GEO DATA SOLUTIONS GDS Inc.

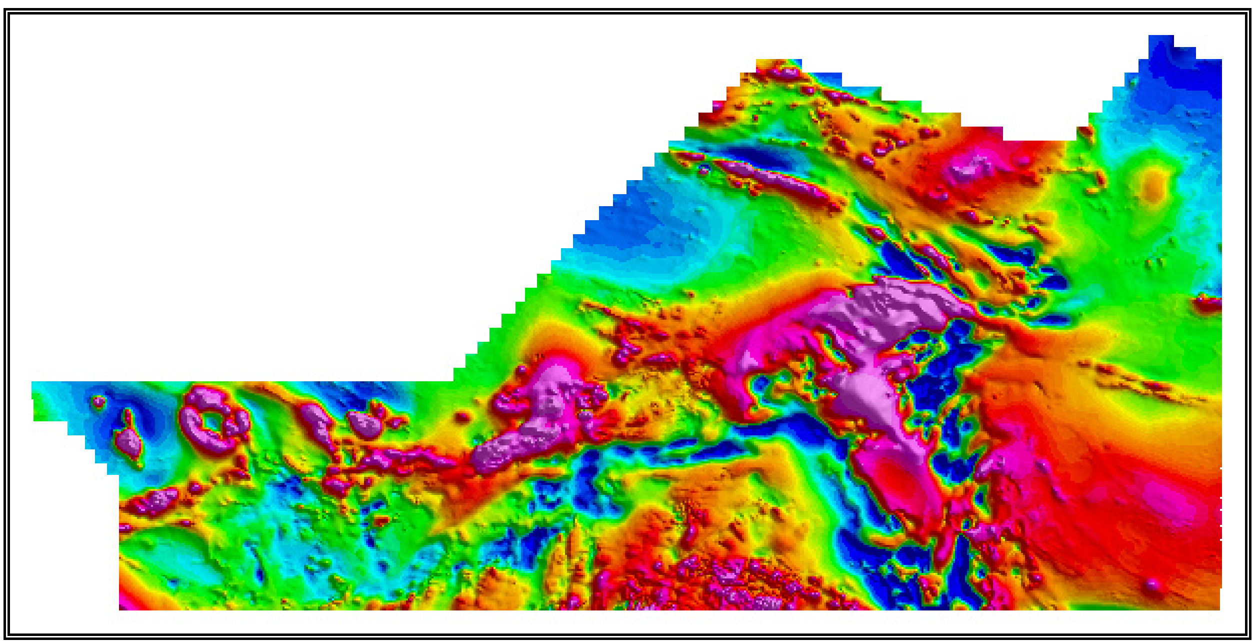
NATURAL RESOURCES CANADA (NRCan)

AEROMAGNETIC SURVEY
over NASH CREEK AREA, YUKON

FINAL TECHNICAL REPORT

Contract # 3000699964

June 2020



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By

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1.0 INTRODUCTION

On November 29th, 2019 **Géo Solutions Données GDS / Geo Data Solutions GDS Inc.** was awarded contract number 3000699964 by Natural Resources Canada. The contract required the execution and compilation of digitally recorded high sensitivity fixed-wing airborne total magnetic field survey consisting of 41,393 l-km over Nash Creek area in Yukon (Figure 1).

The data were recorded using split-beam cesium vapour magnetometer mounted in the tail boom of a Beechcraft King Air A100 (C-FLRB) flying at a nominal terrain clearance of 150 m. The survey was flown on a pre-determined flight surface to minimize differences in magnetic values at the intersections of control and traverse lines. These differences were computer-analysed to obtain a mutually levelled set of flight-line magnetic data.

This report describes the survey procedures and data verification, which were carried out in the field, and data processing, which followed at the office.

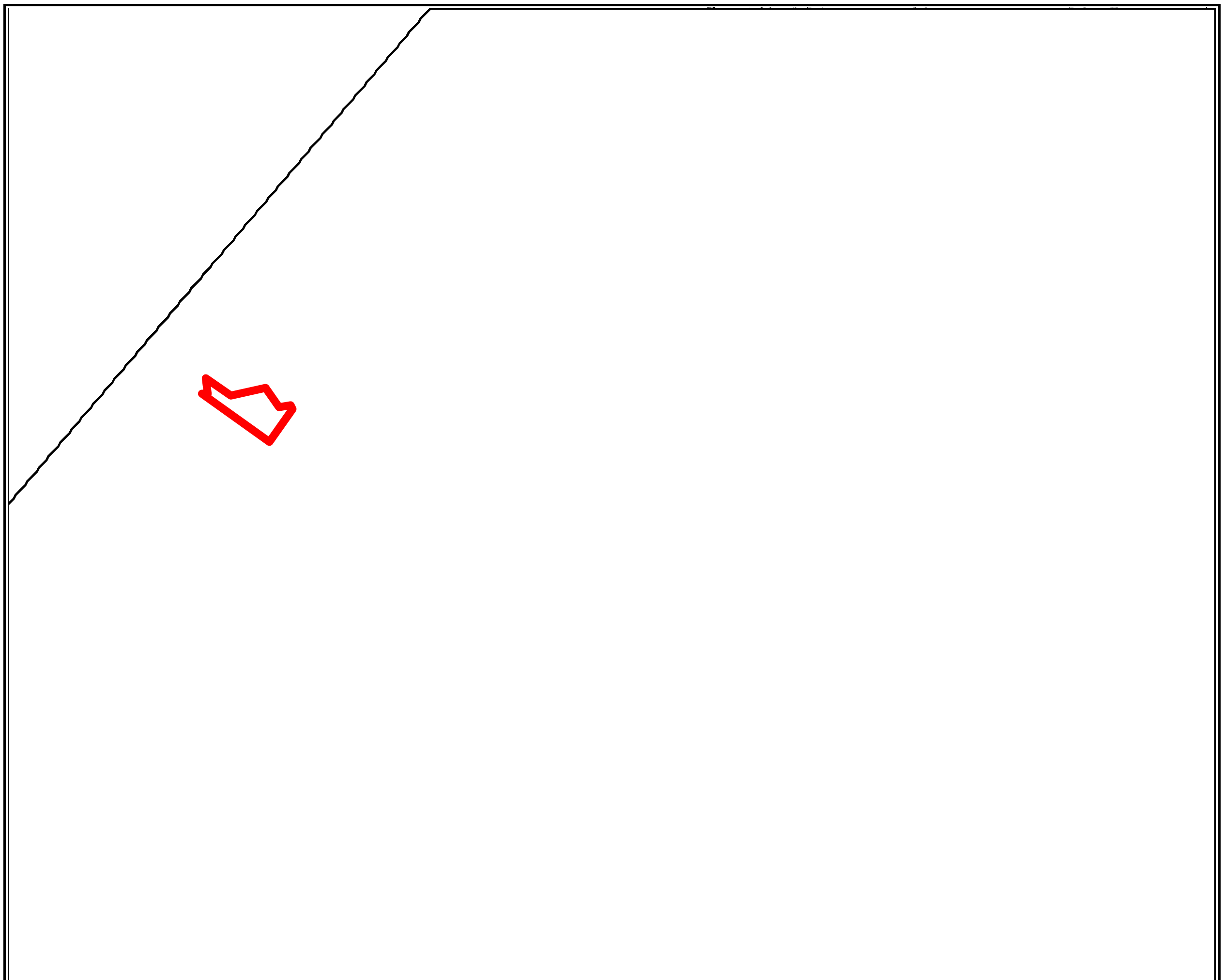


Figure 1: Survey area (red) and base of operations (blue)

2.0 RECONNAISSANCE OF PROJECT

Mobilization started on January 17th, 2020 and the aircraft arrived in Mayo, YT on the next day. Data acquisition flights occurred between January 19th and March 27th. Weather conditions were relatively unstable throughout the survey. There were 35 days that the weather prevented production flying.

During data acquisition period, daylight hours gradually increased from 7 to 13 hours.

In terms of topography, the terrain may be classified as moderate to rugged for most of the area (Figure 2). **GDS** used a 3D navigation system to fly a smooth drape surface with a rate of climb of 5%. The use of this technique minimizes the high height intersection differences between control lines and traverses in order to control and achieve optimal ground clearance in some areas of steep topography. The drape surface was created using Shuttle Radar Topography Mission (SRTM) 1 arc second data (source data in Canada originating from NRCan) along with drape software from the Geological Survey of Canada (Drape_dtm).

There were no restricted or danger zones within the survey area but local wildlife (Caribou and migratory birds) were avoided and reported if observed.

GDS set up its base of operations in Mayo, YT, which is located 6 km south of the survey area. As such, the range capability of the aircraft to fly the survey was suitable to collect large volumes of data on each flight.

