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# Incidence of an Astronaut Not Closing the Pressure Garment Visor on Reentry

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# Pacific Spaceflight Research Brief #2015-2

## Incidence of an Astronaut Not Closing the Pressure Garment Visor on Reentry



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### Abstract

Audiovisual records of a Project *Mercury* pilot's activities during an orbital flight indicate that his visor was left open during reentry and descent to the sea surface, phases of flight during which cabin pressure loss was to be mitigated by suit pressurization; however the suit could not have been pressurized with the visor open. Thus, for a presently-unknown reason, a critical safety step—sealing the visor and making a pressure suit integrity test before re-entry—was overlooked in this flight, a fact itself unreported in any flight review or historical documents known to the author. The lesson is clear: even a highly-motivated, federally-funded project remains at base a collaboration of individuals, the project only being as strong as the proverbial weakest link. Attention to development of thorough and unambiguous procedural checklists is reiterated.

### 1. Introduction

In several years of independently designing, building and testing launch-entry pressure garments, the Pacific Spaceflight research group have learned the essential nature of accurate and thorough checklists in the use of such technology. When systems are formalized, checklists are relatively straightforward to produce, but when technologies are being developed, checklists must change often to track varying system configurations and test objectives. This highlights the problem of 'checklist complacency' in which checklist items are skipped when operators feel they are familiar with checklists.

Adhering to checklists is less difficult, as they form the essential 'script' of our pressurized garment tests. Still, checklist adherence remains a difficulty in all levels of aviation, for reasons including flight crew fatigue, checklist illegibility, aircrew confusion of checklist sequences and meanings, and others [1].

In reviewing audiovisual records of Project *Mercury* spaceflights, and their audio transcripts, the author has identified a case of a Mercury astronaut not closing his pressure garment visor during reentry; this was a phase of flight in which ambient atmospheric pressure (exterior to pressure cabin) were lethally low (effectively hard vacuum), and the pressure garment was worn precisely as a backup in the event of pressure cabin pressure loss. This means that in this case, had a cabin pressure breach occurred, the

pressure garment would not have been able to fulfill its essential function of keeping the astronaut's body at a physiologically-perceived safe, low altitude, in terms of both gas pressure and composition. At some point, the checklist system here failed, as did the pilot's situational awareness and that of the ground team who monitored his voice transmissions closely; nobody noticed that some time after about 1 hour into the roughly five-hour flight, the pilot opened his pressure suit visor, and left it open through the reentry phase. Evidence for this is given in section 2, and the implications discussed in section 3.

### 2. Video and Audio Transcript Evidence

Review of The Mercury 6 (06 February 1962, four-orbit Mercury flight) cockpit footage [2] reveals the open-visor on reentry episode. **Table 1** and **Figures 2 – 9** supplement the table.

For familiarization with the helmet in question, Figure 1 displays the fiberglass-shell, polycarbonate -visor helmet to the modified Navy Mark V pressure garment. In **Figure 1a**, the helmet visor is up, leaving a distinctive black sealing ring or gasket visible around the perimeter of the face opening; this is seen again in **Figure 1b**.

In **Figure 2**, the pilot is listening to the transmission from the ground (row two of Table 1 at 00:04:44), "*Twenty seconds to SECO* (supplementary engine cutoff)."; at this time, the helmet visor is clearly down, with the black sealing

strip noted in Figure 1a and Figure 1b obscured by a metal cover visible in **Figures 1a**.

At 00:16:35 into the flight, the pilot reports a cabin pressure of 5.7psi and a suit pressure of 5.8psi; these figures are correct for the flight plan, indicating a pressure reduction (from 14.7psi ambient at launch) to c.5psi minimum during orbit; the extra 0.1psi in the suit at this point is expected, as while the suit was not meant to be flown fully pressurized, the experience of Pacific Spaceflight test subjects is universally that about 1/10th of one psi is a comfortable suit pressure to keep the helmet off the head and the suit material slightly away from the body. This pressure in the suit cannot be maintained with the visor open, so though there is no video footage of this transmission, the numbers indicate that at this point the visor was closed and sealed.

