Annual Sea Ice Runway Survey, Layout, Setup, and Ice Monitoring

OP-M-504

Revision #2

Approved by [redacted]

Posting Date 7/24/06

Active Divisions/Departments
McMurdo Area Directorate

Information Technology (IT)

Facilities, Engineering, Maintenance and Construction (FEMC)

Raytheon Polar Services Company
McMurdo Area Directorate
Contract No. OPP 0000373

Hard Copy Not Controlled—Controlled Copy Available On-line

Table of Contents

PURPOSE **1**

SCOPE/APPLICABILITY **1**

TERMS AND DEFINITIONS **1**

RESPONSIBILITIES **3**

DISCUSSION **4**

CHOOSING A LOCATION 4
Preliminary Area Survey / Initial Site selection *4*
GCA (Ground Control Approach) Survey *5*
Initial Ice Runway Layout and Clearing *5*
ICE RUNWAY COMPLEX CONSTRUCTION 6
NAVIGATIONAL AID LAYOUT 7
ROAD AND TRANSITION LAYOUT 8
Roads *8*
Sea Ice Transition to Ross Island *8*
Sea Ice Transition to Ross Ice Shelf *8*
Fuel Lines *9*
MAINTENANCE AND MONITORING OF AIRFIELD 9
ICE MONITORING 9
Location of Ice Monitoring Stations *10*
Ice temperature Monitoring *10*
Ice Thickness Monitoring *11*
Ice Monitoring Thermometer Check *11*
Ice Monitoring Reports *11*
SEA ICE DEFLECTION SURVEYS 12
Load Curves for Safe Sea Ice Operations *14*
CLOSING OF ICE RUNWAY 14
Navaids and Equipment *15*

CHRONOLOGICAL SUMMARY OF PROCEDURES **15**

EQUIPMENT **16**

SAFETY CONSIDERATIONS **16**

ENVIRONMENTAL CONSIDERATIONS **17**

REFERENCES **17**

RECORDS **18**

FIGURES ..... ERROR! BOOKMARK NOT DEFINED.

ATTACHMENTS, APPENDICES **18**

Purpose

This document describes procedures and responsibilities of Raytheon Polar Services Company (RPSC) Operations, IT, and FEMC personnel for establishing the airfield and monitoring the conditions at the Annual Sea Ice Runway Complex.

The airfield layout must comply with Air Force manual *32-1076, Design Standards for Visual Air Navigation Facilities.* This manual is available on the Internet: http://www.e-publishing.af.mil/pubs/publist.asp?puborg=AF&series=32

Scope/Applicability

The Annual Sea Ice Runway, used during the austral spring and early summer seasons, accommodates wheeled aircraft including C-17s, C-5s and C-130s. Wheeled aircraft support a high level of passenger and cargo traffic from early October until December each year (MAINBODY). Then, in early December, aircraft operations are moved to Williams Field Skiway (for ski-equipped aircraft) and Pegasus White Ice Runway (for continued wheeled aircraft operations on compacted snow).

This procedure applies to all personnel responsible for setting up and monitoring the Annual Sea Ice Runway. Any deviations from this procedure require prior written approval from the USAP Airfield Manager.

Terms and Definitions

ANG/109th
109th Airlift Wing, 139th Airlift Squadron, New York Air National Guard

C-130, LC-130 "HERCULES"
Turboprop (4 engines) aircraft with a maximum payload of 42,000 pounds. LC-130's are ski-equipped for landing on snow.

C-17 "GLOBEMASTER III"
Turbofan (4 engines) aircraft with a maximum payload of 170,900 pounds.

C-5 "GALAXY"
One of the largest aircraft in the world. Turbofan (4 engines) aircraft with a maximum payload of 270,000 pounds.

