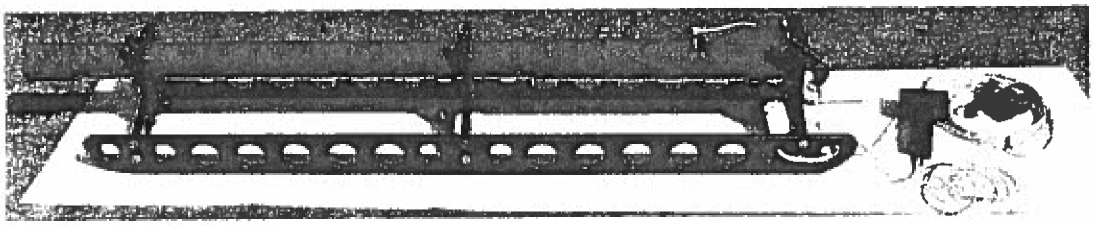

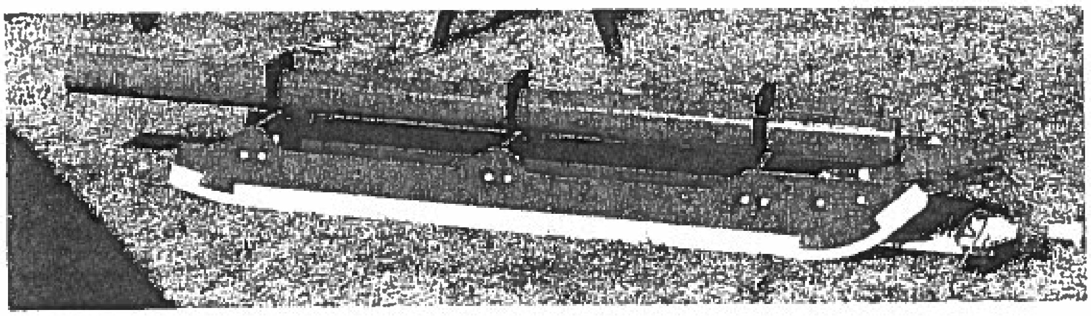

SURFACE ICE SENSOR™

OPERATOR'S MANUAL

by

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Toronto

revised

21 March, 2012

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IMPORTANT INFORMATION:

SAFETY NOTE:

The SIS™ is a complex geophysical system. A great deal of time and effort has been invested to ensure that it is rugged and operationally stable. However, any geophysical tool should be tested frequently when being used for operations where instrumental accuracy is vital. This can be done through routine measurements at one or more "check sites" in the survey area, where the ice thickness and sub-ice water conditions are known by other means at the time of each "check" measurement. SIS™ system accuracy has been specified for nominal ice conditions, where level sea ice is floating on "normal" seawater of conductivity ~2.5 S/m. Certain circumstances, such as the presence of a substantial layer of fresh water under the ice, will yield over-estimates of total ice thickness from an SIS™ unit that is operating perfectly. Other unforeseen or unexpected circumstances, including equipment faults, may also yield misleading results. These considerations underscore the need for rigorous instrument checking and backup measurements during high-priority operations. The SIS™ should never be used as the sole basis for safety-critical assessment of sea ice thickness.

The SIS™ requires a substantial thickness of seawater immediately beneath the sea ice in order to obtain accurate ice thickness estimates. It will not work at all in true freshwater environments, and would require special calibration for use in brackish environments. Operating over shallow seawater (including situations where the presence of thick ice results in a thin sub-ice water layer), or where only a freshwater layer exists between the ice and bottom) will almost always yield substantial over-estimates of ice thickness. Similarly, where thick freshwater layers exist between ice and seawater, ice thickness will be overestimated by approximately the thickness of the freshwater layer, since that layer has an electrical conductivity more similar to sea ice than to seawater. Care should therefore be taken in estuarine environments, or anywhere else where significant freshwater thicknesses may underlie sea ice, to understand the sub-ice water salinity profile and depth and its likely effect on ice thickness estimates.

Proprietary Information:

The information in this document, and the software and hardware described here, are proprietary to Geosensors Inc. They may not be reproduced, stored in a retrieval system or transferred to third parties without the express, written consent of Geosensors Inc. All software included in this system or supplied in support of this system is copyright 2012 by Geosensors Inc.

Every effort has been made to ensure that the material included in this reference is accurate and current. If an error is noted, please contact Geosensors immediately so that the error may be rectified. Contact information for Geosensors is provided in Appendix A.

SURFACE ICE SENSOR™

OPERATOR'S MANUAL

1 Overview

This Operator's Manual provides the information required to assemble and operate the Geosensors Surface Ice Sensor™ (SIS™).

This manual is organised into nine sections, as follows:

1. Overview
2. What's in the box?
3. Assembling the instrument and sled
4. Cabling and power supplies
5. Operating the SIS™
6. Unloading Data from the SIS™
7. Data Processing
8. Troubleshooting Guide
9. Quick-Start Guide

1.1 Description:

The Geosensors Surface Ice Sensor™ is a complete, lightweight, battery-powered system for real-time estimation of sea ice thickness and bulk conductivity. It incorporates a compact, extremely stable, fully digital dual-receiver EM sensor operating at 9 kHz, a 12-channel WAAS-enabled GPS receiver, a power supply subsystem and battery pack, and a high-speed, low power processor. The processor performs real-time inversion of the data for sea ice thickness and conductivity. The sensor and logs both raw and processed data internally for subsequent download and analysis. A hand-held controller permits the operator to interact with the system and view data during operation. The SIS™ can also be operated in an NMEA-output mode in which raw and processed data are output to an external computer for display and logging. The package is sealed and weatherproof. The system is factory-calibrated, with nominal ice thickness accuracy better than 5 cm or 1% under conditions of 0.2 to 5m level sea ice over normal seawater, with 1cm precision. Typical accuracy over thicker ice is still being assessed, but is between 1 and 5% for ice in the 5-10m thick range, and 5 and 10% for thicker ice up to 20m. The close proximity of the sensor to the ice ensures excellent lateral resolution over thin ice; the footprint effect has a substantial effect on lateral resolution over thick ice.

The system is provided with an extra set of batteries, a pair of battery chargers, a data cable, and an AC power supply that can be used for testing or during data unloading operations. The system can be supplied with one or both of two optional sleds: a lightweight unit primarily oriented toward human-towed operations, and a heavier, more rugged unit with a rigid tow bar for operation with a snow machine.

1.2 Basis of Operation:

The SIS™ is an integrated geophysical system comprising a dual-receiver electromagnetic induction sensor (SISEMS), pitch and roll sensors, a GPS receiver and a real-time ice properties processor (RTP). The RTP unit effectively uses the measured EM response from the ice-seawater interface and the response of the ice itself to estimate the distance between itself and sub-ice seawater, and subtracts the height of the sensor above the ice surface.

As part of the same calculation, the unit estimates the bulk electrical conductivity of the sea ice. This conductivity is related to the temperature profile in the ice and the amount of brine that was trapped in the ice during the freezing process or during later events. First-year sea ice tends to be relatively conductive, in the 0.01 to 0.1 S/m range depending on thickness and temperature, while multi-year ice, which has lost most of its brine content during summer melt cycles, tends to be extremely resistive, in the .0001 to .001 S/m range. The absolute accuracy of the SIS™ ice conductivity calculation is still being evaluated, but it appears that the system can readily discriminate between first-year and multi-year, and perhaps between first-year, second-year and multi-year ice, in winter conditions.

The SIS™ capability to simultaneously and continuously estimate sea ice thickness and bulk conductivity is unique among surface-based sensors.

2 What's in the Box?

The first photograph below shows the primary shipping case in its packed state, along with the battery bag. For manual-tow operations, the lightweight sled shown in Section 3 can be used, while for towing behind a snow machine, the heavier sled with tow bar shown in Section 4 should be used. The heavy sled packs in a separate shipping case.

The items in the primary large shipping container are:

1. SIS™ sensor package
2. Lightweight sled components (if purchased), including runners, cross-pieces, clamps and fasteners

Items in the soft-sided battery bag include

1. User Interface with cable
2. Wrench for assembly of lightweight sled
3. Battery packs (4 total=32 AA cells, two packs required for SIS™ operation)
4. Battery chargers (2)
5. Power/Data cable (used for unloading data from the unit)

This bag should be shipped in a hard-sided case, perhaps with the system's computers, or carried as luggage.

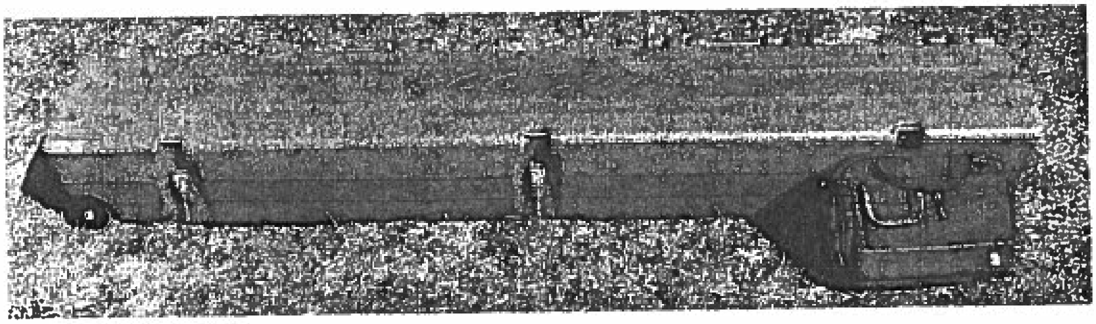


Figure 1: Primary shipping case, with bag for battery packs, chargers and user interface.

The secondary large shipping container houses the heavy sled. It may be amended in future to include overflows from the primary shipping container as well. It is shown in packed form in the next photo.

Photo of packed box #2

3 Assembling the Instrument and Sled

3.1 Lightweight Sled Assembly:

The sled assembly sequence is shown in the following sequence of photos.

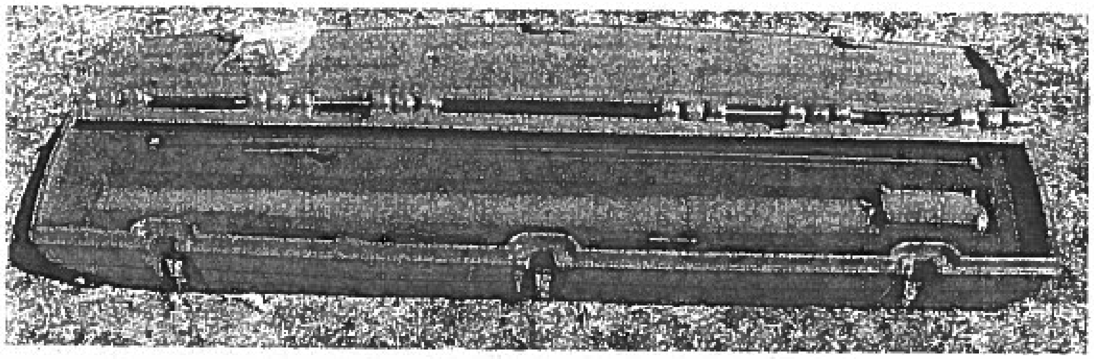


Figure 2: Primary shipping case, top foam insert removed, showing SIS and sled components. Note red-stained nylon fasteners in bag on lid.

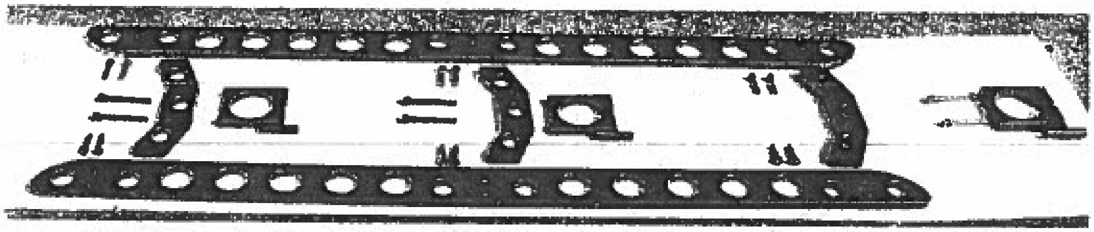


Figure 3: Sled components laid out prior to assembly. Note that forward cross-member is thicker than middle and rear cross-members, and forward clamp has a larger-diameter central hole than rear clamps.

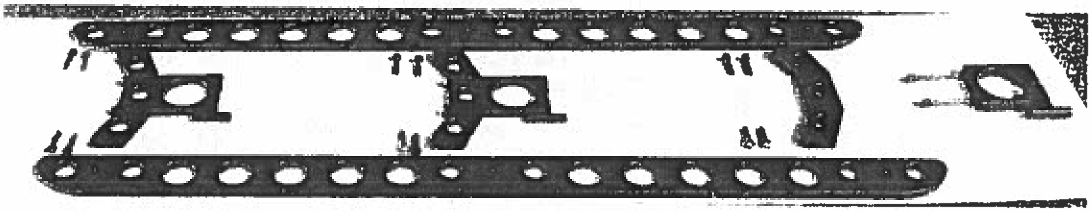


Figure 4: Two clamps have been assembled to cross-members.

