Technical Report

Operation Southern Ice Fields 2016

Southern Chile

for

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1. EXECUTIVE SUMMARY

Sander Geophysics Limited (SGL) conducted a fixed-wing, high resolution gravimetric survey over the Patagonia Ice Fields for Eric Rignot, Chancellor Professor of Earth System Science at the University of California Irvine (UCI) and a Senior Research Scientist at NASA's Jet Propulsion Laboratory (JPL). Gravity data was acquired using SGL's airborne gravity system, Airborne Inertially Referenced Gravimeter (AIRGrav). Please refer to *Appendix I* for a Company Profile of SGL.

The survey was flown using a locally operated Cessna 206, registration CC-ATW. Production flights commenced on July 22, 2016 and data acquisition was completed on August 1, 2016. A total of 8 (1000 to 1007) flights were flown during the survey to complete 3147 line kilometres. The survey operations were conducted from Villa O'Higgins Airport (SCOH), Villa O'Higgins, Chile.

The primary survey lines are oriented north-south and spaced at 2,000 m. The survey was planned taking into account the terrain and the performance of the aircraft at the modelled altitudes and estimated temperature, and was flown with a target clearance of 100 m above ground level. The target average ground speed was 80 knots.

2. INTRODUCTION

This report describes the survey that Sander Geophysics Limited (SGL) flew for Eric Rignot in July of 2016 over the Patagonia Ice Fields.

Gravimetric (AIRGrav) data were gathered during this survey. The instruments used to collect the data are described in this report as well as the tests performed to ensure optimal data quality.

Picture 1: Typical scenery found in the survey area

The Digital Data Compilation section details all processing performed from data acquisition to final product creation.

The Field Operations section contains all information relating to operations at the survey location including the airport used, reference station coordinates and any problems encountered during the survey. Re-flights are listed as well as field crew members.

The following Project Brief gives a quick reference of the details of the survey.

Project Brief

Survey Title	Operation Southern Ice Fields 2016
Client:	Eric Rignot, UCI and JPL
Survey Location:	Patagonia Ice Fields
Survey Start Date:	July 22, 2016
Survey End Date:	August 1, 2016
Contact:	Eric Rignot (Eric.J.Rignot@jpl.nasa.gov)
Technical Inspector:	Eric Rignot (Eric.J.Rignot@jpl.nasa.gov)
Field Office Location:	Villa O'Higgins, Chile
Airport Used:	Villa O'Higgins Airport (SCOH)
Aircraft Type:	Cessna 206
Total line kilometres:	3147
Survey Flying Particulars	
Traverse Lines	
Line direction:	north-south
Line spacing:	2,000 m
Control Lines	
Line direction:	Various directions
Line spacing:	N/A
Survey Altitude:	Radar guidance with target height of 100 m above ground.
Digital Terrain Source:	SRTM
Number of Flights (numbers):	8 (1000 to 1007)
Aircraft Target Ground Speed	80 knots
Data	
Gravity Ties:	Cochrane, Chile (calculated in 2012 during previous icefields project), 980731.098 mGal.
Survey Base Gravity Value:	980810.797 mGal at centre of gravimeter when aircraft parked at its designated parking area in Villa O'Higgins.
Survey Base Parking Location (WGS-84):	W72:33:46.77 S48:27:53.65 282.88 m (location of gravimeter centre, 1.2 m above the ground.)
Base Station Locations (WGS-84)	REF2: W72:33:42.9767 S48:27:52.2176 285.833m REF3 (OHI3): W57:54:04.987 S63:19:15.941 32.15m REF4 (MGUE): W69:23:52.54 S35:46:38.46 1554.15m
Delivery Datum:	WGS-84
Projection:	UTM18S

3. SURVEY AREA

The survey area covers the Patagonian Ice Fields in southern Chile. This is a remote region with only a handful of small towns in the vicinity and high mountains in the survey area itself. The terrain is extremely rugged over most of the area, varying from 0 m above mean sea level (MSL) over some of the ocean fjords to approximately 3500 m above MSL at the high peaks. The weather in the region was cold and humid, with temperatures averaging between 0-5°C over the survey period. Morning fog and thick cloud cover were not uncommon.

Survey Area Map

The survey was flown in three distinct blocks; NPI, SPI, and SPI2. *Figure 1* shows the geographical location of the survey area. The planned survey lines are illustrated in *Figures 2*, *3* and *4*, and are listed in *Appendix II*. The survey lines as actually flown are illustrated in *Figures 5*, *6* and *7*, and are listed in *Appendix III*.

