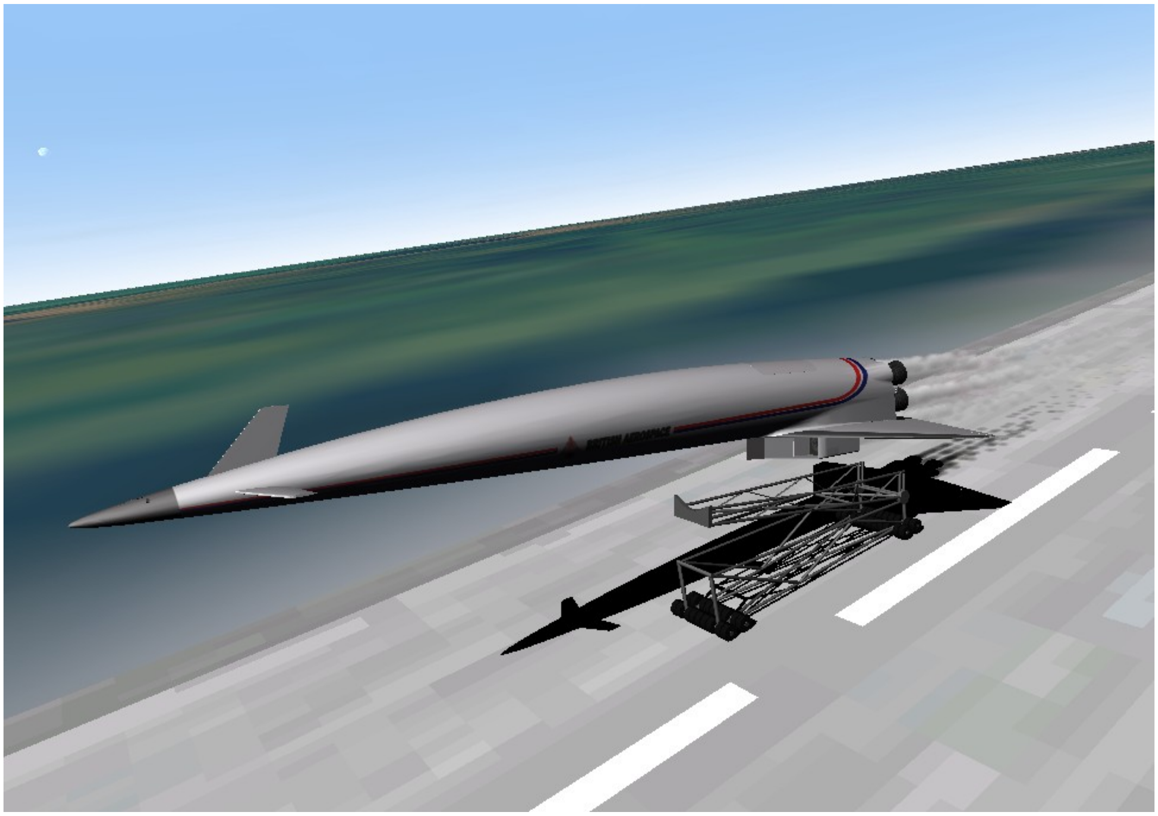
HOTOL with Interim HOTOL — Version 1.03



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Thanks to:
Hendo and Daver and erv, for the CVE-Lite code on which this is based.

And, above all, many thanks go to Martin Schweiger, for actually developing the simulator I used to daydream about in astrodynamics classes!

http://www.orbitersim.com

Unpacking:

Use Winzip to put each subfolder in its matching Orbiter folder.

Kev33's An-225 (not included) is required to run the test drop scenarios. An-225 is located at http://www.orbithangar.com/advsearch.cfm?search=name&text=An-225

Kev33's An-225 does not function properly in Orbiter 2010. I have re-compiled it for Orbiter 2010 and included the .dll in the /Modules folder. I have NOT included the source (though it is available on request), as I'm hoping Kev33 will release his own improved version at some point.

In any case, it will be necessary to install this add-on AFTER installing the An-225, to avoid over-writing the older An225.dll.

You will need to have a runway at Baikonur to properly use this add-on; the stock Orbiter install doesn't come with one. Use the aftermarket Baikonur of your choice.

Or you can change the following lines (between BEGIN_OBJECTLIST and END_OBJECTLIST) to your Baikonur.CFG: (Courtesy Kev33's K-Baikonur)

```
BEGIN_OBJECTLIST
LPAD2
      POS 0 0 0
      SCALE 0 0 0
      TEX Lpad02
      NAV 127.10
END
RUNWAY
    END1 -820 0 1600
    END2 -820 0 -3400
    WIDTH 100
    ILS1 132.6
    ILS2 132.6
    RWTEX Runway2
    NRWSEG 9
    RWSEG1 1 0.018 0.25 0.5 1 0.875
    RWSEG2 1 0.088 0 0.25 0.5 0
    RWSEG3 1 0.018 0.25 0.5 0.75 0.625
    RWSEG4 1 0.088 0 0.25 0.5 0
    RWSEG5 5 0.576 0 0.25 1 0.5
    RWSEG6 1 0.088 0 0.25 0.5 0
    RWSEG7 1 0.02 0.25 0.5 0.625 0.75
    RWSEG8 1 0.088 0 0.25 0 0.5
    RWSEG9 1 0.02 0.25 0.5 0.875 1
END
RUNWAYLIGHTS
    END1 -820 0 1600
    END2 -820 0 -3400
    WIDTH 100
    PAPI 20.0 3.0 -500
    VASI 1.5 152 671
END
END_OBJECTLIST
```

