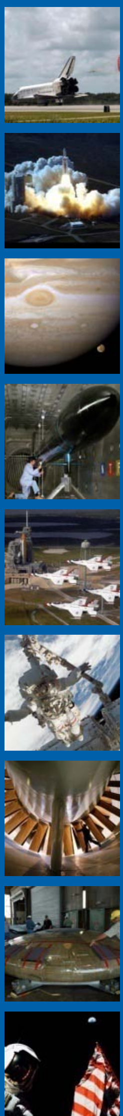
National Aeronautics and Space Administration



Tragic Tangle:

Soyuz-1

Leadership ViTS Meeting

June 2010

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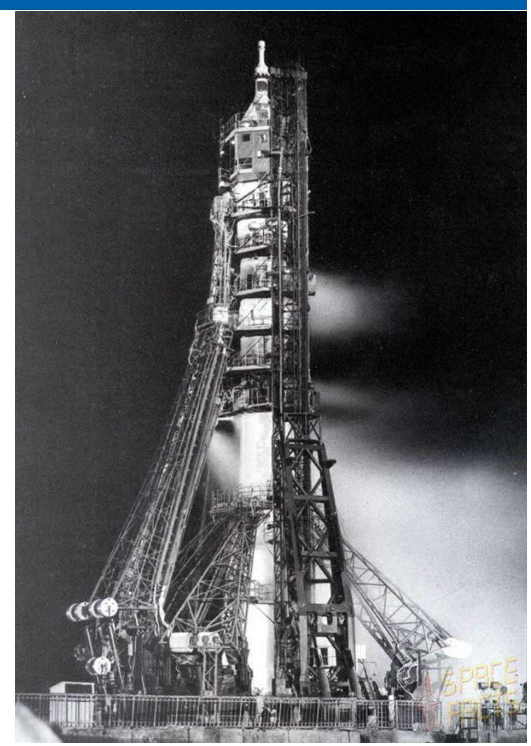
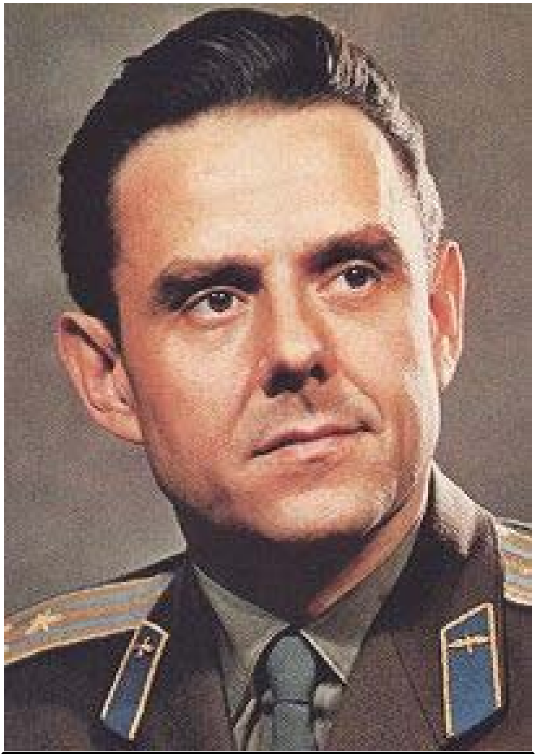


This and previous presentations are archived at:
sma.nasa.gov/safety-messages

THE MISHAP

*On April 23,1967, the Soviet Union launched the Soyuz-*1 *spacecraft to achieve a new and elaborate docking capability. Multiple malfunctions on orbit forced ground crews to abort the mission. In a crippled spacecraft with rapidly draining power reserves, Cosmonaut Colonel Vladimir Komarov heroically maneuvered the craft for re-entry to Earth. Upon re-entry, the vehicle's drag and backup parachutes entangled. With no means of braking, Soyuz-*1 *struck the ground at 90 miles per hour, and the USSR's most experienced cosmonaut was killed.*



Cosmonaut Colonel Vladimir Komarov piloted the *Soyuz*-1 spacecraft.

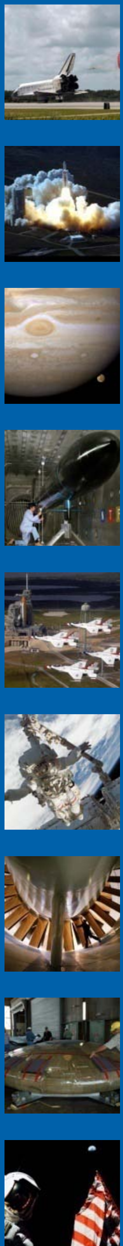
The Space Race Begins

•**1961-1963:** The USSR flies six successful *Vostok* crewed missions.
•**1964-1966:** No Soviet manned flights
•**1961-1966:** The U.S. flies six crewed Mercury and ten crewed Gemini missions, pioneering techniques for use en route to the moon.

Under immense pressure to overtake the Americans, the Soviets planned a 1967 mission involving two *Soyuz* spacecraft to rendezvous, dock, transfer cosmonauts, and commemorate May Day.