Figure 1: Survey Area

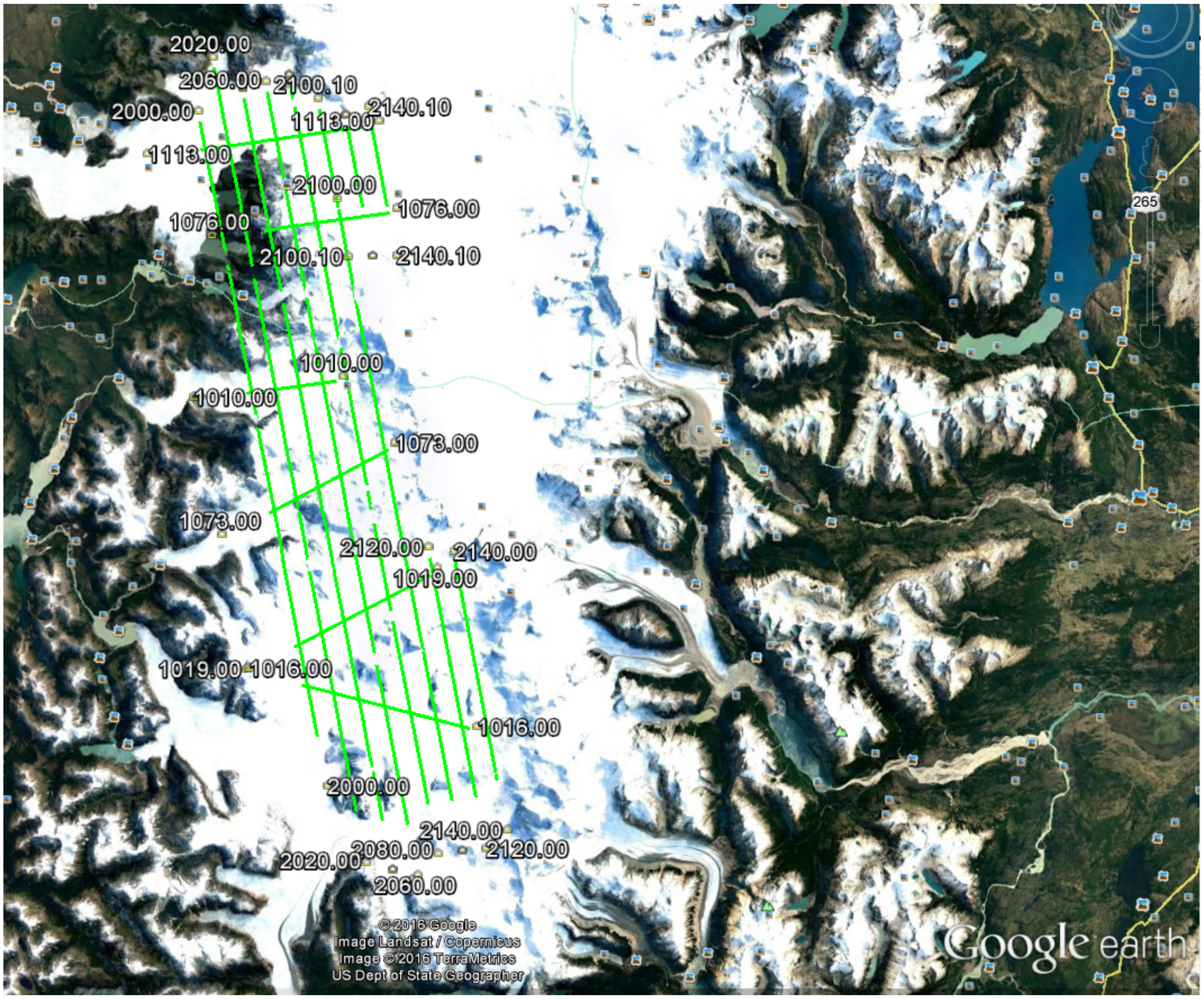


Figure 2: NPI Survey Block Planned Lines

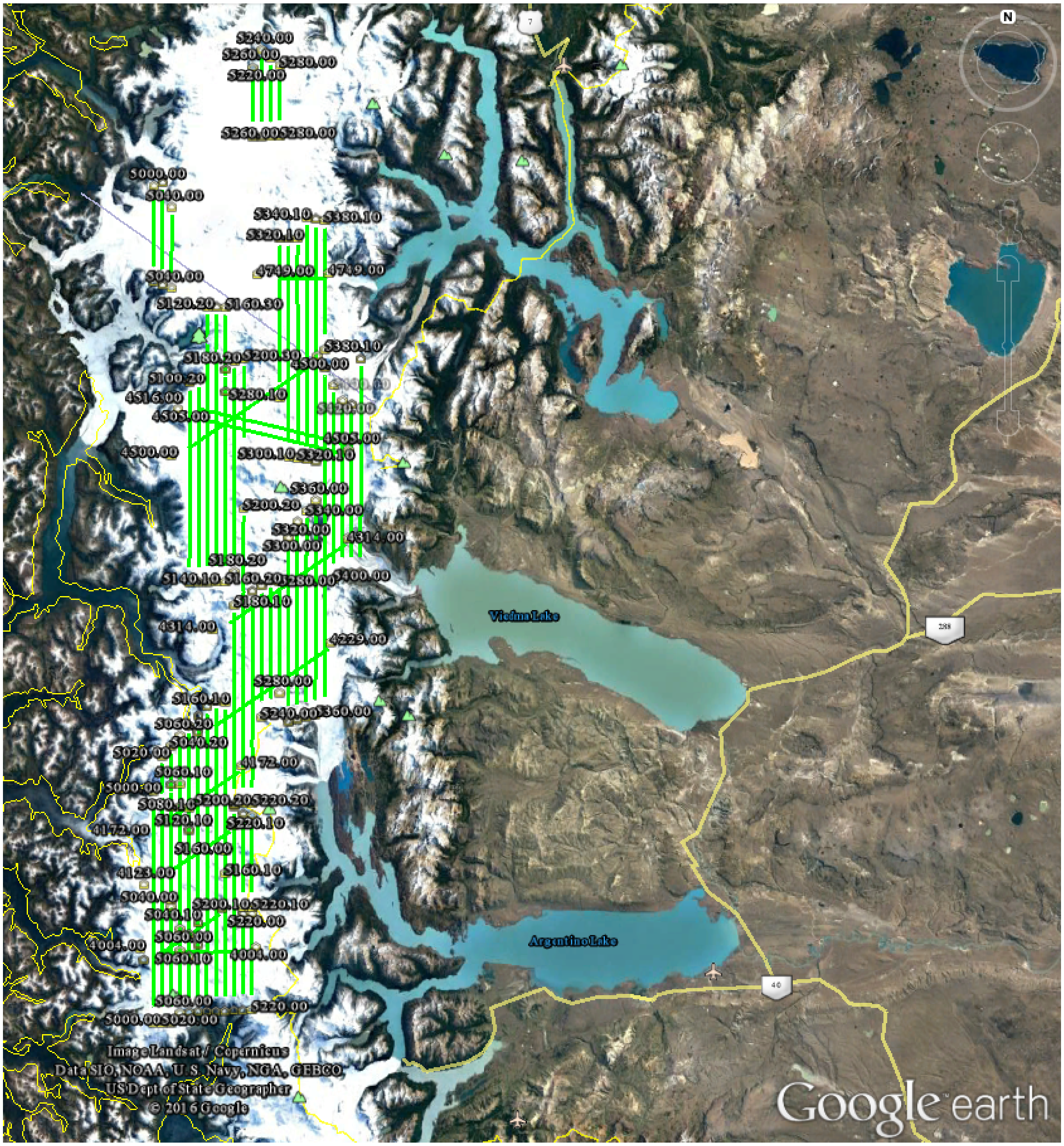


Figure 3: SPI Survey Block Planned Lines

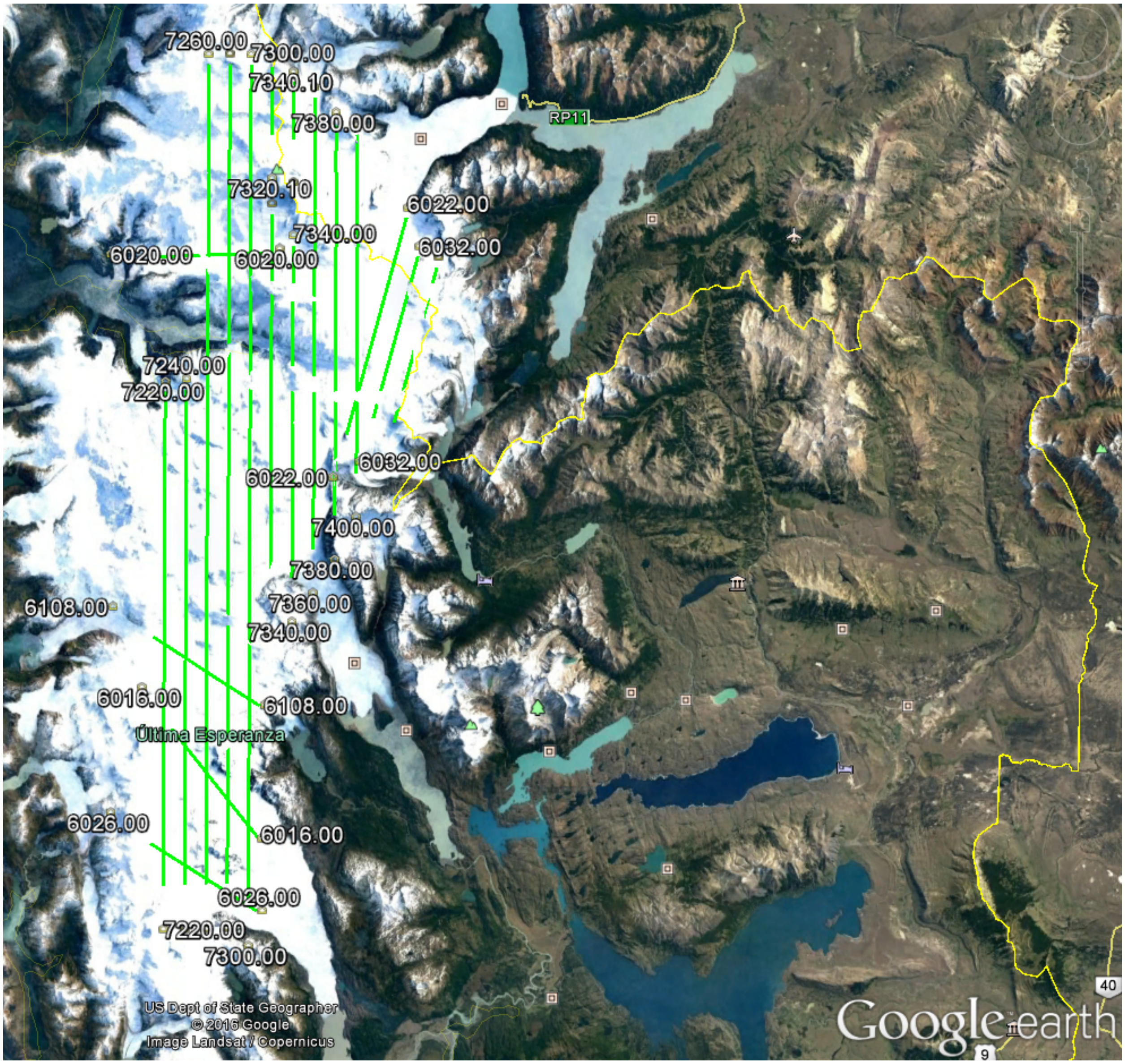


Figure 4: SPI2 Survey Block Planned Lines

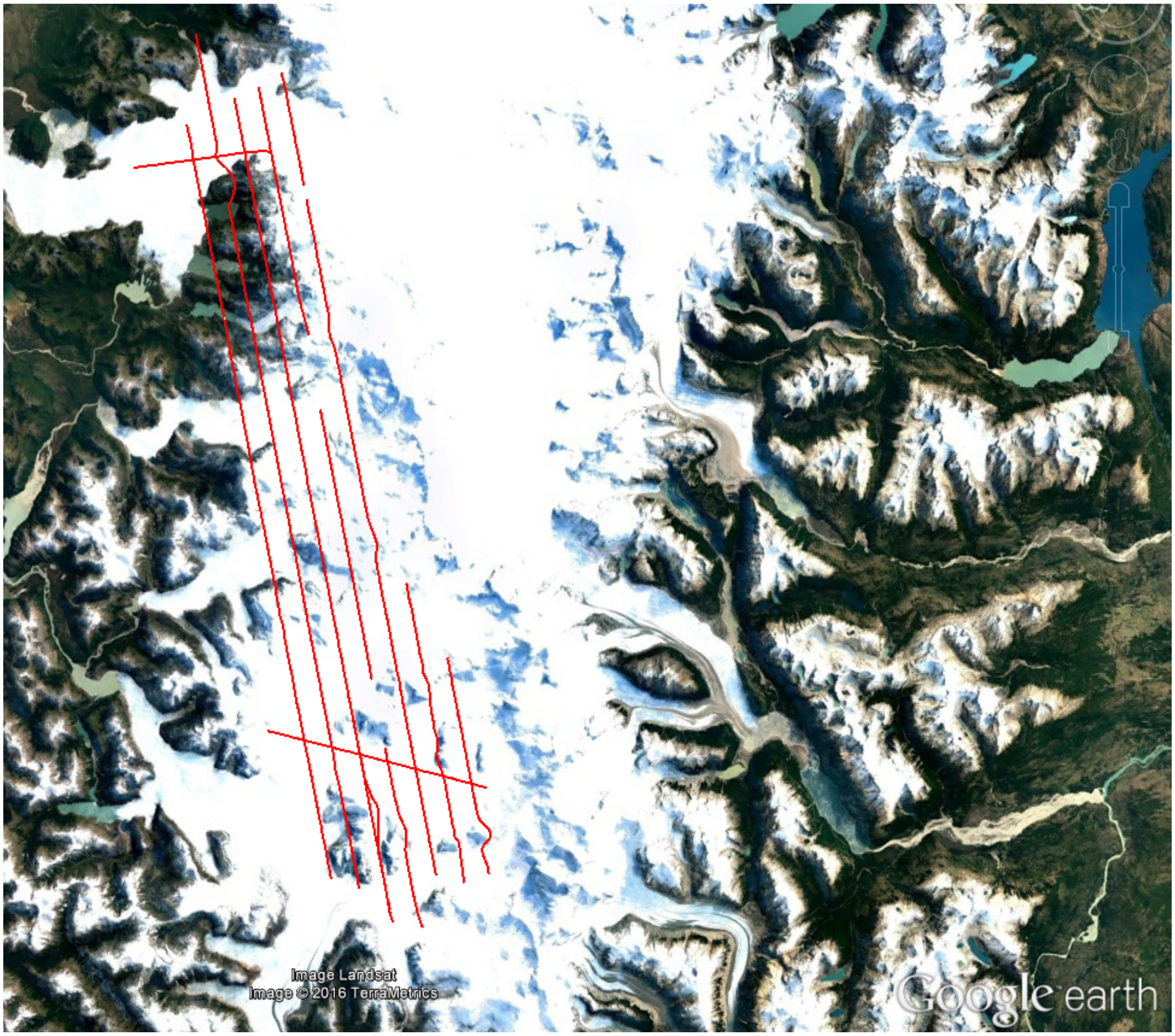


Figure 5: NPI Survey Block Flown Lines

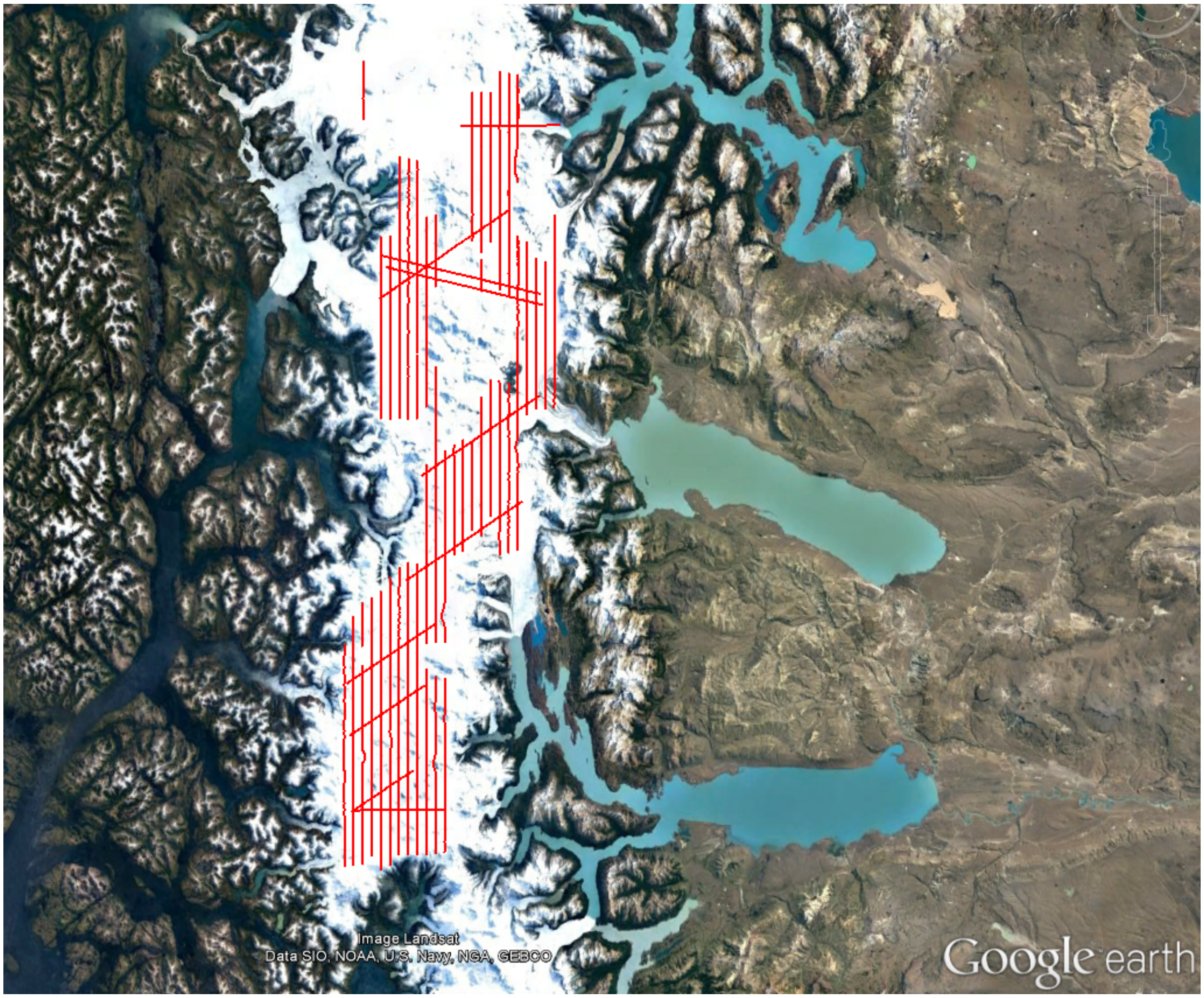


Figure 6: SPI Survey Block Flown Lines

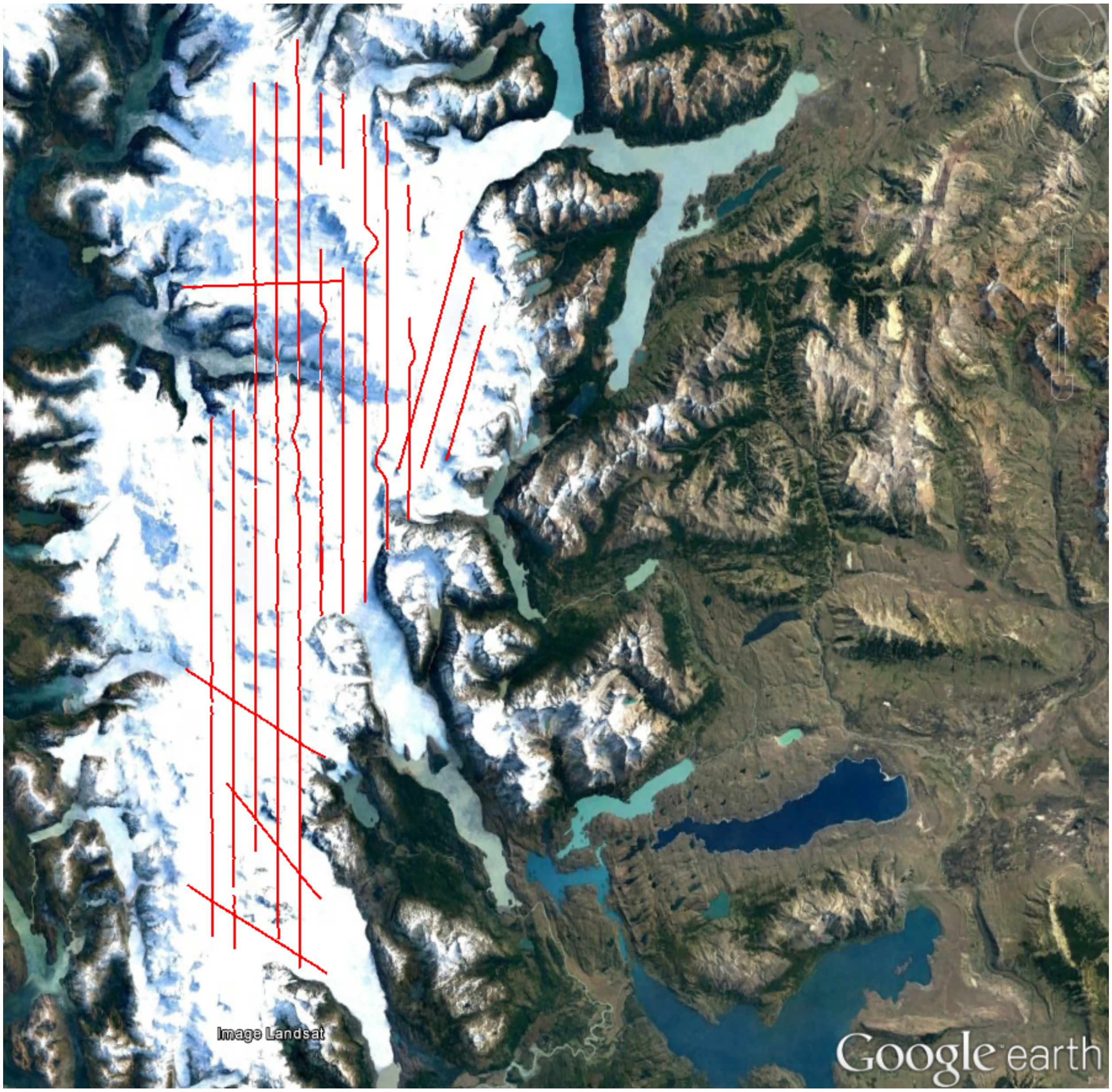


Figure 7: SPI2 Survey Block Flown Lines

Survey Boundary

The block is bounded by the coordinates provided in *Tables 1*, *2* and *3.*

Table 1: NPI Block Simplified Survey Boundary (WGS-84, UTM 18S)

Easting (m)	Northing (m)
598144.8359	4762913.2044
602659.1883	4753801.0141
606607.3963	4752885.9142
612747.6328	4753745.2600
614924.2720	4757465.0701
612244.7257	4771133.6566
610489.3234	4779357.5987
604666.8247	4811708.7429
602518.6645	4811406.4890
601018.3912	4811593.3667
600118.3126	4815993.8623
597665.3920	4816572.5143
593592.2772	4817860.4923
591299.5027	4818707.7209
589354.5413	4816464.7540
598144.8359	4762913.2044

Table 2: SPI Block Simplified Survey Boundary (WGS-84, UTM 18S)

Easting (m)	Northing (m)
598757.489000	4558741.160700
594950.518100	4557490.919300
593877.839500	4518557.753800
598911.501400	4513594.742600
602305.125300	4510455.893000
603778.571900	4505026.856700
602445.586300	4486569.975600
599328.067100	4486918.899200
597446.081800	4485545.179800
588031.930700	4475674.904900
585297.319000	4472464.026300
584177.586100	4418514.760600
590003.366400	4418993.263000
597305.862100	4422810.631300
606002.297400	4423037.130600
606016.764200	4423031.668800
606773.910100	4423477.723900
608691.878400	4485480.873700
624583.815500	4489168.924700
625230.861500	4514136.531800

Easting (m)	Northing (m)
629012.182800	4515281.355000
629958.884500	4556282.967100
625213.861300	4559561.048700
625742.143000	4580484.305500
623700.881100	4582666.014800
617782.401900	4584666.495200
615687.305600	4584306.417800
615108.296000	4561393.661400
610692.677400	4558263.340600
605090.276000	4561285.130400
605324.329200	4573899.434800
599138.575200	4574262.099300
598757.489000	4558741.160700

Table 3: SPI2 Block Simplified Survey Boundary (WGS-84, UTM 18S)

Easting (m)	Northing (m)
602627.327800	4329602.273600
613235.131000	4329958.609600
614066.888000	4360902.112200
617347.586300	4362554.105000
621477.239200	4368295.627500
624528.728700	4374774.097500
625234.070800	4403254.230600
621937.780900	4405056.910700
620033.365500	4407623.647300
615884.784900	4410521.379200
605549.756800	4410779.817500

4. SURVEY SPECIFICATIONS

Data Recording

In the aircraft:

- GPS positional data (time, latitude, longitude, altitude and raw range from each satellite being tracked) 10 readings per second (10 Hz);
- Terrain clearance as measured by the radar altimeter at 10 readings per second (10 Hz);
- Gravimeter data recorded at 128 readings per second (128 Hz);

At the base GPS reference stations:

- GPS positional data (time, latitude, longitude, and raw range from each satellite being tracked) at 10 readings per second (10 Hz).

