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the SAC space shuttle…

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Coach Training Manual

Student Astronaut Challenge

Version 241105.01

SAC

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Chapter 1.1 - Setting Up a SAC Classroom Simulator

In order for your Student Astronaut Challenge team to practice all aspects of the Flight Simulation challenge, you will need to create a classroom flight simulator and utilize Orbiter and two PowerPoint slideshows. The required equipment is minimal and once created can be enhanced with additional optional items.

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Required equipment:

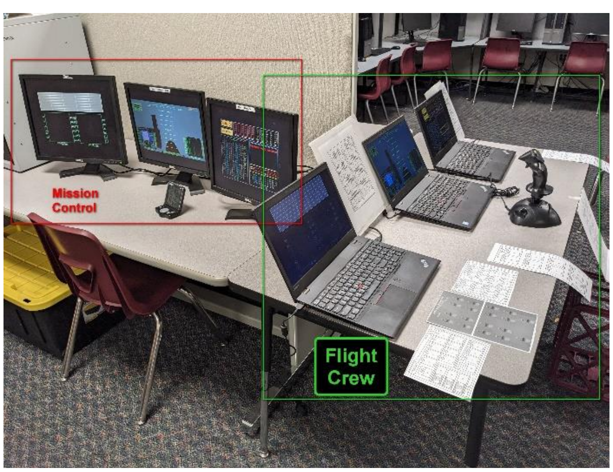
- 3 small desktop or laptop PCs
    - Two of the PCs must have Microsoft PowerPoint installed
- 3 additional monitors and appropriate connecting cables
- 1 basic joystick
- 1 count-up timer
- Switch panel printouts (from SAC website)

Optional equipment:

- Xkeys XK-24 USB keypad (Macropad)
- Xkeys XK-12 Joystick
- Logitech G X52 Flight Control system

Setting up the classroom simulator

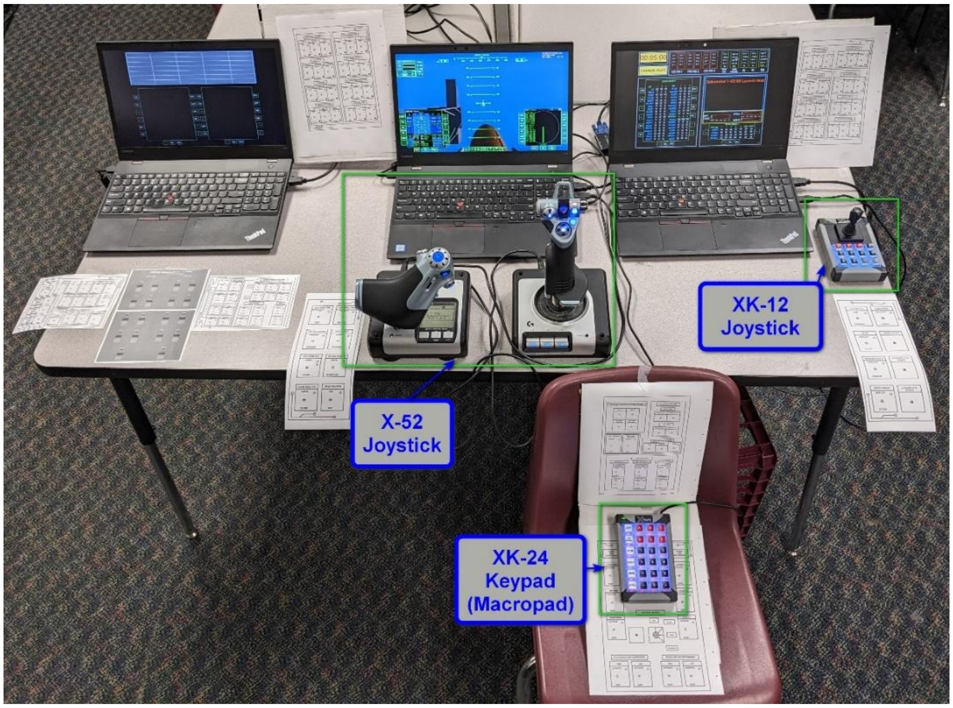
The classroom simulator setup uses the three PCs with the additional monitors attached as duplicated screens. The three PCs are lined up next to each other while their attached monitors are lined up off-to-the-side in the same order. The left-hand PC will run the Flight Engineer PowerPoint, while the right-hand PC will run the Basic Control (Pilot) PowerPoint. The center PC will run the Orbiter 2010 software. The installation of the Orbiter 2010 software is later in this chapter. The joystick is connected to the middle PC and the printed switch layouts are positioned around the three PCs according to the Shuttle Switch Panel Locations document on the SAC website in the Finals Competition Documentation area.



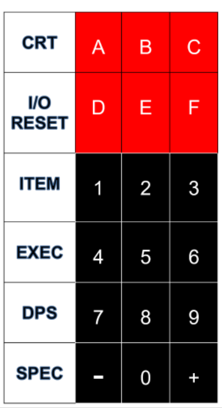
Classroom System

Base Flight Crew Setup

If you want to make your classroom simulator closer to the actual simulator used in the SAC flight simulation challenge, you can add the above listed optional equipment. Any of the optional equipment being used will be attached to the Orbiter 2010 (center) PC. The XK-24 key pad and the XK-12 Joystick will need to be programmed to execute the appropriate commands (see chart below) in Orbiter when the designated key is pressed. Programming instructions come with the keypad. The X52 Flight Controller (joystick and throttle) will replace the above listed Basic Joystick and provide the flight control (yaw, pitch and roll) and throttle functions to the Orbiter 2010 program. I will repeat these three pieces of equipment are <u>completely optional</u>. The basic classroom setup shown above will provide all the flight simulation controls needed to master the Orbiter 2010 program for the SAC events.

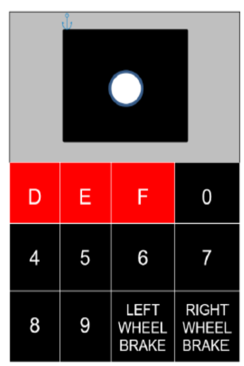


Enhanced System Setup



Left MFD On/off	MFD terminal	MFD Surface Mode	MFD HSI
Turn on/off HUD	RCS Off	Toggle RCS Rot/Lin	Un-dock
Select MFD	Ops 1 program	Ops 2 program	Ops 3 program
Execute program	RCS Kill Rotation	RCS Level	RCS Retrograde
Terminal Dialog Box	RCS Prograde	Re-center HUD view	Reset Pilot Launch MFD
HUD Color	Trim -	Cycle HUD settings	Trim +

XK-24 Keypad



RCS Off	Toggle RCS Rot/Lin	Un-dock	Cycle HUD Settings
RCS Kill Rotation	RCS Level	RCS Retrograde	RCS Prograde
Re-center HUD view	Reset Pilot Launch MFD	Left Wheel Brake	Right Wheel Brake

XK-12 Joystick

Chapter 1.1 - Setting Up a SAC Classroom Simulator

Installing Orbiter 2010 and the PowerPoint Slides

Once the classroom simulator equipment is acquired and setup, it is time to install the necessary software to run the SAC flight simulation missions.

Orbiter 2010 Software

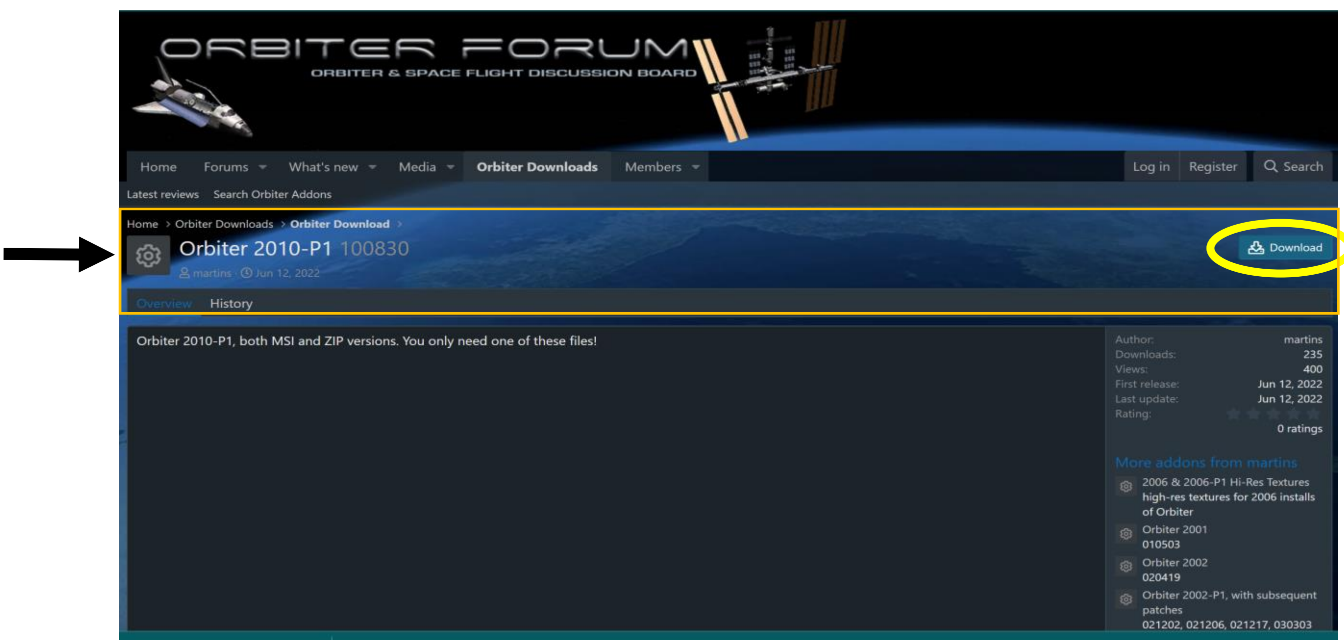
Orbiter is a freeware space flight simulator created by Martin Schweiger, Ph. D., at University College London England. Orbiter is a physics simulator which uses Newtonian physics to simulate the behavior of spacecraft & other objects within our solar system.

Orbiter 2010 Installation

Orbiter 2010 can be installed by two methods - manually by extracting a ZIP file, or automatically by running a Windows MSI installation file. We recommend using the ZIP file process as it does not install any entries into the Windows registry. All instructions for installation are provided as part of the file.

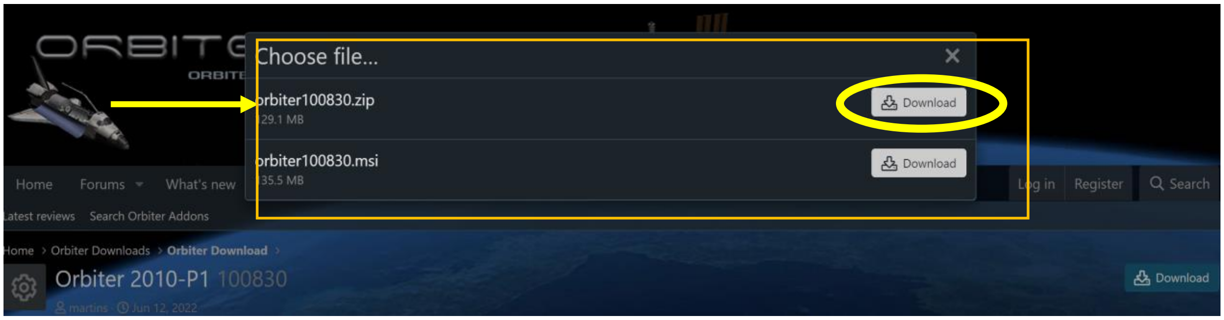
There is a significant amount of reference material and tutorial simulations in the program, feel free to let students explore these as they practice. There are also many help sites and forums on the web for Orbiter.

Orbiter Download Web site is https://www.orbiter-forum.com/resources/orbiter-2010-p1.5428/



Locate the **Orbiter 2010-P1** section and click on the **Download** button to open the **Choose file** dialog.

Chapter 1.1 - Setting Up a SAC Classroom Simulator



Locate the **orbiter100830.zip** file (recommended) and click on the **Download** button to open the download (save) dialog to save the Orbiter 2010 zip file in the Download directory (default location). Depending on your system and browser setup, you might see some messages stating "www.orbiter-forum.com checking for a secure connection" the first time you perform the download. Then double-click the zip file to extract all the files. Once extracted, open the **orbiter100830** folder, scroll down to the **orbiter** application and right-click it to create a shortcut. Place the shortcut on your desktop for ease of use.

The **orbiter sound add on files** is highly recommended and can be found at: http://orbiter.dansteph.com/forum/index.php?page=download

In the **My addons for Orbiter 2010+P1** section, locate the **Orbiter Sound 4.0** box and click on the **download** button to download (save) the **OrbiterSound40_20121120_setup.exe** file. Then double-click on the file and follow the install instructions.

Chapter 1.1 - Setting Up a SAC Classroom Simulator

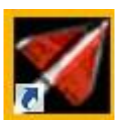
This instructional system only uses a small amount of the capabilities of the Orbiter program. There are other simulated space craft available to fly as well as digital reproductions of the planets and solar systems which can be used in the classroom.

Install Hints for PowerPoint Slideshows

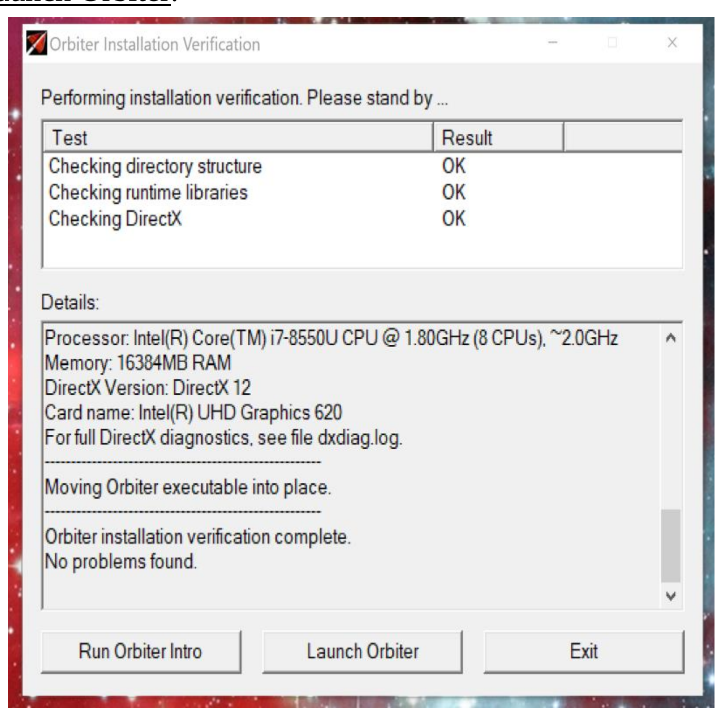
Go to the Student Astronaut Challenge website (http://www.studentastronautchallenge.com) and in the header, click on Reference Material. If Reference Material does not appear in the header, click on More then click on Reference Material in the drop-down list. On the Reference Material page, scroll down to the Finals Competition Software area and click on the **Links** button. Scroll down to the file list. The two PowerPoints that need to be downloaded are the Basic Control Data Panels and Flight Engineer Data Panels. Click on the **download** label after each selection. The files will be automatically downloaded to the Download directory using the website index name. Rename each PowerPoint file to the proper name - **Basic Control Data Panels** and **Flight Engineer Data Panels.** The **Basic Control Data Panels** will need to be placed on the Pilot PC Desktop and the **Flight Engineer Data Panels** will need to be placed on the Flight Engineer PC Desktop. Once placed to the desktop, each PowerPoint can be executed by a double-click.

Setup hints for Orbiter

Once Orbiter is downloaded and installed (either ZIP or MSI), start the program by double-clicking the Orbiter icon.



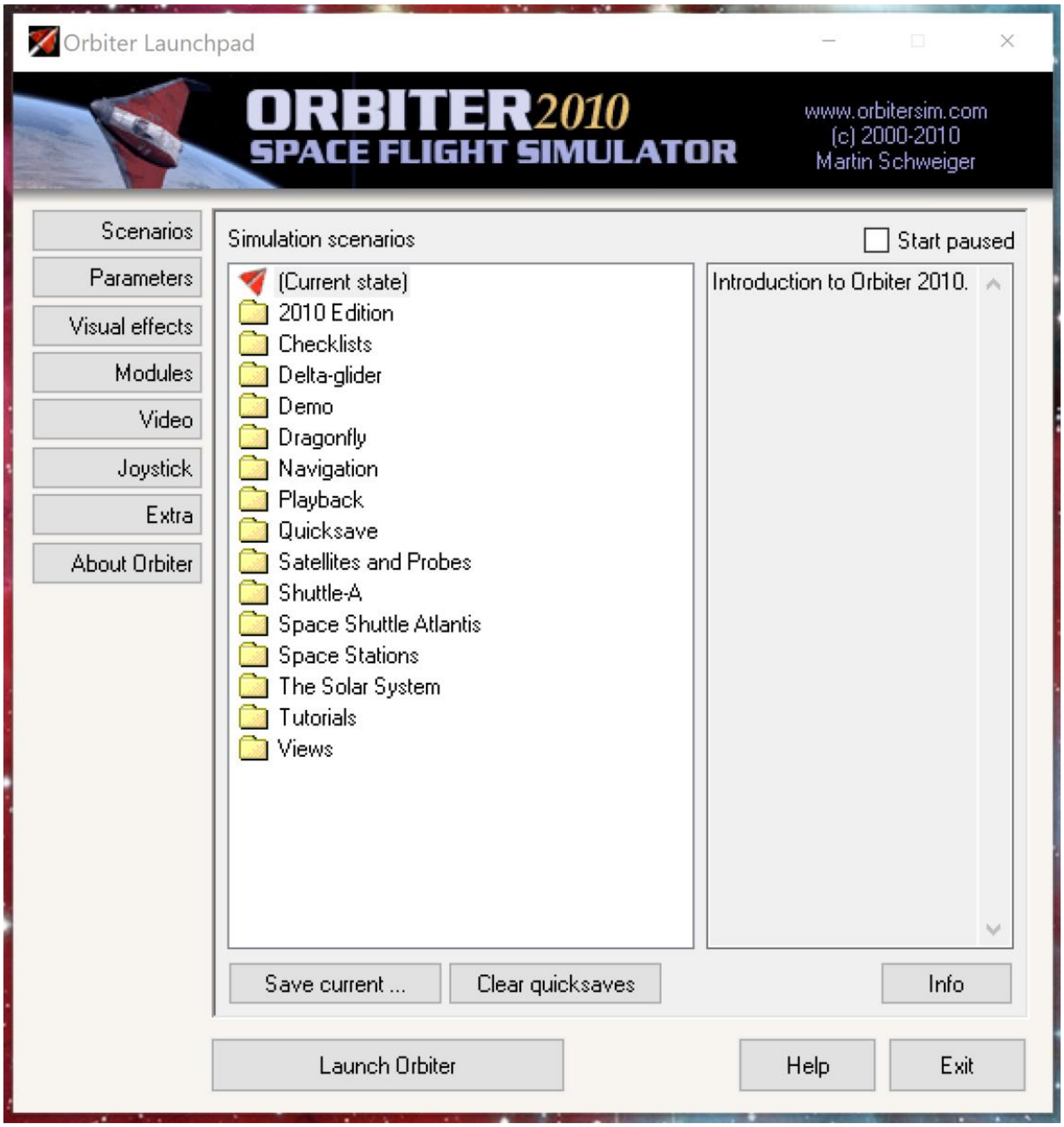
The first time the program is started it will run a check on your PC and when successfully completed, click Launch Orbiter.



Chapter 1.1 - Setting Up a SAC Classroom Simulator

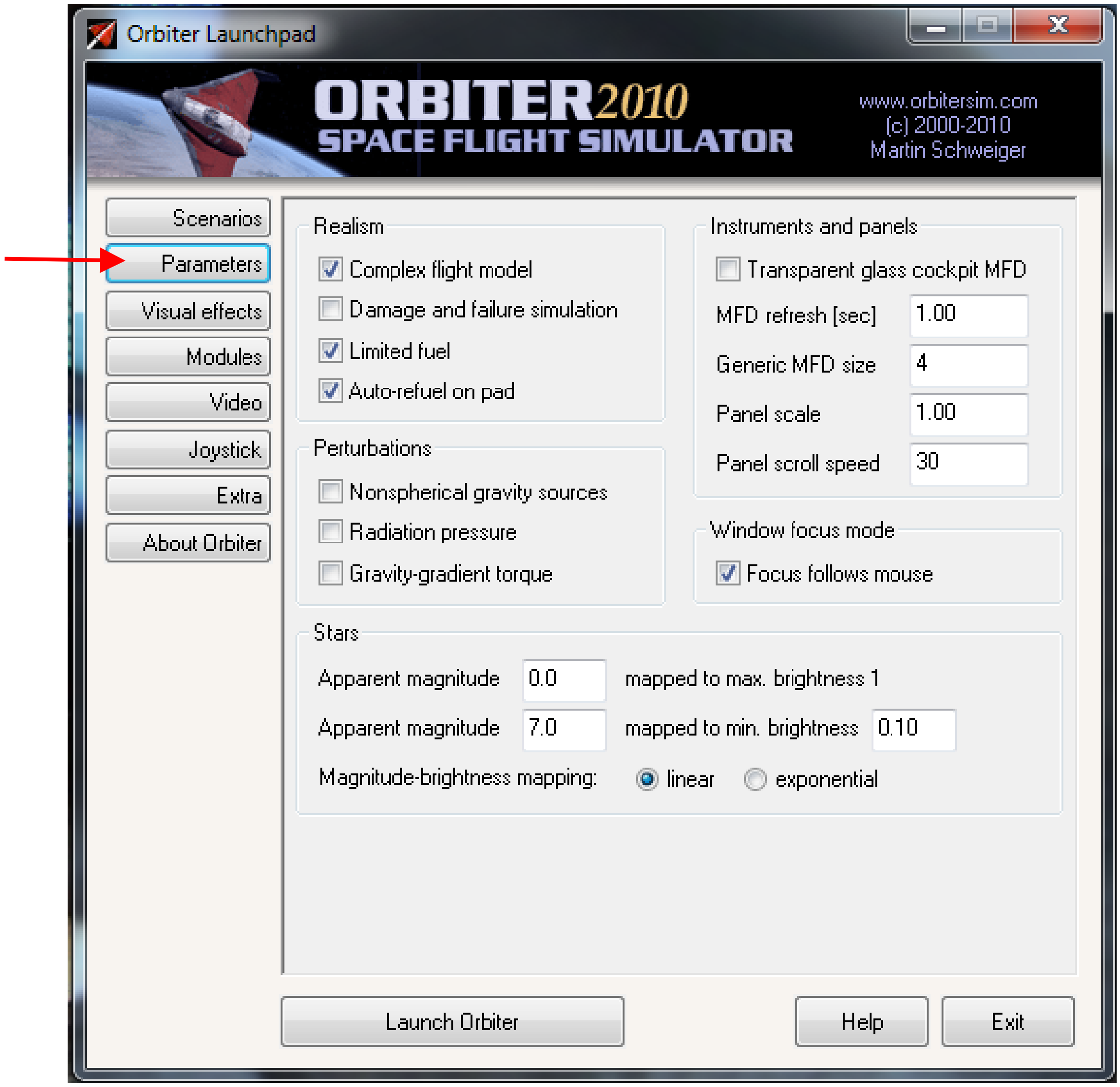
If any of the three checks fail, consult your IT staff. The corrections are pretty simple and should not be a problem.

