ANS

FORM CD-121 (11-63) (PRES. BY A.O. 206-10)

UNITED STATES GOVERNMENT

Memorandum

U.S. DEPARTMENT OF COMMERCE
WEATHER BUREAU

TO : Chief, Spaceflight Metorology Group

DATE: May 21, 1970

In reply refer to:

FROM : MIC, Houston Section, SMG

SUBJECT: Apollo 13 Mission Report

Apollo 13 was launched successfully from Pad 39A at 1313CST on April 11, 1970. The primary objective of the Apollo 13 mission was to perform a manned lunar landing and return to Earth. The lunar landing was targeted to the Fra Mauro area. These objectives were not accomplished.

An explosion in an oxygen tank located in the service module, caused the life support systems and the propulsion system of the command and service modules to be inoperable. To survive, the crew transferred to the lunar module, and by powering down to the extent possible, they had oxygen and water necessary to survive the 90 or so hours necessary to return to Earth. The LM descent propulsion system was used for the TEI burn.

This flight again demonstrated the tremendous technology and resourcefulness that exists within NASA and the aerospace industry and also the management that is able to focus this capability on the job to be done.

Most of the capability of the SMG was also brought to bear on the EOM weather problem. Initially, there were many possible landing points, but on the backside of the moonat approximately GET + 79½ hours, TEI was initiated using the DPS. The spacecraft was targeted to 21S, 165W for a landing at GET + 142.

In the Pacific, Tropical Storm Helen was named and forecast to move in a southeastward direction across the landing point. Helen then became the dominant problem for SMG for the remainder of the flight. Many forecasts were made by several meteorological services. Weather in the targeted area became more critical than usual because it was feared that the ranging capabilities of the command module had been lost. This meant that the only sure way to change the landing point was to make a mid-course correction, at or before, GET+104 hours. The landing longitude could be changed considerably early in the return period, but this amount decreased with time, or as the distance to Earth decreased. Land masses west of the landing area reduced the effective longitude change in that direction to about 5 degrees, and the speed of the primary recovery ship limited the amount of change that could be made in an eastward direction.

The reason for the anticipated loss of ranging capability was, at first, very obscure. It was later determined that the lack of heat in the command module could affect the inertial platform to the extent that it could not be relied upon to produce the necessary accuracy.

In order to get as much meteorological information in the target area as possible, the weather recon was flown directly from its home base in Japan to Samoa. Originally the recon was scheduled to stage from Honolulu, but the change in the EOM from about 2S to 21S, and the acuteness of the weather situation prompted those changes.

Reports from the recon were transmitted in the usual way, but in addition, voice loops were made available to SMG so that we could talk directly with the weather officer aboard the aircraft. This was a tremendous aid because not only could we obtain a better "feel" for the weather in the area, we got the reports sooner. Both were important.

It was gratifying to receive so much cooperation and so many offers of assistance from other agencies and individuals. Airlines sent special AIREPS from the vicinity of Helen; satellite operation schedules were changed; Weather Bureau personnel in Honolulu not working directly on the mission made special efforts; Dr. Simpson in Miami lent his expertise to our cause; and Dr. Cressman called to ask if the Weather Bureau could provide additional help. This is a good example of the cooperative effort, duplicated time and again all over the country, that resulted in the safe return of the Apollo 13 crew.

In the final analysis, the SMG recommendation to keep the landing point at the targeted position was a good one. The spacecraft landed with near ideal weather.

The overall operation went quite well. Considering the nature of this flight, I believe a smooth operation is testimony to the general soundness of SMG operating procedures.

