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European transonic tunnel goes ahead

Four European countries have established a joint company to design and operate a £200 million transonic windtunnel. The agreement, which follows almost ten years of planning, was signed in April by representatives of the national aerospace research establishments of the four countries involved: Britain, West Germany, France, and The Netherlands.

The European transonic windtunnel (ETW) will be located at Cologne, West Germany, on a site adjoining the German aerospace research establishment (DFVLR). It will be a closed-circuit cryogenic tunnel using a nitrogen-air mixture at −180°C. With a 2·4m by 2m test section and a maximum pressure capability of 4·5 bar, the tunnel will operate at Mach 0·15 to 1·3.

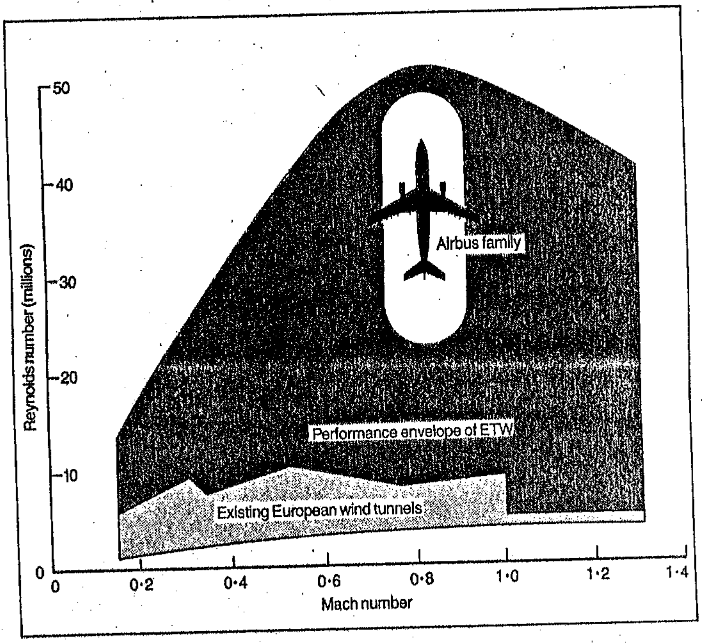
ETW will be of vital importance to the European aircraft industry, the partners believe. The tunnel will provide the full-scale Reynolds numbers capability (around 50 million) that the US industry has access to with its National Transonic Facility.

The facility will be built and run by Cologne-based European Transonic Windtunnel GmbH, in which Britain has an equal 31 per cent share with West Germany and France, the remaining 7 per cent share being held by The Netherlands.

Construction costs will be shared differently, with Germany as host country taking 38 per cent, Britain and France 28 per cent each, and The Netherlands 6 per cent.

Extensive research work was carried out before the formation of ETW GmbH; in Amsterdam, at The Netherlands' National Aerospace Laboratory (NLR), a 1:8·8-scale pilot tunnel was built to assess the aerodynamic performance. A model of the ETW high-speed leg at DFVLR in Cologne was used to quantify turbulence levels. This study led to the chosen circuit geometry whereby liquid nitrogen injection takes place upstream of the compressor. Injection of 75,000 tons of liquid nitrogen a year is necessary.

It is planned to run the tunnel first in early 1993, to be followed by an 18-month commissioning period.



High-speed and turbulent flight is difficult to simulate accurately at full scale in existing European windtunnels

