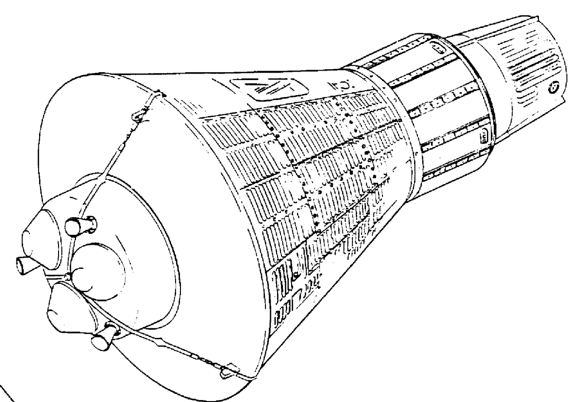
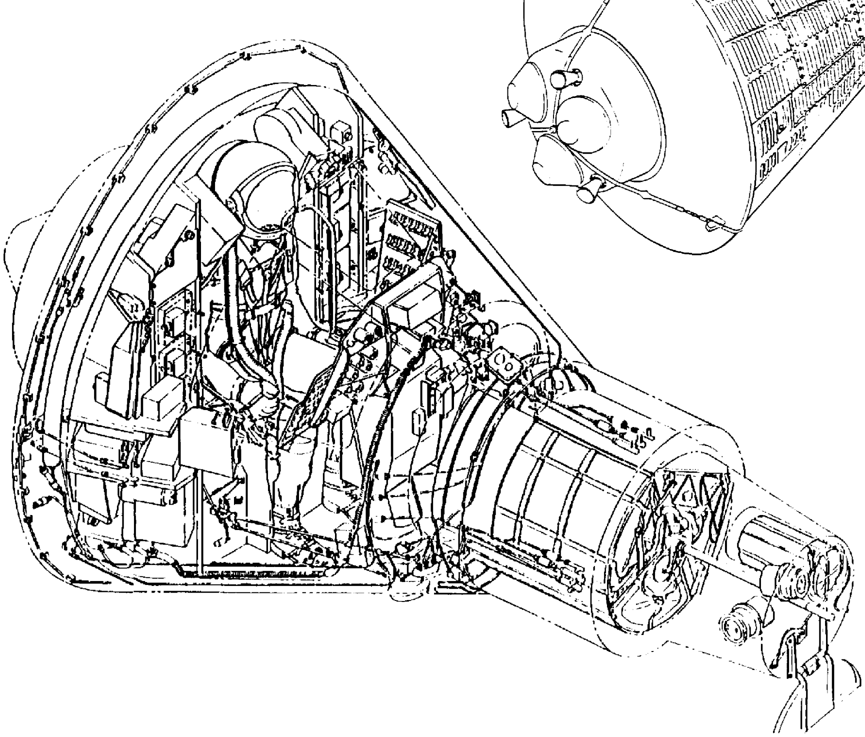
A-OK!

THE WINGS OF MERCURY 2.1

Flight Operations Manual

By Joseph Nastasi





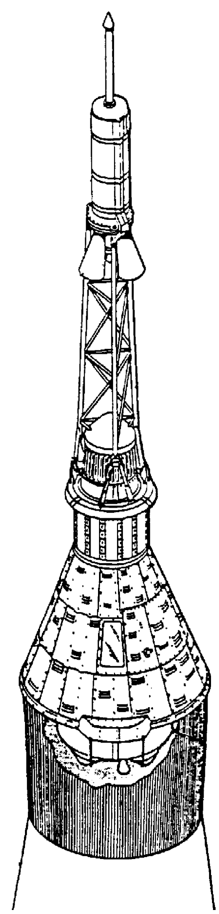


Table of Contents

Acknowledgements

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This product is dedicated to the original Mercury astronauts,
the National Aeronautics and Space Administration, the McDonnell/Douglas company
and the scores of subcontractors involved with Project Mercury.
They truly had "the right stuff!"

Overview

A-OK! The Wings of Mercury, is a Macintosh–based package that simulates the McDonnell Aircraft (now McDonnell/Douglas) Corporation's Mercury Spacecraft. In the early 60's, the Mercury program put the first Americans into space. A-OK! duplicates the experience of operating the Mercury spacecraft, to the point of reproducing all its endearing little quirks, such as the ability to accidentally activate two different attitude control modes simultaneously, draining your fuel in the process!

The Mercury spacecraft was designed to orbit a single human around the earth for three orbits. The initial flights included sub–orbital tests and the original design was stretched to allow six and eighteen orbit missions. Since each spacecraft was modified from mission to mission, no two were alike. The spacecraft represented by this simulator is based on capsule 13, the first orbital model.

The Army's Redstone rocket was used to loft Mercury on the sub–orbital flights. The Air Force Atlas InterContinental Ballistic Missile was used to boost Mercury into orbit. A-OK! can simulate a sub–orbital Mercury/Redstone mission (a fifteen minute, 115 mile high flight over the Atlantic) or a three–orbit Mercury/Atlas mission (which can be as long as five hours!).

The Mercury spacecraft was a cranky, unforgiving creature created by an army of contractors, engineers and politicians under pressure to produce an American space success at the dawn of the Cold War. Despite some early failures and a capsule lost at sea, all of the manned missions were completed successfully. The following table summarizes the manned missions:

Flight	Date	Astronaut	Profile	Duration	Orbits
MR–3	May 6,1961	Alan Shepard	Sub–orbital	00:15:22	NA
MR–4	July 21,1961	"Gus" Grissom	Sub–orbital	00:16:35	NA
MA–6	February 28,1962	John Glenn	Orbital	04:55:23	3
MA–7	May 24,1962	Scott Carpenter	Orbital	04:56:00	3
MA –8	October 3,1962	Wally Schirra	Orbital	09:13:00	6
MA –9	May 15–16,1963	"Gordo" Cooper	Orbital	34:19:49	22

System Requirements

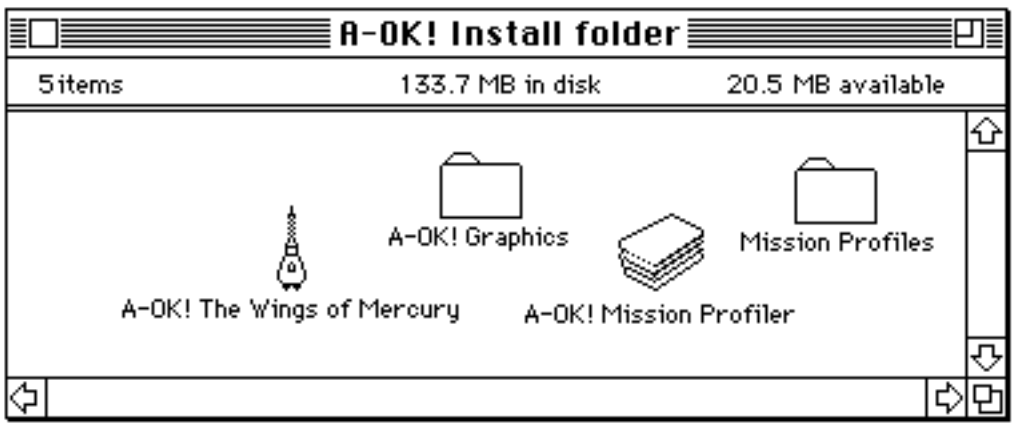
Minimum System Requirements
Color Macintosh (68040 or PowerMac)
16 Meg RAM
12 Meg disk space
System 7.5 or later
QuickTime 3.0
Adobe Acrobat Reader 2.0 or later

Recommended System Requirements
PowerMac (100Mhz or faster)
32 Meg RAM
System 8
A joystick

Installation

A-OK! resides on five floppy disks. Installation is very easy. Simply insert the disk “Disk 1 of 4” into your floppy drive and double–click the file marked “*A-OK! Installer*.” You will be prompted for a destination directory. When the first disk is installed you will be prompted to insert the disk “Disk 2 of 5” into your floppy drive. The process is repeated for the disk “Disk 3 of 5”, “Disk 4 of 5” and “Disk 5 of 5.” Finally, the installer will ask you to re–insert the first disk and display a dialog box asking if you want to continue installing or quit. Click the Quit button.

The fivc files have been joined and expanded and you will have a folder entitled “*A-OK*” that contains the following:



The file “*A-OK! The Wings of Mercury*” is the actual application program. The folder “*A-OK! Graphics*” contains graphic files that are used with A-OK!. The folder “*Mission Profiles*” contains sample mission profiles suitable for training purposes. The HyperCard stack, “*A-OK! Mission Profiler*” allows you to custom–design simulations and is described in Section 17.

Problems

In general, A-OK!’s performance increases as you give it more RAM. Select the A-OK! application and Select Get Info on the File menu. Make sure the Minimum size box to 7000K. The Preferred size box should be set to 10000K. Remember that even though you may have the required amount of RAM *installed*, the System and any other programs running at the same time also use RAM. Select “About this Macintosh…” on the Apple menu before starting A-OK! and read the field “Largest Unused Block.” That figure is the amount of RAM available for A-OK!. If the unused RAM is lower than 7000K, try quitting out of any programs you may have running.

Problems running A-OK! are almost always due to a conflict with a System Extension or INIT, or not having enough *unused* RAM. Try removing unneeded System Extensions. In addition to decreasing the amount of unused RAM for A-OK!, some extensions do “funny things” that interfere with A-OK!’s operation. In particular, System Extensions that compress RAM usually do not work well with A-OK!.

If you have enough RAM available and you are still having problems, move all of your System Extensions contained in the "Extensions" folder (which is in the "System" folder) to a back up folder, with the exception of QuickTime and Sound Manager. Restart your Macintosh and try to run A-OK! again. Gradually move each Extension in the back up folder to the "Extensions" folder, Restart and test again until you find the Extension that is causing the problem.

Getting Started

It is recommended that you read through this manual before attempting a run in the simulator. However, you can get a "quick–look" at the Mercury spacecraft in action by doing the following:

1. Double–click the "A-OK! The Wings of Mercury" icon.
2. Select an astronaut (or a monkey!) from the roster list by double–clicking a name.
3. Select "Yes" when asked for verification of the astronaut selection.
4. Select "Preferences" from the "File" menu.
5. Click on the "Easy" button, under "Difficulty Level."
6. Click on the "OK" button.
7. Select "Sub–Orbital" from the "Mission" menu.
8. Select "Start Simulation…" from the "Control" menu.
9. Click on the "Launch" button.
10. Click on the "OK" button.
11. Hold on!

A-OK! will start a sub–orbital flight that takes you 115 miles above the Atlantic Ocean and about 300 miles from Cape Canaveral. Since Mercury was designed to be completely automatic in operation, and you chose the "Easy" option under "Preferences," you will not have to do anything except watch. During the flight, click on the "Panel Selection" Palette to move across the control panel.

Notes:

> You will hear warning tones thirty seconds before retrofire, and during descent, when the emergency oxygen rate is turned on and the excess fuel is dumped. These tones are normal. You may disable them by moving to the top right of the control panel and turning the AUDIO switch next to the O2 EMER, FUEL QUAN and RETRO WARN warning lights to OFF.
>
> Balloon Help allows you to identify all of the controls, gauges and indicators on Mercury's control panel. A small text balloon will appear with a brief explanation of the item's use. Additionally, enabling Balloon Help will also describe A-OK!'s menu items.
>
> Finally, you may have noticed that the window view is upside–down during ascent and descent. This is because you are on your back and the "top" of the window is actually showing you the bottom of your field of view!

Now that you have tried the sub–orbital flight described above, we'll again recommend that you read through the manual. *What*? Read a manual for a Macintosh program??? Yes, we agree that the Macintosh user interface is the greatest, but the Mercury spacecraft, due to its pioneering role, was *not* a user–friendly device!

1.4

Once you've flown in "chimp mode" (as MA-8 astronaut Wally Schirra called it), the next logical step is to initiate flight–critical events and control the spacecraft's attitude manually. Review the mission by reading "Sub-Orbital Mission Description" in Section 2. Restart a sub–orbital flight using the procedure described above. Disable the Programmer by moving the PRO–GRAMR fuse to the center OFF position. All of the events described in Section 5 "Programmer Description & Operation" will now have to be initiated manually. Open the Flight Plan and Emergency Checklist using the "Documentation" menu to help cue you during flight. During the short period of zero "G," you should try the Manual Proportional, Fly–By–Wire and Rate Stabilization & Control System control modes.

Mastering attitude control and event initiation prepares you for handling the "Average" and "Difficult" levels of the simulator. Section 16 "Menu Descriptions" and Section 17 "Simulation Failure Scenarios" describe the randomly–generated failures that you will have to react to. Also described in Section 17 are sample mission profiles that you can load by selecting "Load Profile…" on the "File" menu. These profiles are focus on various types of failure scenarios and are located in the "*Mission Profiles*" folder.

After mastering sub-orbital missions, you should move on to an orbital mission. Realize that a full three orbit mission is almost five hours long! Luckily, A-OK! does work in the background. You can fly a shorter mission by resetting the retrograde clock by selecting "Reset Retro Time…" on the "Commands" menu. See Section 9 "Retrograde Description & Operation" for the initial retrograde times for each recovery zone. You should also attempt the In–Flight Experiments as described in Section 18.

Finally, you can practice specific parts of an orbital mission by selecting the proper starting point. To practice attitude control or retrograde operations, choose "On-Orbit," "Reentry" and "100,000 Feet" allows you to start the simulation at those points.

A-OK! The Wings of Mercury is a highly realistic simulation. So realistic in fact, that after mastering it, you will know almost as much as the original seven knew about their spacecraft! Good luck and have fun!

Sub-Orbital Mission Description

This section describes the sequence of events in typical Mercury sub–orbital mission. The figure following the text shows the major sub–orbital flight events. Each figure is preceded by a detailed description of flight events showing the event name and the mission elapsed time that the event should occur. Refer to Section 5 “Programmer Description & Operation” for additional details.

T+00:00:00 Lift–off
The Redstone lifts off the pad and the on–board mission clock is started.

T+00:00:16 Pitch Program
The launch vehicle begins 2°/second movement from 90° (spacecraft nose pointing up) to 45° (spacecraft nose pointing forward 45°). This movement is programmed into the launch vehicle and is completely automatic. However, any deviation from the proper launch vehicle attitude will require the astronaut to execute an abort. The Abort Indicator will illuminate and an audible alarm will sound if this action is required.

T+00:01:24 Max Q
This point is where the launch vehicle is hit with the maximum dynamic pressure of the launch. Since the spacecraft will be subjected to high rates of vibration, the astronaut will check that the cabin maintains the proper oxygen pressure, 5.5 pounds/square inch. Failure to maintain proper pressure will require an abort.

T+00:02:20 Booster Engine Cut Off (BECO), Tower Jettison & Capsule Separation
The Redstone booster engine shuts down, ending powered flight. Simultaneously, the escape tower, no longer needed for an abort, is ejected from spacecraft. Mercury then separates from the Redstone and fires small posigrade rockets to increase the distance from the booster. The astronaut can perform the Tower Jettison and Capsule Separation manually by pulling the JETT TOWER and SEP CAPSULE override rings, if required.

T+00:02:35 Turnaround
Using the Automatic Stabilization & Control System (ASCS), the spacecraft turns in yaw and pitch so that it is flying with its retropackage pointing up and in the opposite direction of travel. The attitude at the end of this sequence is 0° yaw and -34° pitch: the proper attitude for retrofire. This is an automatic maneuver that the astronaut may elect to perform manually

T+00:02:45 Attitude Tests
This time period is used to test the astronaut’s ability to control the spacecraft manually using the Fly–By–Wire (FBW) attitude control mode. See Section 18 for more detail.

T+00:04:45 Retro Sequence Start
The spacecraft will begin retrofire in 30 seconds. During this time the Automatic Stabilization & Control System (ASCS) will check for proper retrofire attitude (pitch -34°, yaw 0°). Under normal circumstances, ASCS will not permit retrofire if the spacecraft is not in the proper attitude. This may be bypassed if the astronaut believes that the spacecraft’s attitude is correct.

2.2

T+00:05:15 Retrofire

Since orbital speed is not reached during a sub–orbital flight, retrofire is not required. It is performed in order to provide astronauts retrofire training under real flight conditions.

T+00:06:15 Retro Jettison

One minute after retrofire, the retro rocket package is ejected from the spacecraft leaving the heat shield exposed.

T+00:06:20 Reentry Attitude

The Automatic Stabilization & Control System (ASCS) turns the spacecraft to the proper attitude for sub–orbital reentry into the atmosphere. At the end of this maneuver, the will be pitch of 40° (spacecraft nose pointing above the horizon) and the roll and yaw will be 0°. The astronaut may elect to perform this maneuver manually.

T+00:07:15 .05G

When the Automatic Stabilization & Control System (ASCS) detects the beginning of reentry, it will initiate a 10°/second roll. This maneuver makes the spacecraft more stable during reentry. The astronaut can perform this maneuver manually.

T+00:09:38 Drogue Parachute Deploy

At about 22,000 feet in altitude, the drogue parachute should deploy, slowing the descent rate to 365 feet/second. In addition to slowing the descent rate, the drogue parachute helps stabilize the spacecraft

T+00:09:45 Snorkel Deploy

At about 20,000 feet, the fresh air snorkel deploys. Simultaneously, the Environmental Control System (ECS) switches to the emergency oxygen rate. These actions help cool the spacecraft environment after the heating effects of reentry.

T+00:10:15 Main Parachute Deploy

At about 10,000 feet, the main parachute deploys, slowing the descent rate to 30 feet/second.

T+00:10:20 Landing Bag Deploy

After the main parachute is deployed, the landing bag is deployed. The landing bag is a fabric skirt that is connected to the heat shield. When deployed the landing bag pushes the heat shield away from the spacecraft. This forms an air–filled “bag” that cushions the “G” forces of landing.

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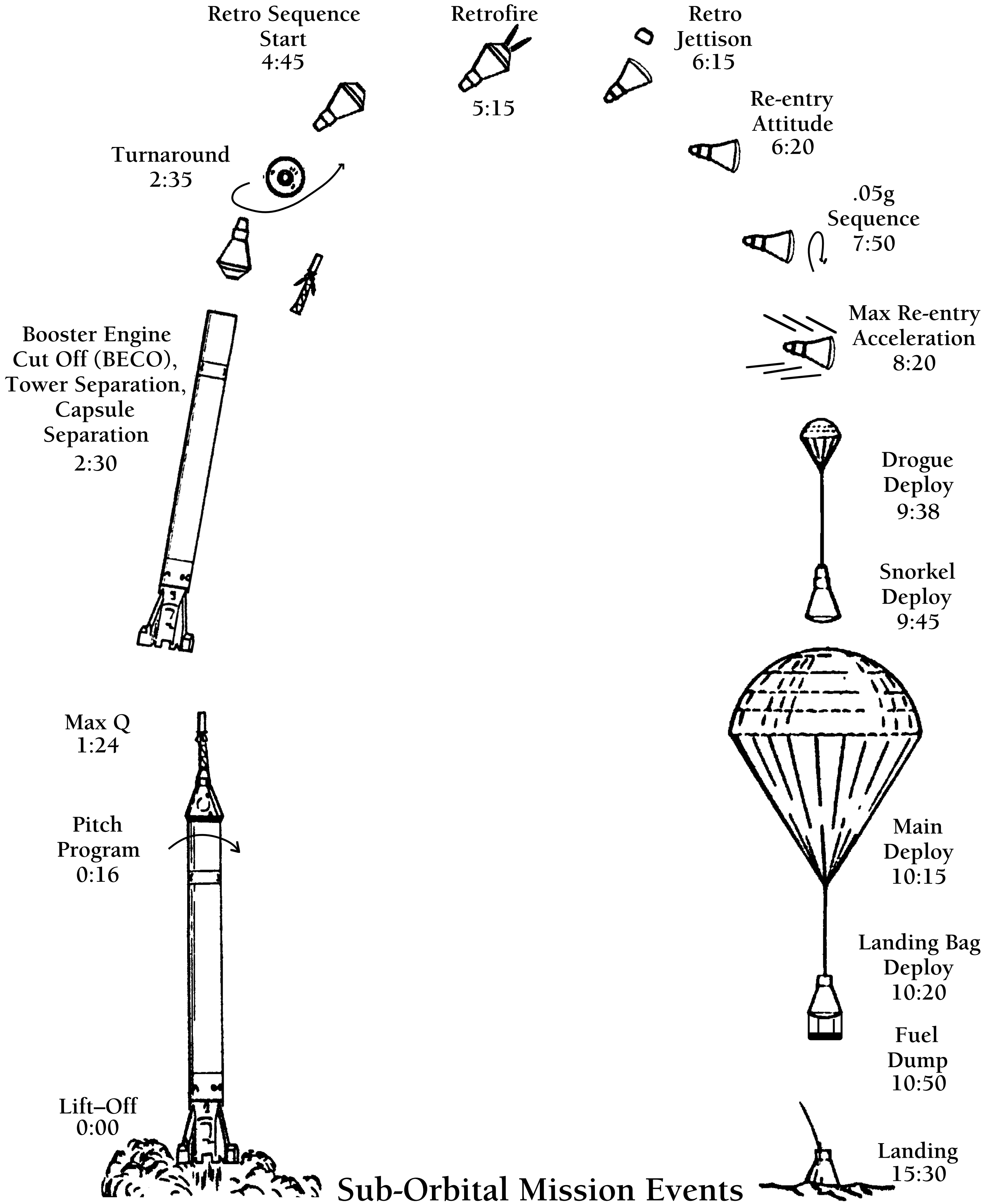
T+00:10:50 Fuel Dump

At about 8,000 feet, any remaining fuel is automatically dumped overboard. The hydrogen peroxide fuel carried on board Mercury is highly poisonous and a rough landing could cause a fuel spill that presents a hazard to the astronaut.

T+00:15:30 Landing & Rescue Aids Deploy

After landing, a rescue aid package is deployed. This package includes a dye marker that marks the landing area and a recovery radio beacon and its associated antenna.



Sub-Orbital Mission Events

2.4
Orbital Mission Description

This section describes the sequence of events in typical Mercury orbital mission. The figure following the text shows the major orbital flight events. Each figure is preceded by a detailed description of flight events showing the event name and the mission elapsed time that the event should occur. Refer to Section 5 “Programmer Description & Operation” for additional details.

T+00:00:00 Lift–off
The Atlas lifts off the pad and the on–board mission clock is started.

T+00:00:02 Roll Program
The launch vehicle rotates along its long axis at -2.5°/second from 30° to 0° roll. This is done so that Atlas puts Mercury into the proper orbital angle with respect to the earth’s equator. This maneuver is programmed into the launch vehicle and is completely automatic. However, any deviation from the proper launch vehicle attitude will require the astronaut to execute an abort. The Abort Indicator will illuminate and an audible alarm will sound if this action is required.

T+00:00:16 Pitch Program
The launch vehicle begins 0.5°/second movement from 90° (spacecraft nose pointing up) to 0° (spacecraft parallel with ground). As with the roll program, this maneuver is automatic, but any deviation from the proper launch vehicle attitude will require the astronaut to execute an abort.

T+00:01:24 Max Q
This point is where the launch vehicle is hit with the maximum dynamic pressure of the launch. Since the spacecraft will be subjected to high rates of vibration, the astronaut will check that the cabin maintains the proper oxygen pressure, 5.5 pounds/square inch. Failure to maintain proper pressure will require an abort.

T+00:02:10 Booster Engine Cut Off (BECO)
The Atlas twin booster engines shut down, leaving the center sustainer engine running.

T+00:02:33 Tower Jettison
The escape tower, no longer needed for an abort, is ejected from spacecraft. The astronaut can perform the Tower Jettison manually by pulling the JETT TOWER override ring, if required.

T+00:05:20 Sustainer Engine Cut Off (SECO) and Capsule Separation
The Atlas sustainer engine shuts down, ending powered flight. Simultaneously, Mercury then separates from the Atlas and fires small posigrade rockets to increase the distance from the booster. The astronaut can perform the Capsule Separation manually by pulling the SEP CAPSULE override ring, if required.

T+00:025 Turnaround
Using the Automatic Stabilization & Control System (ASCS), the spacecraft turns in yaw and pitch so that it is flying with its retropackage pointing up and in the opposite direction of travel. The attitude at the end of this sequence is 0° yaw and -34° pitch: the proper attitude for retrofire. This is an automatic maneuver that the astronaut may elect to perform manually.

T+00:05:50 Orbital Flight
At SECO, the spacecraft will be approximately 80 to 100 nautical miles in altitude. This is the lowest point in the orbit and is called the Perigee. The Apogee or highest point in the orbit, occurs at an altitude of approximately 140 to 150 nautical miles. A-OK!'s orbital mission is programmed for three orbits. Mercury will complete one orbit every 90 to 95 minutes, depending on the altitude of the orbit. The Mercury vehicle that is simulated by A-OK! contains enough consumables for four orbits under normal circumstances.

The astronaut will be expected to test the various attitude control modes, monitor spacecraft systems and maintain communication with the ground stations. Additionally, there are several in–flight experiments that must be conducted. See Sections 18 & 19 for details.

T+04:30:00 Retro Sequence Start
The spacecraft will begin retrofire in 30 seconds. During this time the Automatic Stabilization & Control System (ASCS) will check for proper retrofire attitude (pitch -34°, yaw 0°). Under normal circumstances, ASCS will not permit retrofire if the spacecraft is not in the proper attitude. This may be bypassed if the astronaut believes that the spacecraft's attitude is correct.

T+04:30:30 Retrofire
Three solid rockets, firing for a total of 20 seconds, slow the spacecraft's speed to just below orbital velocity. This causes the spacecraft to begin reentry into the atmosphere. If the retro rockets do not fire or fire while the spacecraft is in the wrong attitude, Mercury will be stranded in orbit.

T+04:31:50 Retro Jettison
One minute, twenty seconds after retrofire, the retro rocket package is ejected from the spacecraft leaving the heat shield exposed.

T+04:33:00 Reentry Attitude
The Automatic Stabilization & Control System (ASCS) turns the spacecraft to the proper attitude for orbital reentry into the atmosphere. At the end of this maneuver, the will be pitch of 1.5° (spacecraft nose pointing above the horizon) and the roll and yaw will be 0°. The astronaut may elect to perform this maneuver manually.

T+04:40:30 .05G
When the Automatic Stabilization & Control System (ASCS) detects the beginning of reentry, it will initiate a 10°/second roll. This maneuver makes the spacecraft more stable during reentry. The astronaut can perform this maneuver manually.

T+04:50:20 Drogue Parachute Deploy
At about 22,000 feet in altitude, the drogue parachute should deploy, slowing the descent rate to 365 feet/second. In addition to slowing the descent rate, the drogue parachute helps stabilize the spacecraft.

2.6

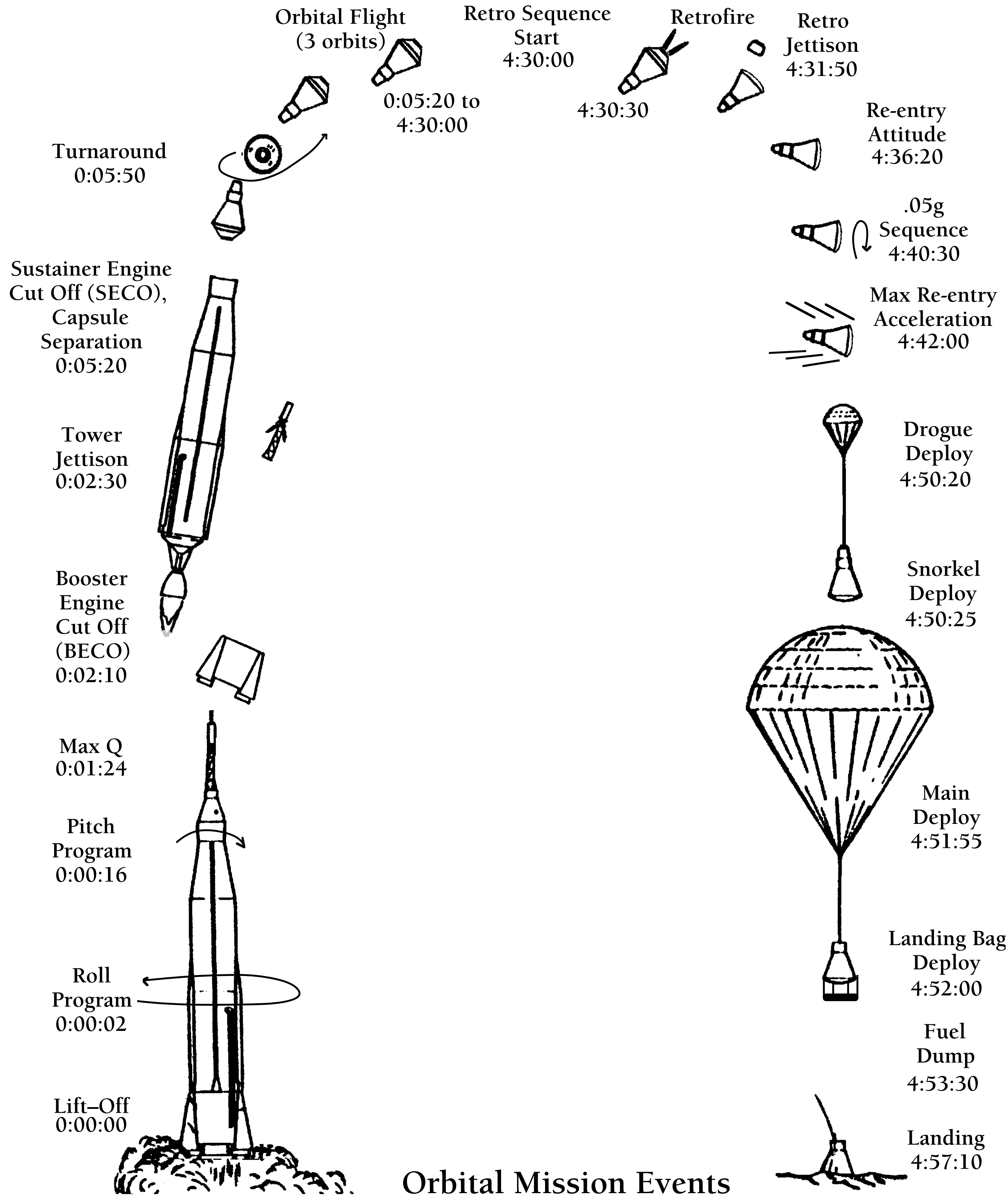
T+04:50:25 Snorkel Deploy
At about 20,000 feet, the fresh air snorkel deploys. Simultaneously, the Environmental Control System (ECS) switches to the emergency oxygen rate. These actions help cool the spacecraft environment after the heating effects of reentry.

T+04:51:55 Main Parachute Deploy
At about 10,000 feet, the main parachute deploys, slowing the descent rate to 30 feet/second.

T+04:52:00 Landing Bag Deploy
After the main parachute is deployed, the landing bag is deployed. The landing bag is a fabric skirt that is connected to the heat shield. When deployed the landing bag pushes the heat shield away from the spacecraft. This forms an air–filled “bag” that cushions the “G” forces of landing.

T+04:52:30 Fuel Dump
At about 8,000 feet, any remaining fuel is automatically dumped overboard. The hydrogen peroxide fuel carried on board Mercury is highly poisonous and a rough landing could cause a fuel spill that presents a hazard to the astronaut.

T+04:57:10 Landing & Rescue Aids Deploy
After landing, a rescue aid package is deployed. This package includes a dye marker that marks the landing area and a recovery radio beacon and its associated antenna.



Orbital Mission Events

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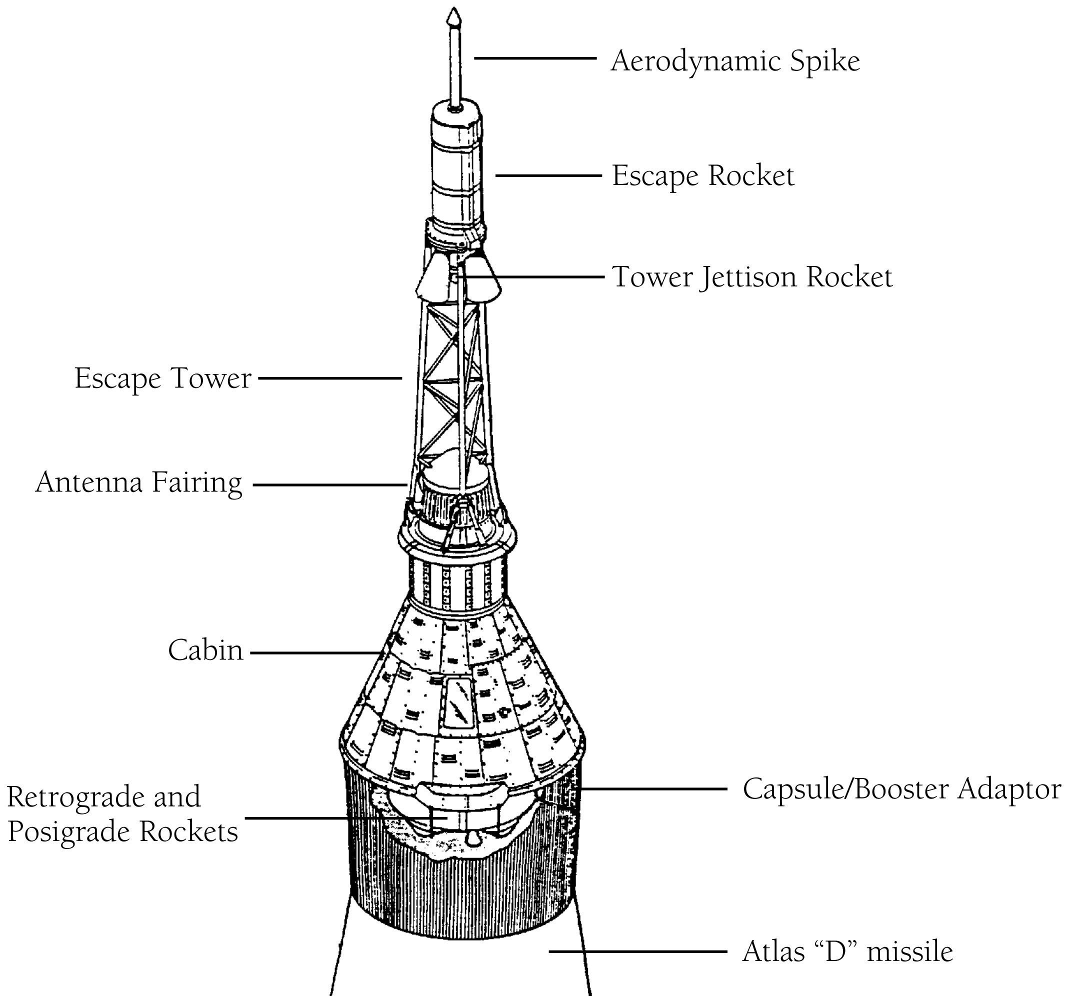
Spacecraft General Description

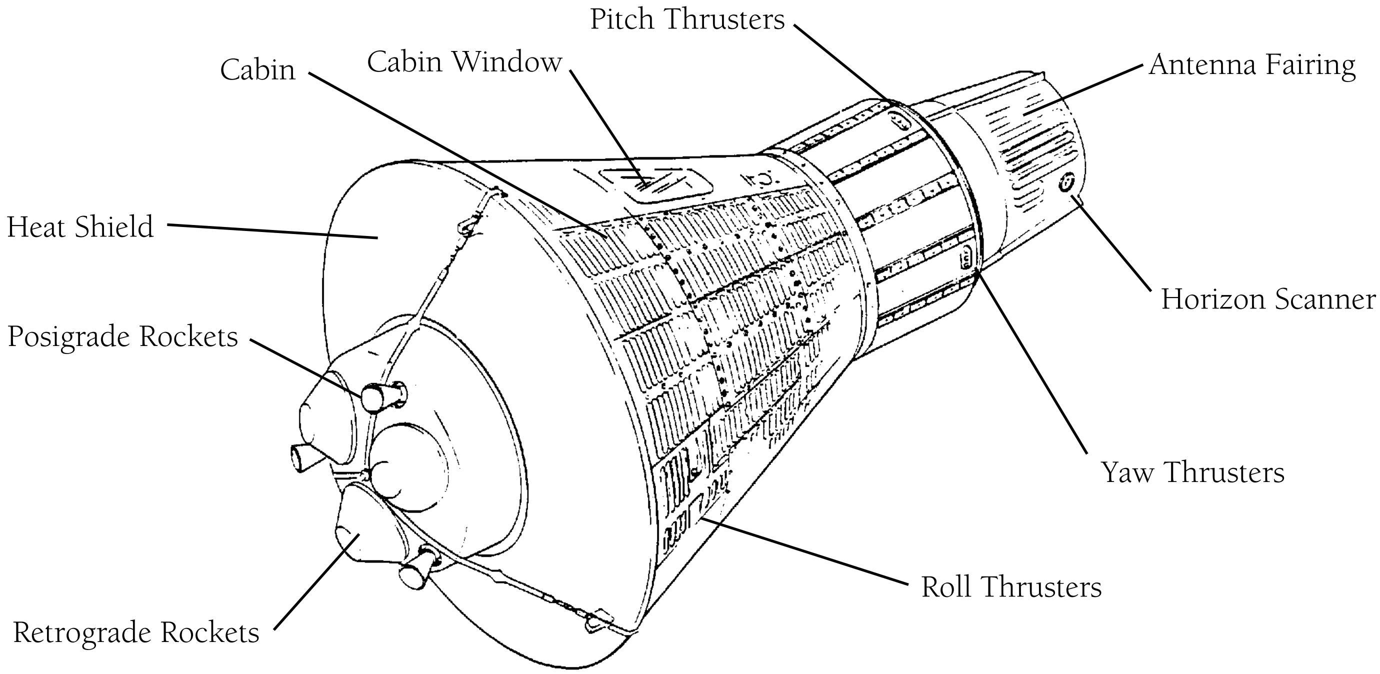
This section provides a general description of the Mercury spacecraft. Refer to the figures "Launch Configuration" and "Orbit Configuration" for external features and "Interior Arrangement", "Cabin Equipment – Aft View" and "Cabin Equipment – Fore View" for internal features. Some spacecraft systems are discussed, in greater detail, in Sections 4 through 12.



Launch Configuration

Spacecraft Exterior

The Mercury spacecraft is an essentially conical structure containing a pressurized area suitable for human occupation during the launch, orbit, and recovery phases of a typical mission. The base of the cone contains a provision for attachment to the Atlas launch vehicle, through use of a special adapter. Explosive charges separate the spacecraft from the adapter. The Redstone booster adapter is similar. The forward end of the cone contains the devices required to recover the spacecraft at the end of a mission, and an escape rocket structure that would allow the astronaut to escape in the event of an aborted launch. Within the spacecraft proper are systems that regulate the environment, flight attitude, data telemetry, and spacecraft recovery.