Following is a tabulation of extra working hours and premium hours required to support Apollo 13:

	COMP	O/T	ND	SUN
Meteorologists	12	40	76	24
Met-Techs	0	54	51	16

Dick

Richard K. Siler

cc: Chief, SOSD
All SMG Sections

WBAN FORM 10A (REV. 1-1-64)

U.S. DEPARTMENT OF COMMERCE - WEATHER BUREAU

SURFACE WEATHER OBSERVATIONS

STATION: Kennedy Space Center

DATE: April 10, 1970

Type (1)	Time (LST) (2)	Sky and ceiling (Hundreds of Feet) (3)	Visibility (Statute Miles) Surface (4)	Visibility (Statute Miles) Tower (4a)	Weather and obstructions to vision (5)	Sea level press. (Mbs.) (6)	Temp. (°F) (7)	Dew pt. (°F) (8)	Wind Direction (00-36) (9)	Wind Speed (Kts) (10)	Wind Character (11)	Altimeter setting (Ins.) (12)	Remarks and supplemental coded data (13)	(14a)	(14b)	Observer's initials (15)
	1500	50 ⊕ 1- ⊕	10			163	78	58	08	11		001	Opaque 4/10			RW
	1600	50 ⊕ 1- ⊕	10			159	75	59	08	08		000	" 4/10			RW
	1700	50 ⊕ 200 ⊕ 1- ⊕	10			159	75	60	10	11		000	" 4/10			RW
	1800	50 ⊕ 200 ⊕ 1- ⊕	10			159	74	59	13	10		000	" 4/10			RW
	1900	50 ⊕ 200 ⊕ 1- ⊕	10			159	72	59	13	12		000	" 3/10			RW
	2000	50 ⊕ 180 ⊕ 1- ⊕	10			159	71	60	12	11		000	" 3/10			RW
	2100	50 ⊕ 180 ⊕ 1- ⊕	10			163	72	62	16	13		001	" 3/10			RW
	2200	50 ⊕ 180 ⊕ 1- ⊕	10			163	72	62	17	13		001	" 3/10			RW
	2300	50 ⊕ 180 ⊕ 1- ⊕	10			159	70	62	21	12		000	" 3/10			RW
	2358	50 ⊕ 180 ⊕ 1- ⊕	10			159	69	62	21	12		000	" 3/10			JH
	20															
					April 11, 1970											
	0100	50 ⊕ 150 ⊕ 1- ⊕	10			152	69	61	21	09		998	Opaque 3/10			JH
	0200	50 ⊕ 150 ⊕ 1- ⊕	10			149	67	61	26	08		997	" 3/10			JH
	0300	1- ⊕	10			149	67	61	32	12		997	" 3/10 Few Ac			JH
	0400	1- ⊕	10			149	67	59	33	09		997	" 3/10 Few Ac			JH
	0500	1- ⊕	10			149	66	58	34	10		997	" 3/10			JH
	0600	70 ⊕ E120 ⊕ 1 ⊕	10			149	65	58	34	08		997	" 9/10 / BINOVC			JH
	0625	50 ⊕ 120 ⊕ U ⊕	10			149	65	59	16	10		997	" 9/10 / BINOVC			JH
													120 ⊕ V ⊕			/
	0700	120 ⊕ U ⊕	10			149	65	60	18	06		997	Opaque 7/10 Few Sc 50			JH
	0800	50 ⊕ E120 ⊕ 1 ⊕	10			156	68	62	28	04		999	" 10 / OCNL BINOVC			JH
	0900	50 ⊕ E120 ⊕ 1 ⊕	8			159	70	63	31	11		000	" 8/10 (1 cu 30)			RW
	1000	120 ⊕ 1- ⊕	10			163	73	60	36	06		001	" 4/10			RW
	1030	150 ⊕ 1- ⊕	10			163	75	59	27	07		001	" 3/10			RW
	1100	150 ⊕ 1- ⊕	10			159	75	58	25	08		000	" 3/10 Few Cu 30			RW
	1130	30 ⊕ 1- ⊕	10			156	77	60	29	06		999	" 4/10			RW
	1200	30 ⊕ 1- ⊕	10			146	77	60	07	06		996	" 5/10			RW
	1230	30 ⊕ 1- ⊕	10			142	76	60	06	10		995	" 5/10			RW
	1300	30 ⊕ E200 ⊕	10			142	75	60	07	10		995	" 7/10			RW
	1315	30 ⊕ E200 ⊕	10			142	77	61	08	10		995	" 7/10 All Cu ovr Land			RW
	1330	30 ⊕ E200 ⊕	10			139	76	60	06	10		994	" 8/10 " " " "			RW
	1345	30 ⊕ E200 ⊕	10			139	76	60	07	09		994	" 9/10 " " " "			RW
	1400	30 ⊕ E200 ⊕	10			136	75	60	07	10		993	" 9/10 " " " "			RW
	1413	E200 ⊕	10			132	76	60	08	10		992	" 6/10 Few Cu ovr Land			RW

