
APOLLO 12 ALSEP DEPLOYMENT

A Collection of Mission Specific Data for the Purpose of Modeling
and Simulating the ALSEP Deployment Work Practice.

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1. APOLLO-12 ALSEP ACTIVITIES

1.1 APOLLO 12 SPECIFICS



1.1.1 Mission Overview

Mission Date: November 14-24, 1969

Mission Time: 10 days, 04 hours, 36 minutes

Landing site: Ocean of Storms. 3.04 degrees South, 23.42 degrees West

Retrieved parts of the unmanned Surveyor 3, which had landed on the Moon in April 1967. Apollo Lunar Surface Experiments Package (ALSEP) deployed. 34kg (75 lbs) of material gathered. Two EVAs totaling 7 hours 50 minutes. Lunar surface stay-time, 31.5 hours; in lunar orbit 89 hours, with 45 orbits. LM ascent stage (purposefully) impacted on Moon (after surface crew returns to orbit).

1.1.2 People involved



Apollo 12 Crew: Pete Conrad, Dick Gordon, and Alan Bean



Mission Commander: Capt. Charles ("Pete") Conrad, Jr.



Command Module Pilot: Richard Francis Gordon, Jr.



Lunar Module Pilot: Alan LaVerne Bean, Commander

[no foto]

EVA CapCom: Dr. Edward G. Gibson, civilian

1.1.3 Modules

Command Service Module (CSM-108): Yankee Clipper

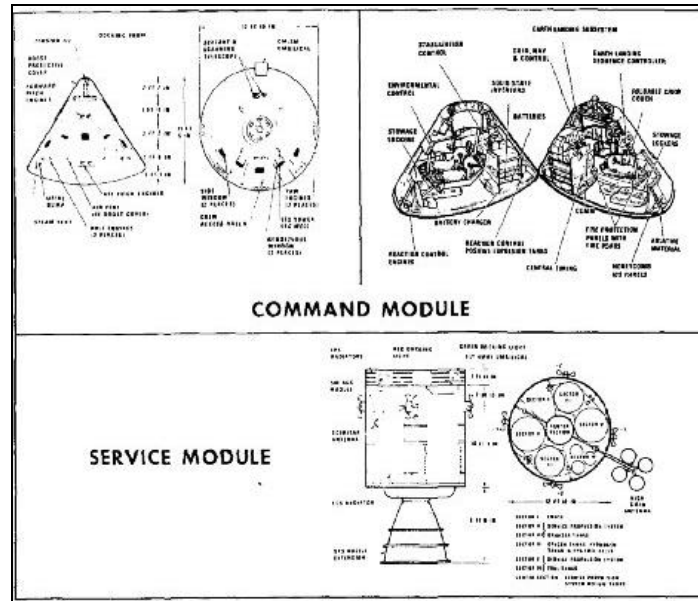


Figure 1. The CSM

Lunar Module (LM-6): Intrepid

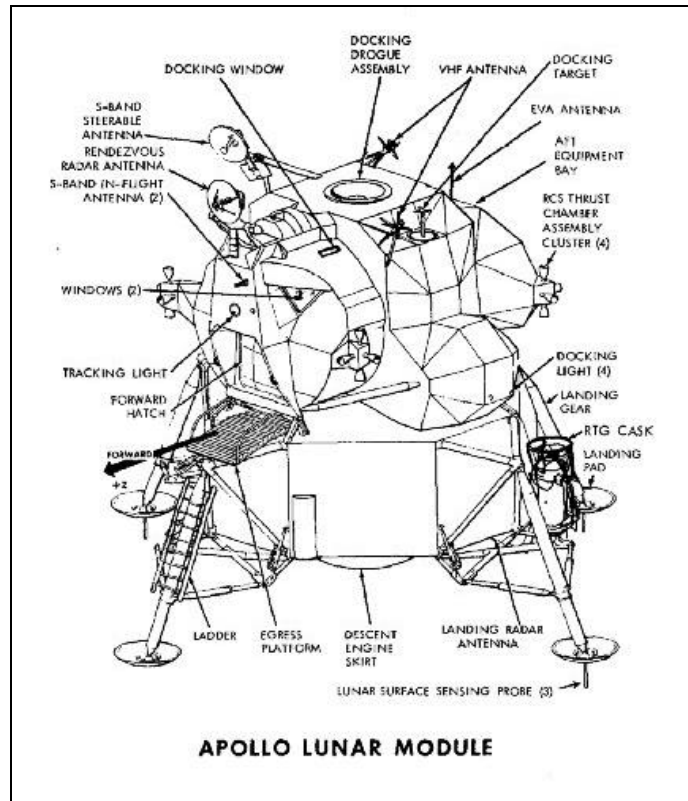


Figure 2. The LM

1.2 APOLLO 12 TRAVERSES

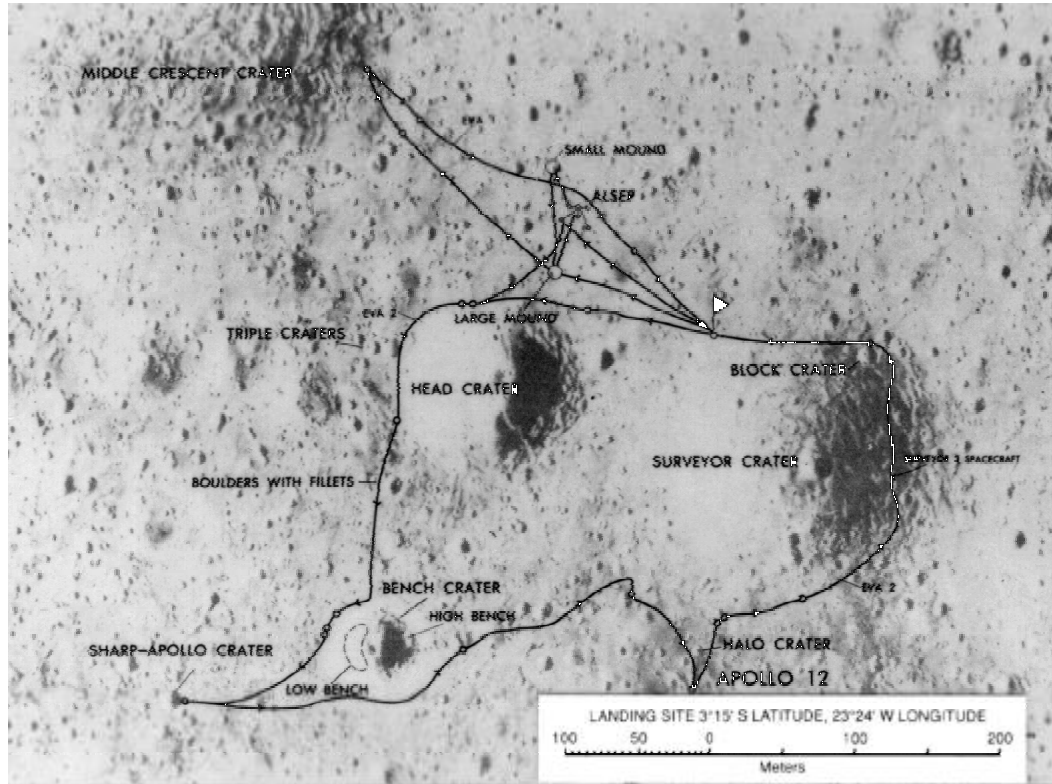


Figure 3. This map is figure 10.15 from the Lunar Sourcebook, G.H. Heiken, D.T. Vaniman and B.M. French, editors, copyright 1991 by Cambridge University Press, reproduced with permission. The traverses shown on this map were deduced from Hasselblad pictures taken by the crew and from their commentary.

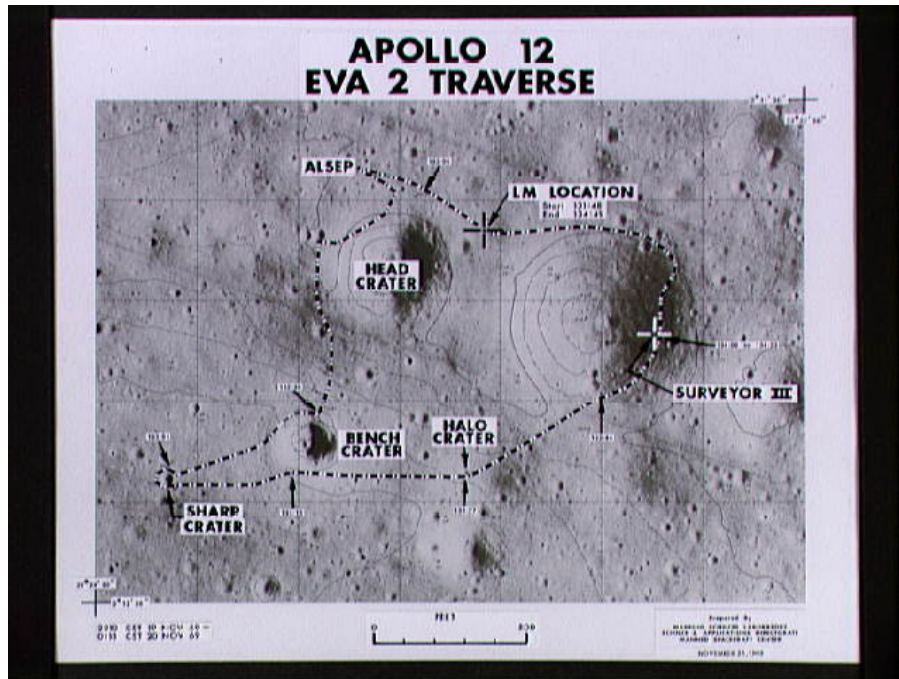


Figure 4. NASA photo S69-59538 is another representation of the traverse.

