

how I learned to fly  
the SAC space shuttle...

and other great info  
from Coach Training



Coach Training  
Manual

Student Astronaut  
Challenge

Version 231026.01



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section one -

space shuttle flight  
simulation challenge



Student Astronaut  
Challenge





# 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.

Required equipment:

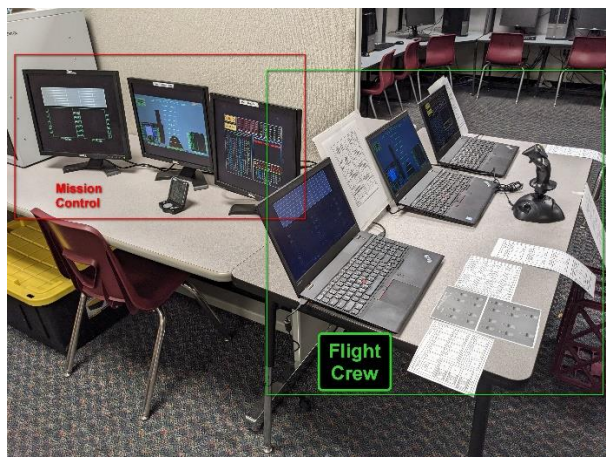
- 3 small desktop or laptop PCs
  - Two of the PCs must have Microsoft PowerPoint installed
- 3 additional monitors and appropriate connecting cables
- 1 basic joystick
- 1 count-up timer
- Switch panel printouts (from SAC website)

**Optional equipment:**

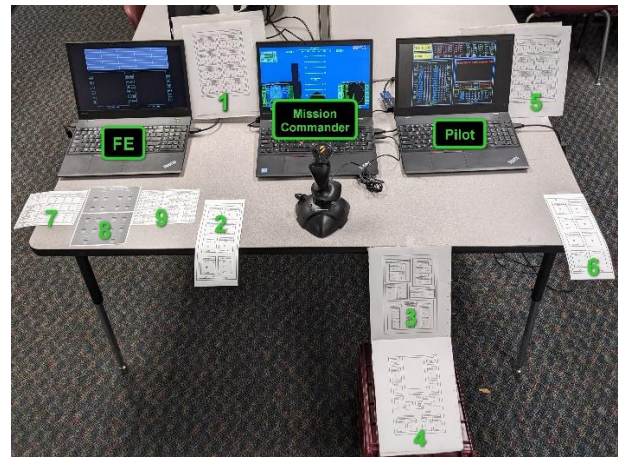
- Xkeys XK-24 USB keypad (Macropad)
- Xkeys XK-12 Joystick
- Logitech G X52 Flight Control system

## **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

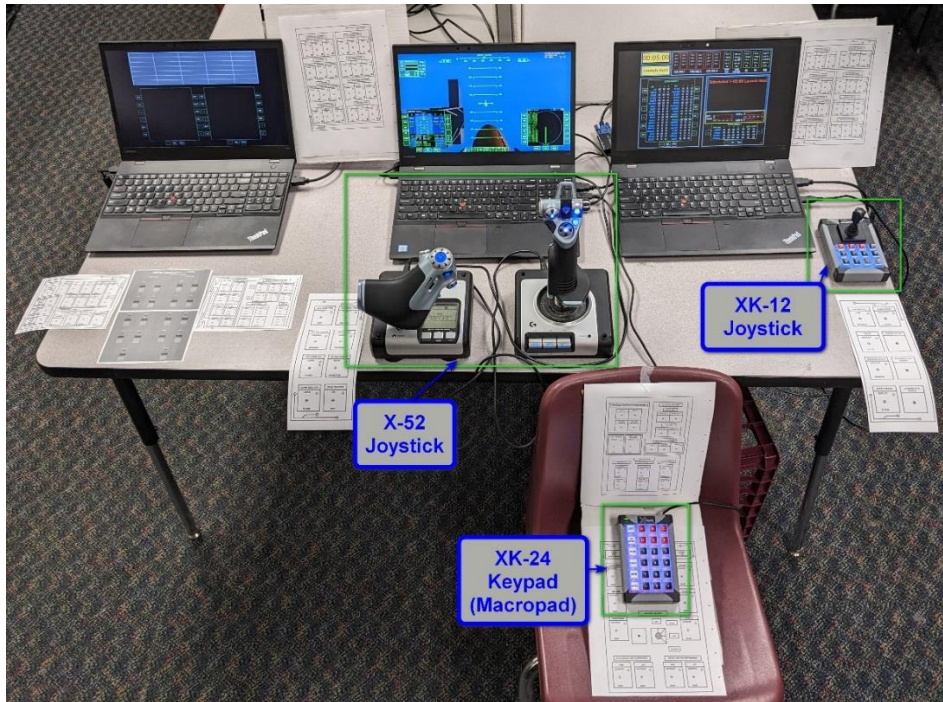


Base Flight Crew Setup

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

# Chapter 1.1 - Setting Up a SAC Classroom Simulator

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 completely optional. 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**

<b>CRT</b>	<b>A</b>	<b>B</b>	<b>C</b>
<b>I/O RESET</b>	<b>D</b>	<b>E</b>	<b>F</b>
<b>ITEM</b>	<b>1</b>	<b>2</b>	<b>3</b>
<b>EXEC</b>	<b>4</b>	<b>5</b>	<b>6</b>
<b>DPS</b>	<b>7</b>	<b>8</b>	<b>9</b>
<b>SPEC</b>	<b>-</b>	<b>0</b>	<b>+</b>

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

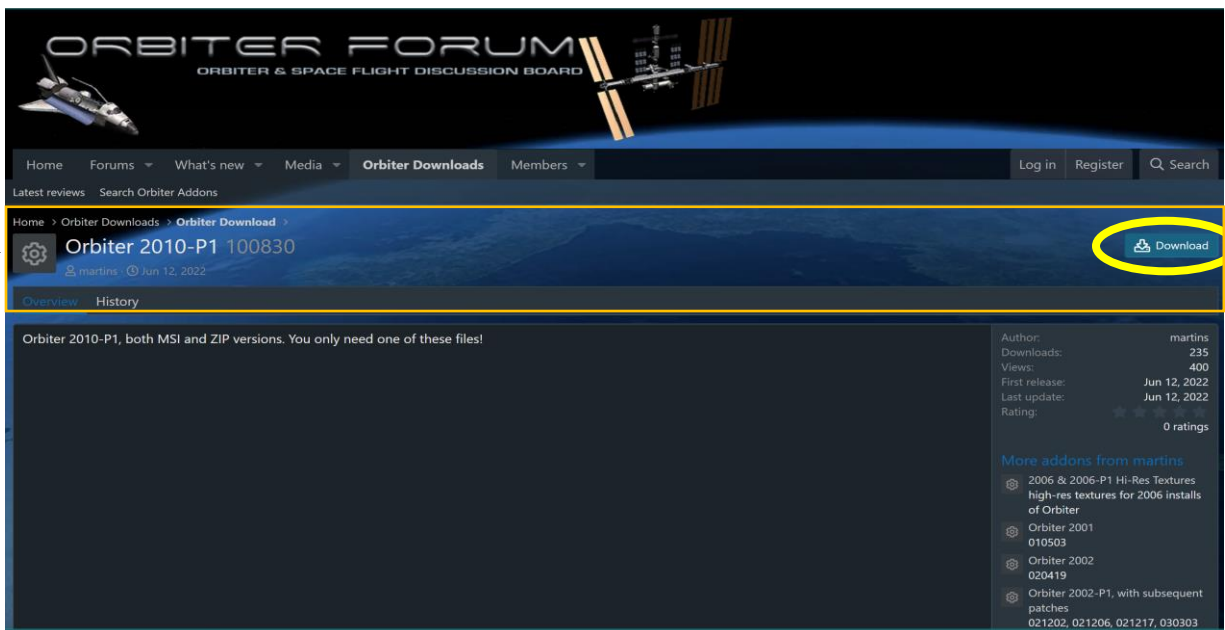
*Orbiter* is a freeware space flight simulator created by Martin Schweiger, Ph. D., at University College London England. Orbiter is a physics simulator which uses Newtonian physics to simulate the behavior of spacecraft & other objects within our solar system.

### 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.

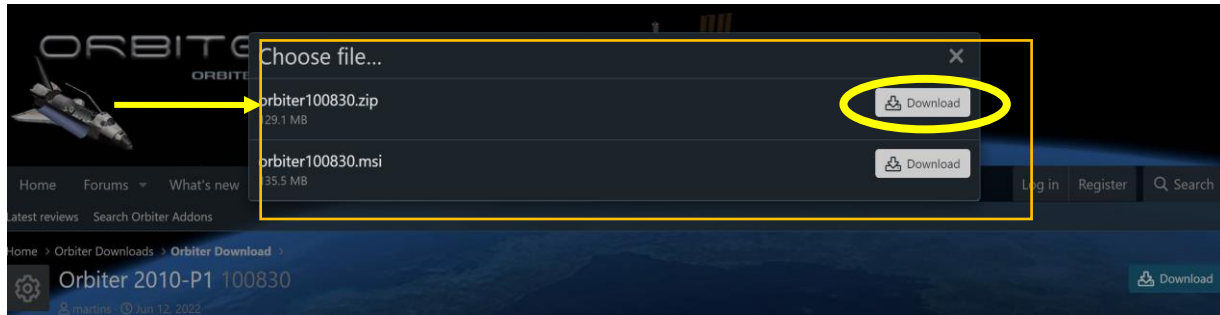
Orbiter Download Web site is <https://www.orbiter-forum.com/resources/orbiter-2010-p1.5428/>



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

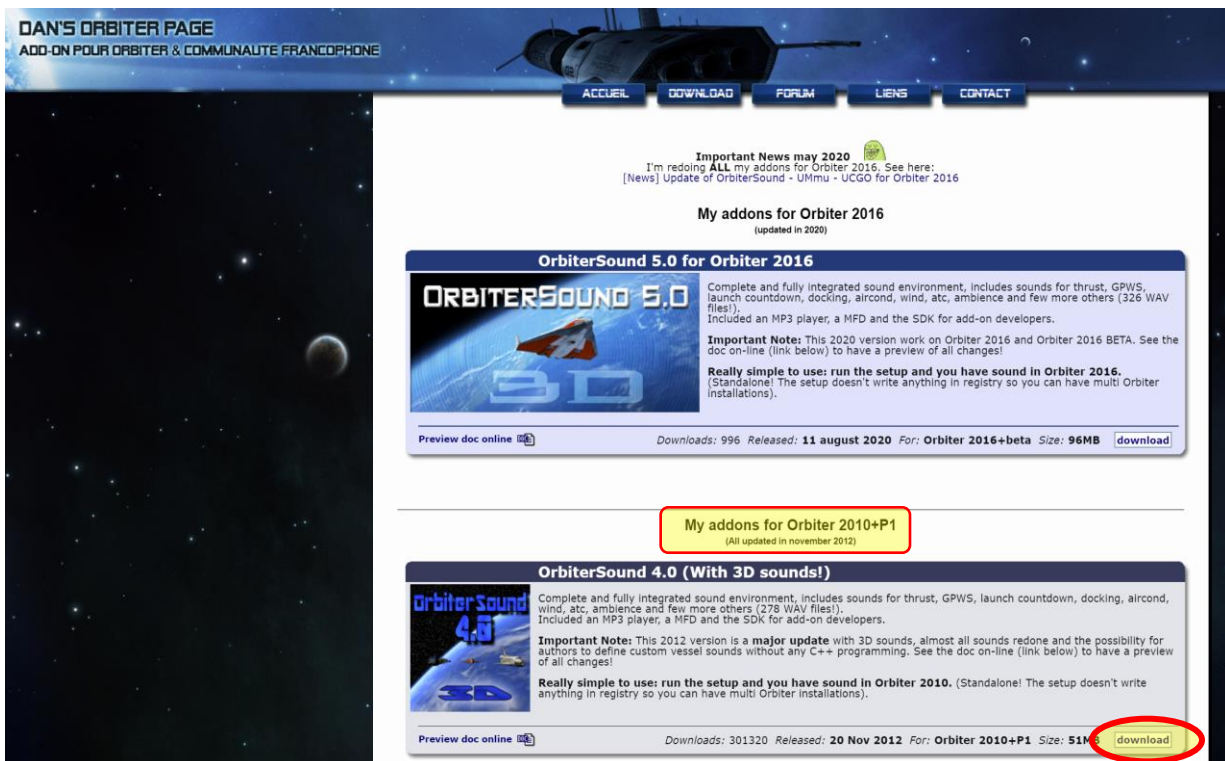


# Chapter 1.1 - Setting Up a SAC Classroom Simulator



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](http://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

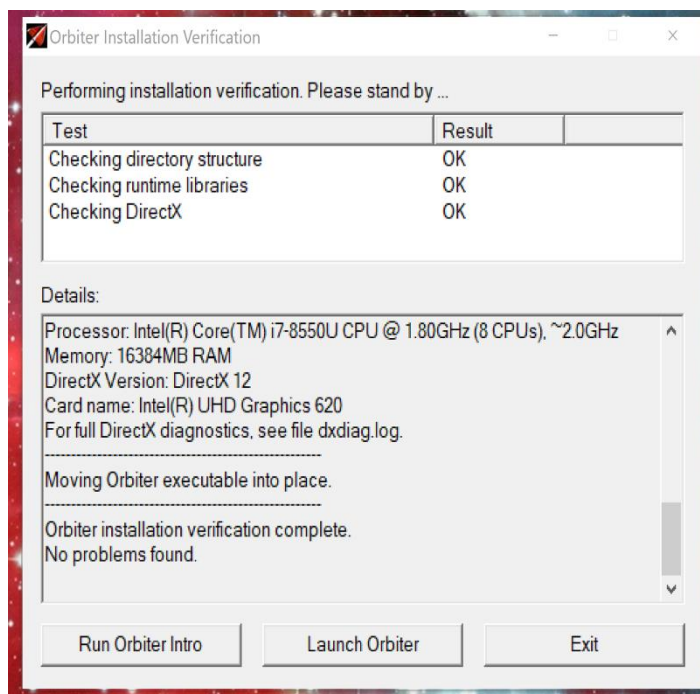
Go to the Student Astronaut Challenge website (<http://www.studentastronautchallenge.com>) and in the header, click on Reference Material. If Reference Material does not appear in the header, click on More then click on Reference Material in the drop-down list. On the Reference Material page, scroll 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