CSFA
Abbreviation for "Commander, Support Forces Antarctica" - the individual commanding all U.S. military personnel assigned to Antarctic Support

ETL
Abbreviation for "Engineering Technical Letter"

GCA
Abbreviation for "Ground Controlled Approach" – an aircraft navigational aid system used to guide aircraft to the runway threshold during periods of low visibility

GPS
Global Positioning System

CSFA
Commander, Support Forces Antarctica

IAW

Abbreviation for "In Accordance With"

IAW AF
Air Wing Instructions, United States Air Force

IFR
Abbreviation for "Instrument Flight Rules" indicating a period during which aircraft must rely upon "instrument" (as opposed to "visual") navigation due to reduced visibility.

IT
Abbreviation for "Information Technology" – the RPSC directorate charged with providing communications and computer connectivity services

Kinematic Control Point
A marked, surveyed reference position, established through the use of Real-Time-Kinematic (RTK) Global Positioning System (GPS) devices. The control point provides an extremely accurate starting point for ground survey work. (See also, RTK.)

Kool-Aid®
Trade name for a U.S. brand of flavored beverage powder – sometimes used in Antarctica to provide a temporary dye-marker on ice surfaces because of its bright colors

LAN
Local Area Network

MAINBODY
Period of time during which the majority of passengers and cargo are flown into McMurdo

Navaid
Aids to navigation

RPSC
Abbreviation for "Raytheon Polar Services Company" a business unit of the Raytheon Corporation

RTK
Abbreviation for "Real Time Kinematic" a position locating system that utilizes a ground transponder at a known location to reduce the inherent error in Global Positioning System satellite signals and produce extremely accurate (nominally 1 centimeter horizontal and 2 centimeters vertical) positioning data.

WINFLY
"Winter Fly-in": usually occurs in August.

Responsibilities

USAP Airfield Manager
Ensures procedures are followed and updated as necessary.

Operations Manager
Coordinates with the Airfield Manager to ensure airfield support activities are accomplished in a timely manner.

Survey Team
Establishes and monitors the Annual Sea Ice Runway in accordance with this procedure and appropriate Air Force documents. Additionally, the Survey Team must:

- Develop a solid understanding of sea-ice dynamics such as ice growth and deterioration, types of cracks, and safe sea-ice travel.
- Maintain constant communication with the RPSC Airfield Manager, Airfield Supervisor, and Area Director; the Support Forces Antarctica Commander, and the McMurdo NSF Representative on the condition of the ice runway. Ice monitoring reports must be accurate and submitted in a timely manner. These reports are the main data source for making decisions on ice runway operations.
- Be knowledgeable and efficient with the use of the Trimble 4800 GPS Survey System or similar RTK GPS Survey Systems. The Ice Runway Complex can be laid out several ways. Specific survey procedures will not be outlined here, as every surveyor will approach the layout differently. Survey control information for GPS baseline solutions is available in the Surveyor's Office, Building 175, at McMurdo Station.

Discussion

Choosing a Location

During WINFLY, a Runway Location Team consisting of the Survey Crew, Fleet Operations and the USAP Airfield Manager will determine the best location of the Annual Sea Ice Runway:

Preliminary Area Survey / Initial Site selection

Shortly after WINFLY begins, the Survey Team will check the sea ice condition to determine the best location for an ice runway and road system. The Survey Team shall make every effort to construct a main and crosswind runways to allow for IFR approaches and to facilitate snow removal operations IAW Engineering Technical Letter (ETL) 05-2, *Design, Construction, Maintenance and Evaluation of the McMurdo Sound (Antarctica) Sea Ice Runway for Heavy Wheeled Aircraft Operations*. www.mucmurdo.usap.gov NOTE: Due to sea ice conditions for the Austral Summer 2006-2007, only a main runway with a suitable ramp is planned for construction. Ice and snow conditions may require consideration of two or three possible sites before making a final decision.