(Note Temp 01503)

following related aviation observation.

T. O Winds at Pad 39-A : Apollo 13 4/11/70

Anemometer	Average wind for 10-minute period prior to launch (degs. / kts)	Peak during 10-minute period prior to launch (kts)	Instantaneous wind at T-0 (deg / kts.)
60' SE pole (26K01, -K02)	080°/09	10	080°/09
60' NW pole (26K02, -K04)	110°/08	11	100°/07
445' - Top of LUT (26C01, - C02)	150°/10	12	155°/10

Passed on
1500 EST
4/20/70
W

Winds at time of Apollo Launches for Larry Junker 7-6318

			500' OR 530' (L) WIND			60' WIND				MSO WIND
APOLLO MISSION	DATE	TIME (EST)	AVG DRN. (°)	AVG SPD. (KTS)	PEAK SPEED (KTS)	AVG DRN (°)	AVG SPD (KTS)	PEAK SPEED (KTS)		
13	4/11/70	1413	150	10	12	080	09	10		080/10
12	11/14/69	1122	270	16	21	270	10	14		220/08+1
11	7/16/69	0932								150/08
10	5/18/69	1149								120/12
9	3/3/69	1100								140/12
8	12/21/68	0751								340/06
7	10/11/68	1105	Pad	37	Launch					080/17+2
6	4/4/68	0700				160	13	—		140/10
5	1/22/68	1748	Pad	37	Launch					070/02
4	11/9/67	0700				040	16	24		040/12

OPTIONAL FORM NO. 10
MAY 1962 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

Weather Abandonment
ANS

TO : FA/Director of Flight Operations

DATE: APR 18 1970

FROM : FL/Chief, Landing and Recovery Division

SUBJECT: Apollo 13 preliminary recovery information

1. The Apollo 13 crew and command module were safely recovered on April 17, 1970, by the primary recovery ship, USS Iwo Jima. The command module landed at a point approximately .5 of a nautical mile from the alternate mission target point, about 550 nautical miles southeast of American Samoa. The location of the landing point, as reported by the recovery ship, was 21°38.4'S, 165°21.7'W. Enclosure 1 shows the relative positions of the command module landing point, the target point, and the position of the recovery ship at the time of splashdown.

2. The first electronic contact with the command module by the recovery forces was an S-band contact received by the Samoa Rescue 4 aircraft at 18:01 G.m.t. Signals from the VHF recovery beacon were first received by the Recovery, Photo, and the Swim 1 helicopters at 18:03 G.m.t. (main parachute deployment), and the first voice transmission received from the astronauts by the recovery forces after S-band blackout was by the Recovery helicopter at that time. The command module was also visually acquired by the Recovery helicopter at main parachute deployment. Splashdown was viewed from the Iwo Jima, and occurred at 18:07:41 G.m.t., as determined by the recovery forces. Upon landing, the command module remained in the stable 1 attitude.

