This is an unscheduled ATM dealing with the results of changes made as required by the ASE deployment during acceptance testing of the E-2C Training Model. The specific test performed by Crew Engineering was the one associated with pull forces on the central station during thumper deployment; however, that test provided an opportunity to evaluate some of the changes recommended earlier and incorporated into the Qual Model hardware used for performing this test. This ATM contains a discussion of the background, purpose, hardware used, facility, procedures and test conditions and recommendations.

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1.0 BACKGROUND

During the deployment of the E-2C Trainer at BxA on 10-12 December 1969, two unsatisfactory conditions were identified which are associated with the subject test performed. First, during the deployment of the Thumper, seemingly high pull forces were noted as the cables were unreeled, in particular the power (flat ribbon) cable. The pull force was such that a DR (AB 6244) was incurred as the power cable was partially pulled away from the cable connector at the Central Station. It was agreed in the post deployment meeting that a further procedural investigation and further tests, using ASE Qual hardware, would be conducted by Bendix to evaluate this condition and to provide data for possible corrective measures.

The second condition was identified during the unlatching and removal of the Safety Release Assy. from the Mortar Package Assy. (MPA). The spring action of the latching switch assembly exerts a torque on the hex head of the inserted UHT and tends to require the astronaut to withdraw the UHT from the latching switch socket at an angle approaching horizontal. Therefore, the insertion depth of the socket has an effect on the ease of UHT withdrawal and reducing the insertion depth was anticipated as being a resolution to the condition.

Subsequent to the E-2C deployment, specific flight configuration design changes were released to minimize or eliminate both of the above conditions. These changes were incorporated into the Qual C Model Thumper and Mortar Box (Safety Release Assy.), therefore providing flight configuration hardware available for the subject Crew Engineering suited test.

2.0 PURPOSE

The primary purpose of this test was to measure the amount of force exerted on the ALSEP central station by the power and geophone cables during the complete deployment of the ASE Thumper. These data are necessary to allow a determination of whether or not the central station might be offset or misaligned by these forces during deployment on the lunar surface. This could either result in operation of the central station under degraded thermal conditions or in pulling over already deployed experiments.

There were two secondary or additional purposes of the test. One was to evaluate the design change on the MPA safety release assembly, which reduced the depth of the latch switch socket, and to determine if the new configuration would enable the crewman to pull the UHT out of the socket easily after rotating the latching switch to the "OPEN" position.

The other secondary purpose of the test was to verify the design changes incorporated in the Thumper and to provide a crew engineering evaluation of the Thumper mechanical operation associated with those changes during deployment. Specifically, the following functions were to be evaluated in light of previous E-2C deployment problems:

1. Ease of power and geophone cable unreeling and the effect of the revised method of adhesive application on the cables.

2. Ease of geophone removal from their stowage configuration.

3. Effectiveness of markers on the geophone cable to provide a warning 3 feet prior to deployment of the 1st geophone and 15 feet ahead for the 2nd and 3rd geophone, respectively.

3.0 HARDWARE USED

Following is a list of the hardware used to support this test:

a) Thumper/Geophone Assy. P/N 2334772, Qual C Model, S/N5. The unit, prior to the test, had the following flight configuration changes incorporated:

1 1. CRD 57672 - addition of a Kapton sleeve in Geophone flag stowage tube to facilitate the flag deployment.

2. CRD 57673 - machining down the diameter of flange on lower handle to eliminate handle hitting flag stowage tube restricting unfolding of Thumper.

3. CRD 57674 - reducing the amount of transfer adhesive applied to power (flat) cable to reduce pull force during deployment.

4. CRD 57676 - (a) rework of geophone liners to obtain a proper stowage fit and smooth withdrawal and (b) addition of white Mylar tape to the geophone cable at designated intervals to provide the astronaut warning of a upcoming geophone to be deployed.