The location of the ice runway is based on the following criteria, as determined by the RPSC Survey Crew:

1. **Ice Thickness:** Measure ice thickness by drilling holes approximately every 0.5-mile along the route leading to the proposed ice runway and at the proposed ice runway site. (Measure along the thresholds of the main and crosswind runways and along the approximate center of the apron.)

2. **Cracks:** Locate and flag any ice cracks along the access route or at the runway site for future monitoring. Make sure each crack is profiled to make sure they are safe for crossing.

3. **Roughness:** Note the roughness of the ice surface. Typically, first-year sea ice is relatively flat (and thus the first choice for ice runway location). Multi-year ice may be undulating and rough due the forces created by the movement of the permanent ice shelf against the annual sea ice and snow melting / ablation on the sea ice from the previous summer. Multi-year ice will be present if the site is located in an area where the sea ice did not "break out" during the previous season.

4. **Snow Cover:** Measure snow depth and density to help Fleet Operations personnel determine the feasibility and cost of snow removal.

5. **Access Determination:** Consider access from McMurdo Station and from the transitions between the Ross Ice Shelf and the annual sea ice. Also consider fuel line access before making a final decision on runway location.

GCA (Ground Control Approach) Survey

The Survey Team will complete a GCA Survey for the Air Traffic Control to include in their Flight Approach Plates for aircraft flying to Antarctica. Procedures for completing the survey are filed in the Surveyor's Office in Bldg. 175, McMurdo Station.

Initial Ice Runway Layout and Clearing

Set an initial control point in the general area of the proposed ice runway (center of apron works best) and run a baseline from a survey control point in McMurdo.

Note The most efficient way to set control points in the sea ice is to drill a 6" hole in the ice, fill it with RED Kool-Aid® and drop a small piece of metal into it. This makes it easy to recover the point with a shovel and a metal detector.

The main and crosswind ice runways are 220 ft wide and 10,000 ft long--with a 1,000-ft overrun for a total length of 11,000 ft each. Refer to the RPSC Runway Drawings for details.

From the initial control point, set the ends of the proposed main and crosswind runways. Set these as kinematic control points (four total) to be used later in the layout of the runways. Mark the initial centerlines of the main and crosswind runways with orange flags set at 1,000-ft intervals.

The equipment operators will then make their initial snow removal pass down the centerline to determine the quality of the ice surface.

After the surface has been cleared, the Survey Team will evaluate and monitor the condition and thickness of the sea ice at the proposed runway location. Check the ice surface for roughness, cracks, and overall condition to determine if it is suitable as a final runway location.

Take snow measurements along the centerlines and apron area. If these calculations reveal excessive snow cover, locate and test the second and/or third optional sites.

Use ETL 05-2, *Design, Construction, Maintenance and Evaluation of the McMurdo Sound (Antarctica) Sea Ice Runway for Heavy Wheeled Aircraft Operations* to establish airfield layouts and clear zones. Any deviations must be coordinated in advance with the USAP Airfield Manager, and will be dependent on the sea ice condition.

Ice Runway Complex Construction

Once the final location is determined, construction of the ice runway can begin. The Survey Team will mark the clearing limits of the runways and apron (100-ft. offset) with flags set at 800-ft. intervals.

The construction schedule of the Ice Runway is very tight and weather-dependent. The Survey Team must maintain constant communication with the USAP Airfield Manager regarding the needs of operators removing the snow. Lay out the runway and building complex in a way that affords the most efficient, productive use of the snow removal equipment.

FEMC and IT personnel will prepare all buildings for electric and LAN capability prior to first flight of MAINBODY.

Refer to the RPSC Ice Runway Drawings for layout of the Ice Runway and Town Complex, including building and fuel tank locations.