When you start Orbiter, it opens the Orbiter Launchpad window where you can setup and customize the Orbiter program:



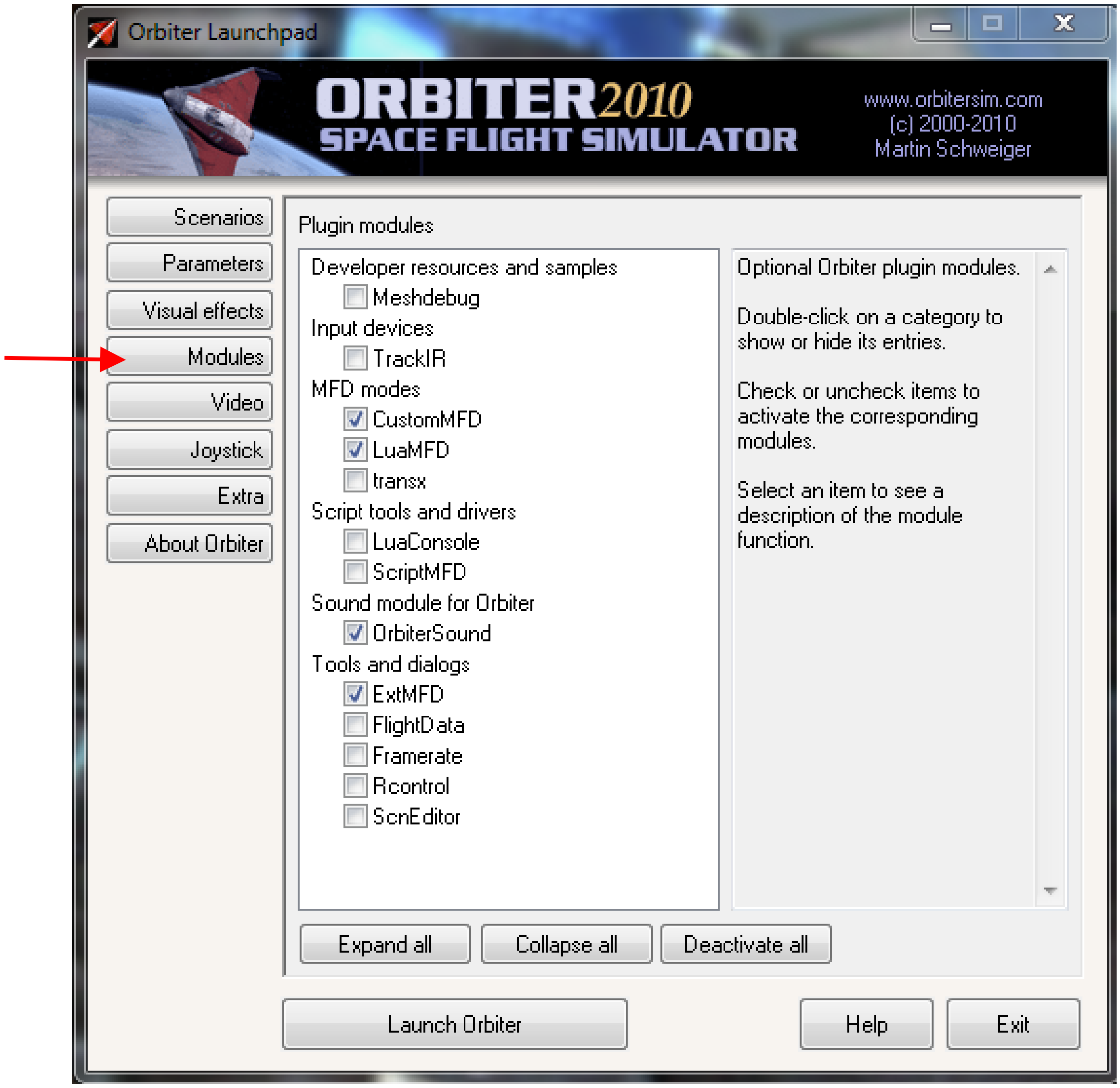
Chapter 1.1 - Setting Up a SAC Classroom Simulator

In the parameters section, use the following settings as a beginning point.



Chapter 1.1 - Setting Up a SAC Classroom Simulator

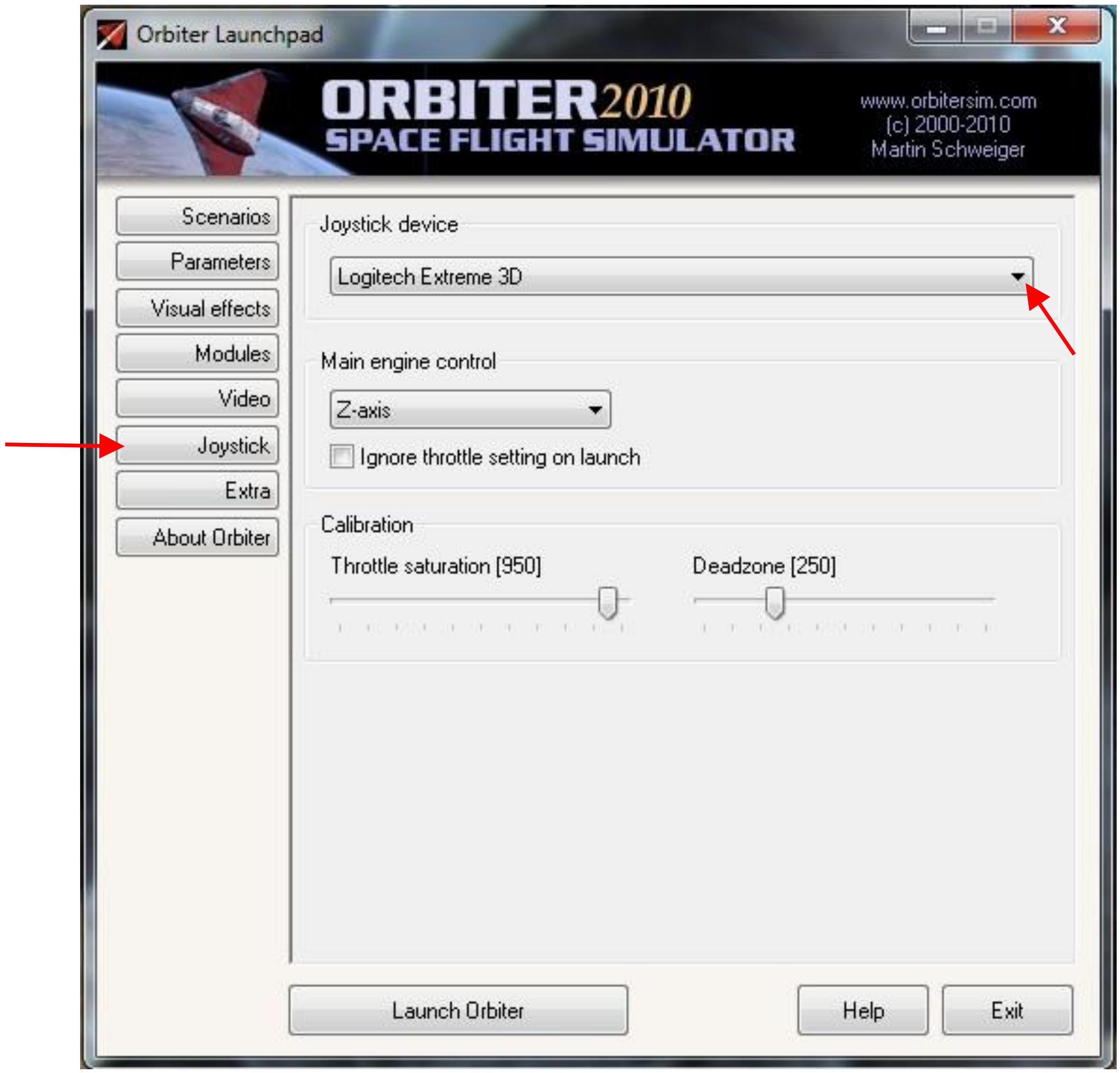
In the Modules section of the Launchpad, **activate the indicated modules** at a minimum by clicking the check box before each selection. You may activate other modules as you encounter a need for them:



On the Video tab, full screen mode usually works the best but you may have to experiment to get the best visual settings for your computer.

Chapter 1.1 - Setting Up a SAC Classroom Simulator

If you are using a joystick (recommended) this is activated in the Joystick section. Plug in your joystick first, then click the down arrow under the Joystick Device label and select your joystick model:



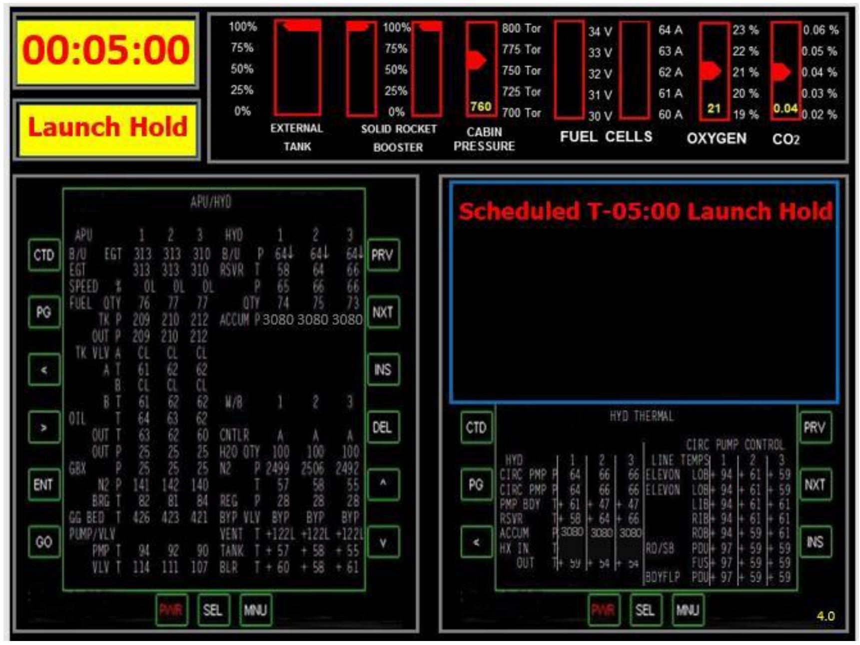
All these setup changes should only be necessary on the initial start of Orbiter.

Chapter 1.1 - Setting Up a SAC Classroom Simulator

Operating the Simulator

Initiating Launch

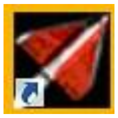
To use the simulator program system, three separate programs are run on the classroom computers, one on each computer. The Mission Commander runs the ***"Orbiter"*** program on their computer. The Pilot runs (double-click the icon) the "***Basic Control Data Panels"*** PowerPoint on their computer: The first slide is:



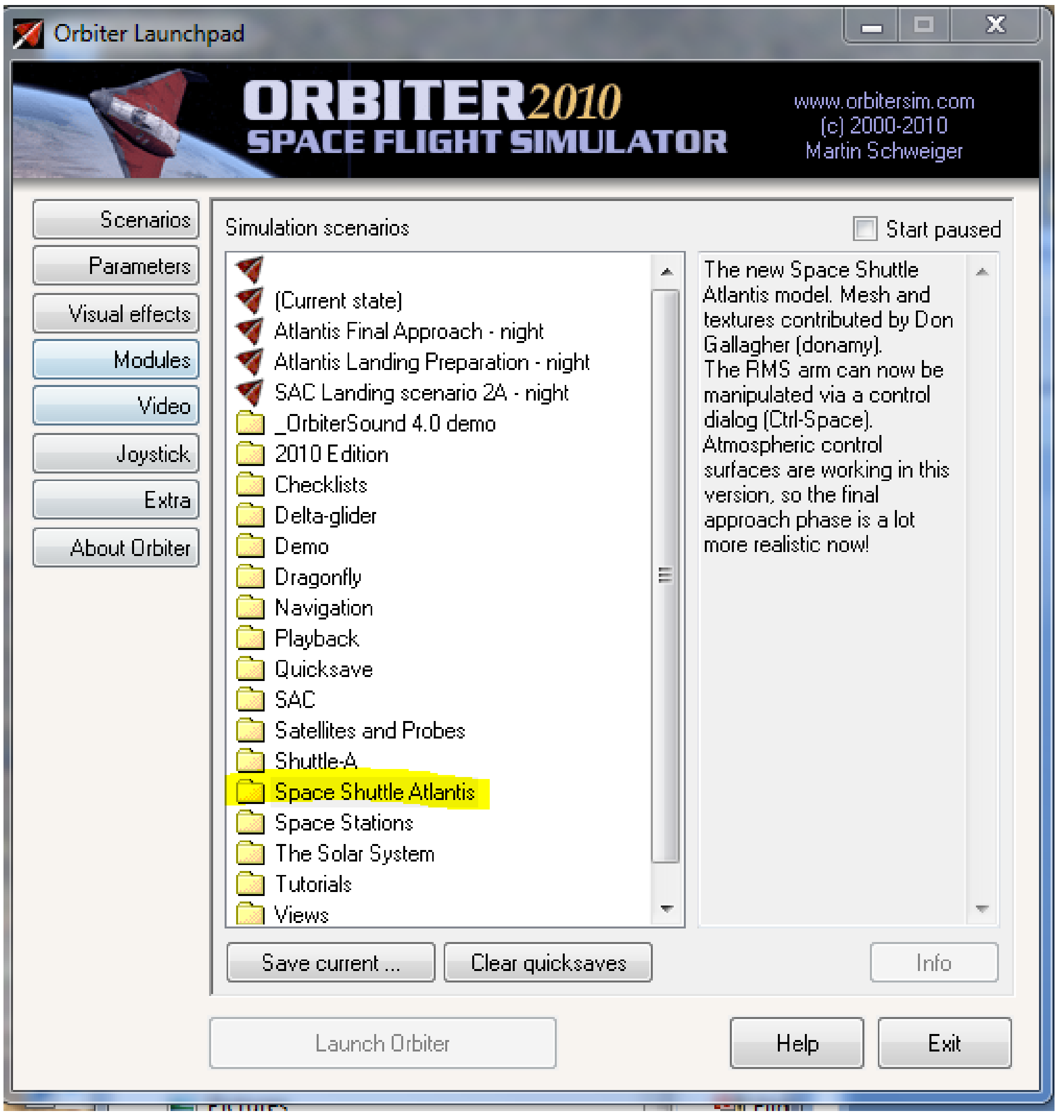
The Flight Engineer runs (double-click the icon) the ***"Flight Engineer Data Panels"*** PowerPoint on their computer. The first slide is:

Chapter 1.1 - Setting Up a SAC Classroom Simulator

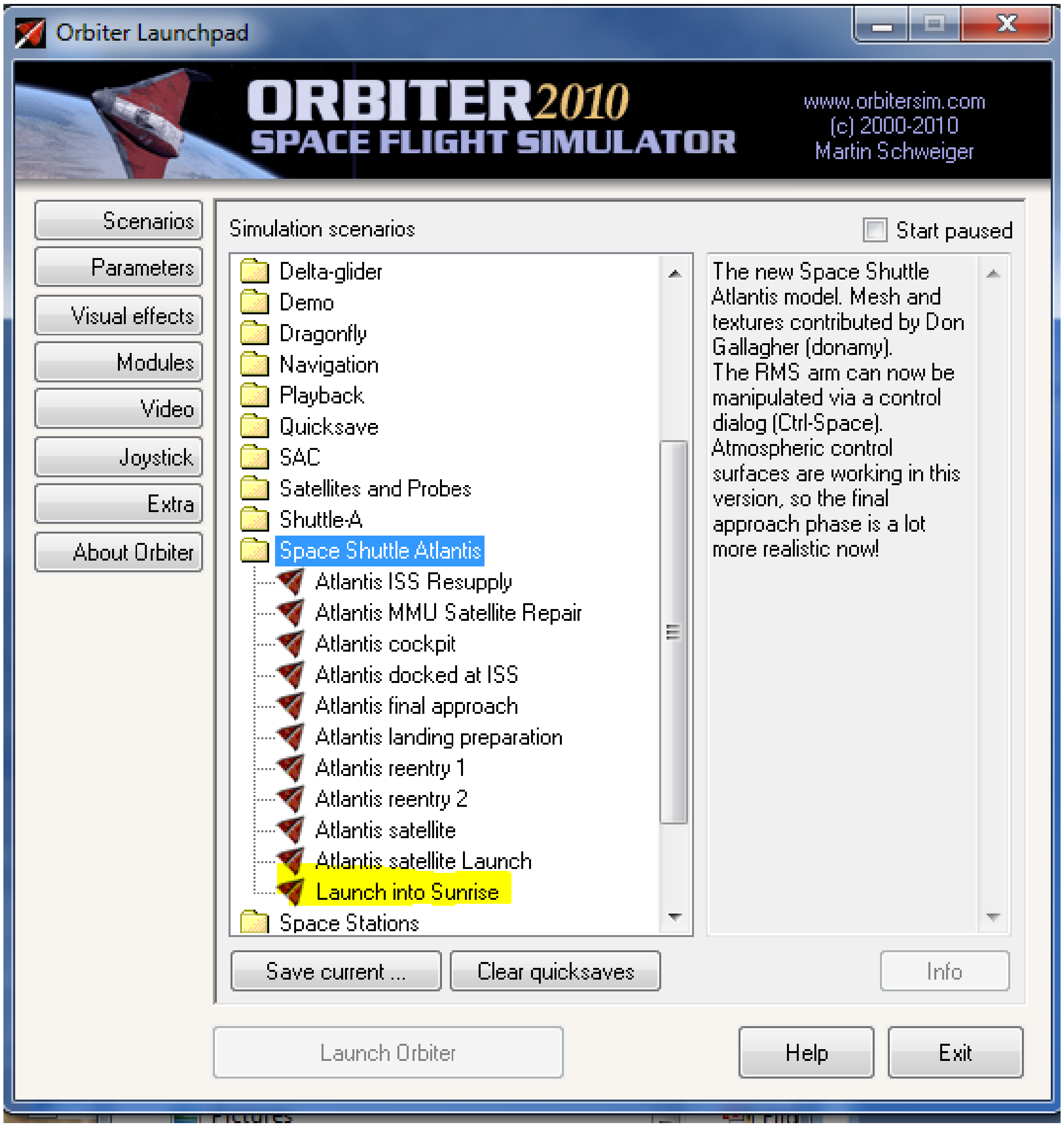
The Mission Commander loads the Orbiter program by double-clicking the Orbiter icon:



Orbiter will display the Launchpad. Select the “Space Shuttle Atlantis” file.



Then locate and select the sub-file "launch into sunrise" program



and then launch orbiter.

This should launch Orbiter displaying an external view of the shuttle on the launch pad.

Chapter 1.1 - Setting Up a SAC Classroom Simulator

Press **F1** to switch to the cockpit view.

Shuttle Launch Commands for the Head Up Display (HUD)

1. Verify the HUD is set to Orbit Earth mode. If **not**, typing the **H** key will cycle through the various HUD options.

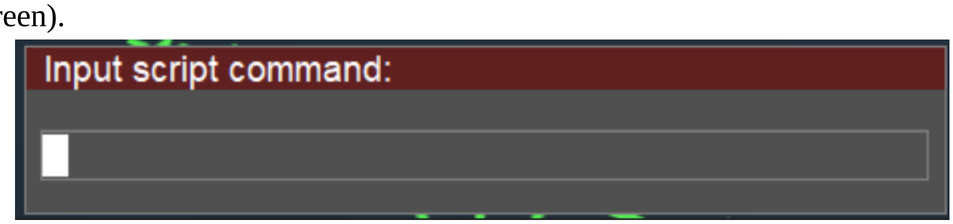
The Mission Commander will need to configure the Multi-Function Displays (MFD) and enter the launch commands into Orbiter.

Shuttle Launch Commands for the Right MFD

1. Have the student use the mouse and click on [SEL] on the right Multifunction Display (MFD) and then [Orbit].

Shuttle Launch Commands for the Left MFD

1. Have the student click **[SEL]** on the left MFD with the mouse and then select **[Terminal MFD]** (you may have to hit **[SEL]** twice to get to this prompt)
2. Then select **[INP].** An "Input Script Command" dialog box will pop up (center of the screen).

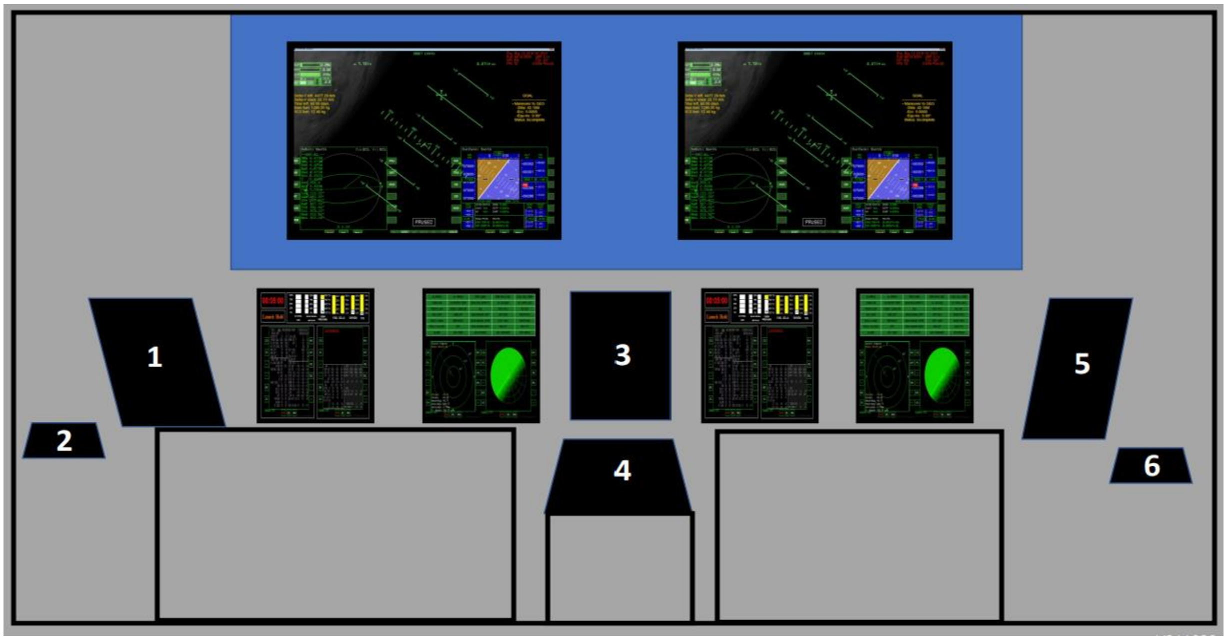


3. In the dialog pop-up box:
    a. Type in ***run"atlantis/launch"*** and press **ENTER**
    b. Select [**INP]** again**,** and then type in ***do_oms2=false*** and press **ENTER**
    c. Select [**INP]** one final time, and then type in ***launch()***
    d. **DO NOT** press **ENTER** until you are queued to launch the shuttle at **T-minus 4 seconds**.

Be careful not to touch the keyboard before T-minus 4 seconds or it may change or erase the final command and mess up your launch timing with the Pilot's PowerPoint.

Position the Switch Panel printouts

To assist the Mission Commander and Pilot in learning the location of the switches they are responsible for during the mission, you should locate and print the switch panel layouts found on the website under the Finals Competition Documentation section. The files needed are Shuttle Switch Panels 1-6 White 8.5x11, Engineering Switch Panels 7 & 9 White 8.5x11 and Engineering Virtual Switch Panel 8. Once these layouts are printed, you can use the chart below to position Panels 1-6 for the Mission Commander and Pilot in the correct location to replicate the SAC Flight Simulator. Note: The SAC simulator has duplicated screens for each flight team member so your classroom layout might be slightly different.



The flight engineer panels 7, 8 and 9 are positioned in numerical order in front of the Flight Engineer.

Switch Types

There are three types of switches in the SAC flight simulator: push button, two position and three position. The push button switches, like MAIN ENGINE POWER, are push-on/push-off buttons that are lit when on and dark when off. The two-position switches, like N2 CNTRL VLV, are toggle type where the down position is normally off/inactive/disable, while the up position is the on/active/enable setting. The third type of switch, like HYD CIRC PUMP, is the three-position toggle style switch. The three positions are down, center and up. Like the two-position switch, the down position is normally off/inactive/disable and the up position is the on/active/enable setting. The center position is the GPC setting which places the switch system under the control of the General Purpose Computers (GPC), which allows the computers to control the use of the system.

Running a flight simulation Mission

At this point in the setup, all the software is ready to execute a flight simulation mission and the switch panels are positioned correctly. Orbiter has the Launch command loaded and ready for execution (Enter) at T-00:00:04 and the PowerPoint slideshows are on their initial slide.

The team is now ready to begin a flight simulation run.