3. The recovery helicopter with the Apollo 13 crew aboard, landed on the deck of the Iwo Jima at 18:53 G.m.t, about 37 minutes after the first swimmer had been deployed to the command module. After preliminary medical examination, Lovell and Swigert were reported to be in good condition, and Haise in fair condition. The command module was secured on the dolly aboard the ship at 19:36 G.m.t. Earth landing system items recovered consisted of one main parachute and the apex cover. As requested by the Mission Director, the necessary actions are being taken to maintain the configuration integrity of the command module, and only urgent return items from the ASHUR list were removed. Qualified escorts will accompany the command module until it is delivered at NR-Downey.

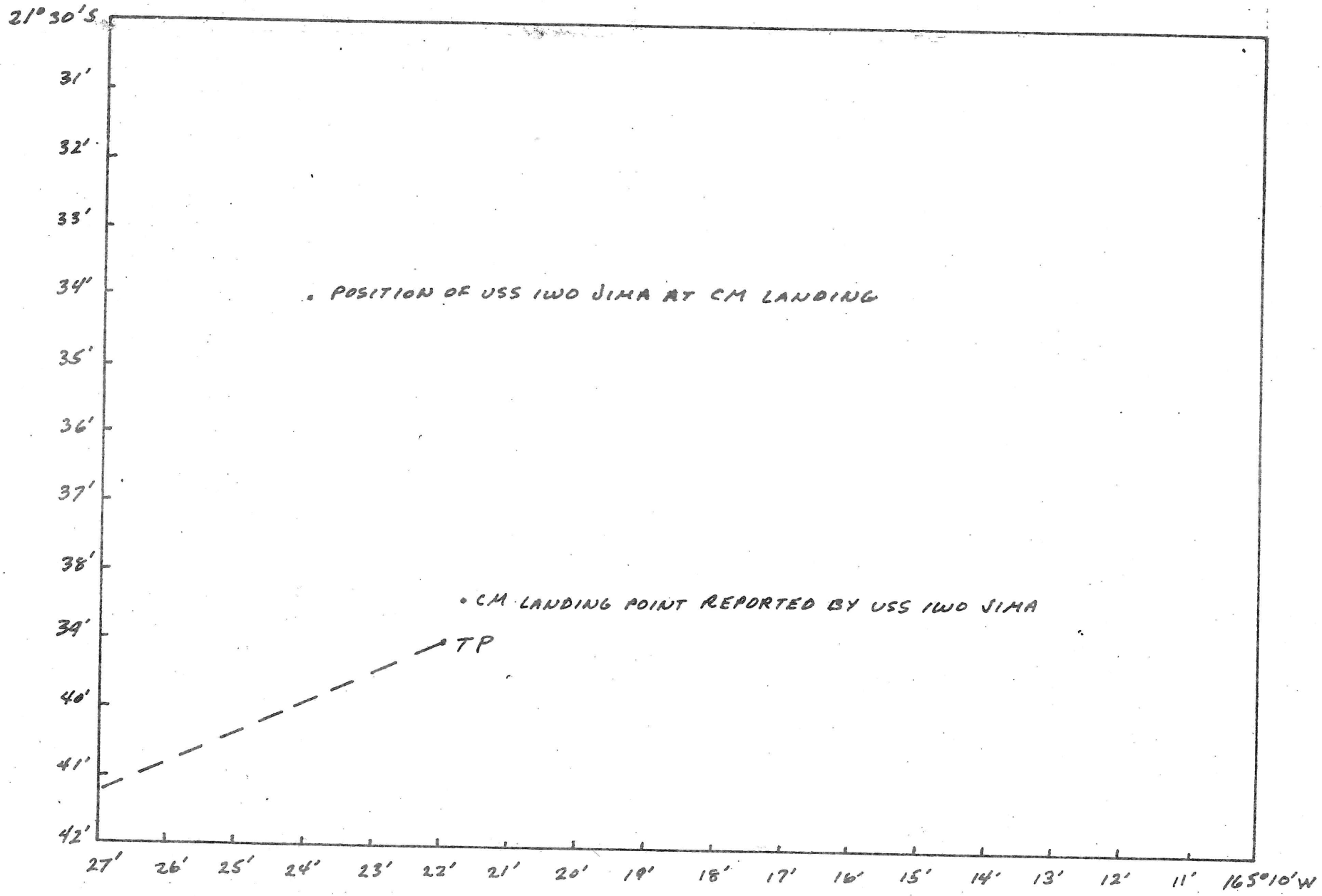
Enclosure 2 provides additional information concerning the recovery operation and the condition of the command module. Enclosure 3 contains estimated times of arrival of the urgent return items at Ellington AFB, and the USS Iwo Jima at Pearl Harbor. Information in this report is subject to changes as more data becomes available.

