

**Dynamic Design:
A Collection Process**

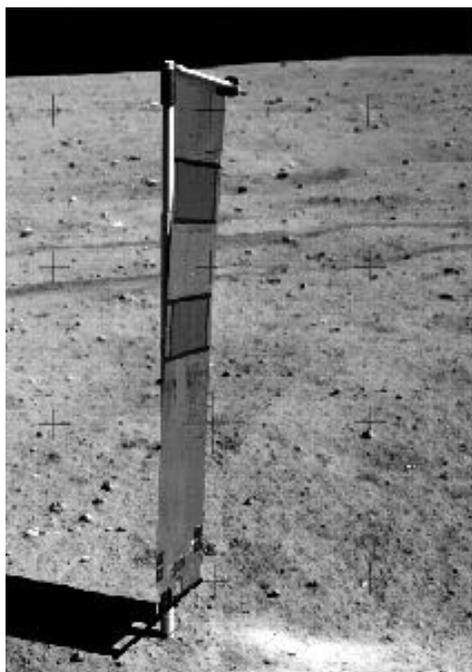
**It Began with Apollo
A Brief History of Solar Wind Sample Return**

STUDENT TEXT

Apollo Collector Design

The first collectors for solar wind sample return were made for the Apollo lunar missions from 1969 to 1972. The Apollo solar wind collection (SWC) experiment consisted of an aluminum metal foil that was deployed to collect a sample of solar wind. This procedure allowed scientists to measure the composition of the solar wind on the lunar surface. The SWC equipment was manufactured by the Swiss National Science Foundation at the University of Bern, a partner in the Genesis mission. The foil weighed 130 grams and had an area of 4200 cm² (30 cm x 140cm). It was deployed on a five-section telescopic pole and unrolled. The foil was stored inside the collapsed pole when taken to the moon. The pole and foil had a total weight of 430 grams for each mission except Apollo 16, which was 450 grams. The pole was 4 cm in diameter and 40 cm in length when collapsed and 1.5 meters long when deployed.

Figure 1



The SWC foil used on Apollo 16 had some sections of platinum, which allowed for easier cleaning operations on Earth. (AS-16-117-18849).

NASA

Purity of the foil was critical to avoid contamination of the lunar samples and background contamination of the experiment itself. The Apollo 16 (see Figure 1) experiment was composed of both aluminum and platinum foils. The platinum foil allowed for treatment with dilute hydrofluoric acid before sample analysis on Earth to remove dust contamination. This treatment allowed for a more accurate analysis of solar wind particles that embedded into the foil by removing more of the surface contaminants as well as some solar wind from the outer portion of the foil. This process provided a more accurate picture of the solar wind that was collected.

Deploying the Experiment

On every Apollo mission, the solar wind experiment was conducted in a similar fashion to ensure consistency. The telescopic pole was extended and the five sections locked automatically. The reel was then pulled out, and the foil was unrolled and fastened to a hook near the lower end of the pole. The pole was planted upright into the ground, but it did not



necessarily have to be at a perfect 90° angle with the moon's surface. It was important that the correct side of the foil was facing the sun. One side of the foil was marked with the word "SUN," which was pointed at the sun.

The following is the conversation that occurred during the Apollo 11 deployment of the solar wind collector. Eric Jones, an astronomer with the Los Alamos National Laboratory, transcribed the conversations as journal entries. Journal entries for all Apollo missions can be found on-line. The entire text can be found at <http://www.hq.nasa.gov/office/pao/History/alsj/a11/a11.step.html#1100253>. The number that precedes each speaker's name refers to the time index of the mission. The speakers are astronaut Buzz Aldrin, Mission Control Capsule Communication Bruce McCandless, and astronaut Neil Armstrong.