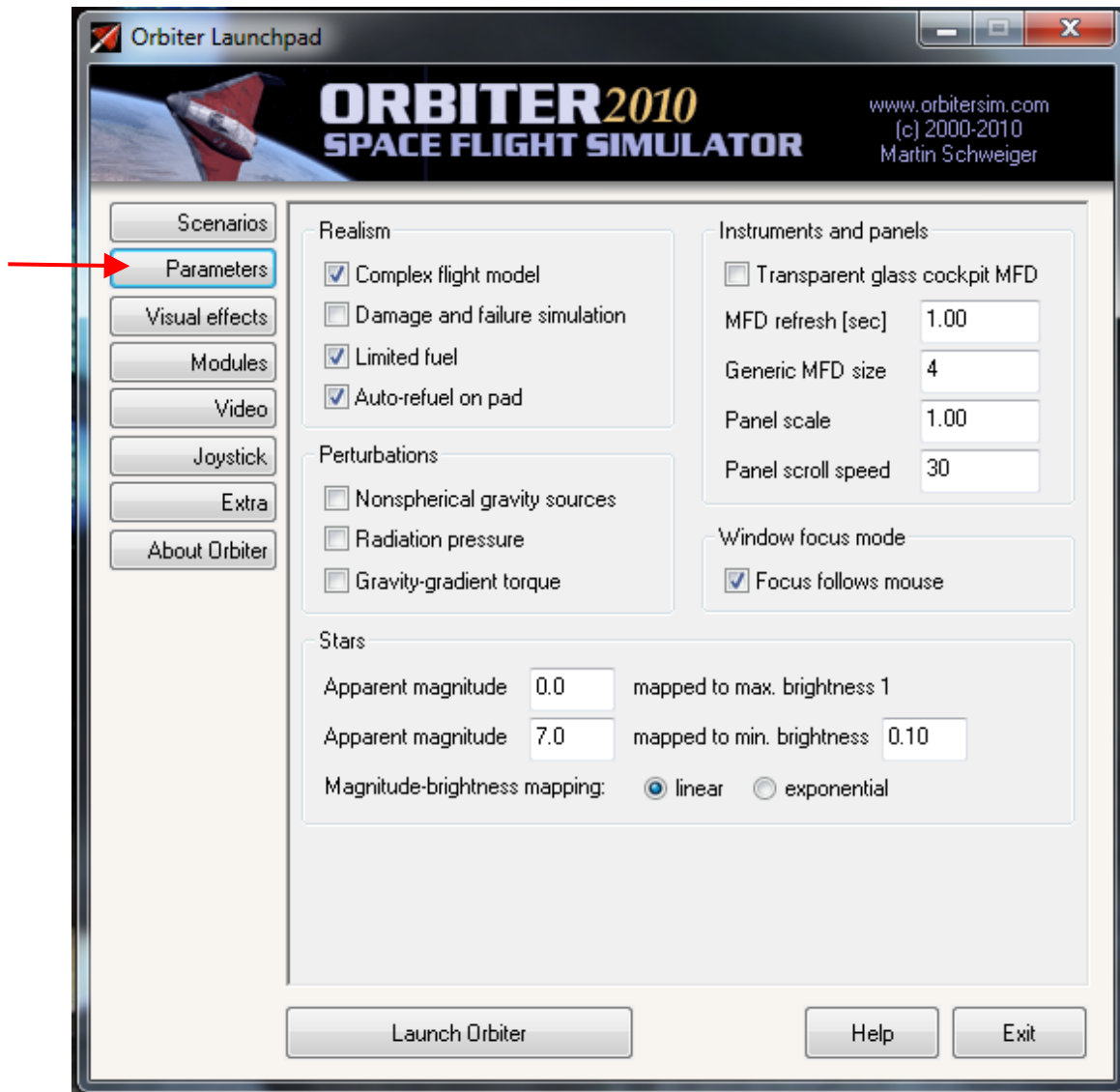
If any of the three checks fail, consult your IT staff. The corrections are pretty simple and should not be a problem.

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



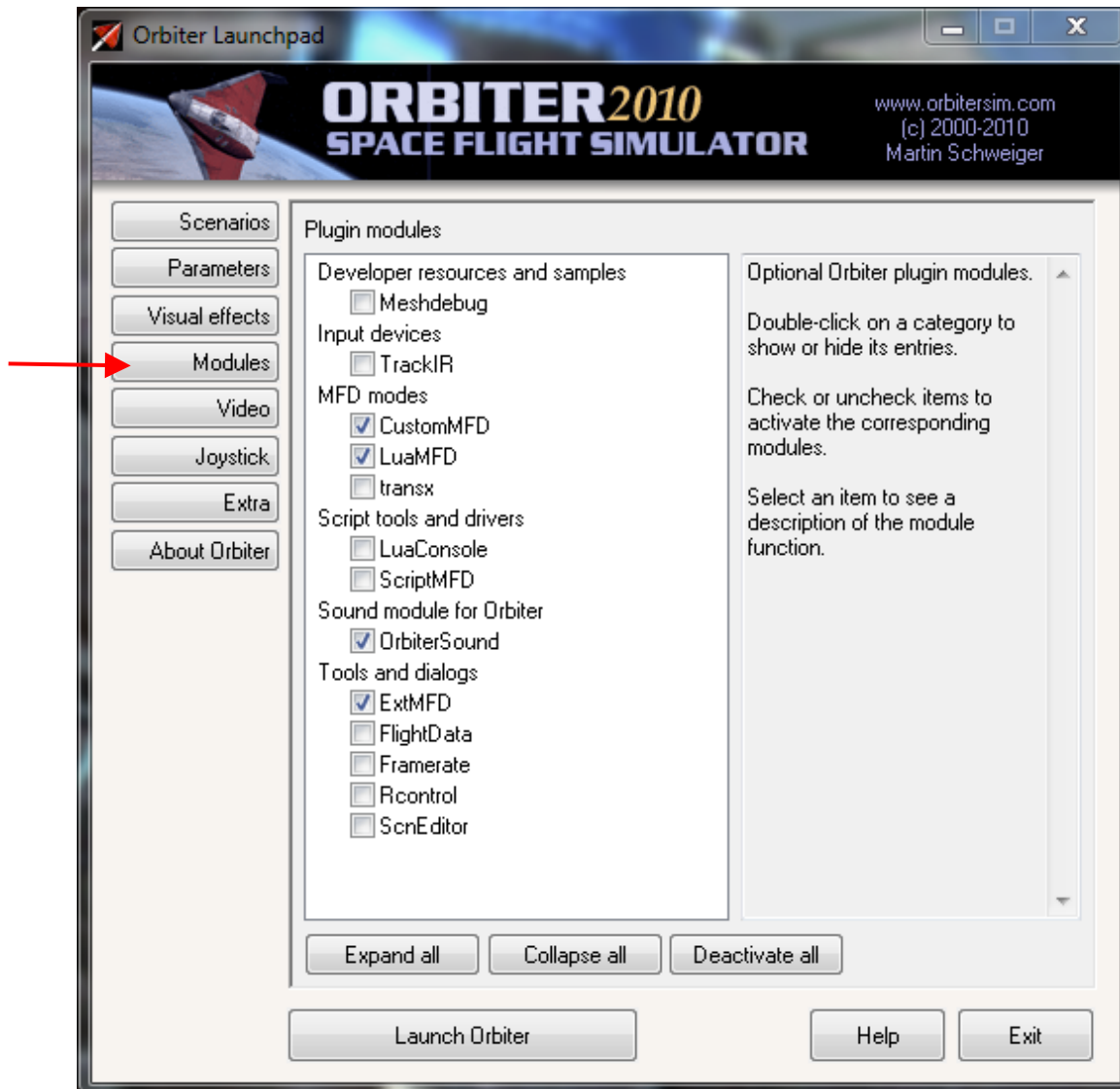
# Chapter 1.1 - Setting Up a SAC Classroom Simulator

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



# Chapter 1.1 - Setting Up a SAC Classroom Simulator

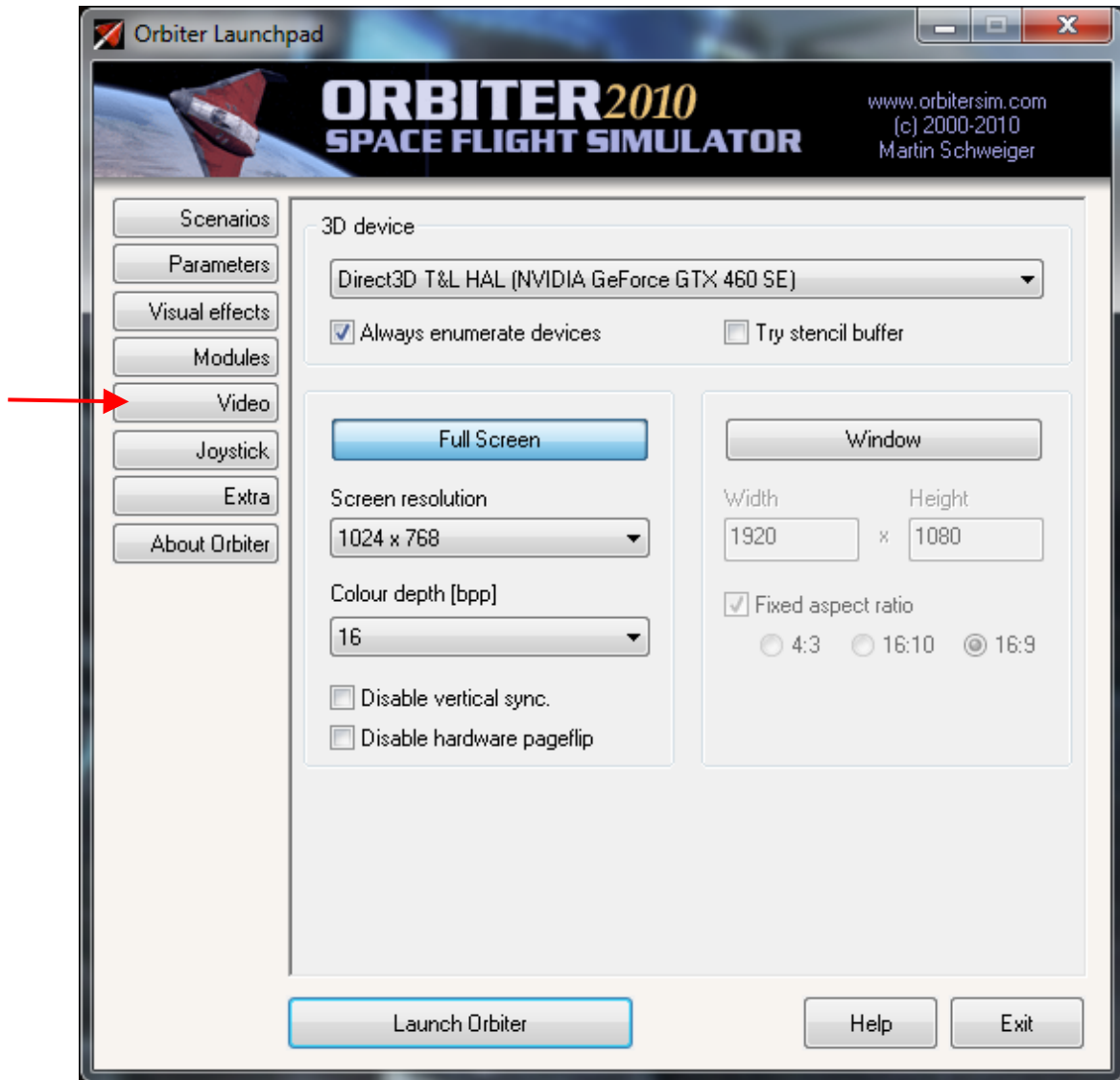
In the Modules section of the Launchpad, **activate the indicated modules** at a minimum by clicking the check box before each selection. You may activate other modules as you encounter a need for them:





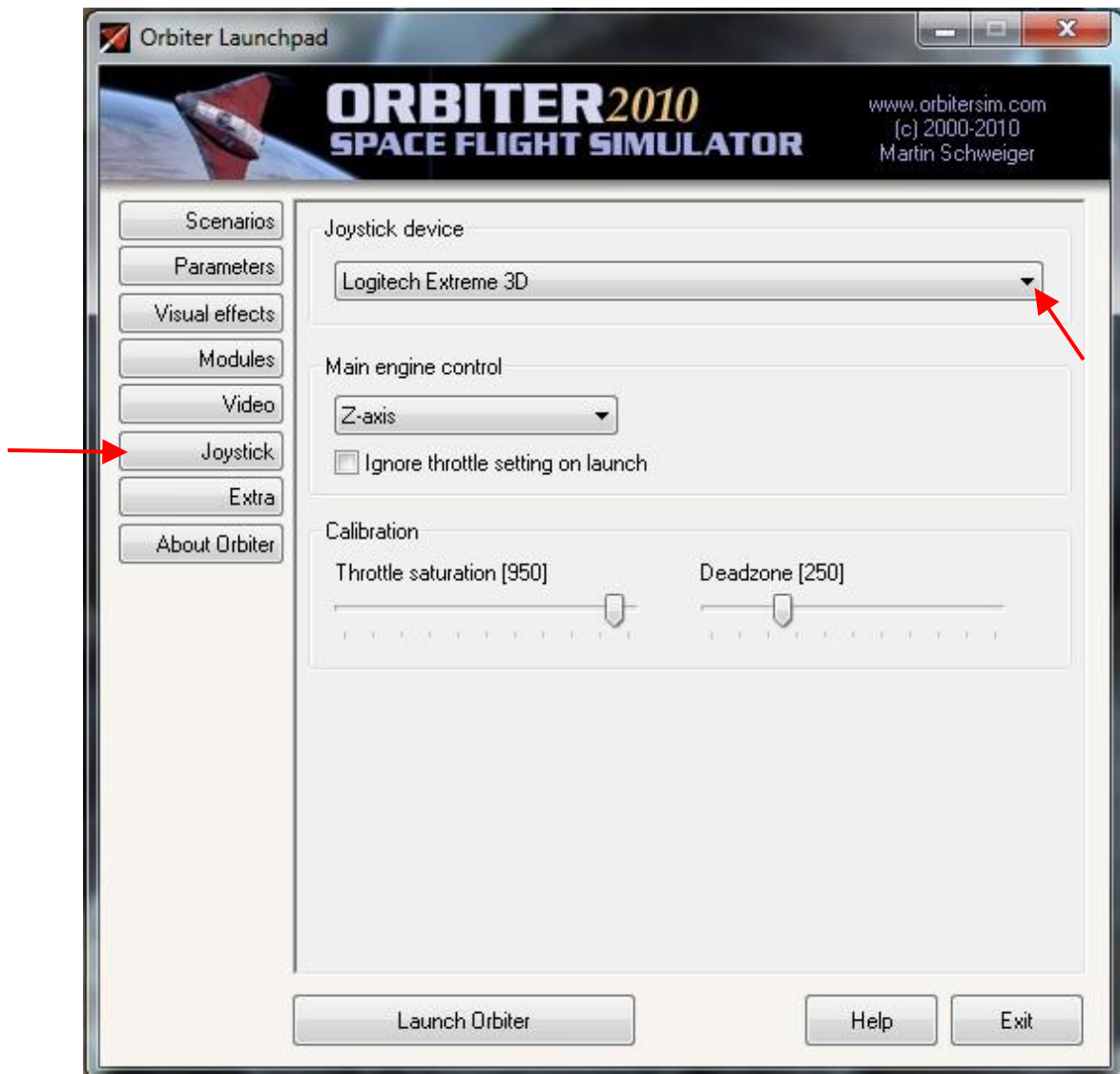
# Chapter 1.1 - Setting Up a SAC Classroom Simulator

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:



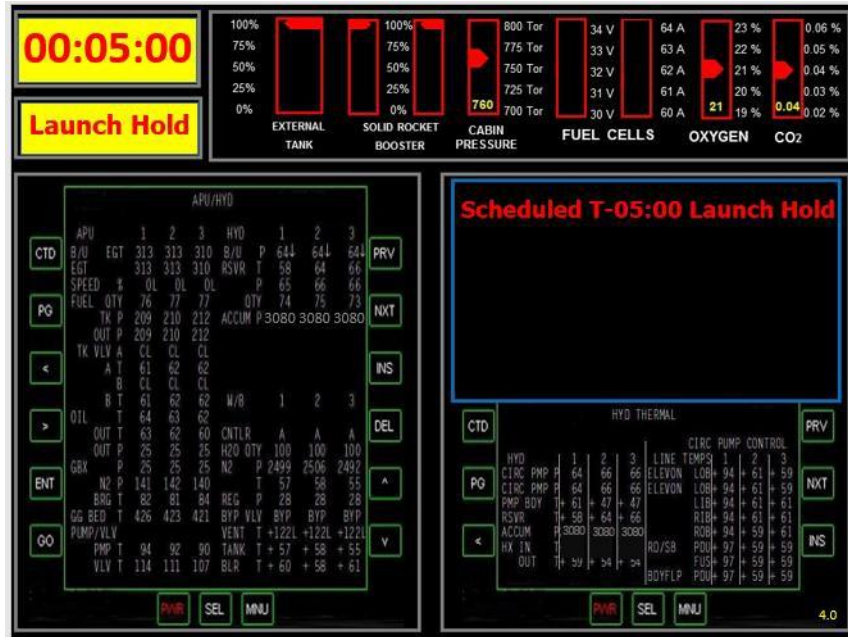
All these setup changes should only be necessary on the initial start of Orbiter.

