The Whirligig

On 16 March 1966, five months after Walter Schirra and Thomas Stafford had been left at the starting gate in NASA's first attempt to launch two vehicles toward rendezvous on the same day, NASA tried again. This time nothing marred the countdown of the Atlas-Agena or the Gemini space vehicle.[45]

[309] The target launch vehicle lifted from pad 14 at 10 o'clock in the morning. Its trajectory was at first low and to the right (south) of the intended flightpath. The sustainer engine rammed the target back on track. In a little more than five minutes, the Atlas had done its job. Now it was Agena's turn. After a short coast, its secondary propulsion system burst into life. The crucial test for the Agena came with the firing of its main engine, and the engineers crossed their fingers and held their breaths. But it worked. The engine ignited and carried the target into a 298-kilometer circular orbit.[46] Planners had wondered if the Agena could so position itself that astronauts could catch it. The answer was yes!

With one up and one to go, attention turned to 19. Fourteen minutes before the Atlas-Agena lifted, Armstrong and Scott slid through the spacecraft hatches into their couches. As the flight-preparation crew helped harness Scott to his parachute, they found one of its catches full of glue. Backup command pilot Conrad and McDonnell pad leader Guenter Wendt began digging it out. Just a little thing like that, Scott thought, "might have cost us a launch," but he could not help smiling as he watched Conrad sweat over the job. The catch came unglued and Gordon, the backup pilot, tried the fitting a few times to prove to Scott that it was working. Learning of the Agena's nearly perfect orbit, Armstrong said, "Beautiful, we will take that one."[47]

Given the Agena's orbital parameters, the Gemini launch vehicle should lift off at 10:40:59 am. The powerful engines of Titan II throbbed into life exactly on time, and Armstrong and Scott felt the hold-down bolts shear for breakaway. GLV-8 started off a little low, as had Atlas, but soon straightened to boost the 3,788-kilogram (8,351-pound) spacecraft into an elliptical orbit 160 by 272 kilometers.[48]

After the first hurdle had been vaulted, the next challenge was catching the target. Procedures were much the same as those for *Gemini VI-A*, although this time there was no friendly target to point its attached transponders toward the spacecraft's radar. Armstrong and Scott began the chase 1963 kilometers behind the Agena.

Thirty-four minutes into the flight, the Sun set and, in the engulfing darkness, the crew could see brilliant fires streaming from their spacecraft's thrusters. As the radiator in the adapter expelled water, the thrusters fired to compensate for a sideward turn. The Carnarvon, Australia, tracking station told them the radiator was not much of a problem and passed to them the Flight Director's "go" for a day's flight.[49]

Over the Pacific, the two astronauts had some time to sightsee. Molokai, Maui, and Hawaii hove clearly into view. Armstrong tried to see Karnai and Oahu, but cloud banks obscured them. Minutes later, Scott said to his partner, "We're going over Baja California now. Can you been it?" But Armstrong had his eyes on the Los Angeles ship basin [310] in the other direction, and his response was, "Oh, look at all those ships!" Armstrong then spotted the Rogers Dry Lake bed. He looked for, but was not certain he found, Edwards Air Force Base, where he had spent seven years piloting experimental airplanes. Over Texas, both men wanted to see if they could spot their homes, but work preempted this scenic interlude. At the low point of their first circuit of Earth, Armstrong aligned the inertial platform for a height adjustment maneuver. At 1:34 hours elapsed time, he touched off a five-second burst of the thrusters for a small retrograde change in velocity, to lower the apogee slightly. Armstrong noticed a problem in cutting off residual thrust. This resulted in varying computer readings and made it difficult to tell the exact deceleration obtained.[50]

On their mission, Schirra and Stafford had been so preoccupied that they had not taken time to eat, which left them hungry, as well as tired, when they caught up to Borman and Lovell. Scott and Armstrong knew they would be very busy all three days of their mission, so each grabbed a package of food and started preparing a meal, which seemed to take longer than they thought it would. When they had to stop and align the platform for a maneuver to raise the perigee, they placed the food packages against the spacecraft ceiling. Weightlessness was handy.[51]