Orbit Configuration

When in place on the nose of the booster, the small end of the spacecraft is facing up. The astronaut is on his back in a sitting position. During the launch phase, the astronaut faces forward with respect to the flight path. When the booster and spacecraft combination reaches orbit, the spacecraft separates from the booster and is rotated 180° about its yaw axis. Throughout the remainder of the flight, the astronaut is facing aft with respect to the flight path.

Dimensions	Configuration	Measurement
Weight	launch	4,265 lb
	orbit	2,987 lb
	splashdown	2,493 lb
Height	launch	26 ft
	orbit	11 ft
	reentry	9 ft, 6 in
Width	heat shield	6 ft, 2 in
	retro package	2 ft, 9 in

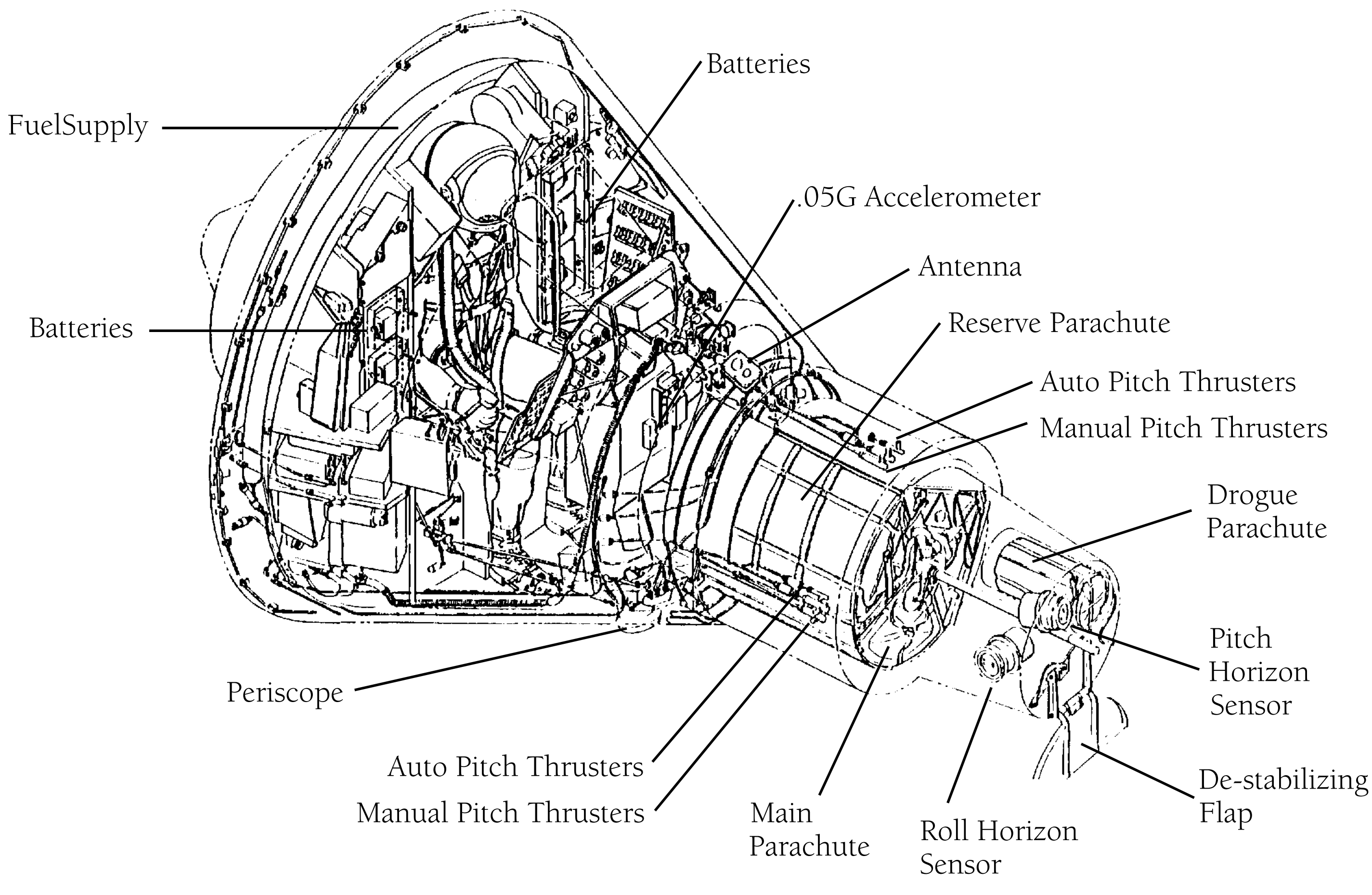
Typical Spacecraft Dimensions

The spacecraft is of a conventional semi–monocoque construction typical of high performance aircraft. The primary structural elements are fabricated with titanium. Construction is designed to protect the internal cabin from excessive heating, noise, and meteorite penetration. The titanium structure is covered with beryllium shingles that provide thermal protection during flight.

The antenna fairing contains the primary bi–cone communication antenna, the pitch and roll horizon scanners, and the drogue parachute. The fairing is constructed of titanium and is jettisoned during the descent phase in preparation for deployment of the main parachute. A spring loaded de–stabilizer flap is attached to the top of the antenna fairing. This flap will force the spacecraft into a reasonable attitude for reentry, although strong oscillations are still possible.

Spacecraft Interior

Within the basic structure is a pressurized cabin that is supported between a small, forward pressure bulkhead and a large, rear pressure bulkhead. The small bulkhead is removable to allow an alternative means of egress from the spacecraft. The cabin interior wall is lined with channeled frames to provide addition strength and a means of supporting internally mounted cabin equipment. The cabin pressure vessel is constructed of inner and outer titanium shells that are seam–welded together.

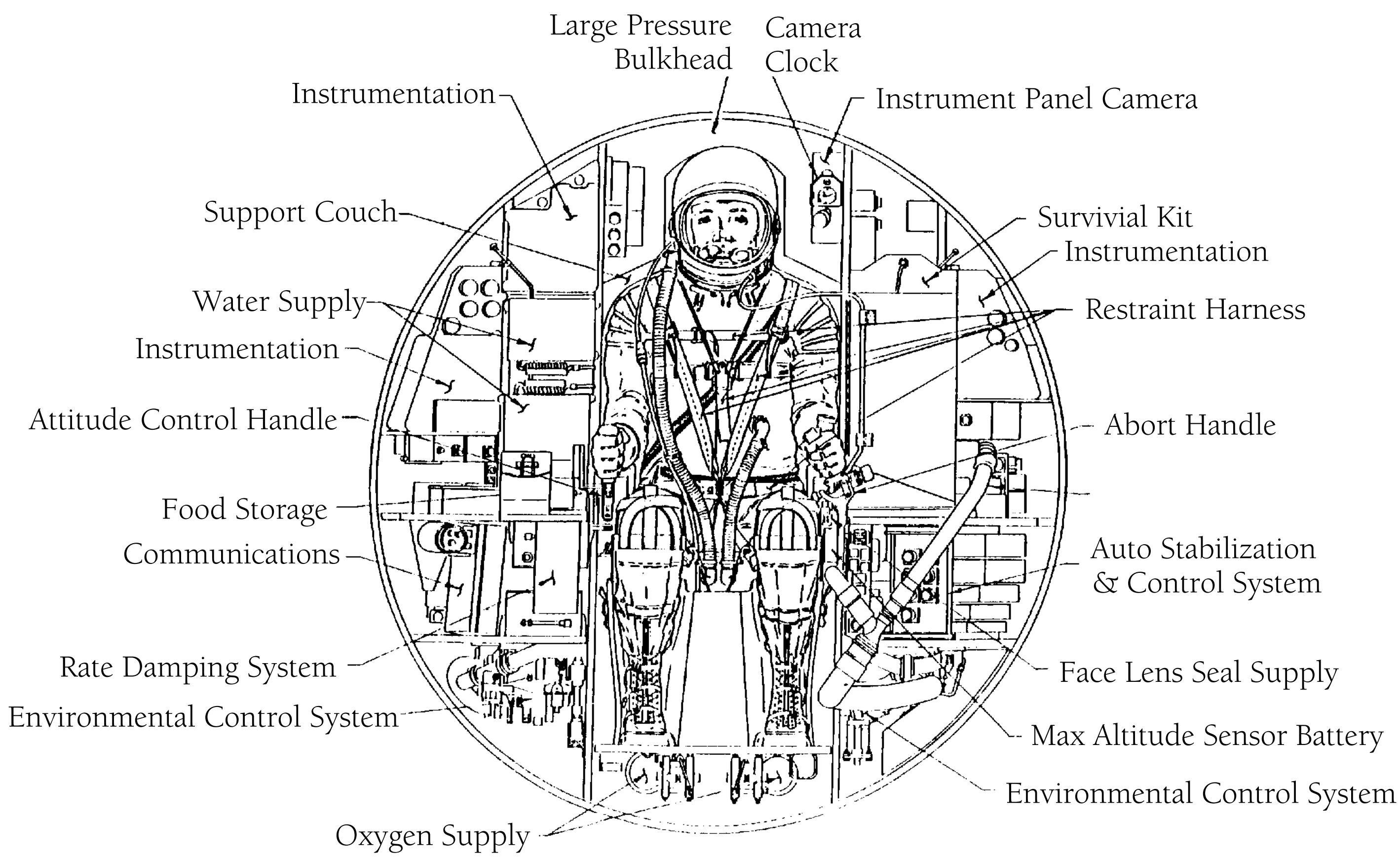


Interior Arrangement

An entrance hatch is located on the right side of the cabin as viewed from the astronaut couch. The hatch is constructed in a manner similar to the cabin: inner and outer welded shells. After the astronaut is inside the spacecraft and all systems are checked out, the hatch is bolted into position. Beryllium shingles are then installed over the hatch for thermal protection. At mission's end, the hatch is explosively released by either the astronaut via an internal plunger, or the recovery crew via an external control. An explosive charge is built into the hatch. The bolts that secure the hatch also incorporate an explosive charge that fractures them, allowing release.

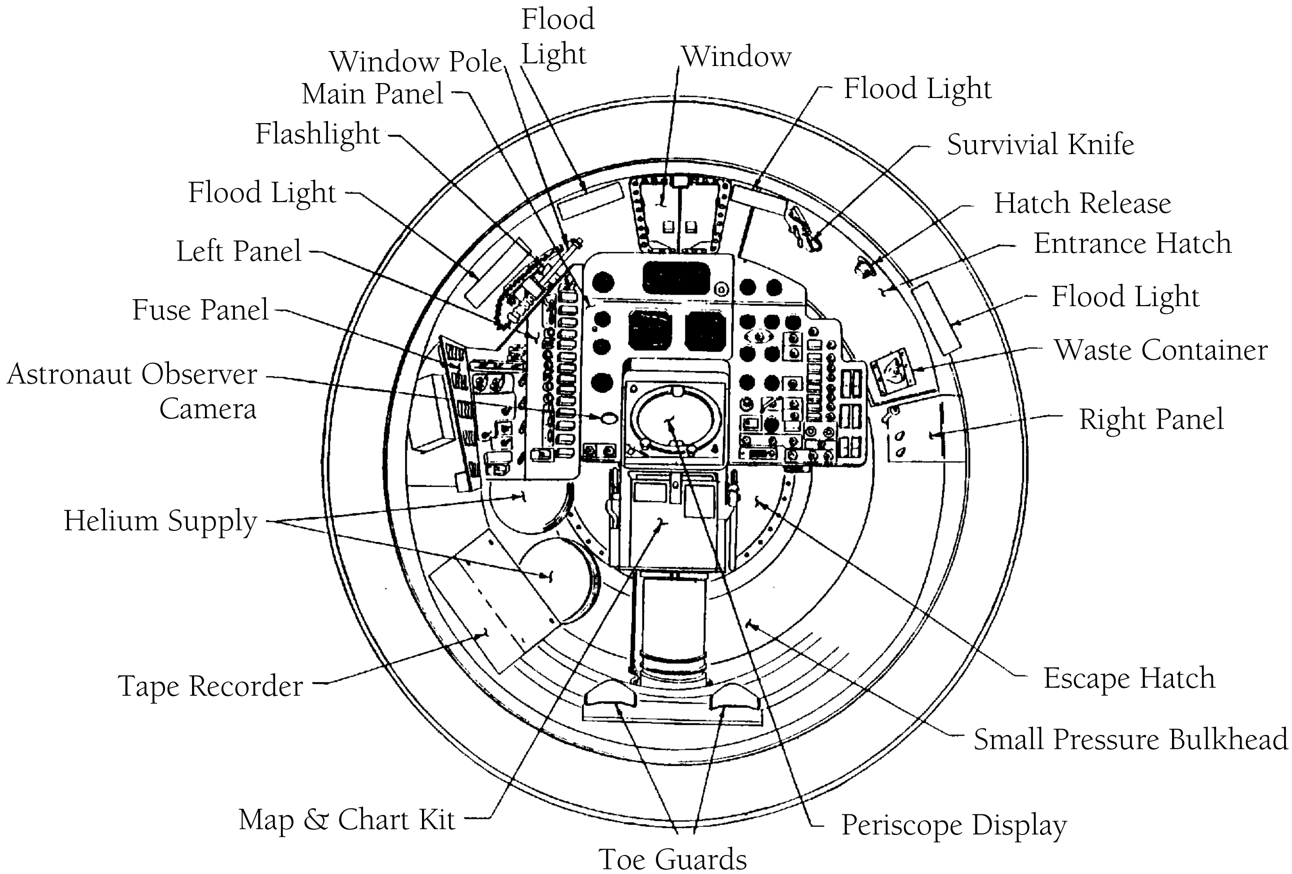
An observation window provides the astronaut with a means of navigation and observation. The window is located above the main instrument panel and consists of inner and outer assemblies that are both pressure–sealed. The window is equipped with retractable filters and door lids, enabling the astronaut to regulate external light entering the cabin. There are two sets of small horizontal marks on each side of the window. These are use to align the spacecraft with the horizon for retrofire (top mark) and reentry (bottom mark) as a backup to the attitude gauges.

The equipment within the spacecraft cabin is arranged so that all operating controls and emergency provisions are accessible to the astronaut when seated and restrained. Cabin equipment consists of instrument and display panels, navigational aids, flight and abort control handles, food and water supply, waste containment, a survival kit, cameras, and communication equipment.



Cabin Equipment – Aft View

The support couch is designed to support the astronaut's body during the high acceleration phases of launch, reentry, and recovery. The couch is molded to the contour of a specific astronaut's body to provide maximum support during flight. The couch can be replaced with a primate couch for test flights with a primate passenger. A restraint system is designed to firmly restrain the astronaut in the support couch during high acceleration. The restraint system consists of shoulder, chest, leg, and crotch straps, a lap belt, and toe guards.



Cabin Equipment – Fore View

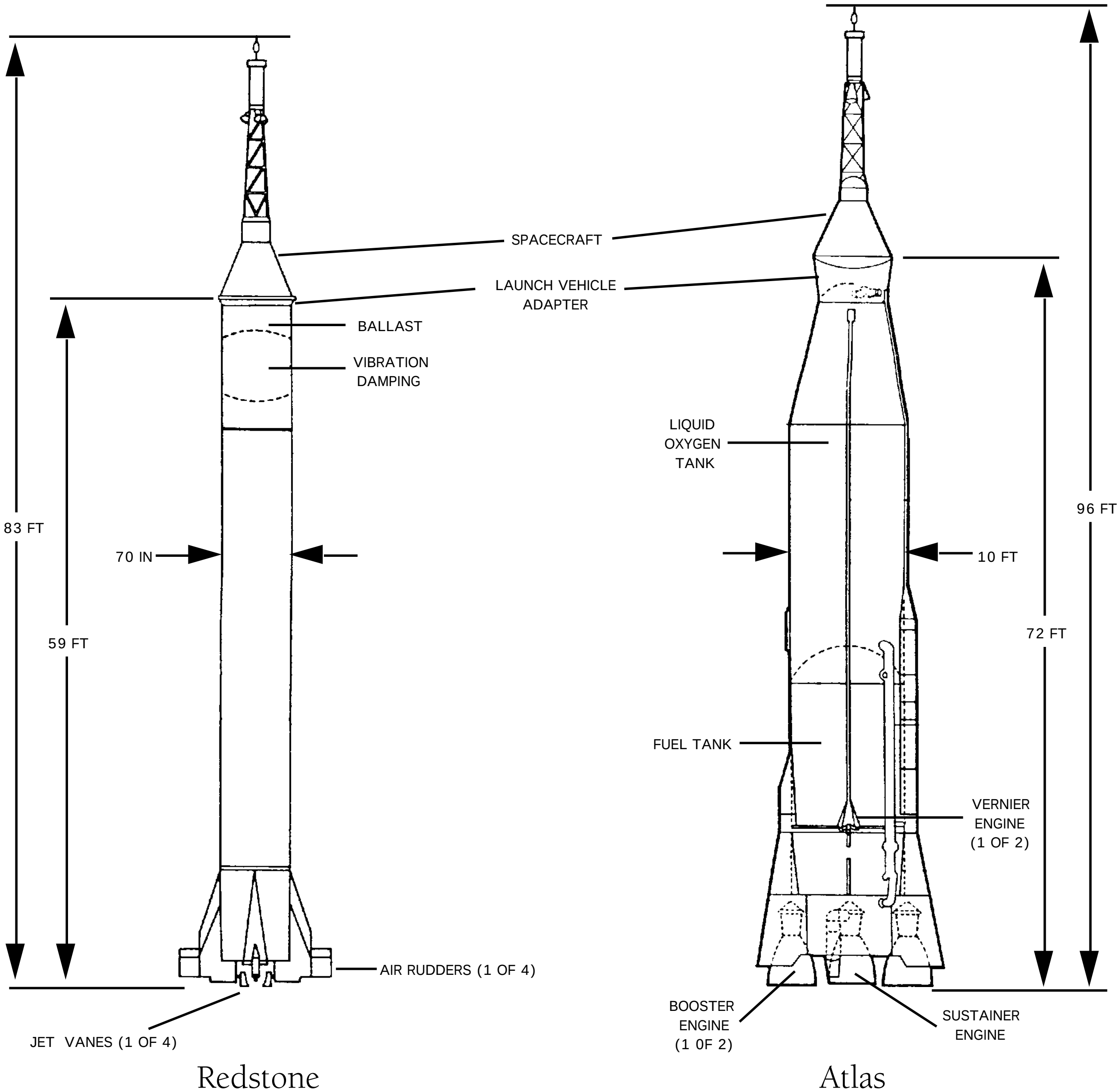
Launch Vehicle General Description

What follows is a general description of the two launch vehicles used in the manned portion of Project Mercury. There is a diagram on page 3.6 that compares the Redstone, used in the sub–orbital flights and the Atlas, used in the orbital missions. A third vehicle, the Little Joe, was a solid–fueled rocket used in early sub–orbital tests of the launch escape and recovery systems

Redstone

The Redstone launch vehicle is a modification of the Army's medium range ballistic missile of the same name. It is a liquid–fueled, single–stage rocket. A single engine provides 78,000 pounds of thrust. The engine burns 75% alcohol/25% water mixture as a fuel and liquid oxygen as an oxidizer. Controlling the booster's directional flight is accomplished by jet vanes mounted just beyond the engine that deflect the exhaust emanating from the nozzle and by air rudders mounted on the tips of the rocket's fins.

Modifications to convert the Redstone to manned flight capability included the addition of redundant systems and the Abort Sensing and Initiation System (ASIS). ASIS is explained in greater detail in Section 12. Additionally, the overall length of the propellant tanks was increased to increase the burning time to the required two and a half minutes. Finally, some ballast and vibration–damping material was added to the top of the vehicle.



Project Mercury Launch Vehicles

Redstone was designed and built by the Army Ballistic Missile Agency. The Redstone is a direct descendant of the German V-2 missile and its conservative design reflects the style of its primary designer, Wernher von Braun.

Atlas

The US Air Force Atlas Inter–Continental Ballistic Missile (ICBM), Series D, was modified to provide the Mercury program its orbital capability. It is a liquid–fueled, single–stage rocket. The Atlas is powered by three engines. Upon receiving the ignition command, all three engines ignite for a combined liftoff thrust of 360,000 pounds. Two booster engines are jettisoned halfway into the powered ascent and one sustainer engine supplies thrust until orbital speed and altitude are achieved.

The Atlas burns kerosene as a fuel and liquid oxygen as an oxidizer. Direction steering is accomplished by gimbaling the engines to alter the thrust direction and by two small vernier engines.

What distingushes Atlas from most launch vehicles is its light, thin–skinned construction in which the propellant tanks also make up most of the aerodynamic frame of the vehicle. The tank walls are so thin that Atlas cannot support its own weight unless the tanks are pressurized or filled with propellant. The Atlas trades off increased handling complexity for greater efficiency. As with Redstone, the primary difference between the ICBM version and Mercury version was the addition of redundant systems and ASIS.

The Atlas was built for the Air Force by Convair. The thin–skinned construction and gimbaled–engine steering were revolutionary advancements. The Atlas had a very long development period, marked by many test failures, before it was declared operational for manned orbital flight.

3.8

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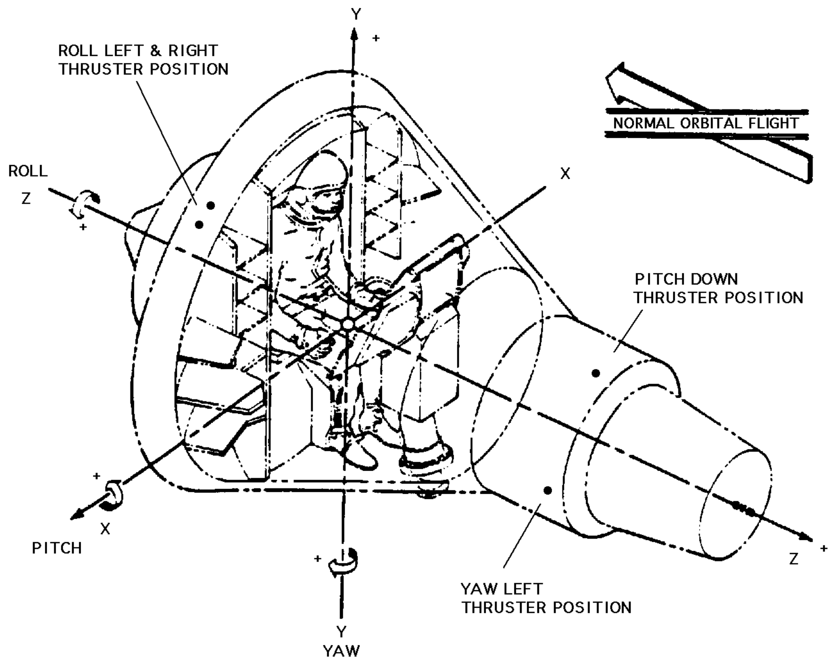
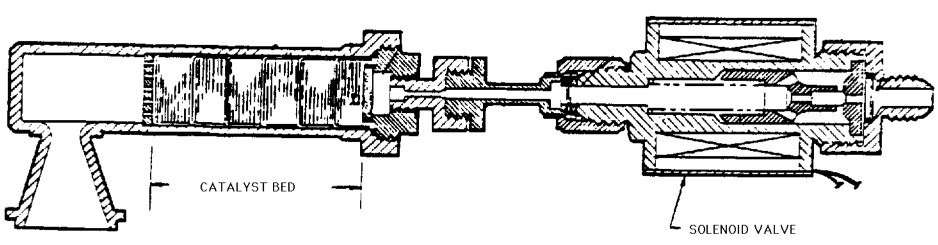
Attitude Control System Description

The Mercury spacecraft can not change its orbit, but it can control its position or attitude. Attitude control is important during retrofire, where the wrong attitude would strand the capsule in orbit, and reentry, where the wrong attitude can cause the spacecraft to burn up. In aircraft, attitude control is accomplished by moving control surfaces that deflect the aircraft against the air. Mercury has to control its attitude in the vacuum of space, so it uses a thruster system to control pitch, yaw and roll.



Mercury Attitude

There are two completely independent fuel supplies, plumbing and thruster systems, called AUTO and MAN. Each uses 90% hydrogen peroxide for fuel. The fuel tanks are pressurized with helium gas that pushes on an internal bladder within the tank, in turn pressurizing the fuel lines. Each of the thrust chambers contains a silver–plated catalyst that decomposes the fuel into a steam–like gas which provides the thrust. The fuel quantity can be monitored using the Control Fuel, Auto & Man Gauges. Additionally, there is a Fuel Quan Warning Light that will illuminate when the AUTO fuel tank is below 10%.



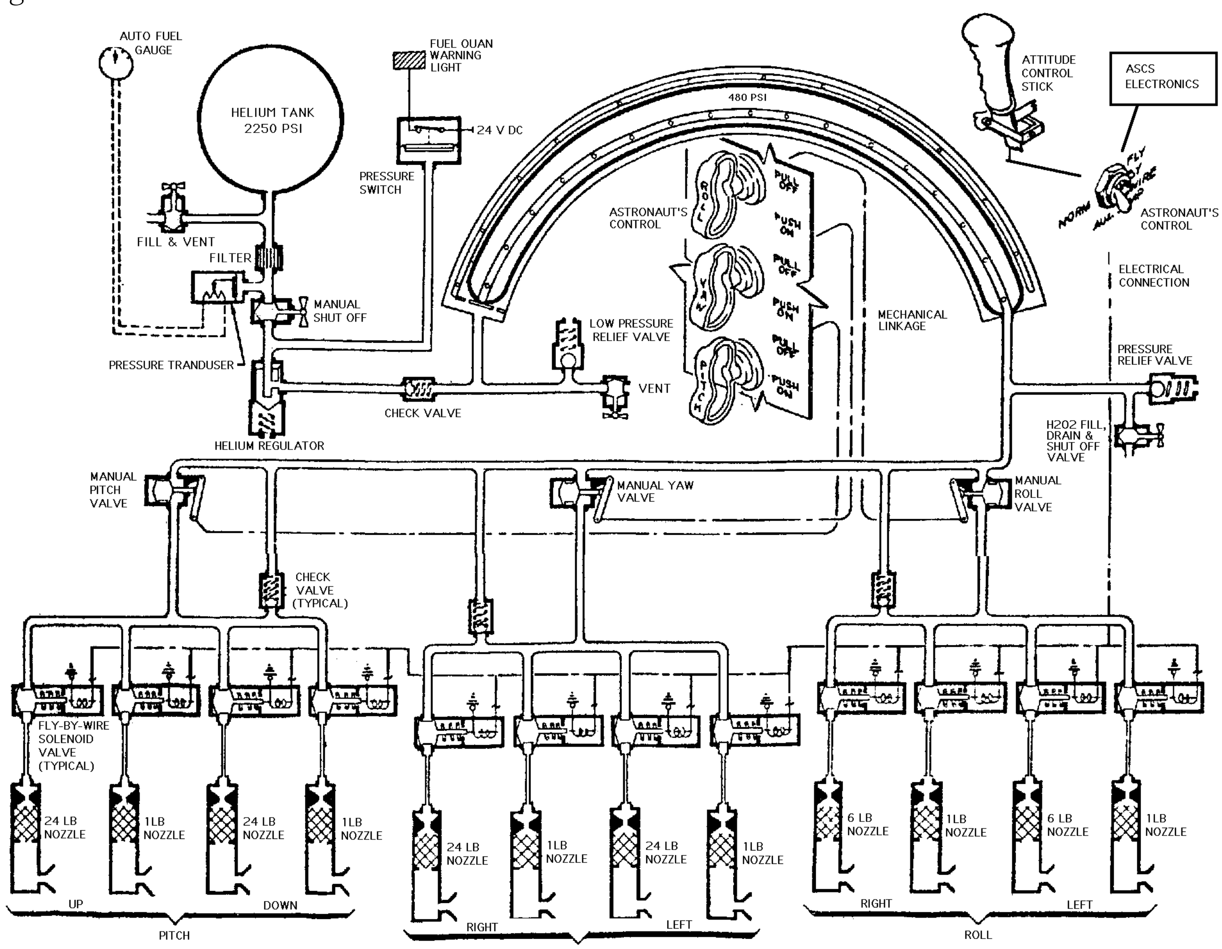
Attitude Thruster (Typical)

Each system has two modes of control. The AUTO system uses one pound thrusters for small adjustments in attitude. Large adjustments in pitch and yaw are handled by twenty four pound thrusters. Six pound thrusters handle large roll maneuvers. The AUTO system is used in two modes. Automatic Stabilization & Control System (ASCS) provides all the necessary attitude changes and stabilization for an unmanned mission and is useful for keeping the spacecraft stable while you complete other tasks. ASCS operates in essentially two modes: orientation, selected by setting the ASCS switch to NORM, and auxiliary damping, selected by setting the ASCS switch to AUX DAMP.

The ASCS orientation mode has four phases of operation that change as the mission programmer sequences through the flight. After BECO and Capsule Separation, ASCS operates in a damping mode that damps out any attitude rates that may have resulted from separation. After five minutes of damping, the orbital attitude phase begins, in which the spacecraft is positioned to the retrofire attitude of -34° pitch, 0° yaw and 0° roll. This is the basic attitude maintained throughout orbital flight.

The reentry attitude phase is triggered by the retrograde package jettison, commanding the spacecraft to an pitch attitude of 1.5° (40° for suborbital missions). The final ASCS orientation phase, .05G roll, is initiated when the spacecraft starts to de–accelerate. The .05G maneuver commands a 10°/second roll that better stabilizes the spacecraft for reentry.

The auxiliary damping or AUX DAMP mode will damp out any attitude rates, essentially holding the spacecraft's attitude in one place. Since AUX DAMP does not use ASCS to sense direction, it will hold attitude regardless of appropriateness for the current mission phase. The AUX DAMP mode operates similar to the post–separation damping phase of the orientation mode, except that it is available throughout the mission.

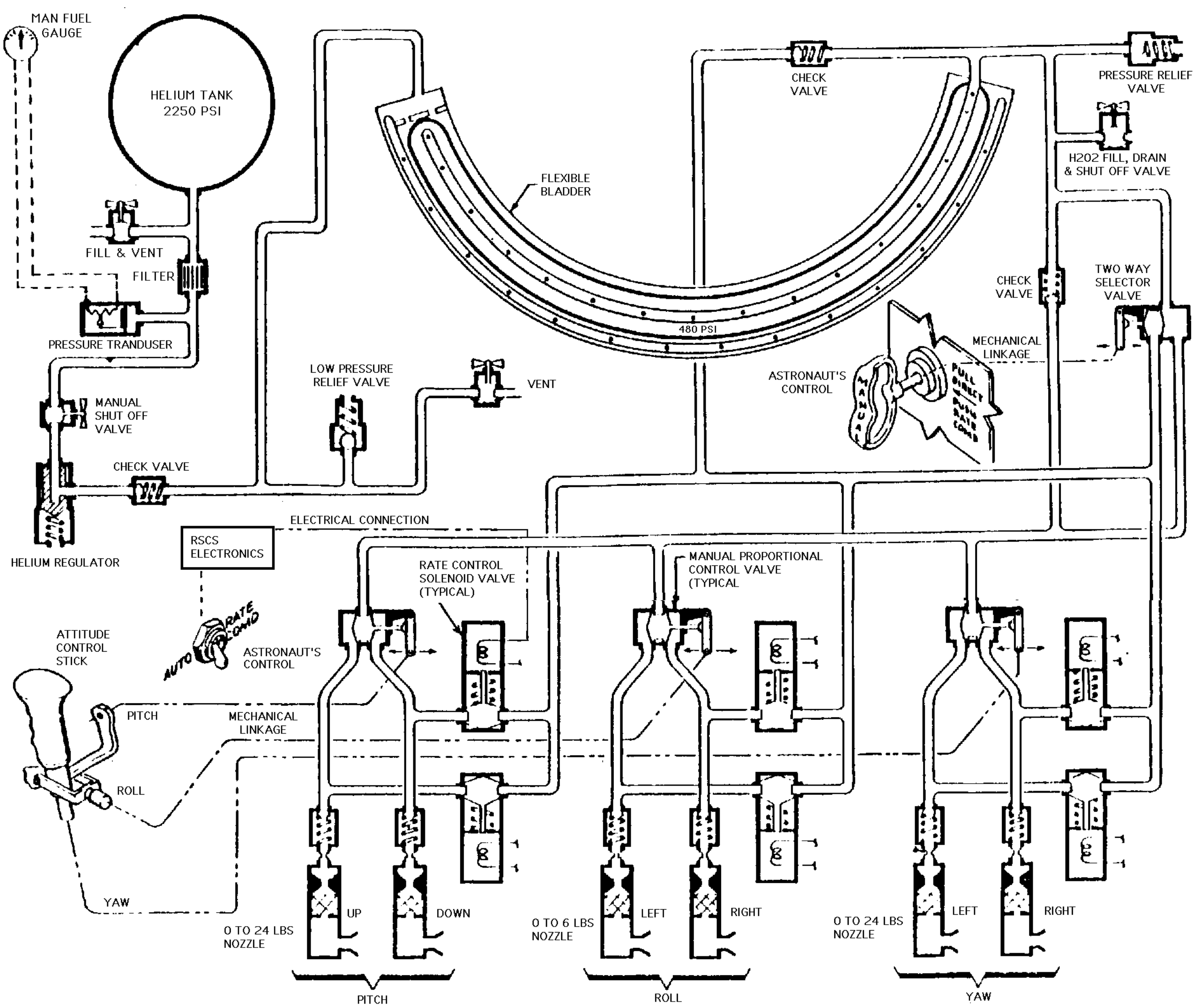


Fly–By–Wire and Auto Stabilization & Control System

Fly–By–Wire (FBW) is operated by the movement of the Hand Controller which actuates the appropriate attitude thruster electrically. A small movement actuates the low power thruster and a large movement actuates the high power thruster. The AUTO thruster system is shown on the previous page.

The MAN system uses variable power thrusters. The pitch and yaw thrusters deliver a power range of four to twenty four pounds. The roll thrusters vary from one to six pounds. The MAN system also is used in two modes. Manual Proportional (MP) varies power by regulating the flow of fuel to the thrusters proportional to the position of the Hand Controller.

The second mode is the Rate Stabilization & Control System (RSCS) which uses part of the ASCS control logic to operate the variable thrusters at their highest power levels. The thrusters are pulsed on and off to keep a constant attitude *rate* based on the position of the Hand Controller. The MAN thruster system is shown below.



Manual Proportional and Rate Stabilization & Control System

4.4

The following table summarizes the various attributes of Mercury's Attitude Control Systems:

Attitude Mode	**Power Required**	**Fuel Supply**	**Main Use**	**Comments**
ASCS	AC & DC	AUTO	Autopilot	Used to execute pre–programmed attitude maneuvers, which results in high fuel usage. Maintaining attitude consumes little fuel.
AUX DAMP	AC & DC	AUTO	Automatic Attitude Rate Damping	Fuel usage is very low when damping slow rates. Damping large rates results in high fuel usage.
FBW	DC	AUTO	Manual Attitude Changes	Fuel usage is very low for slow rates. Good system to use if AC is unreliable. Fine control.
MP	None	MAN	Manual Attitude Changes	Fuel usage tends to be higher than FBW because of higher sensitivity. Good system to use if DC power is unreliable. Coarse control.
RSCS	AC & DC	MAN	Reentry	Fuel usage is very high. Good for fine rate control and useful for stopping tumbling.

Mercury senses movement about its three axis by using three rate gyroscopes as a stable reference and three accelerometers that senses acceleration when the spacecraft is moving about an axis. There is one rate gyro and one accelerometer for each axis: pitch, yaw and roll. The rate gyros drive the ASCS/RSCS rate control electronics and the accelerometers drive the Attitude Rate Indicators. The rate gyros are started during countdown and remain on until the ASCS/RSCS electronics are automatically shut off when the main parachute is deployed.

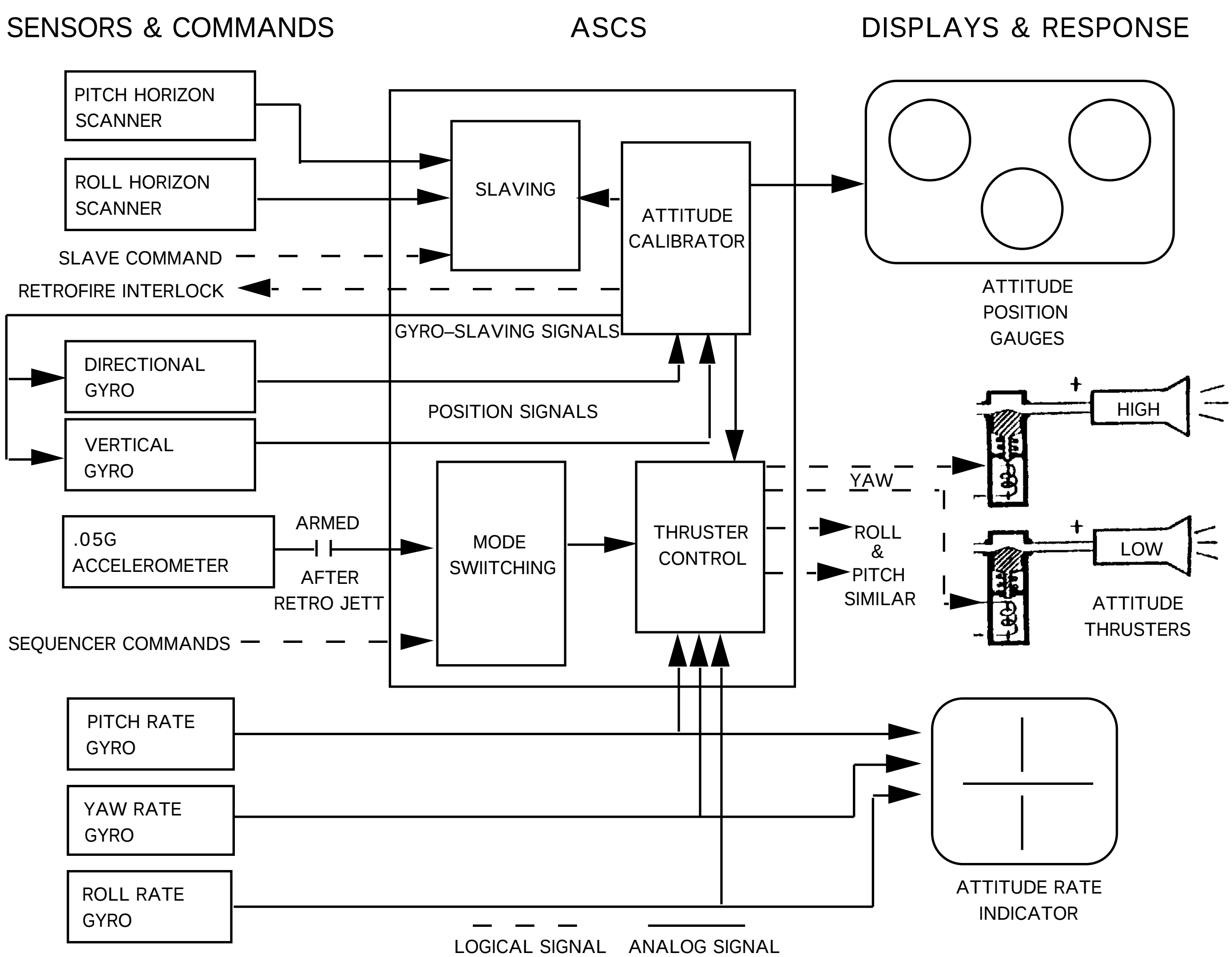
The actual attitude or position of the spacecraft is determined by using two gyroscopes: a vertical that measures the position about the pitch axis, and a directional gyro that measures the position about the roll and yaw axis. The attitude gyros drive the ASCS orientation electronics and Attitude Gauges. Both gyros are "free" gyroscopes, meaning they can operate without any external calibration. By themselves, the attitude gyros determine Mercury's attitude without reference to the earth.