# 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:

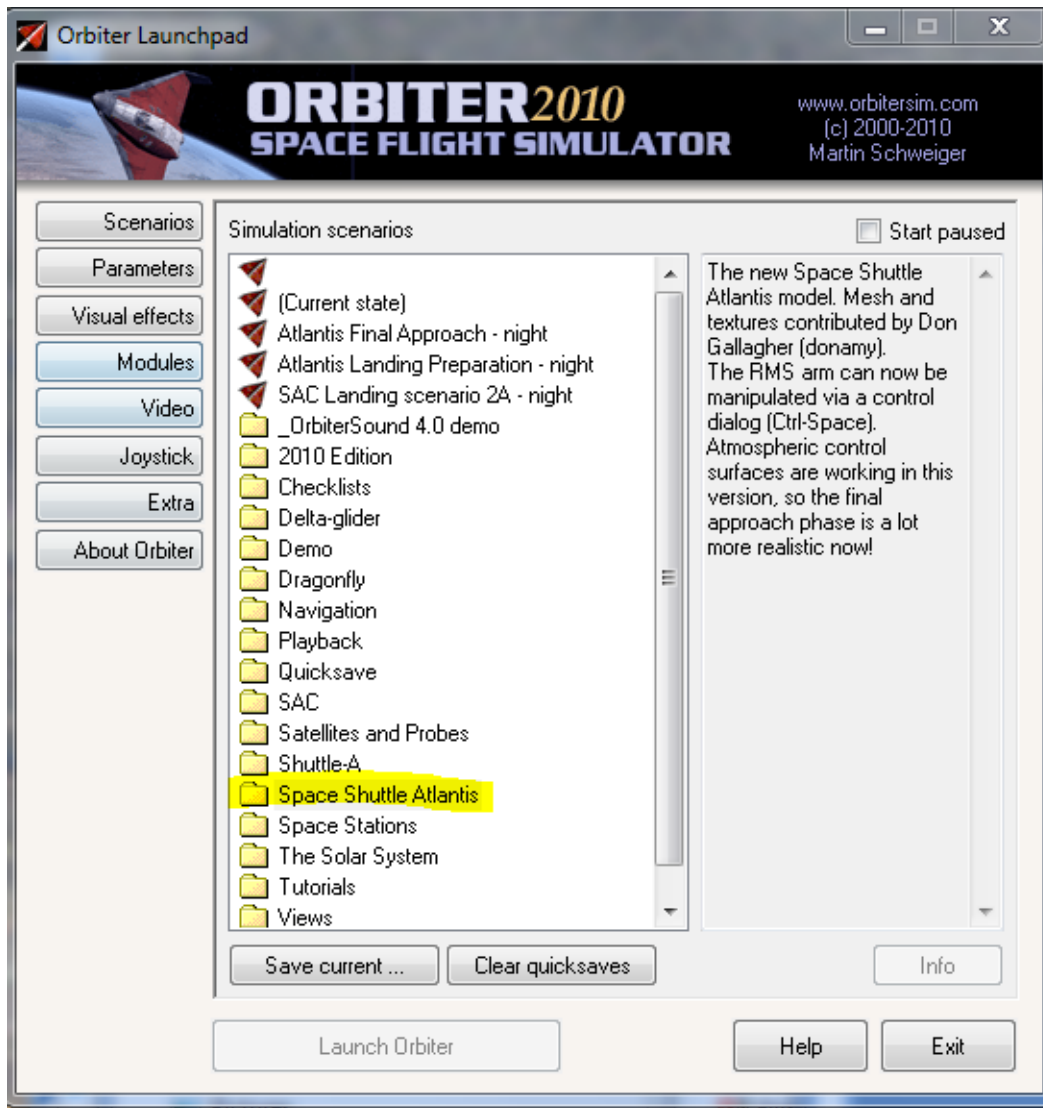


# Chapter 1.1 - Setting Up a SAC Classroom Simulator

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

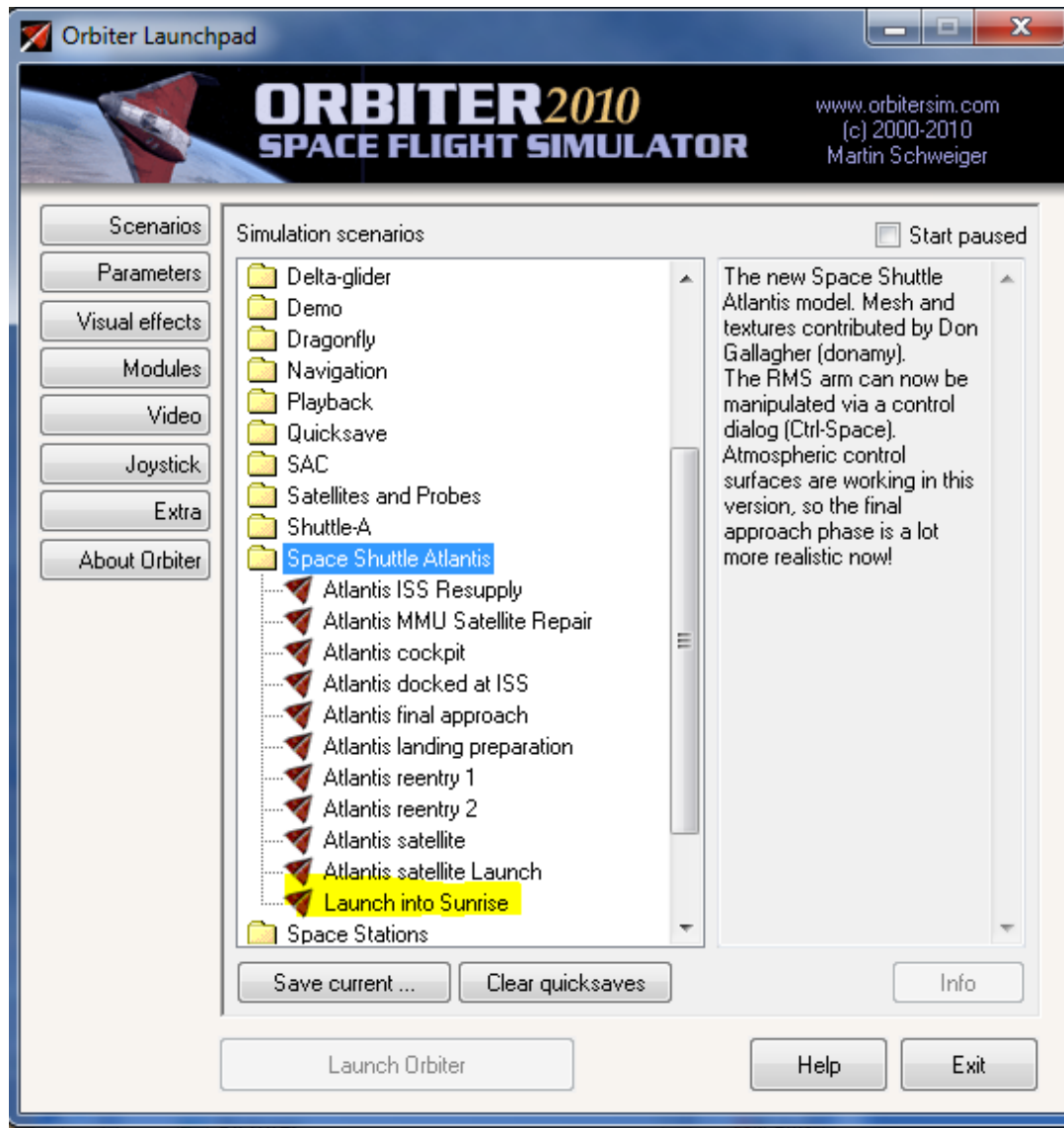


Orbiter will display the Launchpad. Select the “Space Shuttle Atlantis” file.



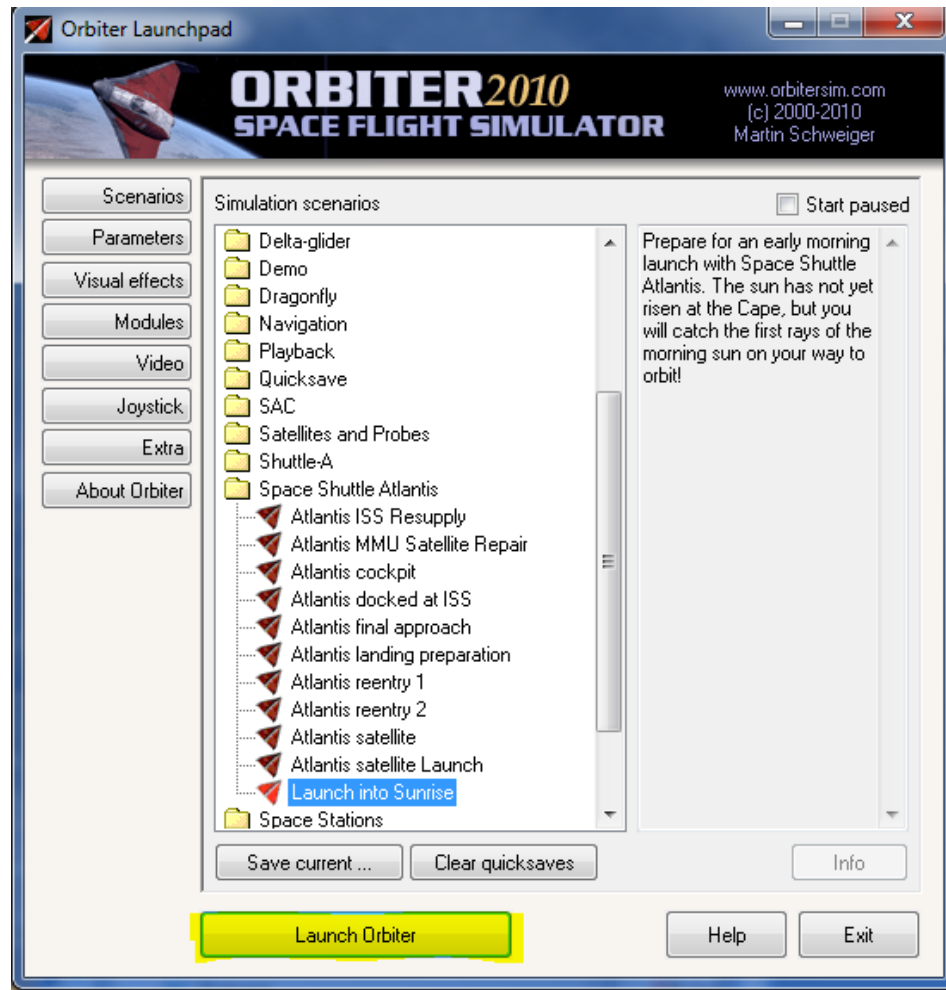
# Chapter 1.1 - Setting Up a SAC Classroom Simulator

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



# Chapter 1.1 - Setting Up a SAC Classroom Simulator

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.



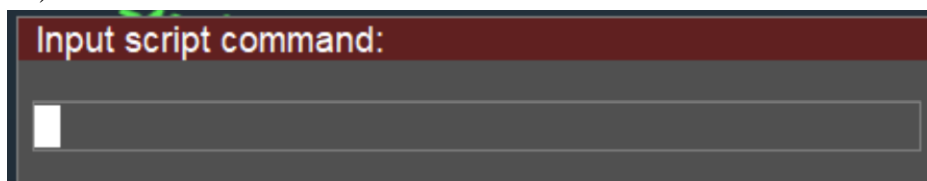
**The Mission Commander will need to configure the Multi-Function Displays (MFD) and enter the launch commands into Orbiter.**

## 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).





# Chapter 1.1 - Setting Up a SAC Classroom Simulator

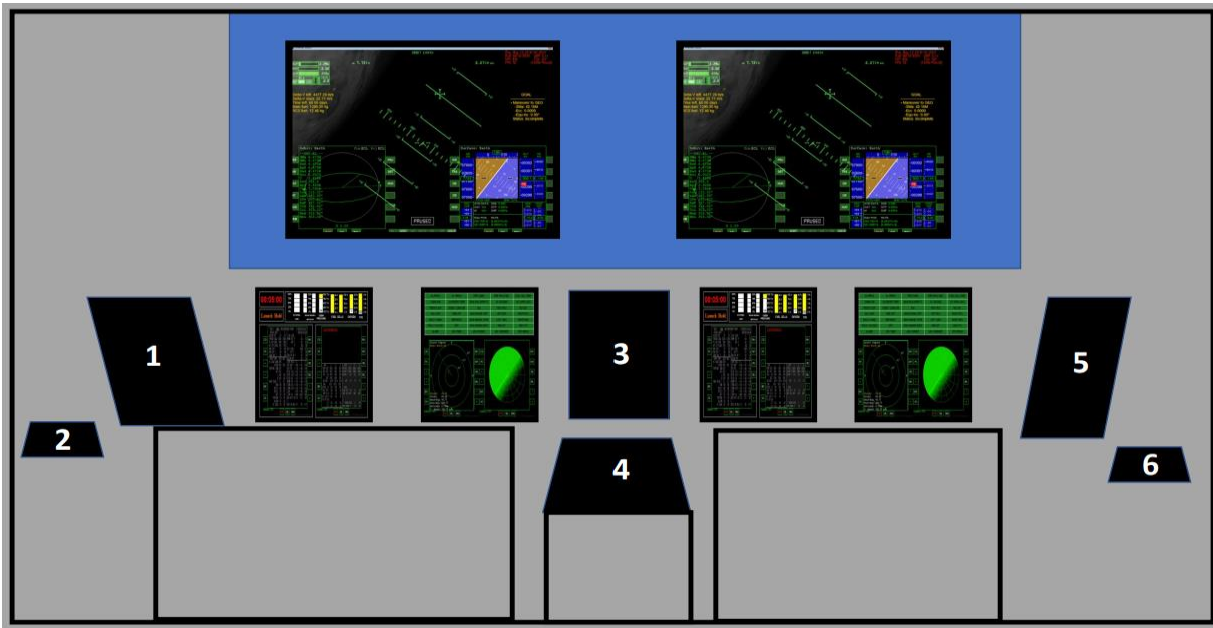
3. In the dialog pop-up box:

- 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



# Chapter 1.1 - Setting Up a SAC Classroom Simulator

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.