In Figure **3a**, the pilot is opening the visor to take a xylose (sugar) pill about 22 minutes into the flight. In **Figure 3b**, the pill is being consumed, and in **Figure 4** the visor is closed again, just a few seconds after it was opened to take the sugar pill.

At 00:52:00, CAPCOM asks the pilot to confirm that his visor is closed (line five of **Table 1**); the pilot confirms this, indicating that he was closing the visor as it had been opened for some unreported time. At 01:13:09 the pilot reports opening the visor to eat; somewhat over a minute later, he reports having eaten (applesauce from a tube) and that he is again closing the helmet visor.

The next video footage pertinent to the subject of this brief is seen at 04:33:09, during the deorbit burn; here (see **Figure 5**) the visor is clearly open, with no metal band covering the black sealing strip identified in other Figures.

Figures **6, 7, 8** and **9** – all time-stamped to altitudes between orbit and 7,000 feet – show an open visor. Viewing the continuous video footage through this period shows that the visor remained open though deorbit burn and landing [2]. **Figure 10** shows the Mercury 3 pilot with visor clearly down at 50,000 feet (video derived from cockpit camera record archived at <https://www.youtube.com/watch?v=4LziZpAmMy8>); the helmet worn here did not differ from that worn by the Mercury 6 pilot discussed in this report.

### 3. Discussion

Why was the helmet visor left open through the reentry phase of the Mercury 6 mission?

The reason might be simple oversight; the **Mercury 6 Flight Plan** [3] contains numerous checklists for the flight, reentry and pickup phases of the mission. As described below, most do not carry explicit instructions to close the visor before reentry. Specifically, the Flight Plan Checklists were: **1. BECO** (booster engine cutoff; e.g. jettison emergency tower), **2., SECO** (supplemental engine cutoff, e.g. periscope out, spot booster, report on tumbling sensations and Og sensations), **3. Orbit Checklist** (various switch settings, none related to life support), **4. Control Systems Check** (checking control performance against expected performance), **5. Yaw Maneuver Check** (perform a yaw maneuver, and then stabilize all rates to zero) and **6, Equipment Stowage** (stowing away flashlight, cameras and other loose items prior to reentry). Life support systems and the helmet visor position are not mentioned in these lists. In the immediate pre-deorbit and reentry phase checklists there is also no mention of the helmet visor or other life support matters: in [3] page 80, *Reference List 7,*

**Preretrosequence Checklist**, the items are 1. Equipment – STOWED, 2. Control System – CHECK (thruster warmup), 3. Emergency Retro Sequence fuse switch – NO. 1, 4. Transmit Switch – UHF, 5. Retro Man fuse switch – NO. 1, 6. Restraint Devices – CHECK, 7. Crosscheck Attitude – Window/Instruments/Scope and 8. Time check CET. It is only in *Reference List 9* [3] page 82, **Post-Entry Checklist**, that we see mention of the visor status: item 9 is 'Astronaut preparation for landing' and item 9d is Disconnect Visor Seal hose followed by 9e, Open visor. These item 9 items are to be carried out after item 8, which is to check main parachute deployment visually, at an altitude of 10,000 feet. Since the visor position was not listed in these checklists, its status might not have been checked; however, as Figure 10 indicates, other mission pilots did not leave the visor open through descent and landing.

A possible contributing reason for this oversight might be imprecision in terminology; while most documents refer to the visor as a visor, the Mercury 6 pilot once refers to the visor as the 'faceplate' (at Mission Elapsed Time of 00:21:59; see [4]). Such discrepancies lead to uncertainties in our experience, but precisely how such would play out in this circumstance is unclear.