Operations requiring specific vertical or pitch attitudes (retrograde, for example) are based on *the earth's horizon* as a reference for 0° pitch. In other words, when the astronaut sees the horizon in the middle of the spacecraft window, the pitch gauge and the control electronics should show 0° pitch. There is an electronics package, called the orbital rate mechanism, that adjusts the output of the pitch gyro by 4°/minute, so that 0° pitch means the vertical attitude is parallel with the earth's horizon.. A positive pitch indicates the spacecraft nose is above the horizon and a negative pitch indicates the nose is below the horizon.

Although this system works reasonably well, gyroscopes will drift over time. Also, large movements in pitch, yaw and roll, especially over 180°, will cause the gyroscopes to tumble and become mis–aligned. Both instances will cause the Attitude Gauges to display the incorrect attitude.

To help maintain accuracy, the attitude gyros can be slaved to a horizon scanner. These devices, mounted in the forward cone of the spacecraft, detect the earth's horizon on the roll and pitch axis. This is done by sensing infrared radiation: the earth radiates infrared energy, space does not (at least in comparison to the earth). Where the energy ends is the horizon. The scanners can only operate with in a range of +/- 35° of the horizon.

The horizon scanners are slaved continuously to the attitude gyros about two minutes after launch until completion of the turnaround maneuver. At that time, the horizon scanners are slaved on a 8.5 minute on/21.5 minute off cycle to conserve power. Ten minutes prior to retrograde (as programmed into the retrograde clock), the scanner slaving is, once again, continuous until retro rocket ignition. Slaving the attitude gyros to the horizon scanners will disconnect the orbital rate mechanism from the vertical gyro since its function is obviously being performed by the pitch horizon scanner. Selecting the GYRO NORM position on the GYRO switch slaves the attitude gyros to the horizon scanners.



ASCS Block Diagram

If you are going to make a large maneuver or you have determined that the horizon scanners are malfunctioning, place the GYRO switch to the FREE position. This will disconnect the gyroscopes from the horizon scanners. You should refrain from executing large maneuvers if the scanners aren't working because there will be no way for you to re–align them. The only way to tell if the scanners are malfunctioning is when an attitude shown on the Attitude Gauge does not agree with your view of the horizon out the window and the GYRO switch is in the GYRO NORM position.

Although Mercury is quite capable of being controlled 360° in all axis, it is advisable to restrict movements to +/- 30°, for two reasons. First, this will allow the horizon scanners to correct the attitude gyros on a continuous basis. Second, it avoids driving the gyros past

their rotational limits. The result of restrained attitude control on instrumentation is increased accuracy of the attitude display readout and, in the case of the gyros, decreased wear by avoiding the hitting a gyro's gimbal limits.

To re–align the gyros, follow the procedure in the Emergency Checklist. Basically, it involves switching to MAN or FBW, caging the gyros, visually aligning the horizon with the center of the window and re–slaving the gyros to the horizon scanners.

WARNING

Placing the GYRO switch to GYROS CAGE while the ASCS switch is in the NORM position, will cause the spacecraft to tumble.

You have several methods of determining the spacecraft's attitude. The view through window allows you to verify proper attitude by using the horizon as a reference. There is a scribe mark next to the window that you should line up with the horizon. This corresponds to 0° in pitch. There is a similar mark above it that can be used to maintain a pitch attitude of -34° during retrofire. The Attitude Gauges display Mercury's attitude *position* in roll, yaw and pitch. The Rate Indicators display attitude *rates* in roll (top vertical needle), yaw (bottom vertical needle) and pitch (long horizontal needle). Any deflection indicates movement along that axis in the direction of the deflection. The Rate Indicators display a range of rates from as little as 0.125°/second to a maximum of 6°/second.

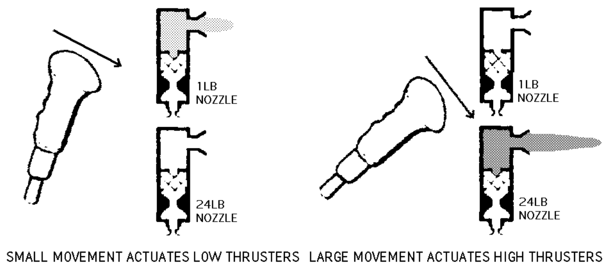
Attitude Control System Operation

The best way to practice attitude control is to switch between ASCS and the three astronaut–controlled modes (FBW,MP and RSCS) while in orbit. Start A-OK! and get into the orbit by doing the following:

1. Double–click the "A-OK! The Wings of Mercury" icon.
2. Select "Preferences" from the "File" menu.
3. Click on the "Easy" button, under "Difficulty Level."
4. Click on the "OK" button.
5. Select "Orbital" from the "Mission" menu.
6. Select "Start Simulation…" from the "Control" menu.
7. Click on the "On Orbit" button.
8. Click on the "OK" button.

You are now in orbit. Mercury is in ASCS and, if you click on the center–top section of the Panel Selection palette, you will see that the spacecraft window and Attitude Gauges. They should indicate that Mercury is holding an attitude of 0° roll, 0° yaw and -34° pitch. In other words, you are heads up (as referenced by the earth), facing backwards (as referenced by the direction of the orbit) and looking down slightly (as referenced by the horizon). The Attitude Rate Indicators needles are centered, indicating no movement.

Enable the FLY BY WIRE mode by moving the ASCS switch to FLY–BY–WIRE. For a more complete description, open up the Checklist by clicking that option under the Documentation menu. The Checklist is also reproduced in this manual.



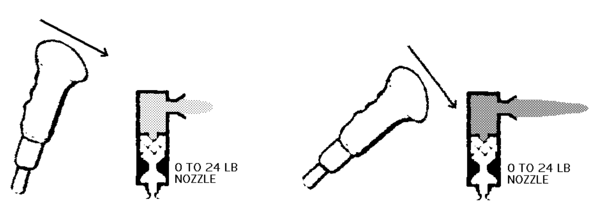
Hand Controller Action for Fly By Wire

Using your mouse (or joystick) and option key, try starting and stopping movement in yaw. Use a very slight left movement at first until you hear a thruster. Return the controller to the center position. You will see the bottom Rate Indicator move to the left and the view out the window will start to move to the left. After a few moments, the yaw Attitude Gauge will start to move showing the current yaw position. Now stop the motion by moving the Hand Controller in the opposite direction (right) until you hear another thruster. Remember to center the controller after you hear the thruster fire.

Try the same motion, but move the Hand Controller further until you hear a more powerful thrusting sound. Move it fast or you will fire both high and low thrusters. The Rate Indicator will deflect further away from the center, indicating a higher attitude rate. The window view and the yaw Attitude Gauge will move quicker, too. Stop the yaw motion by moving the Hand Controller in the opposite direction. Note that every movement in attitude must be stopped by using an equal amount of thrust in the opposite direction.

Try moving the spacecraft in pitch and roll, watching the Attitude Gauges, Rate Indicators and window. FBW tends to be very responsive and easy to control with a little practice.

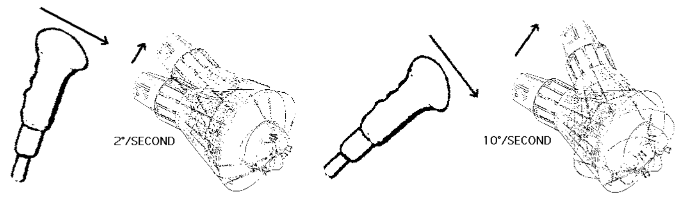
Get into the MP mode by pulling the MANUAL T switch out (DIRECT), setting the ASCS switch to AUX DAMP and the RSCS switch to RATE COMD. Use the procedure defined above to check out MP in yaw, then pitch and roll. Note that large Hand Controller movements produce higher thrust and require an equal movement to stop. MP requires even more practice than FBW to master. Follow the Checklist to return to normal ASCS operation.



Hand Controller Action for Manual Proportional

4.8

Next, follow the Checklist to get into the RSCS mode: ASCS switch to NORM and RSCS switch to RATE COMD. RSCS is semi–automatic in nature. When the Hand Controller is centered, all attitude rates stop. When the Hand Controller is moved and held, the spacecraft moves at a fixed rate relative to the position of the Hand Controller. RSCS uses fuel quickly, so it is usually reserved for reentry.



Hand Controller Action for Rate Stabilization & Control System

Finally, let's explore ASCS. Reset the simulation and start on orbit as described before. Using FBW, start a large pitch down maneuver. Instead of stopping it by commanding an equal pitch up thrust, use ASCS to damp out the pitch rate, by setting the ASCS switch to AUX DAMP. You'll hear a high thruster fire and checking the Attitude Rate Indicator, you'll see the pitch motion has stopped. Switch back to FBW and command a pitch, yaw and roll rate. Switch to AUX DAMP, listen for the thrusters and verify that all motion has stopped.

If you now set the ASCS switch to NORM, you will hear high thruster activity and, upon checking the Attitude Gauges, will see that the spacecraft is moving towards the retrofire attitude. Let's move on to the next orientation phase. Make sure that the ASCS switch is in the NORM position. Fire the retro rockets, by depressing the FIRE RETRO switch on the programmer panel. After retrofire, manually jettison the retrograde package by depressing the JETT RETRO switch. Following jettison, you will hear the high thrusters firing and should see the spacecraft pitching up to the reentry pitch attitude of 1.5°. As in the previous paragraph, switch to FBW and command a pitch rate. Switching to AUX DAMP will stop the rate. Switching to ASCS NORM will re–position the spacecraft to reentry attitude.

Damping the oscillating attitude rates during reentry are a special case. If RSCS is fully functional, it is the best means of reentry control. As with ASCS, RSCS will start a 10°/second roll and hold it steady, when .05g is sensed. MP and FBW are much harder to use as the roll maneuver must be started manually and pitch and roll rates are automatically damped.

Let's observe how the reentry rates build up. Set the difficulty level to "Difficult" by selecting "Preferences..." on the "File" menu. Start an Orbital mission at Reentry (by selecting "Start Simulation..." on the "Commands" menu). Select FBW as per the Checklist and watch the pitch and yaw attitude rates oscillate back and forth, getting larger each second. Now, stop and reset the simulation ("Commands" menu), and start at reentry again.

Reentry rates are best controlled by applying thrust in the opposite direction of the rate, alternating control of the pitch and yaw axis as needed. Repeating the procedure described in the previous paragraph, we'll use FBW to minimize yaw rates. The idea is to counteract the movement of the Rate Indicator needle with an opposite Hand Controller motion, that is, when the needle moves right, you move the Hand Controller left. Sounds simple, but in practice it is very difficult.

General Attitude Control Tips

Attitude control is very difficult. Based on actual mission debriefings, the Mercury astronauts have these comments on attitude control:

Changes in attitude are best made on an axis–by–axis basis. For example, the best way to execute the turnaround sequence manually is to yaw from 180° to 0° *first*, then pitch down to -34°. The same strategy should be used to stop multiple–axis tumbling.

Slower attitude rates are easier to control than fast ones. A slow attitude rate (less than 1°/second) will be easier to stop and will use less control fuel. Unless there is an emergency that requires a quick attitude change, stick to slow rates.

The Rate Indicator should be checked often when the spacecraft is not in ASCS NORM or AUX DAMP. Low attitude rates will not show up on the Attitude Gauges until the spacecraft has move a few degrees and the window view may not be helpful under certain conditions such as during a night pass.

Controlling attitude is much more difficult during a night pass. Since the earth is not visible at all, you must rely on star patterns to detect attitude position and rate. The horizon is still fairly easy to locate by finding the point where the star–rich sky ends and the totally black earth begins.

A good way get used to attitude control during a night pass is to explore the star patterns and their relationship to the proper orbital attitude of 0° roll, 0° yaw, and 0° pitch during daylight. When the sun sets, try moving the spacecraft +/- 30° in each axis, using the star patterns as a reference.

Although the spacecraft can be pointed to any attitude, it is safest to confine attitude excursions to under +/- 30° per axis. In addition to driving the gyroscopes and horizon scanners past their limits, it is also very easy to induce tumbling unless you have become very experienced at controlling Mercury's attitude.

The following summarizes the astronaut's evaluation of Mercury's control modes:

Manual Proportional has at tendency to have a tail–off in thrust that makes it hard to stop attitude rates completely. While there are portions of an orbital mission where some slight drifting is acceptable, use another mode (FBW or RSCS) if you require zero attitude rates and are having problems with MP.

When using Fly–By–Wire, it is fairly easy to actuate the high thrusters accidentally. This results in having to compensate with an equal thrust in the opposite direction, resulting in higher fuel use. Because of this, later models of the Mercury spacecraft had a switch added that disabled the high FBW thrusters. Since it is based on the initial orbital models, A-OK! does not have that switch installed.

The Rate Stabilization & Control System is very responsive, but expensive in fuel usage. One way to keep fuel usage down is to make sure that you keep the Hand Controller steady once you've reached a desired attitude rate. RSCS fires thrusters every time you change attitude rate.

It is possible to engage multiple control modes. For instance, you can control all axis with MP and have AUX DAMP damp any rates other than the ones you are commanding. An advantage to this is that you don't have to stop the rates with a counter-acting thrust; AUX DAMP will stop the rate as soon as you return the Hand Controller to its center position. Setting the ASCS switch to AUX DAMP and pulling out the MANUAL "T" switch. engages this mode. The only problem with using this mode is that it wastes fuel on the axis that you are manually moving because AUX DAMP is continually trying to stop the rate you are commanding with MP. However, this combination is very easy to use if you have enough fuel.

A more efficient variation on the MP/AUX DAMP mode, is manually controlling pitch while using AUX DAMP to hold yaw and roll. Set the ASCS switch to AUX DAMP and pull out the MANUAL "T" switch. Pull the PITCH "T" switch out which will disconnect the AUTO system pitch thrusters from their fuel tank. Engage the Hand Controller and perform a pitch-up. Now if you perform a pitch maneuver it will work using MP only. You will have to stop and start each pitch motion but accidental movements in roll or yaw will be automatically damped out.

Another multiple control mode scenario is double authority. If you engage FBW by moving the ASCS switch to FLY–BY–WIRE and MP by pulling the MANUAL "T" switch, you will engage both the AUTO and MAN system thrusters when the Hand Controller is actuated. Your cue that this is happening is two-fold. First, you will hear the two sets of thrusters fire (They will be heard sequentially in A-OK!; in the actual spacecraft the overall thruster volume would be louder) and second, you should notice that the attitude rates are larger for similar Hand Controller positions when only one control mode is activate. Double authority can be useful for controlling attitude during retrograde and reentry.

WARNING

Engaging two control modes (MP/AUX DAMP, MAN/FBW or RSCS/FBW) will consume fuel extremely quickly!

Finally, the astronauts offered these reflections on retrofire and reentry attitude control:

Correct attitude during retrofire is extremely important. The spacecraft must be held at retrograde attitude of -34° pitch and 0° yaw within a tolerance of +/-15°, and 0° roll within a tolerance of +/-30°. As they are fired, the three retrograde rockets produce a variable acceleration pattern that results in high, variable torques about the pitch and yaw axis. Rapid and accurate responses are required to keep the spacecraft under control during retrofire.

So long as the spacecraft is properly aligned at the start of reentry, it should remain fairly stable, however oscillations in pitch and yaw will occur. These are detected by the rapid back and forth movement of the Rate Indicator needles. These rates should be kept to less than 1°/second. While Mercury is very stable, it *is* possible for the spacecraft to overheat if the oscillations become too large, exposing the sides of the spacecraft to extreme heat. Since the side panels are not able to withstand the temperatures produced, the spacecraft will incinerate. Inducing a roll rate of greater than 4°/second will help keep the oscillations to a minimum.

For more detail on attitude control, refer to the following procedures contained in the Checklists in Section 19: FLY–BY–WIRE MODE, MANUAL MODE, RATE COMMAND MODE, and STABILIZATION SYSTEM EMERGENCIES.

Programmer Description & Operation

All automatic events are controlled by the Programmer. This device triggers events by applying power to their actuating devices on a sequential basis. The events can be triggered by timers, altitude sensors or the initiation of another event.

The Programmer is a long string of indicators lights and switches located to the left of the window. There is an indicator and a switch for every event controlled by the Programmer. The indicators glow green if an event is successfully initiated and red if there is a problem. The switches to the left of these indicators allow you to manually initiate programmed events.

The following lists the Programmer–controlled flight events and the normal automatic triggering conditions for each. The list assumes that all spacecraft systems are operating properly.

Event	**Triggering Conditions**
Tower Jettison	20 seconds after BECO
Capsule Separation	SECO (BECO, if sub–orbital)
Turnaround Maneuver	5 seconds after Capsule Separation
Retro Sequence Start	Time–To–Retrograde time out
Retro Attitude	Attitude and Retro Sequence Start
Fire Retro	30 seconds after Retro Sequence Start
Retro Jettison	60 seconds after Retrograde complete
Reentry Attitude Maneuver	Retro Jettison
.05G Maneuver	Start of reentry into atmosphere
Drogue Parachute Deploy	Altitude Sensor (~22,000 feet)
Snorkel Deploy	Drogue Parachute Deploy
Main Parachute Deploy	Altitude Sensor (~10,000 feet)
Landing Bag Deploy	12 seconds after Main Parachute Deploy
Fuel Dump	Landing Bag Deploy
Rescue Aids Deploy	Landing Impact Sensor

The Reserve Parachute appears on the Programmer panel, but can only be deployed manually. The Drogue Parachute Deploy, Snorkel Deploy and Reserve events do not have accompanying indicator lights, just name plates.

In addition to looking out the window, parachute deployment can be detected in other ways. Drogue deployment can be detected by an accompanying "G" pulse on the Longitudinal Acceleration gauge, the sound of an explosive squib firing, and by watching the altimeter's rate of change before the scheduled drogue deployment, which should slow considerably. Main and Reserve parachute deployment can detected by a 30 feet/minute rate on the Descent gauge.

When the Snorkel deployment opens the cabin vent, the O2 EMER and CABIN PRESS warning lights and tones will come on. The CABIN PRESS light will go out in about 10 seconds as the atmosphere pressure rises. The Fuel Dump event does not have an indicator or a switch. It will sound the FUEL QUAN warning light and tone, however.

5.2

The triggering conditions listed on the previous page apply only to the Programmer. It is possible for you to manually initiate an event *out of sequence*. In many cases, such as jettisoning the retro rocket package before retrofire, this would be a disaster.

WARNING

> When the SQUIB switch is in the ARM position, the Jett Retro, Drogue, Main and Reserve parachute deployment events will operate regardless of spacecraft condition or mission phase!

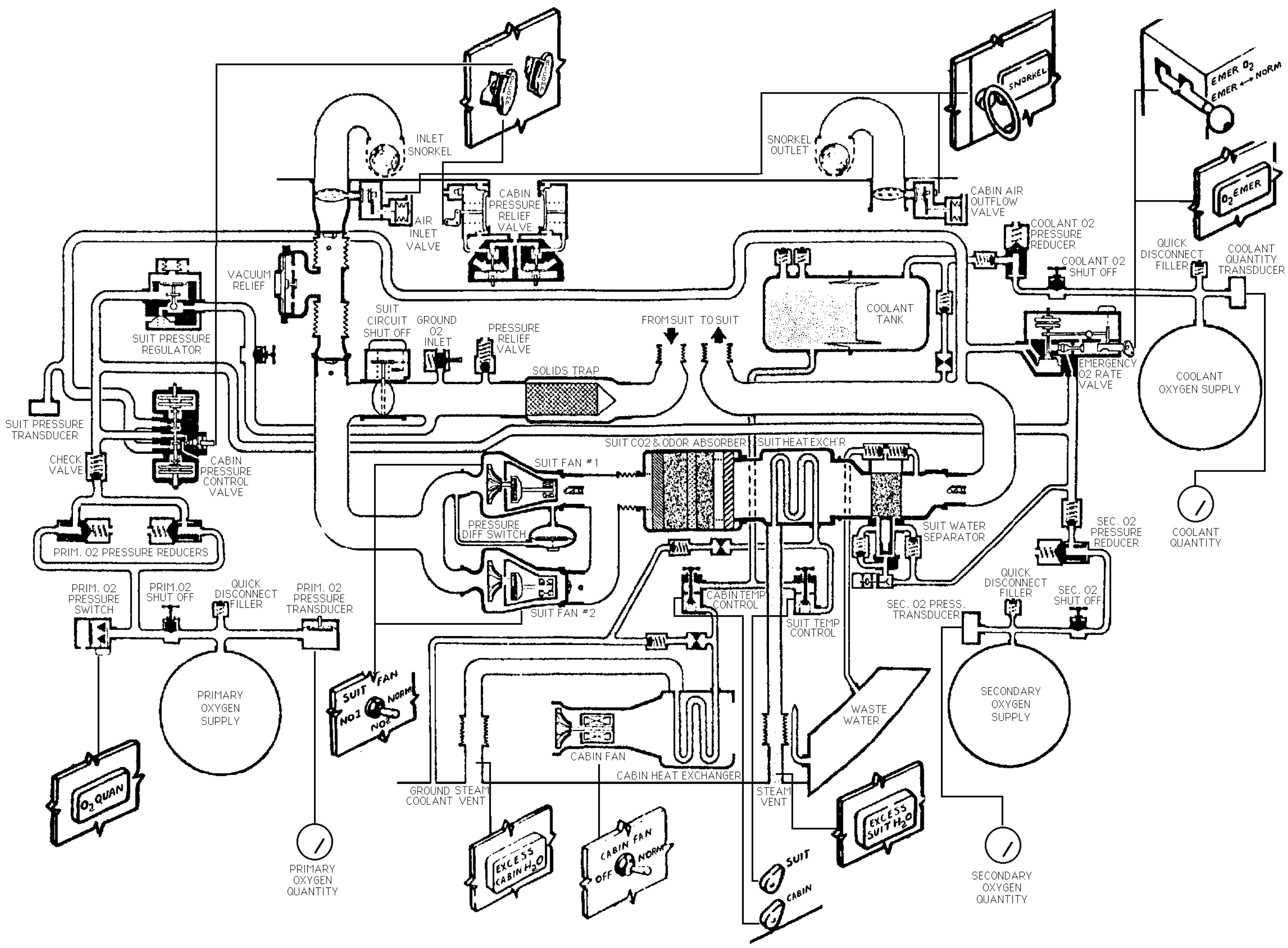
Many events can be disabled by moving the proper fuse to the center position. If an event is disabled, the events *following* it may have be initiated manually if the events are triggered by the disabled event. For example: if you disabled the retro jettison event, you would have to manually position the spacecraft to the proper reentry attitude.

There is a fuse, located on the far right of the panel, that may restore functionality to the Programmer in the event of complete failure. Consult the Emergency Checklist (under the Documentation menu or in this manual) to review the procedures required to override failure of automatic events.

Environmental Control System Description

The Environmental Control System (ECS) is responsible for maintaining a safe environment, providing oxygen and regulating temperature. The ECS supplies oxygen at 5.5 pounds/square inch (psi). Since the Earth's atmosphere is about one–third oxygen and two–thirds nitrogen (minus some trace gases), the astronaut receives the equivalent amount of oxygen. This method has two advantages: a one–gas system is simpler and therefore more reliable, and the lower pressure puts less strain on the sealed cabin.

There are two independent air circuits, one for the pressure suit and one for the spacecraft cabin. The suit is a backup in the event of a cabin leak. Gaseous oxygen is stored at 7,500 psi in two tanks. Oxygen flow is metered into the cabin and suit on an on–demand basis. If the quantity of oxygen in the primary tank falls below 10%, the ECS will automatically switch to the secondary tank.



Environmental Control System

On the launch pad, the cabin is pressurized with pure oxygen at 16 psi. The pressure is allowed to bleed off, following the atmospheric pressure during the climb, until the pressure is 5.5 psi. The regulator then seals the cabin.

Due to the small space and amount of heat–generating equipment installed, the Mercury spacecraft only requires cooling. This is done by passing the air through a heat exchanger. Water, acting as a coolant, also passes through the heat exchanger absorbing the heat in the process. It is then vented overboard. The amount of cooling can be controlled using two knobs (one for the suit, one for the cabin) on the extreme right of the control panel. These controls regulate the amount of water flowing through the heat exchanger; the greater the water flow, the greater the cooling. The water tank is pressurized using a separate tank of oxygen.

Air flow through the suit and cabin is facilitated by fans: one for the cabin and two (a prime and backup) for the suit. If the cabin fan fails, the temperature will rise in the cabin. If the suit fan fails, the backup should come on automatically. There is also a switch for manually selecting it. If both suit fans or the oxygen regulator fail, you can switch to an emergency rate which bypasses the regulator and fans, delivering oxygen at a fixed rate. Engaging this mode will require you to initiate retrograde as soon as possible because it uses up oxygen quickly. During descent, the emergency rate is automatically switched on when the fresh air snorkel is deployed, providing oxygen–enriched air.

The ECS also filters the air for carbon dioxide and odors using lithium hydroxide and activated charcoal. Excess humidity is removed using a mechanism that traps the air–borne water in a sponge. The sponge is periodically squeezed, trapping the water in a holding tank. These functions are automatic.

The ECS requires DC for most of its equipment and AC for the fans. The amount of oxygen and coolant carried aboard the spacecraft varies with the mission. In A-OK! simulations, enough reserves are carried to allow life support for four orbits under normal conditions.

Environmental Control System Operation

Normally, the ECS is completely automatic in operation. However, you should make a habit of checking vital measurements. Cabin pressure should be checked frequently during ascent and descent. Cabin temperature, oxygen and coolant quantity should be checked every ten minutes or so while in orbit.

If cabin pressure cannot be maintained or if you de–pressurized the cabin, the CABIN PRESS warning light will illuminate. It is advisable to end orbital operations as soon as possible. O2 QUAN warning light will illuminate if the primary oxygen tank falls below 10% capacity. You should move the O2 FLOW switch to SEC if that happens. This action will turn off the O2 QUAN warning light and silence the alarm. The O2 QUAN warning light will illuminate again if the secondary oxygen tank also falls under 10%. If the secondary tank is completely empty, you can access the remaining 10% in the primary oxygen tank by moving the O2 FLOW switch to PRI. The warning light and alarm will be activated, since both tanks are under 10% quantity. You can silence the alarm by moving the AUDIO switch, adjacent to the, O2 QUAN warning light, to OFF.

The cabin can be de–pressurized and re–pressurized via two “T” switches on the left side of the panel. The cabin would only be de–pressurized in the event of a fire or fumes. de–pressurizing the cabin will illuminate a warning light. Re–pressurization of the cabin takes about five minutes and uses a large quantity of oxygen.

The cabin temperature will vary depending on what equipment is operating, whether the spacecraft is in a day or night pass and the CABIN TEMP control setting. In general, it preferable to keep the temperature to about 80°. As the temperature increases, so does oxygen use. Turning the CABIN TEMP control too high which will cause the cooling system to freeze. The EX CABIN H2O warning light will illuminate if this happens. If it does, turn the control back a bit, wait a few minutes for the temperature to stabilize, then turn it back up one notch. In A-OK! simulations, the suit temperature control is not operational and the Suit Temp gauge follows the Cabin Temp gauge.

During descent, if the fresh air snorkel does not deploy at about 20,000 feet, it can be deployed manually by pulling the SNORKEL override ring. If the cabin fan fails or if you turn the CABIN FAN switch to OFF to conserve power, the temperature in the cabin will rise. If both suit fans fail, you should engage the emergency oxygen rate by moving the EMERG O2 control (located on the extreme left of the panel) to EMER. In A-OK! simulations, the only way the suit can fail completely is if you run out of oxygen, which would end the simulation!

6.4

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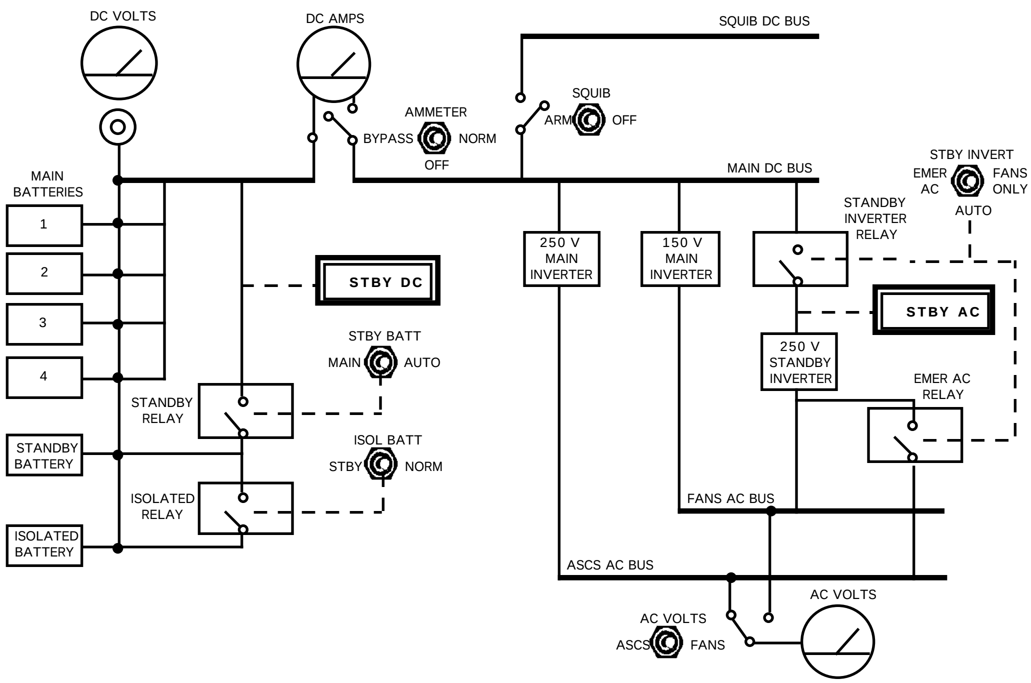
Electrical System Description & Operation

Direct Current is supplied to the spacecraft by six 24 volt rechargable silver–zinc batteries. Four of these batteries, wired in parallel, act as one battery (MAIN). Another 24 volt battery (STANDBY) is used as a backup in the event of failure of the MAIN batteries. The final battery (ISOLATED) is used to power up the critical squibs, which includes the retrograde rockets.



AC & DC Electrical Systems

If the MAIN batteries fall below 18 volts, sensing relays should switch the STANDBY battery to the main bus as long as the STBY BATT switch is in the AUTO position. If the STANDBY battery is not automatically switched in, it can be brought on–line manually by setting the STBY BATT switch to MAIN. Since this battery is not as powerful, you should shut down the ASCS to conserve power by setting the ELECT PWR switch to OFF.

STANDBY battery failure can only be detected by checking its voltage with the voltmeter. If the STANDBY battery fails and the MAIN batteries are operational, disconnect the STANDBY Battery by setting the STBY BATT switch to MAIN. If the MAIN batteries are below 18 volts, ASCS and the photo lights should be shut off. If the MAIN batteries fail completely, you can connect the ISOLATED battery to the main bus by setting the ISOL BATT switch to STBY. Finally, if the ISOLATED battery fails, you can power the squibs from the STANDBY battery by setting the ISOL BATT switch to STBY.

WARNING

Using the ISOLATED battery to power the main bus will deplete its energy rapidly. This action should only be taken in preparation for retrograde!

7.2

There are two MAIN AC inverters. An inverter provides 250 volt, 400 hertz, Alternating Current to the Attitude Control and Stabilization System (ASCS). Another 150 volt inverter supplies AC to the Environmental Control System's (ECS) fans. The 250 volt STANDBY inverter can be switched to either the Fans or ASCS if one main inverter fails. If both main inverters fail, the standby can supply both needs if non–critical ASCS modes are switched off manually. The standby inverter can be switched in automatically or manually.

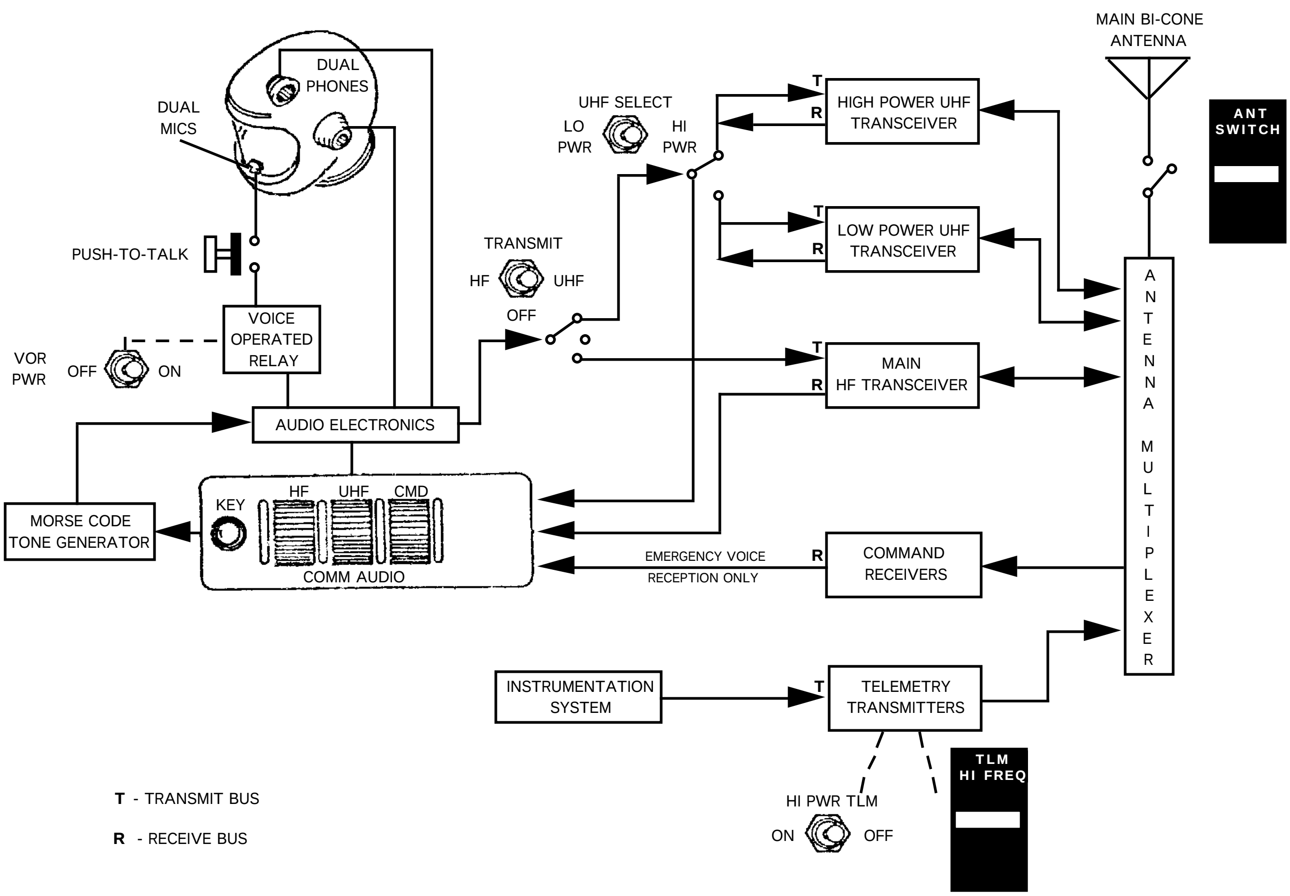
During ascent, retrofire, and descent, the DC Volts, AC Volts and DC AMPS gauge should be checked frequently. It is essential to make sure that the SQUIB switch is in the ARM position and the voltage and amperage levels are correct prior to launch and the retro sequence start.

You can observe the power levels change as you switch various systems on and off. Try turning the following switches on and off, checking the DC AMPS gauge after each switch actuation: HI-PWR-TLM, CABIN LITES, PHOTO LITES, CABIN FAN, (ASCS) ELECT PWR, VOR PWR, and TRANSMIT. Try the following fuses also: PRO-GRAMR, SUIT FAN, and ENVR-CONTRL.

Communications System Description & Operation

The communications system consists of voice, radar, command and telemetry links. The voice radios cover both high–frequency (HF) and ultra–high–frequency (UHF) radio spectrum. In general, HF has poorer quality then UHF, which is considered to be the primary communication channel for orbital operations. HF will be used as a backup for orbital communications. The UHF system contains a primary (HI PWR) and a backup (LO PWR) unit.

A-OK! simulates voice reception from ground stations. In some simulations, voice reception will be the only way of receiving critical information. If excess noise is experienced, try switching to an alternate channel by turning the volume up in UHF and down in HF or vis–versa.



Voice/Telemetry Communications System

A-OK! simulates voice transmission in the form of status requests to the ground stations via the “Transmit…” selection under the “Commands” menu. As above, it is a good idea to use UHF and HF at the proper times. If a transmission does not get through, try an alternate UHF transmitter by switching the UHF SELECT switch to LO PWR or switch to HF using the TRANSMIT switch.