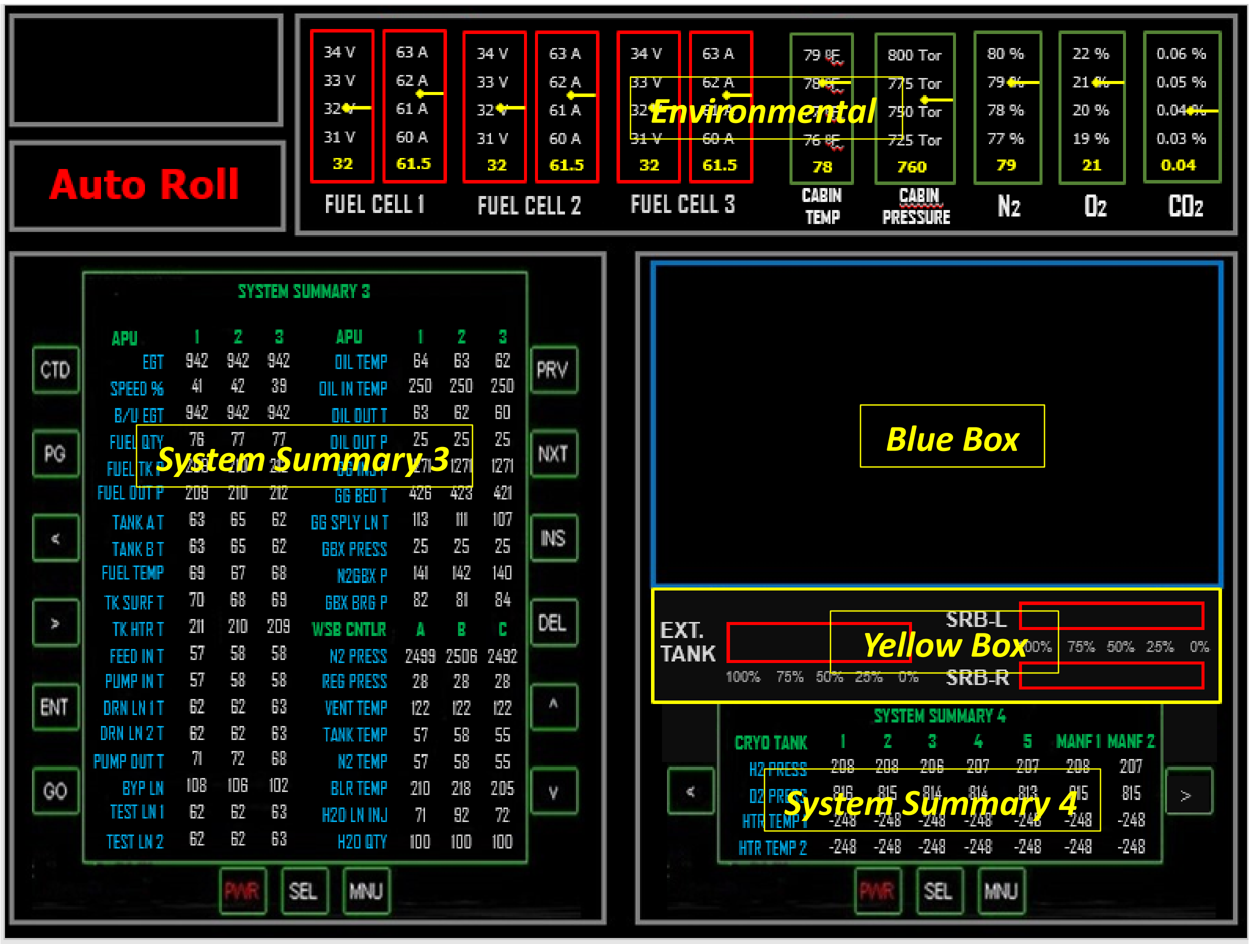
FIX YOUR LITTLE PROBLEM AND LIGHT THIS CANDLE.

Alan Shepard

May 5, 1961

Chapter 1.2 – Pilot Panel

The pilot data panels contain formatted data display and unformatted data displays, each serving a unique purpose. The formatted data displays are the SYSTEM SUMMARY 3 panel, the SYSTEM SUMMARY 4 panel, the Environmental panel and the Yellow Box. The one unformatted data display is the blue box.



The named data values in the SYSTEM SUMMARY 3, SYSTEM SUMMARY 4 and Environmental displays represent physical orbiter systems which will remain consistent in location throughout the flight, though their data values may change.

The Blue Box panel displays data values and messages that in real-time to the current flight simulation run. Since this information is time sensitive to the flight, the data displayed changes on a faster pace than the formatted data displays.

The Yellow Box display represents the real-time fuel status of the Space Shuttle Main Engines (SSME) and Solid Rocket Boosters (SRB) during the current flight simulation run. These data values will remain consistent in location. Since this information is time sensitive to the flight, the SRB data will turn blank after SRB Separations (T+00:02:05) and the SSME data will turn blank after Main Engine Cut-Off (MECO) at T+00:08:55. This display loses its importance after MECO and should not be referenced after that time.

Since the Blue Box and Yellow Box display time sensitive data, they are very important sources for telemetry checks. Fuel status (Yellow box) is critical during the ascent phase of the launch.

Chapter 1.2 – Pilot Panel

HOUSTON, TRANQUILITY BASE HERE. THE EAGLE HAS LANDED.

Neil Armstrong

July 20, 1969

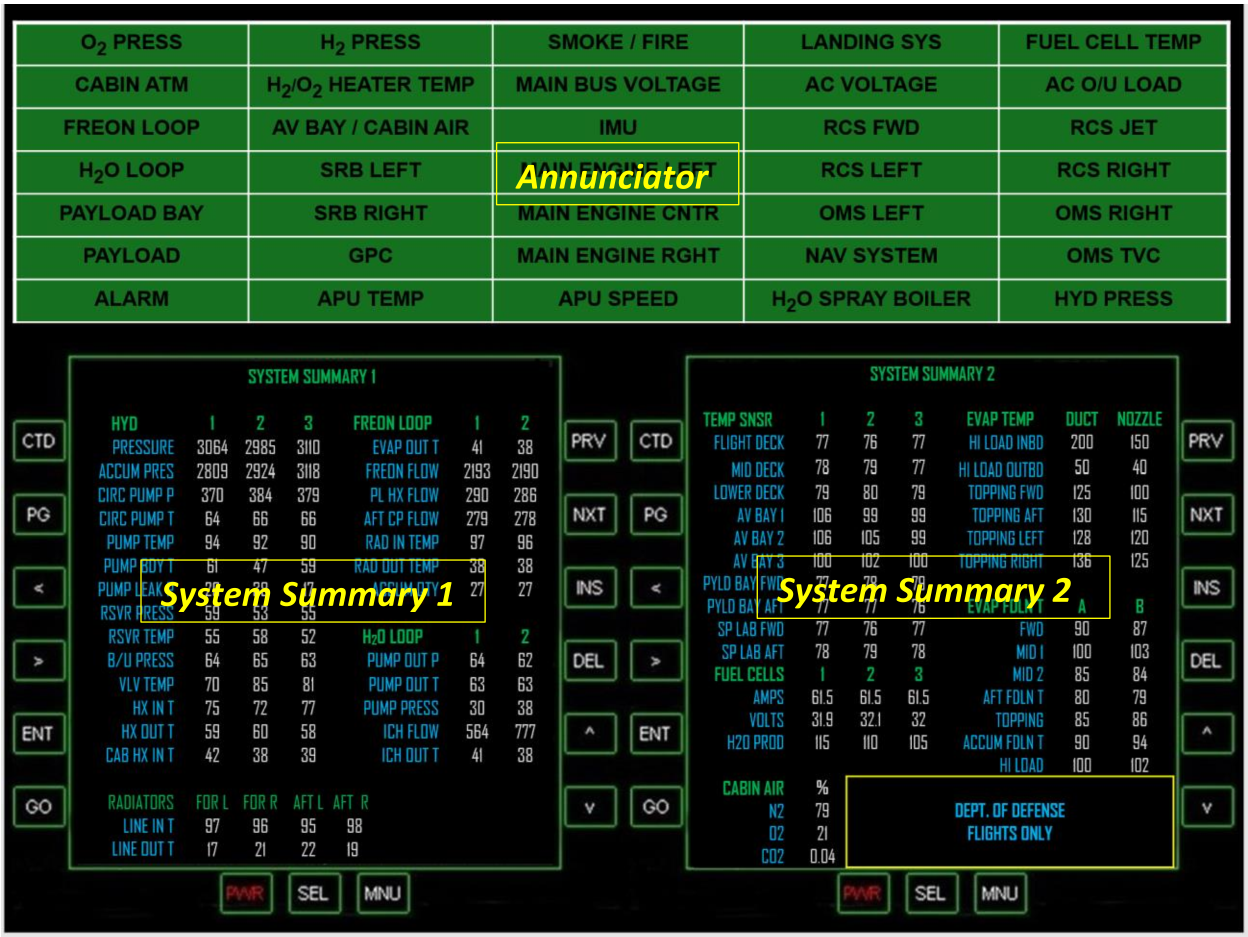
ROGER, TRANQUILITY. WE COPY YOU ON THE GROUND. YOU GOT A BUNCH OF GUYS ABOUT TO TURN BLUE. WE'RE BREATHING AGAIN. THANKS A LOT.

Mission Control

July 20, 1969

Chapter 1.3 – Flight Engineer Data Panel

The flight engineer data panels contain formatted data displays and the annunciator panel, each serving a unique purpose. Additionally, there is a yellow box labelled <u>Dept. of Defense Flight Only.</u>



The formatted data displays are the SYSTEM SUMMARY 1 panel and the SYSTEM SUMMARY 2 panel. The named data values in the SYSTEM SUMMARY 1 and SYSTEM SUMMARY 2 displays represent physical orbiter systems which will remain consistent in location throughout the flight, though their data values may change.

The annunciator panel is a visual indicator of the current status of the named orbiter systems. Green indicates the system is functioning normally and in a nominal state. Yellow is a warning and means the system is still functioning but in an off-nominal state. Red is an alarm and means the system has failed. Grey indicates the system has been powered down. The ALARM indicator (lower-left corner of the annunciator panel) changes to the same color (except gray) as the indicated system. If a system goes into an alarm (red) state, a klaxon will sound until the flight engineer silences it by pressing the <u>Master Alarm Reset</u> button on switch panel 7. Depending on the emergency, multiple systems may go into warning (yellow) or alarm (red) at the same time. In this situation, the team should pay close attention to the order the alarms appeared.

The DOD box will only display data when the flight has been designated as a DOD flight. The information will relate to the DOD portion of the flight and will be unformatted text messages with data values.

Chapter 1.3 – Flight Engineer Data Panel

THAT'S ONE SMALL STEP FOR MAN, ONE GIANT LEAP FOR MANKIND.

Neil Armstrong

July 20, 1969

BEAUTIFUL, BEAUTIFUL. MAGNIFICENT DESOLATION.

Buzz Aldrin

Second man on the Moon

July 20, 1969

Chapter 1.4 – Mission Checklists

The mission checklists are the road map to the shuttle simulation flight and therefore the Flight Engineer can be considered the “driver” of the flight. The checklists will guide the team through the stages of the flight and if correctly followed, will provide all the correct switch settings necessary for a successful flight. There are three different versions of the mission checklist, all of which contain the same flight information, just with some different formatting and helpful hints:

- Mission Checklist - Classroom
- Mission Checklist - Kneeboard
- Mission Checklist - Simulator

All the checklists are located on the SAC website in the Reference Material>Finals Competition Documentation area. The basic checklist format is four columns divided into a variable number of rows. The columns are named **COM**, **TIME**, **PROCEDURE** and **Mission Control Notes** and the rows are identified by the number in the first block of each row, the **COM** block. Be aware that the line spacing within each row is significant. Multiple blank lines in the **PROCEDURE** block of the row indicates that there is information contained in the **Mission Control Notes** block and the flight crew must pause to wait for mission control to act on that information. If a **PROCEDURE** block is completely empty, it means that there is only mission control information for that specific time period (**COM** block).

29	Mission Dependent	STAR TRACKER to OFF (2) Multiple blank lines **here** indicate mission control needs to communicate (see Notes column →) Ku ANTENNA to STOW (7) E - [space bar] and **here** RADIATORS to STOW (7) E - [space bar] and **here** PAYLOAD BAY DOOR to CLOSE (7) E - [space bar] and **here** PAYLOAD BAY POWER to OFF (7)	Advise: Go for Payload Bay Door Close program. Announce: Confirm KU Antenna is stowed Announce: Confirm Radiators are stowed Announce: Confirm Payload Bay Doors are closed

The **COM** column name stands for **COM**munications block and contains sequentially ascending numbers. The COM block can be used to help all team members locate the current checklist location for the flight and it is recommended that it be included in time checks performed by Mission Control.

The **TIME** column displays the current mission time for the beginning of the block. The TIME value will be one of three types: Countdown, Mission Elapsed (MET) or Mission Dependent. The Countdown time will be from the T-00:05:00 Launch Hold to T-00:00:00 Launch, also known as T-minus time. The Mission Elapsed time (MET) will be from T+00:00:01 to mission dependent time, also known as T-plus time. The Mission Dependent time is when the timing of a block is determined by the mission parameters and therefore may change for each mission. During the mission dependent time blocks it is recommended that mission control call the actual MET time in place of the term Mission Dependent. **Note** that the TIME block changes to **ALTITUDE** in the Landing Checklist phase of the flight simulation and it represents the Orbiter altitude in Kilometers at the beginning of that block.

The **PROCEDURE** column contains the commands that will be given to the flight crew by the flight engineer. These are normally commands to direct the flight crew on setting the switches in the proper sequence and position, though they may also be information or verification requests from the flight engineer.

The **Mission Control Notes** column contains announcements and advisements that will be requested by Mission Control.

While the three checklists contain the same flight information, there are important differences between them.

Mission Checklist - Classroom

Initially, the entire team should use the Mission Checklist – **Classroom** to guide them through a mission. The classroom version of the checklist contains all the necessary Orbiter commands to set up the flight and it contains hints to assist the team in learning the flight simulation process. The first page will step the mission commander through the Orbiter 2010 commands to setup the program for a flight simulation run. It also contains some suggestions for creating a custom launch scenario to simplify the setup process. In the main body of the checklist, there are switch location hints and additional information explaining the data item location value that mission control is referencing. The red numbers in parenthesis following the switch commands indicate which switch panel contains the requested switch.

> ENVIRONMENTAL SYSTEM O_2 SYS to OPEN **(5)** – the **(5)** means the ENVIRONMENTAL SYSTEM O_2 SYS switch is on top right-hand (Pilot) switch panel.

The classroom version also contains other hints that explain what some of the Mission Control advisements mean:

C - Confirm that the (WSB CNTLR) BLR TEMP data display is less than **225 degrees F** (Located on Pilot PowerPoint SYSTEM SUMMARY 3 MFD)	Advise: Check Boiler Temp

The hint in blue explains that the Check Boiler Temp advisement is asking the flight crew to check and respond with the current value of the (WSB CNTLR) BLR TEMP data display and that it should be less than **225 degrees F.**

Additionally, the Classroom checklist indicates the specific flight position and the keyboard command needed to perform an Orbiter or PowerPoint command during training. (These commands will be executed through the macro-pad during the competition.)

36	Mission Dependent	*Position The Shuttle to The Correct Attitude – Prograde* **Key in 7** – Prograde **(4)** C –[Use mouse to select prograde on Orbiter screen]
37	Mission Dependent	RE-ENTRY SYS CHECK to ON **(6)** P - [space bar] HYD MAIN PUMP PRESSURE (1/2/3) to NORMAL **(1)**

In COM block 36, the blue text C –[Use mouse to select prograde on Orbiter screen] informs the mission commander (C) to use the mouse to select the Orbiter prograde setting in response to the flight engineer commanding "*Position the Shuttle to the Correct Attitude – Prograde".*

In COM block 37, the blue text P – [space bar] informs the pilot (P) to use the space bar to advance the PowerPoint screen in response to the flight engineer command "RE-ENTRY SYS CHECK to ON".

Mission Checklist – Simulator

The Mission Checklist – Simulator checklist is the same as the Mission Checklist – Classroom with the exception that it does **not contain** the switch location information (number following the command) or any of the blue informational text. It is strictly the required commands and mission control information needed during the flight simulation. This is the checklist that Mission Control will use during the SAC Flight simulation competition.

Mission Checklist – Kneeboard

The Mission Checklist – Kneeboard checklist is a reformatted version of the Mission Checklist – Simulator that contains **only** the first three columns (**COM, TIME and PROCEDURE)** and is six inches by nine inches. This was done to allow the checklist to fit on the kneeboards that the flight crew will have during the mission. Since the **Mission Control Notes** column is omitted, the flight crew will have to pay particular attention to the spacing in the **PROCEDURE** column. The three columns of information in the Knee-board checklist are identical to the Simulator checklist. The flight crew will use the **Kneeboard** checklist during the SAC Flight simulation competition.

Kneeboard **Version 220412.01**

Pre-Launch Checklist

COM	TIME	PROCEDURE
1	T-00:05:00	**Launch HOLD** CABIN DOOR to LATCH ENVIRONMENTAL SYSTEM O_2 SYS to OPEN ENVIRONMENTAL SYSTEM N_2 SYS to OPEN ENVIRONMENTAL SYSTEM H_2O LOOP to OPEN **Key in ITEM** **Select A** **Key in DPS** **Select 1 (OPS 1)** **Key in EXEC** BOILER CNTRL POWER (1/2/3) to ON BOILER CNTRL HTR (1/2/3) to ON BOILER N_2 SUPPLY (1/2/3) to OPEN

Chapter 1.4 – Mission Checklists

THE STARS DON'T LOOK BIGGER, BUT THEY DO LOOK BRIGHTER

Sally Ride

International Space Station

Chapter 1.5 – Team Member Responsibilities

While the six students compete in the Student Astronaut Challenge as a team, in the flight simulation they are divided into two 3 member groups, each performing specific functions leading to the success of the flight. The two groups are Mission Control and the Flight Crew.

The Mission Control positions are the Mission Director, Mission Controller 1 and Mission Controller 2. The individual position responsibilities are:

Mission Director

1. Performs the supervision of the Mission Control team and all ground flight operations and team role assignments.
2. Call out all T-minus and T-plus communication time blocks.
3. Give the **Go/No-Go** order for launch.
4. Perform the ten-second countdown for activating the Flight Engineer's panel at T minus four minutes (T-00:04:00) and the ten-second countdown to launch.
5. Announce negative return at approximately (T+00:04:20)
6. Manage the countdown for the re-entry burn.
7. Call out the specified altitude and airspeed blocks (listed in the Landing checklist) during landing operations.
8. Manage the emergency process including identifying and confirming the emergency with the Mission Commander and approving the emergency procedure that will be followed by the Mission Control team.
9. Confirm all abort and non-abort conditions with the Mission Commander.

The following are recommendations for the roles and responsibilities of the Mission Controllers. It is the responsibility of the Mission Director to assign and monitor team operations.

Mission Controller 1

1. Handle telemetry checks for data on Pilot and Orbiter panels (both responding and initiating)
2. Share reading out loud the designated "announce and advise" communications within the checklist with Mission Controller 2
3. Read the emergency checklist and work with the flight crew when using the emergency checklist
4. Track general flight checklist progress and verify completion
5. Start the MET Launch Clock at T-00:00:00
6. Share the call out of altitude and airspeed on Landing at appropriate intervals with Mission Controller 2. These altitude/airspeed calls would be other than the specific checklist entries.

Mission Controller 2

1. Handle telemetry checks for data on the Flight Engineer panel (both responding and initiating)
2. Share reading out loud the designated "announce and advise" communications within the checklist with Mission Controller 1
3. Track the emergency checklist progress for Mission controller 1

4. Work with the flight crew on the emergency checklist as needed
5. Work with Mission Commander and Flight Engineer on use of the shuttle schematics as they relate to the Flight Engineer checklist and panels during an emergency
6. Track checklist progress and verify completion
7. Share the call out of altitude and airspeed on Landing at appropriate intervals with Mission Controller 1. These altitude/airspeed calls would be other than the <u>specific</u> checklist entries.

The Flight Crew positions are the Mission Commander, Pilot and Flight Engineer. The individual position responsibilities are:

<u>Mission Commander</u>

1. Performs the supervision of the flight crew team and team role assignments.
2. Request the **Go/No-Go** order for launch from Mission Control.
3. Manually flies the Orbiter into the Zero-up attitude.
4. Perform the Deorbit burn procedure under the command of Mission Control
5. Operate the switches on the mission commander side of the cockpit.
6. Observe and audibly verify the switch settings performed by the pilot or flight engineer.
7. Confirm abort scenario selection and lock-in the scenario with the abort selection switch.

<u>Pilot</u>

1. Initiate the <u>Launch Clock Restart</u> when **Go** command issued by the mission director.
2. Operate the switches on the pilot side of the cockpit.
3. Observe and audibly verify the switch settings performed by the mission commander or flight engineer.
4. Assist the mission commander during the Zero-up procedure by executing the "Kill rotation" switch at the mission commander's request.

<u>Flight Engineer</u>

1. Direct the flight crew by calling out switch settings from the mission checklist
2. Initiate the <u>Primary System Radar</u> at <u>exactly</u> T-00:04:00
3. Operate the switches in the flight engineer area of the cockpit.
4. Maintain the position in the checklist during an emergency procedure.

RETURNING, THAT WAS THE CHALLENGING PART.

Buzz Aldrin

Chapter 1.6 – Communication Guidelines

Accurate "ground to space" communication is the critical component to a successful completion of a space flight simulation scenario. To facilitate accurate communications, strict control of who speaks at what time and to whom is critical. To maintain this control NASA has developed a standard communications protocol, which is comprised of three items in a specific order:

1. **Who is being addressed**, a person (e.g. Mission Commander, Pilot) or group (e.g. Mission Control, Enterprise),
2. **Who is speaking**, a person (e.g. Pilot, Flight Engineer) or group (e.g. Atlantis, Mission Control),
3. **The information**.

During shuttle operations, in-flight communications are divided into two main categories which are universally used: **Advise** and **Announce**

<u>Advise</u>

An advisement occurs when the flight crew or Mission Control needs to provide or request important information. This category of communications <u>requires</u> a confirmation from the addressed personnel. There are some standard phrases used to indicate the communication is an advisement and requires a response. "Be advised" or "Do you confirm?" are the most common.

<u>Example</u>:

"*Mission Control, this is Mission Commander; **<u>be advised</u>** we are receiving a caution and warning on the APU system."*

or

"*Mission Control, this is Mission Commander; we are receiving a caution and warning on the APU system. **<u>Do you confirm</u>**?"*

In both these requests, Mission Control would respond with the requested information.

<u>Announce</u>

An announcement occurs when flight crew or Mission Control is relaying information that does not require a confirmation of the information.

<u>Example</u>:

"Atlantis, this is Mission Control, APU pre-start check is underway"

or

"Endeavor, this is Mission Control, External tank cap is retracted"

Additionally, there are standard responses used to relate specific information between the orbiter and Mission Control:

Report:	*"Go"* or *"No Go"*	This is used to: 1) confirm a system is operational or announce there is a problem with a system; or 2) Mission Control can grant (*Go*) or deny (*No Go*) permission for the Flight Crew to proceed with a mission step.

Confirm:	*"Roger"* or *"Copy"*	This is used to confirm receipt of a message.
Status:	"*Nominal"*	This is used to identify if a system is operating normally. In the event a system is operating abnormally (off-nominal) the abnormal system information is identified in the communication.

Orbiter Crew

The Mission Commander is the flight officer responsible for talking to Mission Control, though occasionally the Pilot will speak to Mission Control in the event the Commander is busy or the information is only seen by the Pilot (status information) or if Mission Control requests status information from the Pilot. Normally the Flight Engineer does not speak to Mission Control, only to the Commander and Pilot. The exception to this is when the Flight Engineer is confirming the switch placements on the Engineering panel before the pre-launch checklist process begins.

When using the flight checklist during shuttle operations, the flight crew utilizes a <u>three-step confirmation procedure</u> to ensure the accuracy of the switch settings. The Flight Engineer is responsible for reading off the check list items at the appropriate time. The flight officer who is responsible to turn that system on or off repeats the instruction as they perform the action. The other flight officer confirms that they observed that the action was correctly completed by repeating the instruction and adding either **Check** or **Confirm.** This system is routinely used by trained pilots whether they are flying a passenger jet or the Space Shuttle.

<u>Example:</u>

1) Flight Engineer: (reads checklist)	*"APU / HYDRAULICS (1/2/3) to OFF"*
2) Mission Commander: (performs action)	"*APU / HYDRAULICS (1/2/3) to OFF"*
3) Pilot: (verifies action completed)	"*APU / HYDRAULICS (1/2/3) to OFF* ***<u>Check</u>***

1) Flight Engineer: (reads checklist)	*"APU FUEL TK VLV (1/2/3) to CLOSE"*
2) Pilot: (performs action)	*"APU FUEL TK VLV (1/2/3) to CLOSE"*
3) Mission Commander: (verifies action completed)	*"APU FUEL TK VLV (1/2/3) to CLOSE"* ***<u>Confirm</u>***

Chapter 1.6 – Communication Guidelines

Mission Control Crew

A mission control center (MCC) is an entity that manages aerospace vehicle flights, usually from the vehicle clearing the tower until the landing or the end of the mission. In the FSUS Shuttle simulation system, the MCC is comprised of the Mission Director and two flight controllers. The flight controllers monitor all aspects of the mission using audio and video telemetry while the Mission Director is responsible for assigning duties, directing the Mission Control operations and being the lead on any emergency situation. Together, they support the mission by monitoring the flight checklist to ensure nothing is missed, monitoring telemetry readouts of the shuttle systems and confirming telemetry information with the astronauts. Frequently Mission Control will need to “announce information” during the check list procedures to provide additional information to the shuttle crew. This information is contained in the mission control segment of the checklist.