Two magnetic base stations were set up at magnetic noise-free locations, away from magnetic objects, vehicles, and DC electrical power lines. The base station magnetometers were located at the following coordinates in WGS84:

	Installation date	Latitude	Longitude
Magnetic base A	January 18, 2020	63° 36' 53.0" N	135° 51' 48.0" W
Magnetic base B	January 18, 2020	63° 36' 59.8" N	135° 53' 11.4" W
	January 24, 2020	63° 36' 59.7" N	135° 53' 16.6" W

A GPS base station located on the property of the Bedrock Motel was also installed for the purpose of differentially correcting the aircraft flight path and height for greater accuracy. The antenna location and height are as follows in WGS84 coordinates:

Latitude	Longitude	Altitude (ellips)
63° 36' 38.04" N	135° 52' 47.72" W	506.21

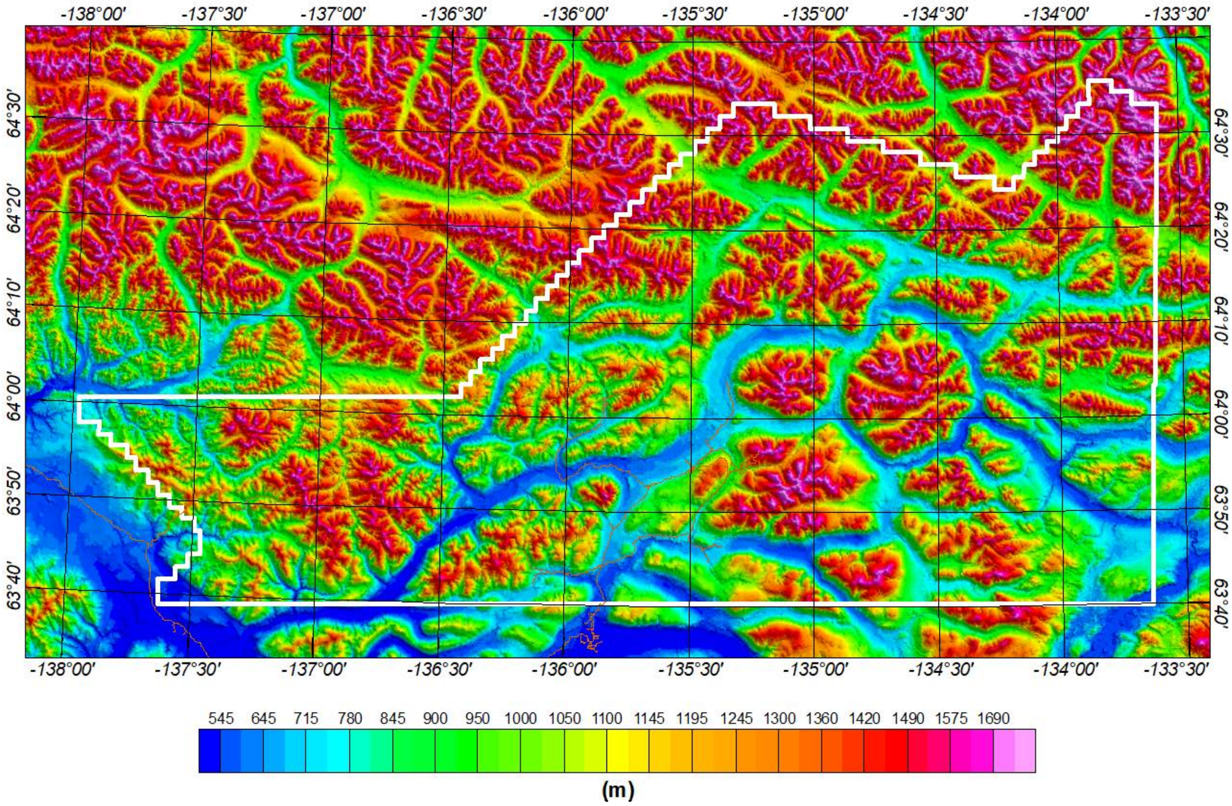


Figure 2: Survey area topographic relief

The survey area consisted of a single block flown with a nominal terrain clearance of 150m and having a line spacing and orientation, relative to UTM zone 8, as shown in the following table.

Table 1: Flight line bearing and spacing			
Area	**Line type**	**Bearing**	**Spacing**
Nash Creek, YT	Traverse	N00° E	400 m
	Control	N90° E	2 400 m

The survey block location is shown on figure 2 while table 2 defines its geographical co-ordinates in NAD83.

Table 2: Survey area coordinates					
	Latitude	**Longitude**		**Latitude**	**Longitude**
1	63.40.54	-133.40.03	**6**	64.16.54	-135.55.06
2	63.40.30	-137.34.00	**7**	64.32.33	-135.17.15
3	63.45.59	-137.22.10	**8**	64.23.05	-134.11.48
4	63.59.21	-137.54.25	**9**	64.34.10	-133.48.03
5	64.00.39	-136.26.58	**10**	64.31.16	-133.36.36

3.0 TESTS AND CALIBRATIONS

The following is a summary of the tests performed before, during or after survey production. Results are presented in appendices A.

Table 3: Tests and calibrations				
Aircraft	**Morewood**	**Altimeters**	**Lag**	**FOM**
C-FLRB	2020-01-09	2020-01-14	2020-02-25	2020-01-09 2020-01-20 2020-03-19

3.1 Magnetometer Tests

The aircraft proceeded to Morewood, ON test site for the calibration of the magnetometers. This calibration included a measurement of the heading error. Two passes in each of four directions were flown to obtain enough statistical data to complete the standard form. Test results were submitted to the Technical Inspector.

Also, the effects of aircraft manoeuvres (roll, pitch and yaw) were determined and the results of this test submitted to the Technical Inspector. The test was performed over a magnetically quiet zone, at a high altitude. It consisted of flying ±10º rolls, ±5º pitches and ±5º yaws peak to peak parallel to survey lines headings (N0ºE, N90ºE, N180ºE and N270ºE) over periods of 4-5 seconds. A compensation Figure of Merit (FOM) for the aircraft was calculated by summing up the peak-to-peak amplitudes of the 12 magnetic signatures. The FOM did not exceed 1.5 nT.

3.2 Altimeter Test

Calibrations were performed by flying a range of altitudes representative of the survey area conditions, above and below the designated survey altitude. These altitudes covered the minimum and maximum range at different altitudes. Typically, these levels were determined by the real time GPS-Z and radar altimeter above an airstrip of known elevation.

3.3 Lag Test

The aircraft performed a lag test to ascertain the time difference between the magnetometer readings and the positioning devices. The test was carried out by flying in opposite directions at the normal survey height over a distinct anomaly to determine any lag in the digitally recorded navigational data. The test results were submitted to the Technical Inspector.

4.0 TIMING

The aircraft (C-FLRB) and its field crew arrived in Mayo on January 18th, 2020. The first production flight began on January 19th and the last flight ended on March 27th.

Excluding calibration and test flights, a total of 40 flights were needed to cover the survey area. Preliminary results were sent to the Technical Inspector progressively during the flying phase while final data were submitted in May 2020. Tables 4 and 5 show the production statistics of the aircraft.

Table 4: Production summary			
	2020		
	January	February	March
C-FLRB			

Table 5: Aircraft statistics		
		C-FLRB
Production flight number range		005 - 046
Production flights		40
Production days		31
Non-production days (weather, test, maintenance)		38
Aircraft on-site		2020-01-18
First production flight		2020-01-19
Last production flight		2020-03-27
Demobilization		2020-03-29
Flight time	Production	174:19
	Ferry and tests	17:17
	Total	**191:36**
L-km flown	Traverses	35 530
	Tie lines	6 115
	Total	**41 645**
Participation		100%

5.0 FIELD AND OFFICE CREW

The general management of the project was monitored offsite by Mr Mouhamed Moussaoui. Mr. Saleh Elmoussaoui was responsible for data quality control while Mr. Mouhamed Moussaoui did the final data processing, consulting with Mr. Frank Kiss, Technical Inspector from the Geological Surveys of Canada, to ensure that the work was carried out according to contractual specifications.

Field and office personnel are listed in table 6.

Table 6: Field and Office Crew

Function	Name
Project Manager	Mr. Mouhamed Moussaoui, P.Eng.
Data Quality Control	Mr. Saleh Elmoussaoui
Field Manager	Mr. Saleh Elmoussaoui Mr. Kenneth Bernier
Field Instrument Operators	Mr. Alireza Kasraei Mr. Kenneth Bernier
Professional Pilots/co-pilots	Mr. Joffrey Perez Mr. Jean-Philippe Lambert
Final Processing	Mr. Mouhamed Moussaoui, P.Eng.
Survey Technical Report	Mr. Mouhamed Moussaoui, P.Eng. Mr. François Caty

6.0 AIRCRAFT AND EQUIPMENT

6.1 Aircraft

A Beechcraft King Air (C-FLRB) flew the geophysical survey (Figure 3). This aircraft was Transport Canada approved to carry out this particular type of survey.

