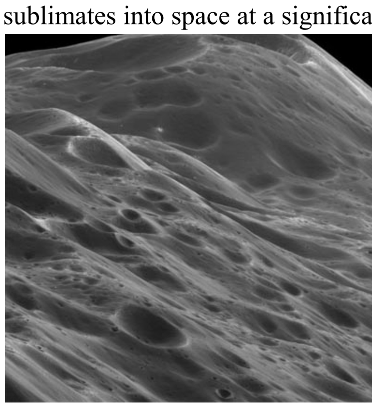
OCESS 2009 Mission Iapetus

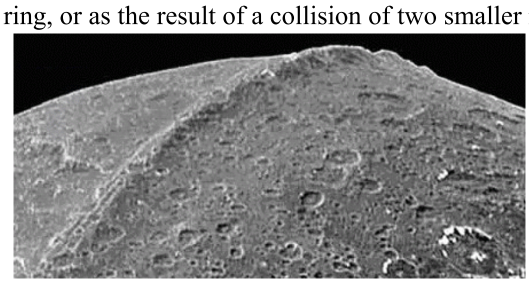
Mission Goals

The Cassini-Huygens mission to the Saturn system has produced a wealth of information on this mini solar system. It has concentrated its research efforts on Saturn itself, the rings and the contribution of the nearby moons to their growth, the weather, land forms, and chemistry of Titan (including the data collected from the Huygens lander), and more recently an investigation the moon Enceladus. Much less attention has been paid to the most distant of the larger moons: Iapetus. One close fly-by has occurred, but no more are planned. The orbit of Iapetus is greatly tilted, so close encounters with the Cassini probe are difficult to arrange. Iapetus demonstrates some fascinating features that merit closer attention. The OCESS 2009 mission will visit Iapetus and investigate some of these features:

1) The moon has a mean radius of almost 800 km yet it its density is only slightly greater than that of water; it is thought to be comprised of 80% water with some rocky material and organic compounds
   - could Iapetus be a large comet captured by Saturn?
2) The surface is intensely cratered, suggesting great age, but the features are quite smooth when viewed at close range suggesting that the surface material sublimates into space at a significant rate.

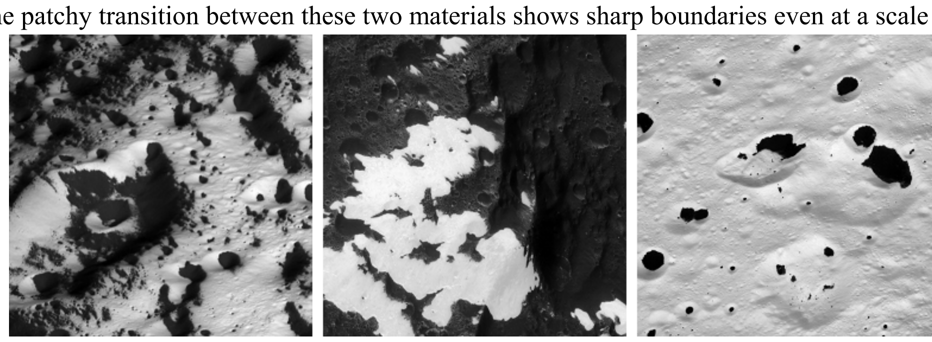


3) An enormous ridge that circles the moon's equator (up to 20 km relief)
   - the ridge may have been formed by flexing of the moon as it passes edge-on to the rings, by the up-welling of material from a molten core early in the history of the moon, by a rapid rotation early in the moon's history, by a collapsed ring, or as the result of a collision of two smaller moons to form Iapetus

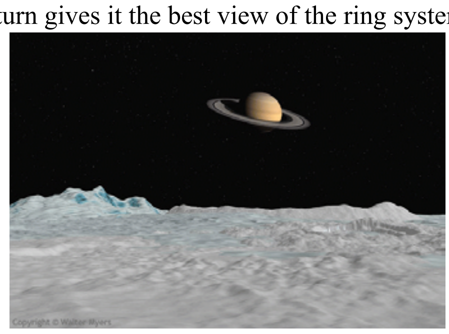


4) There are two distinct regions on the moon: a region of light-coloured material and a region of dark coloured material

   - the patchy transition between these two materials shows sharp boundaries even at a scale of 30 metres



   - the dark material is thought to be composed of complex organic chemicals
5) The moon may have a liquid core due to gravitational forces set up as the moon orbits Saturn
6) The moon may contribute material to Saturn's ring system
7) Iapetus' tilted orbit around Saturn gives it the best view of the ring system of any of the moons



   - this would be useful as a base of observation to monitor changes to the ring system over time

<u>Mission Iapetus 2009 Experiments</u>

1) Survey the equatorial ridge
   a) RADAR survey
   b) direct sampling: surface sampling
      core sampling

2) Seismic survey of interior structure within the moon
   a) distinguish between mechanisms for the formation of the equatorial ridge
   b) determine if the moon has a liquid core