Nearing second apogee (2:18:25 hours), Armstrong fired the thrusters to add 15 meters per second to their speed. Again, tail-off residuals made it hard to get a computer reading.[52] After this maneuver, Armstrong and Scott pulled their food from the ceiling. Although Armstrong's chicken and gravy casserole had been mixed with water for half an hour, it was still dry in spots and not much like home cooking. But he finished it and washed it down with fruit juice to keep from dehydrating. Then he tried a package of brownies, which were stuck together and crumbly. They were hard to eat without scattering weightless scraps all over the cabin.[53]

The next maneuver was designed to push the spacecraft into the target's orbital plane. Armstrong yawed *Gemini VIII's* nose 90 degrees south of the flight path. Over the Pacific Ocean, 25 minutes before completing the second revolution (2:45:50 hours), the command pilot punched the aft thrusters to produce a horizontal velocity change of 8 meters per second. He waited for the ground controllers to tell him if any adjustment was needed. Hearing nothing, he assumed his thrusting had been correct. Over the Guaymas, Mexico, tracking station, Lovell, the Houston CapCom, suddenly cut in on the remote site line to order him to add 0.6 meter per second to his speed. With only a minute to get ready, there was little time to turn the spacecraft and no time to align the platform. "It was a pretty quick loose burn . . . without much preparation," Scott said.[54]

Armstrong and Scott then began the rendezvous radar test. [311] They did not expect to get radar contact as quickly as Schirra and Stafford had, but the Westinghouse development team had promised target acquisition at 343 kilometers. The radar locked on solidly at 332 kilometers, which was good enough.[55]

Over the Tananarive tracking station, 3:48:10 hours after launch. Armstrong nosed the spacecraft down 20 degrees and applied the aft thrusters for an in-plane (with the target) velocity change of 18 meters per second. This gave them a nearly circular orbit close to 28 kilometers below that of the target. The spacecraft was now in position to start the terminal phase of rendezvous.[56]

The crew sighted a shining object 140 kilometers ahead, which must be the Agena. After closing to a range of 102 kilometers, all doubts were erased - the target gleamed in the sunlight. Scott switched the computer from the catchup to the rendezvous mode and watched the distance dwindle on the slide, automatically. Just before sunset, the Agena suddenly disappeared, but at twilight its acquisition lights blinked into view.[57]

When the Agena was at the proper angle (10 degrees) above them, Armstrong aligned the inertial platform for the translation maneuver. Then he pitched *Gemini VIII's* nose up 31.3 degrees and canted the vehicle 16.8 degrees to the left. At 5:14:56 hours, ground elapsed time, the command pilot fired his aft thrusters, later making two small corrections. High over the *Coastal Sentry* Quebec tracking ship, stationed near Antigua Island, at 5:43:09 hours, he braked the spacecraft. Since he could see the Agena, Armstrong judged his braking action by eye as Scott called out radar range and range rate. At a distance of 46 meters, relative velocity between the two vehicles had been canceled. The second rendezvous in the Gemini program had been achieved.[58]

For 36 minutes after rendezvous, Armstrong's delicate maneuvering kept his spacecraft on station with the target vehicle. As the command pilot drove, Scott inspected the Agena - checking antennas, docking lights, and the like. Finding it hard to see all of the target's instrument panel displays near the docking cone, he used the telescopic sight of a hand-held sextant. But a really good look would have to wait until they were docked, when these instruments would become a second dashboard. Meanwhile, Armstrong studied the general appearance of the Agena. It seemed stable, and he nudged the spacecraft to within a meter (about three feet) of the target. Then, at 6:32:42, Keith K. Kundel, CapCom on the *Rose Knot* Victor, radioed, "Go ahead and dock."[59]

Armstrong eased *Gemini VIII* toward the target at a barely perceptible rate of 8 centimeters (3 inches) per second. "About two feet [60 centimeters] out," he told the *Rose Knot* Victor. In a matter of seconds, Armstrong gleefully reported, "Flight, we are docked! [312] It's . . . really a smoothie - no noticeable oscillations at all." For a moment, the flight controllers in Houston could not realize that they had really done It. Then pandemonium broke loose, with back slaps, hand shakes, cheers, and tremendous grins.[60]

Because there had been some difficulty in verifying the Agena's uplinked* stored program commands for the planned docked yaw maneuver and in loading the target's velocity meter, the flight controllers suspected that Agena's attitude control system might be misbehaving. In fact, Lovell, on the remote link through Tanarive just before the spacecraft passed out of communications range, told the crew, "If you run into trouble and the attitude control system in the Agena goes wild, just . . . turn it off and take control with the spacecraft." With this warning raging in their ears, Armstrong and Scott began their docked chores.[61]

