ICEPIC™

INSTALLATION AND OPERATIONS MANUAL

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ABSTRACT

This manual provides guidance for the installation and operation of the IcePic™ helicopter-mounted sea ice thickness measurement system. It is not intended as a substitute for the formal installation and operations documentation provided by JCM Aerodesign, but rather as a non-approved supplement to these documents.

TABLE OF CONTENTS

ICEPIC™ INSTALLATION AND OPERATIONS MANUAL

1 Introduction

The IcePic™ system, also known as EISFlow™ measures sea ice thickness from a helicopter which may be hovering or touched down on the ice surface. Its primary mission is to rapidly and accurately estimate ice thickness without requiring the ice observer to exit the helicopter and drill a hole in the ice. In practice, it has been found that the system is also useful for limited profiling applications, and for obtaining an estimate of the mean thickness of a particular sea ice floe through acquisition of a profile across the floe.

The system was designed to be straightforward to install and operate. The system operates on the principal of electromagnetic induction in seawater: sea ice is far less electrically conductive than sea water, so low-frequency electromagnetic waves pass right through sea ice and reflect from the ice-sea water boundary. The strength of these reflections can be compared to the distance from the sensor to the top of the snow/ice, which is measured by a laser rangefinder, to yield an accurate estimate of sea ice thickness.

This manual begins with a brief discussion of the system's operating modes and accuracy, then offers some suggestions regarding installation and airborne operation of the instrument.

2 General Considerations and Limitations

IcePic™ is typically most accurate when the helicopter on which the sensor is mounted is touched down on the sea ice surface. It is not necessary to shut down the helicopter or even to reduce the helicopter collective setting significantly.

The sensor displays "instantaneous" or "raw" estimates of ice thickness when the sensor is within approximately 10 m of the ice surface. These raw data are continuously logged to a "RAW" file in the system console, which can be copied to removable media by suitable command menu choices. The RAW file can be transcribed using program EISXcribV1 for Windows to yield a DAT file for analysis using the Sensors by Design DAT File Viewer.

Initiating a "sample run" (SR) instructs the sensor to average the raw ice property estimates until the SR is terminated, at which point mean sensor altitude, position and ice properties with their associated uncertainties (computed as standard deviations of the property estimates) are displayed. These SR results are logged to a separate ASCII file (the "TXT" file) which is copied onto removable media by the same command that transfers the RAW file. The TXT file can be imported readily into a spreadsheet for analysis or printing.

IcePic™ was designed to operate over floating sea ice in approximate salinity and temperature equilibrium with sea water, under which conditions the seawater bulk conductivity is approximately 2.5 S/m. Significant departures from these conditions will reduce system accuracy. Such departures are often observed in estuarine environments and during periods of rapid melting, in which case estimated ice thicknesses may be biased upwards considerably by the presence of low-salinity water beneath the ice. In lagoon environments, the opposite case has sometimes been observed in which water salinities and conductivities may be much higher than normal, in which case ice thickness estimates may be biased downwards.

The IcePic™ ice thickness calculation assumes that the water beneath the ice surface is deeper than ten metres. Small deviations from this condition will not generate significant errors. However, if an ice feature is grounded or has a very thin water layer between its bottom and the seafloor, its apparent thickness may be grossly overestimated.

3 Installation Notes

The system must be installed and the installation signed off by a qualified helicopter engineer in conformance with the installation diagrams and limitations of Supplementary Type Certificate SH01-4 (MBB BO105) or SH98-40 (Bell 206L series). The following description is intended to ease the installation process for the helicopter engineer, but must not be considered to be an official directive or document.

BO105 Installation:

The helicopter engineer must perform all helicopter and external aspects of this installation to ensure a safe installation. It has been found that the easiest way to install the BO105 version of the system is as follows:

1. remove the helicopter's Blade Folding Kit stanchions located at the mid-rib of the helicopter's bubble and the aluminum bridge bar of the helicopter's wire strike kit, which is pinned in place in front of the helicopter's standard battery cover
2. affix the system's aluminum support bar to the base of the sensor housing. Note that this joint must be shimmed prior to installation of the bar onto the helicopter to ensure zero play between the aluminium mounting flange at the rear end of the sensor housing and the support bar.
3. affix the three mounting struts to their appropriate flanges on the outside of the housing using appropriate hardware

   WARNING: extreme caution must be employed while affixing these struts: failure to properly shim the mounting flanges and/or over-torquing of their mounting bolts may crack the fiberglass mounting flanges on the tubular sensor housing, resulting in a risk of failure of

these flanges and consequent catastrophic damage to the sensor, helicopter body or rotors!

WARNING: Once these struts are affixed to the sensor housing, it is possible to apply damaging stresses to the mounting flanges through the long moment arm of the struts. Caution must therefore be exercised to prevent the application of such stresses. Strapping the struts to the sensor housing when it is not mounted is a good preventative measure.

4. Attach the middle of the curved aluminum bar to the mating flange on the back plate of the PIC sensor unit before fastening the bottom of the curved bar in place (it is hard to get your hands in there afterwards if you mount curved bar first onto the helicopter). Check this joint and shim as necessary to ensure no play before proceeding. Make sure that the sensor and curved bar are the right side up!

5. With an assistant supporting the weight of the sensor, attach the top (centre) white composite strut (using appropriate hardware) to the mounting hole in the upper portion of the wire strike guide bar. This will support much of the sensor's weight while the aluminum support bar is positioned and fastened in place.

   - Use the proper fastener (AN bolt, washers and locknut) to secure the upper end of the bar to the helicopter. Note that the pit-pin that normally secures the curved bar of the wire strike kit to the helicopter is not sized correctly to fit through the curved aluminum bar.
   - Once the centre strut and the top bolt of the curved bar have been installed, the weight of the sensor is fully carried by the helicopter. Then the rest of this portion of the installation can be completed by the engineer without assistance.
   - Secure the lower end of the bar to the helicopter, again using the supplied AN bolt, washers and locknut.

6. The ball-end joints can be left assembled to their mounting stanchions, in which case the stanchions can be attached using appropriate hardware to the Blade Folding Kit stanchion locations. Care should be taken to avoid overstressing any components including the struts or stanchion during this operation. When the stanchions and support bar are attached to the helicopter, the sensor housing should be rigidly attached to the helicopter, with essentially zero play in all directions (see Appendix A, photograph 1). If play is noted, one of the ball-ends should be adjusted or re-shimmed in its stanchion, or other measures taken to remove the play.

   NOTE: Failure to eliminate play during the installation process will lead to increased noise levels in ice thickness and may eventually cause damage to struts, other system components or the helicopter itself. Frequent inspections should be performed while the sensor is mounted on the helicopter to ensure that play has not developed.

7. The sensor package electrical cables should be routed to the rear seat of the helicopter, via an external route, tie-wrapped to the base of the lower wire-strike kit, the mirror mount, along the port side of the helicopter and through a pre-cut hole in a Lexan replacement for the sliding window. Suitable provision should be made for rapid egress from the helicopter through this door in the event of an emergency. (See Appendix A, photograph 1). Some notes for hookup of the Video-GPS fusebox are also included here, since they will typically be installed at the same time.

- Other IcePic cables: In the PIC sensor box (or possibly in the console box) are two wire bundles. One with the orange-red fine cable is the "inside bundle." The one with the yellow cable is a special cable for the Video-GPS system—see notes below. In a separate bag (video box) you will find the radar altimeter cable (black hard coax cable, BNC at one end and DB9 at the other) that runs between the console and the baggage compartment.
- The inside PIC cable bundle has the power splitter on it. This bundle feeds from the helicopter power plug to the back between the centre helicopter console and the passenger seat. In the passenger area this bundle has a power plug and splitter, the operator display's connector-cable (grey) and the pilot display cable (orange-red), which goes over the front of the dash to the pilot side.
- In the rear seat area there are three plugs from this inside bundle that connect to the console including the big top power plug, the user interface (a green military-type connector) and the manual fid connector (a coax cable and BNC connector—be sure to connect this to the Manual Fid input on the console and not to one of the other BNC connectors!)
- Also in this bag is a power cable (soft black cable) and a skinny grey cable used for the data link cable between the PIC console (DB9 connector, COM port 1), and the video fuse box (use the silver fuse box that works with laptop #1.
- NOTE: In 2011, provision was made inside the sensor housing for a secondary GPS receiver, for use by the Video-GPS and GPR acquisition software. A pair of yellow cables terminated with Microfast 4-pin and DB9 connectors was supplied, one each to DFO and CEEOS. The Microfast connector attaches to the round nickel-plated socket adjacent to the EM connectors on the sensor platform (see photo). The yellow cables are NOT for connection to the IcePic console and could damage the GPS receiver or the console if connected—they must connect ONLY to the Video-GPS/GPR fuse box.
- A second cable bundle (power and data) comes in through the hole in the sliding window for the Video-GPS system.

- The video fuse box should sit behind the passenger seat with plug facing the side door. It should have two cables (28V power and serial data link) from the PIC console.
- The laptop connects to this fuse box for power (black) and video data (connector to the side of the fuse box). There is an extra GPR cable you can ignore. To distinguish these two (video and GPR): start at the laptop end. The video and power connect to the left of the laptop near each other. The GPR connects to the right of the laptop and can be ignored if the GPR is not installed.

8. Remove the back rest seat cushion before installing the console, as it provides more room to insert the flash card. The console should be strapped down to the centre rear seat of the helicopter using the existing safety belt for that seat. An additional ratchet strap around the seat and the console provides an extra degree of security (see photograph 2.)
    - To make sure you have enough room to insert and take out the flash card, put a spacer block between the console and the back seat frame. It is a 2x2inch block about 6inches long and is in the console box and is connected to the console top by a screw
    - The console sits with the plug ends towards the front and the bottom towards side window. The largest [power plug is to the top where also the switch of DC and AC power is located. Try to put some hard foam around the door handle and the console and the engineer has to strap the console to the seat.
    - The black cables are attached to the rear panel of the IcePic™ console.
    - An additional cable runs from the IcePic™ console back to the radar altimeter socket at the rear of the aircraft (located inside the ELT hatch just inside the starboard rear clamshell door.) This cable should be installed if the altimeter socket is available, as it provides a stable backup for the laser altimeter at high altitudes.
9. The operator's interface unit comprises a metal enclosure with a back-lighted transflective LCD display and a keypad. It is intended to be held by the system operator during flight, but may be mounted using Velcro on a TC-supplied tray to the left of the central console (see photograph 3.) The pilot display is in the console box and is mounted in front of the pilot with Velcro. This still has to be customised by the engineer as each pilot wants it at a different place.
    - Extra Velcro is in the GPS Dash box, small 6x6x4 blue-white box in the video box. This Dash GPS is a spare in case the GPS data for the video is not available via the yellow cable from receiver located in the the Pic sensor housing.

- The Operator Display shelf and its square mounting bar are stored in the console box. The engineer has to mount the square bar to the centre console before the shelf can be installed.
- The Pilot's Laser Altitude display may be mounted by itself on top of the helicopter's instrument panel cowling or attached to the Video-GPS system's pilot's navigational display (see photograph 4.) Note that this display is for reference only: the laser altitude sometimes drops out or locks up over water or at high altitude, and must never be used as a primary flight instrument.
- NOTE: As of 2007, the helicopter GPS socket is no longer used. This connector (if present) should no longer be attached to the system.

10. Before powering on the system, test the helicopter power socket (with breaker turned on) with a voltmeter to confirm polarity. The standard IcePic™ power cable is built to fit Coast Guard helicopters, which use pin "A" as ground and "B" as +28VDC (check the label at the helicopter connector on the console power cable to verify—if there is no label, the cable is set up for pin B = 28V. The console will not function with (and could be damaged by) the wrong power polarity. The helicopter engineer should be able to change the helicopter socket's polarity if this proves necessary.

Bell 206L Installation:

The helicopter engineer must perform all helicopter and external aspects of this installation to ensure a safe installation. It has been found that the easiest way to install the Bell 206L version of the system is as follows:

1. Install the aluminum support kit on the helicopter as per the Airtech installation documentation.
2. Install the "root tube" in the support kit's mounting rings
3. Mount the "middle tube" to the root tube's sleeve joint, and affix with Airtech-supplied stainless steel machine screws. Care is required to avoid stripping the captive fasteners mounted in the sleeve joint. Do not use power screwdrivers to install or tighten these screws. Screws should be tight but avoid over-tightening that might break the machine screws or damage the composite tube. The video-laser port in the middle tube should point directly down.

11. Thread the EM pod cables through the installed tubes, bring them out the open end of the middle tube, into the rear end of the "tip tube" (which should be laid out on the floor in front of the middle tube) and out the laser altimeter port. Care should be taken while slipping the cables around the rear of the sensor array and through the port.
    - NOTE: In 2011, provision was made for a secondary GPS receiver, for use by the Video-GPS and GPR acquisition software. A pair of yellow

cables terminated with Microfast 4-pin and DB9 connectors was supplied, one each to DFO and CEEOS. The Microfast connector attaches to the round nickel-plated socket adjacent to the EM connectors on the sensor platform (see photo). The yellow cables are NOT for connection to the IcePic console and could damage the GPS receiver or the console if connected.

4. Install the tip tube housing the system's EM sensor and laser altimeter in the same way. The laser altimeter port in the tip tube (with the cable ends hanging free) should point down. Once the tip tube is installed, the three sensor cables can be attached to their mating connectors, and the cable slack fed back through the tube. The cables should project down from their cables and then arc smoothly back into the tube (see Photo ____) to avoid straining the cables and connectors. Strain relief at this point is advisable.
5. Install the nose cone at the end of the tip tube, securely fastening it as for the other tube sections.
6. The system's electrical cables emerging from the rear end of the root tube should be routed to the forward port seat of the rear cabin of the helicopter via an external route across the aircraft's belly, then up the starboard side, tie-wrapped where practical, and through the sliding window. As usual, suitable provision must be made for rapid egress from the helicopter through this door in the event of an emergency. (See Appendix A, photographs 1, 2 and 4 for 206L)
7. The cables are attached to the rear panel of the IcePic™ console, which should be strapped down to the forward port seat of the rear helicopter cabin using the existing safety belt for that seat. An additional ratchet strap around the seat and the console provides an extra degree of security (see photograph ___ for 206L.)
8. As of 2007, the helicopter GPS socket is no longer used. A cable should not be connected to this socket for the system to operate. An additional cable runs from the IcePic™ console to the radar altimeter socket, which is optional but desirable (a radar altimeter output may not be available in the 206L installation).
9. The operator's interface unit comprises a metal enclosure with a back-lighted transflective LCD display and a keypad. It is intended to be held by the system operator during flight, but may be mounted on a TC-supplied tray to the left of the central console (see photograph 3.) The pilot's laser altitude display may be mounted by itself on top of the helicopter's instrument panel cowling or attached to the Video-GPS system's pilot's navigational display (see photograph 4.)
10. Before powering on the system, <u>test the helicopter power socket</u> (with breaker turned on) with a voltmeter <u>to confirm polarity</u>: the standard IcePic™ power cable is built to fit Coast Guard helicopters, which use pin "A" (located closest to the orientation key slot in the plug) as ground and "B" as +28VDC (check

the label at the helicopter connector on the console power cable to verify—if there is no label, the cable is set up for pin B = 28V. The console will not function with (and could be damaged by) the wrong power polarity. The helicopter engineer should be able to change the helicopter socket's polarity if necessary. In the worst case, a special adapter cable may be required. **WARNING: Many private-sector helicopter contractors employ socket polarities that differ from CCG standards**.

11. After connecting the console to the sensor cables, turning on all white power breakers (for Tx and Aux1 and 2) and connecting the console to AC power using a standard modular power cable, the console may be turned on and initialized (see procedure below). One of the data pages on the user interface provides sensor pitch and roll information. It is desirable to rotate the sensor tube assembly in the mounting rings so that sensor roll is within a few tenths of a degree of zero degrees (this will require loosening of the clamping rings, rotation and re-tightening of the clamping rings).

Laser Altimeter:

In order to achieve the nominal ice thickness accuracy of the system, it is necessary to ensure that all laser rangefinder offsets are configured correctly. The standard "Laser_Offset" value used within the real-time and post-processing software (not user-adjustable) has the value 0.0m, which reflects the calibration of the original Optech ADM #178 that was included in the system at commissioning. Later (Sentinel) altimeters use an internal datum that differs from #178 by about +15 cm, which would make the overall Laser_Offset value -0.15m. Note that this offset is also affected in Sentinel units by irising and masking of the iris (performed to minimize laser receiver saturation at survey height), so the unit's receiver iris and masking of 60% of the iris surface (on side of iris toward Tx lens) should be performed before setting the internal offset. This is only necessary for K00947—K00606 needs no masking.

In order to accommodate the original ADM as well as the newer Sentinel units, the Sentinel's internal offset value should be configured to shorten its output range as indicated below to yield an "adjusted laser datum" as shown below that is equal to the EM datum, to compensate for the difference in its calibration relative to ADM #178. The value output by the laser directly (via its programming port, as viewed in Hyperterminal) should match the distance between the EM datum and the target plane. See the Appendix for further information on laser setup and troubleshooting.

Internal GPS Receivers:

The system is equipped with a Garmin GPS-18x WAAS- and EGNOS-capable 12-channel GPS receiver. This receiver is programmed at Geosensors to output the PGRMF Garmin proprietary NMEA string at 1 second intervals, with differential GPS source set to Auto and WAAS set to auto. Baud rate is set to 9600, with one stop bit, no parity.

A secondary GPS18x is present on the IcePic platform for use by the Video-GPS system. It operates at 19200 baud, outputting GPGGA and GPRMC sentences, through a special 10m yellow Microfast-to-DB9 cable that connects to a Microfast connector adjacent to the laser port and runs back to the fusebox. [This cable is identical to a long Dualem data cable except that it does not have a power pigtail]. If either GPS is damaged or fails in service, see the Appendix for further information.

Normal Operations

The following is the standard operating procedure for the IcePic™. This procedure assumes that the system has been properly installed and checked out while on the ground. Note that the system can be powered up for testing either using the helicopter's Auxiliary Power Unit (APU) or by connecting the IcePic™ console's AC power cable to a suitable 110V extension cord.

Standard Operating Procedure:

1. Prior to takeoff: the IcePic™ console's black Master circuit breaker (left breaker switch when facing the front of the console) should be left in the up or "ON" position, and the helicopter's "DC Socket" breaker in the helicopter console should be in the out or "OFF" position. <u>All three white breakers</u> on the console should be in the <u>up or "ON"</u> position.
2. After the helicopter is airborne (or at least after the second engine is running and the generators turned on), ask the pilot to power up the system by pushing in the "DC Socket" breaker
   - NOTE: at this point, the Video-GPS fuse box (if installed) will show a red LED if it is receiving power. It has spare fuses in the carrying case if one is required.
3. Observe the User Interface Display (UID): it should briefly read "Display Test", then "Booting..." followed by "Initialising..." should come up. If the system fails to boot or initialise after 60 seconds, power down, count to ten, and power up again.
4. After approximately 30 seconds, the "Booting..." message should be replaced by "Initialising...", then "Waiting for System Configuration Data, press BkSpc to skip". This will be replaced after about 10 seconds by "System Configuration Data Received, Press ENT to accept", at which point the operator should normally press the Enter key. NOTE: It is possible to obtain the configuration data from a disk file by pressing BkSp here, in the case where the PicID board is not operating properly or when the system is being recalibrated, but this should only be done under special circumstances.