3) Seismic monitoring
   a) determine if there is seismic activity on Iapetus due either to gravitational forces or internal heating

4) Search for evidence of out-gassing
   a) search for plumes and vents
   b) collect gas samples near the surface
      - towed aerogel on close-approach orbit (20 km altitude periapsis)
      - ionizing gas collector
      - reactive contaminant release

5) Collect and analyze composition of surface material
   a) spatial patterns in light and dark material
   b) composition of light and dark material
      i) mass spectrometry analysis for differences in isotopic composition of the two materials and two regions
      ii) mass spectrometry analysis for molecular composition
      iii) laser-induced breakdown spectroscopy
      vi) qualitative and semi-quantitative analytical chemistry to identify organic compounds and their precursors
         - nitrates, ammonia, amino acids, simple sugars, lipids
         - pH, oxygen levels, salt content
   c) compare to Saturn ring material and known comet samples from previous missions

6) Collect samples of ring material during approach to Iapetus after Saturn aerobraking maneuver

7) Parallax measurements on nearby stars to plan for missions outside the solar system
   a) set up parallax telescope
   b) co-ordinate measurements with OCESS parallax telescope on earth

8) Infrared telescope. To detect faint, cold objects and radiation, an infrared telescope, such as the Spitzer telescope must be kept very cold. If not, the signal that the light sensitive electronics pick up would be swamped by infrared radiation from the telescope itself. Telescopes in Earth orbit use liquid Helium to cool the electronic sensors to achieve the required sensitivity to infrared radiation. A location such as Iapetus is a useful place to set up such a telescope because the low ambient temperature obviates the need for the liquid Helium refrigerant and provides a more stable platform for long-period observations as the orbital speed of Iapetus is much less than that of a satellite in low-Earth orbit. This location also is relatively free of local heat sources compared to the environment of low-Earth orbit. The telescope would have to be constructed or partially constructed prior to the mission then set up and tested after arrival at Iapetus. The purpose of the telescope would be:
   - imaging and mapping Oort cloud objects
   - searching for Kuiper belt objects
   - mapping patterns in cosmic background radiation
   - searching and direct imaging of extra solar planets

9) Cosmic ray exposure dating of the moon's surface.
Cosmic radiation produces changes to the structure and composition of materials at a surface that is exposed to space.
Samples would be collected for analysis on earth.
This analysis could help answer th question of whether the surface of Iapetus is relatively old young and would help to understand the rate at which material sublimates off the surface.

10) Launching a unpowered space probe to help investigate velocity anomalies encountered for several deep space probes including pioneer 10 and 11, NEAR Shoemaker, and Rosetta. The launch of a thermally equilibrated probe on a precise path could help identify possible unknown gravitational forces that may be responsible for the velocity anomalies reported for the probes listed above.