It is not the responsibility of the MCC flight controllers to read off the flight checklist, this is done by the Flight Engineer. The reason for this is that the checklist is time-sensitive and, because of gaps in radio communication, it is possible to miss items.

In the event of an emergency the MCC is responsible for helping the shuttle crew identify the problem by reviewing the telemetry readouts. Once this is accomplished, they then walk them through managing the problem using the Emergency Procedure checklist. This is the one time that Mission Control flight controllers take over reading the checklist since it is emergency-specific. Occasionally emergencies occur that are not covered by the checklist, in which case it is the responsibility of Mission Control to work with the flight crew to analyze the problem and come up with a solution so that the mission can continue.

The key to Mission Control is communication, both between the flight controllers and between Mission Control and the orbiter. The primary purpose of this communication is to ensure that what the astronauts are seeing in their information readouts coincides with what the mission control telemetry is reporting. In the event an abort of the flight is required, the team in Mission Control normally makes the call as they have a more precise knowledge of the orbiter's position than the crew can obtain from onboard systems. During an abort discussion, the Mission Director should poll all team members to get their opinion on the decision. The Mission Director can then recommend an abort decision to the Mission Commander. The Mission Commander, who has full responsibility and authority over the Orbiter, makes the final confirmation of the mission abort.

Telemetry Checks

Telemetry is the automatic capture and transmission of data from a remote source to a base station. In NASA terms, it is the automatic data transmitted from a space craft (an orbiter) to the Mission Control Center. While this process is highly automated and controlled, it is a good practice for the people involved to periodically verify the captured data is transmitted correctly. To accomplish this verification, telemetry check are done between the orbiter and the MCC. The telemetry checks can be initiated by either group and are in the form of an advisement, requiring a response. It is good practice to have both groups (flight crew and Mission Control) initiate telemetry checks at various times. Telemetry checks actually accomplish two goals when done, one is to verify both groups are seeing the same data values (the transmission is correct) and two, ground-to-orbiter communications are still intact. Both items are critical to the success of the mission.

Example:

Check:

"*Mission Control, this is Enterprise,* ***can you confirm*** *that the HYD ACCUM PRESS 1 is 2509 PSI?*

Response:

"Enterprise, this is *Mission Control, we confirm that the HYD ACCUM PRESS 1 is 2509 PSI.*

This accomplishes both parts of the check – the data is correct and communications is working. Telemetry checks can be used at anytime and are useful to fill "dead air" – a time when no other communications is occurring. Do be cautious on telemetry check usage and don't have a constant stream of data requests. In the above example only one system data value was requested, so the response was only for that system. If the request had been for the entire system, then the response would have included all system data values.

Check:

"*Mission Control, this is Enterprise,* ***can you confirm*** *that the HYD ACCUM PRESS is 2509, 2524, and 2602 PSI for systems 1,2 and 3?*

Response:

"Enterprise, this is *Mission Control, we confirm that the HYD ACCUM PRESS is PRESS is 2509, 2524, and 2602 PSI for systems 1,2 and 3.*

When requesting or responding to a telemetry check the actual data value should always be given. A minimal use of the term "Nominal" is ok, but be aware that Nominal means the value is within an acceptable range and is not a precise value. Additionally, since one purpose of telemetry checks is to verify the correctness of the transmission, an actual value needs to be checked not a range (nominal).

If a data value is requested and the receiving group doesn't know where it is located, they should ask for its location. All PowerPoint data values can be located by their screen name (System Summary 1 – 4) and group heading name such as HYD or FREON LOOP on the SYSTEM SUMMARY 1 panel. In the previous example, the requested data values (HYD ACCUM PRES) are located in SYSTEMS SUMMARY 1, HYD group (see diagram below).

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All data values on the **Orbiter** screen can be identified by the display it is located in – HUD, MFD LEFT, MFD RIGHT, FUEL gauge (upper left), Altitude or Airspeed.

HOUSTON, WE'VE HAD A PROBLEM HERE.

John "Jack" Swigert & James "Jim" Lovell

April 13, 1970

Chapter 1.7 – Running a Flight Simulator Mission

Once the Orbiter software and the Pilot and Flight Engineer PowerPoints are setup (see Chapter 1.1), the team is ready to run a flight simulation mission. The Mission Commander will need to input the Orbiter Launch commands to run the Launch Into Sunrise scenario.

1. Start Orbiter using the Launch Into Sunrise scenario.
2. Press the **F1 (PF1)** key to switch the view from the external (default) view of the launchpad to the internal cockpit view.
3. Confirm HUD is on and in Orbit Earth mode. **[Ctrl] H** will turn HUD on and the **H** key will cycle through the various HUD options.
4. Select **[SEL]** on the left MFD with the mouse and then select [**Terminal MFD**]. (You may have to hit **[SEL]** twice to get to this prompt)
5. Select **[INP].** An "Input Script Command" dialog box will pop up.
6. In the dialog pop-up box:
   a. Type in ***run"atlantis/launch"*** and press **ENTER**
   b. Select [**INP]** again**,** and then type in ***do_oms2=false*** and press **ENTER**
   c. Select [**INP]** one final time, and then type in ***launch()***
   d. **DO NOT** press **ENTER** until you are queued to launch the shuttle at **T-minus 4 seconds**.

Flight Checklists

The Flight Engineer will use one of the Mission Checklists (available on the website in the Finals Competition Documentation) to direct the flight crew on setting the switches in the proper sequence and position. Initially, the team should use the Mission Checklist – **Classroom** to guide them through a mission. The classroom version of the checklist contains all the necessary Orbiter commands to set up the flight and it contains hints to assist the team in learning the flight simulation process. The red numbers in parenthesis following the switch commands indicate which switch panel contains the requested switch.

ENVIRONMENTAL SYSTEM O_2 SYS to OPEN **(5)** – the **(5)** means the ENVIRONMENTAL SYSTEM O_2 SYS switch is on top right-hand (Pilot) switch panel.

The classroom version also contains other hints that explain what some of the Mission Control advisements mean:

C - Confirm that the (WSB CNTLR) BLR TEMP data display is less than **225 degrees F** (Located on Pilot PowerPoint SYSTEM SUMMARY 3 MFD)	Advise: Check Boiler Temp

The hint in blue explains that the Check Boiler Temp advisement is asking the flight crew to check and respond with the current value of the (WSB CNTLR) BLR TEMP data display and that is less than **225 degrees F.**

Chapter 1.7 – Running a Flight Simulator Mission

Once the team is comfortable with the switch locations and proper advisement response, the flight crew should move to the Mission Checklist – Kneeboard 6x9 version and the Mission Control group should begin using the Mission Control – Simulator version. These two are the checklists used during the competition. The Kneeboard 6x9 version for the flight crew does not contain the mission control column so the flight crew must pay attention to the spacing which indicates when mission control is making a request.

Starting the Mission

Once the team members are set, the Mission Director will direct the flight crew to begin the mission at the **T-00:05:00 HOLD (Com block 1).** The flight engineer will read the checklist commands to the flight crew who will execute them using the three-step verification procedure.

- The Flight Engineer calls out the switch command
- The flight officer who is responsible to turn that switch repeats the instruction as they perform the action.
- The other flight officer confirms that they observed that the action was correctly completed by repeating the instruction and adding the word **Check** or **Confirm.**

In the classroom simulator, the flight officers will touch the requested switch on the printed switch layout to learn where the actual switch will be in the simulator. The Kneeboard 6x9 checklist will also have the flight officer press the spacebar or another key on their PC to cause the PowerPoint or Orbiter to respond to the switch change. Not all switch changes require a keyboard input so pay close attention and learn which ones do need the input.

During the flight simulation, all team members should follow the proper communications protocol.

1. Who is being addressed
2. Who is speaking
3. The information

The Mission Commander will request a Go/No Go at the designated time and the Mission Director will issue a Go if the checklist is complete at that point, or a No Go is something has not been completed. Once a Go has been issued the Pilot will restart the Countdown clock by pressing the spacebar on the Pilot PC. This action represents pressing the Launch Clock Restart button in the actual simulator. During the flight, Mission Control should call out the **Com block # and Clock time** at each new checklist block to help keep the flight on track. The flight will continue to progress with the flight engineer calling out the checklist items.

The Gauntlet

At the T+00:09:00 mark, just after MECO, is a special section of the checklist referred to as the Gauntlet. Occurring at Com blocks 17-22 (T+00:09:00 – T+00:11:00), the gauntlet contains a large number of commands to complete in the two minute time span. Due to the difficulty of completing the gauntlet in time, some special rules have been implemented to help the team.

- When executing the switch commands
    - The flight engineer must call out the entire command as usual.
    - The flight officer performing the command can abbreviate the switch name as long as it is recognizable.
    - The flight officer that is checking the command, can simply respond with **check** or **confirm.**
- Regular communication protocol can be suspended
- Mission Control can talk-over the flight crew as they only have announcements to make
- The flight crew does not have to wait on the Com block time to occur before continuing with the checklist
- Physically occurring events (ET Sep, OMS Burn Initiating) should be called when they occur as opposed to when the flight crew gets to them in the checklist.

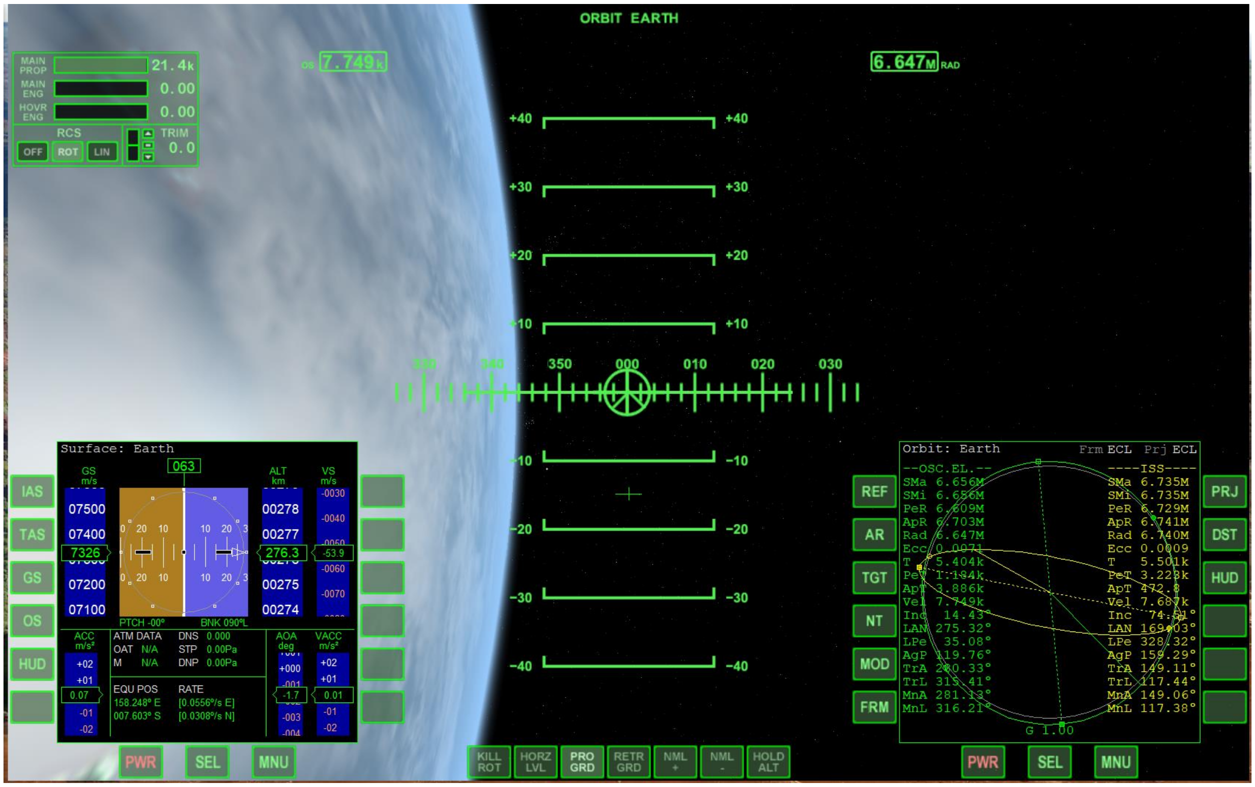
Following completion of the gauntlet, the team <u>must</u> revert to the standard methods and protocols.

<u>In Orbit</u>

Once orbit has been attained, the flight crew will perform several operations that interact with the Orbiter program and the PowerPoints, such as “zero-up”, retrograde, prograde, payload bay door open/close. During these operations, all team members must be aware of what is occurring and make sure to let the operation complete before calling it “completed”. For the Orbiter operations, all team members should know what the completed operation looks like on the Orbiter PC screen, so they won’t call it completed early. For the PowerPoint operations, there will be an indicator on the PowerPoint that shows when the operation is finished. Make sure you wait for that indicator before confirming the operation as complete.

<u>Zero-up</u>

The Mission Commander will manually fly the Orbiter to perform the “Zero-up” maneuver, which is a manual version of the automatic Prograde command. To perform the Zero-up maneuver the Mission Commander will use the joystick to move the orbiter into the flight attitude where all three axis (Roll, Pitch and Yaw) are at zero degrees. The best method to accomplish this task is to fly one axis at a time and make use of the “Kill Rotation” button (along the bottom of the orbiter screen in practice or the 4 button on the macro-pad in the actual SAC simulator. The Kill rotation command may be used repeatedly to stop the orbiter rotation. However, the joystick should not be used when the Kill rotation light is lit. Any joystick input while the Kill Rotation indicator is lit, will cause the computer to continue “fighting” the additional joystick input and prolong the successful termination of the rotation. The best way to practice is place the orbiter program into space and press the prograde button. When complete, the orbiter will be in prograde which is exactly what the "zero-up" maneuver will look like.



Proper "Zero-Up" position

<u>De-Orbit Burn</u>

The De-Orbit Burn procedure is managed by Mission Control and all commands during the procedure will be issued by Mission Control. The Mission Commander will only advance/retard the throttle. Before the flight simulation, the Flight Director will inform the Mission Director of the de-orbit burn time duration. At the time for the de-orbit burn, Mission Control will use this procedure:

- ➢ The de-orbit burn procedure must start within 1 minute after beginning Com Block 35
- ➢ The Mission Director will inform the flight crew of the burn time duration
- ➢ The Mission Director will give the Mission Commander a 10 second countdown to burn initiation
- ➢ The Mission Director will give the Mission Commander a 10 second countdown to burn termination

<u>Landing</u>

In the landing phase of the flight simulation mission, the Mission Commander will fly the Orbiter to a smooth, safe landing at the Kennedy Space Center runway 33, also known as the Shuttle Landing Facility (SLF). To accomplish this task successfully, all team members must contribute in providing timely information to the Mission Commander. When the landing phase begins, the Flight Engineer will continue to call the switch commands as usual, while Mission Control will concentrate on informing the Mission Commander of the current altitude and airspeed of the Orbiter.

In Mission Control, the Mission Director will call out all the com blocks that are specified in the checklist and any information that appears in the checklist. The other mission control members will handle the information callouts for all other suggested blocks. Mission Control can drop the standard communications format as their altitude and airspeed calls are considered global announcements and only the pertinent information needs to be broadcast. The normal com blocks during landing are the ones indicated by the checklist as well as altitude and airspeed calls every 5K in altitude until 10K is reached and then they should be every 1K. This method will provide a fairly consistent stream of altitude and airspeed information to the Mission Commander. Since mission control is only providing two data values to the flight crew, the callout can be abbreviated to one of two formats: both values may be identified by their labels (Altitude, airspeed) or the second can be identified by the label or data measurement. Therefore, Mission Control will call out the altitude first followed by the airspeed in one of two accepted formats:

1) Altitude 20K, Airspeed 840
2) Altitude 20K, 840 TAS

This real-time information will help the Mission Commander make the proper decisions to complete a safe landing.

The Pilot will perform all the switch commands requested by the Flight Engineer as the Mission Commander will only be responsible for flying the landing. All functions should be performed as they are called by the flight engineer, with the Speed Brake deployment being the one exception. The speed brake deployment normally will occur at 500 meters in altitude, but it can be delayed or deployed early at the mission commander’s discretion. To deploy the speed brake early, the mission commander can simply request it be deployed and the pilot will then deploy it without flight engineer intervention. If the mission commander determines the speed brake needs to be delayed, then the mission commander needs to inform the flight engineer prior to 500 meters that the speed brake must he held. The speed brake can be used multiple times at the mission commander’s discretion. In this case, the mission commander will call for the speed brake to be deployed and then retracted at his discretion and then the cycle may be repeated as needed.

Once the orbiter comes to a complete stop, the mission will be complete.

For additional specifics on landing and the use of the Horizontal Situation Indicator (HSI) for instrument landings, refer to the Landing Information manual on the SAC website in the Finals Competition Documentation section.

Chapter 1.7 – Running a Flight Simulator Mission

I BELIEVE THIS NATION SHOULD COMMIT ITSELF TO ACHIEVING THE GOAL, BEFORE THE DECADE IS OUT, OF LANDING A MAN ON THE MOON AND RETURNING HIM SAFELY TO EARTH.

President John F. Kennedy

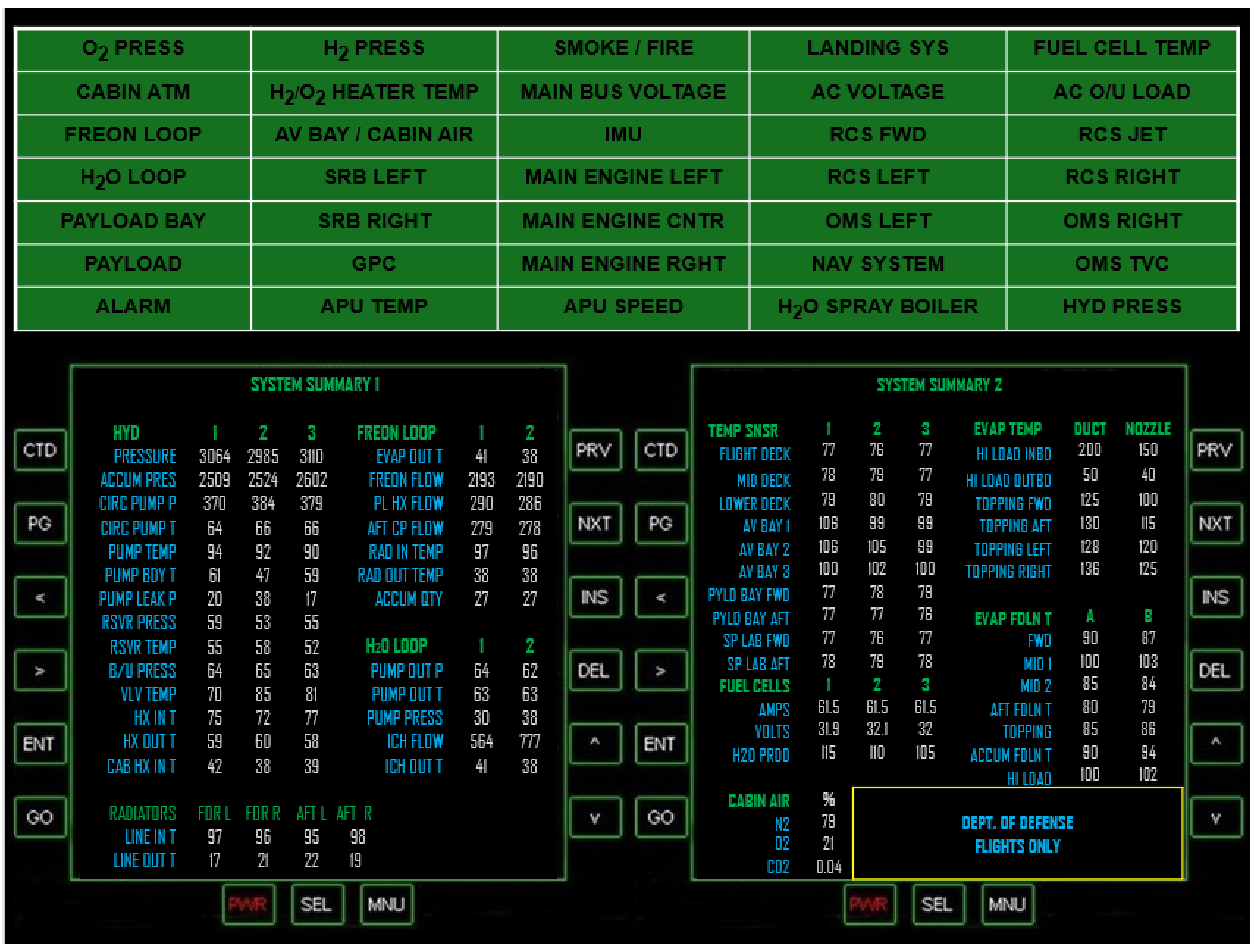
May 25, 1961

Chapter 1.8 – Training for Emergencies

Emergencies may occur in all segments of a flight simulation and need to be handled in a timely manner with full team member understanding and agreement. You will find that practicing, solving and understanding emergencies are a stressful time in your team's development during the Student Astronaut Challenge. The main keys to resolving emergency events are communication and team work. Each team member needs to be able to clearly relate their thoughts on the emergency and their knowledge on possible resolutions. Good team work is vitally important in emergency resolution as it instills confidence in the team as a whole and allows members to be confident in working alone on a problem thread to help resolve the issue.

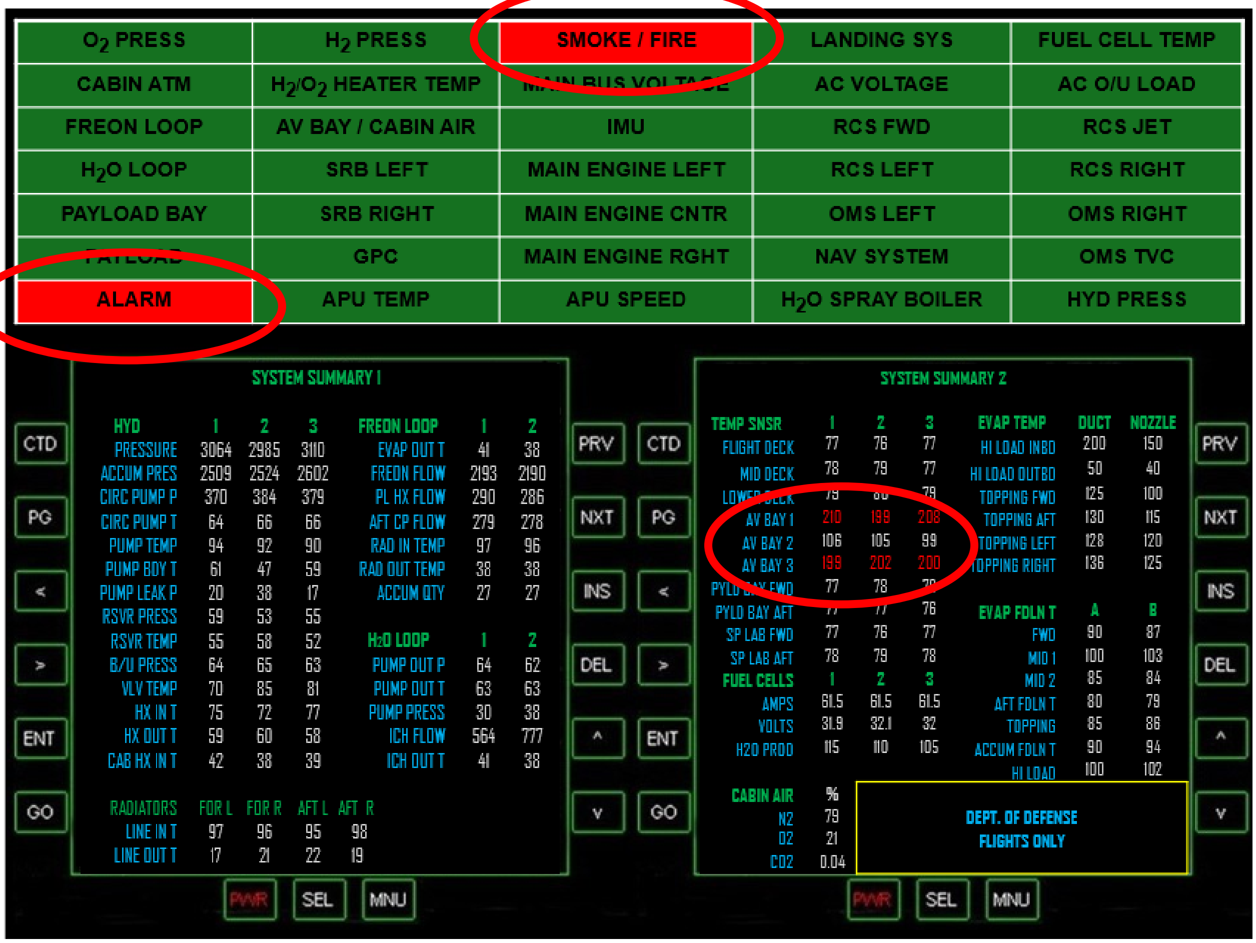
What is an Emergency

In the Student Astronaut Challenge Space Flight Simulation an emergency is any system that is off-nominal such that it requires an immediate response from the team. Be aware that some data values can be off-nominal, but still be within an acceptable range and therefore not an emergency. The best method for determining whether an emergency condition exists is by referencing the annunciator panel on the Flight Engineer data panels. The annunciator panel is a grid of lights that represent the Shuttles main systems. The nominal (normal) condition of these systems is represented by green lights.



