

Space Flight Simulator Instructional System

By Peter Carafano, M.Ed.

History

The space simulator instructional system (SFSI) was developed through a grant research project funded by the Florida Department of Education and administrated by the Science Department at Florida State University Schools. The goal of this project was to develop an instructional system that could help interest students in Science, Technology, Engineering and Math (STEM); improve problem solving, provide for team building and demonstrate the practical application of math and science. This is accomplished through the use of virtual immersion to engage the students in problem solving activities using a modified space flight simulator. A primary goal of this project was ensuring the system could be easily replicated in any classroom with a minimum amount of resources. As part of this grant project, all parts of this system are available free to instructors wishing to use this in their classroom at www.atronautchallenge.com in the reference section.

SFSI Instructional System

The Space Flight Simulator Instructional System (SFSI) is built upon the concept of flight simulators and their use to train pilots and astronauts in the operation of various air and space craft. Most flight simulator programs are either extremely complicated to use or so over simplified that they require no effort. The focus of this system was to develop a flexible simulation program that was not overly complicated but still required student effort for mastery.

The SFSI model modifies the usually technical and complicated simulator program to allow student to perform missions in the NASA Space Shuttle with only moderate training and practice. In this way students can quickly learn how the systems operate and conduct missions that focus on team work and problem solving. The SFSI model also allows for great flexibility for the instructor to modify components of the program to meet the specific needs of the student group.

The system consists of two sections.

1. The student textbook is intended to foster interest in aerospace science by providing information regarding the basic dynamics of flight and how airplanes work, the history of rocketry, how the space shuttle works, the history of Space Stations and our exploration of Mars. Most importantly it also serves to provide a fundamental understanding of how the Space Shuttle flies and operates to help support learning the operation of the space flight simulator.

2. The second component use a classroom space flight simulator system to allow a group of five students (three in the shuttle and two in mission control) to conduct a Space Shuttle mission. This mission goes from launch all the way into orbit and return to earth landing at the Kennedy Space Center. During this mission the teams can experience emergencies that they must identify, manage and solve in order to successfully complete their mission.

The SFSI model effectively uses virtual immersion to engage students by providing a game like impetus to solve the problems provided. Since successful completion of the mission requires that the problem be solved the students are less likely to give up. This is further enhanced by having several teams compete against each other in a competition setting and grading their performances. Since flight operations require a team approach to accomplish, especially when emergencies occur, it enhances participation of all involved.

The Classroom Space Flight Simulator

The classroom simulator uses three to four components to provide the necessary virtual immersion to achieve student engagement. At a minimum three computers or lap tops are all that is necessary to set up the classroom simulator. The computers do not need to be part of a network and can function as “stand alone”. To maximize the capabilities of the program a fourth computer can be used for mission control if needed. A computer Joystick is highly recommended.

1. The Orbiter computer program

Orbiter is a freeware space flight simulator program developed to simulate spacecraft using a realistic flight model by Martin Schweiger PhD. The Orbiter version of the Space Shuttle Atlantis, the only player controllable spacecraft based on a real world design that is included with the basic installation of Orbiter, was used in development of the SFSI model. The Orbiter program provides the visual graphics for the launch, flight and landing of the Space Shuttle. Once the primary file is initiated the program runs continuously from launch all the way into orbit. A separate file is used for the landing component of the shuttle flight.

2. PowerPoint Multi-function display presentations

Power Point presentations are used to simulate the data displays on the Space Shuttle known as MFD's (Multi-function displays) and supply the necessary information for the students on space craft operations. These PowerPoints are pre-timed with the orbiter program to run concurrently and simulate cockpit data and are also used to provide for the ability to give them “emergency situations” during their

flight. An additional “Mission Control” Power Point is also included to work concurrently with the flight simulator program if needed.

3. Shuttle Switch Control Panels

Four switch control panel templates are used to simulate the location of switches that control systems that must be turned on and off by the Mission Commander and Pilot during the flight.

4. The Flight Operational checklists and emergency procedure checklists

Modified pre-flight, in-flight and landing checklists, taken from the actual ones used by Space Shuttle Astronauts, are provided for flight operations. These checklists are time dependent and must be done in very specific orders. An emergency procedure checklist is included for use by mission control to help manage any emergencies that occur during flight.

FSUS Mobile Space Flight Simulator



Using the SFSI Instructional System

Implementation of the system begins with using the Student Textbook to interest the students in aerospace science and provide a foundation for using the space flight simulator. This can be accomplished several ways through individual or group study of the material and classroom discussion. Once completed students are given a general knowledge test based on the textbook, the results are then used to assign initial positions in the five man teams. Eventually these positions can be rotated between the students allowing them to try multiple areas of responsibility.

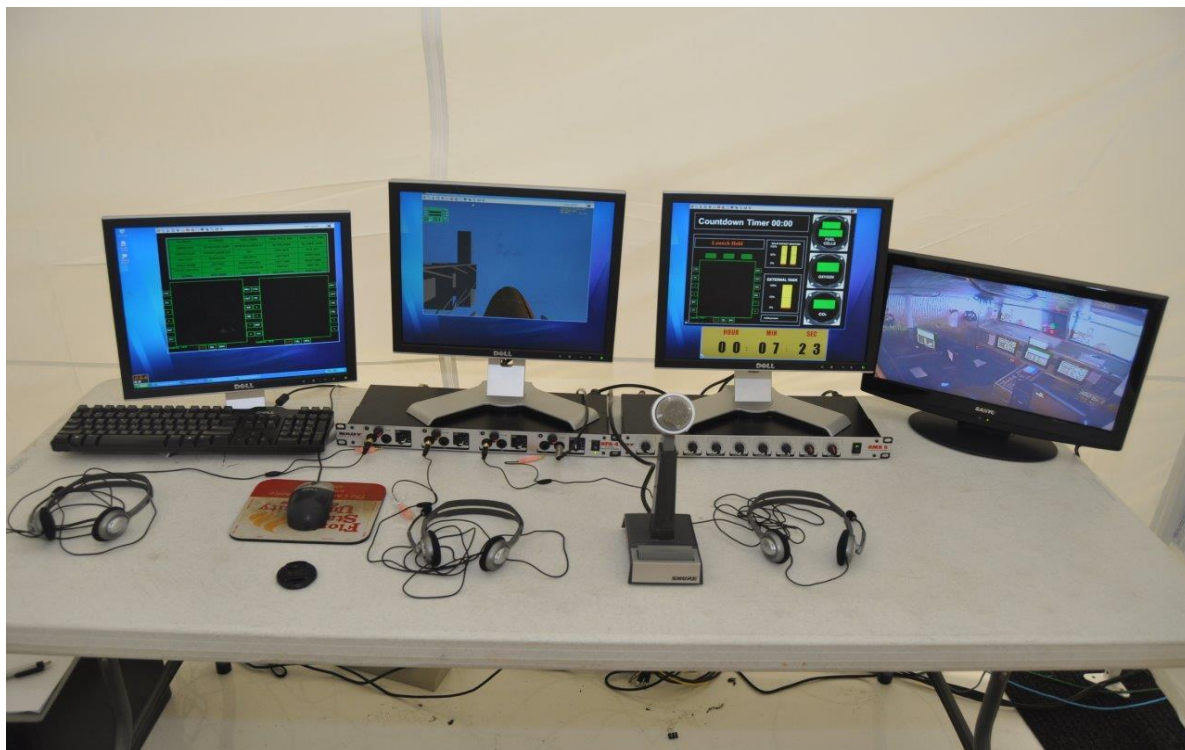
The students are then divided into teams consisting of a Mission Commander, Pilot, Mission specialist and two Mission Control personnel. These students will then practice as a group flying the classroom simulator using the procedure checklists both as desk top practice sessions as well as on the classroom simulator.

When the students have demonstrated that they are proficient at normal flight operations they are then provided emergency situations which can be managed using the emergency flight checklist. Once they become proficient at handling emergency situations using the checklist the instructor provides scenarios which are not covered by the checklist. This requires the students to evaluate the problem, determine possible solutions and make decisions as a team to manage the emergency.