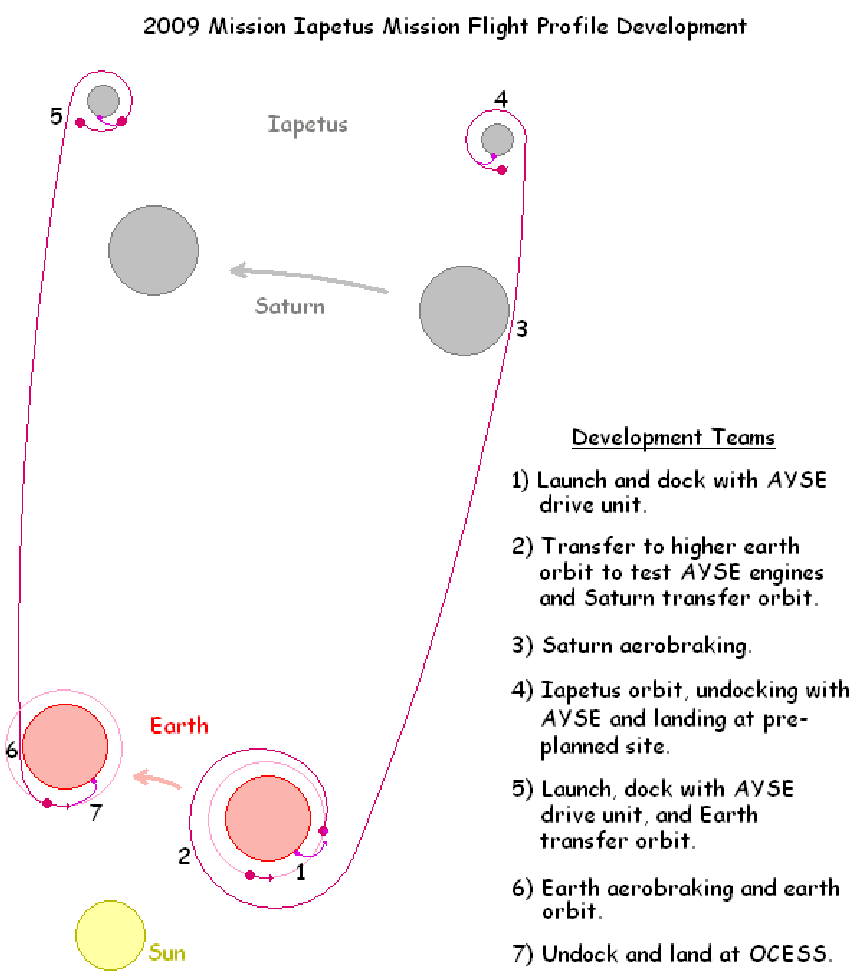
Mission Profile Development Procedures

The 2009 mission to Iapetus will involve a direct, high-speed, continuous thrust transfer orbit from earth orbit to Saturn. The AYSE drive unit will be used to attain the necessary acceleration and power for the required magnetic shielding from solar and cosmic radiation during the outbound and inbound legs of the voyage. Cosmic radiation exposure will be greater while on the surface of Iapetus as the AYSE drive unit will be left in orbit, but no significant harm is anticipated given the duration of surface operations. Application of main engine thrust past the half-way point of each transfer orbit will result in a significantly shorter-duration transfer orbit with, both from a greater maximum speed and a reduced fuel load. Aerobraking at Saturn will slow the spacecraft to a speed suitable for approach to Iapetus orbit. Aerobraking through Earth's atmosphere will accomplish a similar task on the return leg.

It may be possible to realize an additional time savings through reduced fuel load by refueling at Saturn for the return voyage.

Aerobraking at Saturn, in addition to the normal significant dangers inherent in this procedure, poses the added risk of having to pass close to the inner edge of the ring system.

Success of the mission depends on careful and detail planning of each stage of the mission profile. The initial stage of this process is to develop a plan for each phase of the mission. The OCESS membership has been divided up into planning teams, each of which is responsible for a specific phase of the flight plan.



If you do not know of which team you are a part, please email Dr. Magwood or the OCESS chief pilot. Each space sim member, except the chief pilot, should be part of one of the mission profile development teams.

All Teams

All teams should:

- Read section 1.5.1 from the OCESS procedures manual.
  (covers motion in space, motion in orbit, and the ORBIT5S controls and display)

- Document each step in their part of the mission profile.
  Once each team is satisfied that they have worked out a good mission profile, they should, as a team, run through the profile and write out each step that is taken and when (time, distance from target or reference) it is taken.
  Mission profiles will be recorded on the ORBIT5Sm mission control software by the development team and the OCESS pilots once the development process has been completed by all the teams.

- Work out and document steps that might be taken in the event of major failures in critical parts of the mission profile.

- When each team has written up a mission profile, please give it to the chief pilot. She will set up a time to go over it with your team in the Sim office.

Team 1) Launch and dock with AYSE drive unit.

I) Launch safely to an orbit 25 km lower than the AYSE drive unit and 25 km behind it.
II) Dock with AYSE drive unit.

I) Launch to Orbit.

1) Start ORBIT5S and press ‘***r***’ to reload file ‘team1’ then quit the program (‘***q***’ and enter ‘***y***’ at prompt).
   Start ORBIT5SD and read off the altitude of the AYSE drive unit then quit the program (***Esc***)
   (exit the program when you are done)
2) Start ORBIT5SE and hot start the engine systems (choose ‘***h***’, ***Enter***, and ***Enter*** for the three prompts).
   Turn on switches: ***1,2,s,f,g,h,i,j,k,l,m***
   Turn on switch ***c*** (antigravity system)
   Turn on switch ***y*** (antigrav readout shows green background)
   Turning on switch ***y*** limits antigravity system to g loads greater than 5 g (this saves power)
3) Start ORBIT5S (leave ORBIT5SE running in the background).
4) press ‘***r***’ and reload the file “team1”
5) Follow procedures in section 1.5.2 of the OCESS procedures manual (page 10).
6) Practice Launching to an orbit of the correct altitude (25 km less than the AYSE drive).
   Write down each action that you take and when you take it such as:
   - engine settings and fuel loads
   - at what altitudes you pitch over and how many degrees each time
   Reload “team1” each time you try another launch, but if you are using the SRBs, you must wait until they stop or you will instantly launch when you restart.

If you are going to use the solid rocket boosters (SRBs) follow this procedure.
a) increase engine thrust until the engine acceleration shows just under 10.00
   (just less than you need to lift off)
b) quit ORBIT5S
c) Click on the ORBIT5SE window if it is not active.
d) Press ‘Z’ to start the solid rocket boosters.
e) Restart ORBIT5S and choose ‘y’ at the starting prompt.
f) When the SRBs start and the spacecraft lifts off, increase engine thrust to desired level.