A second, more morbid reason for not sealing the visor is possible; the pilot of this flight was told to leave the retrorocket pack attached to his spacecraft during descent, for a number of technical reasons beyond the scope of this paper; the gist of the matter is that the pilot was aware of a major departure from the flight plan in this respect, and might have suspected that his heat shield was damaged, as was suspected by the ground team, but not communicated to the pilot. In this case, it might be that the pilot made a decision to leave the visor open in the event of a cabin pressure breach, suspecting that one would attend any destruction of the space capsule if the heat shield were indeed damaged. The pilot has not reported on this matter in public, and it is mentioned here only as a speculation in possibility.

In any case, it is clear that between 01:14:30 and 04:33:09 Mission Elapsed Time, the Mercury 6 pilot opened the pressure garment visor, after which time he does not appear to close it again. Loss of cabin pressure – the contingency the pressure suit was worn to protect against – would likely have been lethal with the visor open through the bulk of the descent, with time of useful consciousness anywhere above 40,000 feet MSL measured in less than 15 seconds [5] (in one case of likely helmet pressure breach, at c.51,000 feet MSL the pilot was heard to exhale briefly before losing consciousness, and was unable to make even the simple motion of resealing the visor with an arm and hand motion [6]).

### 4. Conclusion

Vigilance with *correct use of terms, development of unambiguous and thorough checklists and adherence to these checklists* is as critical to the successful operation of pressure garments as to the operation of aircraft.

## 5. References

- [1] J.W. Turner and M.S. Huntley. 1991. *The Use and Design of Flightcrew Checklists and Manuals*. US Department of Transportation, Federal Aviation Administration, Office of Aviation Medicine, Washington, D.C.
- [2] "Friendship Seven", NASA documentary film on the Mercury-6, originally stored at the National Archives, and slightly cropped and uploaded to <https://www.youtube.com/watch?v=9fD5IqTREGU>.
- [3] *Flight Plan for Mercury-Atlas Mission 6*. Flight Operations Division, NASA Manned Spacecraft Center, Langley, VA. Jan 1962.
- [4] *Results of the First United States Manned Orbital Space Flight, February 20, 1962*. NASA Manned Spacecraft Center, Langley, VA.
- [5] *Introduction to Aviation Physiology*. Federal Aviation Administration, Civil Aerospace Medical Institute, Oklahoma City, OK.
- [6] Ryan, C. 2008. *Magnificent Failure: Freefall from the Edge of Space*. Smithsonian Books, Washington, D.C.

**Table 1. Audiovisual and Transcript Evidence.** MET = Mission Elapsed Time (time from instant of liftoff), **ALTITUDE MSL** = Flight Plan Altitude at Given MET, in Feet Above Mean Sea Level (MSL), **AMBIENT PRESS** = ambient atmospheric pressure, **TRANSMISSION** = Transmission from Pilot to Ground (P) or Ground to Pilot ('Capcom' or CC), **VISOR** = Visor status, Open or Closed; based on video frame at time of indicated transmission.