5. The next message is “Select Helicopter Type, 1: BO105 2: 206L”, followed by “Press ENT for xxxxx’, where xxxxx may be either BO105 or 206L. This option is “sticky” in the sense that the operator selects it once when installed into a different type of helicopter than during the previous deployment, and thereafter can simply press the Enter key to accept the new default type.
6. After this, the display shows “INITIALISATION DONE. TO COMMENCE SYSTEM OPERATION PRESS ENT” (the up and down arrow keys can be used to adjust display contrast at this time.) <u>During the next two steps</u>, the <u>pilot should observe radio silence</u> (except for urgent or safety-related calls). <u>In the event of radio communication</u> during this period, <u>shut down and restart the system</u>, because the calibration may be incorrect. It is important to **wait until the helicopter has flown away from the ship or concrete pad (and associated metal) before taking the next step**.
7. Press the ENT key (bottom right on keypad) to start the transmitter, self-calibrate the system, and prepare the system to acquire data. To abort operation at this point, press the backspace key (←) twice and ENT to exit.
8. After ENT is pressed, the display reads “TRANSMITTER ON..”, then “CALIBRATING...”, then “PRESS ENT TO BEGIN LOGGING DATA TO SCREEN“.
9. At this point, one can press ENT to begin writing a RAW data file, or ← to go to the “FILE COPY OR EXIT” screen.
10. If ENT is pressed, the next message to come up is “BACKGROUND REQUIRED, PRESS ENT TO INITIATE OR ← TO END LOGGING”. When the helicopter is flying at 125m (411 feet) or higher in <u>straight and level flight at survey speed</u>, and the first site at which ice measurements are desired is a minute or two away, wait 10-15 seconds, then press ENT to initiate the background measurement, which takes about 10 seconds to complete and should be performed in <u>straight and level flight</u>. To abort at this point, press the ← key. <u>Another 10-15 seconds of straight and level flight</u> should be performed before descending to acquire ice data. The pilot should not transmit on the helicopter’s radios for at least 20 seconds prior to initiating the background measurement, and should not transmit until the sea ice measurement run has been completed and the next background measurement made. This procedure ensures the best possible data quality during post-processing. FM radio transmissions are the least damaging form of communication, followed by VHF. HF transmissions are the most disruptive to EM accuracy. Iridum and other satellite phone calls do not appear to cause problems, but should be avoided during background measurements and at startup as a precaution.
11. If a background measurement must be performed at less than 125 m (due to low ceiling or over land or for test purposes on the ground) the UID will read “TOO LOW FOR BACKGND, HIT ENT TO OVER-RIDE, INITIATE BACKGROUND”. To abort at this point, press the ← key.

12. If the background measurement was successful, the UID should read "RDY FOR SAMPLE RUN, PRESS ENT TO BEGIN". When the helicopter descends below 10 m sensor altitude, the UID should also indicate the estimated ice thickness and altitude. One can re-do the background by ascending back to 125 m and pressing ←.
13. Hovering, touching down or flying at 10 m or lower sensor altitude (approximately 4 m skid altitude) will acquire "raw" ice thickness data, which is stored in the RAW file. Data acquired between 5 m and 10 m is not as reliable as data acquired below 5 m. It is possible to get a good idea of the thickness of a floe just by flying over it and observing the raw data display. In order to get a more precise measure of average ice thickness, either at a point or along a profile, one may initiate a Sample Run.
14. Pressing ENT at this time will begin a Sample Run. To end the Sample Run, press ENT again—the UID will show a summary data screen indicating the measurement statistics. Pressing ENT a third time will return to the "RDY FOR SAMPLE RUN, PRESS ENT TO BEGIN" screen and display raw ice thickness data. It is not necessary to make a Sample Run to acquire IcePic™ data, but the Sample run provides statistics on the ice over-flown during the Sample Run which can be useful in assessing a particular ice floe.
15. After a few minutes of data acquisition, the system will prompt the user to obtain a new background measurement with "TIME FOR BACKGROUND, HIT ENT TO CONTINUE". At this point, the helicopter should return to 125 m altitude and ENT should be pressed when flying straight and level, at which point another round of ice measurements can begin.
16. To exit one level of the menu system and get back to the previous level, press ←. Confirmation may be requested, depending on the menu item.
17. The up and down arrow keys may be used to scroll among several "data screens" that are always available during normal operation. These include a "file status" screen that shows logging file name and status, a "positioning status" screen that shows GPS details, a "System Status" screen that shows the status of various key subsystems and inputs, and a "statistics" screen that shows the results of the last Sample Run. Note that if the GPS receiver is in communication with the system, the system time is updated to match the current GPS time. This means that all time stamps on data are given in terms of seconds since midnight in GPS time, which differs from Zulu or UTC time by a date-dependent number of "leap seconds" (14 in 2007). The ←and ENT keys have no effect when these screens are being displayed: to get back to the primary data screen, press the "1" key on the keypad
18. To end data logging, press "1", then ←. The UID will read "REDO BACKGROUND?" One can initiate a new background at this point by pressing ENT, or continue to end logging by pressing ← again, at which point "** NOT RECORDING **" will be displayed. Logging should be terminated before landing on the ship or before long ferry flights in which no sea ice measurement will take place in order to conserve disk space.

19. Pressing ← once again calls up the "FILE COPY OR EXIT?" menu: pressing ENT allows one to copy data files to removable media, while ← will prepare to shut the system down. It is a good idea to copy data onto the transfer media before landing so that the system does not have to be powered up again for data transfer purposes.
20. If copying files, the up/down arrows scroll through possible files to copy to removable media in the console (a Zip-100 drive). Pressing ENT when a file that exists is shown on the display will copy that file to the Zip. Pressing ← aborts the copy operation.
21. When exiting, a final screen comes up that asks for an ENT to confirm system shutdown. After pressing ENT, wait 30 seconds and ask the pilot to pull the "DC Socket" breaker.
22. The system must be powered down before it can be restarted.

Operational comments from Simon Prinsenberg:

No power should be sent to the system before both engines of the helicopter are running. During the start of the second engine there is a power surge and this at times trips the breakers on the console. All three breaker switches should be pointed up (*ie* toward top of console). This normally is the problem if the console is not working.

Once power is provided to the Console, it starts the unit and it goes through its checks. Do not start the profiling mode until you are away from the ship and all that metal.

The same is true when landing: stop the profiling-collecting of data before you land but you do not have to shut the system off. You may want to download the data onto the flash card before you shut down.

The video fuse box will show a red light if it is receiving power. It has spare fuses in the carrying case if you need one.

I normally first handle the PIC operations before I start the Video-GPS laptop. Start the laptop without the USB data link, then connect the data link once the laptop is powered up. It gets mixed up if the fuse box is sending info while the laptop is trying to power up.

Check the time of the laptop, GPS and all clocks to make sure that they make sense. All the video frames are time stamped.

Do two quick backgrounds for the PIC at the start over an area you do not care about and throw the data away. (The system needs to stabilize for ~5 minutes in survey mode before you can start collecting "good" data.)

IcePic™ Background Information for the Pilot

The following information is provided as background material for helicopter pilots working with the IcePic™ system. This information has not been officially certified or sanctioned by Transport Canada, Coast Guard or any other authority, nor should it be construed as an extension of the Flight Manual Supplement or any other official documentation. As in all aviation activities, the pilot is the ultimate authority regarding safety. Safe operation of the aircraft is the direct responsibility of the pilot, who will determine the minimum safe flight altitude and local weather conditions for safe flying on an ongoing basis.

Weather conditions over sea ice can be severe and may change rapidly. Sea ice is also a potentially unstable environment for landing or sitting out bad weather, since it can break up or be compressed with little warning. Pilots who will be performing IcePic™ surveys should therefore be highly experienced in both on-ice and over-ice work in the survey area.

At low helicopter altitudes such as are sometimes used in IcePic™ surveys, there are many potential risks that must be weighed. These include, but are not limited to, helicopter problems, white-out conditions, gusty winds, loss of contrast ("white" conditions) and pilot fatigue or hypnosis.

The IcePic™ system can be operated in multiple modes. All ice measurements should begin and end with a "background measurement", in which the zero levels of the system are measured—the procedure for such measurements is listed above, but the key factor is that the system must be flown to an altitude greater than 125m (420 feet) and held there straight and level at survey speed while the operator performs the background measurement.

Spot Soundings:

The simplest survey mode consists of making one or more "spot soundings", in which the system is flown from background altitude, down to the ice surface, and lightly touched down or hovered, then moved on to the next measurement, and eventually returning to background altitude.

Short Profiles:

The system can also be used to perform short profiles, typically at low speed and low altitude, again starting and finishing with background measurements. Depending on ice conditions and the pilot's judgement, such profiles can be performed at survey altitudes as low as 1 to 2 metres. Lower survey altitudes greatly improve data quality and lateral resolution, and are therefore desirable when safety considerations permit.

Survey Transects.

Longer profiles, running between 10 and 20 minutes long at an optimal survey speed of 65 knots, are often required. Data quality is maximised by acquiring the data at the lowest safe altitude under local conditions, but survey altitude and speed are both subject to the pilot's discretion. If it proves necessary to fly at a higher altitude for safety reasons, more frequent background measurements will be necessary to ensure acceptable data quality.

It may also be useful to employ long transects of this sort for travelling to and from a particular target location, and then to employ short profiles performed at lower altitude and/or spot soundings over the target feature.

If the pilot feels that a situation arising from weather, ice, light, fatigue or any other factor is making data acquisition unsafe, he/she should notify the operator and perform a background measurement (unless this action will itself lead to an unsafe situation) while deciding to continue or abort the mission.

5 System Health/Status

The System Status screen mentioned above is an important tool for operation and troubleshooting of the system. If the GPS is not operating (or disabled or disconnected), or if the laser altimeter is not operational, or there is a problem with the EM subsystem (either transmitter off or no received signal), this will be indicated on the System Status display. It should therefore be checked shortly after system start-up and before ferrying to the survey area.

NOTE: it is possible to acquire ice thickness data without having good GPS data: in such a case, you will acquire ice thicknesses but have no knowledge beyond your written notes as to where the data were obtained. For this reason it is critical to check the System Status display whenever the system is started up.

NOTE: no GPS data is available when the sensor boom is disconnected from the console, because the GPS receiver is mounted inside the boom.

NOTE: if ANY of the System Status indicators are not "nominal", then data acquisition will be compromised. These indicators should read as follows:

LASER OK	GPS OK
TX POWER ON	SIG OK

- The laser can be deactivated by extreme cold, lack of warm-up and insufficient thermal insulation around the base of the laser, yielding a NO RANGE message on this data screen. Landing and allowing the laser to warm up (and ensuring that its thermal protection pad is in place) may solve this problem if it occurs during flight.
- The GPS can take considerable time to re-survey itself after a long-distance move. It is wise to let the system operate on the ground with a clear view of the sky (*ie* outside the hangar, with the sensor housing's laser port pointing down) until the GPS screen reports "GPS time" rather than "UTC time". This can take as much as tens of minutes.
- If "TX POWER OFF" and "NO SIG" are displayed, the transmitter is probably not working. Shut the system down and check all cable connections to the sensor carefully. The Tx Sync BNC connector (at the end of the black coaxial cable at the console end of the cable) must be attached to the TX SYNC connector on the console for the transmitter to operate, and the TX POWER breaker must be in the UP position.

6 PicID subsystem

In July 2011, the extant IcePic systems were equipped with PicID subsystems that provide in-sensor storage for all sensor-related calibration data, as well as sensor platform serial number, laser altimeter serial number, and offset values for the pitch and roll sensors. These data are used automatically by the system.

The PicID configuration data can be updated using a notebook Windows computer equipped with a serial-USB converter or a built-in COM1 serial port, a female to female (null-modem) serial cable, an IcePic console and the IcePic sensor platform. The procedure for this follows.

1. The console and sensor platform should be linked by their usual data and transmitter control cables, and the user interface should also be attached to the system.
   - Connect the notebook computer via the serial-USB converter and the female-female serial cable to the COM2 connector on the back of the console (on the original CONSN1 console, this port is accessed through a cable located inside the console's housing, and a male-female cable will be necessary instead of the female-female cable.)
   - The serial-USB adapter should be set to COM1, 9600 baud, with 8 bits, no parity, 1 stop bit. You can access these settings, once the adapter has been installed properly, via Start\Control Panel\System\ Device Manager\Ports. On a modern notebook computer, there will typically be just one COM port—the one associated with the serial-USB adapter.
   - It is not necessary to connect the Pilot display and the Video-GPS cable to the console.
2. The console should be connected to AC using its usual modular power cable.
3. The Tx and Aux power breakers on the console may be left in the "Off" position during the update. They will have to be turned on before normal operation is resumed.
4. It could prove helpful to attach a video monitor, mouse and keyboard to the console in the event that troubleshooting is required.
5. The configuration file will be provided as part of an "update folder" by a Geosensors representative.
   - The file itself will have a filename of the form PLTSNnnm.CFG, where "nn" is the IcePic sensor platform number (01 for BIO system, 02 for CEOS system) and "m" is the serial number of the PidID board that is installed within the sensor platform.
   - For the rest of this summary, the example filename PLTSN025.CFG will be used as a stand-in for the updated configuration file.
   - The update folder also includes two Win32 console mode programs called CONFIGIP.EXE and LDPARAM.EXE and a "readme.txt" file that briefly summarizes how to use these programs.
6. Use Windows Explorer to copy the entire update folder, which may have a folder name like CalibrationUpdatePltSN2, to a suitable working directory on your notebook computer.

7. Display the contents of this folder by clicking on the folder name in Windows Explorer.

   - Double-click on CONFIGIP.EXE. This will create a temporary console window displaying the following information:

     ```
     Program to prepare ICEPIC binary file ip_param.bin
     for system calibration and configuration data.
     Note: No checks done on parameter values.

     Enter name of input configuration (text) file:
     ```

   - Enter the new configuration files full filename, eg PLTSN025.CFG, followed by pressing the Enter key

   - You will see a file IP_PARAM.BIN with the present date and time appear in your Windows Explorer window.

   - Ensure that the console is connected to the sensor platform and is ready to be turned on, and ensure that the serial cable from the serial-USB adapter is connected to the COM2 connector on the back of the console.

   - Double-click on LDPARAM.EXE in the Windows Explorer window

   - The program will display the following information:

     ```
     Program to update ICEPIC boom parameter table from file ip_param.bin

     Initializing COM1 port
     Note: this program may hang here if another window is using the same com port.

     Waiting for startup message from ICEPIC.
     >>>Power on boom now<<<

     Still waiting....  (Press Q to quit)
     Still waiting....  (Press Q to quit)
     Still waiting....  (Press Q to quit)
     Still waiting....  (Press Q to quit)
     Still waiting....  (Press Q to quit)
     .. (above message repeats until console has been powered on)
     ```

   - Power up the console. You should see the program indicating that the data link has been established and that the transfer is underway, after which the console window will vanish.

   - Turn off the console, count to 10, and turn it on again

   - Allow the normal startup sequence to occur: after the usual startup messages, you will see “Waiting for System Configuration Data, press BkSp to skip”. This will be replaced after about 10 seconds by

     ```
     Configuration Loaded
     Press ENT to accept
     default parameters
     ```

   - If you have the video monitor installed on the console, you will see a set of numerical values appear there as they are received from the sensor before the above message is displayed. If the update was successful, these numerical values should correspond to those in the section headed by “correct” in the configuration file; this can be viewed by editing the file, eg PLTSN025.CFG, with a text editor on the notebook computer.

- At the same time as the "Configuration Loaded" message appears on the User Interface display, the video monitor will show

```
All configuration records received from system
Press Enter to skip loading configuration file
```

- Note that If you press enter to skip loading the file, there will be no further configuration data displayed—the console software will move on to asking you to select the helicopter type. You will only see configuration data from the file FXDMNT.CFG (located on the root of the hard disk) on the monitor if you press a key other than Enter. Thus, for normal operation, Enter should be the only key pressed during the startup, initialization and calibration phases of operation.
- Once you have successfully completed the bulleted tasks above,

8. Eject and remove the USB memory stick from the laptop computer and insert it into the console's USB slot.
   - (You may have to use the keyboard and mouse to "accept" the driver for the memory stick)
   - On the console, use the mouse to start a Windows Explorer window, and view the contents of the USB data key
   - Copy the entire update folder (as a folder, not just the contents of the folder) to the root of the console's C drive
   - Rename the original configuration file in the console's root directory that corresponds to the new configuration file in the update folder (it may have exactly the same name, *eg* PLTSN025.CFG) to a backup filename, *eg* PLTSN025.CFG.Bk1
   - Copy the new configuration file, *eg* PLTSN025.CFG, from the update folder into the root of the console's C drive.
   - Exit all Windows Explorer windows on the console **(important!)**
   - Using the User Interface, record a data file, overriding the background height warning messages. Record at least 10 seconds of data, then exit data recording in the usual way, and use the File Copy function of the User Interface to copy the new RAW file to the USB data key.
   - Send a copy of this file to Geosensors, so that it can be checked. You can also transcribe and check the file yourself, as follows:
     a. after transcription, there will be a file FEMxxxxxx.CFD in the transcription folder.
     b. View this file's contents using a text editor. They should look like the following (though specifics of sensor ID, laser ID, EM corrections and pitch and roll offsets may differ):

```
Sensor ID=PLTSN02
 Laser ID=K00993LR
 EM Corrections:
   1.07985   0.00793
   1.07218   0.08072
   1.06268   0.20738
   0.98646   0.64071
 Pitch and Roll Offsets:   3.300000      -2.900000
 Reference_ppm:       52001
```

c. The EM Corrections should match the "correct" factors in the updated configuration file, eg PLTSN025.CFG. The other important items in this file are the Sensor Platform ID (this should be PLTSN01 for the BIO sensor platform or PLTSN02 for the CEOS platform), the Laser Altimeter serial number, and the offsets used to correct the pitch and roll observations.

- Perform a flight test, preferably over ice of known thickness. If the system does not perform as expected, email the RAW file to Geosensors and contact Scott Holladay (416 483 4691, scott.holladay@geosensors.com) or James Lee (705 357 3714) as soon as possible. If you are telephoning, it would be best to have the console set up with AC power and the video display, keyboard, mouse and sensor platform connected, so that troubleshooting can begin immediately.

7 Data Processing

Whenever it logs data ,the IcePic™ system generates two data files, which are stored in the \Survey directory of the console's hard disk drive (C:). The base filename used for these files is FEMxxxxx.yyy, where xxxxx is a number which increments automatically, and the filename extension yyy is either RAW or TXT. These files are transferred to removable media (USB drive, SD card or Compact Flash card) by the real-time software using the FILE COPY menu item. The removable media should be inserted before starting the file transfer process. Ordinarily, removable media should only be removed after the IcePic™ console has been shut down. However, if a monitor, mouse and keyboard are attached, the removable media can be released from the console using the "safely remove hardware" in the Windows systray (bottom right) without powering off the console. The PC-Card CF adapter, if used, should only be ejected after the console has shut down. The files can then be copied to a suitable directory on the hard disk of the field processing computer using Windows Explorer.

The RAW file is a binary file which captures all data generated by the system during operation as a series of time-stamped data packets. The TXT file is a series of ASCII records, each corresponding to one Sample Run. The Sample Runs are numbered sequentially, starting with the value 1, after every power-up. Data fields in the TXT file are:

1. SR #

2. Mean latitude (N or S, degrees, decimal minutes)
3. Mean longitude (E or W, degrees, decimal minutes)
4. Start time (milliseconds since midnight, GPS time)
5. End time (milliseconds since midnight, GPS time)
6. Mean ice thickness (m)
7. Standard deviation ice thickness (m)
8. Mean ice conductivity (S/m)
9. Standard deviation ice conductivity (S/m)
10. Mean sensor altitude (m)
11. Standard deviation sensor altitude (m)
12. Final normalised fitting error in sample run
13. Final # iterations in sample run

The RAW file may be transcribed using program EISXcribV1 to yield an ASCII summary file (FEMxxxxx.IPP) and also a binary summary file (FEMxxxxx.DAT) which can be interpreted by the Sensors by Design DAT Viewer program for Matlab.

To run EISXcribV1, double-click on the program icon, browse to the location of the RAW file, and double-click on the RAW file. The output IPP and DAT files will be stored in the same directory. They can be moved to another directory if desired using Windows Explorer.