The main characteristics of the aircraft are presented below:

Beechcraft
King Air A100

C-FLRB

Figure 3: Beechcraft King Air twin-engine aircraft

Aircraft Characteristics	C-FLRB
Type	Beechcraft KingAir 100
Empty Weight	3 100 kg
Max charge	5 200 kg
Ceiling	10 000 m
Rate of climb	13.2 m/s
Survey Speed	75 m/s (146 knots)
Fuel Type	Jet fuel
Fuel consumption (2 engines)	270 litres/hr
Survey / Maximum range	5.0 / 6.0 hours

6.2 Magnetometer and digital acquisition systems

6.2.1 Airborne magnetometer

The cesium CS-3 sensor is a versatile and highly sensitive means of accurately measuring the Earth's total magnetic field intensity. Based upon the principle of optical pumping and monitoring, the cesium sensor is capable of resolving millisecond variations as small as 0.005 nT (gamma) or 1 part of 10,000,000 of the Earth's magnetic field. This unique process involves the interaction of the magnetic moment and angular momentum of the valence electron of cesium with the ambient magnetic field to produce an oscillation whose frequency is dependent on the magnetic field intensity. The sensor, operating on an atomic process, contains no moving parts and is inherently simple, rugged, and accurate.

The following table describes the airborne magnetometer. The sensor was mounted in a stinger rigidly attached to each aircraft tail.

Magnetometer	C-FLRB
Manufacturer	Geometrics
Type and Model	Cesium G-822A
Ambient Range	20 000 - 100 000 nT
Sensitivity	± 0.003 nT
Absolute Accuracy	± 10 nT
Noise Envelope	0.10 nT
Sampling Rate	10 Hz
Heading effect	<2.0 nT

6.2.2 Magnetic Compensator and Data Acquisition system

The magnetic field generated by the aircraft was compensated using a DAARC500, an Automatic Aeromagnetic Digital Compensator system manufactured by RMS Instruments. The DAARC500 incorporates a sophisticated and flexible data acquisition system.

The DAARC500 is an instrument used to compensate or correct in real time for the magnetic interference caused by the aircraft itself and aircraft maneuvering in the Earth's magnetic field, when using inboard-mounted high sensitivity magnetometers. The compensation accounts for the effects of permanent magnetism, induced magnetism, Eddy currents and also removes the heading errors caused by the sensors themselves. It provides a frequency bandwidth of DC to 0.9 Hz, the frequencies of most interest to the geophysicist. Other bandwidths are optionally available. The signal(s) from the magnetometer(s) are digitized faithfully without aliasing or phase distortion.

The DAARC500 is based on many years of research and development on automatic aeromagnetic compensation by the National Aeronautical Establishment (NAE), a division of the National Research Council of Canada. Following the transfer of technology, RMS Instruments continued with the development resulting in an instrument which is extremely reliable, capable of accepting the Larmor frequencies of up to four high sensitivity magnetometers, and is based on a sophisticated compensation algorithm which is extremely robust.

Figure 4: The RMS DAARC500 unit and its Graphical User Interface

Data acquisition system	C-FLRB
Manufacturer	RMS Instruments
Model	DAARC500
GPS synchronization	PPS signal
Magnetic compensator	integrated

Geophysical instruments and sensors may be directly connected to the DAARC500, via 8 Outputs and Inputs high speed RS232 digital ports and 16 analogic Inputs ports as well as an ethernet port. Incoming data are real time processed via serial ports. All acquired data are synchronized through a GPS receiver pulse-per-second (PPS).

6.3 Ground base station magnetometer

Two GEM System Inc. Overhauser type ground magnetometers with combined GPS system were used as ground base stations. They provided synchronized GPS time and recorded the total intensity of the earth's magnetic field with a resolution of 0.01 nT.

The primary and secondary magnetic base stations were set up at a magnetic noise-free location, away from magnetic objects, vehicles and DC electrical power lines. Both magnetometers sampled at a rate of one per second. Records, including GPS time, were dumped digitally on a computer, merged with airborne data and displayed daily.

The following table describes the base station magnetometers:

Mag base station	Magnetic Base A	Magnetic Base B
Manufacturer	GEM System inc	GEM System inc
Type	Overhauser	Overhauser
Model	GSM-19 w/ GPS	GSM-19 w/ GPS
Dynamic Range	20 000 - 120 000 nT	20 000 - 120 000 nT
Sensitivity	± 0.01 nT	± 0.01 nT
Sampling Rate	1 Hz	1 Hz
Noise Level	0.10 nT	0.10 nT

Figure 5: The base station magnetometer and console

6.4 Positioning Cameras, Navigation and Flight Path Systems

6.4.1 Video system

The vertically mounted, continuous-recording video camera, with a wide angle lens to maximize ground coverage at survey altitude, operated at all times while aircraft was surveying. Data, which were displayed alphanumerically in the top portion of each frame, included time after midnight, date and GPS generated Lat, Lon, Z co-ordinates. Data and video were available for review immediately after each flight with no further processing.

The following tables describe the video system installed in the aircraft:

Video camera	**C-FLRB**
Manufacturer	Samsung
Model	SNB-7002
Mounting	Vertical
Video Format	Full HD

Video recorder	**C-FLRB**
Manufacturer	Samsung
Model	SRN-470DN

Figure 6: Video camera and digital recorder

6.4.2 Differential GPS and Navigation System

A dual frequency GPS antenna was mounted on aircraft over the cockpit. The following table describes the airborne GPS system, which obtained a complete coverage and provided both real-time navigation and flight-path recovery:

Figure 7: GPS receivers and Navigation System

GPS receiver	**C-FLRB**
GPS Manufacturer	Novatel
Model	DL-V3 L1/L2
Number of Channels	12
Sampling Interval	1 Hz
Differential System	SBAS Real time
Recording media	Compact Flash card

Navigation system	**C-FLRB**
Manufacturer	Agnav
Model	Guia LiNav 3D

A dual frequency Novatel DL-V3 GPS Receiver sampling once every second was also used as a base station for post-flight differential correction of each aircraft's raw GPS data of all flights.

6.4.3 Radar altimeter

A radar altimeter was used for measuring the distance between aircraft and ground accurately. The following table presents the technical characteristics of the altimeter:

Equipment	C-FLRB
Manufacturer	Honeywell
Model	HG8505DA01
Minimum Range	0 to 2400 m
Accuracy	±3 ft + 1%
Resolution	0.03 m
Sampling rate	2 Hz

6.4.4 Barometric altimeter

The following table describes the barometric altimeter with digital output, which was installed in the aircraft:

Equipment	C-FLRB
Manufacturer	Honeywell
Model	PPT0020AWN2VA
Pressure Ranges	0 to 20 psi
Accuracy	0.10 %
Sensitivity	3 mV/m
Recording Interval	1 Hz

While the barometric altimeter data were recorded in flight and used as backup for the GPS height measurements, the output was not archived in the final data set since the differentially corrected GPS height data in comparison were much more precise.

7.0 QUALITY CONTROL - FIELD

All work was performed to the satisfaction and subject to the acceptance of the Technical Inspector. A copy of the Technical Specifications was available to **GDS**'s personnel responsible in the execution of the contract.

After each production day, the instrument operator was bringing the acquired data to the field office in order to achieve quality control. The processing system consisted of a computer equipped with commercial and custom software including that for GPS processing (Novatel WayPoint), profile and flight path plots and all processing software necessary to calculate intersections, and to carry out preliminary levelling and gridding (Geosoft Montaj).

Digital data were verified daily to ensure the recorded parameters met the contract specifications. Positional data were analyzed to verify for the accuracy of the differentially corrected flight path.

7.1 GPS Data

Navigation and positioning were achieved through differential GPS. The aircraft was equipped with a Novatel DL-V3 GPS receiver. After each production day, data including GPS positions were transferred to the field computer systems and merged into the database. GPS data were differentially processed, using NovAtel Waypoint software. The actual surveyed flight path digital data were displayed and compared to the planned flight path. Errors were noted and re-flights called where necessary.

Verification on the positioning included a calculation of a digital elevation model (DEM), using the differentially corrected GPS altitude and altimeter data. The DEM was gridded and displayed.

GPS receivers generated latitudes and longitudes which were then projected to UTM Northing and Easting, with respect to the WGS 84 datum.

7.2 Flight Path Specifications

The survey height was controlled according to a pre-defined smooth drape surface. The nominal terrain clearance was 150 metres except in areas where Transport Canada regulations prevent flying at this height. In areas where obstacles or topography conflicted with the drape surface, the pilot's judgement prevailed within reason. Traverse lines and control lines were flown at the same altitude at points of intersection. The altitude tolerance was limited to +/-15 metres difference between traverse lines and control lines.

All traverse lines intersected a minimum of two control lines. Outside survey boundaries, all traverse lines started or ended by intersecting a control line. In order to provide valid information beyond the map boundaries, traverse and control lines had to be extended over a minimum distance of 1000 meters. No gaps were accepted in the final products.

For each survey flight, adjacent lines were flown consecutively and in opposite directions. Racetrack flying pattern was not permitted.

Lines flown outside the following positioning tolerances were re-flown at GDS' own cost.