MET	ALTITUDE MSL	AMBIENT PRESSURE	TRANSMISSION	VISOR	FIG
00:04:44	>15,000'	<8.0PSI	<b>CC:</b> <i>'Roger 20 seconds to SECO.'</i>	Closed 29:19	2
00:16:35	in orbit c.130mi	<0.000psi	<b>P:</b> <i>'...Cabin pressure holding steady at 5.7 [psi]... suit pressure is indicating 5.8.'</i>	Closed no video	-
00:21:59	in orbit c.130mi	<0.000psi	<b>P:</b> <i>'...preferring to take xylose pill at present time... Unsealing the, going to unseal the faceplate. Over.'</i>	Opening at 33:55, closing at 34:02	3,4
00:52:00	in orbit c.130mi	<0.000psi	<b>CC:</b> <i>'"Roger. You do have your visor closed at this time [asking for confirmation]. Over. "'</i>	-	-
00:52:03	in orbit c.130mi	<0.000psi	<b>P:</b> <i>'That is affirmative. I had it open for a little while; it's closed now. Cabin pressure is holding in good shape. Over.'</i>	Closed no video	-
01:13:09	in orbit c.130mi	<0.000psi	<b>P:</b> <i>'"This is Friendship Seven. Opening visor, going to eat, over.'</i>	Opening no video	-
01:14:30	in orbit c.130mi	<0.000psi	<b>P:</b> <i>'"This is Friendship Seven. Have eaten one tube of food, shutting the visor.'</i>	Closing no video	-
04:33:09	c.360,000'	<0.000psi	<b>P:</b> <i>'"Roger, retros are firing.'</i>	Open 44:10	5
04:43:47	>100,000'	<0.016psi	<b>P:</b> <i>'"This is Friendship Seven. A real fireball outside.'</i>	Open 47:56	6
04:47:55	c.100,000'	c.0.016psi	<b>P:</b> <i>'"My condition is good but that was a real fireball, boy.'</i>	Open 50:16	7
04:48:07	80,000'	0.40psi	<b>P:</b> <i>'"Altimeter off the peg indicating eight zero thousand [ft MSL].'</i>	Open 50:29	8
04:49:20	c.30,000'	4.3psi	<b>P:</b> <i>'"...drogue [parachute] came out at 30,000...'</i>	Open 51:06	9
04:52:14	<7,000'	c.11psi (safe)	<b>P:</b> <i>'"Friendship Seven, going through [landing] checklist...'</i>	No video	-

**FIGURE 1. Mercury 6 Pilot Wearing Pressure Helmet.** In (a) the helmet visor is open, revealing a distinctive black sealing strip around the perimeter of the face opening; this is better seen in (b). 1a derives from a NASA image at <http://www.nasa.gov/content/astronaut-john-glenn-at-cape-canaveral>. 1b is derived from [3].

**a**



**b**



**FIGURE 2. Mercury 6 Pilot at 20 Seconds to SECO, Visor Closed. Sealant strip visible in Figures 1a and 1b not visible, here obscured by metal visor perimeter strip seen in Figure 1a.**



**FIGURE 3. Figure 3a: Pilot Opening Visor c.20 minutes Into Flight. Figure 3b: Pilot Consuming Xylose (Sugar) Pill.**

**a**



**b**





**FIGURE 4. Pilot Closing Visor After Consuming Xylose (Sugar) Pill While in Orbit With Hard Vacuum Beyond Pressurized Cabin Hull.**



**FIGURE 5. Pilot Reporting “*Roger, retros are firing.*” at Entry Interface (Mission Elapsed time 04:33:09), With Hard Vacuum Outside Pressure Cabin and Helmet Visor Open, Altitude c. 360,000' MSL.**