5. CRD 57748 - decreasing thickness of "C" retaining rings on Thumper handles to minimize rotation friction.

The Thumper/Geophone Assy. used in the test did not have a Geophone Flag installed and did not include one flight configuration change, CRD 57750. That change removes Velcro tape (hook and pile) on the power (flat) cable which was installed at the 155 foot mark.

b) Mortar Package Assembly P/N 2334500-4, Qual C Model, S/N 5. The unit, prior to the test, had been reworked to incorporate CRD 57671. This was a flight configuration change to modify the safety release assembly latch switch to reduce the insertion depth in the socket for the UHT from 1/4 to 1/8".

c) UHT - BxA Crew Engineering tool.

d) Two spring scales calibrated with one to register 0 - 10 pounds and the other to register 0 - 20 pounds.

e) Mounting fixture to which the spring scales were attached.

4.0 FACILITY USED

In order to perform this test, a corridor 3 - 4 feet wide and 320 feet long was necessary. This allowed full deployment of the thumper cables and space to setup the spring scale mounting fixture. The area used was found in Plant 2 of the Bendix facility. This was roped off to be wide enough to allow the suited subject and photographer to operate while maintaining a relatively clear corridor (i.e., free of general passage) to keep the cables clean.

5.0 PROCEDURES AND TEST CONDITION

The test was conducted using test procedure TP 2338942. The procedure required a continuous strip of paper 3' x 4' wide be laid out and that the thumper cables be attached to the spring scales by tape at the end which is normally attached to the central station. The suited subject, pressurized to 3.75 psig in an Apollo A7L space suit, and wearing a cryogenic backpack then proceeded down the paper deploying the thumper cables and geophones under 1-G atmospheric conditions. Individual cable pull force measurements were taken during specific phases of the total deployment. Camera coverage was provided for each test. The initial deployment/measurement condition was with the cables deployed up to the first Velcro tape on the power cable. Thus, the first measurement was the pull force associated with unhooking the Velcro tape. The second set of measurements were subsequently taken as a running force as the cables were unreeled up to the 1st geophone. The peak or maximum force on each cable was recorded. Two more sets of similar measurements were made as the cables were deployed between the 1st and 2nd geophone and finally between the 2nd and 3rd geophones. At the completion of the full cable deployment the cables were restowed and the following day the test was repeated.

With the completion of the second thumper cable deployment and the recording of the associated pull forces the suited subject, using the UHT, conducted several evaluations, under 1-G atmospheric conditions, of the unlatching and removal of the Safety Release Assembly. The MPA was deployed on the paper corridor for this test.

6.0 RESULTS AND DISCUSSIONS

a) Cable Pull Force Measurements

The following table is a summary of the results of the ASE thumper cable pull force measurement test performed on 15 and 16 January 1970 at Bendix.

	Measured Peak Pull Forces		
Measurement Condition	Power Cable	Geophone Cable	Total
a. Velcro pull force (run 1)	2.5#	0.75#	3.25#
b. Velcro pull force (run 2)	1.5#	0.25#	1.75#
c. Running force to 1st geophone (run 1)	5.0#	3.25#	8.25#
d. Running force to 1st geophone (run 2)	2.25#	1.75#	4.00#
e. Running force between 1st, 2nd geophone (run 1)	6.75#	4.75#	11.50#
f. Running force between 1st, 2nd geophone (run 2)	7.5#	4.75#	12.25#
g. Running force between 2nd, 3rd geophones (run 1)	12.0#	4.0#	16.0#
h. Running force between 2nd, 3rd geophones (run 2)	4.5#	1.5#	6.0#