Chapter 1.8 – Training for Emergencies

When an emergency condition occurs, these lights will turn red and generally set the master alarm (ALARM) indicator in the lower-left corner to red. A klaxon horn will sound during an emergency to alert the crew to the off-nominal condition. This alarm may be silenced by the Flight Engineer (FE). In addition to the ALARM and system lights turning red, off-nominal data values related to the system will turn red as well.



In this emergency the SMOKE/FIRE and ALARM lights have turned red. Additionally, the AVBAY 1 and AV BAY 3 temperature sensors indicate off-nominal values and are highlighted in red.

Types of Emergencies

In the simulator the types of emergencies may be classified as Basic, Intermediate or Advanced. The Basic and Intermediate emergencies may be encountered in both the Semi-final and Final simulation flights, while an Advanced emergency will only occur in the finals.

Basic Emergencies

Basic emergencies are ones that can be solved by using the Emergency Procedures checklist manual (located on the website in the Finals Competition Documentation area). This manual is only available to the Mission Control group during a flight simulator run. Therefor it is critical that the team be able to communicate well to be able to resolve the emergency in an expeditious manner. The Emergency Procedures checklist starts with a directory which lists the available emergency checklists. Using the annunciator panel and the directory, the team should be able to quickly determine which checklist to use for the indicated emergency. Once Mission Control locates the checklist, they need to discuss it with the flight crew to make sure everyone agrees it is the correct checklist to use. The Mission Director should always make sure this agreement occurs before proceeding.

In our previous example, there is a potential fire in AV BAY 1 and AV BAY 3. This information along with the directory will lead the team to checklist **12B Smoke or Fire in AV Bay**, page 12 of the Emergency Procedures checklist manual. The first action in the checklist (step 1) is to confirm the alarm and determine the location of the fire. Generally, the team will want to isolate the off-nominal system and only work on that system. Our data values show that only Bays 1 and 3 have off-nominal values, so we will only use the checklist for those areas. Once a checklist is started, the team must run it completely through otherwise the alarm may occur again. Since checklists may turn off the affected system, the alarm could clear as the system is no longer active. However, this system may be activated at a later time, which would cause the alarm to re-occur. In our current checklist, the last action (step 6) is to land as soon as practical. This is a forced abort procedure as a fire, even after being extinguished could have cause significant damage to the orbiter. The team should always discuss the possibility of an abort call during and after an emergency. In many cases, calling an abort is the proper conclusion to an emergency. However, make sure the team discusses the reasons for why an abort is the proper call and agree on the call. The Mission Director and Mission Commander have the final call with the Mission Commander making the ultimate decision. Once the team decides to abort, the decision must be made as to which abort to implement. The type of abort to perform is determined by where you are in the flight and what emergency caused the need for an abort. The four possible Shuttle aborts are:

- Return to Launch Site (RTLS)
  - This abort would occur between Launch and T+00:04:20 (Negative Return) and the Orbiter would be flown back to Runway 33/15 at the Kennedy Space Center
- Trans Atlantic Landing (TAL)
  - This abort would occur between T+00:04:20 and T+00:07:30 (approximate) and the Orbiter would be flown to one of the designated landing sites in Europe/Africa. The standard TAL sites are Moron Spain, Zaragoza Spain and Istres France
- Abort Once Around (AOA)
  - This abort would occur after T+00:07:30 (approximate) and before entering orbit. The orbiter would be configured for re-entry and the required re-entry burn would occur shortly after the abort is declared. The “normal” landing site for an AOA is either Edwards Air Force Base in California or White Sands in New Mexico.
- Abort to Orbit (ATO)
  - This abort would occur after T+00:07:30 (approximate) and if the orbiter could enter into a stable orbit. Once in stable orbit, the decision can be made to continue the flight or return home based on mission requirements.

Chapter 1.8 – Training for Emergencies

Intermediate Emergencies

Intermediate emergencies are ones that can be solved with the Emergency Procedure checklists but may also require the use of the Shuttle Schematics and other documentation available to the Mission Control team. This level of emergency may contain multiple alarms or cascade failures which could require the use of schematics to determine the root cause. Familiarity with the Emergency Procedure checklist and the Shuttle Schematics are important to the proper handling of the intermediate level emergencies.

Advanced Emergencies

Advanced emergencies will only be encountered during the finals of the Flight simulation event and they can come in many, perhaps devious, forms. Past emergencies of this type have included everything from flight personnel changes, space debris and large multi-step failures. Due to the complex nature of advanced emergencies, it can be very difficult to prepare for these. As with all emergencies, the best method to solving the problem is to remain calm and break the emergency down into manageable sections. Then work on the sections in a prioritized order and get input on the solution from all team members.

Tips for Solving Emergencies

Many steps go into solving a flight emergency and while the complexity of the emergency will influence the number of steps needed, remember that a good understanding of the overall process is essential.

Communication – this is essential to resolving all flight emergencies as well as running a successful simulation. Make sure all team members participate in the problem solving.

Understand the Problem – Discuss the problem with all team members to reach an understanding of what the presented data is telling you. Remember there is a limited time to resolve flight emergencies, but a good understanding of the problem based on the indicated data is vital to a successful resolution.

Be Observant of Data Displays – When an emergency occurs, vital data may be displayed in many different areas at the same time and some data may be replaced by other emergency-related data as the event evolves. While time is of the essence in emergency resolution, the team needs to be very observant of the Pilot and Flight Engineer data panels as these tend to update during emergencies.

Make a Plan – Once the team understands the problem, make a plan to resolve the problem and include what documentation (emergency checklists, schematics, annunciator panel, switch panels) is needed by Mission Control. Study the available Mission Control documentation and be familiar with the schematics and the interactions between systems. Review the schematics to see what could fail and how it might present itself during an emergency.

Simplify the Resolution Process – If the problem is large (multi-step or cascade emergency), break the issues down into more manageable steps and divide the work among all team members. Assigning tasks help speed the problem solving and lets more eyes review the documentation and display panel data. Even though the Flight Crew doesn't have the manuals, they have cockpit knowledge and the switches available for review. Many times a switch panel review by the flight crew provides vital information to the problem resolution.

Follow Through on your plan – If the team uses an emergency checklist during the event resolution, make sure you complete the checklist to the end. If a switch or system is determined to be faulty and turned off, remember which it was so it is not turned back on later in the flight. Many teams use a physical indicator placed on the switch as a reminder, such as a rubber band, hair band, paper clip, etc.

Abort – The last item of an emergency plan needs to be a discussion on the possible need to abort the flight. If a malfunction persists and cannot be fixed by the team, you must abort. If the system in error is still redundant even with part of it shut down, then the flight could possibly continue, but it needs to be discussed. If the team ignores the emergency, then the Flight Director will initiate an automatic abort. The Mission Director and Mission Commander have the final decision on an abort call, with the Mission Commander being the ultimate decision maker.

Communicate, communicate – Communication among the team is the first and last piece of successfully resolving an emergency. It is the most important tool available to every member of the team. Remember, handling an emergency is a group problem solving exercise and it can not be successful without good communication. Remember the adage **If you see something, say something**! If a team member notices an off-nominal item, speak up and tell everyone. While it might not have any relevance to the emergency, it could be the one vital item that leads to a success resolution and save the flight. Don’t be shy to speak up!

<u>Ways to Practice for an Emergency</u>

Use a printed Annunciator Panel and have an observer or coach select an emergency. The team can then use checklists, schematics and other mission control documentation to resolve the problem. When the team satisfies the observer/coach with their solution, the problem has been resolved. The good part of this system is you don’t even need your computers to practice emergency resolution. As the team gets more familiar with the documentation, the observer/coach can set a time limit on a successful resolution. This will add a level of stress to the exercise and make success all the more enjoyable. An alternate version is to create a set of flash cards with an emergency and time limit listed and have a team member randomly select one.

O_2 PRESS	H_2 PRESS	SMOKE / FIRE	LANDING SYS	FUEL CELL TEMP
CABIN ATM	H_2/O_2 HEATER TEMP	MAIN BUS VOLTAGE	AC VOLTAGE	AC O/U LOAD
FREON LOOP	AV BAY / CABIN AIR	IMU	RCS FWD	RCS JET
H_2O LOOP	SRB LEFT	MAIN ENGINE LEFT	RCS LEFT	RCS RIGHT
PAYLOAD BAY	SRB RIGHT	MAIN ENGINE CNTR	OMS LEFT	OMS RIGHT
PAYLOAD	GPC	MAIN ENGINE RGHT	NAV SYSTEM	OMS TVC
ALARM	APU TEMP	APU SPEED	H_2O SPRAY BOILER	HYD PRESS

Use the Generic Emergency Data Panels - To assist in training for in-flight emergencies without having to modify the PowerPoint slides each time, we have created a generic emergency

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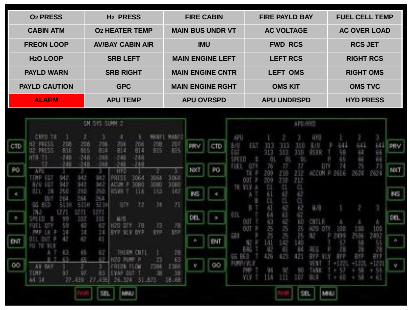
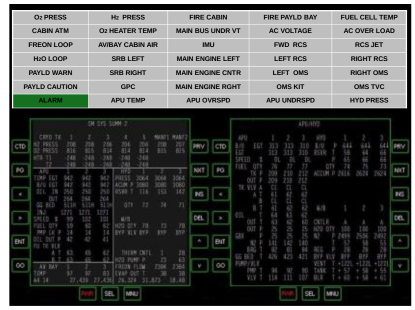
PowerPoint routine - Flight Engineer Data Panels - Generic Emergency. This process will allow a coach to easily decide upon any emergency for their team and let them run through the emergency checklist process to resolve and clear the problem.

The generic emergency PowerPoint slides are based on the latest version of the Flight Engineer Data Panels with the addition of three slides (41, 42 and 43) representing the emergency. The three additional slides have the annunciator panel set to gray to easily identify them as the emergency panels. The first two panels (41 and 42) have the ALARM light in red, indicating a system problem.

Panel 41



Panel 42



Panel 43

The first slide (41) will set the ALARM to red and sound a klaxon alarm to get the flight crew's attention, the second slide (42) will set the ALARM to red and silence the alarm klaxon and the third slide (43) will reset the system to normal (green ALARM light). These slides follow the 'primary orbit' slide and are activated when the Flight Engineer (FE) advances the PowerPoint from the 'primary orbit' slide. (**Note:** Emergencies in the competition may occur at any time during the mission.)

Primary Orbit

To use this routine, the coach will decide upon an emergency and inform the flight crew. When the FE advances the PowerPoint slide from the primary orbit display (by pressing the 'space bar'), the first emergency slide will appear and the klaxon will sound. At this point the team will proceed to the emergency checklist for the problem determined by the coach. The FE will silence the alarm by pressing the 'space bar' and the team will run the checklist performing the designated tasks to isolate the problem. Once the checklist is completed, the coach can decide if the team was successful in clearing the problem. If the team was successful, then the FE will press the 'space bar' to advance to the 'all clear' slide (green ALARM light, slide 43). If the coach determines that the crew did not resolve the problem, the emergency can be resumed by pressing the 'back or left arrow', which will return to slide 41 and sound the klaxon again. This process can be repeated as many times as necessary for the team to successfully isolate and correct the problem. Once the system is on the 'all clear' slide, it will automatically advance to the 'primary orbit' panel after 30 seconds and the flight can continue as normal with the FE returning to the normal flight checklist.

There are several advantages in using this generic process for emergency training:

- the coach can decide on any emergency including ones that don't have a standard checklist;
- a designated team alternate (preferably not Mission Control or a Flight Crew member) can perform the coach's function and determine the emergency;
- the FE data panels do not need to be modified for each emergency;
- emergencies can be repeated quickly and easily to allow the crew to become very familiar with the emergency checklists and process.

Emergency Documentation

During a flight simulation mission, the only documentation the flight crew will have is the Mission Checklist – Kneeboard checklist, however the mission control team will have the following documentation available:

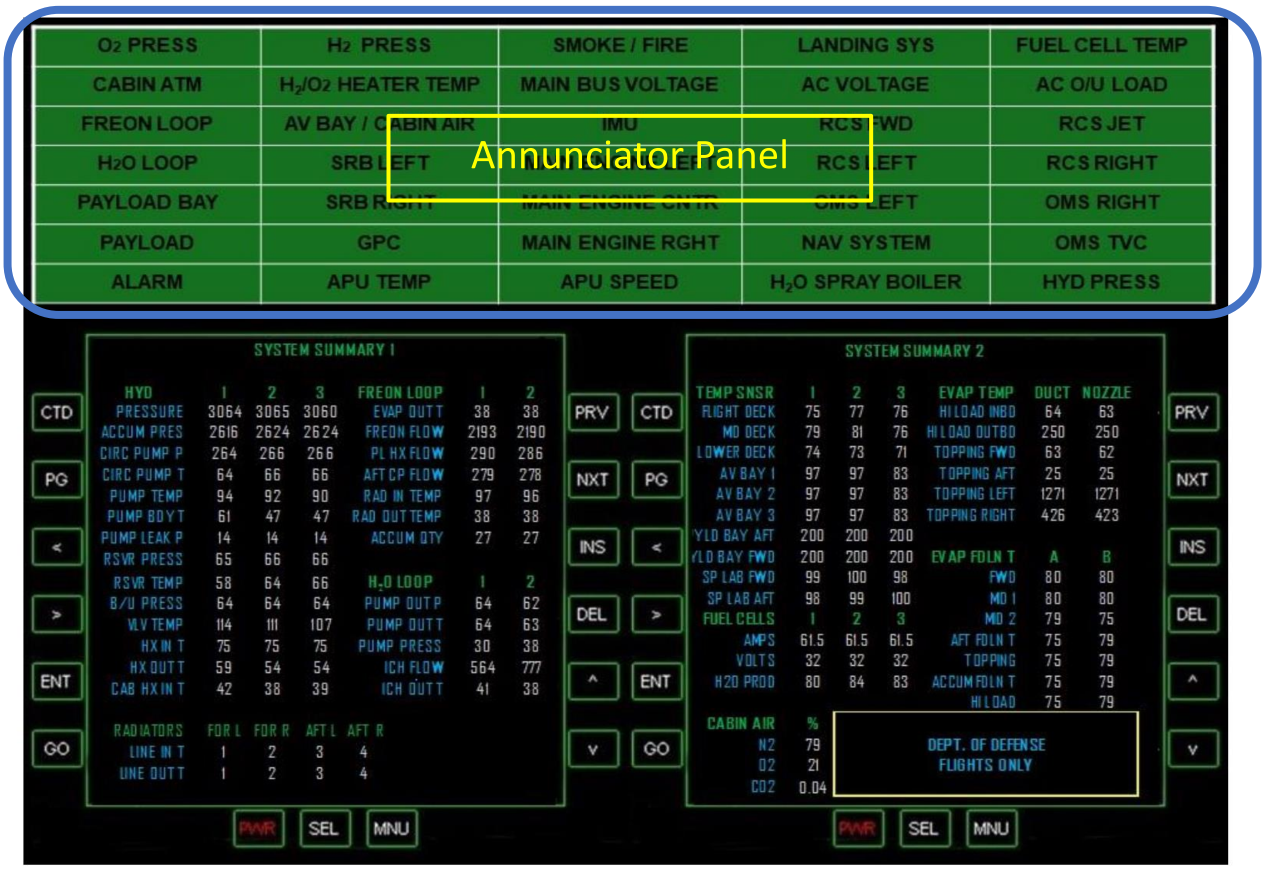
- Mission Checklist – Simulation checklist
- Emergency Procedures
- Flight Engineer Switch Panel Layouts
- Shuttle Annunciator Panel Schematic
- Shuttle Switch Panel Layouts
- Space Shuttle System Schematic Directory

The **Emergency Procedures** manual provides step-by-step resolutions to some common emergencies that can happen in any flight. To successfully resolve any emergency, the team must identify the system and sub-systems that are in an off-nominal condition using indicated data values and messages. Once the off-nominal systems are identified, the team needs to check the Emergency Procedures manual and determine if it covers the current emergency. Using the Emergency Procedures manual:

- Verify the malfunctioning system(s) and only concentrate on those systems
- Run the checklist for just the malfunctioning system(s)
- Once a checklist is started, the team must complete the entire checklist
- When the specific switch that resolves the issue is determined, the team needs to remember which it is
- A suggestion is to mark the identified switch in some manner, like a rubber band or clip
- The last step of an emergency resolution should always be to have an “abort or not abort” discussion
- Once the emergency is resolved, the flight engineer needs to resume the flight at the checklist location the team was at when the emergency occurred.

The **Flight Engineer Switch Panel Layouts** and **Shuttle Switch Panel Layouts** are exact diagrams of the switch panels in the simulator cockpit. The mission control team can use them to assist the flight crew in identifying where specific switches are located. During an emergency they can be useful to locate switches that interact with the off-nominal system and may point the team towards a resolution of the emergency condition. The Flight Engineer **Virtual** Switch Panel Layout shows all the switches contained in FE switch panel 8, the virtual switches contained in the shuttleswitches.com display. The shuttleswitches.com website is a virtual switch panel that displays additional flight engineer switches related to the SAC flight simulator Main Propulsion System (MPS), Orbital Maneuvering System (OMS), Reaction Control System (RCS) and Electrical System. The switches can be changed by mouse-click or touch if you have a touch screen system. These switches are predominately used during intermediate and advanced emergencies. Be aware that the shuttleswitches.com website is an open system and may be accessed by many people at once. When you are training with the site, don't be concerned if some of the switches change as other teams may also be training. The shuttleswitches.com program used by the SAC flight simulator is a dedicated version and is only used by the simulator.

The **Shuttle Annunciator Panel Schematic** manual describes the emergency annunciator panel contained on the flight engineer data panel and defines all the systems displayed in the warning light blocks.



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O2 PRESS	H_2 PRESS	SMOKE / FIRE	LANDING SYS	FUEL CELL TEMP
CABIN ATM	H_2/O_2 HEATER TEMP	MAIN BUS VOLTAGE	AC VOLTAGE	AC O/U LOAD
FREON LOOP	AV BAY/CABIN AIR	IMU	RCS FWD	RCS JET
H_2O LOOP	SRB LEFT	MAIN ENGINE LEFT	RCS LEFT	RCS RIGHT
PAYLOAD BAY	SRB RIGHT	MAIN ENGINE CNTR	OMS LEFT	OMS RIGHT
PAYLOAD	GPC	MAIN ENGINE RIGHT	NAV SYSTEM	OMS TVC
ALARM	APU TEMP	APU SPEED	H_2O SPRAY BOILER	HYD PRESS

The mission control team can use this manual to look up the meaning of the system displayed in the panel in either a yellow (warning) or red (alarm) condition. The definition may direct the team towards the system fault causing the alarm. If the OMS LEFT light was lit (yellow or red), the team would find the following definition:

> OMS LEFT: Indicates detection of a left OMS pod oxidizer or fuel tank ullage pressure out of limits, or an engine abnormal (OMS engine fail to cutoff, fail to ignite, or early shutdown) condition.

The **Space Shuttle System Schematic Directory** provides detailed schematic diagrams of the major orbiter systems. A schematic diagram is a drawing intended to explain how something works by showing the relation between the parts. The Space Shuttle System Schematic Directory is a collection of schematic diagrams of space shuttle systems that provide detailed information to the teams to assist in resolving emergency situations. While these schematic diagrams are based on NASA system schematic diagrams, several have been modified to match the way the SAC flight simulator was constructed. The main changes are reducing the number of the valves and simplifying some of the redundant systems.

In the schematic diagrams, every valve listed has a corresponding switch in the SAC flight simulator, either physical or virtual. This gives the team the ability to control, isolate and re-route parts of a system. Generally, the valve switches names are acronyms based on the valve names. In the example below, the **OVIV** switch controls the **O**xidizer **V**apor **I**solation **V**alve in the schematic. Likewise, the **ORV** switch controls the **O**xidizer **R**elief **V**alve in the schematic.

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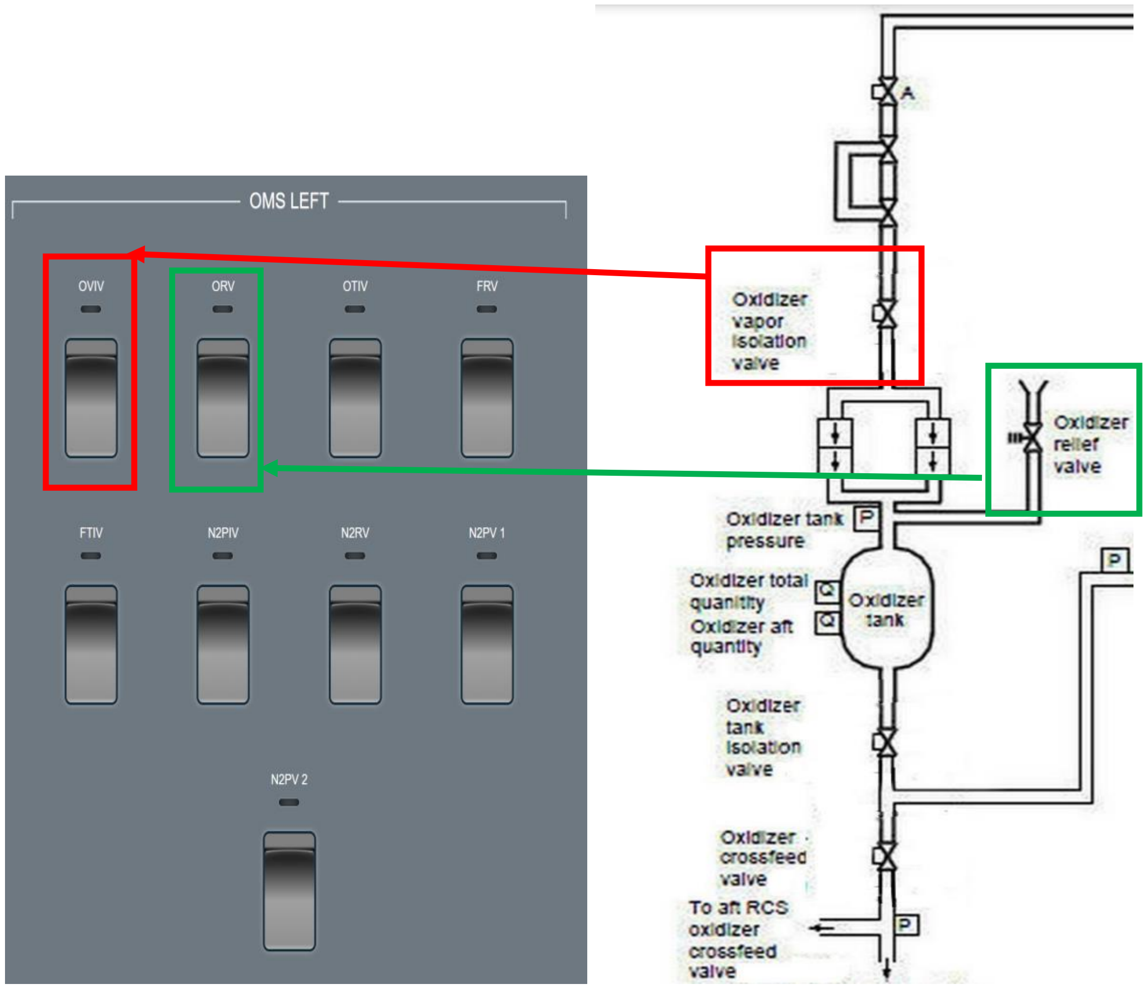
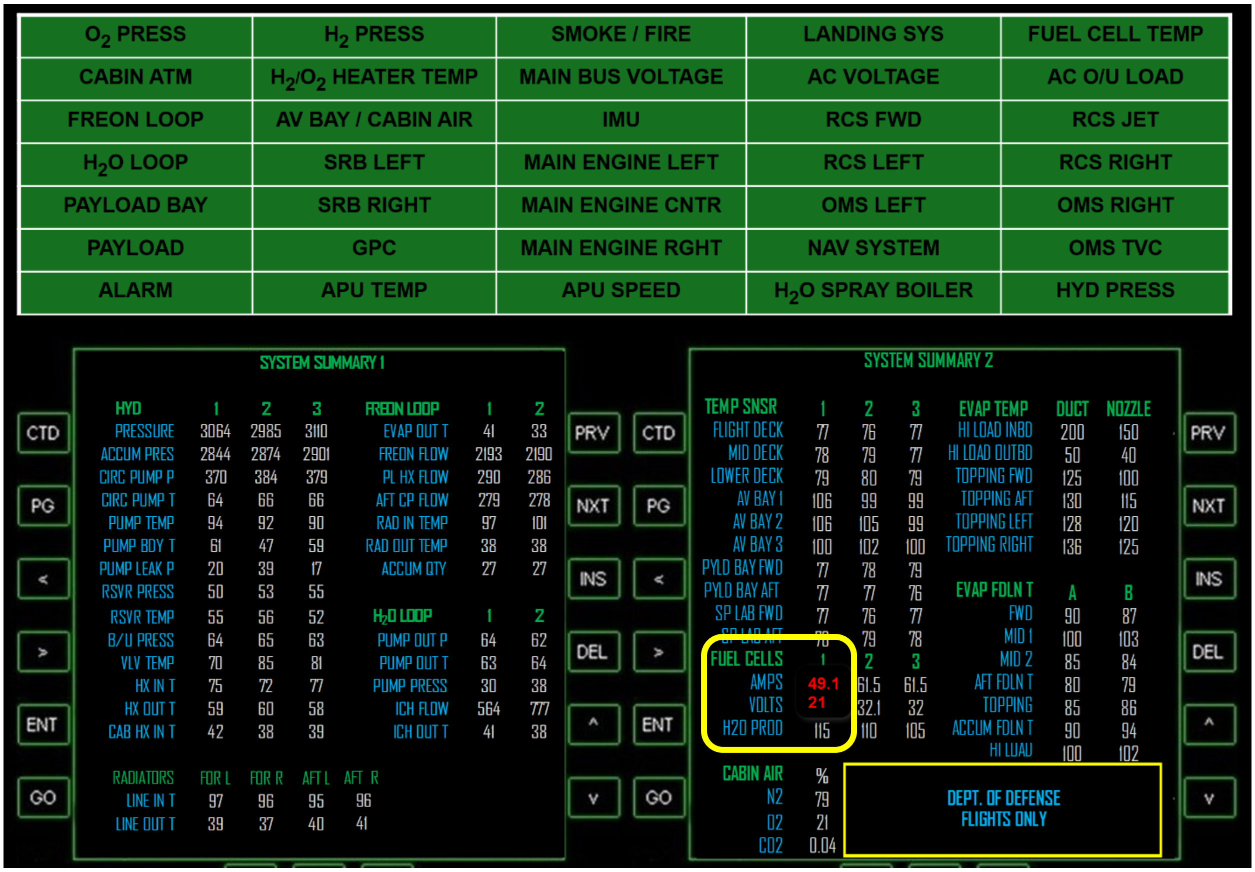