Navigational Aid Layout

After the ice runway and facilities have been established and the snow from the runway has been removed, the Survey Team will mark the Runways in accordance with ETL 05-2, *Design, Construction, Maintenance and Evaluation of the McMurdo Sound (Antarctica) Sea Ice Runway for Heavy Wheeled Aircraft Operations.*

1. **Distance Remaining Markers:** These are signs placed every 1,000 feet, on the left side of the runway, based on the main approach of the runway. Numbers on each board indicate the distance remaining (in 1,000 ft increments) to the departure-end threshold of the runway. Distance remaining markers are numbered on both sides, with the number indicating distance to the runway threshold beyond the marker. Thus, regardless of the direction of travel on the runway, the numbers decrease incrementally (from 9 to 1 on a 10,000-foot runway).

2. **Navaids / Low Visibility Markers:** These are black radar-detectable markers placed on both sides of the main and crosswind runways at 400-ft intervals.

3. **Threshold Markers:** These RED markers are set at the midpoint and at the thresholds of each runway (if possible).

4. **Runway Approach Lights:** These are set up based on centerline of the runway. Check the final plans as to their proper distance from the 0+00 threshold of the main runway.

5. **Approach Line Markers:** Mark the approach lines of all runways with the same type of marker used for the Navaids / Low Visibility Markers. Set these markers on extended centerlines of each runway.

6. **Weather Markers:** These markers extend in each of the Cardinal Directions from the Ice Runway Tower. Using a handheld GPS unit, drive the proper azimuth and distance from the Ice Runway Tower to locate marker positions.

Road and Transition Layout

Roads

The RPSC survey crew is responsible for flagging the roads to the ice runway and the Ross Sea Ice Transitions. Place flags at 100-ft intervals to ensure safe travel to and from McMurdo Station in case whiteout conditions occur.

Sea Ice Transition to Ross Island

The ice road transition from the sea ice to land occurs at McMurdo Station on Ross Island. Typically, two or three tidal cracks parallel the shoreline. Since this area is maintained by Fleet Operations, any sudden changes in the tidal crack locations should be noted and discussed with the Airfield Supervisor.

The survey crew will make sure this transition is flagged for safe travel across it.

Sea Ice Transition to Ross Ice Shelf

The transition from the sea ice to the Ross Ice Shelf is very important because all of the mobile runway equipment and facilities must be transported over this transition at the end of the season. It is essential that RPSC Operations personnel determine the weight and load distribution of the largest module and towing vehicle. From this, the required ice thickness for Periods Two or Three (the most likely thermal periods at the end of the season--see “Ice Monitoring” below) can be taken from Table 1 (Attachment H) or Table 2 (Attachment I).

Choose a location for the transition ramp where there is sufficient sea ice thickness to ensure adequate bearing capacity and in an area where down warping or ridging have not occurred. Down warping is usually caused by excessive surface loading and insulation of the sea ice due to deep snowdrifts.

> **Note** Operators should clear all snowdrifts from the transition to remove the weight and release the “heat” from the sea ice.

In addition, the chosen site should be located away from any fissures or crevasses observed along the edge of the ice shelf.

When the transition site is located where there is sufficient ice thickness and minimal down warping, coordinate with the Airfield Supervisor to establish a schedule for the road layout.

Fleet Operations personnel will construct the transition in early September. The survey crew will support the construction process as needed.

Install one sea ice temperature profile station about 25 ft from the actual transition on the sea ice to record sea ice temperatures. Snow depth and sea ice thickness profiling (50 feet apart) should start at the base of the transition and continue until the sea ice thickness is consistent (usually about 200 ft). Beginning in mid-November, record these data once per week to ensure there is adequate bearing capacity of the sea ice at the transition. Note any abnormalities and discuss them with the Airfield Supervisor.

Fuel Lines

The Fuels Department may also ask for help from the RPSC survey crew in determining their transition on to the ice and location / direction of the fuel lines to the ice runway fuel pits.

Maintenance and Monitoring of Airfield

The Survey Team will monitor and maintain the airfield as follows:

1. **All Navigational Aids:** Check all Distance Remaining Markers, Navaids / Low Visibility Markers, Weather Boards, and Approach Lines weekly (or when requested) to verify the accuracy of their locations. Maintain all navigational aids and markers in satisfactory working condition.

