Name: _____ Date: _____

Reading the Apollo 11 Descent Log

Reading level 14 · 1751 words

In July 1969, at the end of what was called the race to the Moon, Neil Armstrong landed the lunar module Eagle. The most detailed record of those minutes is not a film but a table of clock times: the Apollo Lunar Surface Journal, a transcript with commentary from people who studied the flight. Its clock is mission elapsed time, which counts from liftoff. "Contact light" is logged at 102:45:40, meaning 102 hours, 45 minutes and 40 seconds after launch. In calendar time, the Journal gives that moment as 20:17:40 Coordinated Universal Time on July 20, 1969. Each entry pairs a time with a spoken line, while the commentary around it draws on Armstrong's 1969 technical debrief and the Apollo 11 Mission Report.

A log like this is evidence, and evidence has error bars. The Journal's editor warns that the original NASA transcripts contain notable inconsistencies in their times, and that over intervals of several minutes those times are only suggestive. With the best audio clips, relative timing can be trusted to about two or three seconds. The Journal's own example is the landing radar: the Apollo 11 Mission Report logs it locking on at 102:37:51, while the transcript places the crew's call at 102:38:04, a gap of 13 seconds. Keep that margin in mind through everything that follows, because several of the most dramatic moments last only a few seconds. The Journal's editor went over the mission with Armstrong and Aldrin in 1991.

Powered descent began with the engine firing at 102:33:11, at only 10 percent thrust. Aldrin counted off the seconds, "24, 25, 26," and then called, "Throttle up. Looks good!" Full power for the descent engine was 10,500 pounds. Armstrong later explained the quiet start: the engine ran at 10 percent until the guidance computer judged that the lander was in the right place to throttle up, which gave the computer time to correct for any error in distance. Ten percent of 10,500 pounds is 1,050 pounds of thrust. The Journal times the whole burn from 102:33:07 to 102:45:41, which is 12 minutes 34 seconds, against a plan of 11 minutes 58 seconds. Its own transcript stamps ignition at 102:33:11, so even the burn has a few seconds of slack. The Journal attributes virtually all of the 36-second difference to one decision: to fly beyond a field of boulders.

Eagle was already off target before that decision. By the Journal's account, it was about 6.6 kilometers, or four miles, long of its planned landing point, and only about 0.6 kilometer of that came from Armstrong flying past the boulder field around West Crater. The rest was a navigation error that began earlier in the descent, and Armstrong sensed it early: at 102:36:11 he said they had gone by the three-minute point early and would land long, and the Journal's commentary places him over the crater Maskelyne W about three seconds early. The Journal lays out competing explanations for the error without settling the matter. A September 1969

memo blamed about 6,000 feet of it on thrust from the lander's water boiler, a cooling device, though a Journal contributor doubts that. A flight director later wrote that several navigation problems combined, among them air pressure left in the tunnel between the spacecraft at undocking.

At 102:38:26 Armstrong said, "Program Alarm." The code was 1202, which the Journal says was produced by data overflow in the computer, and a second alarm, 1201, followed. In Houston, the Journal says, the control room's expert on the lander's guidance judged that the overflow would not jeopardize the landing, because the computer was programmed to treat that data as secondary and ignore it. At 102:39:14 Buzz Aldrin, the lunar module pilot, noticed that the alarm appeared whenever the 16/68 display was up, a readout of range and time before the pitchover. He stopped asking for it and had Houston supply the time instead. Houston answered the second alarm with "We're Go. Same type. We're Go." Afterward Armstrong explained why the crew continued: "In simulations we have a large number of failures and we are usually spring-loaded to the abort position. And in this case in the real flight, we are spring-loaded to the land position."

At 102:41:35 the computer switched to its approach program and began rotating Eagle toward upright, and Armstrong got his first good look at the site. He recalled that the computer was aiming "just short ... of a large rocky crater surrounded with the large boulder field with very large rocks covering a high percentage of the surface." He asked for the reading on the landing point designator, an angle scale scribed on his window, and Aldrin read 47 degrees. A contributor writes that sloshing fuel was rocking Eagle by two or three degrees every couple of seconds and would later make that scale essentially useless. Armstrong took manual control and flew on past the boulders. He had practiced that kind of flying 21 times in the Lunar Landing Research Vehicle, the jet-lifted "flying bedstead" built to mimic the Moon's gravity.

The fuel gauge now enters the log. At 102:44:45, with Eagle at about 100 feet, Aldrin called "Five percent" and "Quantity light." A Journal contributor writes that the light had latched at 102:44:31, though another note in the Journal puts the latch at 102:44:45, showing 5.6 percent of the original propellant remaining, and that it started a 94-second countdown to a "Bingo" call, which meant "land in 20 seconds or abort." The contributor adds that a pilot at about 50 feet with his horizontal rates nulled could land on, while at anything over 100 feet he would punch the abort button. Aldrin kept reading out heights and speeds, such as "75 feet. And it's looking good. Down a half, 6 forward." By that rule of thumb, 100 feet was right at the edge, and the countdown was running.

