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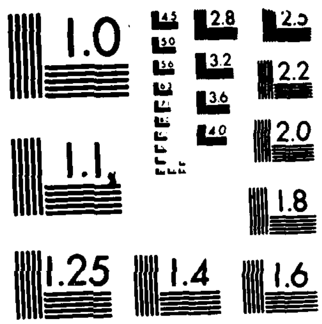

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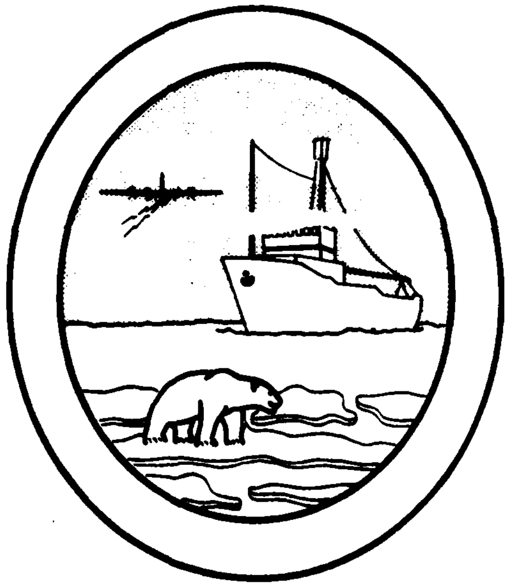
Informal Information Report

A DESCRIPTION OF THE MIZEX 1984 REMOTE SENSING ACTIVITIES

MIZEX Remote Sensing Group

MAY 1984



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ERIM RADAR DIVISION

A DESCRIPTION OF THE MIZEX 1984 REMOTE SENSING ACTIVITIES

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A DESCRIPTION OF THE MIZEX 1984 REMOTE SENSING ACTIVITIES

1 INTRODUCTION

The remote sensing program for MIZEX 84 will involve the coordinated efforts of both ice and ocean scientists using microwave, infrared, and visual remote sensors to investigate MIZ phenomena. Operating from surface, helicopter, ship, aircraft, and satellite platforms, these sensors should provide information on all scales of MIZ processes. This experiment plan sets forth the scientific and operational objectives of these remote sensing efforts and summarizes the individual measurement plans.

1.1. SCIENTIFIC OBJECTIVES

The general objectives of utilizing remote sensors in MIZEX are twofold. The first is to provide remote sensing products such as SAR, SLAR, and passive microwave imagery and aerial photography (dependent on weather) to MIZEX principal investigators. Some of these data will be supplied to investigators in near real-time for the purpose of directing the surface-based remote sensing activities and for planning in situ data collection during MIZEX 84. Other remote sensing mosaics will be provided shortly after the actual field experiment to facilitate a better understanding of the synoptic scale processes occurring during MIZEX. Thus, one role remote sensing will play is to provide boundary conditions and baseline data of the environment of the MIZ experimental zone.

The second objective is to carry out extensive microwave active-passive observations from aircraft, satellites, ship, and surface-based remote sensing systems, and to evaluate the ability of remote sensors to provide detailed geophysical information with respect to the ice and ocean areas found within the MIZ. In order to perform this evaluation in situ physical measurements of the ice and ocean will be made as nearly coincident with the remote sensing data collections, as possible. An effort will also be made to determine the utility of using a combination of active and passive microwave data to extract certain ice parameters such as ice concentration, ice type, and ice roughness. Thus, the second objective of using remote sensors in MIZEX is to evaluate existing algorithms and develop new algorithms, where appropriate, that take remote sensing data as inputs and provide useful geophysical information. It has long been recognized that to optimize remote sensing algorithms, both extensive coincident ground truth measurements and a theoretical understanding of the electromagnetic-surface interactions are required. The theory of how remote sensors measure ocean and ice parameters will be a prime scientific question addressed under MIZEX.

Specific scientific question to be addressed by the MIZEX remote sensing group during MIZEX 84 are:

Ice

1. How do we relate signatures in radar images of the MIZ to the actual microwave cross section of various ice types during the melting season and especially during the transition period prior to melt?
2. How do the active and passive microwave signatures of different ice types vary during the melt season? How do these signatures vary on a diurnal time scale?
3. What minimum resolution (both spatial and frequency) is necessary to detect various ice types?
4. What combination of remote sensing system parameters, active passive, frequency, viewing angle combinations, is most effective in providing data on ice concentration, ice types, ice floe distributions, and ice and ocean kinematics in the MIZ during summer?

5. Which remote sensing system, or combination of systems, is most effective in providing data on measurement of gravity waves as they propagate into the ice?

Ocean

1. How do we relate signatures in radar images of the sea surface to phenomena such as fronts, eddies, and specifically surface layer stability effects, in cold-water regions?
2. Can the SAR successfully image gravity waves and internal waves as they refract due to interaction with the ice edge?
3. Which remote sensing system, active, passive or a combination of systems, can provide the most useful information on ocean circulation in the MIZ?
4. To what extent can the surface wind field be deduced from passive microwave measurements?

1.2 OPERATIONAL OBJECTIVES

Based on MIZEX 83 experience, several operational objectives have been identified by the remote sensing group for MIZEX 84.

1. Deploy remote sensors prior to the transition period before the melt season.
2. Use SAR or SLAR imagery to aid in deployment of drift ship.
3. Identify dedicated ship and helicopter time for remote sensing.
4. Supply real-time remote sensing products to ships.
5. Improve communications between aircraft platforms, ships, and ground parties.
6. Supply helicopters and ground parties with transponders and/or corner reflectors to improve site identification.

7. Identify one person on both the drift station and the ice edge ship to make ice characterization measurements in support of remote sensing.

These objectives have been incorporated to the extent possible in the (tentative) remote sensing schedule (Table 1) and the measurement plans of individual investigators. Note, the exact flight dates of the various aircraft will be subject to local weather condition at the test site.

TABLE 1
REMOTE SENSING SCHEDULE: TENTATIVE FLIGHT DATES

DATE	SMMR	CV-580 SAR	DANISH C-130	NORWEGIAN P-3	CV-990	NOAA P-3	NRL P-3	FRENCH SLAR	GERMAN FALCON	HELOSCAT	ERASME	PQ HELO	PHOTO HELO
Jun 1			⊤										
2	X												
3			1 Flt										
4	X												
5			⊥										
6	X			X									
7													
8	X				X								
9													
10	X				X								
11												X	
12	X												
13				X					⊤				
14	X				X								⊤
15											X	X	
16	X												
17													
18	X				X								
19				X		X(A)				X			
20	X										X		
21											X		
22	X				X					X			
23				X		X(A)					X	X	
24	X				X								
25		X								X			
26	X	X	X	X	X	X	X			X	X	X	
27													
28	X												
29		X	X		X	X	X	X		X	X	X	
30	X								Daily	X			Daily
Jul 1													
2	X	X	X				X	X		X	X	X	
3													
4	X			X		X	X			X		X	
5													
6	X	X				X	X	X		X	X	X	
7		X								X			
8	X												
9							X	X			X		
10	X									X			
11		↓ *		X									
12	X							X			X		
13												X	
14	X									X			
15								X		X	X	X	⊥
16	X												
17													
18	X			X					⊥				
19													
20	X												
21													
22	X												
23			⊤										
24	X												
25													
26	X		1 Flt										
27													
28	X												
29													
30	X		⊥										
31													

* CV-580 Schedule May Slip 5 Days

2
MEASUREMENT PLAN SUMMARIES

The experimental plans for each instrument ensemble on the aircraft, ship/helicopter, and satellite platforms are summarized below.

2.1 AIRCRAFT PLATFORMS

Table 2 lists the instrument ensembles for eight aircraft platforms which will participate in MIZEX 84. Use of all the aircraft listed will provide the required remote sensing data products for the entire experimental period. Table 3 summarizes these expected data products and the ancillary data required for full utilization of the data collected by each sensor. Considering the tight helo schedule, aircraft flights will initially be scheduled to correspond with the helicopter remote sensing schedule, as reflected in Table 1. This is done to maximize the amount of simultaneous surface truth acquired. Use of real-time SAR/SLAR imagery and other remote sensing information telefaxed to the ships will be critical to making these measurements coincident.

2.1.1 IMAGING RADAR

A key element in the MIZEX remote sensing experiment is the collection of SAR and SLAR data. High-resolution imagery showing the location of ice edge-related phenomena is essential to coordinating surface-based sensor activities for optimum scientific productivity. Among the aircraft remote sensors involved in MIZEX, SAR is the only instrument that can produce these high-resolution synoptic maps in near real-time, and nearly independently of weather conditions.