1.3 ALSEP EXPERIMENTS

The Apollo-12 Lunar Surface Experiment Package (ALSEP) experiments included:

- (1) the *passive seismograph*, designed to measure seismic activity and physical properties of the lunar crust and interior;

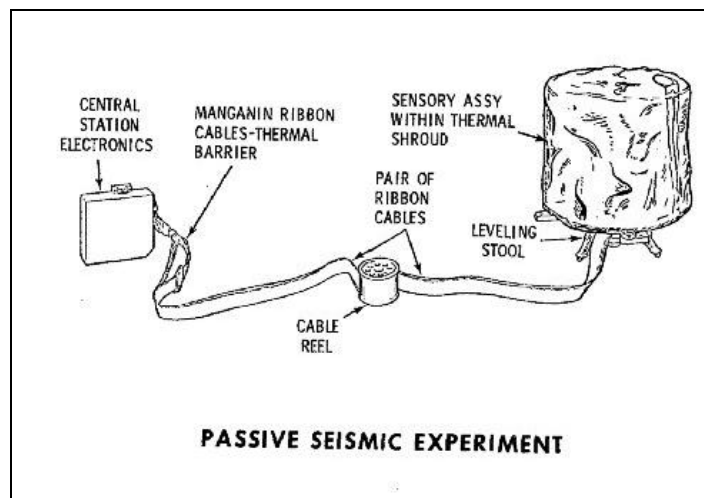


Figure 5. Seismic Experiment equipment

- (2) the *suprathermal ion detector*, designed to measure the flux composition, energy, and velocity of low-energy positive ions;

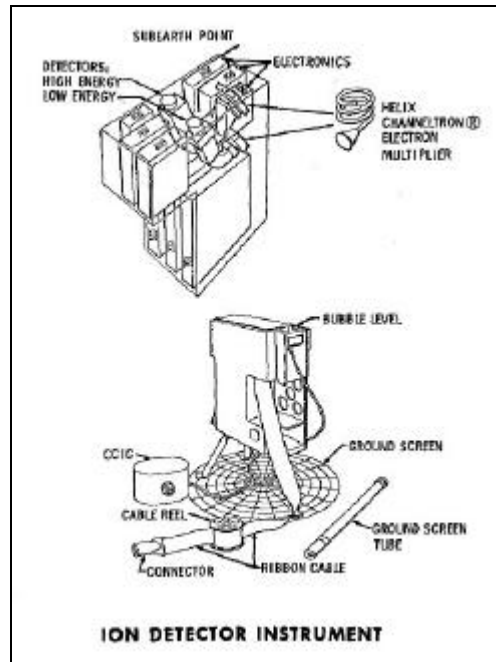


Figure 6. suprathermal Ion Detector equipment

- (3) the *cold cathode ion gauge*, designed to measure the atmosphere and any variations with time or solar activity such atmosphere may have;
- (4) the *charged particle lunar environment experiment*, designed to measure particle energies of solar protons and electrons that reach the lunar surface and to provide data on energy distribution of these solar particles;
- (5) the *lunar surface magnetometer (LSM)*, designed to measure the magnetic field at the lunar surface; and,

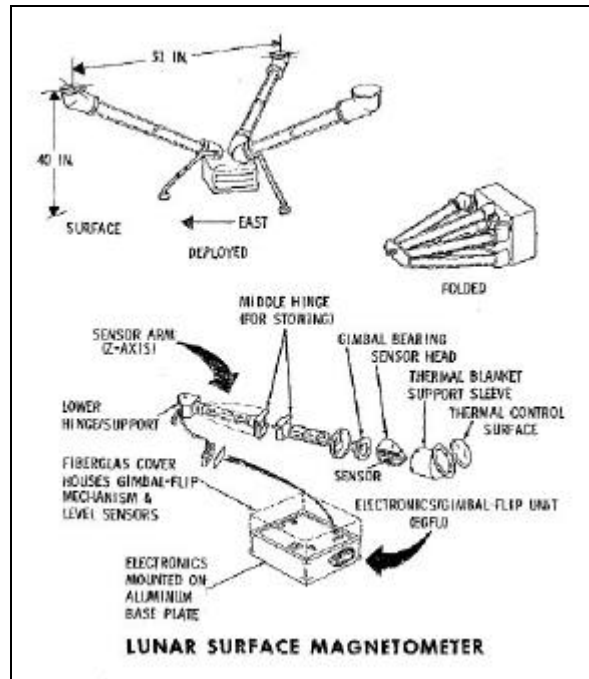


Figure 7. LSM equipment

- (6) the *solar wind spectrometer*, which measured the fluxes and spectra of the electrons and protons that emanate from the sun and reach the lunar surface.

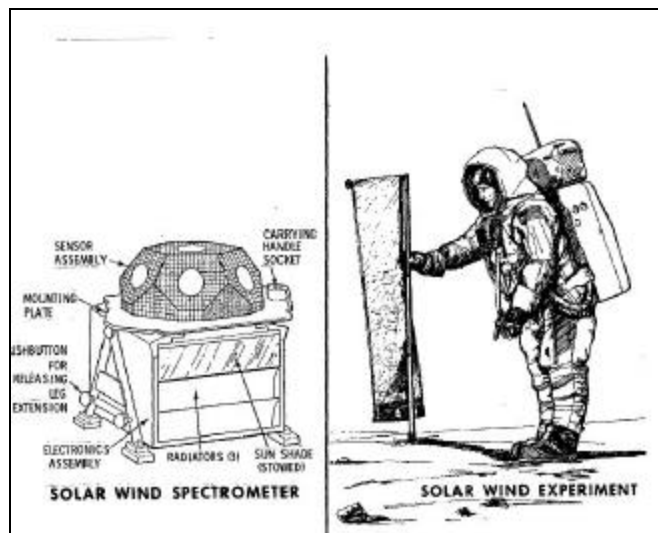


Figure 8. Solar Wind Spectrometer equipment

The ALSEP central station was deployed at 3.0078 S latitude, 23.4245 W longitude.

1.4 ALSEP OFFLOAD CHECKLIST

CDR	LMP
1-15 ALSEP OFFLOAD	1-15 ALSEP OFFLOAD
	OPEN SEQ BAY DOOR
<div style="border: 2px solid black; padding: 5px;"><p>REMOVE PKG 1</p><p>REMOVE PKG 2</p><p>STOW BOOMS DEPLOY HTC</p><p>UNSTOW UHT (2) UNSTOW CASK TOOLS</p><p>CONNECT BAR</p><p>TIP PKG 2</p><p>REMOVE SIDE LOWER CASK</p><p> FUEL RTG</p><p>CLOSE DOORS CONNECT PKGS</p><p>(BACK WALL OF SEQ BAY)</p></div>	
REST/CHECK EMU	REST/CHECK EMU
	SUR-47
	Basic Date <u>October 27, 1969</u>
	Changed _____

Figure 9. Details of the offloading procedure are printed on a decal which is fixed to the back wall of the SEQ Bay. The information on the decal is reproduced on page Surface 47 of the checklist.

The surface checklist (Figure 9) and decal on the SEQ bay show in a relative high detail what the sequence of the parallel activities should be. In Figure 9, the smaller inside square is a picture of the decal on the inside of the SEQ bay that the astronauts see. It is located on the checklist to the left, as if it belongs to the commander's activities, but this is only due to the primitive cut and paste functionality in the days before WYSIWYG text-editors. The interesting additions are the "OPEN SEQ BAY DOOR" and the "REST/CHECK EMU" activities on the checklist. It is obvious that this checklist is very detailed, and contains a good template of the activities of the astronauts. The challenge is to find the actual data in the transcription that corresponds to these activities (see 1.5).

Figure 10 and Figure 11 show the cuff checklists of the commander, Pete Conrad, and the lunar pilot, Al Bean, respectively. Each astronaut was actively involved with developing his own cuff checklist. These cuff checklists were worn on the arm of the astronaut, and provided him with useful activity sequence reminders. From the transcripts it is often very difficult to infer exactly if and when the astronaut was referring to this checklist.

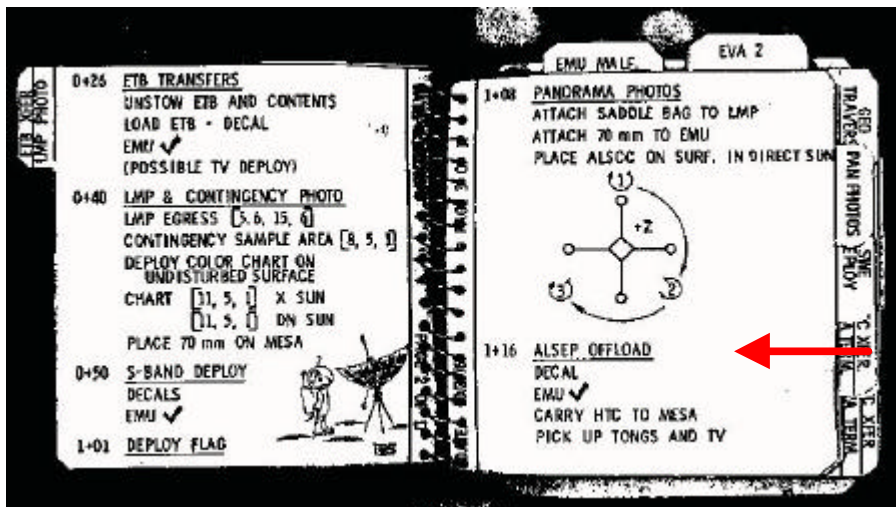


Figure 10. The CDR's cuff checklist for ALSEP Offload

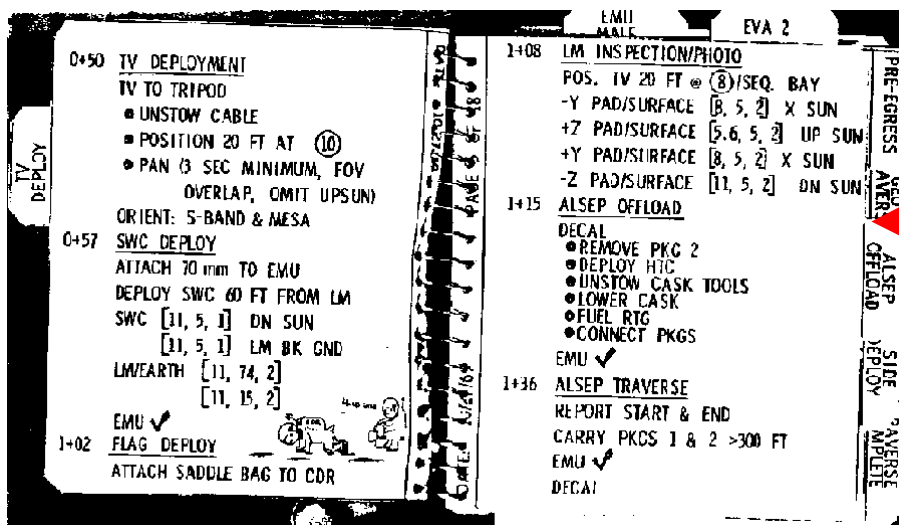


Figure 11. The LMP's cuff checklist for ALSEP Offload (& Traverse)