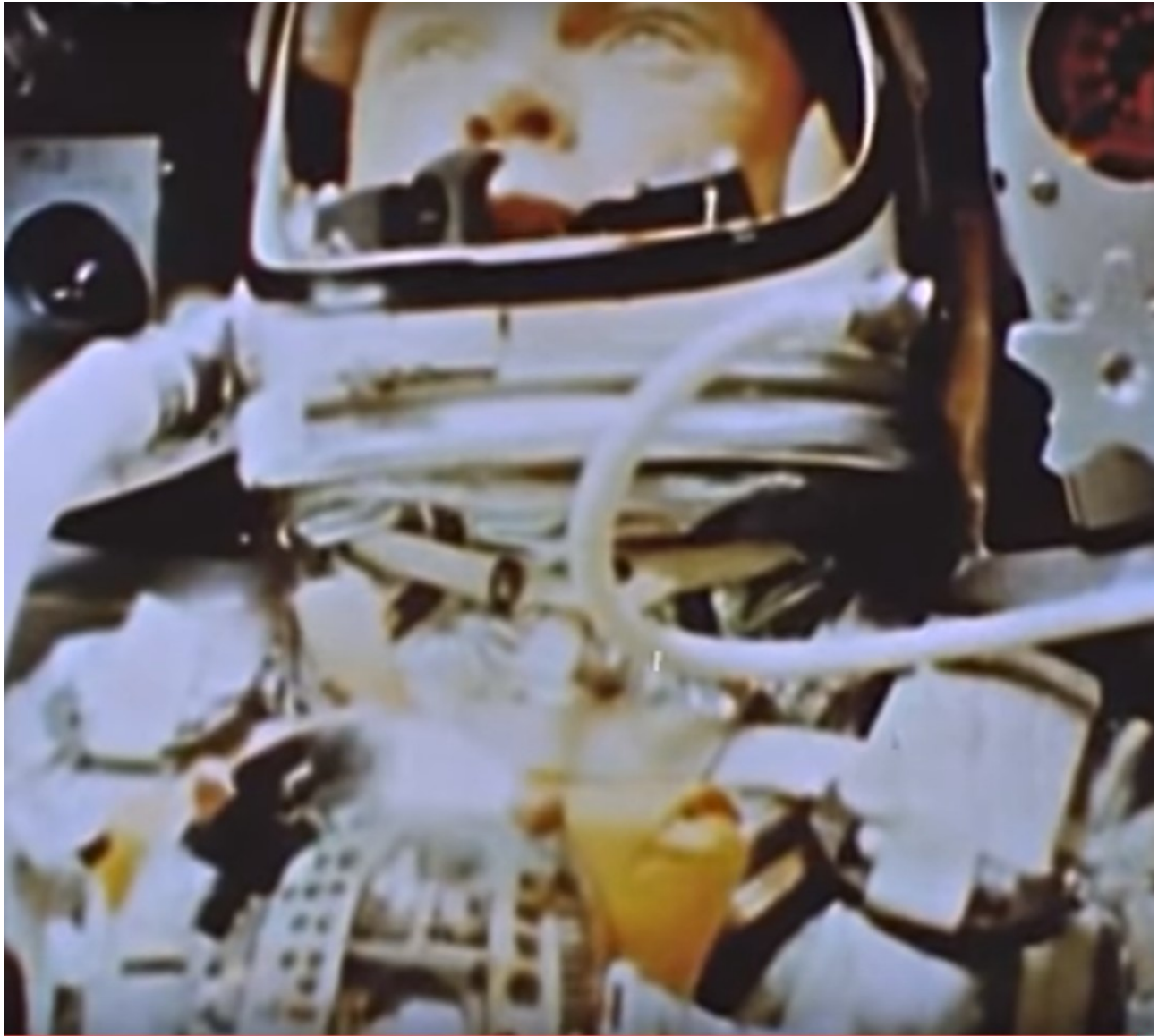
**FIGURE 6. Pilot Reporting “A real fireball outside,” During Reentry (Mission Elapsed time 04:43:47), With Hard Vacuum Outside Pressure Cabin and Helmet Visor Open, Altitude >100,000' MSL.**



