ORBITER
Project Mercury Version 4.60

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http://www.orbitersim.com
August 25th 2003

PROJECT MERCURY FOR ORBITER

1. INTRODUCTION

The possibility of man venturing into space has long ago shifted from the fantasy of "science fiction" to the realm of actuality. We have gone to the moon and returned safely six times and earth orbit has been nearly continually occupied since the early 90's. Project Mercury for Orbiter is an attempt to accurately simulate the Mercury spacecraft and its two launchers, the Redstone and the Atlas. By learning where we were, we can better prepare for tomorrow.

To meet the challenge of the Soviet launch of Sputnik, the National Aeronautics and Space Administration initiated Project Mercury. Through the facilities of McDonnell Aircraft Corporation and NASA, Americans ventured into space for the first time. The mission of Project Mercury was the launch of a manned capsule into orbit around the earth, the study of man's capabilities in space flight, and the subsequent safe return of the capsule and its occupant to the earth's surface. This simple mission laid the foundation for man's first footsteps on another world. The information contained in this manual will provide detailed information on the equipment and procedures utilized to accomplish that mission.

2. SPECIFICATIONS
To added later.

3. VERSION HISTORY

Version 1.1
*Redstone was underpowered fixed to historical ratings. Note the MET+30 change to 55 degree pitch instead of 60 degree pitch
*Included the power for only one Retro now has the power of all three
*Posigrade Rockets automatically fire .5 seconds after staging.
*Abort Mode fixed.

Version 1.2
*Abort Tractor Rocket over powered fixed
*Retro Pack Jettison
*Placement of Retro Jets and Abort Jets
*Accurate Retro Jets
*Parachute mode

Version 1.3
*New Multi-Stage SDK prototype.
*Mercury Capsule has been integrated between the Redstone and Mercury.
*More Accurate handling of sea-level thrust versus vacuum thrust.
*Scenario date has been changed to May 5th 1961 time of launch is in GMT and is exact to the minute.
*Lateral Thruster has been disabled for this model.

Version 1.5
*More fixes to the abort mode.
*Posigrade jets on the Retro pack.
*New Multi-Stage SDK prototype.

*New mesh and texture for the Atlas way to go McDope and Brad. This made me smile!
*New exhaust jets for the Atlas.

Version 1.6
*Booster stage now has a separate mesh thanks to McDope
*Vinka autopilot is in the code for those who like to re-compile and try it.
*Launch Heading now is accurate for the three orbit mercury missions.
*Better Drogue Mesh
*Antenna Housing comes off with the drogue parachute.
*Beacon Experiment Added
*Better values for drag on chutes and capsule.

Version 1.7
*Fix major problem with calculation of booster thrust due to atmospheric pressure. As a result the Redstone should perform more realistically.
*Added the ability to save and load from scenario files
*Fixed the abort tower dll so it isn't over powered.

Version 1.8
*Modified the Touchdown points so that the rocket rests on the ground
*Added Earth 1962

Version 1.9
*Underpowered Retro Rockets fixed

Version 2.0
*Improved the saving and loading of scenarios
*Brian Sikkema's improved mercury mesh

Version 3.0
*Updated every module to 4-19-02 Orbiter
*Enabled Vinka's Autopilot
*Included improved textured mesh for the mercury capsule by Brian Sikkema.
*Added re-entry flames
*Improved drag co-efficient for capsule and parachute.
*Accurate Retro Pack (this should be the last change)
*Changed Scenarios to use Sol_1962
*Added limited thruster fuel for capsule.

Version 4.0
*Updated every module to 12-02-02 Orbiter
*Redstone adapted to new thruster model
*Atlas adapted to new thruster model
*Capsule adapted to new thruster model.
*Added new control panel to Capsule
*Added Scenarios for default orbiter installation

Version 4.5
*Added Retrograde Timer
*Improved ASCS particularly in holding orbital attitude
*Automatic calculation of Retro Times for Orbit 1, 2, & 3.
*More Accurate representation of sequencing lights
*Drogue and Main chutes are now animated

4. LAUNCH - Redstone

The Redstone was an early booster developed by Von Braun's Redstone Arsenal team. The Redstone rocket was the basis for the Jupiter-C which propelled United State's first satellite into orbit.