2. **Lighting Layout:** Check the runway lighting system weekly to verify its location and condition. RPSC electricians are responsible for maintaining the lighting system in satisfactory working condition.

3. **Road Flags:** Check (and replace, as necessary) all road flags between the transitions and the ice runway at least weekly to ensure safe travel for vehicles during poor weather conditions.

Ice Monitoring

The bearing capacity of the sea ice is dependent primarily on the temperature and thickness of the annual sea ice. The expected condition of the annual sea ice sheet near McMurdo Station, Antarctica, can be divided into four seasonal "periods" based on progressive warming, internal melting, and subsequent weakening of the sea ice.

The RPSC survey crew will establish Ice Monitoring stations as described below:

Location of Ice Monitoring Stations

1. **Eight or ten** ice-monitoring stations need to be set up at the ice runway location (eight with a single runway, ten if a crosswind runway is constructed).

2. Set **three** at equal intervals along the ice runway road leading to the runway from McMurdo, **one** at each thresholds of each runway (**two total with a single runway**, **four total with a crosswind runway**) and **two** in the town complex.

   Stations set on the runway thresholds are located on the edge of the runway. **One** town complex station is located next to the Galley Module and **one** is in the fuel pits.

3. Set up **one** ice monitoring profile station in the general vicinity of the intersection of the ice runway road and the ice runway.

Ice temperature Monitoring

Ice Monitoring stations are set up to record near-surface temperatures (about 12” below the surface). Each station should be covered with a protective plywood box clearly marked with a checked flag.

The area around each station should be kept with a 2” cover of snow (10-ft radius from the ice monitoring station) to keep solar radiation from affecting the measurements. (Excessive snow greater than 4” can insulate the ice and affect the ice temperatures.)

Refer the Final RPSC Ice Runway Drawings for the location / layout of the ice monitoring stations and the correct placement of the temperature sensor in the ice.

Ice Monitoring Profile stations are set up to measure ice temperatures at 1-ft intervals, starting at 1 ft and stopping at 10 ft below the ice surface. These profiling stations will be useful in determining the ice temperatures/strength as the season progresses. Refer to the Final RPSC Ice Runway Drawings for location/layout of Ice Monitoring Profile Stations.

Ice Thickness Monitoring

Ice thickness at each station is determined by drilling into the sea ice until the drill "breaks through." Measure the length of the drill flight once it breaks through to determine to thickness of the ice. The "hardness" of the ice can be felt as the drill works its way through the ice.

Ice Monitoring Thermometer Check

The RPSC survey crew shall verify the accuracy of the monitoring equipment. The thermometer shall be capable of a resolution of plus or minus 0.1 degree C. Calibrate the thermometer-thermocouple system before use.

Insert the thermocouple into an ice bath composed of fresh water (not seawater) with a high concentration of crushed freshwater ice to ensure that the water is at equilibrium temperature. Connect the thermocouple to the digital thermometer with which it will be used during monitoring operations. The thermometer should give a reading of +32 degrees Fahrenheit/0 degrees Celsius.

Ice Monitoring Reports

1. **Ice Monitoring Report:** The RPSC Survey Crew will submit an Ice Monitoring Report to the Operations Director, Airfield Manager, and the NSF Representative in McMurdo Station. This report shall be compiled and submitted every time measurements are taken at the ice monitoring stations. This report is used to record the ice thickness, near-surface ice temperature, and snow depth at each of the monitoring stations. This report is compiled and used in conjunction with the temperature range specified for each seasonal period to categorize the ice condition, to determine the minimum ice thickness and parking time allowed for aircraft, and to predict when the ice runway should be shut down for the season. Refer to Attachment D, "Ice Runway Ice Monitoring Report."

