

P1.26 WEATHER AND THE U.S. MANNED SPACEFLIGHT PROGRAM: A BRIEF CHRONOLOGY

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1. INTRODUCTION

The destruction of the space shuttle **Challenger** (STS-51) in January of 1986 illustrated the profound impact that weather can have on spaceflight operations. However, Challenger was just one of many manned space missions to be affected (in one way or another) by weather conditions either before, during, or after launch. This paper will provide a summary, beginning with the earliest Project Mercury missions and continuing to the present day space shuttle program, of those operations that have been affected, for better or worse, by meteorological conditions.



Fig. 1. John Glenn rockets into orbit atop an Atlas missile on 20 February 1962

2. PROJECT MERCURY

The launch of Freedom 7 (5/5/1961), with astronaut Alan Shepard aboard, was the first U.S. manned space mission. As such, extreme care was exercised as to weather conditions for launch. The mission was, in fact, scrubbed one day due to weather. On launch day, an additional 20-45 minute weather delay was necessary.

NASA (the National Aeronautics and Space Administration) maintained strict weather rules for launch throughout the Mercury program. Fig. 1 shows the weather typical of launch days for Project Mercury. Of the six manned Mercury flights, only one (Faith 7, Gordon Cooper aboard, 5/15/1963) was not scrubbed or delayed by weather prior to launch. In the case of Sigma 7 (Walter Schirra aboard, 10/2/1962), a hurricane near one of the recovery areas necessitated moving recovery ships some 215 miles downrange, but the launch proceeded as planned.

3. PROJECT GEMINI

By the time Project Gemini got under way in 1965, NASA had relaxed its launch rules slightly. Clear skies were no longer a requirement for launch. As such, only one of the 10 Gemini missions were scrubbed, (Gemini V), and that was more due to a computer problem than due to weather (there were thunderstorms near the launch pad). In addition, the Gemini V recovery was moved up one orbit due to Hurricane Betsy.

While the Gemini IV launch was not affected by weather, there were concerns over Tropical Storms Babe and Carla near the recovery zones in the western Pacific. The astronauts aboard Gemini VIII, which was aborted early due to problems with the spacecraft thrusters, landed outside the prime recovery zone, and the astronauts became seasick after waiting in high seas for the recovery team to get to them.



Fig. 2. Gemini missions used a modified Titan II rocket

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Fig. 3. The launch of Apollo 11 on 16 July 1969

4. APOLLO, SKYLAB and APOLLO-SOYUZ

The Apollo program was remarkably free of weather related scrubs or delays. Only one launch (Apollo 14) was delayed by weather, and there were no scrubs. The recovery zone for Apollo 11, the first lunar landing mission had to be moved due to weather, but the recovery itself was not affected.

4.1 The Near Tragedy of Apollo 12

There was one spectacular incident in November, 1969 that nearly cost the lives of the crew of Apollo 12. During countdown, a cold front was observed moving slowly southward across central Florida. Skies were overcast at the Cape, and rainshowers were in the area. Not wanting to delay the flight, Mission Control decided to waive Rule 1-404, which stated **“The vehicle will not be launched when its flight path will carry it through a cumulonimbus (thunderstorm) cloud formation.”** The rule existed because the Saturn V rocket was not designed to withstand thunderstorm conditions. Just 36 seconds after launch, the spacecraft suffered a massive electrical anomaly. A second disturbance occurred just 16 seconds later. The guidance platform failed, as well as all other AC power in the spacecraft along with the service module fuel cells. The crew reported their opinion that the rocket had been struck by lightning. It was only through the quick thinking of ground controllers that the crew were able to restore their electrical power. The mission continued without incident after that. It was

later determined from photos and telemetry that the rocket had NOT, in fact, flown into a thunderstorm, but that the lightning was self-induced. Thus NASA was able to say that Rule 1-404 had not been violated in this case. Apollo 12 was the first (and last) manned space flight to be launched into a rainstorm.

Apollo 13, the aborted lunar landing mission had its recovery zone threatened by a tropical storm, but proceeded as planned.



Fig. 4. Lightning strikes the launch tower just after the liftoff of Apollo 12, 14 November 1969

5. THE SPACE SHUTTLE PROGRAM

NASA's Space Transportation System (STS), more commonly known as the space shuttle has been more profoundly affected by weather than any of the previous manned spaceflight projects. This became astoundingly clear on the morning of 28 January 1986, when the shuttle **Challenger** exploded just 74 seconds after lifting off into a clear, cold Florida morning.

Unusually cold weather at the Kennedy Space Center in Florida had sent the temperature below freezing overnight, allowing icicles to form on the launchpad (Fig.5). The cold weather caused the rubber O-rings in the solid rocket boosters (SRB) to lose their flexibility and crack. During launch, the O-rings failed, allowing flaming hot gasses to leak out of the side of one of the

SRBs. The gasses penetrated the thin skin of the external fuel tank and caused a catastrophic hydrogen explosion, destroying the shuttle and killing the seven crewmembers.



Fig. 5. Icicles on the launch pad of Challenger (STS-51) on 28 January 1986

Some engineers at Morton-Thiokol, the company that built the SRBs had argued against launching in such cold weather, but were overruled by NASA administrators. Since that time, NASA has adhered to a strict set of pre-launch rules that cannot be changed or violated. Numerous weather briefings are held from 24 hours to just over 10 minutes prior to a space shuttle launch (see Table above right). In addition, there are strict rules for landing that have resulted in numerous

shuttle missions being forced to divert landing from the Shuttle Landing Facility in Florida to the dry lake bed at Edwards Air Force Base in California.

NASA Schedule of Weather Briefings Prior to Every Launch of the Space Shuttle	
L-24 hr 0 min	Briefing for Flight Director and astronauts
L-21 hr 0 min	Briefing for removal of Rotating Service Structure
L-9 hr 00 min	Briefing for external tank fuel loading
L-4 hr 30 min	Briefing for Space Shuttle Launch Director
L-3 hr 55 min	Briefing for astronauts
L-2 hr 10 min	Briefing for Flight Director
L-0 hr 35 min	Briefing for launch and RTLS
L-0 hr 13 min	Poll all weather constraints

6. REFERENCES

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Summary of Weather-Related Impacts on Early U.S. Manned Space Flight Missions		
Flight	Date	Weather Related Effects
Freedom 7	5/5/1961	First manned flight. One scrub. Launch-day delay due to low clouds
Liberty Bell 7	7/21/1961	Scrubbed twice plus numerous launch-day holds
Friendship 7	2/20/1962	First U.S. orbital flight. Scrubbed four times prior to launch day
Aurora 7	5/24/1962	Launch-day weather delays
Sigma 7	10/3/1962	Recovery ships moved 200+ miles due to threat of Hurricane Daisy
Gemini V	8/21/1965	One launch scrub. Recovery zone moved due to Hurricane Betsy
Gemini VIII	3/16/1966	Recovery in high seas led to astronaut motion sickness
Apollo 11	7/16/1969	First lunar landing. Recovery zone moved due to weather concerns
Apollo 12	11/14/1969	Saturn V struck twice by lightning after liftoff into a rainstorm
Apollo 13	4/11/1970	Recovery zone threatened by tropical storm
STS-51 (Challenger)	1/28/1986	Sub-freezing temperatures led to O-ring failure. Vehicle exploded. Crew of seven lost