The interesting point to make on these cuff checklists is that they seem to be very personalized for each astronaut. This is shown in the above examples (Figure 10 and Figure 11) by the difference in detail on the "ALSEP OFFLOAD" activity. The Pete Conrad's checklist (Figure 10) only contains the word "DECAL", meaning that the sub-activities for offloading the ALSEP are shown on the decal on in the SEQ Bay. On the other hand, the Al Bean's checklist (Figure 11) shows not only the word "DECAL", but also lists all the sub-activities for which he is responsible.

From reading the transcriptions from the Lunar Journal it is not possible to conclude anything about the effectiveness of either checklist. It is most likely that the differences have to be associated with purely individual preferences. Nevertheless, it is an interesting observation.

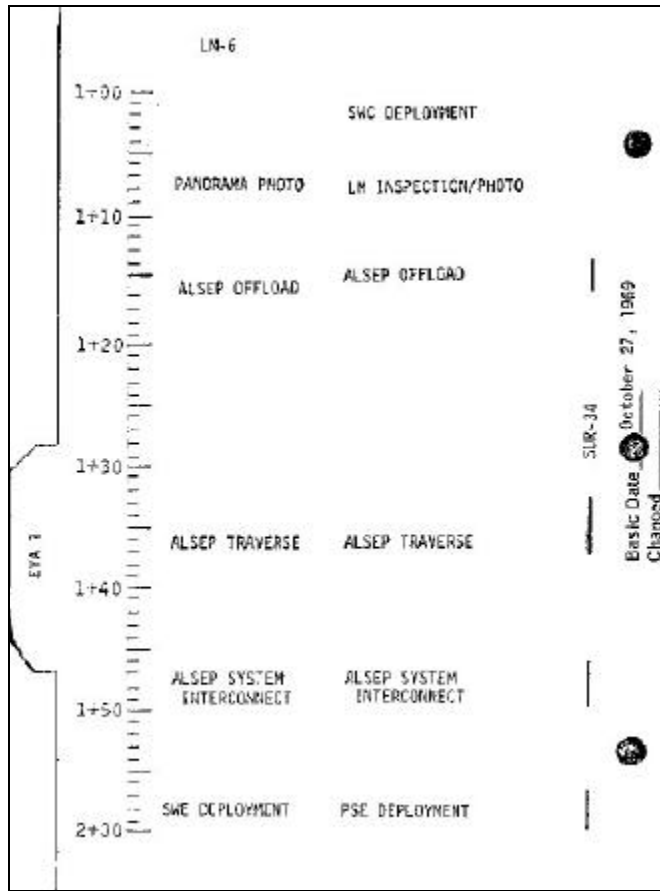


Figure 12. Surface Checklist EVA-1 Timeline (ALSEP Offload)

Figure 12 shows a piece of the original time line for EVA-1. It shows that the ALSEP OFFLOAD activity would *start* around 1:15 hours onto the EVA, and be *done* at 1:36 hours into the EVA, after which they would do the ALSEP TRAVERSE activity. This gives a total activity time of 21 minutes.

From the Apollo Lunar Journal transcription I have calculated that the total time for the actual ALSEP OFFLOAD was 22 minutes and 23 seconds:

ALSEP Offload Begin Time: 116:30:20

ALSEP Offload End Time: 116:52:43

ALSEP Offload Total Time: 000:22:23

The EVA-1 begins with the EVA-1 Preparation. This can be seen as the actual start of the EVA-1. However, this is not the start that is noted in the Lunar Surface Checklist, which starts a little before the CDR Egress (0+10 min into the EVA).

<p>Don EV Gloves & Verify: Wrist Locks (4) - Locked Glove Straps (4) - Adjusted</p> <p>PLSS DIVERTER - MIN (Verify) PLSS PUMP - ON</p> <p>PRESS REC A & B - EGRESS</p> <p>Verify EVA CB Configuration</p> <p>--:13 <u>PRESSURE INTEGRITY CHECK</u></p> <p>PLSS O2 - ON (Tone-On, O2 Flag-0) Press Flag Clear (3.1-3.4 Psid) Cuff Gage 3.7-4.0 Psig O2 Flag Clear</p> <p>PLSS O2 - OFF (Cuff Gage Decay<.3 Psig In 1 Min)</p> <p>PLSS O2 - ON (Cuff Gage 3.7-4.0 Psig, Tone & O2 Flag May Come On)</p>	<p>--:10 <u>CABIN DLPRESS</u></p> <p>Confirm "Go" For EVA From Hou CABIN REPRESS VLV - CLOSE</p> <p>Fwd Dump Valve - OPEN Then AUTO At 3.5 Psia (Verify Cuff Gage Does Not Drop Below 4.8 Psig)</p> <p>Verify: Cabin At 3.5 Psia LM Suit Circuit 3.6 To 4.3 Psia & Decaying PGA > 4.8 Psig & Decaying</p> <p>:00</p> <p>Start Wrist Watch</p> <p>Fwd Dump Valve - OPEN</p> <p>Verify: Tone-On & H2O Flag-A(1.3-1.6 Psia) LM Suit Circuit 3.6 To 4.3 Psia & Decaying PGA >4.8 Psig & Decaying</p> <p>Partially Open Fwd Hatch Fwd Dump Valve - AUTO</p>
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SUR-31

LM-6 Basic Date October 27, 1969
Changed _____




Figure 13. Surface Checklist EVA-1 (EVA Preparation + Start of EVA-1 time clock)

115:07:37 Conrad: Okay, Houston. We're Go to open it (the dump valve) all the way here. How about you?

115:07:43 Bean: They said Go.

115:07:44 Conrad: Okay.

115:07:45 Gibson: Roger, Intrepid. Looks good here.

[For record keeping purposes, EVA starts at this point. NASA Public Affairs gives the time as 115:08:02. That time is probably more accurate than the approximate times that accompany this transcript.]

115:07:48 Bean: That's it, babe. (Pause) Feels good.

115:07:58 Conrad: (Garbled) (Pause)

115:08:01 Conrad: When do we turn on the (PLSS sublimator feed) water?

115:08:03 Bean: Just as soon as we get this thing (the cabin pressure) down real low.

115:08:09 Conrad: I've got a tone.

115:08:10 Bean: That's right.

115:08:13 Conrad: And an H2O flag.

115:08:14 Bean: That's good. Both suits. (Pause)

Given this the following times can be noted:

EVA-1 Begin Time: 115:08:02

ALSEP Offload Begin Time: 116:30:20

?(ALSEP begin – EVA-1 begin): 1:22:18

1.5 ALSEP OFFLOAD ACTIVITIES

This section gives a

1.5.1 LMP: Open SEQ Bay Door Activity



Figure 14. Showing the southeast quadrant of the LM. The upright cylinder stowed against the LM just to the left of the SEQ (Scientific Equipment) bay is the cask holding the plutonium fuel element that will fuel the Radioisotopic Thermoelectric Generator (RTG) that will be deployed as part of the ALSEP (Apollo Lunar Surface Experiment Package).

116:31:34 Bean: Okay. And we'll off-load the ALSEP. (Garbled).

116:31:39 Conrad: Nope. (Pause)

116:31:42 Bean: We ought to be able to move out with this thing.

116:31:44 Conrad: Okay.

116:31:48 Bean: The experiment bay looks real good.

116:31:49 Conrad: Yup.

[The ALSEP experiments are contained in two compact packages which, once Al removes them from the SEQ (Scientific Equipment) Bay on the southeast face of the LM, will be attached to the ends of a carry bar so that Al can take them out to the deployment site some 300 feet west of the LM. Details of the offloading procedure are printed on a decal which is fixed to the back wall of the SEQ Bay. The information on the decal is reproduced on page [Surface 47](#) of the checklist. As on Apollo 11, the pieces of equipment are mounted on booms and, once Pete has slid them

out of the Bay, he lowers them to the ground with pulley-mounted lanyards. Package 2 contains the Radioisotope Thermal Generator (RTG), a small, plutonium-powered electrical generator, which Al will fuel once it is on the ground. Note, also, that the handtool carrier, which they will take with them on the EVA-2 geology traverse, is stowed in the SEQ Bay and will be off-loaded after the two ALSEP packages are out.]

116:31:50 Bean: The LM exterior looks beautiful the whole way around. Real good shape. Not a lot that doesn't look the way it did the day we launched it.

116:32:02 Conrad: (Possibly pulling a lanyard to open the SEQ bay doors) Light one. (Pause)

116:32:12 Bean: Okay. Here we go, Pete. Ohhhhh, up they go, babes. One ALSEP. (Pause)

[They have raised the doors that cover the cavity where the ALSEP packages are stowed.]