Basic classroom simulator setup with cloned monitors



Cloned monitors being used for Mission Control



FSUS Mobile Space Flight Simulator Cockpit



Training Mission Control Center



Astronauts

Three of the five students using the space flight simulator system are responsible for operation of the space shuttle, they are the astronauts. The shuttle flight team consists of three positions.

Commander - sits in the front left seat. He or she maneuvers the space shuttle (along with the Pilot), and is responsible for the shuttle, crew, mission success and safety of the flight. They have full command authority on the ship and is responsible to make all final decisions regarding shuttle operation.

Pilot - sits in the front right seat. He or she assists the Commander in controlling and operating the vehicle on a space mission. A Pilot must have the same familiarity with the ship as the Commander, but isn't in charge of the mission itself. A Pilot will also assist with any other duties that need to be attended to during a mission.

Flight Engineer - sits in the back left seat. He or she is the crew member of a space shuttle who is assigned the responsibility of reading off the pre-flight, in flight and landing checklist. They are also responsible to help monitor the mission clock and ensure all operations are done on time.

Successful operation of the space flight simulator requires all three astronauts to work together effectively, practice their individual jobs and be aware of the jobs and responsibilities of the rest of the crew. This relationship is extremely important when emergencies occur therefore consistent practice is together is necessary to become an effective team.

Communication

Communication is extremely important and strict control of who speaks at what time and to whom is critical. The Mission Commander is the flight officer responsible to talk to Mission Control, 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 Mission Specialists does not speak to mission control only to the Commander and Pilot.

During shuttle operations in flight communications are divided into two main categories which are universally used.

Advise – When the flight personnel or Mission Control needs to tell someone something important. The format is to identify who you want to speak to, who you are and what you need to know or say. Sometimes the term “*advised*” will be used in the statement.

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?”

Announce – When you are relaying information to Mission Control or the Space Shuttle but do not require a confirmation of the information.

Example: *“Atlantis, APU pre-start check is underway”.*

“Endeavor, External Tank Cap Is Retracted”

Additionally standard responses are used to relate specific information between the space shuttle and mission control, they are:

Report: *“Go or No Go”* This is used to confirm a system is operational or announce there is a problem with a system.

Confirm: *“Roger or Copy”* This is used to confirm receipt of a message

Status: *Nominal or Off Nominal”* This is used to identify if a system is operating normally (nominal) or abnormally (off-nominal).

When using the flight checklist during shuttle operations the Mission Specialist is responsible to read 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 completed. This system is routinely used by real pilots whether they are flying a passenger jet or the Space Shuttle.

Example:

Flight Engineer: *“APU / HYDRAULICS (1/2/3) to OFF”*

Mission Commander: *“APU / HYDRAULICS (1/2/3) to OFF”*

Pilot: *“APU / HYDRAULICS (1/2/3) to OFF Check*

Flight Engineer: *“APU FUEL TK VLV (1/2/3) to CLOSE”*

Mission Commander: *“APU FUEL TK VLV (1/2/3) to CLOSE”*

Pilot: *“APU FUEL TK VLV (1/2/3) to CLOSE” Check*

Orbiter Installation

Orbiter is a freeware space flight simulator program developed to simulate spacecraft using a realistic flight model. The developer, Martin Schweiger PhD, felt that space flight simulators at the time were lacking in realistic physics based flight models and decided to write a simulator that made learning physics concepts enjoyable. The simulator was first released on 27 November 2000, with the most recent of several versions released on 30th August 2010. Orbiter has been used as a teaching aid in classrooms, and a community of add-on developers have created a multitude of add-on's to allow users to fly assorted real and fictional spacecraft and adding new planets or solar systems.

The Orbiter version of the Space Shuttle Atlantis, the only player controllable spacecraft based on a real world design that is included with the basic installation of Orbiter, was used in development of the FSUS space simulator.

Installation

Orbiter is free for personal and educational use. By downloading, you agree to the Orbiter Freeware License. Make sure that your computer meets the minimum hardware requirements:

Windows 98/2000/XP/Vista/Win7
1.2 GHz Pentium or equivalent processor
512 MB system RAM
DirectX 7 or newer
DirectX compatible graphics card with 64 MB of memory
Approx. 120 MB free hard disk space for minimum installation.

Orbiter can be installed by two methods - manually by extracting a ZIP file, or automatically by running an MSI installation file. All instructions for installation are provided as part of the file.

Orbiter Download Web site is <http://orbit.medphys.ucl.ac.uk/>

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.

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.

Setup hints

1. In the module section of the main screen make sure you **activate all modules**



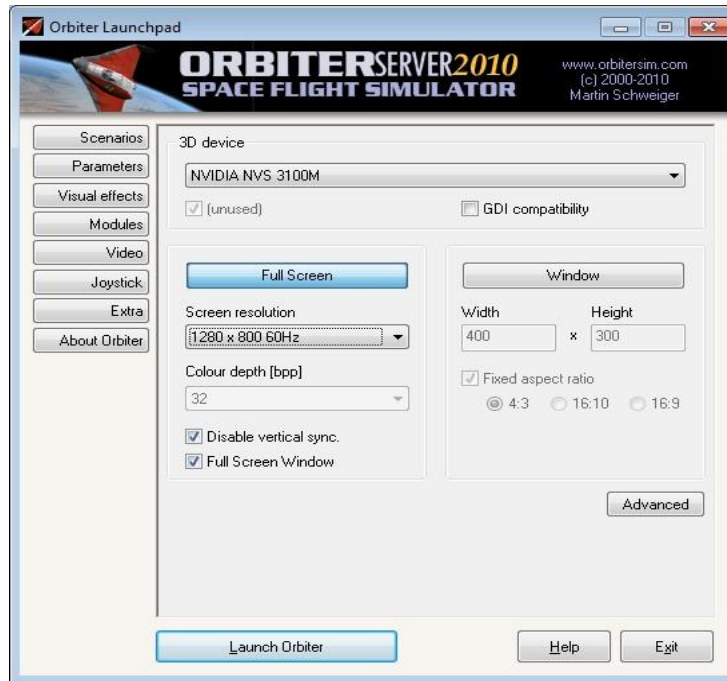
2. If you are using a joystick (recommended) this is activated in the Joystick section.



3. In the parameters section do not check off damage and failure simulation.



4. Full screen mode usually works the best but you may have to experiment to get the best visual settings for your computer.