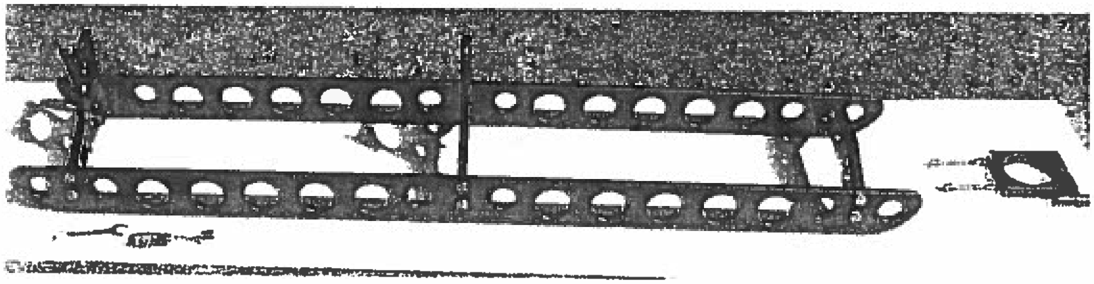


Figure 5: Sides assembled to cross-members, rear and middle clamps attached.

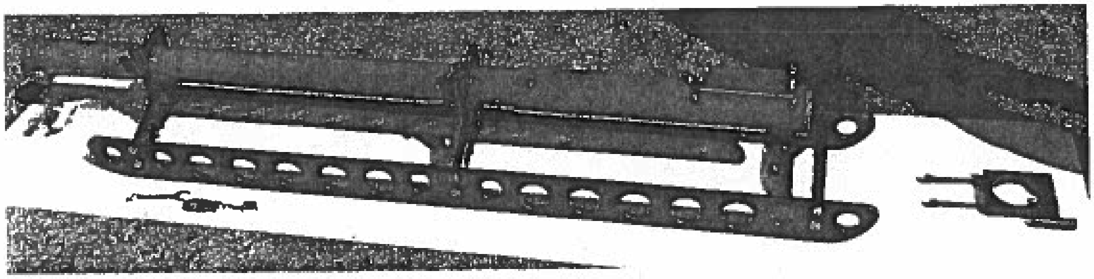


Figure 6: Sensor has been slid into rear clamps from forward end, forward clamp still not installed.

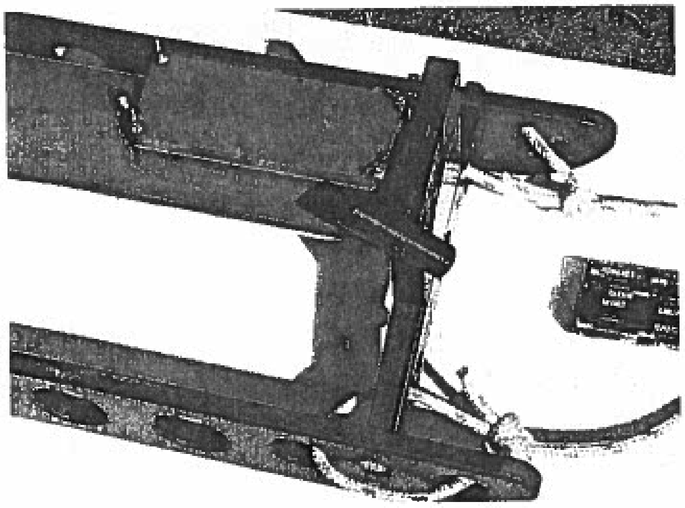


Figure 7: Installation of forward clamp. Note near-flush alignment of bulkhead to clamp surface. Tow rope should not be tied only to cross-member—loop through sides of sled as well.

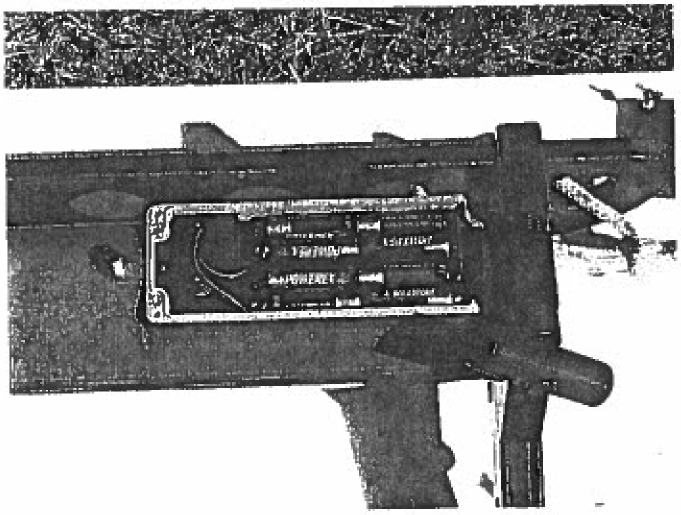


Figure 8: Battery packs reversed and not attached to connectors—use this configuration for pre-survey transport with batteries in compartment to avoid draining batteries unnecessarily. For normal shipping or storage, remove batteries from compartment.

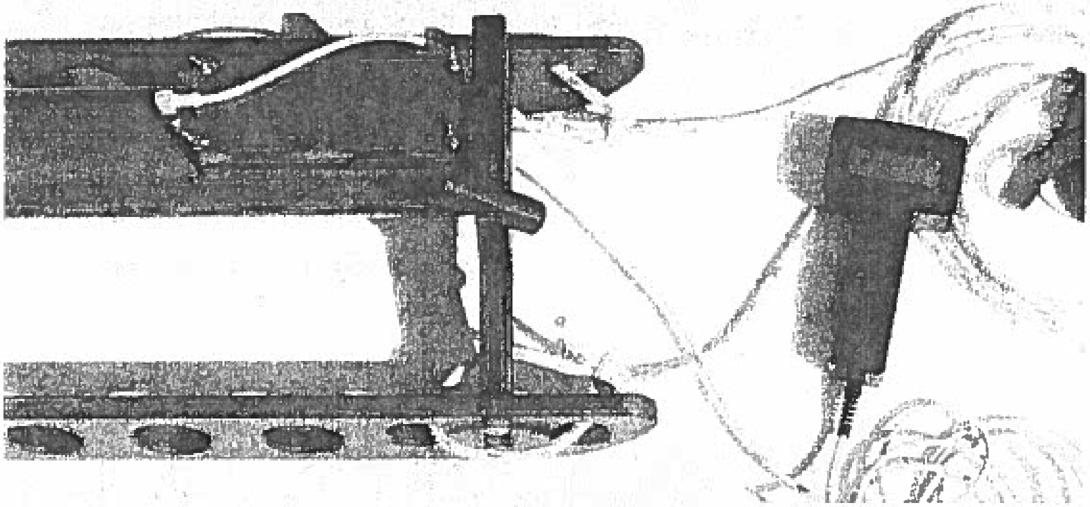


Figure 9: User Interface connected, batteries connected and battery compartment lid tightened. Note File menu on User Interface.

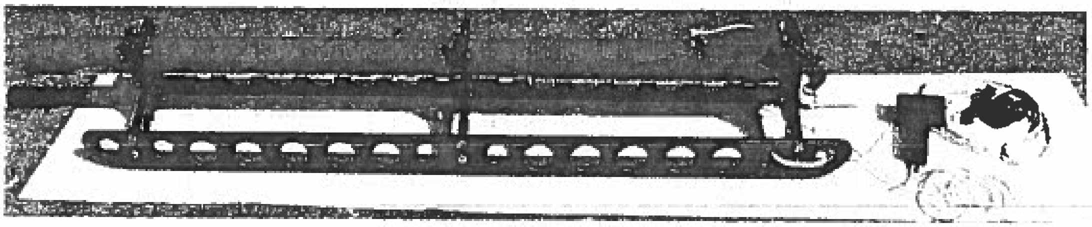


Figure 10: Assembled sled and SIS ready for surveying.

3.2 Heavy Sled Assembly

The heavier sled with rigid tow bar was designed for motorized operation, though it can also be towed by an operator wearing a harness. Its assembly sequence with commentary is shown in the following figures.

The steering system uses a medium-weight bungee material to provide stiff but not brittle steering control--that material will wear over time. Some additional bungee material has been included with the package to permit field replacement of this component.

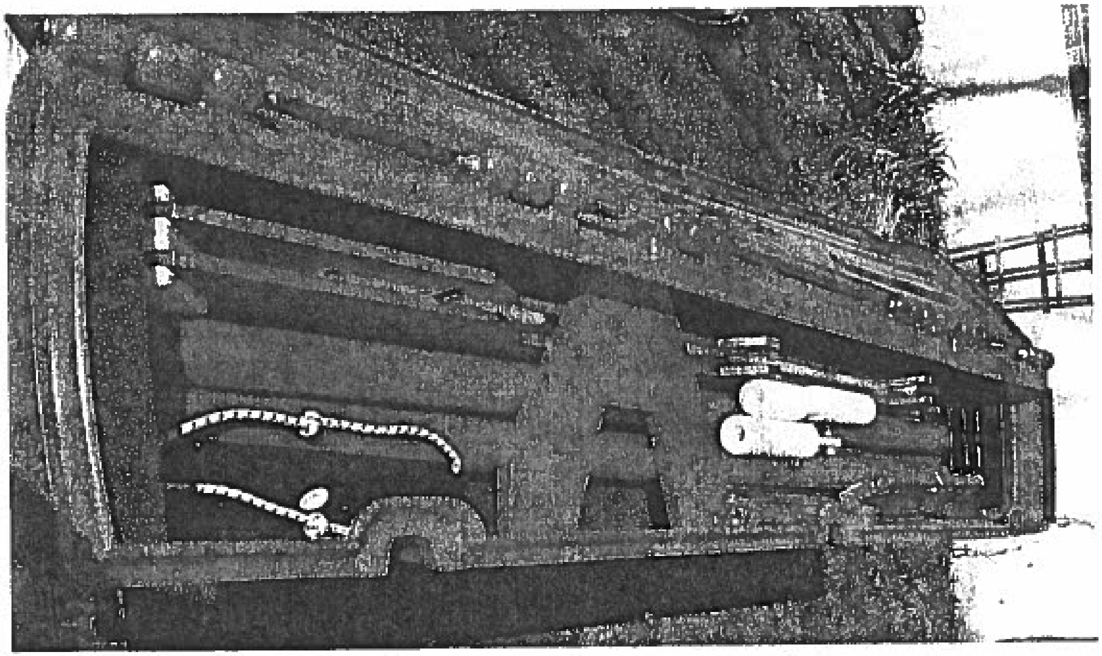


Figure 11: "Heavy" sled packed in its shipping case.

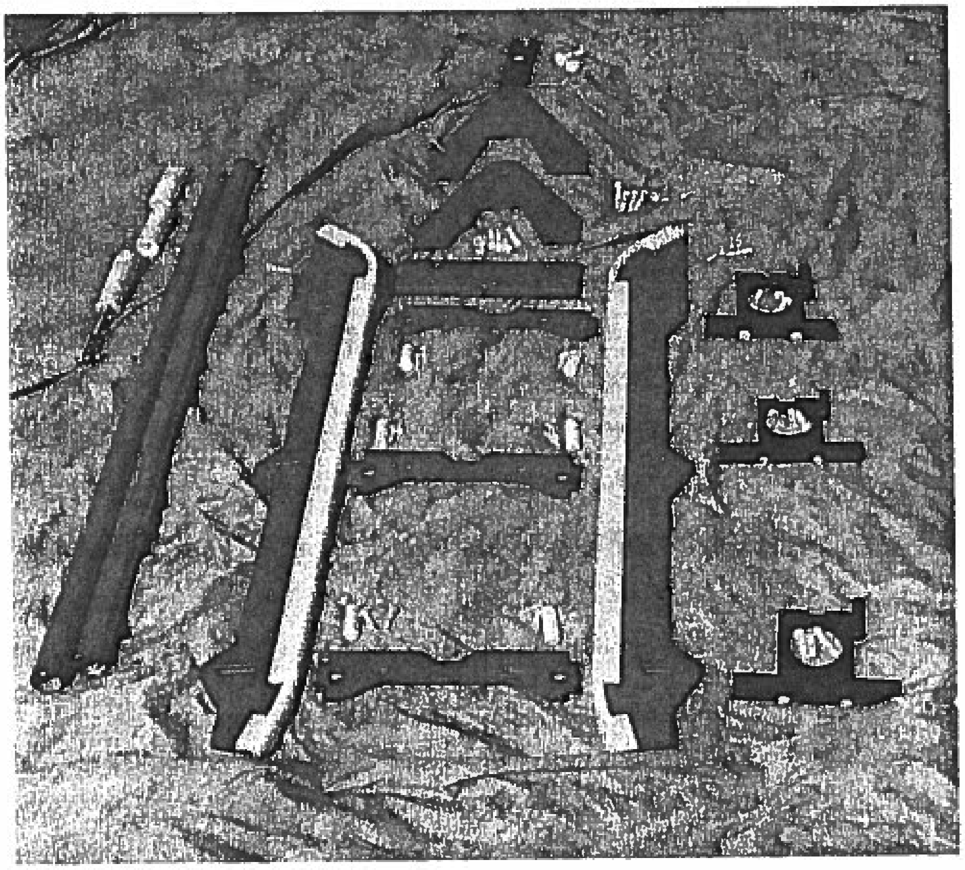


Figure 12: Sled components unpacked prior to assembly.