The Agena was designed to obey orders from the spacecraft, as well as from ground control. Scott commanded the target's attitude control system to turn the vehicle combination 90 degrees to the right. It took five seconds less than the full minute expected. Scott next dialed an order to start the Agena's tape recorder and looked over toward Armstrong. As he did, his gaze skimmed the control panel in the spacecraft. Something had to be wrong - *Gemini VIII* should be in level flight, but the "ball" indicator showed a 30-degree roll. He knew there was no use checking the horizon out the window, as they were passing through Earth's shadow. There would be no help from the ground tracking stations either; they were still out of communications range.[62]

"Neil, we're in a bank," Scott said. He thought perhaps his spacecraft attitude ball had tumbled, but Armstrong's indicator showed an identical mark. The command pilot managed, with bursts from the OAMS, to stop the motion temporarily, but it soon started again. Their immediate reaction was to blame the Agena. As soon as the vehicles were steady enough, Scott commanded the target to turn off its attitude control system, as the communicator had instructed. For four minutes, the two craft steadied and straightened up; the trouble seemed to be over. Armstrong started maneuvering to get the docked vehicles into the correct horizontal position; suddenly they began to roll again, faster and faster. "What's the problem now?" the pilots wondered. They were supposed to do a small test to find out what stress and strain the linkage between the two vehicles could tolerate. That issue was now academic; the immediate question was whether it could stand up under these wild gyrations.

[314] While Armstrong struggled with the controls, Scott photographed the interaction between the two vehicles out of his spacecraft window. The command pilot soon reported that the OAMS propellant had dropped to 30 percent, a strong clue that a spacecraft thruster might be causing the trouble. While Armstrong fought the controls, Scott cycled the target vehicle switches off and on and off again. Then Armstrong jiggled the spacecraft switches as well, to see if they could isolate the problem. Nothing they did seemed to have any effect.[63]

The crew realized that they would have to break away from the Agena to analyze the situation. Past simulation training gave them no clues to what was happening or how to handle it. Scott transferred control of the Agena to the ground stations (which had been locked out to prevent spurious signals), and Armstrong labored to steady the vehicles enough to divorce them. "Go," Armstrong said, and Scott hit the undocking button. Armstrong gave the thrusters a long hard burst, and the spacecraft pulled straight back.[64]

Almost immediately, suspicion about a spacecraft control problem became an established fact as the spacecraft rolled even faster. "And then we really took off," Armstrong and Scott later reported. *Gemini VIII* soon came into acquisition range of the *Coastal Sentry* Quebec. James R. Fucci, CapCom aboard the ship, was concerned and perplexed. He could not get a solid electronic lock-on, but a blinking light signal indicated that the craft had undocked. Unaware that the spacecraft was rolling, so the antennas could not remain in position, he put in a call to the crew to try to find out about these strange signs he saw on his console.

> **Fucci:** *Gemini VIII,* CSQ CapCom. Com check. How do you read?
>
> **Scott:** We have serious problems here . . . we're tumbling end over end up here. We're disengaged from the Agena.
>
> **Fucci:** Okay. We got your SPACECRAFT FREE indication here. . . . What seems to be the problem?
>
> **Armstrong:** We're rolling up and we can't turn anything off. Continuously increasing in a left roll.
>
> **Fucci:** Roger. [37 seconds later] *Gemini VIII.* CSQ.

Armstrong: Stand by.

Scott: We have a violent left roll here at the present time and we can't turn the RCS's off, and we can't fire it, and we certainly have a roll . . . stuck hand control.[65]

After backing away from the Agena, the spacecraft had started to whirl at a dizzying rate of one revolution per second. Armstrong suspected that the maneuvering thrusters were about finished. He and Scott were also having trouble seeing the overhead panel dials; their [315] physiological limits seemed near. They were dizzy, and their vision was blurred. Something had to be done. "All that we've got left is the reentry control system," Armstrong said. "Press on," Scott responded. The two men began to throw switches to cut out the OAMS and cut in the reentry control system. Armstrong tried his hand controller - nothing. Scott tried his - still nothing. They started switching circuitry again - maybe something had been set in the wrong position.

The hand controllers responded!