The general objective for imaging radar is to obtain extensive spatial and temporal coverage of the experimental area in order to provide a synoptic history of the processes going on in the MIZ. The specific scientific objectives pertaining to SAR/SLAR data collection during MIZEX 84 include:

TABLE 2
REMOTE SENSING AIRCRAFT AND INSTRUMENT ENSEMBLES

Aircraft	Nation	Instruments	Frequency (GHz)	Possible Bases of Operation	Flight Patterns	Nominal Altitudes
CCRS CV-580	Canada	Imaging radar (SAR) Scatterometer Aerial Cameras	9.8, 5.3, 1.3 13.3	Tromso Longyearbyen	Mosaics (100 x 70 km)	7 km (23,000 ft)
RDAF C-130	Denmark	Imaging radar (SLAR) Passive microwave imager 35-mm photography	9.4 1.5, 5, 17, 34	Nord	Recon Transects Mosaics	3 km 2 km
B-17	France	Imaging radar (SLAR) Photography INS winds	9.3	Longyearbyen Tromso	Mosaics (90 x 100 km)	3 km 1 km
NOAA P-3	U.S.	Gust probe Laser Profilometer Imaging Radar (SLAR)	 5.4	Bodo	Transects	100 - 3000 ft
USN-NRL P-3	U.S.	Passive microwave imager SSM/I Radiometer PRT-5 infrared profiler INS winds Environmental sensors 60-mm photography	90, 140 19, 22, 31, 37 11?	Andoya	Mosaics (100 x 100 km) Transects - ice targets - along edge - across ships	25,000 ft 3,000 ft
NASA CV-990	U.S.	Passive microwave imager Passive microwave profiler Radar altimeter Scanning radar(10° conical) Aerial cameras, KS-87 INS winds Air temperature	19, 92 10, 18, 21, 37 13.7 13.7	Bodo	Mosaics (110 x 200 km)	10 km (30,000 ft)
Norwegian Air Force P-3	Norway	AXBT		Andoya	To be determined	200 - 500 ft
Falcon	Germany	Meteorology Aerial Camera, Hasselblad Radar Altimeter		Longyearbyen Tromso	Transects (50 km) - 11 to ice edge - along and across mean wind	300 - 36,000 ft

TABLE 3
AIRCRAFT SENSOR DATA PRODUCTS AND
ANCILLARY DATA REQUIREMENTS

Sensor	Data Products	Ancillary Remote Sensing	Surface Truth
SAR/SLAR	Radar Imagery Mosaics Digital Data	Passive Microwave Imagery Aerial Photography*	Pitch and Roll Buoy Data Air/Snow/Ice Temp H_2O Content Physical Surface Properties Surface Microwave Measurements Dielectric Constant
Passive Microwave Imager	Imagery Mosaics	SAR Imagery Aerial Photography* Other PMI Data	Air/Snow/Ice Temp H_2O Content Physical Surface Properties Surface Microwave Measurements Dielectric Constant
Radar Altimeter	Significant Wave Height Wind Speed Ice Roughness	SAR Imagery Scatterometer Aerial Photography* Laser Profiles	Pitch and Roll Buoy Data Meteorology Physical Surface Properties
Laser Profilometer	Roughness Profiles	Aerial Photography*	

*From Helo or Aircraft

1. Obtain ice imagery during the transition period prior to the melt season.

2. Obtain imagery of gravity and internal ocean waves, both in open water and propagating into the ice.

3. Locate fronts and eddies in the open ocean off the ice edge with SAR imagery.

4. Monitor temporal changes in the dynamic features of the ice edge and in the open water.

5. Evaluate SAR's ability to monitor large-scale (temporal) deformation of ice in the MIZ.

6. Provide additional data for evaluation of SAR algorithms to measure ice concentration and floe size distributions.

7. Determine the diurnal variation in radar signatures of various ice types in the MIZ in the summer season.

8. Determine the physical mechanism by which SAR images waves in ice.

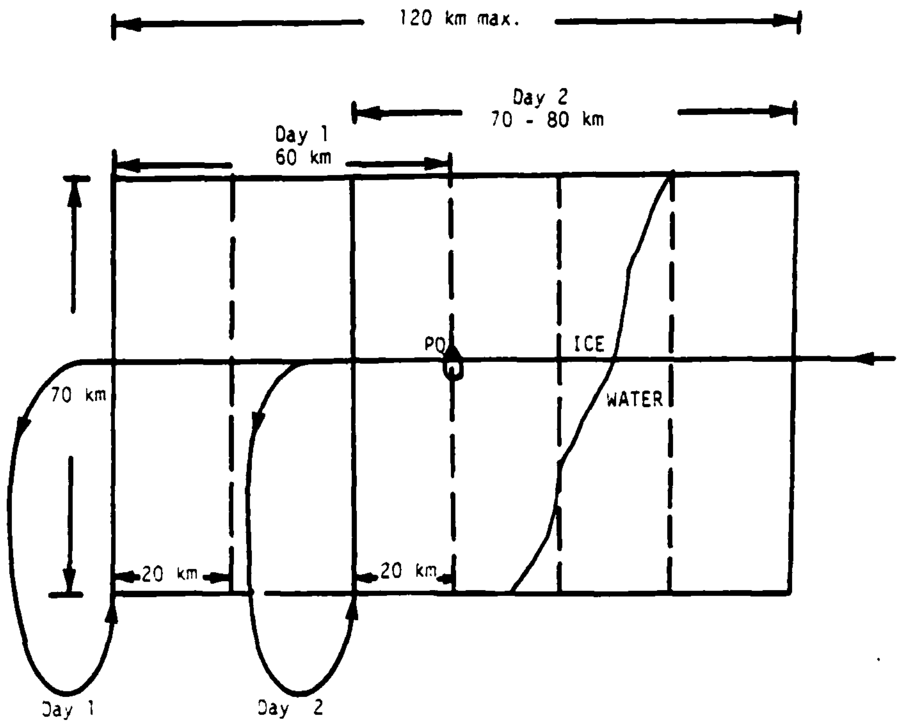
9. Obtain and compare coincident airborne SAR and near-surface scatterometer data to provide useful information about the scattering properties of the ice.

Meeting many of these objectives relies on having near-coincident surface-based measurements of the type listed in Table 3. Discriminability of ice types, for example, can only be evaluated on the basis of adequate ground truth. Real-time SAR and SLAR data will be utilized during the experiment to insure that all ice types within the imaged area are sampled. The synoptic imagery can also be used to locate and measure anomalous signatures, as well as coordinate overflights with surface measurements. Deployment of corner reflectors with ground parties as well as with buoys will aid in registering surface measurements on SAR or SLAR imagery during data analysis.

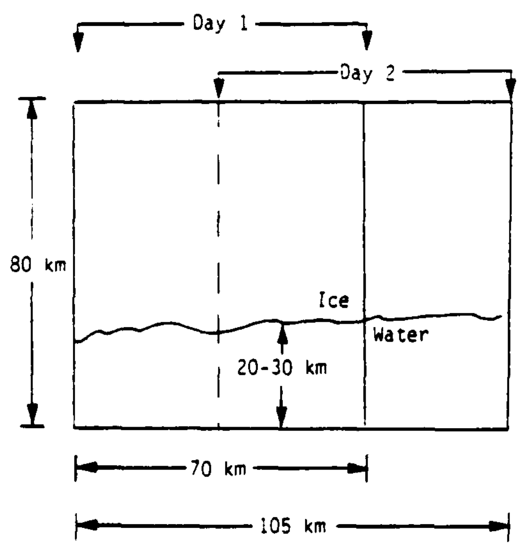
As indicated in Table 3 four imaging radar systems will operate during MIZEX 84. Dedicated imaging radars will be participating the period 24 June - 15 July as indicated in Table 1. Reconnaissance radar flights to be made on or before 1 June to support buoy deployment and mooring position decisions for Polar Queen will be carried out by the RDAF C-130 if available.

The ERIM/CCRS CV-580 SAR system has been tentatively scheduled for six flights during a 15-day period that occurs between 24 June and 15 July. The aircraft carries a 4-channel SAR that can operate at X-, L-, or C-band, a 13.3 GHz scatterometer and aerial photography cameras and flies at a nominal altitude of 7 km (23,000 ft) with a mission time of 5 hours. As in MIZEX 83, the CV-580 would base out of Tromso, with refueling stops at Longyearbyen, and collect 3 m resolution imagery in approximately 80 km x 70 km mosaics. Flight patterns are shown in Figure 1. Imagery would also be collected on transit to and from the experiment area.