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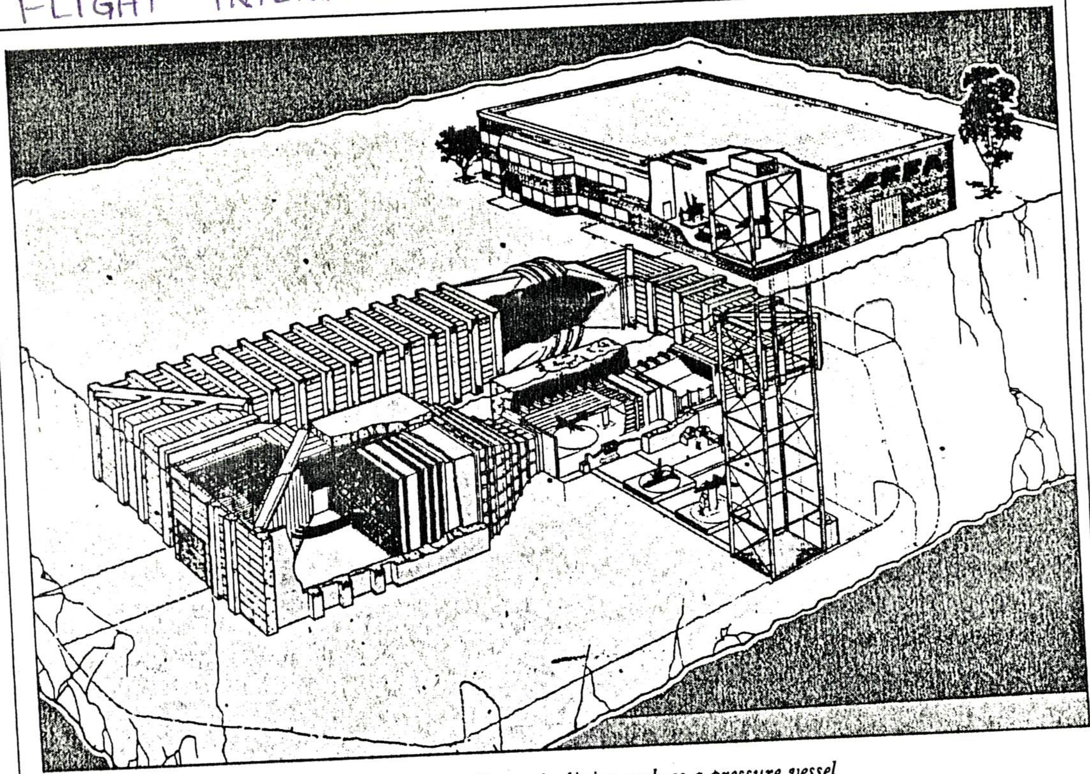

Buried underground, the Swedish windtunnel will use the living rock as a pressure vessel

Swedish tunnel goes underground

Sweden's Aeronautical Research Institute plans to construct a low-speed wind-tunnel 50m below ground. The project will be unique, marking the first time that such a facility will be blasted out of solid rock.

With a $36m^2$ cross-section and a claimed attainable Reynold's number of 11·5 million (based on a 0·6m mean chord), the facility will be one of the largest outside the USA. The tunnel will be pressurised to 4 bar, and will be capable of Mach 0·23.

According to the research institute's Stig Lundgren, there are two reasons for choosing an underground site. The airfield location, near Stockholm, has limited space, and the surrounding rock will serve as a pressure vessel, which will improve safety and reduce cost.

The SKr400 million ($67 million) project awaits Government approval. It is hoped that the tunnel will be fully operational in 1993-94.

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Ariane 4: the big shot

Arianespace contends that June's Ariane 4 mission is, strictly speaking, not a test flight. But the maiden flight of the 60m-tall vehicle, which already boasts 20 launch bookings, will be the "big shot". **Tim Furniss** profiles the launcher destined to be Europe's workhorse of the 1990s.

ARIANE 4 is a unique launcher. With a quick juggle of solid- and liquid-propellant strap-on boosters, and with the help of a new dual satellite-carrying structure called Spelda (in addition to the Ariane 3 Sylda and various fairings) it can be configured as a six-in-one launcher, capable of placing between 1·9 tonnes to 4·2 tonnes into geostationary transfer orbit.

The vehicle was given the go-ahead by Esa in 1982, to provide a flexible launch capability to match a predicted trend in the market to carry dual payloads of up to 2,500kg, and heavy satellites such as the Intelsat VI. The project is under the management of the French space agency, Cnes.