Box 1

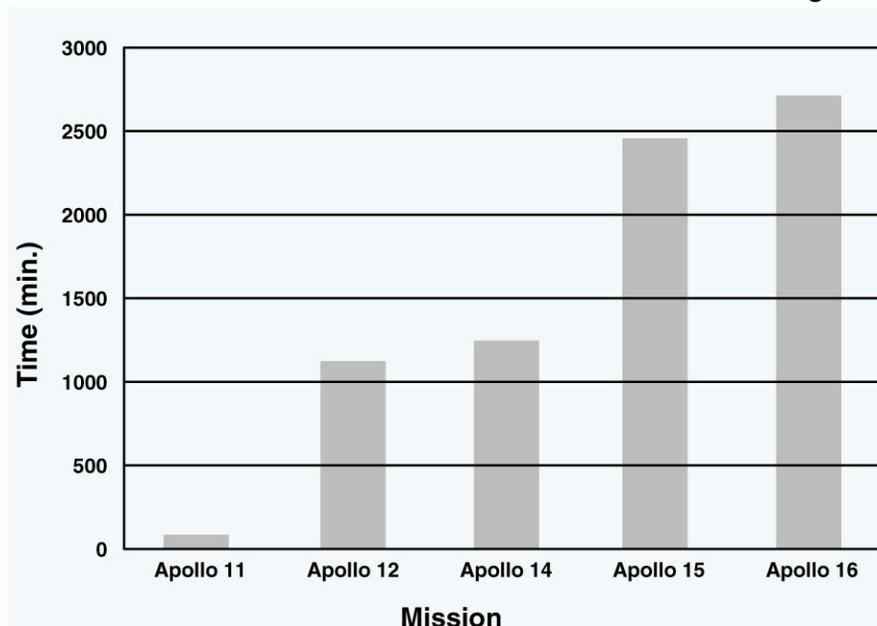
110:03:20 Aldrin: "Okay. You can make a mark, Houston." (Garbled)
110:03:24 McCandless: "Roger. Solar wind." (Pause)
[As per his checklist, Neil stops to take a pair of pictures of Buzz with the Solar Wind Collector. The pictures are AS11-40-5872 (**)
<http://www.hq.nasa.gov/office/pao/History/alsj/a11/as11-40-5873.jpg>
See a video of the deployment at:
<http://www.hq.nasa.gov/office/pao/History/alsj/a11/a11.v1100253.mov>
(Be aware this takes over five minutes to load and is a very short movie.)

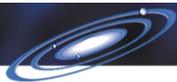
110:03:36 Aldrin: "And, incidentally, you can use the shadow that the staff makes to assist you getting it perpendicular." (to the sun line) (garbled)

110:03:50 McCandless: "Roger." (Long Pause)
[Aldrin, from the 1969 Technical Debrief - "In putting [the SWC pole] in the ground, it went down about 4 or 5 inches. It wasn't quite as stable as I would have liked it to have been, but it was adequate to hold it in a vertical position...Once you go past a depth of 4 or 5 inches, the ground gets quite hard. However, I didn't get much of a cue to this at this point while installing the solar wind experiment."]

The Apollo collector device foils were exposed for different durations (see Figure 2). It was exposed for 77 minutes on Apollo 11, 18 hours, 42 minutes on Apollo 12, 21 hours on Apollo 14, 41 hours, 8 minutes on Apollo 15, and 45 hours, 5 minutes on Apollo 16.

Figure 2





Retrieval

The reel was spring-loaded to facilitate rewinding the foil. The foil was able to be retracted similar to a window shade or an overhead projection screen. It was detached from the telescopic pole, placed in a Teflon™ bag, and placed in a sample return container. The pole was not taken back to Earth. Each mission had varying amounts of success when trying to retrieve the foil. During his 1969 debriefing Buzz Aldrin states:

Box 2

"The solar wind disengaged from its staff quite easily. When it rolled up, it had a tendency to sneak off to the side and crinkle on the edges. I spent some 20 to 30 seconds unrolling it and trying to get it a little smoother. I then remembered that they really didn't care about exact neatness. All they wanted was the material back, because they were going to cut it up in many pieces anyway. So I just bunched it together and it slid into its container (the Teflon™ bag) fairly easily."