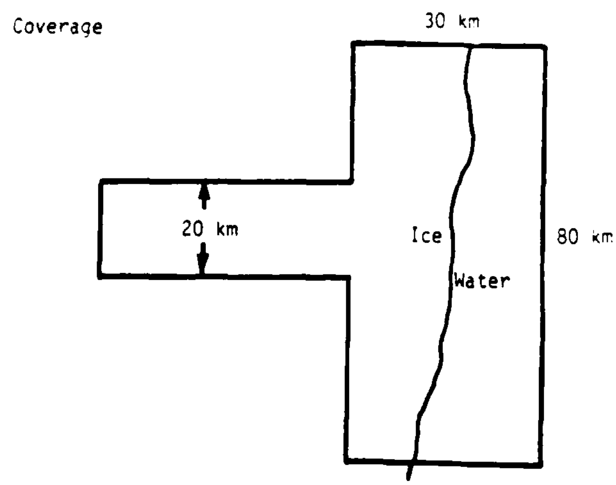
Six missions are tentatively planned for the CV-580, each with approximately four hours of data collection time. Achieving six missions within this time period will depend upon receiving logistical support in order to overnight at Longyearbyen, and on weather conditions both at the experiment site and on Svalbard. A tentative schedule for the five missions is given in Table 4. The synoptic mapping missions at the beginning and end of the deployment period will supply the base map of the experimental area needed to understand the spatial and temporal variability of MIZ characteristics. The X-L mission will be devoted primarily but not exclusively to imaging open ocean phenomena. Its timing will depend somewhat on surface conditions and the possibility of obtaining coincident surface measurements. The X-C mission will obtain imagery of both ocean and ice, providing another data set for ERS-1 validation.



CV-580 Synoptic Mapping - 25, 26 June. X-Band Wide Swath



CV-580 Synoptic Mapping: 6, 7 July



CV-580 Ocean T: 29 June and 2 July

Figure 1. CV-580 Flight Patterns

TABLE 4
TENTATIVE CV-580 MISSION SCHEDULE

Days of Deployment	Activity	SAR Mode
1-2	Preparation	
3	Synoptic Mapping Overnight Longyearbyen	X-band Wide Swath
4	Synoptic Mapping Return Tromso	X-band Wide Swath
5-6	Reconfigure to X-L	
7-8	Ocean Imaging Dependent on Weather	X-L Extended Swath
9-10	Reconfigure to X-C	
11	Ice/Ocean Imaging	X-C Extended Swath
12-13	Reconfigure	
14	Synoptic Mapping	X-band Wide Swath

The RDAF C-130 aircraft is equipped with a 9.4 GHz (X-band) SLAR and a passive microwave imager. As in MIZEX 83 the C-130 will operate out of Nord, flying at 3000 m on radar data collection, and record digital and video data along the ice edge and over the test area as well as during transit from Nord. Five flights are planned, as indicated in Table 1: one at the beginning and end of the experiment and three during the period 26 June - 2 July.

The French VARAN S imaging radar (SLAR), carried on a B-17 aircraft, will provide real-time imagery and digitally recorded coverage of the ice and ocean areas near Polar Stern during the period 27 June to 19 July. The flights planned during this period (see Table 1) will be made in conjunction with helo scatterometer flights and ground based measurements. The mosaics collected on these missions will have a resolution of approximately 10 m and will cover a 100 x 90 km area with 15 km line spacing, as indicated in Figure 2. The first two flights will be made at 1000 m and 3000 m altitude, respectively, and based on the real-time output, an optimum altitude will be chosen. In addition to the 9.4 GHz (X-band) HH polarization SLAR, the B-17 will also carry an RC-10, 98 mm focal length mapping camera. The aircraft will tentatively base out of Tromso for two of the 6 flights and Longyearbyen for the other four.

SLAR imagery will be collected by the NOAA P-3 primarily to document meteorological and laser measurements. The P-3 experiment plan is summarized under "Laser Profiles".

2.1.2 CORNER REFLECTORS

As in MIZEX 83, an array of corner reflectors will be deployed around the drift ship in order to provide control points for measuring large-scale ice-field deformation with the SAR. Examination of SAR imagery from MIZEX 83 indicated that the corner reflectors were not large enough to be seen if deployed alone, but groups of two or

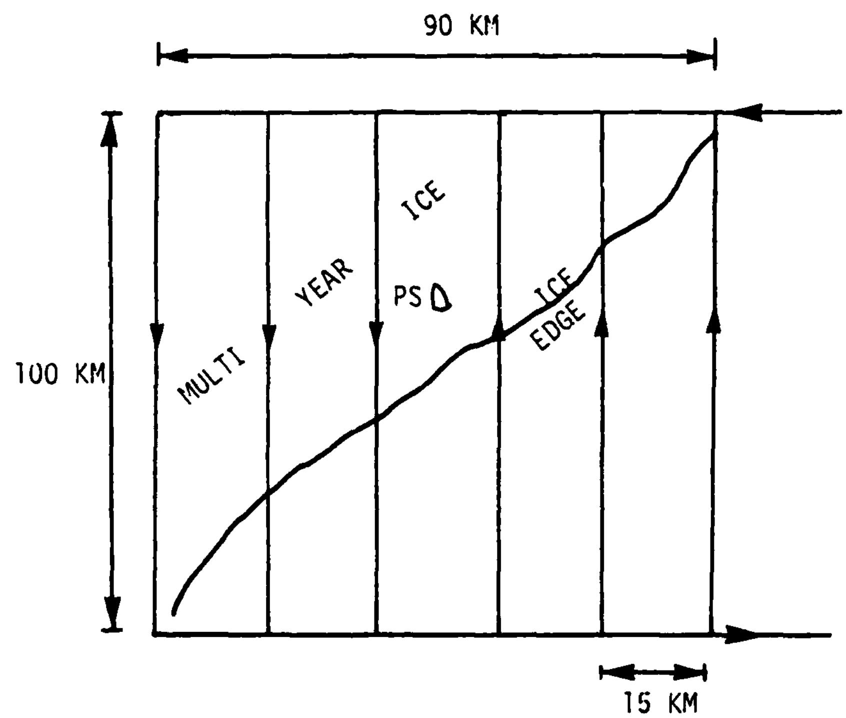


Figure 2. Flight Pattern for the French B-17 (X-Band SLAR)

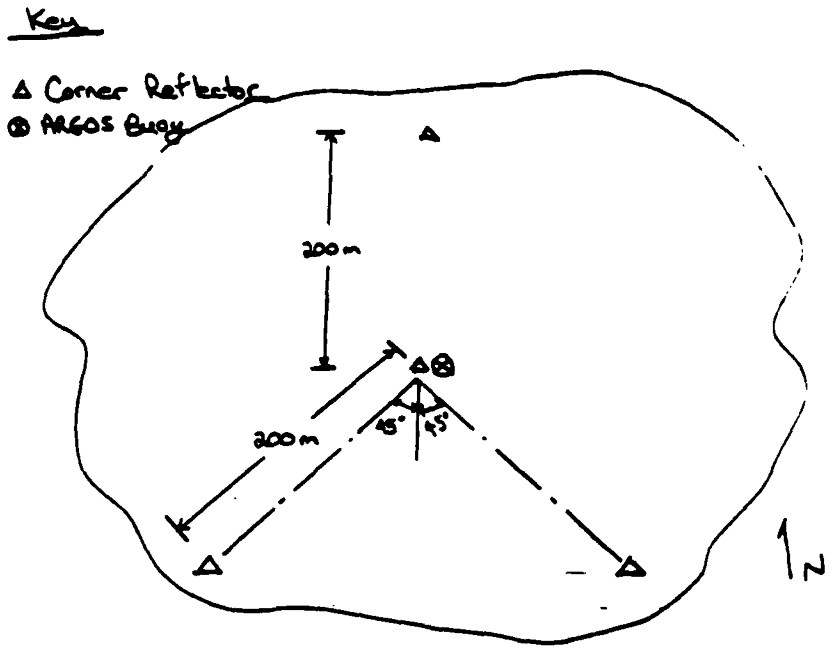
more were located. Reflector size will therefore be increased to 1 m x 1 m. These corner reflectors will also be set out on floes where surface measurements are made to aid in identify sites of coincident coverage for data analysis. Deployment geometries are indicated in Figue 3.