If the June V22 "demonstration" mission for the European Space Agency successfully carries Meteosat P2, Amsat, and Panamsat into orbit, Arianespace will take over Ariane 4 for the first commercial launch. This will carry Astra and an operational Meteosat, MOP 1, hopefully on V27 in September. By April next year, with the launch of V33, Ariane 4 will have taken over all launch operations. Europe's target is to sell about 100 launches between now and the year 2000.

Compared with Ariane 3, the new launcher has major differences: new 4m-wide fairings; the Spelda external supporting structure; a new vehicle equipment bay; reinforced main structures and tanks to tolerate increased loads; a stretched first stage; uprated Ariane 3 solid rocket boosters; and new liquid-propellant boosters with Viking engines.

Reflecting the launcher's inheritance of previous Ariane technology, the list of contractors is the same: Aérospatiale (first and third stages and Sylda adaptors); Erno (second stage, and liquid boosters); Matra (vehicle equipment bay); Contraves (fairings); British Aerospace (Spelda); SNIA BPD (solid boosters and separation rockets); SEP (propulsion systems for three stages); Air Liquide (third-stage tanks); and Casa (adaptors).

The total cost of the Ariane 4 development programme has been about $550 million. In terms of national percentages, industrial contributions are led by France, with 61·68 per cent, followed by West Germany (17·20 per cent), Belgium (4·30 per cent), Italy (6·2 per cent), the UK (4·68 per cent), Switzerland (1·63 per cent), Spain (1·87 per cent), Sweden (1·14 per cent), The Netherlands (1·05 per cent), Denmark (0·18 per cent), and Ireland (0·07 per cent).

The six possible configurations of Ariane 4 are Ariane 40 (with no thrust augmentation), which can place 1·9 tonnes into geosynchronous transfer orbit; Ariane 42P, with two solid boosters (2·6 tonnes); Ariane 44P, with four solid boosters (3·01 tonnes); Ariane 42L, with two liquid boosters (3·2 tonnes); Ariane 44LP—the V22 configuration—with two solid and two liquid boosters (3·7 tonnes); and, finally, the four-liquid-booster Ariane 44L, which can place 4·2 tonnes into GTO. A maximum of 7,000kg can be placed into low Earth orbit.

Each configuration can have one of seven "spacecraft compartments" or fairing-satellite structures. For single satellite launches there is the type 01 short fairing (4m wide and 8·6m long with a volume of 60m^3); the type 02 long fairing (4m wide and 9·6m long, with a volume of 70m^3); and the type 03 extra long fairing (4m wide, 11·1m long, and with a volume of 86m^3). Each is made of two shells in aluminium honeycomb with carbonfibre facing.

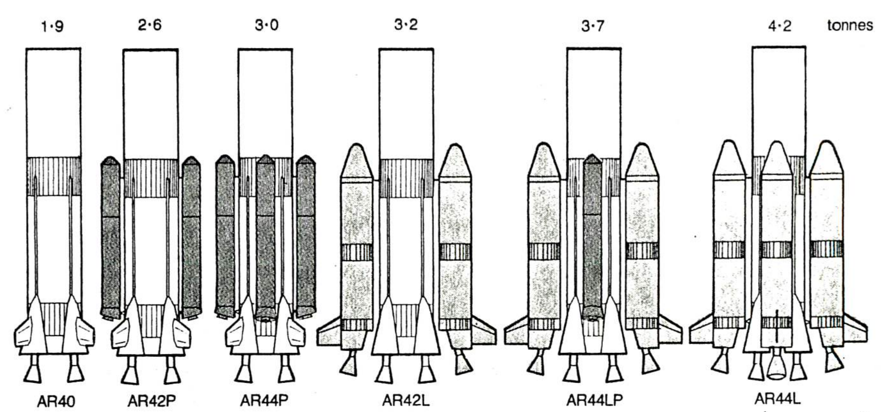
There are three "dual" launch configurations. The type 02 long fairing, combined with the type 001 Sylda 4400 structure, can carry satellites within internal volumes of 25m^3 and 14m^3, respectively. The latter is typically a Pam D-class satellite. The Sylda, as also used on Ariane 3, is a sandwich shell, with a multi-layer carbon skin bonded to a metallic honeycomb core.