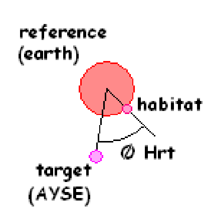
Record the fuel used in your first launch with a full fuel load. Multiply this by an appropriate safety factor (multiply by 2 or 3, your choice).
Reload ‘team1’, Quit ORBIT5S.
Press ‘***3***’ on the ORBIT5SE software to dump all the fuel except the amount you calculated above.
Restart ORBIT5S. Press ‘***y***’ at the starting prompt.
Continue the launch procedure as before.
Document how much fuel was used with the lower fuel load and how much more acceleration the main engines can deliver.

When you have completed this section, you should have a set of launch procedures that you follow each time that you launch. If you follow these procedures each time with the same starting fuel load, you should follow exactly the same path each time.

Any time that you need to make an adjustment to the engineering software, quit the ORBIT5S program. Once the adjustments are made, restart the ORBIT5S program and press ‘**y**’ and **Enter** at the opening prompt.

Procedure for determining the correct location of the AYSE drive unit at launch so that the two spacecraft are close together at the end of the habitat launch procedure:

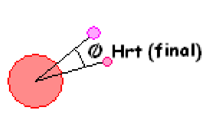
7) Find the correct angular separation from the AYSE drive unit on launch so that it is in the correct position (25 km above and ahead when you circularize your orbit).
   Launch when the AYSE drive unit is behind you (coming towards you).
   The θHrt readout is critical to your launch. It is the angle between you and the target.
   a) Select ***reference*** as ***Earth***.
   b) Select ***target*** as ***AYSE***.



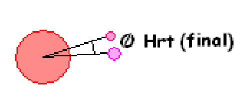
   c) Record the θHrt when you launch.
   d) Record the θHrt when you circularize your orbit.

   c) and d) can be used to find the correct θHrt for launch.

i) If you are too far behind the target at the top of your launch, add the final θHrt to the launch θHrt.



ii) If you are ahead of the target at the top of your launch, subtract the final θHrt from the launch θHrt.



II) Rendezvous with AYSE drive unit.
1) Read section 1.5.3 (pages 11 to 14) in the OCESS procedures manual.
2) When maneuvering towards the AYSE drive unit, follow the procedures in section 1.5.4.2
Note, that we want to limit the use of large engine thrust levels aimed at the AYSE drive.
Follow these procedures until within 2 km of the AYSE drive.
Your speed should be less than 2 m/s at this point.
Coast from this point until at the correct distance within the AYSE drive.
3) Press Alt and Enter to minimize the ORBIT5S software.
4) Use the ORBIT5SE software to dock the HAB to the AYSE drive unit.
Follow procedures on page 29 (section 1.6.5.6).

Team 2) Transfer Orbit to Saturn.

I) Test AYSE engines by using them to increase orbit altitude to 500 km and re-circularize.
II) Enter transfer orbit to Saturn.
- your goal is to: bring the HAB to a distance of 5 000 000 km from Saturn
have the HAB aimed at the centre of Saturn
have the HAB at an appropriate speed (see below for a list of end speeds)

We do not know yet, what speed will be appropriate.
Therefore, you should develop several different transfer orbit profiles with different end speeds:
1 000 000 m/s
500 000 m/s
350 000 m/s
250 000 m/s
100 000 m/s

Remember that your mission profiles should document each action that you take.

1) Read section 1.5.3, 1.5.4, and 1.5.5
2) Start ORBIT5S software.
3) Press “r” to load the file “team2”
4) Quit the flight software.
5) Start ORBIT5SE in the same directory.
Hot start the engine systems (choose ‘***h***’, ***Enter***, and ***Enter*** for the three prompts).
Dock the AYSE drive (press **F12**, ***Enter***, ***F12***).
Turn on switches ***F1*** and ***F2*** to link the HAB and AYSE electrical systems.
Transfer fuel to the HAB if needed
(if you need to abandon the AYSE drive during the mission, you will want to have a good fuel supply)
Turn on switch ***c*** (antigravity system)
Turn on switches ***a*** and ***b*** to start the magnetic shields. Press **+** to until the field strength is 30%.
Turn on switches ***F6***, ***F7***, ***F8***, ***F9***, and ***F10***
6) Restart the Orbit 5S software.
7) Press “***y***” at the initial prompt to restart where you left off in step 4.

I) Increase Orbit to 500 km.
1) a) Follow procedure 1.5.3.1 (page 11).
b) Save the situation at the start of the next step as ‘team2a’ so you don’t have to repeat these steps.

II) Saturn Transfer Orbit.
1) Follow procedures 1.5.4.2, 1.5.5.2, and 1.5.5.3
2) Quit ORBIT5S periodically to check the fuel supply and AYSE reactor temperature.
If the fuel supply gets too low or the temperature too high, you are using too much power.
Type ‘***y***’ and ***Enter*** at the starting prompt when you restart ORBIT5S.
3) At the end of each trial, press ‘***r***’ to reload “team2a” to try another process or a different end speed.

