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The Spaceplanes of Europe
(Part Three)

HOTOL: The British Spaceship

The United Kingdom (U.K.) is planning to enter the European spaceplane competition with the HOTOL (HOrizontal Take-Off and Landing) reusable launch vehicle. Currently, the concept is being studied in a cooperative effort between the British government and the British aerospace industry. The government is represented by the new British National Space Centre (BNSC). The industry representatives are British Aerospace, serving as project manager, and Rolls-Royce, handling propulsion development. HOTOL supporters hope that the spaceplane will be adopted as a European space project, with the first operational flights occurring by the year 2005.

HOTOL is a winged spacecraft about 60 meters (197 ft.) long, with a wingspan of about 20 meters (66 ft.) and a takeoff weight of about 200,000 kg (441,000 lbs.)--approximately the same size and weight as the Concorde supersonic transport. The HOTOL could carry up to 8 metric tons (17,600 lbs.) into low earth orbit in an 8 meter (26 ft.) by 4.6 meter (15 ft.) payload bay.

In its baseline configuration, the HOTOL is designed to be unmanned, and operated automatically during its flight. A modified version, with added safety features, could carry human passengers into orbit inside a manned capsule designed to fit in the HOTOL payload bay (more on this later).

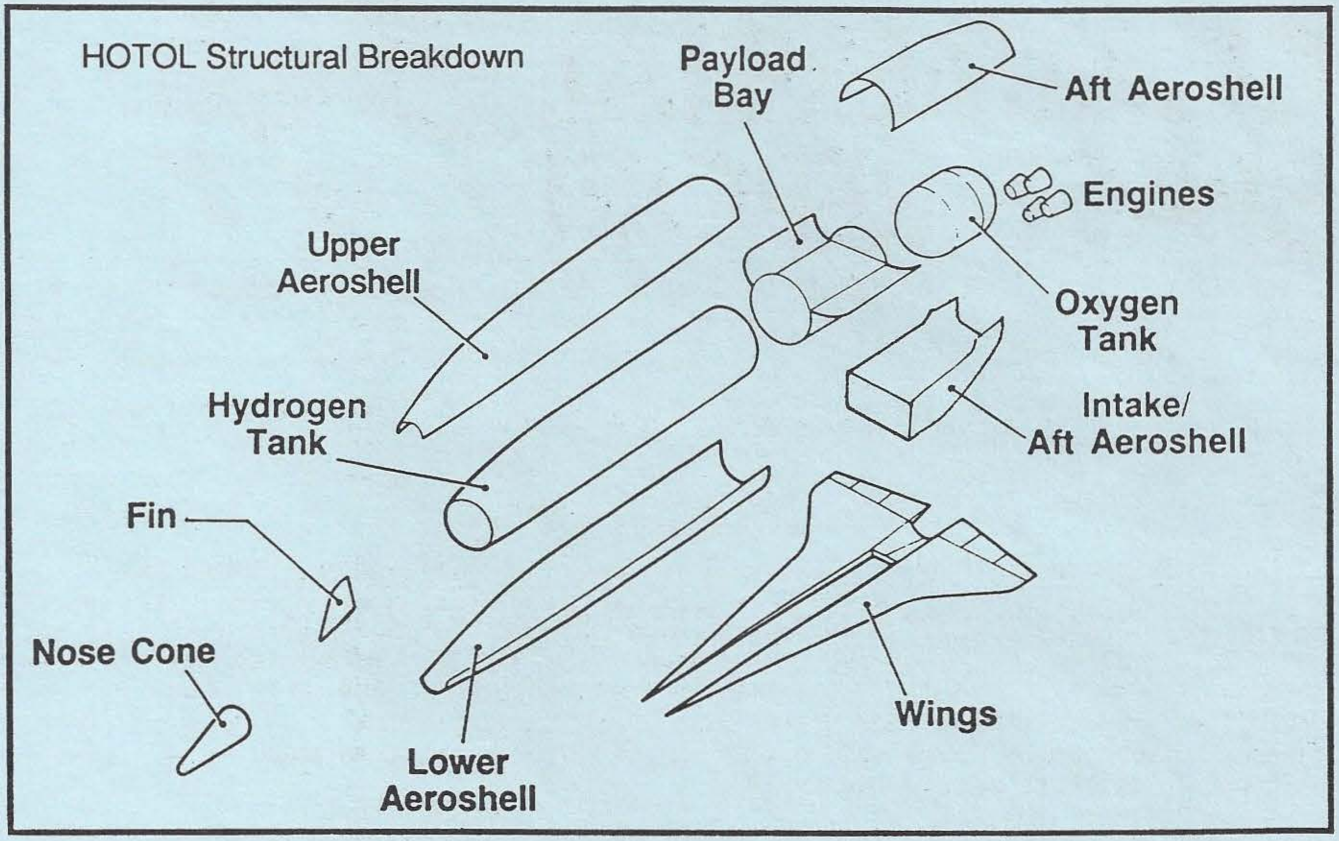
The British spaceplane is a single-stage-to-orbit vehicle, requiring no additional boosters. This sets it apart from the other European spaceplane concepts described in this series of articles--both the Hermes and Sanger vehicles would rely on auxiliary boosters to attain orbit (as does, incidentally, the U.S. Space Shuttle).