Technical Specifications

The following technical specifications were adhered to:

- A minimum of 4 satellites in-view is required for both the mobile and base station GPS system for periods longer than 30 seconds.
- The target average flying speed for the survey aircraft is 80 knots.

Flight Line Specifications

The planned survey area flight line specifications are listed in the following table. Control lines were placed in locations to maximize intersections while maintaining ideal terrain clearances. The line direction is with respect to the UTM zone reference frame. A listing of theoretical flight lines and their coordinates is given in *Appendix II*. Note that lines 1010, 1019, 1073, 1076 and 2140 could not be flown due to weather and time limitations. Thus whilst the planned total was 3189 km, the total achieved was 3147 km.

Table 4: Planned flight line specifications

Line Number	Line Type	Line Spacing (m)	Line Direction
NPI Block			
2000-2140	Traverse	2000 m	170º
1019 & 1073	Control	n/a	64º
1016	Control	n/a	105º
1010, 1076 & 1113	Control	n/a	83º
SPI Block			
5000-5420	Traverse	2000 m	0º
4053, 4123, 4172, 4229, 4314 & 4500	Control	n/a	57º
4505 & 4516	Control	n/a	105º
4004 & 4749	Control	n/a	90º
5440 & 5460	Control	n/a	0º
5000, 5020 & 5040	Control	n/a	0º
5220, 5240, 5260 & 5280	Control	n/a	0º
SPI2 Block			
7220-7400	Traverse	2000 m	0º
6020	Control	n/a	90º
6026 & 6108	Control	n/a	124º
6016	Control	n/a	140º
6022, 6032 & 6042	Control	2000 m	17º

Survey Ground Speed

The targeted average ground speed was 80 knots.

Terrain Clearance

The extremely rugged nature of the survey area meant that adapting a draped surface for height guidance would result in extreme clearances above the ice surface. Therefore, in order to maximise the resolution of the gravity data the aircraft used a radar altimeter to maintain a terrain clearance of 100 m wherever possible. For this reason, traverse lines and control lines may not match well in altitude at intersections, but this was considered to be a reasonable compromise.

5. SURVEY EQUIPMENT

SGL provided the following instrumentation for this survey; see *Appendix IV* for further details:

Airborne Navigation and Data Acquisition System

Sander Geophysics Data Acquisition System (SGDAS)

The SGDAS is the latest version of airborne navigation and data acquisition computers developed by SGL. It is the data gathering core for all the different types of survey data. The computer incorporates an altimeter analog to digital converter and a NovAtel GPS multi-frequency receiver (see the GNSS and GPS Receivers section below for the details) which automatically provides the UTC time base for the recorded data. The system acquires the different data streams from the sensors and receives and processes GPS signals from the GPS antenna. Navigation information from the navigation side of the computer guides the pilots along the pre-planned flight path in all three dimensions. Profiles of the incoming data are displayed in real-time to the pilots for continuous monitoring. The data are recorded in database format on redundant solid-state data storage modules. The AIRGrav system incorporates an additional data acquisition system; Gravity DAS (GDAC). The GDAC controls the AIRGrav system records the data collected, and includes a separate user interface.

Airborne Gravity System

Sander Geophysics AIRGrav

SGL's AIRGrav (Airborne Inertially Referenced Gravimeter) uses a Schuler tuned inertial platform. This platform supports three orthogonal accelerometers, which remain fixed in inertial space, independent of the manoeuvres of the aircraft, allowing precise correction of the effects of the movement of the aircraft. Accelerometer data are recorded at 128 Hz and later down sampled to 2 Hz in processing. The gravity sensor used in AIRGrav is a very accurate accelerometer with a wide dynamic range. The system is not affected by the strong vertical motions of the aircraft, allowing the final gravity data to be almost completely unaffected by aircraft dynamics up to what is considered "moderate" turbulence. The instrument is also rendered as an inertial navigator, and as such the platform levelling is essentially unaffected by horizontal accelerations. Gravity data are consistently acquired with a noise level of less than 0.2 mGal with a half sine wave ground resolution of 1.8 to 2 km, given adequate line spacing.

Reference Station Acquisition System

Novatel DL-4

The GPS reference stations use a Novatel DL-4 integrated GPS receiver and data logger which records onto compact flash cards. The Novatel OEM4 receiver forms an integral part of the DL-4 system. It provides averaged position and raw range information of all satellites in view, sampled every 0.1 s. The comparative navigation data supplied during all production flights allows for post-processed differential GPS (DGPS) corrections for every survey flight.

Picture 2: Reference station setup with sensor in the background

Reference Station And Airborne Acquisition System GPS Receivers

Novatel OEM4 receiver boards

The OEM4 is a high performance, high accuracy, dual-frequency GPS receiver that is capable of receiving and tracking the L1 C/A code, L1 and L2 carrier phase, and L2 P-code (or encrypted Y-code) of up to 24 GPS satellites. The GPS data are recorded at 10 Hz. The OEM4 was employed in the airborne acquisition system (SGDAS), the GDAC in the aircraft and in the DL-4 reference station.

Altimeters

TRA 3500 Radar Altimeter System

The TRA 3500 Radar Altimeter unit provides AGL altitude information from 0 m up to 762 m maximum. The system consists of a TRA 3500 receiver/transmitter unit, two antennas and one TRI 40 indicator. The TRA has an accuracy of 5 to 7%.

Picture 3: Survey aircraft

Survey Aircraft

Cessna 206 (CC-ATW)

The Cessna 206 is an all metal, high wing single-engine aircraft powered by a Continental IO-520-A 285 hp engine driving a constant speed and full feathering propeller. The aircraft has fixed gear, extendable flaps and manually adjustable trim tabs. The aircraft is owned and operated by a local pilot based in Puerto Varas. Alterations were made to the aircraft allowing for the installation of an SGL gravimeter, radar altimeter and data acquisition computers. All survey modifications are certified to meet the requirements of the Chilean Directorate General of Civil Aviation (DGAC).

Data Processing Hardware and Software

Compilation of the data was performed on high performance desktop and laptop computers optimized for data processing tasks. SGL's proprietary geophysical software was used for data processing.

6. SYSTEM TESTS

Gravity System Tests

Gravimeter Calibration

An initial calibration was performed on the gravimeter's accelerometers at the survey location. In order to tie the measurements to those of the previous project in 2012, a gravity tie was performed by flying from Cochrane to Villa O'Higgins with the gravimeter in operational mode. The local gravity value in Cochrane in 2012, determined from EGM2008, was 980731.10 mGal. The final transferred local gravity value in Villa O'Higgins was determined to be 980810.80 mGal. All flights were referenced to that value.

On start-up before each flight, the AIRGrav system automatically aligns its platform. Before and after each flight, the consistency of the measured gravity was confirmed by recording data at a fixed location on the ground. The results, presented in *Figure 8*, are given as deviations from the local gravity value at the base of operation. The pre- and post-flight static values are used to help level the final data set (see the Line Adjustments and Gridding section of the gravity data processing) and to verify the operation of the system. An alignment of the AIRGrav system was performed prior to every flight, while accelerometer calibrations were performed on a weekly basis. The design of the platform is such that the sensor can be "tumbled" in the gravity field at a calibrated point to set the scale factor and offset. The gravimeter was calibrated at the survey base to re-determine the accelerometer scale factors (which vary slightly with time) by rotating the platform through 180 degrees to measure ±1 g.

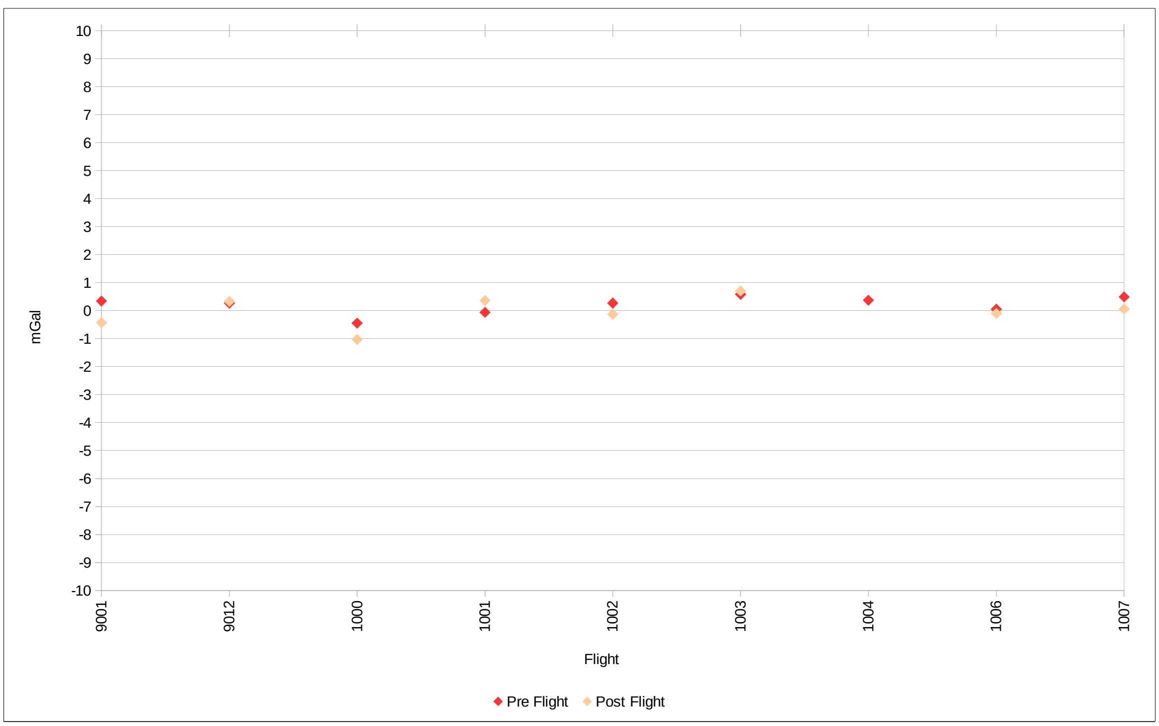


Figure 8: Ground gravity static measurements made before and after each survey flight

7. FIELD OPERATIONS

Operations were conducted from Villa O'Higgins Airport, Villa O'Higgins, Chile (SCOH). A total of 7 production flights were flown, from July 22 to August 1, 2016.

The survey aircraft, Chilean registered Cessna 206 CC-ATW, was hired from and operated by Vincente Randall Beasley. Survey equipment installation and testing began on July 11 in Puerto Varas. The aircraft was ferried to Villa O'Higgins on July 19. The Villa O'Higgins Airport features a hard surfaced runway of 4,200 ft. The GPS reference station were set up on July 14 at Cabañas de Montaña, where the crew stayed for the duration of the project. Survey familiarization was completed on July 22 and production commenced.

When not survey flying the aircraft was parked at the northern section of the apron. Each survey flight departed and returned to this location. The gravimeter was calibrated at this parking spot daily to the local gravity value as established by the initial gravimeter calibration (see section 6 System Tests). Table 5 shows the position of the aircraft in the WGS-84 datum.

Table 5: Aircraft parking locations

Latitude	Longitude	Elevation (m)
S48:27:53.65	W072:33:46.77	282.88

Aircraft certification and mechanical issues caused significant delays in getting the project started. While weather was generally good considering that the survey was flown in the winter, 5 flights were cancelled and 2 flights were terminated due to adverse weather conditions. Productino was completed on August 1. The Weekly Reports are in *Appendix V*.

Reference Stations

The reference stations were set-up at the crew accommodations on July 14. The first reference station's (REF1) receiver failed and was not used for the survey. *Table 6* shows the WGS-84 coordinates of the one reference station that was employed (REF2).

Table 6: Locations of reference stations

Station #	Location	Latitude	Longitude	Elevation
REF2	Villa O'Higgins	S48:27:52.2176	W072:33:42.9767	285.833 m

The position of the REF2 reference station GPS antenna was differentially corrected by Precise Point Positioning (PPP) corrections using the algorithm developed by the Natural Resources Canada (NRCAN) (http://webapp.geod.nrcan.gc.ca/geod/tools-outils/ppp.php) adapted to run under SGL's suite of software. In addition to the installed reference station, data from two International GPS Service (IGS) reference stations were used to differentially correct the airborne positional data: OHI3 (Northern Antarctic peninsula) and MGUE (Malargue, Argentina).

Re-flights

Certain lines were reflown because the flying height deviated significantly from the nominal survey height of 100 m. Some deviations from the planned survey lines were required in places of extreme topography. No lines were reflown because of equipment malfunction. Some lines were not flown due to weather and time limitations. All flown lines were delivered. Coordinates and times of the actual lines flown are listed in *Appendix III*.

Field Personnel

Table 7 shows a list of SGL technical personnel who participated in the field operations.

Table 7: Survey field crew

	Name	Dates in Field
Project Manager	Al Pritchard (SGL)	N/A
Crew Chief	Max Buneta (SGL)	July 11 2016 – August 6 2016
Pilot	Vincente Beasley	July 19 2016 – August 2 2016 (Villa O'Higgins)
Technician	Ted McEwen (SGL)	July 10 2016 – August 8 2016

8. DIGITAL DATA COMPILATION

Preliminary processing for on-site quality control was performed in the field as each flight was completed. This included verifying the data on the computer screen, profiling all of the data channels, and creating preliminary data grids.