Table 7: Flight plan specifications					
Area	**Line type**	**Bearing**	**Spacing**	**Min/Max separation**	**Min. overfly distance**
Nash Creek	Traverse	N00° E	400 m	300 / 500 m	1 000 m
	Control	N90° E	2 400 m	-	1 000 m

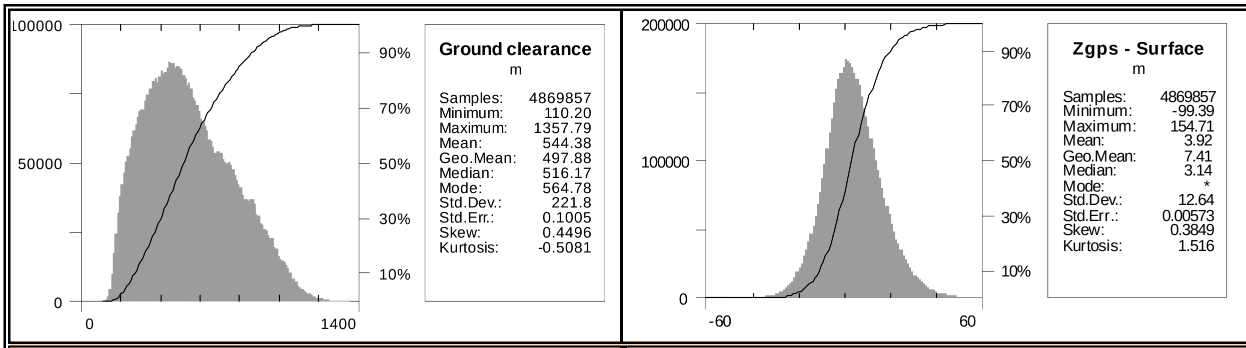


Figure 8: Ground clearance (left) and deviation from flight surface (right)

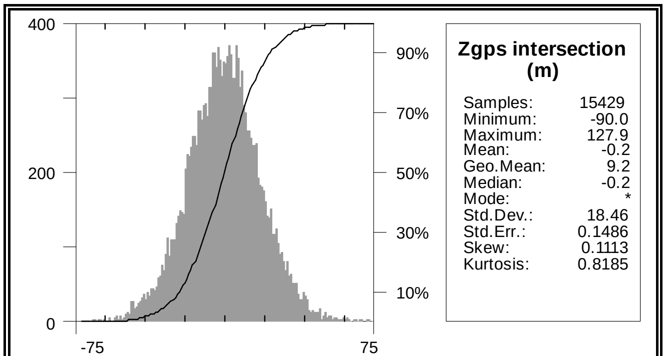


Figure 9: Traverse/Tie Altitude difference

7.3 Diurnal Specifications

Diurnal magnetic variations were monitored and recorded using two base stations. Base station and aircraft acquisition time were synchronized via GPS time.

For each base station, a maximum tolerance of 3.0 nT (peak to peak) deviation from a long chord equivalent to a period of one minute was requested. An additional maximum tolerance of 0.50 nT (peak to peak) deviation from a long chord equivalent to a period of 15 seconds for each station was also requested.

7.4 Maintenance of speed and sampling

The pilot flew this survey with an average ground speed of 310 kilometres per hour. As the data is recorded at a rate of 10 Hz, the density is equivalent to one sample data every 8.6 meters on the ground.

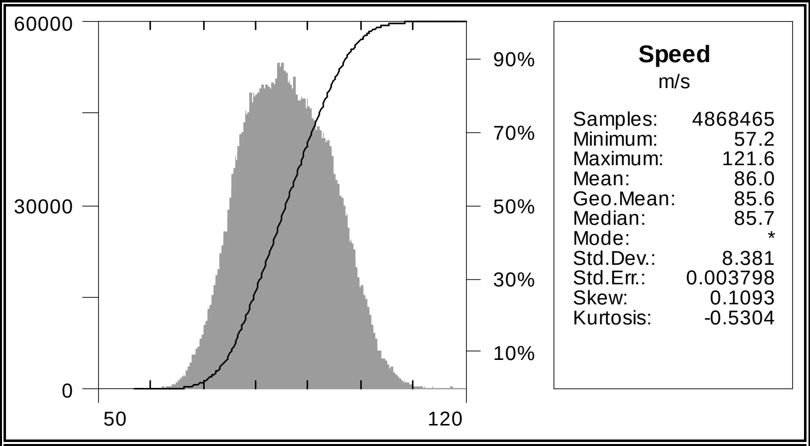


Figure 10: Aircraft speed statistics

7.5 Magnetic data

All magnetic data recorded in flight were checked for noise by an inspection of the fourth difference trace.

When enough and adequate data were accumulated, magnetic values for traverse/tie line intersections were calculated and preliminary magnetic levelling were carried out. Finally, preliminary magnetic grids were produced to ensure data veracity and completeness.

8.0 FINAL DATA PROCESSING

Since the data had been edited and processed throughout the data acquisition phase, it was not expected that additional serious problems would be encountered. Nevertheless, further editing and compilation procedures were carried out to detect and correct for any remaining isolated errors. The processing stages, such as refining the positioning, levelling and gridding through to final contours, are shown in figures 11 and 12. The processing was monitored closely by the Project Leader. The digital data, as well as the preliminary and final products were submitted to the Technical Inspector for checking according to the contract specifications.

8.1 Positioning Data (GPS and altimeters)

The raw GPS data from the aircraft and the base stations were recovered. Waypoint's GrafNav software was used for post-processing and for verifying the raw GPS data. The latitudes and longitudes were converted from the WGS84 spheroid to the local map projection and datum in UTM coordinates. A point to point speed calculation was then done from the final X, Y, Z coordinates and reviewed as part of the quality control. The flight data was then cut back to the proper survey line limits and a preliminary plot of the actual flight path was done and compared to the planned flight path to verify the navigation.

The positional data, which includes the radar altimeter and post-processed corrected GPS elevation values were checked and corrected for spikes using a fourth difference editing routine. The raw radar altimeter data was adjusted using the calibrations determined from the altimeter flight test. Some subtle noise filters, such as a non-linear of 0.3sec and a low pass of 0.5sec, were then applied to the data. The filtered radar altimeter data were also lagged to account for system parallax.

A digital elevation model (DEM) was then computed by subtracting the altimeter values from the differentially corrected GPS elevation values.

8.2 Magnetic base station data

The recorded magnetic diurnal base station data were loaded into the flight database based on common GPS time stamps. After initial verification of its integrity, the data were checked and corrected for small DC shifts and cultural events.

8.3 Airborne Magnetic Data

The RMS DAARC500 binary raw data (mag, analog and serial inputs) were reformatted and loaded into the Oasis Montaj database.

A detail check of the magnetic data was done along each flight. The magnetic data were corrected for spikes followed by lag correction. After that, a filter was applied to remove some small noise detected on the data. The noise removed had a wavelength cut-off of 0.9sec.

The airborne magnetic data were not corrected for diurnal drift. Tests showed that subtraction of ground from airborne magnetometer data did not enhance the overall quality.

Prior to levelling, the magnetic data was corrected for small height departures from the intended drape surface as the datum in order to bring magnetic total filed levelling traverse line and control line intersections values to the same altitude. The Taylor series expansion consisting of continuations using the grid of the First Vertical Derivative of the pre-levelled magnetic data, and the differences between Zgps and drape surface were applied for this purpose.

Tie line levelling process was then applied to the corrected magnetic data. This consists of calculating the positions of the control points (intersections of traverses and tie lines), calculating the magnetic differences at the control points and analyzing to produce a smooth pattern of adjustments to the levelling network in order to reduce the misclosures to zero. In areas of steep magnetic gradient and/or of rugged topographic relief, the intersection adjustments have been deleted or an appropriate adjustment assigned to a traverse line. Due to the nature of the magnetic field in the area and the diurnal variation along the survey, pseudo-tie lines were created between actual flown control lines and introduced to help and improve the levelling of the total magnetic field data.

No micro-levelling has been applied to the magnetic data.

To produce the Residual Magnetic Field, the International Geomagnetic Reference Field (IGRF), defined at the average GPS altitude of 1630 m for the current mid-survey date of 2020/02/25, was first calculated from the year 2020 model, and then removed from the levelled magnetic data.

8.4 Gridding of the Residual Magnetic Field and First Vertical Derivative

The grid of the Residual Magnetic Field and its First Vertical Derivative were calculated by using the minimum curvature algorithm with software developed by the Geological Survey of Canada and gridded with a cell size of 100 metres. Minimum curvature gridding provides the smoothest possible grid surface that also honours the profile line data.

The First Vertical Derivative of the magnetic field is the rate of change of the magnetic field in the vertical direction. Computation of the first vertical derivative removes long-wavelength features of the magnetic field and significantly improves the resolution of closely spaced and superposed anomalies. The grid of the First Vertical Derivative was computed from the gridded Residual Magnetic Field data using a fast Fourier transform.