FLIGHT PLAN

MET+0	Launch
MET+2	HUD To Surface Mode
MET+4	Bring up Surface Mode MFD
MET+16	Pitch to 80 degrees
MET+26	Pitch to 60 degrees
MET+36	Pitch to 45 degrees
MET+160	BECO (Booster Engine Cut Off)
MET+165	Posigrade Rockets Cut Off
MET+185	Yaw around 180 degrees
MET+190	Orient to -34 deg pitch 270 deg yaw and 0 roll
MET+285	Arm Retrograde Rocket
MET+315	Retrograde Rocket Fire
MET+335	Retro Cut off
MET+395	Retro Jettisoned
MET+350	Pitch To +40 deg Pitch
	At .05 G Deceleration 10 deg/sec roll.
	At 6.5k drogue will deploy
	At 3k main will deploy
	Slashdown!!!
	Cut Mains by tapping P once

KEYBOARD

A	Jettison Abort	
J	Jettison Capsule	
E	Abort Eject	Emergency Abort
P	AutoPilot	Toggles the Auto Pilot on and off

NOTE: The only axis controlled by the joystick or keyboard is pitch and yaw. This is accomplished by gimballing the engine.

4. LAUNCH - Atlas

The Atlas Rocket was the United State's first ICBM. In the early 60's it was the only American Rocket with enough power to put the Mercury Capsule into orbit. It features a unique stage and a half design where the two booster engines were jettisoned 135 seconds after launch. This shed over 3050 kg from the rocket's weight and the central rocket (the sustainer) continues to push the rocket into orbit. The Atlas was the basis for several later launch systems including the Atlas-Agena and Atlas-Centaur.

FLIGHT PLAN

MET+0	Launch
MET+2	HUD To Surface Mode
MET+4	Bring up Surface Mode MFD
MET+15	Pitch to 80 degrees heading 57.5 degrees east
MET+35	Pitch to 70 degrees
MET+55	Pitch to 60 degrees
MET+75	Pitch to 50 degrees
MET+95	Pitch to 40 degrees
MET+115	Pitch to 30 degrees
MET+135	MECO
MET+135	Pitch to 20 degrees
MET+145	Jettison Abort Tower by tapping J once
MET+155	Pitch to 10 degrees
MET+165	Pitch to 0 degrees
MET+225	Pitch to -12 degrees
MET+285	Pitch to 0 degrees
MET+30?	SECO - Cut Engines at 7.410 km/sec
SECO+2	Jettison Capsule by tapping J once
SECO+3	Posigrade Rocket Cut off
SECO+20	Pitch Around 180 degrees
SECO+50	Orient to -34 deg pitch 180 deg yaw and 0 roll

KEYBOARD

J	Jettison Stage	Atlas -> Atlas Sustainer -> Atlas Sustainer No Abort -> Mercury Capsule
E	Abort Eject	Emergency Abort
P	AutoPilot	Toggles the Auto Pilot on and off

NOTE: The only axis controlled by the joystick or keyboard after booster jettison is pitch and yaw. This is accomplished by gimballing the engine.

Mercury Control

Switches

| *Pull Knobs*		*Pull Rings*		*Push Buttons*			*Switches*		
IN	OUT	IN	OUT	COVER	OUT	IN	LEFT	MID	RIGHT
Pull Knob can be pulled out or pushed in. If it is cocked to the right it is pushed in. If it is cocked to the right it is pull out. Click with the left mouse button to pull out and click with the right mouse button to push in.		Pull Rings only activate once with the left mouse button. If it is cocked to the right it is in. If it is cocked to the left it is out and can't be pushed back in.		Push buttons have a cover to guard them. Click once with the left mouse to remove the cover. To activate click with the left mouse button. The switch will turn red and back to green when you release the left mouse button.			To switch to the left click with the left mouse button. The switch will go from right->mid->left. To switch to the right click with the right mouse button. The switch will go from left->mid->right.		

Attitude Control

Attitude control is setup by the switches to the left. The important gauges are in the center panel. There is a higher resolution panel of the flight gauges in the Flight Control panel. You can access this by using the Ctrl-<up arrow> from the main panel. You can return to the main panel by Ctrl - <dn arrow>. While not corresponding to anything historical it overcomes the limited resolution of the computer screen.