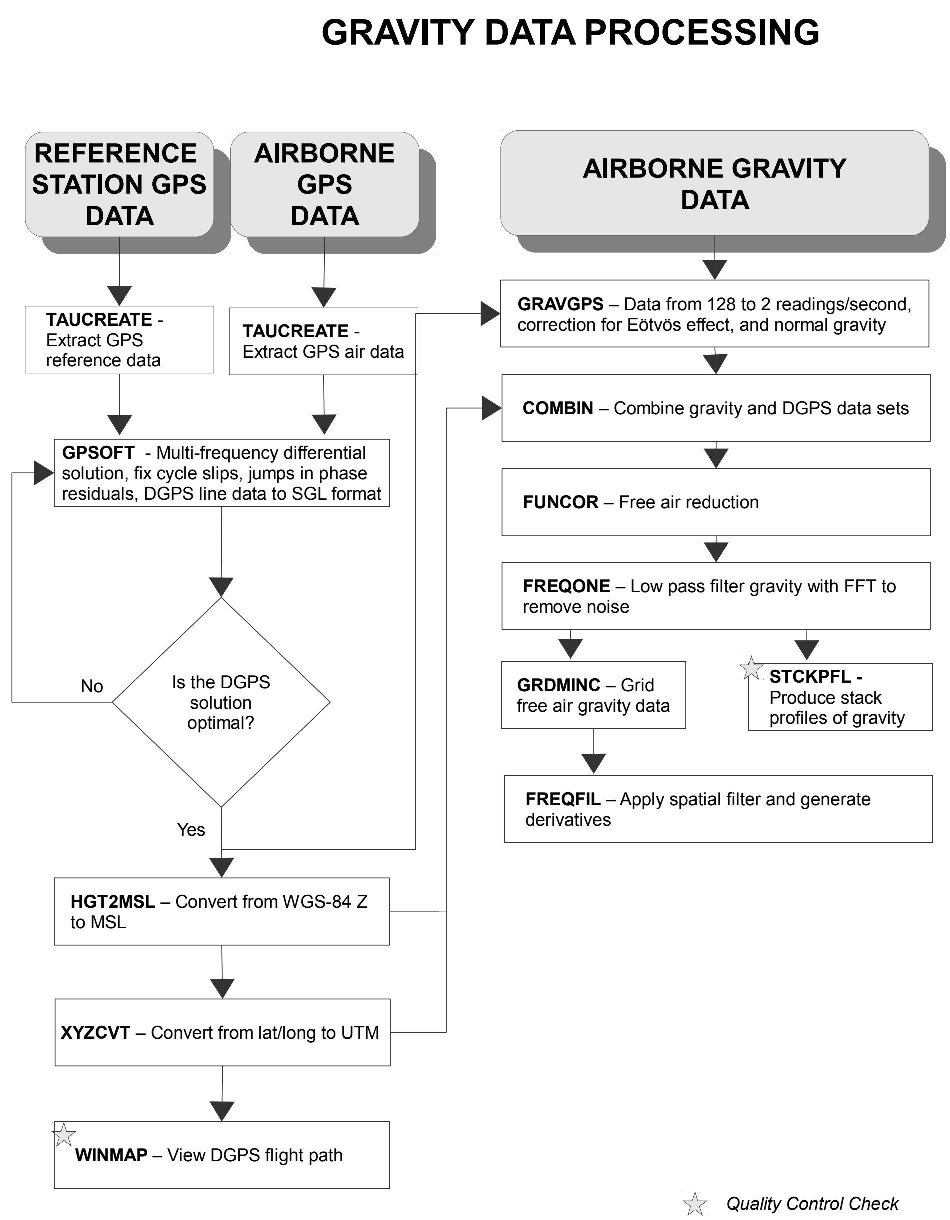


Figure 9: Gravity data processing flowchart

Gravity Data

A gravity data processing flowchart is presented in *Figure 9*. Gravity data are recorded at 128 Hz. Accelerations are filtered and down sampled to match GPS measurements using specially designed filters to avoid biasing the data. Gravity is calculated by subtracting the GPS derived aircraft accelerations from the inertial accelerations. In survey flying, accelerations in an aircraft can reach 0.1 G, equivalent to 100,000 mGal. Data processing must extract gravity data from this very noisy environment. This is achieved by modelling the movements of the aircraft in flight by extremely accurate GPS measurements. The calculated gravity is corrected for the Eötvös effect and normal gravity and the sample interval is reduced to 2 Hz. These operations are all performed by SGL's proprietary GravGPS software.

Advances in gravity processing allow for the generation of enhanced gravity data. These advances involve the use of GPS phase angle corrections, the integration of GPS processing with inertial data from the gravimeter and the advanced analysis of system states and uncertainties. This processing helps reduce system noise and allows for the generation of high quality, low noise raw gravity data through a wider range of survey conditions than was previously possible. The following standard corrections were applied to the gravity data:

a) Eötvös correction,

$$\delta g_{E\ddot{o}tv\ddot{o}s} = -2 W_s v_x \cos\Phi - \frac{v_x^2}{\frac{r}{\left(1-e^2 \sin^2\Phi\right)^{1/2}} + h} - \frac{v_y^2}{\frac{r\left(1-e^2\right)}{\left(1-e^2 \sin^2\Phi\right)^{3/2}} + h}$$

where, Φ	=	is the latitude of the aircraft,
v_x and v_y	=	the velocities of the aircraft in the *x* (east) and *y* (north) direction,
r	=	the Earth's radius at the equator (6,378,137 m)
e	=	a correction for Earth's flattening towards the poles (0.0818191908426),
W_s	=	the angular velocity of Earth's rotation (7.2921158553 × 10^{-5} rad/s),
h	=	the altitude of the plane above the ellipsoid.

b) Normal gravity,

$$g_{Normal} = \frac{9.7803267715\left(1 + 0.0019318513353 \sin^2\Phi\right)}{\sqrt{1 - 0.0066943800229 \sin^2\Phi}}$$

where Φ is the latitude of the aircraft;

c) Free air correction,

$$g_{fa} = -(0.3087691 - 0.0004398 \sin^2\Phi) h + 7.2125 * 10^{-8} h^2,$$

where h is height of the aircraft in metres above the GRS-80 ellipsoid;

d) Static correction, g_{sc}, based on static ground recordings and repeat lines;

Thus, the Free-Air gravity anomaly in mGal is determined:

$$Free\ Air\ Gravity\ Anomaly = G - g_{fa} - g_{sc}$$

where G is the calculated gravity in mGal adjusted for Eötvös effect and normal gravity.

Gridding and Filtering

Statistical noise in the data is reduced by applying a cosine tapered low pass filter to the time series line data. For this survey, 20, 28, 36 and 42 second half wavelength filters were employed. The data were gridded using a minimum curvature algorithm that averages all values within any given grid cell and interpolates the data between survey lines to produce a smooth grid. The algorithm produces a smooth grid by iteratively solving a set of difference equations minimizing the total second horizontal derivative while attempting to honour the input data (Briggs, I.C, 1974, Geophysics, v 39, no. 1). Grids were generated using a 500 m grid cell size.

Low pass filtering, directly equivalent to spatial averaging, is applied to the grid to achieve better noise reduction than by simply increasing the degree of line filtering. Essentially, the survey area is over-sampled by a line spacing that is smaller than the grid filter used. A range of grid filters are used and evaluated for noise levels and signal content. Final data for this survey was filtered with a 1.25 km half-wavelength grid filter.

The aircraft had to deviate from the planned lines a number of times mostly due to terrain. Strong maneuvers can cause inaccurate gravity measurements. A quality flag was produced identifying segments where horizontal gravity measurements were excessive. Grids of data with and without the flagged data removed have been provided.

Merged Grids

Gravity data from 2016 was merged with previously acquired data in 2012 by gridding all line data together from both years and then applying the spatial grid filter. In addition to the free air gravity and first vertical derivative of the free air gravity, a grid of the flying height with the same spatial filter was generated. This represents the observation height that can be used for upward or downward continuation to a different height.

Positional Data

A positional data flowchart is presented in *Figure 10.* A number of programs were executed for the compilation of navigation data in order to reformat and recalculate positions in differential mode. SGL's GPS data processing package, GPSoft, was used to calculate DGPS positions from raw 10 Hz range data obtained from the moving (airborne) and stationary (ground) receivers using combinations of L1 and L2 phase signal.

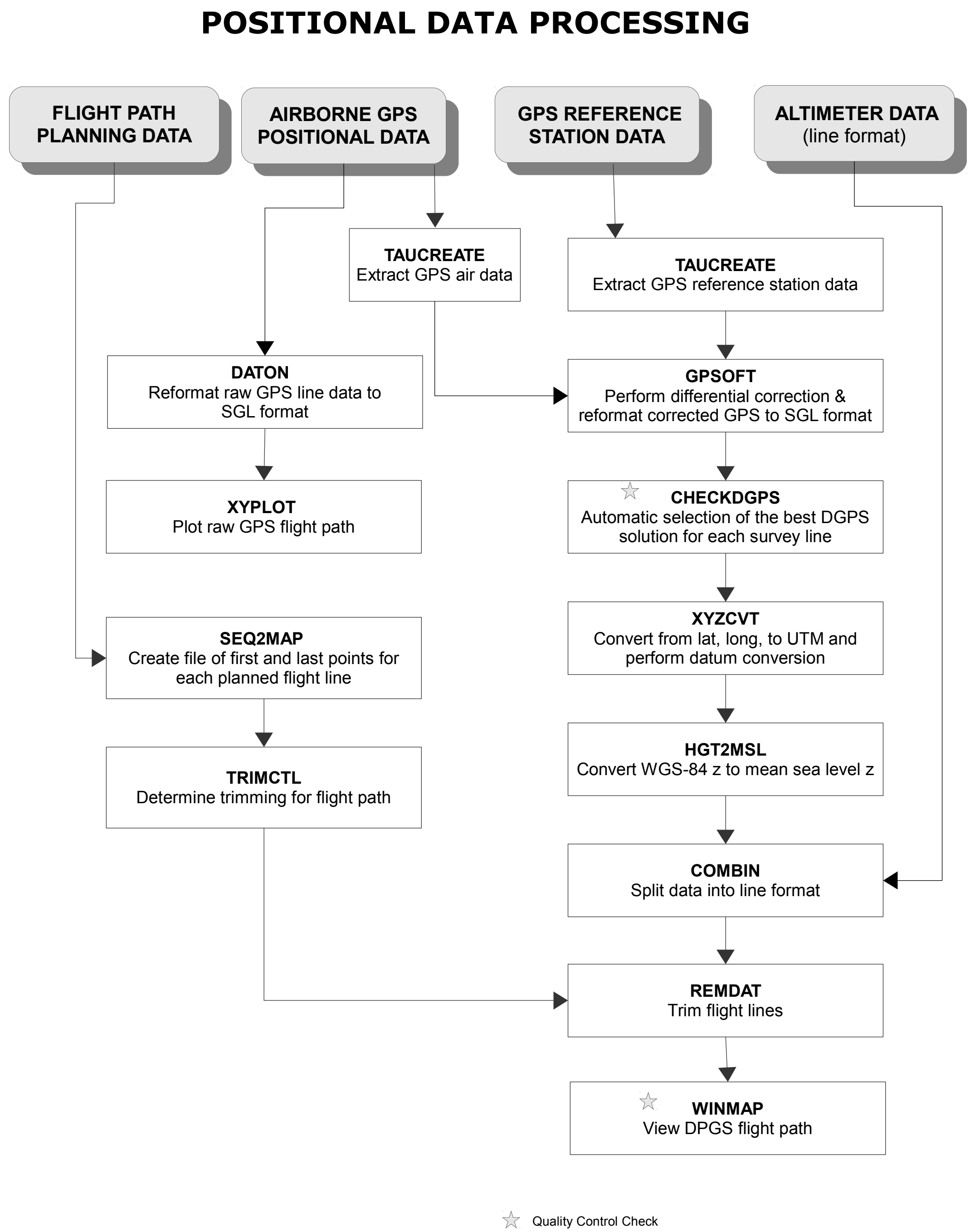


Figure 10: Positional data processing flowchart

Accurate locations of the GPS antenna were determined by differentially correcting the SGL reference station position data using permanent GPS reference stations. This technique provides a final receiver location with an accuracy of better than 5 cm. The entire airborne data set was processed differentially using the calculated reference station location.

Positional data (x, y, z) were recorded and all data processing was performed in the WGS-84 datum. The delivered data were provided in x, y locations in UTM projection zone 18S, with respect to the WGS-84 datum. Positions were also delivered in the WGS-84 datum. See *Table 8 f*or the ellipsoid parameters.

Table 8: Ellipsoid parameters for WGS-84

Ellipsoid	WGS-84
Semi-major axis	6378137.0
1/flattening	298.257223563

Elevation data were recorded relative to the GRS-80 ellipsoid and transformed to mean sea level (MSL) using the Earth Gravitational Model 2008 (EGM2008).

9. FINAL PRODUCTS

Gravity Line Data Format

A listing of the data channels delivered in ASCII format with a sampling rate of 2 Hz can be found in *Table 9*.

Table 9: Gravity line data channels and format

Name	Units	Field Length	Null	Description
LINE	08	-	-	Line Number XXXX.YY where XXXX is line number and YY is segment number
FLT	06	-	-	Flight Number
YEAR	05	-	-	Year
DOY	05	-	-	Day of year
FTIME	10	s	*	Seconds Past Midnight UTC
UTM-X	11	m	*	X coordinate, WGS-84 UTM 18S
UTM-Y	11	m	*	Y coordinate, WGS-84 UTM 18S
UTM-Z	10	m	*	GPS Elevation (above WGS-84 Ellipsoid)
MSL-Z	10	m	*	GPS Elevation (above EGM2008 Geoid)
LAT	13	degree	*	Latitude, WGS-84
LONG	13	degree	*	Longitude, WGS-84
SRTM	11	m	*	Topography Derived from SRTM (above EGM2008 Geoid)
FX	11	mGal	*	X Acceleration
FY	11	mGal	*	Y Acceleration
FZ	11	mGal	*	Z Acceleration
STATCOR	11	mGal	*	Static Correction (based on pre/post flight static recordings)
ACC_Z_STAT	11	mGal	*	Z acceleration with static correction applied
GPS_ACC_Z	11	mGal	*	Aircraft GPS Z acceleration
GRVRAW	11	mGal	*	Raw Gravity (ACC_Z_STAT - GPS_ACC_Z)
LATCOR	11	mGal	*	Latitude Correction
EOTCOR	11	mGal	*	Eötvös Correction
FACOR	11	mGal	*	Free Air Correction
FRA20s	11	mGal	*	Free Air Corrected Gravity, 20 s half-wavelength filter
FRA28s	11	mGal	*	Free Air Corrected Gravity, 28 s half-wavelength filter
FRA35s	11	mGal	*	Free Air Corrected Gravity, 36 s half-wavelength filter
FRA42s	11	mGal	*	Free Air Corrected Gravity, 42 s half-wavelength filter
FA1250	11	mGal	*	Free Air Corrected Gravity, 28 s half-wavelength filter, 1250 m half-wavelength spatial filter (sampled from grid)
QFLAG	11	-	*	Quality Flag

Digital Grids

The following are provided as digital grids in Grid Exchange Format (GXF) in WGS-84 UTM Zone 18S. A version of the grids is included which merges this data set with the 2012 data set.