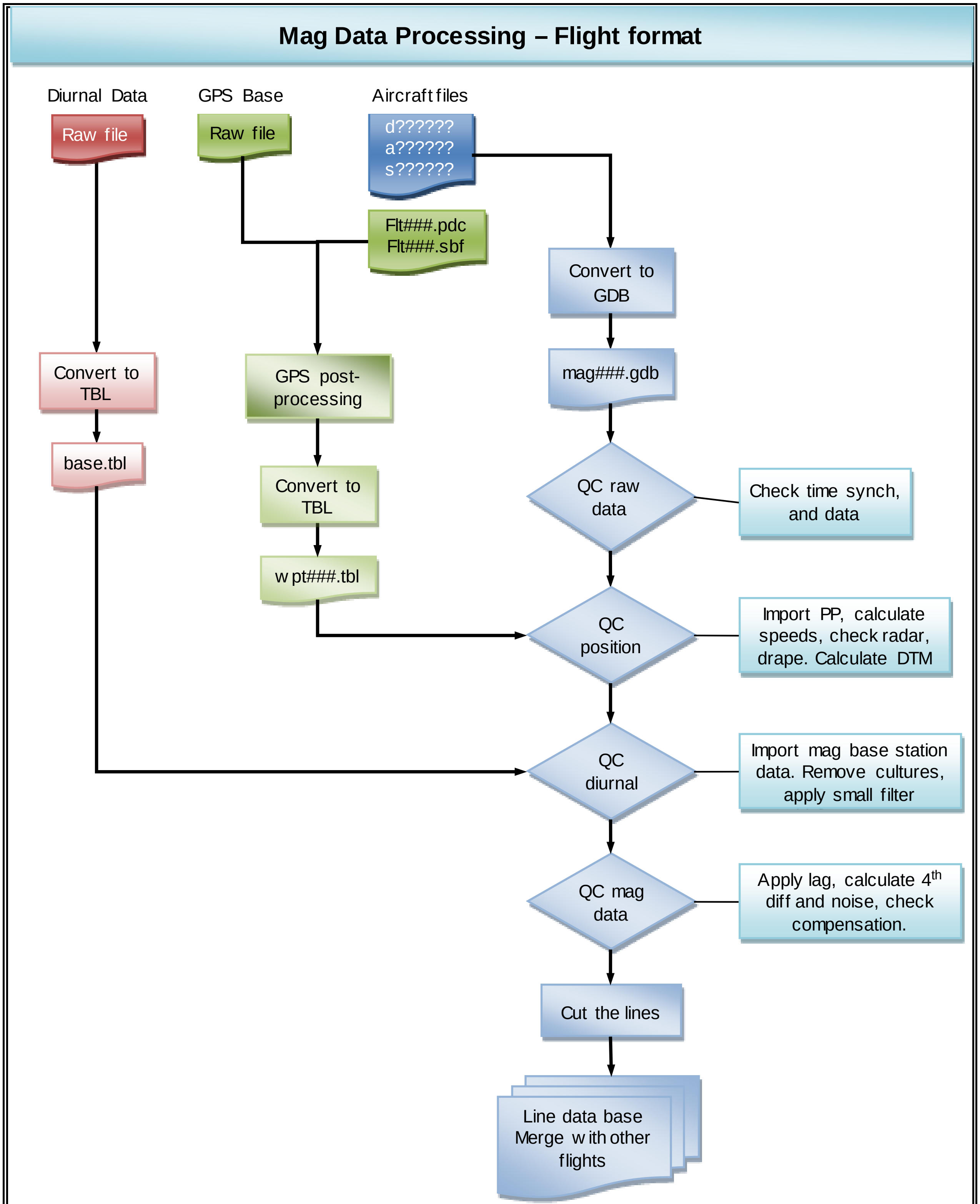


Figure 11: Typical magnetic data processing flowchart – Flight format

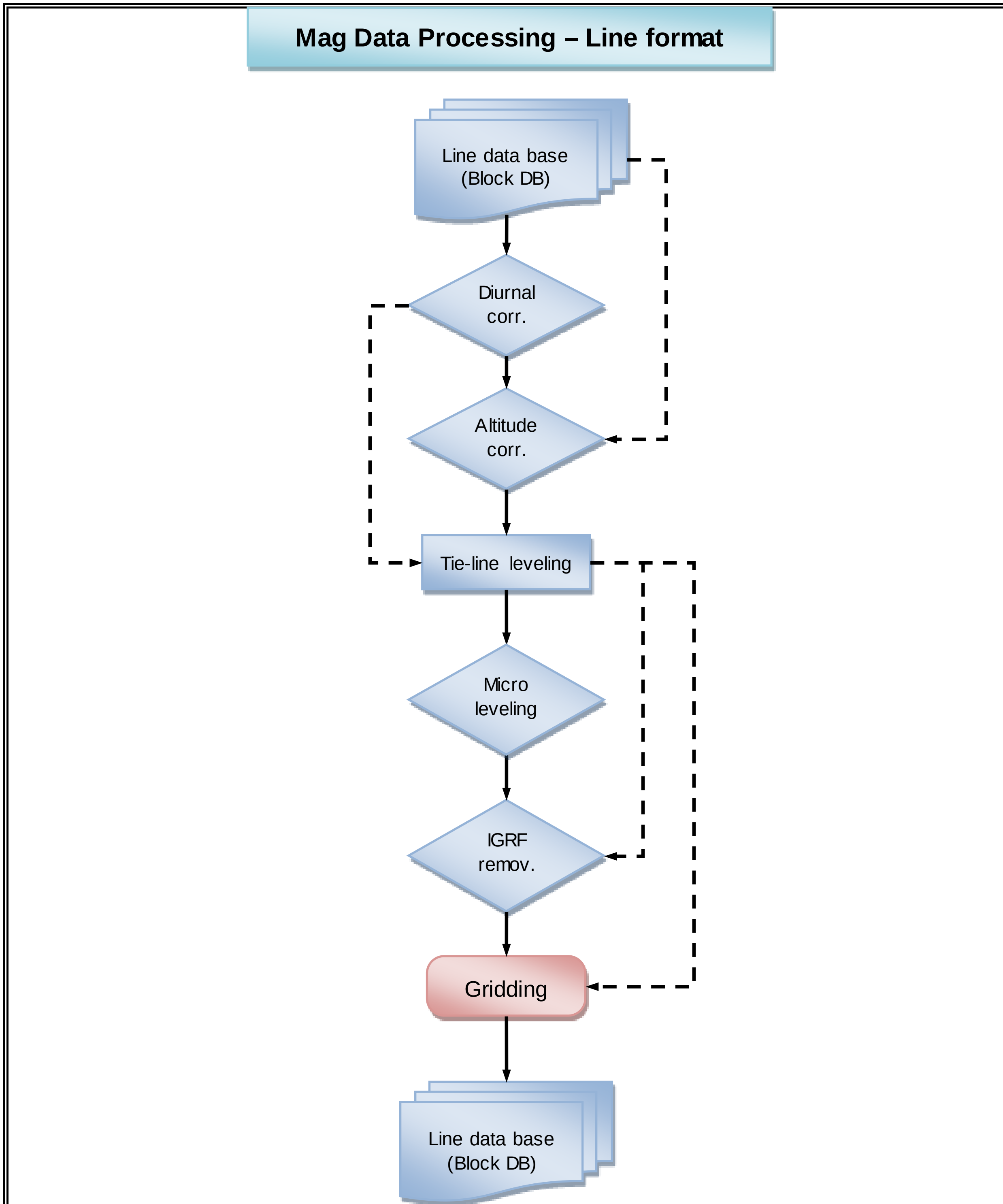


Figure 12: Typical magnetic data processing flowchart – Line format

9.0 FINAL PRODUCTS

9.1 Compilation Specifics

Grid cell size: 100 meters

The following parameters were processed:

- Total Magnetic Field data
- Residual Total Magnetic Field data
- First Vertical Derivative of the Magnetic Field data
- Second Vertical Derivative of the Magnetic Field data
- Digital Elevation Model data

9.2 Final Products

Data archives on USB card (2 copies) (table 8)

- Magnetic line archive profiles in Geosoft Montaj binary database
- Geosoft format grid file for each of the processed parameters
- Final technical report (PDF)

Final Report

- Final technical report (3 paper copies).

