

Application of remotely piloted aircraft systems (RPAS) to regional airborne geophysical mapping: a concept study

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R. Fortin, M. Coyle, D. Oneschuk, O. Boulanger,
A. Grenier, B. Harvey, and M. Ouellet

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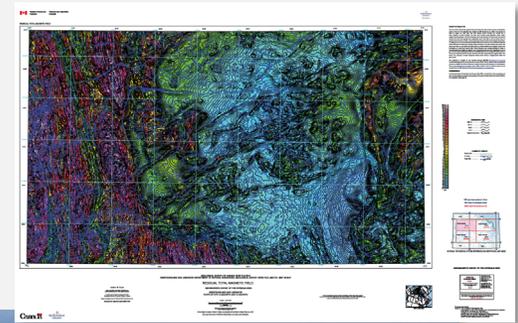
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Airborne Geophysics at the Geological Survey of Canada (GSC)

The role of the Airborne Geophysics Section is to support the GSC programs with acquisition and analysis of airborne geophysical data.

- The two main GSC programs are the Geo-Mapping for Energy and Minerals (GEM) and the Targeted Geoscience Initiative (TGI).
- Aeromagnetic and gamma-ray spectrometry surveys, and occasional gravity and targeted electromagnetic surveys, are conducted to support framework mapping activities.
- The Airborne Geophysics Section provides contract supervision, QA\QC of data, public data release and data analysis/interpretation.
- Importance of airborne geophysics at the GSC.
 - **CAN\$40M of investment over the last 10 years** (2010-2020), more than 60 surveys, some contracts in excess of CAN\$1M.
 - Acquired data supported mapping and exploration activities at the GSC.
 - Return value of GEM and TGI programs estimated at \$7 for every \$1 invested. (Ernst and Young, report to NRCan, 2020)

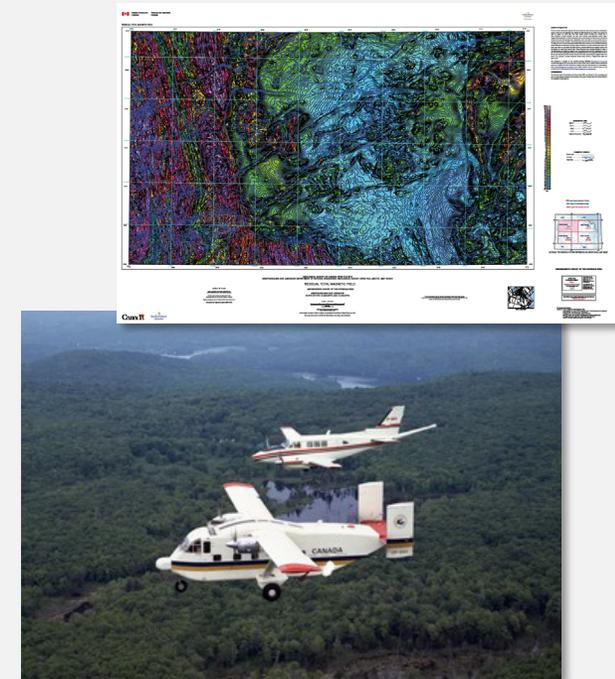


Toward RPA-borne geophysics: a concept study

GEM activity P-050

Concept study on the application of remotely piloted aircraft (RPA) to regional airborne geophysics

The goal of this activity is to conduct a concept study on the application of RPA to regional airborne geophysical surveying. The main output will be a preliminary concept of operations that will provide a framework for further development. It will review benefits, gaps and limitations, inform industry on pathways to transitioning to RPA, and initiate drafting of RPA survey technical requirements in support of GSC programs.



Airborne Geophysics: aeromagnetic and radiometric survey equipment and aircraft installation

High-accuracy magnetometer

Noise envelope: <2 pT
Heading error: <0.2 nT
Weight: 1-3 kg (sensor+electronics)



credit: Geometrics

Gamma-ray spectrometer

Pack of 5 NaI(Tl) 'logs':
20L of detector volume
2 or 3 packs are used for surveys
Weight: 100-125 kg



credit: RSI inc.