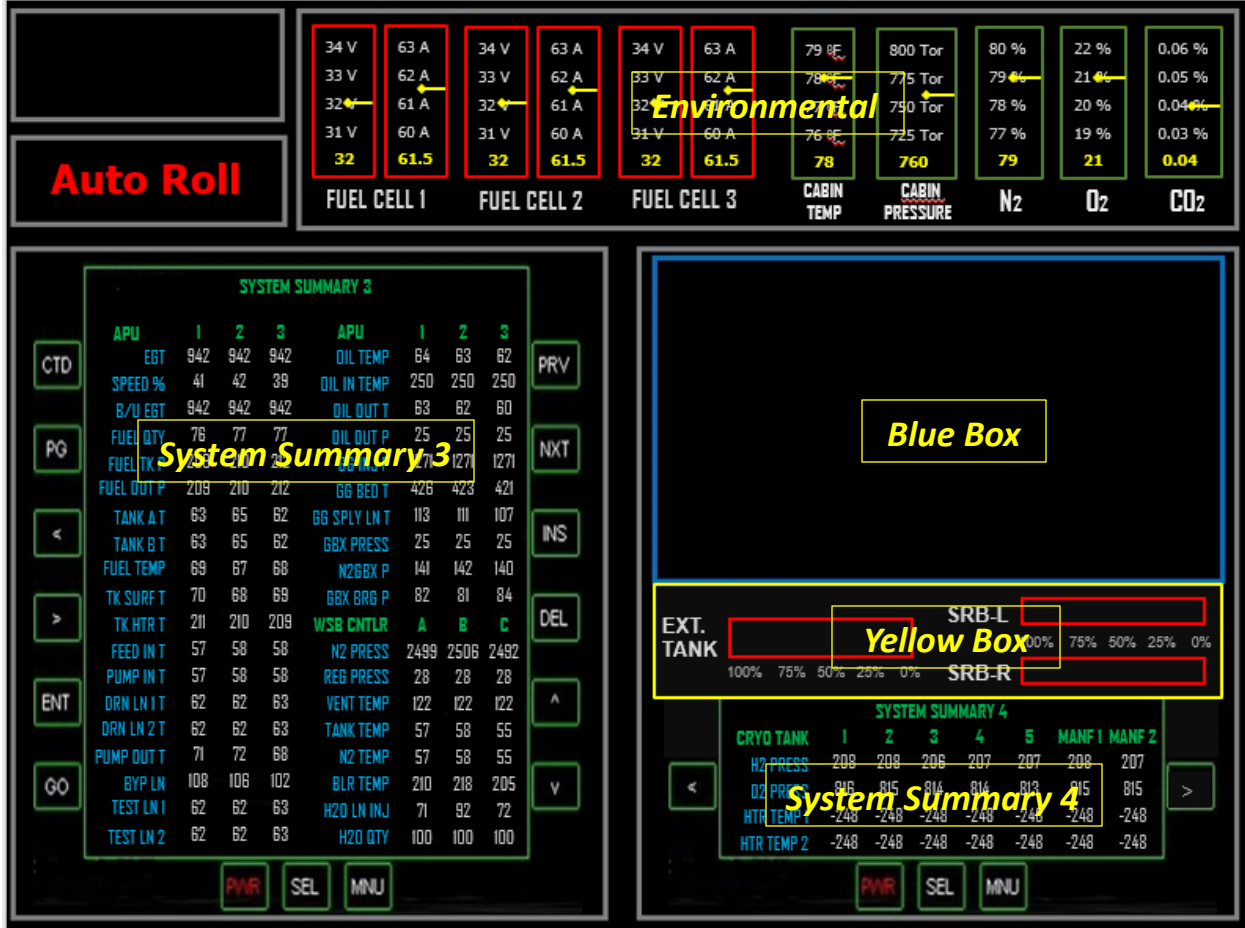
FIX YOUR LITTLE PROBLEM AND LIGHT THIS CANDLE.

*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*

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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 Dept. of Defense Flight Only.

O <sub>2</sub> PRESS	H <sub>2</sub> PRESS	SMOKE / FIRE	LANDING SYS	FUEL CELL TEMP
CABIN ATM	H <sub>2</sub> /O <sub>2</sub> HEATER TEMP	MAIN BUS VOLTAGE	AC VOLTAGE	AC O/U LOAD
FREON LOOP	AV BAY / CABIN AIR	IMU	RCS FWD	RCS JET
H <sub>2</sub> O LOOP	SRB LEFT	<b>Annunciator</b>	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 <sub>2</sub> O SPRAY BOILER	HYD PRESS

**SYSTEM SUMMARY 1**

CTD	HYD	1	2	3	FREON LOOP	1	2	PRV	CTD
	PRESSURE	3064	2985	3110	EVAP OUT T	41	38		
PG	ACCUM PRES	2809	2924	3118	FREDN FLOW	2193	2190	NXT	PG
	CIRC PUMP P	370	384	379	PL HX FLOW	290	286		
	CIRC PUMP T	64	66	66	AFT CP FLOW	279	278	INS	<
	PUMP TEMP	94	92	90	RAD IN TEMP	97	96		
<	PUMP BOY T	61	47	59	RAD OUT TEMP	38	38	DEL	>
	PUMP LEAK	58	58	57	RSVR PRESS	59	57		
	RSVR PRESS	59	53	55	H <sub>2</sub> O LOOP	1	2	ENT	>
>	RSVR TEMP	55	58	52	PUMP OUT P	64	62		
	B/U PRESS	64	65	63	PUMP OUT T	63	63	ENT	>
	VLV TEMP	70	85	81	PUMP PRESS	30	38		
ENT	HX IN T	75	72	77	ICH FLOW	564	777		
	HX OUT T	59	60	58	ICH OUT T	41	38		
	CAB HX IN T	42	38	39					
GO	RADIATORS	FDR L	FDR R	AFT L	AFT R				
	LINE IN T	97	96	95	98				
	LINE OUT T	17	21	22	19				

**System Summary 1**

**SYSTEM SUMMARY 2**

PRV	CTD	TEMP SNSR	1	2	3	EVAP TEMP	DUCT	NOZZLE	PRV
		FLIGHT DECK	77	76	77	HI LOAD INBD	200	150	
		MID DECK	78	79	77	HI LOAD OUTBD	50	40	NXT
		LOWER DECK	79	80	79	TOPPING FWD	125	100	
		AV BAY 1	106	99	99	TOPPING AFT	130	115	NXT
		AV BAY 2	106	105	99	TOPPING LEFT	128	120	
		AV BAY 3	100	102	100	TOPPING RIGHT	136	125	INS
		PYLD BAY FWD	77	79	79	EVAP FDLN T	A	B	
		PYLD BAY AFT	77	77	76	FWD	90	87	DEL
		SP LAB FWD	77	76	77	MID 1	100	103	
		SP LAB AFT	78	79	78	MID 2	85	84	DEL
		FUEL CELLS	1	2	3	AFT FDLN T	80	79	
		AMPS	61.5	61.5	61.5	TOPPING	85	86	>
		VOLTS	31.9	32.1	32	ACCUM FDLN T	90	94	
		H2O PROD	115	110	105	HI LOAD	100	102	>
		CABIN AIR	%						
		N2	79						
		O2	21						
		CO2	0.04						

**System Summary 2**

**DEPT. OF DEFENSE FLIGHTS ONLY**

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 Master Alarm Reset 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	<p><b>STAR TRACKER to OFF (2)</b></p> <div style="border: 1px solid red; padding: 2px; margin: 5px 0;">Multiple blank lines <b>here</b> indicate mission control needs to communicate (see Notes column →)</div> <p><b>Ku ANTENNA to STOW (7)</b> E - [space bar]</p> <div style="border: 1px solid red; padding: 2px; margin: 5px 0; text-align: center;">and here</div> <p><b>RADIATORS to STOW (7)</b> E - [space bar]</p> <div style="border: 1px solid red; padding: 2px; margin: 5px 0; text-align: center;">and here</div> <p><b>PAYLOAD BAY DOOR to CLOSE (7)</b> E - [space bar]</p> <div style="border: 1px solid red; padding: 2px; margin: 5px 0; text-align: center;">and here</div> <p><b>PAYLOAD BAY POWER to OFF (7)</b></p>	<div style="border: 1px solid blue; padding: 5px; margin: 5px 0;">Advise: Go for Payload Bay Door Close program.</div> <div style="border: 1px solid blue; padding: 5px; margin: 5px 0;">Announce: Confirm KU Antenna is stowed</div> <div style="border: 1px solid blue; padding: 5px; margin: 5px 0;">Announce: Confirm Radiators are stowed</div> <div style="border: 1px solid blue; padding: 5px; margin: 5px 0;">Announce: Confirm Payload Bay Doors are closed</div>
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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

# Chapter 1.4 – Mission Checklists

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<sub>2</sub> SYS to OPEN (5) – the (5) means the ENVIRONMENTAL SYSTEM O<sub>2</sub> 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**.

## Chapter 1.4 – Mission Checklists

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	<i>Position The Shuttle to The Correct Attitude – Prograde</i>  <b>Key in 7 – Prograde (4)</b> C –[Use mouse to select <u>prograde</u> 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



# Chapter 1.4 – Mission Checklists

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	<b><u>Launch HOLD</u></b>  CABIN DOOR to LATCH  ENVIRONMENTAL SYSTEM O <sub>2</sub> SYS to OPEN  ENVIRONMENTAL SYSTEM N <sub>2</sub> SYS to OPEN  ENVIRONMENTAL SYSTEM H <sub>2</sub> O LOOP to OPEN  <b>Key in ITEM</b> <b>Select A</b> <b>Key in DPS</b> <b>Select 1 (OPS 1)</b> <b>Key in EXEC</b>  BOILER CNTRL POWER (1/2/3) to ON  BOILER CNTRL HTR (1/2/3) to ON  BOILER N <sub>2</sub> 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

## Chapter 1.5 – Team Member Responsibilities

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 specific checklist entries.

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

### **Mission Commander**

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.

### **Pilot**

1. Initiate the Launch Clock Restart 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.

### **Flight Engineer**

1. Direct the flight crew by calling out switch settings from the mission checklist
2. Initiate the Primary System Radar at exactly 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**

## Advise

An advisement occurs when the flight crew or Mission Control needs to provide or request important information. This category of communications requires 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.

### Example:

*“Mission Control, this is Mission Commander; **be advised** 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. **Do you confirm?**”*

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

## Announce

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

### Example:

*“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 ( <i>Go</i> ) or deny ( <i>No Go</i> ) permission for the Flight Crew to proceed with a mission step.
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# Chapter 1.6 – Communication Guidelines

Confirm:	<i>“Roger”</i> or <i>“Copy”</i>	This is used to confirm receipt of a message.
Status:	<i>“Nominal”</i>	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 three-step confirmation procedure 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.

### Example:

- |  |  |
|--|--|
| 1) Flight Engineer:<br>(reads checklist)             | <i>“APU / HYDRAULICS (1/2/3) to OFF”</i>                         |
| 2) Mission Commander:<br>(performs action)           | <i>“APU / HYDRAULICS (1/2/3) to OFF”</i>                         |
| 3) Pilot:<br>(verifies action completed)             | <i>“APU / HYDRAULICS (1/2/3) to OFF <b><u>Check</u></b>”</i>     |
| 1) Flight Engineer:<br>(reads checklist)             | <i>“APU FUEL TK VLV (1/2/3) to CLOSE”</i>                        |
| 2) Pilot:<br>(performs action)                       | <i>“APU FUEL TK VLV (1/2/3) to CLOSE”</i>                        |
| 3) Mission Commander:<br>(verifies action completed) | <i>“APU FUEL TK VLV (1/2/3) to CLOSE” <b><u>Confirm</u></b>”</i> |

# 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,

## Chapter 1.6 – Communication Guidelines

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 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).



# Chapter 1.6 – Communication Guidelines



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<sub>2</sub> SYS to OPEN (5) – the (5) means the ENVIRONMENTAL SYSTEM O<sub>2</sub> 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 if 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

# Chapter 1.7 – Running a Flight Simulator Mission

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 must revert to the standard methods and protocols.

## In Orbit

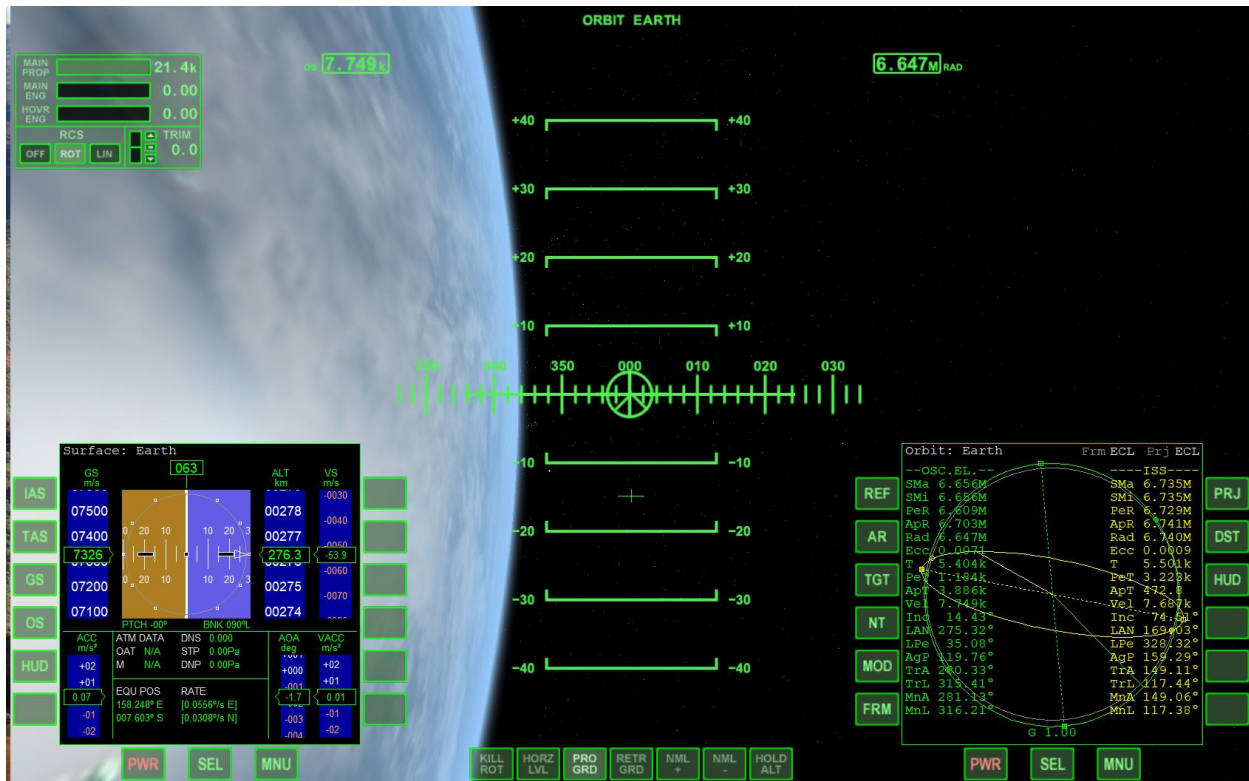
Once orbit has been attained, the flight crew will perform several operations that interact with the Orbiter program and the PowerPoints, such as “zero-up”, retrograde, prograde, payload bay door open/close. During these operations, all team members must be aware of what is occurring and make sure to 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.