This remarkable performance depends on the successful development of advanced concepts in the fields of aerospace structures and propulsion systems.

Structure:

HOTOL's airframe would be constructed using advanced materials and techniques. Composites, for example, figure heavily in British Aerospace's proposed structure design. The liquid hydrogen tank (seen in the illustration on page 2), comprising most of the forward fuselage, would have no structural bracing but would be supported and held rigid by its own internal pressure (the propellant tanks of the U.S. Atlas/Centaur launch vehicle are constructed in much the same way).

Engineers hope to save development and operational costs on HOTOL's thermal protection system. HOTOL is designed to have low planform loading during reentry. This means that a low vehicle mass is spread over a large planform area (those lower surfaces of the wings and fuselage on which atmospheric reentry forces act). This results in lower reentry heating, and would allow a majority of HOTOL's thermal protection to



consist of high-temperature metals rather than thermal tiles of the type used on the U.S. Space Shuttle orbiter. Such metallic surfaces are considered cheaper to produce, easier to maintain, and more durable than tiles.

Propulsion:

HOTOL designers pinpoint the vehicle's propulsion system as the key to the feasibility of the HOTOL concept. During most of its flight, HOTOL would be propelled by rocket engines burning liquid hydrogen and liquid oxygen from propellant tanks on board. However, during the first portion of its flight, while still within the atmosphere, HOTOL will be able to use oxygen from the atmosphere to burn its hydrogen fuel. In theory, this will allow HOTOL to get by with less oxygen carried on board, resulting in a smaller LOX tank and less total on-board propellant weight during flight to orbit.

HOTOL's proprietary propulsion system, currently under development at Rolls-Royce, has been designated the RB 545 or "Swallow" engine. Unfortunately for those interested, the engine design is not only proprietary, but the patent has been classified by the British government for its military potential, and little has been released in the way of technical details.

Best bet is that the RB 545 is some form of Liquid Air Cycle Engine (LACE). In this type of engine, air entering the vehicle's inlets during flight through the atmosphere is condensed and liquefied. The liquid air is then directed to high-performance rocket engines to be combined with liquid hydrogen and burned, replacing or supplementing oxygen stored in the vehicle's on-board propellant tanks. As the spaceplane's velocity and altitude increase, the airbreathing elements are shut down, and the vehicle switches over to oxygen from its internal LOX tank. From then on, until orbital velocity is attained, the engines operate like any other rocket.

LACE systems have been extensively studied in the U.S. and elsewhere, with much work in the field taking place in the 1960s. In the basic LACE system, air entering forward inlets is slowed to subsonic speed and is cooled to cryogenic temperatures by liquid hydrogen propellant flowing through a heat exchanger. Then both the liquid air and the liquid hydrogen are pumped into the engines for combustion.

More advanced designs separate the liquid oxygen from the other components of air (primarily nitrogen). The oxygen goes to the engines, while the other gases are discarded overboard. These latter designs are called Air Collection and Enrichment Systems (ACES), and, while more complex, are more efficient than the basic LACE, which suffers performance losses due to the presence of inert gases in the combustion chamber. It is likely that the RB 545 is an ACES rather than a LACE.

It is not known whether the HOTOL vehicle design incorporates any other types of airbreathing engines such as scramjets, ramjets, normal turbojets, or even some hybrid combination of these. British Aerospace has displayed models of HOTOL at various aerospace exhibits, and the illustration on page 5 is closely based on a photograph of such a model. The illustration shows four rocket engines prominently mounted in the tail of the spaceplane, as one would expect on an ACES vehicle, along with smaller nozzles for orbital maneuvering system (OMS) engines. However, the illustration also depicts various other outlets at the back of the air intake assembly which would seem to indicate the presence of some form of additional airbreathing propulsion system. Admittedly, it could also indicate an attempt by HOTOL designers to throw nosy investigators off the track, but I don't think this is the case.

Without some form of low-speed airbreathing engine, HOTOL would have to reenter and land in an unpowered glide like the Space Shuttle, without go-around capabilities. Rocket engines, LACE or otherwise, are not suitable for circling around airports waiting to land. Although weight is critical in any single-stage-to-orbit launch system, it is unlikely that HOTOL's designers would go to the lengths that they have to make the spaceplane capable of takeoff and landing from standard runways without giving the vehicle the auxiliary propulsion necessary to do it easily and safely.

A typical HOTOL mission would go as follows:

HOTOL would take off from a runway 3000 meters (9,800 ft.) in length, with a takeoff roll of about 2,300 meters (7,500 ft.)--about the same as that of the Concorde. Ground acceleration would be about half a gee.

Originally, the HOTOL was designed to ride a trolley during its takeoff run, to save the on-board landing gear from having to carry the full takeoff weight (as was explained in the August, 1987 *C.S.R.*). Recently, though, HOTOL's developers have announced that it may be possible to design an undercarriage that is both strong enough to support the fully-fueled spaceplane, yet light enough to carry into orbit without a severe payload penalty. This would bring HOTOL into the realm of the true spaceship, free of all cumbersome auxiliary launch hardware, and requiring only propellant and a runway for launch.

