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THE INTERROGATION RECORDING AND LOCATION SYSTEM (IRLS) EXPERIMENT

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AND
LOCATION SYSTEM (IRLS) EXPERIMENT

Interim Report
April 14 - May 31, 1969

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September 1969

GODDARD SPACE FLIGHT CENTER
Greenbelt, Maryland

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AND

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ABSTRACT

The Interrogation, Recording, and Location System (IRLS) is a satellite technological experiment designed to demonstrate the feasibility of employing polar orbiting satellites to determine position-location and to collect scientific data from remote instrumented platforms which are deployed on a global scale on, or above, the surface of the earth. The experiment commenced with the launching of the Nimbus III satellite in April 1969. The following report presents the results of the 2 months of orbital operation during which period, balloon-borne, shipborne, ice island, buoy, and land deployed platforms underwent regularly scheduled interrogations by the IRLS system aboard the Nimbus III Satellite. Over 440,000 bits of conveniently formatted engineering and scientific data were collected from points around the world; location accuracies were in accordance with design expectations.

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THE INTERROGATION RECORDING
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LOCATION SYSTEM (IRLS) EXPERIMENT

1. INTRODUCTION

The launching of the Interrogation, Recording and Location System (IRLS) aboard the Nimbus III satellite represented a significant advancement in the evolution of satellite data collection and position-location technology applied on a global scale. The IRLS experiment has demonstrated the feasibility of employing polar orbiting satellites to determine position-location and collect scientific data from remote instrumented platforms which are deployed around the globe either on or above the surface of the earth. This objective was achieved in accordance with a pre-established operational plan wherein the satellite, ground computer equipment and globally deployed platforms functioned as an entity during orbit-to-orbit operation to provide locations and data collection from balloonborne, shipborne, ice island, buoy and land deployed platforms. Many of platforms underwent regularly scheduled interrogations by the satellite throughout the first two months of operations—over 440,000 bits of conveniently formatted engineering and scientific data were collected. The location accuracies achieved were in accordance with design expectations.

In addition, the experiment has afforded an opportunity to the potential user community to participate in and contribute to the system technological evaluation while also performing specific scientific experiments. This participation consisted in the actual operation of the IRLS platforms deployed around the globe.

2. PLATFORM DEPLOYMENT PLAN

The IRLS technological platforms activated during the first two months of operation were deployed in accordance with the plans depicted in Figure 1. As shown, platforms were situated in both the north and south pole regions, the continental United States, and near Puerto Rico, In addition, the IRLS Ground Acquisition and Command Station in Alaska was operated in a platform mode during specific test periods. In the formulation of the deployment plan, various cases of interest were considered for the purpose of evaluating the system performance from both the technical and operational standpoints. The cases may be characterized by platforms which are:

Stationary and precisely located (ISE)
Moving between interrogations on the same pass (balloon)
Moving between orbital passes (ice island, ship)

Stationary but unstable (buoy)
Deployed near equator
Deployed near poles

The rationale behind the separate consideration of each case is that each will exhibit various performance characteristics, and in some instances different operational procedures are required in order to develop the most effective interrogation sequence. In addition, operational limitations imposed by atmospheric disturbances in the polar regions and RFI in congested areas required investigation.

3. PARTICIPATING IRLS EXPERIMENTERS

Table 1 lists the various participating IRLS experimenters responsible for installation and operation of the platforms depicted in Figure 1. A number of fixed platforms for technological evaluation of the experiment were under control of the principal investigator. Other platforms are utilized by cooperating

Table 1

IRLS Participating Experimenters

Platform II	Agency	Experimenter(s)	Deployment	Initial Location
P_{02} (ISE)	NASA/GSFC	C. Cote L. Roach	Stationary	GSFC 39N 76.85W
P_{23}	Office of Naval Research (ONR) Naval Oceanographic Office (NOO) Naval Research Laboratory (NRL)	Dr. William Campbell Gerald Wolfson	T3 Ice Island-	85°N 126°W

Table 1 (continued)

Platform II	Agency	Experimenter(s)	Deployment	Initial Location
P_{22}	National Science Foundation (NSF) ESSA	Col. Merle R. Dawson Charles Roberts	USNS Eltanin-	39°S 143E
P_{24}	Naval Oceanographic Office (NOO)	Robert Kee William Abner	BUOY (Moored)	17.73N 66.42W
P_{20} P_{21}	National Center for Atmospheric Research	Alvin Morris Thomas Grey	Balloon	32°N 104.4W
P_{25}	NASA/GSFC	C. Cote	Stationary	80.6W 28.0N
P_{01} (ISE)	NASA/GSFC	C. Cote	Stationary	40.09N 75.40W

government agencies and non-profit organizations to evaluate both the performance and usefulness of IRLS in their scientific programs. All participants provided their own sensors for obtaining the data to be collected—the respective platform addresses were assigned by the National Aeronautics and Space Administration.