Attitude Gauges

Flight Control Panel
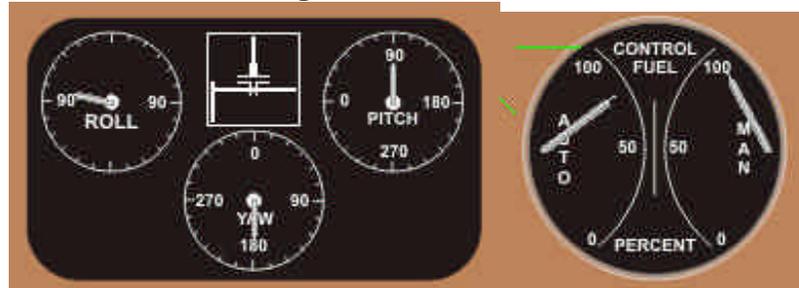
Main Panel Gauges

Unlike an aircraft and later space craft; pitch, roll, and yaw are divided into three separate gauges. In the center of the three gauges is the rate indicator for all three axis.

The rate indicator is perhaps one of the most useful instruments you have. With this you can accurately null out your rates when maneuvering your capsule. When all three lines are center you have zeroed your rates.

| **Pitch Up** | **Pitch Down** | **Yaw Right** | **Yaw Left** | **Roll Right** | **Roll Left** |
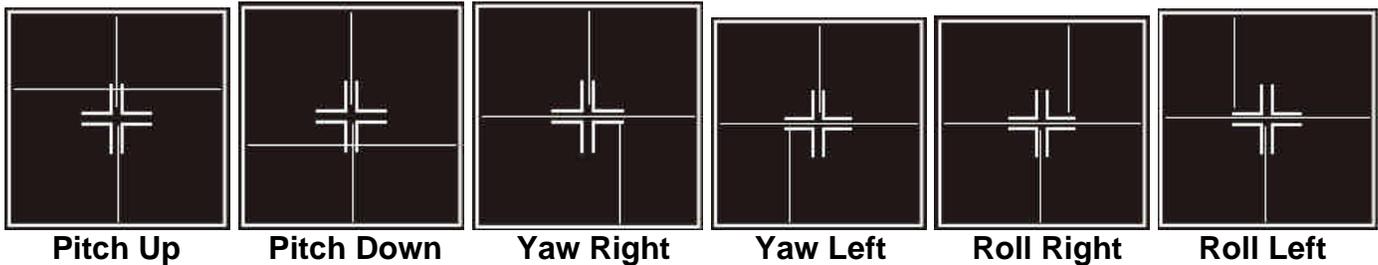
The fuel gauge has indicators for both the manual and auto fuel quantity. The needle on the left is the quantity of auto fuel remaining. The needle on the right the quantity of manual fuel remaining. Zero remaining for both automatic and manual fuel tanks is at the bottom of the gauge.

It is important to monitor your fuel usage particularly during long orbital mission. You only have 7 kg of auto and 7 kg of manual fuel. All your automatic system use the automatic thrusters. If you run out of automatic fuel you will have to fly the capsule using manual thrusters throughout retrograde and re-entry.

Attitude Modes

The Mercury Capsule had several modes you can control attitude with. The modes are Automatic Stabilization & Control System, Auxiliary Damping, Fly By Wire, Rate Stabilization & Control System, and Manual Proportional. The switches, and knobs allow you to select one or more of these modes.

ASCS, Aux Damp, FBW, both draw upon automatic fuel. RSCS & Manual Proportional draw upon manual fuel. In the case of complete electrical failure only Manual Proportional is available to be used as the joystick is directly connected, via mechanical linkage, to the valves controlling the manual thrusters.

The Mercury had 12 thrusters for pitch and yaw, and 12 more for roll. There was a manual thruster that could controlled from 0 to 24 lbs of thrust. The automatic thrusters were either completely on or completely off. There were two sets one produced 24 lbs of thrust while the other produced 1 lb of thrust. The pitch and yaw thruster were located around the nose of the capsules while the roll thrusters were located near the base.