'Geodetic' GNSS receiver

Horizontal Position Accuracy:
Single point: 1.5 m
DGPS: <1 cm
Weight: 1-2 kg (receiver+antenna)



credit: Novatel, Antcom

Radar altimeter

Measurement accuracy : 3-5 % (>1 m)
Range: >800 m :
Weight: 1-2 kg (transceiver+antenna)



credit: FreeFlights systems



Beech King Air A100 with magnetic sensor in a 'stinger' and 3x 125kg radiation detector packs.



AS350 Astar with magnetic sensor 'stinger' and 2x 125kg radiation detector packs

Geological Survey of Canada survey requirements:

Magnetic signal noise envelope: <0.1 nT

Magnetic heading error: <2 nT

Positional accuracy: <1 m

Airborne Geophysics: Concept of Operations

Gifford River survey, Nunavut

Flown by GDS inc.

Magnetic and Gamma-ray spectrometry

Line spacing: 400m

Terrain clearance: 125m

Target ground speed: 75 m/s

Total coverage: 83 000 lkm

Survey operations:

From August 16, 2017 to March 29, 2018

107 survey flights

Total flight time: 404 hrs

Two aircraft mobilized
on site:

Beechcraft King Air A100

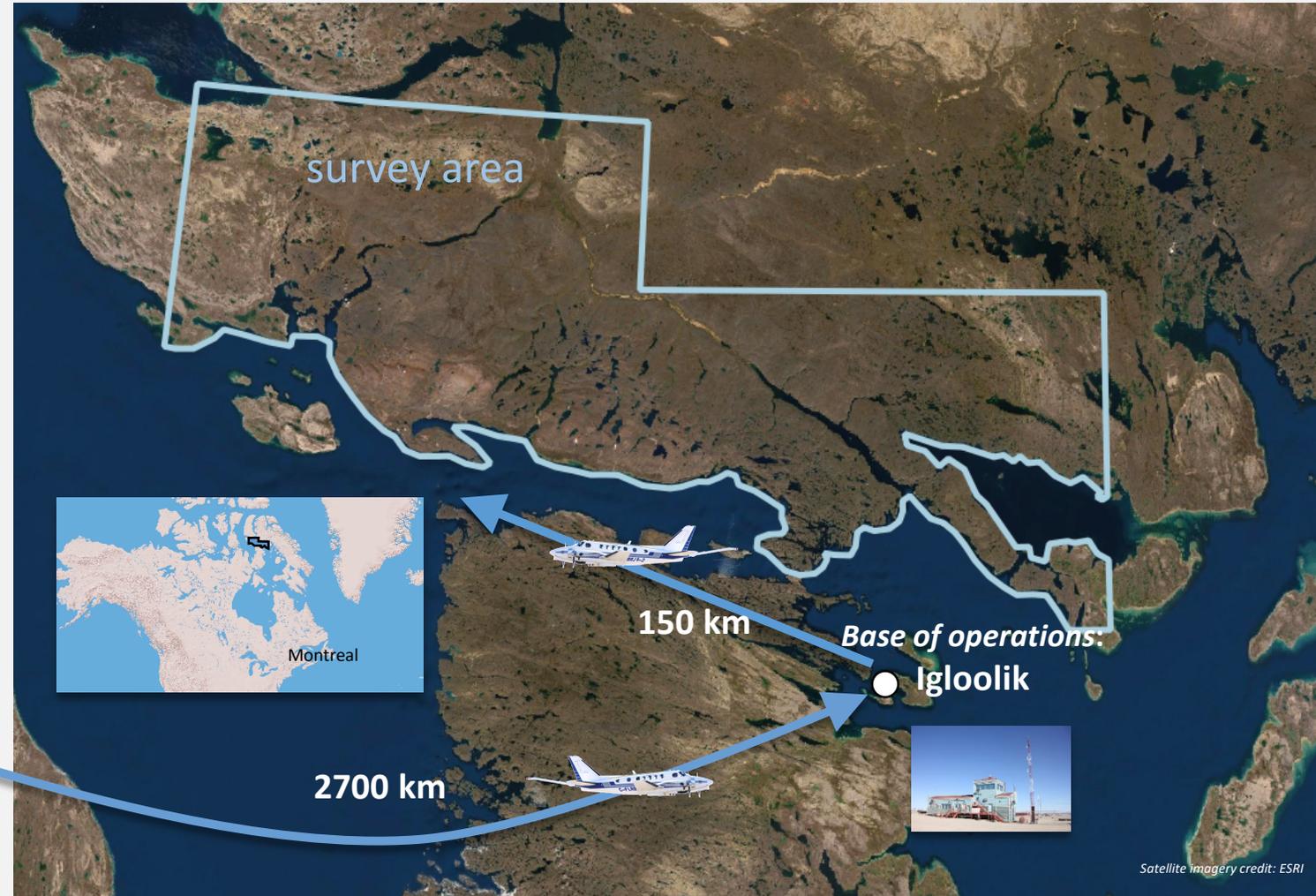
Piper Navajo PA-31



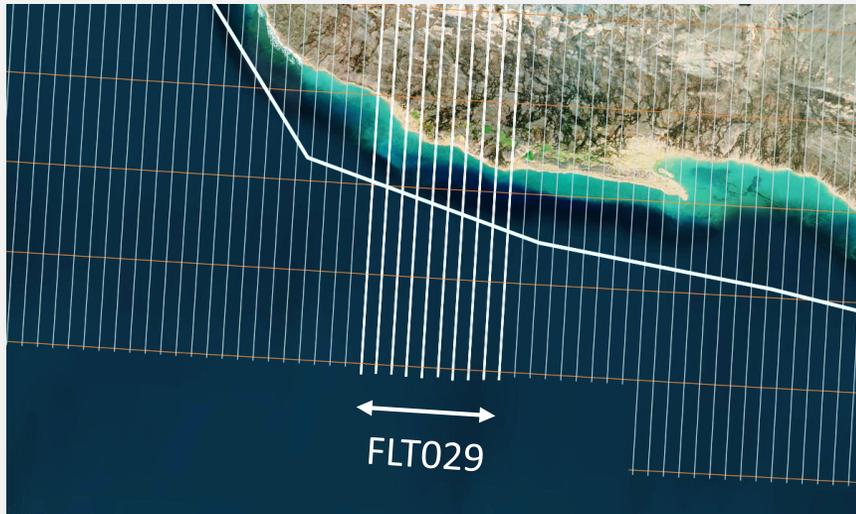
credit: Sander Geophysics

Home Base

(e.g. Ottawa, Montreal..)