Whether or not just any runway of sufficient length would suffice is unclear. If the electronic systems needed for HOTOL's automated operation require extensive ground installations above and beyond those navigation aids normally installed at major airports, then possibly only a few runways may be adapted to handle HOTOL operations.

When the takeoff velocity of 145 meters/sec. (324 mph) is reached, HOTOL would rotate to 24 degrees and begin its climb. The spaceplane would accelerate--using its airbreathing cycle--at an average of about 1.15 G, reaching 1,100 km/hr (680 mph) within 90 seconds. An altitude of 12 km (40,000 ft.) would be achieved within five minutes, and an altitude of 26 km (85,000 ft. or sixteen miles) within nine.

26 kilometers up, at a velocity of about Mach 5, HOTOL would shut down its air-breathing unit and switch to its on-board oxygen tank to operate as a pure rocket for the rest of the flight. Here also the spaceplane would cease to fly as an aircraft and enter a ballistic trajectory.

Orbital velocity would be achieved at an altitude of about 90 km. (56 miles). HOTOL would then coast to its orbital altitude of 300 km (186 miles), and circularize its orbit using its OMS rocket engines. Attitude control in space would be provided, as with most space vehicles, by a number of small auxiliary thrusters.

Mission duration would be limited to about 50 hours, partially because of the need to maintain hydrogen pressure inside the pressure-stabilized forward fuselage.

Reentry would begin with the firing of the OMS engines to deorbit the vehicle. HOTOL would reenter the atmosphere at a high angle of attack, about 80 degrees. The angle of attack would slowly flatten out as speed is reduced, leading into a hypersonic glide at an altitude of about 25 km (15.5 miles.) The spaceplane would have a significant cross-range, enhancing operational flexibility.

The approach and landing would be the same as for any aircraft. Initial approach angle would be 8 degrees, flaring out to 3 degrees at touchdown. Touchdown velocity would be 77 m/sec (172 mph). The landing roll, on a wet runway, would be about 1,500 meters (4,900 ft.)

Projected turnaround time for HOTOL is touted to be as short as 48 working hours--a figure based on low-maintenance heat shield materials and structure, simplified payload interfaces, airline-style checkout procedures, and HOTOL's single-stage-to-orbit design which needs no vehicle integration with auxiliary boosters or carrier vehicles. Some more conservative voices talk about turnaround times more along the lines of seven days, but this is still amazingly short when compared to existing launch systems.

Costs:

The HOTOL is advertised as having a total development cost of $12.1 billion, including an initial development cost of about $6.3 billion and total recurring costs (over a 20 year operational lifetime) of $5.8 billion. Recurring costs would, of course, be more if more vehicles were built.

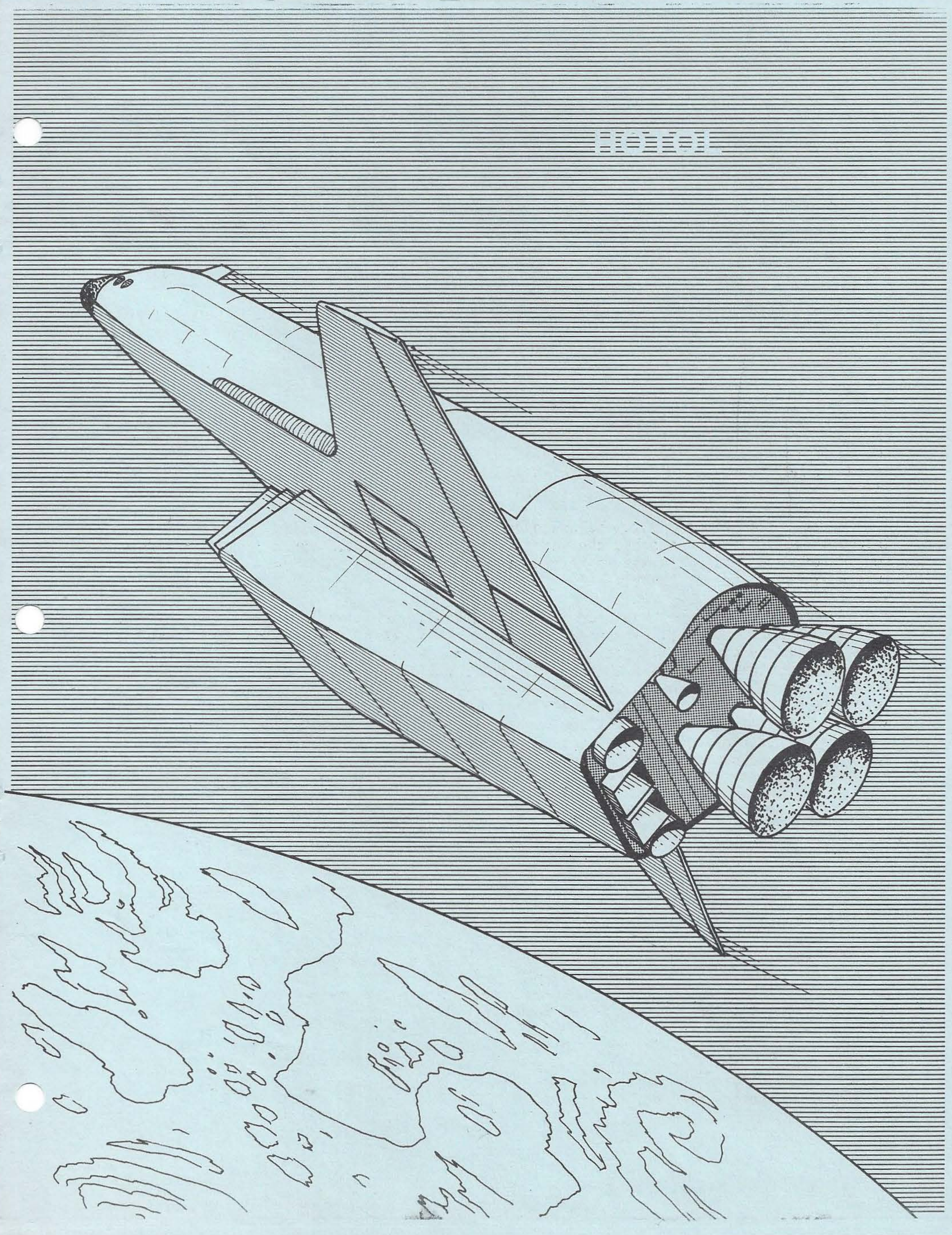
Launch fees are expected to be about $5 million/flight, based on operating costs per flight of about $1.1 million. This works out to about $625.00/kg or about $280/lb., an exceedingly low price compared with current launch prices, but such low operating costs and launch prices are typical of reusable, single-stage-to-orbit concepts.