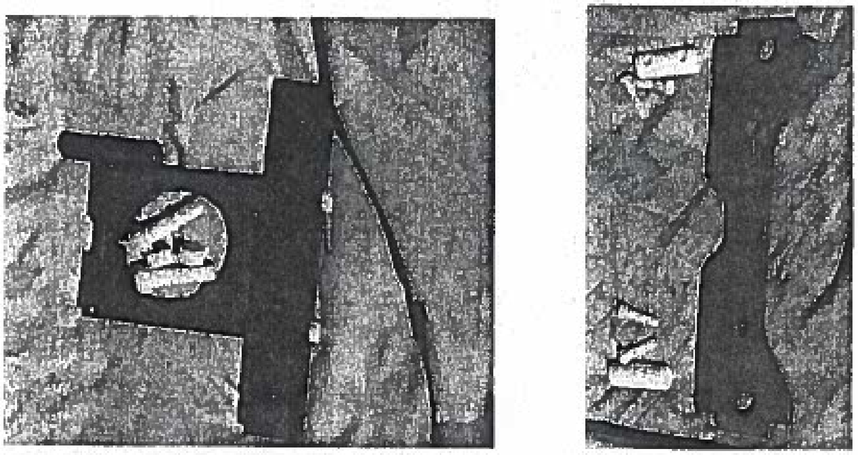


Figure 13: (left) SIS™ clamp with retaining bolts—these are 3/8 x 2" nylon bolts; (right) sled cross-member with retaining bolts.

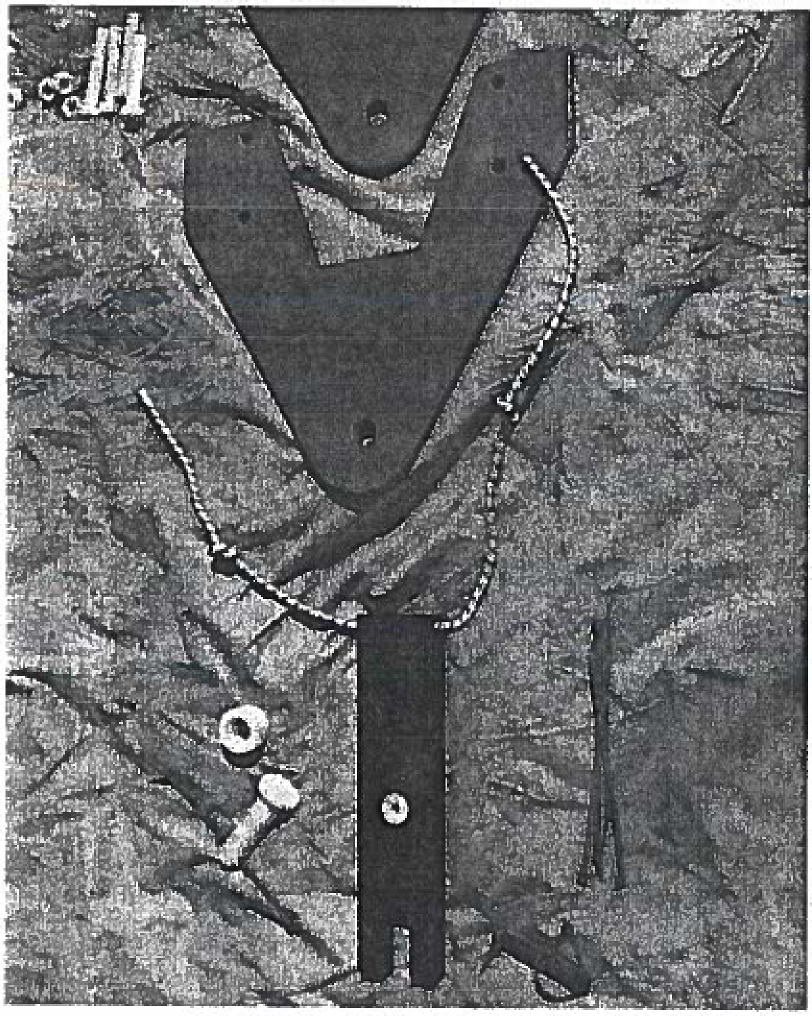


Figure 14: Steering yoke components, part 1.

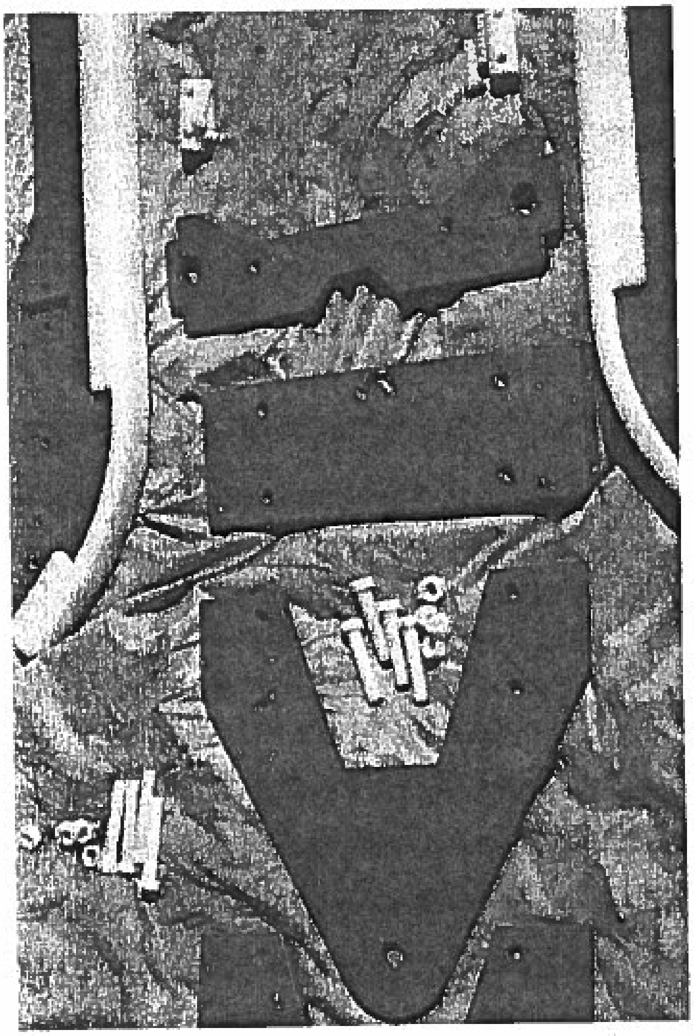


Figure 15: Steering yoke components, Part 2, with forward cross-piece and its retaining pins and bolts.

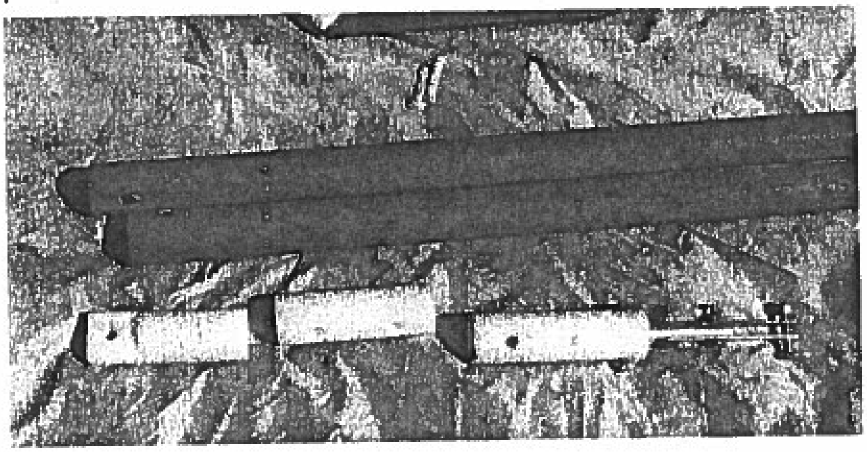


Figure 16: Tow bar segments (red) with steering yoke insert (left), junction plug (centre) and hitch plug (right). The junction plug joins the two tow bar segments.

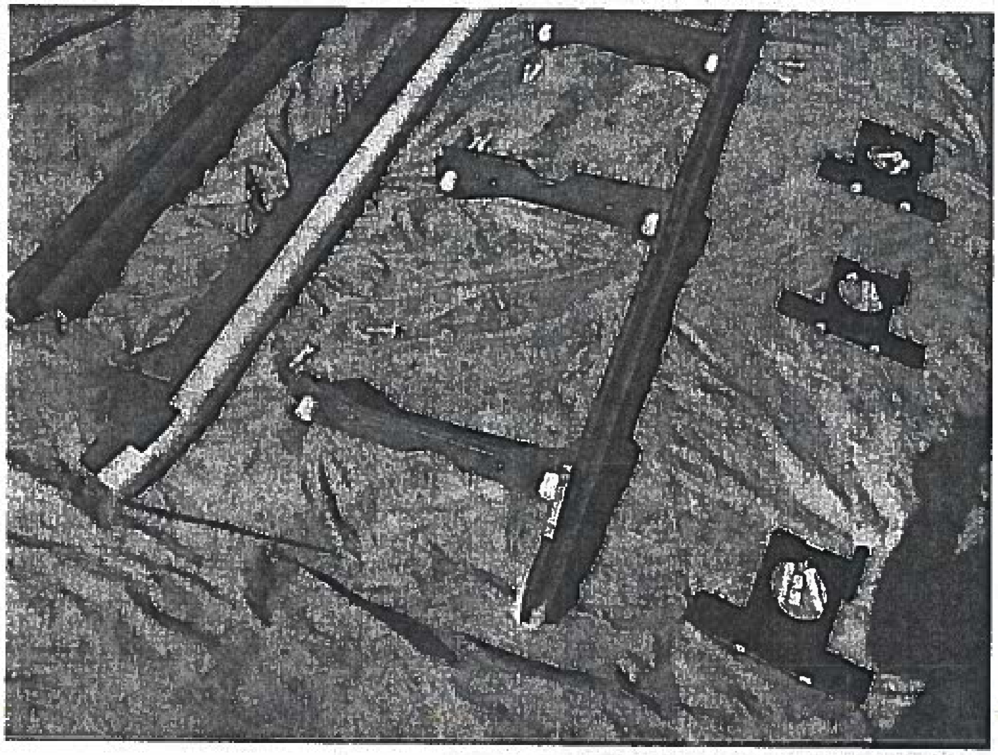


Figure 17: Left skid of sled assembled to cross-pieces. All cross-pieces are identical and interchangeable. The rear cross-piece is shown upside-down in this photograph—the cross-pieces should all have their round indentations facing upwards.

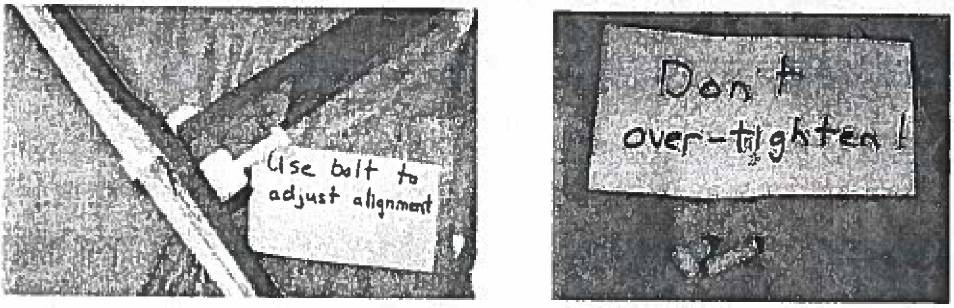


Figure 18: The cross-pieces are attached to the left and right skids by Delrin dowels secured to the skids by nylon bolts. Be careful to avoid over-tightening these bolts, as they will snap and require considerable effort to remove.