Your goal is to minimize fuel use and time spent during the transfer orbit for each end speed.
Slower speeds reduce fuel use for propulsion, but increase fuel use for radiation shields. We will need to look at what radiation shield settings are needed, but longer exposures probably require higher shield settings.

Team 3) Saturn Aerobraking

1) Read sections 1.5.4.2 and 1.5.6

Remember that we are not trying to slow down enough to get in to orbit around Saturn. We are slowing down enough to reach Iapetus which is several million kilometres on the other side of Saturn. Your test of success is that after aerobraking the spacecraft “rises” away from Saturn towards Iapetus at a speed that will allow it to reach the orbit or Iapetus with minimal engine use.

There are five starting situation files: team3a, team3b, team3c, team3d, and team3e
Each of these situation files starts you a little less than 5 million kilometres from Saturn, aimed right at the center of Saturn, but with five different speeds (as described in the section for team 2). You will have to determine how much aerobraking can accomplish without excessive acceleration (we don’t want the astronauts to be crushed).

Keep in mind that the engines cannot be used during aerobraking and the spacecraft must be kept in the correct orientation.

Remember that your mission profiles should document each action that you take.

2) Start ORBIT5S software.
3) Press “***r***” to load the file “team3a”
4) Quit the orbit software.
5) Start ORBIT5SE in the same directory.
Hot start the engine systems (choose ‘***h***’, ***Enter***, and ***Enter*** for the three prompts).
Dock the AYSE drive (press **F12**, ***Enter***, ***F12***).
Turn on switches ***F1*** and ***F2*** to link the HAB and AYSE electrical systems.
Transfer fuel to the HAB if needed
(if you need to abandon the AYSE drive during the mission, you will want to have a good fuel supply)
Turn on switch ***c*** (antigravity system)
Turn on switches ***a*** and ***b*** to start the magnetic shields. Press + to until the field strength is at least 30%.
Turn on switches ***F6***, ***F7***, ***F8***, ***F9***, and ***F10***
6) Restart the Orbit 5S software.
7) Press “***y***” at the initial prompt to restart where you left off in step 4.

8) Adjust the velocity of the orbit so that you pass to the right of Saturn (as if you were entering a prograde orbit).
- Choose NAVmode ***ccw prog***
- Set a low engine thrust percentage
- Repeatedly press ‘***o***’ to monitor the periapsis (minimum altitude) of your orbit past Saturn.
- Your goal is to pass between 100 and 500 km above the “surface” of Saturn.

Choose a periapsis within this range and see what happens.

9) Choose NAVmode ***retr Vtrg*** and set 0% engine thrust.
This setting aims the spacecraft in the direction opposite to the direction it is travelling.
This orients the heat and radiation shield so that it protects the spacecraft during aerobraking.

There are two criteria to satisfy in this maneuver:
You must pass close enough to slow down sufficiently, but not too close that you slow down too much.
If aerobraking acceleration is too high, you will overtax the antigravity system and the astronauts will die.

10) As you coast towards Saturn, keep checking your periapsis (press ‘***o***’ or ‘***n***’)
It will shift back and forth slightly, this is normal and need not be corrected.
If it stays too high or too low, re-orient the spacecraft and use engine thrust to correct it.
This involves pushing directly to the left or right of your path.
Always return to NAVmode ***retr Vtrg***. You must be in this mode when aerobraking starts.

11) After aerobraking is complete and you are through the atmosphere, monitor the path of the spacecraft.
It should continue away from Saturn at a speed larger than ***ref Vo*** towards Iapetus.
The goal is that it should easily reach the orbit of Iapetus without falling back towards Saturn and without the need for engine thrust to speed it up or slow it down too much. You may have to alter the transfer orbit to Iapetus sideways to intersect it, but that is the job of team 4.

If you do not slow down enough, reload “team3a” and try a lower periapsis.
If you slow down too much, reload “team3a” and try a higher periapsis.
If you cannot slow down enough without excessive acceleration, reload one of the other situation files to try a slower starting speed.

What is excessive acceleration?

Hab alone ('***y***' on, engines off, mag shield off): 220 m/s^2 sustained (300 m/s^2 safe peak for 15 s)
AYSE ('***y***' on, engines off, mag shield off): 4600 m/s^2 sustained (7500 m/s^2 safe peak for 15 s)
AYSE ('***y***' on, engines off, mag shield 100%): 4000 m/s^2 sustained (6500 m/s^2 safe peak for 15 s)

If excessive acceleration is encountered, the maximum current from the reactors will be exceeded and reactor damage will result. The anti-gravity system does not have a maximum output. The alternative to reactor damage due to excessive current to the anti-gravity system in a high acceleration situation, is the loss of the crew; the mission cannot be completed without the crew. The shorter the duration, the higher the maximum acceleration that can be counteracted, because the reactor takes time to overheat.