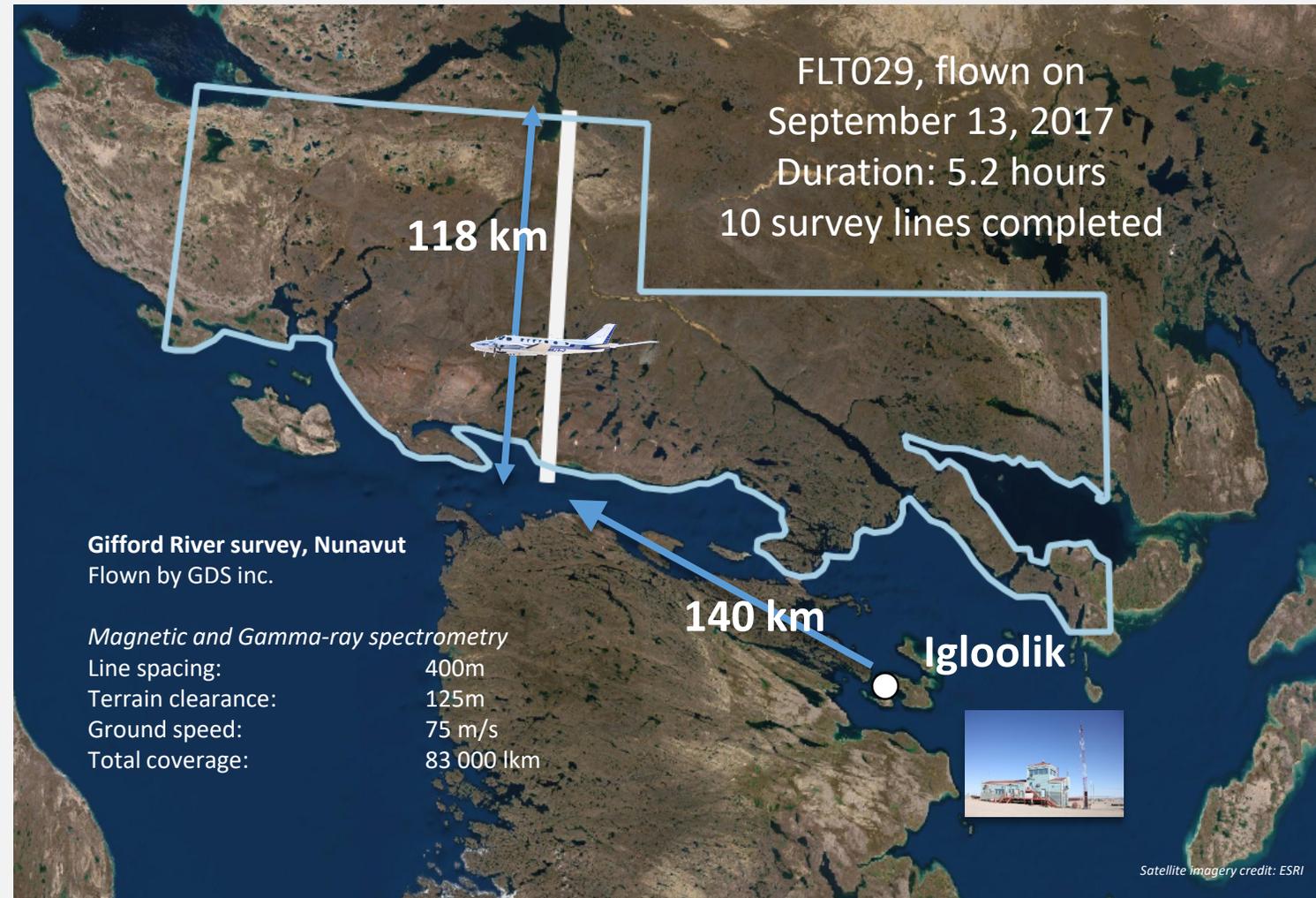


Airborne Geophysics: daily operations



Flight operations:

- ground checks
- ferry to first line: 140 km (27.5 min)
- 10 survey lines: 1184 km (4.3 hr)
- ferry back to base: 140 km (27.5 min)
- Post-flight checks, data recovery
- Flight data QC

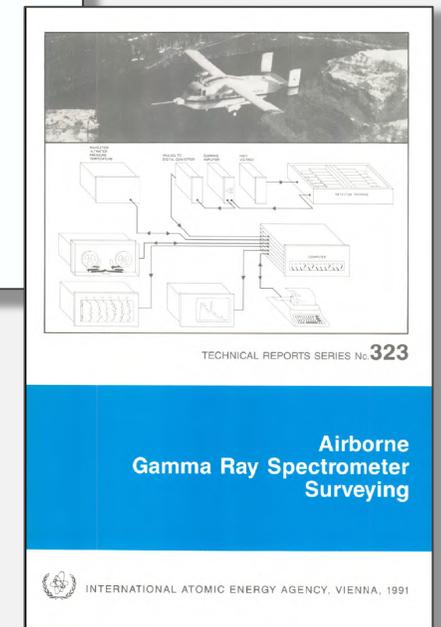
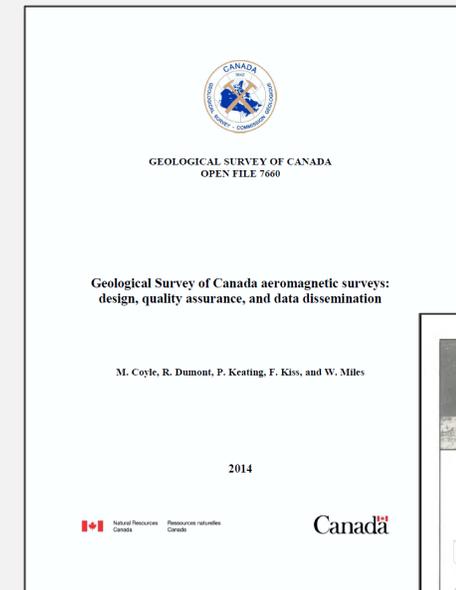


Aeromagnetic and radiometric survey: guidelines and specifications



Well established and accepted guidelines have been published and are in use by government agencies and private industry around the world. These de facto standards ensure data validity and consistency between surveys flown with different platforms for different goals.