2.1.3 PASSIVE MICROWAVE SENSORS

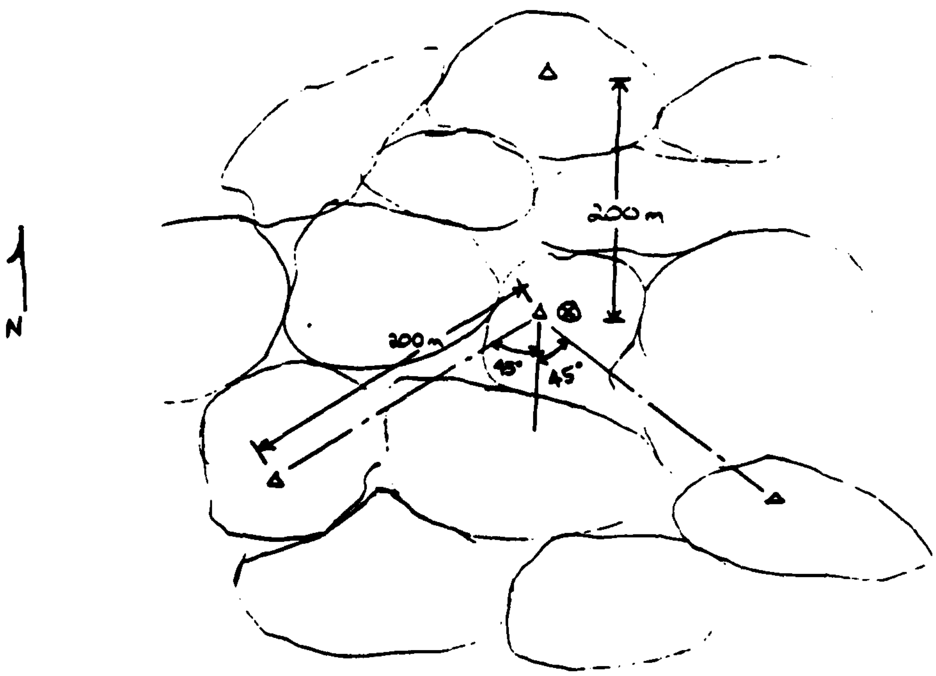
The purpose of the passive microwave sensor platform flights is to develop measurement and analysis techniques for the all-weather remote determination of the type, age, concentration, surface characteristics and ridging of sea ice and for the locations of polynyas, leads, and sea-ice edge. Collection of useful data for this purpose depends on having coincident passive microwave surface measurements. Coordination with and location of ground parties is therefore critical to these missions and could be improved over MIZEX 83 if helicopter and ground parties were equipped with radio transponders.

The three aircraft platforms carrying passive microwave sensors during MIZEX 84 are the NRL P-3, the NASA CV-990, and the RDAF C-130.

The primary sensors carried by the NRL P-3 are a passive microwave imager operating at 90 and 140 GHz, and a profiler operating at 19.3, 22.2, 31.4, and 37 GHz. The two flight configurations of the NRL P-3 are high altitude (25,000 ft) mapping, low altitude (3,000 ft) transects. Plans call for the P-3 to fly three high altitude missions and three low altitude missions during the period 26 June - 9 July (see Table 1). Mosaics obtained on high altitude missions will cover an area of approximately 100 x 100 km, centered on Polar Queen, and concentrating on the ice with coverage of 15-20 km of ocean off the ice edge (Figure 4). The low levels transects will be made over the ship, along the ice edge, and over specific ice targets near the edge and amongst large floes where surface measurements will be obtained.



Proposed Corner Reflector Deployment Pattern
Assuming Single Large Floe



Proposed Corner Reflector Deployment Pattern
Assuming Smaller Compacted Floes

Figure 3. Corner Reflector Deployment Geometries

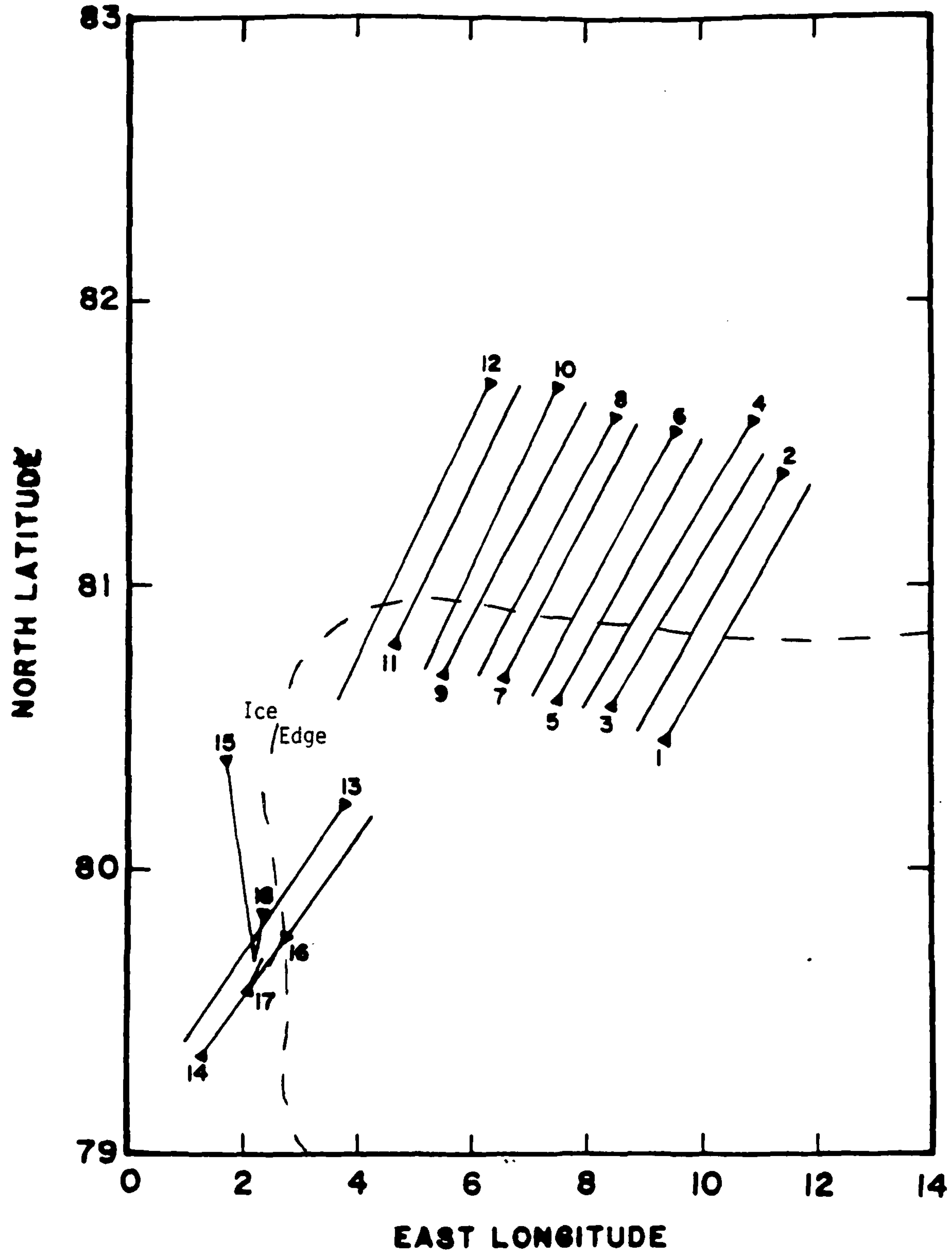


Figure 4. Example Flight Track Pattern for NRL P-3 PMI

The CV-990 platform carries a passive microwave imager operating at 19 and 92 GHz and profiling radiometers operating at 10, 18, 21, and 37 GHz. The CV-990 is scheduled for seven flights in the period between 8 June and 29 June to be coordinated with the Nimbus-7 SMMR (see Table 1). The standard mission will be to obtain a 110 x 200 km mosaic; Figure 5 shows possible flight scenarios. The CV-990 flies at a nominal altitude of 10 km and will base out of Bodo.