In situation files 'team3b' to 'team3e' with slower starting speeds, orbit projection may not reach Saturn. If so, coast towards Saturn until it does, then adjust the orbit to pass to the right of Saturn as was done when starting with 'team3a.' Alternatively, you can adjust the orbit so that Vtan is a few thousand m/s on the assumption that you will need to have this much sideways speed when the correct orbit has been set up.

Team 4) Landing on Iapetus

1) Read sections 1.5.5 to 1.5.8

Remember that your mission profiles should document each action that you take.

2) Start ORBIT5S software.
3) Press '***r***' to load the file "team4"
4) Press to quit the orbit software.
5) Start ORBIT5SE in the same directory.
   Hot start the engine systems (choose '***h***', ***Enter***, and ***Enter*** for the three prompts).
   Dock the AYSE drive (press **F12**, ***Enter***, ***F12***).
   Turn on switches ***F1*** and ***F2*** to link the HAB and AYSE electrical systems.
   Transfer fuel to the HAB if needed
   (if you need to abandon the AYSE drive during the mission, you will want to have a good fuel supply)
   Turn on switch ***c*** (antigravity system)
   Turn on switches ***a*** and ***b*** to start the magnetic shields. Press + to until the field strength is at least 30%.
   Turn on switches ***F6***, ***F7***, ***F8***, ***F9***, and ***F10***
6) Restart ORBIT5S and type '***y***' at the starting prompt to restart where you left off.
7) Coast towards Iapetus until you are close enough to check your periapsis with orbit projection ('***o***').

8) Adjust the velocity of the orbit so that you pass to the right of Iapetus (you are entering a prograde orbit).
   - Choose NAVmode ***ccw prog***
   - Set a low engine thrust percentage
   - Repeatedly press '***o***' to monitor the periapsis (minimum altitude) of your orbit past Saturn.
   - Your goal is to pass between 100 km above the surface.

9) Choose NAVmode ***retr Vtrg*** and set 0% engine thrust.
   This setting aims the spacecraft in the direction opposite to the direction it is traveling.
10) Monitor the Acc value.
11) When the Acc gets to about 20, start engines to slow down.
    Continue to press '***o***' to monitor the orbital approach.
    - if the periapsis drops below 100, choose manual orientation and rotate away from the planet to raise the periapsis
12) Continue using engines until the orbital track makes a pronounced curl around Iapetus.
    At this point, stop engines.
13) When you reach periapsis (Vcen will be nearly zero):
    - choose ***ccw retro*** orientation
    - fire engines until Vtan equals ***ref Vo***
    - circularize your orbit
14) When you are certain that your orbit is stable and circular, undock from the AYSE drive (sect. 1.5.8)
15) When you have achieved sufficient separation for AYSE, recircularize your orbit.
    Save your situation as 'team4a'
16) Select ***module*** as your target; this is your landing site.
    Follow the procedures in section 1.5.7
    Remember that Iapetus has no atmosphere to slow you down, but it has a very small gravity as well.

Chose Iapetus as your reference and module as your target.
Pick a reasonable θHrt to start your de-orbit engine burn.
After landing, look at the θHrt again. Follow step 7 from team 1's instructions to modify your de-orbit procedure. Reload 'team4a' and try your modified de-orbit θHrt.

Team 5) Iapetus Departure

Lift-off from Iapetus, dock with AYSE drive, initiate return orbit to Earth
You are carrying out much the same job as teams 1 and 2 with the following differences.
A) You will load file 'team6'
B) You do not have solid rocket boosters (if you do use them, you will end up somewhere near Pluto).
C) The gravity on Iapetus is very low, so spacecraft weight is not an issue and engine thrust levels can be quite low.
D) The goal is to get to within 1,000,000 km from earth, going directly towards the center of earth, with a speed of 100,000 m/s towards earth.
E) Be careful not to hit any of Saturn's other moons as you start the transfer orbit to Earth.

Team 6) Aerobraking around Earth

You are carrying out the same process as team 3 with the following differences.
A) You will load file 'team6'
B) If you find that you cannot slow down enough without excessive acceleration through the atmosphere, you must use your engines to slow down before entering Earth's atmosphere (use ***retr Vtarg*** orientation)
C) Your goal is to end up with a highly elliptical orbit after leaving the atmosphere (your apoapsis should be more than 10,000 km). This means that it will take many hours to complete an orbit and re-enter the atmosphere. This is important because engine failure is possible during aerobraking. We need time to fix any breakdowns before the orbit is complete.