## Zero-up

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

# Chapter 1.7 – Running a Flight Simulator Mission

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

## De-Orbit Burn

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

## Landing

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

## Chapter 1.7 – Running a Flight Simulator Mission

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 be 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.

O <sub>2</sub> PRESS	H <sub>2</sub> PRESS	SMOKE / FIRE	LANDING SYS	FUEL CELL TEMP
CABIN ATM	H <sub>2</sub> /O <sub>2</sub> HEATER TEMP	MAIN BUS VOLTAGE	AC VOLTAGE	AC O/U LOAD
FREON LOOP	AV BAY / CABIN AIR	IMU	RCS FWD	RCS JET
H <sub>2</sub> O 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 <sub>2</sub> O SPRAY BOILER	HYD PRESS

**SYSTEM SUMMARY 1**

CTD	HYD	1	2	3	FREON LOOP	1	2
PRV	PRESSURE	3064	2985	3100	EVAP OUT T	41	38
PG	ACCUM PRES	2509	2524	2602	FREON FLOW	2193	2190
<	CIRC PUMP P	370	384	379	PL HX FLOW	290	286
>	CIRC PUMP T	64	66	66	AFT CP FLOW	279	278
ENT	PUMP TEMP	94	92	90	RAD IN TEMP	97	96
GO	PUMP BODY T	61	47	59	RAD OUT TEMP	38	38
	PUMP LEAK P	20	38	17	ACCUM QTY	27	27
	RSVR PRESS	59	53	55			
	RSVR TEMP	55	58	52	<b>H<sub>2</sub>O LOOP</b>	<b>1</b>	<b>2</b>
	B/U PRESS	64	65	63	PUMP OUT P	64	62
	VLV TEMP	70	85	81	PUMP OUT T	63	63
	HX IN T	75	72	77	PUMP PRESS	30	38
	HX OUT T	59	60	58	ICH FLOW	564	777
	CAB HX IN T	42	38	39	ICH OUT T	41	38
	RADIATORS	FOR L	FOR R	AFT L	AFT R		
	LINE IN T	97	96	95	98		
	LINE OUT T	17	21	22	19		

**SYSTEM SUMMARY 2**

PRV	TEMP SNSR	1	2	3	EVAP TEMP	DUCT	NOZZLE	PRV
NXT	FLIGHT DECK	77	76	77	HI LOAD INBD	200	150	NXT
INS	MID DECK	78	79	77	HI LOAD OUTBD	50	40	INS
<	LOWER DECK	79	80	79	TOPPING FWD	125	100	<
>	AV BAY 1	106	99	99	TOPPING AFT	130	115	>
ENT	AV BAY 2	106	105	99	TOPPING LEFT	128	120	ENT
GO	AV BAY 3	100	102	100	TOPPING RIGHT	136	125	GO
	PYLD BAY FWD	77	78	79				
	PYLD BAY AFT	77	77	76	<b>EVAP FOLN T</b>	<b>A</b>	<b>B</b>	
	SP LAB FWD	77	76	77	FWD	90	87	
	SP LAB AFT	78	79	78	MID 1	100	103	
	<b>FUEL CELLS</b>	<b>1</b>	<b>2</b>	<b>3</b>	MID 2	85	84	
	AMPS	61.5	61.5	61.5	AFT FOLN T	80	79	
	VOLTS	31.9	32.1	32	TOPPING	85	86	
	H2O PRDD	115	110	105	ACCUM FOLN T	90	94	
					HI LOAD	100	102	
	<b>CABIN AIR</b>	%						
	N2	79						
	O2	21						
	CO2	0.04						

DEPT. OF DEFENSE  
FLIGHTS ONLY



# 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.

O <sub>2</sub> PRESS	H <sub>2</sub> PRESS	<b>SMOKE / FIRE</b>	LANDING SYS	FUEL CELL TEMP
CABIN ATM	H <sub>2</sub> O <sub>2</sub> HEATER TEMP	MAIN BUS VOLTAGE	AC VOLTAGE	AC O/U LOAD
FREON LOOP	AV BAY / CABIN AIR	IMU	RCS FWD	RCS JET
H <sub>2</sub> O 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
<b>ALARM</b>	APU TEMP	APU SPEED	H <sub>2</sub> O SPRAY BOILER	HYD PRESS

SYSTEM SUMMARY 1							
CTD	HYD	1	2	3	FREON LOOP	1	2
	PRESSURE	3064	2985	3110	EVAP OUT T	41	38
	ACCUM PRES	2509	2524	2602	FREON FLOW	2193	2190
	CIRC PUMP P	370	384	379	PL HX FLOW	290	286
	CIRC PUMP T	64	66	66	AFT CP FLOW	279	278
	PUMP TEMP	94	92	90	RAD IN TEMP	97	96
	PUMP BOY T	61	47	59	RAD OUT TEMP	38	38
	PUMP LEAK P	20	38	17	ACCUM QTY	27	27
	RSVR PRESS	59	53	55			
	RSVR TEMP	55	58	52	H <sub>2</sub> O LOOP	1	2
B/U PRESS	64	65	63	PUMP OUT P	64	62	
VLV TEMP	70	85	81	PUMP OUT T	63	63	
HX IN T	75	72	77	PUMP PRESS	30	38	
HX OUT T	59	60	58	ICH FLOW	564	777	
CAB HX IN T	42	38	39	ICH OUT T	41	38	
RADIATORS: FOR L FOR R AFT L AFT R							
LINE IN T	97	96	95	98			
LINE OUT T	17	21	22	19			

SYSTEM SUMMARY 2						
TEMP SNSR	1	2	3	EVAP TEMP	DUCT	NOZZLE
FLIGHT DECK	77	76	77	HI LOAD INBD	200	150
MID DECK	78	79	77	HI LOAD OUTBD	50	40
LOWER DECK	78	80	78	TOPPING FWD	125	100
AV BAY 1	<b>210</b>	<b>199</b>	<b>208</b>	TOPPING AFT	130	115
AV BAY 2	106	105	99	TOPPING LEFT	128	120
AV BAY 3	<b>199</b>	<b>202</b>	<b>200</b>	TOPPING RIGHT	136	125
PYLO BAY FWD	77	78	78			
PYLO BAY AFT	77	77	76	EVAP FOLN T	A	B
SP LAB FWD	77	76	77	FWD	90	87
SP LAB AFT	78	79	78	MID 1	100	103
FUEL CELLS	1	2	3	MID 2	85	84
AMPS	61.5	61.5	61.5	AFT FOLN T	80	79
VOLTS	31.9	32.1	32	TOPPING	85	86
H <sub>2</sub> O PROD	115	110	105	ACCUM FOLN T	90	94
				HI LOAD	100	102
CABIN AIR	%					
N <sub>2</sub>	79					
O <sub>2</sub>	21					
CO <sub>2</sub>	0.04					
<b>DEPT. OF DEFENSE FLIGHTS ONLY</b>						

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. Therefore 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

## Chapter 1.8 – Training for Emergencies

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 (RTL)
  - 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

# Chapter 1.8 – Training for Emergencies

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!

## Ways to Practice for an Emergency

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 <sub>2</sub> PRESS	H <sub>2</sub> PRESS	SMOKE / FIRE	LANDING SYS	FUEL CELL TEMP
CABIN ATM	H <sub>2</sub> O <sub>2</sub> HEATER TEMP	MAIN BUS VOLTAGE	AC VOLTAGE	AC O/U LOAD
FREON LOOP	AV BAY / CABIN AIR	IMU	RCS FWD	RCS JET
H <sub>2</sub> O 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 <sub>2</sub> O 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

# Chapter 1.8 – Training for Emergencies

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

# Chapter 1.8 – Training for Emergencies

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



# Chapter 1.8 – Training for Emergencies

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.

O <sub>2</sub> PRESS	H <sub>2</sub> PRESS	SMOKE / FIRE	LANDING SYS	FUEL CELL TEMP
CABIN ATM	H <sub>2</sub> /O <sub>2</sub> HEATER TEMP	MAIN BUS VOLTAGE	AC VOLTAGE	AC O/U LOAD
FREON LOOP	AV BAY / CABIN AIR	IMU	RCS W/D	RCS JET
H <sub>2</sub> O LOOP	SRB LEFT	SRB RIGHT	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 <sub>2</sub> O SPRAY BOILER	HYD PRESS

Annunciator Panel

SYSTEM SUMMARY 1

CTD	HYD	1	2	3	FREON LOOP	1	2
	PRESSURE	3064	3065	3060	EVAP OUTT	38	38
	ACCUM PRES	2616	2624	2624	FREON FLOW	2193	2190
PG	CIRC PUMP P	264	266	266	PL HX FLOW	290	286
	CIRC PUMP T	64	66	66	AFT CP FLOW	279	278
	PUMP TEMP	94	92	90	RAD IN TEMP	97	96
	PUMP BODY T	61	47	47	RAD OUT TEMP	38	38
<	PUMP LEAK P	14	14	14	ACCUM QTY	27	27
	RSVR PRESS	65	66	66	H <sub>2</sub> O LOOP	1	2
	RSVR TEMP	58	64	66	PUMP OUTP	64	62
>	B/U PRESS	64	64	64	PUMP OUTT	64	63
	WV TEMP	114	111	107	PUMP PRESS	30	38
ENT	HX IN T	75	75	75	ICH FLOW	564	777
	HX OUT T	59	54	54	ICH OUTT	41	38
GO	CAB HX IN T	42	38	39			
	RADIATORS	FOR L	FOR R	AFT L	AFT R		
	LINE IN T	1	2	3	4		
	LINE OUTT	1	2	3	4		

SYSTEM SUMMARY 2

PRV	CTD	TEMP SNSR	1	2	3	EVAP TEMP	DUCT	NOZZLE	PRV
		FLIGHT DECK	75	77	76	HI LOAD INBD	64	63	
		MD DECK	79	81	76	HI LOAD OUTBD	250	250	
NXT	PG	LOWER DECK	74	73	71	TOPPING FWD	63	62	NXT
		AV BAY 1	97	97	83	TOPPING AFT	25	25	
		AV BAY 2	97	97	83	TOPPING LEFT	1271	1271	
		AV BAY 3	97	97	83	TOPPING RIGHT	426	423	
INS	<	YLD BAY AFT	200	200	200	EVAP FOLN T	A	B	INS
		YLD BAY FWD	200	200	200	FWD	80	80	
		SP LAB FWD	99	100	98	MD 1	80	80	
DEL	>	SP LAB AFT	98	99	100	MD 2	79	75	DEL
		FUEL CELLS	1	2	3	AFT FOLN T	75	79	
		AMPS	61.5	61.5	61.5	TOPPING	75	79	
		VOLTS	32	32	32	ACCUM FOLN T	75	79	
		H <sub>2</sub> O PROD	80	84	83	HI LOAD	75	79	
		CABIN AIR	%						
		N2	79						
		O2	21						
		CO2	0.04						

DEPT. OF DEFENSE  
 FLIGHTS ONLY

PWR
SEL
MNU

## Chapter 1.8 – Training for Emergencies

O2 PRESS	H <sub>2</sub> PRESS	SMOKE / FIRE	LANDING SYS	FUEL CELL TEMP
CABIN ATM	H <sub>2</sub> /O <sub>2</sub> HEATER TEMP	MAIN BUS VOLTAGE	AC VOLTAGE	AC O/U LOAD
FREON LOOP	AV BAY/CABIN AIR	IMU	RCS FWD	RCS JET
H <sub>2</sub> O 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 <sub>2</sub> O 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:

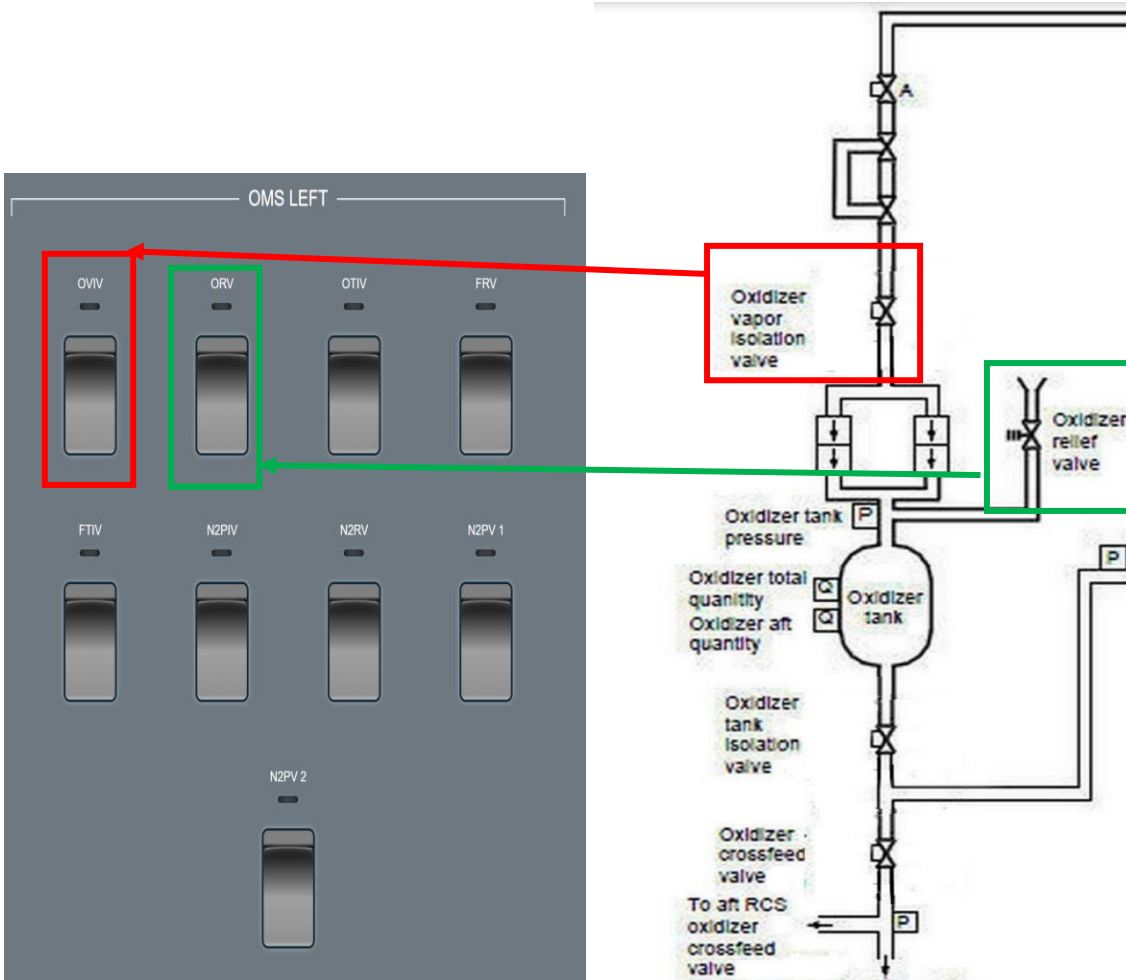
OMS LEFT: Indicates detection of a left OMS pod oxidizer or fuel tank ullage pressure out of limits, or an engine abnormal (OMS engine fail to cutoff, fail to ignite, or early shutdown) condition.

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 Oxidizer Vapor Isolation Valve in the schematic. Likewise, the ORV switch controls the Oxidizer Relief Valve in the schematic.