Constant forces during the test were not recorded, but were noted to be between 4 - 8 pounds. With the peak pull forces recorded, the central station, on a friction free surface, would not be moved or misaligned with the exception of those recorded under items (e), (f) and (g) above. The force recorded under item (g) is attributed to an artifact which occurred during the test. During the first run, the subject was required to stop while the camera filming the seqeunce was relocated. When the subject resumed his traverse, it is surmised that he maintained the cables in tension and then jerked the thumper forward with the result being a high force spike noted at the scales. In any event, the central station would probably have moved. Examination of the data revealed that high forces were recorded both times as the subject resumed deployment of the thumper after stopping to deploy the second geophone. The forces recorded prior to and after that are moderate and would not have, per se, affected the central station with the exclusion of the 12 pound force mentioned earlier. It should also be noted that the paper corridor, upon which the deployment was conducted, presented essentially a friction free surface to the cables. Cable deployment on the lunar surface would provide some drag and therefore, tend to reduce the pull force exerted on the central station These forces are attributable to increased weight impinging on the cable from material accumulating on it. They are not friction forces in the true sense of the word; rather they act as friction forces. Some theories have been advanced as to why the high forces occur including some thought that these high forces are the result of overcoming inertia and acceleration of the reels until they reach a constant velocity. At that time, the force exerted drops off sharply.

b) Safety Release Assembly (MPA) Evaluation

The suited subject conducted several UHT insertions switch unlatching, and UHT withdrawals to verify that the socket insertion depth in the Safety Release Assembly latching switch does permit a smooth UHT withdrawal.

c) Thumper Functional Deployment Evaluation

1. Ease of power and geophone cable unreeling - both cable reels appeared to operate smoothly with no "jerkiness" associated with the reel rotations for the pull off of either the power cable or the geophone cable as had been encountered during the E-2C deployment. On the other hand the amount of transfer adhesive applied to both cables did prevent cable spool-off, as intended during the entire thumper deployment. Therefore, the present adhesive application is considered satisfactory.

2. Ease of geophone removal from its stowage cavity - the deployment of the three geophones on both test runs verified a smooth but firm withdrawal of each geophone with no problems encountered. The present method of establishing a geophone stowage "fit" is considered satisfactory and resolves the difficulty experienced on the E-2C Trainer.

3. Effectiveness of geophone warning markers - both test runs of the thumper deployment verified that the white markers on the geophone cable do provide adequate warning of the approach to a geophone. It is interesting to note that the suited subject reported that the warning is actually provided by viewing the white markers as they appear on the reel and progressively are exposed to the point that they flap with the reel rotation and finally pull off as the point of attachment to the cable is deployed. This awareness of a white marker occurs some 30 feet prior to a geophone. The suited subject could not, in fact, actually see the white marker as it left the reel (at the 15 foot point) because of the visual limitations of the helmet, but commented that the awareness of the white marker no longer being on the reel was the cue that he had arrived near (within 15 feet) the point of geophone deployment and permitted him to proceed more cautiously up to the geophone. In summary, the warning provided by the addition of the white markers by the addition of the white markers is considered satisfactory.

7.0 RECOMMENDATION

There are alternative actions which could be taken to resolve the problem of pull forces being exerted against the central station during deployment of the thumper and the possible misalignment of the central station as a result of these forces.

The first possible action would be to request that the crewman not deploying the thumper hold onto or otherwise restrain the cable (especially the power cable) during thumper deployment. This would especially be critical during and immediately after emplacement of the second geophone. Its advantage is that no additional hardware is required and its disadvantage is that it requires some minor amount of time for the second crewman to perform this task.

Another alternative is to have the crewman deploying the thumper carry a stake which he might implant into the soil and anchor the cable. to it. The advantage of this approach is that it keeps thumper deployment a one man task; the disadvantages are: (1) extra weight, (2) another task to be performed by a crewman holding the thumper and (3) there would be the stowage impact to be evaluated.

Finally, the thumper plate itself might be used as the "anchor" or as a means to reduce the force seen at the central station by being dragged into the lunar soil. In order to provide this capability, the crewman would be required to wrap the power cable around the handle and the plate such that when the plate is emplaced on the lunar surface with the handle down, the cable would exit under the base of the plate in-line with the handle.

The forces exerted on the plate would tend to pull the forward end into the ground increasing drag. This method is recommended by Bendix since it keeps the thumper deployment a one-man task while maximizing the use of existing hardware.