4. PERFORMANCE EVALUATION

4.1 Activation Period

The IRLS subsystem was activated on Wednesday, April 16 during orbit 32. All telemetry functions indicated nominal conditions; no affects on spacecraft controls were observed. Experiment operations were initiated at GSFC utilizing the Ground Acquisition and Command Station (GA & CS) located in the Nimbus

Ground Station. The Alaska IRLS station was inoperative following a computer malfunction.

Initially, difficulties were encountered at GSFC in properly orienting the ground station antenna during spacecraft acquisition. The resulting misalignment of the antenna axis with respect to the spacecraft position caused loss of communication during command land operations. Once corrected, however, communication with the spacecraft was of extremely high quality; subsequent operations from Goddard have been carried out without incident. The Alaska station was reactivated the week of April 22, and has since served as the primary station.

4.2 Communication Link

To date, sufficient data have been compiled to ascertain that the flight borne subsystem and sensory platforms are performing in accordance with design expectations over slant range distances below 2,000 km. The theoretical predictions on system performance established the communication link threshold (6db c/n) at a slant range of 2,100 km, thus allowing sufficient margin to operate over distances in the 2,500 km range under best case conditions. In actual operation, the 401.5 MHz down-link has performed in accordance with, and even exceeded, theoretical predictions. This was particularly evident during the NCAR balloon flights where the balloon successfully received and decoded its address on two successive orbits.

The 466 MHz up-link has not equalled the down-link performance for slant range distances in excess of 2,000 km, on a repetitive basis. Although interrogations have been conducted successfully over these ranges, the number of platform responses received has been below that required for reliable mission planning on a daily basis. The system operating limit has, therefore, been defined as 2,000 km for interrogation planning purposes; this provides reliable operation above 25° elevation angles which is more than sufficient for conduction of the experiment.

4.3 Location Analysis

The ability of the IRLS system to determine platform locations to within the design goal of 1.5 km for fixed stationary platforms has been demonstrated under conditions of minimum satellite along and cross track position errors (accurate ephemeris data). The following locations were obtained on the GSFC ISE under these conditions:

Orbit No.	GSFC Known Location	IRLS Location	Error
338	38 59 43N, 76 51 04W	38 59 51N, 76 50 51W	0.825 km
403	38 59 43N, 76 51 04W	38 59 06N, 76 50 48W	1.210 km
457	38 59 43N, 76 51 04W	38 59 12N, 76 50 42W	0.980 km

Trends observed in location data obtained for known fixed platforms over extended periods of time are characterized by the data shown in Table 2. In the table, location errors from the known position are shown for the GSFC ISE and the Naval Oceanographic Office Buoy taken over a time span covering 300 orbits. The GMT days of ephemeris update utilized in defining the respective orbits for location computation are also indicated. The increasing trends in error within each epoch period clearly illustrate the sensitivity of the IRLS system to uncertainties in satellite orbital position at the times of interrogation. It is also interesting and significant to note that the increasing and decreasing trends in location error are almost identical for the two independently operating platforms. Of particular interest is orbit 457 (two days after epoch) which shows a marked improvement in location for each platform while previous and following orbits showed larger errors. Similar patterns have been observed in other instances, which further substantiates the conclusion that orbital uncertainties contribute heavily to IRLS location errors.

The fact that the absolute errors are almost identical for the respective platforms over the total time span further indicates that the system is relatively insensitive to variations in location geometry try for fixed platforms not situated on or near the satellite orbital plane (subtrack). For platforms situated near the orbital plane, relatively small errors in satellite altitude, ranging, etc., translate into large errors in position. For example, the following errors were obtained for the buoy during the time span covered in Table 2:

Orbit	Platform Position	Satellite Position (Closest Approach)	Location Error
474	17.73N 66.42W	17.8N 67.4W	30.8 km
541	17.73N 66.42W	17.6N 66.3W	29.8 km
698	17.73N 66.42W	17.3N 65.9W	36.9 km

As shown, the platform was within 50 miles of the subtrack in each instance; distances in excess of 150 miles have yielded acceptable data on a consistent basis.

Table 2

IRLS Location Error Trends

Orbit	P_{02} - ISE (N. Miles Error)	P_{24} - BUOY (N. Miles Error)	Epoch
434	5.2	4.9	132
443	5.4	4.6	
448	3.1	3.7	
457	.53	.22	
461	2.9		
472		2.6	
500		6.7	
501	6.0		136
524	4.2	4.6	
529	7.8		
535		7.3	
541	8.1		
562		8.9	
568		7.9	
604		10.8	
608		1.8	149
658		4.3	
676		2.3	153
712	2.1		
716		2.1	155
729	3.7	2.3	
743	4.4	3.8	

Location data obtained from moving platforms is discussed in connection with experiments described in the following sections.

5. TECHNOLOGICAL PLATFORM EXPERIMENTS

5.1 GSFC - ISE

The ISE being precisely located at GSFC serves as the prime reference point for obtaining performance data of the type discussed in Section 4.3. In addition, tests are conducted to determine the performance characteristics of loop-vee, spiral, and crossed dipole antennas within the IRLS system.