Manned Operations:

The HOTOL is designed to operate unmanned, but a manned version could easily be developed. One vehicle out of a possible fleet of five or six HOTOLs would be dedicated to manned missions. This vehicle would be modified with additional safety, monitoring, power, and communications systems. The vehicle would also be subjected to more exacting and strenuous testing and quality control procedures.

The crew would be housed in a special pressurized capsule that would mount inside the HOTOL payload bay, situated between the hydrogen and oxygen tanks. Perhaps this capsule would include some form of ejection mechanism in case of emergency.

(TEXT CONTINUED ON PAGE 6)


HOTOL

Three basic types of manned mission are envisioned:

Personnel transport missions: Crewmembers would be ferried to and from orbital installations such as a permanently manned space station or a man-tended space platform. The spaceplane would maneuver into position to permit the docking of the crew capsule with the station or platform.

Sortie missions: Payloads would be carried in the crew capsule or next to it in the payload bay. Tests or experiments would be conducted in orbit, then the payload and crew would be returned to earth.

Servicing missions: Spacesuited crewmembers would leave the vehicle to repair or service orbiting satellites.

Two types of crew capsule would be developed for the manned HOTOL. One of these would be large enough to fill the whole payload bay, and would be used primarily for personnel transport missions. The other type of capsule would be smaller, filling only half the payload bay and containing fewer crewmembers. The other half would be dedicated to a cargo pallet, which could carry cargo, equipment, or experiments.

The term passenger may be more appropriate than crewmember for the people on board the HOTOL. HOTOL planners have given considerable thought as to whether or not personnel on board the spaceplane should have a role in actively piloting a spacecraft which is designed to operated reliably as an automatic system. A study was done, and the answer finally arrived at was "no." There are reasons for this:

First, as mentioned, HOTOL is designed to operate automatically, and prior to any inauguration of manned flights the vehicle should already have exhibited an extensive record of successful flights in this unmanned mode. Plugging a new piloting system into this is asking for trouble.

Second, as far as actual piloting goes, there is not a whole lot a pilot can do inside the HOTOL anyway. The crew capsule is stuck behind the hydrogen tank and in front of the oxygen tank--visibility is poor to non-existent. Any commands given would have to be filtered through a computer system anyway. Like the U.S. Space Shuttle, and a number of advanced fighter aircraft, an active on-board computer is essential to the operation of the HOTOL. As with these other vehicles, a total failure of the redundant computer systems while in flight would mean the certain, possibly even instantaneous, destruction of the spaceplane. It is worth noting that the U.S. Shuttle could easily be made fully capable of flying a mission unaided by human piloting, as are some passenger airliners. That this has not yet been done can probably be attributed more to the ego of the astronauts/pilots and the normal human distrust of computers than anything else.

Although a piloting role has been ruled out for HOTOL crewmembers, program officials feel that the crew should have an "executive role" in controlling the vehicle. This role involves making strategic mission decisions and leaving the computers to handle the piloting details, and is similar to the role that would be performed by ground control personnel in managing the normal unmanned HOTOL missions.

If this is not sufficient for the silk-scarf boys, perhaps the designers of HOTOL's manned capsules can include a dummy pilot's station with no real connection to the vehicle--similar to the toy steering wheels in the back seats of automobiles provided by thoughtful parents for their eager offspring.