A schematic diagram represents a system in a simple, easy-to-understand way to show how the different components or sub-systems are connected and interact with each other. A primary use of schematics is to help identify the source of a problem and provide a means for the team to resolve an issue with the system or sub-system. This information will allow the active emergency to be corrected and return the orbiter to a safe flight environment. Additionally, the schematics can help the team decide if an abort is a necessary resolution of the emergency.
The teams need to study the schematic diagrams to get a good understanding of how the primary shuttle systems work and interact with each other. By knowing the schematics the teams will be able to dissect an emergency quicker and hone in on the specific parts (valves, switches, electrical, etc.) that are the possible source of the emergency and how they can be isolated from the functioning part of the system.

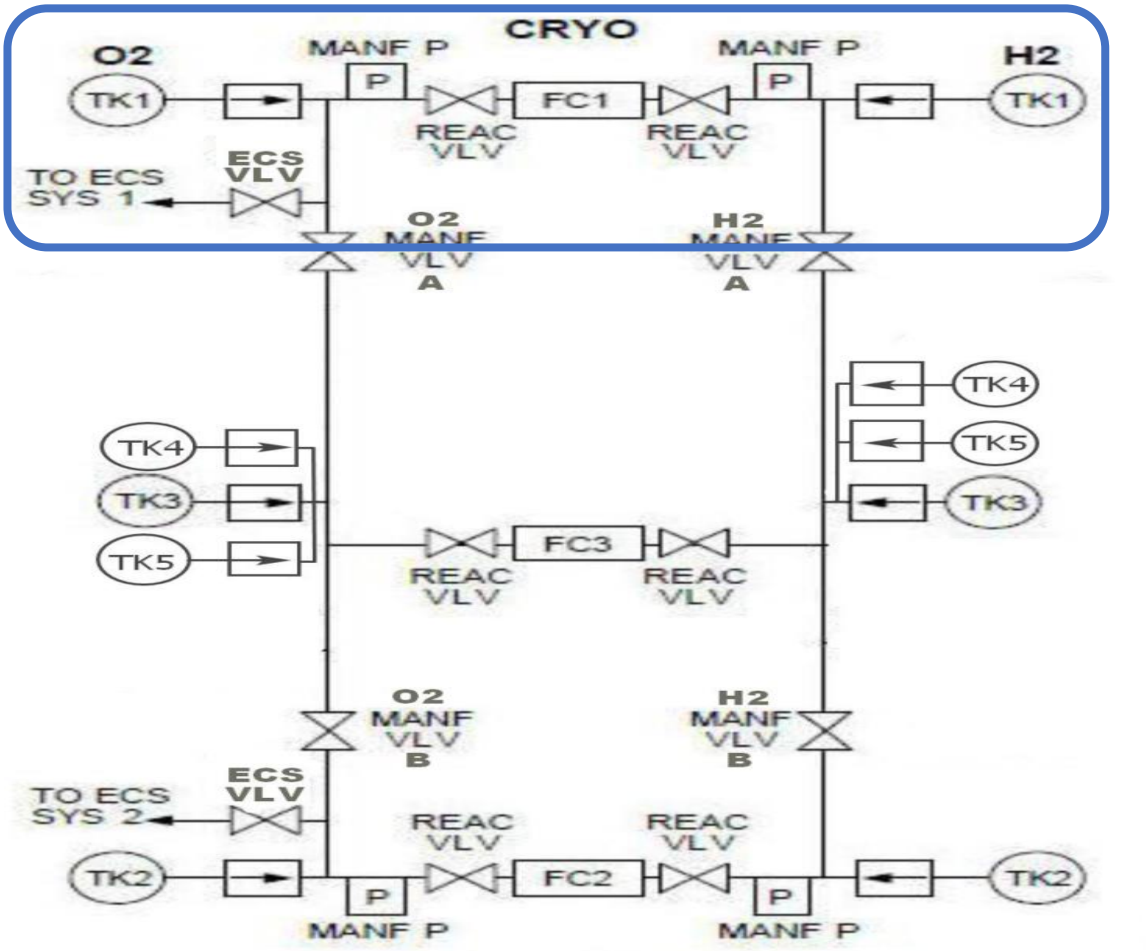
<u>Using the schematics</u>

The flight engineer panel displays off-nominal values for Fuel Cell #1.



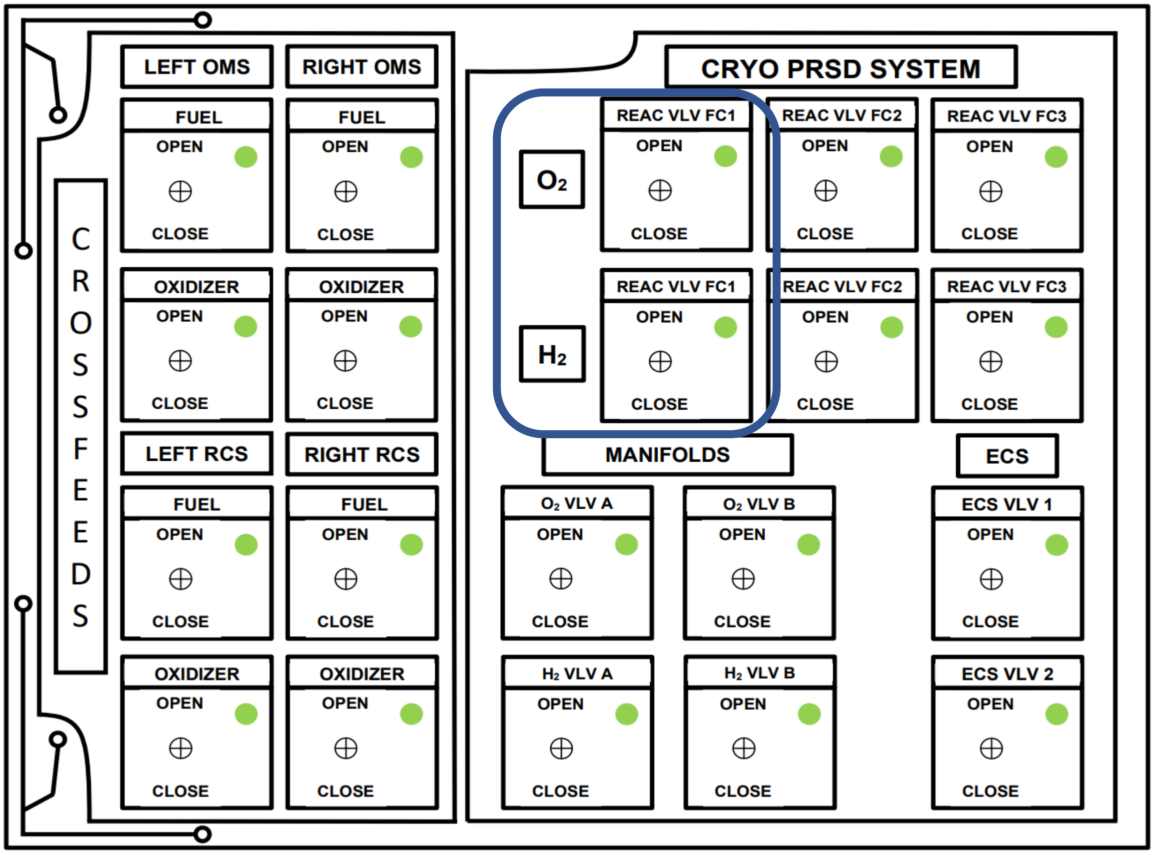
Since fuel cells are not covered by the Emergency Procedures manual, the team should locate the fuel cell schematic (Cryogenic Power Distribution System – PRSD System, page 16) and review how Fuel Cell #1 integrates into the entire system. If the team determines the solution to the issue will be restarting Fuel Cell #1, they need to determine how to accomplish that task by reviewing the schematic diagram.

Cryogenic Power Distribution System Schematic

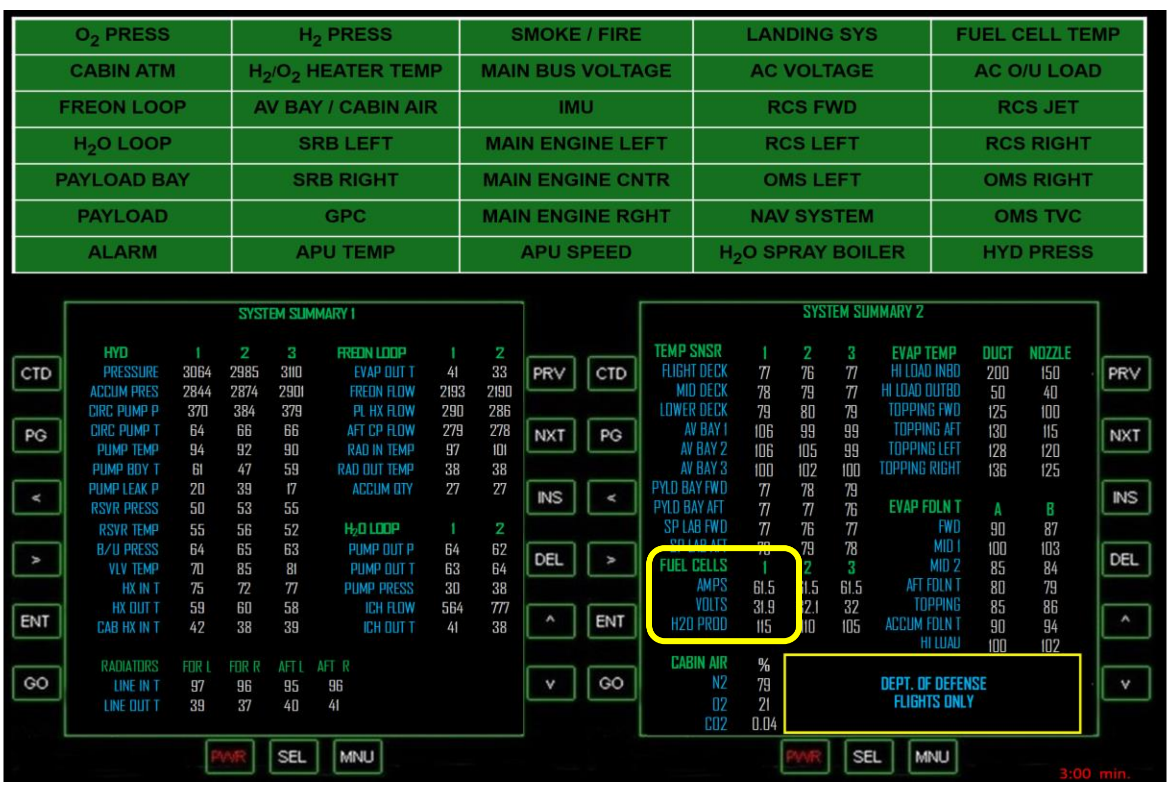


PRSD System

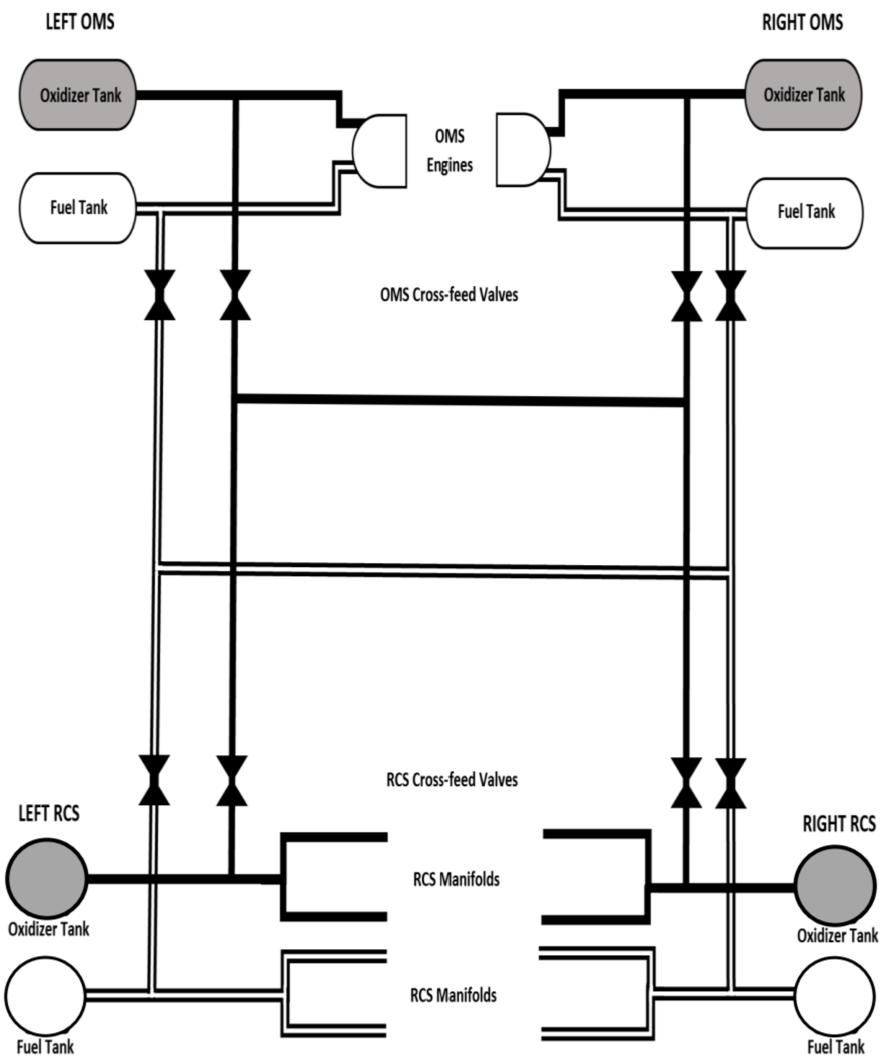
Since the “normal” way to restart a system is simply to turn it off and then back on, the team needs to determine how best to accomplish that. From the schematic, the fuel cell is powered by hydrogen (H2 TK1) and oxygen (O2 TK1) through their respective reaction control valves (REAC VLV). To shutdown fuel cell #1, the team will close both REAC VLVs and then to restart fuel cell #1, they will open both REAC VLV. This is done using the CRYO PRSD SYSTEM switches on the flight engineer panel 9, specifically the O2 REAC VLV FC1 and H2 REAC VLV FC1. Setting the switches to CLOSE (down) and then to OPEN (up) will restart the fuel cell #1.



The team should then verify that the fuel cell #1 data values are back to nominal.



One example of the system interactions is the OMS-RCS Cross-feed system. This is a system of valves and pipes that connect the fuel and oxidizer systems for both the OMS and RCS systems. This connection will allow the sharing of fuel and oxidizer between the two systems. Reference the OMS and RCS Cross-feed Valves schematics (page 12).



OMS and RCS Cross-feed Valves

Note: OMS and RCS Tank Isolation and Manifold Isolation Valves not shown

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I HAVE NEVER LOST AN AMERICAN IN SPACE, SURE AS HELL AREN'T GOING TO LOSE ONE NOW. THIS CREW IS COMING HOME. YOU GOT TO BELIEVE IT. YOUR TEAM MUST BELIEVE IT. AND WE MUST MAKE IT HAPPEN.

Gene Kranz

Message to flight controllers after the Apollo 13 explosion

Chapter 1.9 - Flight Simulator Common Issues

Through the many years of the Student Astronaut Challenge Flight simulation events, the staff has noticed certain common issues that keep occurring with both new and experienced teams. What follows is an accumulated list of these observations. The "problem" is listed first followed by an explanation or suggestions for correcting it.

General Observations

These are "problems" that both the flight crew and the mission control team have experienced over the years.

1. Using data points that are not known by all team members - When doing telemetry checks, use data points that are known to your team members. During the competition is not a good time to surprise someone with a telemetry check on a new data values.
2. Not knowing the location of a data point - If you are asked for a telemetry check and you do not know where that data value is located, ask a team-mate for its screen location. There are no points lost for asking the location. This is actually a good example of communications and team work.
3. Being repetitive on the telemetry data points checks – Don't use the same data point checks repeatedly, use many different ones. Some important ones can be repeated often, such as fuel status during ascent, but don't lose sight that there are hundreds of data values that can be checked.
4. Incorrectly naming a data point – Use the correct terminology for data points and switch terms (example: CIRC is circulation, not circular). Refer to the SAC Glossary if you are not sure what the abbreviation means.
5. Checking non-existent data points - Don't do telemetry checks on non-existent data points (example: don't check SRB fuel status after SRB separation)
6. Over-used or inappropriate humor - Some levity and humor is acceptable, but do not go overboard - be "professional"! Remember that the flight may be displayed with audio on the jumbo-tron.
7. Ignoring an abort possibility - After resolving an emergency, discuss whether to abort/not abort and include rationale for decision.
8. Ignoring an error or mis-information - Always speak-up if you recognize an error or missing information (don't be tentative). You may see the one item that will resolve an emergency.
9. Not knowing what would be nominal for data values - Understand the range of values for systems so if a data point is not normal, you will know if it is still within an acceptable range (i.e. a nominal value)

Flight Simulator team

These are "problems" that are more specific to the flight crew:

1. Getting ahead of the block or time – do not start another time block until the indicated time has occurred. One exception to this is during the gauntlet (T+00:09:00 –

T+00:11:00) where you can continue on regardless of time until you get to through block 22. The other exception is during "Mission dependent" time blocks. You can continue through these if it makes sense to the current mission status. In general, Mission Control will call time blocks so pay attention to them for timing clues.

2. Uncertain about switch location – study, study, study. If is very helpful, especially during the gauntlet, to know all your switch locations.
3. Not listening to the FE - Make sure you listen to the Flight Engineer and follow all their commands. Make sure you check the other person performing an FE command for switches.
4. Missing the Radar initiation time - The Flight Engineer **must** start Radar (PRIMARY SYSTEM RADAR to ON) at **exactly T-4:00 minutes**
5. Missing the Launch exec time - The Mission Command **must** execute the Launch command at exactly T-00:00:04
6. Not completing the gauntlet on time - The flight crew needs to practice the T+9:00-11:00 Time gauntlet to become proficient enough to make the time limit.
7. Missing the Zero-up maneuver - The Mission Commander **must** understand what "zero-up" (manual prograde (needs to be at 0,0,0)) means and how it looks. Commanders, you can see what the zero-up position looks like by starting Orbiter in space and pressing the Prograde button along the bottom of the screen. Also you can check the Landing Manual on the website.
8. Failure to follow the de-orbit burn procedure - Make sure you follow the De-orbit burn procedure relayed to you by Mission Control.
9. Hard landing – practice landing and remember to flare up so the orbiter can use the air cushion to smoothly touchdown.
10. Missed landing on the runway – practice, practice, practice
11. Ran off the runway – monitor landing speed and location on the runway
12. Telemetry checking within the orbiter (not verifying telemetry with MC) - All telemetry checks are between the flight crew and Mission Control. Telemetry checks can be initiated by either group – flight crew or Mission Control.

Mission Control team

1. Inconsistent on calling T-minus and T-plus minute marks – make sure you call all the comm/time blocks. Once the time becomes Mission Dependent, call the comm block and the MET time.
2. Missed T-10 second countdown – make sure to give the flight crew a T-10 second countdown to launch.
3. Missed T-4 second Execute confirmation – confirm that the Mission commander did execute the launch command at T-00:00:04
4. Did not start Mission Elapsed Time clock – Mission Control **must** start the MET clock (count-up)

Chapter 1.9 - Flight Simulator Common Issues

5. Getting ahead of the block or time – when calling comm/time blocks don't rush or get ahead. Wait until the correct time occurs.
6. Calling events before they occur – be careful on calling events before they complete, especially orbiter events like prograde, retrograde, Zero-up. Give the orbiter space craft time to complete before proceeding. During Payload Bay door open/close, let each item complete (watch the status display on the FE panels).
7. Did not confirm "Zero Up" (manual prograde) or called when did not occur – again, make sure an event completes before calling it. If the flight crew tries to proceed before an event completes, request they wait.
8. Failed to follow De-orbit burn process – Mission Control runs the entire de-orbit burn procedure, the Mission Commander only advances/retards the throttle. The de-orbit procedure is:
    - Flight Director will inform the Mission Director of the burn time duration (usually before the flight simulation begins)
    - The de-orbit burn procedure must start within 1 minute after beginning Comm Block 35
    - The Mission Director will inform the flight crew of the burn time duration
    - The Mission Director will give the Mission Commander a 10 second countdown to burn initiation
    - The Mission Director will give the Mission Commander a 10 second countdown to burn termination
9. Failed to call altitude and ground speed on landing – be aware of the altitude and airspeed during orbiter landing. Mission control is responsible for communicating them to the Mission Commander. These calls are considered general announcements and the normal communication format does not need to be followed. When calling altitude and airspeed, insert the actual data value from the orbiter screen (not the word altitude or airspeed). You can also abbreviate the call to "Altitude 20 kilometers, airspeed 820". Since altitude was named, everyone knows the other value has to be airspeed in m/s. It is suggested to call the Altitude/airspeed every 5K until the orbiter hits 10K and then start calling them every 1K.
10. "Dead" air – dead air is when no one is talking and only the 'space' buzz can be heard. Some dead air is good, but not too much as it could be a loss of comms. Telemetry checks are a great way to fill dead air.
11. Inconsistent communication format – make sure you maintain the proper communications format: Who do you want to talk to; Who is speaking; what do you need.
12. Failing to recognize screen prompts – be cognizant of the pilot panel blue box data and the pilot panel upper left corner message box. This is real-time data.
13. Failed to monitor fuel status – During the ascent stage, fuel is critical, so checking the SRB and SSME fuel status is vital.
14. Failure to visually verify data points with other MC personnel - Verify telemetry data points by pointing them out to the other Mission controllers.