The close proximity of the ISE to the IRLS GA & CS located in the Nimbus Ground Station has enabled operational tests of total system compatibility during GSFC passes. During such tests, complete data-dump, command load and interrogation sequences have been performed and monitored in real time. These tests were invaluable in establishing system confidence during activation orbits.

Operations with the ISE have also enabled analysis of the affects of RFI in the 400 MHz band on IRLS performance. The high level of commercial and industrial RF daytime activity in the Maryland, Washington, Virginia and Delaware area has had a marked impact on bit error rates and number of platform responses—while nighttime passes have yielded high quality data. Studies are currently in progress to determine the degree of desensitization imparted to the satellite receiver as a result of RFI.

5.2 Office of Naval Research (ONR), Naval Oceanographic Office (NOO), and Naval Research Laboratory (NRL) Ice Island Experiment (T3)

The technological platform delegated to ONR is situated on a floating ice island in the Arctic which is approximately seven miles long, three miles wide and 150 feet in depth. The island is currently moving within an area bounded by 84° and 85°N latitude by 124° and 126°E longitude. The platform represents a case of interest characterized by motion between orbital passes only for location evaluation purposes. The objective of ONR's participation is to enable Navocean-NRL to evaluate the IRLS position determination capability, and to demonstrate the capability of IRLS to collect and disseminate seismometer data from the arctic region within hours—rather than the usual weeks or months.

Operations with T3 commenced in early May 1968 and have since continued on a regular basis. Initially, manually inserted calibration voltages were collected from the platform data channels as part of a test procedure to determine the quality of data collected by the IRLS system—the results were excellent. Once qualified for operation, data inputs to the platform assumed the following format:

CHANNEL		CHANNEL
1	PLATFORM HOUSE-KEEPING	15 SEISMOMETER (CONT.)
2		16 WATER CURRENT DIRECTION
3		17 WATER CURRENT SPEED
4		18 TRANSIT LOCATIONS DEGREES LAT./LONG., TENS
5		19 TRANSIT LOCATIONS DEGREES LAT./LONG., UNITS
6		20 TRANSIT LOCATIONS DEGREES LAT./LONG., TENTHS
7	SEISMOMETER, EVENT ANALYZERS	21 TRANSIT LOCATIONS DEGREES LAT./LONG., HUNDREDTHS
8		22 TRANSIT LOCATIONS DEGREES LAT./LONG., THOUSANDTHS
9		23 AIR TEMP.
10		24 GMT HR. OF LOCATION
11		25 GMT MIN. OF LOCATION
12		26 GMT MIN. OF LOCATION
13		27 ICE TEMP.
14		28 DAY OF MONTH

The geographical location of the platform has enabled regularly scheduled interrogations to be conducted on a five hour interval basis. During each pass, five to seven of the above data frames are collected. Channels 18 to 28 contain island position fixes as determined by the Navy Transient satellite which in turn serves as references for IRLS location analysis. The positions are manually inserted by resident personnel prior to each Nimbus pass. In Figure 2, island movements during May are plotted showing Transit locations, received through IRLS, and corresponding IRLS locations for orbits near epoch times. As shown, the differences are in the order of one to two nautical miles.

Future operations with T3 will be conducted at an increased daily rate in response to the participant's desire for more frequent seismometer readings and location data. It is anticipated that two to three hour interrogation intervals will be provided. T3 and other IRLS experimenters data is dissiminated through the U. S. Mail on a daily basis.

5.3 National Science Foundation (NSF)-USNS Eltanin Experiment

The platform delegated to the National Science Foundation (NSF) is installed aboard the USNS Eltanin. The Eltanin is operated by the Military Sea Transportation Service for the National Science Foundation as part of the U. S. Antarctic Research Program. This vessel for research in the marine and atmospheric sciences has been continually in the Southern Oceans since mid-1962 on 60 day cruises down to the ice pack. The scientific complement of about 35 men and women often includes foreign guests. The Civil Service crew numbers 48. The ship is shown in Figure 3. The ship represents a case of interest characterized by motion between orbits, as with the ice island, for location analysis. An added factor of consideration in such an application is ship stability (tilt, roll; etc.) under heavy seas. The NSF objective is to demonstrate the capability of relaying weather data from the ship to the Weather Bureau (ESSA) in hours rather than the former days or weeks, which in turn would enable use of the data in formulating weather charts.

Operations with the ship began in early May and consisted basically of platform evaluation and qualification through the relay of calibrated reference voltages, while the ship lay at anchor. This operation continued throughout the month, with the ship located off the SE coast of Australia. The results of the evaluation phase were excellent; the ratio of responses to scheduled interrogations was above 80% with extremely high quality data. An analysis of location accuracy could not be performed on a repetitive basis during this time since Transit positions were not relayed in the IRLS data. However, an amateur radio contact was established between GSFC and the ship on May 7 just prior to an IRLS interrogation during orbit 311. The IRLS interrogation occurred at 1200 hours, 56 minutes UT and yielded the following location:

40.07°S Lat.   152.04°E Long.