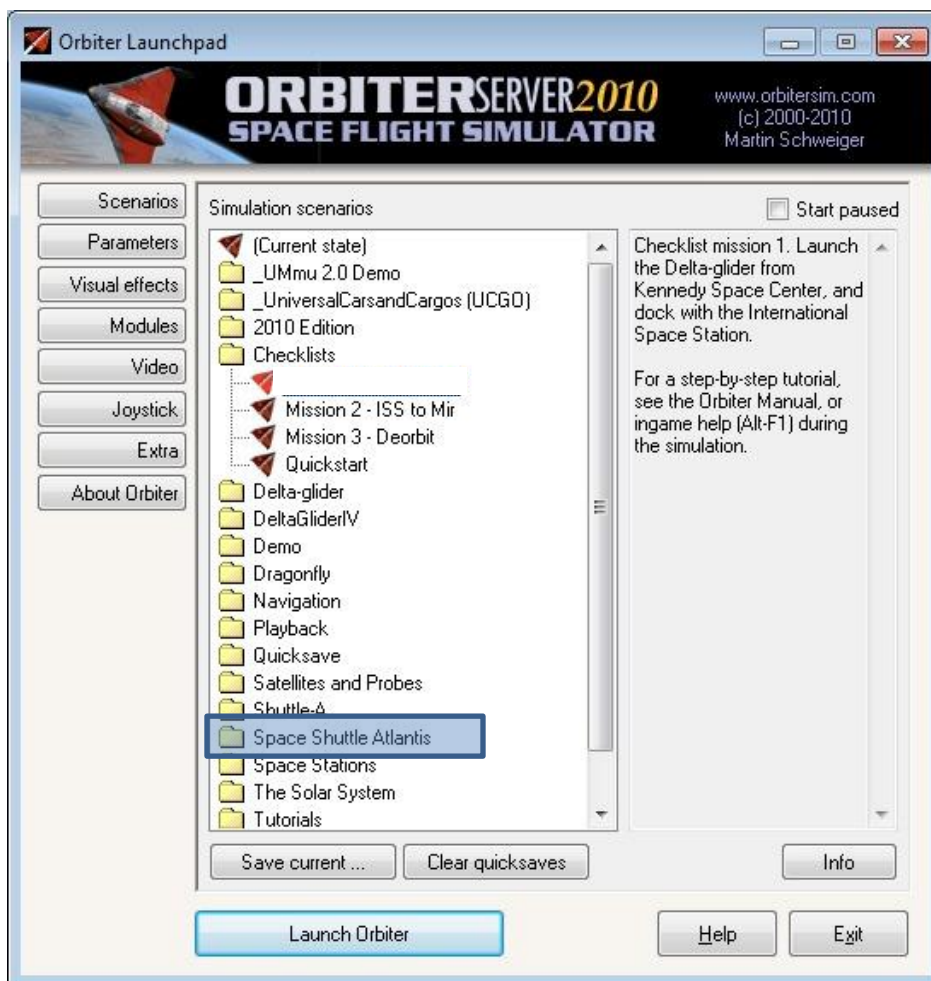
Operating the Simulator

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 the “**Basic Control Panel Master**” Power Point on their computer and the Mission Specialist runs the “**Mission Specialist Panel**” Power Point on their computer.

The switch panel practice sheets for the Mission Commander and Pilot, using the schematic provided should be set up in their proper location. Set up the computers and chairs following the position for each member of the flight crew as space allows.

Have the Mission Commander load the Orbiter program.



Have them select the “Space Shuttle Atlantis” File. Then locate and select the sub-file “launch into sunrise” program and then launch orbiter.



Mission Commanders Screen (Orbiter)

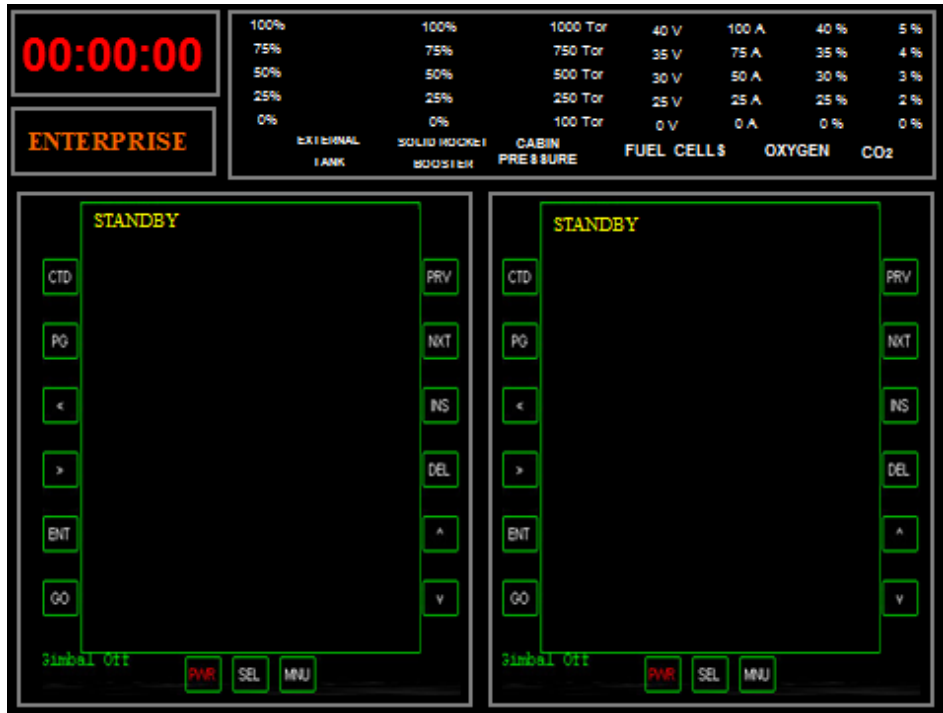
Use F1 to get into the shuttle cockpit view. The shuttle launch view will be different from the screen above; you will see the sky and the launch tower instead of a runway.

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

Have the student input and follow the Shuttle Launch Commands for the right Terminal Multi-Function Display (MFD), but **DO NOT** hit the last **ENTER** command until launch.

Shuttle Launch Commands for the Left Terminal MFD(Mission Commander)

1. Have the Student hit **[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.
Type in **run"atlantis/launch"** and press **ENTER**
3. Select **[INP]** and then type in **do_oms2=false** and press **ENTER**
4. Select **[INP]** and then type in **launch()**
5. Press **ENTER** when you are queued to launch the shuttle at T-minus 4 seconds. Be careful not to touch the keyboard before then or it may change or erase the final command and mess up your launch timing with the Pilots Power Point.



Pilot Screen

Have the Pilot launch the “**Basic Control Panel Master**” power point; they should be on the very first slide.



Mission Specialist Screen

Have the Mission Specialist launch the “**Mission Specialist**” power point; they should be on the very first slide.

Operating the program

The Mission Commander will use the H key to change you HUD settings during the procedural checklist. Once the Shuttle is launched, at T-minus 4 seconds, the Mission Commander will have to change the left MFD settings. Have the Student hit **[SEL]** on the left MFD with the mouse and then select **[Surface Mode]**.

At any time if you need to exit the program and start again or run the landing simulation use F4 then Exit. A full set of instructions regarding the key commands are in the Orbiter literature that comes with the program.

The orbiter "Launch into sunrise program" you will go from launch through the de-orbit burn without stopping. When it comes time to land you will need to exit the program and select "Atlantis Landing Preparation and go through the landing checklist..

Once all three students computer are set and the Pilots PowerPoint is initiated, have the students follow the time prompts in the checklist as you go. The checklist is designed to be used with these programs and provides prompts when to hit specific keys for the Orbiter program and when to press the **[space bar]** for the PowerPoints

Launch Simulation

Once the Mission Commander has his screen ready and he is showing "launch()" in the dialog window have the pilot press the **[space bar]** to begin the launch clock.

Have the mission specialist read through the launch checklist using the Pilots master countdown clock. The Mission Commander and Pilot will use the will use the switch panel templates to turn systems on and off.

At five minutes the launch clock will stop, once mission control gives the go-ahead for launch have the pilot select **[space bar]** again to re-start the clock.



Pilot Screen

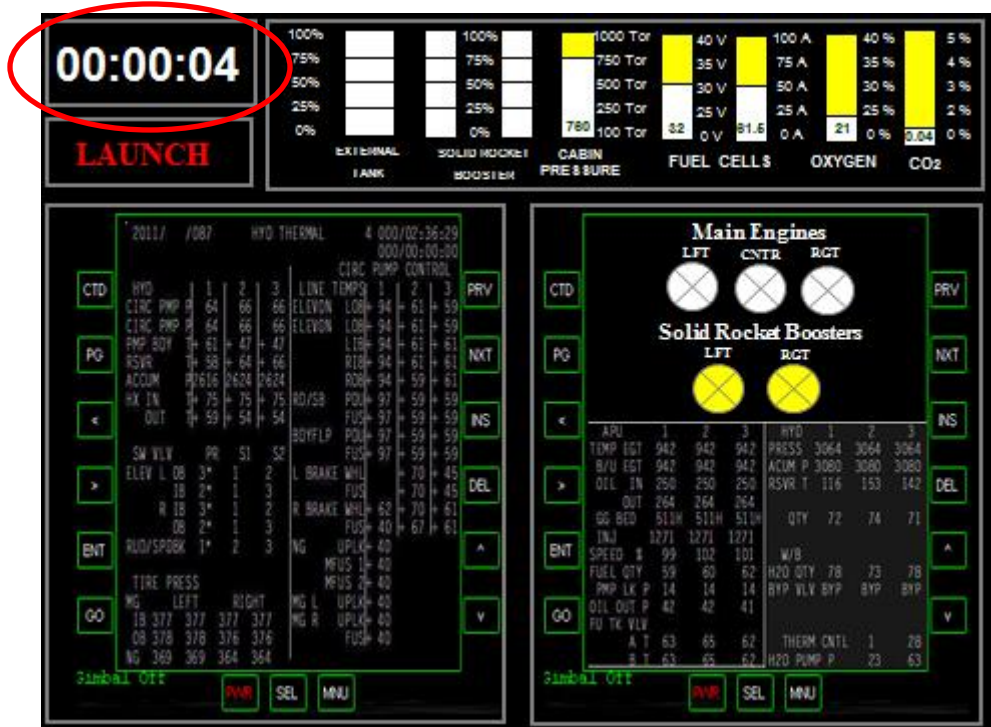
At four minutes the mission specialist will have to initiate or launch their power point, have them press the **[space bar]** to do so.