The IPP file is a column-oriented ascii data file. IPP data columns are, in order,

1 TimeStmp –System timestamp in milliseconds since 0000 Sunday morning. ✓

2 GPSTime –GPS time of week in seconds since 0000 Sunday morning. ✓

3 Lat –Latitude in degrees and decimal degrees ✓

4 Lon –Longitude in degrees and decimal degrees ✓

5 TimeDelay_lsr –Time delay between laser sample and 0.1 second system "tick"

6 Laser –Laser altimeter output

7 Laser_Return –Strength of laser return, out of about 6500

8 iLaser_Warn –warning character (decimal code for the ascii symbol (see table below)

9 Mfid –Manual fiducial (incremented with pushbutton adjacent to user interface)

10 RadAlt –Radar altitude if present and connected to console

11 Pitch –Sensor pitch

12 Roll –Sensor roll

13 SysCurr—Console DC current draw (should be ~5.5-9A if Pic only operating)

14 SysVolt --Console DC supply voltage (normally about 28V)

15 IntTemp –Internal temperature in C of console

16-23 (curr_FDEM_dat_pkt(j),j=1,8)--8 columns of EM data in ppm (parts-per-million)

24-31 (curr_FDEM_Zero_pkt(j),j=1,8)--8 columns of EM baselevel data in ppm

32 NParam –Number of parameters in inversion model, normally 3 for real-time data

33 NIter —Number of iterations during inversion of this sample

34 RMN —Normalized RMS fitting error in ppk during inversion of this sample

35 Sig$_{ice}$ –ice conductivity estimate

36 T$_{ice}$ –ice thickness estimate

37 Sig$_{seawater}$ –seawater conductivity (normally fixed in real time)

(there can be more T and Sig column pairs if additional layers are used for inversion)

Laser warning codes:

“^”--9 --saturation of receiver (return signal too strong)
"<"-- 2--partial dropout (fewer than 50% of laser shots returned to unit--common with specular reflection and at high altitude)
"*"-- 5--saturation/dropout (both saturation and dropout--also common with specular reflection)
"NO RANGE"--1--no laser shots detected by receiver (again, this is common with specular reflection, also at high altitude)

Raw laser data are output into the .LS2 output file during transcription. NaN is used where the NO RANGE condition is present.

To run the DAT File Viewer, double-click on the DATfileviewer icon on the desktop, and use the file\open menu item to browse to the DAT file to be viewed. See the Sensors By Design documentation on this program for details.

Transcription also generates a FEMxxxxxx.CFD file which displays the configuration data used by the system. This is normally obtained from the PicID board in the sensor platform, ensuring that each sensor platform is properly identified and calibrated. The file contents should look like the following (though specifics of sensor ID, laser ID, EM corrections and pitch and roll offsets may differ):

```
Sensor ID=PLTSN02
 Laser ID=K00993LR
 EM Corrections:
   1.07985   0.00793
   1.07218   0.08072
   1.06268   0.20738
```

```
  0.98646    0.64071
Pitch and Roll Offsets:   3.300000      -2.900000
Reference_ppm:        52001
```

8 Troubleshooting History and Guidelines

The system has exhibited very few operational problems so far, so there is not much of a troubleshooting database to draw upon. The first step in troubleshooting is to check the System Status data page after system startup and initialisation. The following are in approximately chronological order.

A laser altimeter problem was encountered during a period of intensely cold weather in 2003. The Optech laser altimeter (ADM3 Alpha, SN178) failed to operate at progressively higher temperatures, until at the end it would no longer acquire data at room temperature without an extended "warmup" period—the symptom was the ADM outputting NO RANGE continuously, even after a many minutes of warmup. It was determined that there was no thermostatic heater in the ADM (contrary to the manual, and unlike Optech Sentinel rangefinders) to bring it up to operating temperature—but this was not the actual problem with the unit. During its first trip back to Optech, a leaky capacitor on the counter board internal to the altimeter was replaced, and the fan wiring was secured. Later it was determined that the counter board itself was faulty and had to be replaced. The most obvious indication of this problem to the operator was that the ice thickness estimates became visibly incorrect, typically 1m too thick when the helicopter was touched down on the ice. Checking the data screens to monitor the laser altimeter output quickly narrowed down the problem to the altimeter, which would read "NO RANGE" when it was in fault mode.

The only short-term remedy for this condition was to swap out the altimeter for a spare unit. The spare unit (the unpainted "gold anodized" Sentinel 3100 DV, SN K00606, purchased off-the-shelf from Optech and flown Air Canada Cargo to Charlottetown) was installed on March 6, 2003. The thermostatic heater circuit in K0606 was enabled in 2004 allowing it to start under -25C conditions. No problems were encountered with that unit winter 2007, when apparently small changes in its AGC circuits made the unit's receiver circuit start to saturate in the critical operational altitude range 4-10m, yielding erroneous ice thickness estimates. After diagnosing the laser as the source of the error, this effect was corrected using a 1.9 cm diameter "iris" over the receiver lens of the unit that reduced incoming light levels sufficiently to prevent saturation. This unit was returned to Optech for testing and repair and was adjusted, but continued to saturate (when no iris was used) over ice in the main profiling altitude range of 4-10m. A new unit, K0947, purchased at the time of the repair, exhibited the same symptoms, even after K0947 was switched to CP (clear path) internal ranging software from its original DV (dust and vapour, uses trailing-edge of laser pulse rather than rising pulse for ranging). As a result, irises were placed on both units and 947 was very carefully re-evaluated. The conclusion was that the optical convergence distance of Sentinels, which appears to be about 4m, is far too short for work over snow and ice in the 1-10m altitude range with the full receiver optical aperture. This distance needs to be adjusted to 10-30m in order to prevent saturation with the full aperture—this adjustment is planned for summer 2008. In the mean time, the 1.9 cm iris was reinstalled. When used with 60% masking on the transmitter side of the iris, this arrangement yielded very good accuracy (cm level) over the tested range of 1 to 6.5m for very dark and very bright targets, though this aperture may be too small to yield high-quality results at very low altitudes over very thin, dark ice or open water. Since this is an unusual combination (higher altitudes are desired over open water or very thin ice!) this should be an acceptable compromise for the 2008 field season. An adjustment to the internal offset of rangefinder #947 was necessary to make it work with the -0.2m laser offset distance used in the real-time and post-processing software—this adjustment is +50 mm "forward" (ie shortening the observed range.) #606 and units purchased for the University of Manitoba system will require a similar amount of internal offset adjustment.

The repaired (March 2008) unit, ADM3 Alpha SN178, is now available in the spares kit. A DC 30W heater has been installed to reduce thermal stresses on the rangefinder electronics that may have caused this unit's initial failure in 2003.

During operations in -35C conditions in 2009 with no external insulation on the base of the heater-equipped Sentinel, occasional dropouts in laser operation ("NO RANGE" message) would occur. These appear to have been related to the external airflow cooling the footplate of the instrument sufficiently that heat flow out of the unit exceeded the heaters' capability to maintain the instrument at temperatures above 0C continuously. An external foam insulation pad that entirely covers the footplate and leaves just the altimeter optics housing protruding appeared to be a good solution.

Another problem that has occurred a few times is that the system fails to boot or initialise. This can generally be remedied by powering down and re-starting. The source of this failure has not yet been determined.

If the operator has performed maintenance on the console (deleting data in the Survey directory, for example) and left a Windows Explorer window open on the desktop at shutdown, **this will cause problems at startup**. The console's mouse and display must be re-attached, the console powered up, and the Windows Explorer window(s) shut down. Any other persistent application windows that might have been left open (with the exception of the IcePic software's window itself) should also be closed (not minimized, but closed.)

Unauthorised software should not be installed on the console for any reason, as it may interfere with the operation of the IcePic software.

Troubleshooting

Some basic troubleshooting steps are listed below. Each should be performed as required, and the results written down before calling for technical assistance.

1. No user interface display more than 50 seconds after power-up: verify that
    - MASTER breaker (left-most of circuit breakers on IcePic™ console front panel) is in the up position
    - connectors are all in place on back of console and on user interface display unit
    - power connector is plugged into DC socket
    - "DC Socket" breaker is being closed
    - helicopter power is turned on and/or APU is properly plugged in
    - Green LED next to Master Breaker is lit if heli power is turned on
2. Display comes up as "Display Test" but does not proceed to "Booting" or "Initializing"
    - Power down, count to 10, power up
    - Repeat one more time
    - If this doesn't solve the problem, connect display, mouse and keyboard, write down names and messages in any dialogue boxes that may appear, and call for help
3. System Status item LASER item does not read "OK"
    - If LASER reads "OFF", the laser altimeter has either been turned off or disconnected (but note information above)
    - If LASER reads NO RANGE or POOR and the sensor height is not excessive, shut the system down, land and check the laser altimeter lenses to make sure that they are clear of snow or other materials. This message may be encountered over open water as well due to specular (mirror) reflection of beam away from laser receiver lens by the water.
    - If LASER SAT, the altimeter receiver is saturating, *i.e.* its incoming signal strength is too high. This does not normally happen below 5 m sensor height: if it does, call for technical support.
    - It is not uncommon for the laser to flip briefly into SAT or POOR or even NO RANGE mode during data acquisition. However, if it locks into this mode for a wide range of heights or when parked on the surface, there is probably a laser problem that must be corrected (or it may be an effect from very low temperatures: read above section thoroughly).
4. System Status item GPS item does not read "OK" and/or there is no GPS or UTC time available
    - For 2007 and later, the system was modified to receive GPS data from an embedded 12-channel Garmin GPS-18 WAAS-enabled receiver mounted

inside the sensor boom. If there is no satellite visibility, the unit will display "UTC TIME" and the system's last dead-reckoning position. When satellites become visible, the display becomes "GPS Time" and positions become "live".

- The sensor boom must be connected to the console to get GPS data
- The GPS receiver will not generate valid positions if the sensor boom is covered by a radio-reflecting object, blanket or other item, or is indoors or very close to a building.
- If there is no GPS or UTC time available and/or System Status for GPS is not "OK", there is a cable/connector fault (most likely), a software fault or the GPS receiver is not operating for some reason. It is possible to accidentally disable the GPS receiver by changing the SERIAL parameters in the FXDMNT.CFG file or by modification of the GPS receiver's internal settings.
- If GPS positions are NOT being displayed and the system is indoors or very close to a building, they should reappear after the system is taken outdoors. It may take up to 5 or 10 minutes to re-acquire a position if the receiver has been reset or if the system has been relocated by a large distance since the last successful GPS operation.

5. System Status item TX POWER does not read "ON"
   - Shut down system
   - Make sure that all console breakers are in the UP position
   - Check all cables and connectors inside and outside the helicopter.
   - If no loose connectors or cable problems are found, call for help.
6. System Status item SIG does not read "OK"
   - The transmitter sync cable may not be attached at either the sensor end or the console end, or it may be attached to the wrong BNC connector on the back of the console. Make sure that it is connected to the TX SYNC connector. Shut down the system before attempting to correct this situation.
   - There could be a cable fault, or one of the sensor cable connectors may not be seated correctly at either the sensor or console end. Shut down the system before attempting to correct this situation.
   - If these do not fix the problem, call for help
7. Pilot's altitude display does not reach 0 just as helicopter skids touch down (note that this display shows estimated altitude in feet below skids).
   - The sensor boom is located at different heights above ground in the BO105 and 206L installations. There is therefore a selection within the FXDMNT.CFG to handle this, under the heading "helicopter". The choices are either 206L or BO105.

- If the altitude at touchdown is incorrect, then the helicopter type in FXDMNT.CFG described above is probably incorrect.
- If the indication is only slightly wrong (less than a foot) it may be due to helicopter being mounted on slightly lower skidgear than the standard "high skidgear". Popout floats appear to be typically mounted on "medium" skidgear.

8. Pilot's altitude display blanks out at high altitude (or intermittently at low altitude over flat water, very smooth ice, ice that has been melted and refrozen with shiny surfaces, or over very wet ice.)
    - This effect is caused by dropouts in the laser altimeter output
    - The effect was worsened by the irising and masking necessary to prevent Sentinel altimeter saturation in 1-10m altitude range over sea ice, but this should be much less common since mid-2008 Sentinel reconfiguration by Optech that allows the full laser receiver aperture to be used.
    - If seen at high altitude, this effect indicates that the radar altimeter cable is not connected to radar altimeter output (BO105 installation only).
    - If seen at low altitude, this is normally caused by specular (mirror-like) reflection of the laser beam away from the receiver optics. When no reflected laser pulse can be seen, the rangefinder cannot generate a range estimate.
    - Ensure that the EM/Laser platform displays roll very close to zero (within a few tenths of a degree) when the helicopter is sitting on a level surface. The roll angle can be checked or monitored on the appropriate user interface data page during adjustments. <u>The following adjustments should only be performed by the helicopter engineer:</u>
        - the roll angle can be adjusted in the 206L system by loosening the main boom clamps and rotating the boom slightly.
        - In the 105 system, it should be possible to obtain zero roll angle by adjusting the ball-joints on the two side struts.
    - Use of an ADM (#178) may also reduce this effect. Upgrades to Sentinel laser rangefinders executed in summer 2008 to extend their optical convergence distance to ~30m should permit use of wide-open receiver optics and thus much better receiver signal capture. The two CEOS Sentinel lasers are both set up this way and appear to exhibit good performance over open water. After the upgrade, the two BIO Sentinel lasers have essentially identical performance to the CEOS lasers.
    - Snowfall, ice fog and other conditions that reduce specular reflection from the ice surface may reduce or eliminate this effect.
9. After a new installation, system steps through Power-on Self Test (visible if monitor hooked up) but then reports "Boot Failure" or "Hard Disk Drive Failure". This occurred after shipment from the Arctic to BIO on Feb 22,

2010. The fault turned out to be that the IDE disk drive cable had vibrated out of the back of the PC-Card drive unit, presumably due to vibration during shipping. After powering off and opening the console, then carefully grounding out static by putting one hand on an exposed metal surface within the console, the IDE connector was carefully re-inserted into its connector. The system then booted up properly. It may be necessary to use a bit of RTV at the SIDES of these connectors where they meet the case or connector shroud to ensure retention (never near the actual connections!)

10. In summer 2010, CONSN2 (newer of the two BIO consoles) had a CMOS memory battery failure. This might have been caused by an earlier exposure to water and subsequent leakage of charge. This problem was corrected in 2011 by adding a new external CMOS battery.
11. In summer 2011, the **PicID subsystem** was added to the system to provide interchangeability of sensors and consoles: either sensor platform should now work transparently with any of the three existing consoles without operator intervention. This is because the sensor platforms now provide their platform serial number, laser serial number, calibration information, and pitch and roll offsets to the console. These data are also logged within the RAW file for later reference. New versions of the transcription and inversion programs were developed to utilize these data. The hardware and software were designed for robust performance and have been thoroughly tested, including an airborne test at Quebec, but it is still possible that bugs will be encountered with the system. The consoles will be set up such that they have the same calibration data on disk in the file FXDMNT.CFG, so that they can be operated even if some or all of the calibration data are not provided by the PicID board. The PicID board also acts as a portal for the GPS18x GPS data coming into the console. In the event of a board failure, it is likely that GPS data output from the system will stop. It may be possible to continue to operate under this condition by logging the GPS data using the Video-GPS system, logging the IcePic data at the same time, and merging the datasets during postprocessing.
12. Note that a separate, secondary GPS18x is mounted within the sensor boom for the use of the Video-GPS system. The secondary receiver connects to the Video-GPS fusebox via a 10m yellow Microfast-to-DB9 cable that interconnects with the platform via a receptacle located next to the laser port. The **DB9 connector on this cable should ONLY be attached to the appropriate GPS port on the fuse box**—if it is connected to a serial port on the IcePic console, it may cause damage to the GPS18x or to the console.

Appendix A: IcePic™ Installation Photographs

Figure 1: IcePic sensor installed on BO105 CG-362 in Charlottetown, PEI.

Figure 2: IcePic console installed in rear seat of CG-362. Note ratchet strap passing below seat support which secures console to seat. A seat belt should also be tightened around the console to provide additional restraint.

Figure 3: Power and GPS data connections to helicopter, with handheld user interface unit in foreground.

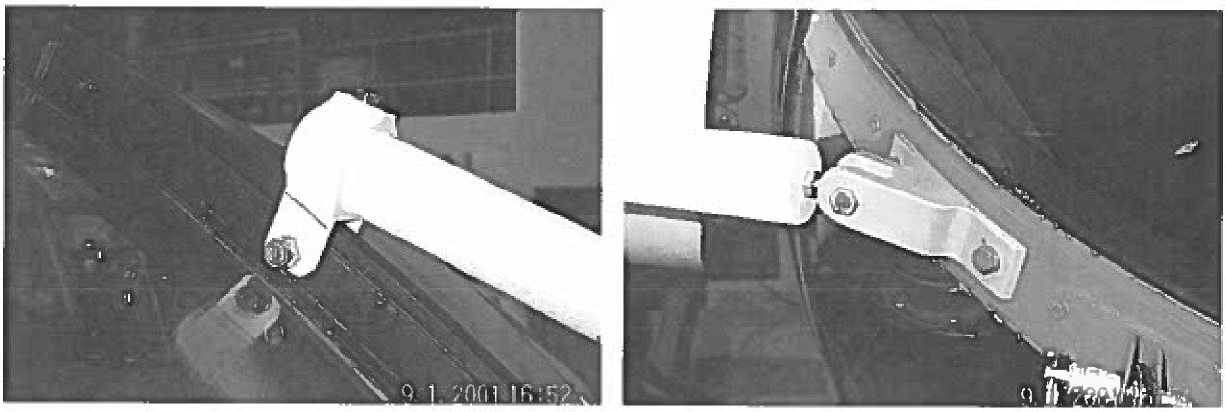

9. 1. 2001 16:52

Figure 4: Photographs 4 and 5: mounting strut connection to central rib (left) and port mounting strut ball-end mounted in stanchion (right). Care should be taken to adjust ball-ends such that sensor roll reading is zero when helicopter is on a level surface.

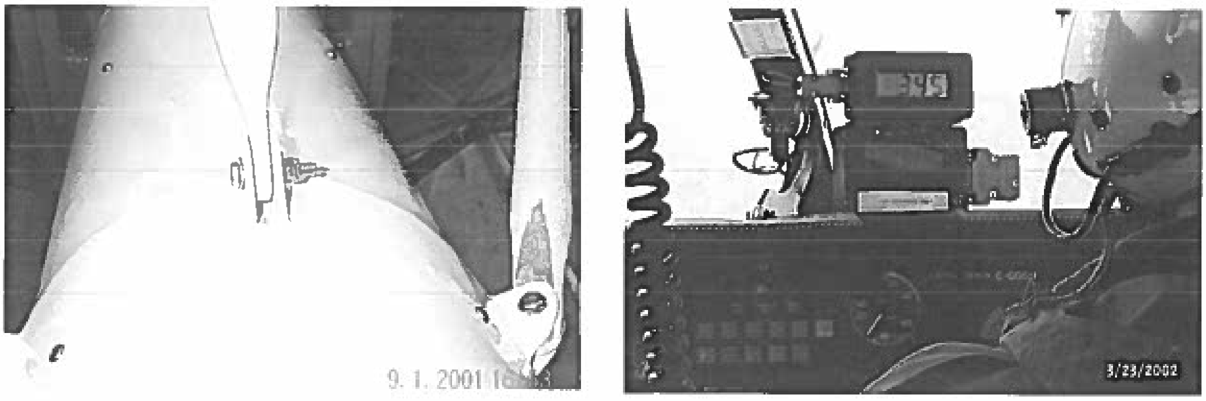
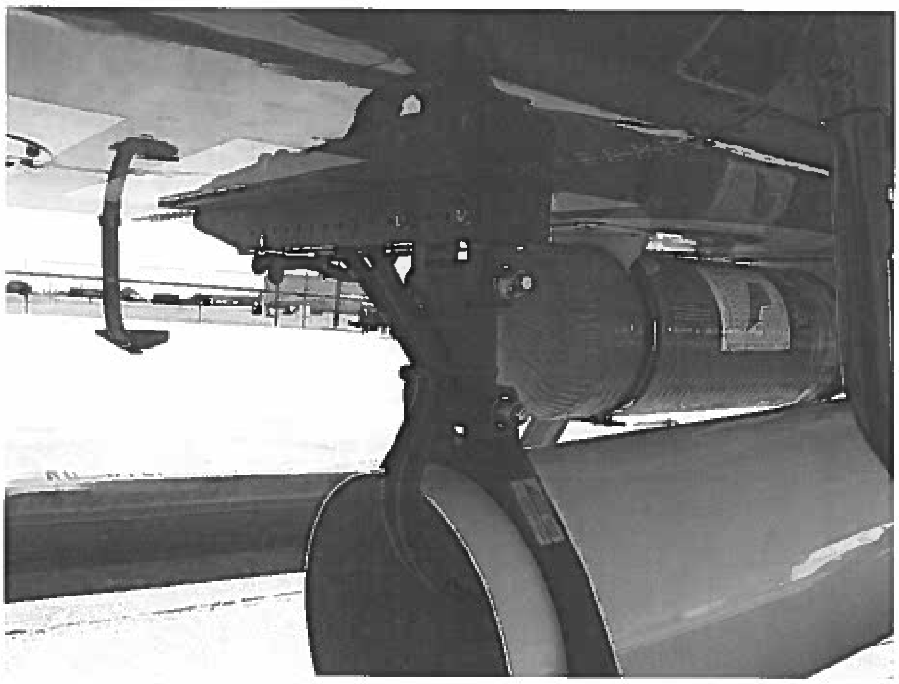