1.5.2 CDR: Remove PKG 1 Activity

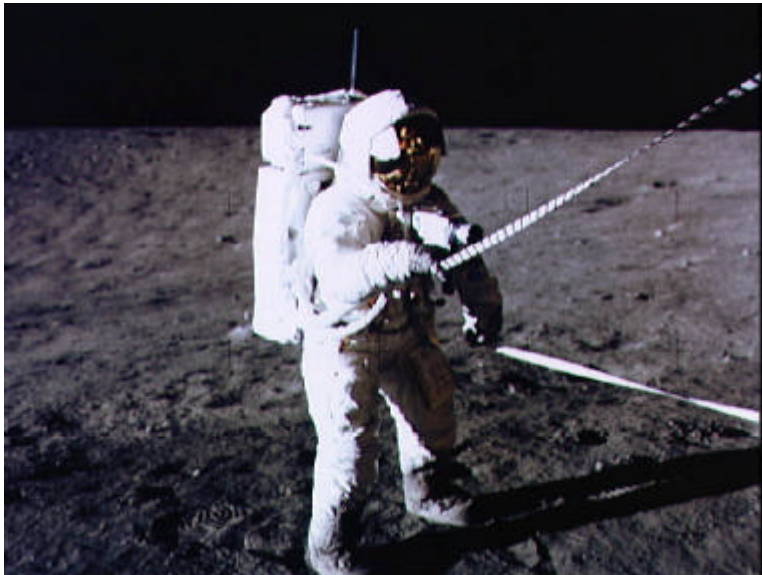


Figure 15. NASA picture AS12-47-6913: Pete is using a lanyard to pull the ALSEP packages out of the SEQ Bay on a rail. Note his chest-mounted camera, the OPS antenna behind his head, his cuff checklist and the pocket mounted on his left thigh to hold the contingency sample

116:32:22 Conrad: There it is.

116:32:24 Bean: There it is, is right. (Now we) just lay it on the lunar surface. (Pause) Better go to intermediate cooling, get good and chilled down. (Pause) Okay.

116:32:44 Conrad: Wait a minute. (Garbled) You've got to go easy.

116:32:48 Bean: Sure do. (Pause) Here it (probably the first package) comes.

116:32:53 Conrad: Coming right out.

116:32:54 Bean: And just about right. Riding right out on the boom, Houston. Sure looks pretty.

116:33:02 Gibson: (Making a mis-identification) Roger, Pete. We copy. (Long Pause)

116:33:36 Bean: (Wanting to take a picture) Look at me, Pete. (Pause) It's a good shot, babe. The LM and everything's reflecting in your visor. (Pause)
[AI's photos AS12-47- [6913](#) (**) and [6914](#) (**) show Pete using a tape to guide the first of the ALSEP packages out of the SEQ Bay. Photo [47-6915](#) (**) was probably taken late in the ALSEP off-load.]

[Bean - "I don't know if they ever tried to see if people could just pull the packages out and stand them on the ground. I think some of the things we did like this, where we had these nice, wonderful things that would deploy them and let them down, well, we didn't really need them. Now, I think one of the reasons they claimed we needed the rails and pulleys was, if you stroked the front gear, then it would be too high to reach in there. But I think the first thing a person ought to do when they're designing these things is see if - like taking stuff up the stairs (that is, the ladder) - if you can just grab it and do it. And then, if you can't come up with the most simplest thing in the world to do it. Nothing that's quite this fancy. Even if you had that high attitude, if you just had tabs pulled down, you could have pulled on the tabs and pulled it out and reach your hands up and got it. My comment would be to try to do it always the easy way first. And, if there's any way to do it the easy way, then don't build all that other stuff."]

[For Apollo 17, Cernan and Schmitt decided not to fly with the rails and pulleys and had no trouble getting the ALSEP packages out of the SEQ Bay.]

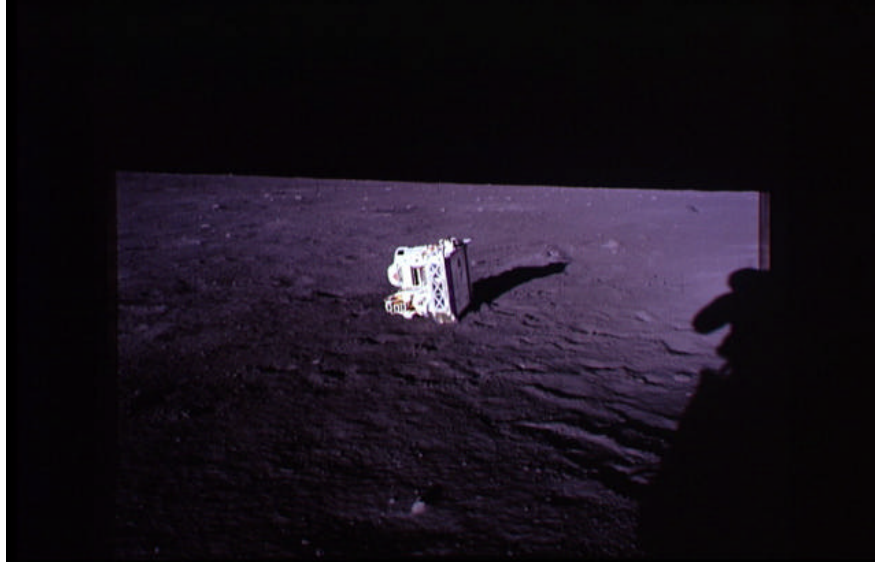


Figure 16. **NASA picture AS12-47- 6784:** This picture shows ALSEP Package 1, the one that Pete took out of the SEQ bay and then moved to its present location to get it out of the way. Note that Pete's shadow shows that he is wearing a saddlebag

1.5.3 LMP: Remove PKG 2 Activity

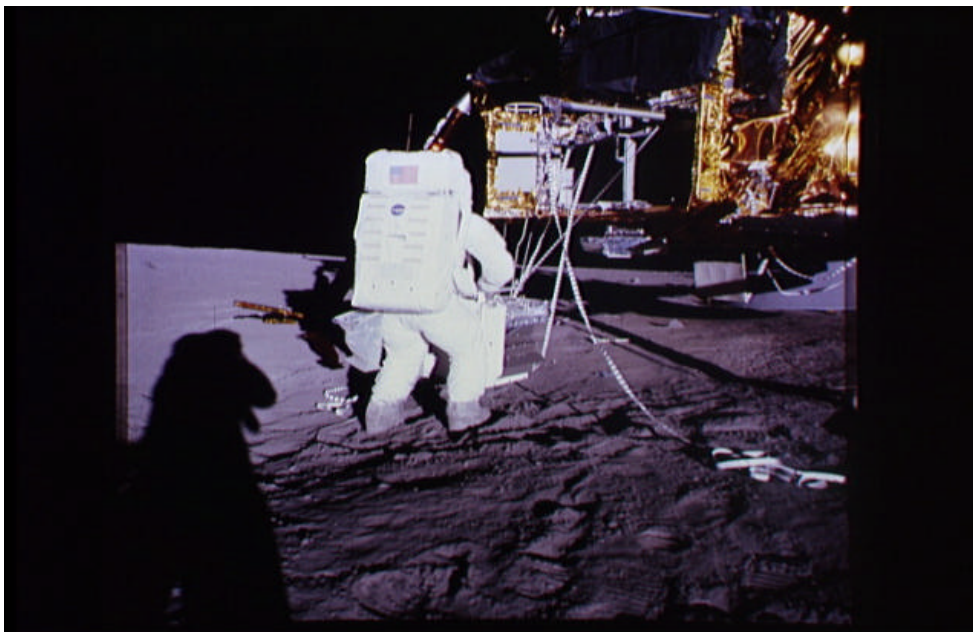


Figure 17. **NASA picture AS12-47- 6783:** Down-Sun photograph of AI, who seems to have the RTG package in hand. We can see the "saddlebag" he is wearing at his left hip. The saddlebag material resembles the Teflon cloth used for the Sample Containment Bags (SCB's) used on Apollo's 15, 16 and 17 Note that the transmitted light in the shadow of the saddlebag has a reddish-brown color. We can see the boom on which the RTG package rode as it was pulled out of the SEQ bay. We can also see the pulleys that were operated with the tapes. The SEQ bay door that covered the righthand 2/3rds is folded up out of the way. At the left side of the bay, we can see the vertically hinged portion of the door pulled back out of the way. Note that the SEQ bay is not an integral part of the LM structure but, rather, hangs on the outside. Below the SEQ bay, we can see a shield which protects the landing radar (mounted on the bottom of the Descent Stage) from heat radiating from the engine bell.

116:33:53 Bean: Lay her on the ground. Okay, I'll get mine out. (Long Pause) Right out on the boom, just like advertised.

116:34:13 Conrad: Wait until I get this (meaning the first ALSEP package) out of your way.

116:34:14 Bean: Okay. (Long Pause)

*[Pete's picture 6783 (**)] shows Al removing ALSEP package 2. After taking that picture, Pete turns to take 6784 (**) of the package (No. 1) that he (Pete) just moved out of the way. He then turns back to Al and takes 6785 (**), showing package No. 2 on the ground. The dark fins on this package are radiators to cool the Radioisotope Thermoelectric Generator (RTG) which will power the ALSEP experiments.]*



Figure 18. NASA picture AS12-46- 6785: Al has placed the RTG package on the ground. Note the cooling fins on the RTG. Note the pull rings on the edge closest to Al. These pull rings are used to release "pip pins" with which some pieces of equipment are attached to the RTG pallet. The light-colored piece of gear that is attached to the part of the RTG pallet that is on top in this picture is the SIDE (Suprathermal Ion Detection Experiment). Note the deployment rail and pulleys extending out from the SEQ bay above the upper ends of the lanyards. The distinctive ring-shaped top of the fuel cask can be seen behind the lefthand SEQ bay door. Note the saddlebag on Al's left hip and note, also, that Pete's shadow shows that he is wearing one too.

1.5.4 LMP: Deploy Hand Tool Carrier Activity

116:34:44 Gibson: Yankee Clipper, Houston. Omni Charlie; Omni Charlie.