Video archive

- Flight path videos on external USB hard drive

Table 8: Digital archive content	
File	**Description**
\	
File list & description.pdf	Digital archive content
\NashCreek-Technical Report	
Nash_Creek_Technical_Report.pdf	Technical Report
\NashCreek-Profile	
Nash_Creek_Channel_list.pdf	Database channel list and description
Nash_Creek_Final.gdb	Magnetic database (Geosoft GDB)
\NashCreek-Grids (Geosoft GRD, NAD83 UTM zone 8N, Cell size: 100 m)	
NashCreek_TF.grd	Magnetic Total field
NashCreek_RTF.grd	Residual Magnetic Total field
NashCreek_VG1.grd	Magnetic First vertical derivative
NashCreek_VG2.grd	Magnetic Second vertical derivative
NashCreek_DEM.grd	Digital Elevation Model

Profile Data

- Magnetic line archive profiles are provided in Geosoft Montaj binary database (GDB) sampled at 10Hz. The content of the database is summarized as followed:

Table 9: Final database channel listing

Channel Name	Description	Units
FIDCOUNT	Fiducial counter	
FLIGHT	Flight number	-
LINE	Line number	-
AIRCRAFT	Aircraft registration name	-
DATE	Date of flight line (YYYYMMDD)	-
UTCTIME	Time, UTC (Universal Time Clock) -- second of day	sec
LONG	Longitude (NAD83)	deg
LAT	Latitude (NAD83)	deg
EASTING	Easting (NAD83, UTM zone 8N)	m
NORTHING	Northing (NAD83, UTM zone 8N)	m
GPSALTR	Uncorrected GPS altitude (real-time)	m
GPSALT	Differentially Corrected GPS Altitude	m
SURFACE	Drape Surface	m
RALT	Final radar altitude (Terrain clearance)	m
DEMRAW	Raw digital Elevation Model (GPSALT – RALT)	m
DEMLEV	Levelled digital topography	m
DIURNRAW	Raw Diurnal, main base station	nT
DIURNAL	Edited Diurnal / ground magnetics (main base)	nT
DIUR2RAW	Raw Diurnal, base station 2	nT
DIURNAL2	Edited Diurnal / ground magnetics (base 2)	nT
FLUXLONG	Longitudinal Vector of Magnetic field (fluxgate)	nT
FLUXTRAN	Transverse Vector of Magnetic field (fluxgate)	nT
FLUXVERT	Vertical Vector of Magnetic field (fluxgate)	nT
MAGUNCOM	Raw uncompensated, unlagged mag	nT
MAGCOM	Raw compensated, unlagged mag	nT
MAGRAW	Raw compensated, lagged mag	nT
MAGHFCOR	High-Frequency correction to mag	nT
ALTCOR	Taylor series correction factor for height variations	nT
MAGCOR1	Pseudo Tie line correction to Traverse Lines	nT
MAGTLCOR	Tie-line levelling corrections to mag	nT
SRVMGLEV	Final tie-line leveled mag	nT
IGRF	IGRF correction calculated at alt 1630.0 m, date 2020/02/25; 2020 model	nT
SRVMGRES	Leveled residual magnetic field	nT
LINETYPE	Line type (Line, Tie Line)	-
LINENAME	L for survey Line, T for Tie Line followed by the Line/Tie Line number	-

Note: All intermediate processing steps (correction channels) are presented.
Example: **SRVMGLEV = MAGRAW + MAGHFCOR + ALTCOR + MAGCOR1 + MAGTLCOR**

10.0 CONCLUSION

Flown from January 19th to March 27th, 2020, the aeromagnetic survey was completed within the time frame allowed by the contract.

All airborne and ground-based records were of excellent quality. Determined from the fourth difference of the lagged and edited airborne magnetic data, the noise level for the measured Total Magnetic Field was well within the accepted limits.

GPS results proved to be of high quality. The flight path was surveyed accurately according to the digital elevation model available. The speed checks showed no abnormal jumps in the data.

It is hoped that the information presented in this report, and the accompanying digital products, will be useful both in planning subsequent exploration efforts and in the interpretation of related exploration data.

Respectfully Submitted,

___________________________________ ______June 1, 2020_______

Mouhamed Moussaoui, P.Eng. OIQ #39716 Date

President, Geo Data Solutions GDS inc.

APPENDIX A

CALIBRATION AND TESTS

BEECHCRAFT KING AIR A100

C-FLRB

AEROMAGNETIC SURVEY SYSTEM CALIBRATION TEST RANGES
AT MOREWOOD, ONTARIO; MEANOOK, ALBERTA and BAKER LAKE, NUNAVUT

AIRCRAFT TYPE AND REGISTRATION: King Air 100, C-FLRB
ORGANIZATION (COMPANY): Geo Data Solutions GDS Inc.
MAGNETOMETER TYPE: Geometrics, Cs G-822A
COMPILED BY: Saleh

SITE AND DATE: Morewood 9-Jan-20
HEIGHT FLOWN: 1500 feet
SAMPLING RATE: 10.0 /sec
DATA ACQUISITION SYSTEM: RMS DAARC500

Direction of flight across the intersection point	Time that Survey Aircraft was over the intersection point (UTC)	Total Field Value Recorded in Survey Aircraft over intersection point T1 (nT)	Observatory Diurnal Reading over intersection point T2 (nT)	Height flown over the intersection point (m)	Difference in the total field between the Observatory and the value at the altitude flown over the intersection point C* (nT)	Calculated Observatory Value T3=T2-C* (nT)	Error Value T4=T1-T3 (nT)
North	17:50:13.0	53399.8	54034.2	457.2	640.1	53394.1	5.7
South	17:45:49.0	53399.5	54035.4	452.8	640.3	53395.1	4.4
East	18:08:30.0	53406.4	54040.0	466.5	639.6	53400.5	6.0
West	18:04:25.0	53404.7	54038.7	465.0	639.7	53399.1	5.6
North	17:58:24.0	53404.2	54037.9	464.7	639.7	53398.2	6.0
South	17:54:38.0	53401.1	54036.0	451.4	640.3	53395.7	5.4
East	18:16:28.0	53402.9	54036.8	465.8	639.6	53397.2	5.7
West	18:12:32.0	53404.0	54037.9	470.9	639.4	53398.6	5.4

*C is the difference in the total field between the Blackburn, Meanook or Baker L. observatories (O) and the value (B) at the test site intersection point above the designated height

Ottawa(O)/Morewood(B), Ontario: 1500 Feet, C = (O-B) = 640.1 nT
Meanook(O)/Meanook(B), Alberta: 1000 Feet, C = (O-B) = 0.0 nT
Baker Lake(O)/ Baker Lake(B), Nunavut: 1000 Feet, C = (O-B) = 75.0 nT

Total: **44.2311 nT**

Average North-South Heading Error (T4 North - T4 South): **0.8936 nT**
Average East-West Heading Error (T4 East - T4 West): **0.3293 nT**

Number of Passes for Average: 8

Ave: **5.5289 nT**

FOM Test

Geo Data Solutions GDS Inc.

Location: Lac St Jean , Quebec
Pilot: Martin Boyer , Jeoffery Perez
Operator: Alireza Kasraei
Compiled by: Saleh

Date: 9-Jan-20
Aircraft: C-FLRB
Configuration: Stinger
Altitude: 9,581.1 ft

Sensor3 - Tail Stinger

North (360°)	Fid range	Uncompensated mag (nT)	Compensated mag (nT)	Improv. Ratio
PITCH	59251.2 to 59264.5	0.529	0.137	3.861
ROLL	59271.4 to 59285.9	0.382	0.098	3.898
YAW	59296.1 to 59301.5	0.165	0.096	1.719
	TOTAL	**1.076**	**0.331**	**3.251**

East (90°)	Fid range	Uncompensated mag (nT)	Compensated mag (nT)	Improv. Ratio
PITCH	59389.8 to 59398.4	0.272	0.139	1.957
ROLL	59408.2 to 59415.7	0.805	0.107	7.523
YAW	59417.8 to 59422.5	0.226	0.094	2.404
	TOTAL	**1.303**	**0.340**	**3.832**

South (180°)	Fid range	Uncompensated mag (nT)	Compensated mag (nT)	Improv. Ratio
PITCH	59489.2 to 59494.8	0.255	0.087	2.931
ROLL	59508.9 to 59514.9	0.222	0.071	3.127
YAW	59534.5 to 59539.5	0.110	0.106	1.038
	TOTAL	**0.587**	**0.264**	**2.223**

West (270°)	Fid range	Uncompensated mag (nT)	Compensated mag (nT)	Improv. Ratio
PITCH	59595.1 to 59601	0.356	0.116	3.069
ROLL	59619.9 to 59627.4	0.390	0.075	5.200
YAW	59642.1 to 59646.7	0.165	0.087	1.897
	TOTAL	**0.911**	**0.278**	**3.277**

Uncomp. Mag (nT)	Comp. Mag (nT)	Improv. Ratio
3.88	**1.21**	**3.20**

FOM Test

Geo Data Solutions GDS Inc.