Chapter 1.9 - Flight Simulator Common Issues

THE SCENERY WAS VERY BEAUTIFUL. BUT I DID NOT SEE THE GREAT WALL [OF CHINA].

Yang Liwei

China's first astronaut (taikonaut) on his inability to see The Great Wall of China from space, which has often been said to be visible.

October 2003

Chapter 1.10 - Creating a Custom Orbiter 2010 Scenarios

In the Orbiter program, each run is controlled by a scenario selected in the Orbiter Launchpad Scenario tab. Orbiter comes with pre-programmed scenarios for selected common flights, such as launch, landing and in-orbit flights. These standard scenarios allow for immediate use of the Orbiter program and allow for a quick beginning to training practice. While the standard scenarios will provide excellent flight characteristics and training, there are additional flight parameters that will enhance the realism and training capabilities of the scenario. Fortunately, the Orbiter program will allow the standard scenarios to be modified and saved for repeated use. Some reasons for creating a custom scenario would be to add functions not provided in the standard scenario; to create a scenario that started at a new point in the flight other than launch or landing; or to save certain repetitive setup sequences to make starting a training flight easier. Since Orbiter lets you make and save changes to an active scenario, you can create your own modified scenarios that will setup Orbiter the same way each time.

In the Student Astronaut Challenge Flight Simulation competition, we routinely utilize two custom scenarios – one replacing the normal launch scenario and the other replaces the normal landing scenario on runway 33. Other custom scenarios are used in different parts of the flight simulation, in particular some emergency scenarios. The SAC custom launch scenario is based on the **Launch into Sunrise** default scenario modified to save some repetitive changes needed for each launch run. The SAC custom landing scenario is based on the **Atlantis Landing Preparation** default scenario modified to add the Horizontal Situation Indicator (HSI) function used for instrument landing situations. This custom scenario programs the HSI to the Kennedy Space Center VOR and Runway 33 frequencies.

Useful Launch Scenario modifications

There are a few additional settings you might want to make to create your custom Launch scenario. These additional setting changes will help simplify your training process.

Programming additional Orbiter settings:

1. Start Orbiter and the “Launch into Sunrise” scenario
2. Press **F1** to change to the inside cockpit view.
3. Repeatedly press **[CNTL] + X** to zoom out the cockpit view until you see the tips of the Solid Rocket Boosters.
4. Press **I** to turn off the extraneous information displays in the upper-right corner.
5. Press [**Exit**]
6. When the Orbiter host screen returns select the [**Save Current**].
7. Under Scenario name type in **“Launch”**. This will allow you to start the launch scenario each time with the correct HUD already set up.

Useful Landing Scenario modifications

Orbiter Instrument Landing Displays

Chapter 1.10 - Creating a Custom Orbiter 2010 Scenarios

The Horizontal Situation Indicator (HSI) combines the directional gyro and the NAV indicator into one instrument that provides heading, course reference, and course deviation and glide slope information. The HSI makes it easier to visualize the aircraft's position with reference to the selected course.

- **VOR:** surface-based omnidirectional radio beacons, typically with a range of several hundred kilometers. VOR signals can be fed into the HSI (horizontal situation indicator) to obtain direction and distance to the designated runway. In Orbiter the VOR for the Kennedy Space Center is used.

- **ILS:** Many runways are equipped with Instrument Landing Systems to provide specific heading and glide slope information and are provided by the HSI. In Orbiter the ILS for Cape Canaveral runway 33 is used.

When using the “Atlantis Final Approach” program in Orbiter, the VOR for the Kennedy Space Center and Runway 33 will be already configured in the HSI. In the orbiter when running the “Atlantis Landing Preparation” program (competition landing scenario) neither the VOR or ILS has been programmed into the HSI.

When properly programmed, the VOR for KSC will be received immediately and the ILS for Runway 33 will be received 30 kilometers from the runway. In the competition this has been set up for you in the simulator therefore it is recommended you practice with it under similar conditions. Orbiter does allow you to program your HSI and save the scenario so that it will be pre-programmed each time you practice your competition level landings.

Programming the HSI Multi-Function Display for Orbiter:

1. Start Orbiter and select the “Atlantis Landing Preparation” scenario
2. Once the program opens immediately hit the **F4** key
3. Quickly select **[Time Warp**] and a “Time Acceleration” window will appear.
4. Select [**0.1x]** time acceleration. This will slow the program down so you can modify the HSI without losing too much altitude.
5. Press **I** to turn off the extraneous information displays in the upper-right corner.
6. Turn on the Left MFD by selecting [**PWR**]
7. Then hit the [**SEL**] until you see the COM/NAV mode on the right side of the panel.
8. Select [**COM/NAV**]
9. Navigation 1(NAV1) will be in yellow showing 108.00 MHz, use the arrow key on the left side of the MFD to change the receiver to 134.20 MHz, which is runway 33 at Cape Canaveral. This is the **ILS** frequency.
10. The **[<< or >>]** keys change by +/- 1.0 MHz and the **[< or** >] keys change by +/- 0.10
11. Select [**SL+**] to switch to navigation 2 (NAV2). Using the arrow keys, on the left side of the MFD, change the receiver to 112.70 MHz which is the frequency at which the Kennedy Space Center is broadcasting. This is the **VOR** frequency.

12. Select the [**SEL**] and then when the Mode screen returns, select [**HSI**].
13. Select the [**LR**] and then [**NAV**] on the left side of the HSI MFD to ensure you have both NAV's visible. NAV 1 will have no signal but will show 134.20 MHz, NAV 2 will show VOR KSC at 112.70 MHz.
14. Immediately hit [**Exit**] (it is not necessary to exit time warp)
15. When the Orbiter host screen returns select the [**Save Current**].
16. Under Scenario name type in **"Landing"**. This will allow you to return to the landing scenario each time with the correct HSI already set up.

You may have to practice several times until you get the hang of the settings. Once you complete it and have sufficient altitude to practice you will save it. If you make a mistake after saving just repeat the procedure and save with the same name format and it will over-write the last saved program.

ANYONE WHO SITS ON TOP OF THE LARGEST HYDROGEN-OXYGEN FUELED SYSTEM IN THE WORLD, KNOWING THEY'RE GOING TO LIGHT THE BOTTOM, AND DOESN'T GET A LITTLE WORRIED, DOES NOT FULLY UNDERSTAND THE SITUATION.

John Young

Space Shuttle flight STS-1

1981

section two –

space shuttle landing simulation challenge

Student Astronaut Challenge

Chapter 2.1 – Landing Simulation Challenge

The Landing Simulation Challenge is two rounds (including run-offs and finals) where team members, working in pairs, each perform one of three types of landings of the Space Shuttle Enterprise flight simulator and the operation and responsibilities of the Mission Commander and the pilot/mission controller. The Landing Simulation Challenge uses similar documentation as the Flight Simulation Challenge, but there is some enhanced documentation specific to the Landing Simulation Challenge:

- Landing Simulation Challenge Checklist – Classroom – A modified version of the landing phase checklist for the flight simulation event. The Classroom version details how to set up and run the Landing Simulation Challenge during team training and important information to remember.
- Landing Simulation Challenge Checklist – Simulation - A modified version of the landing phase checklist for the flight simulation event. The Simulation version is the one used during the competition.

Run-off Landing Simulation Challenge event

In the run-off event, the team will perform three landings by pre-assigned two-member teams, using the Landing Simulation Challenge simulator. Each team will pair up their six members into three groups, the selection of each group is up to the team's discretion. The order in which each group will fly in will be randomly assigned.

Mercury Division:

- During the landing event, one team member will fly the Simulator while the other team member will perform all other duties required by the checklist in the Procedures column. After their run they will switch places and repeat the simulation.
- There will be three different landing scenarios used for the Landing Simulation Challenge which are a standard KSC runway 33 landing during the day, a runway 33 landing at night and an instrument-only landing where only one team member will have full view of the simulator screen while the team member flying the shuttle will only have a view of the instruments.

Apollo Division:

- During the landing event, one team member will fly the Simulator while the other team member will perform all other duties required by the checklist in the Procedures column. After their run they will switch places and repeat the simulation.
- There will be three different landing scenarios used for the Landing Simulation Challenge which are a standard KSC runway 33 & 15 landing during the day, a runway 33 & 15 landing at night and an instrument-only landing 33 day where NEITHER team member will have full view of the simulator screen, only the instrument panel.

Finals Landing Simulation Challenge event

The Landing Simulation Challenge finals will be held in the Space Shuttle Flight Simulator cockpit and only the top three teams from the run-off will compete. Each of the finalist teams will select their finals team, however, **the groups that initially participated in the runoff must be**

maintained (you can't mix and match for the finals). Since there are only three teams competing, they will be sequestered during the finals event and each team will fly the same landing scenario, selected by the SAC staff. Additionally, the finals will be broadcast on the Jumbotron for the audience to view.

Hints

General

- Have all your team members practice landings since they are all performing the actual landing during the competition.
- Have all of your flight crew familiar with the note sections in the classroom checklist.
- Remind them to communicate during the event and not to fall into the "trap" of just watching the team member fly.

Instrument-only landing

- Study the Landing Information document for a good description on what it is and how to perform an instrument landing
- Configure the HSI MDF in Orbiter to provide the instrument landing flight gauges. Reference the Creating Custom Orbiter scenarios documentation. Knowledge of the HSI will assist in all landing scenarios.
- Have all your team members practice instrument only landing since they might have to perform the actual landing during the competition (it is randomly assigned).

Night landing

- A night landing is like an instrument-only landing though there may have some external visual indicators that are not present during an instrument-only. Knowing how to use the HSI is critical to a successful landing.

Resources:
The Student Astronaut Challenge will **NOT** provide any resources to teams to modify the orbiter program for evening scenarios or runway 15 approaches. The information to modify the program can be found in the reference material that comes with the program or online in many of the various Orbiter Forums and/or additional resources that are available.

Scoring
The flight teams are scored on how well they communicate throughout the landing process, perform their individual jobs and their knowledge and understanding of the landing process.

> IT SUDDENLY STRUCK ME THAT THAT TINY PEA, PRETTY AND BLUE, WAS THE EARTH. I PUT UP MY THUMB AND SHUT ONE EYE, AND MY THUMB BLOTTED OUT THE PLANET EARTH. I DIDN'T FEEL LIKE A GIANT. I FELT VERY, VERY SMALL.
>
> *Neil Armstrong*
>
> *Aug 16, 2019*

section three –

engineering challenge

Student Astronaut Challenge

Chapter 3.1 – Engineering Challenge

The Engineering Challenge is a hands-on challenge where students take on various roles to engage in an aerospace related scenario. Each year the challenge is redesigned to reflect unique roles, components, and goals. Rather than relying on predetermined skillsets and documentation, the challenge emphasizes communication, consensus building, and on-the-fly problem solving.

Students work as two (three-person) teams in which they decide which team member is best suited for each role. These roles are not assigned and can be switched among the students on a team as the challenges unfolds. However, one student from each three-person team must be designated as the point of contact for the purpose of interacting with the challenge staff during the scenario (e.g. requesting hints, asking clarifying questions). This designated team member is still allowed to assist with the challenges but are required to monitor communications at all times. If needed, they may transfer that responsibility to another team member temporarily.

Challenges vary by year and may include tasks that lead to a winning solution, or performance-based activities that accumulate points. Typically, a briefing will be sent one to two weeks before the challenge. This is meant to provide a general overview of the scenario without divulging challenge details. The briefing will also be posted on the website.

<u>Format</u>

- The team will have 45 minutes to progress through the scenario.
- The standard communications format will depend on the type of mission. This will be given to teams in a briefing before the challenge.
- While a scenario briefing will be available ahead of time. Most scenario details will only be available to the team once the challenge begins.
- **Apollo division** – 2 hints can be requested without point deductions.
- **Mercury division** –4 hints can be requested without point deductions.
- Judging criteria:
    - Communication
    - Teamwork
    - Professionalism
    - Complete tasks correctly
    - Complete tasks quickly

<u>Suggestion</u>

Since good communication is critical to successfully completing this challenge, it is recommended that the team plays the game "<u>Keep Talking and Nobody Explodes</u>". While this <u>is not</u> the challenge, it will help the team learn how to communicate effectively. It is an inexpensive game and there are many example videos on YouTube.

Chapter 3.1 – Engineering Challenge

TO BE THE FIRST TO ENTER THE COSMOS, TO ENGAGE, SINGLE-HANDED, IN AN UNPRECEDENTED DUEL WITH NATURE – COULD ONE DREAM OF ANYTHING MORE?

Yuri Gagarin

The first human in space, completing one orbit of Earth on April 12, 1961 section four –

design challenge

Student Astronaut Challenge

Chapter 4.1 – Design Challenge

The Design Challenge is a multi-part event relating to designing solutions or physical structures, all based on a space-related issue(s). Teams will be awarded one combined score for both parts of the challenge.

1) **Apollo Division** – **Lab Design Challenge and Presentation -** a design challenge to solve a specific space-related issue. The topic will be announced by coaches training. Teams will create an infographic of their solution and will explain their idea during a 20 minute PowerPoint presentation to a panel of judges during the Finals competition. Rubric for the Infographic and submission details – including a deadline - will be posted on the website.

2) **Mercury Division** – **Mailbox Challenge and Presentation** – a mailbox design challenge to create a physical mailbox for a specific space-related theme as part of the Blue Origin's "Club for the Future" Postcards into Space program. The prototype will be constructed of inexpensive material and used at their school to allow students the opportunity to 'mail' postcards to space. The mailed post cards can be sent to Blue Origin (information on their website) so they can be flown on a mission. Teams will present their design proposal with photographs to a team of judges during the competition. Teams may also bring their prototype mailboxes to Kennedy Space Center. Rubric for the mailbox will be posted on the website.

3) **Apollo and Mercury Divisions** - **Patch** – a patch design challenge to create a team flight patch related to an identified theme. Teams will include a color drawing of their patch along with their design description as part of their Design Challenge presentation. The patch design will be judged based on NASA's mission flight patch criteria and its relevance to the theme. Rubric for the patch and submission details – including a deadline - will be posted on the website.

I KNEW I WAS ALONE IN A WAY THAT NO EARTHLING HAS EVER BEEN BEFORE.

Michael Collins

Aboard Apollo 11 while Buzz Aldrin and Neil Armstrong descended to the Moon section five –

additional information

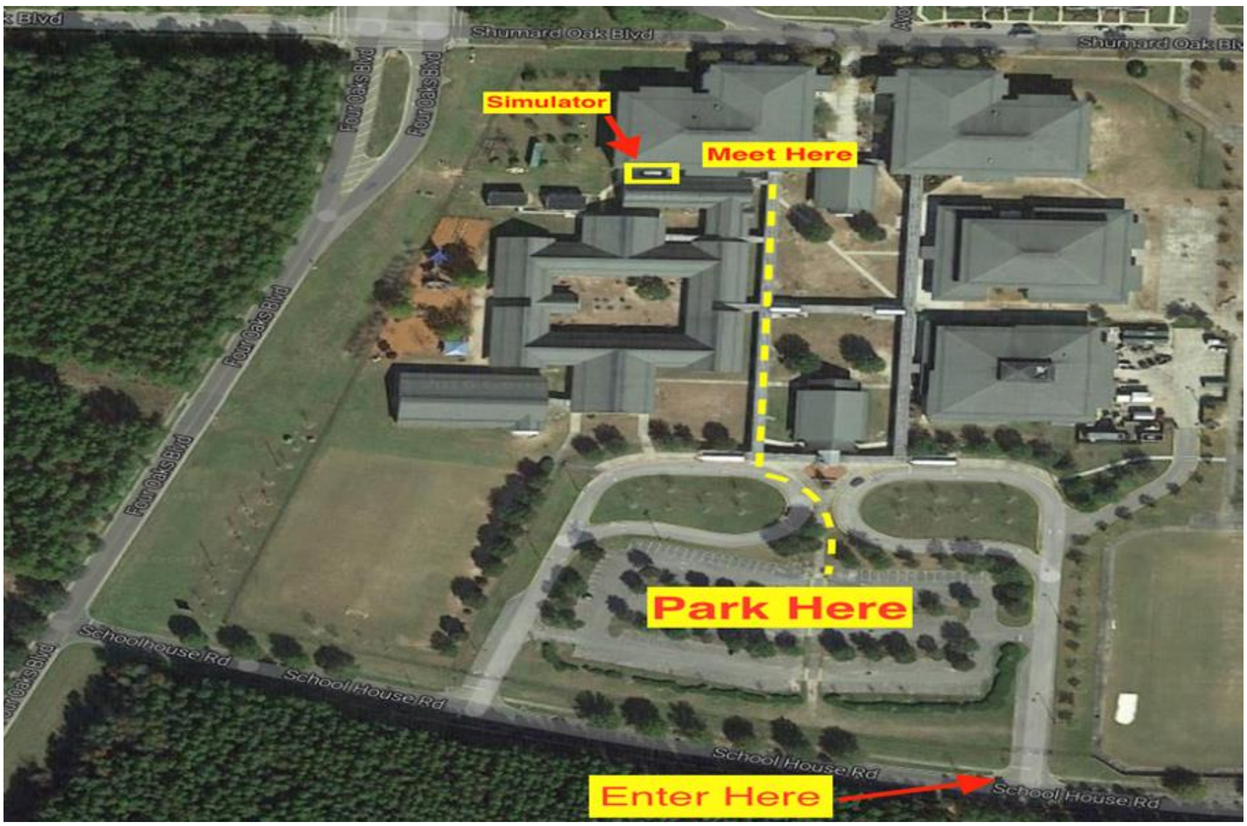
Student Astronaut Challenge

Chapter 5.1 – Location and Schedule

The goal of the Student Astronaut Challenge Coach Training program is to familiarize you with the Space Simulator instructional system, which was developed by Florida State University Schools. In addition, we will be familiarizing you with the various events your team will be participating in at the Student Astronaut Challenge Finals competition at Kennedy Space Center next February. The following is the event information and training schedule for the weekend. Please park in the main parking area off of School House Road, there will be signs to direct you to the training area

Training location

Florida State University Schools (Florida High School)
3000 School House Road Tallahassee, Fl., 32311.



Contact information

Peter Carafano
Student Astronaut Challenge Director
(850) 510-9298

Below is a sample Coach Training agenda. The specific agenda will be emailed to all coaches prior to the weekend training.

Chapter 5.1 – Location and Schedule

Coach Training Agenda

Saturday | Competition and Event Information | 8:30am - 5pm
Includes light breakfast and lunch

8:00-9:00 - Check in and light breakfast (provided)
9:00-9:15 - Competition Overview and Coach Manual Resources
9:15-10:00 - Space Flight Simulation Challenge Basics
    [anatomy of a flight, **classroom checklist**, communication, common issues]
10:00-10:30 - Engineering Challenge
    [video, practice advice]
10:30-10:50 - Patch Challenge - **rubric** overview
10:50-11:30 - Design Challenge - challenge and **rubric** overview
    [Apollo - Lunar Regolith | Mercury – Club for the Future Mailbox]
11:30-12:15 - Checklist Run Through
12:15-12:30 - Landing Challenge Overview

12:30-1:15 – Lunch (provided)

1:15-1:30 - Q&A
1:30-2:30 - Mission run through
2:30-3:00 - Classroom Sim Setup
3:00-5:00 - Simulator Tours and Hands-on Practice
4:00-5:00 - Orbiter Install and Setup
    (Please be sure you have administrator rights on the device you bring to install orbiter.)

Sunday | Technical Manual and Emergencies | 8am-1pm
8:00-8:30 - Review Mission Milestones
    [MECO, Payload Bay Operations, Zero up, Deorbit Burn, Gauntlet]
9:00-9:30 - Technical Manual Overview
10:00-12:00 - Emergencies
12:00-1:00 - Wrap up - Q&A

I KNOW THE SKY IS NOT THE LIMIT BECAUSE THERE ARE FOOTPRINTS ON THE MOON – AND I MADE SOME OF THEM!

Buzz Aldrin

Chapter 5.2 – SAC Staff Contact Information

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submit team information: **tinyurl.com/astrochall2022**

Chapter 5.2 – SAC Staff Contact Information

Follow us on Social Media!

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THE DREAM IS ALIVE.

John Young

STS-1 Landing

April 14, 1981

Chapter 5.3 - SAC GLOSSARY/ABBREVIATIONS

V. 240826.01

A	
A	Ampere. The SI base unit of electric current.
a, A	Acceleration. a = Δ velocity / Δ time. Acceleration = Force / Mass
Abort	To bring a flight to a premature end because of a problem or fault.
AC	Alternating current
AC Bus	An electrical pathway that distributes alternating current electrical power to various Orbiter systems.
AC Bus Sensor	The AC bus sensor monitors each AC phase bus for over or under voltage, and each phase inverter for an overload signal.
AC Bus System	A three-bus system that distributes alternating current electrical power to the forward, mid, and aft sections of the orbiter for equipment used in those areas.
Acceleration	Change in velocity. Note, since velocity comprises both direction and magnitude (speed), a change in either direction or speed constitutes acceleration.
ACCUM	Accumulator
AFT	Aft is the area near, toward or in the stern or rear of an aircraft/spacecraft. Opposite of Fore or Forward
ALT	Altitude or Altimetry data.
AO	Announcement of Opportunity.
AOA	Abort Once Around. A type of abort that results in less than one orbit of Earth. The flight enters orbit and immediately executes the de-orbit routine to initiate a reentry and landing.
AOS	Acquisition of Signal.
Aphelion	Apoapsis in solar orbit.
Apoapsis	The farthest point in an orbit from the body being orbited.
Apogee	Apoapsis in Earth orbit.

APU	Auxiliary Power Unit. A device that provides energy for functions other than propulsion. The Space Shuttle APUs provides hydraulic pressure. The Space Shuttle has three redundant APUs, powered by hydrazine fuel. They function during powered ascent, re-entry, and landing. During ascent, the APUs provides hydraulic power for gimballing of Shuttle's engines and control surfaces. During landing, they power the control surfaces and brakes.
Argument	Angular distance.
Argument of periapsis	The argument (angular distance) of periapsis from the ascending node.
Ascending node	The point at which an orbit crosses a reference plane (such as a planet's equatorial plane or the ecliptic plane) going north.
Asteroids	Small bodies composed of rock and metal in orbit about the sun.
ATO	Abort To Orbit. A type of abort that results in the orbiter entering Earth orbit at an altitude that is less than the planned mission altitude.
AU	Astronomical Unit. AU is based on the mean Earth-to-sun distance, 149,597,870 km. Refer to "Units of Measure" section for complete information.
AV BAY	Avionics Bay. The avionics system features a five-computer central processing complex, which provides software services to all vehicle subsystems that require them.
AZ	Azimuth.
B	
BAT	BATTERY.
BDY	Body.
BLR	Boiler.
Boiler System	See Water Spray Boiler.
BPS	Bits per Second. This unit is the same as Baud rate.
B/U	Back Up.
BYP	Bypass.

C	
c	The speed of light. c is equivalent to 299,792 km per second.
Carrier	The main frequency of a radio signal generated by a transmitter prior to application of any modulation.
C-band	A range of microwave radio frequencies in the neighborhood of 4 to 8 GHz.
CDT	Central Daylight Time. Offset = UTC-5:00
Centrifugal force	The outward-tending apparent force of a body revolving around another body.
Centripetal acceleration	The inward acceleration of a body revolving around another body.
Chandler wobble	A small motion in the Earth's rotation axis relative to the surface, discovered by American astronomer Seth Carlo Chandler in 1891. Its amplitude is about 0.7 arcseconds (about 15 meters on the surface) with a period of 433 days. It combines with another wobble with a period of one year, so the total polar motion varies with a period of about 7 years. The Chandler wobble is an example of free nutation for a spinning non-spherical object.
Channel	In telemetry, one particular measurement to which changing values may be assigned.
CIRC	Circulation.
Clarke orbit	Geostationary orbit.
CNTRL	Control (or Controller).
Coma	The cloud of diffuse material surrounding the nucleus of a comet.
Comets	Small bodies composed of ice and rock in various orbits about the sun.
COMM	Communication system
Conjunction	A configuration in which two celestial bodies have their least apparent separation.
CP	Cold Plate.
CRT	Cathode Ray Tube. A video display device that allows onboard monitoring of orbiter systems, computer software processing, and manual control for flight crew data and software manipulation.
CRYO	Cryogenic.