Once manned HOTOL missions are routine, the possibility exists that the HOTOL could be used as an intercontinental passenger transport. Flying a suborbital trajectory, HOTOL could take up to 60 passengers from London, England to Sydney, Australia in 67 minutes--an impressive performance.

Unfortunately, HOTOL will probably not find much of a market for this capability, due to excessively high prices. The cost of flying HOTOL suborbitally between two points on the Earth's surface would not be all that much lower than the cost of flying to orbit. If this is the case, the fee per passenger could be as high as $5 million/60 or over $80,000 (current first class service between London and Sydney runs about $5,000). This is a lot of money just to get somewhere fast, and although some people may need such a service, there are not enough of them to make it pay.

The more likely use for HOTOL's intercontinental capability is to improve performance to orbit. A HOTOL, with its on-board payload, could fly a suborbital trajectory from an airport in London, for example, to an airport located close to the equator. There the spaceplane could be refueled, and launched into orbit. The equatorial launch would permit HOTOL to carry significantly more payload into space.

Developmental History:

The basic idea for HOTOL began at a meeting of the British Interplanetary Society in May of 1982, where participants were discussing the need of low cost space transportation. Engineer Alan Bond, who was in attendance, spent the next few months developing the basic idea for HOTOL's airbreathing propulsion system. The concept rattled around for a while, until it caught the interest of British Aerospace, which was exploring spaceplane ideas at the time.

In early 1986, a two-year, $4.5 million proof-of-concept study was funded, and is currently underway. Of this money, $2.1 million came from the British government, while the balance was put up by the two major study participants, British Aerospace and Rolls-Royce. The study is due to be completed in November of 1987.

If all goes well in November, then work will proceed on further concept definition. This will consist of a two-year airframe definition study, and studies on engine definition, development, and manufacturing, and the work will then proceed to prototyping and construction.

British HOTOL backers hope to sell both the British government and the European Space Agency (ESA) on HOTOL, so that development funding can be acquired from both sources. At this time, though, the spaceplane is running into snags on both fronts.

HOTOL is not receiving much support from the British government. Nor, for that matter, is any part of the civilian British space effort. In 1985, the British National Space Centre was formed to consolidate the British civilian space effort, and to develop a long-range plan for the British space program. It is the BNSC which is currently overseeing the HOTOL project on behalf of the government. Unfortunately for the BNSC (and HOTOL), the agency, like the National Aeronautics and Space Administration (NASA) in the United States, is a prime target for budget cutters. The British government has frozen the BNSC budget at its current level of about $190 million annually (the BNSC has been requesting an annual budget of at least $320 million).

The European Space Agency is also largely unenthusiastic about HOTOL. HOTOL is competing with other programs for ESA funds, such as the Ariane 5 expendable launch vehicle, the Hermes and Sanger spaceplanes, and the Columbus space station. The prime competition is with the Hermes/Ariane 5 launch system, which is presently enjoying the status of an approved ESA program. The French developers of the Hermes and the Ariane 5 see HOTOL as a long-term solution for low-cost space transportation and claim that their vehicles are needed now to fill the gap.

HOTOL backers claim that the best course of action would be to extend the operating lifetime of the current Ariane 4 booster. If a manned capability is needed in the short term, then it should be addressed by developing a low-cost, manned ballistic space capsule for the Ariane 4 until HOTOL or another more sophisticated spaceplane comes on line (British Aerospace is studying just such a space capsule design). The current Ariane 5 concept, no longer needed for manned operations in the near term, could be scrapped in favor of taking the time to develop a more advanced and powerful heavy-lift booster. Under this scenario, the Hermes would be unnecessary.

The ESA has tended to lean towards the French point of view. For one thing, the ESA is already well along on the development of the Hermes/Ariane 5 launch system, and would need to see a good reason why it should switch tracks now. In addition, the ESA is upset about Britain's negative attitude about space funding. An ESA meeting is scheduled for November 9, where it will be decided which European space projects will continue to be developed, and how much funding ESA members will devote to these projects. The U.K. has shown reluctance to support the present Ariane5/Hermes/Columbus ESA program--which the British government feels is an expensive and overambitious program (to be fair, the British are not alone among ESA members in this view). An unwillingness to contribute on the part of the U.K. has naturally resulted in the ESA taking a dim view of contributing to any British space projects in return.

If the British government and the ESA drop the HOTOL ball, British industry may have to look for funding alternatives. One such alternative would be to finish the project with private financing, if not from British sources, then from sources in the U.S., Japan, or elsewhere. The amount of investment is not small--$6.3 billion is not peanuts--but investments of such size have been made before (Boeing, along with its partners, plans on spending about $10 billion on the company's 7J7 aircraft project). Certainly developing HOTOL using private financing is more attractive from a free market viewpoint than relying on government funds, and it would help prove that space transportation need not be supported by the taxpayer.

But as things stand, it is more likely that British Aerospace and Rolls-Royce will not take the leap into the private sector, but will continue to seek out government funding in Britain or elsewhere (the companies have no doubt been casting an eye across the Atlantic at the multi-billion dollar U.S. National Aerospace Plane [NASP] program, and may hope to get a piece of the action). Industries which have spent much of their existence surviving on government contracts, or were in fact owned by the government, are not comfortable in the purely private sector (one might as well expect North American Rockwell to go out and build a low-cost launch system out of its own pocket). If government funds are not to be found, then the two British companies will most likely just drop the project.