3/23/2002

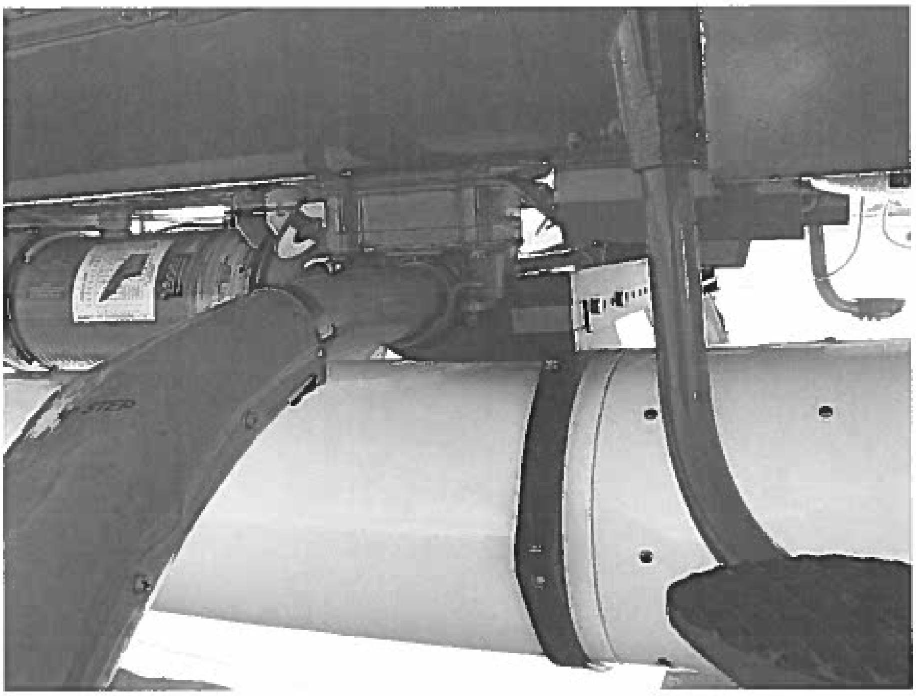
Figure 5: Struts mounted to sensor housing flanges (left). Laser altitude display (top) and Video-GPS system's cross-track navigational display (bottom) mounted on instrument panel cowling (right)

206L Installation Photographs:

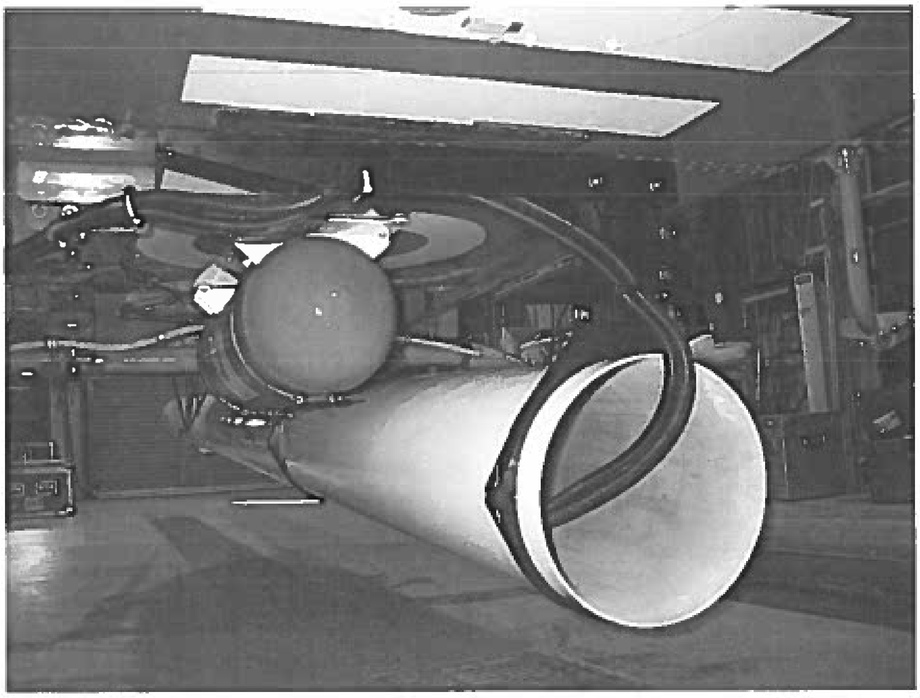
206L system installed. Note vertical cable run visible between auger and pilot Harrison Macrae.



Rear of main boom, showing offset from nitrogen pressure vessel, rear mounting point, cable routing and clamping ring.

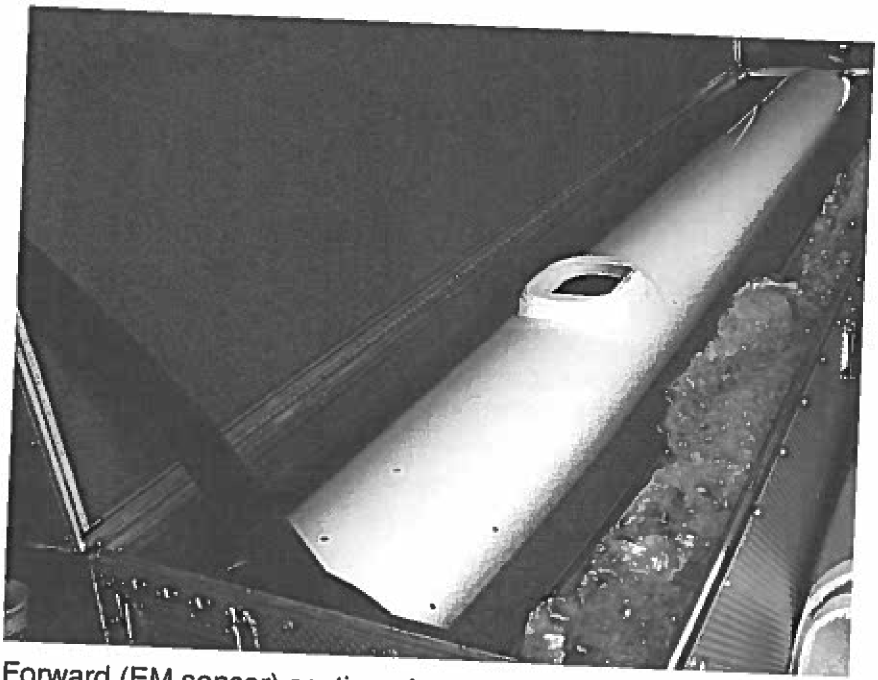


Forward mount structure, clamping ring, and slip joint (secured with #10 fasteners) between root tube and middle tube.



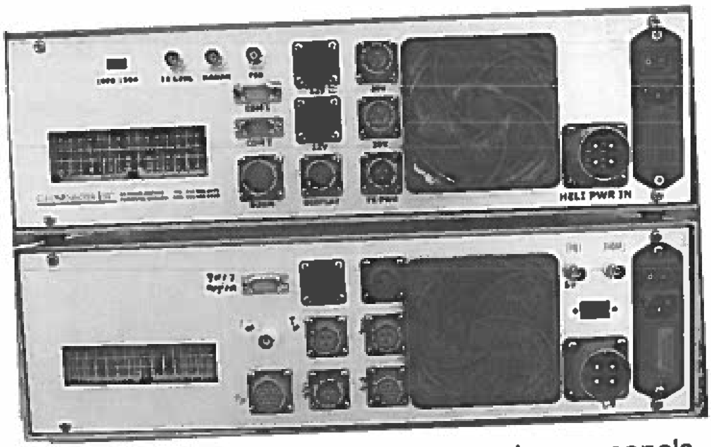
View from rear along boom, showing relationship between boom and nitrogen pressure vessel. Note cable run cross underside of helicopter.

Installation on a Great Slave Helicopters 206L-4, looking forward, showing installation on the port side of the aircraft necessitated by the presence of a high-pressure nitrogen line on the starboard side.

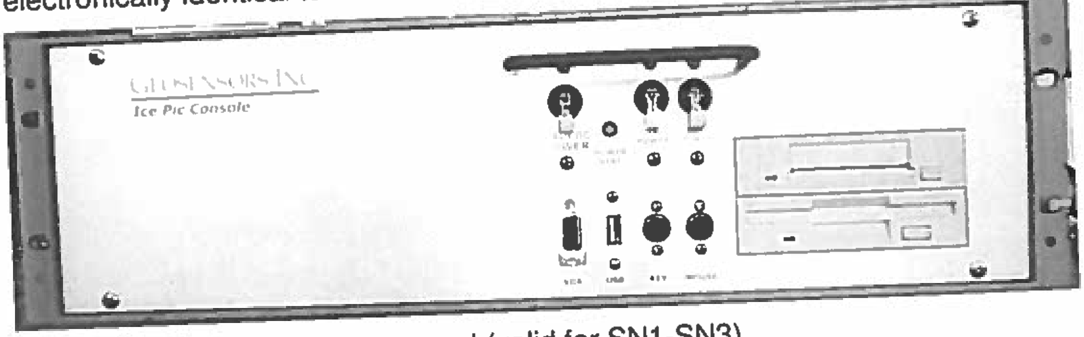


Forward (EM sensor) section of 206L boom in 206L Shipping Case #1. Mounting hardware is stored in slot to right of boom. The IcePic sensor array is not installed inside the boom in this photo, or the laser altimeter would be visible in the port.

Middle and root tubes of 206L boom in 206L Shipping Case #2. The secondary port in the longer (middle) tube is for access of video-GPS. The nose cone is stored against the end of the root tube to reduce shipping case length.

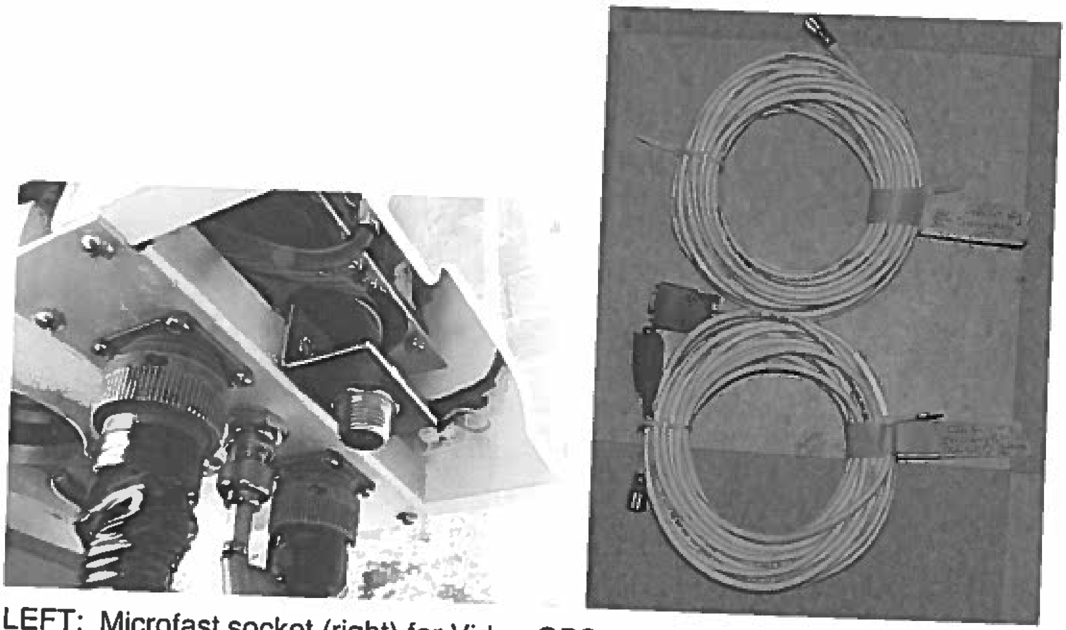


BIO-owned SN2 (top) and SN1 console rear panels. SN1 was the original system console and has had numerous upgrades. In most ways it is electronically identical to SN2: the main difference is no external COM2 on SN1

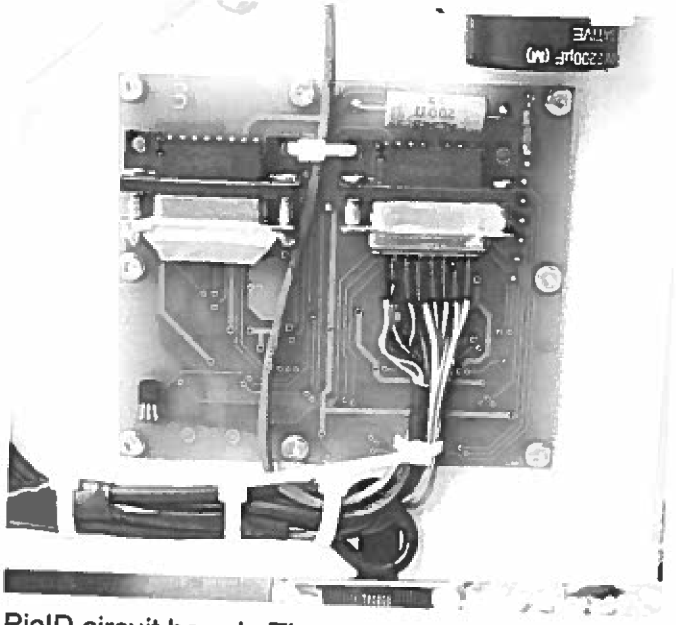


Revised IcePic Console front panel (valid for SN1-SN3).

PicID Subsystem and Secondary GPS Connection Photos



LEFT: Microfast socket (right) for Video-GPS receiver cable. RIGHT: special Video-GPS cables that can attach to this connector. The nickel plated Microfast plug attaches to the Microfast socket, while the black DB9 connects to the Video-GPS fusebox.



PicID circuit board. The two sockets on this board are NOT interchangeable—NEVER attempt to plug the cable, shown attached to the socket at right, to the left-side socket—this will damage the board and require major repair work.

IcePic Dimensions and Weights:

BO105 System Dimensions:

main tube: 69"

main tube with end fitting : 71-1/4"

end cap: 11-1/2" plus 1" for the flange for an OAL of 12-1/2"

The length of the assembly (end cap, tube and end fitting) is 82-3/4".

System Weights:

The weight of the assembled tube minus support struts is ___.

Total weight of the exterior installation, including tube, struts and cables is ___.

Console weight is ___

Shipping Case Descriptions:

BO105 System

Sensor Case: 87" wide x 15.25 x 15.25 Approx empty weight 80 lbs.

- With sensor, cable and struts, approximately 130 lb.

Console Case: 24.5" wide x 18.00 x 9.500 Approx empty weight 30 lbs.

- With console, cables, user interface and displays, approximately 60 lb.

206L System

Boom Case #1: 96 x 19.5 x 15.25 inches.

Boom Case #2: 73.5 x 28.75 x 15.25 inches

Console Case: 24.5" wide x 18.00 x 9.500 Approx empty weight 30 lbs, with console, cables, user interface and displays, approximately 60 lb.

An additional shipping case for the system spares kit and toolbox should be procured and used—there is insufficient room in the main shipping cases for these items, and they need to be available for either the BO105 or the 206L installations.

Appendix B: General IcePic™ Operations Summary

1. Prior to takeoff: all console switches up or "ON", helicopter "DC Socket" breaker "OFF", flash memory card in socket
2. When airborne: ask pilot to engage the "DC Socket" breaker
3. User Interface Display (UID): shows "Display Test", then "Booting…" and by "Initialising…" If system doesn't boot or initialise after 90 seconds, power down, count to ten, and power up again. No radio Tx during steps 4-6 below.
4. ~75 seconds after power-up, "Booting…", "Initialising…", "Loading configuration data…" (must press ENT to continue), "Helicopter Selection (press 1, 2 or ENT to select helicopter type and continue), and finally "INITIALISATION DONE. TO COMMENCE SYSTEM OPERATION PRESS ENT"
5. Press ENT key to start transmitter prepare system to acquire data. To abort operation at this point, press the backspace key (←) twice and ENT to exit.
6. Dsplay next reads "TRANSMITTER ON..", "CALIBRATING…", "PRESS ENT TO BEGIN LOGGING DATA TO SCREEN".
7. 2-3 minutes prior to start of ice data acquisition, press ENT to begin writing a RAW data file, or ← to go to the "FILE COPY OR EXIT" screen.
8. Press ENT—the next message to come up is "BACKGROUND REQUIRED, PRESS ENT TO INITIATE OR ← TO END LOGGING". With helicopter flying at 125m (400 feet), straight and level, and one minute or so previous to first profile start point, press ENT to initiate background measurement, wait for response, then wait 10 more seconds before beginning descent. Radio silence should be observed for 10 seconds prior to initiating the background measurement and until the background and measurement profiles have been completed and the next background measurement made.
9. After background, UID should read "RDY FOR SAMPLE RUN, PRESS ENT TO BEGIN". When the helicopter descends below 6 m sensor altitude, the UID should also indicate the estimated ice thickness and altitude.
10. Pressing ENT at this time begins a Sample Run. To end the Sample Run, press ENT again—UID shows summary data screen. Press ENT a third time returns to the "RDY FOR SAMPLE RUN…" screen and display raw ice data.
11. To end data logging, press "1", then ←. The UID will read "REDO BACKGROUND?" A final background should be performed if the preceding survey leg is to be used for analysis. Otherwise, one can end logging by pressing ← again, at which point "** NOT RECORDING **" will be displayed.
12. Pressing ← once again calls up the "FILE COPY OR EXIT?" menu: press ENT to copy data files to media, ← will prepare to shut the system down. If exiting, a final screen appears requesting ENT to confirm system shutdown. Press ENT, wait 30 seconds and have the pilot pull the "DC Socket" breaker.

The system must be powered down before it can be restarted.

Appendix C: IcePic™ Data Inversion Summary

Overview:

Inversion of IcePic™ EM and laser data to obtain ice property information is performed in real time by the console, with the results being displayed in real time on the User Interface. Advanced users have the option of reprocessing IcePic™ data in order to correct for the effects of EM drift, to adjust the model used for inversion, or to recalibrate data. These topics will be discussed in this Appendix. It is assumed that any user attempting data inversion is thoroughly familiar with standard IcePic™ data acquisition and processing, and is an experienced Microsoft Windows XP user. This software has been found to work under Windows Vista as well, but it is not supported under Vista at this time.

In most cases, the only task required to optimize the inversion of an IcePic™ dataset is to perform EM baseline drift (referred to as "drift") corrections. After these corrections have been set up, the data can be inverted using program EISInvertV1. This program generates a suite of output files that can be plotted, merged with other data or otherwise analyzed.

What is inversion, and how is it used in the IcePic™?

A common problem in many disciplines is that physical phenomena must be modelled using complex, often nonlinear mathematics, which relate a set of "model parameters" that describe the model to a "calculated response" that correspond to real-world physical measurements. This process is known as "forward modelling." Forward modelling is useful in that it aids understanding of the modelled phenomenon, but in many cases the real objective is to start with physical measurements or "observations" and "inverse model" or "invert" them to obtain estimates of model parameters, in order to profile or map a parameter of interest, such as ice thickness.

While it is possible under very limited circumstances to perform such inversions mathematically or using exact, so-called "direct inverse" formulations, the nonlinear or ill-posed nature of many forward models precludes this approach as a general solution to the parameter estimation problem. Most inversion methods are therefore based on iterative, successive-approximation solutions that "fit" the calculated response of a mathematical model to the observed response of the real-world analogue of that model.

Geophysics is richly supplied with phenomena of this sort, of which electromagnetic induction sounding is one example. The IcePic™ system utilizes inversion methods in real time to estimate values of ice thickness, conductivity and seawater conductivity (or a subset of these parameters) based on observed electromagnetic induction (EM) measurements obtained from an airborne EM sensor, together with the distance to the ice/snow surface obtained from a laser rangefinder and sensor orientation data obtained from a third sensor.

Since sensor observations always include noise and systematic error, and because the numerical model may not resemble the real world situation in some way(s), there is a limit to the accuracy with which inversion can estimate the model parameters from the observations, and in some cases the inversion process can fail altogether. Part of the art and science of designing successful sensor systems and related inversion methods is to maximize the robustness of the parameter estimation process and to define an "operating envelope" within which the inversion process will work reliably for a given input data quality while permitting practical acquisition of the input data.