At 1300 hours UT, a Transit position was obtained and the following location was relayed to GSFC via radio:

40.0°S Lat.   152.02°E Long.

The computed error shows 3.4 nautical miles from the Transit position. Since orbit 311 occurred approximately five days from epoch, the error was expected.

During the same orbit, a 4 nautical mile error was computed for the ISE located at GSFC; the platform was, therefore, operating correctly with the error attributed to system trends as discussed in Section 4.3. The ship is scheduled to depart from Australia in early June for extended cruises through the Antarctic area, at which time weather data will be relayed during interrogations.

5.4 National Center for Atmospheric Research (NCAR) Balloon Flight Experiments

Two GSFC/NCAR balloon flight experiments were conducted during May where IRLS platforms were carried aloft to altitudes of 72,000 and 104,000 feet respectively. Balloon launch operations were conducted by the NCAR balloon launch team; coordination between the balloon team and GSFC both before and during the flights was carried out by the ESSA/IRLS Balloon Prediction Center. The experiements served as a prelude to a 30 balloon tropical wind experiment planned for Nimbus D.

The first launch took place on May 11, from Boulder, Colorado under weather conditions favorable for a four to five day flight. During launch the balloon gondola carrying the platform batteries, thermal control, and ballast control suffered a severe shock just prior to release--the effect of which was not immediately ascertained. In Figure 4, the gondola, parachute, and balloon are shown just prior to release.

The balloon reached float altitude (72,000 feet) in approximately one hour, as predicted, and proceeded on a southeasterly course. An IRLS interrogation occurred during orbit 368 which placed the balloon approximately 73 nautical miles from the launch site. Shortly after the interrogation, the NCAR on-board balloon cut down mechanism fired inadvertently, as a result of damage imparted during launch, terminating the flight after eight hours.

Locations furnished to GSFC by ESSA and NCAR based on field, photographic, radar fixes obtained at the time of IRLS interrogation, indicated a position less than 1.5 nautical miles from the IRLS location. Since only one interrogation occurred, no wind estimate was possible. A crude estimate based upon total travel from the ground to the IRLS interrogation indicated a mean wind of 15 knots at 330°. NCAR data for mean wind at 72,000 feet on May 11 indicated 13.4 knots at 340°.

The second launch took place on May 29, from Palestine, Texas and, as before, a four to five day duration flight was attempted. The first IRLS interrogation occurred during orbit 609 at a balloon altitude of 104,000 feet. The received data was marginal and yielded no location data, however, evidence of varying power supply voltage was present. Subsequently, successful interrogations occurred on orbits 616 and 622 which yielded the following positions:

616	31.41°N	95.42°W
622	32.1°N	96.12°W.

An attempt to interrogate the balloon on the following orbit (623) was made in effort to obtain a two hour interval wind measurement. Due to the long slant range, distances involved (> 2000 km) parity errors in the identifying address codes received from the platform prevented recognition of the data by the ground computer and thus a position computation was not performed. However, the IRLS system did successfully measure the slant range distances which enables a manual computation of the balloon position to be performed.

The balloon flight terminated approximately 30 hours after launch and, as before, was caused by premature firing of the NCAR balloon cut-down mechanism. It is believed that the cut-down was related to intense lightning discharges within the immediate vicinity acting on the NCAR balloon command receiver.

Preliminary locations furnished by NCAR indicates three to four nautical mile errors in IRLS balloon location. However, the reference positions were estimates and will be refined once the balloon ground terrain photographs are developed and studied. The mean wind motion was extremely light as is evidenced by the IRLS locations. A third balloon flight is scheduled for August.

5.5 Naval Oceanographic Office (NOO) Buoy Experiment

The NOO platform has been installed on an ocean buoy moored off the coast of Puerto Rico. The platform is battery powered, utilizes an archimedean spiral antenna, and is in continuous day-by-day operation. The objective of Navoceano's participation is to evaluate the position determination capability of IRLS for future application to drifting buoys and to evaluate the data transmission capability of IRLS as influenced by the buoys' environmental factors.

The buoy became operational in early May and has since been deemed one of the more reliable platforms within the system. In fact, because of the high ratio of successful responses, buoy data are utilized in evaluating the performance of IRLS, as shown in Section 4.3. As far as environmental factors are concerned, the effect on the communication link has been noticeable only to the extent that occasional interrogations are lost. The data received during the successful responses have been of extremely high quality.