8.2

These are the ground stations that you will communicate with during an orbital mission:

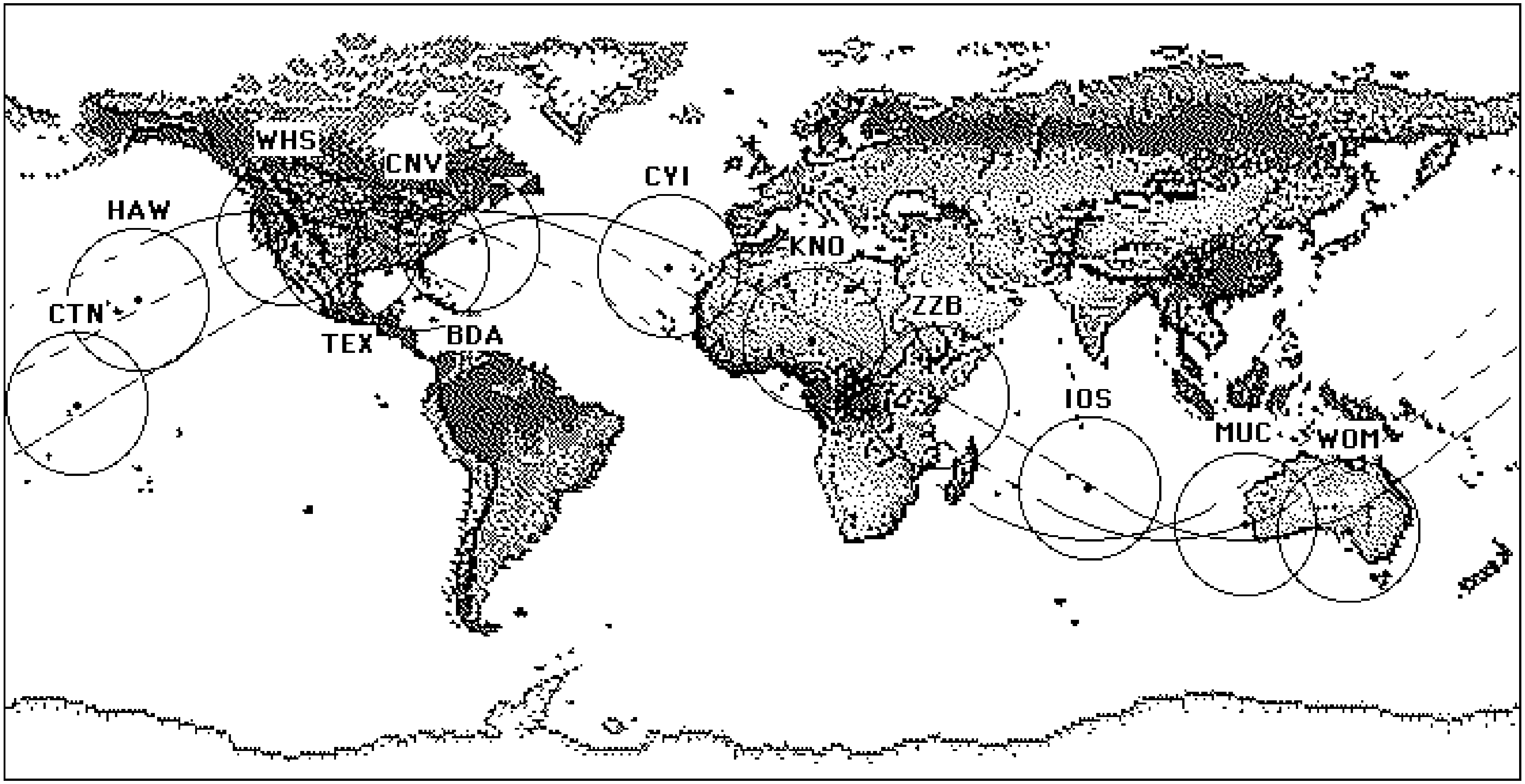
Station	Call Letters
Cape Canaveral	CNV
Bermuda	BDA
Canary Islands	CYI
Kano, Africa	KNO
Zanzibar	ZZB
Muchea, Australia	MUC
Woomera, Australia	WOM
Canton Island	CTN
Hawaii	HAW
White Sands, New Mexico	WHS
Corpus Christi,Texas	TEX

There is also a communication ship in the Indian Ocean (call sign: IOS), so that there are no communication gaps longer than ten minutes. The contact times for each orbit are listed in the Flight Plan. The times listed are based on the predicted orbit, so they may vary by a couple of minutes depending on the actual orbit attained.

You will have an eight minute window of communication with each station. However, when transmitting on the low power UHF transmitter (UHF SELECT switch set to LO PWR), the transmission window is about five minutes. If you hear static after a transmission, the spacecraft is probably out of range. This can also be caused by using the wrong frequency or due to a failure in the communication system. See the Project Mercury Ground Station map on the next page for the approximate location of each station.

Since on–board gauges have limited resolution, it is a good idea to request status over every ground station. This is especially true for fuel and oxygen gauges. Also, be prepared to receive new information such as updated retrograde times.

Mercury Ground Stations receive spacecraft telemetry via on a different radio link than voice communication. If the ground station responds to a status request with “no downlink,” you should verify that the HI FREQ TLM switch is in the ON position. If you still can not establish a telemetry link, try setting the HI FREQ TLM fuse to POS 2.



PROJECT MERCURY GROUND STATIONS

CNV	Cape Canaveral	ZZB	Zanzibar	CTN	Canton Island
BDA	Bermuda	IOS	Indian Ocean Ship	HAW	Hawaii
CYI	Canary Islands	MUC	Muchea, Australia	WHS	White Sands, NM
KNO	Kano, Nigeria	WOM	Woomera, Australia	TEX	Corpus Christi, TX

Orbit One: — — — — - **Orbit Two:** — — — — - **Orbit Three:** - - - - -

8.4

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Retrograde Description & Operation

On orbital missions, retrograde operations are arguably the most critical point in flight. If the retrograde rockets are damaged or fired at the wrong angle, the spacecraft will be stranded in orbit.

The timing of the retrograde event is also a crucial factor as it determines where the Mercury spacecraft will land. Approximately 25 minutes elapses between retrograde and landing. If the retrograde time is too early or too late, the recovery zone will be under–shot or over–shot, respectively. The greater the difference in the correct and actual retrograde times, the further the spacecraft will be from the recovery zone. As an example, retrograde occurring one minute late will cause the spacecraft to miss the recovery zone by approximately 50 miles.

The initial retrograde time of 04:33:00 is based on the end–of–mission recovery zone and is based on a nominal orbital altitude of 675,000 thousand miles. Retrograde times will change based on the actual orbital altitude attained. The lower the altitude of the orbit, the faster the spacecraft is moving relative to the ground. This will cause the ideal retrograde time for each landing zone to occur sooner than the nominal times. If the orbital altitude is higher than the nominal altitude, the orbital ground speed will be slow, resulting in later retrograde times.

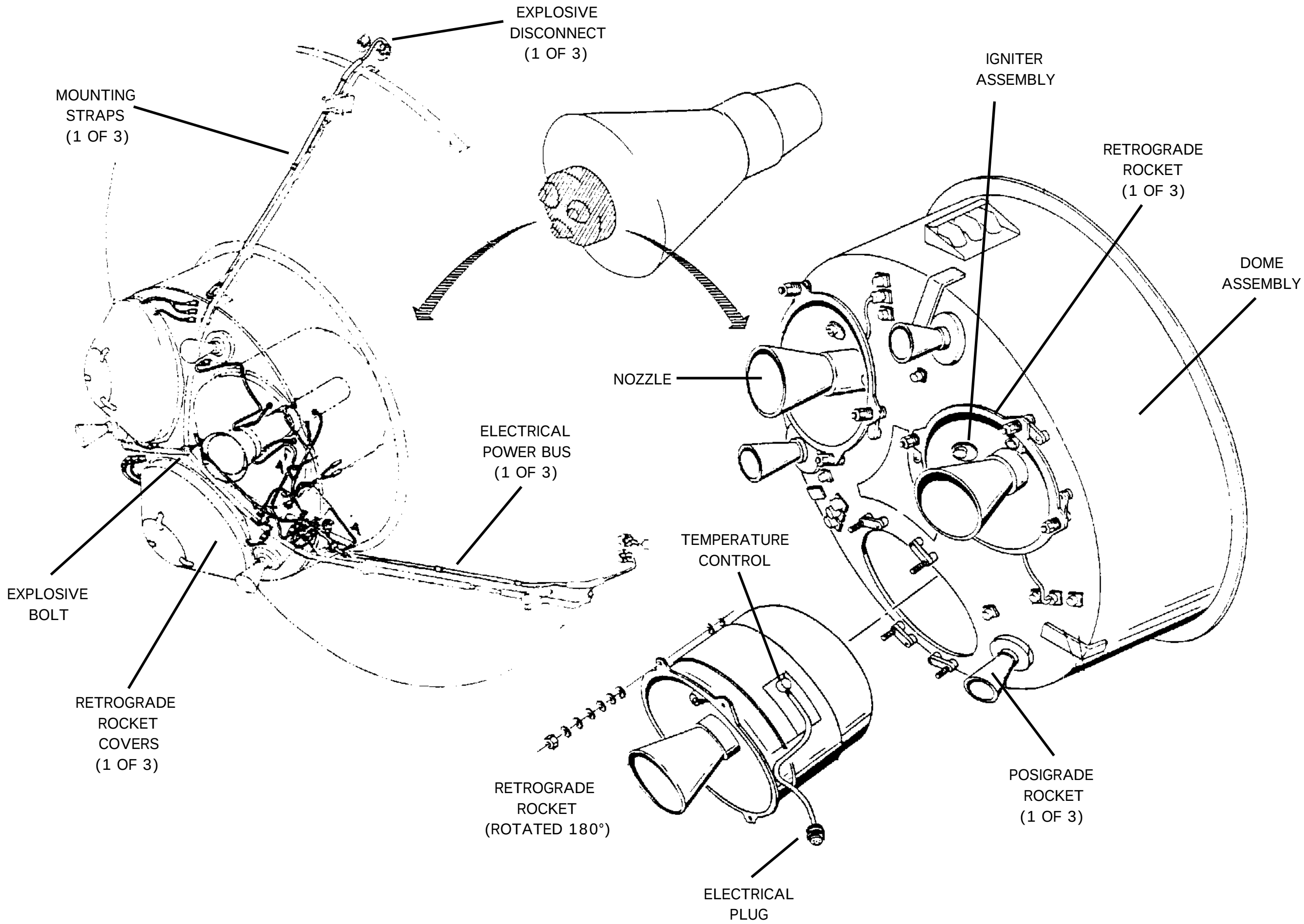
The spacecraft is being tracked by radar and as its orbital trajectory is determined, the ideal retrograde times may change. As you pass over the appropriate ground station, you will be advised, via ground station communication, of the updated retrograde time for the next recovery zone. You should record these updated values on paper or use the Note Pad desk accessory. If an emergency situation develops, reset the retro clock to the next available recovery zone. The retrograde clock can be reset using the Retrograde Reset Handle or by selecting “Reset Retro Timer…” from the “Commands” menu. See the Project Mercury Recovery Zones map on page 9.3, for the approximate location of all the retrograde and recovery zones available.

Recovery Zone	Time	Recovery Zone	Time	Recovery Zone	Time
1A	*	2A	01:35:00	3A	03:10:00
1B	00:18:00	2B	01:53:00	3B	03:28:00
1C	00:34:00	2C	02:08:00	3C	03:43:00
1D	00:58:00	2D	02:33:00	3D	04:08:00
1E	01:12:00	2E	02:47:00	3E	04:22:00
1F	01:22:00	2F	02:58:00	3F	04:33:00

* The spacecraft would only land in area 1A in the event of an aborted launch.

Retrograde Rocket Package Description

The retrograde rocket system consists of the three retrograde rockets, their igniters and the associated wiring necessary for ignition. The retro rockets are housed in the jettisonable retrograde package along with the posigrade rockets. The package is shown on the next page.

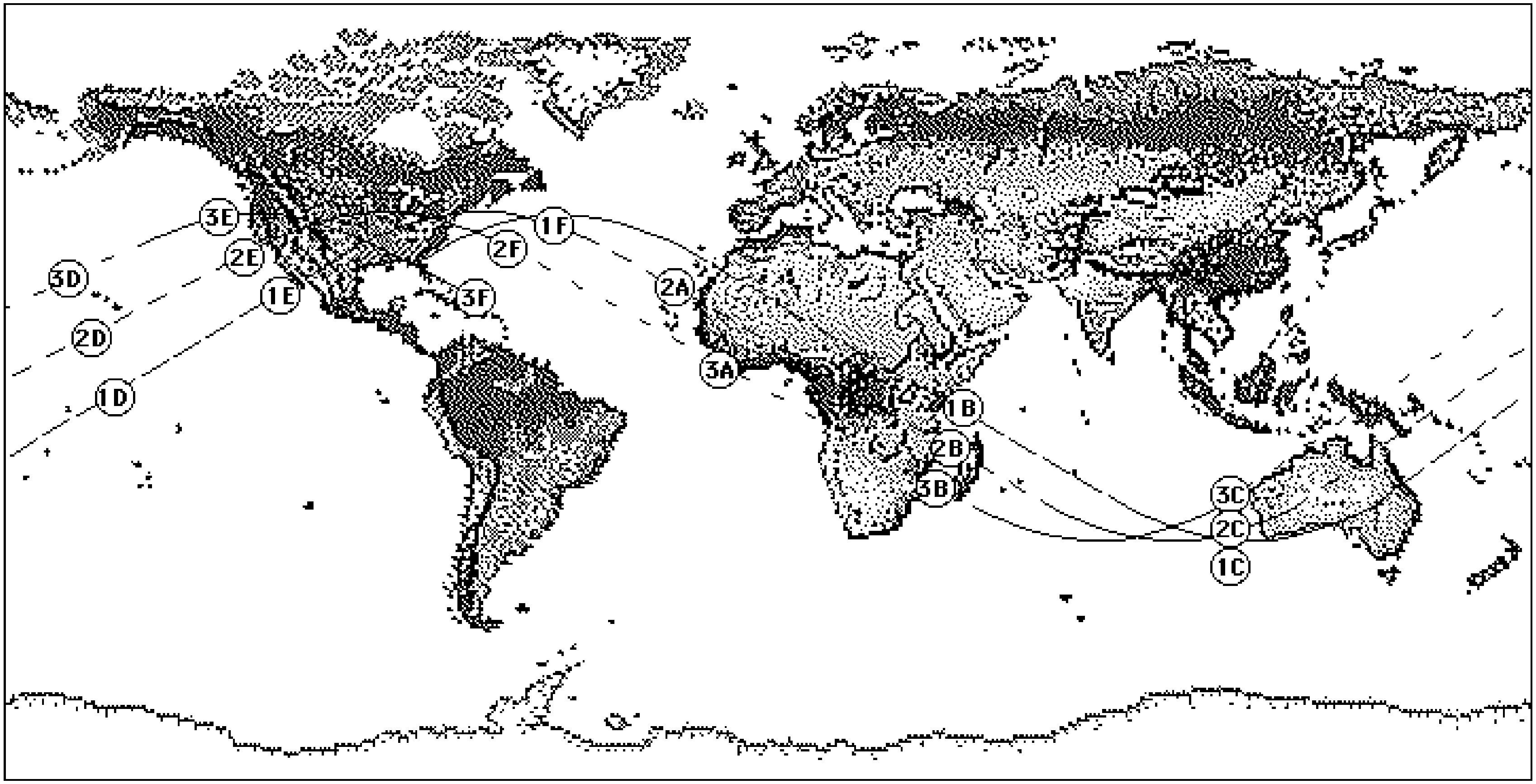


Retrograde Package

The retro package is mounted to the spacecraft by means of three straps joined at the bottom center of the package by an explosive bolt. Sixty seconds following retrograde, this bolt detonates, the straps are released, and a spring assembly ejects the package away from the heat shield. To protect the retrograde rockets, particularly from micro–meteorite damage, each rocket has a metal cover over its exposed nozzle. The cover is blown off by the rocket exhaust. The rockets are mounted so as to direct the thrust direction towards the spacecraft's center of gravity at the time of retrofire. This minimizes the effect on the spacecraft's attitude.

Each retrograde rocket is 15.5 inches long, 12 inches in diameter, and weighs almost 70 pounds. Each rocket delivers about 1000 pounds of thrust for about ten seconds. Two igniters per rocket are provided for increased redundancy. Upon receiving the retrofire signal, all three rockets receive 24 volt DC power, however the No. 2 and No. 3 rockets have a five and ten second time delay, respectfully. Therefore, retro No. 1 ignites immediately, retro No. 2 ignites five seconds after No. 1, and retro No. 3 ignites five seconds after No. 2. The total retrograde firing time is twenty seconds.

Also mounted on the Retrograde Package are the three Posigrade rockets that push the spacecraft away from the booster at a rate of 15 feet/second. These are ignited immediately following the Capsule Separation event. Each rocket is 14.7 inches long and 2.8 inches in diameter and weight approximately 5.25 pounds. Each Posigrade rocket provides 370 pounds of thrust for one second. As with the Retrograde rockets, dual igniters increase reliability. Also, ignition of only one Posigrade is necessary for a successful separation.



PROJECT MERCURY RECOVERY ZONES

ORBIT NUMBER → 3A LANDING ZONE

ZONE LETTER

Orbit One: —— **Orbit Two:** – – – **Orbit Three:** - - -

9.4

Retrograde Events Description

There are four events on the Programmer panel that are associated with the retrograde sequence:

RETRO SEQ This event starts the retrograde sequence either at the time programmed into the TIME–TO–RETROGRADE clock, by a command received from the ground or by pressing the RETRO SEQ switch. When the retro sequence is started the spacecraft will pitch to -34° if it is not already at that attitude. Normally, there is a 30 second delay between retro sequence start and the actual retrofire, which allows the spacecraft time to attain the proper position. On ascent, this delay is disabled (by setting the RETRO DELAY switch to INST), to allow the retro rockets to assist in pushing the spacecraft away from the booster in the event of an abort.

IN RETRO ATT This event prevents retrograde rocket ignition until the spacecraft is within the required pitch and yaw limits. The spacecraft's attitude must remain within +/- 15° of the nominal retro attitude of 0° yaw and -34° pitch during the retrograde rockets are firing.

Each retro rocket is individually slaved to this attitude permission circuit. For example, if the spacecraft is in the proper attitude when the first retro rocket is ignited and then moves out of proper retro attitude, only the *first* retro rocket will fire. To fire the rest of the retro rockets, you must place the spacecraft back in the proper attitude. The IN RETRO ATT switch allows you to disable the attitude permission circuit. This is usually done if your attitude gauges are malfunctioning and you have confirmed proper attitude using the window as a reference.

WARNING

> Placing the IN RETRO ATT switch to the BYPASS position will permit retrofire at any attitude!

FIRE RETRO This event actually applies power to the retrograde firing circuit, igniting the retro rockets as described above. Each retrograde rocket has a fuse associated with it. Placing any of these to the OFF position will prevent that retro rocket from firing. If a retro rocket does not fire because of a blown fuse, placing the appropriate fuse to POS 2 will place a new fuse into the circuit. You must press the FIRE RETRO switch again.

When the difficulty level is set to "Average" or "Difficult," A-OK! will simulate the torquing forces of the retrograde rockets. This means that each retro rocket firing will knock the spacecraft out of its proper alignment. You must control attitude manually, unless the ASCS is operational and switched on, or the difficulty level is set to "Easy."

JETT RETRO This event jettisons the spent retrograde package and can be manually activated by pressing the JETT RETRO switch. This event is powered (like many events, including retro rocket ignition) by the squib bus. The SQUIB switch must be in the ARM position. Because of the potentially disastrous effects of releasing the retrograde package before retrograde, a separate arming switch, AUTO RETRO JETT, must be set to ARM in order for the Programmer to automatically jettison the retrograde packages. You should only do this during ascent and after firing the retro rockets! Finally, the Jett Retro event triggers the Reentry Attitude Maneuver as described in Section 2.

In summation, the accuracy of retrograde time and retrograde attitude determines if the spacecraft will land in the desired recovery zone, indeed if it will land at all!

Reentry System Description & Operation

Reentry into the earth's atmosphere is another very critical point in the mission. It is important that the spacecraft's attitude be held in the position during reentry. While there are differences between an orbital and sub–orbital reentry, the basic phases are the same.

The start of reentry is defined as .05G or when Mercury first begins to de–accelerate and its sensors pick up an acceleration of one fiftieth of a "G." This should not be confused with the ASCS .05G maneuver which is explained below. At approximately the half–way point the spacecraft reaches maximum de–acceleration. The extreme friction caused by plunging through the air with a blunt–faced shield generates and extreme amount of heat, which also peaks at the half–way point.

A sub–orbital reentry lasts about 50 seconds, with the peak de–acceleration occurring at about 30 seconds. Since a Mercury spacecraft following a sub–orbital trajectory de–accelerates from 7,700 feet/second to 1600 feet/second, the danger of overheating due to improper attitude is not as great. However, since the period of de–acceleration is shorter than an orbital reentry, the "G" load is much higher, reaching a maximum of -11 "G."

An orbital reentry lasts for three minutes, with the peak occurring at 90 seconds. A spacecraft in orbit has to de–accelerate from 25,717 feet/second to 1600 feet/second, therefore it will experience a much higher heat load than a sub–orbital spacecraft. The "G" load of a Mercury de–accelerating from orbit is only -7.7 "G." While its initial speed is faster, the total de–acceleration time is longer than a sub–orbital spacecraft.

You should monitor the Longitudinal Acceleration Gauge during Reentry. Follow the "G" forces on the negative portion of the gauge's scale. The positive section displays "G" forces during Ascent.

The heat shield used in the orbital spacecraft is made from a mixture of fiberglass and resin that is ablative in nature; as it heats up, it vaporizes, carrying the heat away in the process. Sub–orbital models use a beryllium heat sink shield that stores heat during reentry and slowly releases it back into the air during the rest of the descent.

As per the Checklist, you should pre–cool the cabin by turning up the coolant flow prior to retrofire. If ASCS is on and operating normally, the start of reentry will initiate the .05G maneuver which rotates the spacecraft about its roll axis at 10°/second. This action makes Mercury more stable during reentry. If the .05G telelight does not come on at the expected time, you should initiate it manually by pressing the .05G switch or put the attitude control system into RSCS and control the roll (along with the pitch and yaw) using the Hand Controller. RSCS is the preferred method of manually flying a reentry.

WARNING

If the Landing Bag is deployed before reentry, the spacecraft will burn up! After ascent, leave the LANDING BAG switch in the OFF position until reentry is complete.

10.2

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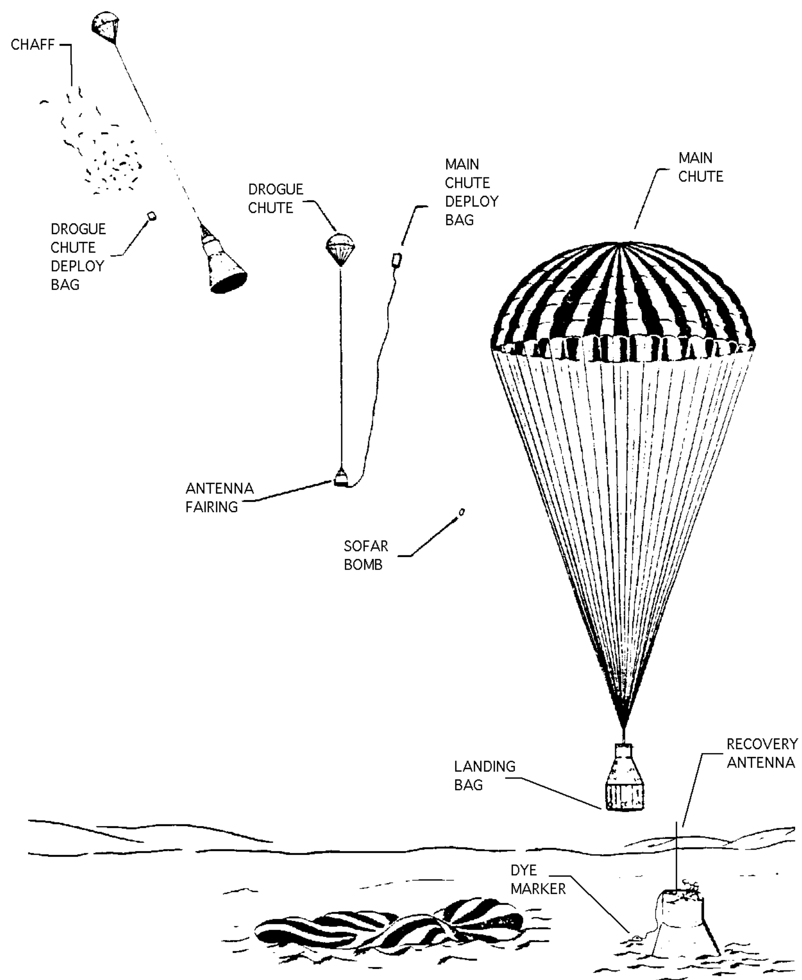
Landing System Description & Operation

The landing system consists of the Drogue Parachute, Main and Reserve Parachutes and the Landing Bag. At about 21,000 feet, the Drogue Parachute is deployed to de–accelerate and stabilize the spacecraft. The Drogue is a six–foot–diameter conical ribbon–type parachute that slows the spacecraft to about 365 feet/second. The Drogue is deployed by means of a pyrotechnic mortar.

At the time of Drogue deployment, a chaff package is ejected. The chaff package disperses finely cut metal foil over a 600 square foot area. This creates a large radar reflection area (larger than the spacecraft itself) that can be detected by search planes hundreds of miles away.



Landing System Components

At about 10,000 feet, the Main Parachute deploys, slowing the descent to about 30 feet/second. An identical Reserve Parachute may be deployed manually in the event that the Main Parachute's performance is unsatisfactory. The Main and Reserve Parachutes are 63–foot–diameter ring–sail types. Both parachutes are deployed using inflatable ejector bags that push the parachutes out of their storage case. The ejector bags are inflated using a hot gas generated by a solid fuel charge. Upon landing, the Main Parachute is automatically disconnected and the Reserve Parachute is ejected.

11.2

At the time of Main Parachute deployment, a SOFAR (SOund Fixing And Ranging) bomb is deployed. The SOFAR bomb is detonated underwater at a predetermined depth of 3500 feet. Shock waves from the explosion are detected by sound detectors aboard recovery ships or shore bases. A positional fix can be determined from the various readings. The SOFAR bomb has a range of 3000 miles.

The Landing Bag is a rubberized cloth assembly about four feet long. Before release, the heat shield is held directly to the spacecraft by a mechanical latch and the Landing Bag is folded and contained between the heat shield and the spacecraft. After release, the heat shield drops down and extends the bag to its full length. For a water landing, the bag attenuates the landing shock from approximately 45 “G” to approximately 15 “G.”

After landing, a Rescue aid package is automatically deployed. It releases a dye that marks the landing area with a bright green that is easily seen from the air. A recovery beacon antenna is then deployed and the beacon’s transmission started. This beacon provides the recovery team with a fix on the landing site.

You should monitor your altitude on the Altimeter which will become active at 100,000 feet. The spacecraft’s rate of descent is displayed on the Descent Rate Gauge. Notice that the gauge’s scale stops at 140 feet/second. If your rate of descent is above that, it doesn’t matter what the value is!

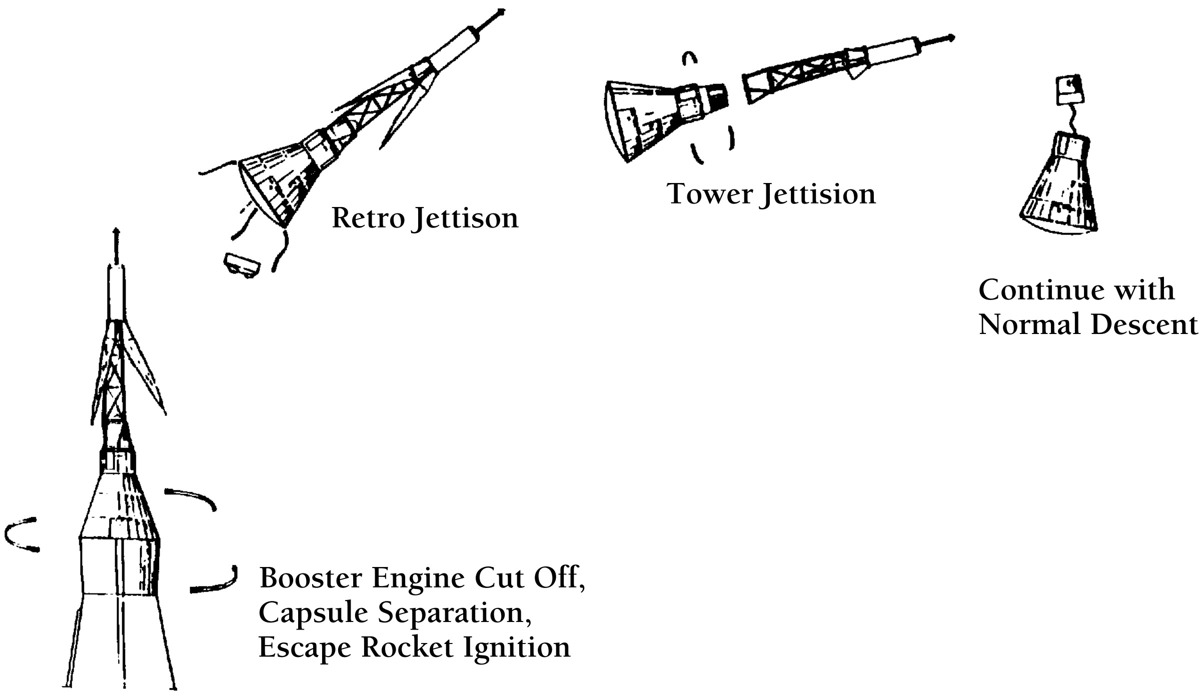
If the parachutes, or Landing Bag are not deployed automatically, you can deploy them manually using the DROGUE, LANDING BAG, or RESCUE switches, or the MAIN or RESERVE override rings. If that fails, you can set the appropriate fuse switch (located on the extreme left panel) to the POS 2. If you detect that the Main Parachute is damaged after deployment (by a descent rate over 30 feet/second), deploying the Reserve Parachute should slow the descent rate to its proper value providing that you are at least 3000 feet high. Finally, if the Rescue Aids are not deployed upon impact, you will have thirty seconds in which to deploy them, after which the simulation ends. An un–deployed Rescue package will result in a delayed recovery.

Refer to Section 2 for additional information on descent and landing events. Refer to the Emergency Checklists in Section 19 for specific emergency procedures.

Abort System Description & Operation

The Mercury spacecraft can abort a mission by separating itself from a malfunctioning booster any time during the countdown, and during the powered ascent. During the countdown, an abort can be initiated by a signal from Mercury Control or actuating the Abort Handle, located on the left–hand side of the cabin. After liftoff, the booster's failure sensing system can also initiate the abort.

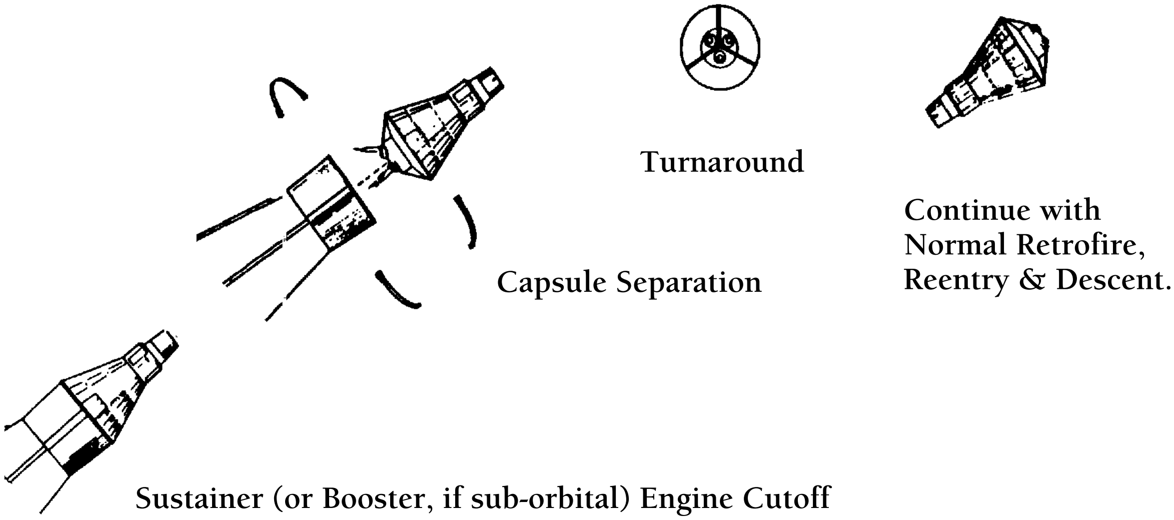
An abort signal from any source will shut down the booster engines, illuminate the Abort warning light and separate the spacecraft from the booster. The retrograde package is jettisoned as soon as Capsule Separation is sensed. After Capsule Separation, the escape rocket fires for one second, separating the spacecraft from the booster by a distance of 2,600 feet. This figure is based on the minimum altitude required for proper deployment of the parachutes. After the escape rocket burns out, the Tower Jettison occurs. At that point, the flight continues with a normal descent.



Tower Abort Events

On aborts over 20,000 feet, fuel dumping, snorkel, drogue and main parachute, and landing bag deploy will occur at their normal altitudes. Pad aborts will initiate these events in rapid sequence as soon as the spacecraft is at least 2,600 feet above the ground.

On sub–orbital missions, the escape tower is attached for the entire powered flight. Orbital spacecraft jettison the tower about halfway through the five minute ascent to orbit. Aborts after the escape tower is jettisoned are similar: the booster is shut down, the ABORT warning light is illuminated and capsule separates. At that point the retrograde rockets are fired to increase the distance between the spacecraft and booster.



Post–Tower Abort Events

WARNING

On Post–Tower Aborts, the RETRO DELAY switch must be set to INST so that the retrorockets will fire immediately and increase the distance between the malfunctioning booster and the spacecraft. Failure to do this increases the chance of the booster crashing into the spacecraft.

A-OK! simulates the abort handle with the *command–A* key combination. This allows you to initiate an abort while looking at any part of the control panel. You should be prepared to recognize when an ascent is not proceeding normally. The most obvious is if the booster begins to deviate from the programmed attitude changes: you notice a pitch movement or the roll program does not terminate at the proper time, etc. Major system failures within the spacecraft also require an abort: loss of cabin pressure, electrical failure, etc.

The Mercury spacecraft/launch vehicle monitored critical booster parameters with the Abort Sensing & Implementation System (ASIS). This system monitors the pressures and temperatures of key booster components (such as tanks and fuel pumps), and various flight dynamics parameters: speed, attitude and attitude rates.

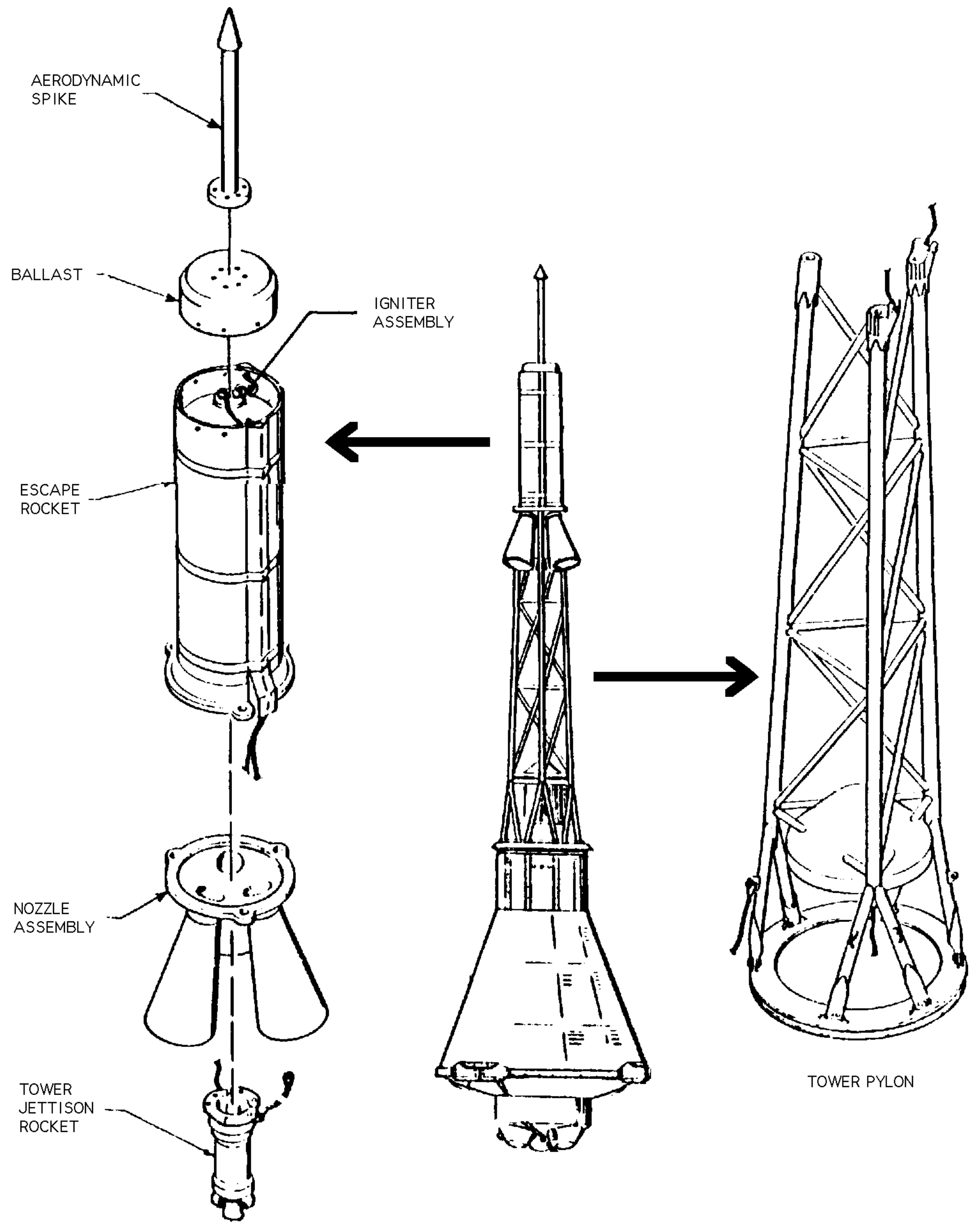
Upon sensing an abort condition, ASIS will warn both the astronaut and Mercury control that an abort is forthcoming, following through by shutting the booster down and executing an abort sequence. The astronaut is warned via the ABORT warning light just left of the Attitude Gauges.

If A-OK! simulates a launch abort condition (only on a difficulty level of “Average” or “Difficult”), ASIS will warn you by illuminating the Abort indicator and sounding a warning tone, but will *not* execute the abort. If the ABORT warning light illuminates, you will have literally seconds to initiate an abort with a *command–A* key combination. Failure to do so will result in an explosion. See section 17, “Simulation Failure Scenarios,” for a description of possible launch–related failures.