Formats:	Grid Exchange (GXF)
Grid Cell Size:	500 m
Datum:	WGS-84
Projection:	UTM18S

Table 10: Delivered digital grids

Grid File Name	Block	Units	Description
NPI-FRA-1250-V1	NPI	mGal	Free-Air Gravity (28 s half-wavelength filtered data gridded, followed by 1250 m half-wavelength spatial filter applied to the grid)
NPI-FVDFRA-1250-V1	NPI	Eötvös	First Vertical Derivative of Free-Air Gravity (20s half-wavelength line filter, 1250 m half-wavelength spatial filter)
NPI-FRA-1250-V2	NPI	mGal	Free-Air Gravity (28 s half-wavelength filtered data gridded, followed by 1250 m half-wavelength spatial filter applied to the grid)-Quality Flag Applied
NPI-FVDFRA-1250-V2	NPI	Eötvös	First Vertical Derivative of Free-Air Gravity (20s half-wavelength line filter, 1250 m half-wavelength spatial filter)-Quality Flag Applied
SPI1-FRA-1250-V1	SPI	mGal	Free-Air Gravity (28 s half-wavelength filtered data gridded, followed by 1250 m half-wavelength spatial filter applied to the grid)
SPI1-FVDFRA-1250-V1	SPI	Eötvös	First Vertical Derivative of Free-Air Gravity (20s half-wavelength line filter, 1250 m half-wavelength spatial filter)
SPI1-FRA-1250-V2	SPI	mGal	Free-Air Gravity (28 s half-wavelength filtered data gridded, followed by 1250 m half-wavelength spatial filter applied to the grid)-Quality Flag Applied
SPI1-FVDFRA-1250-V2	SPI	Eötvös	First Vertical Derivative of Free-Air Gravity (20s half-wavelength line filter, 1250 m half-wavelength spatial filter)-Quality Flag Applied
SPI2-FRA-1250-V1	SPI2	mGal	Free-Air Gravity (28 s half-wavelength filtered data gridded, followed by 1250 m half-wavelength spatial filter applied to the grid)
SPI2-FVDFRA-1250-V1	SPI2	Eötvös	First Vertical Derivative of Free-Air Gravity (20s half-wavelength line filter, 1250 m half-wavelength spatial filter)
SPI2-FRA-1250-V2	SPI2	mGal	Free-Air Gravity (28 s half-wavelength filtered data gridded, followed by 1250 m half-wavelength spatial filter applied to the grid)-Quality Flag Applied
SPI2-FVDFRA-1250-V2	SPI2	Eötvös	First Vertical Derivative of Free-Air Gravity (20s half-wavelength line filter, 1250 m half-wavelength spatial filter)-Quality Flag Applied
FRA-1250	2015+2016	mGal	Free-Air Gravity (28 s half-wavelength filtered data gridded, followed by 1250 m half-wavelength spatial filter applied to the grid)
FVDFRA-1250	2015+2016	Eötvös	First Vertical Derivative of Free-Air Gravity (20s half-wavelength line filter, 1250 m half-wavelength spatial filter)
HGT-1250	2015+2016	m	Height above ellipsoid (1250 m half-wavelength spatial filter applied to the grid

Appendix I

Company Profile

About Us

Sander Geophysics Limited (SGL) provides worldwide airborne geophysical surveys for petroleum and mineral exploration, and geological and environmental mapping. Services offered include high resolution airborne gravity, magnetic, electromagnetic, and radiometric surveys, using fixed-wing aircraft and helicopters.

SGL head office in Ottawa, Canada

Dr. George W. Sander (1924-2008) founded SGL in 1956 to provide ground geophysical surveys. The first airborne surveys were performed as early as 1958, and by 1967 airborne geophysical surveys were the company's main focus. Operations have expanded steadily since SGL was founded more than 50 years ago. The company is led by co-Presidents Luise Sander and Stephan Sander.

Worldwide Operations

SGL's head office and aircraft maintenance hangar are located at the International Airport in Ottawa, Canada. Sander Geophysics has operated on every continent including Antarctica, over diverse conditions ranging from the tropics to deserts, mountains and offshore.

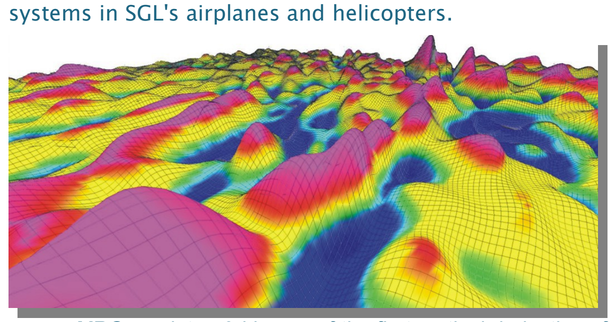
Facilities at the head office include a state of the art data processing department with an integrated digital cartographic department and a fully equipped electronics workshop for research, development and production of geophysical instruments. A Transport Canada Approved Maintenance Organization (AMO) for fixed-wing aircraft and helicopters allows most aircraft maintenance and modifications to be performed in-house.

Services

Airborne Surveys

- **Gravity (AIRGrav)**
- **Magnetic Total Field**
- **Magnetic Gradient**
- **Electromagnetic**
- **Gamma-ray Spectrometer**
- **Scanning LiDAR**

SGL offers gravity surveys with **AIRGrav** (Airborne Inertially Referenced Gravimeter), which was designed specifically for the unique characteristics of the airborne environment and is the highest resolution airborne gravimeter available. **AIRGrav** can be flown in an efficient survey aircraft during normal daytime conditions and is routinely flown in combination with magnetometer systems in SGL's airplanes and helicopters.


***AIRGrav** data: 3d image of the first vertical derivative of terrain corrected Bouguer gravity*

Data Processing

Immediate data processing is part of SGL's standard quality control procedure, and provides clients with rapid results for evaluation while a survey is in progress. Sander Geophysics offers a full range of data enhancement programs and integrated interpretation services by experienced geoscientists. Available products in digital and/or hard copy include:

- **Contour, colour or shaded relief maps of any parameter or combination of parameters**
- **NASVD processed gamma-ray spectrometer data**
- **Filtered line or grid products such as vertical or horizontal gradients, frequency slices,**

high/low-pass or band-pass filtered, amplitude of the analytic signal, reduction to the pole, upward or downward continuation

- **Computed depth to basement**
- **Calculated digital terrain models**
- **Two- or three-dimensional modelling**
- **Cultural editing**
- **Complete geophysical interpretative reports**

ENVIRONMENTAL MONITORING

The company also provides environmental monitoring services using gamma-ray spectrometers and specialized processing to detect and quantify natural and anthropogenic radiation.

HEALTH & SAFETY

Sander Geophysics is a founding and active executive member of the International Airborne Geophysics Safety Association (IAGSA), which promotes the safe operation of helicopters and fixed-wing aircraft on airborne geophysical surveys.

SGL has developed and implemented a Safety Management System (SMS) and comprehensive Health, Safety and Environment (HSE) policies that govern all aspects of company operations. Safety initiatives include:

- **Project-specific Aviation Risk Analysis (ARA) and Personnel Risk Analysis (PRA) for all surveys**
- **Real-time satellite tracking of SGL aircraft**
- **HSE and first aid training for all field personnel**
- **Low-level flight and aircraft simulator training for pilots**
- **Advanced safety training appropriate to the survey location, such as water-egress, wilderness survival, etc.**

SGL's excellent safety record reflects the quality and experience of its survey crews. This, combined with management's ongoing commitment to safety, helps to ensure that Sander Geophysics is a safe and reliable choice for airborne geophysical surveys.

PERSONNEL

Sander Geophysics has over 160 experienced permanent employees, including geophysicists, software and hardware engineers, aircraft maintenance engineers and pilots.

AIRCRAFT

SGL owns and operates seventeen aircraft, including eight Cessna Grand Caravans and a Twin Otter all equipped for geophysical surveys.

The Grand Caravans have been modified to allow the installation of a tri-axial magnetic gradiometer system. The company's fleet also includes three all composite Diamond DA42 Twin Stars, modified for gravity and horizontal magnetic gradient surveys, and two AS350 B3 helicopters equipped for gravity, magnetic and radiometric surveys. Extensive modifications have been made to all of the survey aircraft to accommodate geophysical instruments and to reduce the aircraft's magnetic field. Typical Figures of Merit (FOM) for Sander Geophysics' fixed-wing aircraft are less than 1 nT. The company's aircraft are flown and maintained by licensed and experienced permanent employees of Sander Geophysics.

SGL aircraft

RESEARCH & DEVELOPMENT

Nearly one-third of the company's resources are devoted to developing new and more efficient instrumentation for airborne geophysical surveying, and to further refine its full suite of software for geophysical data processing.

Appendix II

NPI-Ctrl-1 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T1019.0	S47:14.12	W073:42.60	S47:10.89	W073:33.63	6.92	12.82
T1073.0	S47:08.14	W073:44.28	S47:05.31	W073:36.44	6.06	11.21

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 12.98 nautical miles
= 24.03 kilometers.

Total length of all lines = 12.98 nautical miles
= 24.03 kilometers.

NPI-Ctrl-2 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T1016.0	S47:15.82	W073:42.13	S47:17.74	W073:31.04	7.79	14.42

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 7.79 nautical miles
= 14.42 kilometers.

Total length of all lines = 7.79 nautical miles
= 14.42 kilometers.

NPI-Ctrl-3 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T1010.0	S47:02.75	W073:45.78	S47:02.21	W073:39.86	4.08	7.56
T1076.0	S46:55.46	W073:44.60	S46:54.70	W073:36.36	5.70	10.55
T1113.0	S46:51.81	W073:48.81	S46:50.78	W073:37.53	7.81	14.46

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 17.59 nautical miles
= 32.57 kilometers.

Total length of all lines = 17.59 nautical miles
= 32.57 kilometers.

NPI-Trav - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T2000.0	S47:18.16	W073:41.10	S46:50.54	W073:48.83	28.13	52.10
T2020.0	S47:21.55	W073:38.52	S46:48.08	W073:47.91	34.08	63.12
T2040.0	S47:21.91	W073:36.80	S46:49.53	W073:45.91	32.97	61.06
T2060.0	S47:22.11	W073:35.13	S46:49.23	W073:44.39	33.48	62.01
T2080.0	S47:21.17	W073:33.78	S46:48.93	W073:42.87	32.84	60.83
T2100.0	S47:21.00	W073:32.21	S46:54.54	W073:39.70	26.96	49.93
T2100.1	S46:54.46	W073:39.72	S46:50.02	W073:40.97	4.52	8.37
T2120.0	S47:20.85	W073:30.63	S47:10.11	W073:33.69	10.95	20.27
T2120.1	S46:54.44	W073:38.12	S46:50.78	W073:39.15	3.73	6.91
T2140.0	S47:20.04	W073:29.25	S47:10.29	W073:32.03	9.93	18.39
T2140.1	S46:54.42	W073:36.53	S46:50.41	W073:37.65	4.08	7.57

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 221.68 nautical miles
= 410.56 kilometers.

Total length of all lines = 221.68 nautical miles
= 410.56 kilometers.

SPI-Ctrl-1 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T4053.0	S50:15.13	W073:47.44	S50:10.33	W073:36.33	8.60	15.93
T4123.0	S50:05.99	W073:47.35	S50:00.36	W073:34.36	10.09	18.68
T4172.0	S49:59.63	W073:47.37	S49:53.23	W073:32.65	11.46	21.22
T4229.0	S49:47.82	W073:37.25	S49:38.58	W073:16.24	16.47	30.50
T4314.0	S49:35.52	W073:34.44	S49:26.08	W073:13.09	16.81	31.13
T4500.0	S49:14.64	W073:42.02	S49:04.39	W073:18.91	18.31	33.91

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 81.73 nautical miles
= 151.37 kilometers.

Total length of all lines = 81.73 nautical miles
= 151.37 kilometers.

SPI-Ctrl-2 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T4505.0	S49:11.04	W073:40.27	S49:15.35	W073:13.09	18.33	33.95
T4516.0	S49:09.81	W073:40.34	S49:14.13	W073:13.08	18.38	34.05

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 36.71 nautical miles
= 67.99 kilometers.

Total length of all lines = 36.71 nautical miles
= 67.99 kilometers.

SPI-Ctrl-3 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T4004.0	S50:15.00	W073:47.44	S50:14.80	W073:30.09	11.14	20.63
T4749.0	S48:54.33	W073:25.66	S48:54.20	W073:16.84	5.82	10.78

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 16.96 nautical miles
= 31.40 kilometers.

Total length of all lines = 16.96 nautical miles
= 31.40 kilometers.

SPI-Ctrl-4 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T5440.0	S49:27.64	W073:12.04	S49:10.26	W073:12.12	17.39	32.21
T5460.0	S49:27.57	W073:10.38	S49:04.79	W073:10.50	22.80	42.22

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 40.19 nautical miles
= 74.43 kilometers.

Total length of all lines = 40.19 nautical miles
= 74.43 kilometers.

SPI-Ctrl-5 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T5000.0	S48:52.76	W073:48.20	S48:43.95	W073:48.13	8.81	16.31
T5020.0	S48:53.14	W073:46.57	S48:43.58	W073:46.50	9.57	17.72
T5040.0	S48:53.52	W073:44.93	S48:46.59	W073:44.89	6.93	12.84

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 25.31 nautical miles
= 46.87 kilometers.

Total length of all lines = 25.31 nautical miles
= 46.87 kilometers.

SPI-Ctrl-6 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T5220.0	S48:35.45	W073:30.17	S48:29.88	W073:30.16	5.58	10.33
T5240.0	S48:35.43	W073:28.54	S48:27.71	W073:28.53	7.73	14.32
T5260.0	S48:35.41	W073:26.91	S48:28.69	W073:26.91	6.73	12.46
T5280.0	S48:35.39	W073:25.29	S48:29.62	W073:25.29	5.77	10.69

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 25.81 nautical miles
= 47.79 kilometers.

Total length of all lines = 25.81 nautical miles
= 47.79 kilometers.