Armstrong steadied the motion and then turned off one ring of the reentry control system to conserve fuel. He then carefully reactivated the maneuver thrusters; now they were able to tell that No. 8 had "failed on" - that is, it had stuck open![66]

Using the reentry control thrusters meant that the *Gemini VIII* mission would have to come to an end as soon as possible. That was a mission rule. True, the spacecraft was operating in a backup mode - but it was the prime mode for reentry. If these thrusters developed leaks, the crew would have absolutely no means of getting the spacecraft into position for the critical retrofire that would return them to Earth. Attitude control before and after reentry was essential to reenter the atmosphere safely. Here was a case where the fail-safe maneuvers that Headquarters had insisted on early in the program were impossible - there was virtually no maneuverability left in the orbital thrusters. Armstrong and Scott also remembered, wistfully, that Kraft, the flight controllers, and engineers had nursed other missions to completion. Could the same be done for them now? This was but a fleeting hope, as the Hawaiian tracking station communicator told them to get their spacecraft into position for reentry.[67]

Gemini VIII's problems were certainly the most frustrating of any Gemini had yet encountered. The flight control team's ability to respond to real problems on previous missions, keeping spacecraft flying to wring all useful data from failures as well as successes, had bolstered confidence in the program and promoted "real-time" planning. But *Gemini VIII's* failure had forced the astronauts to resort to a last-ditch mode for attitude control before the ground crews had a chance to provide the options that might have allowed the flight to go on.

John Hodge, in his first trial as chief flight director, now had only one choice left - which contingency recovery landing area would be best? If he waited much longer, it would take a full day (or 15 revolutions) for the crew to reach a splashdown point from which they could be quickly recovered. Since the orbital track had precessed westward, landing during the sixth or seventh orbits would have to take place in the Pacific Ocean. When the Landing and Recovery Division recommended a touchdown in the seventh circuit, Hodge agreed.

Kranz had dropped by to listen to the spacecraft and target docking. Since Hodge had been at the flight director's console for 11 hours, [317] he and Kranz decided that the second shift should report for duty immediately, catch up on all information, and direct the final phases of the mission. Had the flight continued for three days, reentry would have taken place on Kranz' shift, anyway, and he and his men had more practice in recovery procedures than Hodge and his group.[68]

The engineers who had worked so hard on the Agena's problems found their situation just as exasperating as that of the flight controllers. After the docking, Smith, Harold W. Nolan, and others from Lockheed had retired to nearby motel rooms to celebrate the momentous event. Very shortly, Smith called Nolan, saying, "We've got trouble!" Nolan switched on his television, only to hear newscasters reporting that the Agena was at fault. Smith's motel room became the initial Lockheed failure-analysis command post, the first guess being that the target's attitude control system had failed.

Many other engineers and program officials also heard about the spinning spacecraft while out of touch with minute-by-minute developments. Mueller, for instance, had remained at Cape Kennedy only through launch and the early phases of the mission. Then he took off for Washington to attend the annual Robert H. Goddard Memorial Dinner, sponsored by the National Space Club. The pilot of the NASA aircraft heard what was happening over the plane's radio and informed Mueller. They returned to Florida, where Merritt Preston met Mueller's party with a motorcycle escort, the prelude to a hair-raising ride to the old Mercury Control Center in time for spacecraft retrofire.[69]

Most of NASA's leaders at Headquarters had, in fact, already headed for the Goddard dinner - the prestigious social event of the year for the space community. At the opening reception, Deputy Administrator Seamans** was called to the telephone to learn of *Gemini VIII's* plight. He immediately phoned Houston Flight Control and learned that the spacecraft spinning had been stopped. When he told the chairman of the dinner about the trouble, Seamans was asked to make a brief announcement: he said the flight would have to be aborted, but the crew seemed in no immediate danger. Vice President Hubert H. Humphrey, the principal speaker, asked to be told as soon as the crew had been successfully recovered. Before he had finished his address, Humphrey was able to inform his listeners that Armstrong and Scott had landed safely. Seamans vowed that never again would he be caught in a public position during the critical phase of any succeeding flight. He needed privacy and better communications with the Control Center.[70]

As a rule, McDonnell (the spacecraft contractor) sent several of its [318] experts from the Cape to Houston after launch and first orbit to be available as troubleshooters. On 16 March 1966, a NASA Gulfstream left Florida for Texas with about 14 passengers, among them several high-ranking McDonnell engineers. Over New Orleans, the pilot cut in a commercial radio broadcast to the cabin. The announcer was talking about an imminent recovery in the Pacific. This was all the startled passengers heard, since the news announcement ended there. Something had obviously gone wrong, but what was it? There was nothing to do but wait until they got to Houston.