CST	Central Standard Time. Offset = UTC-6:00
D	
DAP	Digital Auto Pilot. A software-based system that controls the orientation of the Space Shuttle. It can perform three-axis automatic maneuvers, attitude tracking, and rotation about any axis or body vector. Crew interface to the Digital Auto Pilot is via the Orbiter cathode ray tubes/keyboard interface, which allows the crew to control parameters in the software.
DC	Direct Current. (Electrical)
DC Bus	An electrical pathway that distributes direct current electrical power to various Orbiter systems.
DC Bus System	A three-bus system that distributes direct current electrical power to the forward, mid, and aft sections of the orbiter for equipment used in those areas.
DEC	Declination
Declination	The measure of a celestial body's apparent height above or below the celestial equator.
Density	Mass per unit volume. For example, the density of water can be stated as 1 gram/cm3.
Descending node	The point at which an orbit crosses a reference plane (such as a planet's equatorial plane or the ecliptic plane) going south.
Doppler Effect	The effect on frequency imposed by relative motion between transmitter and receiver. See Chapters 2, 4 and 5.
Downlink	Signal received from a spacecraft.
DPS	Data Processing System. (Maro-pad command)
DRN LN	Drain Line.
Drogue Chute	A drogue parachute, also called drag chute, is a parachute designed for deployment from a rapidly moving object.
DSN	NASA’s Deep Space Network.
E	
Eccentricity	The distance between the foci of an ellipse divided by the major axis.
Ecliptic	The plane in which Earth orbits the sun and in which solar and lunar eclipses occur.

ECLSS	Environmental Control and Life Support System
ECS	Environmental Control System. A part of the ECLSS.
EDL	(Atmospheric) Entry, Descent, and Landing.
EDT	Eastern Daylight Time. Offset = UTC-4:00
EGT	APU Exhaust Gas Temperature
Ellipse	A closed plane curve generated in such a way that the sums of its distances from the two fixed points (the foci) is constant.
ELV	Expendable launch vehicle.
EM	Electromagnetic
EMF	Electromagnetic force (radiation).
EMR	Electromagnetic radiation.
Equator	An imaginary circle around a body which is everywhere equidistant from the poles, defining the boundary between the northern and southern hemispheres.
Equinox	The equinoxes are times at which the center of the Sun is directly above the Earth's equator. The day and night would be of equal length at that time if the Sun were a point and not a disc, and if there were no atmospheric refraction. Given the apparent disc of the Sun and the Earth's atmospheric refraction, day and night actually become equal at a point within a few days of each equinox. The vernal equinox marks the beginning of spring in the northern hemisphere, and the autumnal equinox marks the beginning of autumn in the northern hemisphere.
ERT	Earth-received time. UTC of an event at DSN receive-time, equal to SCET plus OWLT.
EST	Eastern Standard Time. Offset = UTC-5:00
ET	Ephemeris time. A measurement of time defined by orbital motions. Equates to Mean Solar Time corrected for irregularities in Earth's motions. Obsolete, replaced by TT, Terrestrial Time.
ET	External Tank
eV	Electron volt. A measure of the energy of subatomic particles.
EXEC	Execute. (Macro-pad command)

EXT	External.
F	
f, F	Force. Two commonly used units of force are the Newton and the dyne. Force = Mass X Acceleration.
FDLN	Feedline.
FDS	Flight Data Subsystem.
FE	Flight Engineer. A cockpit crew member.
FLT	Flight.
Fluorescence	The phenomenon of emitting light upon absorbing radiation of an invisible wavelength.
FM	Frequency modulation.
FTS	Frequency and Timing System. A part of the Deep Space Network. Also, frequency and timing data.
FWD	Forward. The area near, toward or in the front of an aircraft/spacecraft. Opposite of Aft.
G	
G	Universal Constant of Gravitation. Its tiny value (G = 6.6726 x 10-11 Nm2/kg2) is unchanging throughout the universe.
g	Acceleration due to a body's gravity. Constant at any given place, the value of g varies from object to object (e.g., planets), and also with the distance from the center of the object. The relationship between the two constants is g = GM/r2 where r is the radius of separation between the masses' centers, and M is the mass of the primary body (e.g., a planet). At Earth's surface, the value of g = 9.8 meters per second per second (9.8m/s2). See also weight.
GBX	Gearbox.
GG	Gas Generator.
Gamma rays	Electromagnetic radiation in the neighborhood of 100 femtometers wavelength.
GEO	Geosynchronous Earth Orbit.

Geostationary	A geosynchronous equatorial circular orbit. Also called Clarke orbit.
Geosynchronous	A direct, circular, low inclination orbit about the Earth having a period of 23 hours 56 minutes 4 seconds.
GMT	Greenwich Mean Time. Obsolete. UT, Universal Time is preferred.
GNC	Guidance, Navigation, and Control System.
GPC	General Purpose Computer Control. When the toggle switch is in the straight up or middle position (not on or off) it allows the valve to be controlled by the flight software loaded in the general-purpose computer.
Gravitation	The mutual attraction of all masses in the universe. Newton's Law of Universal Gravitation holds that every two bodies attract each other with a force that is directly proportional to the product of their masses, and inversely proportional to the square of the distance between them. This relation is given by the formula: F = Gm1m2/d2, where F is the force of attraction between the two objects, given G the Universal Constant of Gravitation, masses m1 and m2, and d distance. Also stated as Fg = GMm/r2 where Fg is the force of gravitational attraction, M the larger of the two masses, m the smaller mass, and r the radius of separation of the centers of the masses. See also weight.
Gravitational waves	Einsteinian distortions of the space-time medium predicted by the theory of general relativity. The first direct observation of gravitational waves was made on September 14th 2015 by LIGO and Virgo collaborations. (Not to be confused with gravity waves, see below.)
Gravity assist	Technique whereby a spacecraft takes angular momentum from a planet's solar orbit (or a satellite's orbit) to accelerate or decelerate the craft.
Gravity waves	Certain dynamical features in a planet's atmosphere (not to be confused with gravitational waves, see above).
GTO	Geostationary (or geosynchronous) Transfer Orbit.
H	
H_2	Chemical formula for Hydrogen Gas.
HA	Hour Angle.
Halo orbit	A spacecraft's pattern of controlled drift about an unstable Lagrange point (L1 or L2 for example) while in orbit about the primary body (e.g., the Sun).
He	Helium.

Heliocentric	Sun-centered.
Heliopause	The boundary theorized to be roughly circular or teardrop-shaped, marking the edge of the sun's influence, perhaps 100 AU from the sun.
Heliosphere	The space within the boundary of the heliopause, containing the sun and solar system.
Helium System	During prelaunch, the pneumatic helium supply provides pressure to operate the liquid oxygen and liquid hydrogen pre-valves and outboard and inboard fill and drain valves. The three engine helium supply systems are used to provide anti-icing purges.
HGA	High-Gain Antenna onboard a spacecraft.
Hohmann Transfer Orbit	Interplanetary trajectory using the least amount of propulsive energy.
Horizon	The line marking the apparent junction of Earth and sky.
Hour	A measure of time equal to 60 minutes.
Hour Angle	The angular distance of a celestial object measured westward along the celestial equator from the zenith crossing. In effect, HA represents the RA for a particular location and time of day.
HSI	Horizontal Situation Indicator. The HSI is used to assist in following both the glideslope and localizer. When tuned to the proper frequency, the navigation radio, or NAV, sends a signal to the HSI and two indicators will appear. The indicators are oriented perpendicular to each other - one oriented horizontally and the other vertically. The pilot maneuvers the aircraft so that the indicators form a "+" in the center of the HSI. When this occurs, the pilot knows that the aircraft is both on the proper glide path and is lined up with the runway.
HUD	Head-Up Display or Heads-Up Display. The HUD is any transparent display that presents data without requiring users to look away from their usual viewpoints. The origin of the name stems from a pilot being able to view information with the head positioned "up" and looking forward, instead of angled down looking at lower instruments.
HX	Heat Exchanger.
HYD	Hydraulic.
Hydraulic System	This system distributes the hydraulic pressure produced by the Auxiliary Power Unit (APU) System. The Hydraulic System is made up of three independent hydraulic systems, each of which is mated to a corresponding APU.

I	
ICH	Interchanger.
IF	Intermediate Frequency. In a radio system, a selected processing frequency between RF (Radio Frequency) and the end product (e.g., audio frequency).
ILS	Instrument Landing System. The ILS is a precision landing aid that is used to provide accurate azimuth and descent guidance signals for guidance to aircraft for landing on the runway under normal or adverse weather conditions.
IMU	Inertial Measurement Unit. IMUs consist of an all-attitude, four-gimbal, inertially stabilized platform. They provide inertial attitude and velocity data to the navigation software. Guidance uses the attitude data, along with state vectors from the navigation software, to develop steering commands for flight control.
Inclination	The angular distance of the orbital plane from the plane of the planet's equator, stated in degrees.
Inferior conjunction	Alignment of Earth, sun, and an inferior planet on the same side of the sun.
Inferior planet	Planet which orbits closer to the Sun than the Earth's orbit.
INBD	Inboard.
INJ	Injector.
INT	Internal.
Ion	A charged particle consisting of an atom stripped of one or more of its electrons.
IR	Infrared, meaning "below red" radiation. Electromagnetic radiation in the neighborhood of 100 micrometers wavelength.
ISOE	Integrated Sequence of Events.
ISOL	Isolation.
Isolation valves	The propellant tank isolation valves are located between the propellant tanks and the manifold isolation valves and are used to isolate the propellant tanks from the remainder of the propellant distribution system.
Isotropic	Having uniform properties in all directions.
Istres, France	Trans-Atlantic Abort landing site. Alternate #2

IUS	Inertial Upper Stage.
K	
K-band	A range of microwave radio frequencies in the neighborhood of 12 to 40 GHz.
Keyhole	An area in the sky where an antenna cannot track a spacecraft because the required angular rates would be too high. Mechanical limitations may also contribute to keyhole size.
Klystron	A microwave traveling wave tube power amplifier used in transmitters.
Ku-band	The Ku band, used primarily for satellite communications, is the portion of the K-band radio spectrum in the 12 to 18 gigahertz (GHz) range. The symbol is short for "K-under", because it is the lower part of the original NATO K-band, which was split into three bands (Ku, K, and Ka) because of the presence of the atmospheric water vapor resonance peak at 22.24 GHz, (1.35 cm) which made the center unusable for long range transmission.
Kuiper belt	A disk-shaped region about 30 to 100 AU from the sun considered to be the source of the short-period comets.
L	
Lagrange points	Five points with respect to an orbit which a body can stably occupy. Designated L1 through L5.
LAN	Local area network for inter-computer communications.
Laser	Light Amplification by Stimulated Emission of Radiation. Compare with Maser.
Latitude	Circles in parallel planes to that of the equator defining north-south measurements, also called parallels.
L-band	A range of microwave radio frequencies in the neighborhood of 1 to 2 GHz.
LCP	Left-hand circular polarization.
LEO	Low Equatorial Orbit.
LGA	Low-Gain Antenna onboard a spacecraft.
Light	Electromagnetic radiation in the neighborhood of 1-nanometer wavelength.
Light time	The amount of time it takes light or radio signals to travel a certain distance at light speed.
Lightspeed	299,792 km per second, the constant c.
Lightyear	A measure of distance, the distance light travels in one year, about 63,197 AU.

LN	Line.
Local time	Time adjusted for location around the Earth or other planets in time zones.
Longitude	Great circles that pass through both the north and south poles, also called meridians.
LOS	Loss of Signal, used in DSN operations.
LOX	Liquid Oxygen.
M	
m, M	Mass. The kilogram is the standard unit of mass. Mass = Acceleration / Force.
Main Propulsion System	Within the orbiter aft fuselage, liquid hydrogen and liquid oxygen pass through the manifolds, distribution lines and valves of the propellant management subsystem. During prelaunch activities, this subsystem is used to control the loading of liquid oxygen and liquid hydrogen in the external tank. During SSME thrusting periods, propellants from the external tank flow into this subsystem and to the three SSMEs. The subsystem also provides a path that allows gases tapped from the three SSMEs to flow back to the external tank through two gas umbilicals to maintain pressure in the external tank's liquid oxygen and liquid hydrogen tanks. After MECO, this subsystem controls MPS dumps, vacuum inerting and MPS re-pressurization for entry.
Major Axis	The maximum diameter of an ellipse.
MANF	Manifold.
Maser	A microwave traveling wave tube amplifier named for its process of Microwave Amplification by Stimulated Emission of Radiation. Compare with Laser. In the Deep Space Network, masers are used as low-noise amplifiers of downlink signals, and also as frequency standards.
Mass	A fundamental property of an object comprising a numerical measure of its inertia; the amount of matter in the object. While an object's mass is constant (ignoring Relativity for this purpose), its weight will vary depending on its location. Mass can only be measured in conjunction with force and acceleration.
MDT	Mountain Daylight Time. Offset = UTC-6:00
Mean solar time	Time based on an average of the variations caused by Earth's non-circular orbit. The 24-hour day is based on mean solar time.

MEC	Master Events Controller. Two master events controllers (MEC's) are installed within the Orbiter to provide the control interface for critical liftoff and stage-separation functions.
MECO	Main Engine Cut Off. The point where the main engines shut down. This occurs on the orbiter at approximately 8 minutes and 55 seconds into the flight.
Meridians	Great circles that pass through both the north and south poles, also called lines of longitude.
Meteor	A meteoroid which is in the process of entering Earth's atmosphere. It is called a meteorite after landing.
Meteorite	Rocky or metallic material which has fallen to Earth or to another planet.
Meteoroid	Small bodies in orbit about the sun which are candidates for falling to Earth or to another planet.
MFD	Multi-Function Display. The MFD is a small screen in an aircraft/spacecraft that can be used to display information to the pilot in numerous configurable ways.
MGA	Medium-Gain Antenna onboard a spacecraft. MLI
µm	Micrometer (10^{-6} m).
MLI	Multi-layer insulation (spacecraft blanketing).
MMU	Mass Memory Unit. The principal function of the MMU, besides storing the basic flight software, is to store background formats and code for certain displays and the checkpoints that are written periodically to save selected data in case the systems management GPC fails.
Modulation	The process of modifying a radio frequency by shifting its phase, frequency, or amplitude to carry information.
Moron, Spain	Trans-Atlantic Abort landing site. Primary
MST	Mountain Standard Time. Offset = UTC-7:00
MSTR	Master.
Multiplexing	A scheme for delivering many different measurements in one data stream.

N	
N	Newton, the SI unit of force. One Newton is equal to the force required to accelerate a 1-kg mass, 1 m per second per second ($1m/s^2$).
N_2	Chemical formula for Nitrogen gas.
Nadir	The direction from a spacecraft directly down toward the center of a planet. Opposite of Zenith.
NE	Near Encounter phase in flyby mission operations.
NiCad	Nickel-cadmium rechargeable battery.
Nm	Nautical Miles.
Nodes	Points where an orbit crosses a reference plane.
Non-coherent	Communications mode wherein a spacecraft generates its downlink frequency independent of any uplink frequency.
Nucleus	The central body of a comet.
Nutation	A small nodding motion in a rotating body. Earth's nutation has a period of 18.6 years and an amplitude of 9.2 arc seconds.
O	
O_2	Chemical formula for Oxygen Gas.
OB	Observatory phase in flyby mission operations encounter period.
OMS	Orbital Maneuvering System. The OMS is a system of rocket engines for use on the space shuttle orbiter for orbital injection and modification.
One-way Comm	Communications mode consisting only of downlink received from a spacecraft.
Oort cloud	A large number of comets theorized to orbit the sun in the neighborhood of 50,000 AU.
Opposition	Configuration in which one celestial body is opposite another in the sky. A planet is in opposition when it is 180 degrees away from the sun as viewed from another planet (such as Earth). For example, Saturn is at opposition when it is directly overhead at midnight on Earth.
OTM	Orbit Trim Maneuver. A spacecraft propulsive maneuver.
OUTBD	Outboard.

OWLT	One-Way Light Time. The elapsed time between Earth and a spacecraft or solar system body.
P	
P	Pressure. See also Press
PAM	Payload Assist Module upper stage.
Parallels	Circles in parallel planes to that of the equator defining north-south measurements, also called lines of latitude.
PDT	Pacific Daylight Time. Offset = UTC-7:00
PE	Post Encounter phase in flyby mission operations.
Periapsis	The point in an orbit closest to the body being orbited.
Perigee	Periapsis for Earth orbit.
Phase	1 - The angular distance between peaks or troughs of two waveforms of similar frequency 2 - The particular appearance of a body's state of illumination, such as the full or crescent phases of the Moon; 3 - Any one of several predefined periods in a mission or other activity.
Photovoltaic	Materials that convert light into electric current.
PL	Payload. (Also see PYLD)
Plasma	Electrically conductive fourth state of matter (other than solid, liquid, or gas), consisting of ions and electrons.
PM	Post meridiem (Latin: after midday), afternoon.
PRESS	Pressure.
Prograde	1 - Orbital motion in the usual direction of celestial bodies within a given system, i.e. in the direction of the planet’s rotation. 2 - Orbit in which the spacecraft moves in the same direction as the planet rotates.
PRSDS	Power Reactant Storage and Distribution System
PST	Pacific Standard Time. Offset = UTC-8:00
PWR	Power.
PYLD	Payload.

Q	
QTY	Quantity
Quasar	Quasi-stellar object observed mainly in radio waves. Quasars are extragalactic objects believed to be the very distant centers of active galaxies.
R	
RA	Right Ascension.
RAD	Radiator.
Radian	Unit of angular measurement equal to the angle at the center of a circle subtended by an arc equal in length to the radius. Equals about 57.296 degrees.
RAM	Random Access Memory.
RCS	Reaction Control System. The RCS is a subsystem of a spacecraft whose purpose is attitude control and steering by the use of thrusters. An RCS system is capable of providing small amounts of thrust in any desired direction or combination of directions. The RCS engines use a hypergolic propellant which lights up when its two components (Fuel and Oxidizer) come into contact. This allows the system to be almost fail-safe due to the simple nature of the propellant.
REAC	Reactant.
RECIRC	Recirculation.
Reflection	The deflection or bouncing of electromagnetic waves when they encounter a surface.
Refraction	The deflection or bending of electromagnetic waves when they pass from one kind of transparent medium into another.
REG	Regulator.
Regolith	The layer of unconsolidated rocky material covering bedrock.
Retrograde	1 - Motion in an orbit opposite to the usual orbital direction of celestial bodies within a given system, i.e. in the opposite direction of the planet’s rotation. 2 - Orbit in which the spacecraft moves in the opposite direction from the planet's rotation.
RF	Radio Frequency.
RFI	Radio Frequency Interference.

RGA	Rate Gyro Assembly. The orbiter Rate Gyro Assemblies are used by the flight control system during ascent, entry and aborts as feedback to final rate errors that are used to augment stability and for display on the commander's and pilot's attitude director indicator.
Right Ascension	The angular distance of a celestial object measured in hours, minutes, and seconds along the celestial equator eastward from the vernal equinox.
Rise	As in ascending above the horizon.
ROM	Read-only Memory.
RSVR	Reservoir.
RTLS	Return To Launch Site. A type of abort that results in the immediate return to the launch site, usually runway 15/33 at the Kennedy Space Center.
S	
s	Second. The SI base unit of time.
SA	Solar Array. Photovoltaic panels onboard a spacecraft.
SAR	Synthetic Aperture Radar
Satellite	A small body which orbits a larger one. A natural or an artificial moon. Earth-orbiting spacecraft are called satellites. While deep-space vehicles are technically satellites of the sun or of another planet, or of the galactic center, they are generally called spacecraft instead of satellites.
S-band	A range of microwave radio frequencies of about 2 to 4 GHz.
SCET	Spacecraft Event Time. Equal to ERT minus OWLT.
SCLK	Spacecraft Clock Time. A counter onboard a spacecraft.
Sec	Second.
Second	The SI base unit of time.
Semi-major axis	Half the distance of an ellipse's maximum diameter, the distance from the center of the ellipse to one end.
Set	As in going below the horizon.
SI	The International System of Units (metric system).

SI base unit	One of seven SI units of measure from which all the other SI units are derived.
SI derived unit	One of many SI units of measure expressed as relationships of the SI base units. For example, the watt, W, is the SI derived unit of power. It is equal to joules per second. W = J/s = $m^2 * kg * s^{-3}$ (Note: the joule, J, is the SI derived unit for energy, work, or quantity of heat.)
Sidereal time	Time relative to the stars other than the sun.
SNR	Signal-to-Noise Ratio.
SOE	Sequence of Events.
Solar wind	Flow of lightweight ions and electrons (which together comprise plasma) thrown from the sun.
Specific Impulse	A measurement of a rocket's relative performance. Expressed in seconds, the number of which a rocket can produce one pound of thrust from one pound of fuel. The higher the specific impulse, the less fuel required to produce a given amount of thrust.
Spectrum	A range of frequencies or wavelengths.
SRB	Solid Rocket Booster.
SSME	Space Shuttle Main Engines. The SSMEs are reusable liquid-fuel rocket engines, each Orbiter ascent to orbit is propelled by three engines
Star Tracker	The star tracker system is part of the orbiter's navigation system which works to help maintain the IMU during flight.
STS	Space Transportation System. STS is commonly known as the Space Shuttle. It is comprised of the Orbiter, External Tank (ET) and Solid-Rocket Boosters (SRB).
Subcarrier	Modulation applied to a carrier which is itself modulated with information-carrying variations.
SYS	System.
T	
TAL	Trans-Atlantic. A type of abort that results in the Orbiter landing at a pre-designated landing site in Europe or Africa based on the orbit inclination. The main TAL sites are Moron and Zaragoza, Spain and Istres, France.
TCM	Trajectory Correction Maneuver. A spacecraft propulsive maneuver.

TCS	Thermal Conditioning System. The TCS consists of an air revitalization system, water coolant loop systems, atmosphere revitalization pressure control system, active thermal control system, supply water and wastewater system, waste collection system and airlock support system. These systems interact to provide a habitable environment for the flight crew in the crew compartment in addition to cooling or heating various orbiter systems or components.
TK	Tank (Listed on Data Panels)
TNK	Tank (Listed on Switch Panels)
TOS	Transfer Orbit Stage, upper stage.
Transducer	Device for changing one kind of energy into another, typically from heat, microphone, or speaker.
Transponder	An electronic device which combines a transmitter and a receiver.
TRM	Transmission Time. UTC Earth time of uplink.
True anomaly	The angular distance of a point in an orbit past the point of periapsis, measured in degrees.
U	
UHF	Ultra-high frequency (around 300MHz).
Uplink	Signal sent to a spacecraft.
UT	Universal Time. UT is also called Zulu (Z) time, previously Greenwich Mean Time. UT is based on the imaginary "mean sun," which averages out the effects on the length of the solar day caused by Earth's slightly non-circular orbit about the sun. UT is not updated with leap seconds as is UTC.
UTC	Universal Time (Coordinated). The world-wide scientific standard of timekeeping. It is based upon carefully maintained atomic clocks and is highly stable. Its rate does not change by more than about 100 picoseconds per day. The addition or subtraction of leap seconds, as necessary, at two opportunities every year adjusts UTC for irregularities in Earth's rotation.
UV	Ultraviolet (meaning "above violet") radiation. Electromagnetic radiation of about 100 nanometers wavelength.
V	

Velocity	A vector quantity whose magnitude is a body's speed and whose direction is the body's direction of motion.
VLV	Valve.
VOR	Very High Frequency Omni-Directional Range. VOR is a ground-based electronic system that provides azimuth information for high and low altitude routes and airport approaches.
W	
W	Watt. The watt a measure of electrical power equal to potential in volts times current in amps. (The Watt can also be expressed as W = J/s. See SI derived units)
Walking orbit	A spacecraft orbit that precesses, wherein the location of periapsis changes with respect to the planet's surface in a useful way.
WSB	Water Spray Boiler**.**
Water Spray Boiler	The water spray boiler (WSB) system consists of three identical independent water spray boilers, one for each APU/hydraulic system. The boilers are located in the aft fuselage of the orbiter. Each WSB cools the corresponding APU lube oil system and hydraulic system by spraying water onto their lines; as the water boils off, the lube oil and hydraulic fluid are cooled.
Wavelength	The distance that a wave from a single oscillation of electromagnetic radiation will propagate during the time required for one oscillation. Also, the distance between two corresponding points on a wave. For example, the distance between two crests.
Weight	The gravitational force exerted on an object by a higher mass body. The weight of an object with mass m is w=mg. Units: Newtons. The gravitational field strength, g, is the local acceleration due to a body's gravity.
WWW	World-Wide Web.
X	
X-band	A range of microwave radio frequencies of about 8 to 12 GHz.
X-ray	Electromagnetic radiation of about 100 picometer wavelength.
Z	
Z	Zulu in the phonetic alphabet, stands for UT, Universal Time.

Zaragoza, Spain	Trans-Atlantic Abort landing site. Alternate #1
Zenith	The point on the celestial sphere directly above the observer. Opposite the Nadir.