In Houston, the capsule communicator counted down the same clock. "60 seconds," he called at 102:45:02, and "30 seconds" at 102:45:31. Armstrong's 1969 debrief explains his choices low down. Below about 30 feet he picked a final spot, noticed that Eagle was drifting backward and to the left, and fought it with what he called "possibly spasmodic control motions." He was reluctant to slow his descent further because "we were close to running out

of fuel. We were hitting our abort limit." In a 2001 interview Armstrong said there was a lot of concern about coming close to running out of fuel, and that he was very cognizant of it. A Journal contributor adds that an engine cutout at any height above 10 feet would have meant a harder touchdown than the landing gear was designed to take.

The gauge, it turned out, was wrong. A Journal contributor writes that fuel sloshed in the tanks as Eagle pitched and swayed, uncovering the sensor and latching the low-level light nearly 30 seconds early. Post-flight analysis indicated Eagle landed with about 770 pounds of fuel, of which about 100 pounds could not be used. The remainder was enough for roughly 45 seconds, including about 20 seconds for an abort. A contributor explains that as Armstrong pitched the lander over to fly past the crater, the propellant-quantity devices could not accurately gauge what was left. The Journal adds that the other five commanders who landed on the Moon touched down with 1,100 to 1,200 pounds of usable fuel, and that the boulder detour cost Apollo 11 the equivalent of roughly 530 pounds.

Touchdown itself is logged as "Contact light" at 102:45:40. Probes 67 inches long hang below three of Eagle's footpads, and when one touches the surface a light comes on. The Mission Report, as quoted in the Journal, puts the landing at 102:45:39.9, with Eagle moving about 2.1 feet per second to the left and 1.7 feet per second downward. Aldrin called "Contact light," but Armstrong said later, "I didn't hear it, nor did I see it." The engine was still running at touchdown, which was not necessarily intended, and he called it "a very gentle touchdown." Eighteen seconds after contact, and after telling Aldrin "Engine arm is off," he reported, "Houston, Tranquility Base here. The Eagle has landed."

Houston's reply shows the strain of the previous minutes, because the communicator began, "Roger, Twan ...", corrected himself, and went on, "Tranquility. We copy you on the ground. You got a bunch of guys about to turn blue. We're breathing again." The editor notes how natural the stumble was, since the call sign had just changed from Eagle to Tranquility Base. About six hours and 38 minutes passed before the first step, and for timing that step the Journal's editor anchors on the opening of the hatch, which the Mission Report gives as 109:07:33 and which seems to him relatively certain. By the Journal's best timing, Armstrong stepped firmly onto the surface at 109:24:17 and began his famous sentence at 109:24:23.

The sentence is "That's one small step for (a) man; one giant leap for mankind." The parentheses mark a word that Armstrong intended but that no recording clearly shows. After the mission, Armstrong said he had meant to say "for a man" and believed he had. He also agreed that the "a" did not seem to be audible in the recordings, and the Journal's editor, who has listened repeatedly, says he hears no convincing evidence of it. In 2006 a claim of finding it in the waveform drew wide attention, but the Journal's editor reports that later analyses by people with audio experience did not support it, and the Journal, which notes that the world heard the line without the "a" at the time, prints the "a" in parentheses to honor Armstrong's intent.

Even the first step has more than one time. The Mission Report gives initial contact with the Moon as 109:24:15, which is 02:56:15 Coordinated Universal Time on July 21, 1969. Later in the mission NASA told the press 109:24:20, and the Journal's reading of the restored video gives 109:24:17. The Journal calls a two-second gap between two careful analyses "unimportant," and soon after that, Armstrong was describing the ground: "Yes, the surface is fine and powdery. I can kick it up loosely with my toe." Subtracting 109 hours 24 minutes 15 seconds from 02:56:15 puts liftoff at 13:32 UTC on July 16. Armstrong died on August 25, 2012, at the age of 82, and the log of those twelve and a half minutes is still open for anyone to read.

Questions

1. What does mission elapsed time count from?

A. The moment of landing
B. Liftoff
C. The start of the broadcast

2. Why did the fuel light come on about 30 seconds early?

A. The tanks were almost empty
B. The engine had stopped
C. Sloshing fuel uncovered the sensor

3. Why does a 13-second gap in the log matter for moments that last a few seconds?

A. The gap is bigger than the moment itself
B. The radar was broken
C. Houston never replied

4. In this book, what does "audible" mean?

A. Written down
B. Able to be heard
C. Easy to forget

5. Why did Eagle use more fuel than the plan?

A. The engine leaked
B. Houston asked for a longer burn
C. Armstrong flew past a field of boulders

6. How does the Journal treat the word "a" in Armstrong's sentence?

A. It prints it in parentheses to honor his intent
B. It leaves it out completely
C. It says the recordings prove he said it

Words to know

propellant: rocket fuel
elapsed: passed
sloshing: splashing around
audible: able to hear
designator: marker
navigation: finding position

Answer key: Reading the Apollo 11 Descent Log

1. B. Liftoff
2. C. Sloshing fuel uncovered the sensor
3. A. The gap is bigger than the moment itself
4. B. Able to be heard
5. C. Armstrong flew past a field of boulders
6. A. It prints it in parentheses to honor his intent