116:34:47 Gordon: (Garbled)

[Comm Break for 1:30 mins]

[There is a considerable amount of static on the comm circuit, possibly caused by interference from the Command Module. Gibson asks Dick Gordon to switch to omni directional antenna C,

one of four. At [116:37:38](#), Gibson will give Gordon pointing angles for the high gain antenna. And, at [116:38:26](#), Gibson will tell Conrad and Bean that Houston is beginning to think that the interference - which the LM crew is also hearing - is originating somewhere in the comm downlink from the LM, rather than from the Command Module.]

[During this Comm Break, AI is probably removing the Handtool Carrier from the SEQ Bay.]

1.5.5 LMP: Unstow Cask Tools Activity

There is nothing in the transcription where it is obvious that Conrad has done this. I assume that this was done during the Comm Break as well.

1.5.6 CDR: Stow Booms Activity

There is nothing in the transcription where it is obvious that Conrad has done this. I assume that this was done during the Comm Break as well.

1.5.7 CDR: Unstow Universal Handling Tools (UHT) (2) Activity

There is nothing in the transcription where it is obvious that Conrad has done this. I assume that this was done during the Comm Break as well.

1.5.8 CDR: Close SEQ Bay Door Activity

116:36:25 Conrad: Okay. SEQ Bay door is coming closed. (Pause) Uh-oh. It's all right. Push that door...(Pause) What am I hung up on.

1.5.9 LMP/CDRmove Cable from CDR's Foot Activity

116:36:49 Bean: I don't know. (Long Pause)

116:37:13 Conrad: Hey, AI, (garbled). I have something (garbled)?

116:37:16 Bean: Let me look, Pete. (Pause) Here's one here. Let me get it off for you.

116:37:21 Conrad: Thank you. (Pause)

116:37:27 Bean: Okay, lift your left foot up and you're okay. (Pause) Okay.

[Evidently, Pete has gotten his foot caught in a cable, a common problem given the near impossibility of seeing one's own feet.]

116:37:30 Conrad: Thank you. (Pause)

1.5.10 CapCom/CMP: Changing Antenna on CSM Activity

116:37:38 Gibson: Yankee Clipper, Houston. High Gain Antenna: Pitch, minus 13; Yaw, 225. (Long Pause, the comm improves noticeably)

116:38:08 Bean: Hey, Houston, do you hear this constant beeping in the background?

116:38:13 Gibson: That's affirmative. We've heard it now for about the past 45 minutes.

116:38:17 Bean: What is it? (Responding to the second half of Gibson's communication) That's right, so have we. What is it?

116:38:26 Gibson: (Static returns briefly) Intrepid, we've tried to isolate it. It appears it's something on the downlink coming from the LM. (Long Pause)

1.5.11 LMP: Lower Cask Activity

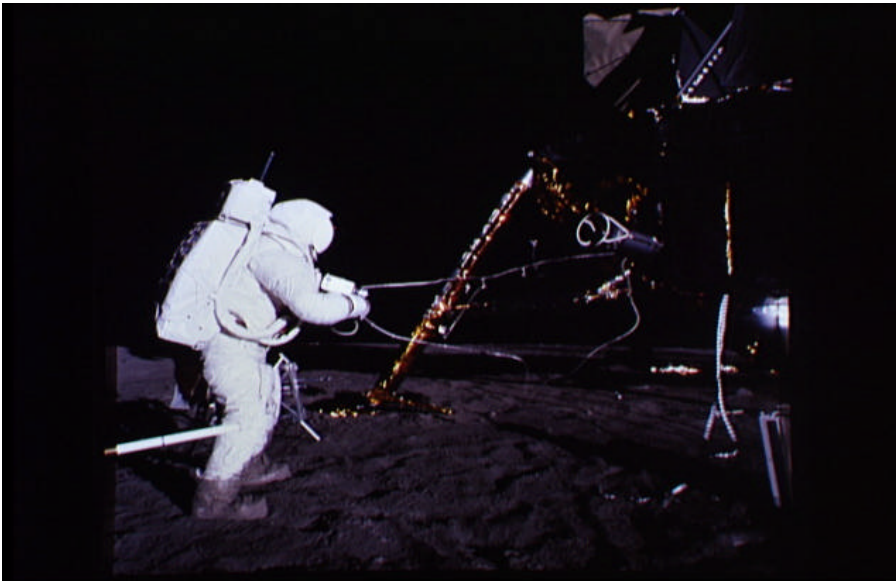


Figure 19. At about 116:40:44, Al is pivoting the RTG fuel cask into the horizontal position. The graphite-lined cask contains a plutonium fuel element and was designed to protect the element in the event of a launch abort and re-entry. Once he has the cask lowered, Al will use a special tool to remove the protective dome on the cask and then to remove the fuel element for placement in the RTG. Note that the SEQ bay doors are closed. The object just beyond Al is the Handtool Carrier which he took out of the SEQ bay after the RTG package.

116:38:45 Conrad: Hey, Al.

116:38:46 Bean: Yes, sir. And there's the lunar tools all set up for you, fella.

116:38:50 Conrad: Okay.

[Al is about to fuel the RTG. To do so, he rotates the cask which contains the plutonium fuel element down 90 degrees to a horizontal position. He then removes a protective dome, and, finally, removes the element and inserts it into the RTG. Pete will hand him the appropriate tools. The fuel cask was designed to survive re-entry into the Earth's atmosphere just in case there

was a launch accident. On Apollo 13, the LM was used to get the crew and their crippled Command Module back to Earth and was abandoned just prior to re-entry. The fuel cask survived the journey and currently resides at the bottom of the Tonga Trench in the western Pacific.]

116:38:53 Bean: This ALSEP's doing okay. (Pause; static has cleared) Old Chuck Wethered will be happy to know we're throwing it up for him, here. That's all right.

116:39:05 Conrad: Here you go. Now, what do you need of these?

116:39:10 Bean: I need anything you've got. (Garbled)...

116:39:11 Conrad: There you go.

116:39:12 Bean: ...that tool.

116:39:14 Conrad: How about this? You need that one?

116:39:17 Bean: How about the...Here, let me put that on. No, no. You put that in the package 2, and I'll pick that up later.

116:39:23 Conrad: It's already in package 2.

116:39:25 Bean: Then one must be yours.

116:39:29 Conrad: Okay. (Pause)

[The items in question may be the Universal Handling Tools, or UHT's, which are long-handled tools with which they will release the bolts holding the experiments onto the pallets that form the bases of the packages. Or, they may be discussing tools associated with the fueling operation. Package 2 is the RTG package.]

116:39:34 Bean: Okay. I put that there. (Pause) Excuse me, Pete, I'll move it (possibly the Handtool Carrier) over and plant it.

1.5.12 CDR: Connect Pkg-1 to Carry Bar Activity

116:39:48 Conrad: Wait a minute.

116:39:49 Bean: All right.

116:39:51 Conrad: Got to put this together right. Where's the arrow? (Pause)

[Pete may be attaching ALSEP package number 1 to the carry bar, or he may be doing some assembly of the HTC.]

116:39:59 Bean: Shall I let down the cask while we wait?

[Al is asking if he should rotate the cask down to the horizontal position.]

116:40:01 Conrad: Wait a minute. Here you go.

116:40:04 Bean: Okay.

116:40:05 Conrad: (I want to) put this together. (Pause)

1.5.13 LMP: Lower Cask Activity (continued)

116:40:?? Bean: Houston, we're going to go ahead and pull down the fuel cask right now, and then I'll take the element out of it.

116:40:26 Gibson: Roger, Al. Copy. You're working with the fuel cask.

116:40:31 Conrad: (To Al) Wait, wait, wait, wait, wait! (Laughs)

116:40:35 Bean: I knew it. That's a bad place to put it (the HTC?), Pete.

116:40:38 Conrad: Huh?

116:40:39 Bean: That's a bad place to put it.

116:40:40 Conrad: Yeah. (Pause)

116:40:44 Bean: Fuel cask comes down beautifully. In position. Came down just right.

*[Pete's photo of Al lowering the fuel cask to the horizontal position is AS12-46-6786 (**).]*

1.5.14 CDR: Remove SIDE Activity

116:40:49 Conrad: Oh, I know what I have to do, Al. And I'm standing here not doing it.

[Pete is supposed to be removing the SIDE (Suprathermal Ion Detector Experiment) from package 2 - as per the ALSEP deployment decal, but not his cuff checklist - so that Al can fuel the RTG.]

116:40:55 Bean: Okay, maybe I need to move the SIDE on.

116:40:57 Conrad: Yeah. (Pause)

116:41:00 Bean: We're moving right along, Houston. We're catching up. (Long Pause)

116:41:29 Conrad: Houston! You can log me for my first Boyd bolts on the Moon. (Pause)

[Bean - "A questionable honor."]

[Conrad - "Boyd bolts were a real pain in the ass."]

[The various experiment modules were attached to the two ALSEP packages by Boyd bolts. In order to remove the Boyd bolts holding down the SIDE, Pete inserted the head of the UHT into a guide sleeve that covered a bolt, engaged the bolt, and turned the UHT about a half turn to release the bolt. Despite having the little alignment tubes to help guide them, the astronauts found that getting the UHTs properly positioned could be a major problem. The bolts were often in deep shadow and difficult to see. In addition, dust sometimes got into the sleeves and added to the difficulty.]

1.5.15 LMP: Remove the Cask Dome Activity



Figure 20. At about 116:43:02, Al is using the dome removal tool. The fuel element is at about 1500 degrees and even the dome is hot enough that Al wants to avoid touching it. The RTG is the dark object at his right. The Handtool Carrier (HTC) is at his left with the hammer sticking up out of the corner nearest the camera. The foreground object at the lower right is ALSEP Package 1, the one that Pete offloaded. Note that Pete has removed the SIDE from the RTG pallet. It was attached on the side which is now facing the right edge of the picture. Pete took the SIDE off the RTG package at 116:41:29 (see 1.5.14). Note that the Universal Handling Tool (UHT) is sticking out of the right side of the base of the RTG pallet. Pete used the UHT to release a Boyd Bolt that was holding the SIDE on.