Each interrogation yields a frame of data containing the following sensory data:

1	PLATFORM HOUSE-KEEPING DATA	15	TILT VANE #1
2		16	TILT VANE #2
3		17	TILT VANE #3
4		18	TILT VANE #4
5		19	TILT VANE #5
6		20	TILT VANE #6
7	LEAK DET (SUB-SURF)	21	TILT VANE #7
8	PRESSURE (SUB-SURF)	22	COMPASS #1
9	PRESSURE (SURFACE)	23	COMPASS #2
10	GROUND	24	COMPASS #3
11	INCLINATION (SURFACE)	25	COMPASS #4
12	LEAK DET (SURFACE)	26	COMPASS #5
13	BATTERY VOLTAGE	27	COMPASS #6
14	GROUND	28	COMPASS #7

During each pass five to seven of the above frames are collected and later disseminated on a daily basis through the U. S. Mail. Due to the Navy's interest in the buoy subsurface leak detector, GSFC has agreed to provide a minimum of two interrogations daily throughout the lifetime of the buoy.

5.6 Air Weather Service, Balloon Interrogation Package, Woodshole Oceanographic Institute

In addition to the experiments described above, special tests were conducted with other platforms prior to deployment. The AWS platform was activated early in the experiment by Radiation Inc., Melbourne, Florida (IRLS Prime Contractor) for qualification purposes prior to delivery; and in support of IRLS evaluation of multiframe platform performance. During each interrogation, the AWS unit relays six data frames to the satellite which in turn enables up to 42 total frames to be collected during each pass. Throughout testing, from 20 to 42 data frames were received during each pass which more than adequately demonstrated the ability of IRLS to receive, format, store, and relay large amounts of sensory data from a single source.

The IRLS Balloon Interrogation Package (BIP) developed for the Nimbus D balloon experiment has undergone successful interrogations by the Nimbus III satellite. Unlike the Nimbus III platforms, the BIP contains a six watt transmitter (6 db less power) designed for operation with the more sensitive Nimbus D receiver. The successful interrogations of the BIP were a prelude to an IRLS animal tracking experiment planned for August. The total animal pack will be a self-contained collar containing the BIP package complete with power source and antenna.

The Woodshole platform underwent interrogations and as an aid to the experimenter in troubleshooting the platform during final stages of design. The platform is expected to be deployed on a free floating buoy in June.

6. PERFORMANCE STATISTICS

The following tables (3 and 4) contain statistics related to performance efficiency achieved through May 31, 1969. A total summary and week by week breakdown of activity for each platform is provided.

Table 3

IRLS Performance Statistics Summary

Week	Scheduled Interrogations	Responses	Data Frames Expected	Data Frames Received
1	49	25	79	45
2	118	86	156	114
3	60	50	216	149
4	153	127	471	357
5	199	162	374	360
6	290	231	466	335
7	351	200	527	270
Total	1220	881	2289	1630

Table 4

IRLS Performance Statistics

	Platform	Scheduled Interrogations	Responses	Data Frames Expected	Data Frames Received	Min/Max Slant Ranges
Week - 1						
Orbits	P_{23} ONR(T3)	18	4	18	4	1963/2135
32-72	P_{02}, P_{03} ISE	19	13	37	35	1702/1754
4/16/69-4/19/69	GSFC GA & CS	8	8	24	6	1047/2234
Total		45	25	79	45	
Week - 2						
Orbits	P_{23} ONR(T3)	66	54	66	51	1368/2400
72-169	P_{02}, P_{03} ISE	12	11	48	40	1669/1893
	P_{21} NCAR #1	14	9	14	9	1500/1665
	P_{22} NCAR #2	14	8	14	8	1500/1665
	P_{46} BIP	12	6	12	6	1302/1577
Total		118	88	154	114	

Table 4 (continued)

	Platform	Scheduled Interrogations	Responses	Data Frames Expected	Data Frames Received	Min/Max Slant Ranges
Week - 3						
Orbits	P_{23} ONR(T3)	22	21	22	21	1364/1955
194-246	P_{02}, P_{03} ISE	17	15	108	70	1334/2170
	P_{25} AWS	13	9	78	53	1194/1789
	P_{24} Buoy	5	3	5	3	1615/1874
	P_{46} BIP	3	2	3	2	1100/1347
Total		60	50	216	149	
Week - 4						
Orbits	P_{23} ONR(T3)	22	22	22	22	1271/2278
249-349	P_{02}, P_{03} ISE	50	44	200	151	1096/1827
	P_{25} AWS	36	24	204	139	1160/1993
	P_{21} NCAR	13	6	13	6	1131/1603
	P_{22} Eltanin	22	21	22	21	1127/1847
	P_{24} Buoy	10	10	10	10	1083/1563
Total		153	127	471	349	

Table 4 (continued)