Frequency of Ice Monitoring: The RPSC survey crew will conduct ice monitoring weekly from WINFLY through mid-December (runway closure). The frequency of measurements may vary depending upon the actual ice conditions and changes in ice thickness and temperature (taking measurements twice a week is possible during the

warmer periods). During data acquisition, the condition of the sea ice shall be visually monitored for the presence of any cracks and for assessing its overall appearance.

All recorded monitoring data such as ice temperatures, ice thickness, snow depths, ice crack locations and widths, surveying procedures, and other observations or activities by the RPSC survey crew shall be recorded in the RPSC surveyors' field books and shall be organized by date, page number, and book number. These field books are kept in the Surveyors Office, Bldg. 175, McMurdo Station.

ICE PERIOD INFORMATION

- **Period No. 1** runs from WINFLY until about mid November. Temperatures below 14 degrees Fahrenheit.
- **Period No. 2** runs from mid November through mid December. Temperatures between 14 and 23 degrees Fahrenheit.
- **Period No. 3** runs from mid December through early January. Temperatures between 23 and 27 degrees Fahrenheit.
- **Period No. 4** runs from mid January through late February. Temperatures above 27 degrees Fahrenheit.

These are estimated dates and may vary somewhat from season to season. Refer to Figure 1, "Near-Surface Temperature of McMurdo Annual Sea Ice for Normal Operating Season."

Sea Ice Deflection Surveys

1. **Benchmark:** The RPSC survey crew shall establish a benchmark for measuring deflection elevations by setting a hub in a location where it will not be disturbed or subject to settlement. This location is computed to be 100 times the distance, relative to the thickness of the sea ice. (For a typical ice sheet thickness of 7 feet and Seasonal Period 1 conditions, a distance of 700 feet is computed.)

   An “ASSUMED” elevation for the benchmark can be used. Using an engineer's level and rod, elevation readings can be taken at any point by referencing to the benchmark. Changes in elevation at the measured point represent the deflection at that point. For deflection readings, the absolute elevation is not important, only the change in elevation over time.

2. **Buildings and Fuel Tanks:** The heaviest structures on the ice runway complex (the galley, crash shack, the passenger terminal, the fuel tanks) shall be monitored by the

RPSC survey crew for deflection if the ice conditions (e.g., thin sea ice, warm ice temperatures) deem it necessary. These facilities shall be surveyed every time the ice monitoring is performed to measure the deflections due to the creep deformation of the sea ice. If ice conditions require it, they may need to be monitored more frequently.

When deflections approach 10% of the thickness of the ice, the survey crew shall notify the Operations Manager, the Airfield Manager, and the NSF representative in McMurdo Station. Refer to Attachment E, "Ice Runway Deflection & Ice Thickness Monitoring Report."

3. **Aircraft Deflection Surveys:** The survey crew will perform aircraft deflection surveys to assure that the ice beneath aircraft does not deflect beyond a safe limit to support the aircraft. The deflection surveys will be done on a plane-by-plane basis, depending on the measured ice thickness and the seasonal period for the ice. Mark the location of the plane based on the Final RPSC Ice Runway Drawings. The spot should be marked (orange spray paint works well) where the front wheel would be located.

   Based on the plane type and landing gear configuration, mark the area where the remaining landing gear would be located. The landing gear locations should be established and their elevations recorded before the plane lands. After the plane is parked, acquire elevations on both sides of the plane every 10 minutes. If the deflection of the aircraft approaches 10% of the thickness of the ice, notify the MCC Supervisor, the ATS Tower, and the Airfield Manager that the plane may have to be moved. The rate at which the ice deflection of 10% was reached and the amount of cargo left to be unloaded from the aircraft will be considered in determining whether the plane needs to be moved.

   The deflection area for each plane is different, so the deflection zone charts should be checked to determine how far the plane has to be moved in order to be relocated to a safe position. There should be at least two other pre-determined spots already laid out in case the plane has to be moved. After the plane is relocated, repeat the deflection monitoring process.

