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AN OVERVIEW OF THE BRITISH AEROSPACE "HOTOL" TRANSATMOSPHERIC VEHICLE

J. Mesnard

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16. Abstract

The article describes British Aerospace's space-going aircraft and economical launcher "Hotol," so named for its horizontal take-off and landing ability. The craft uses Rolls Royce's new Swallow engine, the principle behind which is still secret, which burns atmospheric oxygen until it leaves the atmosphere and then switches to liquid oxygen. This lightens the craft's fuel load tremendously, so that it can carry significant payloads and still take off and land like a normal airplane. A typical future mission for the craft is described.

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AN OVERVIEW OF THE BRITISH AEROSPACE
"HOTOL" TRANSATMOSPHERIC VEHICLE

J. Mesnard

At the beginning of the year, the British National Space Center allocated three million pounds to cover the expenses of a feasibility study on "Hotol". In ten years, this could be the first unmanned space-going aircraft, capable of placing cargoes on the order of ten tons into low orbit. The operating principle of its propulsion is still secret, and another mystery remains: which partners will Great Britain choose? /34

The primary distinction of "Hotol" is its engine, the mysterious "Swallow," whose secret is jealously guarded by Rolls Royce. It concerns a hybrid motor with two operating modes: in high atmosphere (above 30 km, when the plane reaches orbit speed), it's a rocket engine operating with liquid hydrogen and liquid oxygen; but as soon as it reaches altitudes of dense atmosphere, it uses atmospheric oxygen instead of liquid oxygen.

One key element that eludes Rolls Royce at this point is the process which will permit a combustible cryogenic such as liquid hydrogen to react with atmospheric oxygen. Everything that is publically known can be summed up in one sentence: The trick is in "judicious use of turbo engines."

This key to the "Swallow" engine still exists only on paper--its validity remains to be proven. This is precisely the reason for the money allocated several weeks ago--England will not be able to keep this to herself for too long. She will have to choose her partners when proof of the possibility of "Hotol" has been presented. Will England turn to the United States or

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*Numbers in the margin indicate pagination in the foreign text.

adopt a European partner from among the ranks of the ESA (European Space Agency)? British officials are calling for a maximum delay of two years to make the decision, since 1988 is the year that the results of the study on the "Swallow" process should be finalized. They may have to arrange for their international support, without which "Hotol" will never see daylight, before that date, because if they keep Rolls Royce's secret for too long, they will risk losing the lead they now seem to hold.

Their potential partners, whether American or European, will refuse involvement without first having knowledge of the details of the engine which, otherwise, they will have to discover by themselves.

Light-weight launch trolley and landing gear

The advantage that "Hotol" will have over other satellite launchers in use at the end of the century will be its lightness. Unlike the engines used on "Hermes," on the American space shuttle, or still on "Ariane V," it will be relieved of a great part of the liquid oxygen reserves needed to reach orbit. This considerable savings in mass will make it possible, for the first time, to place objects in orbit without the use of non-recoverable boosters; this will allow a 100% reusable /35
machine to put masses of 7 to 11 tons into orbit.

In particular, this lightness will allow take-off similar to that of an airplane. British Aerospace desires to draw the greatest possible profit from this savings in mass made possible by the "Swallow" process, thereby achieving a launcher which is much cheaper than its competitors (a ratio of 1 to 5 is discussed for launching costs at equal mass). British Aerospace engineers have therefore chosen to launch "Hotol" on an ordinary, albeit rather long, runway (hence the acronym HOTOL--Horizontal Take-off and Landing). It will not use conventional landing gear, which would have to be very strong and therefore heavy due to the significant mass at take-off, but rather a trolley similar to the type used in 1954 on the "Baroudeur" SE 5000's.

Thus relieved of a significant amount of weight, "Hotol" is further equipped with tricycle-type landing gear, much lighter, which allows it to land on a runway upon its return, when its weight will be a fifth of what it was at take-off.

Description of a Mission

Let's imagine that we are at the beginning of the third millennium . The "Hotol" had its first flights in 1996 and is now in service. Starting at this point, a mission can be described.

Although it could carry passengers if necessary, or a technical team which would not be involved in piloting, the space-going aircraft is principally designed for entirely automatic missions with no men aboard.

"Hotol," ready for take-off, rests in its trolley at the end of a long runway (3000 m) used regularly by standard planes. Its mass is approximately 200 t. About 60% of the volume of its fuselage (62 m long) is occupied by a reservoir containing 48 tons of liquid hydrogen, behind which is the cargo compartment, then a reservoir containing only 108 tons of liquid hydrogen (a conventional engine requires 348 tons).

The fuselage, whose section is circular and whose last two thirds are cylindrical, has a maximum diameter of 5.7 m. It is attached to low-set wings with a span of only 20 m, whose geometry resembles that of the "Concorde." For stabilization, it has three small surfaces at the front which allow it to adjust its trajectory during the aerodynamic phases of the flight.

The engine is started. The "Hotol" advances on the runway, carried by its laser-guided trolley. Acceleration stabilizes at 0.56 g. After 2300 m the monster reaches its take-off speed of 150 m/s and rises out of its trolley, which is braked immediately by parachute and will also be reused.

At take-off, the vertical acceleration component is 1.15 g. The space-going aircraft progressively gains altitude on a trajectory 24° above horizontal. Two minutes after take-off it reaches Mach 1 and continues to climb, swallowing atmospheric oxygen and spitting out a cloud of water vapor. Four minutes and 30 seconds after the brakes were released, "Hotol" is at an altitude of 12,000 m. Four-and-a-half minutes later, it is at 26,000 m, flying at Mach 5. The air becomes less and less dense; the engine is going to change its operating mode. The air intake closes, and the liquid oxygen in the reservoir at the back of the fuselage passes into the engine chambers. The engine functions from this point on like that of a typical launcher.

At an altitude of 90 km, "Hotol" reaches orbit velocity. The engine stops. A small auxiliary rocket engine allows maneuvering in orbit. "Hotol" can reach an altitude of 300 km to put a seven-ton payload into orbit, or it can place an even greater mass in a lower orbit.

Its mission lasts 50 hours, during which time it is guided constantly by a planetary navigation system using stations on the ground and aboard satellites. When the mission is completed, the OMS (Orbital Maneuvering System) makes the craft redescend into an orbit with a perigee at an altitude of 70 k.

When it enters the very high atmosphere, "Hotol's" angle of incidence is very steep, on the order of 80°. For this reason, only the lower surfaces have a special thermal protection coating. The rest of the fuselage is constructed essentially of titanium. Gradually, the angle of incidence decreases, and the hypersonic reentry flight begins at an altitude of approximately 25 km.

The airplane's aerodynamic efficiency for the moment is on the order of 4.5. It continues to decelerate and descend. Kepler's law would tend to make it accelerate, but the burning touch of the atmosphere slows it more and more. At certain points on the nosecone and on the leading edge of the wing, the temperature reaches 1400°C. This is low compared to the shuttles.

The Mach number has now fallen below 1, and the angle of incidence continues to decrease. "Hotol" has become a simple airplane again. Its aerodynamic efficiency is 6.5--not a glider, but almost! Its trajectory is 16° above horizontal. The angle of incidence ceases to decrease, the speed stabilizes, the walls cool. "Hotol" approaches the beginning of the runway with the precision as if there were a pilot aboard, and even better. The landing gear appears. The craft touches ground at 170 knots (88 m/s); it rolls 1800 m and stops. Maybe it will even return to the parking lot by itself...