ASCS mode was tied into the sequencer and provided hands off attitude for various phases of the mission. Currently the ASCS will do the following:

For 5 seconds after BECO	dampen any oscillations from separation.
After 5 seconds after BECO	Turn 180 degrees in the yaw axis.
After turnaround is complete	Orient the capsule in -34 degree pitch, 0 yaw, 0 roll.
After Retro jettison	Pitches the capsule up to +40 degrees sub orbital. +1.5 degrees orbital.
After .05g deceleration	Rolls the Capsule 10 deg/sec.

Aux Damp mode will dampen out any rates. However it can't dampen any rates under .5 deg/sec.

Fly by Wire ties the automatic thrusters to the joystick controls. A full extension of the joystick will activate the 24 lbs thrusters. If extended less then 3/4 of full the 1 lb thrusters will be activated.

RSCS Mode moves the capsule at a given rate. Full extension on the joystick will cause the axis to rotate at about 10 deg/sec. Returning the joystick to the neutral position halts any rotation on that axis.

Manual Proportional ties the manual thrust to the joystick. The amount of thrust generated is dependent on the joystick position.

Attitude Layout

This select between Norm (ASCS), Aux Damp, and Fly By Wire.

Auto connects the ASCS to the automatic thrusters. Rate Command connect the ASCS to the manual thrusters. Auto allows the use of ASCS and Aux Damp mode, Rate Comd allows the use of RSCS mode.

Pulling this engages the joystick to the manual thrusters. If you have Auto and Fly by Wire set you will have double authority in all axis. This uses fuel from both the manual and automatic tanks.
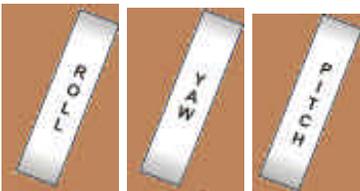
Pulling these knobs will shut the supply of automatic fuel to that axis. This is useful for when you want the ASCS to control one or two axis while you maneuver the others with manual proportional.

The attitude gauges are not connected directly to Orbiter's heading functions. Instead, like the real Mercury they are kept track by monitoring the angular rates around the three axes. Gyro Caged stops the gyros and zero out their position. You can then orient yourself to zero pitch, yaw, and roll and reengage them. Free, means that the gyros are free to rotate and rely only on angular velocity to compute their position. Gyro Norm ties the Mercury horizon scanners to the pitch and roll axis. This is simulated by having those two axes query Orbiter for the horizon pitch and roll. Yaw is always computed through angular velocity.

Mode Summary

MODE	ASCS	Auto Ctl	Manual	Notes
ASCS Auto	Norm	Auto	In	
Aux Damp	Aux Damp	Auto	In	
FBW	FBW	Auto	In	
RSCS	Norm or Aux	Rate Comd	In	
Manual Prop	Norm or Aux	Rate Comd	Out	
MP & ASCS Auto	Auto	Auto	Out	Disable one or more of the automatic axes to properly use.
MP & FBW	FBW	Either	Out	Double authority, wasteful of fuel.
RSCS & FBW	FBW	Rate Comd	In	Good for holding retro fire attitude.

ASCS Summary

The below chart summaries the various ASCS Modes when Norm Auto Mode is selected.

LAUNCH	ASCS is in launch mode awaiting capsule separation.
DAMPING	Any excessive motion is damped for five seconds after capsule separates.
TURNAROUND	Five seconds after capsule separation the turnaround maneuver is initiated in the yaw axis.
ORBITAL ATTITUDE	After turnaround and until Retro Sequence is begun Orbital Attitude is held at -32 deg pitch, 0 yaw, and 0 roll.
RETRO ATTITUDE	After Retro Sequence is initiated Retrofire Attitude is held at -32 deg pitch, 0 yaw, and 0 roll. It is the same as Orbital Attitude except the thrusters are operated at a higher power to cancel motion induced by retrofire.
RE-ENTRY ATTITUDE	After Retro Jettison the capsule will pitched to +40 degree for sub-orbital missions and +1.5 degrees for orbital missions.
.05 G ROLL	When the capsule is subjected to .05 G deceleration in the longitudal axis a 10 deg/sec roll is initiated.
LANDING	ASCS will initiate drogue chute and main chute deployment at pre-determined altitudes.

Sequencer

This controls the sequence of events that make up a complete Mercury Mission. They are arranged from top to bottom in the order they occur in the mission.