Location: Mayo , Yukon
Pilot: JF Lambert , Jeoffery Perez
Operator: Alireza Kasraei
Compiled by: Saleh

Date: 20-Jan-20
Aircraft: C-FLRB
Configuration: Stinger
Altitude: 9,581.1 ft

Sensor3 - Tail Stinger

North (360°)	Fid range	Uncompensated mag (nT)	Compensated mag (nT)	Improv. Ratio
PITCH	76000 to 76016.7	0.262	0.111	2.360
ROLL	76052.1 to 76070.9	0.728	0.038	19.158
YAW	76083 to 76099.1	0.108	0.088	1.227
	TOTAL	**1.098**	**0.237**	**4.633**

East (90°)	Fid range	Uncompensated mag (nT)	Compensated mag (nT)	Improv. Ratio
PITCH	76202 to 76219.8	0.172	0.075	2.293
ROLL	76239.2 to 76257.4	1.344	0.026	51.692
YAW	76276.2 to 76287.6	0.122	0.146	0.836
	TOTAL	**1.638**	**0.247**	**6.632**

South (180°)	Fid range	Uncompensated mag (nT)	Compensated mag (nT)	Improv. Ratio
PITCH	76381.8 to 76396.3	0.300	0.091	3.297
ROLL	76418.7 to 76435.7	1.004	0.100	10.040
YAW	76473 to 76484.6	0.226	0.173	1.306
	TOTAL	**1.530**	**0.364**	**4.203**

West (270°)	Fid range	Uncompensated mag (nT)	Compensated mag (nT)	Improv. Ratio
PITCH	76575.1 to 76595.9	0.225	0.102	2.206
ROLL	76618.3 to 76638.1	0.446	0.045	9.911
YAW	76669.5 to 76685.3	0.117	0.089	1.315
	TOTAL	**0.788**	**0.236**	**3.339**

Uncomp. Mag (nT)	**Comp. Mag (nT)**	**Improv. Ratio**
5.05	**1.08**	**4.66**

ALTIMETER CALIBRATION
Geo Data Solutions GDS Inc.

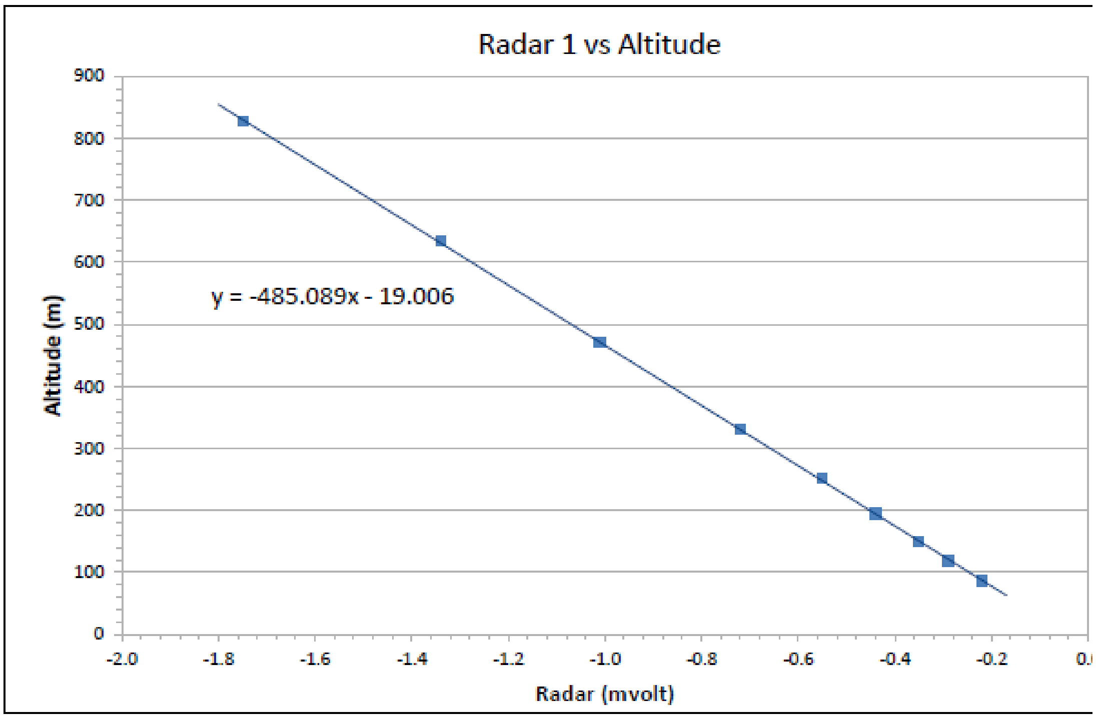
Pilot: Joffery Perez JF Lambert
Operator: Alireza Kasreai.
Compiled by: Saleh

Date: 14-Jan-20
Location: St-Honoré
Aircraft: C-FLRB

Terrain clearance (ft)	Zgps (m)	Topo (m)	Altitude (m)	Radar (mV)
280	251.43	161.89	87.04	-0.22
380	282.70	161.74	118.46	-0.29
490	313.98	161.59	149.89	-0.35
630	358.74	161.78	194.46	-0.44
820	415.95	161.71	251.74	-0.55
1080	495.46	161.46	331.50	-0.72
1540	634.83	161.55	470.78	-1.01
2070	797.37	161.37	633.50	-1.34
2710	991.19	161.57	827.12	-1.75

*first 3 passes were done on 13- Jan-20

Ave. Error: **±1.71**
Error %: **0.8%**

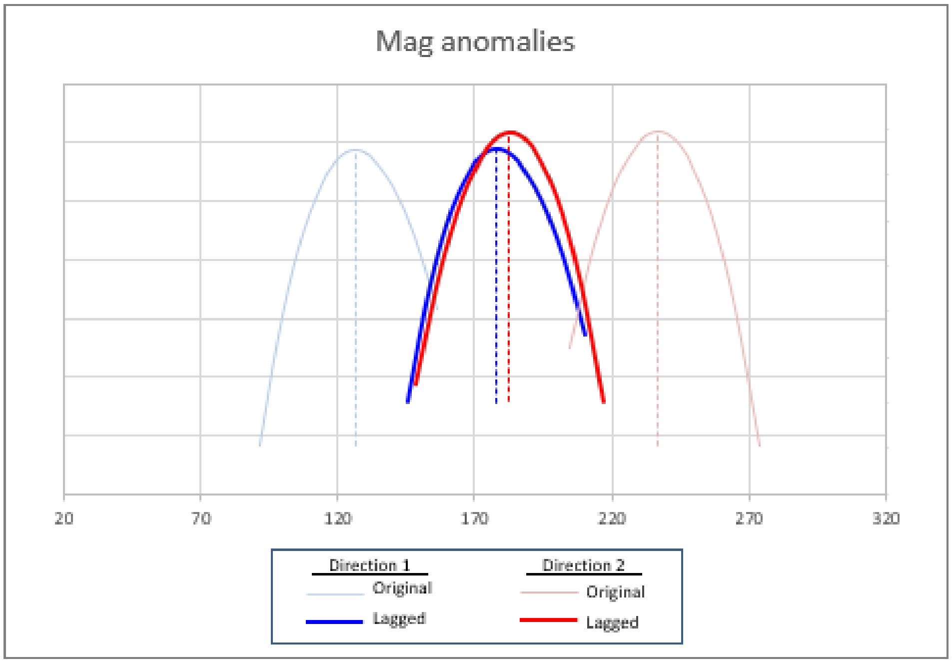


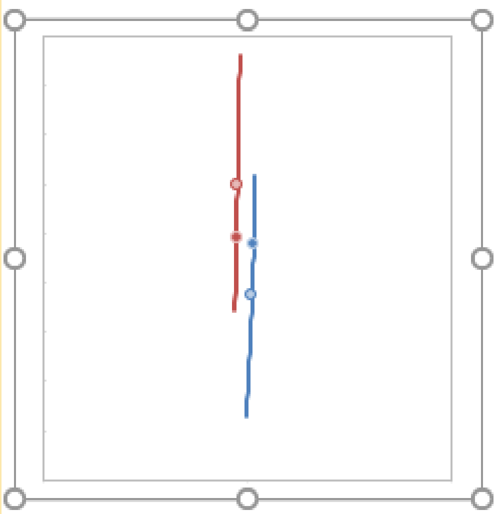
Lag Test

Geo Data Solutions GDS Inc.

Location: Mayo Yukon
Date: 25-Feb-20
Compile: Saleh

Aircraft: C-FLRB
Configuration: Stinger
Final Lag: 0.63





Ave. dist. btw. lines:	4.21
Ave. speed both dir:	83.72
Dist. btw. points:	110.05
Calculated Lag:	0.63
Dist. after lag:	4.99

Line	Fiducial (sec)	Mag Field (nT)	X (m)	Y (m)	Z (m)	Speed (m/s)
13541	74771.77	57151.978	495651.21	7148938.52	2008.34	81.23
13540	74438.17	57147.839	495647.54	7149048.58	2015.39	86.21

Ave Speed = 83.72 m/s
Distance btw peaks = 110.05 m
Tail Lag = +0.63 sec

APPENDIX B

DAILY REPORT

G.D.S. GEO DATA SOLUTIONS Inc.