Original Signed By
J. B. Hammack

Jerome B. Hammack

Enclosures 3

FL:DHCordiner:nab


21°30'S
31'
32'
33'
34'
35'
36'
37'
38'
39'
40'
41'
42'
• POSITION OF USS IWO JIMA AT CM LANDING
• CM LANDING POINT REPORTED BY USS IWO JIMA
TP
27'
26'
25'
24'
23'
22'
21'
20'
19'
18'
17'
16'
15'
14'
13'
12'
11'
165°10'W

Enclosure 1

Enclosure 2

Flight Crew and Command Module Recovery Information

1. Recovery ship: USS Iwo Jima

2. CM Landing information:
   a. Time of landing: 17/18:07:41 G.m.t
      How determined: Visual by recovery forces
   b. CM landing point: 21°38.4'S, 165°21.7'W
      Reporting unit: USS Iwo Jima
      How determined: Ship's navigation system

3. Ship position at time of CM landing: 21°34'S, 165°24'W

4. Contacts during CM descent:

	Unit Reporting	Type	G.m.t. of acquisition	Coordinates of reporting unit	Remarks
a.	Samoa Rescue 4	S-band	1801	18°35'S, 164°04'W	
b.	USS Iwo Jima	Visual	1802		
c.	Recovery/Swim 1/ Photo helicopters	VHF recovery beacon	1803		Main parachute deployment
d.	Recovery helicopter	VHF/AM voice	1803		
e.	Recovery helicopter	Visual	1803		170°M- 5 n.mi.

5. Weather in vicinity of CM landing point at time of landing:
   a. Cloud cover/cloud base:
      (1) Lower level: 1 tenth/2000 ft.
      (2) Total coverage: 6 tenths
   b. Barometric pressure: 29.821 inches
   c. Sea Temperature: 79°F
   d. Air Temperature: 79.6°F
   e. Relative humidity: --
   f. Visability: Unrestricted
   g. Wind velocity/direction: 6 knots/270°T
   h. Wave height/period/direction: 1 ft/2 sec/270°T
   i. Swell height/period/direction: 6 ft/~~2 sec~~/130°T
      11 sec?
   j. Unit reporting: USS Iwo Jima
   k. Time of report: 17/1800 G.m.t.

6. Observations prior to retrieval:
   a. CM flotation attitude: Stable I
   b. Main parachutes: Released
   c. Uprighting bags: Fully inflated 15 minutes after landing
   d. Flashing light: Erected-observed to be operating after landing
   e. Sea dye marker from cabin: Not deployed
   f. VHF recovery antennas: Both deployed
   g. Recovery interphone: Not used
   h. Swimmer radios: Operated satisfactorily

7. Location of CM at time of retrieval: 21°39.1'S, 165°20.9'W

8. Weather at time of CM retrieval:
   a. Total cloud cover: 9 tenths
   b. Barometric pressure: 29.845 inches
   c. Sea temperature: 79.5°F
   d. Air temperature: 79.6°F
   e. Relative humidity: 80 percent
   f. Visability: Unrestricted
   g. Wind velocity/direction: 5 knots/270°T
   h. Wave height/period/direction: 1 ft/2 sec/270°T
   i. Swell height/period/direction: 5 ft/10 sec/130°T