Indicator Lights

RETRO SEQ	RETRO SEQ	RETRO SEQ
Unlit	Normal	Abnormal

For most events there is an indicator light that shows the event's status. Unlit means the event has not occurred yet. Green Normal means that the event has occurred normally. Red Abnormal means the event was triggered but was not able to complete or did not occur.

JETT TOWER	**Jettison Abort Tower** This will indicate whether the abort tower has been jettisoned. To jettison the tower early pull the ring switch. The light will turn red two seconds prior to Tower Jettison.
CAPSULE SEP	**Capsule Separation** This will indicate whether the capsule has separated from the rocket. To separate early pull the ring switch. The light will turn red two seconds prior to Capsule Separation.
RETRO DELAY NORM INST	**Retro Delay** Setting this to Norm will cause Retro-Fire to initiate 30 seconds after the retro-fire sequence is started.
SQUIB	**Squib Bus** Arm ties the squib battery into the squib bus thus powering the circuit. The squib bus controls all pyrotechnics on the capsules such as Abort Jettison, Retro Pack Jettison, Beacon Jettison, Chute Housing Jettison. Off will disconnect the squib battery from the bus and prevent any pyrotechnics from firing

|	
	Auto Retro Jettison Due the importance of the Retro Pack a separate switch is on the part of the squib bus circuit going to the retro pack jettison pyros. This switch must be set to arm as well as the Squib bus switch in order for the Retro Pack to Jettison.
	Retro Sequence This indicates whether the retro sequence has started or not. For this version of the simulation the retro sequence has to be started manually via the push button. When the button is pushed the indicator will turn green.
	Retro Attitude Before the sequencer will ignite the Retro Rockets you must be in the correct retro attitude. If you set the switch to BYPASS you will be able to fire the retro rockets from any attitude. If you are in Retro Attitude the indicator will turn green otherwise it will turn red.
	Fire Retro This indicates when the retro rockets have finished firing. To manually initiate retrofire press the push button to the left. 15 seconds before retrofile the light will turn red.
	Jettison Retro This indicates when the retro pack has been jettisoned. This will occur automatically 60 seconds after retro fire. Jett Retro will also cause the ASCS to pitch the capsule to re-entry attitude. To manually jettison the retro pack press the push button to the left. The light will turn red two seconds before retro-jettison.
	.05 G Roll This will indicate when .05 G deceleration is experienced by the capsule and initiate a 10 deg/sec roll to stabilize the capsule during re-entry. To manually initiate the roll press the push button to the left.
	Drogue Deployment To manually deploy the drogue chute, press the push button to the left.
	Snorkel This is not enabled in this version.
	Main Chute Deployment This will indicate whether the main chute is deployed. To deploy the main chute manually pull the ring switch to the left.
	Reserve Chute Deployment To deploy the reserve chute pull the ring switch to the left.
	Landing Bag Deployment This will indicate if the landing bag is deployed. Auto will cause the landing bag to deploy five seconds after deployment of the main chute. Manual will immediately deploy the landing bag.
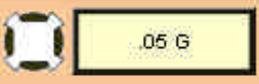
Other Controls

Auto Pilot

In the historic Mercury this was used for indicating to mission control whether the astronaut was ready to launch. In this simulation this is used to indicate with the autopilot for the rocket is turn on or off.

Abort
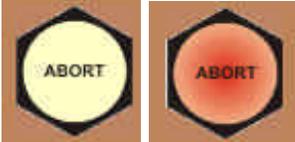
This is used to indicate whether there is an abort in progress.

Altimeter
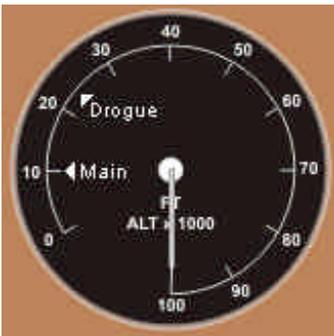
Used to measure altitude below a hundred thousand feet. Markers for Drogue and Main chute deployment are marked.

Acceleration Meter

Used to mearsure the Longitudinal Acceleration on the capsule. It is useful both during launch and re-entry. During launch you can use the positive acceleration to monitor various rocket events. The Redstone will peak at 9 Gs before separation. The Atlas will peak at 7 Gs before Booster separation and peak again at 7 Gs before capsule separation. During a sub-orbital re-entry you will briefly hit 11 Gs and during a orbital re-entry you will hit a max of 7 Gs during re-entry but for a much longer period of time.