One key factor in the robustness of parameter estimation to errors in the input data is to minimize the number of "free" model parameters, which are those parameters that are allowed to vary while other parameters are held "fixed." This effect arises from the fact that varying different model parameters can yield similar effects in the calculated response of the model. Distinguishing these similar effects from each other becomes progressively (and rapidly) more difficult as the number of free parameters increases relative to the number of input data. A related issue is that the input data frequently display some "dependence," meaning that a change in one model parameter affects all of the calculated response to varying degrees. This effect can be reduced but rarely eliminated by careful sensor design.

Such considerations guided the design of the IcePic™ and its inversion subsystem, though it was recognized from the outset that improvements over "real-time" data inversion would be possible. The principal way to obtain such improvements is through post-acquisition correction for systematic effects.

The largest systematic effect of this type is so-called "EM baseline drift", normally abbreviated to "drift." As described below, this type of systematic error results in a slow creep of the measured EM response values away from their "true" values (the values that would be measured in the absence of drift). It can be measured by repeatedly flying the EM sensor to a substantial height (normally about 125m) over the course of the flight—at this height, the response of the seawater beneath the instrument becomes negligible, and whatever value is measured by the instrument may be taken as drift error. Thus, while drift error cannot be readily estimated in real time while the instrument is at survey altitude, it can be readily estimated post-flight and corrections introduced that essentially eliminate drift error.

Another potential improvement in inversion results may sometimes be obtained through adjustment of the core parameters of the model. For example, the most robust type of inverse calculation for IcePic™ data is to estimate ice thickness while assuming *a priori* "fixed" values for ice conductivity and seawater conductivity, but if a substantially erroneous value is used for one of these conductivities, systematic errors in the estimated ice thickness will result. The normal real-time inversion parameters for this system are ice thickness and conductivity, while seawater conductivity is assumed to be constant. This has been found to be a good approximation in most offshore areas, especially during cold conditions, but adjustments may be necessary in near-shore or estuarine conditions.

A third, very specialized model adjustment would be the introduction of an extra layer into the inversion model. Since this increases the number of model parameters, it must be accompanied by the use of *a priori* fixed values for many of the parameters (and this *a priori* data must be available from other sources, such as synchronized CTD casts in the survey area.) Under some circumstances this type of model can be used to extract useful information, for example on sub-ice brackish water layers.

Understanding Drift:

Drift is a phenomenon common to all electromagnetic induction sensing systems, characterized by a progressive shift in the base or zero level of a given EM data channel with respect to time. The base or zero level of an EM channel is defined as that channel's output at high altitude (above 125m), while EM anomaly values are defined as the deviation of the EM channel's output from the base level due to the EM response of nearby conductive objects or media (such as seawater.) For the Ice Pic™ array, such responses are always positive in sign, whereas EM drift can be positive or negative. EM drift is mainly driven by temperature changes in the system structure, in the skin and frame of the helicopter, and in the electronics. EM responses that mimic drift can also be seen—if the helicopter is climbing, turning or descending, the slight distortion in the aircraft's geometric relationship with the EM system caused by this movement will generate an apparent shift in response that disappears when the aircraft assumes a straight and level flight profile. This is an important reason for always holding straight and level flight (with radio silence throughout) for 10 sec before an IcePic™ background measurement is started and for 10 sec after the completion of the background measurement.

Drift is normally corrected for by using high altitude background measurements at the beginning and end times of a flight segment to determine the system's base level at those times—a linear interpolate between these two background measurements can then be computed and subtracted from the EM measurements over the course of that flight segment. Drift is usually a low-amplitude, slowly changing quantity, so such interpolation is usually highly effective unless background measurement intervals were too long.

For real-time inversion purposes, the system's background level is reset to zero during every background measurement executed by the operator. This results in a large transient jump in the base level during the resetting process, which serves to identify these measurement points.

As an aside, note that it is possible to observe drift effects directly during a long ferry at high altitude (at high altitude, measured response should be zero). At the beginning of the data segment immediately following a background measurement, all EM channels should read close to zero ppm (they are set to zero during the background acquisition process). Over time, the EM responses deviate slowly from zero. This effect is usually weak and quite linear as a function of time for periods of five to ten minutes at the start of a flight, and up to 20 or 30 minutes late in a flight, if air temperature conditions are stable. If there are strong temperature variations during a flight segment, drift effects will be increased and may be nonlinear with respect to time. Under such conditions, it is necessary to perform more frequent background measurements.

The inversion program, known as EISInvertV1, reads in the RAW data file (with filename of the form FEMxxxxx.RAW) and a corresponding series of background measurement points stored in the file FEMxxxxx RAW.LIN (henceforth known as the LIN file). There should be one LIN file per RAW file after transcription. If the LIN file is empty or contains blanks, no drift correction will be performed by the inversion program. The inversion program determines the base levels at each background point, determines the baseline corrections, and subtracts them from the observed data. There should be two background measurement points, at the segment's beginning and end, for each measurement segment, although there will sometimes be a final segment (such as when the system has been landed and shut down on the ice) when the final background is missing. The inversion program can cope with this situation automatically.

Data Processing Sequence:

The recommended steps for inversion of an IcePic™ data file are:

Step 1: RAW Data File Transcription to DAT, IPP, EXT and XYM files.

Step 2: View DAT file with DatFileViewer

Step 3: Use EXT file with Pick_BG Matlab program to pick background points

Step 4: Invert Data with EISInvertV1

Step 5: Check drift correction results in IPP, amend background picks and re-invert if necessary

Step 6: Check inverted data using DatFileViewer or other means

Transcribing Raw Data:

Data transcription is performed using the program EISXCRIBV1, which is typically activated from a program icon on the desktop. This program requests an input FEMxxxxx.RAW (where xxxxx is a numeric sequence number) filename using a GUI menu, and permits the user to browse to the "processing" folder in which the RAW files are located on the processing computer.

Transcription converts the binary RAW data file into a set of ASCII files that can be viewed using text editors or easily read by other programs. Files created during transcription include the DAT, IPP, EXT and LIN files. Apart from the DAT file, these files all have filenames FEMxxxxx as for the RAW file. The DAT file has a special format to its filename to simplify its use for analysis: this may be summarized as FEMxxxxx-ddmmmyyyyttt, where dd, mmm and yyyy are day, abbreviated month name, and year, and where ttt is a code for the type of inversion (for real-time inversion, ttt=RAW, while for post-processed results, ttt=PPR).

The IPP file is described in the main body of this document. The EXT file is a data extract that is provided for use in background picking for drift correction.

The LIN file is an empty file that the user may fill with background measurement timestamps. These should be selected as pairs in the following sequence:

- First background point > 3 or 4 seconds after the real time background measurement at the start of a survey segment
- Second background point > 3 or 4 seconds before the real time background measurement at the end of a segment

There will typically be several background pick pairs in a given RAW file, one pair per segment.

If a file is being re-transcribed and an existing, non-blank FEMxxxxRAW.LIN file exists, the transcription program does not over-write the existing LIN file. However, it is wise to back up background picks in a separate directory to protect them from accidental erasure or modification.

If there is no final background measurement in a segment, as sometimes occurs when the aircraft lands on the ice, the inversion program will use the initial background sample as a fixed value for that final interval. For this reason, it is preferable to terminate data acquisition (*i.e.* close the output RAW file) after landing on the ice for more than a few tens of seconds, even if the engine is kept running and further profiling is planned. Initiating a new RAW file at background altitude after such a landing ensures that background measurements can be maintained in their proper sequence.

The preferred way to obtain background picks is to use the Matlab program Pick_BG, as described below.

Picking Background Points:

The LIN file can be created (with considerable effort) by plotting the EM profiles from the IPP or EXT files generated during transcription and manually typing times corresponding to the high altitude background measurements into the LIN file, one per line. However, the manual method is laborious and prone to error.

A Matlab application called Pick_BG can be used to simplify the procedure. It should be possible to simply use the Pick_BG icon in the root of the processing folder chain (*eg* C:\IcePic_Proc). The Properties for this icon are shown in the screenshot below.

Pick_BG

Target type: Application

Target location: bin

Start in: C:\IcePic_Proc\Data\Raw_files

Shortcut key: None

Run: Normal window

Alternatively, the program can be run "manually" as follows: first, the Matlab path should be extended to include the folder in which Pick_BG.m and its subtroutines reside (*eg* C:\IcePic_Proc\mfiles). When this is complete, the processing directory (*eg* C:\IcePic_Proc\Data\Raw_files) selected as the default folder, and the application may be started up by typing Pick_BG into the Matlab command window. The EXT file corresponding to the RAW file is selected via dialog box, and the pertinent data are displayed in graphical form. The mouse is used to control the vertical green dot-dashed cursor in the program's graphical "data" window to select background points, two per segment (there is no need to select background points in a segment entirely acquired at high altitude, although there is no harm in doing so). When this process is complete, these points must be saved to the LIN file by clicking on the "save points" button and entering the LIN filename, *i.e.* FFFxxxxxRAW.LIN, where FFFxxxxx corresponds to the RAW filename. If some other filename is used, the inversion program will ignore it and not use it for drift correction. An example of this procedure is given later.

Tips for picking background points:

1. Rescale the altitude and EM vertical axes by clicking with the left and right mouse buttons (or the mouse wheel) and entering reasonable levels. Preset values of -20 and +20 have been provided, but set others as needed.
2. Look for a flat spot in EM data just after the initial background for a segment or just before a final one
3. Don't place background points too close to the real-time background measurement transients—they should be at least 3-4 seconds, corresponding to 30-40 samples on the displayed X axis, away from the nearest edge of such transients.
4. Remember that turns, ascents and descents generate spurious shifts in base level—always attempt to select background points where the aircraft is in straight and level flight at 125m or higher.

5. Noise effects or errors in picking can sometimes create substantial errors in drift correction. Large errors can be spotted either through unreasonable ice thickness behaviour in inversion output, while smaller errors can be located by looking at the drift-corrected EM data profiles using the Matlab program PlotBaseline: the straight-line baselines should match the near-zero EM profiles at the background points that were picked.

Control Files:

Three text files are used to control details of the data inversion process. These files should be present in the folder where the RAW and TXT data files are located. Changing these files can yield unexpected behaviour and generate increased error in the inverted results, so such changes should only be made by experienced users and/or in consultation with Geosensors. Changes in the real-time control files are especially risky, as they could result in rapid increases in ice thickness error or other problems.

The first control file is the "system definition", or SDF file. Both the real-time and post-processing software look for the file FXDMNT.SDF in the same folder as that for the RAW file. This file describes the parameters of the EM system (size, frequencies etc.) It does not typically require adjustment during post-processing.

The second control file is the "Inversion Model" or IMF file. Both the real-time and post-processing software look for the file FXDMNT.IMF in the same folder as that for the RAW file. This file specifies the number of layers model (normally two, one for ice and one for seawater), with a "starting" value as well as minimum and maximum values for each, and controls which parameters are "free" and which are "fixed". This file also includes controls for the maximum number of iterations, the target fitting accuracy and whether the model is "reset" to the starting model for every measurement sample or is allowed to use the result from the previous sample as the starting model for the next measurement site. For real time inversion, it is necessary to limit the number of iterations and to use the previous values in order to limit computation time per site, but for post-processing more iterations can be used and parameter reset can be turned on or off as desired. Similarly, the model parameters themselves do not typically require adjustment, particularly for real time inversion, unless (for example) it is known *a priori* that the near-surface seawater conductivity in the survey area is substantially different from 2.5 S/m.

The FEMxxxxxRAW.LIN file is the third type of control file for inversion. It lists timestamps at which background measurements were made, and was described earlier in this section.

Data Inversion Step:

Once the background points have been saved to the LIN file, the inversion program can be run to create a new set of inversion results. These will be stored in a file named FFFFFFFPPR.IPP if the calibration is not adjusted, and FFFFFFFCAL.IPP if the calibration has been adjusted.

DAT files for use with the DATFileViewer program are also generated by the inversion program—these will all have filename FFFFFFFPPR-DDMMMYYYY.DAT, where DD, MMM and YYYY are the day of the month, the month in alphabetic format (eg JAN) and YYYY is the year.

To perform data inversion, use the EISInvertV1 program icon to activate the inversion program. During startup, the program asks a series of questions:

- Which PIC Core was used to acquire the data—at present, this would be the DFO system (SN1) or the CEEOS system (SN2). Enter 1 or 2 respectively for these two choices. Use 0 for old data (acquired prior to 2008). This choice sets up specific pitch and roll offset values for each system.
- Are background corrections to be applied to the file?—answer Y or N.
- Another question that may be asked governs treatment of the final background point, in case this background point was not located at the end of the final data segment.

The program then inverts the data and generates an IPP and DAT file. These files can be used for analysis or plotting. Other output files are also generated for use by legacy applications, such as XYM files.

Other Tools:

A RAW file utility called PicSplit is also provided. PicSplit permits the user to break a RAW file into smaller segments for specialized processing. A PicSplit shortcut icon is supplied with the software folder.

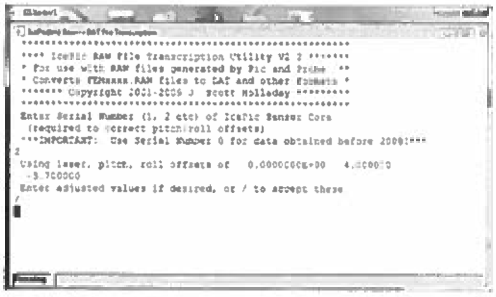
To use PicSplit, a special LIN file named FEMxxxxxSPLIT.LIN (where xxxxx is the RAW file number as usual) must be constructed before running the program. This can be done using Pick_BG. The RAW file will be split at each timestamp listed in the LIN file. Thus, if one timestamp is entered, the RAW file will be split into two parts; two timestamps will split the RAW file into three parts, and so on. The output files are named FEMxxxxS01.RAW, FEMxxxxS02.RAW and so on.

The usual locations for file splitting would be at one or more background measurement points. The segmented RAW files can be operated on using the transcription and inversion programs in the same way as the RAW files that they were created from.

Data Processing Example:

Step 1: RAW Data File Transcription to DAT, IPP, EXT and XYM files:

The RAW file for this example is FEM28110. The first step is to transcribe the data:



```
*******************************************************
**** IcePic RAW File Transcription Utility V2.2 *******
* For use with RAW files generated by Pic and Probe  **
* Converts FEMxxxx.RAW files to DAT and other formats *
******* Copyright 2001-2008 J. Scott Holladay *********
*******************************************************
Enter Serial Number (1, 2 etc) of IcePic Sensor Core
 (required to correct pitch/roll offsets)
***IMPORTANT:  Use Serial Number 0 for data obtained before 2008!***
2
Using laser, pitch, roll offsets of   0.0000000E+00   4.000000
 -5.700000
Enter adjusted values if desired, or / to accept these
/
```

Figure C-1: initial EISXCRIBV1 dialog, with Pic sensor SN2 selected and default pitch, roll and laser offsets accepted.

Browsing to the directory in which the RAW file resides permits selection of the raw file as indicated below, to be followed by clicking on the "Open" button.

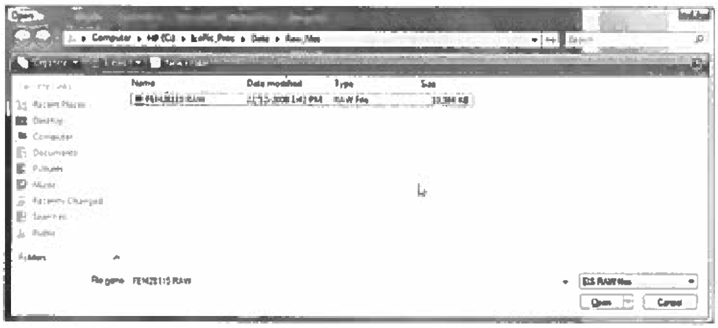
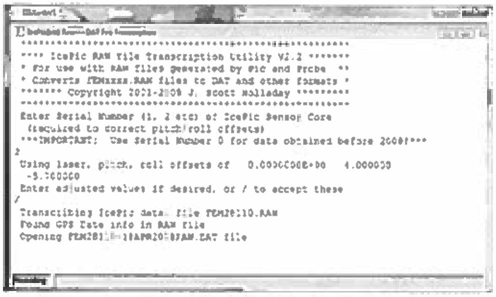
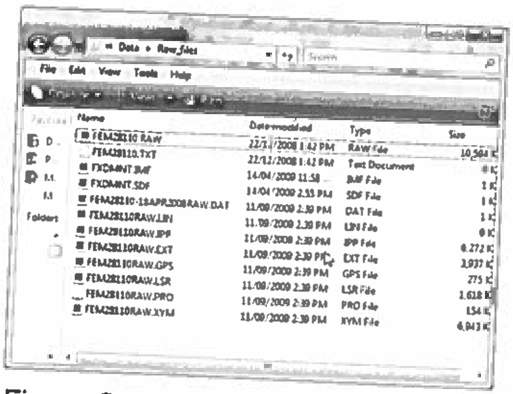


Figure C-2: RAW file input selection.



```
*******************************************************
**** IcePic RAW File Transcription Utility V2.2 *******
* For use with RAW files generated by Pic and Probe  **
* Converts FEMxxxx.RAW files to DAT and other formats *
******* Copyright 2001-2008 J. Scott Holladay *********
*******************************************************
Enter Serial Number (1, 2 etc) of IcePic Sensor Core
 (required to correct pitch/roll offsets)
***IMPORTANT:  Use Serial Number 0 for data obtained before 2008!***
2
Using laser, pitch, roll offsets of   0.0000000E+00   4.000000
 -5.700000
Enter adjusted values if desired, or / to accept these
/
Transcribing IcePic data file FEM28110.RAW
Found GPS Date info in RAW file
Opening FEM28110-18APR2008RAW.DAT file
```

Figure C-3: RAW file has been transcribed. Another RAW file can be selected for transcription, or the "Cancel" button can be clicked to terminate the program. The resulting files are listed in the next screenshot:



Name	Date modified	Type	Size
FEM28110.RAW	22/12/2008 1:42 PM	RAW File	10,504 K
FEM28110.TXT	22/12/2008 1:42 PM	Text Document	8 K
FXDMNT.BMF	14/04/2009 11:58 ...	BMF File	1 K
FXDMNT.SDF	14/04/2009 2:33 PM	SDF File	1 K
FEM28110-18APR2008RAW.DAT	11/09/2009 2:39 PM	DAT File	1 K
FEM28110RAW.LIN	11/09/2009 2:39 PM	LIN File	0 K
FEM28110RAW.IPP	11/09/2009 2:39 PM	IPP File	6,272 K
FEM28110RAW.EXT	11/09/2009 2:39 PM	EXT File	3,937 K
FEM28110RAW.GPS	11/09/2009 2:39 PM	GPS File	275 K
FEM28110RAW.LSR	11/09/2009 2:39 PM	LSR File	1,618 K
FEM28110RAW.PRO	11/09/2009 2:39 PM	PRO File	154 K
FEM28110RAW.XYM	11/09/2009 2:39 PM	XYM File	6,943 K

Figure C-4: Sample RAW file directory showing the input RAW and TXT files, the two FXDMNT control files (to be used during the inversion step) and the output files inverted from the RAW file data. The DAT file output can be used to view the real-time inversion results via DatFileViewer.

Running the Matlab program PlotBaseline (start Matlab, then use CD command to change directory to the processing directory, which is in this case "C:\IcePic_Proc\Data\Raw_files". Selecting the FEM28110RAW.IPP file yields the following "Figure 1" plot of the lowest frequency inphase and quadrature results, which has been stretched horizontally to make it easier to view. The program scales the results to focus on the near-zero responses obtained at background altitude—the strong responses from lower altitudes are mostly cut off the top of the plot. At this scale, there is very little drift evident.