For a short video of Buzz Aldrin retrieving the solar wind collector go to:

<http://www.hq.nasa.gov/office/pao/History/alsj/a11/a11.clsout.html>

The difficulty in rolling up the foil after collection varied from one mission to another. Apollo 12 astronaut Alan Bean had a tougher time rolling up the foil from that mission's SWC. He described the need to have the foil and tape looked at in lunar conditions for future missions. Astronauts Alan Bean and Pete Conrad are speaking with mission control's Ed Gibson:

Box 3

134:55:26 Bean: "Solar wind doesn't like to roll up much. (Pause) Little rascal, doesn't want to roll up. (I'll) just wrap it around here best I can, without getting any dirt on it." (Pause)

134:56:13 Bean: "Okay. We got that solar wind."

134:56:17 Conrad: "Good boy!"

134:56:20 Bean: "Houston, we got that solar wind, but it didn't roll up in a very neat package."

134:56:26 Gibson: "Roger, Al. We copy. That's all right." (Long Pause)

134:56:46 Conrad: "Hey, it sure didn't, did it?"

134:56:48 Bean: "No. It just didn't. It split right near the top."

134:56:50 Conrad: "Can I help you?"

134:56:51 Bean: "Yeah. You can hold that, and I'll just try to roll it up as best I can without getting any...I already got a little dirt on it that's not doing any good. (Pause) You see what I mean?"

134:57:02 Conrad: "Yeah."

134:57:03 Bean: "Not a lot I can do about it. I'm sure it's [the solar wind] a good experiment. That thing is fragile."

134:57:09 Conrad: "Here, let me hold this end, and you just wrap it tight. That a boy."

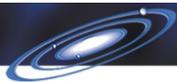
134:57:14 Bean: "I'll squeeze it down."

[This is probably where Al is compressing the roll with his hands to get it tight enough to fit in the bag.]

134:57:15 Conrad: "That a..."

134:57:16 Bean: "And chase down any of those noble gases or whatever that crud is. Okay. Stick that in there? (To Gibson) Looks bad, but I think it will do the job, Houston. We squashed it in so it's..."

[continued below]

**Box 3 (continued)**

[The experimenters are looking for relative abundances of isotopes of helium, argon, and neon, the chemically-inert noble gases in the solar wind.]

134:57:27 Conrad: "Where is it [the bag]?"

134:57:29 Bean: "It's right...Let me get it for you."

134:57:32 CapCom: "Roger, Al."

134:57:34 Bean: "There you go. Okay. It just doesn't look so good, Houston."

Bean and Conrad could not get the foil to roll up automatically. They finally used their hands to roll it, and as a result the foil was soiled by the dirt adhering to their gloves. After it was rolled, they discovered that it was too big to fit into the container that was to be used to return it, and had to crush it with their hands. Upon inspection during the second EVA they decided that the foil tended to "set" and that it would not roll up because the set was stronger than the tension of the roller.

Alan Bean said during his technical debrief:

Box 4

"I would like to recommend that, before the next flight goes up, somebody take a look at what is actually happening to that foil as it sits out in the lunar environment. It may not be the foil that's presenting the problem. It might be (that) the tape that they are using on it actually cracks or gets stiff or something. It may be the same effect they are seeing in those Teflon™ bags."

On subsequent Apollo missions the retrieval of the SWC had varying degrees of success. On Apollo 14, half of the foil rolled up automatically. Apollo 15 the astronauts had to roll all of the foil manually because it would not roll up mechanically. There was no reported difficulty recovering the Apollo 16 foil.

Although there were no design changes for the retrieval of the experiment, the Apollo 16 foil was made of platinum and aluminum so that it could be cleaned with hydrofluoric acid in order to remove dust. The need for cleaning may have been a result of dust getting onto the foil during the retrieval procedure in previous missions.

Questions:

Write your answers in your journal. Be prepared to discuss.

1. Describe the design of the Apollo foil experiments in your own words.
2. Describe how the astronauts deployed and retrieved the SWC.
3. Suppose you were an engineer and heard Alan Bean's recommendation during his technical debrief. Describe the steps you would take to help remedy the problem of retrieving the SWC.