Rate of Descent Meter

If your rate of descent is over 40 ft after main chute deployment; something is wrong and it is time to deploy the reserve chute.

Retrograde Timer

The retrograde clocks show the elapsed mission time and the time to retro fire. When the retrograde clock counts down the retro fire sequence will begin. 30 seconds later the retro rockets will fire, and 60 seconds later the retropack will jettison.

When you achieve orbit with the Mercury Atlas the retro time for 3 orbits will be automatically calculated. You can change the retro time by using the lever at the bottom to increment or decrement the retro time. In addition you can tap the letter 'E' to have the retro time for your current orbit be automatically calculated. The prime landing zones for each orbit are as follows

Orbit 1   30 degrees north, 54 degrees west
Orbit 2   24.75 degrees north, 59.8 degrees west
Orbit 3   18.25 degrees 67.25 degrees west

In a future version I will be including calculations for emergency landing zones. For those of you examining the source code the algorithm I use is not accurate for high inclination orbits.

Time Zero Switch

This will start the clock. The clock normally start when you lift 2 inches (50 mm) off the launch pad.

Earth Path Indicator
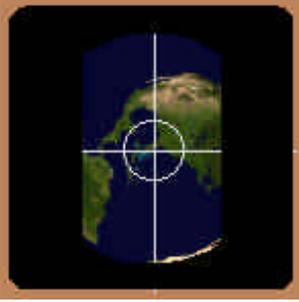
This tells you your location on the earth. The circle indicate the field of view if you use a standard mercury orbit. In addition the earth globe is a true 3D globe based on Radu's 3D Adi ball and is good for any orbital inclination.

FACING

Generally you want to orient to -34 deg pitch 0 deg yaw and 0 roll when not drifting or performing maneuvers.

LIMITED THRUSTER FUEL

Every maneuver takes up fuel. There is 15.8 kg in the Automatic Tanks and 11.3 kg in the Manual tanks. Once you use up both of the tanks you will not be able to maneuver at all. The maneuvers performed by the ASCS are done with the automatic tanks. It is recommend that most manual maneuvers be performed either in manual mode or in rate control (RSCS) mode

KEYBOARD

See control panel for controlling the capsule.

RE-ENTRY

For both sub-orbital and orbital you want to orient to -34 deg pitch 180 deg yaw and 0 roll for re-entry and hold that through the firing of your retros.

Sub-Orbital

You want to initiate re-entry at MET+315 seconds. This was not critical but was done to test the re-entry procedures. After jettisoning the Retro you want to hold +40 pitch throughout re-entry.

Orbital

For the three orbit missions you want to initiate re-entry at 130 deg longitude west near the end of the third orbit. If you are using the Sequencer you want to start the retro sequence at 132 deg west. You will travel through 67 degrees of your orbit after retro fire. After jettisoning the Retro you want to hold +1.5 pitch throughout re-entry.

PARACHUTES

If Pressure rises above 48000 PA the drouge chute will deploy
If pressure rises above 68000 PA the drouge will be cut and the main chute deployed
If Pressure is above 68000 when the capsule enters re-entry mode the drogue chute will be disabled.
You must have increasing pressure (losing altitude) in order for any chutes to be deployed

PARACHUTE KEYBOARD

J	Jettison Parachute	Jettison Chute
P	Deploy Backup	Deploy Backup

6. SCENARIOS

Project Mercury

      The scenarios found under this directory run with the default installation of orbiter.

Mercury Atlas

      Fly the Mercury Atlas into orbit.

Mercury Redstone

      Fly the Mercury Redstone into a sub-orbital path.

Earth 1962

These Scenarios require the download of the Earth:1962 add-on.

MR-3 Freedom 7
MR-4 Liberty Bell 7
MA-6 Friendship 7
MA-7 Aurora 7
MA-8 Sigma 7
MA-9 Faith 7

7. CREDITS

Rob Conley   - Module
Dealer McDope   -Redstone & Atlas Mesh
Brian Sikemma   - Mercury Capsule Mesh & Textures
Vinka   - Autopilot
Brad Hodges   - Additional Meshes & Textures
Shrox   - Retro Rocket Mesh.

Thanks for your support and help