Introduction:

Welcome to the HOTOL add-on! This add-on models two significantly different unmanned reusable launchers with similar names: the HOTOL partially-airbreathing trolley-launched spacecraft, and the pure-rocket air-launched follow-on, Interim HOTOL. While they share a name, a logo, and a wing design, the two are dissimilar in operation.

HOTOL stands for, simply, HOrizontal TakeOff and Landing, which were unusual enough features when studies began in the early 1980's. HOTOL was studied intently by a group within British Aerospace from the early to late 1980's.

Like the U.S. X-30 to which it is sometimes compared, the HOTOL was a single-stage-to-orbit runway-launched vehicle which used airbreathing engines on the ascent. Unlike X-30, the HOTOL's airbreathing engines were used for only a portion of the ascent, rocket power taking over entirely from about Mach 5. This simpler system freed HOTOL from the need to develop complex scramjets and the super-lightweight thermal protection (and active cooling) required to take advantage of them. To reduce landing gear mass, HOTOL used a launch trolley. HOTOL was conceived as a purely unmanned launcher, though humans could presumably be carried in the payload bay.

It ended badly, as all British launcher projects tend to do. Government money was not forthcoming, and there was no chance of it being done any other way. Just to make certain there was no private or multinational development, the British government went to the trouble of classifying HOTOL's RB-545 engine details; even today, accurate details on this engine are hard to come by.

Interest briefly resurged in 1990 when studies on an "Interim HOTOL" were performed; by skipping the complex airbreathing engine and using an Antonov An-225 Mriya shuttle-carrier for a launch platform, a workable rocket-only assisted-SSTO vehicle might be built for significantly less money. That money was not forthcoming, either.

HOTOL eventually morphed into SKYLON, on which low-level component work continues today, but without any chance of completion in the near future.

HOTOL Operation:

Two HOTOL missions are provided: a due-east launch of a satellite, and a more complex rendezvous with the ISS. A logistics module with docking adapter is in the cargo bay.

Happily, the autopilot included with the HOTOL add-on works from runway to orbit, so you may want to hit "O" and watch it do its thing a few times before trying it yourself.

Alternatively, throttle up. Scenarios that begin on the launch trolley also begin with some nose-up trim, saving you the trouble. This should allow a nice, smooth rotation at about 180 m/s. Continue a shallow climb, about 15-20 degrees.

The HOTOL propulsion system consists of four main engines and an airbreathing component which is driven off the turbopumps of the rocket engines and functions from zero to Mach 6.5, below about 32 km altitude (above which, there's not enough air to drive the system). This is modeled in Orbiter as the four rocket engines with rocket-like fuel burn rates, plus additional "free" thrust in the form of air augmentation. It's necessary to stay low enough to make use of the air augmentation, but high enough that air drag doesn't penalize you unnecessarily. (Rough rule of thumb: if the re-entry flames are on during ascent, you're too low for your current airspeed). A shallow climb to cross Mach 6.5 at 32 km, after which a pullup to continue to space on rocket power, is the ideal. Do not stay in the thicker air unnecessarily, as you're still spending fuel at a goodly rate. Climb on rocket power (above Mach 6.5) requires finesse, as you can't descend too low, but the low power of the rocket engines means you can't climb too steeply, either. Obtain a happy medium level, climbing as increased speed permits. This desired climb rate will increase as you burn off fuel and accelerate.

The inlet ramps are animated according to your speed. When the inlets are fully closed, you've exceeded Mach 6.5 and are on pure rocket power. The airbreathing engines are shut down permanently at this point; they are not usable after re-entry! Late in the ascent, the two upper engines will be permanently shut down to keep from exceeding 3.0 G's.

Whether flying the autopilot or hand-flying, expect to be deposited in an orbit with the perigee, at burnout, still within the atmosphere at 80-100 km altitude. You'll need an apogee burn to stay up for multiple orbits.

The main fuel tank also runs the RCS and will be required for on-orbit maneuvers and the de-orbit burn. Save some!