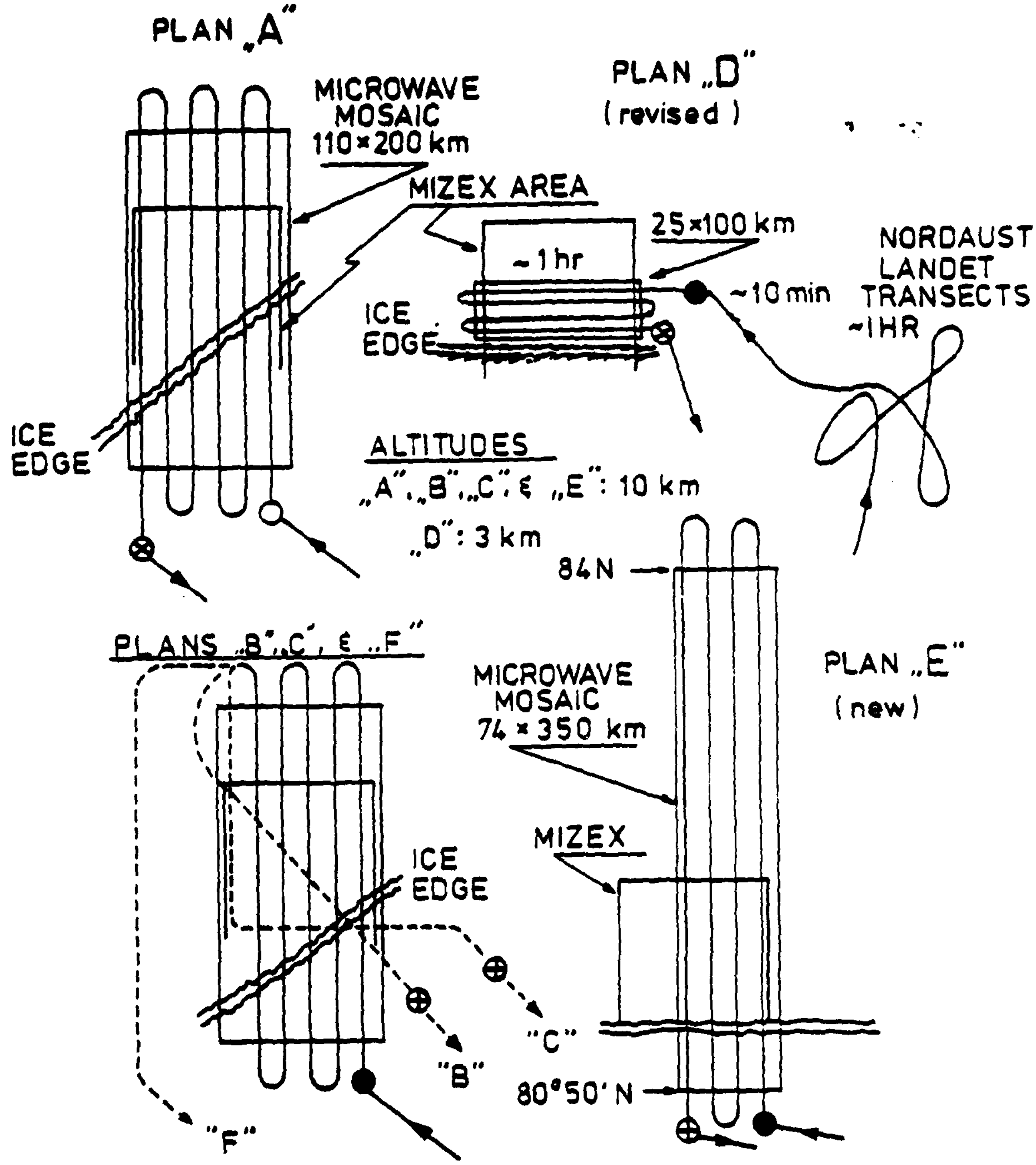
Operation of the RDAF C-130 during MIZEX 84 has been described above. The aircraft obtains passive microwave imagery at an altitude of 2000 m.

2.1.4 LASER PROFILES

A requirement for more detailed information on ice surface roughness over long tracks has recently been expressed by the acoustics group and by scientists modeling the atmospheric boundary layer and ice dynamics. The laser profilometer carried on the NOAA P-3 aircraft would be able to meet this requirement. Three scenarios have been suggested.

The first is to fly three 200 km tracks approximately parallel, perpendicular and at 45° to the ice edge (see Figure 6) and crossing the acoustics array. The array will be approximately 30 km into the ice field. In addition one long track (~500 km) will be flown across the array toward the central Arctic. Laser profiles will be made in conjunction with SUS charge drops, either coincidently or immediately following (within 2 hours). These flights would take place twice during the 7 day period 20 June - 26 June.

The second scenario is to fly a 6-leg star pattern in the neighborhood of Kvit Bjorn in conjunction with surface wind stress measurements (see Figure 7). Requirements are for each leg to be a minimum of 500 meters, with a minimum sampling rate of 1 sample/meter, and a vertical resolution of approximately 1 cm. The pattern



NASA / CV - 990

1984 SCHEDULE

Flights June	8	10	14	18	20	22	26	29
Flight Plan	"A"	"E"	"A"	"A"	"A/F"	"A/F"	"A/F"	"D"
Mosaic Alt.	10	10	10	10	10	10	10	3