Raymond Hill, McDonnell's Gemini manager at the Cape, recalled that his company's policy changed radically after "I . . . was caught with my pants down." In the future, senior McDonnell officials - Hill, Walter Burke, John Yardley, and Robert Lindley - would not be in transit at the same time during a flight. Hill stayed at the Cape, Burke went to Houston for the first day of the flight and then back to St. Louis, and Yardley and Lindley went to Houston and stayed until the mission was over. McDonnell specialists, who had previously remained in St. Louis to handle test set-ups and to answer questions by telephone and teletype, were shifted, along with their subcontractor counterparts, to Houston to work directly with GPO systems engineers during the mission.[71]

Meanwhile, Navy recovery forces in the Pacific were swinging into action. A destroyer, the U.S.S. *Leonard F. Mason,* steamed at flank speed toward the expected landing point 800 kilometers east of Okinawa and 1,000 kilometers south of Yokosuka, Japan.[72]

With *Gemini VIII* now flying over the southern latitudes, Kranz had only three tracking stations in position to keep in touch with the crew*** - *Coastal Sentry* Quebec, *Rose Knot* Victor, and Hawaii.[73] The spacecraft was in darkness over the Congo when Kranz's Houston flight controllers began the final countdown for retrofire. Through the remote stations, Scott reported, "Props OFF," and Armstrong said, "Hang in there." Seconds later, Scott said, "Okay. Four retros bed in AUTO RETROFIRE. . . ."

Armstrong was worried that he and Scott might land in some remote wilderness where they would be hard to find. He later said he had been thinking of the steamship Andrea Doria, which had gone down in the Atlantic on 26 July 1956. Although the liner's radios were operating, it had taken the rescue vessels a day and a half to find the sinking ship. He wanted Scott to doublecheck his every move - "I keep thinking there's something we've forgotten about," he said, "but I [319] don't know what it is." Scott answered reassuringly, "We've done everything, as far as I know." Over China, *Gemini VIII* slipped down in the fringes of the atmosphere.[74]

Everything clicked off properly during descent. As they neared a landing, Armstrong asked his partner, "Do you [see] water out there?" Looking into the first faint light of dawn, Scott replied, "All I see is haze." Then his voice quickened, "Oh, yes, there's water! It's water!" Less than two minutes later, Scott yelled, "LANDING - SAFE." The flight had lasted 10 hours 41 minutes 26 seconds.[75]

The crew went quickly through the postlanding checklist, putting switches and valves in their correct positions. Then antennas were extended so they could communicate with the recovery forces. "Naha RESCUE 1, Naha SEARCH 1," Scott called, but no answer came. They were not very worried, however, as Houston Flight Control had told them the rescue planes would get to them shortly and the *Mason* should reach them in three hours. This meant their landing had been very close to the contingency touchdown point.[76]

Several aircraft, including two HC-54 Rescuemasters - one from Naha Air Base, Okinawa, and the other from Tachikawa Air Base, Japan - had raced to fetch the crew. The HC-54 from Naha got there first. Suddenly the pilot shouted, "I got it!" He had seen the spacecraft, with its main parachute in full bloom, drifting to the ocean's surface. Three pararescuemen were equipped and ready to jump. Armstrong and Scott saw one of the three as he parachuted down. Because of the waves, the frogmen had trouble hooking the flotation collar to the spacecraft. The rough sea also made them queasy, a feeling shared by the astronauts. But the swimmers persisted and secured the collar within 45 minutes of spacecraft landing. Demonstrating excellent cooperation with NASA and careful planning, the Department of Defense recovery forces had reacted to the emergency landing as though it were normal. Armstrong and Scott had few complaints about recovery in this remote area.[77]

Three hours later, as promised, the *Mason* pulled alongside and fastened a line to the spacecraft. Climbing the Jacob's ladder in sea swells of 4 to 5 meters was hard, but they made it. On deck, the tired astronauts managed smiles and greetings for the welcoming sailors. Still feeling nauseated, the *Gemini VIII* crew headed immediately for sick bay. Medical personnel helped them strip off their pressure suits. Their undergarments were soaked with sweat. They were thirsty, but clinical examination showed minimal dehydration. The *Mason* reached Okinawa the next day, and the two astronauts flew on to Hawaii, then home.[78]

Once the manned phase of the *Gemini VIII* mission was over. Hodge and Kranz turned back to the target vehicle. Because Scott had the foresight to pass the control of the target back to the ground, [320] there was a chance to put the Agena through its paces and see how it reacted to commands. There was still hope that the Agena for *Gemini VIII* might be used as a passive target for Gemini IX or X.