   Coordination with the MCC Supervisor, the ATS Tower, and the Airfield Manager is required so that a plan of action is in place in case the plane needs to be moved. Refer to Attachment F for curves showing parking times for various aircraft types and weights, plotted for the four seasonal periods of the sea ice sheet.

Load Curves for Safe Sea Ice Operations

The ability of the sea ice to support aircraft, vehicles, and equipment can be determined from the ice thickness and the seasonal period of the ice. Structural analyses of the ice, combined with empirical data, have been used to develop graphs and charts for allowable loading. Vehicle and Equipment Loading Tables of the minimum allowable ice thickness are presented for the four seasonal periods in Attachments H and I for specific support vehicles and various equipment combinations (Vaudrey, 1976). It is particularly important to monitor the condition of the road at the Ross Ice Shelf transition ramp to ensure the integrity of the road at that location. RPSC Operations will determine the specific equipment combinations and their respective weights and loading patterns for travel over the sea ice/ice shelf transition at the end of the season after closure of the ice runway.

1. **Aircraft Loading:** The data for required ice thickness versus gross aircraft weight shall be based on the graphs for the four seasonal periods in Attachment F for landing, takeoff, and parking of the C-130, C-5 and C-17 aircraft (Barthelemy, 1990).

2. **Vehicle and Equipment Loading:** The data for required ice thickness versus gross vehicle and equipment weight shall be based on the tables presented for the four seasonal periods in Attachments H and I for specific support vehicles and various equipment combinations (Vaudrey, 1976).

   Note Refer to Section V.G. "Curves" below.

Closing of Ice Runway

The closing of the sea ice runway is jointly determined by the NSF Representative, the CSFA, and the Airfield Manager based on input from the survey crew on the ice thickness, snow depth, and ice temperature, which determines the seasonal period of the ice. Factors influencing the closing are the ability of the ice runway to support the aircraft and facilities safely and the condition of the sea ice transitions, particularly the transition ramp to the Ross Ice Shelf. The sea ice runway must be closed and the facilities moved onto the Ross Ice Shelf before that transition becomes unable to accommodate the traffic. The ability of the roads and transitions to safely support runway operations and the relocation of the runway is determined and certified by the Operations Manager.

Navaids and Equipment

1. **Removal and Storage:** When the final flight operations have been completed, it is the responsibility of the survey crew and the USAP Airfield Manager to ensure that all the navaids and ice runway equipment are removed promptly and efficiently from the ice runway site. Store the navaids and other equipment properly to ensure that the set-up procedure will run smoothly at the beginning of the next season. The storage must be documented so the equipment can be located easily.

Chronological Summary of Procedures

WINFLY to MAINBODY

1. Working with RPSC Operations, lay out the ice runway site (all phases), help locate the transition (if required), and make sure ALL roads are flagged.
2. Initial WINFLY GCA requirements.
3. Install ice-monitoring stations at the main ice runway and additional ice monitoring stations at other locations, such as the transition ramp to the Ross Ice Shelf.
4. Continue recording ice thickness, ice temperatures, and snow depths and determine the seasonal period of the ice.
5. Final GCA Requirements toward end of WINFLY-Early MAINBODY

MAINBODY to Closing

1. Make sure all the navaids on the ice runway are functional.
2. Measure ice thickness, ice temperatures, and snow depths at a frequency determined by the seasonal period of the ice.
3. Monitor ice deflection beneath parked aircraft as required.
4. Maintain the all navaids at the ice runway site.
5. Monitor the sea ice transition ramps to the Ross Ice Shelf.

Closing

1. Remove all navaids from the ice runway (perform any repairs), and store them properly.
2. Make sure Ice runway Site is completely clear of all equipment and materials.

Equipment

The following equipment should be used for the layout of the ice runway and the ice monitoring. All of this equipment is located in the Field Engineer's office in Building 175.