WARNING

The SQUIB switch must be set to ARM before the abort system can receive power.

The Launch Escape System consists of the tower pylon, an escape rocket and a tower jettison rocket. Refer to the diagram on the next page. The escape rocket is an electrically–ignited, solid fuel engine that provides an average thrust of 52,000 pounds for about one second. The engine is 70 inches long, 15 inches wide, and weighs 350 pounds. The thrust is vectored through a three–nozzle assembly in which the exit cones are canted 19 degrees away from the centerline so as to direct the rocket exhaust away from the tower and spacecraft.



Launch Escape System Components

12.4

The escape rocket engine is mounted on the top of the lattice–work tower pylon which is in turn mounted on the top of the spacecraft.The tower pylon is constructed of tubular steel and is ten feet long.

After a tower abort, the tower pylon is jettisoned by a solid rocket mounted at the bottom of the escape rocket engine. The tower jettison rocket is an electrically–ignited, solid fuel engine that provides 850 pounds of thrust for one and a half seconds. The engine is 18 inches long, 5.5 inches wide, and weighs 20 pounds. The thrust is vectored through a three–nozzle assembly in which the exit cones are canted 30 degrees away from the centerline.

Countdown Procedures

As an option of “Start Simulation” (in the “Commands” menu), A-OK! can start the simulation at T minus three minutes into the countdown. When starting from the countdown, you should follow the Entrance Checks procedure, listed in the Checklist, which will insure that all switch positions are in the proper position and all gauges are reading nominal values.

After completing the Entrance Checks, you should follow the Prelaunch Checks procedure which arms the squibs and verifies that the spacecraft is able to supply them with the necessary power. Once this procedure is completed, you should monitor the Abort Indicator at the top of the panel for the duration of the countdown and launch.

The time–to–launch will be announced every 30 seconds during the countdown. You will hear status reports on various spacecraft systems, such as consumable quantities and programmed retrograde time.

At T-1:30 (90 seconds), listen as the launch director calls for the following status milestones:
Fuel Tanking?
Lox Tanking?
Launch vehicle internal power?
Spacecraft internal power?

Next, the launch director will request verification that all spacecraft systems are ready:
Mercury Capsule?

You should respond by placing the LAUNCH CONTL switch to the READY position.
The launch director will respond:
Capsule is go.

If you are behind in your Entrance or Prelaunch checks, leave the LAUNCH CONTL switch in the OFF position. the launch director will respond:
Holding for Mercury Capsule.

The count will hold at T-60 seconds until you set the LAUNCH CONTL switch to READY. At that time, the launch director will respond:
Capsule is go.

At T-00:15, the launch director will count the seconds to ignition.

13.2

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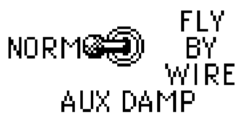
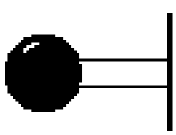
Switch Operation

There are over 95 switches and controls on the Mercury control panel. These are divided into ten types. Switch operation is simple: click the side of the switch that you want to move the lever (or dial) in. Unlike standard Macintosh mouse action, switches and controls will move as soon as you click them, *not* when the mouse is released. The idea is to make the act of actuating a switch as realistic as possible: if you accidentally "bumped" the wrong switch on the real control panel, it could be a very bad day! After starting A-OK!, you can try out these switches. Resetting the simulation (by choosing "Reset Simulation" from the "Commands" menu) resets all switches and any actions you may have initiated.



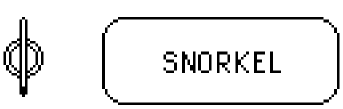
The Three Position Toggle Switch selects between three choices or modes. This switch is moved by clicking on the right to move the toggle right and the left to move the toggle left. Two clicks are required to move the switch from one extreme to the other. The Three Position Toggle Switch shown here puts the Automatic Stabilization & Control System into its normal, auxiliary rate damping or fly by wire mode.

The Two Position Toggle Switch selects between two choices or modes. This switch is moved by clicking on the right to move the toggle right and the left to move the toggle left. The Two Position Toggle Switch shown here enables or disables the audio alarm associated with the warning indicators on the top right corner of the control panel.

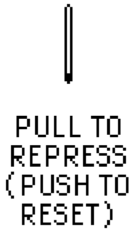


The Emergency Oxygen Rate Valve handle engages the emergency rate when pulled to the left position. This is done by clicking on the space to the left of the black handle. Clicking on the right of the black handle returns this control to its right–hand position.

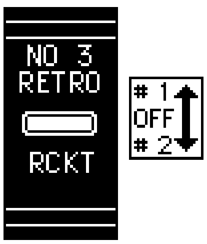
The Push Button initiates events that are either automatic or manual in nature. This control is actuated by clicking on it. The Push Button shown here manually opens the drogue parachute if it does not open automatically.



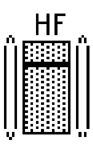
The Override Ring initiates events that are normally automatic, but need to be initiated manually. Once pulled, it can not be activated again. This control is actuated by clicking on it. The Ring shown here is used to manually open the fresh air snorkel during descent.



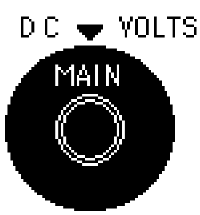
The “T” Switch controls flow of fuel or oxygen and has two positions. This control is moved “out” by clicking on it. A second click returns it to the “in” position. The “T” Switch pictured here will re–pressurize the cabin with oxygen. This may be done if the cabin was manually de–pressurized to clear the cabin of fumes, for example.



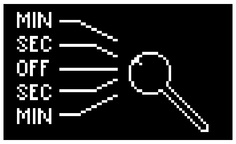
The Fuse Switch controls power to various systems. It is also used to initiate critical events during and in–flight emergency. Positions 1 and 2 select primary and backup fuses which, assuming that the fuses aren’t blown, apply power to the various systems. The center position disrupts power and prevents that systems operation. The Fuse Switch is moved by clicking on the top half to move up and the bottom half to move down. The Fuse shown here controls power to the third retro rocket. You might want to turn the retro rockets off to disable retrofire if you are having problems keeping the spacecraft in the proper retro attitude or position, for example.



The Volume Control adjusts volume of various audio channels and has many levels. This control is adjusted up by pressing on the top half of the control and adjusted down by pressing on the bottom half. The Volume Control show here adjusts the volume of the High Frequency radio.



The Selector Switch has multiple positions and can select many options or control the flow of coolant. Clicking on either the left or right half moves the control on way or the other. The Selector Switch shown here switches the DC voltmeter to various batteries and circuits allowing the astronaut to monitor the voltage levels.



The Retro Reset Lever has multiple positions and is used to reset the Time–To–Retrograde clock on a. digit–by–digit basis. Seconds and minutes are incremented by clicking MIN or SEC *above* the center OFF position or decremented by clicking MIN or SEC *below* OFF. Holding the mouse down will continuously increment or decrement. To change hours, the minutes must be incremented past 59 or decremented below 00. An alternate method of resetting the Time–To–Retrograde timer is to select “Reset Retro Timer…” on the “Commands” menu. This allows you to enter the new retrograde time using the keyboard. See Section 16.

Hand Controller Operation

The Mercury Hand Controller is simulated by using the mouse. Alternately, you can use a joystick by selecting “Preferences” under the “File” menu. Pressing the “option” key enables the Hand Controller simulation. Pitch is controlled by moving the mouse up and down, Yaw is controlled by moving the mouse left and right and Roll is controlled by pressing the shift key down while moving the mouse left and right.

	Mouse	Joystick
Pitch:	option or shift and ↑↓	option or shift and ↑↓
Yaw:	option and ←→	option and ←→
Roll:	shift and ←→	shift and ←→

Releasing and re–pressing the option or shift key will automatically center the Hand Controller. While using the mouse or a joystick as a Hand Controller, the cursor change to the Hand Controller icon.

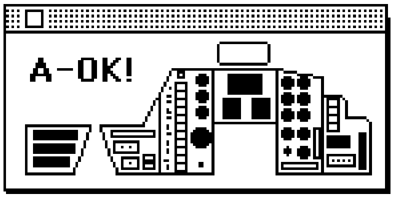
When using a joystick with programmable fire buttons, we suggest that you configure the top button to type the option key and the trigger button to type the shift key. If another button is available it should be configured to type *command–A* key, which triggers the abort sequence. Using this setup allows you to grab the joystick and enable the Hand Controller by pressing the top button. Roll control is obtained by squeezing the trigger. Finally, the abort sequence is started by hitting another button.

14.4

Telelight and Warning Indicators

There are 22 Indicators on the control panel. Some of them are Telelight Indicators that display the status of automatic events that are normally initiated by the spacecraft Programmer. These glow green when an event is successfully initiated and red when the initiation attempt failed. A Warning Indicator glows yellow whenever a potentially dangerous condition exists. They are accompanied by an audible tone that may be disabled by setting the appropriate AUDIO switch to OFF. All indicator lights may be dimmed by setting the WARN LIGHTS switch to DIM. The Sep Capsule Indicator shown here is an example of a Telelight Indicator. It displays the status of the separation of the spacecraft from the booster.

Panel Selection Palette



This is a floating palette that displays a miniature version of the Mercury control panel. When the mouse is moved over to the palette, the cursor changes from a hand to an arrow. Pressing and releasing over any section of the miniature panel moves you to that portion of the spacecraft panel. The palette may be moved to any spot on the screen by pointing to the top of the palette and moving the mouse while holding down the mouse button. You can close the palette by clicking the close box on the top left of the palette. Selecting "Show Panel Selection Palette" from the "Commands" menu will re–open it.

Control Panel Descriptions

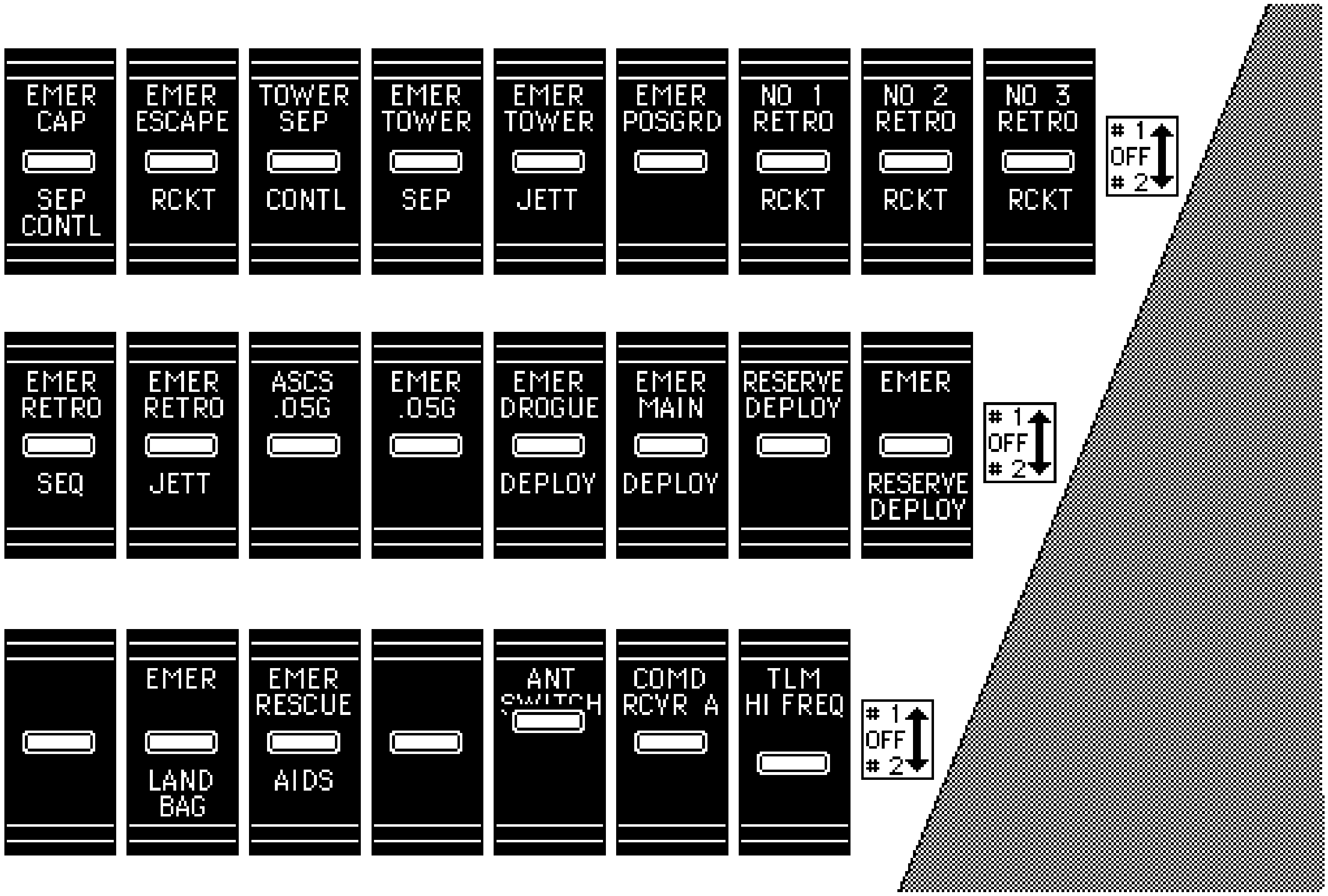
The Mercury control panel is divided into ten sections. It's a good idea to have A-OK! running while you become familiar with the control panel. Double–clicking the "A-OK!" icon will take you inside the Mercury cockpit, looking at the far left section of the panel. It's also a good idea to turn on System 7's Balloon Help and get more information by pointing to each control and indicator. The following pages contain a section by section overview of the control panel.

The control panel was coded to indicate specific functional areas by color:

Flight Sequencer & Fuses	Medium Tan
Attitude Control	Dark Brown
Altitude and Descent	Light Tan
Flight Instruments	Light Grey
Life Support	Light Blue
Electrical	Light Green
Warning	Medium Green
Communications	Dark Green

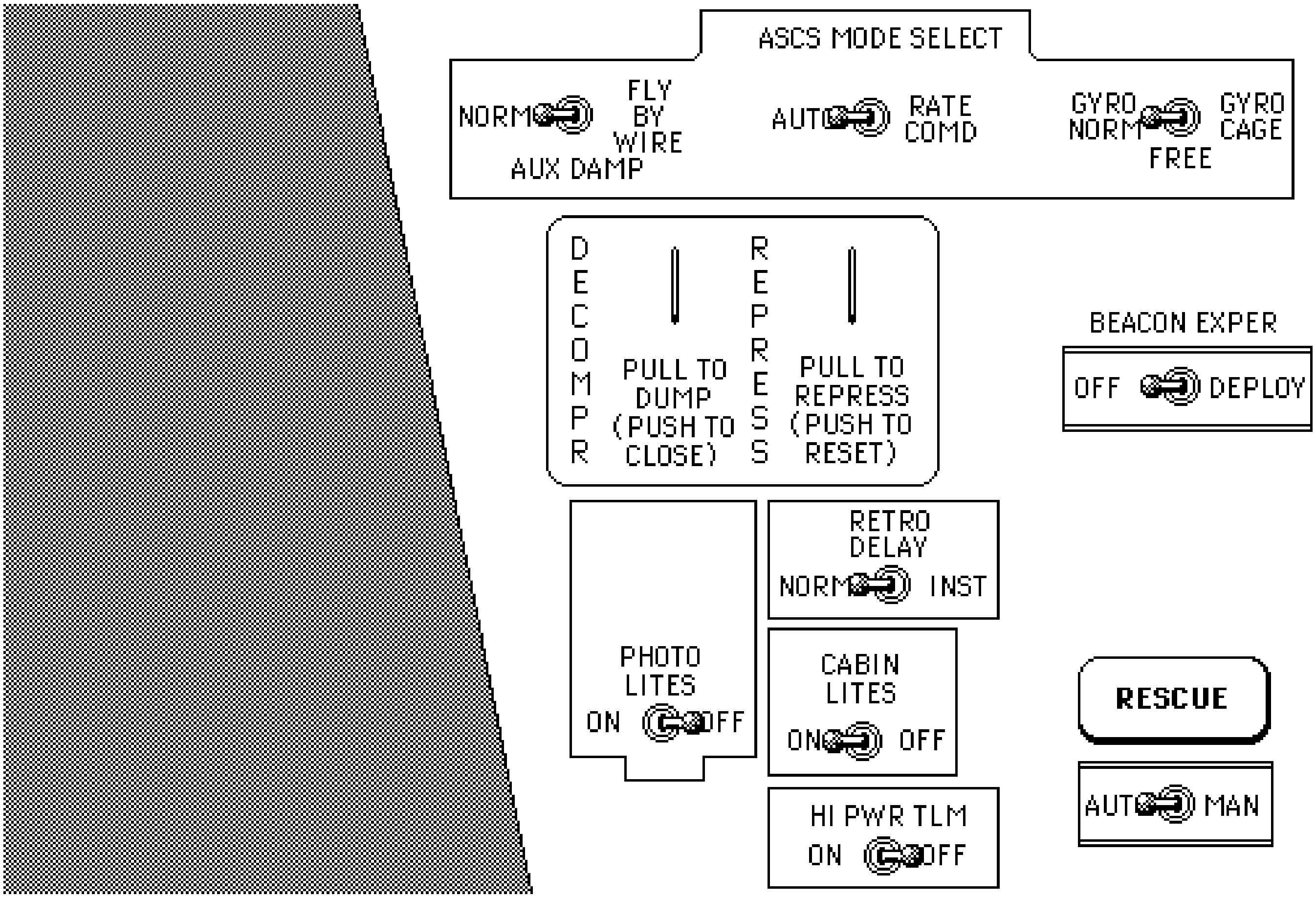
It was hoped that by color–coding panel sections by function, control locations would be easier to memorize. The astronauts felt that this was not really helpful so color–coded control panels were not used in later manned spacecraft.

15.2



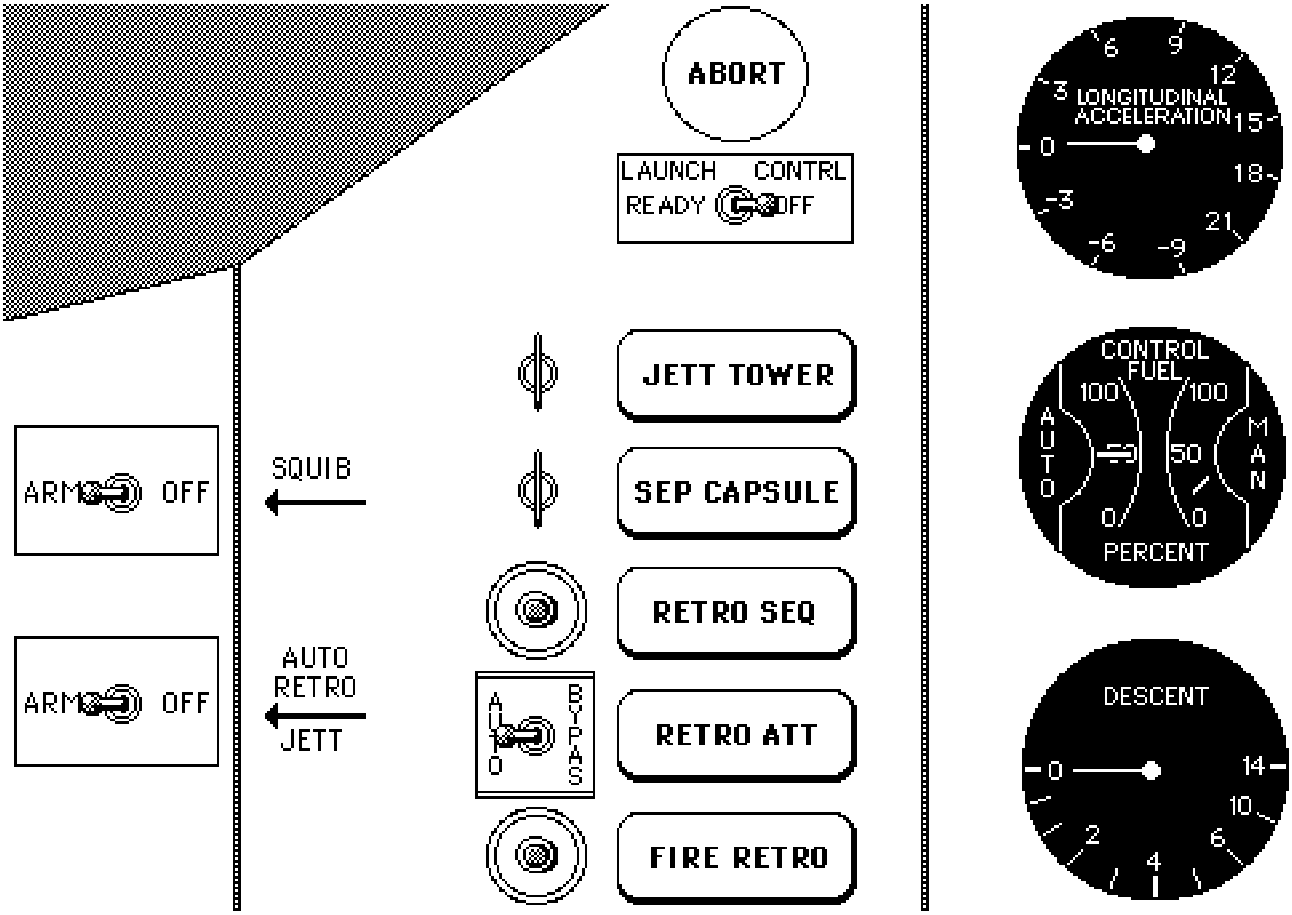
Fuses

This section contains most of the Fuse Switches used in the spacecraft. Fuse Switches are used to control power to various systems and can be used to actuate events manually, when the normal manual procedures fail. Refer to Sections 7,17,19.2 and 19.9.



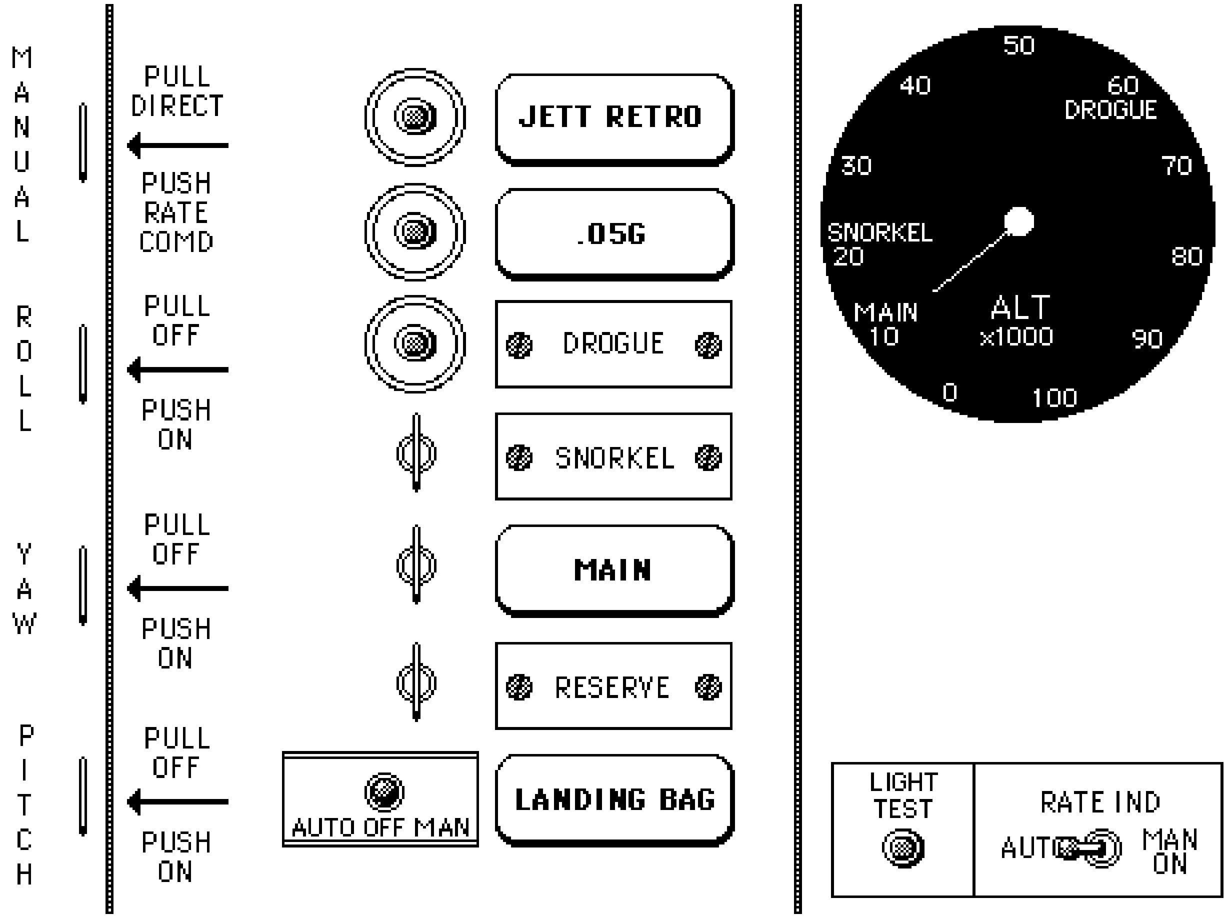
Attitude Control and Cabin Pressure Control

The top section changes the Automatic Stabilization & Control System (ASCS) modes. The two "T" Switches below that decompress and re–pressurize the spacecraft cabin. The switches on the bottom control various lighting systems and miscellaneous functions. Finally, the Flashing Beacon Experiment is deployed with the switch on the center right. Refer to Section 4, 6 and 18.



Programmer and Gauges

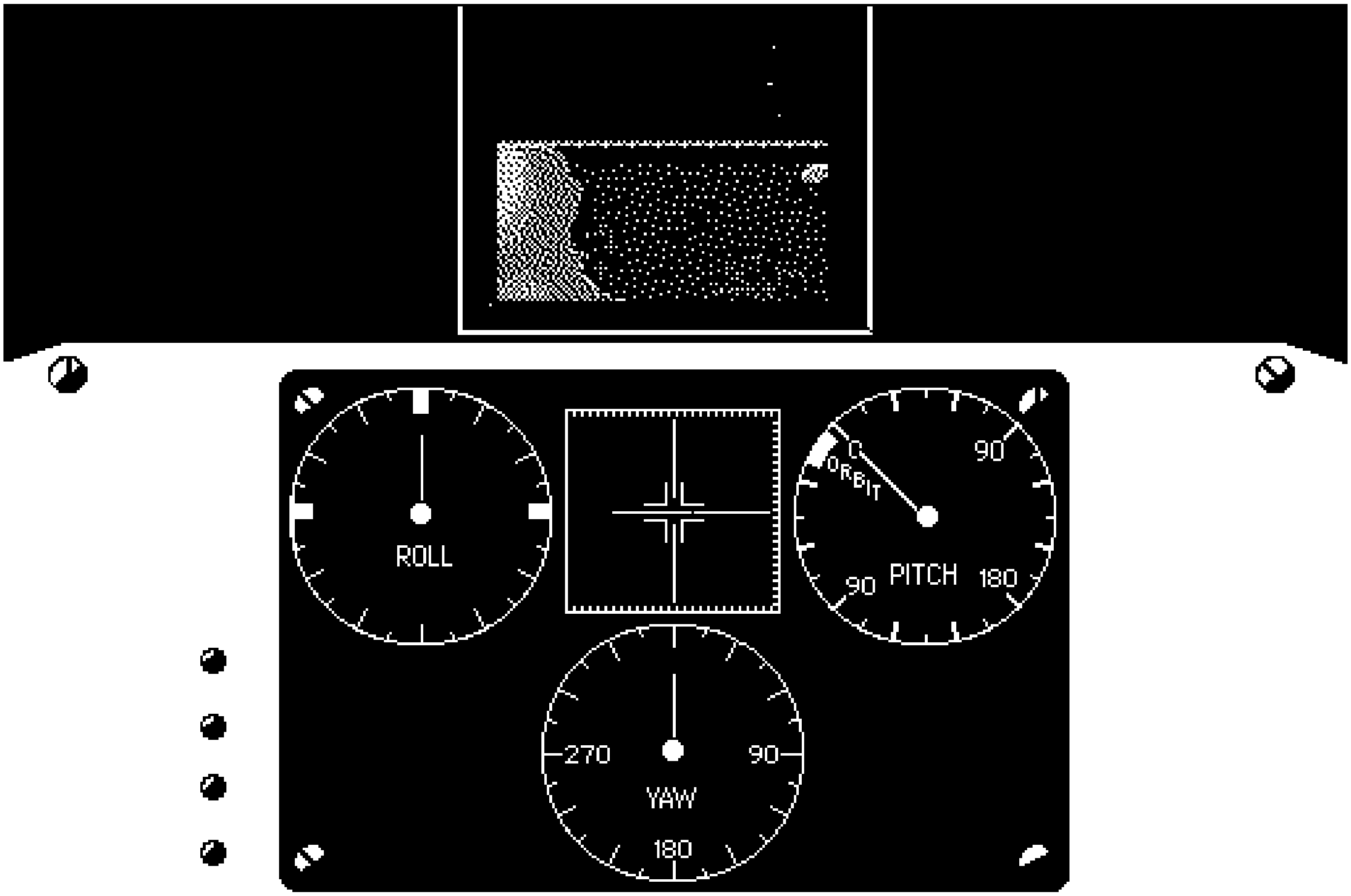
The gauges to the right display acceleration, fuel quantity and final descent rate. The indicators and switches in the center display the status of, and allow the manual initiation of, automatic events controlled by the Programmer. The switches on the far left arm all pyrotechnic devices (almost all Programmer events require the squib bus to be armed) and disable the retro package jettison event. Refer to Sections 5, 10, 11, and 19.



Programmer, Gauges and Fuel Control

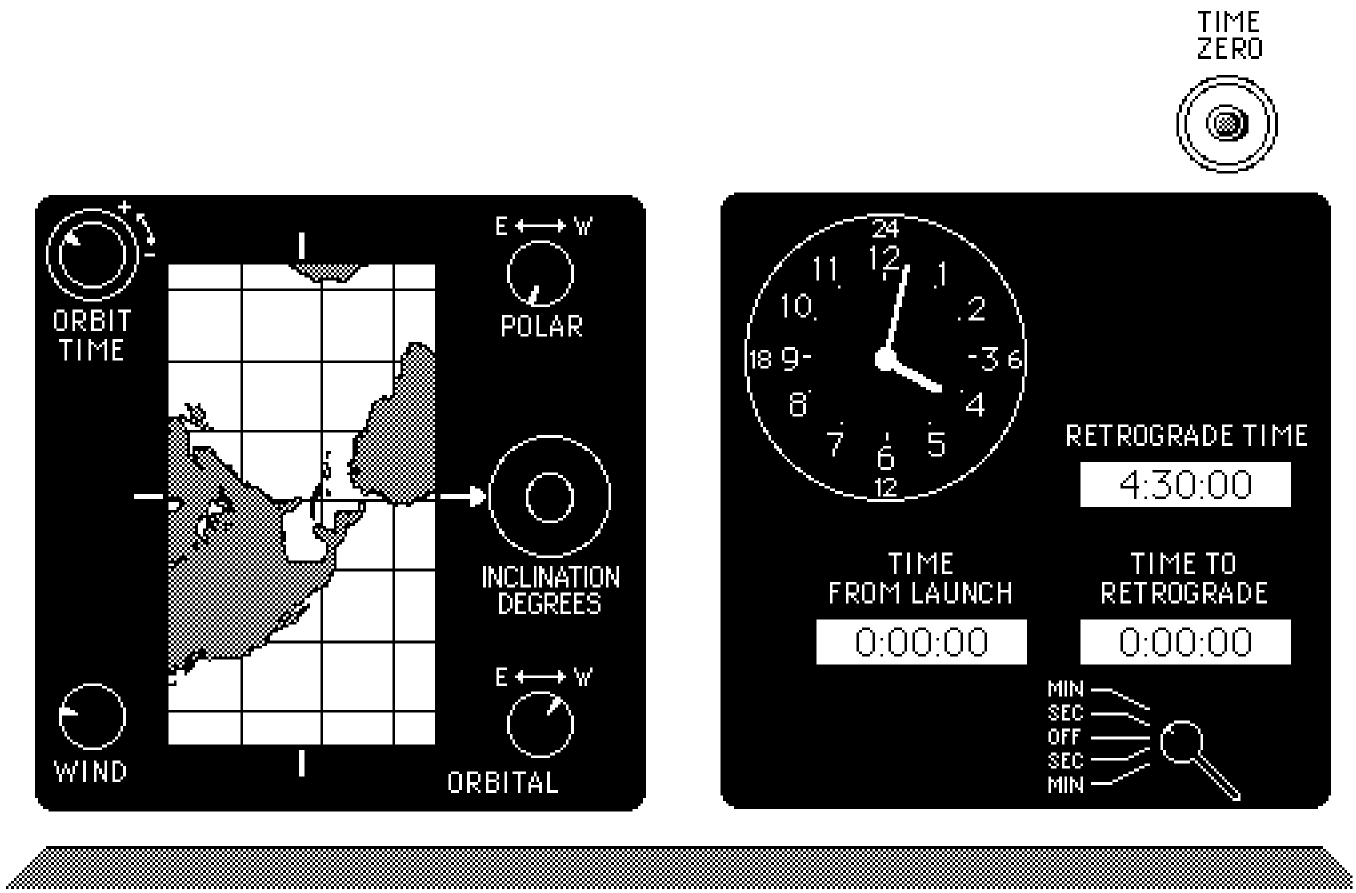
The large gauge on the right displays the altitude when the spacecraft is under 100,000 feet. The indicators and switches in the center display the status of, and allow the manual initiation of, automatic events controlled by the Programmer. The “T” Switches on the far left control fuel flow to each set of spacecraft thrusters. Refer to Sections 4, 5, and 19.

15.6



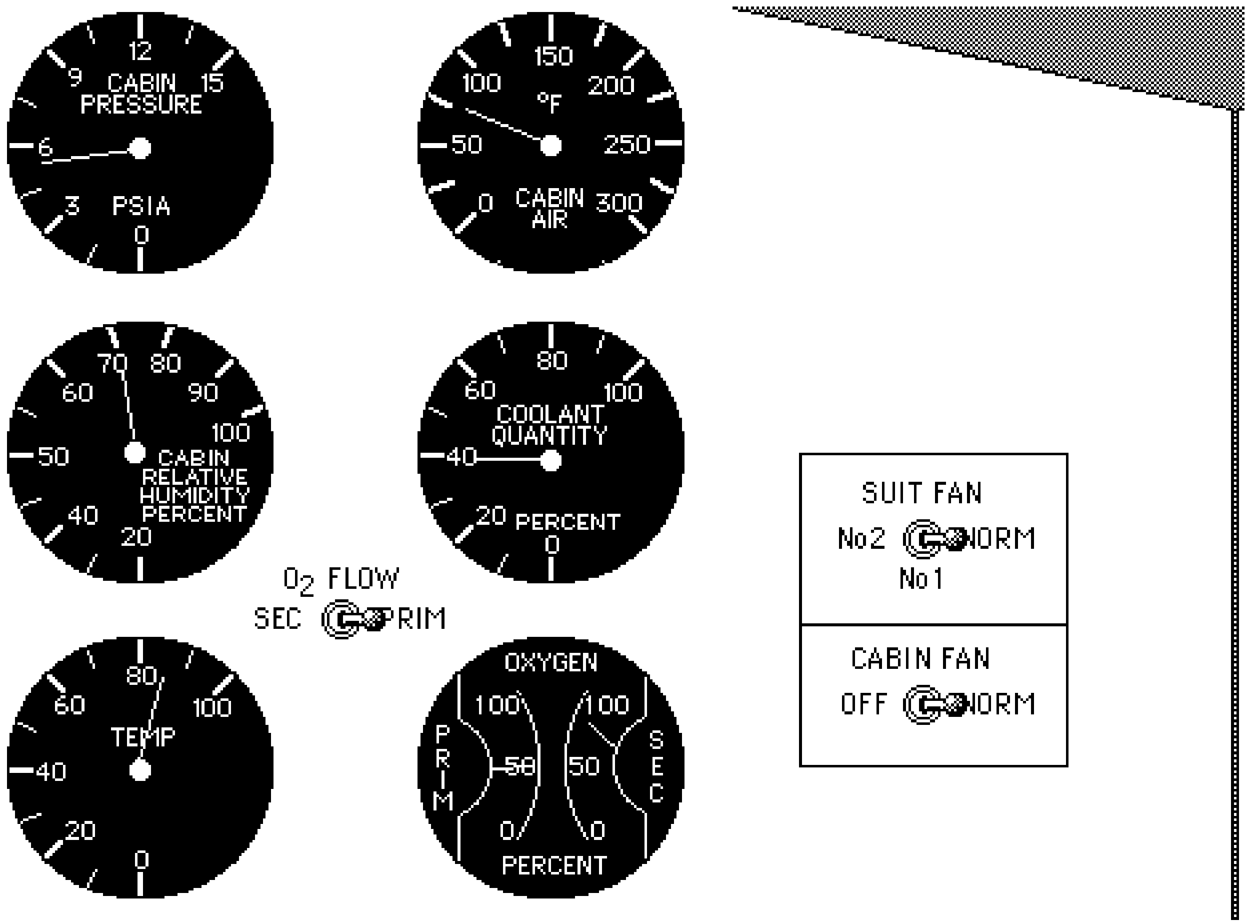
Window, Attitude Gauges and Rate Indicators

This section of the control panel contains a window that provides a view that the astronaut can use to verify the spacecraft's attitude. The Attitude Gauges display the spacecraft's roll, yaw and pitch attitude. The square Rate Indicator, located in the center of the screen displays attitude rates. See section 4.