# Chapter 1.8 – Training for Emergencies



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.

## Using the schematics

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

# Chapter 1.8 – Training for Emergencies

O <sub>2</sub> PRESS	H <sub>2</sub> PRESS	SMOKE / FIRE	LANDING SYS	FUEL CELL TEMP
CABIN ATM	H <sub>2</sub> /O <sub>2</sub> HEATER TEMP	MAIN BUS VOLTAGE	AC VOLTAGE	AC O/U LOAD
FREON LOOP	AV BAY / CABIN AIR	IMU	RCS FWD	RCS JET
H <sub>2</sub> O 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 <sub>2</sub> O SPRAY BOILER	HYD PRESS

SYSTEM SUMMARY 1									
CTD	HYD	1	2	3	FREON LOOP	1	2	PRV	CTD
	PRESSURE	3064	2985	3110	EVAP OUT T	41	33		
	ACCUM PRES	2844	2874	2901	FREON FLOW	2193	2190		
PG	CIRC PUMP P	370	384	379	PL HX FLOW	290	286	NXT	PG
	CIRC PUMP T	64	66	66	AFT CP FLOW	279	278		
	PUMP TEMP	94	92	90	RAD IN TEMP	97	101		
	PUMP BODY T	61	47	59	RAD OUT TEMP	38	38		
<	PUMP LEAK P	20	39	17	ACCUM QTY	27	27	INS	<
	RSVR PRESS	50	53	55					
	RSVR TEMP	55	56	52	H <sub>2</sub> O LOOP	1	2		
>	B/U PRESS	64	65	63	PUMP OUT P	64	62	DEL	>
	VLV TEMP	70	85	81	PUMP OUT T	63	64		
	HX IN T	75	72	77	PUMP PRESS	30	38		
ENT	HX OUT T	59	60	58	ICH FLOW	564	777		ENT
	CAB HX IN T	42	38	39	ICH OUT T	41	38		
	RADIATORS	FOR L	FOR R	AFT L	AFT R				
	LINE IN T	97	96	95	96				
GO	LINE OUT T	39	37	40	41			v	GO

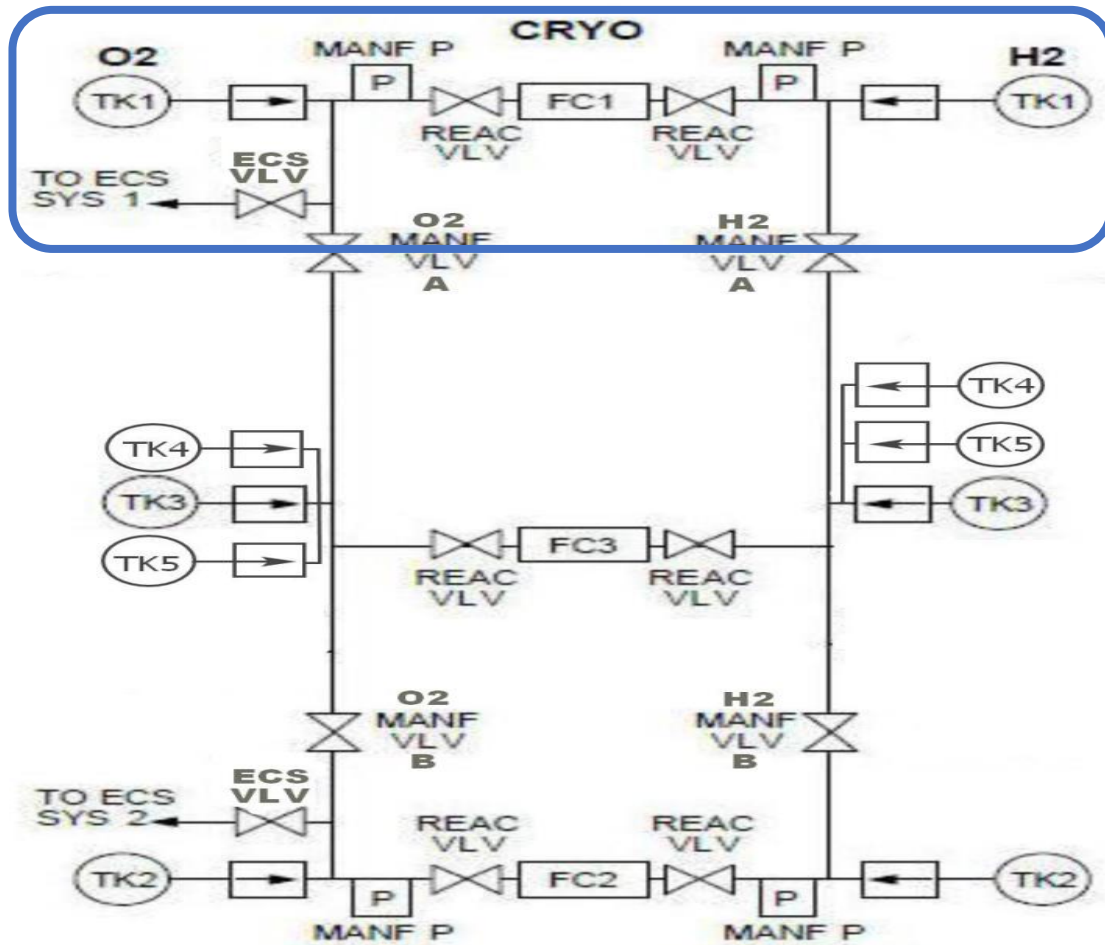
  

SYSTEM SUMMARY 2									
	TEMP SNSR	1	2	3	EVAP TEMP	DUCT	NOZZLE		
	FLIGHT DECK	77	76	77	HI LOAD INBD	200	150		PRV
	MID DECK	78	79	77	HI LOAD OUTBD	50	40		
	LOWER DECK	79	80	79	TOPPING FWD	125	100		
	AV BAY 1	106	99	99	TOPPING AFT	130	115		NXT
	AV BAY 2	106	105	99	TOPPING LEFT	128	120		
	AV BAY 3	100	102	100	TOPPING RIGHT	136	125		
	PYLD BAY FWD	77	78	79					INS
	PYLD BAY AFT	77	77	76	EVAP FOLN T	A	B		
	SP LAB FWD	77	76	77	FWD	90	87		
	SP LAB AFT	76	79	78	MID 1	100	103		DEL
	FUEL CELLS	1	2	3	MID 2	85	84		
	AMPS	49.1	61.5	61.5	AFT FOLN T	80	79		
	VOLTS	21	32.1	32	TOPPING	85	86		
	H <sub>2</sub> O PROD	115	110	105	ACCUM FOLN T	90	94		
					HI LUAW	100	102		
	CABIN AIR	%							
	N <sub>2</sub>	79			DEPT. OF DEFENSE				
	O <sub>2</sub>	21			FLIGHTS ONLY				
	CO <sub>2</sub>	0.04							v

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.

# Chapter 1.8 – Training for Emergencies

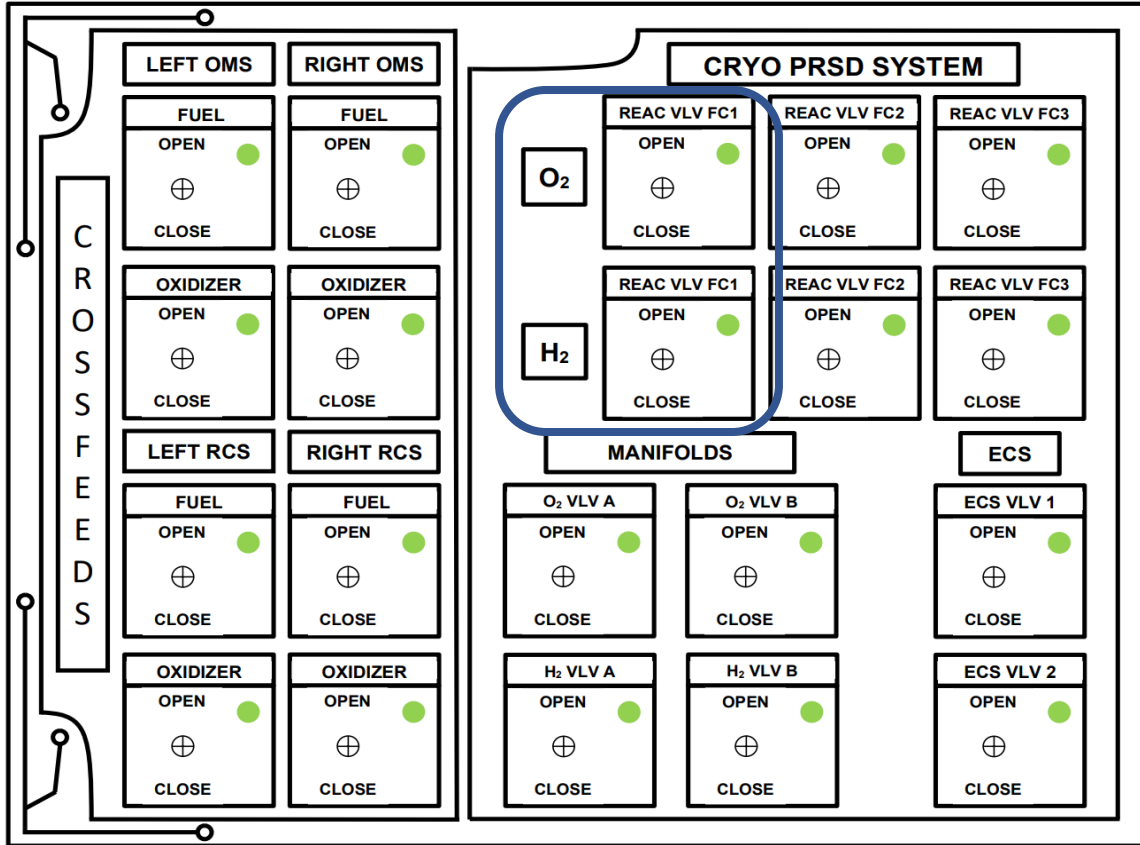
## Cryogenic Power Distribution System Schematic



### 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.

# Chapter 1.8 – Training for Emergencies



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

O <sub>2</sub> PRESS	H <sub>2</sub> PRESS	SMOKE / FIRE	LANDING SYS	FUEL CELL TEMP
CABIN ATM	H <sub>2</sub> /O <sub>2</sub> HEATER TEMP	MAIN BUS VOLTAGE	AC VOLTAGE	AC O/U LOAD
FREON LOOP	AV BAY / CABIN AIR	IMU	RCS FWD	RCS JET
H <sub>2</sub> O 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 <sub>2</sub> O SPRAY BOILER	HYD PRESS

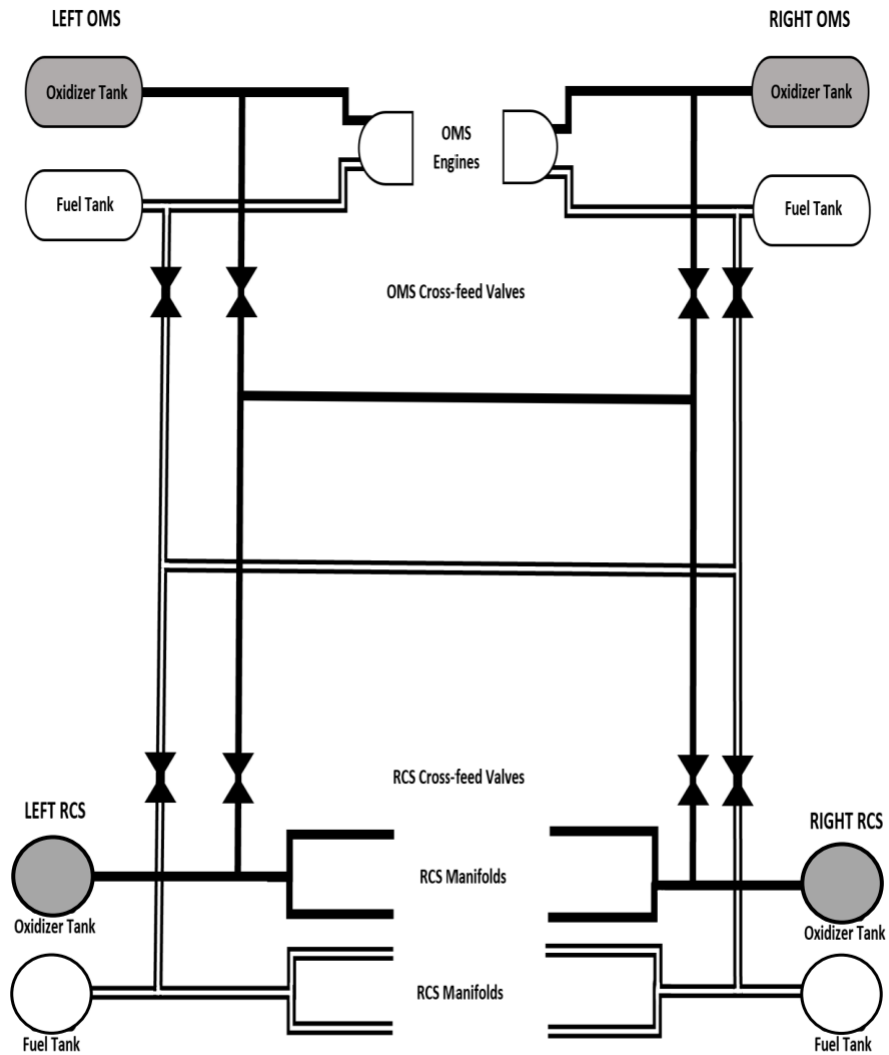
  

SYSTEM SUMMARY 1						SYSTEM SUMMARY 2									
CTD	HYD	1	2	3	FREON LOOP	1	2	TEMP SNSR	1	2	3	EVAP TEMP	DUCT	NOZZLE	PRV
	PRESSURE	3064	2985	3100	EVAP OUT T	41	33	FLIGHT DECK	77	76	77	HI LOAD INBD	200	150	
PG	ACCUM PRES	2844	2874	2901	FREON FLOW	2193	2190	MID DECK	78	79	77	HI LOAD OUTBD	50	40	NXT
	CIRC PUMP P	370	384	379	PL HX FLOW	290	286	LOWER DECK	79	80	79	TOPPING FWD	125	100	
	CIRC PUMP T	64	66	66	AFT CP FLOW	279	278	AV BAY 1	106	99	99	TOPPING AFT	130	115	
	PUMP TEMP	94	92	90	RAD IN TEMP	97	101	AV BAY 2	106	105	99	TOPPING LEFT	128	120	
	PUMP BOY T	61	47	59	RAD OUT TEMP	38	38	AV BAY 3	100	102	100	TOPPING RIGHT	136	125	
	PUMP LEAK P	20	39	17	ACCUM QTY	27	27	PYLD BAY FWD	77	78	79				
	RSVR PRESS	55	56	55				PYLD BAY AFT	77	77	76	EVAP FOLN T	A	B	
	RSVR TEMP	55	56	52	H <sub>2</sub> O LOOP	1	2	SP LAB FWD	77	76	77	FWD	90	87	
	B/U PRESS	64	65	63	PUMP OUT P	64	62	SP LAB AFT	79	79	78	MID 1	100	103	
	VLV TEMP	70	85	81	PUMP OUT T	63	64	AV BAY 1	106	99	99	MID 2	85	84	
	HX IN T	75	72	77	PUMP PRESS	30	38	AV BAY 2	106	105	99	AFT FOLN T	80	79	
ENT	HX OUT T	59	60	58	ICH FLOW	564	777	AV BAY 3	100	102	100	TOPPING	85	86	
	CAB HX IN T	42	38	39	ICH OUT T	41	38	PYLD BAY FWD	77	78	79	ACCUM FOLN T	90	94	
								PYLD BAY AFT	77	77	76	HI LLDU	100	102	
GO	RADIATORS	FOR L	FOR R	AFT L	AFT R			TEMP SNSR	1	2	3				
	LINE IN T	97	96	95	96			FUEL CELLS	1	2	3				
	LINE OUT T	39	37	40	41			AMPS	61.5	11.5	61.5				
								VOLTS	31.9	12.1	32				
								H2O PRD	115	110	105				
								CABIN AIR	N2	%					
								O2	21						
								CO2	0.04						

3:00 min.