Figure 5. CV-990 Flight Plans

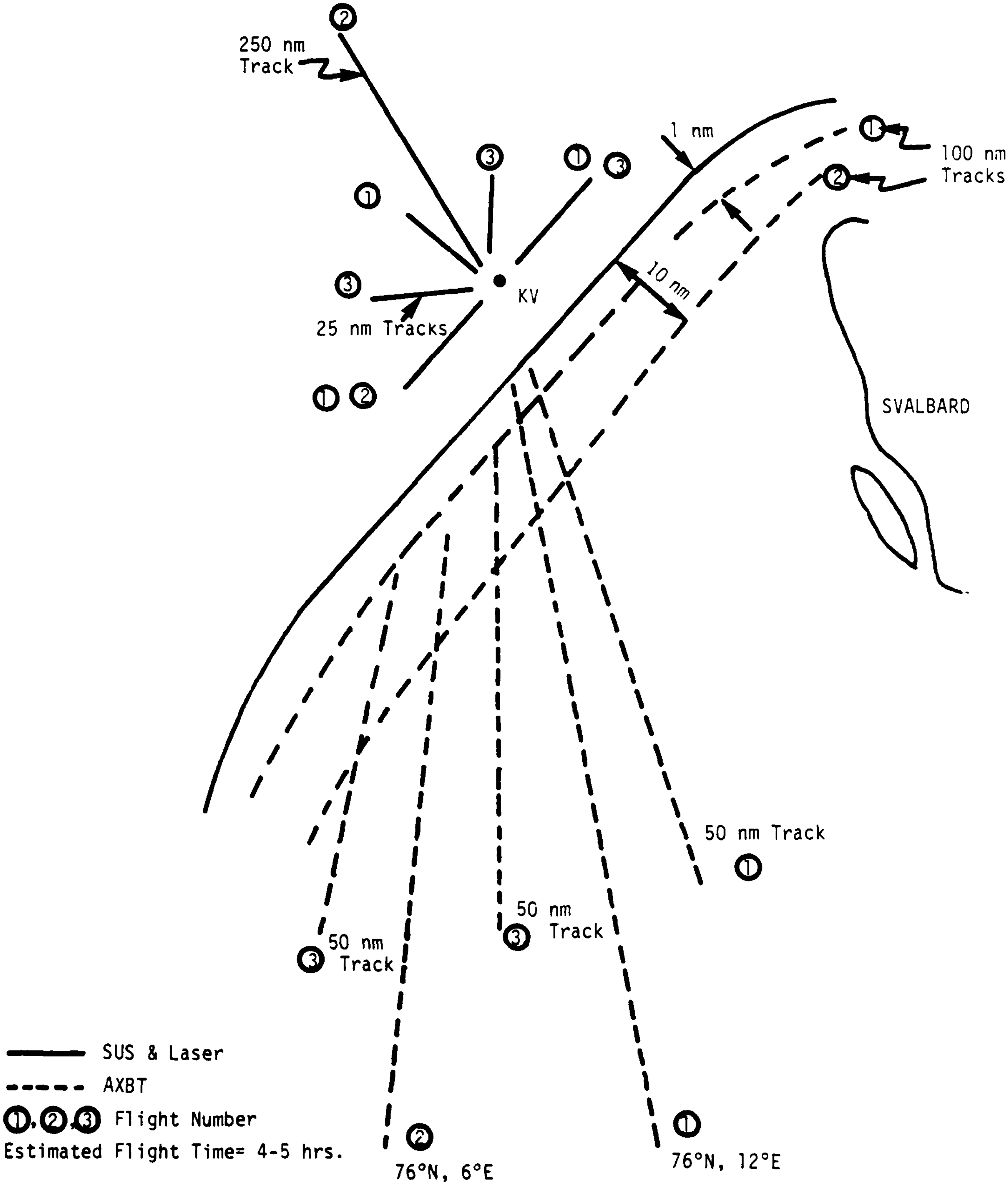


Figure 6. Laser Profilometer and AXBT Flight Lines in Support of Acoustics

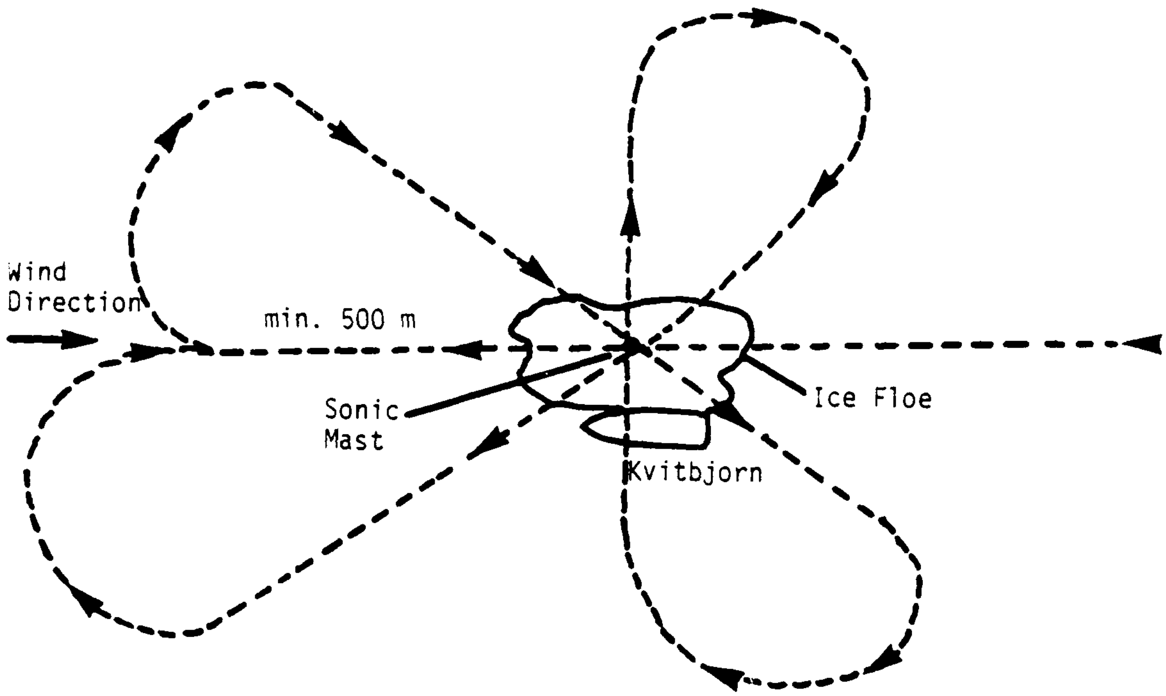


Figure 7. Laser Profilometer Flight Lines in Support of Meteorological Program

must be centered within ±50 m of a marker placed on the ice, and flown four times during the period 3 July - 24 July, each flight separated by several days.

The third flight scenario is to fly two very long approximately E-W tracks, one at the beginning of the experiment, and the second near the end (see Figure 8). These would be made across the ice edge, over Polar Queen, and well into the pack or to the Greenland coast. Polar Queen would hopefully be located as far south as indicated by Track 2 near the end of the experiment.

The NOAA P-3 is scheduled for six flights during the period 15 June - 7 July basing out of Bodo. Gust probe measurements, laser profiles over both ice and ocean, and SLAR imagery (transects) will be obtained with that order of priority. In addition to the flight scenarios described above, two other flight scenarios are suggested. One: to take low level wind and laser measurements over water simultaneous and coincident with the CV-990 passive microwave and altimeter measurements. This would allow validation of passive microwave wind retrievals. Two: obtain laser profiles over ice coincident with CV-990 altimeter profiles along several different tracks perpendicular to the ice edge. Roughness information from the two sensors will be compared and used as surface truth for SAR imagery.

2.1.5 RADAR ALTIMETER

Radar altimeters will be carried on two aircraft platforms, the NASA CV-990 and the German Falcon. The 13.7 GHz system on the CV-990 has been contributed by the Rutherford Appleton Lab, U.K., and will be used to measure significant wave height, surface winds over the ocean, and possibly ice surface roughness. The altimeter can operate compatibly with the passive microwave imager at an altitude of 10 km and will obtain profiles along the flight tracks indicated in Figure 5.

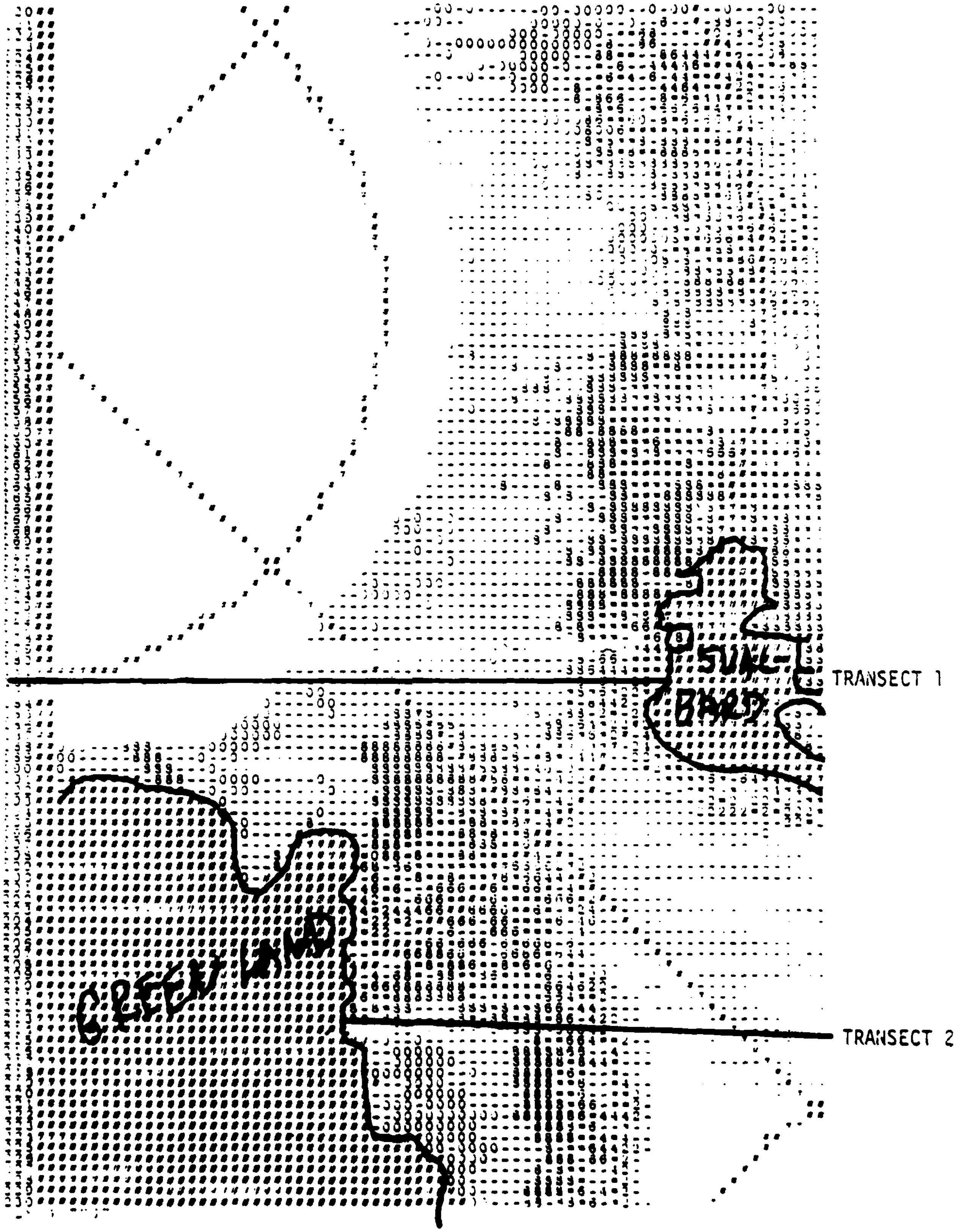


Figure 8. Suggested Laser Profilometer Transects, Crossing Polar Queen, for Beginning (1) and End (2) of Experiment

The German Falcon, primarily a meteorology aircraft, will also carry an altimeter with a height resolution of ~30 cm and horizontal resolution of ~1 m. Flight patterns for the Falcon are shown in Figure 9. One consists of 50 km transects parallel to the ice edge; the other 50 km transects along and across the mean wind direction.