Soyuz and Apollo Test Failures

•**November 1966:** *Kosmos*-133 unmanned *Soyuz* suffers maneuvering problems upon re-entry and automatically self-destructs over the Pacific.
• **December 1966:** Second unmanned *Soyuz*' booster explodes on pad
•**January 1967**: Apollo 204 fire kills three astronauts.
• **February 1967:** *Kosmos*-140 unmanned *Soyuz* heat shield experiences 30mm burn-through during entry.
•**April 1967:** Despite failures, as May Day approaches, Design Bureau gives order for dual *Soyuz* mission.



WHAT HAPPENED?

Mission Anomalies From the Start

•Short-wave radio failure reduced communications to a brief line-of-sight UHF comm window each orbit.

•Left solar panel would not deploy, meaning the vehicle’s power supply would last only 28 hours (19 orbits) if the right solar panel could not be oriented toward the sun.

•Solar-stellar attitude control sensor was inoperable, robbing the vehicle of its primary maneuvering system, rendering mission objectives unobtainable and preventing solar recharging of *Soyuz*-1 power.

Mission Aborted; New Reentry Procedure Created

•Falling cabin temperature, depleting power reserves, failed primary/secondary maneuvering systems, and ineffective manual control forced ground crews to abort *Soyuz*-1 and cancel imminent *Soyuz*-2 launch.

•Failed re-entry on the 17th orbit meant the only remaining opportunity for re-entry would take place on the 19th orbit; it would require an untried manual procedure written on-the-spot.

• Cosmonaut Komarov flew the complex maneuver flawlessly, beginning a nominal re-entry trajectory.

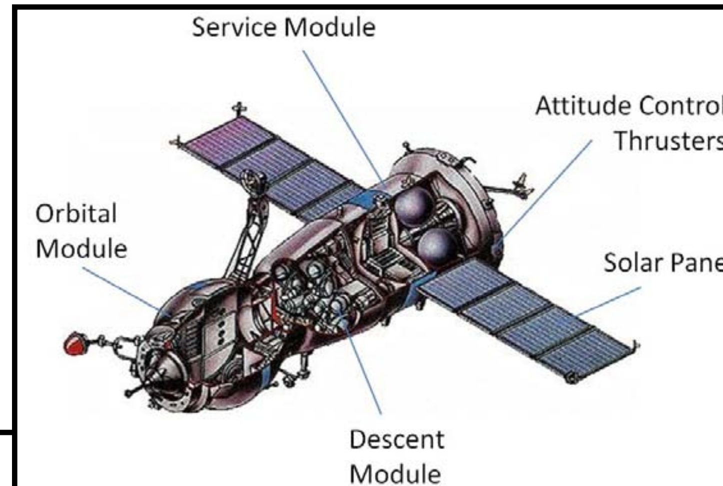
The Mishap

•Upon re-entry, the (pilot) drag parachute deployed properly.

•The main parachute failed to deploy, and when the backup parachute was activated, it tangled with the drag chute and did not fully open.

•Without adequate braking, the spacecraft slammed to the earth at 90 miles per hour.

•Impact forces were fatal, and fire consumed the spacecraft.



PROXIMATE ISSUES

The primary parachute failure mode caused backup parachute failure. *Soyuz*-1 struck Earth's surface at a fatal 90 mph velocity. A tumbling, asymmetric, overheating spacecraft scenario was an alternative possible cause of cosmonaut Komarov's death.

The charred remains of *Soyuz*-1

UNDERLYING ISSUES

Manufacturing Oversight:

•During manufacturing, the spacecraft was exposed to high temperatures in a test chamber used to polymerize a thermal protection coating. The parachute containers were unprotected during this process, allowing masses of hard resin to build up inside the containers, enough to impede the parachutes' ability to deploy and to jettison (unanticipated common cause). The same failure mode existed in *Soyuz*-2 (with 3 crewmembers at risk).

Schedule Pressure:

•Space race resulted in immense pressure on program managers to fly before ready.

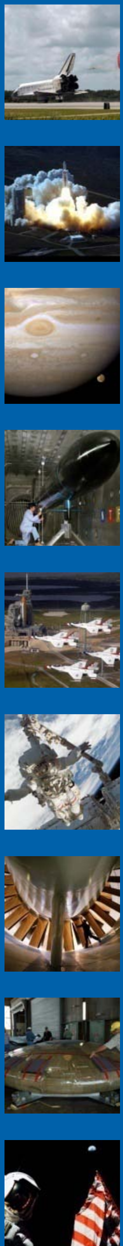
•Gemini success, Apollo 204 failure, and four-year USSR manned flight gap created internal pressure on engineers to regain a technical edge in space.

Real time Decision Making (a good story):

•Superb real time problem solving by the ground and flying by the pilot (re: Apollo 13?)

•Good judgment by ops team in last minute cancellation of *Soyuz*-2 (saved 3 lives?)

FOR FUTURE NASA MISSIONS



- We must do our best to eliminate common cause failures through proper design for failure tolerance and appropriate analysis of accident scenarios.

- Schedule is an important element of any program, but when it becomes the big driver, leaders must ensure they understand the risks to performance and safety, and mitigate appropriately.

NASA painting: Apollo-Soyuz, 1975

NASA photo: International Space Station w/ Soyuz, 2004

- We must not let schedule define our flight test program, but rather, let it be defined by risk and technical performance…allow for the chance that we may need another flight test before we "go operational."
- As this mishap and our own Apollo 13 mission abort show us, we must plan for contingencies, but we must understand our systems well enough that our flight and ground teams can react to and handle