Pilot Screen

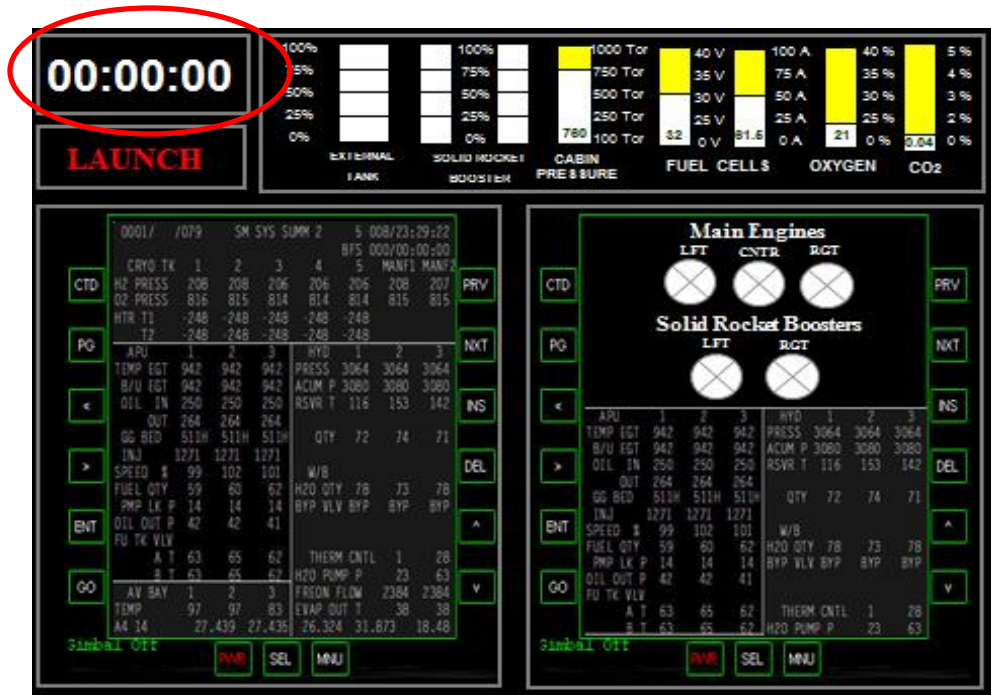
Mission Specialist Screen

At T-minus four seconds have the Mission Commander pressing the **[ENTER]** key to initiate the launch procedure in the *Orbiter* program.



Pilot Screen

At T-minus 00:00 have the pilot and mission control start a flight timer (a stop watch would work fine).



Pilot Screen

Flight Simulation (Ascent, orbit insertion, de-orbit burn)

Have the mission specialist read through the checklist following the flight timing prompts on the stop watch. As you go through the sequences one person acknowledges the checklist commands (the person that actually turns the switch on and off) and the other student must verbally confirm that it was done.

Use the mouse to select and switch the Commanders MFD to surface mode. Once you have achieved orbit you have several actions to accomplish.

The Mission Commander must place the orbiter in zero – zero attitude using the RCS engines (joystick) and the **[kill rotation]** icon on the Orbiter screen (using the mouse). The HUD should be in orbit mode.

The Mission Specialist must open the payload bay doors; this is done by pressing the **[space bar]**

O2 PRESS	H2 PRESS	FIRE CABIN	FIRE PAYLD BAY	FUEL CELL TEMP
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FREON LOOP	A/BAY CABIN AIR	IMU	FWD RCS	RCS JET
H2O LOOP	SRB LEFT	MAIN ENGINE LEFT	LEFT RCS	RIGHT RCS
PAYLD WARN	SRB RIGHT	MAIN ENGINE CNTR	LEFT OMS	RIGHT OMS
PAYLD CAUTION	GPC	MAIN ENGINE RGT	OMS KIT	OMS TVC
ALARM	APU TEMP	APU OVRSPD	APU UNDRSPD	HYD PRESS

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H2 PRESS 208 208 206 206 206 208 207			
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FUEL QTY 76 77 77 QTY 74 75 73			
TK P 209 210 212 ACCUM P 2616 2624 2624			
OUT P 209 210 212			
TK VLV A CL CL CL			
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H T 61 62 62 W/B 1 2 3			

Mission Specialist screen

Once the shuttle is configured for mission proceed to the de-orbit checklist. The pilot must run the de-orbit system check; this is done by pressing the [space bar]. The Mission Specialist must close the payload bay doors; this is done by pressing [space bar].

100%	100%	1000 Tor	40 V	100 A	40 %	5 %
75%	75%	750 Tor	35 V	75 A	35 %	4 %
50%	50%	500 Tor	30 V	50 A	30 %	3 %
25%	25%	250 Tor	25 V	25 A	25 %	2 %
0%	0%	100 Tor	0 V	0 A	0 %	0 %

EXTERNAL TANK	SOLID ROCKET BOOSTER	CABIN PRESSURE	FUEL CELLS	OXYGEN	CO2
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FREON FLOW 2193 2190			
PUMP OUT P 64 62			
PL HX FLOW 290 286			
OUT T 64 63			
ATT CP FLOW 279 278			
P 30L 38			
RAD IN T 97 95			
TECH FLOW 564L 777			
RAD OUT T 38 38			
OUT T 41 38			
EVAP OUT T 38 38			
CAB HX IN T 42 38			

O2 PRESS	H2 PRESS	FIRE CABIN	FIRE PAYLD BAY	FUEL CELL TEMP
CABIN ATM	O2 HEATER TEMP	MAIN BUS UNDR VT	AC VOLTAGE	AC OVER LOAD
FREON LOOP	A/BAY CABIN AIR	IMU	FWD RCS	RCS JET
H2O LOOP	SRB LEFT	MAIN ENGINE LEFT	LEFT RCS	RIGHT RCS
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ALARM	APU TEMP	APU OVRSPD	APU UNDRSPD	HYD PRESS