9. Significant events during retrieval operations:

Event	Time (G.m.t.)
Swimmers deployed on main parachutes	17/1809
First swimmer deployed to CM	1816
Flotation collar inflated	1824
LPU bag delivered to leader swimmer	1831
CM hatch opened for LPU transfer	1832
CM hatch opened for crew egress	1835
Flight crew pickup complete	1842
Recovery helicopter on ship	1853
Time astronauts in sick bay	1905
Shot line passed to CM	1925
Recovery hook attached	1929
B and A crane hook attached	1931
CM secured on dolly	1936
CM secured in hangar deck	1950
Side hatch opened for CM inspection	2000

10. Condition of flight crew: Lovell and Swigert - good, Haise - fair.

11. Earth landing system components retrieval:
   a. One main parachute was retrieved - condition was unknown.
   b. The apex cover was retrieved and sustained major damages. The apex cover was hit by a small boat and boat propeller during recovery; however, swimmers reported major damage to the cover prior to boat arrival. The following damage was observed after recovery:
      1. Some broken radioluminescent discs
      2. Apex cover broken on EVA handle side
      3. Ring broken on side
      4. Cover somewhat warped
   c. Drouge parachutes and deployment bags were sighted but not recovered.

12. Postretrieval observations of CM: No major damage to the command module was observed. The following abnormal conditions were noted.

Exterior:

a. Heat shield: There appeared to be more and deeper heat streaking in the areas of compression and shear pods.

b. Right side roll thruster was blistered (no additional information available at time of report).

c. Yellowish - tan film on outside of hatch window - no damage.

Interior:

a. Interior surfaces were very damp and cold. Water was assumed to be from condensation. No pooling of water on floor was observed.

13. Additional remarks:

a. Water samples were not taken because of the lack of water in the command module.

b. A propellant dump was performed.

c. Personnel radiation dosimeter readings were as follows:

1. SN 1034 (Swigert): 02041 at 17/2134 G.m.t.
2. SN 1030 (Lovell) : 11029 at 17/2300 G.m.t.
3. SN 1035 (Haise) : 10034 at 17/2300 G.m.t.

d. The STARS pickup off the deck of the Iwo Jima was made at 17/2208 G.m.t.

e. Items identified on the final ASHUR urgent return list were to be flown by COD to Samoa and then by C-141 to Ellington AFB via Hawaii (see logistics schedule - enclosure 3).

Enclosure 3

LOGISTICS

C-141 (Urgent Items Return)

	G.m.t.	c.s.t.
ETD Samoa	18/2030	18/1430
ETA Hickam AFB	19/0235	18/2035
ETD Hickam AFB	19/0435	18/2235
ETA Ellington AFB	19/1235	19/0635

Air Force 2 (Astronaut Return)

	c.s.t.
ETD Hawaii	April 19 - afternoon
ETA Ellington AFB	April 19 - evening

USS Iwo Jima

	G.m.t.	c.s.t
ETA Pearl Harbor	24/1800	24/1200

AWS

U.S. DEPARTMENT OF COMMERCE
Environmental Science Services Administration
WEATHER BUREAU PACIFIC REGION
P.O. Box 3650
Honolulu, Hawaii 96811

Date: April 30, 1970

Reply to Attn of: WF1225

Subject: Apollo 13 Operation Report

To: Chief, Spaceflight Meteorology Group, WF122

Apollo 13 was the fifth of the Apollo manned lunar spaceflights and the third scheduled to land men on the surface of the moon. The launch took place from Cape Kennedy, Florida as scheduled at 0913HST on April 11, 1970 and the Trans Lunar Injection burn occurred during the second revolution as Apollo 13 passed over Australia. The flight was routine until the afternoon of April 13 when an explosion made an abrupt change in the flight plan. The explosion in the service module caused a loss of power supplied by the fuel cells and the loss of the main breathing oxygen supply. The systems were shut down and for the remainder of the flight power and oxygen for breathing were supplied by the Lunar Module. The astronauts used the Lunar Module descent engine to place Apollo 13 on a free return trajectory and after passing behind the moon to adjust course and speed for a reentry and splashdown at 21-39S 165-00W. Reentry, splashdown and recovery were normal with splashdown occurring about three nautical miles from the Primary Recovery Ship USS IWO JIMA. The astronauts were transferred to an Air Force C-141 the following day at Pago Pago and flown to Honolulu where they were met by the President and special awards were made. The command module was brought to Pearl Harbor by the USS IWO JIMA for deactivation and then flown to Houston.