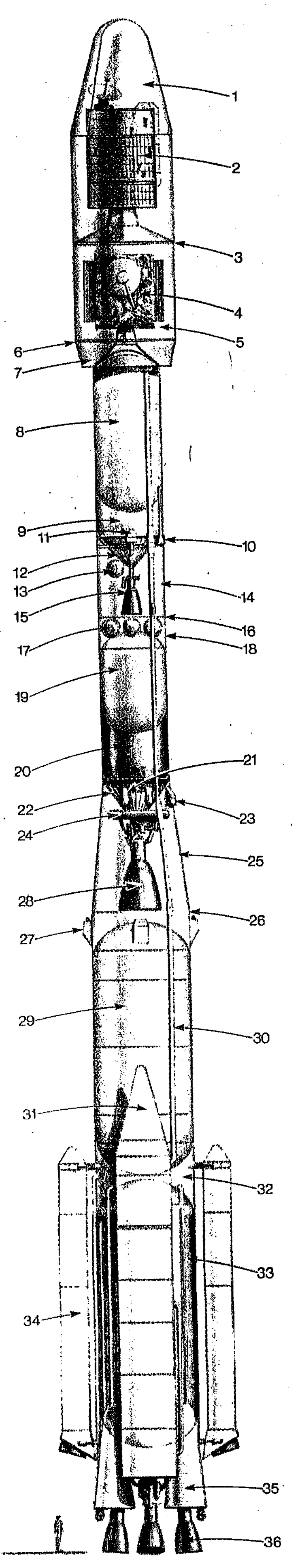
The Ariane 4 Spelda is made of curved aluminium panels with carbonfibre reinforced plastic skin. A type 02 short fairing and an add-on type 10 short Spelda can house 49m^3 and 32m^3, respectively—the Spelda carrying a Pam DII-class satellite. A triple launch (as on the maiden flight) is possible with a type 02 long fairing combined with a type 10 short Spelda, allowing a Pam DII-class satellite to be carried together with two other Ariane 3-class passengers within a volume of 59m^3. Finally, there is the combination of the type 01 short fairing with 49m^3 volume, and type 20 long Spelda with a volume of 42m^3.

The 23m-long first stage of Ariane 4, designated L220, is derived from the L140 first stage from the Ariane 2 and 3, and is equipped with four Viking V engines fuelled by 226 tonnes of UH25 (25 per cent hydrazine hydrate and 75 per cent unsymmetrical dimethyl hydrazine) and nitrogen tetroxide, held in identical propellant tanks, 3·8m in diameter and 7·4m long.

Between the upper nitrogen tetroxide and lower UH25 tanks is a cylindrical inter-tank skirt, 2·6m high, containing a 0·73m-high common water tank, holding a

Ariane IV weight lifting capacity to geosynchronous transfer orbit





maximum of 8,200lit. Above the nitrogen tetroxide tank is a 1·5m-high forward skirt which supports eight first-stage retrorockets and connects the first stage with an interstage structure. Beneath the UH25 tank is the 2·3m-high thrust frame containing the four engines.

The Viking V engines develop a total thrust of 2,700kN (606,960lb) on the ground and 3,000kN (674,400lb) in vacuum. The same thrust can be matched by four Viking VI liquid-propellant boosters in the 44L version. The Viking V engines have a burn time of 206sec, 51sec more than Ariane 3, as a result of stretched tankage.

The solid rocket boosters, called PAP, ignite 3sec after the main engines. These are just over 1m in diameter and 12·2m long. They are similar to Ariane 3's boosters, but have been stretched to increase burn time by about 10sec. They contain 9·5 tonnes of flexadine powder solid propellant, and produce a thrust of 650kN (146,120lb) for 42sec, after which they are jettisoned by four spring separation mechanisms generating a force of between 66kN and 59kN (14,837lb and 13,263lb) to provide a lateral separation velocity of 5m/sec.