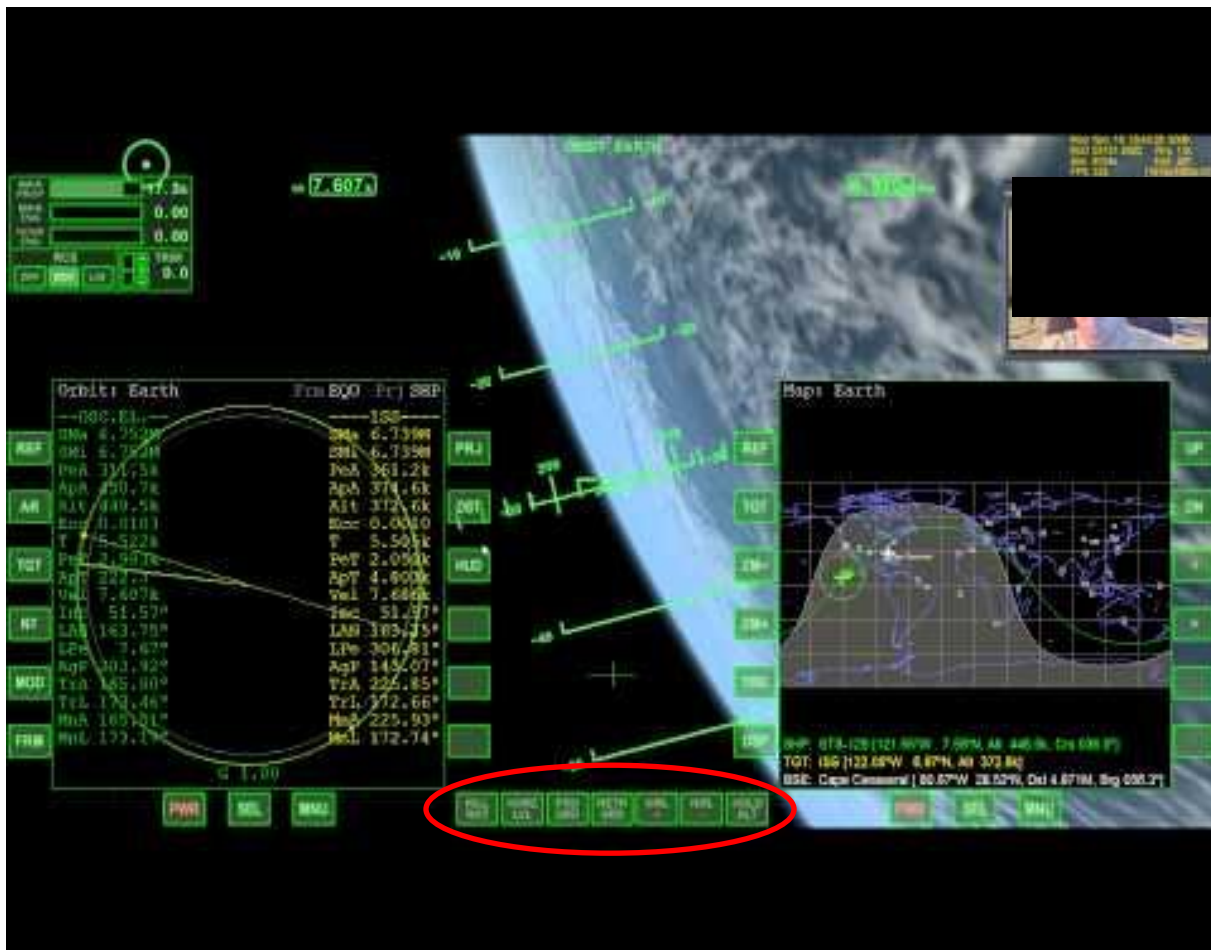
0001 / 079	SM SYS SUMM 2	5 008/23:29:22	BFS 000/00:00:00
CRYO TK 1 2 3 4 5	MANF1 MANF2		
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O2 PRESS 816 815 814 814 814 815 815			
HTR T1 -248 -248 -248 -248 -248			
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2011 / 086	APU/HYD	4 008/02:36:12	000/00:00:00
APU 1 2 3 HYD 1 2 3			
B/U EGT 313 313 310 B/U P 644 644 644			
EGT 313 313 310 RSVR T 58 64 66			
SPEED \$ 0L 0L 0L P 85 66 66			
FUEL QTY 76 77 77 QTY 74 75 73			
TK P 209 210 212 ACCUM P 2616 2624 2624			
OUT P 209 210 212			
TK VLV A CL CL CL			
B CL CL CL			
H T 61 62 62 W/B 1 2 3			

Pilot Screen

Mission Specialist Screen

The Mission Commander will select the **[retrograde]** icon in *Orbiter* using the mouse,, perform a de-orbit burn using the throttle key (Cntrl + or Cntrl -) and then select **[prograde]** to return the shuttle to normal orientation.



Mission Commanders Screen (Orbiter)

Landing

The orbiter program operates in real time, in order to land at the Kennedy Space center you would have to circle the earth for an hour , perform a de-orbit burn and try to reach Florida. Although this can be done with extensive practice this process it is not usually practical.

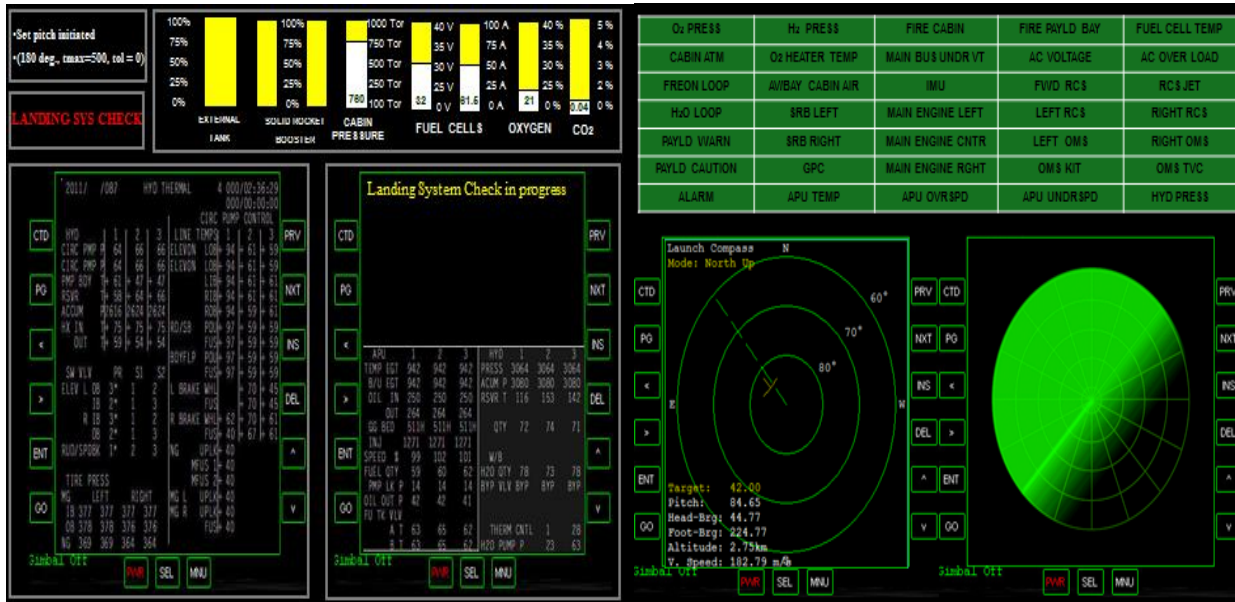
Have the Mission Commander exit out of the Orbiter program using the **F4 key** and then select **[exit]**. When landing select “Atlantis Landing Preparation” to practice the actual approach to the Kennedy Space Center. If the Mission Commander would like to just practice their landing select the “Atlantis Final Approach” file which brings you directly to the final approach to the Kennedy Space Center runway. This also demonstrates the use of the horizontal situation indicator or HSI.

As soon as the *Orbiter* program loads immediately begin the landing checklist.



Mission Commanders Screen (Orbiter)

Have the Pilot press the [space bar] to begin the Landing System check and have the Mission Specialist press the [space bar] to initiate the Landing System Radar.



Pilot Screen

Mission Specialist Screen

The Mission Commander must hit the **G** key to put the gear down before landing. During actual landing the pilot should operate the simulated switches for gear arm, gear down, chute deploy, speed brake deploy and wheel breaks

Mission control

A mission control center (MCC) is an entity that manages aerospace vehicle flights, usually from the point of lift-off until the landing or the end of the mission. In the SFSI system the two flight controllers monitor all aspects of the mission using telemetry. They support the mission by monitoring the flight checklist to ensure nothing is missed, monitor telemetry readouts of the shuttle systems and confirm telemetry information with the astronauts. Frequently Mission Control will need to “announce information” during the check list procedures, these areas are highlighted in the checklist.