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* "Uplink" was a term used by flight controllers to denote information telemetered from the tracking network to the spacecraft and Agena. "Downlink" meant the opposite - from space to the ground.

** On 21 December 1965, Seamans had been sworn in as Deputy Administrator of NASA, replacing Hugh Dryden, whom died on 2 December.

*** Because the orbital track of a spacecraft during a day's flight ranges from 30 degrees north latitude to 30 degrees south, the maximum number of tracking stations were available during only 3 of the 15 revolutions in the 24-hour time period.

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45 See pp. 483-86 above; "Gemini VIII Mission Report," p. 1-1.

46 Gemini 8 mission commentary transcript, 16 March 1966, tape 20, pp. 2-3, tape 21, p. 1; "Gemini VIII Mission Report," pp. 6-3, -4; "Atlas SLV-3, Space Launch Vehicle Flight Evaluation Report, SLV-3 5302," General Dynamics GDC/BKF66-012 and Supplemental Report No. 7 to "Gemini VIII Mission Report," 17 June 1966, p. 10; "Gemini Agena Target Vehicle 5003, Systems Test Evaluation (45-Day Report)," LMSC-A817204 and Supplemental Report No. 6 to "Gemini VIII Mission Report," 5 May 1966, p. 2-12.

47 "Gemini VIII Technical Debriefing," 21 March 1966, pp. 1-2; Scott interview; Gemini 8 mission commentary, tape 23, p. 1.

48 Gemini 8 mission commentary, tape 30, p. 1, tape 31, p. 1, tape 34, p. 2; "Gemini VIII Debriefing," pp. 5, 6; "Gemini VIII Mission Report," pp. 2-1, 6-4, -5; "Launch Vehicle No. 8 Flight Evaluation," Martin Co. Engineering

Report No. 13227-8 and Supplemental Report No. 2 to "Gemini VIII Mission Report," April 1966, pp. vii, II-1, -2.

49 "Gemini VIII Mission Report," p. 4-2; "Gemini VIII Debriefing," p. 13; Gemini 8 mission commentary, tape 37, p. 4; "Gemini VIII Voice Communications (Air-to-Ground, Ground-to-Air and On-Board Transcription)," McDonnell Control No. C-115471, n.d., pp. 8-10.

50 "Gemini VIII Debriefing," pp. 18-20; "Gemini VIII Mission Report," pp. 4-2, 7-2; "Gemini VIII Voice," pp. 15-18.

51 "Gemini VIII Debriefing," pp. 21, 22; "Gemini VIII Voice," p. 25.

52 "Gemini VIII Debriefing," pp. 22-23; "Gemini VIII Mission Report," pp. 4-2, 7-2.

53 "Gemini VIII Debriefing," pp. 23-25; "Gemini VIII Mission Report," p. 7-25.

54 "Gemini VIII Debriefing," pp. 27-29; "Gemini VIII Mission Report," pp. 4-2, 7-3; Gemini 8 mission commentary, tape 44, pp. 4-6; "Gemini VIII Voice," pp. 34-35.

55 "Gemini VIII Debriefing," pp. 29-30; "Gemini VIII Voice," pp. 39-40; Ben Vester et al., interview, Baltimore, 25 May 1966.

56 "Gemini VIII Debriefing," p. 30; "Gemini VIII Mission Report," pp. 4-2, -3, 7-3, -4; "Gemini VIII Voice," p. 40.

57 "Gemini VIII Debriefing," pp. 34, 35, 36, 37-38; "Gemini VIII Mission Report," pp, 4-3, 7-3, -4, -8, -19; "Gemini VIII Voice," pp. 43, 44, 45, 47.

58 "Gemini VIII Debriefing," pp. 36-40, 41, 42, 43-47; "Gemini VIII Mission Report," pp. 4-3, 7-4, -19; "Gemini VIII Voice," pp. 55-60.