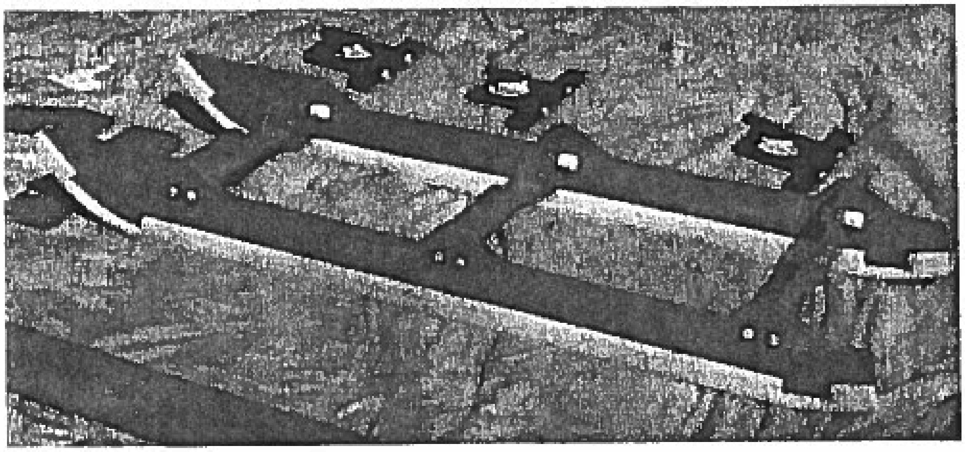


Figure 19: Cross-pieces and skis assembled.

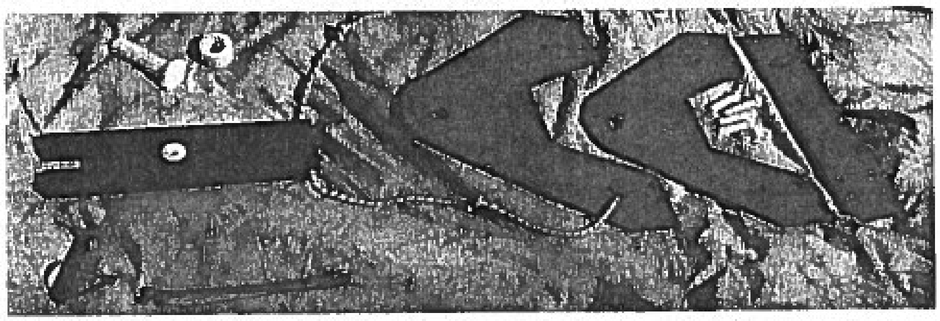


Figure 20: Steering yoke parts before assembly.

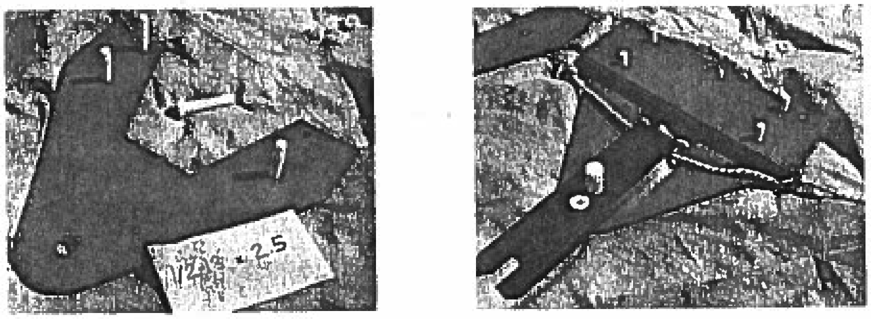


Figure 21: Assembly of lower and middle portions of steering yoke. Note that ½-13 x 2.5" bolts are used for this step. The figure-8 knots in the bungee should be about 1-2 cm farther apart than the width of the middle plate.

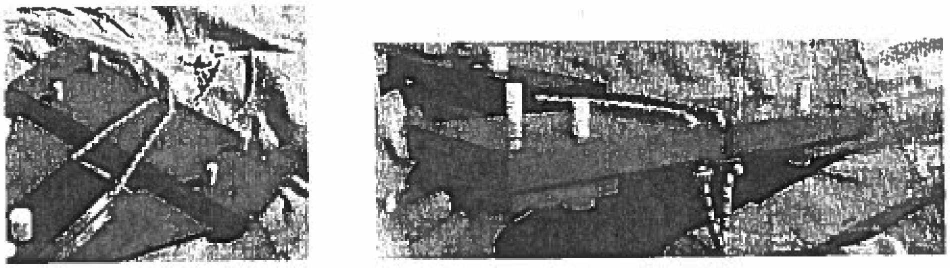


Figure 22: The bungee cord is stretched through the slots at the back of the middle rectangular plate (left) and secured by figure-8 keeper knots as shown on right.

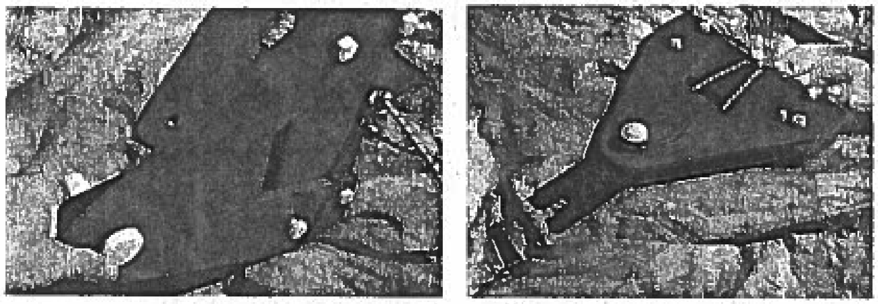


Figure 23: The heavy Delrin clevis pin inserts from the bottom and is secured with a Delrin washer and tie-wrap at the top. The black Delrin pin at left will be used to secure the tow bar to the yoke. It may be preferable to put the bungee knots on the top side rather than the bottom—this can be determined by the user.

Figure 24: The yoke is secured to the skids using the indicated bolts, which are 3/8-16 x 2.0" nylon. These screw into threaded inserts in the middle plate.

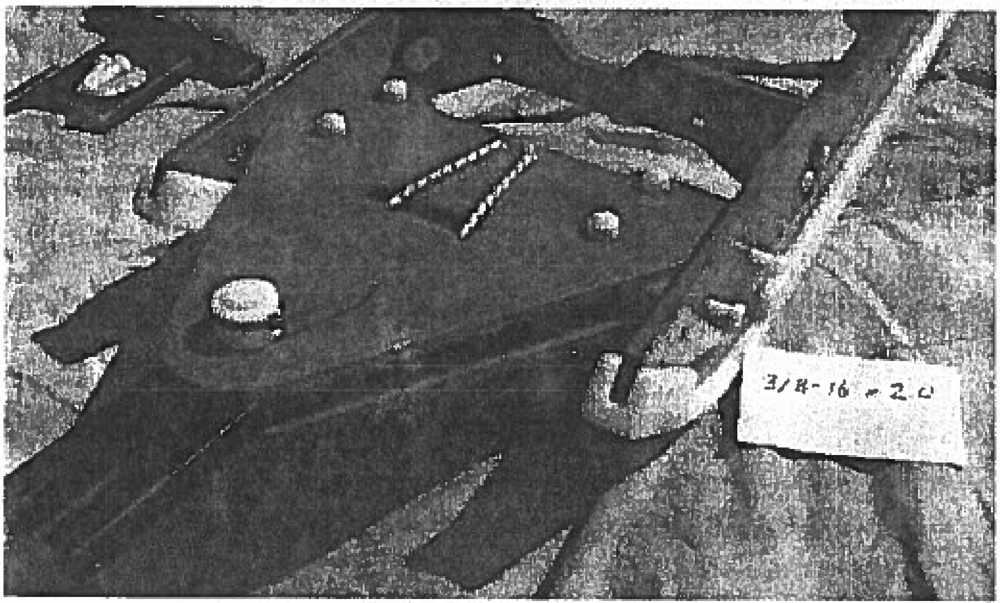


Figure 25: Steering yoke assembly mounted to skids, preparatory to tightening retention bolts.

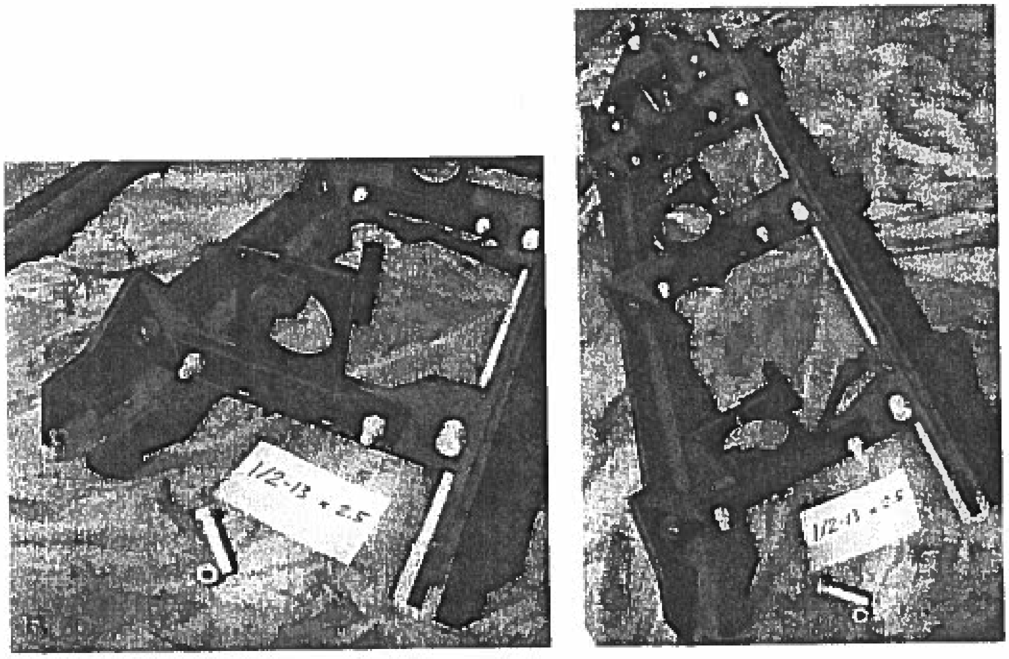


Figure 26: Before the sensor clamps are attached to the cross-members, they should be slid onto the SIS unit (not shown here). The large-diameter clamp fits on from the front, while the two smaller-diameter clamps slide on from the rear. The clamps are then attached to the SIS using ½-13 x 2.5 inch nylon bolts.

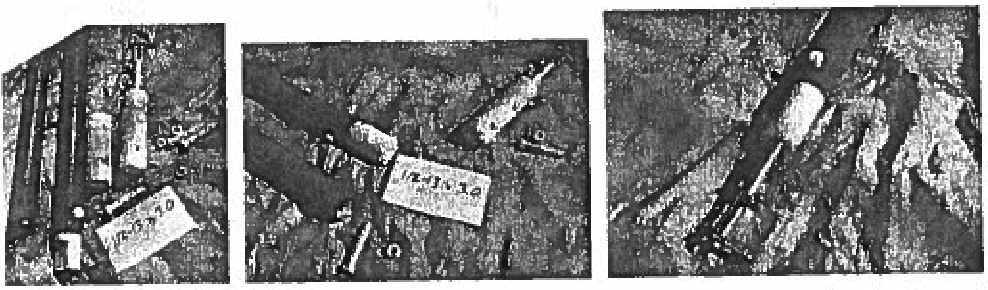


Figure 27: The tow bar segments are joined using ½-13 x 3.0 inch nylon bolts, as is the forward "trailer hitch" plug.

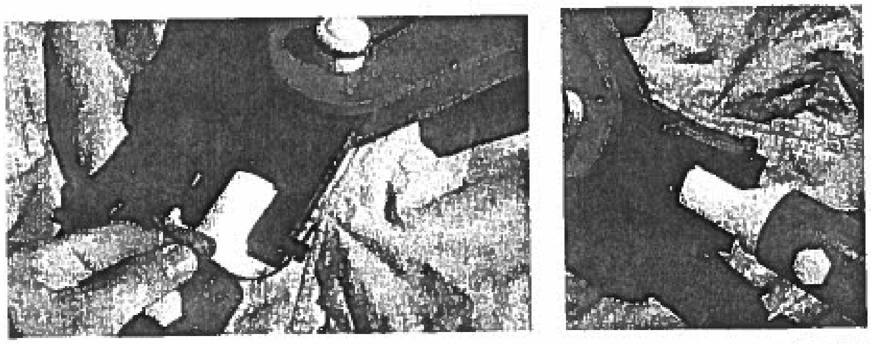


Figure 28: Finally, the tow bar is attached to the steering yoke using the black Delrin pin, retained by a pair of tie wraps. These can be only partially tightened, permitting them to be cut and re-used several times.