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

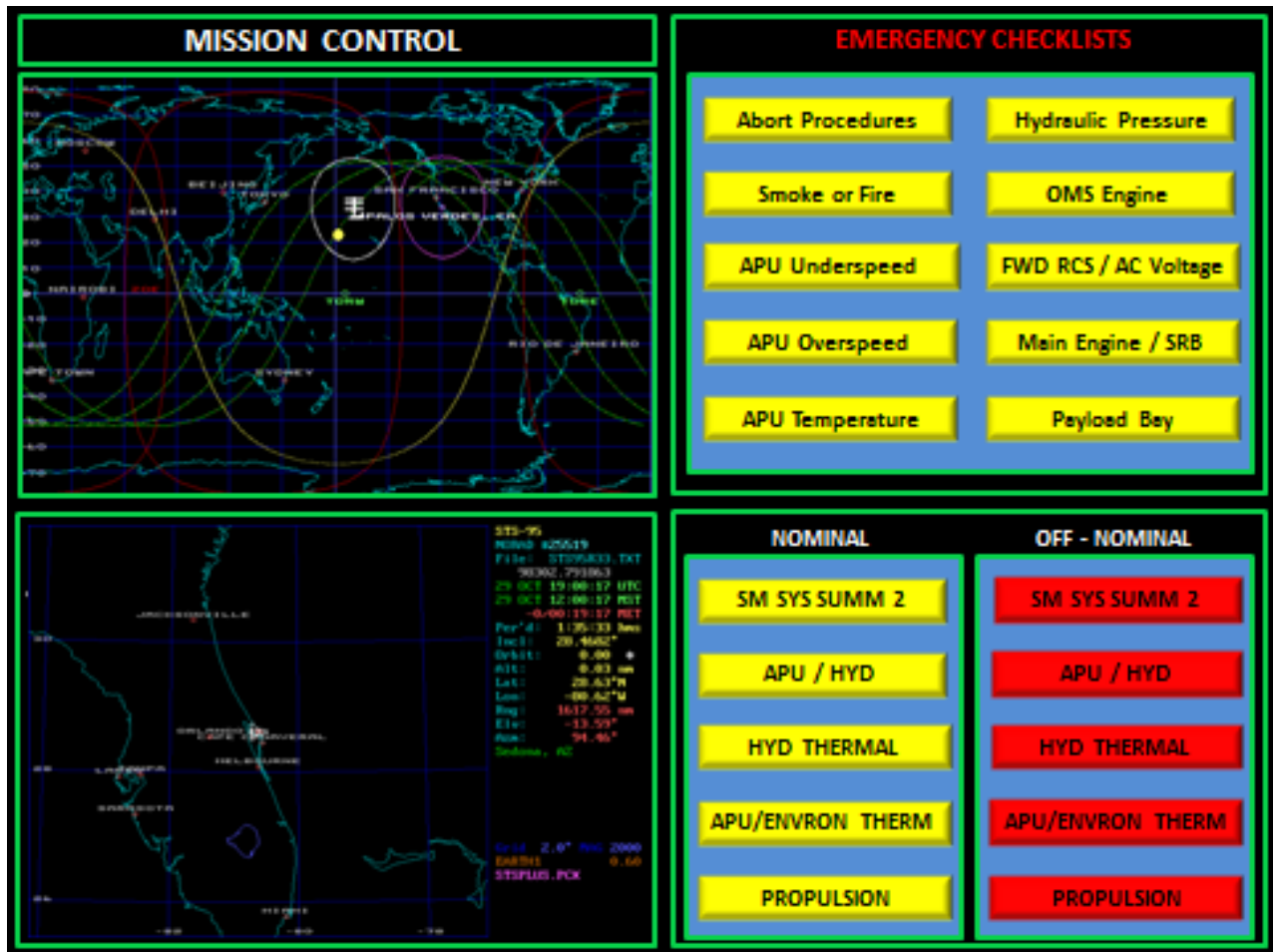
In the event of an Emergency the flight controllers are responsible to help the shuttle crew identify the problem by reviewing the telemetry readouts. Once this is accomplished they then walk them through managing the problem using the Emergency Procedure checklist. This is the one time that Mission Control flight controllers take over reading the checklist since it is emergency specific. Occasionally emergencies occur that are not covered by the checklist. 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, ensuring that what the astronauts are seeing in their information readouts coincide with what their telemetry is telling them. In the event an abort of the flight is required normally the team in Mission Control Center makes the call because they have a more precise knowledge of the orbiter's position than the crew can obtain from onboard systems. However, the Mission Commander has full responsibility and authority over the Space Shuttle. Although he cannot override an abort decision from Mission Control he can initiate a mission abort at any time.

Mission Control Telemetry

The optimum method for mission control to see the telemetry data from the space simulation is to have cloned monitors from all three computes set up so the Mission control team can see what the flight crew sees on their monitors. Using laptop computers this can be done simply by running a separate monitor off the VGA output and placing the monitors on a separate table for Mission Control. If using a standalone computer a “Y” cable can be used to attach an additional monitor if the computer is not built for two monitor outputs. A third option is simply seating the Mission Control Team close enough to the flight crew to see the monitors, however this is the least desirable because their view can easily be obstructed.

The final option is to use the “Mission Control” PowerPoint on a fourth computer which can be used in conjunction with the simulator program and allows for basic telemetry access, especially during emergencies. When an emergency occur the flight controllers can use the mouse to click on the effected system under the “Off-Nominal” heading. When the emergency is resolved they simply click on the reset button to restore the system. They can also access the emergency checklist from this program as well instead of using hard copy if they so desire.

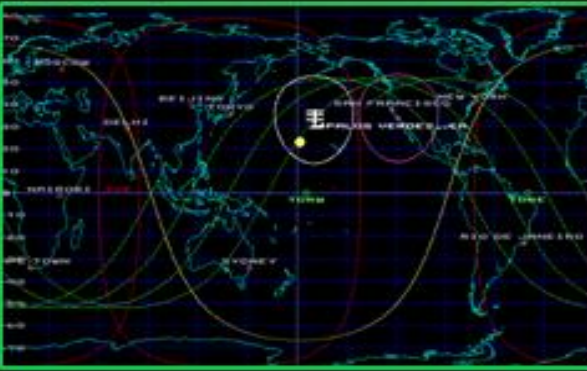



Mission Control Communication

Speaking back and forth between the Space Shuttle and Mission Control does not have to be overly complicated. For realism you could use a set of five inexpensive hand held radios with headsets. Although an “open mike” capability is preferred when using this type of communication system “push to talk” will work just as well.

Mission Control Nominal Screen

MISSION CONTROL

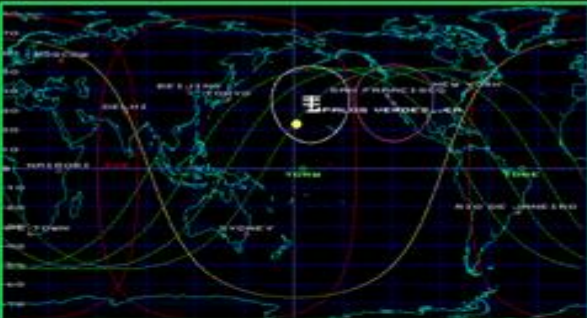
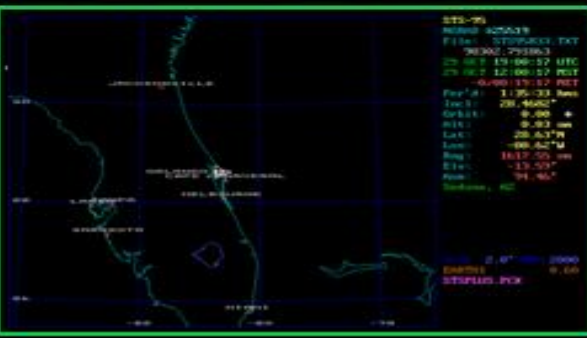
SM SYS SUMM 2

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CRYO TK	1	2	3	4	5	MANF1	MANF2	
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O2 PRESS	816	815	814	814	814	815	815	
HTR T1	-248	-248	-248	-248	-248			
T2	-248	-248	-248	-248	-248			
APU	1	2	3	HYD				
TEMP EGT	942	942	942	PRESS	3064	3064	3064	
B/U EGT	942	942	942	ACUM P	3080	3080	3080	
OIL IN	250	250	250	RSVR T	116	153	142	
OUT	264	264	264	QTY	72	74	71	
GG BED	511H	511H	511H					
INJ	1271	1271	1271					
SPEED %	99	102	101	W/B				
FUEL QTY	59	60	62	H2O QTY	78	73	78	
PMP LK P	14	14	14	BYP VLV	BYP	BYP	BYP	
OIL OUT P	42	42	41					
FU TK VLV					THERM CNTL			
A T	63	65	62	1			28	
B T	63	65	62	H2O PUMP P	23			63
AV BAY	1	2	3	FREON FLOW	2384			2384
TEMP	97	97	83	EVAP OUT T	38			38
A4 14	27.439	27.435						18.48