# Chapter 1.8 – Training for Emergencies

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

## Chapter 1.8 – Training for Emergencies

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 –

# Chapter 1.9 - Flight Simulator Common Issues

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.

## Chapter 1.10 - Creating a Custom Orbiter 2010 Scenarios

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 control team. The Landing Simulation Challenge uses much of the same documentation as the Flight Simulation Challenge, but there is some 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 setup and run the Landing Simulation Challenge during team training.
- 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.
- Landing Simulation Challenge Switch Panel checklist – A diagram of the switch locations used during the Landing Simulation Challenge.

## **Run-off Landing Simulation Challenge event**

In the run-off event, the team will perform three landings by two-member teams, using the Landing Simulation Challenge simulator. Each two-member team is comprised of one Flight Simulation mission control member (mission director, mission controller 1 or mission controller 2) and one Flight Simulation flight crew member (mission commander, pilot or flight engineer). During the landing event, the mission control member of the pair will fly the landing (acting as Mission Commander) while the flight crew member will perform all other duties required by the checklist in the Procedures column. The three different landing scenarios used for the Landing Simulation Challenge are a standard KSC runway 33 landing, a night landing and an instrument-only landing. The flight teams are scored on how well they communicate, perform their specific functions and accuracy of the landing.

## **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, keeping with the run-off member specifications. 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 mission control team members practice landings since they are the ones performing the actual landing during the competition.
- Have your flight crew practice calling out altitude and airspeed as they will be performing the mission control functions during the Landing Simulation Challenge.
- Remind them to communicate during the event and not to fall into the “trap” of just watching the team member fly.

# Chapter 2.1 – Landing Simulation Challenge

## 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 mission control team members practice landing since they are the ones performing the actual landing during the competition.
- Have all your mission control team members practice the instrument landings since the landing scenario is assigned by random draw.

## Night landing

- A night landing is very much 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.

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 are provided an aerospace related problem. Working as two three-person teams, they are required to use teamwork, communication, and problem-solving skills to solve a series of challenges and reach a solution. Concise and accurate communication is essential to resolving all the problems presented to the team.

## Major Changes

In the past, the Flight Crew and Mission Control team for the Space Flight Simulator Challenge were required to switch positions during the Engineering Challenge. **Starting in 2024, teams will be able to decide where each team member will participate for the Engineering Challenge.**

In order to allow for more flexibility in the challenges, specific rolls will not be assigned except for communication. One student from each 3-person team must be in charge of communication. The communication specialists are still allowed to assist with the challenges but are required to monitor communications at all time. If needed, they may transfer that responsibility to another team member temporarily.

Each year, a team briefing will be given to the teams that will describe the mission for that year. During the 2022-23 Finals, teams were given the briefing right before the challenge. For the 2023-24 Finals, we hope to have the team briefing available by coaches training. It will also be posted on the website.

## Format

- The team will have 45 minutes to work through and solve as many of the assigned tasks as possible.
- The standard communications format will depend on the type of mission. This will be given to teams in a briefing before the challenge.
- All pertinent information will be provided to the team once the challenge starts.
- **Apollo division** – Max of 2 hints before a 3-point deduction for additional hints.
- **Redstone division** – Max of 4 hints before a 1-point deduction for additional hints.
- Judging criteria:
  - Communication
  - Teamwork
  - Professionalism
  - Complete tasks correctly
  - Complete tasks quickly

## Suggestion

Since good communication is critical to successfully completing this challenge, it is highly recommended that the team plays the game “Keep Talking and Nobody Explodes”. While this is not 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).

- 1) **Apollo Division – Advanced Design Challenge** - 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. Rubrics for the Infographic and presentation will be posted on the website.
- 2) **Mercury Division – Mailbox Challenge** – a mailbox design challenge to create a physical mailbox for a specific space-related theme as part of the Blue Origins "Post Cards into Space" club. 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 will be flown on a Blue Origins flight and returned to the school so they mail be returned to the students. They will now have a postcard that has been to space. 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 to be displayed at the entrance.
- 3) **Both Divisions - Patch** – a patch design challenge to create a team flight patch related to a specific space-related theme of either Advanced Design Challenge or the Mailbox Challenge. 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. The winning patch design will be printed on a banner for the winning school to display.

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

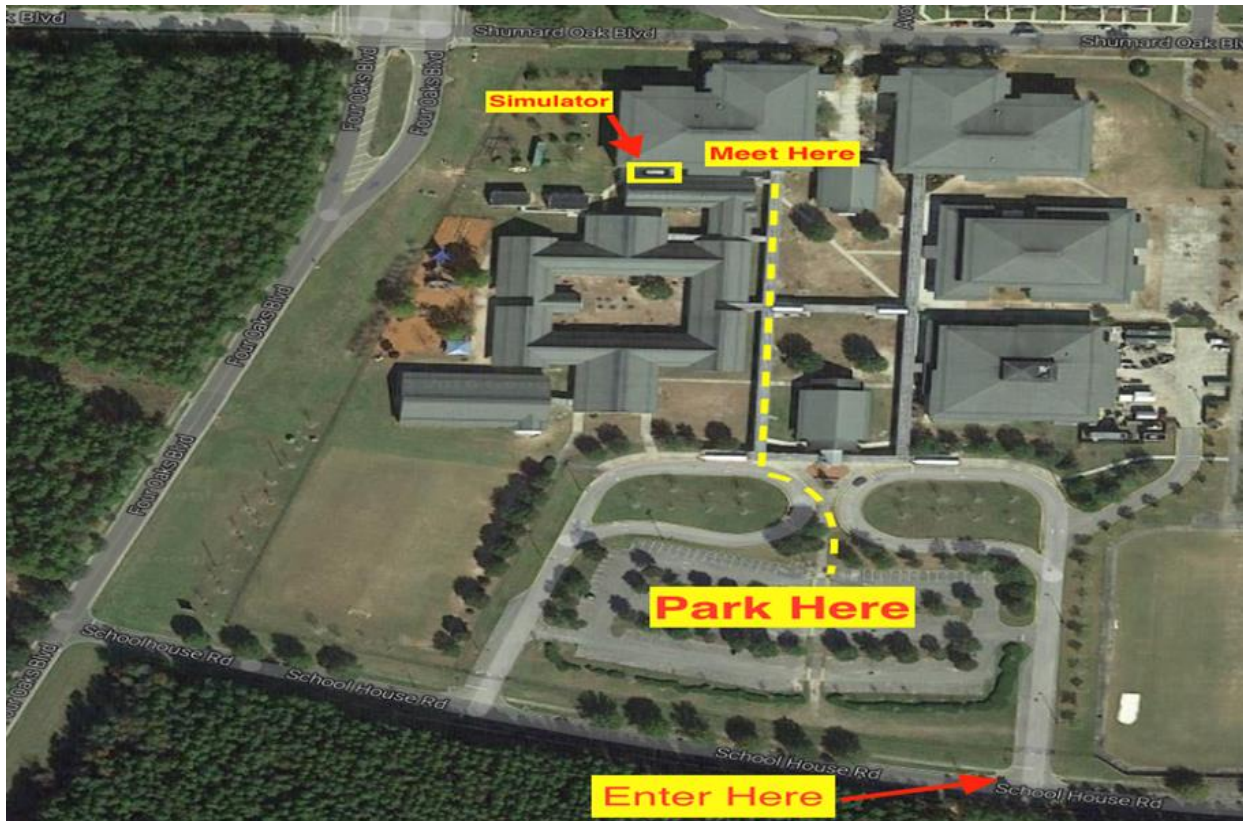


# Chapter 5.1 – Location and Schedule

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 in February, 2024. 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

## Training Agenda

Friday, November 3 | Orbiter Install and Setup | 6pm-9pm | optional

Please be sure you have administrator rights on the device you bring to install orbiter.

Saturday, November 4 | Competition and Event Information | 830am - 5pm

Includes light breakfast and lunch

# Chapter 5.1 – Location and Schedule

8:00-9:00 - Check in and breakfast

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

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

Sunday, November 5 | Technical Manual and Emergencies | 8am-1pm

8:00am-8:30am - Review Mission Milestones

[MECO, Payload Bay Operations, Zero up, Deorbit Burn, Gauntlet]

9:00am-9:30am - 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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**Social Media, Patch Challenge:**

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submit team information: [tinyurl.com/astrochall2022](https://tinyurl.com/astrochall2022)

## Chapter 5.2 – SAC Staff Contact Information

**Follow us on Social Media!**

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**[www.facebook.com/StudentAstro](http://www.facebook.com/StudentAstro)**

**THE DREAM IS ALIVE.**

*John Young*

*STS-1 Landing*

*April 14, 1981*

# Chapter 5.3 - SAC Glossary



<b>A</b>	Ampere, the SI base unit of electric current.
<b>a, A</b>	Acceleration. $a = \Delta \text{ velocity} / \Delta \text{ time}$ . Acceleration = Force / Mass
<b>Abort</b>	To bring a flight to a premature end because of a problem or fault.
<b>AC</b>	Alternating current
<b>AC Bus</b>	An electrical pathway that distributes alternating current electrical power to various Orbiter systems.
<b>AC Bus Sensor</b>	The AC bus sensor monitors each AC phase bus for over- or under voltage and each phase inverter for an overload signal.
<b>AC Bus System</b>	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.
<b>Acceleration</b>	Change in velocity. Note that since velocity comprises both direction and magnitude (speed), a change in either direction or speed constitutes acceleration.
<b>ALT</b>	Altitude or Altimetry data.
<b>AO</b>	Announcement of Opportunity.
<b>AOA</b>	Abort Once Around. A type of abort that results in less than one orbit of Earth. The flight enters orbit and immediately executes the deorbit routine to initiate a reentry and landing.
<b>AOS</b>	Acquisition of Signal.
<b>Aphelion</b>	Apoapsis in solar orbit.
<b>Apoapsis</b>	The farthest point in an orbit from the body being orbited.
<b>Apogee</b>	Apoapsis in Earth orbit.
<b>APU</b>	Auxiliary Power Unit is 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 gimbaling of Shuttle's engines and control surfaces. During landing, they power the control surfaces and brakes.

<b>Argument</b>	Angular distance.
<b>Argument of periapsis</b>	The argument (angular distance) of periapsis from the ascending node.
<b>Ascending node</b>	The point at which an orbit crosses a reference plane (such as a planet's equatorial plane or the ecliptic plane) going north.
<b>Asteroids</b>	Small bodies composed of rock and metal in orbit about the sun.
<b>ATO</b>	Abort To Orbit. A type of abort that results in the orbiter entering Earth orbit in an altitude that is less than the planned mission altitude. Due to how low the orbit is, will depend on whether any of the planned mission can be completed.
<b>AU</b>	Astronomical Unit, based on the mean Earth-to-sun distance, 149,597,870 km. Refer to "Units of Measure" section for complete information.
<b>AZ</b>	Azimuth.

## B

<b>BAT</b>	Abbreviation for BATTERY.
<b>Boiler System</b>	See <b>Water Spray Boiler System</b> .
<b>BPS</b>	Bits per Second, same as Baud rate.

## C

<b>c</b>	The speed of light, 299,792 km per second.
<b>Carrier</b>	The main frequency of a radio signal generated by a transmitter prior to application of any modulation.
<b>C-band</b>	A range of microwave radio frequencies in the neighborhood of 4 to 8 GHz.
<b>CDT</b>	Central Daylight Time. Offset = UTC-5:00
<b>Centrifugal force</b>	The outward-tending apparent force of a body revolving around another body.
<b>Centripetal acceleration</b>	The inward acceleration of a body revolving around another body.

<b>Chandler wobble</b>	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.
<b>Channel</b>	In telemetry, one particular measurement to which changing values may be assigned.
<b>CIRC</b>	Abbreviation for CIRCULATION.
<b>Clarke orbit</b>	Geostationary orbit.
<b>CNTRL</b>	Abbreviation for CONTROL.
<b>Coma</b>	The cloud of diffuse material surrounding the nucleus of a comet.
<b>Comets</b>	Small bodies composed of ice and rock in various orbits about the sun
<b>COMM</b>	Communication system
<b>Conjunction</b>	A configuration in which two celestial bodies have their least apparent separation.
<b>CRT</b>	Cathode Ray Tube video display device that allows onboard monitoring of orbiter systems, computer software processing and manual control for flight crew data and software manipulation.
<b>CST</b>	Central Standard Time. Offset = UTC-6:00

## D

<b>DAP</b>	The Digital Auto Pilot software-based system that controls the orientation of the Space Shuttle. It can perform three-axis automatic maneuver, attitude tracking, and rotation about any axis or body vector. Crew interface to the Digital Auto Pilot was via the Orbiter cathode ray tubes/keyboard interface, which allowed the crew to control parameters in the software.
<b>DC</b>	Direct Current. (Electrical)
<b>DC Bus</b>	An electrical pathway that distributes direct current electrical power to various Orbiter systems.
<b>DC Bus System</b>	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.

<b>DEC</b>	Declination.
<b>Declination</b>	The measure of a celestial body's apparent height above or below the celestial equator.
<b>Density</b>	Mass per unit volume. For example, the density of water can be stated as 1 gram/cm <sup>3</sup> .
<b>Descending node</b>	The point at which an orbit crosses a reference plane (such as a planet's equatorial plane or the ecliptic plane) going south.
<b>Doppler Effect</b>	The effect on frequency imposed by relative motion between transmitter and receiver. See Chapters 2, 4 and 5.
<b>Downlink</b>	Signal received from a spacecraft.
<b>DPS</b>	Abbreviation for DATA PROCESSING SYSTEM. (Maro-pad command)
<b>DSN</b>	NASA's Deep Space Network.