Recco support for this mission was provided by the Air Force. Tentative flight tracks had been made to support the original planned splashdown point at 1-34S 157-30W with flights on EOM-2 and EOM-1. The aircraft, a WC-135, and crew were to be at Hickam AFB on April 18 at which time I was to brief the crew. The mishap to Apollo 13 required a major change to this schedule. The aircraft flew from Japan the next day directly to Pago Pago via Tropical Storm Helen which was located about 600 nautical miles west northwest of the planned EOM point. A Recco flight was made on EOM-2 which included T.S. Helen and the area to the east of the splashdown point. When it became apparent that Helen would pose no threat to recovery operations, the EOM-1 Recco track was devised for a late afternoon early evening flight to investigate the weather along the reentry track from the planned impact point for a distance of about 300 miles in case it became necessary to extend the reentry range. Since by this time it appeared that wind and sea conditions

would be satisfactory, the aircraft was to look primarily for thunderstorm activity or other turbulence. Reports indicated isolated CB's in the general area but none near the splashdown point.

Liaison with the Navy continues to be excellent. After the accident, I was in contact a number of times with Captain Houston, Commanding Officer of the Fleet Weather Central. Forecasts were coordinated with the Navy whenever possible. However, the Navy issues its forecasts for only a 24-hour period and for a circular area with a 500 nautical mile radius centered on the operating area of the recovery ship.

Weather reports from the USS IWO JIMA were good. All ABC reports were received and most of these within one-half hour after observation time. A few synoptic reports were missing but some were delayed for up to 18 hours. The quality of the reports appeared to be good.

At the time of the emergency on board Apollo 13, it was possible that Tropical Storm Helen could be in the recovery area by EOM. However, the storm stayed in the vicinity of 175W drifting slowly southward and weakening. Weather conditions at splashdown were:

Scattered clouds at 2500 feet, high broken clouds.
Visibility 7 miles (IWO JIMA never reported greater than 7 miles).
Wind 2706.
Sea 2-foot waves and a 6-foot swell.
Temperature 79°F.
Pressure 1009.8 mb.

Weather satellite products played a very important part in making forecasts for Apollo 13. ATS-1 digitized photos were available only during the last three or four days of the flight and these had to be used with caution since the gridding of these pictures was not reliable. The ATS-1 of 162132GMT appears to be about 10 degrees off in longitude and 5 degrees in latitude. The ESSA 9 digitized mosaics were much better.

Operational support from WBFO Honolulu during the first half of the flight was the same as on previous missions consisting of one forecast shift per day and two 2-hour met tech plotting periods. This would have been adequate had the mission gone as originally planned. After the emergency there was a significant increase in the workload and WBFO Honolulu kindly provided two additional forecasters to assist. Three hourly sectional surface maps similar to the EOM map attached were plotted and analyzed. Additional pilot reports were requested and received from airlines flying near T.S. Helen. Southern hemisphere surface and 300 mb. "coded" progs were received from Australia via Vandenberg AFB.