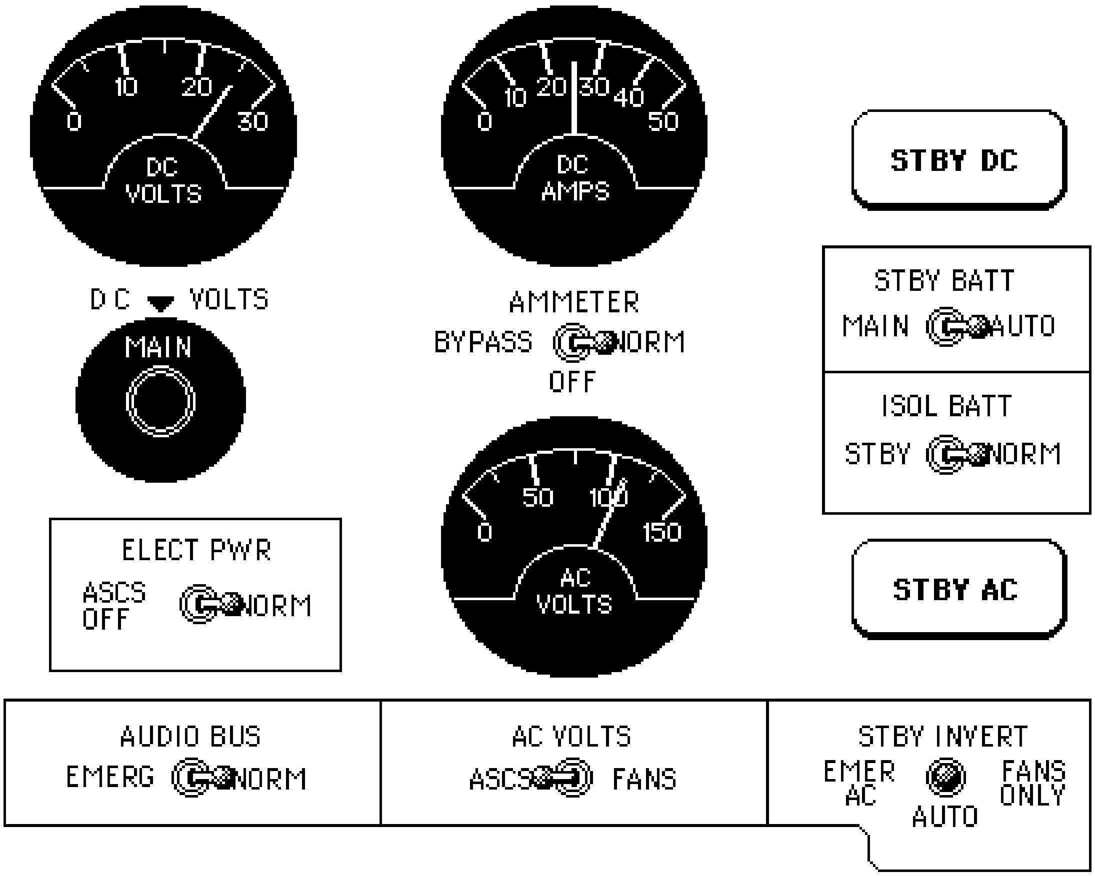
Earth Position Indicator and Clocks

This section contains the Earth Position Indicator which displays the ground track that the spacecraft is following while in orbit. The three digital displays to the right display mission elapsed time, retrograde time and time to retrograde. The lever under the digital displays allows the astronaut to reset the retrograde timer.



Environmental Control System

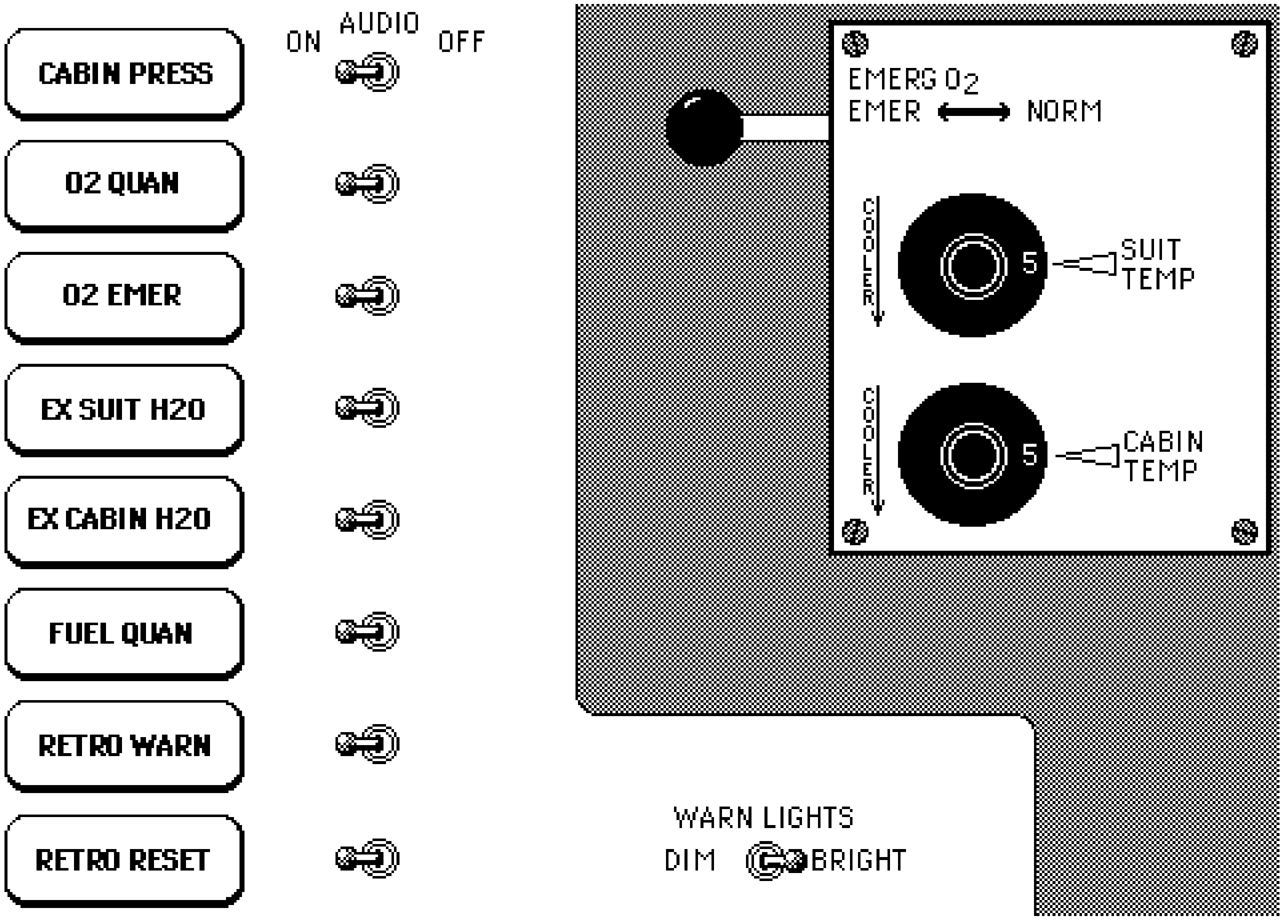
This section contains gauges that display the current status of both the cabin and suit environment. The switches allow selection of oxygen tanks and control the cabin and suit fans that circulate air. See Section 6.



Electrical System

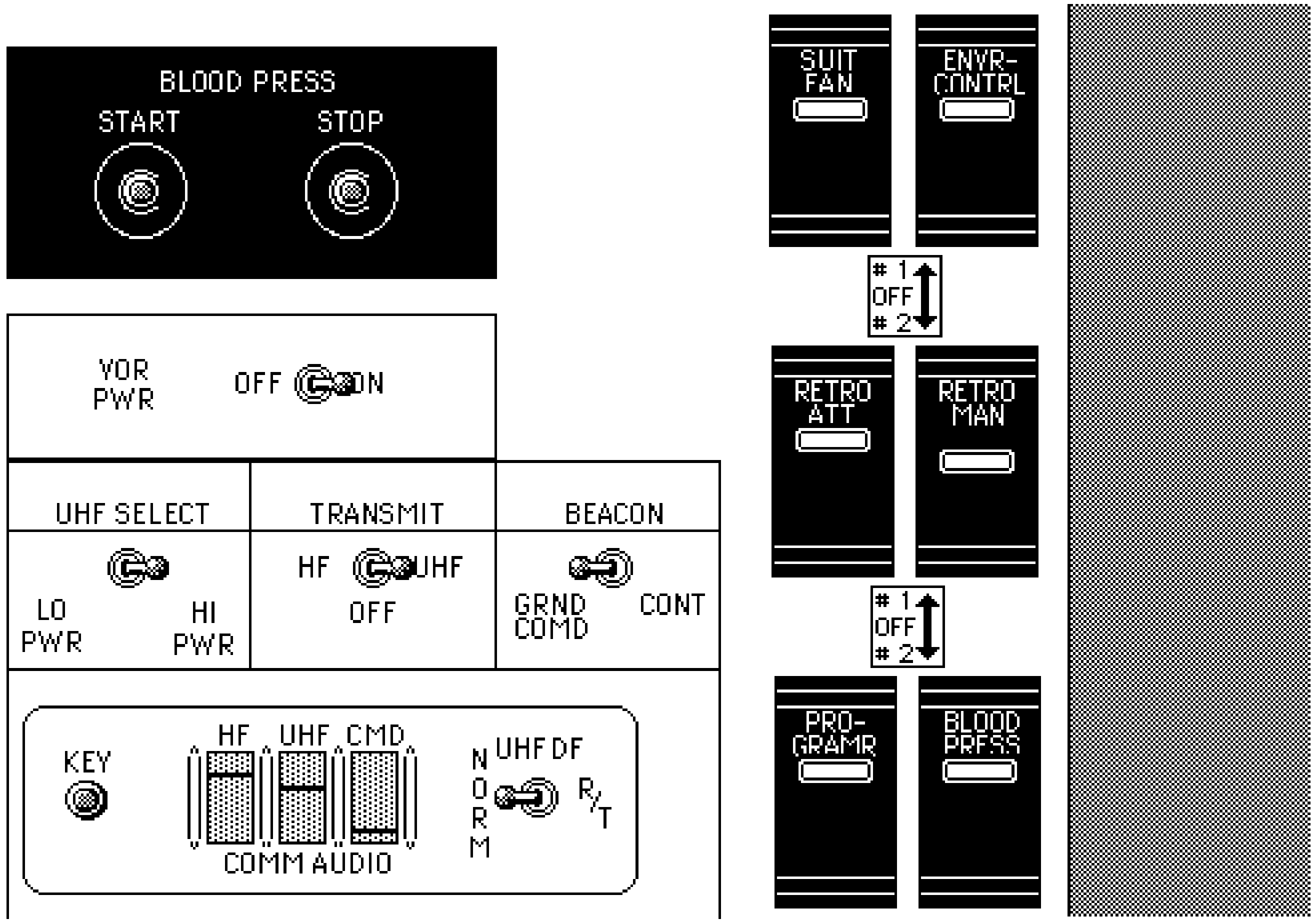
This section contains gauges and indicators that display the current status of the DC and AC electrical systems. The switches allow selection of various backup batteries and AC inverters. See Section 7.

15.10



Warning System and Temperature Control

This section contains the indicators that are used to warn the astronaut of emergency or potentially dangerous conditions. The switches to the immediate right of the Warning Indicators control the audio alarm associated with each warning light. The controls to the far right regulate the flow of coolant, thereby allowing the astronaut to control the temperature of the suit and cabin. The black–knobbed control above the coolant controls, turns on the emergency oxygen rate on and off. See Sections 5,6, and 10.



Communication System and Fuses

This section controls the spacecraft's communication system. The fuses on the far right provide backup fuses for major systems like the Environmental Control System and the Programmer. The push buttons on the top control the Blood Pressure Experiment. See Sections 8 and 18.

15.12

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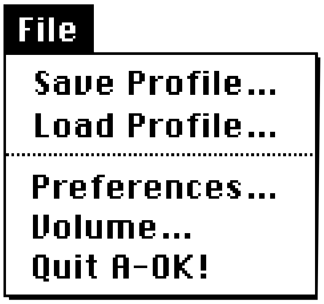
Menu Descriptions

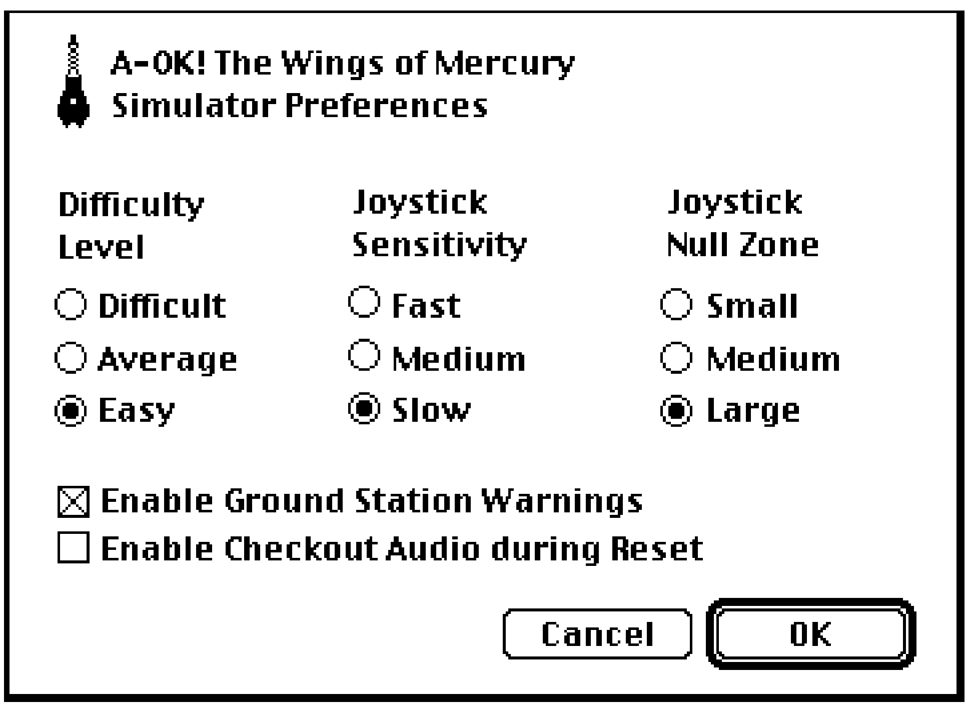
This section describes the A-OK!'s menus and dialog boxes.



Save Profile… allows you to save the current mission's profile which includes flight dynamics and failure modes. Only available while a mission is running or finished. Once the simulation is reset, the current profile is erased.

Load Profile… allows you to use a previously–saved mission profile with a new simulation. This selection allows you to repeat a mission's flight dynamics and failure modes, both of which are normally random, for a new simulation. Only available after the simulator has been reset.

Preferences… allows you to choose options that affect how you use the simulator. These options are saved even after you quit A-OK! The preferences include:



Enable Ground Station Warnings: Enables the audio reception of ground station reports about possible problems and suggested fixes.

Enable Checkout Audio during Reset: Plays highlights from the countdown of Friendship Seven during startup and when the simulation is being reset.

Difficulty Level: As the level of difficulty increases, the number of anomalies and emergencies increase, requiring increased manual operation by the astronaut. At the highest level of difficulty, it is unlikely that you will be able to complete the mission successfully and your challenge will be to abort at the proper time!

At all difficulty levels: You can initiate events manually. However. if you do something reckless (like deploying all your parachutes in orbit), you will jeopardize the mission and more–than–likely lose your simulated life! You can control the spacecraft's attitude manually using FBW, MAN or RSCS. Again, if you drain your fuel tanks dry, you will be unable to control the spacecraft. So be warned, reckless event initiation and attitude control will have disastrous results, even at the "Easy" level!

Easy: All spacecraft systems will be 100% operational, including the Programmer and ASCS, which will allow you to just sit back and watch.
If ASCS is turned off, the spacecraft will not experience any random attitude rates. Similarly, retrofire and reentry will not induce attitude rates either.

Average: All spacecraft systems will be 100% operational at the start of the mission. When not on ASCS NORM or AUX DAMP, the spacecraft will experience random attitude rates in pitch and yaw *only*. Retrofire and reentry will induce attitude rates that must be controlled if not on ASCS NORM or AUX DAMP. You will experience up to two minor system problems during the mission.

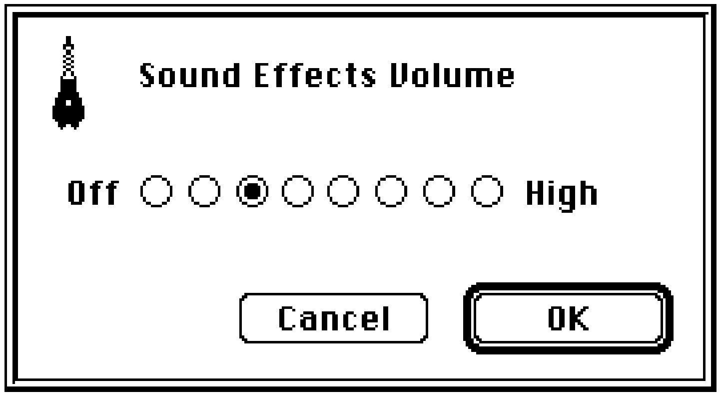
Difficult: Sometime during the mission (usually fairly early), the Programmer will fail, requiring you to initiate every subsequent event *manually*. When not on ASCS, the spacecraft will experience random attitude rates in pitch, yaw *and* roll. Retrofire and reentry will induce attitude rates that must be controlled if not on ASCS. At some point during the mission, ASCS will fail and you will be *required* to fly the spacecraft manually.

In addition to the ASCS and Programmer failures, at *least* two minor system problems will arise during the mission. Finally, there is a strong possibility of either an abort condition arising during ascent, or a major system failure during orbit or descent!

Joystick Sensitivity allows you to adjust how fast the thrusters respond to the movement of the joystick or mouse.

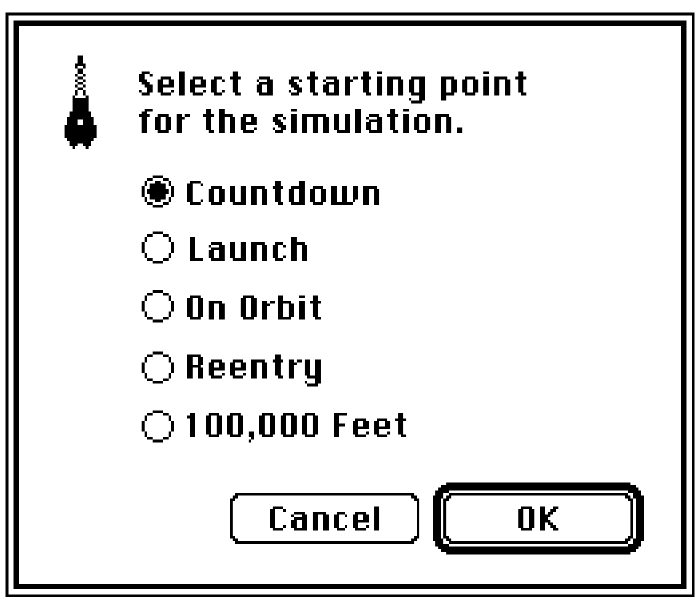
Joystick Null Zone allows you to adjust how far the joystick or mouse has to move before actuating the thrusters.

Volume allows you to adjust the volume of the simulator's sound effects and transmissions.



Quit A-OK! quits the program after first verifying that you really do want to quit.

Start Simulation… will prompt you to select a starting point. Click one of the radio buttons to make your selection and then click "Start." The starting points are outlined below:



Countdown starts at the T minus three minute mark in the countdown. You should verify the positions of all switches and the status of all indicators in the capsule using the appropriate Checklist. You will also hear the launch director verify key countdown milestones. When you have successfully completed the PreLaunch Check turn the LAUNCH CONTL switch to READY.

Launch or T minus zero, is the exact moment of engine ignition. If you choose this starting point, you can assume a clean PreLaunch Check: all capsule switches will be properly set for launch.

On Orbit is only available on the orbital mission. It starts the simulation at T plus seven minutes. At this point, the capsule is in orbit, is separated from the Atlas booster and has automatically turned around to the retrograde attitude. You can assume that all launch phase events worked properly and that all switch positions are correct for initial orbital operations.

Reentry is only available on the orbital mission. It starts the simulation at T plus four hours, thirty nine minutes. At this point, the capsule is in the proper attitude and is about to reentry the earth's atmosphere. You can assume that all previous mission events occurred properly and that all switch positions are correct for the reentry operation.

100,000 Feet is only available on the orbital mission. It starts the simulation at T plus four hours, forty two minutes. At this point, the capsule has just successfully competed the reentry operation and is at an altitude of 100,000 feet falling at a speed of 1600 feet per second. You can assume that all previous mission events occurred properly and that all switch positions are correct for the terminal phase of the mission.

In addition to these starting points, you can practice retrograde operations by selecting "On-orbit" and initiating retrograde by either pressing the RETRO SEQ START switch or programming a new retrograde time by selecting "Reset Retro Timer..." on the "Commands" menu.

Fast Fwd Simulation will speed up the simulation to the fastest speed your computer capable of. On a 25 Mhz 68040, for example, the simulation will run at almost three times real time. You can use this feature to improve performance on a slower machine or to fast forward from one point in the mission to another. A check mark indicates that the simulation is running in fast forward mode.

Pause Simulation will stop the simulation. Most capsule switches are still operational and you can bring up the Flight Plan or move around the control panel. Time and consumable (oxygen, coolant and fuel) use are suspended. However, operating any of the manual attitude control modes will consume fuel and switching to the emergency oxygen rate or re–compressing the cabin will consume oxygen.
Additionally, many Programmer events can still be initiated manually.

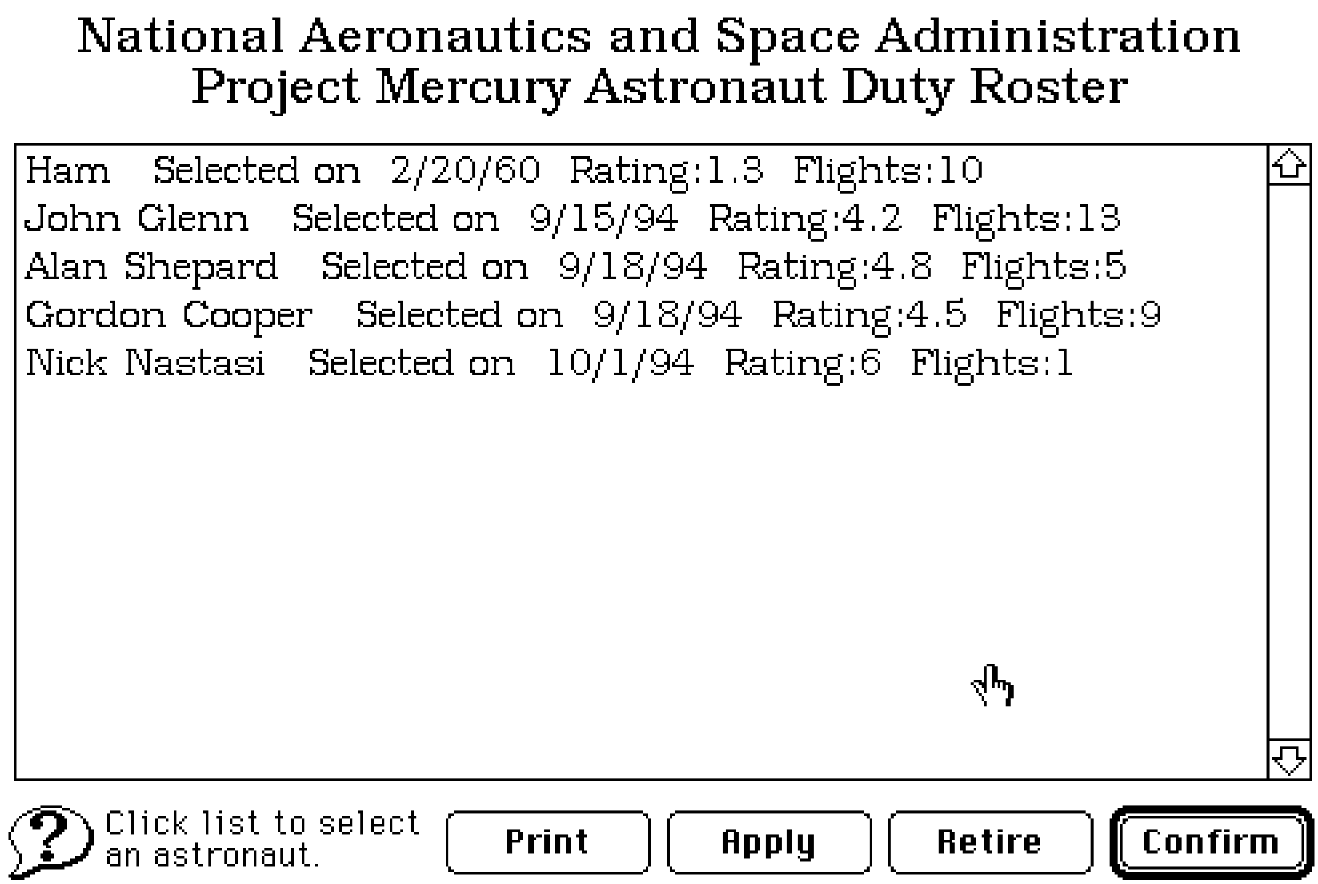
Continue Simulation continues the simulation from where it was paused.

Reset Simulation resets all simulator systems. Since you will not be able to return to or save the current simulation if you select this option, you will be asked to confirm the reset.

Reset Retro Timer… allows you to reset the timer that controls the time of retro sequence start. You will be prompted to enter the new retrofire time in hours:minutes:seconds. This option does not check for a valid retrograde time, so reset it with care! If the retro rockets have already been fired, this selection is disabled. The Retro Timer can, also be reset using the Retrograde Reset Handle immediately below it.

Show Panel Selection Palette opens the palette if you have previously closed it. If the palette is still visible, this selection is disabled.

Astronaut Duty Roster… displays a list of astronauts from which you can select to fly the next mission. The selection date, rating and total flight experience is displayed for each astronaut. Each of the buttons on this screen are explained below.



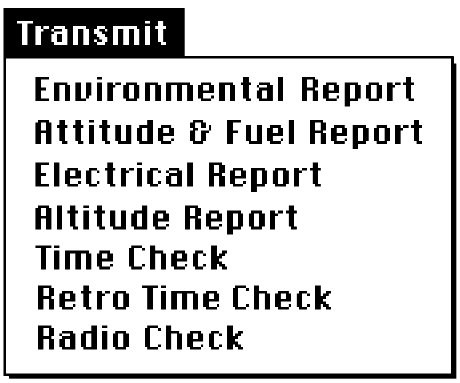
Confirm allows you to choose the astronaut highlighted (by clicking his or her name) for the next mission. Double–clicking the name is an alternate way to choose an astronaut.

Retire deletes an astronaut from the duty roster.

Apply allows you to add a new name to the duty roster. If this button is clicked the following dialog box is displayed, prompting you for the first and last name of the applicant (separated by a space) and the applicant's sex.

Print will print the entire duty roster to a printer.

? turns balloon help on and off.



This menu gives you a choice of following status requests that will be transmitted to the ground station. If you are out of range or there is an anomaly within the communication system, your transmission will not go through.

Environmental Report You will receive the current environmental telemetry: oxygen quantity, coolant level, etc.

Electrical Report You will receive the current electrical telemetry: voltage levels and power consumption.

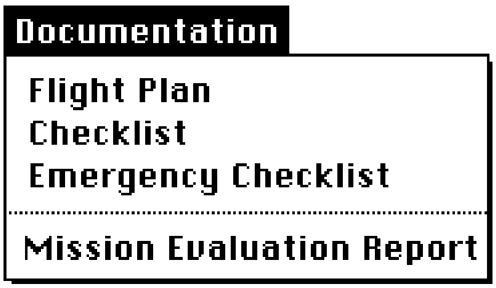
Attitude & Fuel Report You will receive the current attitude and fuel quantities.

Altitude Report You will receive the current altitude in thousands of feet or nautical miles when altitude is over 100,000 feet..

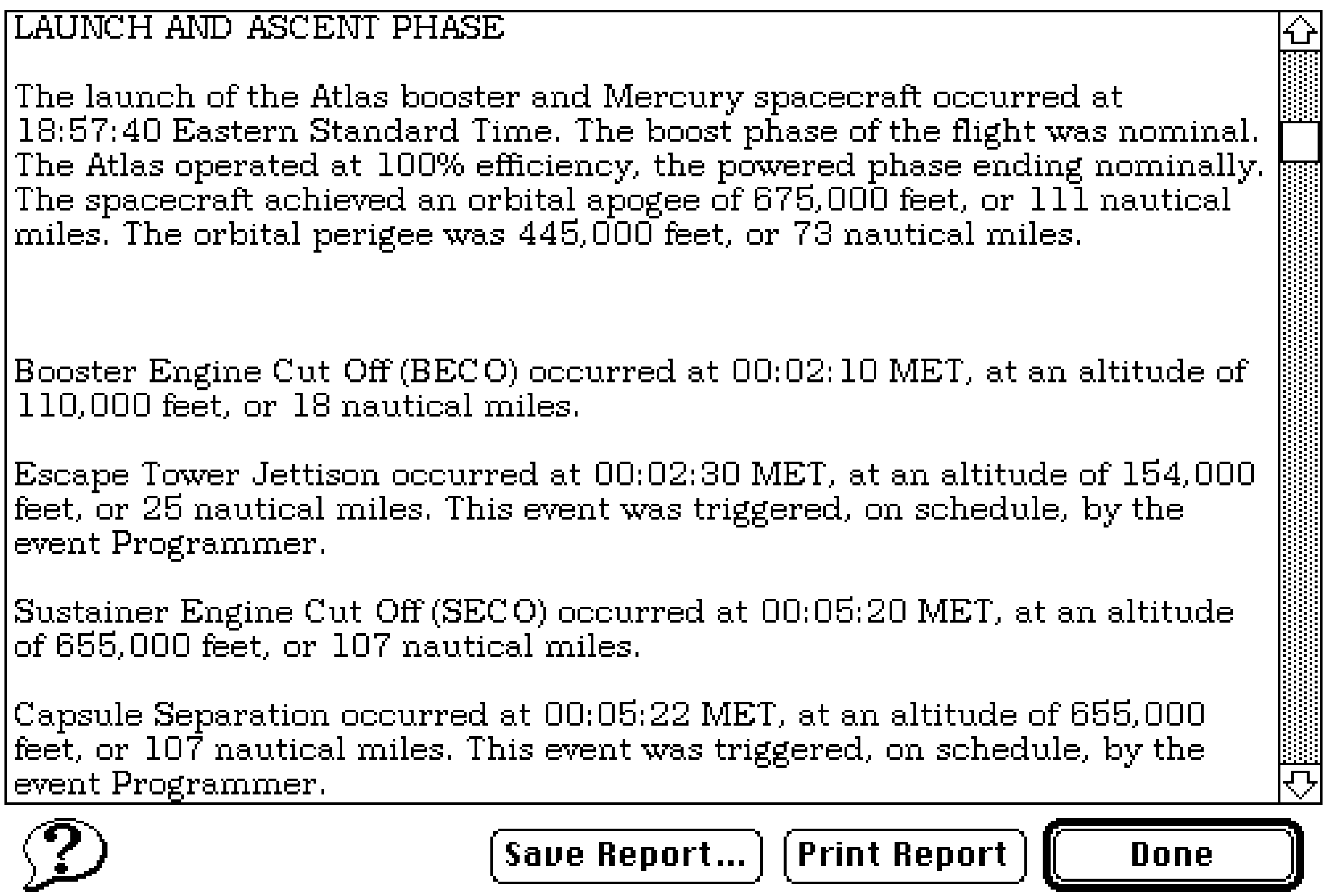
Time Check You will receive the current mission elapsed time and time to retrograde, if appropriate.

Retro Time Check You will receive an updated retrograde time for the next available landing zone, the end of the current orbit, and the end of the mission..

Radio Check You will receive a verification of your transmission including the frequency you transmitted on. The ground station will identify itself.



Mission Evaluation Report produces a report that time–tags all major events, displays final telemetry readings and evaluates astronaut/spacecraft performance. This item is only available when a mission has completed. See section 21 for more information.



Save Report… allows you to save the report to a text file.

Print Report prints the report to the currently–selected printer.

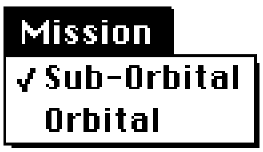
Done returns you to the Mercury cockpit..

? turns balloon help on and off.

Flight Plan brings up a time–ordered list of all major flight events from countdown to splashdown. This on–line document may be kept open during the simulation.

Checklist brings up a quick reference for all normal flight procedures. This on–line document may be kept open during the simulation.

Emergency Checklist brings up a quick reference of all emergency flight procedures. This on–line document may be kept open during the simulation.



The items in this menu are not available while a simulation is running or paused. You must reset the simulation before you change Mission modes. The simulator automatically adjusts all required parameters, including flight documentation, when Mission modes are changed.

Sub–Orbital selects a fifteen minute Mercury/Redstone mission.

Orbital selects a three orbit Mercury/Atlas mission.

Balloon Help allows you to select or de–select System 7 balloon help. When Balloon Help is enabled, A-OK! will display a description of each control, switch, gauge and indicator on the control panel.

Simulation Failure Scenarios

As stated in Section 16, you can select three levels of difficulty for a simulation run. Depending on the difficulty level (which is adjusted by selecting “Preference…” from the “File” menu), a variety of failure scenarios will be *randomly* generated. At any time during or after a simulation, you can save a mission profile using by selecting “Save Profile…” from the “File” menu. Previously saved mission profiles may be loaded, *after* the simulation is reset, by selecting “Load Profile…” from the “File” menu. If you’d rather not know what can happen, stop reading! All of the possible failure scenarios are listed and explained below.

Failures are divided into two types: time–based, those occurring at a preset time, randomly selected during the mission, and event–based, which are failures in systems that are used once (the main parachute, for example) and will fail upon activation. Most failures are recoverable, but when the difficulty level is set to “Difficult,” some failures are unrecoverable. Consult the Emergency Checklist for the exact step–by–step procedures. Since it is impossible for NASA to simulate *all* failures, you may have to find solutions to anomalies on your own. As an example you may want to try clearing up a faulty system by switching its power off and on.

Event-based failures

Roll Program Failure

Instead of the nominal 2.5°/second roll program, the launch vehicle will develop an ever–increasing roll rate and will not stop at the proper roll angle of 0°. This failure can only be corrected by a launch abort. In this scenario, the Abort Sensing & Implementation System (ASIS) will detect the excess roll rate when it reaches 5°/second and inform you by illuminating the ABORT warning light and sounding an audible alarm. ASIS will fail to actually initiate the abort sequence. You must do this manually (by typing a *command–A*) within 7 seconds, otherwise the excessive rate will tear the launch vehicle apart. Since test range rules require the destruction of any launch vehicle operating in a manner that could cause it to crash in populated areas, the Range Safety Officer will have no choice but to destroy the vehicles, ending the simulation. Since a sub–orbital mission does not require a booster roll program, this failure is limited to orbital missions.

Pitch Program Failure

Instead of the nominal 0.5°/second pitch program, the launch vehicle will develop an ever–increasing pitch rate and will not stop at the proper pitch angle of 0° for orbital missions (45° sub–orbital). This failure can only be corrected by a launch abort. As with the Roll Program Failure, the Abort Sensing & Implementation System (ASIS) will detect the excess pitch rate when it reaches 5°/second and inform you by illuminating the ABORT warning light and sounding an audible alarm. ASIS will fail to actually initiate the abort sequence. You must do this manually (by typing a *command–A*) within 7–10 seconds, otherwise the excessive rate will send the launch vehicle on an uncontrolled trajectory, Since test range rules require the destruction of any launch vehicle operating in a manner that could cause it to crash in populated areas, the Range Safety Officer will have no choice but to destroy the vehicles, ending the simulation.

Tower Jettison Failure

The escape tower will fail to automatically jettison at 150,000 feet and will not respond when commanded manually by pulling the JETT TOWER switch. If this condition remains uncorrected, it will result in failures during descent because deployment of the parachutes requires that the escape tower is jettisoned.

17.2

Capsule Separation Failure

The spacecraft will fail to separate from the booster after engine shutdown and will not respond when commanded manually by pulling the SEP CAPSULE switch. The excess weight and drag of the launch vehicle will cause the spacecraft to start to reenter into the earth's atmosphere if this condition is not corrected within a minute of the initial failure. If the spacecraft is not immediately separated and put into the proper reentry attitude, the simulation will end with the spacecraft being incinerated.

Fire Retro Failure

In this scenario, the retrograde firing sequence will not start automatically after the 30 second delay or by manually pressing the FIRE RETRO switch. Failure to initiate retrofire within a short time frame will result in the recovery zone being overshot. See Section 10 "Retrograde Description & Operation," for additional information on the relationship between retrograde time, orbital height and landing accuracy. If the problem can not be resolved within a few minutes, it might be better to plan for a new recovery zone as long as there are no other major problems.

Retro Rocket Failure

The second and third retro rockets have blown fuses and are not operational. Failure to correct this will result in the spacecraft remaining in orbit because one retro rocket does not have sufficient thrust to slow the spacecraft down for reentry. As with the Fire Retro Failure, the less the completion of retro rocket ignition deviates from to the correct time, the less the landing error will be.

Drogue Parachute Failure

The drogue parachute will fail to deploy at 22,000 feet and will not deploy manually when the DROGUE switch is pressed. If the drogue parachute is not deployed, the spacecraft will be traveling too fast to properly deploy the main parachute. This will damage the main chute and result in a dangerously high descent rate. If this should happen, successful deployment of the reserve parachute should arrest the descent rate to a safe 30 feet/second.

Main Parachute Failure

The main parachute will fail to automatically deploy at 10,000 feet and will not deploy manually when the MAIN switch is pulled. If the main parachute is not deployed, the spacecraft will crash unless the reserve parachute is manually deployed.

Reserve Parachute Failure

In this scenario, the reserve parachute fails to deploy when commanded by pulling the RESERVE switch. Since this is the last level of backup for landing, it is essential that this failure be corrected while the spacecraft is at least 2,000 feet from impact to allow proper deployment. Otherwise, the spacecraft will crash.

Landing Bag Failure

The landing bag will fail to automatically deploy at 9,000 feet and will not deploy manually when commanded by moving the LANDING BAG switch to MAN. If this failure remains uncorrected, the spacecraft and astronaut will be subjected to high "G" loads upon landing that will result in major injuries.

Time-based Failures

ASCS Failure
The Automatic Stabilization & Control System, including Rate Stabilization, will experience an internal electronic glitch and cease to operate. At the “Average” level, you should be able to correct the problem. At the “Difficult” level, key components will fail permanently; you will have to control spacecraft attitude manually using MP or FBW.

DC Power Failure
The main battery will fail with an undervolt condition. If the difficulty level is “Average,” the electrical system will switch to the standby battery automatically. If the level is “Difficult,” you must switch the standby battery in manually. Finally, the standby battery will *also* fail within five minutes if the difficulty level is set to “Difficult.”

DC Isolated Battery Failure
The Isolated Battery will fail with an undervolt condition. At the “Difficult” level, this failure may be combined with with the DC Power Failure described above. Therefore, while not having immediate consequences, *all* DC power failures should be taken seriously.