Daily Report

Date	Flying Time			Production (Km)				Flights	Comments
	Flown	Survey	Ferry	Total	Accepted	Extra	Rejected		
6-Jan-20									Preparing for project
7-Jan-20									Installing equipements
8-Jan-20									Installing equipements
9-Jan-20	3:30		3:30					002	tests FOM MoreWood
10-Jan-20									Bad weather
11-Jan-20									Bad weather
12-Jan-20									Bad weather
13-Jan-20									
14-Jan-20	2:15		2:15					003	
15-Jan-20	1:24		1:24					004	Altimeter Test
16-Jan-20									severe cold weather
17-Jan-20									Crew Mobilisation
18-Jan-20									Crew arrival to Mayo, Setting bases
19-Jan-20	3:17	3:05	0:12	781.8	780.6			005	First production flight , cloudy weather in the north part
20-Jan-20	3:45	3:34	0:11	936.3	934.9			006	Cloudy weather north block
21-Jan-20	1:44		1:44					007	Bad weather flight aborted due to weather, FOM test done
22-Jan-20									Bad weather
23-Jan-20									Bad weather
24-Jan-20									Bad weather
25-Jan-20	2:56	2:25	0:31	378.4	360.4	16.4	-0.1	008	small flight due to weather
26-Jan-20									Bad weather
27-Jan-20									Bad weather
28-Jan-20	5:02	4:43	0:19	747.5	722.2	0.0		009	
29-Jan-20									
30-Jan-20	5:50	4:57	0:53	1 155.8	1 144.6			010	
31-Jan-20									Bad weather
1-Feb-20									Bad weather
2-Feb-20	6:03	5:53	0:10	1 526.5	1 518.4			011	
3-Feb-20	2:01	1:42	0:19	377.9	374.2			012	Bad weather
4-Feb-20									Bad weather
5-Feb-20									Bad weather
6-Feb-20									Bad weather
7-Feb-20	2:12	0:54	1:18	130.0	129.6			013	Bad weather
8-Feb-20									Bad weather
9-Feb-20	6:03	5:41	0:22	1 225.1	1 218.5	0.8	-0.9	014	
10-Feb-20	7:45	7:17	0:28	1 756.0	1 746.0			015 016	
11-Feb-20	7:38	7:08	0:30	1 580.2	1 565.4			017 018	
12-Feb-20									Bad weather
13-Feb-20									Bad weather
14-Feb-20	7:32	6:52	0:40	1 600.9	1 586.5			019 020	
15-Feb-20	7:25	6:56	0:29	1 887.4	1 880.0			021 022	
16-Feb-20									Cold weather -46
17-Feb-20	3:36	3:23	0:13	903.7	900.3			023	
18-Feb-20	6:06	5:39	0:27	1 484.9	1 478.8	2.9	-0.1	024	
19-Feb-20									Bad weather
20-Feb-20									Bad weather
21-Feb-20	4:40	4:16	0:24	868.9	860.0		-0.1	025	
22-Feb-20									Bad weather
23-Feb-20									Bad weather, aircraft inspection whitehorse
24-Feb-20									Bad weather
25-Feb-20	2:24	2:01	0:23	482.4	480.4		-0.1	026	
26-Feb-20									Bad weather
27-Feb-20									Bad weather
28-Feb-20	5:30	5:07	0:23	1 187.6	1 098.8	81.4		027	
29-Feb-20	9:23	8:36	0:47	2 046.5	2 017.2	15.1		028 029	
1-Mar-20									Bad weather
2-Mar-20									
3-Mar-20									
4-Mar-20									
5-Mar-20	6:29	6:23	0:06	1 595.0	1 574.0	14.9		030	
6-Mar-20	10:09	9:45	0:24	2 570.5	2 553.4	7.5		031 032	
7-Mar-20									Bad weather
8-Mar-20									Bad weather
9-Mar-20									
10-Mar-20									
11-Mar-20	6:06	4:57	1:09	1 439.1	1 431.1			033	
12-Mar-20	10:36	10:06	0:30	2 527.8	2 463.7	54.5	0.0	034 035	
13-Mar-20	6:13	5:59	0:14	1 388.2	1 339.0	49.8	-5.3	036	
14-Mar-20	10:51	10:21	0:30	2 679.9	2 636.2	34.4		037 038	
15-Mar-20	10:46	10:07	0:39	2 587.1	2 513.4	63.8		039 040	
16-Mar-20	5:58	5:31	0:27	1 423.1	1 418.9		-0.1	041	
17-Mar-20	4:57	4:29	0:28	1 169.5	1 164.1	0.4		042	
18-Mar-20									
19-Mar-20	1:00		1:00					043	
20-Mar-20									
21-Mar-20	6:11	5:47	0:24	1 584.4	1 580.4			044	
22-Mar-20									
23-Mar-20	5:30	4:59	0:31	1 282.9	1 203.7	74.6	0.0	045	
24-Mar-20									
25-Mar-20									
26-Mar-20									
27-Mar-20	5:58	5:46	0:12	1 178.2	933.0	247.8	-7.7	046	LAST FLIGHT SURVEY COMPLETED
28-Mar-20									
29-Mar-20									Crew Demobilization

FLIGHT SUMMARY

Flight	Date	Pilot/co-pilot	Operator	Processor	Flight time Survey	Ferry	Total	Kilometers
002	9-Jan-20	Martin Jeoffrey	Alireza	Saleh		03:30	03:30	
003	14-Jan-20	Martin Jeoffrey	Alireza	Saleh		02:15	02:15	
004	15-Jan-20	Jeoffrey, J-Philippe	Alireza	Saleh		01:24	01:24	
005	19-Jan-20	Jeoffrey, J-Philippe	Alireza	Saleh	03:05	00:12	03:17	780.6
006	20-Jan-20	Jeoffrey, J-Philippe	Alireza	Saleh	03:34	00:11	03:45	934.9
007	21-Jan-20	Jeoffrey, J-Philippe	Alireza	Saleh		01:02	01:02	
008	25-Jan-20	Jeoffrey, J-Philippe	Alireza	Saleh	02:25	00:31	02:56	360.4
009	28-Jan-20	Jeoffrey, J-Philippe	Alireza	Saleh	04:43	00:19	05:02	722.2
010	30-Jan-20	Jeoffrey, J-Philippe	Alireza	Saleh	04:57	00:53	05:50	1144.6
011	2-Feb-20	Jeoffrey, J-Philippe	Alireza	Saleh	05:53	00:10	06:03	1518.4
012	3-Feb-20	Jeoffrey, J-Philippe	Alireza	Saleh	01:42	00:19	02:01	374.2
013	7-Feb-20	Jeoffrey, J-Philippe	Alireza	Saleh	00:54	01:18	02:12	129.6
014	9-Feb-20	Jeoffrey, J-Philippe	Alireza	Saleh	05:41	00:22	06:03	1218.5
015	10-Feb-20	Jeoffrey, J-Philippe	Alireza	Saleh	06:17	00:12	06:29	1500.7
016	10-Feb-20	Jeoffrey, J-Philippe	Alireza	Saleh	01:00	00:16	01:16	245.2
017	11-Feb-20	Jeoffrey, J-Philippe	Alireza	Saleh	06:05	00:18	06:23	1308.1
018	11-Feb-20	Jeoffrey, J-Philippe	Alireza	Saleh	01:03	00:12	01:15	257.2
019	14-Feb-20	Jeoffrey, J-Philippe	Alireza	Saleh	06:10	00:25	06:35	1389.6
020	14-Feb-20	Jeoffrey, J-Philippe	Alireza	Saleh	00:42	00:15	00:57	196.9
021	15-Feb-20	Jeoffrey, J-Philippe	Alireza	Saleh	05:36	00:15	05:51	1493.3
022	15-Feb-20	Jeoffrey, J-Philippe	Alireza	Saleh	01:20	00:14	01:34	386.7
023	17-Feb-20	Jeoffrey, J-Philippe	Kenneth	Saleh	03:23	00:13	03:36	900.3
024	18-Feb-20	Jeoffrey, J-Philippe	Kenneth	Saleh	05:39	00:27	06:06	1478.8
025	21-Feb-20	Jeoffrey, J-Philippe	Kenneth	Saleh	04:16	00:24	04:40	860.0
026	25-Feb-20	Jeoffrey, J-Philippe	Kenneth	Saleh	02:01	00:23	02:24	480.4
027	28-Feb-20	Jeoffrey, J-Philippe	Kenneth	Saleh	05:07	00:23	05:30	1098.8
028	29-Feb-20	Jeoffrey, J-Philippe	Kenneth	Saleh	05:43	00:21	06:04	1302.3
029	29-Feb-20	Jeoffrey, J-Philippe	Kenneth	Saleh	02:53	00:26	03:19	714.9
030	5-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	06:23	00:06	06:29	1574.0
031	6-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	05:43	00:11	05:54	1470.6
032	6-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	04:02	00:13	04:15	1082.9
033	11-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	04:57	01:09	06:06	1431.1
034	12-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	06:07	00:20	06:27	1497.5
035	12-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	03:59	00:10	04:09	966.2
036	13-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	05:59	00:14	06:13	1339.0
037	14-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	05:55	00:12	06:07	1445.3
038	14-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	04:26	00:18	04:44	1190.9
039	15-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	06:08	00:19	06:27	1520.5
040	15-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	03:59	00:20	04:19	992.9
041	16-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	05:31	00:27	05:58	1418.9
042	17-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	04:29	00:28	04:57	1164.1
043	19-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh		01:00	01:00	
044	21-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	05:47	00:24	06:11	1580.4
045	23-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	04:59	00:31	05:30	1203.7
046	27-Mar-20	Jeoffrey, J-Philippe	Kenneth	Saleh	05:46	00:12	05:58	933.0