Launch to Intercept Orbiting Target

Parameters: HAB fuel load @ MES = 25000 kg
intercept target's orbital altitude = 315 km
HAB intended orbital altitude = 350 km (so we end up above the target)

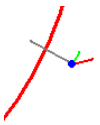
Abreviations: MES = main engine start
MECO = main engine cut-off
SRBI = solid rocket booster ignition
MET = mission elapsed time
Qmax = point of maximum dynamic atmospheric pressure
indicated by top readout in second display box on orbit software

Plan: The spacecraft is vulnerable to re-entry in the case of engine failure until orbital Vtan is reached. Launch to orbit profile is designed to minimize the time taken to reach ref Vo orbital speed. Initial vertical launch takes the spacecraft out of the thick part of the atmosphere as rapidly as possible to minimize fuel use and time to reach orbital speed. Roll to ccw prog orientation is initiated at a point such that when ccw prog orientation is reached, the spacecraft has the necessary vertical velocity to coast up to the desired orbital altitude while the engines are used only to accelerate the spacecraft to the necessary Vtan as rapidly as possible. If the procedure is followed, the spacecraft should reach the desired maximum orbital altitude (Vcen = 0) at the same time as Vtan reached the required value to maintain a circular orbit at that altitude. This minimizes the time taken to circularize the orbit after final MECO. With the correct angular separation from the target at liftoff, the spacecraft should reach the top of its orbit and complete circularization just as the target pulls along side.

Procedure

Start ORBIT5tm.exe
Press "x"
Press "r" to load "OCESS".
Press "l" (lower case "L") to display target data rather than reference ('r' notations disappear in target data box)

MET	Conditions	Actions
-0:30:00		Pilot: cen=HAB; (press "tab" to get to "center" then press "L") targ=earth; (press "tab" to get to "target" then press "3") ref=earth; (press "tab" to get to "target" then press "3") NAVmode=deprt ref ("F5") press "t" and <space> to lock view center targ = ISS (press "tab" to get to "target" then press "s")
-0:10:00		Use "{" or "}" to offload or load fuel to get a fuel load of 26000 kg Press the same key ("{" or "}") to stop the process.
-0:01:50	θHRT = 20°	press "Z" & select "launch1" (to redraw track, press "z")
-0:00:30		Pilot: throttle to 70% (press "PgDn" until at 70%)
-0:00:20		confirm engine acceleration >10.00 m/s^2
-0:00:02	θHRT = 12.92°	press "w" for SRB ignition
0:00:00	θHRT = 12.76°	confirm acceleration > 53.9 m/s^2 (accel increases at constant engine setting as fuel mass drops)
0:00:02		Pilot: sets NAVmode = MAN (press F1) targ = Earth (tab to "target" and press "3")
0:00:17	Qmax Vcen > 480 m/s	Pilot increases throttle to 90% ("PgDn" until at 90%) confirm accel > 56.9 m/s^2
0:00:31	alt = 13.00 km Vcen > 740 m/s	Pilot initiates 2°/s ccw roll (press "Home" 4 times)

0:1:17	oriented ccw prog Vcen > 1640 m/s Vtan > 1520 m/s alt > 70.00 km apoapsis > 215 km	When the green arrow is parallel to the earth's surface and perpendicular to the grey vector (θ Pch = 90°), stop the roll maneuver by going to ccw prog Press F2 
0:01:32	alt = 100.00 km Vcen > 1550 m/s Vtan > 2550 m/s	Confirm atmospheric drag < 0.001 m/s^2
0:02:01	alt = 140.00 km Vcen > 1300 m/s Vtan > 4000 m/s apoapsis > 280 km	Confirm SRB shutdown confirm accel > 13.1 m/s^2
0:06:06	apoapsis = 348 km alt > 320 km Vcen = 280 m/s Vtan > 7200 m/s	MECO (critical that this happens at apoapsis = 348 km) Vcen will reach zero at the top of the orbit (apoapsis). Since it is important that Vtan equal ref Vo at the top of the orbit, the engines must be fired to accelerate the spacecraft so Vtan = ref Vo starting just before the top of the orbit, when Vcen is approx. 40 m/s
0:09:10	Vcen = 40 m/s Vtan > 7150 m/s alt = 348 km	Main engines to 100% thrust Monitor Vtan
0:09:51	Vtan = ref Vo Vcen = 0 m/s alt = 350 km	MECO Evaluate Vcen and Vtan
0:10:15		If Vcen and Vtan have large variances from target values: 1) correct Vtan using main engines at small throttle settings 2) set NAV mode to deprt ref and adjust Vcen to zero 3) set NAV mode to ccw prog and reset Vtan to ref Vo If Vcen and Vtan variances are small: 1) use RCS thrusters to correct each velocity
0:11:15		Confirm orbit cicularization at near 350 km (± 20 km)
0:12:00		Confirm distance, direction, and relative speed for target 1) Set targ = desired target 2) Note direction vector to target 3) Note Vcen, Vtan, velocity vector to target 4) Note distance to target
0:12:30		Plan approach to dock with target.

Extension Activity: can orbit be attained after loss of an engine?

Repeat the process and simulate a loss of engine by reducing engine percent to 67% between T=0:02:00 and T=0:06:00.