AC Inverter Failure
The ASCS AC inverter will fail. You may power ASCS with the Fans AC inverter, but only for short periods; the combined load will cause the Fans inverter to overheat and fail. At the “Difficult” level, both AC inverters will fail at the same time. Lack of AC power will prevent the cabin and suit fans from operating, and the only attitude control available will be Fly–By–Wire and Manual Proportional.

Oxygen Regulation Failure
A failure in the cabin pressure regulator will cause oxygen to be consumed at a higher than normal rate. If at the “Difficult” level, the consumption rate will be ten times higher.

Cabin Pressure Failure
In this scenario, a cabin structural weld will fail. Oxygen will start leaking out of the cabin at a slow rate if at the difficulty level is set to “Average” and at a higher rate if the level is “Difficult.” The mission should be ended as soon as possible.

Fuel Leak Failure
A pressure valve will rupture and the Manual Fuel tank will loose about 50% of its contents. At the “Difficult” level, the force of the rupture will cause a large leak in a fuel line coming from the Automatic Fuel tank, leaving about 10% of fuel. At best, this will certainly cut the mission short.

Programmer Failure
The programmer electronics will blow a fuse due to a temporary power surge. At the “Average” level, this failure is recoverable, but at the “Difficult” level, the surge will permanently damage some relays. This will force all sequenced operations to be executed manually.

17.4

Telemetry Failure

In this scenario, the telemetry receiver electronics has blown a fuse. A request for certain readings will cause the ground station to confirm the absence of the telemetry downlink. This failure is not usually permanent.

Sample Mission Profiles

These Mission Profiles are designed as a convenient way to train for specific mission failures. Each Mission Profile is described below. Although starting points are suggested, you may start a simulation at any point when using these profiles. However, starting a simulation *after* scheduled failures does not make any sense, such as starting the Launch Event Failure profile at 100,000 Feet!

Launch Event Failures

This Mission Profile simulates a complete failure of the event Programmer, and the JETT TOWER and the SEP CAPSULE events. It may be started either at Countdown or Launch. Both JETT TOWER and SEP CAPSULE events will fail requiring activation using the procedures described in the Emergency Checklist. The Programmer will attempt to initiate the JETT TOWER event about 20 seconds after Booster Engine Cut Off (BECO). The JETT TOWER telelight will glow red since the event has failed.

At 00:03:30 MET, the event Programmer will also fail. Since the Programmer has failed, the SEP CAPSULE event will not be automatically initiated. Pulling the SEP CAPSULE ring will cause its telelight to glow red until successfully activated using emergency procedures.

Retro/Reentry Failures

This Mission Profile simulates multiple failures during Retrograde operations and should be started On Orbit. The Automatic Stabilization and Control System (ASCS) will not function which means all attitude control must be accomplished using Fly–By–Wire (FBW) or Manual Proportional (MP). You should manually reset the Retro Timer to a new retrograde time, preferably a time that will cause splashdown at a recovery zone. Note: 1B is the first available zone upon achieving orbit.

The RETRO SEQ START event will start at the time you reset the Retrograde Time clock to. At that time, the RETRO SEQ START telelight will glow green. The RETRO ATT telelight will then glow either green or red depending on whether or not the spacecraft is in the correct retrograde attitude of 0° yaw, 0° roll and -34° pitch (+/- 15°). Since ASCS is not functional, the spacecraft's attitude at RETRO SEQ START will depend on whether or not you maintained proper attitude before this event. The RETROFIRE event will attempt to fire the retrorockets 30 seconds later. Since there is a failure, you must use the procedures described in the Emergency Checklist to fire the retrorockets. Time is of the essence because each minute of delay will cause the spacecraft to miss the recovery zone by 50 miles! Remember: ASCS is non–functional so you will have to hold attitude during retrofire.

Once retrograde is complete, the Programmer will attempt to jettison the retrograde package about two minutes later, assuming that the AUTO RETRO JETT switch is set to ARM. This will also fail, as indicated by a red JETT RETRO telelight, and require emergency procedures. Normally, this event also signals ASCS to position the spacecraft into the reentry attitude of 2° pitch, but that will have to be performed with FBW or MP. About 10 minutes later, reentry begins as signaled by the "LOS in five minutes" call and the red glow out the window. The .05G roll maneuver will fail and you must keep the attitude rates under control manually, with Rate Stabilization and Control System (RSCS) being the preferred mode during reentry.

Descent Event Failures
This Mission Profile simulates a complete failure of the event Programmer, the Landing Bag, the Rescue Aids and the Drogue, Main, Reserve parachutes. It should be started at 100,000 Feet. These events will fail requiring activation using the procedures described in the Emergency Checklist. The Programmer will fail immediately, so none of the descent events will happen automatically with the exception of the Snorkel deployment.

Electrical Failures
This Mission Profile should be started On–Orbit. At 00:08:00 MET, both primary AC Inverters will fail. The standby AC inverter will initially be switched to the Fans AC bus, which will cause ASCS to be shut down. Setting the STBY INVERT switch to EMER AC will allow the standby inverter to power both buses.

The Main DC battery will fail at 10:00 MET. The Main DC bus will not automatically switch to the standby battery and the STBY DC AUTO Warning Light will not illuminate, so a low voltage reading and inoperative equipment will be your only cue that something is wrong.

At 00:15:00 MET, the standby battery will also fail. This will leave spacecraft systems powered only by the Isolated Battery. To operate in this mode, the ISOL BATT switch must be in the STBY position.

At 00:30:00 MET, the Isolated battery will fail. At this point, if the spacecraft is not at least on a safely-deployed Main parachute, the simulation will end in a crash because without power, the squibs cannot deploy any parachutes. If the spacecraft is still in orbit when the Isolated battery fails, the simulation will end with the spacecraft stranded in orbit.

ECS Failures
This Mission Profile should be started On–Orbit. At 00:10:00 MET, the cabin will develop a severe pressure leak. The CABIN PRESSURE gauge will decrease from 5.5 psi to 0 psi in about a minute. The pressure suit will keep you alive, *however*, mission rules stipulate that the flight be ended at the next recovery zone.

At 00:15:00 MET, the suit oxygen regulator will fail. This failure, coupled with the cabin pressure leak, is consuming oxygen at an *extremely* rapid rate. If left unchecked, this condition will deplete the entire oxygen supply in minutes. You should engage the emergency oxygen rate by pulling the EMER O2 handle to the left. This will by–pass the failed regulator and bring oxygen consumption down to an acceptable rate.

If retrograde has not occurred by this time, retrofire should be initiated immediately. Even if the emergency oxygen rate is engaged, oxygen consumption is higher than normal. Keep in mind that you will need oxygen after retrofire, during reentry, and until about 20,000 feet. If the oxygen supply is exhausted before the snorkel is deployed, the simulation will end.

Abort with Tower Jett Failure
This Mission Profile may be started either at Countdown or Launch.. A few seconds after the pitch program starts, the booster will start to develop severe pitch rates. You will have about 30 seconds in which to abort the mission. There is another problem. The Programmer will fail to jettison the Escape Tower. Since the parachutes will not deploy with the Escape Tower still on the spacecraft, you have just a few seconds to jettison the tower so that the Drogue and Main parachutes can deploy. However, be

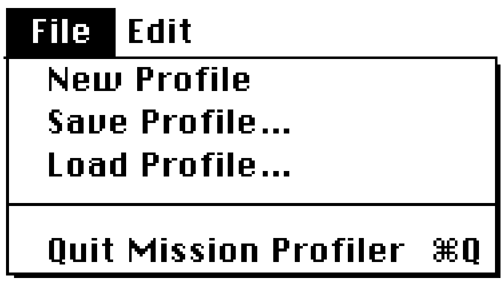
prepared to actuate these events using emergency procedures. You can buy yourself an extra few thousand feet by delaying the abort, but you run the risk of having the booster break up or be destroyed by the RSO.

Mission Profiler Utility

This utility will allow you to create your own Mercury mission profiles or modify the ones generated (as long as you saved them) by A-OK! The Wings of Mercury. The Mission Profiler is a HyperCard stack and will work with HyperCard 2.1, 2.2 or the HyperCard Player.

Menu Descriptions

When first started, the Mission Profiler will list all systems and failures as "go" or basically a clean mission. Before we get into generating failures, let's look at the "File" menu at the top of the screen.



New Profile resets any profile you may have been working on.

Save Profile… allows you to save the mission profile currently being edited.

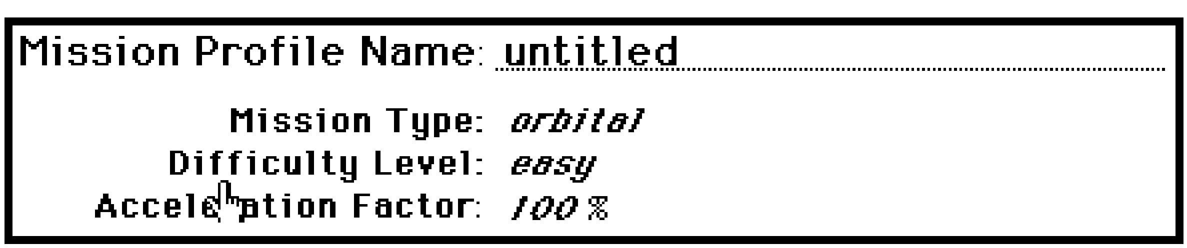
Load Profile… allows you to load a previously generated mission profile.and save profiles.

Quit Mission Profiler quits the Mission Profiler after verifying that you really do want to quit.

Notes: A Mission Profile can also be opened by any text editor, but if modified, the Mission Profile can become unloadable by either the Mission Profiler or A-OK!. If you load a Mission Profile generated by version 1.0 of A-OK!, it will be converted to the latest version. A dialog box will let you know when this takes place. Since it does not read version 1.0 profiles, you should save the newly-converted profile before using it in later versions of A-OK!. The "Edit" menu is not used in the Mission Profiler.

General Information Section

The box on the bottom left of the Mission Profiler screen contains the Mission Profile Name, which you can change by moving the cursor over the field. The cursor will change from a hand to an I bar. Clicking will allow you to edit using standard Macintosh editing procedures.



Other fields in this box allow you to change the Mission Type (orbital or sub-orbital), the Difficulty Level (easy, average or difficult) and the Acceleration Factor (100—95%). The Mission Type, Difficulty Level and Acceleration Factor fields (the boxes with the italic font) are changed by clicking them. As each is clicked, the field will cycle through all possible values.

The Difficulty Level normally decides what type and frequency of failures occur, but when you build a Mission Profile from scratch, the Difficulty Level is used only to introduce varying levels of attitude drift and to determine if you can recover from some failures. Read Section 16 for more information on the Difficulty Level.

The Acceleration Factor basically varies the performance of the booster (either Redstone or Atlas) and therefore, varies the orbital altitude at BECO or the peak altitude on a sub–orbital mission. When this field is 100%, booster performance is at its maximum efficiency. As this number decreases, so does the booster's performance.

Status & Failure Section

This section allows you to enable and disable failures.

System Status	Event Status	Time-Based Failures
1 ASCS: *go*	Booster Roll Program: *go*	1 ASCS: *go*
2 Programmer: *go*	Booster Pitch Program: *go*	3 DC Power: *go*
Audio Bus: *go*	Tower Jettison: *go*	4 DC Isolated Battery: *go*
3 DC Power: *go*	Capsule Separation: *go*	5 AC Inverter: *go*
4 Isolated DC: *go*	Retro Sequence: *go*	Oxygen Regulation: *go*
5 AC Inverter: *go*	Fire Retro: *go*	Cabin Pressure: *go*
Standby AC: *go*	ASCS .05G Roll: *go*	Fuel Leak: *go*
ASCS AC: *go*	2 Retro Jettision: *go*	2 Programmer: *go*
Fans AC: *go*	Drogue Chute: *go*	Telemetry: *go*
Retro Rocket #1: *go*	Main Chute: *go*	
Retro Rocket #2: *go*	Reserve Chute: *go*	
Retro Rocket #3: *go*	Landing Bag: *go*	
	Rescue Aids: *go*	

System Status
This section allows you to disable various systems. If a system's status is *nogo*, it will be non–operational from whatever point the simulation is started. Note that the systems marked with a numerical code can also be disabled by the Time-Based Failure that has the same code. As each field is clicked, the display will cycle between *go* and *nogo*.

17.8

Event Status

This section allows you to disable specific sequenced events. If the Programmer Failure is set, the events marked with the code 2 will not be initiated automatically, but are still available manually unless disabled in this section. The first two events are controlled, not by the spacecraft's programmer, but by the booster. These failures can be set to two levels: *nogo 1* and *nogo 2*. The difference is the rate at which the attitude rates build up, *nogo 2* being the fastest. As each field is clicked, the display will cycle between go and *nogo*, or *go*, *nogo 1* and *nogo 2*.

Time–Based Failures

This section allows you to schedule a Time-Based Failure for any point during a mission. Clicking on a display while it shows *go* will bring up a dialog box that asks for the time you would like to schedule the failure. While the time you enter is checked for proper time syntax (HH:MM:SS), the Mission Profiler does not check for an appropriate time entry. It is possible, for example, to schedule a failure after the scheduled end of a mission. If you click in a field with a time displayed, it will change back to *go*.

Notes:

> If you schedule a Time–Based Failure and set its corresponding System Status to *nogo*, the system will be disabled at the start of the simulation, not at the time you just entered. Since it is possible to re-enable some systems after they fail, setting a System Status to *nogo* and scheduling a Time–Based Failure that affects the same system will present the following scenario. If a system is non–operational initially and, if the astronaut succeeds in restoring it to operational status, it will fail again at the time scheduled by the Mission Profiler.
>
> Since A-OK! can handle more than one event per second, you may set the failure time to any time. This feature allows you to set up multiple failures to occur on exactly the same time. For example, you could set the DC Power Failure and DC Isolated Battery Failure to occur at 00:07:00 MET, simulating a major power problem early in an orbital mission.

In-Flight Experiments

Project Mercury, although essentially an engineering program, supported several scientific and technology experiments not directly related to the program's objectives. These experiments included in–flight photography, medical and visual acquisition and tracking. You will be required to perform the following experiments during your mission and failing to do so will affect your rating for that mission. Conversely, performing additional experiments will increase your rating.

Blood Pressure Experiment

Medical data such as heart rate, respiration and body temperature are monitored automatically by sensors placed on the astronaut's body. Blood pressure readings require manual initiation by the astronaut. The blood pressure measuring system consists an occluding cuff which is attached internal to the pressure suit, a pulse sensor, a pressure transducer, and a pressure source.

Manual operation is started by depressing the BLOOD PRESS START switch. This action opens a valve that pressurizes the cuff with oxygen at a pressure of 4.4 psi. The cuff then bleeds off until 0.75 psi is reached in approximately 25 seconds. During this cycle the pulse rate and pressure are transmitted to the ground. Depressing BLOOD PRESS STOP releases the pressure completely and stops measurements.

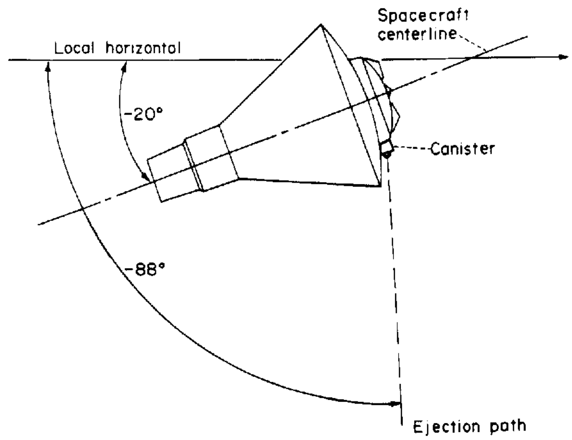
The spacecraft must be in range of a ground station and the telemetry system must be operational in order for a measurement to be received. Additionally, stopping the measurement cycle early will ruin the data. Therefore, BLOOD PRESS STOP should not be depressed for at least 30 seconds after starting the measurement. If you have the "Enable Ground Station Warnings" option checked in the "Preferences" dialog box, you will be notified when the ground has received a good blood pressure reading.

Sub-orbital missions should include at least four blood pressure readings. Orbital missions should include at least three readings per orbit. If the minimum readings are not taken, your rating will be lowered. Your rating increases if you send more measurements than are scheduled. Refer to the Flight Plans for the schedule measurement times and the Checklists (Section 19) for the detailed BLOOD PRESSURE procedure.

Flashing Beacon Experiment

This experiment investigated the problem of visually finding and tracking an object while in orbit. This was a necessary precursor to the ability for two spacecraft to rendezvous. This experiment was actually performed on Gordon Cooper's 22 orbit MA–9 mission, however it is included in A-OK!'s three orbit simulation. Obviously, this experiment is not performed on sub–orbital simulations.

A flashing beacon will be ejected from the spacecraft and tracked by the astronaut at varying distances in orbit. The beacon is a six–inch–diameter sphere weighing about ten pounds and equipped with two xenon gas–discharge lamps located at opposite poles. These lamps flash simultaneously at a rate of one signal per second and are powered by mercury–cell batteries with a lifetime of over five hours. The beacon is designed to appear as a second magnitude star when viewed at a distance of eight nautical miles during the night portion of an orbit.



Beacon Deployment Attitude

The beacon is stowed in a small canister mounted on the retrograde package and is ejected from this canister by a spring at a rate of 10 feet/second. Deployment is accomplished by turning the BEACON EXPER switch to DEPLOY. The spacecraft must be at a very specific attitude for proper deployment of -20° Pitch, 0° Yaw, and 0° Roll. This attitude will provide an ejection path of -88° below the horizon.

The time of deployment is also crucial. The beacon should be deployed at 00:45:00 Mission Elapsed Time, within plus or minus 30 seconds. If deployment is too late or too soon, the beacon's path will not be correct and it will be almost impossible to acquire it visually.

After a successful deployment, the beacon should be visible as soon as the spacecraft enters a night pass, although you should wait until the scheduled time before positioning it. The proper attitude for each beacon sighting is -20° Pitch, 180° Yaw, and 0° Roll. At that attitude, a properly–deployed beacon should appear in the center of the window. After sighting and tracking the beacon, you can return to normal attitude of -34° Pitch, 0° Yaw, and 0° Roll, and then try to re–acquire the beacon, provided the mission is proceeding normally and control fuel quantities are adequate.

Your rating will suffer if you fail to deploy the beacon properly or to sight it at least once per night pass. You will gain an additional point if you can re–acquire the beacon more than once on a night pass. Refer to the Orbital Flight Plan for exact deployment and tracking times, and the Orbital Checklist (Section 19) for the following procedures: BEACON DEPLOY and BEACON OBSERVE.

Attitude Control Experiments

An orbital mission has five planned experiments involving attitude control. The first one tests the feasibility of tracking an object (the booster) in orbit. The next three are intended to evaluate each type of astronaut control mode: Manual Proportional (MP), Fly–By–Wire (FBW), and the semi–automatic Rate Stabilization and Control System (RSCS). See Section 4 for a detailed description of each system. The final experiment is intended to evaluate the astronaut's ability to recover from drifting flight. Sub–orbital missions will only include the FBW experiment. If you have the "Enable Ground Station Warnings" option checked in the "Preferences" dialog box, you will be notified of the start and ending time of each experiment. With the exception of the Drift Recovery Experiment, you can use ASCS to return the spacecraft to nominal retrograde attitude.

Booster Observation
The booster (Redstone for sub–orbital, Atlas for orbital) should be visible after turnaround. After the turnaround sequence, the spacecraft should be moved down to –50° Pitch. Once the booster is acquired, move to 20° Yaw and back to 0° Yaw to test your ability to track the booster in the Yaw axis. Return the spacecraft to nominal attitude. Any attitude control mode may be used for this experiment. In sub– orbital missions, you must perform this quickly as not to fall behind. In orbital flight, you will have a time slot in the flight plan, but can acquire the booster during the first 30 minutes of orbit before it falls out of orbit.

Fly–By–Wire Check
The spacecraft should be in the nominal attitude of -34° Pitch, 0° Yaw, and 0° Roll prior to the start of the test, which is scheduled for 00:16:00 MET. After switching for FBW, the spacecraft should be moved to an attitude of -14° Pitch, 340° Yaw, and -20° Roll, one axis at a time: pitch, then yaw, then roll. This attitude should be held until the end of the experiment period which is five minutes in duration.

The parameters for this experiment are different for the sub–orbital mission, mostly due to the short duration of the mission. The final attitude should be -14° Pitch, 340° Yaw, and 0° Roll, or no roll movement. The duration of the test is two and a half minutes. The attitude should be held until that time.

Manual Proportional Check
The spacecraft should be in the nominal attitude of -34° Pitch, 0° Yaw, and 0° Roll prior to the start of the test, which is scheduled for 00:25:00 MET. After switching for MP, the spacecraft should be moved to an attitude of -20° Pitch, 180° Yaw, and 0° Roll, one axis at a time: pitch, then yaw. As before, the final attitude should be held until the end of the experiment period. This is also a rehearsal for achieving the attitude required for observing the flashing beacon experiment.

Rate Stabilization and Control System Check
The spacecraft should be in the nominal attitude of -34° Pitch, 0° Yaw, and 0° Roll prior to the start of the test, which is scheduled for 01:35:00 MET. After switching for RSCS, the spacecraft should be moved to an attitude of 0° Pitch, 30° Yaw, and 20° Roll, one axis at a time: pitch, then yaw, then roll. As before, the final attitude should be held until the end of the experiment period.

Drift Recovery Experiment
In several Mercury missions, drifting flight was used as means of fuel conservation. This experiment investigated the astronaut and spacecraft's ability to recover from extreme attitudes as a result of drifting flight. The experiment starts at 02:55:00 MET, when the spacecraft is placed in an attitude of -34° Pitch, 0° Yaw, and 0° Roll. The Automatic Stabilization and Control System (ASCS) is then powered off and the gyros caged. The drifting period will last for 30 minutes during which no attitude changes should be made except in response to emergencies.

At 03:25:00 MET, the astronaut should chose either MP or FBW and position the spacecraft back to the nominal attitude of -34° Pitch, 0° Yaw, and 0° Roll. RSCS or ASCS should not be used unless you are experiencing difficulty in correcting the spacecraft's attitude.

Your rating will suffer if you fail to complete any of the attitude control experiments. Refer to the Flight Plans for the start times of each attitude control experiment and the Checklists for the following procedures: FBW CHECK, MP CHECK, RSCS CHECK, DRIFT MODE, and DRIFT RECOVERY.

18.4

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Sub-Orbital Flight Plan

T-00:05:00 Entrance Check
T-00:03:00 Prelaunch Check
T-00:00:30 Ready switch
T+00:00:00 Launch
T+00:00:16 Pitch Program
T+00:02:30 BECO, Tower Jettison, Cap Sep
T+00:02:30 BECO CHECK
T+00:02:35 Turnaround Program
T+00:03:10 FBW CHECK
T+00:04:10 BOOSTER OBSERVATION
T+00:04:30 RETROGRADE CHECK
T+00:04:45 RETROGRADE
T+00:05:15 Retrofire
T+00:06:15 Retro Jettison
T+00:06:20 RE-ENTRY
T+00:07:15 .05g
T+00:15:30 LANDING

Sub-Orbital Checklist

ENTRANCE CHECKS:
1. All fuses - NO.1
2. Squib switch - OFF
3. Auto Retro Jett switch - OFF
4. ASCS switch - NORM
5. RSCS switch - AUTO
6. Gyro switch - GYRO NORM
7. Decomp T switch - IN (CLOSED)
8. Repress T switch - IN (RESET)
9. Manual T switch - IN (RSCS)
10. Roll T switch - IN (ON)
11. Yaw T switch - IN (ON)
12. Pitch T switch - IN (ON)
13. Retro Delay switch - INST
14. Cabin Lights switch - ON
15. Hi-Pwr TLM switch - OFF
16. Rescue switch - AUTO
17. Landing Bag switch - AUTO
18. All Sequence Override rings - IN
19. Retro Att switch - AUTO
20. Launch Contl switch - OFF
21. Fuel Quantity gauges - CHECK:
    a. Auto Fuel - 100%
    b. Man Fuel - 100%
22. Rate of Descent indicator - CHECK: 0 ft/sec
23. Altimeter - CHECK: 0 feet
24. Light Test switch - ON
    CHECK: all indicator lights GREEN
25. Rate Ind switch - AUTO
26. Earth Path Indicator - CHECK: proper location
27. Satellite Clock - CHECK:
    a. Time From Launch - 00:00:00
    b. Retrofire Time - 00:04:45
    c. Time To Retrofire - 00:04:45
28. Attitude Rate indicators - CHECK:
    a. Rate - 0°/sec
    b. Pitch - +90°
    c. Roll - 0°
    d. Yaw - +180°
29. Cabin Pressure gauge - CHECK: 15.5 psi
30. Cabin Air Temperature gauge CHECK: 70-80°F
31. Coolant Quantity gauge - CHECK: 100%
32. O2 Quantity gauge - CHECK:
    a. Primary - 100%
    b. Secondary - 100%
33. Suit Fan switch - NORM
34. Cabin Fan switch - NORM
35. Stby Batt switch - AUTO
36. Isol Batt switch - NORM
37. Electric Pwr switch - NORM
38. Ammeter switch - NORM
39. Ammeter - CHECK: 20 amps
40. DC Voltmeter - CHECK: 24 volts all switch positions
41. DC Volts switch - MAIN
42. Audio Bus switch - NORM
43. AC Voltmeter - CHECK: 115 volts all switch positions
44. AC Volts switch - FANS
45. Stby Invert switch - AUTO
46. Communications Audio Volume
    a. HF/UHF - 3/4 up
    b. CMD - 0
47. UHF DF switch - NORM
48. UHF Select switch - HI PWR
49. Transmit switch - OFF
50. Beacon switch - GRND COMD
51. All Warning Tone switches - ON
52. Warning Lights switch - BRIGHT
53. All Main Panel fuses - NO.1
54. Emer O2 switch - NORM
55. Suit and Cabin Temp Control - 5

PRELAUNCH CHECK:
1. Squib switch - ARM
2. Auto Retro Jett switch - ARM
3. DC Volts - ISOL
4. DC Voltmeter - CHECK 24 volts
5. Abort indicator - MONITOR
6. Transmit switch - UHF
7. Retro Delay switch - INST
8. Launch Contl switch - READY

BECO CHECK
1. Retro Delay switch - NORM
2. Attitude Rate indicators - CHECK:
    a. Rate - 0°/sec
    b. Pitch - -34°
    c. Roll - 0°
    d. Yaw - 0°

Sub-orbital Checklist - cont.

3. ECS gauges - CHECK:
   a. Cabin Pressure - 5.5 psi
   b. Cabin Air Temp - 85°
   c. Coolant Quantity - 100%
   d. O2 Quantity - both 100%
4. Electrical gauges - Check:
   a. DC Amps - 33 amps
   b. DC Volts - 24 volts
   c. AC Volts - 115 volts

FLY-BY-WIRE MODE:
1. ASCS switch - FLY-BY-WIRE
2. RSCS switch - AUTO
3. Manual T switch - IN (RSCS)
4. Hand Controller controls attitude

To return to normal operation:
5. ASCS switch - NORM

MANUAL MODE:
1. Manual T switch - OUT (DIRECT)
2. ASCS switch - AUX DAMP
3. If aux damping desired, RSCS switch - AUTO
4. If no aux damping desired, RSCS switch - RATE CMD
5. Hand Controller controls attitude

To return to normal operation:
6. ASCS switch - NORM
7. RSCS switch - AUTO
8. Manual T switch - IN (RSCS)

RATE COMMAND MODE:
1. Manual T switch - IN (RSCS)
2. RSCS switch - RATE COMD
3. Hand Controller controls attitude

To return to normal operation:
4. RSCS switch - AUTO

RETROGRADE CHECK:
1. Check Rate Command Mode: If inoperative, select Manual Mode
2. Transmit switch - UHF
3. Beacon switch - CONT
4. Auto Retro Jett switch - OFF
5. If necessary, use RATE COMMAND and FLY-BY-WIRE to maintain attitude.

RETROGRADE:
1. Retro Warn Light - ILLUMINATED
2. Retro Seq telelight - GREEN
3. Retro Att telelight - GREEN
4. Attitude indicators - CHECK:
   a. Pitch - -34°
   b. Yaw - 0°
   c. Roll - 0°
5. Fire Retro telelight - GREEN
6. Auto Retro Jett switch - AUTO

RE-ENTRY:
1. Jett Retro telelight - GREEN
   60 seconds after retrofire
2. ASCS positions capsule in re-entry attitude
   Attitude indicators - CHECK:
   a. Pitch - +40°
   b. Yaw - 0°
   c. Roll - 0°
3. Monitor Attitude indicators until .05G
4. .05G telelight - GREEN
   150 seconds after retrofire
5. Roll Attitude indicator - CHECK: 10°/sec

LANDING:
1. 22,000 feet - Drogue chute deploy CHECK
2. 21,000 feet - Snorkel deploy CHECK
   a. O2 Emer Warning Light - ILLUMINATED
   b. O2 Press Warning Light - ILLUMINATED
3. 10,000 feet - Main chute deploy CHECK:
   a. Main telelight - GREEN
   b. Longitudinal Acceleration - 3.5 G
   c. Descent Rate indicator - 30 feet/sec
4. Landing Bag telelight - GREEN
5. Fuel Quan Warning Light - ILLUMINATED
6. After impact, Rescue telelight - GREEN

FBW CHECK:
1. FLY-BY-WIRE MODE
2. Move spacecraft to desired attitude,
   one axis at a time,
3. Attitude indicators - CHECK:
   a. Pitch - -14°
   b. Yaw - 340°
   c. Roll - 0°
4. Hold attitude 150 seconds
5. Move spacecraft to desired attitude,
   one axis at a time
6. Attitude indicators - CHECK:
   a. Pitch - -34°
   b. Yaw - 0°
   c. Roll - 0°
7. Return to normal mode

BOOSTER OBSERVATION:
1. Move spacecraft to desired pitch attitude,
2. Attitude indicators - CHECK:
   a. Pitch - -50°

Sub-orbital Checklist - cont.

b. Yaw - 0°
c. Roll - 0°
3. Booster at center of window
4. Move spacecraft to desired pitch attitude.
5. Attitude indicators - CHECK:
   a. Pitch - -34°
   b. Yaw - 0°
   c. Roll - 0°
6. Return to normal mode

Sub-Orbital Emergency Checklist

LAUNCH:
ABORT:
1. If Abort Light is illuminated, actuate Abort Handle
2. Sep Capsule telelight - GREEN
3. Jett Tower telelight - GREEN
4. Main chute deploy - CHECK:
   a. Main telelight -GREEN
   b. Longitudinal Acceleration - 3.5 G
   c. Descent Rate indicator - 30 feet/sec
5. If Main telelight is RED, Main Override ring - PULL
6. If Main chute fails, Reserve Override ring - PULL
7. Snorkel ring - PULL

TOWER FAILS TO JETTISON:
1. Jett Tower Override ring - PULL
2. If Tower fails to jettison:
   a. Twr Sep Contl fuse - NO.2
   b. Emer Twr Sep fuse - NO.2
   c. For normal jettison, Emer Escape Rckt fuse - NO.2
   d. On aborts, Emer Twr Jett fuse - NO.2

CAPSULE FAILS TO SEPARATE:
1. Sep Capsule Override ring - PULL
2. Emerg Cap Sep Contrl fuse - NO.2
3. If capsule fails to separate:
   a. Emer Posgrd fuse - NO.2
   b. On aborts, Emer Escape Rckt fuse - NO.2

STABILIZATION SYSTEM EMERGENCIES:
FAILURE OF AUTOMATIC MODE:
1. Use Rate Command (RSCS) to stop any tumbling:
   a. Manual T switch - PUSH (RATE COMD)
   b. RSCS switch - RATE COMD
   c. Stop tumbling one axis at a time
   d. Reposition capsule to orbit attitude
2. switch to Manual Mode:
   a. Manual T switch - PULL (DIRECT)
   b. ASCS switch - AUX DAMP
   c. If ASCS damping is desired, RSCS switch - AUTO
3. Auto Fuel gauge - CHECK

If ASCS failed on only one axis, ASCS can be used for the other axis
4. Failed axis T switch - PULL (OFF)
5. ASCS switch - NORM
6. RSCS switch - AUTO
7. Use hand controller on failed axis

FAILURE OF FLY-BY WIRE MODE:
1. Auto Fuel gauge - CHECK
2. ASCS switch - NORM
3. If ASCS has also failed, Manual T switch - PULL (DIRECT)
4. ASCS switch - AUX DAMP
5. Use hand controller to maintain desired attitude

FAILURE OF RATE STABILIZATION MODE:
1. Manual T switch - PULL (DIRECT)
2. RSCS switch - AUTO
3. ASCS switch as desired:
   a. AUTO - Automatic Mode
   b. AUX DAMP - Manual Mode
   c. FBW - Fly-By-Wire Mode

ATTITUDE GYRO SLAVING FAILURE:
1. Manual T switch - PULL (DIRECT)
2. ASCS switch - AUX DAMP
3. Gyro switch - GYRO CAGE
4. Use hand controller to visually align capsule with horizon.
5. Gyro switch - GYRO NORM
6. ASCS switch - NORM
7. Attitude indicators - CHECK:
   a. Pitch - 0°
   b. Roll - 0°
   c. Yaw - 0°
8. Manual T switch - PUSH (RATE COMD)

ENVIRONMENTAL CONTROL SYSTEM EMERGENCIES:
CABIN DEPRESSURIZATION:
1. Faceplate - CLOSED
2. All suit connections
3. Decomp T switch - PULL (DUMP)

CABIN PRESSURIZATION:
1. Decomp T switch - PUSH (CLOSE)
2. Repress T switch - PULL (REPRESS)
3. At 5.5 psi cabin pressure, Repress T switch - PUSH (RESET)
4. Emer O2 switch - NORM
5. Suit Fan switch - NO.1
6. After 30 seconds, Suit Fan switch - AUTO

EMERGENCY OXYGEN:
1. Emer O2 switch - EMER
2. To return to normal operation:
   a. Emer O2 switch - NORM

19.4

Sub-orbital Emerg. Checklist - cont.

b. Suit Fan switch - NO.1
c. After 30 seconds,
Suit Fan switch - AUTO

MAIN SUIT FAN FAILURE:
1. Suit Fan switch - NO.1
2. If NO. 1 fan is inoperative,
Suit Fan switch - NO.2

3. If NO. 2 fan is inoperative,
Emer O2 switch - EMER
4. Initiate retrofire within one orbit

EXCESS SUIT OR CABIN WATER:
1. Suit or Cabin Temp Control - WARMER

ELECTRICAL SYSTEM EMERGENCY OPERATION:
MAIN BATTERY FAILURE:
1. Elect Pwr switch - ASCS OFF
2. Photo Lites switch - OFF
3. Six minutes prior to retrograde sequence,
Stby Btry switch - MAIN
4. Elect Pwr switch - NORM
5. Retrograde when convenient.

STANDBY BATTERY FAILURE:
1. Stby Batt switch - MAIN
2. DC Volts - CHECK
If main batteries low,
3. Elect Pwr switch - ASCS OFF
4. Photo Lites switch - OFF
5. Retrograde when convenient.
If main batteries fail,
6. To power radios,
Audio Bus switch - EMERG
7. To power main bus,
Isol Batt switch - STBY
8. Retrograde ASAP

ISOLATED BATTERY FAILURE:
1. Before retrograde,
Isol Batt switch - STBY
2. Retrograde when convenient.

COMPLETE ELECTRICAL FAILURE:
1. Ammeter switch - BYPASS

SINGLE INVERTER FAILURE:
1. Determine what inverter failed.
2. Retrograde when convenient.

DOUBLE INVERTER FAILURE:
1. If both ASCS and fans are required,
Stby Invert switch - EMER AC
2. If ASCS not required,
Stby Invert switch - AUTO
3. Retrograde ASAP.

TELEMETRY FAILURE:
1. TLM HI FREQ fuse - NO.2

FIRE OR FUMES IN CABIN:
1. Decompress cabin.
2. Determine source of fire or fumes.
3. Turn off affected equipment.
4. If fire or fumes, extinguished,
Recompress cabin.
5. Retrograde when convenient.

RETROGRADE:
FAILURE TO START RETRO SEQUENCE:
1. Retro Seq switch - DEPRESS
2. If Retro Seq telelight - RED,
a. Emer Retro Seq fuse - NO.2
b. Retro Seq switch - DEPRESS
3. Fire Retro switch - DEPRESS
4. If capsule not in retro attitude,
a. RSCS switch - RATE COMD
b. ASCS switch - FLY-BY-WIRE
c. Position capsule to retro attitude
d. Retro Att switch - BYPASS
e. Fire Retro switch - DEPRESS

FAILURE TO ATTAIN RETRO ATTITUDE:
1. Cross check attitude indicators with
horizon
2. If capsule in retro attitude,
a. Retro Att switch - BYPASS
b. Fire Retro switch - DEPRESS
3. If capsule is not in retro attitude,
a. Manual T switch - PUSH (RSCS)
b. RSCS switch - RATE COMD
c. ASCS switch - FLY-BY-WIRE
d. Position capsule to retro attitude
4. If retro rockets do not fire automatically,
a. Retro Att switch - BYPASS
b. Fire Retro switch - DEPRESS

RETRO ROCKETS FAIL TO FIRE:
1. Retro Att telelight - GREEN
2. Fire Retro switch - DEPRESS
3. If Fire Retro telelight - RED,
a. No1, No2, No3 Retro Rckt fuse - NO.2
b. Retro Man fuse - NO.2
c. Fire Retro switch - DEPRESS
4. Fire Retro telelight - GREEN

FAILURE TO MAINTAIN RETRO ATTITUDE:
1. Squib switch - OFF
2. Reposition capsule to retro attitude
3. Retro Att switch - BYPASS
4. Squib switch - ARM
5. Fire Retro switch - DEPRESS

RETRO PACKAGE FAILS TO JETTISON:
1. Jett Retro switch - DEPRESS
2. If Jett Retro telelight - RED,
a. Retro Jett fuse - NO.2
b. Emer Retro Jett fuse - NO.2
3. Jett Retro switch - DEPRESS

FAILURE TO MAINTAIN RE-ENTRY ATTITUDE:
1. Manual T switch - PULL (DIRECT)
2. ASCS switch - AUX DAMP
3. Position capsule to re-entry attitude

Sub-orbital Emerg. Checklist – cont.