The following is a breakdown of support provided by WBFO, Honolulu:

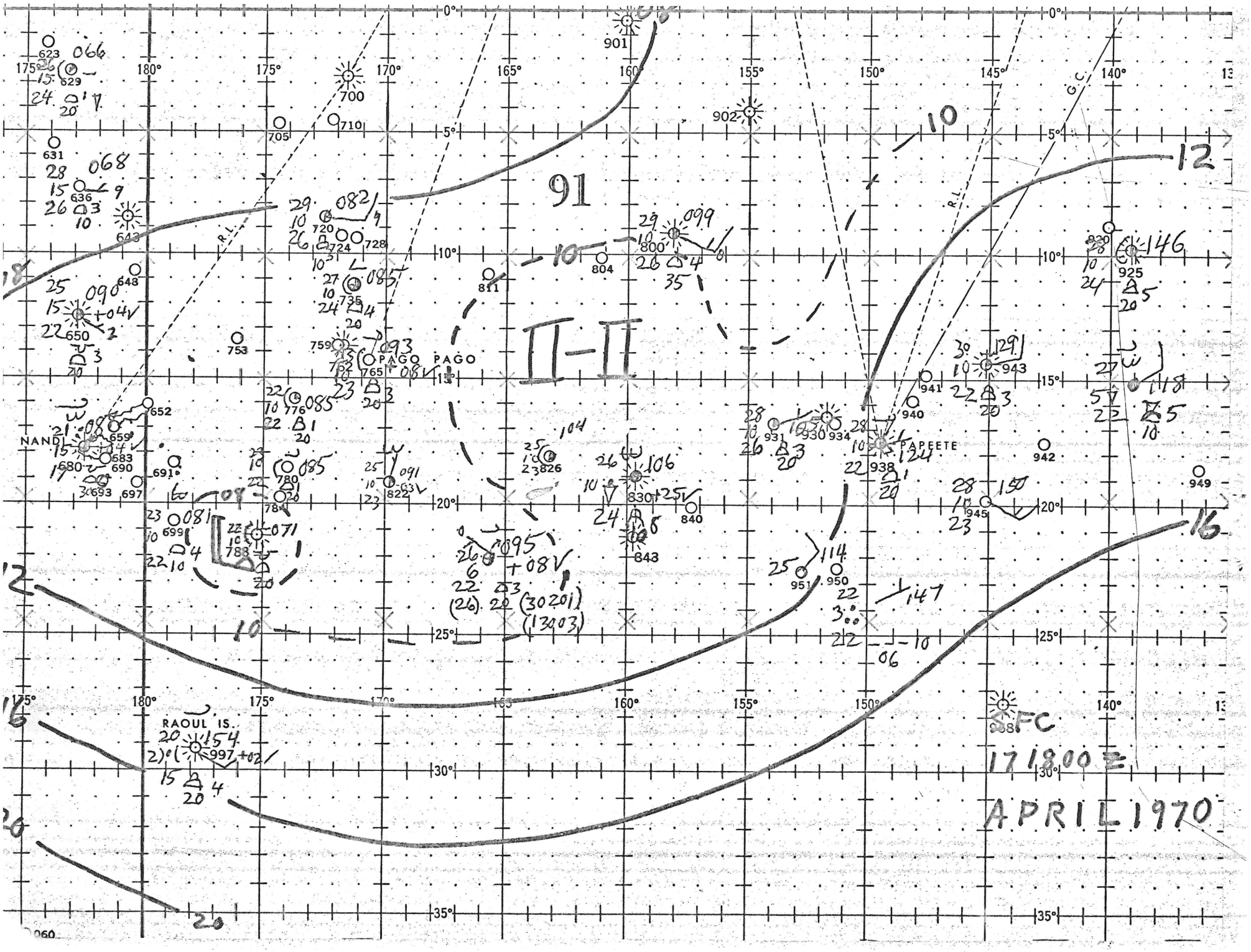
Grade	R	OT
12	48	14
11	32	8
7		8
6		16
5		4

I worked a total of 36 hours overtime during the mission.

O. A. Gorden, Jr.
Honolulu Representative, SMG

Attachment

cc:
Chief, SOSD
SMGs, Miami, Cape Kennedy, Suitland
MIC, WBFO Honolulu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II-II
PAGO PAGO
PAPEETE
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APRIL 1970