	Platform	Scheduled Interrogations	Responses	Data Frames Expected	Data Frames Received	Min/Max Slant Ranges
Week - 5						
Orbits	P_{23} ONR(T3)	76	68	76	68	1171/2300
368-437	P_{02}, P_{03} ISE	57	43	232	241	1108/2600
	P_{22} Eltanin	48	35	48	35	1163/2300
	P_{21} NCAR	7	7	7	7	1152/1779
	P_{24} Buoy	11	9	11	9	1094/1844
Total		199	162	374	360	
Week - 6						
Orbits	P_{02}, P_{03} ISE	34	20	120	76	1257/1795
438-532	P_{23} ONR(T3)	106	93	106	93	1252/2406
	P_{01} ISE(GE)	27	15	96	46	1282/1780
	P_{22} Eltanin	72	60	72	60	1201/2094
	P_{24} Buoy	41	37	41	37	1105/1671
	P_{26} Woodshole	3	0	3	0	1653/1951
	P_{20} (Alaska)	7	6	28	23	1653/1951
Total		290	231	466	335	

Table 4 (continued)

	Platform	Scheduled Interrogations	Responses	Data Frames Expected	Data Frames Received	Min/Max Slant Ranges
Week - 7						
Orbits	P_{03} ISE	24	5	96	19	1172/1820
533-639	P_{01} ISE	29	14	107	45	1253/1793
	P_{23} ONR(T3)	123	62	123	62	1220/2027
	P_{22} Eltanin	70	63	70	63	1184/2043
	P_{24} Buoy	44	31	44	31	1105/1653
	P_{21} NCAR	41	11	41	110	1169/2184
	P_{25} AWS	5	5	30	30	1139/1549
	P_{26} Woodshole	16	9	16	9	1129/1454
Total		352	200	527	396	

7. CONCLUSION

Based upon the results of the first 2 months of technological evaluation, emphasis during upcoming months will be devoted to further analysis of the system sensitivity to orbital uncertainties. In particular, tests will be performed to ascertain the accuracy of IRLS ranging, considered independently from locations occurring in order to further substantiate the conclusion that errors are induced into the system from external sources.

Additional platform experiments will be performed in addition to a third NCAR balloon flight. Upcoming experiments include the following:

1. A demonstration of the technological capability of interfacing weather reconnaissance aircraft with a meterological satellite. An IRLS platform will be installed on an aircraft operated by the Air Weather Service (AWS).

2. Additional evaluation of the capability and reliability of the IRLS data transmission system through daily interrogations of a platform installed on a Texas Tower located on Argus Island near Bermuda. Data will consist of calibrated reference voltages plus:

    - wave height
    - surface temperature
    - water velocity
    - sub-surface temperature.

3. A demonstration of IRLS application to commercial interprizes through experiments with a platform installed on a ship of opportunity traveling in the Pacific Ocean. Periodic interrogations will enable continual remote surveillance of ship movements over vast areas of the ocean.

4. Investigation and analysis of ocean eddies through interrogations of a free floating buoy in the vicinity of Cape Hatteras and Georges Bank (Cape Cod).

In addition, operations with the afore mentioned platforms will continue on a daily basis. With the increasing amounts of data anticipated, an expanded and more comprehensive technological evaluation will be reported.