116:42:40 Bean: [...] (Pause) Okay, I'm unlocking the cask dome, right now. It unlocked perfectly. Shaking it down, trying to get it off.

116:43:00 Conrad: There you go.

116:43:02 Bean: It came off beautifully. (I'll) put the tool and the dome aside.

116:43:09 Conrad: Very nice.

*[Pete's photos AS12-46- [6787](#) (**) and [6788](#) (**) show Al removing the dome and then putting it out of the way.]*

[Al is about to fuel the RTG. To do so, he rotates the cask which contains the plutonium fuel element down 90 degrees to a horizontal position. He then removes a protective dome, and, finally, removes the element and inserts it into the RTG. ...]

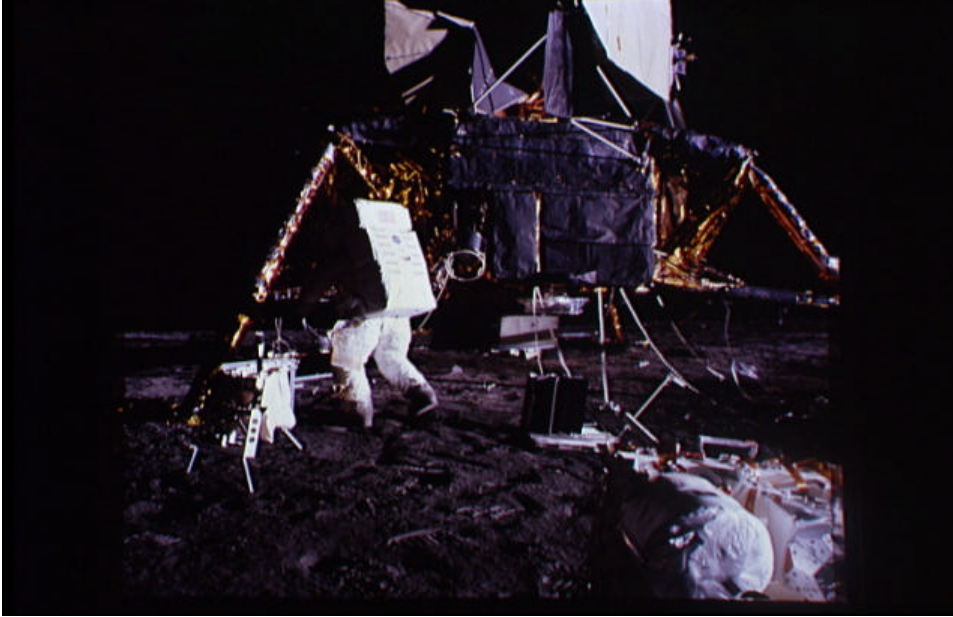


Figure 21. 116:43:09 AI is putting aside the dome that he has just removed from the fuel cask.



Figure 22. 132:00:36 AI took this view under the engine bell to show a rock that remained in place. Note the fuel cask dome at the left of center, with the dome removal tool still in place. The fuel cask is at the upper right.

1.5.16 CapCom/CMP: Unkown Activity

116:41:25 Gibson: Yankee Clipper; Houston. Go to Wide Deadband.

1.5.17 LMP: Fuel RTG Activity

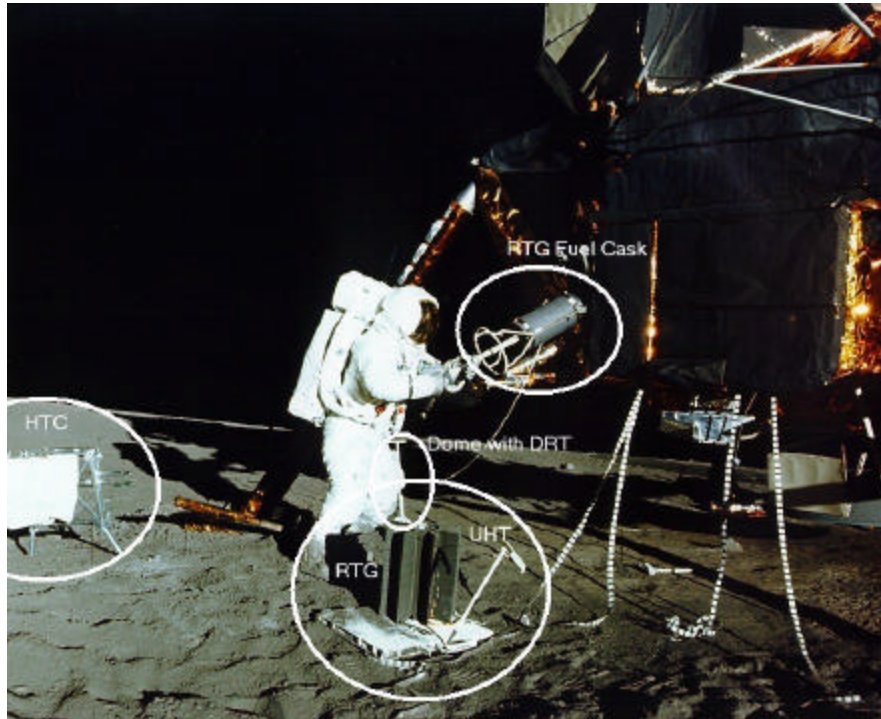


Figure 23. 116:43:38 Al has inserted the fuel element extraction tool. The dome is beyond his left leg, beneath the minus-Y (south) strut. We can also see the Handtool Carrier and the RTG. Pete took this photo from up-Sun of Al.

[... Pete will hand him the appropriate tools. The fuel cask was designed to survive re-entry into the Earth's atmosphere just in case there was a launch accident. On Apollo 13, the LM was used to get the crew and their crippled Command Module back to Earth and was abandoned just prior to re-entry. The fuel cask survived the journey and currently resides at the bottom of the Tonga Trench in the western Pacific.]

116:43:10 Bean: Okay. I'll get out the cask removal tool. (Pause) Why don't you stand over there, Pete?

[Conrad - "I think you wanted me to move around so I could take a picture of you pulling the element straight out."]

1.5.18 CDR: EMU Adjustment Activity

116:43:22 Conrad: I've got to go back to Min cooling. I'm about to freeze to death. (Garbled)

1.5.19 LMP: Fuel RTG Activity (continued)

116:43:27 Bean: Yeah. Okay. (Pause)

116:43:35 Conrad: Go ahead.

116:43:36 Bean: I am.

116:43:38 Conrad: Oh.

*[Pete's pictures of AI removing the fuel element are AS12-46-46-6789 (**)* and *6790 (**).]*

116:43:39 Bean: Yeah; it's not...(Pause) There you go. (Pause) Sliding right in there. Okay, tighten up the lock (garbled). Hold it. (Long Pause) You got to be kidding.

116:44:10 Conrad: Make sure it (the removal tool)'s screwed all the way down. (Pause)

116:44:25 Bean: That could make a guy mad, you know it?

116:44:28 Conrad: Yup. (Pause)

116:44:32 Bean: Let me undo it a minute, and try it a different way.

116:44:34 Conrad: Yup. (Pause)

116:44:38 Bean: It can really get you mad.

[Conrad - "If I remember right, basically that cask had two steel rings inside it, that were imbedded in the carbon. That's a carbon cask. That's a re-entry cask. And there are two rings inside. And the plutonium rod fit in and seated in those two rings. Then it had a thing on the top that you screwed the tool in. And there was something on the top..."]

[Bean - "Like three jaws. You squeeze them in, supposedly. As you tightened it, something happened to them, and then you pulled it out. It sounds to me like right here I started to pull and we could see it isn't pulling and we started talking about 'it makes you mad'. Then we decided to unlock the tool and relock it. Because the tool had little bitty pins and we were afraid if we pulled, we'd break it and then we really would be sunk. So we took it off, put it in a different way and locked it down again to see if, somehow, it would work better. And it didn't work any better."]

116:44:41 Conrad: Houston, AI put the tool on, screwed it all the way down, and the fuel element would not come out of the cask. He's taking the tool off, and he's working her again.

116:44:54 Gibson: Roger, Pete. We copy. (Long Pause)

116:45:13 Conrad: (To Houston) (You) guys got any suggestions?

116:45:17 Bean: It really kind of surprises me. (Pause)

116:45:25 Conrad: (Garbled) come over and look.

116:45:27 Bean: I tell you what worries me, Pete. If I pull on it too hard, it's a very delicate lock mechanism. Maybe (I should) not push the pins in quite so far, and wiggle it a little. I just get the feeling that it's hot and swelled in there or something. Doesn't want to come out. I can sure feel the heat, though, on my hands. (Pause) Come out of there! Rascal. (Pause)

[AI has correctly diagnosed the problem just from feel.]

[Conrad - "Now, the problem turned out that they never calculated the amount of time the plutonium was in there. It heated those two rings to where they expanded and were just snug on there. I guess by tapping the hammer on it, I gave it just enough bounce that the load AI was

putting on it would overcome the friction holding it. And he'd get it a little bit more and little bit more."]

116:45:55 Conrad: Suppose it outgassed or something? (Pause)

116:46:04 Bean: Say, Houston?

116:46:06 Gibson: Go ahead.

116:46:11 Bean: Okay. We've really got a problem, I guess. I've tried using different pins... You know, it's got a three-pin removal tool, so I tried using different pins in different holes. That doesn't appear to have any effect. You know, everything operates just exactly like it does in the training mockups and up at GE (General Electric Corporation). The only problem is, it just won't come out of the cask. I am suspicious that it's just swollen in there or something and friction's holding it in. But it's such a delicate tool, I really hate to pull on it too hard. I think what we can do...

116:46:48 Conrad: Hey, I'll be with you.

116:46:50 Bean: ...go get that hammer and bang on the side of it.

116:46:52 Conrad: No. I got a better idea. Where's the hammer?