SPI-Trav - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T5000.0	S50:21.50	W073:48.87	S49:56.51	W073:48.68	25.01	46.32
T5020.0	S50:21.49	W073:47.18	S49:52.26	W073:46.98	29.25	54.18
T5040.0	S50:21.48	W073:45.50	S50:09.54	W073:45.42	11.95	22.14
T5040.1	S50:07.61	W073:45.41	S49:55.71	W073:45.33	11.91	22.06
T5040.2	S49:55.64	W073:45.33	S49:51.05	W073:45.30	4.59	8.50
T5060.0	S50:20.39	W073:43.80	S50:13.00	W073:43.76	7.39	13.69
T5060.1	S50:12.92	W073:43.76	S49:55.60	W073:43.66	17.33	32.10
T5060.2	S49:55.53	W073:43.66	S49:49.87	W073:43.63	5.66	10.48
T5080.0	S50:20.36	W073:42.12	S50:13.63	W073:42.08	6.73	12.47
T5080.1	S50:13.57	W073:42.08	S49:58.44	W073:42.00	15.14	28.04
T5080.2	S49:58.38	W073:42.00	S49:48.70	W073:41.95	9.68	17.93
T5080.3	S49:28.79	W073:41.85	S49:07.64	W073:41.73	21.16	39.19
T5100.0	S50:20.34	W073:40.43	S50:12.24	W073:40.39	8.11	15.02
T5100.1	S50:12.17	W073:40.39	S49:47.52	W073:40.28	24.66	45.67
T5100.2	S49:28.77	W073:40.19	S49:07.27	W073:40.09	21.52	39.85
T5120.0	S50:20.33	W073:38.75	S49:57.41	W073:38.65	22.93	42.47
T5120.1	S49:57.31	W073:38.65	S49:46.39	W073:38.61	10.93	20.24
T5120.2	S49:28.76	W073:38.53	S48:58.61	W073:38.41	30.17	55.87
T5140.0	S50:20.30	W073:37.06	S49:45.74	W073:36.94	34.59	64.05
T5140.1	S49:28.74	W073:36.88	S48:58.67	W073:36.77	30.09	55.72
T5160.0	S50:20.25	W073:35.37	S50:03.56	W073:35.33	16.70	30.93
T5160.1	S50:03.52	W073:35.32	S49:45.84	W073:35.27	17.69	32.77
T5160.2	S49:28.72	W073:35.22	S49:06.09	W073:35.15	22.64	41.93
T5160.3	S49:06.00	W073:35.15	S48:58.72	W073:35.13	7.28	13.49
T5180.0	S50:20.20	W073:33.69	S49:58.23	W073:33.64	21.99	40.72
T5180.1	S49:55.26	W073:33.63	S49:34.24	W073:33.58	21.03	38.95
T5180.2	S49:27.56	W073:33.56	S49:05.16	W073:33.50	22.41	41.51
T5200.0	S50:20.16	W073:32.00	S50:11.09	W073:31.99	9.07	16.80
T5200.1	S50:07.57	W073:31.98	S49:59.15	W073:31.96	8.43	15.60
T5200.2	S49:55.13	W073:31.96	S49:22.70	W073:31.90	32.45	60.10
T5200.3	S49:13.32	W073:31.88	S49:04.89	W073:31.86	8.43	15.62
T5220.0	S50:20.00	W073:30.31	S50:11.09	W073:30.30	8.91	16.51
T5220.1	S50:07.59	W073:30.30	S49:59.35	W073:30.29	8.24	15.26
T5220.2	S49:55.14	W073:30.29	S49:32.58	W073:30.26	22.57	41.81
T5240.0	S49:44.82	W073:28.61	S49:31.94	W073:28.60	12.90	23.88
T5260.0	S49:44.46	W073:26.94	S49:31.32	W073:26.94	13.15	24.36
T5280.0	S49:41.98	W073:25.28	S49:31.46	W073:25.28	10.52	19.49
T5280.1	S49:06.75	W073:25.29	S48:50.37	W073:25.29	16.38	30.34
T5300.0	S49:45.44	W073:23.61	S49:26.25	W073:23.63	19.20	35.56
T5300.1	S49:13.84	W073:23.64	S48:50.35	W073:23.65	23.50	43.53
T5320.0	S49:45.17	W073:21.95	S49:24.33	W073:21.98	20.85	38.62
T5320.1	S49:13.99	W073:21.99	S48:50.33	W073:22.02	23.67	43.84
T5340.0	S49:44.89	W073:20.28	S49:23.02	W073:20.33	21.88	40.53
T5340.1	S49:14.11	W073:20.34	S48:47.87	W073:20.39	26.26	48.63
T5360.0	S49:44.61	W073:18.62	S49:21.72	W073:18.68	22.91	42.43
T5360.1	S49:14.33	W073:18.69	S48:48.05	W073:18.75	26.29	48.69
T5380.0	S49:44.34	W073:16.95	S49:05.89	W073:17.07	38.48	71.26
T5380.1	S49:01.01	W073:17.08	S48:48.24	W073:17.12	12.78	23.67
T5400.0	S49:28.37	W073:15.35	S49:08.00	W073:15.42	20.38	37.75
T5420.0	S49:27.60	W073:13.69	S49:09.83	W073:13.77	17.78	32.92

SPI-Trav - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 903.61 nautical miles
= 1673.49 kilometers.

Total length of all lines = 903.61 nautical miles
= 1673.49 kilometers.

SPI2-Ctrl-1 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T6020.0	S50:36.37	W073:30.95	S50:36.25	W073:21.74	5.87	10.87

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 5.87 nautical miles
= 10.87 kilometers.

Total length of all lines = 5.87 nautical miles
= 10.87 kilometers.

SPI2-Ctrl-2 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T6026.0	S51:06.14	W073:31.41	S51:09.63	W073:22.81	6.44	11.94
T6108.0	S50:55.68	W073:31.25	S50:59.16	W073:22.68	6.44	11.93

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 12.89 nautical miles
= 23.87 kilometers.

Total length of all lines = 12.89 nautical miles
= 23.87 kilometers.

SPI2-Ctrl-3 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T6016.0	S51:00.32	W073:29.73	S51:05.87	W073:22.76	7.08	13.12

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 7.08 nautical miles
= 13.12 kilometers.

Total length of all lines = 7.08 nautical miles
= 13.12 kilometers.

SPI2-Ctrl-4 - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T6022.0	S50:45.42	W073:15.85	S50:34.42	W073:11.15	11.41	21.12
T6032.0	S50:44.60	W073:13.74	S50:36.38	W073:10.23	8.53	15.80
T6042.0	S50:44.78	W073:12.05	S50:36.92	W073:08.70	8.15	15.09

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 28.08 nautical miles
= 52.01 kilometers.

Total length of all lines = 28.08 nautical miles
= 52.01 kilometers.

SPI2-Trav - PLANNED SURVEY LINES
WGS-84

SEGMENT	START		END		LENGTH	
NO	LAT	LONG	LAT	LONG	NM	KM
T7220.0	S51:08.28	W073:30.36	S50:43.23	W073:30.34	25.07	46.43
T7240.0	S51:08.26	W073:28.64	S50:43.13	W073:28.64	25.15	46.58
T7260.0	S51:08.24	W073:26.93	S50:26.76	W073:26.94	41.51	76.88
T7280.0	S51:08.22	W073:25.21	S50:26.76	W073:25.25	41.49	76.85
T7300.0	S51:09.12	W073:23.50	S50:26.75	W073:23.56	42.40	78.53
T7320.0	S50:53.21	W073:21.82	S50:34.30	W073:21.86	18.92	35.05
T7320.1	S50:30.32	W073:21.87	S50:26.84	W073:21.87	3.49	6.45
T7340.0	S50:52.67	W073:20.11	S50:35.89	W073:20.16	16.79	31.10
T7340.1	S50:30.53	W073:20.17	S50:27.56	W073:20.18	2.98	5.51
T7360.0	S50:51.21	W073:18.41	S50:28.28	W073:18.49	22.95	42.50
T7380.0	S50:49.50	W073:16.71	S50:29.64	W073:16.79	19.87	36.80
T7400.0	S50:47.35	W073:15.02	S50:30.20	W073:15.10	17.16	31.78

Total control line length = 0.00 nautical miles
= 0.00 kilometers.

Total traverse line length = 277.78 nautical miles
= 514.46 kilometers.

Total length of all lines = 277.78 nautical miles
= 514.46 kilometers.

Appendix III

NPI - FLOWN LINES
WGS-84, UTM18S

LINE	TIME	TIME	MIN X	MAX X	MIN Y	MAX Y	FLIGHT	DAY	YEAR
1016.00	73033.50	73440.00	595833.09	612667.68	4760730.80	476536087	1000	204	2016
1113.00	50909.00	51180.00	586169.24	596958.31	4808863.30	480989099	1004	208	2016
2000.00	69334.50	70661.00	590362.84	600561.46	4753807.64	481215244	1000	204	2016
2020.00	71085.00	72651.50	591129.53	602650.84	4753009.72	481926109	1000	204	2016
2040.00	68727.00	69134.50	602275.06	605299.84	4750380.00	476729316	1000	204	2016
2040.01	49024.00	50649.00	594062.09	605036.25	4751402.75	481411793	1004	208	2016
2060.00	45425.00	45764.00	604841.05	607531.15	4750019.75	476399020	1004	208	2016
2060.01	45960.00	46470.00	600323.76	603927.90	4769188.54	478996448	1004	208	2016
2060.02	46660.00	47137.50	596077.33	599548.45	4795654.29	481429059	1004	208	2016
2080.00	47391.00	47586.50	597722.80	599360.12	4807169.25	481598823	1004	208	2016
2080.01	47755.50	48904.00	599601.00	608643.53	4753963.31	480565243	1004	208	2016
2100.00	67905.00	68417.00	606823.66	610750.32	4753747.36	477574777	1000	204	2016
2120.00	67368.50	67684.00	609889.69	612131.91	4758187.29	476997030	1000	204	2016

SPI - FLOWN LINES
WGS-84, UTM18S

LINE	TIME	TIME	MIN X	MAX X	MIN Y	MAX Y	FLIGHT	DAY	YEAR
4004.00	57163.00	57652.00	586125.52	606920.19	4432845.46	4432884.45	1003	207	2016
4053.00	57908.00	58277.00	586720.83	599945.96	4432927.60	4441529.16	1003	207	2016
4123.00	58955.00	59433.50	586289.11	602724.92	4449378.12	4459987.53	1003	207	2016
4172.00	60850.50	61433.00	585572.26	605373.60	4460548.29	4473462.86	1003	207	2016
4229.00	60172.50	60935.50	599165.29	624938.97	4482965.49	4499674.61	1002	206	2016
4314.00	74773.00	75105.00	616962.86	629270.72	4514758.37	4522738.41	1001	205	2016
4314.01	73612.50	74020.00	602964.65	616377.05	4505672.59	4514541.31	1002	206	2016
4500.00	57875.00	58679.00	594506.12	622322.01	4544538.66	4562614.98	1001	205	2016
4505.00	68277.50	69075.00	596197.17	629949.82	4542552.96	4551401.89	1006	213	2016
4516.00	72363.00	73222.50	595927.42	629797.88	4544844.79	4553747.26	1003	207	2016
4749.00	60000.00	60506.00	613115.10	635027.26	4581837.97	4581903.32	1006	213	2016
5000.00	51735.00	52875.00	584344.88	585371.85	4420393.53	4469190.14	1003	207	2016
5020.00	49120.00	49872.00	586782.06	587457.33	4442147.63	4475388.71	1003	207	2016
5020.01	54758.50	55551.50	586343.92	587056.62	4421120.63	4455047.94	1003	207	2016
5040.00	55654.00	56491.50	588313.20	589032.84	4420738.26	4456564.80	1003	207	2016
5040.01	59692.00	59932.00	589041.41	589220.67	4455069.48	4463826.05	1003	207	2016
5040.20	60233.00	60442.00	589318.66	589519.15	4468624.20	4478273.86	1003	207	2016
5040.30	73403.00	73716.00	591698.80	591982.51	4583692.76	4596719.70	1006	213	2016
5060.00	53242.50	54541.00	590362.55	591538.08	4422723.96	4479442.72	1003	207	2016
5080.00	48560.00	48897.00	592327.10	592630.80	4419444.01	4435054.65	1003	207	2016
5080.01	50191.00	51290.00	592582.38	593556.04	4434103.44	4479872.32	1003	207	2016
5080.30	59217.50	59895.00	594586.10	595173.29	4529863.45	4557658.80	1001	205	2016
5080.31	74525.50	74838.50	594353.98	594621.73	4518960.37	4531447.38	1003	207	2016
5080.32	69425.00	69863.00	594740.12	595212.18	4539639.81	4558145.29	1006	213	2016
5100.00	46992.50	48465.00	594368.11	595616.42	4420378.44	4483727.83	1003	207	2016
5100.20	73446.50	74421.00	596338.33	597144.85	4517967.04	4558310.57	1003	207	2016
5120.00	58336.00	59825.50	596350.10	597691.62	4422723.71	4485806.11	1002	206	2016
5120.20	62537.00	63900.00	598359.54	599548.72	4518293.22	4575677.82	1003	207	2016
5140.00	56643.50	58192.50	598363.82	599720.37	4422749.09	4486958.78	1002	206	2016
5140.10	58406.50	59735.00	600316.96	601525.24	4517927.63	4575030.11	1006	213	2016
5160.00	55028.00	56509.00	600352.92	601701.44	4422794.14	4486749.57	1002	206	2016
5160.20	44917.50	46209.00	602342.87	603500.33	4517952.91	4573761.76	1003	207	2016
5180.00	53889.00	54875.50	602371.99	603214.90	4422846.58	4463744.50	1002	206	2016
5180.10	49049.50	49961.00	603322.31	604142.74	4469080.61	4508195.32	1002	206	2016
5180.20	75269.00	76257.50	604221.29	605247.18	4520540.38	4562077.63	1003	207	2016
5200.00	52687.00	53589.00	604276.01	605194.91	4422895.55	4461984.30	1002	206	2016
5200.20	47561.50	48970.00	605323.36	606594.91	4469258.10	4529535.79	1002	206	2016
5200.30	70207.50	70570.50	606924.70	607250.17	4546734.78	4561501.09	1006	213	2016
5220.00	51544.50	52445.50	606369.00	607179.59	4423149.39	4460966.79	1002	206	2016
5220.20	50160.50	51165.00	606699.02	608191.05	4469220.13	4511207.42	1002	206	2016
5240.00	72515.50	73067.50	609730.47	610228.88	4488285.56	4512347.28	1002	206	2016
5260.00	71566.50	72158.50	611754.02	612252.50	4488903.31	4513442.14	1002	206	2016
5280.00	70623.00	71089.00	613841.04	614249.64	4493476.27	4513140.79	1002	206	2016
5280.10	71267.00	72053.00	615099.34	615823.56	4556626.97	4589266.51	1006	213	2016
5300.00	61470.50	62186.00	615823.43	616455.23	4492799.60	4522747.22	1002	206	2016
5300.10	54898.00	55513.00	617098.37	617642.39	4554053.19	4580277.00	1001	205	2016
5300.11	71019.50	71132.00	616937.79	617021.92	4546483.09	4551041.50	1006	213	2016
5300.12	72197.50	72493.00	617574.70	617821.74	4577433.03	4589260.55	1006	213	2016
5320.00	73685.00	74375.00	617920.93	618527.02	4496459.14	4526287.43	1001	205	2016
5320.10	53848.00	54371.00	619164.86	619698.56	4557264.97	4580929.04	1001	205	2016
5320.11	72564.00	72857.00	619565.75	619824.79	4577408.92	4589272.00	1006	213	2016
5340.00	72446.50	73258.00	619680.43	620498.03	4491601.14	4525453.07	1001	205	2016
5340.10	52226.50	53327.00	620935.47	621919.31	4546326.59	4593771.90	1001	205	2016
5360.00	71539.50	72345.50	621747.52	622516.32	4488414.06	4524819.72	1001	205	2016
5360.10	51023.00	51998.50	623007.41	623917.46	4550184.93	4593388.24	1001	205	2016
5360.11	74568.00	75746.50	622892.44	623915.93	4544534.60	4593391.75	1002	206	2016
5380.00	50687.00	50895.50	625001.63	625119.92	4548013.35	4557547.20	1001	205	2016
5380.01	69909.00	71419.50	623743.93	625158.79	4488887.03	4556893.75	1001	205	2016
5380.10	48832.00	48938.00	625752.48	625849.77	4583308.00	4589251.13	1001	205	2016
5380.11	49575.50	49884.00	625537.13	625846.90	4579200.52	4593015.91	1001	205	2016
5380.12	50155.00	50444.00	624756.54	625697.71	4569209.58	4581253.09	1001	205	2016
5400.00	55821.50	56629.00	626346.10	627143.65	4518434.15	4556354.11	1001	205	2016
5420.00	56818.00	57563.00	628440.44	629077.11	4521108.29	4552910.55	1001	205	2016
5440.00	67246.00	67935.00	630439.15	631053.22	4521309.61	4552074.62	1006	213	2016
5460.00	66134.50	67118.00	632384.88	633278.35	4519770.56	4561249.18	1006	213	2016