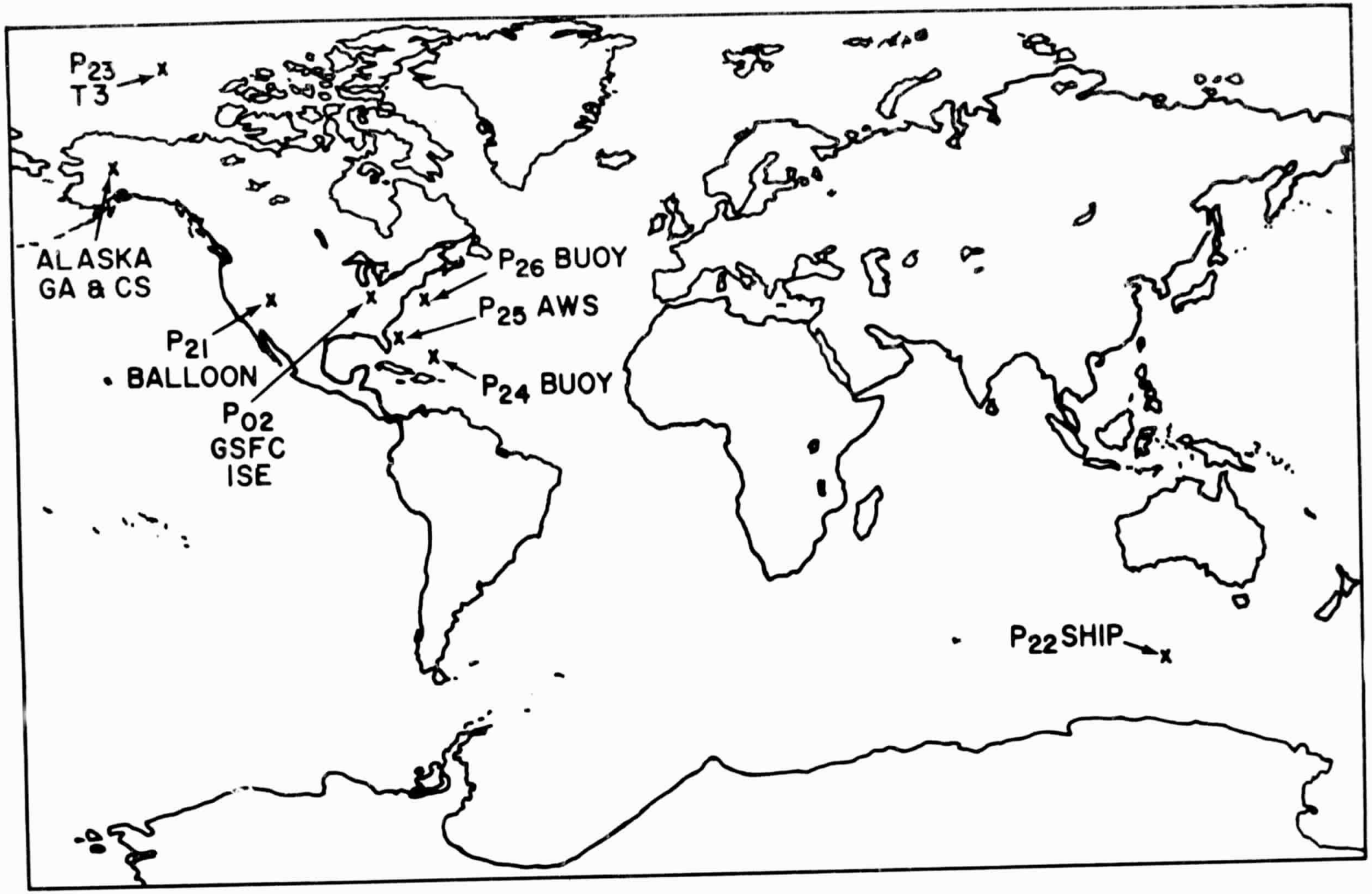

Figure 1. IRLS Platform Deployment Plan

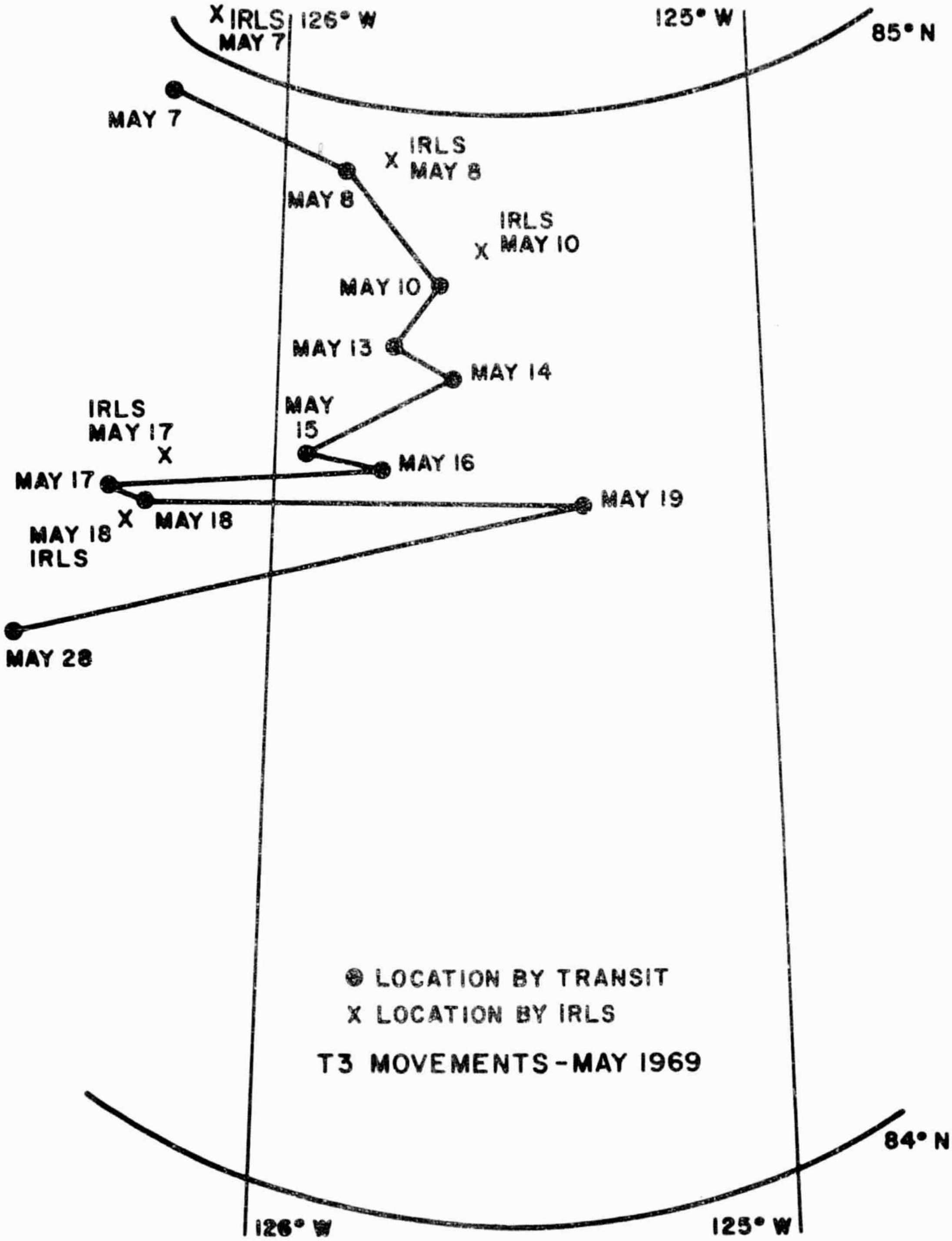

Figure 2. T3 Ice Island Movements in