The new 2m-diameter, 19m-long liquid boosters are called PAL. Each contains 39 tonnes of UH25 and nitrogen tetroxide in two separate tanks. Their Viking VI engines each have a thrust of 750kN (168,600lb) and burn for 143sec. The booster rockets are ignited at the same time as the main engines. They separate using pyrotechnic release of the front attachments and coupling ring, plus the firing of six retrorockets, identical to the first-stage retros.

After the first-stage engines cut off at T+203sec, and as the vehicle enters a period of virtual zero acceleration, the first stage is disconnected by a pyrotechnic cutting cord, and separation occurs at a velocity of less than 1m/sec. Two seconds later, the first-stage retros and second-stage acceleration rockets fire, followed by second-stage ignition. The acceleration rockets shut down 4sec later and are jettisoned 8sec after this.

The L34 second stage measures 11·6m high and 2·6m in diameter. It is equipped with a single Viking IV engine fuelled by 34 tonnes of nitrogen tetroxide and UH25 held in a 6·5m-high tank divided into two vessels by a common bulkhead. The nitrogen tetroxide feedline from the upper tank passes within the UH25 tank. The second-stage aft skirt, nearly 1·6m high, connects the 3·3m-high interstage conical skirt and second-stage thrust frame. The aft skirt houses a water tank, four acceleration rockets, a pyrotechnic cutting system, and retro-rockets for second/third-stage separation. The forward skirt connects the second stage to the carbonfibre second/third-stage interstage skirt. The Viking IV engine imparts a thrust of 798kN (179,390lb) and burns for 130sec. Separation is accomplished in a manner similar to the first/second-stage separation.

The cryogenic H10 third stage is 11·4m long and 2·6m in diameter. The liquid hydrogen (LH) and liquid oxygen (LOX) tanks, holding a combined load of 10·5 tonnes, form a cylinder nearly 7·6m high divided into two vessels by an insulating intermediate bulkhead. The tankage is prolonged by a short forward skirt, nearly half a metre high, connecting with the equipment bay, and by a short rear skirt on which the thrust frame is mounted. This also contains acceleration rockets and a pyrotechnic cutting system. The stage's HM7B cryogenic engine has a thrust of 63kN (14,160lb) and a burn time of 725sec.

This engine has been uprated since malfunctioning three times during the four Ariane failures to occur in 21 missions. The engine is gimbal-mounted along the pitch and yaw axes. Roll control is achieved by a system of auxiliary gaseous hydrogen nozzles.

A turbopump drives the propulsion system from a generator fed with liquid oxygen and liquid hydrogen in a 0·9:1 mix ratio, limiting the temperature to 880K. The turbopump has two shafts, the first rotating at about 60,000 r.p.m. and acting as the turbine and

Key.

1 Fairings
2 Upper spacecraft
3 Upper spacecraft separation plane
4 Inner spacecraft
5 Spelda
6 Inner spacecraft separation plane
7 Vehicle equipment bay (VEB)
8 Liquid hydrogen tank
9 Liquid oxygen tank
10 Roll and attitude control system
11 Third-stage acceleration rockets (2 × 2)
12 Third-stage thrust frame
13 Helium pressurisation tank
14 Interstage 2-3
15 Third-stage engine—HM-7B
16 2-3 separation plane
17 Second-stage helium pressurisation tanks (3)
18 Second-stage front skirt
19 N_2O_4 tank
20 UH25 tank
21 Second-stage retro-rockets (2)
22 Second-stage thrust frame
23 Second-stage acceleration rockets (4)
24 Second-stage torroidal water tank
25 Interstage 1-2
26 1-2 separation plane
27 First-stage retro-rockets (4 × 2)
28 Second-stage engine—Viking IV
29 N_2O_4 tank
30 External cable duct
31 Liquid strap-on boosters (2)
32 Intertank skirt
33 UH25 tank
34 Solid-propellant strap-on boosters
35 Engine cowlings
36 First-stage engines—4 Viking V