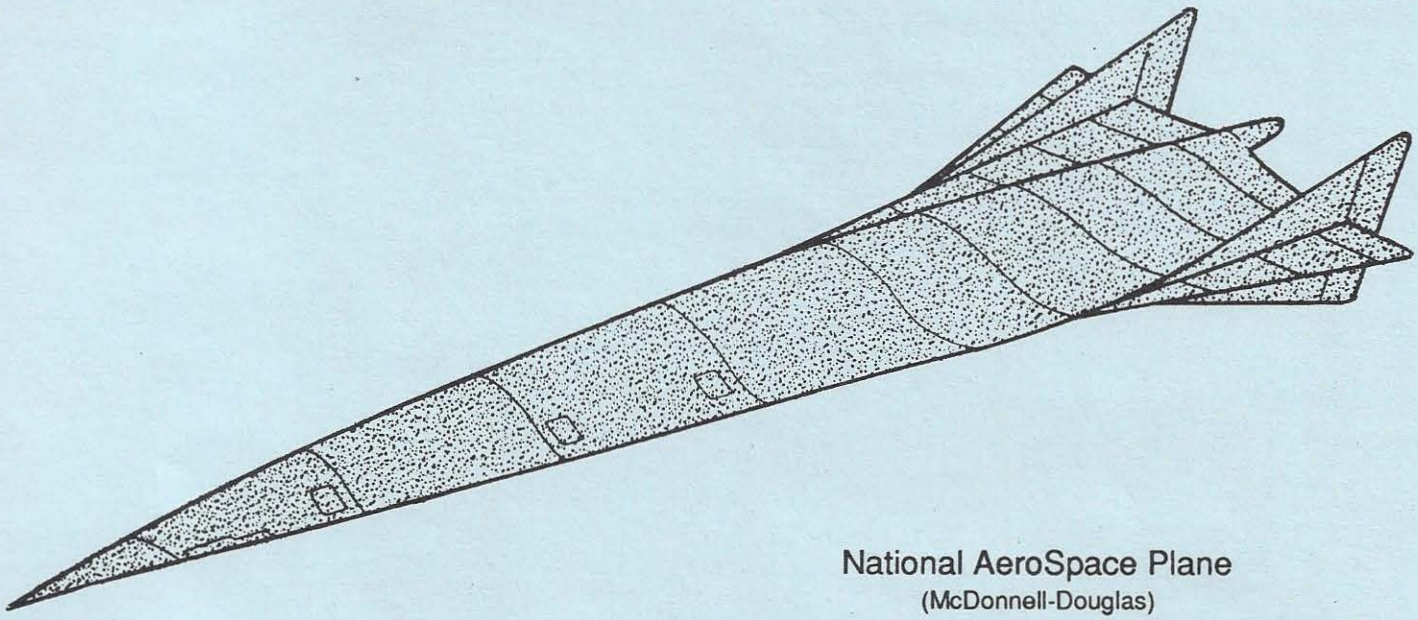
Alan Bond, the originator of the HOTOL engine concept, may not be willing to give up that easily. Bond owns the patent on which the RB 545 engine is based, and has only licensed it to Rolls-Royce. If British Aerospace and Rolls-Royce drop the HOTOL project, Bond has threatened to take his patent elsewhere, and he may find a warm reception in Europe, Japan, or the United States. Bond is not cowed by the fact that the British government has classified his patent, stating that he is willing to risk even jail to see a vehicle built around his ideas. I wish him success--there are too few such people in this business.

* * *

NASP Backing Away From Mach 25 Airbreathers

Good, old-fashioned rockets are beginning to make a comeback at the U.S. National Aerospace Plane project. Managers are beginning to lean away from airbreathing engines and back toward regular rocket engines for propulsion in the high Mach number regimes that the NASP would pass through on its way to space.

The NASP program has long advocated the use of airbreathing engine technology all the way up to Mach 25 and orbital velocity, with grudging acknowledgment that some rocket propulsion may be needed for orbital adjustments or the like. However, after a preliminary examination of the problems of a Mach 25 airbreather, the industry is coming around. As I have discussed in earlier issues, hypersonic airbreathing propulsion



National AeroSpace Plane
(McDonnell-Douglas)

is difficult to develop, and is increasingly so at high Mach numbers. The designers of other spaceplane concepts, such as HOTOL, or the German Sanger (*C.S.R.*, Aug. 1987) restrict the airbreathing portions of their flight regimes to Mach 6 or less, switching to rocket propulsion for the remainder of the flight to orbit. Even at these relatively low Mach numbers, there are considerable technological difficulties to overcome. Despite this, the NASP designers stubbornly insisted on using airbreathers all the way to orbit.