4. ASCS switch - NORM
5. Cross check attitude indicators with horizon
6. If capsule still fails to maintain re-entry attitude,
   a. ASCS switch - AUX DAMP
   b. Hold re-entry attitude
   c. Roll Rate indicator - 10°/sec

.05G FAILURE:
1. .05G switch - DEPRESS
2. ASCS .05G, Emer .05G fuses - NO.2
3. .05G switch - DEPRESS

DROGUE CHUTE FAILURE:
1. Drogue button - DEPRESS
2. If drogue chute does not deploy,
   a. Emer Drogue Deploy fuse - NO.2
   b. Drogue switch - DEPRESS

MAIN CHUTE FAILURE:
1. Main ring - PULL
2. If main chute not deployed, Emer Main Deploy fuse - NO.2
3. If main chute still not deployed, Reserve ring - PULL

RESERVE CHUTE FAILURE:
1. Reserve Deploy fuse - NO.2
2. Emer Reserve Deploy fuse - NO.2

LANDING BAG FAILS TO DEPLOY:
1. Landing Bag switch - MAN
2. Emer Landing Bag fuse - NO.2

RESCUE AIDS FAIL TO DEPLOY
1. Rescue switch - MAN
2. Emer Rescue Aids fuse - NO.2

Orbital Flight Plan

T-00:05:00 Entrance Check
T-00:03:00 Prelaunch Check
T-00:00:30 Ready switch
T+00:00:00 Launch
T+00:00:02 Roll Program
T+00:00:16 Pitch Program
T+00:02:00 Bermuda
T+00:02:10 BECO
T+00:02:33 Tower Jettison
T+00:05:20 SECO
T+00:05:25 Turnaround Program
T+00:07:00 ORBIT CHECK
T+00:08:00 BLOOD PRESSURE
T+00:09:00 BOOSTER OBSERVATION
T+00:14:00 Canary Islands
T+00:16:00 FBW CHECK
T+00:21:00 Kano
T+00:25:00 MP CHECK
T+00:29:00 Zanzibar
T+00:31:00 BLOOD PRESSURE
T+00:39:00 Indian Ocean Ship
T+00:45:00 BEACON DEPLOY
T+00:48:00 Muchea
T+00:50:00 Night Pass
T+00:54:00 Woomera
T+00:55:00 BEACON OBSERVATION
T+01:07:00 Canton
T+01:10:00 Hawaii
T+01:11:00 BLOOD PRESSURE
T+01:21:00 White Sands
T+01:26:00 Day Pass
T+01:27:00 Corpus Christi
T+01:31:00 Cape
T+01:35:00 RSCS CHECK
T+01:37:00 Bermuda
T+01:40:00 BLOOD PRESSURE
T+01:49:00 Canary Islands
T+01:55:00 Kano
T+02:03:00 Zanzibar
T+02:04:00 BLOOD PRESSURE
T+02:14:00 Indian Ocean Ship
T+02:17:00 Night Pass
T+02:24:00 Muchea
T+02:25:00 BEACON OBSERVATION
T+02:28:00 Woomera
T+02:43:00 Canton
T+02:40:00 Hawaii
T+02:41:00 BLOOD PRESSURE
T+02:55:00 Day Pass
T+02:55:00 DRIFT MODE
T+02:56:00 White Sands
T+03:00:00 Corpus Christi
T+03:05:00 Cape
T+03:12:00 Bermuda
T+03:13:00 BLOOD PRESSURE
T+03:24:00 Canary Islands
T+03:25:00 DRIFT RECOVERY
T+03:31:00 Kano
T+03:38:00 Zanzibar
T+03:39:00 BLOOD PRESSURE
T+03:46:00 Night Pass
T+03:49:00 Indian Ocean Ship
T+03:50:00 BEACON OBSERVATION
T+03:57:00 Muchea
T+04:03:00 Woomera
T+04:17:00 Canton
T+04:20:00 Hawaii
T+04:21:00 BLOOD PRESSURE
T+04:22:00 Day Pass
T+04:25:00 RETROGRADE CHECK
T+04:28:00 White Sands
T+04:30:00 RETROGRADE
T+04:30:30 Retrofire
T+04:31:50 Retro Jettison
T+04:33:00 RE-ENTRY
T+04:40:30 .05g
T+04:50:00 LANDING

Orbital Checklist

ENTRANCE CHECKS:
1. All fuses - NO.1
2. Squib switch - OFF
3. Auto Retro Jett switch – OFF

Orbital Checklist - Cont.

4. ASCS switch - NORM
5. RSCS switch - AUTO
6. Gyro switch - GYRO NORM
7. Decomp T switch - IN (CLOSED)
8. Repress T switch - IN (RESET)
9. Manual T switch - IN (RSCS)
10. Roll T switch - IN (ON)
11. Yaw T switch - IN (ON)
12. Pitch T switch - IN (ON)
13. Retro Delay switch - INST
14. Cabin Lights switch - ON
15. Hi-Pwr TLM switch - OFF
16. Rescue switch - AUTO
17. Landing Bag switch - AUTO
18. All Sequence Override rings - IN
19. Retro Att switch - AUTO
20. Launch Contl switch - OFF
21. Fuel Quantity gauges - CHECK:
    a. Auto Fuel - 100%
    b. Man Fuel - 100%
22. Rate of Descent indicator - CHECK: 0 ft/sec
23. Altimeter - CHECK: 0 feet
24. Light Test switch - ON
    CHECK: all indicator lights GREEN
25. Rate Ind switch - AUTO
26. Earth Path Indicator - CHECK: proper location
27. Satellite Clock - CHECK:
    a. Time From Launch - 00:00:00
    b. Retrofire Time - 04:33:00
    c. Time To Retrofire - 04:33:00
28. Attitude Rate indicators - CHECK
    a. Rate - 0°/sec
    b. Pitch - +90°
    c. Roll - +30°
    d. Yaw - +180°
29. Cabin Pressure gauge - CHECK: 15.5 psi
30. Cabin Air Temperature gauge CHECK: 70-80°F
31. Coolant Quantity gauge - CHECK: 100%
32. O2 Quantity gauge - CHECK:
    a. Primary - 100%
    b. Secondary - 100%
33. Suit Fan switch - NORM
34. Cabin Fan switch - NORM
35. Stby Batt switch - AUTO
36. Isol Batt switch - NORM
37. Electric Pwr switch - NORM
38. Ammeter switch - NORM
39. Ammeter - CHECK: 20 amps
40. DC Voltmeter - CHECK: 24 volts all switch positions
41. DC Volts switch - MAIN
42. Audio Bus switch - NORM
43. AC Voltmeter - CHECK: 115 volts all switch positions
44. AC Volts switch - FANS
45. Stby Invert switch - AUTO
46. Communications Audio Volume
    a. HF/UHF - 3/4 up
    b. CMD - 0
47. UHF DF switch - NORM
48. UHF Select switch - HI PWR
49. Transmit switch - OFF
50. Beacon switch - GRND COMD
51. All Warning Tone switches - ON
52. Warning Lights switch - BRIGHT
53. All Main Panel fuses - NO.1
54. Emer O2 switch - NORM
55. Suit and Cabin Temp Control - 5

PRELAUNCH CHECK:
1. Squib switch - ARM
2. Auto Retro Jett switch - ARM
3. Hi-Pwr TLM switch - ON
4. DC Volts - ISOL
5. DC Voltmeter - CHECK 24 volts
6. Abort indicator - MONITOR
7. Transmit switch - UHF
8. Retro Delay switch - INST
9. Launch Contl switch - READY

ORBIT CHECK:
1. Retro Delay switch - NORM
2. Attitude Rate indicators - CHECK:
   a. Rate - 0°/sec
   b. Pitch - -34°
   c. Roll - 0°
   d. Yaw - 0°
3. ECS gauges - CHECK:
   a. Cabin Pressure - 5.5 psi
   b. Cabin Air Temp - 85°
   c. Coolant Quantity - 100%
   d. O2 Quantity - both 100%
4. Electrical gauges - Check:
   a. DC Amps - 33 amps
   b. DC Volts - 24 volts
   c. AC Volts - 115 volts

FLY-BY-WIRE MODE:
1. ASCS switch - FLY-BY-WIRE
2. RSCS switch - AUTO
3. Manual T switch - IN (RSCS)
4. Hand Controller controls attitude

To return to normal operation:
5. ASCS switch - NORM

MANUAL MODE:
1. Manual T switch - OUT (DIRECT)
2. ASCS switch - AUX DAMP
3. If aux damping desired, RSCS switch - AUTO
4. If no aux damping desired, RSCS switch - RATE CMD
5. Hand Controller controls attitude

To return to normal operation:
6. ASCS switch - NORM
7. RSCS switch - AUTO
8. Manual T switch - IN (RSCS)

RATE COMMAND MODE:
1. Manual T switch - IN (RSCS)
2. RSCS switch - RATE COMD
3. Hand Controller controls attitude

To return to normal operation:
4. RSCS switch - AUTO

Orbital Checklist - Cont.

BEFORE RETROGRADE:
30 minutes before:
1. Cabin Temp Control - COOLER
2. Suit Temp Control - COOLER

RETROGRADE CHECK:
3. Check Rate Command Mode:
   If inoperative, select Manual Mode
4. Transmit switch - UHF
5. Beacon switch - CONT
6. Auto Retro Jett switch - OFF
7. If necessary, use RATE COMMAND and FLY-BY-WIRE to maintain attitude.

RETROGRADE:
1. Retro Warn Light - ILLUMINATED
2. Retro Seq telelight - GREEN
3. Retro Att telelight - GREEN
4. Attitude indicators - CHECK:
   a. Pitch - -34°
   b. Yaw - 0°
   c. Roll - 0°
5. Fire Retro telelight - GREEN
6. Auto Retro Jett switch - AUTO

RE-ENTRY:
1. Jett Retro telelight - GREEN
   60 seconds after retrofire
2. ASCS positions capsule in re-entry attitude
   Attitude indicators - CHECK:
   a. Pitch - +1.5°
   b. Yaw - 0°
   c. Roll - 0°
3. Monitor Attitude indicators until .05G
4. .05G telelight - GREEN
   600 seconds after retrofire
5. Roll Attitude indicator - CHECK: 10°/sec

LANDING:
1. 22,000 feet - Drogue chute deploy CHECK
2. 21,000 feet - Snorkel deploy CHECK
   a. O2 Emer Warning Light - ILLUMINATED
   b. O2 Press Warning Light - ILLUMINATED
3. 10,000 feet - Main chute deploy CHECK:
   a. Main telelight - GREEN
   b. Longitudinal Acceleration - 3.5 G
   c. Descent Rate indicator - 30 feet/sec
4. Landing Bag telelight - GREEN
5. Fuel Quan Warning Light - ILLUMINATED
6. After impact, Rescue telelight - GREEN

BLOOD PRESSURE:
1. Blood Pressure fuse - No.1
2. If within ground station range,
   Blood Press Start switch - DEPRESS
3. After 30 seconds,
   Blood Press Stop switch - DEPRESS

BOOSTER OBSERVATION:
1. Attitude indicators - CHECK:
   a. Pitch - -50°
   b. Yaw - 0°
   c. Roll - 0°
2. Booster at center of window

BEACON DEPLOY:
1. Squib switch - ARM
2. Attitude indicators - CHECK:
   a. Pitch - -20°
   b. Yaw - 0°
   c. Roll - 0°
3. Beacon Deploy switch - DEPLOY
4. Squib switch - OFF

BEACON OBSERVATION:
1. Attitude indicators - CHECK:
   a. Pitch - -20°
   b. Yaw - 180°
   c. Roll - 0°
2. Beacon at center of window

FBW CHECK:
1. FLY-BY-WIRE MODE
2. Move spacecraft to desired attitude,
   one axis at a time
3. Attitude indicators - CHECK:
   a. Pitch - -14°
   b. Yaw - 340°
   c. Roll - -20°
4. Hold attitude 300 seconds
5. Move spacecraft to desired attitude,
   one axis at a time,
6. Attitude indicators - CHECK:
   a. Pitch - -34°
   b. Yaw - 0°
   c. Roll - 0°
7. Return to normal mode

MP CHECK:
1. MANUAL MODE
2. Move spacecraft to desired attitude,
   one axis at a time
3. Attitude indicators - CHECK:
   a. Pitch - -20°
   b. Yaw - 180°
   c. Roll - 0°
4. Hold attitude 300 seconds
5. Move spacecraft to desired attitude,
   one axis at a time,
6. Attitude indicators - CHECK:
   a. Pitch - -34°
   b. Yaw - 0°
   c. Roll - 0°
7. Return to normal mode

Orbital Checklist - Cont.

RSCS CHECK:
1. FLY-BY-WIRE MODE
2. Move spacecraft to desired attitude, one axis at a time
3. Attitude indicators - CHECK:
   a. Pitch - 0°
   b. Yaw - 30°
   c. Roll - 20°
4. Hold attitude 300 seconds
5. Move spacecraft to desired attitude,
   one axis at a time,
6. Attitude indicators - CHECK:
   a. Pitch - -34°
   b. Yaw - 0°
   c. Roll - 0°
7. Return to normal mode

DRIFT MODE:
1. Attitude indicators - CHECK:
   a. Pitch - -34°
   b. Yaw - 0°
   c. Roll - 0°
2. ASCS switch - FLY-BY-WIRE
3. Gyro switch - GYRO CAGE
4. Electric Pwr switch - OFF
5. Monitor attitude visually

DRIFT RECOVERY:
1. Electric Pwr switch - ON
2. Gyro switch - FREE
3. FBW or MANUAL MODE
4. Move spacecraft to desired attitude
5. Attitude indicators - CHECK:
   a. Pitch - -34°
   b. Yaw - 0°
   c. Roll - 0°
6. Hold attitude 300 seconds
7. Gyro switch - GYRO NORM
8. Return to normal mode

Orbital Emergency Checklist

LAUNCH:
ABORT PRIOR TO TOWER JETTISON:
1. If Abort Light is illuminated, actuate Abort Handle
2. Sep Capsule telelight - GREEN
3. Jett Tower telelight - GREEN
4. Main chute deploy - CHECK:
   a. Main telelight -GREEN
   b. Longitudinal Acceleration - 3.5 G
   c. Descent Rate indicator - 30 feet/sec
5. If Main telelight is RED, Main Override ring - PULL
6. If Main chute fails, Reserve Override ring - PULL
7. Snorkel ring - PULL

ABORT AFTER TOWER JETTISON:
1. If Abort Light is illuminated, actuate Abort Handle
2. Sep Capsule telelight – GREEN

3. Attitude indicators - CHECK:
   a. Pitch - -34°
   b. Yaw - 0°
   c. Roll - 0°
4. Retro rockets fired from ground, If needed
5. Complete normal Landing procedures

TOWER FAILS TO JETTISON:
1. Jett Tower Override ring - PULL
2. If Tower fails to jettison:
   a. Twr Sep Contl fuse - NO.2
   b. Emer Twr Sep fuse - NO.2
   c. For normal jettison, Emer Escape Rckt fuse - NO.2
   d. On aborts, Emer Twr Jett fuse - NO.2

CAPSULE FAILS TO SEPARATE:
1. Sep Capsule Override ring - PULL
2. If capsule fails to separate:
   a. On aborts before tower jettison, Emer Escape Rckt fuse - NO.2
   b. On aborts after tower jettison, Emer Posgrd fuse - NO.2

ABORT FROM ORBIT:
1. In the event of a severe emergency requiring an immediate abort, Retro Seq switch - DEPRESS
2. If conditions permit:
   a. Select recovery area
   b. Compute retrograde time
   c. If time permits, reset retrograde clock
   d. If there is insufficient time, 30 seconds before retrofire time, Retro Seq switch - DEPRESS
4. Complete normal landing procedures

STABILIZATION SYSTEM EMERGENCIES:
FAILURE OF FLY-BY WIRE MODE:
1. Auto Fuel gauge - CHECK
2. ASCS switch - NORM
3. If ASCS has also failed, Manual T switch - PULL (DIRECT)
4. ASCS switch - AUX DAMP
5. Use hand controller to maintain desired attitude

FAILURE OF RATE STABILIZATION MODE:
1. Manual T switch - PULL (DIRECT)
2. RSCS switch - AUTO
3. ASCS switch as desired:
   a. AUTO - Automatic Mode
   b. AUX DAMP - Manual Mode
   c. FBW - Fly-By-Wire Mode

FAILURE OF AUTOMATIC MODE:
1. Use Rate Command (RSCS) to stop any tumbling:
   a. Manual T switch - PUSH (RATE COMD)
   b. RSCS switch - RATE COMD

Orbital Emerg. Checklist – Cont.

c. Stop tumbling one axis at a time
d. Reposition capsule to orbit attitude
2. Switch to Manual Mode:
a. Manual T switch - PULL (DIRECT)
b. ASCS switch - AUX DAMP
c. If ASCS damping is desired, RSCS switch - AUTO
3. Auto Fuel gauge - CHECK
If ASCS failed on only one axis, ASCS can be used for the other axis
4. Failed axis T switch - PULL (OFF)
5. ASCS switch - NORM
6. RSCS switch - AUTO
7. Use hand controller on failed axis

ATTITUDE GYRO SLAVING FAILURE:
1. Manual T switch - PULL (DIRECT)
2. ASCS switch - AUX DAMP
3. Gyro switch - GYRO CAGE
4. Use hand controller to visually align capsule with horizon.
5. Gyro switch - GYRO NORM
6. ASCS switch - NORM
7. Attitude indicators - CHECK:
a. Pitch - -34°
b. Roll - 0°
c. Yaw - 0°
8. Manual T switch - PUSH (RATE COMD)

ENVIRONMENTAL CONTROL SYSTEM EMERGENCIES:
CABIN DEPRESSURIZATION:
1. Faceplate - CLOSED
2. All suit connections
3. Decomp T switch - PULL (DUMP)

CABIN PRESSURIZATION:
1. Decomp T switch - PUSH (CLOSE)
2. Repress T switch - PULL (REPRESS)
3. At 5.5 psi cabin pressure, Repress T switch - PUSH (RESET)
4. Emer O2 switch - NORM
5. Suit Fan switch - NO.1
6. After 30 seconds, Suit Fan switch - AUTO

EMERGENCY OXYGEN:
1. Emer O2 switch - EMER
2. To return to normal operation:
a. Emer O2 switch - NORM
b. Suit Fan switch - NO.1
c. After 30 seconds, Suit Fan switch - AUTO

MAIN SUIT FAN FAILURE:
1. Suit Fan switch - NO.1
2. If NO. 1 fan is inoperative, Suit Fan switch - NO.2
3. If NO. 2 fan is inoperative, Emer O2 switch - EMER
4. Initiate retrofire within one orbit

EXCESS SUIT OR CABIN WATER:
1. Suit or Cabin Temp Control - WARMER

ELECTRICAL SYSTEM EMERGENCY OPERATION:
MAIN BATTERY FAILURE:
1. Elect Pwr switch - ASCS OFF
2. Photo Lites switch - OFF
3. Six minutes prior to retrograde sequence, Stby Btry switch - MAIN
4. Elect Pwr switch - NORM
5. Retrograde when convenient.

STANDBY BATTERY FAILURE:
1. Stby Batt switch - MAIN
2. DC Volts - CHECK
If main batteries low,
3. Elect Pwr switch - ASCS OFF
4. Photo Lites switch - OFF
5. Retrograde when convenient.
If main batteries fail,
6. To power radios, Audio Bus switch - EMERG
7. To power main bus, Isol Batt switch - STBY
8. Retrograde ASAP

ISOLATED BATTERY FAILURE:
1. Before retrograde, Isol Batt switch - STBY
2. Retrograde when convenient.

COMPLETE ELECTRICAL FAILURE:
1. Ammeter switch - BYPASS

SINGLE INVERTER FAILURE:
1. Determine what inverter failed.
2. Retrograde when convenient.

DOUBLE INVERTER FAILURE:
1. If both ASCS and fans are required, Stby Invert switch - EMER AC
2. If ASCS not required, Stby Invert switch - AUTO
3. Retrograde ASAP.

TELEMETRY FAILURE:
1. TLM HI FREQ fuse - NO.2

FIRE OR FUMES IN CABIN:
1. Decompress cabin.
2. Determine source of fire or fumes.
3. Turn off affected equipment.
4. If fire or fumes, extinguished, Recompress cabin.
5. Retrograde when convenient.

RETROGRADE:
FAILURE TO START RETRO SEQUENCE:
1. Retro Seq switch - DEPRESS
2. If Retro Seq telelight - RED,
a. Emer Retro Seq fuse - NO.2
b. Retro Seq switch - DEPRESS
3. Fire Retro switch - DEPRESS
4. If capsule not in retro attitude,
a. RSCS switch - RATE COMD
b. ASCS switch - FLY-BY-WIRE
c. Position capsule to retro attitude
d. Retro Att switch - BYPASS
e. Fire Retro switch - DEPRESS

FAILURE TO ATTAIN RETRO ATTITUDE:
1. Cross check attitude indicators with horizon

Orbital Emerg. Checklist - Cont.

2. If capsule in retro attitude,
   a. Retro Att switch - BYPASS
   b. Fire Retro switch - DEPRESS
3. If capsule is not in retro attitude,
   a. Manual T switch - PUSH (RSCS)
   b. RSCS switch - RATE COMD
   c. ASCS switch - FLY-BY-WIRE
   d. Position capsule to retro attitude
4. If retro rockets do not fire automatically,
   a. Retro Att switch - BYPASS
   b. Fire Retro switch - DEPRESS

RETRO ROCKETS FAIL TO FIRE:
1. Retro Att telelight - GREEN
2. Fire Retro switch - DEPRESS
3. If Fire Retro telelight - RED,
   a. No1, No2, No3 Retro Rckt fuse - NO.2
   b. Retro Man fuse - NO.2
   c. Fire Retro switch - DEPRESS
4. Fire Retro telelight - GREEN

FAILURE TO MAINTAIN RETRO ATTITUDE:
1. Squib switch - OFF
2. Reposition capsule to retro attitude
3. Retro Att switch - BYPASS
4. Squib switch - ARM
5. Fire Retro switch - DEPRESS

RETRO PACKAGE FAILS TO JETTISON:
1. Jett Retro switch - DEPRESS
2. If Jett Retro telelight - RED,
   a. Retro Jett fuse - NO.2
   b. Emer Retro Jett fuse - NO.2
3. Jett Retro switch - DEPRESS

FAILURE TO MAINTAIN RE-ENTRY ATTITUDE:
1. Manual T switch - PULL (DIRECT)
2. ASCS switch - AUX DAMP
3. Position capsule to re-entry attitude
4. ASCS switch - NORM
5. Cross check attitude indicators with horizon

6. If capsule still fails to maintain re-entry attitude,
   a. ASCS switch - AUX DAMP
   b. Hold re-entry attitude
   c. Roll Rate indicator - 10°/sec

.05G FAILURE:
1. .05G switch - DEPRESS
2. ASCS .05G, Emer .05G fuses - NO.2
3. .05G switch - DEPRESS

DROGUE CHUTE FAILURE:
1. Drogue button - DEPRESS
2. If drogue chute does not deploy,
   a. Emer Drogue Deploy fuse - NO.2
   b. Drogue switch - DEPRESS

MAIN CHUTE FAILURE:
1. Main ring - PULL
2. If main chute not deployed,
   Emer Main Deploy fuse - NO.2
3. If main chute still not deployed,
   Reserve ring - PULL

RESERVE CHUTE FAILURE:
1. Reserve Deploy fuse - NO.2
2. Emer Reserve Deploy fuse - NO.2

LANDING BAG FAILS TO DEPLOY:
1. Landing Bag switch - MAN
2. Emer Landing Bag fuse - NO.2

RESCUE AIDS FAIL TO DEPLOY
1. Rescue switch - MAN
2. Emer Rescue Aids fuse - NO.

Mission Evaluation Report

At the end of a simulation, A-OK! will display the report in a scrolling window. Using the two buttons provided, you may print the report or save it to a file. Clicking the “Done” button returns you to the simulator. If you want to view the report again, select “Mission Evaluation Report” under the “Documentation” menu. This can be done only if the simulation has not been reset, since that action erases the data required to generate the report.

The Mission Evaluation Report is divided into five sections. “Astronaut Background Data” describes the selected astronaut and his or her experience level.

“Launch Phase” discusses the booster performance, including the orbit or altitude peak reached, and sequential launch events, such as Booster Engine Cutoff (BECO) and JETT TOWER. All abort scenarios are discussed here as well.

“Orbital Phase” or “Sub–Orbital Coast Phase” reports on activities during orbital flight or the suborbital coast period between the SEP CAPSULE and RETROFIRE events. This section details the performance of major spacecraft systems and the astronaut’s interactions with them. The systems discussed are the event Programmer, telemetry, environmental, attitude control, and electrical.

“Astronaut Tasks” details the results of the in–flight experiments that were conducted on the mission. This includes a complete listing of all blood pressure readings, beacon acquisitions, etc.

“Retrograde and Reentry Phase” discusses entire all retrograde events, including time of retrograde, retrorocket performance, retrograde event sequencing and astronaut interaction with any of these systems. This section ends with an evaluation of the reentry period.

“Descent and Landing Phase” reports on the spacecraft’s final descent from 100,000 feet to splashdown. Events sequenced by the Programmer such as parachute deployment are discussed, as are landing speed and accuracy.

When discussing astronaut interaction, the report indicates when the astronaut performs or fails to perform a critical manual function. For example, an event can be reported as being initiated automatically by the event Programmer or, manually by the astronaut. Additionally the event can be reported as a failure that either was or was not corrected by the astronaut’s actions.

The report’s final paragraph is a summation of the astronaut’s performance and assigns the astronaut a point–based rating. The maximum rating is thirteen for an orbital mission and eight for a sub–orbital mission. Especially poor simulations can generate a score as low as -18. The rating displayed in the “Astronaut Duty Roster” is calculated by dividing the total of all the ratings to date by the total number of missions simulated.

The following logic used to calculate the mission rating of a just–completed simulation.

Orbital missions start with a rating of three. Sub–orbital missions start with a rating of two.

If the difficulty level was “average,” subtract one from the rating If the difficulty level was “easy,” subtract two from the rating.

20.2

For the following actions that result in complete mission failure, subtract six from the rating.

- •Aborting the mission while still on the launch pad.
- •Aborting the mission during ascent in the absence of mission–threatening failures.
- •Being destroyed by the Range Safety Office because the mission was not aborted soon enough.
- •Separating the spacecraft from the booster before engine shutdown which causes the booster to slam into the spacecraft.
- •Deploying the Landing Bag in orbit or misalignment of reentry attitude enough to cause the spacecraft to be incinerated.
- •Stranding the spacecraft in orbit either by jettisoning the retrograde package before they are fire, or proceeding with retrofire while the spacecraft's attitude is severely out of alignment.
- •Crashing the spacecraft due to improperly deployed or malfunctioning parachutes.

If the automatic fuel supply was consumed at a rate more than 30% per orbit, subtract one to the rating. If the manual fuel supply was consumed at a rate more than 30% per orbit, subtract one to the rating.

If the primary oxygen supply was consumed at a rate less than 30% per orbit, add one to the rating.If the secondary oxygen supply was consumed at a rate less than 30% per orbit, add one.

If the oxygen regulator failed, and no action was taken, subtract one from the rating. If the proper action was taken, add one to the rating. If the emergency oxygen rate was engaged without a reason, subtract one from the rating.

If the cabin temperature became greater than 100° F, and no action was taken to control it, subtract one from the rating. If greater than 130° F, subtract two from the rating. If the cabin temperature dropped below 60° F, and no action was taken to control it, subtract one from the rating.

If the scheduled blood pressure readings were not taken, subtract one from the rating. If more readings were taken then scheduled, add one to the rating.

If the flashing beacon was not deployed successfully, subtract one from the rating. If the beacon was successfully acquired at least once per orbit, add one to the rating. If the beacon was re-acquired more than once during a night pass, add two to the rating.

If the booster was acquired after orbital insertion, add one for each acquisition.

If all scheduled attitude control experiments were attempted, add one from the rating.

If the landing occurred within 20 miles of a recovery zone, add one to the rating. If the landing occurred within 5 miles of a recovery zone, add two to the rating.

If the landing velocity was less than 50 feet per second, add one to the rating. If the landing velocity was greater than 50 feet per second, subtract four from the rating.

If the rescue aids were not properly deployed and no attempt was made to deploy them manually, subtract two from the rating.

See Section 16 for more information on the use of the Evaluation Report.

Simulator Design Philosophy

A-OK! The Wings of Mercury is an extremely realistic simulation that is based on the original NASA documents used in the design and operation of the actual Mercury spacecraft. Like any other simulation, however, we did have to make a few design trade–offs. Some of these trade–offs may be addressed in future versions of A-OK!.

Unlike some of the flight simulators currently available, A-OK! has over 90 working switches and controls. In order to increase realism, all switches are displayed on–screen in their actual position on the control panel instead of requiring the astronaut to remember 90 key combinations! Since the entire panel does not fit on a normal 14 inch monitor, the panel was broken up into ten sections. Using the Panel Selection Palette to go to the proper section of the control panel is very much analogous to being able to focus in on the proper part of the control panel instantly. In fact, part of the physiological studies pursued in Project Mercury dealt with following (via an on–board movie) the astronaut's eyes during the flight. His eye movements were then charted and analysed.

The on–orbit window view is not meant to be representative of any specific landmarks on the earth or in the sky. You will not see the ground move as you orbit. Since the window view is used to provide a visual reference of Mercury's attitude, the view will change when the spacecraft moves in pitch, roll or yaw.

The Earth Position Indicator had controls that allowed the astronaut to manually adjust the scrolling map based on orbital altitude and inclination. A-OK! automatically adjusts these parameters for you, so these controls are not operational.

Most Mercury spacecraft had a Periscope installed just below the Earth Position Indicator. Its basic purpose was to provide the astronaut with another means of verifying attitude. It consisted of a circular screen, a lens assembly that was extended and retracted from the side of the spacecraft. and and on The Programmer panel contained a telelight to indicate whether is was extended or retracted and a switch to control lens assembly motion. The Periscope was finally dropped for the last Mercury mission and was viewed by the astronauts as a backup to the window view. During a night pass it was practically unusable due to light loss from its complicated lens and mirrors. A-OK! does not include the Periscope for these reasons.

The “Transmit” menu deviates slightly from standard Macintosh implementation to emulate actual communication procedures. Inside the spacecraft you would have no cue that you were out of range or that the transmitter was not functional, so you would attempt transmission and get silence back. Therefore, the “Transmit” menu will not dim or become disabled even if communication is not possible.

Another deviation from standard Macintosh implementation is the use of the mouse to actuate switches and controls. A control will be moved as soon as it is clicked, *not* when the mouse is released. If you accidentally click on a switch, there is no second chance: just like the real thing! Standard Macintosh items like menus and buttons operate normally.

21.2

The following switches can be actuated but have no visible effect other than consuming electrical power if switched on:

PHOTO LITES, CABIN LITES, VOR PWR

The following switches can be actuated but have no visible effect:

COND RCVR A fuse, LITE TEST, RATE IND, KEY, BEACON, UHF DF, CMD COMM AUDIO control and SUIT TEMP control.

Glossary

.05G
The point at which the spacecraft starts to be de–accelerated as pull of the earth's gravity becomes stronger than the spacecraft's orbital speed.

.05G Maneuver
When .05G is sensed, the spacecraft begins a 10°/second roll. This can be automatically or manually initiated.

Accelerometer
A device that proportionally measures movement. Three of these mounted along the spacecraft's vertical,longitudinal and lateral axis measure yaw, roll and pitch attitude rates.

Activated Charcoal
Used to filter odors from the spacecraft air.

Altitude
The spacecraft's height, in feet, above sea level.

Altitude Gauge
Displays the spacecraft's height as referenced by air pressure. Displays altitude to 100,000 feet.

Anomaly
An unexplained event in a spacecraft system.

Apogee
The highest point in an elliptical orbit.

ASIS
Abort Sensing & Implementation System that monitors critical launch vehicle parameters and initiates an abort, if warranted.

Atlas
The missile used to launch the Mercury spacecraft into orbit.

Attitude
The position of the spacecraft in three–dimensional space.

Attitude Gauges
Displays the Pitch, Yaw and Roll position in degrees.

Attitude Rate Indicator
Displays movement along any axis (Pitch, Yaw and Roll) showing rates as little as 0.125°/second to 6°/second, full scale.

ASCS
Automatic Stabilization & Control System that automatically holds attitude (NORM and AUX DAMP mode) and performs all required attitude changes during a flight (NORM mode).

BECO
Booster Engine Cut–Off. The shutdown of the two outside engines on the Atlas booster, or the single engine on the Redstone booster.

Beryllium
An alloy, used in the external shingles and the sub–orbital heat shield, that has the ability to store heat efficiently.

Bus
A collection of wires used to route power through the spacecraft.

Cage
The action of stopping the internal movement of the gyroscopes, usually as a precursor to a large attitude maneuver or re–alignment to the horizon.

Damping
Using the NORM or AUX DAMP mode of ASCS to stop all attitude rates, essentially holding the current attitude.

Downlink
The telemetry channel from spacecraft to ground station.

Drogue Parachute
A small parachute used to stabilize the spacecraft during descent so as to allow proper deployment of the main parachute.

Earth Position Indicator
Displays the spacecraft's current position on the ground.

ECS
Environmental Control System. Sustains the astronaut with a 5.5 psi oxygen environment, controlling oxygen flow, temperature and waste management.

Escape Rocket
A solid rocket, providing 52,000 pounds of thrust for one second, that pulls the spacecraft away from a booster that is about to explode or is not flying properly.

Escape Tower
A lattice–type structure that holds the Escape Rocket to the spacecraft. It is Jettisoned by a 800 pound thrust solid rocket mounted at the bottom of the Escape Rocket.

FBW
Fly–By–Wire provides manual attitude control using two levels of thrust controlled by the Hand Controller.

G
A unit used to measure acceleration. One "G" is the acceleration exerted by the force of gravity. Zero "G" is no acceleration or weightlessness.

Gyroscope
A device containing a spinning wheel that stays in the same position regardless of opposing forces, such as the movement caused by the spacecraft thrusters. Three of these are hard–mounted within the spacecraft, one gyro aligned with each of the spacecraft's vertical, longitudinal and lateral axis. This assembly provides a stable position from which to measure the spacecraft's attitude rate and drive the Attitude Rate Indicator. Two other sets of gyroscopes are used to measure vertical and directional position and drive the Attitude Gauges.

Hand Controller
A three degree–of–freedom control stick that is used to control the spacecraft's attitude using thruster jets.

Heat Shield
A round shield located at the broad base of the spacecraft used to protect the spacecraft from the heat of Reentry. The orbital model is composed of a special plastic that melts during Reentry, carrying away the intense heat as it burns away. The sub–orbital model is composed of beryllium which stores the heat and releases it after Reentry.

HF
High Frequency radio channel.

Horizon Scanner
A device that can sense the horizon by searching for the end of the earth's infrared radiation against the relatively low infrared radiation of space. Two of these are normally be slaved to the vertical and directional gyroscope assemblies and will keep them from drifting while the spacecraft is within +/-35° of the horizon.

Hydrogen Peroxide
Used as fuel for the Attitude thrusters.

Infrared Radiation
Electromagnetic radiation given off in the form of heat. Measured by the horizon scanners.

Inverter
Converts direct current to alternating current.

Jettison
To eject a spacecraft component that is no longer needed, such as Tower Jettison.

Lateral Axis
An imaginary line running from left to right through the center of the spacecraft.

Longitudinal Acceleration
The acceleration along the long axis of the spacecraft (and booster, during ascent).

Longitudinal Acceleration Gauge
Displays the Longitudinal Acceleration in "G" units.

Longitudinal Axis
An imaginary line, running through the center of the spacecraft, from the front to the back.

Lithium Hydroxide
Used to remove the Carbon Dioxide from the spacecraft air.

Max Q
The point during ascent when the launch vehicle is subjected to maximum dynamic pressure, causing the greatest stresses during launch..

MP
Manual Proportional provides manual attitude control using variable thrust controlled by the Hand Controller.

Orbital Mission
A three orbit flight that lasts almost five hours. After two such missions, Mercury's capability was extend to six and twenty two orbit missions.

Perigee
The lowest point in an elliptical orbit.

Pitch
Movement about the spacecraft's Lateral Axis. Zero degrees Pitch is when the nose aligned with the earth's horizon.

Posigrade Maneuver
A small forward maneuver that increases the distance between the spacecraft and the booster after separation. This maneuver is automatically initiated after separation.

Posigrade Rockets
Three solid rockets, providing 400 pounds thrust each, mounted on the retrograde package that provide the required thrust for this maneuver.

Programmer
A series of electrical relays and switches used to sequence key flight events automatically.

PSI
Pounds per Square Inch. A measurement of atmospheric pressure.

Redstone
The missile used to launch Mercury on its sub–orbital test flights.

Reentry
The movement through the earth's atmosphere after the Retrograde Maneuver, that results in the spacecraft slowing down to sub–orbital speeds.

Reentry Attitude Maneuver
An automatic maneuver that places the spacecraft in the proper attitude so the Heat Shield can protect the spacecraft from the intense heat of Reentry. This can be automatically or manually initiated.

Retrograde Maneuver
A small maneuver that slows the spacecraft to just below orbital speed.

Retrograde Rockets
Three solid rockets, providing 1,000 pounds thrust each, mounted on the retrograde package that provide the required thrust for the Retrograde maneuver.

RSCS
Rate Stabilization & Control System provides semi–automatic rate control using the Hand Controller.

Roll
Movement about the spacecraft's Longitudinal Axis. Zero degree Roll is when the spacecraft is heads–up with respect to the earth.

SECO
Sustainer Engine Cut–Off. The shutdown of the center engine on the Atlas booster.

Squib
A device, usually electrically initiated, that performs an action using a small explosive charge.

Sub–Orbital Mission
A fifteen minute test flight used to verify the Mercury spacecraft and procedures prior to the Orbital Mission. The spacecraft reaches orbital height, but not orbital speed.

Telemetry
The radio link that transmits information and measurements from the spacecraft as opposed to the HF and UHF voice communication channels.

Turnaround Maneuver
A maneuver, executed after ascent, that turns the spacecraft from a forward–facing to a backwards–facing position. This can be automatically or manually initiated.

UHF
Ultra High Frequency radio channel.

Vertical Axis
An imaginary line running from top to bottom through the center of the spacecraft.

Yaw
Movement about the spacecraft's Vertical Axis. Zero degree Yaw is when the Heat Shield is facing the direction of travel.

Index

Colophon

The body text of this manual was set in Berkeley and Berkeley Bold at 12 points with 14 point leading. The titles were set in Berkeley Bold at 18 and 14 points. The flight plans and checklists were set in Monaco at 9 points. The index is set in Berkeley at 10 points with 12 point leading.

Many of the illustrations used in this manual were taken from the Project Mercury Familiarization Manual and the Mercury Flight Operations Manuals. These documents were produced by the McDonnell Aircraft Corporation for NASA and were de–classified in 1974. All of the original illustrations were enhanced for greater clarity.

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