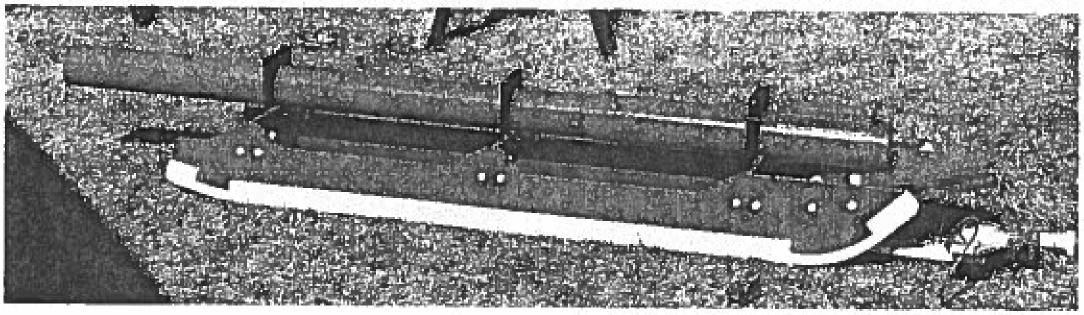


Figure 29: Assembled sled with SIS™ installed. An obsolete version of the tow bar interface is shown in this view.

3.3 Installing the SIS™ Unit:

Lightweight sled:

Prior to field operations, the sensor package must be slipped into the lightweight sled and locked in place using the rear clamps only of the selected sled, as shown in the figures above, with the forward clamp left uninstalled. The forward clamp is then installed, captivating the instrument. The clamps should be tightened to a tight finger-tight level. They may become tighter outdoors after assembly in warm conditions owing to differential thermal expansion of the various plastics used.

Heavy sled:

As indicated above, the instrument must be loosely assembled with all three clamps prior to bolting the clamps onto the heavy sled. After securing the clamps to the sled, the instrument can be oriented to zero roll and the clamps tightened.

UI Connections

The yellow cable from the user interface (UI) attaches to the nickel plated connector just behind the battery enclosure. Just prior to commencing survey measurements, two battery packs should be inserted into the battery enclosure and connected to the power clips. See the next section regarding SIS™ power supplies. The UI should be attached to the instrument before connecting the batteries and closing the lid. See next section for cabling suggestions and precautions to prevent cable damage during operations.

4 Cabling and Power Supplies

4.1 UI and Cable:

The User Interface has a backlit, 4 line, 40 character display, and includes four pushbuttons labelled 1-4 from top to bottom of the UI housing. These buttons permit the user to navigate the menus of the SIS™ software. While the UI incorporates an 8-cell battery compartment in its handle, battery packs should not be inserted in this compartment, as it is not capable of operating the SIS on its own.

4.2 Data and Motorized Surveying Cables:

Apart from the yellow cable attached to the UI, the system is provided with a yellow Data Cable with a circular 4-conductor Microfast connector at one end and a female D9 connector at the other. This cable is used for data unloading from the instrument, and can also be used to control the instrument from a remote computer or log ice thickness data into a remote computer during data acquisition.

A second cable is supplied with the heavy sled, and provides a circular Microfast plug at one end for attachment to the instrument, a female Microfast jack at the other end for attachment to the UI or a Data Cable, and a grey power cable which can be connected to a DC supply in the 12-32V range. A lighter plug has been supplied with this cable, so that the cable can be used to provide power to the instrument from a snow machine.

4.3 The Battery Compartment:

The SIS battery packs supplied with the instrument use cells of the high-capacity NiMH type (note that alkaline AA batteries can also be used in an emergency). This type of battery self-discharges slowly during storage and should be recharged just prior to operation, as well as after every use. The UI should be connected to the sensor before installing the batteries. Connecting both battery packs to the instrument's power leads turns the instrument on. No external switches have been used in order to maximise the robustness and weatherproofing of the battery compartment.

The UI will beep, then display a series of text pages after power-up, culminating in the File Menu. If the UI display is backlit or shows any text, the instrument is powered up (and therefore depleting batteries).

The battery packs are connected in series. Only one pack needs to be disconnected to power the unit off.

4.4 AC Power Supply:

For non-survey operations such as data unloading, it is recommended to use the AC power supply "brick", which should be plugged into the DC socket inside the battery compartment. This "brick" has a universal AC input for use with 110VAC to 240VAC. Its output is 24VDC, with the connector's tip positive. If the power plug is inserted, no power will be drawn from the batteries (nor will they be charged), but note that if the batteries are installed and connected, unplugging the DC power cable will not power the SIS™ down—it will simply switch to battery power.

5 Operating the SIS™

5.1 Pre-survey considerations, precautions and checklist

While the SIS is weatherproof, it is not immersion-proof, so exposure to water should be limited as much as possible. If water, particularly brine, is introduced into the battery compartment, the batteries should be removed and the compartment washed out with clean, preferably de-ionized water. The compartment can be dried with a hair dryer or allowed to drain while upside down overnight. This will minimize harmful corrosion of the electrical components of the battery compartment.

The instrument should be placed on the ice or snow surface before surveying and allowed to come to ambient temperature. This will maximise instrument stability. It is not necessary to power up the instrument before this step.

The instrument should never be powered up adjacent to highly conductive objects such as metal shipping cases, tool boxes, aluminium boat hulls, steel ship's decks and truck beds, etc. Doing so will affect the instrument's calibration and will almost certainly result in non-recoverable data errors. Turning the instrument off for 10 minutes and restarting in a clean (i.e. on-ice, no adjacent metal) environment will reset this condition and allow surveying to proceed.

The SIS™ operates at 9.0 kHz. If two SIS units are operated within a few hundred metres of each other, their strong transmitted fields will interfere with the other unit. Units should be operated at least 200 metres apart to eliminate the chances of such interference.

Equipment Checklist:

1. SIS™ instrument and sled, towing rope or carrying strap
2. User Interface
3. Spare battery packs
4. Battery chargers (if batteries are to be recharged using an AC generator while on-site, perhaps during a lunch break)
5. Computer, USB-Serial adapter and Data Cable (if data are to be uploaded and checked on-site during breaks).
6. AC power supply (for powering the unit from an AC generator while uploading data to a computer)
7. Quick-start guide or this reference

5.2 Power-on

The unit can be powered up by attaching two battery packs to the battery clips in the compartment. Note that although these clips match the 9V battery form factor, a pair of ordinary 9V batteries will not operate the SIS for more than a few seconds.

If desired, and if an AC generator is handy, initial startup and testing can be performed under AC power using the AC supply "brick" and plugging it into the DC jack inside the compartment. This will disconnect the batteries and prevent depletion of their charge, but will not recharge them—they must be removed and inserted into an appropriate NiMH battery charger, such as the ones supplied with the unit, in order to be recharged.

5.3 The User Interface menus

The user interacts with the SIS™ through a series of menus on the system's UI. The same menus can be viewed/accessed using a computer connected to the system using the Data/Power cable and a serial interface adapter.

After power-up, a series of menus, including the following "splash page",

```
>> SEA ICE SENSOR <<
 SN1S1001  SIS v1.0.5
 Copyright  2005-2012
  by Geosensors Inc.
```

are displayed and held for 5 seconds. Next, the Filename menu appears, as shown below.

Filename Menu.

Normally Press 1 & go to Root Menu.

```
1 - OK  SURVEY NAME IS
2 -OK  AAAnnnnn
3 -EDIT
4 - SHUTDOWN
```

where AAAnnnn represents the default filename. Row numbers from 1 (top) to 4 (bottom) in this menu correspond to the UI number keys 1 to 4: thus pressing keys 1 or 2 accepts the default filename, key 3 goes to the Edit Filename menu, and key 4 transfers the user to the Shutdown menu.

The filename used by the SIS, and which will permit identification of a particular session of data acquisition post-survey, comprises three alphanumeric characters, followed by a five-digit integer: the default filename is SISnnnnn, where nnnnn represents the integer portion of the name. The unit stores the most recently used filename, and increments its numeric component by one at the next power-up. When the user first turns on the instrument after receiving it, nnnnn will be a small value like 00001. Pressing the 1 or 2 key will accept the filename as displayed.

The user can edit the filename to change the alphanumeric or the numeric portion. Note that while the alphanumeric portion can assume any values, the numeric portion should never be edited to include non integer (ie values 0 through 9) values.

To edit the filename when this menu first appears, press the 3 key on the UI. This transfers the user to the Edit Filename menu, as shown below.

```
Up            1 - U     SURVEY NAME EDIT       Edit Filename Menu.
Down          2 - D     AAAnnnnn
Move Right.   3 - MR    -
              4- OK (format AAANNNNN)
```

Again, AAAAnnnn represents the current filename, and each line of the menu (in this case with mnemonic letters U, D, MR and OK) correspond to UI keys 1-4. Subsequent presses of the 3 key will move the '-' cursor to the right beneath the filename's characters. Placing the cursor beneath a particular character and pressing the 1 or the 2 keys (corresponding to U(p) and D(own) on the UI will scroll up or down through a preset list of characters and numbers. Pressing the 3 key again moves the cursor to the right (it will reappear beneath the left character after it is moved from the 8'th character of the filename), while pressing the 4 key exits editing mode.

Pressing the 1 or 2 key at this point accepts the filename and transfers the user to the Root menu, 3 allows further filename editing, while 4 goes to the Shutdown menu, shown below:

```
  SHUTDOWN Menu        Shutdown Menu
Shutdown SIS
Shutdown SIS
Return to previous
```

In this menu, pressing key 1 has no effect, pressing keys 2 and 3 will shut down the SIS software, and pressing key 4 returns the user to the menu from which the shutdown menu was accessed.

Normally, the user would simply press 1 in the Filename menu, which takes them to the Root menu, as shown below:

SIS Root Menu.

```
1 Survey Menu      S R
2 RTP Setup        I O
3 TURN EM COMM OFF S O
4 Shutdown SIS       T
```

Real Time Processing (RTP)

1-Root Menu.

In this case, the "SIS Root" menu is identified by the two columns at the right side of the display. This is the "home" menu for the SIS™ software, via which most other functions can be reached. In this menu, the 1 key transfers the user to the Survey Menu, 2 to the Real Time Processing setup menu, 3 turns the EM sensor's communications off, and the 4 key transfers to the Shutdown menu.

The Survey menu is the most commonly used Root Menu option, and is shown below:

```
1 Acquisition Menu
2 View Last Sample
3 View GPS Output
4 Exit Survey Menu
```

The key 1 option in the Survey menu is the Acquisition Menu, while 2 allows the user to review the last measurement, 3 shows the most recent GPS fix, and 4 exits the Survey Menu and returns to the Root Menu.

The Acquisition menu controls the start and end of data acquisition, and after acquisition is started, shows the ice thickness and conductivity estimates as they are processed. It initially looks like the following:

```
1 Go   *
2 Rset
3 Test
4 Exit
```

but after key 1 is pressed ("Go" for data acquisition), it changes to the following:

```
1 G L Cond  Thick
2 R 1 0.001 _1.00m   I
3 T 2 2.500 __.__m   N
4 < 3 _.___  _.__m   V
```

In this menu, pressing the G or 1 key continues to acquire data, pressing R or 2 resets the inversion model to its starting condition, pressing T or key 3 activates

5 seconds worth of "test mode", in which synthetic data are fed to the inversion program to validate that it is working properly, and the < or 4 key terminates acquisition and returns to the Acquisition Menu. The underscores represent parameters not being inverted (this example is for a two-layer model).

If inversion has been turned off in a separate menu (discussed below), then the Go Menu would look something like the following instead:

```
G F Inph  Quad ppt
  1 11.01  5.01 11 E
T 2  7.01  3.01 01 M
< (INVERSION OFF)
```

The G, T and < commands (keys 1-4) act as in the previous version of the display, but the 2 key has no effect. In this display, the values shown are the four EM responses displayed in parts per thousand. The 11 in line 2 and 01 in line 3 indicate that both inphase and quadrature components of the horizontal coplanar receiver are used, while only the quadrature output for the perpendicular receiver is used.

2- Survey Menu

The View Last Data menu looks like the following:

```
L   Con Thk E=m.mmm
1  .011 1.35  m  I
2 2.550 0.00  m  N
3 0.000 0.00  m  V
```

This is a static display. Pressing the 4 key returns to the previous menu.

3- Survey Menu.

The View GPS Output menu yields a display similar to the following:

```
  I Time __:__:__._
  F Lat  +53'23.22153
  R Lon -079'45.39821
4 < P+21.1R-15.3V19.9
     Pitch  Roll  Voltage
```

The 1, 2 and 3 keys on this menu have no effect. The underscores represent GPS time in hours, minutes and seconds. The < or 4 command returns control to, the previous menu. The first two lines of this display are the latitude and longitude, while the last line shows the instrument's Pitch (positive for battery pack end up) and Roll (counterclockwise about the instrument's axis viewed from the receiver end, *i.e.* with battery pack away from the operator) in degrees, and the battery pack's state of charge. The 19.9V shown here indicates that the two series-connected NiMH battery packs are nearly fully charged. NiMH batteries offer a relatively flat discharge curve from their fully charged state, dropping rapidly as they approach the depleted state. When the displayed voltage declines to 18V or less, the battery packs are almost discharged and should be changed out.