116:46:54 Bean: That's what I said.

116:46:55 Conrad: No, no. But I want to try and put the back end in under that lip there and pry her out. Let me go get the hammer. Be right back. Where did you put it?

116:47:06 Bean: Huh? What? Hammer's on the MESA.

116:47:08 Conrad: Okay. (Pause)

116:47:11 Bean: Let me get the tool off; it's starting to warm up.

116:47:14 Conrad: Okay. (Pause)

116:47:26 Bean: Can't figure that out. (Long Pause)

116:47:44 Gibson: Al, when you're working on that, try to make sure you've got the pins all the way in. Tighten up on it; then you can try pushing down on it a little, before you pull it out.

116:47:57 Bean: Okay. (To Pete) Don't touch these needles (the pins on the removal tool); if these break off, that's all she wrote.

116:48:01 Conrad: Yeah. I understand.

[If the pins break off the tool, they will have no chance of getting the fuel element out.]

[Conrad - "There was no problem with radiation. We weren't going to have it out that long."]

[Bean - "We had to use the tool because we didn't want it to touch anybody's suit."]

[Conrad - "Right. It was too (thermally) hot. It would burn your suit."]

116:48:02 Bean: And don't pound on anything (garbled).

116:48:03 Conrad: No, no. I'm not going to.

116:48:05 Bean: Okay. (Pause) We'll try again. Rotate and try it this way. (Pause) (The removal tool) drives in there just like it's going to do the job. Only it doesn't do the job.

[Conrad - "It was really stuck in there."]

[Bean - "Yes, but we didn't know it."]

[Conrad - "It didn't have to do with the latch."]

[Bean - "Which we said earlier. Everything seemed to operate, but it wouldn't come out."]

116:48:23 Conrad: Oh man, look at this dust fly. (Pause)

116:48:29 Bean: Just a minute. Just a minute. (Let me) get those pins in there again. (Pause)

116:48:38 Conrad: You're not getting those pins all the way in.

116:48:41 Bean: They're not in now because I'm lining them up. Just a damn minute. Now they are all the way in. They're all the way...Not quite. That bottom one down there's...(Pause) Now, my recommendation would be pound on the casket, then...you know.

[Pete begins hitting on the side of the cask with the flat of the hammer.]

116:48:56 Bean: Hey, that's doing it! Give it a few more pounds. (Pause) Got to beat harder than that. (Pause) Keep going. It's coming out. It's coming out! (Pause) Pound harder.

116:49:08 Conrad: Keep going.

116:49:10 Bean: (Laughs, cheering him on) Come on, Conrad!

116:49:14 Conrad: Keep going, baby.

116:49:15 Bean: That hammer's a universal tool.

116:49:17 Conrad: You better believe it...

116:49:18 Bean: There, you got it!

116:49:19 Conrad: Got it.

116:49:20 Bean: Got it, Houston. (Pete giggles) That's beautiful. That's too much.

116:49:24 Gibson: Well done, troops.

116:49:26 Conrad: I gotta go put the...

116:49:28 Bean: We got it, babe! It fits in the RTG real well! It's just the cask was holding in on the side.

116:49:37 Gibson: Yankee Clipper. One minute to LOS.

116:49:40 Bean: Don't come to the Moon without a hammer. (Pause) That's it, Pete.

116:49:50 Conrad: (Laughing)

116:49:51 Bean: Outstanding!
116:49:52 Conrad: (Laughing; Pause)

[Conrad - (From the 1969 Technical Debrief) "(When we started to off-load the ALSEP), the first thing we noted was that, as soon as we put the packages down on the surface, they began to accumulate dust. Everything went as advertised until Al screwed the cask removal tool on the cask (means the fuel element in the cask) and (it) would not budge. We got the normal fix-it: the hammer. While I beat the blazes out of the side of the container, Al managed to start the (element) out. He'd get a little notch of it every time I'd hit the container. And I really, I guess, started cracking the container. We finally got the element out and the generator fueled."]

[Bean - (From the 1969 Technical Debrief) "It looked to me like the part that was sticking was about the first inch or so, because Pete would beat on it, and it would move out one-eighth inch or so until about an inch of it extended from the cask. Once the element was about an inch out, it suddenly came free and came all the way out, if that will be any aid to whoever is designing the equipment. Something was holding it that first inch."]

[The Apollo 12 Mission Report contains the following discussion about the fuel element removal problem. "Thermal tests and analyses show that dimensional tolerances can diminish with (increasing) temperature and result in binding between the latch fitting (C-ring) on the cask and the contact surface on the back plate of the capsule. The longitudinal contact distance for these two surfaces is approximately 0.6 inch, and extraction was easily accomplished once this distance was negotiated." For Apollo 13, the outer diameter of the 0.10 inch long contact surface was to be increased by "as much as 0.005 inch for ease of capsule extraction." None of the later crews experienced any friction problems in removing the fuel element from the cask. See, also, Al's description of the extraction at [121:46:16](#).]

116:49:57 Bean: Let's make our move (and carry the ALSEP out to the deployment site).

116:49:58 Conrad: I'm ready. (Pause)

116:50:05 Bean: That cask's going (in?). Okay, Houston. The fuel element is in the RTG. I can feel it radiate heat already! (To Pete) Put your hand over here.

116:50:13 Gibson: Copied that, Al.

1.5.20 LMP: Connect Packages Activity

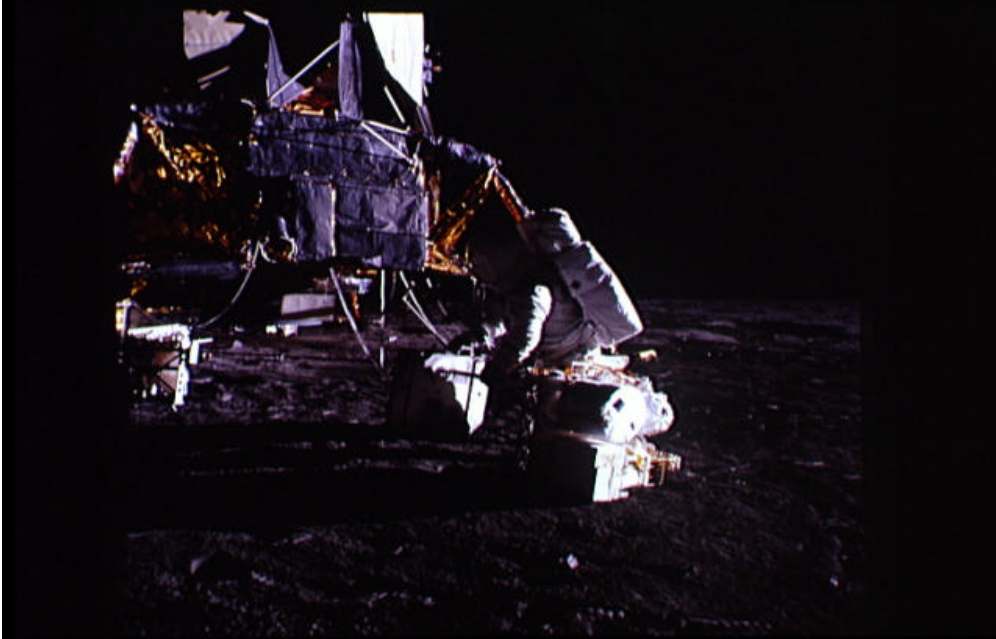


Figure 24. At about 116:50:59, Al is attaching the RTG package to the carrybar which will later serve as the Central Station antenna mast. Note the dirt that has gotten on the bottom of the RTG pallet - the surface facing the camera.

116:50:16 Conrad: Wait a minute; don't move...No, wait a minute, Al. Have you got a strap around your boot? Let me look and see.

116:50:21 Bean: Okay.

116:50:23 Conrad: No. You're all right.

116:50:24 Bean: All right?

116:50:25 Conrad: Yeah.

116:50:26 Bean: Boy, this thermal coating doesn't mean a thing here (because it gets dirty so quickly).

116:50:29 Conrad: Uh-huh. That thing is really getting covered with dirt.

116:50:33 Bean: Gosh! I hope they made allowances for it.

116:50:36 Conrad: Me, too. Okay. You're in, pal.

[Al is attaching the ALSEP packages to the carry bar. The thermal coating that Al is referring to is the reflective, white-cloth covering on the packages. As mentioned previously, any dirt that gets on the covers will increase the amount of sunlight absorbed and, therefore, the internal temperatures of the various pieces of equipment. He is hoping that the designers took into account the possibility that these internal temperatures could be higher than the lowest possible values.]

[Bean - "The trouble was in lining it up. You had to line up the package perpendicular to the shaft to the nearest degree and you couldn't ever do it. That was a hard job to do. We needed a better alignment way to click those in. In fact, when I carried it out, it fell off once, didn't it? They had little over-center holders and you'd hit a bump and it would come right out. 'Cause the thing was (flexing and) bending. When I carried that baby out, it was like carrying springs. In training, we just carried makeshift ones and the pole was stiffer."]

[Getting the packages properly locked onto the carrybar was always a problem and, on Apollo 16, one of Charlie Duke's packages came off the bar while he was carrying it. It fell four or five feet to the surface and bounced and rolled after it hit. There was, however, no apparent damage to the equipment.]

116:50:41 Bean: It doesn't look like it (is properly attached). Let me look at that just a second.

116:50:44 Conrad: Okay.

116:50:45 Bean: It's the right way. (Pause)

116:50:52 Conrad: That's it.

116:50:54 Bean: Hey, feel the heat off that machine. That's amazing.

116:50:59 Conrad: 1400 degrees (Fahrenheit). (In a conspiratorial tone) Almost as hot as the Sun! (Chuckles)

*[Conrad - "I must have taken this picture (AS12-46-6791 (**)) just about the time you hooked up the RTG. You've got your hand over the side and that's when you're talking about the heat, because your hand is right next to the radiator."]*

*[Pete also took 6792 (**) about this time.]*

116:51:06 Bean: Hey, do me a favor.