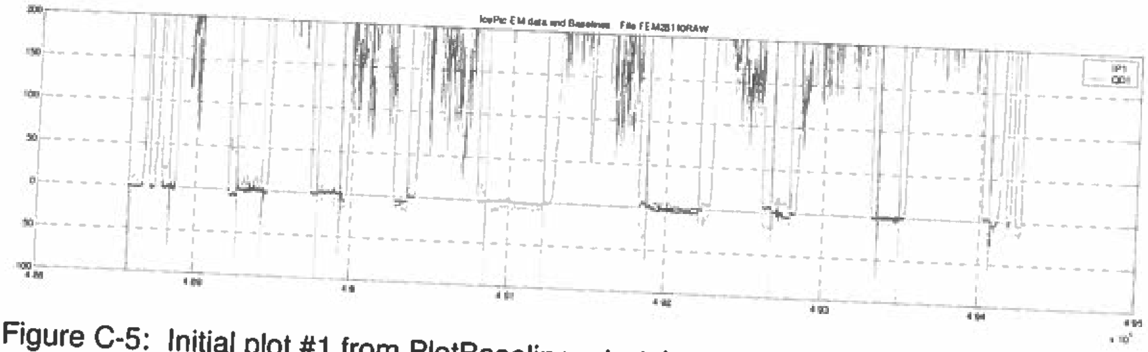


Figure C-5: Initial plot #1 from PlotBaseline, stretched horizontally for legibility. The data shown here are the lowest-frequency inphase and quadrature data, plotted as a function of timestamp. The narrow negative spikes are mostly due to artifacts of the real-time baselining process, although radio transmissions by the pilot result in similar, though usually wider (*i.e.* longer duration) spikes.

Zooming in on the Y range ± 20 ppm indicates a small amount of drift in the inphase (red), with less in quadrature (blue), which shows up as broad, relatively constant deviations from zero at high altitude.

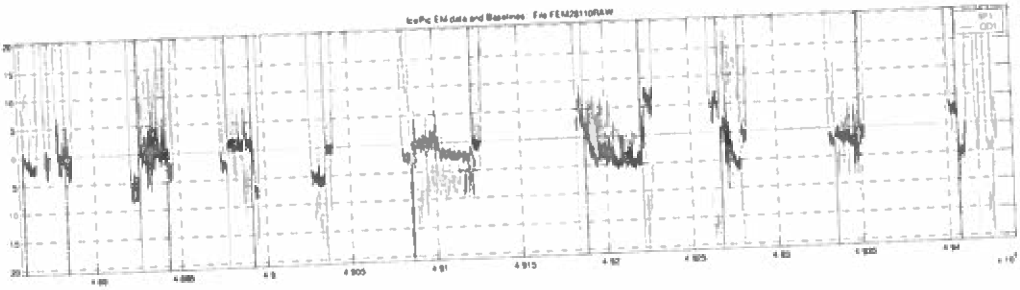


Figure C-6: Zoomed plot of same data. Inphase drift of roughly ± 10 ppm is visible, with smaller amounts of quadrature drift.

Step 2: View DAT file with DatFileViewer (for the real-time inversion results):

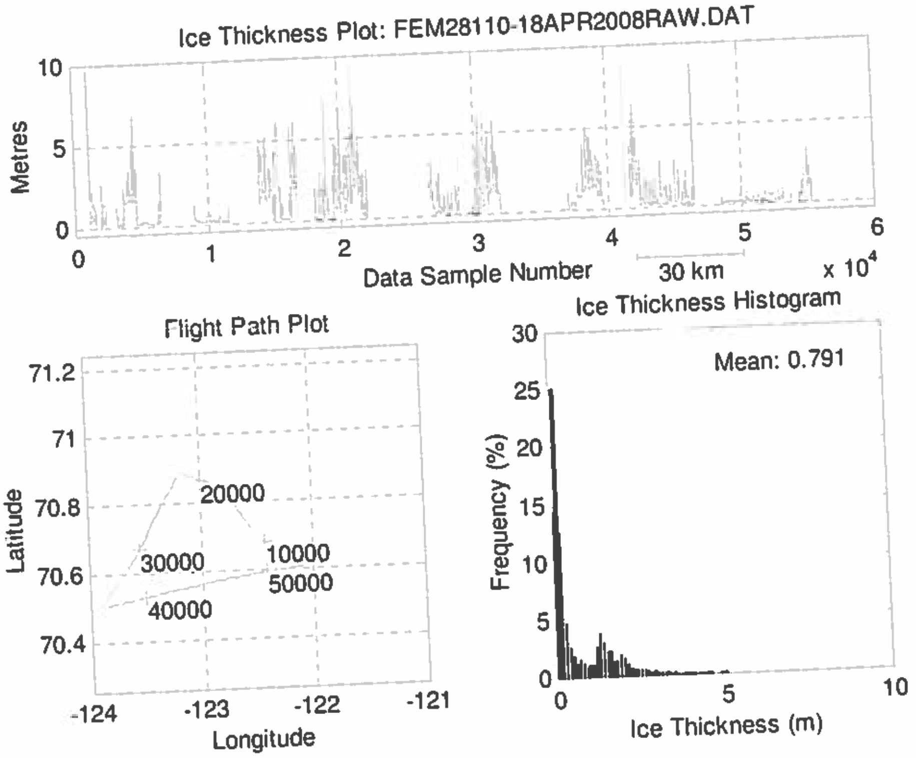
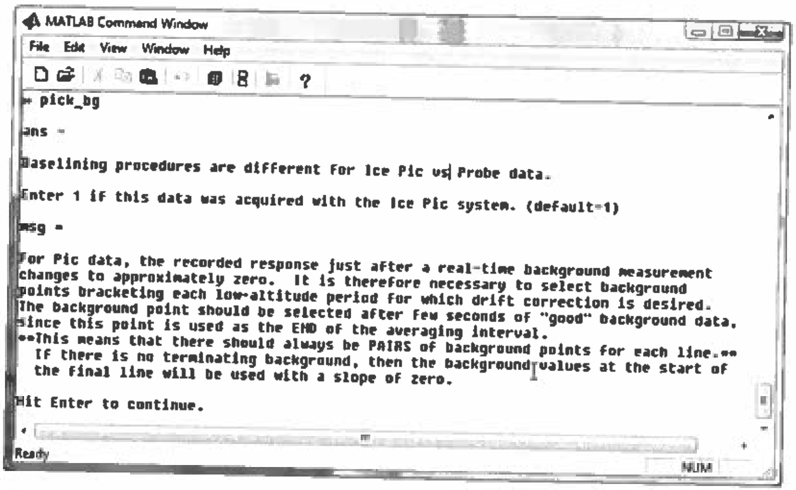


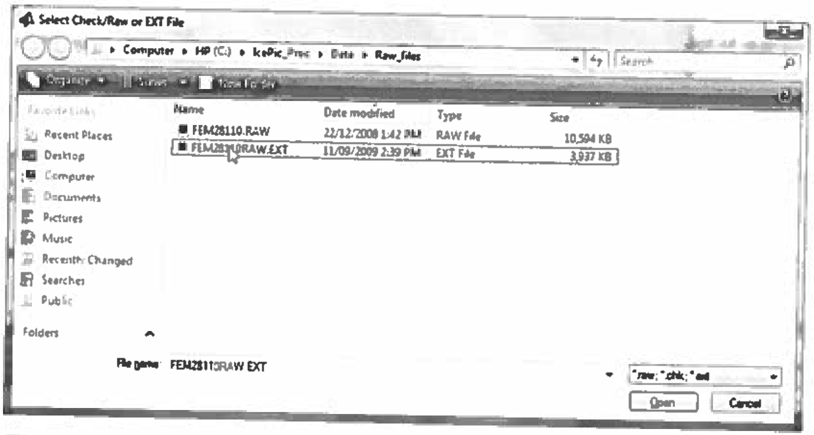
Figure C-7: DatFileViewer plot of real-time results for the entire dataset.

Step 3: Use EXT file with Pick_BG Matlab program to pick background points: The program is started by typing Pick_BG into the Matlab command window and answering the startup question about the data source:



```
>> pick_bg

ans =

Baselining procedures are different for Ice Pic vs Probe data.

Enter 1 if this data was acquired with the Ice Pic system. (default=1)

msg =

For Pic data, the recorded response just after a real-time background measurement
changes to approximately zero.  It is therefore necessary to select background
points bracketing each low-altitude period for which drift correction is desired.
The background point should be selected after few seconds of "good" background data,
since this point is used as the END of the averaging interval.
**This means that there should always be PAIRS of background points for each line.**
  If there is no terminating background, then the background values at the start of
  the final line will be used with a slope of zero.

Hit Enter to continue.
```

Figure C-8: Pick_BG startup in Matlab.



Name	Date modified	Type	Size
FEM28110.RAW	22/12/2008 1:42 PM	RAW File	10,594 KB
FEM28110RAW.EXT	11/09/2009 2:39 PM	EXT File	3,937 KB

File name: FEM28110RAW.EXT

*.raw; *.chk; *.ext

Figure C-9: Selecting FEM28110RAW.EXT as the input data for the program

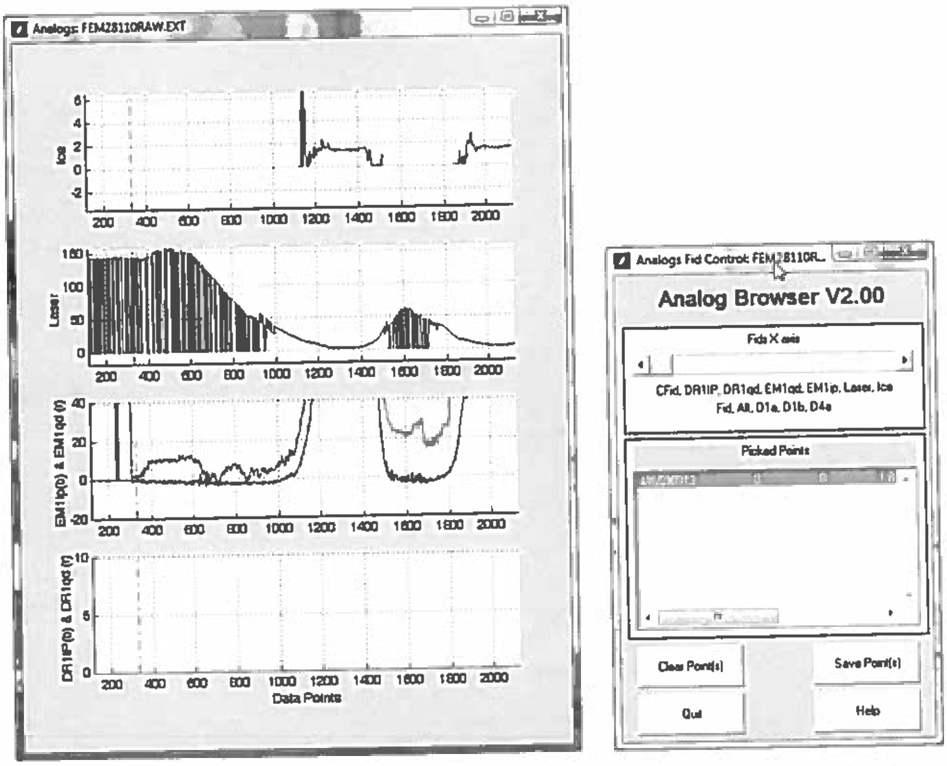
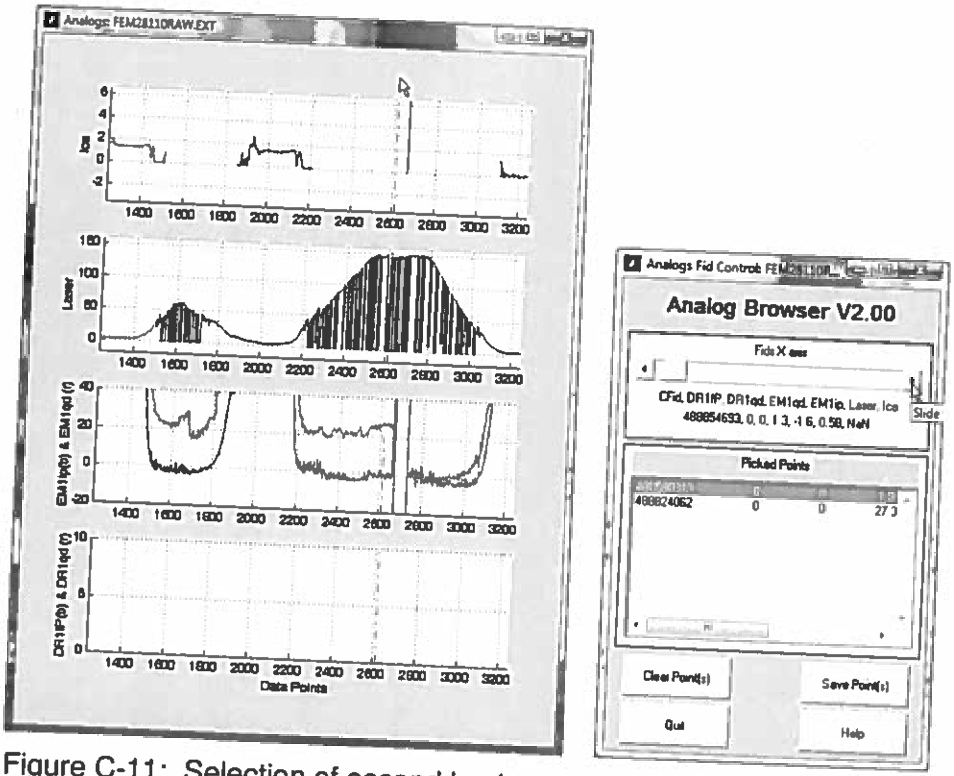


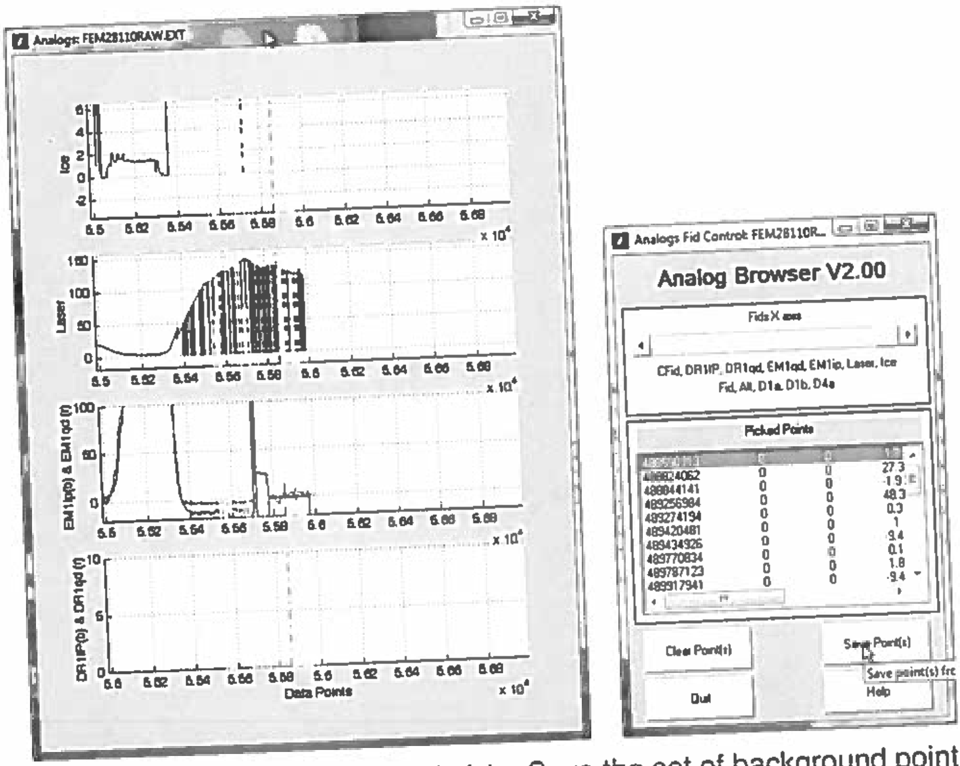
Figure C-10: Initial windows for data (left) and control (right). The four panes of the left window show real-time ice thickness, laser altitude, low-frequency inphase and quadrature and nominal base level corrections (all zero in this case), respectively. The vertical green cursor line toward the left of the data window (around 350 on the X scale) selects the initial zero base level for the first data segment (use left-click). Data are acquired at 10 Hz, so 100 samples on the X axis corresponds to 10 seconds. Note that the blue quadrature trace shows little variation with time between 300 and 1000, while the red inphase trace varies more strongly. This effect is due to the inphase component's higher sensitivity to motion of the sensor relative to the helicopter caused by manoeuvring forces.



CFid, DR1IfP, DR1Iqd, EM1Iqd, EM1Ip, Laser, Ice
488854633, 0, 0, 1.3, -1.6, 0.58, NaN

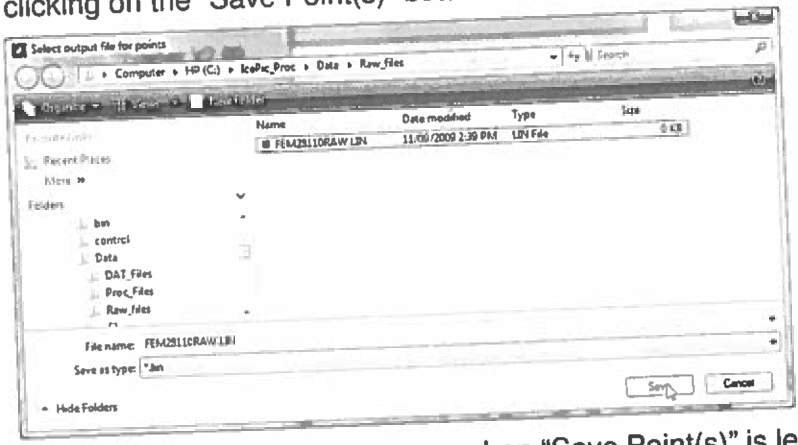
488824062 0 0 27.3

Figure C-11: Selection of second background point for first segment. Left-clicking on the slider arrow scrolls the data through the data window. Selecting (with the green cursor line) the flat section of data adjacent to the second real-time background point (seen as a jump in the EM signals between 2580 and 2720) and left-clicking on it picks out the sample time corresponding to the selection and writes it into the "Picked Points" pane of the control window. The next background point to be picked will be just to the right of the base level jump, at about 2800. Right-clicking re-paints the image.



[illegible]			
488824062	0	0	27.3
488844141	0	0	-1.9
489256984	0	0	48.3
489274194	0	0	0.3
489420481	0	0	1
489434926	0	0	-9.4
489770834	0	0	0.1
489787123	0	0	1.8
489917941	0	0	-9.4

Figure C-12: Final background pick. Save the set of background points by clicking on the "Save Point(s)" button



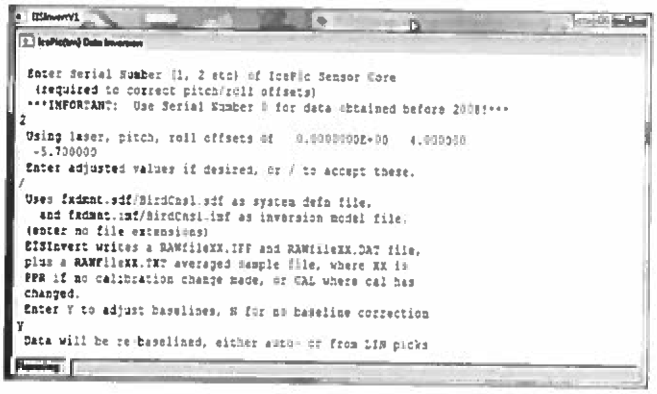
Name	Date modified	Type	Size
FEM28110RAW.LIN	11/09/2009 2:39 PM	LIN File	0 KB

File name: FEM28110RAW.LIN
Save as type: *.lin

Figure C-13: This menu pops up when "Save Point(s)" is left-clicked. Selection of the FEM28110RAW.LIN file as the background picks output data file. After clicking the "Save" button on this menu and accepting the over-write of the original blank LIN file with the picked background points, this step is complete. Click on the "Quit" button of the Pick_BG control window to exit the program.

Step 4: Invert Data with EISInvertV1:

At this point, the background points have been picked, and the inversion step can begin: double-click on the EisInvertV1 icon to run the inversion program. It is possible to force the program to invert data without baseline correction by entering "N" at the relevant question below.



```
 Enter Serial Number (1, 2 etc) of IcePic Sensor Core
  (required to correct pitch/roll offsets)
 ***IMPORTANT:  Use Serial Number 0 for data obtained before 2008!***
2
 Using laser, pitch, roll offsets of    0.0000000E+00   4.000000
  -5.700000
 Enter adjusted values if desired, or / to accept these.
/
 Uses fxdmnt.sdf/BirdCnsl.sdf as system defn file,
   and fxdmnt.imf/BirdCnsl.imf as inversion model file.
 (enter no file extensions)
 EISInvert writes a RAWfileXX.IFF and RAWfileXX.DAT file,
 plus a RAWfileXX.TXT averaged sample file, where XX is
 PPR if no calibration change made, or CAL where cal has
 changed.
 Enter Y to adjust baselines, N for no baseline correction
Y
 Data will be re-baselined, either auto- or from LIN picks
```

Figure C-14: Startup window for the inversion program. Note the "Y" response to the question about baseline correction.