So dazzled was everyone with the high specific impulse numbers of the airbreathing engine, that no one noticed the disadvantages: immense airframe heat loads as the spaceplane plows through the atmosphere at Mach 25, the inability to accurately model the bizarre airflows at these speeds, the high cost of the liquid hydrogen which is gulped by airbreathers at a far faster rate per unit of thrust than in a rocket, the drag generated by even the most efficient air inlets, the inability to reach orbital speeds at an altitude high enough to keep your spaceplane from vaporizing as it slams through the air, and last but not least--the research and development cost and time required to solve these problems.

No one brought forward the advantages of a rocket engine: high thrust-to-weight, thrust independent of vehicle velocity, higher thrust as a function of engine cross-section and the resulting lower drag, the ability to operate in a vacuum, and the relative simplicity of design, development, and test.

For many airbreathing launch vehicle designs, it can be shown that similar designs are more effective using rocket propulsion alone. In these cases, if the weight of the airbreathing systems is removed, rocket engines added, and the extra hydrogen tankage is turned over to both hydrogen and oxygen, calculations result in improved performance despite the relatively low specific impulse early in the flight regime.

It is interesting that the more studies that are done on single-stage-to-orbit, the closer everyone gets to rockets as the propulsion system of choice. Now, NASP managers are claiming that they planned on using rocket propulsion all along. Right.

Keep this in mind: If you are looking for a way to push the frontiers of science and technology to its limits, for a long term research project that may one day yield new and undreamed of technologies, then perhaps research on a Mach 25 airbreathing NASP would be the way to go. Fine.

On the other hand, if you are not looking for a long-term research project, if you are looking for a method of bringing humanity into space cheaply, efficiently, and *soon,* then the NASP is emphatically *not* the solution, and those who try to sell it as such are worse than frauds.

NASP Contracts Awarded

At present, the following companies have received NASP contracts from NASA and the Department of Defense: Three out of five competitors--General Dynamics, McDonnell-Douglas, and Rockwell International--each received this month a 36-month, $25.5 million contract for vehicle technology development, involving airframe design and vehicle integration. These companies will move on to the next design phase (oddly, the losing competitors were Lockheed and Boeing, both companies with extensive airframe and aircraft experience. Go figure).

Contracts for NASP engine development were awarded earlier, and went to Rockwell's Rocketdyne division, and a team consisting of Pratt and Whitney and Marquart. The loser in this case was the team of General Electric and Aerojet.

* * *

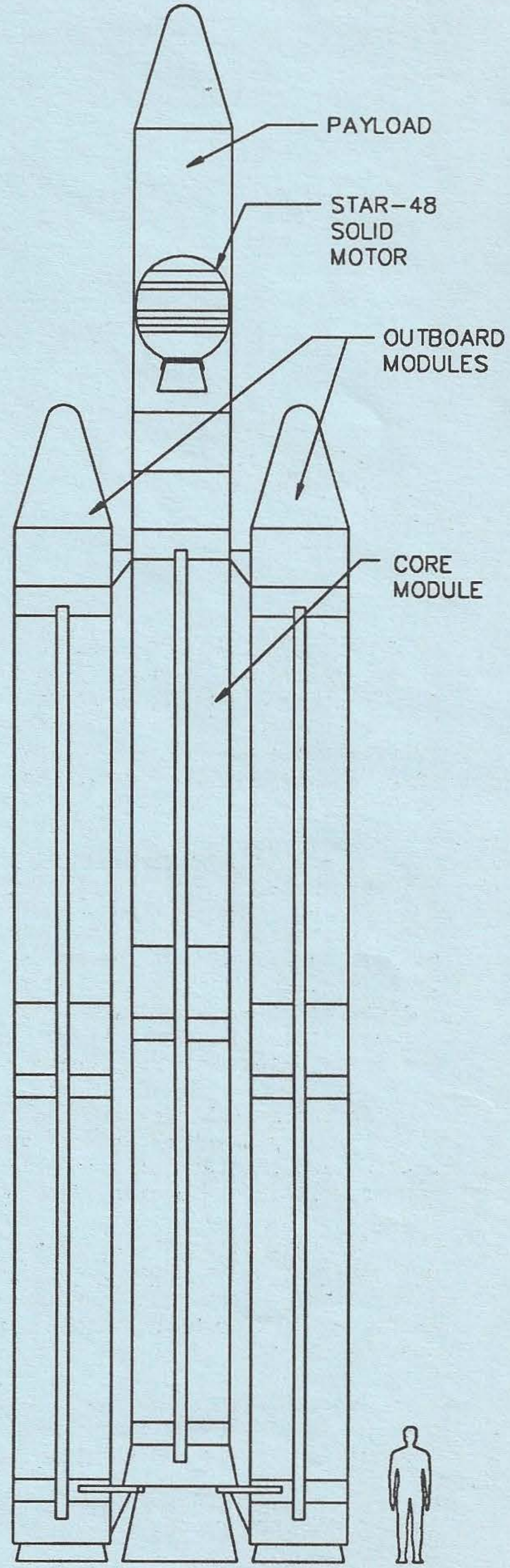
Update: American Rocket Company (AMROC)

AMROC Announces Another New Vehicle:

AMROC is pushing ahead with a new launch vehicle configuration, called "Slingshot", or the ILV-S. Slingshot is a small clustered hybrid, consisting of a central 51-inch module flanked by two similar outboard modules (see illustration at right). The two outboards form the first stage, while the central module forms the second stage. The third stage consists of a Morton Thiokol Star-48 solid rocket motor.