MAIN SCREEN

Mission Control Off- Nominal Screen

MISSION CONTROL

SM SYS SUMM 2

0001/ /079	SM SYS SUMM 2					5	008/23:29:22	
						BFS	000/00:00:00	
CRYO TK	1	2	3	4	5	MANF1	MANF2	
H2 PRESS	208	208	206	206	206	208	207	
O2 PRESS	816	815	814	814	814	815	815	
HTR T1	-248	-248	-248	-248	-248			
T2	-248	-248	-248	-248	-248			
APU	1	2	3	HYD				
TEMP EGT	942	942	942	PRESS	3064	3064	3064	
B/U EGT	942	942	942	ACUM P	3080	3080	3080	
OIL IN	250	250	250	RSVR T	116	153	142	
OUT	264	264	264	QTY	72	74	71	
GG BED	511H	511H	511H					
INJ	1271	1271	1271					
SPEED %	99	22	101	W/B				
FUEL QTY	59	60	62	H2O QTY	78	73	78	
PMP LK P	14	14	14	BYP VLV	BYP	BYP	BYP	
OIL OUT P	42	42	41					
FU TK VLV					THERM CNTL			
A T	63	65	62	1			28	
B T	63	65	62	H2O PUMP P	23			63
AV BAY	1	2	3	FREON FLOW	2384			2384
TEMP	97	97	83	EVAP OUT T	38			38
A4 14	27.439	27.435						18.48

RESET

Checklist

Emergency Conditions and Problem Solving

The most important component of the SFSI system is to help students learn how to problem solve in situations that reflect real life conditions. Additionally it focuses on the perspective that a team approach works the best, especially if all the members are involved in the process equally.

Some of the most common difficulties with teaching problem solving in the classroom, from a group perspective, is that:

1. Either one or several student will take charge and make all the decisions leaving some not involved in the process.
2. The students will not thoroughly think through the problem and come up with a wrong answer.
3. The group will become discouraged and give up and wait for the teacher to give them the “right answer”.
4. The group will come up with “any answer” just so they can get finished and wait to hear what the “right answer” was.

Sometimes assigning a grade or just “finding the right answer” is not enough to motivate students to solve the problem. The SFSI system was designed to help by addressing these four areas. The SFSI process is constructed around the basic method for managing problems which consists of:

1. Understand the Problem
2. Create a plan to address the problem using a series of actionable steps
3. Maintain motivation so you don't give up or get frustrated when it takes a while to successfully resolve the problem.

The first step in the SFSI process is to have the students use the simulator to perform normal flight operations as a team. This process is practiced as many times as possible so that they are used to working together and become confident in each other abilities.

The second step is to give them simple emergency situations that they can solve using an emergency checklist procedure. This provides them with the confidence to manage emergencies and involves all the students in the process. Students will normally realize at this time that the textbook reference information on the Space Shuttle and the Glossary of terms is very helpful in understanding the shuttle systems. It is at this time that the instructor normally re-visits the textbook units on how the shuttles work and what the glossary says about the various systems.

The third step is to give them emergency situations that are not covered by the emergency checklist. To manage this type of problem the students will now need to work together to evaluate the system involved, using their understanding of how the systems work, develop several steps to solve the problem and work together to mitigate

the emergency and successfully complete their mission. The key to this step is not allowing the mission to continue until they have solved the problem.

To help engage the students in the third step of the process, frequently it is presented as a classroom competition. Using a grading rubric the students can be scored on how well they address the problem and complete the mission. The scores can then be used to determine a “winner” for the event.

Meeting the Challenge of the Emergency

Mission Control has many responsibilities when an emergency happens. Students will have to depend on individual and team capabilities, training, and roles in ways that are hard to describe. They must trust the team’s abilities and judgment, but also watch for signs, both within the team and outside, of good intentions yielding problematic results. They must be reasonable and evenhanded, understanding that you cannot entirely eliminate risk. The emergency is a time when a mission team shows what it is really made of.

Initiating an Emergency

The Emergency situations are developed using the “Mission Specialist” Power Point files. The files can be altered to present changes in data showing abnormal conditions on the shuttle which includes the activation of the emergency warning enunciator panel. Once the warning occurs the students will follow the emergency checklist until the system is restored.

Emergency Procedures

Hydraulic Pressure	Hydraulic Pressure
<p>1. Alarm system ----- SILENCE</p> <p>2. Notification of Mission Control ----- Confirm</p> <p>3. HYD PRESSURE A. PRESS 1 ----- Check B. PRESS 2 ----- Check C. PRESS 3 ----- Check</p> <p>4. HYD MAIN PUMP PRESSURE A. 1 ----- LOW B. 2 ----- LOW C. 3 ----- LOW</p> <p>5. HYD CIRC PUMP A. 1 ----- OFF B. 2 ----- OFF C. 3 ----- OFF</p> <p>6. APU / HYDRAULICS A. 1 ----- OFF B. 2 ----- OFF C. 3 ----- OFF</p> <p>7. HYD PRESSURE A. PRESS 1 ----- Check B. PRESS 2 ----- Check C. PRESS 3 ----- Check</p> <p>8. HYD MAIN PUMP PRESSURE A. 1 ----- NORMAL B. 2 ----- NORMAL C. 3 ----- NORMAL</p>	<p>9. HYD CIRC PUMP A. 1 ----- ON B. 2 ----- ON C. 3 ----- ON</p> <p>10. APU / HYDRAULICS A. 1 ----- START/RUN B. 2 ----- START/RUN C. 3 ----- START/RUN</p> <p>11. HYD PRESSURE A. PRESS 1 ----- Check B. PRESS 2 ----- Check C. PRESS 3 ----- Check</p> <p>12. Re-assess system</p>

7
Main Screen

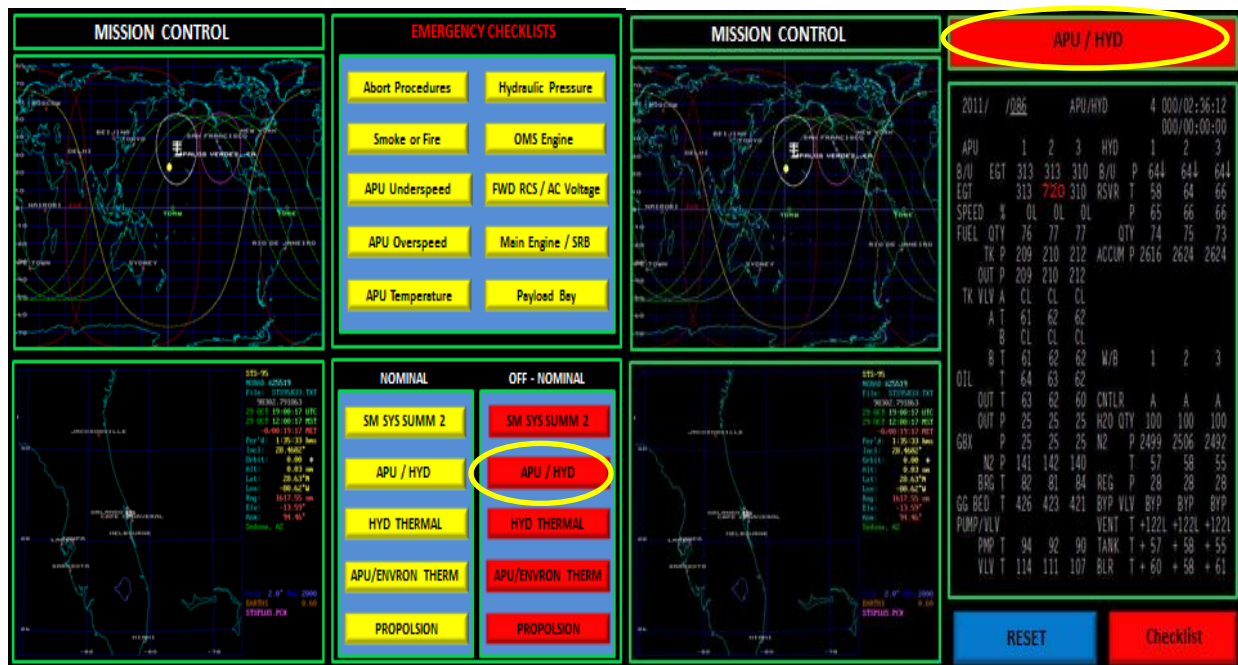
When the emergency occurs it will show up on the “Caution and Warning Panel” and an audible alert tone will be heard. The Mission Specialist must silence the system using the [space bar] on the computer. If using the Mission Control Power Point, have them

select the OFF-Nominal section that the Mission Specialist is showing on their screen in the orbiter. (For this example it is "APU/HYD")



Mission Specialist Screen

If using the Mission Control Power Point, have them select the OFF-Nominal section that the Mission Specialist is showing on their screen in the orbiter. For this example it is "APU/HYD")



After the emergency procedure is complete the Mission Specialist will reset the system again using the [space bar] on the computer and clear the emergency.