SPI2 - FLOWN LINES
WGS-84, UTM18S

LINE	TIME	TIME	MIN X	MAX X	MIN Y	MAX Y	FLIGHT	DAY	YEAR
6016.00	50777.00	51023.00	608597.38	614345.99	4337055.74	4344490.49	1007	214	2016
6016.01	51352.00	51472.00	606662.54	610151.49	4342426.18	4347039.08	1007	214	2016
6020.00	55403.00	55714.00	603599.36	616936.13	4392844.35	4392961.73	1006	213	2016
6022.00	59051.00	59525.00	622655.96	628760.26	4376539.81	4397411.59	1007	214	2016
6026.00	50934.00	51317.00	602449.14	614947.01	4329888.34	4338471.99	1006	213	2016
6032.00	60694.00	61042.50	624809.70	629515.72	4376813.38	4392520.23	1007	214	2016
6042.00	61565.00	61856.00	626827.55	630216.20	4376487.98	4387888.91	1007	214	2016
6108.00	52331.50	52487.00	603174.42	608378.12	4354153.44	4357650.42	1007	214	2016
6108.01	52753.50	52900.00	609501.74	615324.47	4349652.38	4353442.10	1007	214	2016
7220.00	49434.00	50025.00	604969.67	605531.02	4354923.88	4380988.26	1006	213	2016
7220.01	50193.00	50664.00	604524.76	604960.53	4334032.71	4353984.93	1006	213	2016
7240.00	47913.00	48024.00	606512.02	606601.83	4332398.04	4337493.01	1006	213	2016
7240.01	48153.00	48690.00	606613.43	607093.51	4338461.37	4361001.80	1006	213	2016
7240.02	48860.00	49351.50	607067.26	607510.01	4361082.07	4381570.16	1006	213	2016
7260.00	48456.00	49305.00	609346.32	610137.91	4374573.08	4411080.01	1007	214	2016
7260.01	49508.00	50181.00	608719.02	609404.41	4344150.18	4374356.18	1007	214	2016
7260.02	50430.00	50489.00	608648.85	608761.42	4341315.64	4343753.84	1007	214	2016
7280.00	51710.00	51955.00	610558.42	610733.03	4333784.67	4343452.01	1006	213	2016
7280.01	52171.00	52551.00	610708.96	611030.95	4342991.23	4358325.47	1006	213	2016
7280.02	52717.00	53946.00	611001.10	612133.09	4357699.82	4411057.54	1006	213	2016
7300.00	45715.00	47609.00	612455.92	614160.42	4330437.07	4415127.83	1006	213	2016
7320.00	53782.50	53975.00	615127.32	615288.88	4362558.94	4370629.90	1007	214	2016
7320.01	57985.00	58675.00	615254.67	615825.02	4366411.22	4395336.38	1007	214	2016
7320.10	54129.00	54180.50	616036.40	616124.24	4407035.79	4409235.35	1006	213	2016
7320.11	54360.00	54461.00	615965.59	616072.94	4403458.41	4407955.77	1006	213	2016
7340.00	54188.50	54300.00	617129.68	617209.90	4362739.50	4367043.14	1007	214	2016
7340.01	57253.50	57813.00	617152.88	617772.40	4368558.90	4394200.08	1007	214	2016
7340.10	54704.50	54865.00	617973.85	618177.26	4403763.44	4410097.15	1006	213	2016
7360.00	54430.00	54538.00	619139.81	619245.07	4363699.61	4368424.41	1007	214	2016
7360.01	55907.50	56850.00	619184.96	620061.81	4367410.75	4407443.81	1007	214	2016
7380.00	54944.00	55825.00	620449.09	622053.21	4369267.73	4407387.99	1007	214	2016
7400.00	59823.50	59882.50	623866.99	623976.54	4397912.32	4400487.77	1007	214	2016
7400.01	60108.00	60501.00	623304.54	623997.43	4371517.12	4389454.11	1007	214	2016

Appendix IV

Equipment List

Part	Serial No.	Description	Manufacturer
AirGrav Control Computer	GEER-02	AirGrav Control Computer	SGL
CP306 Computer	143342030	Kontron 306V Computer	Kontron
GPS Antenna	NVH03280020	Model 702	Novatel
GPS Antenna	NVH05410055	Model 702	Novatel
GPS Antenna	NRK04090015	Model SK600	Novatel
GPS Receiver	NYB06280008	DL4+RT2W	Novatel
GPS Receiver DL-V3	NBV07250016	Outputs RT2	Novatel
Gravimeter System	GRV G2-11	Airborne Gravimeter Platform	SGL
Radar Altimeter	4403206	TRA-3000	Free Flight Systems
Radar Altimeter	6233066	TRA-3000	Free Flight Systems
Radar Altimeter	4332140	TRI-40	Free Flight Systems
Radar Altimeter	4182079	TRI-40	Free Flight Systems

Appendix V

SANDER GEOPHYSICS AIRBORNE GEOPHYSICAL SURVEY

260 Hunt Club Road, Ottawa, ON K1V 1C1 Canada Tel: +1 613-521-9626 Fax: +1 613-521-0215 www.sgl.com

SURVEY DETAILS

Survey Name	Operation Southern Ice Field - 2016	**Client Name**	Eric Rignot
Survey Location	Villa O'Higgins, Chile	**Contact Name**	Eric Rignot
Project Code	Rignot16.CHL	**Contact Phone**	
Total km	3020.1	**Client Address**	
Line Spacing	2000m		
Survey Type	Gravity / Radar	**Email**	Eric.J.Rignot@jpl.nasa.gov

SURVEY PRODUCTION SUMMARY

	NPI	SPI	SPI2		NPI	SPI	SPI2
Production This Week (km)	0.0	0.0	0.0	**Total km Flown to Date**	0.0	0.0	0.0
Total Remaining (km)	481.6	1924.2	614.3	**km Reflown This Week**	0.0	0.0	0.0
Percent Complete (%)	0.0	0.0	0.0	**Flight Time This Week (h)**		0.0	
Prod km/Day This Week	0.0	0.0	0.0	**Prod km/Flt Hour This Week**			

WEEKLY PRODUCTION

Week 1			Flight No.	Flight Time	No. of Lines Flown	No. Reflight Lines Flown	Production (km) NPI	SPI	SPI2	Reflown (km) NPI	SPI	SPI2
TOTALS				**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
11-Jul	**Mon**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	n/a				**Remarks**	Puerto Varas, Chile: AirGrav installation commences in locally operated aircraft CC-ATW.						
Geomag												
12-Jul	**Tue**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	n/a				**Remarks**	AirGrav installation ongoing. Initial system calibration and alignment performed.						
Geomag												
13-Jul	**Wed**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	n/a				**Remarks**	AirGrav installation complete. Short test flight flown in the afternoon. All systems operational. Max arrives in Villa O'Higgins						
Geomag												
14-Jul	**Thu**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	Marginal				**Remarks**	Base station set up and testing in Villa O'Higgins. Aircraft ferry preparations.						
Geomag												
15-Jul	**Fri**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	Clear. No wind.				**Remarks**	Flat tire during aircraft ferry. Aircraft remains in Puerto Varas for repairs. Ongoing base station testing.						
Geomag												
16-Jul	**Sat**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	Marginal				**Remarks**	Ted arrives in Villa O'Higgins. GPS base station set up and troubleshooting. Aircraft grounded in Puerto Varas						
Geomag												
17-Jul	**Sun**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	Mostly clear, north wind				**Remarks**	Aircraft grounded in Puerto Varas. GPS base station troubleshooting.						
Geomag												

Comments SGL crew arrived in Chile. AirGrav installation was completed in Puerto Varas, while the base station was concurrently set-up in Villa O'Higgins. The aircraft suffers a flat tire, and remains in Puerto Varas for repairs.

Signed Max Buneta

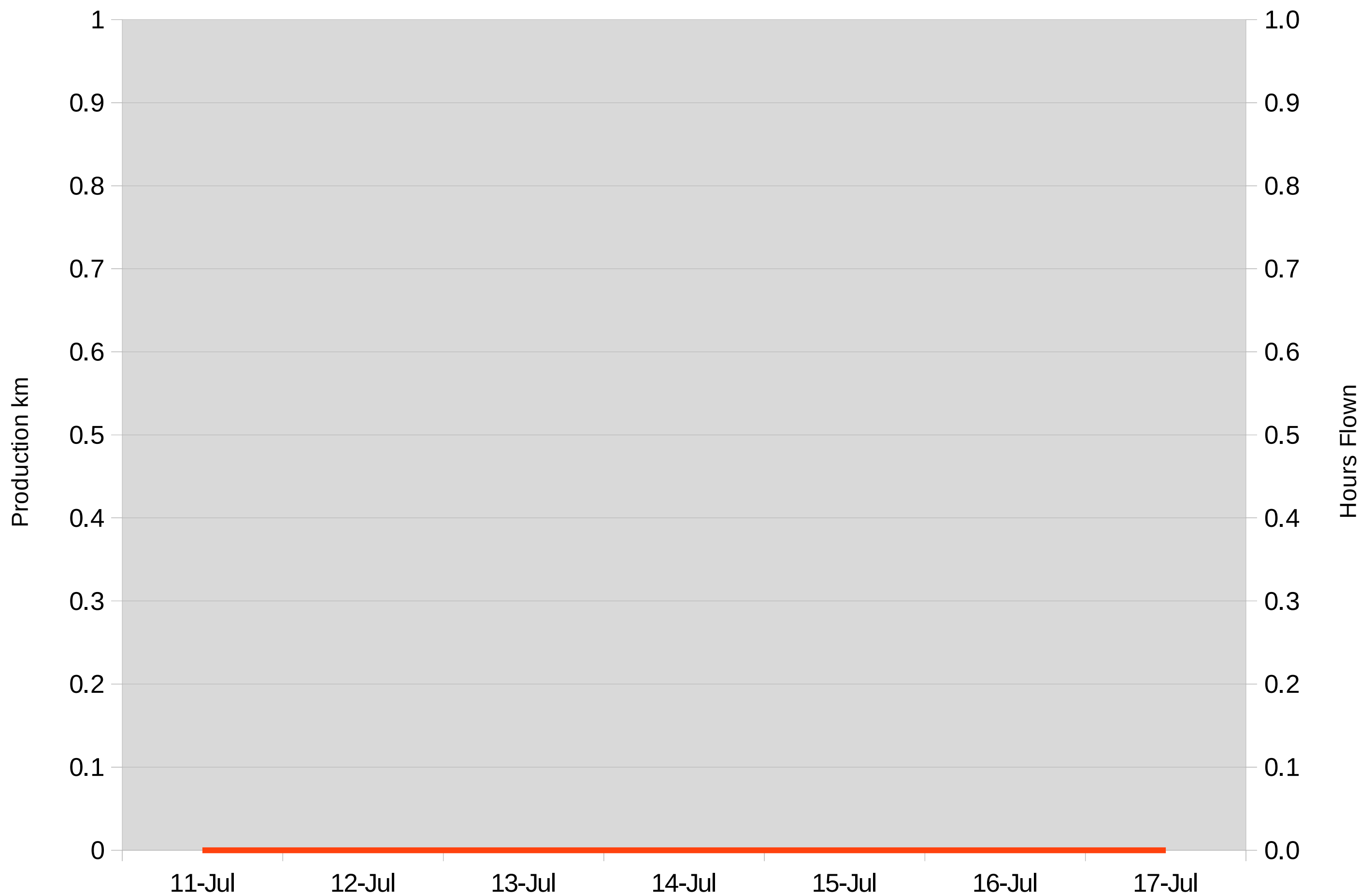
Sander Geophysics Ltd.

Week 1 **Page 2**

PERSONNEL ON SITE THIS WEEK

Name	Position	Arrival This Week	Departure This Week	On Site?	No. of Days On Site This Week	No. of Days on Site To Date
Max Buneta		11-Jul-16		ON SITE	7	7
Ted McEwen				ON SITE	7	8

WEEKLY PRODUCTION KILOMETRES AND HOURS FLOWN



SANDER GEOPHYSICS AIRBORNE GEOPHYSICAL SURVEY

260 Hunt Club Road, Ottawa, ON K1V 1C1 Canada Tel: +1 613-521-9626 Fax: +1 613-521-0215 www.sgl.com

SURVEY DETAILS

Survey Name	Operation Southern Ice Field - 2016	**Client Name**	Eric Rignot
Survey Location	Villa O'Higgins, Chile	**Contact Name**	Eric Rignot
Project Code	Rignot16.CHL	**Contact Phone**	
Total km	3020.1	**Client Address**	
Line Spacing	2000m		
Survey Type	Gravity / Radar	**Email**	Eric.J.Rignot@jpl.nasa.gov

SURVEY PRODUCTION SUMMARY

	NPI	SPI	SPI2		NPI	SPI	SPI2
Production This Week (km)	189.0	1081.6	0.0	**Total km Flown to Date**	189.0	1081.6	0.0
Total Remaining (km)	292.6	842.6	614.3	**km Reflown This Week**	0.0	54.0	0.0
Percent Complete (%)	39.2	56.2	0.0	**Flight Time This Week (h)**		24.1	
Prod km/Day This Week	27.0	154.5	0.0	**Prod km/Flt Hour This Week**		52.7	

WEEKLY PRODUCTION

Week 2			Flight No.	Flight Time	No. of Lines Flown	No. Reflight Lines Flown	Production (km) NPI	Production (km) SPI	Production (km) SPI2	Reflown (km) NPI	Reflown (km) SPI	Reflown (km) SPI2
TOTALS				**24.1**	**35.0**	**1.3**	**189.0**	**1081.6**	**0.0**	**0.0**	**54.0**	**0.0**
18-Jul	**Mon**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	Mostly clear											
Geomag					**Remarks**	Spare tire tube arrives. Aircraft repaired.						
19-Jul	**Tue**	CC-ATW		4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	Broken 8000ft											
Geomag					**Remarks**	Aircraft ferry from Puerto Varas to Villa O'Higgins. Stop in Cochrane to create a gravity tie with 2012 project.						
20-Jul	**Wed**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	cloud, wind											
Geomag					**Remarks**	No flight due to weather						
21-Jul	**Thu**	CC-ATW		0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	wind, turbulence, cloud											
Geomag					**Remarks**	Short test flight flown close to base to test radar altimeter, practice flying with navigation system.						
22-Jul	**Fri**	CC-ATW	1000	4.1	4.6	0.0	189.0	0.0	0.0	0.0	0.0	0.0
Weather	clearing in afternoon											
Geomag					**Remarks**	Afternoon survey flight over NPI.						
23-Jul	**Sat**	CC-ATW	1001	7.3	12.0	0.4	0.0	497.6	0.0	0.0	9.8	0.0
Weather	Clear. Windy over ice field											
Geomag					**Remarks**	Survey flight over SPI. Clear but intermediate winds, and some turbulence.						
24-Jul	**Sun**	CC-ATW	1002	7.9	18.4	0.9	0.0	584.0	0.0	0.0	44.2	0.0
Weather	Clear, calm											
Geomag					**Remarks**	Survey flight over SPI. Clear and very calm.						