2- Root Menu

The Real-Time Processing Setup menu, reached from the Root Menu, permits control of the inversion process through three sub-menus. This menu is shown below:

`Enable/Disable RTP`

`Select Model Setup`

`Set RTP Controls`

`Return to Root Menu`

Command key 1 selects the Enable/Disable Real Time Processing submenu, which controls whether inversion is enabled (default) or disabled, and enables access to the Real-Time Ground Truth Calibration feature of the system. Key 2 selects the Model Setup menu described below, and Key 3 selects the Real Time Processing Controls menu. The 4 key returns to the previous menu.

The Enable/Disable RTP menu is shown below.

`Disable RT Inversion` (becomes `Enable RT Inversion` if disabled)

`Calib to ice thickns`

`RESERVED`

`(prev menu)`

Key 1 turns off real-time inversion. EM and GPS data will still be recorded and displayed, but no inversion results will be acquired or displayed in real time. This function is primarily for use in troubleshooting.

Key 2 enables a real-time ground truth calibration procedure that permits the user to use readily available information (ice thickness) to estimate ice conductivity and sub-ice seawater conductivity from the observed EM data. The revised calibration (the new ice and seawater conductivity values) can then be used for subsequent survey work by selecting Model 1, labelled GTCal, in the Model Setup menu described below. It may prove useful when working in areas where the seawater deviates significantly from the usual 2.55 S/m seen for sub-ice seawater, such as areas of restricted circulation or in brackish waters. The Real-time ground truth calibration process is described at the end of this section.

The Model Setup Menu, reached from the Real Time Setup Menu, allows the user to select between different starting models with different choices of free parameters.

In this menu, the ^ and v commands move up and down through a predefined list of model definitions. The #1 model definition is reserved for ice and water conductivities set through real-time ground truth calibration, while #2 through #8 correspond to models suitable for First-Year (FY) thin ice, FY thick ice, MY Summer ice, MY winter ice, a three-layer MY model, a 3 layer model for use over soils (for non-ice testing of the instrument) and a two-layer model with all three model parameters free to vary.

```
^  L Con Thk #kModID
v  1 0.011Y 1.35Y  M
>  2 2.550N 0.00N  O
<  3 0.000N 0.00N  D
```

where k represents the currently selected model (1-8) and ModID is a mnemonic description for the different model setups.

The Real-time Processing Control Menu allows the user to cycle through 8 predefined sets of inversion controls, labeled 1 through 8. These controls include the number of iterations, the fitting tolerance, and whether the inversion "resets" for every new data sample.

```
U RTP CONTROL SET #_
D Max #Iter _8      R
S RMN_TOL    .001   T
< Reset      Yes    C
```

Pressing U (1 key) moves up through the list, D (2 key) moves down, S selects the current set to use for subsequent inversions, and < returns to the previous menu.

The third submenu on the Root Menu, “Turn EM Comm Off”, deactivates the SISEMS EM sensor for one power cycle after the next power-off.

```
DEACTIVATE SISEMS
 AT NEXT POWERUP?
    1   -> YES
    2-4 -> NO
```

Pressing the 1 key deactivates the SISEMS for one power cycle after power off. A second power-off restores SISEMS operation. This function is for use by Geosensors in troubleshooting and maintenance, and should not be used without special training.

Ground Truth Calibration Process

The Ground Truth Calibration menu is reached through the Enable/Disable Inversion submenu of the Real-Time Inversion menu. The procedure takes place in five stages. The system must be located on flat, uniform ice, with at least 4m of seawater present beneath the ice, and with no significant ice thickness variation within 4 ice thicknesses in any direction (ie 8m when working on ~2m ice). Such conditions are often found on refrozen leads.

The initial series of displays are described below. The first display is shown for 4 seconds:

```
GROUND TRUTH CALIB:
Stage 1:  place SIS
on flat ice where
ice thickness known.
```

The second display, which is shown for 2 seconds, is

```
Ensure no auger hole
within 2m of SIS and
sub-ice water > 10m.
1:Continue, 4:Quit
```

The third display, shown for 1 second, is

```
Enter known snow+ice
thickness beneath
SIS unit in next
menu.
```

At this point, the user enters the local snow+ice thickness, estimated from auger measurements or similarly precise means, using an entry menu similar to that for the Enter Filename menu described above.

```
U   Measured T1 EDIT '
D       1.0000000
MR      -
OK
```

Selecting the 3 key moves the cursor to the right, while pressing the 1 or 2 keys move up and down through the numerals 0-9. This allows the numeric value to be set, after which the 4 key can be pressed to accept the edited value. After the thickness has been entered, the following is displayed:

```
Ground truth sno+ice
thickness entered
=ttttttt.ttttttt m
```

This is followed by a series of displays as the system acquires multiple samples over the ground truth site:

```
Ground truth inverse
calculation underway
Inversion iteration
#iiiii for T1=ttt.tt
```

where iiii represents the iteration number, and ttt.tt is the ground truth calibration thickness, followed by a summary of the two estimated conductivities determined by inversion with the known snow plus ice thickness:

```
Average estimated
conductivities are
Sig1=ss.ssss S/m
Sig2=SS.SSS S/m
```

As mentioned earlier, these values are saved in Inversion Model #1, labeled GTCal. This inversion model is automatically selected for the remainder of the survey session, and can be selected in later sessions through the Real Time Processing and Model Selection menus.

It is wise to perform a normal inverted measurement at the ground truth calibration site after completing the ground truth calibration process, in order to verify that the real-time inverted ice properties match those entered and determined during the calibration process, and that the fitting error is negligible. The ground truth calibration process can be repeated multiple times, if desired, to obtain a sense of the accuracy and stability of the water and ice conductivity estimates.

5.4 Survey methodology

General Considerations and Constraints

The SIS™ is built to withstand reasonable levels of impact or vibration. However, like any complex device that includes precision structures and electronics, it should not be dropped onto hard surfaces, run over or into by vehicles, or rammed into ice blocks at speed. Cable runs have been minimized in the Mk2 system, but the user interface (UI) to sensor cable is somewhat vulnerable to damage, particularly from sharp edges or crushing, localized loads, and it does become stiffer and more vulnerable at extremely low temperatures.

The SIS™ has been carefully sealed and should be weatherproof, but it is not immersion-proof—never permit it to be submerged in water. If this does occur, remove the battery packs at once, rinse (with fresh water) and dry the affected components system, including the interior of the battery compartment, in order to remove any salt.

If the instrument is being towed by a snow machine, its special tow cable with internal power feed should be used, and the UI plugged into this cable, with the power plug being attached to the vehicle's power system or a set of batteries, taking care to ensure the correct polarity. Note that the instrument's internal battery packs will not charge when external power is being used, and that battery packs should not be connected inside the battery housing under this power configuration. External power applied through this cable can range in voltage from about 12V to 32VDC, but should not lie outside this range. The instrument will run whenever its power is connected.

The tow cable should be attached to the tow bar, sled and probably the snow machine as well, including service loops at all hinge points in order to avoid straining the cable or its connectors. Tie wraps are not ideal for this job because if pulled tight, they tend to kink the conductors and could under some conditions cause localized fatigue and failure of the cable. Use strain and compression relief wherever tie wraps may be desired, such as several wraps of tape around the wire, tapering to each side of the attachment point, to increase the minimum radius of curvature and avoid fatigue.

There is a battery socket built into the UI's handle, but this should not be used for running the SIS™—the handset's internal electronics are not capable of operating the full instrument for more than a few seconds.

Running a Survey

Safety Considerations:

While the SIS™ yields remarkably accurate ice thickness estimates under normal operating conditions, the system should not be used as the sole basis of assessment of the safety of an ice mass for walking, landing an aircraft, driving a vehicle, etc, as its ice thickness estimates can be affected by a variety of conditions, including but not limited to sub-ice freshwater layers (these may be common in summer or in estuarine environments), shallow sub-ice seawater caused by a shoal, sub-ice rafting, lateral proximity to thick ice blocks, and a variety of potential user or internal errors. In any safety-critical situation, multiple measurements of different types should be used to assess ice thickness!

Maximising Positional Accuracy:

The GPS built into the SIS™ is a highly sensitive, 12-channel device with WAAS/EGNOS differential capability. Under good satellite visibility conditions, its nominal accuracy is on the order of 3m. Based on experience to date, its repeatability under these conditions for intervals of an hour or so appears to be ~1m. The GPS stores its last position and ephemeris information in internal non-volatile memory, so it can usually re-locate itself rapidly if it has not been moved substantially since its last fix. However, if the instrument has been moved hundreds or thousands of km since its last fix, the ephemeris data are likely to be incorrect, and the unit may take up a few minutes to re-establish a good fix.

For this reason, the instrument should be allowed to run for a few minutes before starting to survey if it has been moved a substantial distance since its last fix.

Maximising Sensor Stability:

The EM sensor used in the SIS™ is internally thermally compensated, so that its base or zero level should be accurate at any normal temperature, such as +10°, 0° or -20°C. However, rapidly changing internal temperature, such as would occur when the instrument cools down from indoors temperatures to -20°C, will cause transient base level errors that could be strong enough to affect ice thickness estimates, particularly over thick ice where small EM responses are expected.

Therefore, at the outset of a survey, unpack the sensor immediately and install it in its sled at the survey base site to allow the sensor to come to equilibrium with local temperature conditions at the survey site. If the instrument is very warm relative to its surroundings, 30 to 60 minutes is not too long for this process. If the instrument was stored outdoors or on deck, rather than indoors, there should be less of a thermal change and a shorter acclimatization period, say 15 minutes, can be used. After transporting the instrument in a heated helicopter, the same general considerations apply. The instrument does not need to be running during the acclimatization period—it can be turned on just a few minutes before surveying is to start.

Importance of Base Site and Survey Loops:

It is useful to establish a base site when working on a given floe or on landfast ice, to which the system can be returned frequently to monitor the stability of the instrument and to detect and correct for ice motion. The easiest way to do this is to define one measurement site, preferably on flat, undeformed ice, as a base, marked on the ice and perhaps located by a non-metallic stake and flag. Obtaining ice thickness estimates using an auger at one or more locations around this base site will allow rapid assessment of the instrument's accuracy: note that cuttings and particularly brine or slush from any auger holes (and the holes themselves) should be kept more than 1-2m (more over very thick ice) away from the sensor location to avoid affecting the EM response of the ice at the measurement site.

Placing the survey sled on this location in the same orientation relative to the markings at the beginning and end of each survey loop (and noting any changes in snow thickness etc from one measurement to the next) ensures that geometrical coupling changes relative to nearby, possibly hidden ice structures does not change the sensors EM measurement and apparent ice thickness.

Loop Duration:

Special circumstances are addressed below, but in general it is a good idea to perform surveys in relatively short loops of duration 1 hour or less when working on mobile ice, with the start and end of each loop including measurements at the base site.

Survey Filenames:

The survey filename entered or accepted in the Filename Menu, which will have the form AAAnnnnn (eg SIS00001), is the label that is stored in the instrument's internal memory to identify a particular survey segment. It is advisable to separate survey segments from each other by shutting down and restarting the sensor between segments, which permits the sensor software to increment the survey's numeric portion by 1 (eg to SIS00002).

A shutdown and restart that does not record any sensor data will not be incremented. Thus, if the user shuts down, restarts and accepts a new incremented filename, then shuts down again, then the instrument will propose the same incremented file number at the next startup.

It is useful to shut down the instrument when a long pause will be required in data acquisition—this will reduce battery drain. At startup, the user should note the new filename, as usual. The resulting separate data files can be appended to each other after unloading and transcription to facilitate ice motion correction or for plotting as a whole.

Checking the Battery Charge:

The charge state of the battery pack can be checked via the View GPS Output item of the Acquisition Menu—the number at the bottom right of the display is the battery voltage. This voltage should remain close to 20V for most of the battery packs' charge, due to the relatively flat discharge curve of NiMH cells. When this voltage starts to decline rapidly, say near 18V, the batteries are nearly exhausted and the instrument should be shut down for battery replacement, before restarting the survey. As usual, the filename will increment after the restart, which should be recorded in the operator's notes.

Fast ice vs Pack ice

Except in the unusual case of performing surveys along short lines consisting of measurements at a series of marked and surveyed-in locations, ice drift is a major consideration for recovery of the survey track from GPS measurements. Thus, when surveying on moving ice (unless there is a network of ice beacons for tracking ice drift, including one beacon on the floe being surveyed) it is essential to perform surveys in loops. Keeping loop durations short will reduce interpolation errors arising from velocity changes that might occur while the loop is being performed.

On stationary ice, it is helpful but not essential to perform loops, since correction for ice drift velocity is not required.

Summer vs Winter multi-year ice

There are four distinct two-layer model setups (#2 to #5) available in the Model Setup menu that are intended to cover thin (~1m or less) first year sea ice, thicker (~2m) first year sea ice, summer multi-year ice, and winter multi-year ice. There is also a three-layer MY model setup available, but this is not recommended for use during surveys with single-separation SISEMS sensors. Summer MY ice is slightly more conductive than winter MY ice by virtue of its temperature, and has a much greater likelihood of being invaded by seawater, which would sharply increase its bulk conductivity. Thus the summer MY ice configuration has a higher starting ice conductivity and more range in this parameter than the winter MY ice setup.