59 "Gemini VIII Mission Report," pp. 4-3, 7-4, -19; "Gemini VIII Debriefing," pp. 47-49; "Gemini VIII Voice," pp. 60, 61, 64, 65, 67, 68, 70; "Air-Ground Playback Briefing," 17 March 1966, tape 6A, p. 1.

60 "Gemini VIII Voice," pp. 70, 71; Gemini 8 mission commentary, tape 58, p. 1.

61 "Gemini VIII Mission Report," p. 6-1; "Gemini VIII Voice," p. 74; Scott and Armstrong interviews; Gemini 8 mission commentary, tape 60, p. 2.

62 Scott and Armstrong interviews; "Gemini VIII Debriefing," pp. 54, 55-56.

63 Scott and Armstrong interviews; "Gemini VIII Debriefing," pp. 55-59; "Gemini VIII Mission Report," pp. 4-4, 7-6, -7, -20, -21.

64 "Gemini VIII Debriefing," pp. 59-60; Scott and Armstrong interviews.

65 "Air-Ground Playback Briefing," tape 6A, p. 1; Scott interview; James R. Fucci, telephone interview, 12 Aug. 1969; "Gemini VIII Voice," p. 75.

66 [Ivan D. Ertel], *Gemini VIII: Rendezvous and Docking Mission,* MSC Fact Sheet No. 291-E (Houston, April 1966); Charles A. Berry, interview, Houston, 18 March 1968; Armstrong and Scott interviews; "Gemini VIII Debriefing," pp. 60, 61; "Gemini VIII Voice," pp. 76, 80, 81.

67 John D. Hodge, interview, Houston, 12 March 1968; Mathews, interview, Houston, 2 Dec. 1966; Armstrong and Scott interviews; "Gemini VIII Voice," pp. 77, 78; "Air-Ground Playback Briefing," tape 6A, p. 1.

68 Hodge and Schneider interviews; Eugene F. Kranz, interview, Houston, 28 April 1967; Clifford E. Charlesworth, interview, Houston, 13 Dec. 1966; "Gemini VIII Voice," p. 81; see pp. 228-29, above.

69 Nolan interview; Preston, interview, Cape Kennedy, Fla., 24 May 1967.

70 Letter, Seamans to Eugene M. Emme, 3 Oct.1969; NASA Release No.65-388, "Seamans Takes Oath as Webb's Deputy at Space Agency," 21 Dec. 1965.

71 Raymond D. Hill, Jr., interview, Titusville, Fla., 24 May 1967; TWX, Mathews to McDonnell, Attn: Burke and Lindley, "Contract NAS 9-170, Gemini, Support of Gemini VIII Mission," GS-10100, 8 March 1966.

72 [Ertel], *Gemini VIII;* "Gemini 8 Post Recovery Press Briefing," 16 March 1966, tape 4A, pp. 4-5; Gemini 8 mission commentary, tape 63, p. 1; "Gemini 8 Pilots [sic] Report," 26 March 1966, tape A, p. 1.

73 "Recovery Requirements, Gemini VIII," 31 Jan 1966; Kranz interview.

74 "Gemini VIII Voice," pp. 93, 98, 102, 103; Armstrong interview; Encyclopedia Americana, International ed., s.v. "Disasters."

75 "Gemini VIII Voice," pp. 109, 111; "Gemini VIII Mission Report," p. 4-11.

76 "Gemini VIII Debriefing," pp. 90-91; "Gemini VIII Voice," pp. 96, 109, 111, 112.

77 "Post Recovery Press Briefing," tape 4A, p. 5, tape 4B, p. 1; "Gemini VIII Mission Report," pp. 6-32, -33, 7-23, -36; "Gemini VIII Debriefing," pp. 94, 95, 96; "Gemini VIII Voice," p. 93; [Ertel], *Gemini VIII;* Lt. Jerry Poppink, "Pararescueman!" The Airman Magazine, August 1966, pp. 13, 14, 15.

78 "Gemini VIII Mission Report," pp. 6-33, -34, -36, 7-11, -36, -37, -38; Poppink, "Pararescueman!" p. 14; "Gemini VIII Debriefing," pp. 96-97; [Ertel], *Gemini VIII;* "Air-Ground Playback Briefing," tape 6A, p. 2; Don J. Green interview, Houston, 29 June 1967; Toni Zahn, telephone interview, 13 Aug. 1969.

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