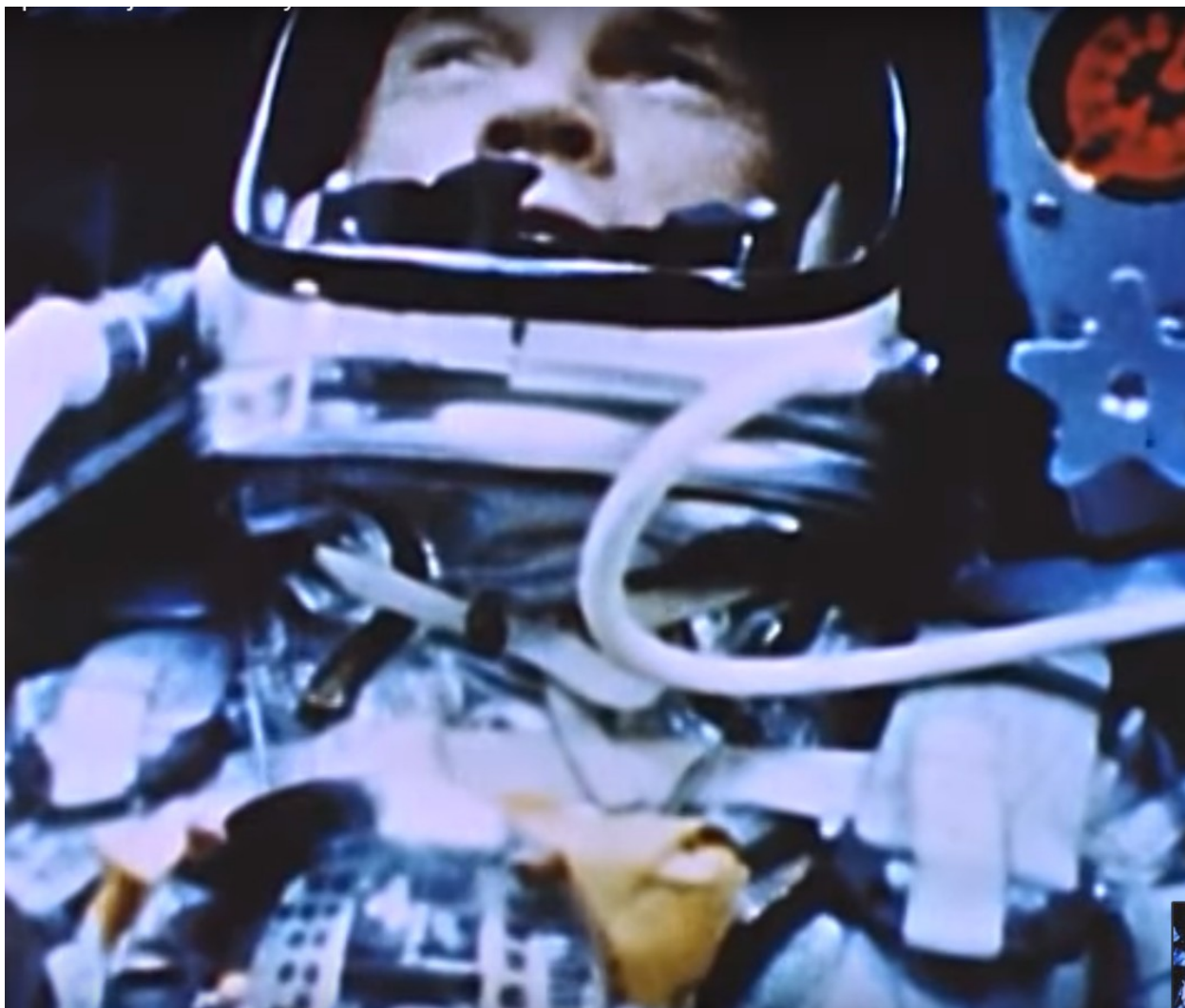
**FIGURE 7. Pilot Reporting “*My condition is good but that was a real fireball outside, boy!*” During Reentry (Mission Elapsed time 04:47:55), With Hard Vacuum Outside Pressure Cabin and Helmet Visor Open, Altitude c. 100,000' MSL.**



**FIGURE 8. Pilot Reporting “*Altimeter off the peg indicating eight zero thousand.*” During Reentry (Mission Elapsed time 04:48:07), With <0.0psi Ambient Pressure Outside Pressure Cabin and Helmet Visor Open, Altitude 80,000’ MSL.**



**FIGURE 9. Pilot Reporting “...drogue [parachute] came out at 30,000...” During Reentry (Mission Elapsed time 04:49:20), With 'Only Just Physiologically Safe' Ambient Pressure of 4.3psi Outside Pressure Cabin and Helmet Visor Open, Altitude c. 30,000' MSL.**



**FIGURE 10. Mercury-Redstone 3 Pilot Reporting Altitude of 50,000' MSL During Reentry With Helmet Visor Closed, Black Sealing Ring Obscured by Metal Visor Rim.**