Trimble 4800 GPS Survey System: Used to determine initial ice runway locations and determine runway coordinates for USAF Flight Operations after the runway is established.

Topcon 301 Total Station / Wild T-2 Theodolite: Assist in layout of runway.

Engineer's level and rod: Used to measure the deflections of the aircraft, fuel tanks, and other ice runway structures.

Power Head drill and extensions: For measuring sea ice thickness

Digital thermometer and "T" thermo-couplers: Used to record ice temperatures.

Safety Considerations

1. **GENERAL:** Operations on the Ross Ice Shelf and the sea ice shall be in accordance with the current edition of the Field Manual for the United States Antarctic Program ("Field Manual"), as applicable.
2. **SURVIVAL TRAINING:** All members of the RPSC survey crew and others who are working on the Ross Ice Shelf or the sea ice shall have taken and passed the RPSC survival training course as described in section 3.3 of the Field Manual, and shall be EH&S sea-ice trained.

3. **ECW GEAR:** All members of the survey crew and others who are working on the Ross Ice Shelf or the sea ice shall wear adequate extreme cold weather (ECW) clothing as required. Refer to Chapter 1, "Extreme Cold Weather Clothing," of the Field Manual.

4. **SEA ICE WORK:** Sea ice work shall be in accordance with Chapter 16, "Sea Ice," of the Field manual.

Environmental Considerations

1. **NEPA REGULATIONS:** All National Environmental Protection Act (NEPA) regulations applicable to Antarctica shall be observed.

2. **RETROGRADE HAZARDOUS MATERIALS:** All hazardous and non-native materials shall be removed from the site upon conclusion of operations.

3. **TOILET FACILITIES:** Approved toilet facilities shall be established where required.

References

ETL 05-2, Design, Construction, Maintenance and Evaluation of the McMurdo Sound (Antarctica) Sea Ice Runway for Heavy Wheeled Aircraft Operations.

Air Force manual *32-1076, Design Standards for Visual Air Navigation Facilities*

EQUIPMENT CALIBRATION: Survey equipment and other applicable equipment shall be kept in current calibration according to the manufacturers' recommendations, and the calibration shall be documented.

PEER CHECKS: Calculations, data recording, reports, and other documents shall be given a peer check or review to ensure accuracy.

STANDARD PROCEDURES: All applicable RPSC quality assurance procedures shall be observed.

A. Barthelemy, J. (1990) *Thirty-five Years of Sea-Ice Runway Operation - McMurdo Station, Antarctica*, International Association of Hydraulic Research Ice Symposium 1990, Espoo, Finland.

B. Brier, F. (1973) *Improved Transportation Ramps for McMurdo Station, Antarctica*, Technical Note N-1317, Naval Civil Engineering Laboratory, Port Hueneme, California.

C. Hoffman, C. et al. (1979) Engineering *Manual for McMurdo Station*, prepared for Naval Support Force, Antarctica by Naval Civil Engineering Laboratory, Port Hueneme, California.

D. Thomas M. and K. Vaudrey (1973) Snow *Road Construction Technique by Layered Compaction of Snow blower Processed Snow*, Technical Note N-1305, Naval Civil Engineering Laboratory, Port Hueneme, California.

E. Vaudrey, K. (1976) Revised *Aircraft Load Curves and Vehicle Ice-Thickness Tables for Annual Ice Sheet Operations Near McMurdo, Antarctica*, Technical Note N-1431, Naval Civil Engineering Laboratory, Port Hueneme, California.

F. Vaudrey, K. (1977) *Ice Engineering - Study of Related Properties of Floating Sea-Ice Sheets and Summary of Elastic and Viscoelastic Analyses*, Technical Report R-860, Naval Civil Engineering Laboratory, Port Hueneme, California.

Records

The records keeping for the Ice Runway is located in the surveyor's office. The field books and drawings pertaining to that year provide all necessary records and procedures.

Attachments, Appendices

None