Slingshot's design payload is 750 lbs. into a 135-nautical-mile circular orbit at an inclination of 28.5 degrees, or 600 lbs. into a 135-nautical-mile circular polar orbit--roughly similar to the payload of a Scout booster.

Slingshot's first two hybrid stages were originally conceived as a high-performance sounding rocket, capable of boosting small payloads to velocities as high as 20,000 feet per second. AMROC realized that by adding an off-the-shelf spinning solid rocket motor, that they could convert this sounding rocket into one capable of delivering payloads to orbit.



ILV-S
"SLINGSHOT"

AMROC expects to charge about $5 million for a Slingshot launch (as a comparison, a typical Scout launch costs about $10 million). A considerable portion of Slingshot's launch fee will have to be applied towards the purchase of the Star-48 motor, which normally costs about $1.5 million. The first launch of a Slingshot vehicle is planned for sometime in 1989.

The Slingshot vehicle is an indication of AMROC's intent to back away from the ungainly ILV-1 design, which consists of twenty-two of the 51-inch modules along with their accompanying oxygen tanks. Slingshot, which can carry a paying cargo into orbit, yet is much smaller and easier to develop than the ILV-1, reflects a more conservative strategy on the part of AMROC, with a potentially greater chance of success.

AMROC To Loft SDIO Payloads:

The Strategic Defense Initiative Organization (SDIO) may fly experimental payloads on AMROC's first two suborbital test launches if current negotiations turn out well. The two launches are tentatively scheduled for February and April of 1988, and would take place at Vandenberg Air Force Base in California. If AMROC succeeds, SDIO would be the company's first paying customer.

The two sounding rockets would each consist of a single hybrid engine 51 inches in diameter, with a flight weight of 26,000 lbs. and a thrust at sea level of about 70,000 lbs. This engine is the module from which AMROC constructs its larger, clustered launch vehicles (the largest such vehicle, the 300-ton ILV-1, was depicted in the August, 1987 *C.S.R.*).

The first launch would carry a 220 lb. payload to an altitude of 100 nautical miles. The remainder of the payload capacity would be taken up by AMROC flight test instrumentation.

The second launch would carry a larger payload capable of observing the behavior of the launch vehicle's exhaust plume during the flight (the ability to analyze the characteristics of missile exhausts is an important factor in the development of Strategic Defense systems). AMROC claims that their hybrid motors, which operate by burning a solid, rubber-like fuel in combination with a flow of liquid oxygen from a propellant tank, would possess exhaust plume characteristics similar to those of a liquid-fueled rocket rather than those of a normal solid-fueled rocket. This is important to SDIO, since Soviet rockets are primarily liquid-fueled.

AMROC would gain more from this deal than a paying customer (it is reported that the SDIO is paying relatively little for the two launches). AMROC had long planned these suborbital flights as part of the company's test program for its commercial launch vehicles. During the process of negotiating with the government to use the Vandenberg launch site, though, AMROC ran into difficulty with the government's liability requirements for commercial launchers. Currently, government policy demands liability coverage to such an enormous extent that insurance premiums for launches such as AMROC's could exceed $500,000.

However, if AMROC can conduct these two test launches on behalf of the Department of Defense, then the company will fall under the liability umbrella of the government, and would no longer needs to purchase its own insurance. So, despite receiving only a small launch fee for its services, AMROC comes out ahead by avoiding a half-million in insurance premiums.

AMROC Engine Test Inconclusive:

On October 15th, AMROC conducted a static test of a full-scale hybrid engine module with less than satisfactory results. The 70,000 lb. thrust engine fired for five seconds, but had to be shut down. Problems included a strong, 5 Hz vibration--probably the result of combustion instabilities--and a burst propellant line.

These problems may push AMROC's two planned sounding rocket launches further into 1988 unless a quick fix for the engine's instabilities can be found during further tests. The test engine's fuel grain was contained in a steel casing. Flightweight engine casings will be constructed from filament-wound composites.

* * *

Note to subscribers

The bad news is that the *Commercial Space Report* is running even later than usual, finally forcing me into a solution I have been trying to avoid: the creation of one of those infamous Two-In-One Double-Sized Issues.

The good news is the reason: little Katiana Shenandoah Brosz arrived earlier than expected, checking in at 7 pounds, 13 ounces on October 3rd. Suffice it to say that disorganized is a mild term to describe the situation, but there are no complaints from this department.

This issue compresses September and October into one, and I am going to try to bring out the November issue as soon as possible. Since the renewal notices are computer-generated, and the computer (the fool!) thinks all these issues are a leisurely month apart, this is going to make the renewal notices a little erratic if you are up for renewal about now. Don't worry--although the computer generates the notices, I process the returns personally, and I will see that no one who renews after a reasonable amount of time will miss any issues. Thanks again for your patience.

Until next time,

The Commercial Space Report (C.S.R.) is published monthly, and endeavors to report and analyze developments in the field of private initiatives in space transportation and exploitation.

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