May 1969 as Determined by the Transit and IRLS Systems

Figure 3 USNS Eltanin

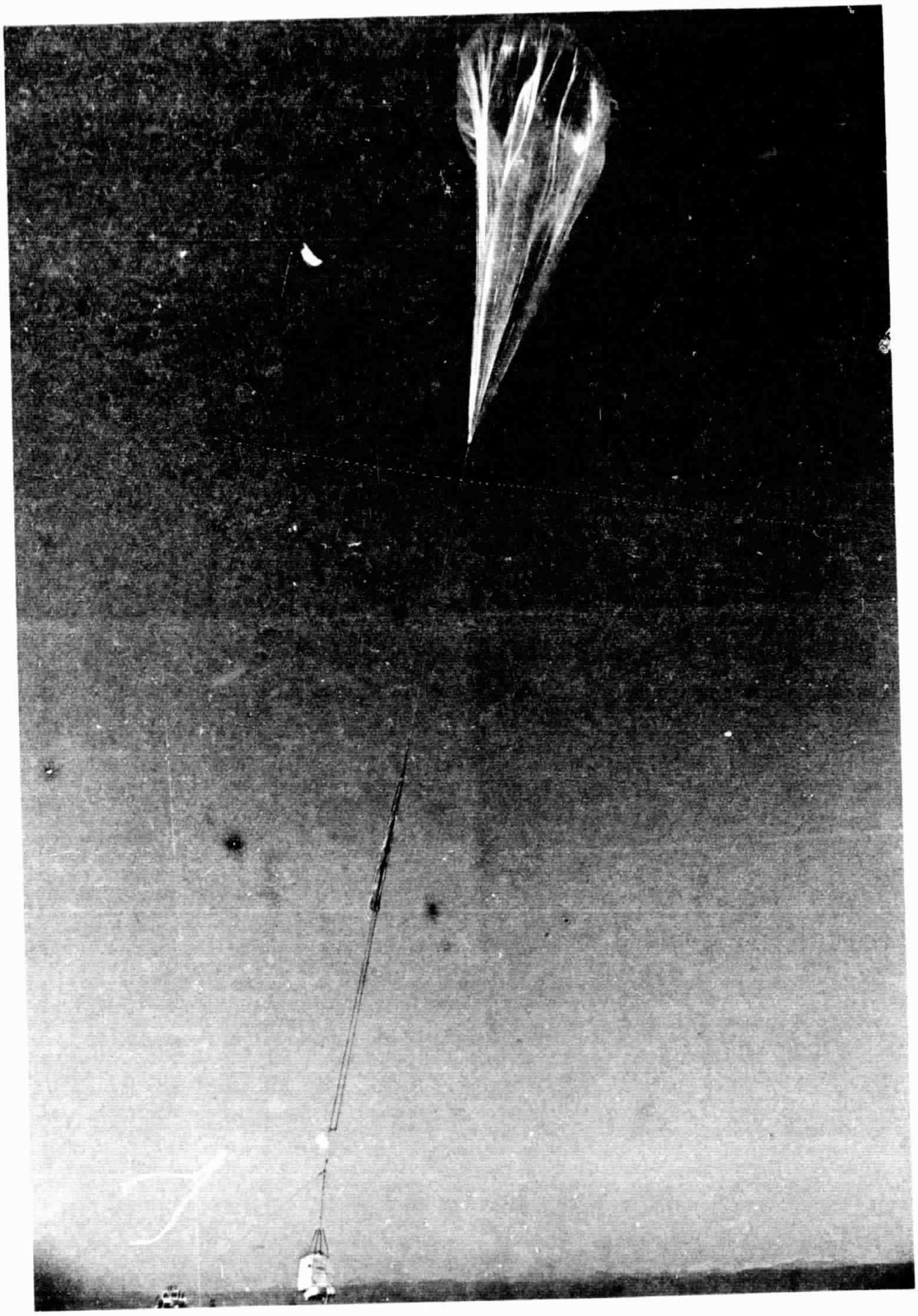

Figure 4 May 11, 1969 IRLS Balloon Launch