## E

<b>Eccentricity</b>	The distance between the foci of an ellipse divided by the major axis.
<b>Ecliptic</b>	The plane in which Earth orbits the sun and in which solar and lunar eclipses occur.
<b>EDL</b>	(Atmospheric) Entry, Descent, and Landing.
<b>EDT</b>	Eastern Daylight Time. Offset = UTC-4:00
<b>EGT</b>	APU Exhaust Gas Temperature
<b>Ellipse</b>	A closed plane curve generated in such a way that the sums of its distances from the two fixed points (the foci) is constant.
<b>ELV</b>	Expendable launch vehicle.
<b>EM</b>	Electromagnetic
<b>EMF</b>	Electromagnetic force (radiation).
<b>EMR</b>	Electromagnetic radiation.
<b>Equator</b>	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** Abbreviation for EXTERNAL TANK

**eV** Electron volt, a measure of the energy of subatomic particles.

**EXEC** Abbreviation for EXECUTE. (Macro-pad command)

**EXT** Abbreviation for EXTERNAL.

## F

**f, F** Force. Two commonly used units of force are the Newton and the dyne. Force = Mass X Acceleration.

**FDS** Flight Data Subsystem.

**FE** Far Encounter phase of mission operations.

**FE** Abbreviation for FLIGHT ENGINEER. (Cockpit crew member)

**Fluorescence** The phenomenon of emitting light upon absorbing radiation of an invisible wavelength.

**FM** Frequency modulation.

**FTS** DSN Frequency and Timing System. Also, frequency and timing data.

## G

<b>G</b>	Universal Constant of Gravitation. Its tiny value ( $G = 6.6726 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$ ) is unchanging throughout the universe.
<b>g</b>	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 $g = GM/r^2$ 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 ( $9.8\text{m/s}^2$ ). See also weight.
<b>Gamma rays</b>	Electromagnetic radiation in the neighborhood of 100 femtometers wavelength.
<b>GEO</b>	Geosynchronous Earth Orbit.
<b>Geostationary</b>	A geosynchronous equatorial circular orbit. Also called Clarke orbit.
<b>Geosynchronous</b>	A direct, circular, low inclination orbit about the Earth having a period of 23 hours 56 minutes 4 seconds.
<b>GMT</b>	Greenwich Mean Time. Obsolete. UT, Universal Time is preferred.
<b>GPC</b>	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.
<b>Gravitation</b>	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: $F = Gm_1m_2/d^2$ , where $F$ is the force of attraction between the two objects, given $G$ the Universal Constant of Gravitation, masses $m_1$ and $m_2$ , and $d$ distance. Also stated as $F_g = GMm/r^2$ where $F_g$ 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.
<b>Gravitational waves</b>	Einsteinian distortions of the space-time medium predicted by general relativity theory (not yet directly detected as of March 2010). (Not to be confused with gravity waves, see below.)



<b>Gravity assist</b>	Technique whereby a spacecraft takes angular momentum from a planet's solar orbit (or a satellite's orbit) to accelerate the spacecraft or the reverse.
<b>Gravity waves</b>	Certain dynamical features in a planet's atmosphere (not to be confused with gravitational waves, see above).
<b>GTO</b>	Geostationary (or geosynchronous) Transfer Orbit.

## H

<b>H<sub>2</sub></b>	Chemical formula for Hydrogen Gas.
<b>HA</b>	Hour Angle.
<b>Halo orbit</b>	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).
<b>Heliocentric</b>	Sun-centered.
<b>Heliopause</b>	The boundary theorized to be roughly circular or teardrop-shaped, marking the edge of the sun's influence, perhaps 100 AU from the sun.
<b>Heliosphere</b>	The space within the boundary of the heliopause, containing the sun and solar system.
<b>Helium System</b>	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.
<b>HGA</b>	High-Gain Antenna onboard a spacecraft.
<b>Hohmann Transfer Orbit</b>	Interplanetary trajectory using the least amount of propulsive energy.
<b>Horizon</b>	The line marking the apparent junction of Earth and sky.
<b>Hour</b>	A measure of time equal to 60 minutes.
<b>Hour Angle</b>	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** The Horizontal Situation Indicator is used to follow 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 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** Abbreviation for HEAT EXCHANGER.

**HYD** Abbreviation for 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

**IF** Intermediate Frequency. In a radio system, a selected processing frequency between RF (Radio Frequency) and the end product (e.g., audio frequency).

**IMU** The Inertial Measurement Units 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.

<b>ILS</b>	Instrument Landing System. 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.
<b>INT</b>	Abbreviation for INTERNAL.
<b>Ion</b>	A charged particle consisting of an atom stripped of one or more of its electrons.
<b>IR</b>	Infrared, meaning "below red" radiation. Electromagnetic radiation in the neighborhood of 100 micrometers wavelength.
<b>ISOE</b>	Integrated Sequence of Events.
<b>ISOL</b>	Abbreviation for ISOLATION
<b>Isolation valves</b>	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.
<b>Isotropic</b>	Having uniform properties in all directions.
<b>Istres, France</b>	Alternate #2 Trans Atlantic Abort landing site.
<b>IUS</b>	Inertial Upper Stage.
<b><u>K</u></b>	
<b>K-band</b>	A range of microwave radio frequencies in the neighborhood of 12 to 40 GHz.
<b>Keyhole</b>	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.
<b>Klystron</b>	A microwave traveling wave tube power amplifier used in transmitters.
<b>Ku-band</b>	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.

**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

<b>m, M</b>	Mass. The kilogram is the standard unit of mass. $\text{Mass} = \text{Acceleration} / \text{Force}$ .
<b>Main Propulsion System</b>	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.
<b>Major Axis</b>	The maximum diameter of an ellipse.
<b>Maser</b>	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.
<b>Mass</b>	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.
<b>MDT</b>	Mountain Daylight Time. Offset = UTC-6:00
<b>Mean solar time</b>	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.
<b>MECO</b>	The Main Engine Cut Off point is where the engines shut down at about 8 minutes and 30 seconds into the flight.
<b>Meridians</b>	Great circles that pass through both the north and south poles, also called lines of longitude.
<b>Meteor</b>	A meteoroid which is in the process of entering Earth's atmosphere. It is called a meteorite after landing.
<b>Meteorite</b>	Rocky or metallic material which has fallen to Earth or to another planet.

<b>Meteoroid</b>	Small bodies in orbit about the sun which are candidates for falling to Earth or to another planet.
<b>MFD</b>	Multi-function display is a small screen in an aircraft that can be used to display information to the pilot in numerous configurable ways.
<b>MGA</b>	Medium-Gain Antenna onboard a spacecraft. MLI
<b>μm</b>	Micrometer (10 <sup>-6</sup> m).
<b>MLI</b>	Multi-layer insulation (spacecraft blanketing).
<b>Modulation</b>	The process of modifying a radio frequency by shifting its phase, frequency, or amplitude to carry information.
<b>Moron, Spain</b>	Primary Trans Atlantic Abort landing site.
<b>MST</b>	Mountain Standard Time. Offset = UTC-7:00
<b>MSTR</b>	Abbreviation for MASTER.
<b>Multiplexing</b>	A scheme for delivering many different measurements in one data stream.
<u><b>N</b></u>	
<b>N</b>	Newton, the SI unit of force equal to that required to accelerate a 1-kg mass 1 m per second per second (1m/sec <sup>2</sup> ).
<b>N<sub>2</sub></b>	Chemical formula for Nitrogen gas.
<b>Nadir</b>	The direction from a spacecraft directly down toward the center of a planet. Opposite of Zenith.
<b>NE</b>	Near Encounter phase in flyby mission operations. NiCad
<b>NiCad</b>	Nickel-cadmium rechargeable battery.
<b>Nodes</b>	Points where an orbit crosses a reference plane.
<b>Non-coherent</b>	Communications mode wherein a spacecraft generates its downlink frequency independent of any uplink frequency.
<b>Nucleus</b>	The central body of a comet.
<b>Nutation</b>	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

<b>O<sub>2</sub></b>	Chemical formula for Oxygen Gas.
<b>OB</b>	Observatory phase in flyby mission operations encounter period.
<b>OMS</b>	The Space Shuttle Orbital Maneuvering System, is a system of rocket engines for use on the space shuttle orbiter for orbital injection and modifying its orbit
<b>One-way Comm</b>	Communications mode consisting only of downlink received from a spacecraft.
<b>Oort cloud</b>	A large number of comets theorized to orbit the sun in the neighborhood of 50,000 AU.
<b>Opposition</b>	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.
<b>OTM</b>	Orbit Trim Maneuver, spacecraft propulsive maneuver.
<b>OWLT</b>	One-Way Light Time, the elapsed time between Earth and spacecraft or solar system body.

## P

<b>PAM</b>	Payload Assist Module upper stage.
<b>Parallels</b>	Circles in parallel planes to that of the equator defining north-south measurements, also called lines of latitude.
<b>PDT</b>	Pacific Daylight Time. Offset = UTC-7:00
<b>PE</b>	Post Encounter phase in flyby mission operations.
<b>Periapsis</b>	The point in an orbit closest to the body being orbited.
<b>Perigee</b>	Periapsis for Earth orbit.
<b>Phase</b>	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.
<b>Photovoltaic</b>	Materials that convert light into electric current.

<b>Plasma</b>	Electrically conductive fourth state of matter (other than solid, liquid, or gas), consisting of ions and electrons.
<b>PM</b>	Post meridiem (Latin: after midday), afternoon.
<b>Prograde</b>	1 - Orbital motion in the usual direction of celestial bodies within a given system, i.e. in the direction of the planets rotation; 2 - Orbit in which the spacecraft moves in the same direction as the planet rotates.
<b>PST</b>	Pacific Standard Time. Offset = UTC-8:00
<b>PWR</b>	Abbreviation for POWER.

## Q

<b>Quasar</b>	Quasi-stellar object observed mainly in radio waves. Quasars are extragalactic objects believed to be the very distant centers of active galaxies.
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## R

<b>RA</b>	Right Ascension.
<b>Radian</b>	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.
<b>RAM</b>	Random Access Memory.
<b>RCS</b>	The reaction control system 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 Fuel 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 system.
<b>RECIRC</b>	Abbreviation for RECIRCULATION.
<b>Reflection</b>	The deflection or bouncing of electromagnetic waves when they encounter a surface.
<b>Refraction</b>	The deflection or bending of electromagnetic waves when they pass from one kind of transparent medium into another.



<b>Regolith</b>	A blanket of unconsolidated, loose, heterogeneous superficial deposits covering solid rock. It includes dust, broken rocks, and other related materials and is present on Earth, the Moon, Mars, some asteroids, and other terrestrial planets and moons.
<b>Retrograde</b>	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 planets rotation; 2 - Orbit in which the spacecraft moves in the opposite direction from the planet's rotation.
<b>RF</b>	Radio Frequency.
<b>RFI</b>	Radio Frequency Interference.
<b>RGAs</b>	The orbiter Rate Gyro Assemblies are used by the flight control system during ascent, entry and aborts as feedbacks to final rate errors that are used to augment stability and for display on the commander's and pilot's attitude director indicator.
<b>Right Ascension</b>	The angular distance of a celestial object measured in hours, minutes, and seconds along the celestial equator eastward from the vernal equinox.
<b>Rise</b>	As in ascending above the horizon.
<b>ROM</b>	Read-only Memory.
<b>RTLS</b>	Return To Launch Site. A type of abort that results in the immediate return to the Kennedy Space Center Runway 33.
<b><u>S</u></b>	
<b>s</b>	Second, the SI base unit of time.
<b>SA</b>	Solar Array, photovoltaic panels onboard a spacecraft. SAR
<b>SAR</b>	Synthetic Aperture Radar
<b>Satellite</b>	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.
<b>S-band</b>	A range of microwave radio frequencies in the neighborhood of 2 to 4 GHz.
<b>SCET</b>	Spacecraft Event Time, equal to ERT minus OWLT.
<b>SCLK</b>	Spacecraft Clock Time, a counter onboard a spacecraft.

<b>Sec</b>	Abbreviation for Second.
<b>Second</b>	The SI base unit of time.
<b>Semi-major axis</b>	Half the distance of an ellipse's maximum diameter, the distance from the center of the ellipse to one end.
<b>Set</b>	As in going below the horizon.
<b>SI</b>	The International System of Units (metric system).
<b>SI base unit</b>	One of seven SI units of measure from which all the other SI units are derived.
<b>SI derived unit</b>	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. $W = m^2 * kg * s^{-3}$ (Note: the joule, J, is the SI derived unit for energy, work, or quantity of heat.)
<b>Sidereal time</b>	Time relative to the stars other than the sun.
<b>SNR</b>	Signal-to-Noise Ratio.
<b>SOE</b>	Sequence of Events.
<b>Solar wind</b>	Flow of lightweight ions and electrons (which together comprise plasma) thrown from the sun.
<b>Specific Impulse</b>	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.
<b>Spectrum</b>	A range of frequencies or wavelengths.
<b>SRB</b>	Abbreviation for SOLID ROCKET BOOSTER.
<b>SSME</b>	Space Shuttle Main Engines are reusable liquid-fuel rocket engines, each Space Shuttle ascent to orbit is propelled by three engines.
<b>Star Tracker</b>	The star tracker system is part of the orbiter's navigation system which works to help maintain the IMU during flight.
<b>STS</b>	Space Transportation System, generally known as the Space Shuttle. It is comprised of the Orbiter, External Tank (ET) and Solid-Rocket Boosters (SRB).
<b>Subcarrier</b>	Modulation applied to a carrier which is itself modulated with information- carrying variations.

## T

<b>TAL</b>	Trans Atlantic. A type of abort that results in the Orbiter landing on 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.
<b>TCM</b>	Trajectory Correction Maneuver, spacecraft propulsive maneuver.
<b>TCS</b>	Thermal Conditioning System 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.
<b>TNK</b>	Abbreviation for TANK
<b>TOS</b>	Transfer Orbit Stage, upper stage.
<b>Transducer</b>	Device for changing one kind of energy into another, typically from heat, microphone or speaker.
<b>Transponder</b>	An Electronic device which combines a transmitter and a receiver.
<b>TRM</b>	Transmission Time, UTC Earth time of uplink.
<b>True anomaly</b>	The angular distance of a point in an orbit past the point of periapsis, measured in degrees.

## U

<b>UHF</b>	Ultra-high frequency (around 300MHz).
<b>Uplink</b>	Signal sent to a spacecraft.
<b>UT</b>	Universal Time, 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** Coordinated Universal Time, 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 in the neighborhood of 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** Abbreviation for VALVE.

**VOR** Very High Frequency **O**mnidirectional **R**ange. VOR is a ground-based electronic system that provides azimuth information for high and low altitude routes and airport approaches.

## W

**W** Watt, a measure of electrical power equal to potential in volts times current in amps.

**Walking orbit** A spacecraft orbit that precesses, wherein the location of periapsis changes with respect to the planet's surface in a useful way.

**Water Spray Boiler System** The Water Spray Boiler system (WSB) is used to cool its associated APU lubricating oil and the orbiter hydraulic fluid while the system is active. It cools by the evaporation of water sprayed onto the fluid lines.

**Wavelength** The distance that a wave from a single oscillation of electromagnetic radiation will propagate during the time required for one oscillation.

**Weight** The gravitational force exerted on an object of a certain mass. The weight of mass  $m$  is  $mg$  Newtons, where  $g$  is the local acceleration due to a body's gravity.

**WWW** World-Wide Web.

## X

**X-band** A range of microwave radio frequencies in the neighborhood of 8 to 12 GHz.

**X-ray** Electromagnetic radiation in the neighborhood of 100 picometer wavelength.

## Z

**Z** Zulu in the phonetic alphabet, stands for UT, Universal Time.

**Zaragoza, Spain** Alternate #1 Trans Atlantic Abort landing site.

**Zenith** The point on the celestial sphere directly above the observer. Opposite the Nadir.

I WOULD LIKE TO DIE ON MARS. JUST NOT ON IMPACT.

*Elon Musk*

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I'M COMING BACK IN... AND IT'S THE SADDEST MOMENT  
OF MY LIFE.

*Ed White*

*first American spacewalk during the Gemini 4 mission*

*June 3, 1965*