, peak output 160 mW (60 mW continuous), beamwidth 0.0004° (400 m-diameter circle at the distance of receiver). Receiver: silicon avalanche photodiode (SI-APD), followed by a low-noise trans-impedance amplifier; 1.5 nW useful received power. CCD acquisition/tracking sensors direct fine-pointing mechanism of orthogonal mirrors. A 1 m telescope at the Teide Observatory on Tenerife will also act as a test station.

S/Ka-band Data Relay (SKDR)

The 2.85 m antenna tracks a LEO user satellite via either loaded pointing table values and/or error signals to receive up to 450 Mbit/s Ka-band or up to 3 Mbit/s S-band for relay via the feeder link to Earth. Up to 10 Mbit/s Ka-band and 300 kbit/s S-band can be transmitted by Artemis to LEO satellite. Single Ka-band transponder (plus one backup) 25.25-27.5/23.2-23.5 GHz rx/tx, adjustable EIRP 45-61 dBW, G/T 22.3 dB/K, up to 150 Mbit/s each of three channels LEO to Artemis and up to 10 Mbit/s Artemis to LEO. RH/LHCP on command. One S-band transponder (plus one backup) 2.200-2.290/2.025-2.110 GHz rx/tx, adjustable EIRP 25-45 dBW, G/T 6.8 dB/K, 15 MHz bandwidth, up to 3 Mbit/s single channel LEO to Artemis and up to 300 kbit/s Artemis to LEO. RH/LHCP on command. Artemis broadcasts 23.540 GHz beacon to help the LEO satellite track it.

SILEX and SKDR feeder link

Three transponders (plus one backup, 4-for-3) act as Artemis-ground links for SILEX and SKDR. 27.5-30/18.1-20.2 GHz rx/tx, EIRP 43 dBW, G/T 0 dB/K, 234 MHz bandwidth, linear vertical polarisation.

L-band Land Mobile (LLM)

Designed principally for mobile users such as trains and trucks. Artemis carries 2.85 m antenna and multiple element feed for pan-European coverage and three European spot beams. Three 1 MHz plus three 4 MHz SSPA channels, providing up to 650 2-way circuits with EIRP >19 dBW 1550 MHz L-band transmitting to terminals (1650 MHz receiving) and 14.2/12.75 GHz Ku-band rx/tx for the feeder links to the home stations. All channels fully tunable and most commandable LH/RHCP. LLM provides an operational service in conjunction with Italsat-2's European Mobile System package (also funded through ESA).

attitude control (RCS thrusters for wheel offloading). Unified Propulsion System: conventional bipropellant (MMH/N_2O_4) system of a single 400 N Liquid Apogee Engine (LAE, for insertion into GEO) and two redundant branches of eight 10 N RCS thrusters each. Propellants in two Cassini-type 700-litre tanks; helium pressurant in three spheres. LAE operates at regulated 15.7 bar, then isolated once in GEO for RCS to operate in blowdown mode. E/W positioning maintained by RCS; N/S by ion thrusters. Ion Propulsion Subsystem (IPS) comprises two thruster assemblies, one each on N/S faces: a 15 mN RF Ion Thruster (RIT) and an 18 mN Electro-bombardment Thruster (EIT). Each is powered and monitored separately, but with common propellant supply (40 kg Xe). 600 W required in operation.

Power: twin 4-panel solar wings provide 2.8 kW at equinox after 10 years to 42.5 Vdc bus; eclipse protection by two 60 Ah nickel-hydrogen batteries.

Communications: satellite control from Control Centre and TT&C station in Fucino Mission Control; In-Orbit Testing from ESA Redu. See separate box for Artemis communications payload.