Team 7) Earth Arrival

Achieve a stable orbit around Earth, undock with AYSE, and land at OCESS launch pad.
You will start out just as does team 4, but you will reload file 'team7'
Follow steps 1 to 6 from team 4's instructions the proceed as follows:
7) Test engine systems.
8) Choose ***ccw retro*** orientation and fire engines until apoapsis is 400 km.
9) Coast up to apoapsis and circularize your orbit. (Step 13 from team 4).
10) Undock with AYSE.
   a) When you are certain that your orbit is stable and circular, follows steps in sect. 1.5.8
   b) When you have achieved sufficient separation for AYSE, recircularize your orbit.
   c) Save your situation as 'team7a'
11) Initiate landing at the correct point to end up at OCESS
   Select ***OCESS*** as your target; this is your landing site.
   Follow the procedures in section 1.5.7

   Pick a reasonable θHrt to start your de-orbit engine burn.
   After landing, look at the θHrt again.
   Follow step 7 from team 1's instructions to modify your de-orbit procedure.
   Reload 'team7a' and try your modified de-orbit θHrt.

Remember that you do have an atmosphere on earth and a significant gravity.
   Use of a parachute is sensible.
   Exit ORBIT5S at the appropriate moment
      atmospheric acceleration without the parachute should be less than 100.00
   Press '***Y***' in ORBIT5SE, restart ORBIT5S, and type '***y***' at the starting prompt.

Software Bug List
- fuel load changes unpredictably when ORBIT5S or ORBIT5SE are loaded or new situation files are loaded
- simulator fuel leak settings do not appear to alter fuel supply
- malfunctions to internal resistance of sources and other electrical devices does not properly alter the rate of temperature change

Software Modifications List
- make a definite location for docking of HAB into AYSE drive
- reduce maximum AYSE thrust at full fuel load
- limit number of parachutes (simulators can do this at the moment)

Things To Do Prior To Mission

- not complete
+ partially complete
= mostly complete
complete

- install quarter-round frame for breakout panels
+ install corner bead on drywall edges
+ mud and tape drywall joints in the habitat
- paint the habitat, including external and internal markings
- build work stations for control room
- build kitchen counter top, cabinet, and cupboard for kitchen
- build counter top and shelves for hotlab
- repair glovebox and install into hotlab
- construct and install airlock wheels
- install refrigerator and microwave oven
- build bunk beds
- install safety rail around perimeter of habitat
- purchase and install folding doors to separate storage room from airlock
- install engineering systems into mechanical room: fuel lines, fuel cell, power distribution, bus bars, navicomp, life support
- purchase battery water pump for kitchen

- run CAT5 cable from switch to internal network drops; replace CAT5 cable connectors
- reorganize CAT5 patch panels
- ask BL&T for another castoff switch and a router
- install door sensors and run wires to EECOM station
- install camera system into habitat
- install Corel camera computer into simulator area
- reset camera settings in the Corel camera management system once cameras are in place
- complete wiring for electrical relays
- set up simulator computer, TV, and camera system
- set up the rest of the simulator video and audio systems (switching, VCR)
- set up network communication process between Lisgar and 440 Albert St.

- complete control panel wiring and interface circuit boards
- build mock mass spectrometer, atomic emission spectroscope (LIBS), gas analyzer, seismic sensors, telescope, etc.
- improve the core sampler (better teeth, more reliable extraction system)
- complete final EVA suit
- modify EVA helmet ventilation system
- complete modifications to EVA suit mechanical packs

- complete plans for planetary surface
- construct planetary surface
  - build up substructure for any elevated surfaces
  - paint murals
  - decide material for faux ice surface
  - place samples
  - build up stratigraphic sequence for coring locations
  - sheet over any elevated surfaces with plywood/drywall
  - construct external features on spacecraft to "sink into ice"
  - build up faux ice surface including cliff faces
  - install mechanisms for sim list item 6

- complete the review of old equipment for disposal
- clear out old mission control room
clear out simulator balcony
- organize supply room
- set up mission control room in sim office
- purchase new light bulb for infocus camera

- rework simulator software to incorporate control of electrical relays
- modifying software to account for changes in the spacecraft habitat
- modify software to address the bug list
- write software to display data from mass spec, LIBS, radar, gas analyzer, magnetic field detector, seismic recorders, telescope...
- write biocom software
- write software to manage communication between Lisgar and 440 Albert St.
- set up orbit for comet
- set up orbit for Cassini probe and place Huygens probe on Titan

- set meal plan and purchase food
- update equipment and supply lists for kitchen, hotlab, storage room (esp. repair supplies, tools)
- stock hotlab with equipment and supplies
- clean all kitchen equipment and place into kitchen
- check emergency equipment inventory (flashlights, batteries, chargers, repair kits, etc.)
- purchase supplies for the head: liquid gold and toilet paper

- contact Community Use of Schools
- set up meeting with Occupational Health and Safety Department
- print and distribute permission forms
contact BL&T for phone and network drop to sim balcony
- inquire about use of video conferencing system for mission (may require separate network drop)
- set date for mission

+ complete mission profile development and documents
+ complete emergency procedures and repair procedures documents
+ set up mission duty schedule
+ complete mission experimentation instructions
+ finalize simulator event schedule
- additional training sessions:
  # drywall procedures; esp. issues surrounding sheetrock-90 product
  - connecting CAT5 cable wires, network architecture, network functions
  - electronics and soldering
= piloting, engineering, and simulator training
- flight testing