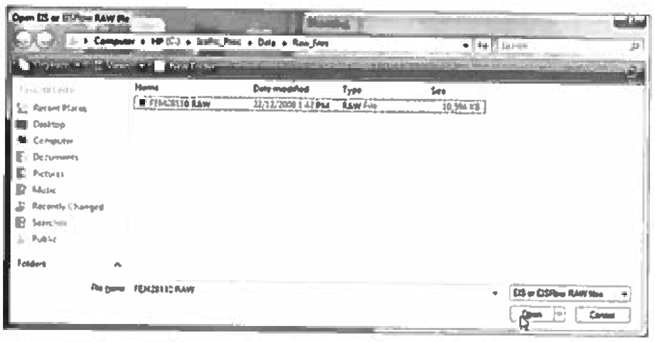


Figure C-15: Selection of RAW file for inversion. A similar menu selects the corresponding TXT file.

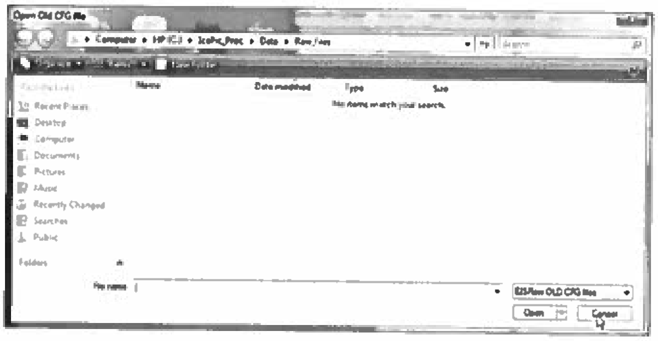
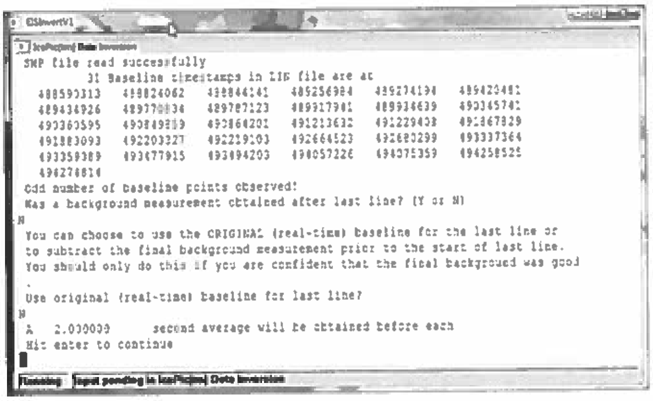


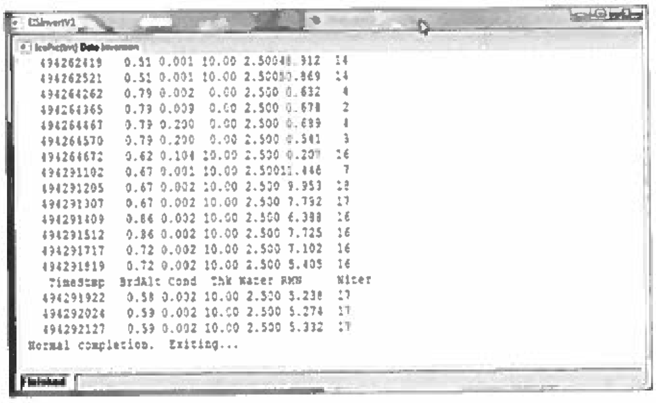
Figure C-16: The "old" and "new" CFG files would be used to change the EM calibration of the observed data, which is beyond the scope of the present discussion. Click "Cancel" for both of these menus.



```
SMP file read successfully
         31 Baseline timestamps in LIN file are at
   488590313   488824062   488844141   489256984   489274194   489420481
   489434926   489770834   489787123   489917981   489934639   490345741
   490360595   490849859   490864201   491213632   491229438   491367829
   491883093   492203327   492219103   492664523   492680299   493337364
   493359389   493477915   493494203   494057226   494075359   494258525
   494278814
 Odd number of baseline points observed!
 Was a background measurement obtained after last line? (Y or N)
N
 You can choose to use the ORIGINAL (real-time) baseline for the last line or
 to subtract the final background measurement prior to the start of last line.
 You should only do this if you are confident that the final backgroud was good
 .
 Use original (real-time) baseline for last line?
N
 A   2.000000      second average will be obtained before each
 Hit enter to continue
```

Figure C-17: In the main program window, the system configuration data and baseline picks are listed. Since there was only one background selection in the final segment, the program requests further information to ensure that the final segment is treated properly. In this case, the answer is "N", because the final segment (which was entirely at high altitude) did not have a second background point selected, so rather than having a pair of background measurements for this segment, there was just one. Because this was a valid background point, it is not necessary to use the real-time baseline for this segment, so the response to the final question is "N". Pressing the Enter key in response to the prompts starts the inversion process.

As the inversion program works through the data file, each output line in the main program window displays timestamp, laser altitude, ice conductivity, thickness and water conductivity, followed by a measure of fitting error and the number of iterations.



```
   494262419    0.51 0.001 10.00 2.50048.312  14
   494262521    0.51 0.001 10.00 2.50050.869  14
   494264262    0.79 0.002  0.00 2.500 0.632   4
   494264365    0.79 0.009  0.00 2.500 0.678   2
   494264467    0.79 0.200  0.00 2.500 0.689   4
   494264570    0.79 0.200  0.00 2.500 0.541   3
   494264672    0.62 0.104 10.00 2.500 0.207  16
   494291102    0.67 0.001 10.00 2.50011.446   7
   494291205    0.67 0.002 10.00 2.500 9.953  18
   494291307    0.67 0.002 10.00 2.500 7.792  17
   494291409    0.86 0.002 10.00 2.500 6.388  16
   494291512    0.86 0.002 10.00 2.500 7.725  16
   494291717    0.72 0.002 10.00 2.500 7.102  16
   494291919    0.72 0.002 10.00 2.500 5.405  16
    TimeStmp   BrdAlt Cond  Thk Water RMS     Niter
   494291922    0.58 0.002 10.00 2.500 5.238  17
   494292024    0.59 0.002 10.00 2.500 5.274  17
   494292127    0.59 0.002 10.00 2.500 5.332  17
 Normal completion.  Exiting...
```

Figure C-18: At the conclusion of the inversion run, the last few samples inverted by the program may be seen, followed by a "normal completion" message. A separate menu pops up that can be used to close the inversion execution window.

Step 5: Check drift correction results in IPP, amend background picks and re-invert if necessary:

Checking the baselines in the inverted data file FEM28110PPR.IPP can be done using Matlab program PlotBaseline.

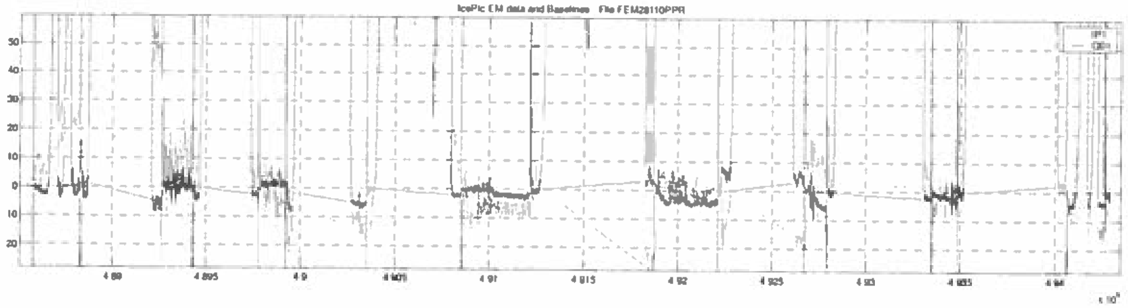


Figure C-19: The input data shown earlier, with baseline corrections shown as straight-line interpolates spanning each segment. Most of the corrections are reasonably small, though there are two segments in which corrections of up to 30 ppm were required for the inphase (red), with much lower corrections for quadrature (blue) (this plot does not show the corrected data.)

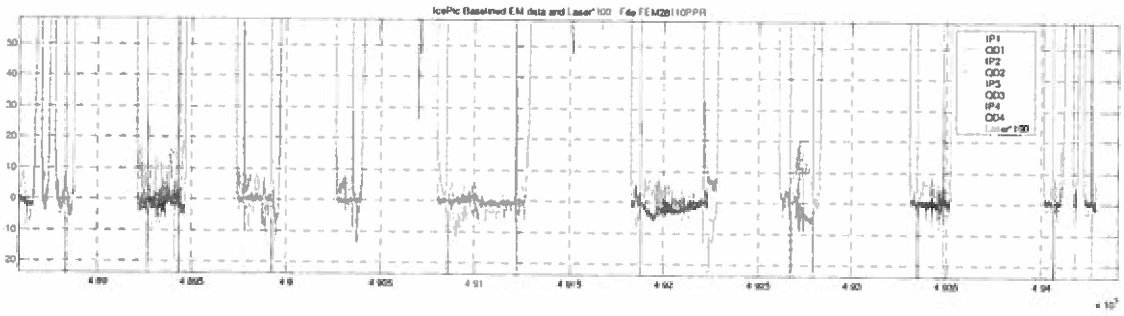


Figure C-20: Corrected data plot for the lowest frequency. For most of the high-altitude sections of data, inphase varies much more than quadrature, as expected. Small deviations from zero in the quadrature due to manoeuvre noise are acceptable. It is to avoid contamination of the background data by manoeuvre and radio noise that straight and level flight for 10 seconds before initiation and 10 seconds after the conclusion of every real-time background measurement, with radio silence throughout, is required.

Step 6: Check inverted data using DatFileViewer or other means:

The inverted data should be checked with DatFileViewer or other visualization software, as shown below. The inverted DAT file in this case is FEM28110-18APR2008PPR.DAT.

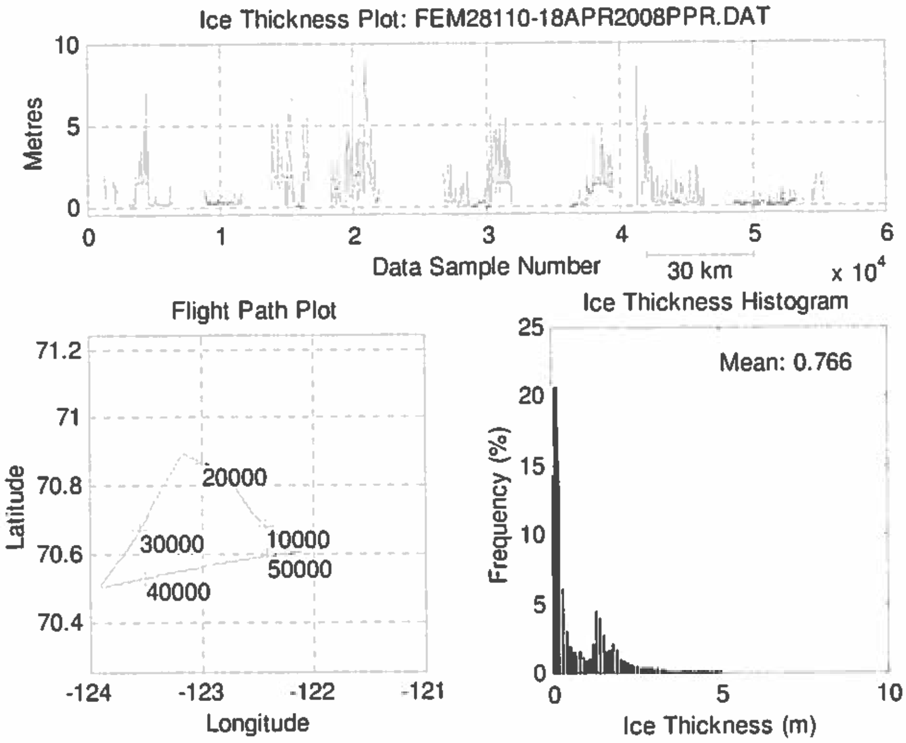


Figure C-21: Post-processed results plotted with DatFileViewer. At this scale, there are no substantive difference visible relative to the real-time inversion results.

Appendix D: Summer Surveys and Multiyear Ice

There are at least three issues that may affect summer/fall work over melting or MY ice.

1. Laser altimeter performance over open water in melt ponds and leads (specular reflection of the beam away from receiver)
2. Effect of mixing between seawater and meltwater beneath the ice
3. Potential presence of very thick ice

Of these, probably the most troublesome is #1, in that if you don't get a return from the water surface, you really can't estimate ice, or snow plus ice, or meltwater plus ice thickness. This should be improved by the presence of a light to moderate breeze, which should roughen the water surface, or the presence of a skin of ice (though glassy black ice seems to be pretty reflective too).

Fundamentally, if the meltwater is comparable in bulk conductivity to the ice, it won't be possible to identify it directly from the standard EM+laser measurements. There may be combinations of other simultaneous measurements (eg radar) that would permit extraction of surficial meltwater thickness. I don't hold out much hope of using Pic data to distinguish sub-ice meltwater from ice if conductivities are comparable.

The mixing issue is one that we're still learning about. Very careful data acquisition and postprocessing procedures may permit identification of areas where mixing zones are thick.

Very thick ice (>10m) would mean that the EM system would be trying to estimate depth to seawater that is >10 m plus survey altitude. While this is has been done, particularly for MY ice that retains some integrity at depth (*ie* doesn't become brine-riddled and relatively conductive), it requires very careful survey and processing methodology, and rather low survey altitudes. We would expect reduced accuracies for thick ice of any kind compared to normal, say 2m, ice.

Regarding "very careful" survey methods, the considerations include:

a. Acquiring frequent background measurements--these can be less frequent later in a flight, but at the beginning they should be at the outset, then after 5 min, then after 10, then after 15 and so on. 125m should be regarded as a minimum background height..

b. Maintaining straight and level flight for 5 sec before, 10 seconds after completion of the background measurement. This seems like a long time to the pilot and operator, but it makes a big difference when trying to postprocess.

c. Always obtaining a final background before closing a survey file.

d. It is a good idea to close a survey file before landing. A new short file can be opened at background altitude to capture the landing if desired.

e. Radio traffic strongly affects the EM measurements. HF is normally the worst, VHF better, FM best. If the pilot needs to make routine radio calls, he should inform the operator first, so that the operator does not try to obtain a background measurement during a radio transmission. The operator should wait at least 10 sec after a radio call has ended to perform a background.

f. Using the lowest survey altitude consistent with the pilot's safety requirements. This will vary with weather, wind speed and direction, surface contrast, light and so on

g. Always hook up to the radar altimeter if it is available (many or most CCG BO105's have this). It might be worth considering adding a dedicated radar altimeter to the 206L implementation of the system (*eg* attached at the rear of the sensor boom) in the long term. Laser altimeters often have difficulty at higher altitudes, particularly over open water. While the upgraded (as of summer 2009, in all systems) laser altimeters usually achieve good performance to 200m, the radar altimeter is a useful high-altitude backup. Unfortunately, even some BO105 helicopters are no longer providing connectors for this signal.

f. During installation, make sure that the Pic's roll readout is zero when the helicopter is on a level surface. This reduces the tendency of the laser beam to reflect away from the altimeter's receiver. Speed adjustments during flight might also help with optimising laser altimeter intensities.

Appendix E: Conversion from BO105 to 206L mount

When switching from the BO105 mount to the Bell 206L mount, a number of tasks must be performed besides watching the helicopter engineer install the mount and housing on the 206L.

It might be worth printing this and using it as a checklist.

1. Once the engineer has started the installation (he'll need to mount the aluminum parts first), it will be necessary to remove the Pic sensor core from the BO105 housing that it is currently in. Remove the #10 pan head machine screws that secure the nosecone and the EM Core to the cylindrical shell. Do not remove the four screws holding the support plate at the aft end of the tube to the shell. The core slides out of the housing fairly easily--grip it at the outer end of the tube by the central platform or where the central gusset meets the lower ring bulkhead--NOT the upper part of the ring bulkhead, which could be damaged by pulling hard on it. Please DO NOT TOUCH ANY OF THE ELECTRONIC COMPONENTS OR CONNECTIONS, as static buildup can and will damage the components.

2. The core should be put on a smooth surface, preferably on the floor (so that it can't roll off and fall as it could from a table). If there is an anti-static mat available, that would be even better.

3. In the unlikely event that the laser altimeter is not already installed--Locate the laser altimeter in its shipping/storage box--it should already be mounted on its baseboard. Again, AVOID TOUCHING ANY OF ITS CONNECTORS. Remove the two #10 machine screws from the sides of the baseboard. Slide the baseboard into the corresponding slot in the transmitter/laser mounting platform, insert the machine screws and make sure that they mate properly with the threaded inserts in the baseboard, tighten (do not over-tighten), and continue with the installation. Here are the full instructions sequence for de- and re-installing a laser altimeter from the Pic Core, in case this is ever required:

> If necessary, these units may be removed from the laser mount as follows (assumes that the Sensor Core platform has been removed from its housing). As always when servicing electronic equipment, care must be taken to avoid electrostatic discharge damage. Always touch a grounded point before touching any electrical terminal. Always disconnect the platform connectors before attempting to service the platform. Never touch electrical terminals when power is being applied to the platform.
>
> 1. Ensure that laser altimeter optics are pointing down before proceeding.
> 2. Remove retaining screws on main laser connector (a DB25 with a secondary grounding lug). Ensure that these screws are not lost!
> 3. Remove laser support board retaining screws on left and right of side of laser mount (facing rear of sensor platform). The screw on the right side is recessed.
> 4. Slide laser support board up and out of laser mount.

5. Remove the four screws that attach the laser to the laser support board. These screws are hard to replace, so be careful not to drop them.
6. Using blue or purple Loc-tite (removeable grade), install the replacement rangefinder to the laser support board with the same machine screws, taking care not to cross-thread or over-torque the screws–the rangefinder shell is relatively thin aluminium and the threads are vulnerable to damage. Never use a screw longer than the screws provided, as there are unprotected circuit boards close to the inside of the rangefinder shell.
7. Replace the laser support board in the laser mount and install the two retaining screws. Connect the laser heater (yellow/black cable with white connector).
8. Reinstall the main laser connector using blue or purple Loc-tite, ensuring that the grounding lug is connected.
9. If necessary, the replacement rangefinder can be programmed at this time by powering up the sensor platform from the console–only the large multi-pin connector should be attached for this step, not the BNC or 3-pin high-voltage transmitter power connector.
10. It may be necessary to modify the PicID settings to include the serial number of the laser altimeter, if it differs from the serial number listed in the PicID configuration data for this platform. See PicID section in manual.

4. After the laser has been installed and its cable harness connected (there is a DB25 connector on a short cable which also includes a grounding wire with lug, as well as and a white two-wire connector for the laser heater. The grounding lug is to be screwed down with one of the retaining screws for the connector, using loctite as usual). When this is completed, the unit should be ready to slide into the 206L tip tube. This may be easier to do if the tube is already mounted onto the helicopter. Note that it is important for the paired Pic cables to run from the rear of the tube to the downward looking hole in the tip tube before the Pic core is installed.
5. Slide the Pic core into the tip tube, again taking care to avoid touching cables and electronic components. The core has a sliding fit within the tube. Once in place, locate the captive fasteners in the Pic core through the four holes in the tip tube located just forward of the laser hole. An awl is a good tool for this step. Finger tighten the four machine screws (attached to outside of BO105 Pic tube) into these captive fasteners to ensure that they are not cross threaded, then tighten.
6. Attach the main cables to the three connectors, leaving a 5-6 inch loop of cable descending from the connectors before going back up into the tube in order to avoid straining the connectors or cable.
7. The cable run from the back of the tube into the port (left) side of the helicopter will be secured to the helicopter by the helicopter engineer. Attach the connectors at the end of this cable, as well as the cable harness located in the Pic Console box, to the corresponding connectors on the back of the console. There should be no ambiguity for all but the BNC cable coming from the Pic core:

this cable should be connected to the Tx Control connector. Another BNC connector on the console is for the Manual Fiducial or ManFid, and connects to the pushbutton fid marker in the cable harness going forward to the power connector. There is a final BNC connector for a radar altimeter connection in the BO105 system, which is not used for the 206L installation. The heavy AC power cord provides ground power to the console, independent of the helicopter DC power supply.