O ₂ PRESS	H ₂ PRESS	FIRE CABIN	FIRE PAYLD BAY	FUEL CELL TEMP
CABIN ATM	O ₂ HEATER TEMP	MAIN BUS UNDR VT	AC VOLTAGE	AC OVER LOAD
FREON LOOP	A/WBAY CABIN AIR	IMU	FVWD RCS	RCS JET
H ₂ O LOOP	SRB LEFT	MAIN ENGINE LEFT	LEFT RCS	RIGHT RCS
PAYLD WARN	SRB RIGHT	MAIN ENGINE CNTR	LEFT OM\$	RIGHT OM\$
PAYLD CAUTION	GPC	MAIN ENGINE RIGHT	OM\$ KIT	OM\$ TVC
ALARM	APU TEMP	APU OVR SPD	APU UNDR SPD	HYD PRESS

0001/ /079	SM SYS SUMM 2	5 008/23:29:22			
CRYO TK	1 2 3 4 5	MANF1 MANF2			
H2 PRESS	208 208 206 206 206 208 207				
O2 PRESS	816 816 814 814 814 815 815				
HTR T1	-248 -248 -248 -248 -248				
T2	-248 -248 -248 -248 -248				
APU	1 2 3	H2O 1 2 3			
TEMP EGT	942 942 942	PRESS 3064 3064 3064			
B/W EGT	942 942 942	ACUM P 3080 3080 3080			
OIL IN	250 250 250	RSVR T 116 153 142			
OUT	264 264 264				
GG BED	511H 511H 511H	QTY 72 74 71			
INJ	1271 1271 1271				
SPEED %	99 102 101	W/B			
FUEL QTY	59 60 62	H2O QTY 78 73 78			
PMP LK P	14 14 14	BYP VLV BYP BYP			
OIL OUT P	42 42 41				
FU TK VLV					
A T	63 65 62	THERM CNTL 1 28			
B T	63 65 62	H2O PUMP P 23 63			
AV BAY	1 2 3	FREON FLOW 2384 2384			
TEMP	97 97 83	EVAP OUT T 38 38			
A4 14	27.439 27.435	26.324 31.873 18.48			

2011/ /086	APU/HYD	4 000/02:36:12			
APU	1 2 3	HYD 1 2 3			
B/U EGT	313 313 310	B/U P	644 644 644		
EGT	313 313 310	RSVR T	58 64 66		
SPEED %	OL OL OL	P	65 66 66		
FUEL QTY	76 77 77	QTY	74 75 73		
TK P	209 210 212	ACCUM P	2616 2624 2624		
OUT P	209 210 212				
TK VLV A	CL CL CL				
A T	61 62 62				
B T	61 62 62	W/B	1 2 3		
OIL T	64 63 62				
OUT T	63 62 60	CNTRLR	A A A		
OUT P	25 25 25	H2O QTY	100 100 100		
GBX P	25 25 25	N2 P	2499 2506 2492		
N2 P	141 142 140	T	57 58 55		
BRG T	82 81 84	REG P	28 28 28		
GG BED T	426 423 421	BYP VLV	BYP BYP BYP		
PUMP/VLV		VENT T	+122L +122L +122L		
PMP T	94 92 90	TANK T	+57 +58 +55		
VLV T	114 111 107	BLR T	+60 +58 +61		

If using the Mission Control Screen the controllers will click on reset and return to a nominal screen showing the emergency cleared.

MISSION CONTROL

APU / HYD

2011/ /086	APU/HYD	4 000/02:36:12			
APU	1 2 3	HYD 1 2 3			
B/U EGT	313 313 310	B/U P	644 644 644		
EGT	313 313 310	RSVR T	58 64 66		
SPEED %	OL OL OL	P	65 66 66		
FUEL QTY	76 77 77	QTY	74 75 73		
TK P	209 210 212	ACCUM P	2616 2624 2624		
OUT P	209 210 212				
TK VLV A	CL CL CL				
A T	61 62 62				
B T	61 62 62	W/B	1 2 3		
OIL T	64 63 62				
OUT T	63 62 60	CNTRLR	A A A		
OUT P	25 25 25	H2O QTY	100 100 100		
GBX P	25 25 25	N2 P	2499 2506 2492		
N2 P	141 142 140	T	57 58 55		
BRG T	82 81 84	REG P	28 28 28		
GG BED T	426 423 421	BYP VLV	BYP BYP BYP		
PUMP/VLV		VENT T	+122L +122L +122L		
PMP T	94 92 90	TANK T	+57 +58 +55		
VLV T	114 111 107	BLR T	+60 +58 +61		

MAIN SCREEN

Since these Power Points are completely editable the instructor can modify them however he or she chooses to provide various emergencies to allow for situations not covered by the emergency checklist. When using this format it is important for the

instructor to determine when the correct procedure has been followed and instruct the Mission Specialist when they are permitted to press the **[space bar]** on the computer to restore to system to normal.

The worst possible outcome of an Emergency is the “Mission Abort”. To meet this need procedures to mitigate this specific possibility are outlined in the emergency procedures guide and discussed in the student text book. A mission abort procedure is an emergency procedure that is needed due to equipment failure on the Space Shuttle which cannot be mitigated. Most commonly this occurs during ascent such as a main engine failure. The “Mission Abort” is a very useful too when teaching problem solving at the advance stages of the SFSI system. Making that type of decision requires maturity and the realization that the safety of the team is more important than the mission.



Mission Control Team working through an inflight Emergency

Instructional Recommendations

The SFSI simulator system can be as simple or as elaborate as you like depending on your resources and creativity. The more realistic the simulator is the more fun the students can have flying the simulator and working with mission control. Use of this instructional system over the last four years has demonstrated that the regardless of the complexity and realism incorporated in constructing your simulator the results are the same.

When developing your own emergencies outside of the given Power Points be very careful you do not alter the timing for the slides. Normally Emergencies are best performed before launch, after the final OMS burn or during orbit.

A full mission from start to finish takes 45 minutes to complete if there are no problems or emergencies. Emergency conditions can prolong the simulation up to 1 ½ hours, especially if they are outside the Emergency Procedure checklist.

As part of the original grant project FSUS designed and constructed a Space Flight Mobile Simulator. This simulator incorporates the use of macro boards to replace the keyboard and mouse for the three computers. Multiple monitors are used to simulate an actual cockpit and provide mission control with views of all cockpit screens. An aviation quality communication system is used along with gaming chairs/sound system to enhance the feel of the simulation. Additionally all the computers were networked together and a “teacher” computer was added to allow complete control over all the programs using Virtual Network Computing (VNC) software.

To demonstrate the success of this system and support its dissemination to teachers this instructional system has been incorporated into a statewide competition in Florida sponsored by Florida State University Schools, Coaxis and NASA. This competition is known as the “*State of Florida Student Astronaut Challenge*” and is held every year at the Kennedy Space Center and consists of three events.

Event one consist of an engineering challenge where students are provided a space flight operation related problem and will be required to devise and present a procedure for solving the problem. Event two consists of an original presentation and demonstration of a focused experimental proposal by the team that could be performed on the International Space Station on a provided topic. Events three consist of teams performing the pre-flight operation, launch, orbit and landing of the Space Shuttle Enterprise flight simulator and the operation and responsibilities of the mission control team with and without emergency conditions.

References

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