Motorized Surveying and Survey Speed

The heavy sled with rigid tow bar should be used if the SIS™ is operated behind a snow machine or ATV—there would be safety and other issues with towing the lightweight sled behind motorized transport, such as being struck from behind during sudden stops, losing control of the sled due to inadequate steering control, and so on.

While the data acquisition and RTP system are capable of operating at sample rates of at least 2 Hz, it has been limited to 1 Hz for the present time to maximize reliability. This means that at a walking pace of 1 m/s, spatial sampling will be on the order of 1m. Operating at higher speeds will increase the spatial sampling interval proportionately.

One way to think about required spatial sampling density is that it's desirable to have multiple samples per EM footprint. If the EM footprint is approximately 3.3 x (ice thickness plus .2m sensor height) in diameter, 1m sampling (corresponding to a tow speed of 3.6 km/hr) would be adequate down to about .4m ice thickness. For 2m ice, the footprint is 7.3m, so the sensor could be towed as fast as 3.6 m/s or 13 km/hr without seriously undersampling the ice thickness. Except over relatively flat ice that would not require a high sampling rate, it seems unlikely that higher speeds would be employed routinely.

5.5 Battery life

Estimated battery life is a little over three hours with freshly charged NiMH 2700 mAhr cells. All battery packs should be kept warm (inside the user's coat, for example) when not in use. Batteries should be charged just before heading out for the day to maximize their charge. Installed batteries are warmed by waste heat from the processor located beneath the battery compartment while surveying, extending their life under cold conditions. It is very important to avoid shorting the exposed terminals on the battery packs—never leave several battery packs loose inside a pocket. Shorting the connections can cause a fire or severe burns, and may damage or destroy the batteries themselves. Rather, wrap them or slip them into non-conductive sleeves before putting them in a pocket, or separate them into multiple (empty) pockets, or into pouches in a belt or harness worn inside the user's coat. Battery voltage can be checked via the View GPS Output display.

5.6 Power-off

It is important to shut down the system using the Shutdown Menu before disconnecting power to ensure that the Filename and other information are updated properly. At least one battery pack must be disconnected to turn off the instrument. If AC power is being used, disconnecting it will not turn off the instrument if the batteries are still connected.

6 Unloading Data from the SIS™

6.1 Connecting a computer to the SIS™

An RS232 serial interface is required in order to unload data or communicate with the SIS for other purposes. Since most modern computers, particularly laptops, do not include RS232 ports, it is usually necessary to use a USB-Serial Adapter. If a computer(s) was purchased as an option with the SIS, such an adapter has been provided. The adapter will have been configured during its installation to act as COM1: this can be checked or repeated through the Control Panel/System/Device Manager/Ports/Advanced menu when the device has been plugged into its USB port.

Note that on some computers, plugging the interface cable into a different USB port may change the serial port's operating parameters, including its COM port number. The same USB port should therefore always be used to eliminate this possibility. As a convention, the top, left, front USB jack on laptop computers should always be configured to use with the USB-Serial adapter—this should minimize the number of COM port mismatches that are encountered.

The serial port adapter should connect to the female DB9 plug on the Data/Power Cable, while the other end of this cable attaches to the connector used by the User Interface during field operations.

6.2 Operating the SISMk2Unload program

Unloading data from the SIS Mk2 system is performed using the following sequence (a different program and sequence are required for the SIS Mk1 system). The software, shortcut and folder configuration set up on the computers delivered with the system is assumed.

Downloading data.
*Can be done inside.

1) Connect instr. w̄out Power to the laptop
2) Power up the System w̄ the plug or batteries.
3) Open SIS Mk2 Unload.
4) Unload .RAW data.
5) clear data
6) Power down & disconnect.

1. Start the computer up. There is no password, just press Enter. The display should look like the screenshot below (the background image will likely be different.)

2. Connect the sensor to the computer using the serial-USB adapter
3. Verify that the adapter was installed properly (the information bubble shown by the computer at lower right should indicate that the device was installed as COM1)
4. Connect the power supply to the instrument
5. Double-click on the SISMk2Unload icon on the desktop (green and white, near bottom left of screen in screenshot above)

6. The program should connect to the instrument, unload the data in RAW form to a file named as follows: **XChhmmss-ddmmyyyy.RAW**, where hh,mm,ss are the time of day in hours, minutes and seconds, and ddmmyyyy is the date. The RAW file is a "container file" that may include data from multiple survey episodes, each with their own filename. As such, the RAW file comprises critical data that should be archived, with its filename noted in the operator's field notebook. It can be re-transcribed at a later time to put the data into different formats as required.

   Note: it is wise for the user to use Windows Explorer (also available from a desktop icon) to verify that the RAW file has been downloaded to the user directory and that it has the expected (non-zero) length before answering "y" to erase the survey data from the SIS™ main memory. The RAW file can even be copied to a second data volume (eg a USB stick) for safekeeping before proceeding with the erasure.

7. The program then requests permission to clear the survey data from the instrument's memory. This should be done whenever practical because otherwise, the existing data will have to be unloaded again before any new data are unloaded (so the RAW files become larger and larger as data accumulate in the system's memory.) The sensor has a limit of 65000 total records, including EM, GPS and inverted ice property records; when the memory becomes full, the instrument overwrites the oldest data first.
8. After clearing the memory, the program transcribes the data to ASCII (text) output files written in the ICE format, into the same folder where the RAW file was stored, and exits.

6.3 Data Transcription

The RAW file described above can be transcribed to a variety of formats using program SISMk2Xcribe. It is operated as follows:

1. (follow same startup process as for data unloading, but the SIS sensor and the serial connection are not required, just the RAW files from a previous unload operation.)
2. Double-click on the black FieldData icon, which starts a Command Line window in the FieldData folder, where RAW files are deposited by the SISMk2Unload program.
3. Using Windows Explorer, note the particular RAW file to be transcribed. This program only reads one RAW file at a time. The user can type the entire filename, or use the following method to capture the filename to the Windows Clipboard: First, left-click once on the filename entry in Windows Explorer—this should highlight the filename, but not the extension. Hold down the shift key and click to the right of the .RAW extension—this should highlight the entire filename. Press the <CTRL> and C keys simultaneously to copy the filename to the Clipboard.

4. Return to the Command Line window. Type SISMk2Xcrib, followed by a space, then right click with the mouse—this should write out the stored filename from the Clipboard into the command line. Press the spacebar again and type the format selector: one letter selected from the left column of the following summary. Lowercase or uppercase letter codes work identically for format selection.

*

Format Selector	File Extension	Format Description	Used For
i	.ICE	Position, ice parameters, sensor and GPS info	Quick-look assessment
p	.IDF	"Inversion Data File", includes EM data in ppm for use by inversion program.	Post-processing
L	.LOG	"Log" format (mainly used for diagnostics)	EM sensor troubleshooting

5. The program will read the RAW file, identify one or more SISnnnnn filenames stored within the RAW file, and output the data for those files in the selected format.

As an example, the command line to produce an ICE format file or files from the raw file XC130803-03142012.RAW unloaded from the Mk2 system will look something like the following:

```
SISMk2Xcrib XC130803-03142012.RAW i
```

Space Space

6.4 Data file Names and Types

The *RAW file*, such as file XC130803-03142012.RAW, extracted by the SISMk2Unload program from the sensor, can be thought of as compressed data that encapsulates everything that was stored by the sensor during acquisition.

The *transcribed* files generated by the transcription process have output filenames of the form SSSnnnnn.ext, where SSS is the filename prefix set by the user (default value is SIS), nnnnn is the file number assigned by the user or the instrument, and ext is the file's extension. There are several file extensions, with corresponding formats, available from the unloading and transcription programs, which are summarized in the appendices. The default extension and format is ICE, for which a sample line (with some whitespace excised) is included below. A DAT file is also generated by the program, which can be viewed with the Sensors By Design DatFileViewer application.

The data fields for the ICE format are: **Latitude, Longitude, Sig₁, T₁, Sig₂, RMN, reserved, Height, Pitch, Roll, Time_Sec, reserved, reserved, reserved, reserved, dmode, NSAT, HDOP, GPS_Alt** where Sig_1 is the estimated ice conductivity in S/m, T_1 the estimated ice thickness in m, Sig_2 the estimated seawater conductivity, RMN the normalized fitting error, Height the sensor height above snow/ice surface in m, Pitch and Roll the sensor orientation in degrees, Time_Sec is the GPS time in seconds, DMODE is the GPS operating mode (0 for no fix, 1 for normal fix, 2 for WAAS differential fix), NSAT is the number of satellites used for the fix, HDOP is the horizontal dilution of precision, and GPS_Alt is the estimated GPS altitude. "Reserved" indicates data fields that will be used by future versions of the software.

```
44.263763 -79.118520 3 0.0047  0.4800  2.4600 0.0071 1 0.20 0.00 0.00  63772 0 0  168470.3  1360.9 2 9  1.100  265.6
```

7 Data Processing

Displaying real-time data from the ICE file:

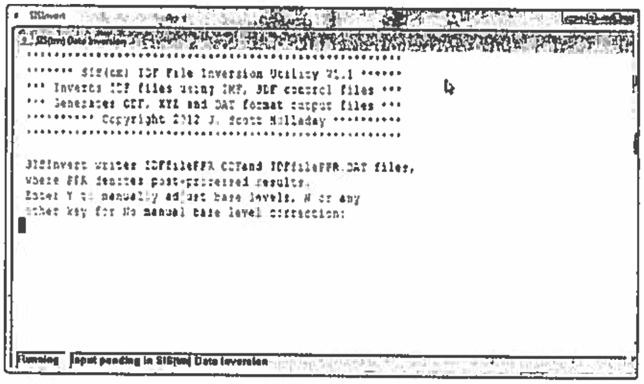
The most straightforward way to view data from the ICE-format file would be to import it into Excel or a GIS program. Individual survey loops can be broken out and drift-corrected. Users of the Sensors By Design Datfileviewer program can view the DAT file output of the transcription process directly.

Re-inverting data:

Reprocessing SIS™ data can be performed to make better use of *a priori* data such as known ice or sub-ice seawater conductivities, or to correct the acquired data for small static errors. The specialized program used for this purpose, called SISInvert, is described below.

SISInvert is a Windows-compatible version of the software used within the SIS to estimate ice thickness and conductivity. It is operated by clicking on the appropriate Start Menu icon (or the Windows Desktop icon)—an enlarged view of the program icon is show below.

Clicking on the icon brings up the SISInvert Data Inversion window, shown below. In the following sequence, an SISMk1 data file from 2011 is used, but the program works identically with SISMk2 IDF files.

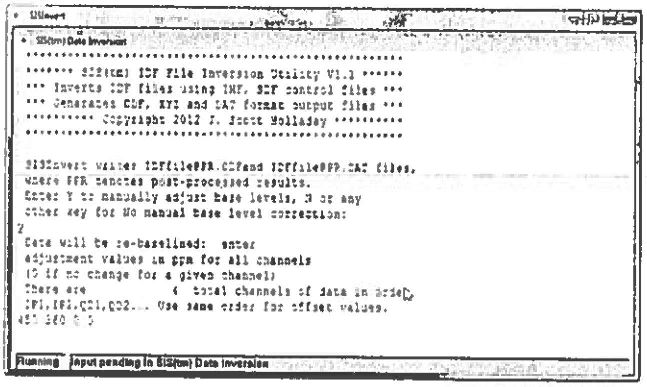


```
**************************************************
******* SIS(tm) IDF File Inversion Utility V1.1 ******
*** Inverts IDF files using INF, SDF control files ***
*** Generates CDF, XYZ and DAT format output files ***
********** Copyright 2012 J. Scott Holladay **********
**************************************************

SISInvert writes IDFfilePPR.CDFand IDFfilePPR.DAT files,
where PPR denotes post-processed results.
Enter Y to manually adjust base levels, N or any
other key for No manual base level correction:
```

The banner at the top of the screen identifies the software version and requests user input regarding adjustment of base levels. Since base levels are normally so stable that such offsets are negligible, the normal user response would be to press the upper- or lower-case "N" key or the <Enter> key to skip this step.