[Al is ready to start carrying the ALSEP and wants Pete's help in getting his hands properly positioned. The problem is one of not really being able to see something so low and close while, at the same time, trying to get low enough to grab the bar. On Apollo 16 and 17, Duke and Schmitt, respectively, generally bent forward to grab the bar and then, as they lifted the packages, ran forward to get it under control. Al may be trying to a more controlled, static lift.]

116:51:07 Conrad: What do you need? No, go lower. There you go. You got it.

116:51:11 Bean: Okay.

1.5.21 CDR: Pick Up Tongs and SIDE Activity

116:51:14 Conrad: Okay; let me go scout...smoke over the area.

[Pete is saying that he'll go out west of the spacecraft and look over the potential deployment area. They need to be at least 300 feet from the LM to minimize the amount of dust blown onto the experiments during launch. The reason that they will do the deployment west of the LM is that, shortly after liftoff, the spacecraft will tilt toward the west - so that it can catch up with the orbiting Command Module - and, as a result, will blow most of the dust toward the east.]

116:51:17 Bean: Okay. Got everything you need?

116:51:22 Conrad: (Examining his cuff checklist at 1+36) All right, there's no TV, so I got the SIDE (subpallet) and the picker-uppers for the rocks!

116:51:30 Bean: Okay.

[Had the TV still been working at this point, Pete would have now pointed it at the planned deployment site. Pete removed the SIDE experiment from the RTG package at [116:41:29](#) and will handcarry it out to the deployment site. This is the "subpallet" item on his checklist. The "picker-upper" is a pair of tongs that he got from the MESA at some time since they started the ALSEP off load.]

116:51:31 Conrad: Okay. Let's go right off to our little mound over there; how does that grab you?

[There are two conical mounds of dirt near the ALSEP deployment site which, evidently, the crew has already noticed. They did not, however, mention the mounds during the site description they did prior to the EVA preps.]

116:51:36 Bean: Okay. Now, something's wrong.

116:51:39 Conrad: What's the matter? (Long Pause, probably while they make sure the packages are secure on the carrybar)

116:51:49 Bean: Well, it's kinda...The thing doesn't...Well, let's try it.

116:51:57 Gibson: Pete, we copy. You've got the UHT, tongs, and (SIDE) subpallet.

1.5.22 LMP: EMU Check Activity

116:52:07 Bean: We're making our move, Houston. I can tell this is going to be a workload. I'll take it easy.

116:52:16 Conrad: (To Houston) How long did you say our shadow was...(that is), the LM's shadow, 150 feet?

116:52:24 Gibson: Stand by, Pete.

116:52:26 Bean: No, that isn't any 150 feet. (Pause)

[If the shadow is 150 feet, they'll only have to go twice that far to get to the 300 foot minimum distance.]

116:52:34 Conrad: Take your time, Al; I'll just go on out...

116:52:36 Bean: That's what I'm doing. What's the hurry? We got it made.

116:52:38 Conrad: No, I'm just going out to scout the area, that's all.

116:52:40 Bean: Okay, I'm going to set it down and rest...

116:52:42 Conrad: Okay.

116:52:43 Bean: ...and go to intermediate cooling. (Garbled) (Pause)
[Al is carrying the ALSEP low, with his arms hanging down.]

[Bean - "It was hard to carry that way; it kept bumping your knees. And then your knees would knock and it would rattle and jump."]

[Conrad - "Well, it weighed about 300 Earth pounds, so it had a lot of momentum."]

[Bean - "On Earth, when they gave us one that weighed like it did on the Moon (that is, a 50 pound mockup), it had the momentum of the light masses. But you get up there with those big masses, even though it weighed the same, it wobbled different."]

[Ed Mitchell (Apollo 14) discovered that it was easier to carry the ALSEP with the carry bar cradled in the crook of his elbows. Jim Irwin (Apollo 15), Charlie Duke (Apollo 16), and Jack Schmitt (Apollo 17) also carried their ALSEP high, either on their hands at shoulder height or in the crook of the elbows and had less trouble than did Al.]

[Bean - (From the 1969 Technical Debrief) "After we mated the ALSEP and got ready to carry it out, the workload carrying it out was about the same as I had guessed from working on Earth. The hard part is holding that weight in your hands. Even though it is not much (about 300 pounds on the Earth, but only 50 on the Moon), the combination of the weight, the fact that you're moving along, and the fact that your gloves don't want to stay closed (against the internal pressure of the suit) tends to make it a fairly difficult task. I would say that it would be acceptable to carry it this way for distances of up to 500 feet; but at distances greater than that, I don't think you want a hand carrier arrangement. You will want to have a strap that fits over your shoulder, or something like that. It's not your legs that get tired; it's a combination of your hands and arms, and it just makes you tired. Another thing that occurred that we hadn't seen on Earth is that, as you bounce along at one-sixth g, the RTG package tends to rotate. The c.g. (center of gravity) is not exactly lined up beneath the crossbar. It tended to rotate and unlock the two-piece crossbar. This was disturbing because I would have to stop once in a while and relock the crossbar. I would recommend that we definitely put some sort of snap lock on that cross piece so that, when you put it in position and it rotates to the carry position, it locks there. If it had opened up as we carried it, we might have dropped the gear and broken some of it on the lunar surface. It's funny that never showed up in any of our one-sixth g work in the airplane or anywhere else, but it was a continual problem on the lunar surface."]

[During the 1969 Technical Debrief, Pete and Al discussed the rest they could get by just standing still, arms hanging down and leaning forward to put their center of mass over their feet.]

[Conrad, from the 1969 Technical Debrief - "The position described is a very comfortable position. I never got tired. It's just a normal position to rest in. You can stand perfectly still in that position and rest. Did you (Al) feel the same way about resting? Did you just stand?"]

[Bean, from the 1969 Technical Debrief - "I never remember doing anything but standing there; and never seemed to get tired. As you said earlier, you could work 8 hours out there; if you got tired, you could probably stand against something or just stand there, cool off, and press on. At the end of the EVA, I was feeling as good, particularly in my legs, as I was at the start."]

1.6 ALSEP OFFLOAD ACTIVITY TABLE

Activity	Begin Time	End Time	Total Time	? from EVA Begin	? from ALSEP Offload Begin	Performer	Objects Worked On
1. Open SEQ Bay Door	116:31:34	116:32:22	00:00:48	1:23:06	0:00:00	LMP	SEQ Bay
2. Remove PKG-1	116:32:22	116:33:53	00:01:31	1:23:54	0:00:48	CDR	ALSEP PKG-1
3. Remove PKG-2	116:33:53	116:34:44	00:00:51	1:25:25	0:02:19	LMP	ALSEP PKG-2
4. Deploy Hand Tool Carrier	116:34:44	116:38:46	00:04:02	1:26:16	0:03:10	LMP	HTC
5. Unstow Cask Tools	116:34:44	116:36:25	00:01:41	1:26:16	0:03:10	LMP	Cask Tools
6. Stow Booms	116:34:44	116:36:25	00:01:41	1:26:16	0:03:10	CDR	ALSEP Booms
7. Unstow UHT	116:34:44	116:36:25	00:01:41	1:26:16	0:03:10	CDR	UHT
8. Close SEQ Bay Door	116:36:25	116:36:49	0:00:24	1:27:57	0:04:51	CDR	SEQ Bay
9. Remove Cable from CDR's Foot	116:36:49	116:37:30	0:00:41	1:28:21	0:05:15	LMP/CDR	
10. Changing Antenna on CSM	116:37:38	116:38:45	0:01:07	1:29:10	0:06:04	CapCom/CMP	High Gain Antenna

Activity	Begin Time	End Time	Total Time	? from EVA Begin	? from ALSEP Offload Begin	Performer	Objects Worked On
11. Lower Cask	116:37:30	116:40:44	0:03:14	1:29:02	0:05:56	LMP	RTG Fuel Cask
12. Connect Pkg-1 to Carry Bar	116:39:48	116:40:44	0:00:56	1:31:20	0:08:14	CDR	ALSEP PKG-1
13. Take Photo of LMP lowering the fuel cask to the horizontal position is AS12-46-6786	116:40:44	116:40:49	0:00:05	1:32:16	0:09:10	CDR	Haselblad Camera
14. Remove SIDE	116:40:49	116:41:29	0:00:40	1:32:21	0:09:15	CDR	SIDE experiment attached to ALSEP PKG-2
15. Remove the Cask Dome	116:40:44	116:43:09	0:02:25	1:32:16	0:09:10	LMP	Cask Dome
16. Take Two Photo's of LMP Removing Cask Dome and Putting it Aside	116:40:44	116:43:09	0:02:25	1:33:01	0:09:55	CDR	Haselblad Camera
17. Unknown	116:41:25	???	???	1:32:57	0:09:51	CapCom/CM	
18. Fuel RTG (take the fuel element out of the cask)	116:43:09	116:49:20	0:06:11	1:34:41	0:11:35	LMP/CDR	Fuel Element
19. EMU Adjustment	116:43:22	116:43:35	0:00:13	1:34:54	0:11:48	CDR	EMU

Activity	Begin Time	End Time	Total Time	? from EVA Begin	? from ALSEP Offload Begin	Performer	Objects Worked On
20. Fuel RTG (put the fuel element into the RTG)	116:49:20	116:50:16	0:00:56	1:40:52	0:17:46	LMP/CDR	Fuel Element and RTG
21. Connect Pkg-2 to Carry Bar	116:50:16	116:51:14	0:00:58	1:41:48	0:18:42	LMP/CMP	ALSEP Pkg-2
22. Take photo <i>AS12-46-6791</i> of connecting PKG-2 to the Carry bar	116:50:45	116:50:52	0:00:07	1:42:17	0:19:11	CDR	Haselblad Camera
23. Pick Up Tongs and SIDE	116:51:14	116:51:57	0:00:43	1:42:46	0:19:40	CDR	SIDE, UHT, and Tongs