Mission Event Schedule

Mission Time	Event	Notes
	Launch to low earth orbit - post-launch check	
	Rendevous & dock with AYSE	
	Systems check over 2 orbits	
	Saturn transfer orbit (STO) initiated	
	Transit through asteroid belt (ABT)	
	Saturn Aerobraking	
	Ring material collection	
	Iapetus transfer orbit	
	Iapetus orbit insertion	
	AYSE undocking	
	Transfer to low Iapetus orbit	
	Radar topographic/subsurface survey from low orbit	
	Atmospheric sampling maneuvers	
	Launch of seismic sensors & detonator from orbit	
	Landing on Iapetus	
	Sampling of surface materials & setup of instrumentation	reconnaissance
		mapping of surface features
		setup of seismic sensors
		surface sample collection
		core sampling
		setup of parallax telescope
		set up of infrared telescope
	Sample analysis	
	Parallax experiments	
	Testing of infrared telescope	
	Seismic detonation and analysis of seismic data	
	Systems check and preparation for departure	
	Launch to orbital rendevous with AYSE	
	Dock with AYSE	
	AYSE systems check	
	Initiate Earth transfer orbit	
	Transit of asteroid belt	
	Earth aerobraking	
	Low Earth orbit insertion	
	Undock with AYSE	
	Landing @ OCESS	

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Simulator Event Schedule

Mission Time	Event	Notes
0:00:02:00 On ascent	Main electrical bus short	Hab main engines fail Electrical systems must be switched to backup main bus - approx. 3 min procedure Launch to orbit must be completed at reduced thrust after restart Main bus segment must be replaced once stable orbit achieved
0:00:45:00 Low earth orbit	Stowaway	Stowaway found in post-launch check Dock with ISS and drop off stowaway
After STO	Decompression event	Exterior door in sleeping quarters suffers catastrophic failure Some unsecured items will be lost - SOP for keeping gear secured will be practiced prior to launch - Post-launch check will include checks for lock-down of gear
Near beginning of ABT	Large asteroid near miss	A large asteroid will be detected while passing through asteroid belt Asteroid warning will prompt check of tracking data MC will run collision prediction and suggest modification of track Crew will go through SOP for collision preparation
Saturn Aerobraking	Hotbox crack	Crack forms during high g and heat load in Saturn aerobraking EVA necessary to replace panel on exterior wall of hotbox Will need to have large Saturn mural for one of the walls in W027
After ring passage	Detection of earth-orbit crossing comet on far side of Saturn	MC will run predictions and will find that collision with earth likely Hab will rendezvous with comet after parking AYSE in Iapetus orbit Hab will land on comet and apply thrust to alter orbit MC will run revised collision predictions to check altered orbit
Iapetus Landing	Engine nozzles melt into ice on landing	Hab becomes partially locked in refrozen ice on surface of Iapetus Astronauts must assess situation including risk of damaging hab structure & systems and devise a plan with MC assistance (MC will have blueprints) to free up locked components Astronauts will carry out plan and ultimately will be successful
Iapetus day 1	Meteor shower while on Iapetus	Damage to wall sections and ceiling Loss of pressure in certain modules
	Secondary power bus malfunction	Loss of power and communications Crew will have to initiate diagnosis & repair w/o MC assistance
	Small seismic events	Small seismic events will be detected - before or after exploratory detonation is set off Seismic monitoring equipment will malfunction Astronauts/MC will be unsure if signals are real or not Damaged equipment will have to be repaired to - ensure safety of hab - complete seismic investigations
	Ice & slush geyser	Astronauts will be caught in geyser plume while on repair EVA Ejecta will damage some EVA suit components EVA astronauts will have to re-enter hab before completing decontamination because if suit damage. These astronauts will have to be confined to storage room off airlock while ejecta samples are collected and analyzed for chemical and biological hazards.
After decon	Major seismic event	Damage to engine systems and life support systems
After seismic damage repair	Meteor shower	Second small asteroid impact on day before departure Some damage to wall sections with minor pressure loss
Reported prior to departure	Cassini com systems failure	Cassini main antenna damaged during second meteor shower Hab will rendezvous with Cassini after docking with AYSE AYSE must be parked near Cassini and rendevous made with hab alone Torn wires must be cut out and new sections spliced on a large mast to comm dish on EVA. Power to comm system will have to be disconnected prior to work and reconnected after work is complete. This disconnect process will be difficult as such a procedure will not be one that was anticipated in Cassini construction. Hab remains near Cassini while comm system is tested.
Just before or after asteroid belt transit	Failure of logic systems in NAV computer	NAV system will reset to manual Secondary logic systems will have to be connected by resetting pinout connections on NAV computer control board, replacement of computer cards, and testing of circuits using multimeter and LED output patterns