Comments With tire repaired, the aircraft arrived on Tuesday. A familiarization flight was flown on Thursday. Weather cleared up on Friday, and three survey flights were flown. Dual flights flown on Sat, Sun.

Signed Max Buneta

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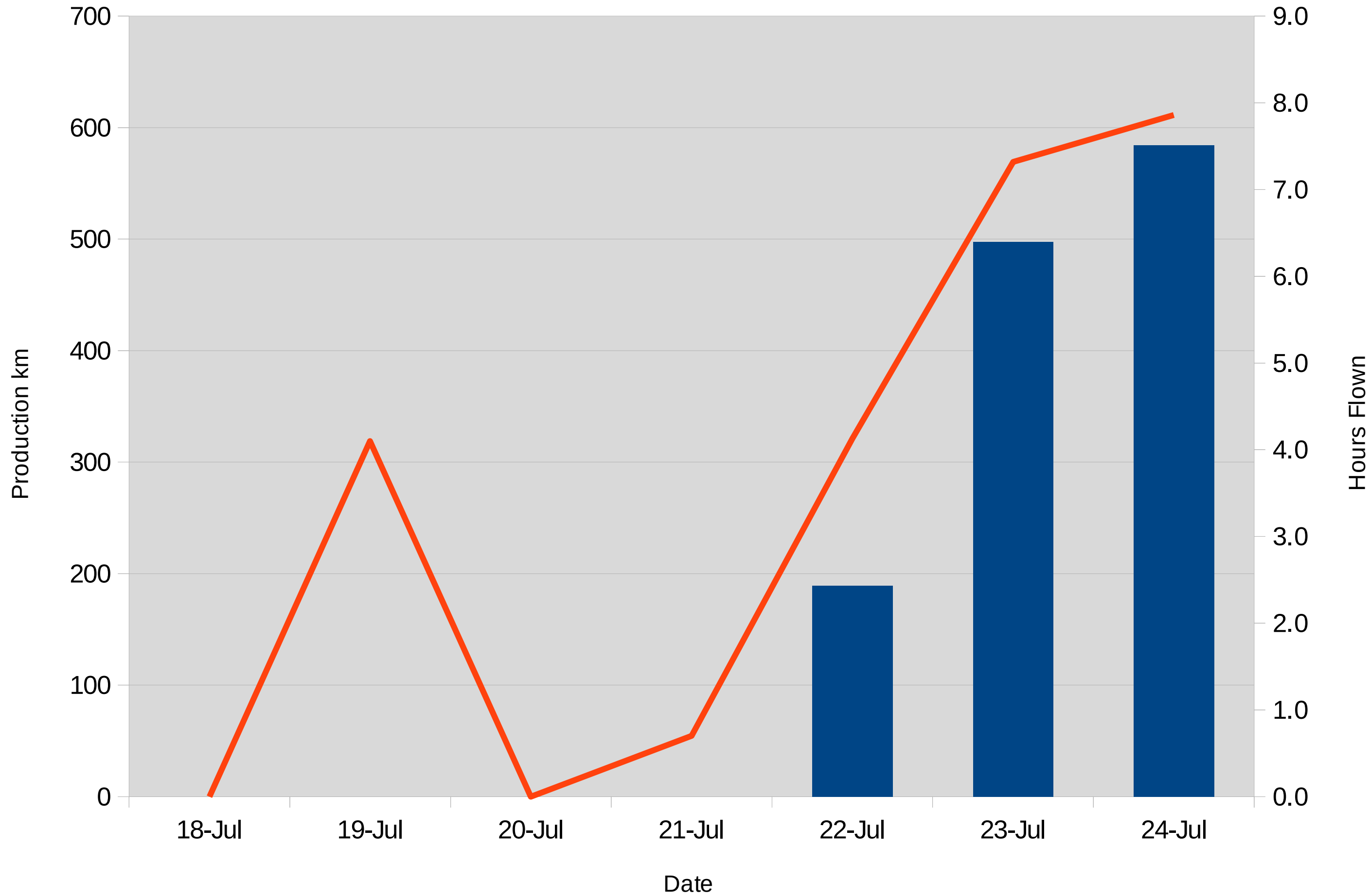
Week 2 **Page 2**

PERSONNEL ON SITE THIS WEEK

Name	Position	Arrival This Week	Departure This Week	On Site?	No. of Days On Site This Week	No. of Days on Site To Date
Max Buneta				ON SITE	7	14
Ted McEwen				ON SITE	7	15

WEEKLY PRODUCTION KILOMETRES AND HOURS FLOWN



SANDER GEOPHYSICS AIRBORNE GEOPHYSICAL SURVEY

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SURVEY DETAILS

Survey Name	Operation Southern Ice Field - 2016	**Client Name**	Eric Rignot
Survey Location	Villa O'Higgins, Chile	**Contact Name**	Eric Rignot
Project Code	Rignot16.CHL	**Contact Phone**	
Total km	3020.1	**Client Address**	
Line Spacing	2000m		
Survey Type	Gravity / Radar	**Email**	Eric.J.Rignot@jpl.nasa.gov

SURVEY PRODUCTION SUMMARY

	NPI	SPI	SPI2		NPI	SPI	SPI2
Production This Week (km)	176.8	908.6	283.1	**Total km Flown to Date**	365.8	1990.2	283.1
Total Remaining (km)	115.8	-66.0	331.2	**km Reflown This Week**	18.0	0.0	0.0
Percent Complete (%)	76.0	103.4	46.1	**Flight Time This Week (h)**		13.1	
Prod km/Day This Week	25.3	129.8	40.4	**Prod km/Flt Hour This Week**		104.4	

WEEKLY PRODUCTION

Week 3			Flight No.	Flight Time	No. of Lines Flown	No. Reflight Lines Flown	Production (km) NPI	SPI	SPI2	Reflown (km) NPI	SPI	SPI2
TOTALS				**13.1**	**43.5**	**0.3**	**176.8**	**908.6**	**283.1**	**18.0**	**0.0**	**0.0**
25-Jul	**Mon**	CC-ATW	1003	8.5	23.3	0.0	0.0	643.0	0.0	0.0	0.0	0.0
Weather	Clear, calm				**Remarks**	Two flights flown over SPI.						
Geomag												
26-Jul	**Tue**	CC-ATW	1004	3.4	3.5	0.3	176.8	0.0	0.0	18.0	0.0	0.0
Weather					**Remarks**	Flight over NPI. Aircraft returned early due to survey power electrical fault. System repairs.						
Geomag												
27-Jul	**Wed**	CC-ATW	1005	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	Overcast, light snow				**Remarks**	Short test flight to test survey power. Attempted survey flight over SPI, but returned due to weather.						
Geomag												
28-Jul	**Thu**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	Overcast				**Remarks**	No flight due to weather.						
Geomag												
29-Jul	**Fri**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	Low cloud over ice fields				**Remarks**	No flight due to weather.						
Geomag												
30-Jul	**Sat**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather	Low cloud over ice fields				**Remarks**	No flight due to weather.						
Geomag												
31-Jul	**Sun**	CC-ATW	1006	0.0	16.7	0.0	0.0	265.6	283.1	0.0	0.0	0.0
Weather	Clear, calm				**Remarks**	Flight over SPI2 and SPI. SPI completed, and a few additional lines flown.						
Geomag												

Comments Three flights were flown this week. Bad weather and an electrical fault slowed production, but we are making excellent progress overall. The SPI block has been completed, and only small portions of NPI and SPI2 remain.

Signed Max Buneta

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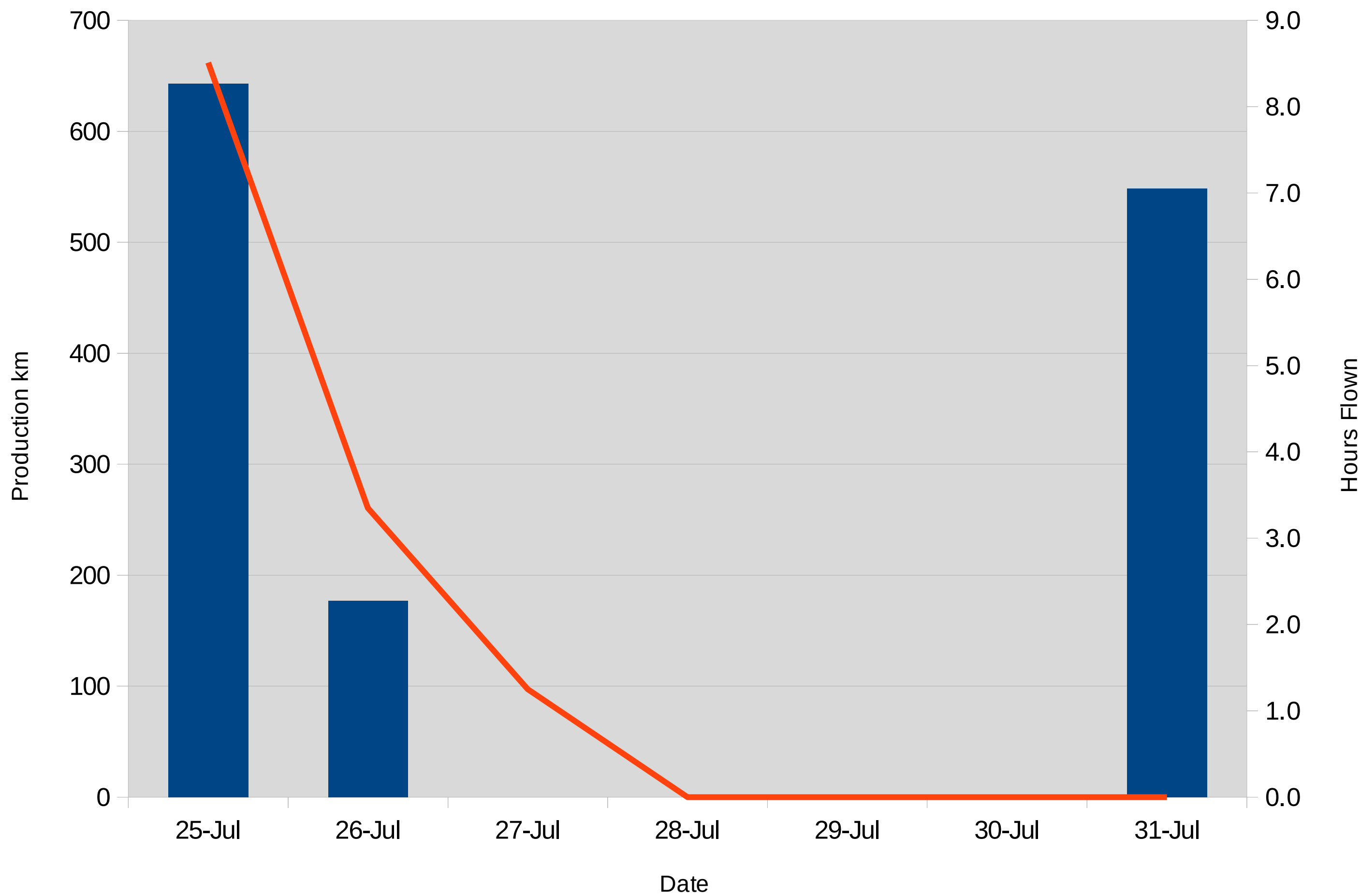
Week 3 **Page 2**

PERSONNEL ON SITE THIS WEEK

Name	Position	Arrival This Week	Departure This Week	On Site?	No. of Days On Site This Week	No. of Days on Site To Date
Max Buneta				ON SITE	7	21
Ted McEwen				ON SITE	7	22

WEEKLY PRODUCTION KILOMETRES AND HOURS FLOWN



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SURVEY DETAILS

Survey Name	Operation Southern Ice Field - 2016	**Client Name**	Eric Rignot
Survey Location	Villa O'Higgins, Chile	**Contact Name**	Eric Rignot
Project Code	Rignot16.CHL	**Contact Phone**	
Total km	3020.1	**Client Address**	
Line Spacing	2000m		
Survey Type	Gravity / Radar	**Email**	Eric.J.Rignot@jpl.nasa.gov

SURVEY PRODUCTION SUMMARY

	NPI	SPI	SPI2		NPI	SPI	SPI2
Production This Week (km)	0.0	0.0	331.2	**Total km Flown to Date**	365.8	1990.2	614.3
Total Remaining (km)	115.8	-66.0	0.0	**km Reflown This Week**	0.0	0.0	0.0
Percent Complete (%)	76.0	103.4	100.0	**Flight Time This Week (h)**		0.0	
Prod km/Day This Week	0.0	0.0	47.3	**Prod km/Flt Hour This Week**			

WEEKLY PRODUCTION

Week 4			Flight No.	Flight Time	No. of Lines Flown	No. Reflight Lines Flown	Production (km) NPI	SPI	SPI2	Reflown (km) NPI	SPI	SPI2
TOTALS				**0.0**	**11.0**	**0.0**	**0.0**	**0.0**	**331.2**	**0.0**	**0.0**	**0.0**
1-Aug	**Mon**	CC-ATW	1007	0.0	11.0	0.0	0.0	0.0	331.2	0.0	0.0	0.0
Weather	Clear, light wind											
Geomag					**Remarks**	Survey flight on SPI2. SPI2 block completed.						
2-Aug	**Tue**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather												
Geomag					**Remarks**							
3-Aug	**Wed**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather												
Geomag					**Remarks**							
4-Aug	**Thu**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather												
Geomag					**Remarks**							
5-Aug	**Fri**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather												
Geomag					**Remarks**							
6-Aug	**Sat**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather												
Geomag					**Remarks**							
7-Aug	**Sun**	CC-ATW		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Weather												
Geomag					**Remarks**							

Comments

Signed

Sander Geophysics Ltd.

Week 4 **Page 2**

PERSONNEL ON SITE THIS WEEK

Name	Position	Arrival This Week	Departure This Week	On Site?	No. of Days On Site This Week	No. of Days on Site To Date
Max Buneta				ON SITE	7	28
Ted McEwen				ON SITE	7	29

WEEKLY PRODUCTION KILOMETRES AND HOURS FLOWN