2.1.6 AERIAL PHOTOGRAPHY

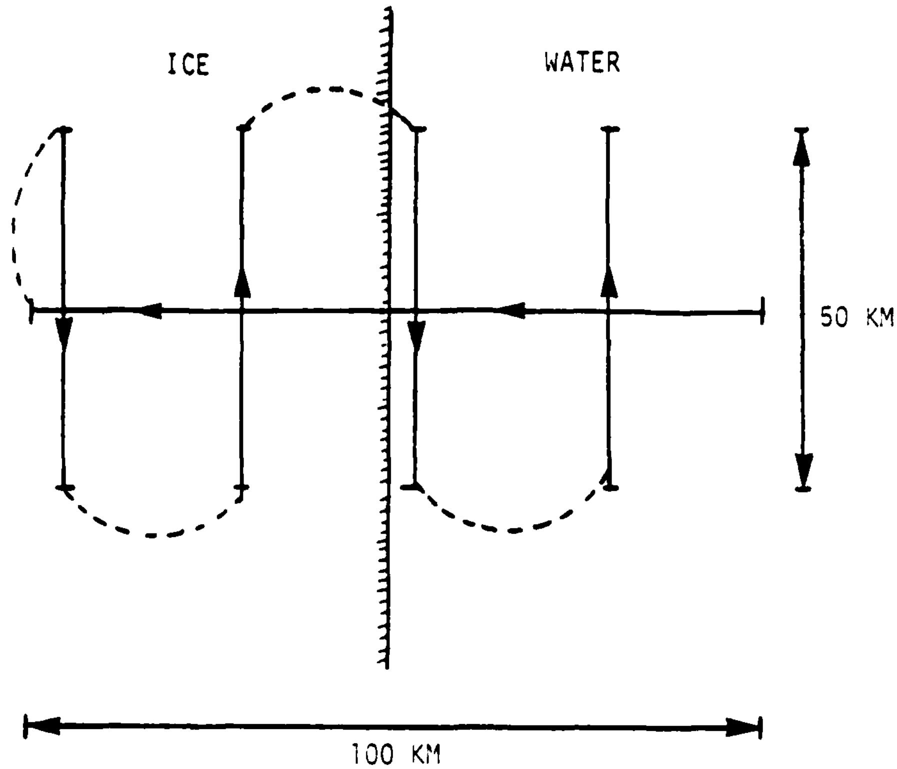
Although high level aerial photography would provide valuable information for validation of other remote sensing data, MIZEX 83 experience showed that its collection in summer is usually frustrated by cloud cover. During MIZEX 84, the German Falcon will provide aerial photography when weather permits in addition to meteorological data collection, which is its primary mission. The Falcon is equipped with a 6 cm format Hasselblad downlooking, hand-controlled camera. Table 2 indicates that several other platforms are also equipped with aerial cameras and could provide supplemental photography as in the 83 experiment. As in MIZEX 83, most of the photography will be collected by helicopter primarily in support of the ice program as described in that experiment plan.

2.1.7 AXBT DROPS

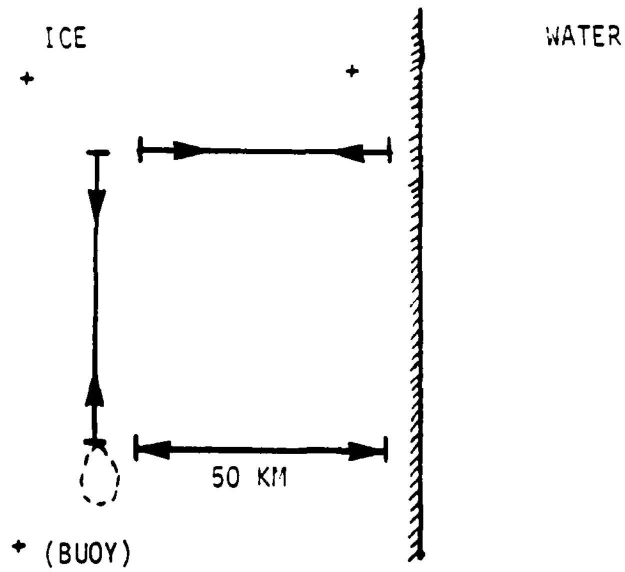
As in MIZEX 83, a Norwegian Air Force P-3 will drop AXBT sensors for ocean parameter measurements. Six to eight flights have been tentatively scheduled at one week intervals throughout the period 5 June - 19 July. Grid patterns for the drops will be determined by the field coordinator prior to each flight to optimize measurement of MIZ conditions.

2.2 SHIP/HELICOPTER PLATFORMS

Remote sensing instruments operating from ship and helicopter platforms or from the ice surface are listed in Table 5. These



(a)



(b)

Figure 9. Flight Schemes for German Falcon Meteorology Plane

TABLE 5
HELICOPTER AND SURFACE-BASED REMOTE SENSING INSTRUMENTS

Surface Platforms	Nation	Instruments	Frequency (GHz)
Polar Queen	U.S. Univ. of Wash.	Passive microwave Radiometer (mobile)	10, 18, 37 & 90
Polar Stern	U.S. Univ. of Kansas	Microwave step Scatterometer	1 to 18 selected
		Dielectric Constant Measurements	1 to 4
	France CNES	RAMSES II Scatterometer (Ship-mounted)	3 to 8 and 8 to 16; 5.35, 9, 13.6, 16 (selected)
		ER/ ME Scatterometer (Helicopter-mounted)	5.35
	U.S. ERIM	Resonant cavity (Dielectric constant measurements) Incident Power Receiver	1.3, 5 & 10
Valdivia	Germany Max Planck	CODAR	HF

include microwave scatterometers, passive microwave and infrared radiometers, and devices for measurement of dielectric properties.

The overall purpose of the surface-based sensors is to make measurements of the scattering coefficients and brightness temperatures over a wide range of frequencies, angles, and polarizations of the ice and ocean in the Marginal Ice Zone to better understand the interaction of microwave radiation with ice, snow and oceans. These measurements will provide quantitative indications of the ability to measure the difference between different categories of ice during the summer months and will provide an indication of the ambiguities in the ability to discriminate ice conditions which may be uniquely characteristic of these regions. In addition, the optimum frequency and angle of incidence will be determined for these conditions. The experiment plan requires measurements at as many different ice sites and with as many different types and thicknesses of ice as feasible within the constraints of the experiment.

Helicopter and surface-based remote sensing must be coordinated at two levels: amongst the different sensors themselves and between helicopter or surface-based and aircraft sensors. Coordination between surface-based active and passive sensors will be made so that simultaneity will exist when possible. It is also very important in the understanding of the interaction process to measure the physical properties of the snow and ice coincident with the surface remote sensing measurements. The surface program will coordinate efforts to measure surface roughness, salinity profiles, ice thickness, physical properties of the snow and ice, and acquire air-snow-ice temperatures.

2.2.1 UNIVERSITY OF KANSAS SCATTEROMETER

The primary objective of the near-surface scatterometer program is to make a description of the scattering coefficients of sea ice in the marginal ice zone. Physical and electrical property characterization measurement of the site will also be coordinated with the near-surface measurement program to derive the maximum benefit from the use of radar remote sensors; and to specify and improve future designs of aircraft- and spaceborne-system radars, continuous expansion is needed of our knowledge of the microwave interaction with ice and its impact on the design of and interpretation of ice-observing radars. Near-surface remote sensing and ice characterization measurements must be coordinated with both active and passive aircraft measurements. This is extremely important to the interpretation and calibration of the airborne remote sensing data products. The experiment plan also requires measurement at as many ice sites and with as many different types and thicknesses of ice as feasible within the constraints of the experiment. Experiments will address diurnal cycle effects on the microwave response of ice.

The surface-based sensors will be operated in two modes: ship-based and helicopter-based. Operation will be made in both modes because they are complementary and make complete use of available experiment time.

Measurements, using a Bell 206B helicopter as an airborne-platform for the calibrated radar, will be made to examine features not accessible from the ship and to provide spatially detailed measurements of representative ice types in the MIZ and pack ice region. To understand the influence of MIZ on the ice in this zone it is important to also acquire information from ice within the pack adjacent to the MIZ.

Measurements using the ship as a floating platform will be made to give added detail to the angular response, polarization response, include more detail to the frequency response, include angles near grazing, and allow the performance of detailed diurnal cycle experiments. Operation in the ship-based mode requires that the ship be moored to an ice floe and 4 hours of station time to acquire microwave and ice characterization data. Occasional stations of longer duration will be needed to perform more intensive ice characterizations. (Physical property measurements will be the same as in MIZEX 83.)

Helicopter time will also be required to do characterization measurements of sites investigated by the HELOSCAT and also to investigate sites which are determined to be of significance from aircraft remote sensing products. Time will be requied to perform reconnaissance of the region so that descriptions may be made in terms of ice types, or state, and for identification of sites to be investigated.

The scatterometer program operation requires 2 persons and will be staged from Polar Stern. The HELOSCAT experiments are scheduled as indicated in Table 1. The 13 flight days scheduled for HELOSCAT measurements should either precede, overlap, or follow aircraft overflights. Remaining time will be used to obtain as complete regional coverage (MIZ to pack) as possible.