However, if the user does wish to apply an offset to one or more data channels, pressing Y, then <Enter>leads to a user query:



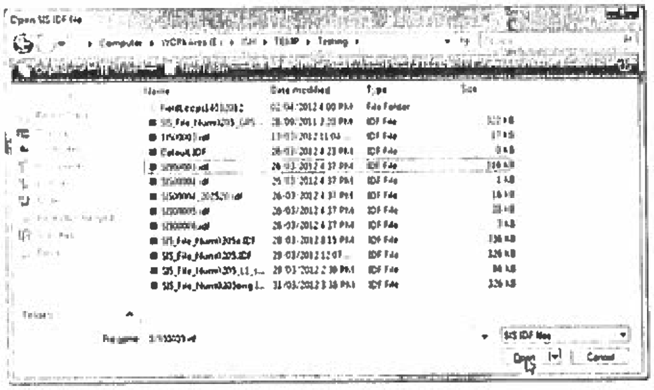
```
**************************************************
******* SIS(tm) IDF File Inversion Utility V1.1 ******
*** Inverts IDF files using INF, SDF control files ***
*** Generates CDF, XYZ and DAT format output files ***
********** Copyright 2012 J. Scott Holladay **********
**************************************************

SISInvert writes IDFfilePPR.CDFand IDFfilePPR.DAT files,
where PPR denotes post-processed results.
Enter Y to manually adjust base levels, N or any
other key for No manual base level correction:
Y
 Data will be re-baselined:  enter
 adjustment values in ppm for all channels
 (0 if no change for a given channel)
 There are            4  total channels of data in orde
 IP1,IP2,QD1,QD2... Use same order for offset values.
450 200 0 0
```

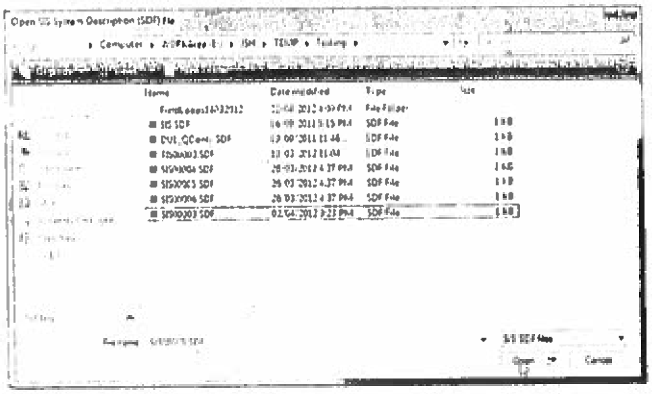
At this point, the user would enter offsets in ppm units of all of the four EM channels used by the system, in the order IP1, IP2, QD1, QD2, using 0 for those channels not requiring adjustment. This would be useful for reprocessing the 2011 SISMk1 data, for example, which had a small offset of about 200 ppm in its IP1 channel. The offsets entered by the user are subtracted from the observed data. Entering four zeros is equivalent to skipping the offset adjustment step. Another way to enter and use input offsets will be discussed below.

Returning to the normal operating sequence, pressing N or any other key in response to the "Enter Y to adjust base level..." query brings up the "Open SIS IDF file" dialog window shown below, in which the user may select the desired "IDF-format" file set up during data unloading and transcription. This dialog window allows browsing to files in other folders on the user's computer. When the correct data file has been located and selected with a left-click, the filename will appear in the "File Name" box at lower left in this dialog, at which point the user can click on the "Open" button. Alternatively, double-clicking on the filename in the list will select and open the file.

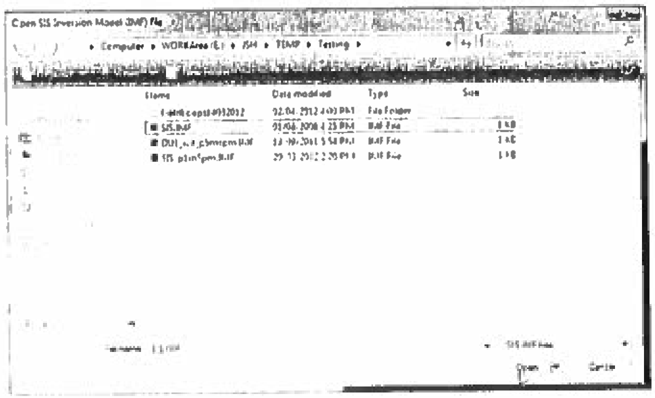
(Failing to select a file (by pressing the Escape key or clicking on the Cancel button) in this and subsequent dialogs aborts the SISInvert session.)



When the IDF file has been selected and opened successfully, the Open SIS System Description (SDF) file dialog appears.

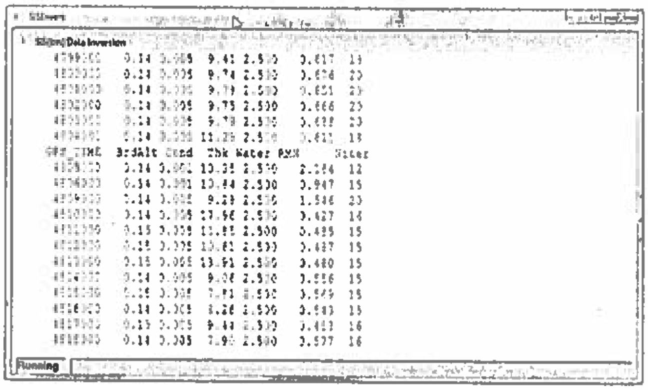


The System Description file, which is automatically generated for each IDF during standard data transcription but is normally equivalent to the standard system description included in SIS.SDF, provides the inversion software with the geometrical information required to process the EM data properly. After double-clicking on the appropriate file filename or single-clicking and clicking on the Open button at lower right, the Open Inversion Model File dialog appears.

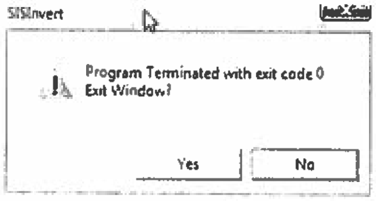


This dialog allows the user to select a pre-defined file that defines how SISInvert will process the IDF. The IMF file can be edited by advanced users when necessary for special circumstances or to "tweak" the inversion for *a priori* information (the user should always name the resulting file something other than SIS.IMF!) The default SIS.IMF file will typically yield stable and useful results, while incorrect changes to the IMF can lead to unpredictable and sometimes misleading inversion results.

When the IMF has been selected and opened, the inversion process starts, with a scrolling display of inverted results punctuated by column identification labels:



No input is possible during the data inversion process, although typing <CTRL>C will abort program execution. When inversion has been concluded, a final dialog appears:



Program Terminated with exit code 0
Exit Window?

Clicking on the Yes button closes the program window and this dialog. Clicking on No leaves the program window open for inspection. It may be closed by clicking on the X icon at the upper right corner of the window.

Note that after program execution is complete, the file locations for the IDF, SDF and IMF are saved, and will be used as the starting folder for the next Open IDF File dialog.

When inversion has been completed, two new files will be present, located in the same folder as the original IDF file. In the present example, these filenames would be as follows: note that PPR has been appended to the original IDF filenames to distinguish them from real-time results unloaded and transcribed from the instrument. The ICE format file

SIS00003PPR.ICE

lists position, time and model parameters ice thickness, ice conductivity and water conductivity. The ODF file

SIS00003PPR.ODF

includes the same information, plus the observed and fitted EM responses.

It is also possible to set up EM input offsets ahead of time for one or more files. Using a text editor, a file may be created with the same name as the IDF file and extension .OFF, *e.g.* SIS00003.OFF

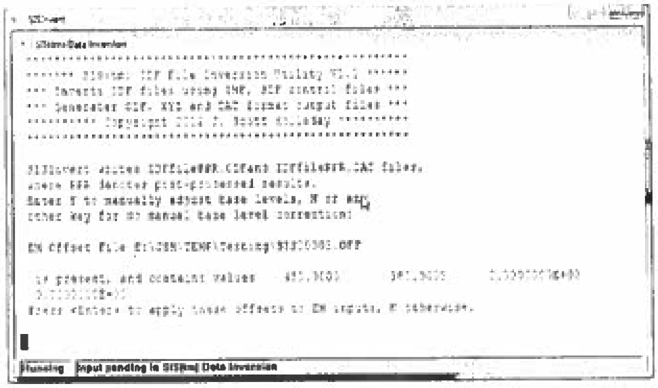
The same offsets that the user would enter as manual offsets may be typed into this file. Using the values shown in the example above, the first (and only) line of this file would look like

450 360 0 0

The file should then be saved to the same folder as its corresponding .IDF file. If the same offset is to be applied to several files, copies of this file can be made and renamed to match those files.

When manual offsets have not been specified in SISInvert, the program checks for the existence of a file with the same name as the IDF file, and extension .OFF just before starting to read the IDF file.

The values read out of the .OFF file are presented to the user as shown in the screenshot below:



The user then has the option of rejecting these values by typing N and <Enter> or accepting them by typing <Enter>. The inversion then proceeds as before, using the offsets or not according to the user's choice. This method was included so that old data files could be reprocessed without requiring the user to remember whether some or all of them required offset adjustment: if the .OFF file is present in the same folder as its corresponding .IDF file, the program will automatically find it in the folder and point out its existence and stored offset values to the user.

8 Troubleshooting Guide

9 Quick-Start Guide

Appendix A: File formats

Inversion Data File (IDF)

Ice Model File (ICE)

Output Data File (ODF)

Datfileviewer File (DAT)

10 Appendix A: Geosensors Contact Information

Please contact Geosensors as follows:

Geosensors Inc.
Attn: Scott Holladay
66 Mann Ave
Toronto, ON M4S 2Y3
Canada

Tel: 416 483 4691
Fax: 416 438 9909
Email: Scott.Holladay@geosensors.com

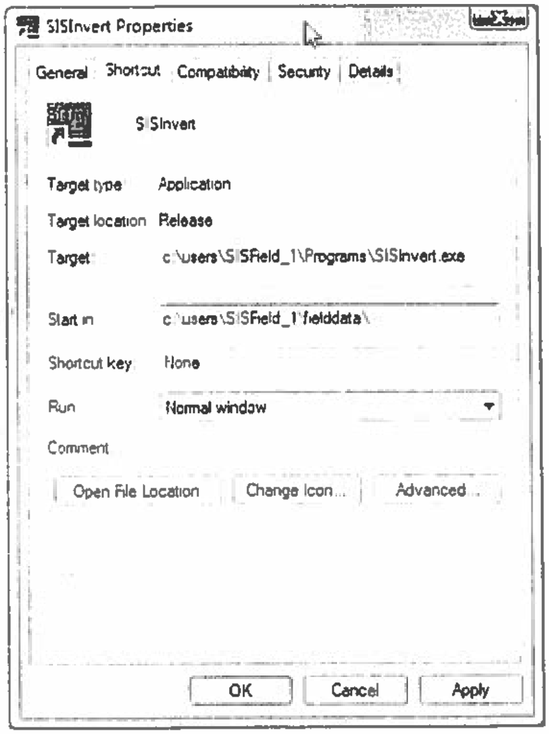
10 Field Computers

10.1 User Folders

Two Toshiba notebook field computers were supplied with the SISMk2 package. The main working folder on these computers is c:\users\SIS_Field_n, where n=1 or 2.

The main working folder has the usual AppData hidden folder, Contacts, Desktop, My Documents etc. To these folders has been added \Programs, \FieldArchive and \FieldData.

\Programs is the common location for all software, shortcuts, icons etc required by the user to unload data from the sensor and process it. There is a readme.txt in this folder summarizing the contents. It is likely that the shortcut file supplied with SISInvert will need to be edited to point properly to the full location of the corresponding icon, SISInvIcon.ico. Once the shortcut works properly, it should be copied to the desktop and to the Start menu. When modified, the shortcut Properties should look like the following:



SISInvert Properties

SISInvert

Target type: Application
Target location: Release
Target: c:\users\SISField_1\Programs\SISInvert.exe
Start in: c:\users\SISField_1\fielddata\
Shortcut key: None
Run: Normal window
Comment:

The folder \FieldData is the main location for data to be retrieved to, processed in, etc. Subfolders may be used within \FieldData to separate current surveys. Data that are no longer current should be archived to \FieldArchive.

The file Readme.txt in \FieldData reminds the user how to download data from SISMk2 and from the "old" SISMk1 system.

The desktop icon labelled \FieldData opens a command window in folder \FieldData in which the data unload operation can be conducted.

10.2 Using the Command Line interface

The RAW filenames generated by the SISMk2Unload program can be a bit long to type easily. When transcribing the data using SISMk2Xcrib, their values can be copied onto the Windows Clipboard out of the Windows Explorer window by highlighting the filename and typing <CTRL>C, then pasted into the command line by positioning the pointer and clicking the right mouse button. The same trick can be used for other tasks in the Command Line window. Thus, in the following command line:

```
C:\users\SISField_1\FieldData> SISMk2Xcrib   XC130803-03142012.RAW   p
```

--the "C:\users\SISField_1\FieldData >" portion is the prompt, indicating the current default folder,
--the "XC130803-03142012.RAW" is the raw filename copied from Windows Explorer,
--the "SISMk2Xcrib" is the transcription program name for the Mk2 sensor, and
--the "p" denotes that the transcription program is to generate a "ppm" file of type .IDF, which can be used as an input to the SISInvert inversion program.

To unload data from the SISMk2 and generate IDF files in addition to the automatically generated .ICE and .SDF files, the user would type (at the c:\users\SISField_1\FieldData> prompt)

```
SISMk2Unload p
```

and follow the prompts.