8. Before connecting the power cable to the helicopter power socket, verify that the polarity of the power plug is A = ground, B = +28VDC. There should be a polarity swapping cable in the BIO cable kit–if you don't have one, the engineers at the helicopter base may be able to prepare one for you. After installation of a polarity reversal cable, if necessary, double-check that the polarity of the power plug is A = ground, B = +28VDC. (Note that there is also a power splitter cable in the kit that allows use of the power socket by the IcePic system and the DC-AC inverter located to the right of the front passenger seat in the BO105. This cable splitter does NOT reverse polarity.)
9. The shorter of the two DB9 connector cables coming from the console bundled with the helicopter power cable is for the user interface box, while the longer one goes to the pilot's laser altitude display.
10. The engineer will strap the console down to keep it stationary during all maneuvers.

After completing the installation, you should ensure that the DC breaker on the pilot's panel is NOT closed and turn the master breaker on the console off, then run the system from AC by connecting the AC cord to a suitable extension cord and engaging the AC on/off switch located at left rear on the console. It is a good idea to connect a monitor, mouse and keyboard the first time you start up in a new installation so that you can see the full system display and particularly any error messages or dialog boxes. If you see anything out of the normal (especially dialog boxes) then call Geosensors at 416 483 4691 or email scott.holladay@geosensors.com

When the checkout has been completed, shut down the console and turn the AC power switch OFF. Close the Master power breaker and verify that Tx and Aux breakers are closed in preparation for flight operations. The system will be powered up when the pilot closes the DC Socket breaker on his control panel.

Appendix: Memory Cards and the IcePic Console

IcePic consoles SN1 and SN2 use PCMCIA adapters with CompactFlash cards. They can also use USB memory keys (see comments below regarding use of these USB devices).

The SN3 console unit should also handle PCMCIA (also known as PC-Card) memory cards, CompactFlash, and Secure Digital (SD cards).

SD cards are commonly used in digital cameras, and they are available in pretty big capacities (up to 16 or 32 GByte). Many/most laptops have direct plug-in reader slots for SD--it would be good to check field computers for this capability. For these reasons, assuming that both the console and your field computers can read/write SD cards, these are the recommended devices for SN3 and later.

The console can use one or more USB memory keys. With these devices (and possibly with some memory cards) you should "introduce" the particular memory key to the console with a display and mouse hooked up, to allow it to go through a recognition process. Once the console "knows" the device, it will recognize it again in future. Failure to do this may result in the console refusing to transfer data to the device, or even appearing to hang.

Here's how you can verify that your preferred memory card will work with the console (definitely not rocket science, but I'll spell it out anyway.)

Hook up the console to power, the User Interface, a display, keyboard and mouse. Gather some examples of different data cards that you might like to use.

Start up the console.

After the console has booted through to the IcePic application, click on the Start button, then insert the memory card of your choice into the appropriate slot in the card reader.

The computer should, after a few seconds, offer to "open" the device in various applications, such as Windows Explorer, Photo Viewer etc.

Click on Windows Explorer, but do not tell the computer to automatically open Explorer every time the card is plugged in.

You should be able to view files on the selected card. Try transferring files to and from the card.

Exit Windows Explorer, remove the card, wait 10 seconds, and re-insert it. Don't respond to the resulting dialog box. Also, make sure that there are no Windows Explorer windows open on the desktop. If they are present, they can sometimes interfere with IcePic application operation, and can even re-appear on subsequent reboots of the system.

BTW, it's always a good idea to start up the console once before a survey with a display attached, to confirm that there aren't any pending dialog boxes. Doesn't happen often, but it's a pain if it happens when you're in the air!

I also use this check boot as an opportunity to reset the FXDMNT.NUM file ID number and perhaps to clear out the RAW files left in the SURVEY directory, if they have been archived.

Click on the IcePic application window. Pick up the IcePic User Interface Box. Press Enter on the UI to accept the system identification information (may not show up if no sensor attached), Enter to get through the helicopter type selection, and again to commence system operation.

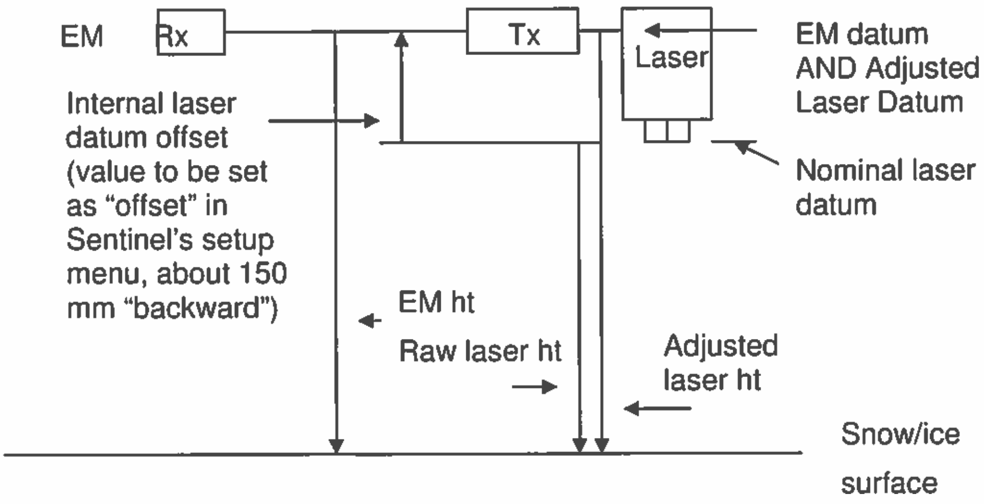
Press the back-arrow to get out to the File Copy or Exit menu

Save a file, or several, using the File Copy menu, then exit the application and shut down the system.

You should then be able to see and transfer the RAW files and associated TXT files when you plug the card into your computer, using Windows Explorer.

Archiving:
I'm very careful to archive all data from a survey, check the files by transcribing them, and make backups before I erase the data cards. Simon keeps data cards un-erased for quite a while (he has many of them) as a third level of backup.

Appendix: Laser Altimeter



Geometry for Sentinel internal laser corrections relative to EM datum

Thus, the Sentinel units should be set up as follows:

- Low resolution metric (cm rather than mm)
- Continuous trigger
- Range/dropout/intensity output
- Window: distance--0, time--0.
- Unfiltered last pulse
- "process variable" output (NOT "Menu")
- 15 Hz (current Optech max, may be upgraded to 20Hz in future)
- No analog output settings are required
- Internal offset for Sentinel rangefinders:
  - BIO K00947: 150 mm "backward" (lengthens range by 15.0 cm)
  - BIO K00606: 160 mm "backward"
  - UM K00753: 150 mm "backward"
  - UM K00755: 150 mm "backward"
  - [for BIO ADM #178: no adjustment possible or required]

Programming of Optech rangefinders is performed using a standard male-female 9 pin serial cable at 9600 baud, no parity, 1 stop bit, as per the Optech manual. The menu tree may be accessed by typing the character M. Lowercase commands are not recognized. This programming may be performed from a laptop with a USB-serial adapter.

> NOTE: If no laptop or other computer is available for this programming, it can be done using the COM1 serial port on the console if necessary (this connector is the upper DB9 connector on Pic consoles SN2 and later, and is the only such connector on Pic console SN1). However, the console must NOT be running the standard IcePic data acquisition/real-time-processing application when this COM port is attached to the programming port, as it will probably scramble the rangefinder's programming.

Laser altimeters in the spares kit will normally be pre-programmed to this standard, and should thus be drop-in replacements. However, if they have been serviced by Optech and not subsequently programmed by Geosensors, it will necessary to re-program them.

If necessary, these units may be removed from the laser mount as follows (assumes that the Sensor Core platform has been removed from its housing). As always when servicing electronic equipment, care must be taken to avoid electrostatic discharge damage. Always touch a grounded point before touching any electrical terminal. Always disconnect the platform connectors before attempting to service the platform. Never touch electrical terminals when power is being applied to the platform.

1. Ensure that laser altimeter optics are pointing down before proceeding.
2. Remove retaining screws on main laser connector (a DB25 with a secondary grounding lug). Ensure that these screws are not lost!
3. Remove laser support board retaining screws on left and right of side of laser mount (facing rear of sensor platform). The screw on the right side is recessed.
4. Slide laser support board up and out of laser mount.
5. Remove the four screws that attach the laser to the laser support board. These screws are hard to replace, so be careful not to drop them.
6. Using blue or purple Loc-tite (removeable grade), install the replacement rangefinder to the laser support board with the same machine screws, taking care not to cross-thread or over-torque the screws—the rangefinder shell is relatively thin aluminium and the threads are vulnerable to damage. Never

use a screw longer than the screws provided, as there are unprotected circuit boards close to the inside of the rangefinder shell.

7. Replace the laser support board in the laser mount and install the two retaining screws. Connect the laser heater (yellow/black cable with white connector).
8. Reinstall the main laser connector using blue or purple Loc-tite, ensuring that the grounding lug is connected.
9. If necessary, the replacement rangefinder can be programmed at this time by powering up the sensor platform from the console—only the large multi-pin connector should be attached for this step, not the BNC or 3-pin high-voltage transmitter power connector.

Appendix: GPS Receiver Reprogramming and Repairs

If it proves necessary to reprogram the GPS18x receiver, this can be done via the secondary (lower) DB9 COM port located on the rear panel of all IcePic consoles with serial number 2 or higher. This programming is best performed from a laptop with a USB-serial adapter or a desktop computer with a standard serial communications port, using the Garmin application "SNSRCFG_280.exe", and using a standard female-to-female crossover (null-modem) serial cable.

> NOTE: If no laptop or other computer is available for GPS programming, programming can be performed using the COM1 serial port on the console (this connector is the upper DB9 connector on Pic consoles SN2 and later, and is the only such connector on Pic console SN1. The secondary port COM2 on SN1 is located inside the console's case on a lashed-down cable located above the housing of the EM transmitter's power supply). COM2 should be connected to the upper COM1 socket using a 9-pin female-to-female null modem (crossover) cable. The console MUST NOT be running the standard IcePic data acquisition/real-time-processing application at any time while the primary (upper) COM port is attached to the secondary (lower) COM port, as it will at best scramble the GPS unit's programming and possibly make it impossible to communicate with the device at all.

The GPS core can also be programmed using a special adapter cable/housing arrangement obtained from a "standard" Garmin GPS18X PC adapter kit. Installation of the electronics within the GPS housing is described below for completeness, and because knowledge of access to the electronics could be required if the GPS electronics were to fail in service. However, the adapter unit is typically kept in Geosensors' electronics shop, so the only field option for repair will typically be to replace the installed unit with the spare unit included in the spares kit. This step should only be taken after consulting with Geosensors, as it is somewhat difficult and risky.

Installation/deinstallation of the GPS electronics head from the Garmin housing.

1. The GPS18X head is a three-piece assembly. The base brings the cable into the electronics enclosure, while the top acts as a cap. The GPS core sits inside this enclosure. [Note: A "new" unit may have its cap sealed to the base with RTV and thus require substantial effort to open, using a screwdriver blade to pry the top free at a few locations before carefully pulling the cap off. (see photos 1 and 2 below). Non-electronics specialists should not attempt this task, as damage could be done to the GPS unit, its housing or its bond to the sensor platform.] Note the black alignment pegs that protrude slightly through the metal ground plane. These correspond to the + shaped hold-downs in the cap. The cap has a cutout on one edge that corresponds to the cable side of the lower enclosure.
2. Once the top has been removed, the electronics assembly can be grasped by the large metal ground plan (avoiding the central GPS antenna itself)

and rotated toward the cable exit side of the enclosure (photo 3.) Note that the extra black round object to right is a lens cap used to support the bottom of the enclosure and is not relevant to this discussion.

3. The small white plug that enters the tan-coloured socket on the electronics module can be gently worked free from its mating socket with a thumbnail or small screwdriver. (photo 4). A black or yellow wire joining the enclosure base to the module can be cut to free the module without damage to the unit.
4. The new electronics module from the spares kit (removed in the same manner as above from its protective housing) can then be mated with the enclosure using the reverse of the above procedure, remembering to align the holes in the ground plane with the black plastic pegs, and that the "lid" has a cutout that is oriented toward the cable side of the enclosure.
5. The top is then reinstalled. It should snap cleanly together and show a constant gap around its perimeter. If not, then the lid has not been aligned with the base properly.

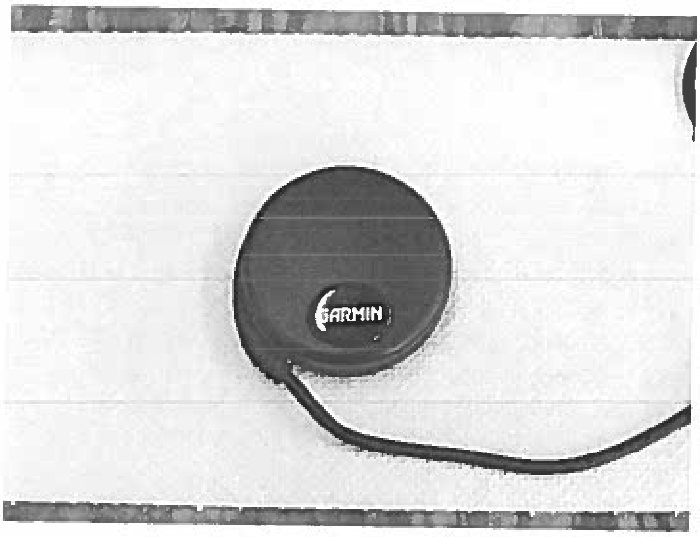


Photo 1: GPS18X housing before disassembly. Lid may be bonded to base with RTV and require considerable effort to pry free, but once opened, the lid is relatively easy to pry open with a flat screwdriver blade.

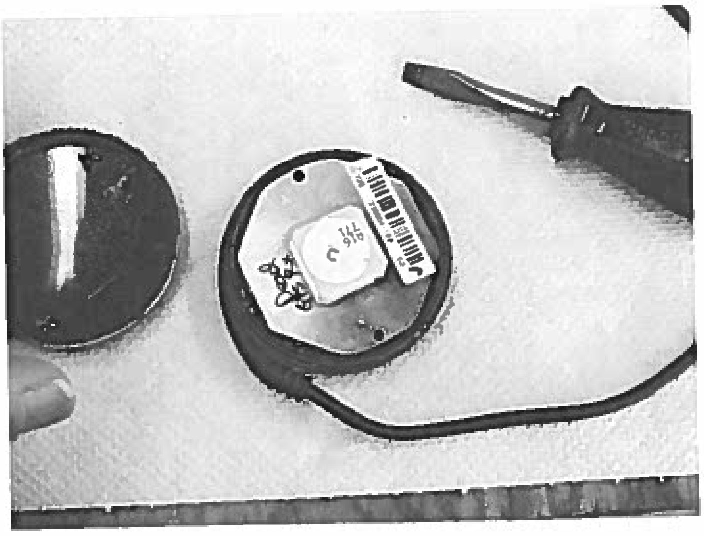


Photo 2: Housing with lid pried off using a flat-bladed screwdriver. Do not touch antenna assembly at centre of ground plane–ground plane is safe to touch. Note black plastic alignment pegs on which ground plane sits.

Photo 3: Rotate module about cable near cable entry to expose connector (white plug mated into beige socket to upper right of unit in this photo).

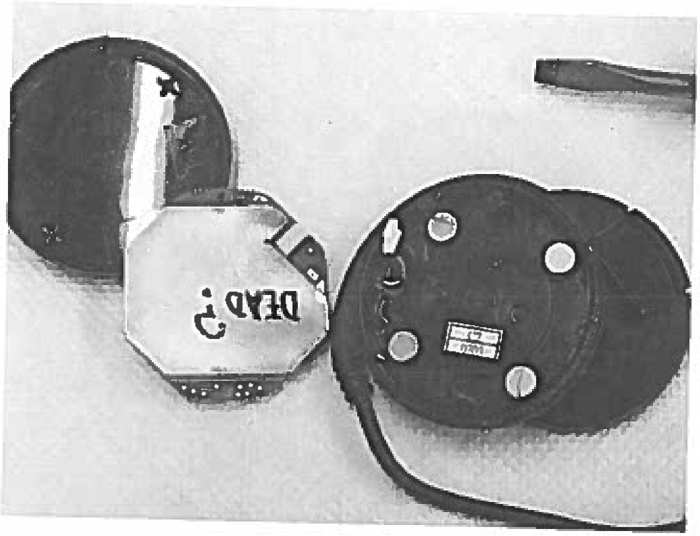


Photo 4: Disconnect electronics module

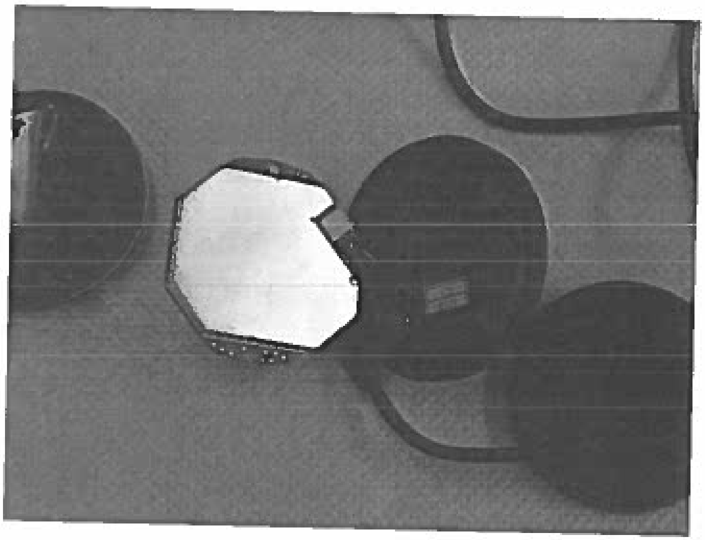


Photo 5: Install replacement electronics module. Unit should then be rotated back down into base and aligned with pegs as in Photo 2 above. Lid should be aligned with cutout adjacent to cable entry on left and snapped down. Failure to snap down easily probably indicates mis-alignment.

Photo 6: Reassembly complete

Programming the GPS receiver:

1. The Garmin program "SNSRCFG_280.exe" can be used to program the unit without resorting to large amounts of typing. Refer to the Garmin document "425_TechnicalSpecification.pdf" for further information about configuration settings. This program should be accessible via a shortcut on the console's Windows desktop. It can also be downloaded direcly from the Garmin website.
2. Before connecting the GPS serial port to COM1 on the IcePic console, ensure that the console is running in Windows with the IcePic data acquisition/real-time processing program <u>terminated</u>. Failure to shut down the IcePic program could reprogram the GPS and make it hard or impossible to access.
3. After connecting the GPS serial port to COM1, start SNSRCFG_280.exe. You will have to select GPS18X from the menu of receivers that the program can configure. It may be necessary to use the setup menu to select COM1 for operation after the main dialog box appears.
4. Click on the "connect" button and wait for the program to locate the GPS18. This should happen at 9600 baud. The GPS will not connect to the IcePic software at other baud rates.
5. Download the configuration from the GPS18X using the appropriate button.
6. Use the configure dropdown button to select a configuration option (output strings or GPS configuration, for example). Avoid changing parameters not listed below.
7. The key parameters are:
   - Automatic fix mode
   - Automatic differential mode
   - Automatic selection of differential source

- Dead reckoning valid time–set to 5 sec
- NMEA output time 1 second

8. Note that WAAS and EGNOS signals, which provide differential GPS corrections to a WAAS-equipped GPS receiver such as this one, are reportedly strong in most of Canada, Alaska and the USA and their neighbouring waters. It may prove desirable to disable this capability if operating in areas where these signals are weak.
9. After setting up the parameters on the dialog page, the revised parameters must be sent to the GPS using the appropriate menu-bar button.
10. Once this has been done, power the unit off and on again and reconnect to verify that it has received the correct setup information.
11. Save the program configuration to disk and exit.
12. Re-seal the housing with RTV to provide moisture protection to the electronics.