HOTOL Keys:

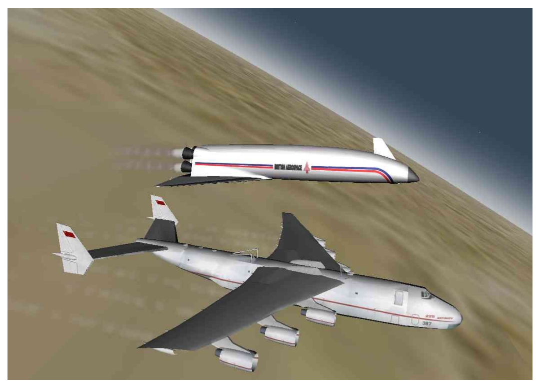
O – Autopilot toggle on/off
J – Jettisons the launch trolley or payload

K – Open/close the payload bay door
G – Lower/raise the landing gear
B – Toggles the wheel brakes
U – Enter a new launch azimuth

Use the on-board propulsion system to de-orbit. The HOTOL aerodynamics are very similar to those of the shuttle. Start your descent about 160 degrees out from your intended landing point.

Re-enter and land as though you were flying the Space Shuttle. Set yourself up for a glidepath of about 20 degrees. Aim a kilometer or so short of the runway, and "pre-flare" a kilometer from that, aiming for the start of the runway. Drop the gear a kilometer out, and grease that pig on! You'll need about 110 m/s over the threshold to maintain a good pitch rate, but you can hold the nose off and touch down more slowly – 90 m/s or so.

If you abort a HOTOL take-off and return to the runway, you'll find it necessary to burn off most of the fuel before attempting a landing. Not only would a higher landing weight collapse the gear (though this is not modeled for Orbiter), but the higher weight will mean higher approach speeds, without sufficient pitch authority to flare for touchdown. The resulting crash is sure to be spectacular.



Interim HOTOL Operation:

Two sets of Interim HOTOL scenarios are provided: probe launch and ISS logistics missions, each starting from the runway or already in the air.

The Interim HOTOL is a joint UK-Russian venture, so it flies from Baikonur.

Keys and operation of the Interim HOTOL are exactly the same as HOTOL, above. However, operation is different. Instead of climbing from the launch trolley, you'll fly the An-225 to 10 km or so. Initiate a pitch-up to 40 degrees or so, then begin pitching DOWN. In this way, you'll ensure that the An-225 does not climb into the Interim HOTOL upon release.

After separating from the An-225 (CTL-J), you won't want to stay in the atmosphere; you'll want to get out of it as quickly as practical. Climb out at 30-35 degrees, but be prepared to push back over quickly; the Interim HOTOL has a lot more thrust, and burns through its fuel, MUCH faster than the airbreathing HOTOL. You'll want to return to level flight after about 120 seconds or so, by which time you'll already be at 90 km altitude for burnout.

Unlike the airbreathing HOTOL, which shut down engines to stay below 3.0 G's, Interim HOTOL throttles to stay below 5.5 G's. The faster acceleration makes things happen much more rapidly.

The autopilot ("O" key) can be actuated after separation, and will take the vehicle to orbit. It will not attempt to maintain a specific launch azimuth, but will retain the one at separation, so proper steering of the An-225 is critical.

Orbital operations, de-orbit, and landing are very similar to the HOTOL.

Known issues:

Gross and dry weight of the HOTOL do not match up with figures published on astronautix.com. The astronautix figures appear to describe an X-30-like vehicle more than they do HOTOL. I would up with a higher gross weight AND a lower dry weight than astronautix describes. I lowered the dry weight a bit more still to permit missions to the ISS. Given that HOTOL was marginal just to make orbit in the first place, this is probably unrealistic. I've also granted the airbreathing phase greater efficiency than is probably warranted.

Some sources on the net describe the RB-545 as a Liquid Air Cycle Engine (LACE), collecting LOX from the atmosphere in flight and storing it in the tanks. This is incorrect; the RB-545 could not do this. It doesn't do so in this simulation, either.

No drawings or artwork of a launch trolley exists, save for a 1982 painting of a very different configuration which wouldn't fit on the version here. The launch trolley modeled here is designed by the authors.

HOTOL studies discussed missions to the ISS (then called Space Station Freedom), but not in any detail. Exact design and features of the logistics module are by the add-on authors, not the HOTOL design team.

Interim HOTOL numbers match exactly those given on Astronautix and elsewhere, but one feature which makes little sense is the choice four RD-0120's on the back end of the craft. These are vastly overpowered for the task; half the thrust would do as well, and of course save on mass as well. Interim HOTOL was a design in flux all the time, but any source that describes it insists it had four RD-0120's, so I've remained faithful to this.

Bibliography:

Web:
The indispensable Astronautix: http://www.astronautix.com/lvs/hotol.htm

Other media:
Some guy used to make a resin model of the HOTOL:
http://sputnik.freehomepage.com/Models/HOTOL.html

Version history:

v1.03
Re-compiled for Orbiter 2010.
Kev33's An-225 re-compiled for Orbiter 2010. Source available on request.
Comments removed; trolley arm remains rotated after separation.
Fixed a bug that would rotate the payload instead under some circumstances.

v1.02
Updated for Orbiter 06 Patch 1; had to comment out lines that rotated the trolley arm after separation

v1.01
Updated for Orbiter 060504.

v1.0
First release

v0.91
Added Interim HOTOL
Changed HOTOL mass, aero properties

v0.9
First beta release.