2.2.2 CNES SCATTEROMETERS

CNES will operate two scatterometer systems from Polar Stern during the period 13 June - 19 July. The RAMSES II System is a ship-mounted, selectable frequency, scatterometer that takes measurements with HH, VV, HV, and VH polarizations and incidence angles of 0 to 60°. For stations on water or ice with the ship close to ice floes, in order to make measurements at nadir, minimum time requirement is one hour. Prolonged stations of approximately five hours are also required: eight on the ice and three on water (depending on sea-state and wind speed). These stations will be coordinated with remote sensing aircraft and helicopter flights.

The ERASME is a helicopter-mounted, single frequency, scatterometer taking measurements at all four polarizations and 0° to 20°, 20° to 40°, and 40° to 60° incidence angle. The ERASME is scheduled to make 11 flights as indicated in Table 1 which will be coordinated with aircraft and ground-based sensors. Scatterometer profiles will be obtained along tracks from the ice edge to the pack ice from an altitude of 300 m. It is estimated that four profiles could be obtained per flight, the number and length of tracks being dependent on sea-ice conditions as well as weather conditions.

2.2.3 UNIVERSITY OF WASHINGTON PASSIVE MICROWAVE RADIOMETER

The goal of the project is to provide surface-based measurements of microwave emission from the ice types characteristic of the marginal ice zone areas of the northern Greenland Sea/Fram Strait region. The measurements will be carried out in support of and in conjunction with the overflights conducting passive microwave observations. The results will be compared with SMMR satellite imagery to improve and extend the capability to map ice concentration and ice type distribution. The potential for 90 GHz observations will also be investigated.

Measurements consist of dual polarization microwave brightness temperatures at frequencies of 10, 18, 37, and 90 GHz made on the ice by transporting the instruments along tracks on available ice floes using a sled specially designed for that purpose. Track length is limited by the floe size, but was typically 50 to 100 m in MIZEX 83. Observations are then obtained at selected locations along these tracks of the dependence of brightness temperature on angle of incidence. Sky brightness temperatures are obtained when possible at each frequency.

A series of measurements are planned from Polar Queen to obtain areal and temporal coverage of the data, and to provide support for passive microwave aircraft overflights. Carrying out the experiment from Polar Queen will facilitate making observations of diurnal variation in brightness temperature and variations during the transition into the melt season. As in MIZEX 83, a series of surface characterization measurements is also to be carried out. These consist of salinity and temperature profiles in the ice and snow together with visual descriptions and closeup photography of the crystal structure of the snow and uppermost ice layers.

2.2.4 ICE PROPERTIES MEASUREMENTS - CRREL

In cooperation with the ice characterization measurements carried out by the U. of Kansas and U. of Washington, detailed ice properties measurements will be made by a group from the Cold Regions Research and Engineering Lab (CRREL). These physical property measurements will include temperature, salinity, density, porosity, and crystal structure assessment of the ice and snow. The distribution of free water in the upper layer and the small-scale surface roughness will also be determined. Particular emphasis will be placed on obtaining measurements in the upper 50 cm, that being of direct interest to the remote sensing studies. However, these physical property studies will be conducted for the entire thickness of the ice when possible. The primary objectives for examining the complete thickness section are to study the distribution of brine inclusions and possibly of frazil ice (if any) present and to characterize the crystal structure of the various ice types present including c-axis orientations in the congelation ice. These additional studies will support the thermodynamic, oceanographic, and ice modeling studies taking place as part of MIZEX. Also since most of the structure characterization of the ice will be performed at CRREL, very little additional time will be required to retrieve entire cores.

Temperature and densities will be measured on site and salinity samples will be prepared for measurement aboard ship. If freezer space is available on board, preparation and examination of thin sections from the upper layers of the core will be carried out aboard ship. Core samples will be returned to CRREL for additional analysis as needed.

2.2.5 DIELECTRIC CONSTANT MEASUREMENTS - ERIM

In addition to supporting the U of Kansas scatterometer measurements, the ERIM team will make dielectric constant measurements of surface snow and ice, and snow/ice layers at various depths. Physical properties such as temperature, snow density and surface roughness will also be measured at each measurement site. These measurements will be coordinated with CRREL activities in order to obtain as many different measurements as possible. Whenever possible, dielectric and physical property measurements should be coincident with SAR-580 imaging flights. In these cases, X-band calibration reflectors will be deployed at measurement sites.

2.3 SATELLITE REMOTE SENSORS

Table 6 lists the satellite platforms potentially supplying remote sensing data during MIZEX 84. As in MIZEX 83, AVHRR data are acquired in real-time at the Tromso Telemetry Station and supplied to the MIZEX Tromso coordination center. AVHRR and Meteor imagery is supplied to the ice breakers through a real-time link at Lyngby, Denmark, where it is analyzed and transmitted from Copenhagen by Telefax on HF.

The NIMBUS-7 SMMR data are acquired at NASA-Goddard where brightness temperature maps are generated and transmitted over OMNET to the Tromso coordination center. Both SMMR and especially AVHRR data were useful in experiment planning during MIZEX 83.

All Landsat data obtained during MIZEX 84 will be archived at the University of Bergen. DMSP imagery is archived at the National Snow and Ice Center in Boulder and generally is available 10 days to one month after acquisition.

TABLE 6
SATELLITE SENSORS

Satellite	Sensor Name	Type	Ground Station
NOAA	AVHRR	Vis + IR	Tromso (Norway)* Lyngby (Denmark)*
Meteor (Soviet)		Vis + IR	Lyngby (Denmark)*
DMSP	OLS	Vis + IR	NORDA (U.S.)
LANDSAT-D	MSS + TM( )	Vis + IR	NORDA (U.S.) Bergen (Norway)
NIMBUS-7	CZCS THIR SMMR	Vis IR Microw.	Lannion (France) Lannion (France) NASA-Goddard (U.S.)

NOAA = National Oceanic and Atmospheric Administration
DMSP = Defense Meteorological Satellite Program
AVHRR = Advanced Very High Resolution Radiometer
OLS = Optical Line Scanner
MSS = Multispectral Scanner
TM = Thematic Mapper
CZCS = Coastal Zone Color Scanner
THIR = Thermal High-Resolution Infrared
SMMR = Special Scanning Microwave Instrument
NORDA = Navy Oceanographic Research and Development Activity

*Real time

3
REMOTE SENSING COORDINATION

Coordination of remote sensing activities relies on adequate communications between the surface-based and aircraft platforms. To improve communications over the MIZEX 83 experience, a coordination center will be set up in the field (Polar Queen/Polar Stern) as well as in Tromso at the Tromso Telemetry Station. In order to achieve coordinated remote sensing goals a strict communications schedule between the coordination centers needs to be established and adhered to.

Coordination of all aircraft platforms will be done through the Tromso Coordination Center. Tromso is in direct telephone communication with all aircraft bases except NORD, with additional lines of communication. Tromso will supply met information obtained from ships as well as from the Tromso Weather Forecasting Center, ice edge and feature positions (i.e., eddies, fronts, large floes) determined from satellite or previous aircraft imagery and ship reports, and ship positions, to all aircraft via teletype, telemail, telefax, or radio.

On the day previous to a mission, prior to 1600 Z, all aircraft platforms will be required to supply information on mission objective, flight altitude, sensor configuration, flight pattern, take-off time, and expected time-on-target. This will be used to complete an information matrix which will be transmitted to Polarstern at the evening ship communication period, and to all aircraft bases. Modifications to the matrix must be reported into the coordination center prior to the 0500 Z ship communication on the day of the mission.

Following each mission, each platform should go through a flight debriefing, reporting into the Coordination Center the status of instrumentation, success of data collection mission, and any geophysical information obtained from visual observations or real-time data on ice edge location, ice features, eddies, fronts, or internal waves. Coordinates of these features will be transmitted to the ships to aid coordination of surface verification of in situ measurement. Ships should similarly report feature locations and have instruments such as pitch and roll buoys operating during overflights.

Coordination of helicopter and surface-based remote sensing will be coordinated at the Field coordination center on Polar Stern. Scientists at that center will have access to SAR and SLAR and other remote sensing products or interpretations sent via TELEFAX from which to identify sites to be investigated by helicopter and ground parties. These will be areas typical of what is seen in the aircraft data as well as "interesting" areas that should be surface truthed. Locations of these sites and operational plans will be communicated to the Tromso center the day before aircraft overflights so that flight plans can be adjusted accordingly.

Prior to arriving on site, all aircraft must check with the Field coordination center. Once over the area, radio communication with the ships should be kept to a minimum. Location of specific ground sites by aircraft will be facilitated by the use of VHF beacons to be deployed with the ground parties.

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