1) Can you attain orbit with a loss of an engine at any point between 2 and 6 minutes after launch?

a) can stable orbit be attained with 1 engine malfunction or two engine malfunctions?

b) which is more of a problem, an early or late malfunction?

c) what are the options if attaining orbit is not possible?

i) hold a nose up attitude to maintain climb rate - what will this do to total fuel used?

ii) dump fuel - what effect might this have on the mission?

- what might you have to do before departing from orbit?

2) If orbit cannot be achieved, an abort must be made.

What should you do before attempting a landing?

Practice AYSE docking.
Mission 2012/2013 launch to deploy Jupiter Orbiting Space Telescope (JOST).
The AYSE drive unit is in a relatively circular orbit at an altitude of 567 km.

There are 7 mission situation files that can be accessed for this training.

1) m2012xz: pre-launch from OCESS.
2) m2012ya: launched from OCESS @ ~8 km alt.
3) m2012yb: on station about 60 km from AYSE
4) m2012yc: lining up with AYSE docking port
5) m2012yd: lined up with AYSE docking port, but not properly oriented.
6) m2012ye: lined up with AYSE docking port and in correct alignment
   some minor line-up adjustment to perform with position control thrusters
7) m2012yf: in position for AYSE docking.

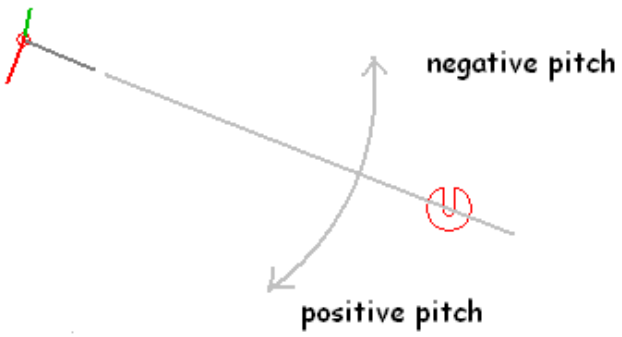
Pre Launch

1) Set ref=earth and targ=AYSE
2) Set NAVmode = Dept. ref
3) Dump HAB fuel is needed to 20500 kg
4) a) At θHrt = 11.5° and dropping: set engine % to generate 9.0 m/s^2 acceleration
   b) At θHrt = 11.0° and dropping: ignite SRBs and set engine % to 70%
   c) Set NAV mode to MAN
5) When maximum air drag is reached, increase engine % to 90%
6) At 15 km altitude initiate 2.0°/s ccw roll
   This is 2 km higher than usual, but the AYSE is at a greater than usual altitude.
7) At pitch angle of 90° stop the roll and select NAV mode = ccw prog
8) Continue 90% engine output after SRB separation
9) When apoapsis projection reaches 510 km, stop main engines.
10) When nearing apoapsis and Vcen is approx. 50 m/s
    a) set engines to 90%
11) a) Main engine cutoff when Vtan = ref Vo
    b) Circularize orbit.
12 You should not be at about the position in m2012yb

Line up with AYSE drive unit

The goal of this procedure is to get the HAB to pass in front of the AYSE docking port

1) a) Set NAV mode = app targ
   b) Set targ = AYSE
   c) Set ref=earth
   d) NAVmode = MAN
   e) if pitch angle is not displayed, press 'p' (will see θ Pch)
   f) if target data is not displayed (you are seeing a bunch of "R" after data) press 'l'
2) a) center on AYSE and zoom in to see the docking port.
   the docking port is on the left side of AYSE
   from the point of view of the HAB
   this is the "negative" direction
   (right is the positive direction



3) a) zoom out
   b) rotate the HAB until θ Pch is approximately -5
   c) apply 10% thrust until Acc reads 0.1 to 0.2
   d) stop thrust
   e) rotate HAB to a θ Pch of approximately -90
   f) press 'p' to display velocity vector angle to target
   g) if θ Vtg is positive, apply engine thrust of +10 % until θ Vtg is approx -5.0
   h) if θ Vtg is negative, apply engine thrust of -10% until θ Vtg is approx -5.0
4) When the HAB is almost lined up (looks like m2012yc):
   a) select NAV mode = retr Vtrg
   b) when re-orientation is complete, select NAV mode = MAN
   c) apply positive engine thrust to slow the space craft gradually to come to a stop lined up with the docking port
      when done, the red and grey vector lines both point down the center of the docking port
5) a) When lined up (looks like m2012yd), select NAV mode = app targ
   b) When re-oriented, select NAV mode = MAN
      The green, red, and grey vector arrows should no point down the docking port.
      You should be very slowly drifting towards the HAB, if not, use forward RCS thruster
6) Use RCS thrusters to shift the HAB sideways until both docking lights show green.
   Remember to use opposite thrust to zero out the Vtan when you are properly aligned.
7) Use forward RCS thruster to induce a Vcen of about -1.0
8) As the spacecraft will drift sideways, you must continue to use side-to-side RCS thrusters to keep Vtan close to zero.
   If a docking light changes to yellow, use RCS thrusters to push HAB towards opposite side.
9) When end of docking port turns green, use reverse RCS thruster to bring Vcen to zero.
   If the green indicator goes back to red, reverse slightly until it turns green again and stop motion.
10) You are now in position and can initiate a docking.