- Coyle, M., Dumont, R., Keating, P., Kiss, F., and Miles, W. 2014. **Aeromagnetic surveys: Design, quality assurance, and data dissemination**. Geological Survey of Canada, Open File 7660. 48 pp.
- Teskey, D. 1991. **Guide to aeromagnetic specifications and contracts**. Geological Survey of Canada, Open File 2349. 93 pp.
- International Atomic Energy Agency, 1991. **Airborne Gamma Ray Spectrometer Surveying**, Technical Reports Series, No. 323, IAEA, Vienna.
- Grasty, R.L., and Minty, B.R.S., 1995. **A guide to the technical specifications for airborne gamma-ray surveys**. AGSO Record 1995/60.



Toward regional RPA-borne geophysics: expectations

Airborne Geophysics flight operations are repetitive and prolonged but require accurate navigation. RPAS could provide a favorable alternative to traditional aircraft.

Potential benefits of using RPAS for airborne geophysics:

- Operational efficiency compared to pilot-on-board aircraft operations:
 - increased daily/per flight production.
 - reduced deployment efforts.
- Accurate navigation for precision work.
- Reduced environmental footprint:
 - Lower fuel consumption and reduction in emission of greenhouse gases.
 - reduced noise level/disturbance to wildlife.
- Frontiers surveying.



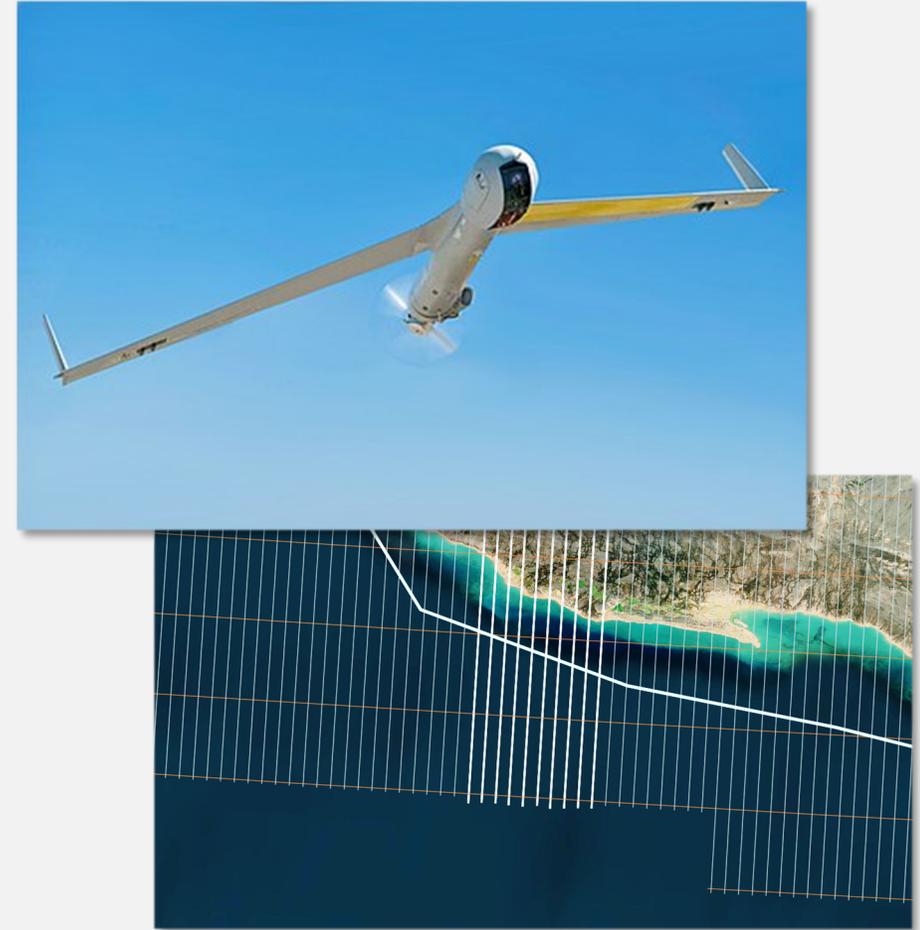
Toward RPA-borne geophysics: flight operations challenges

Flight operations of RPAS for regional airborne geophysics imply:

- low-level flying.
- beyond visual-line of sight (BVLOS) operations.
- distance of 100s km between air vehicle and operator.

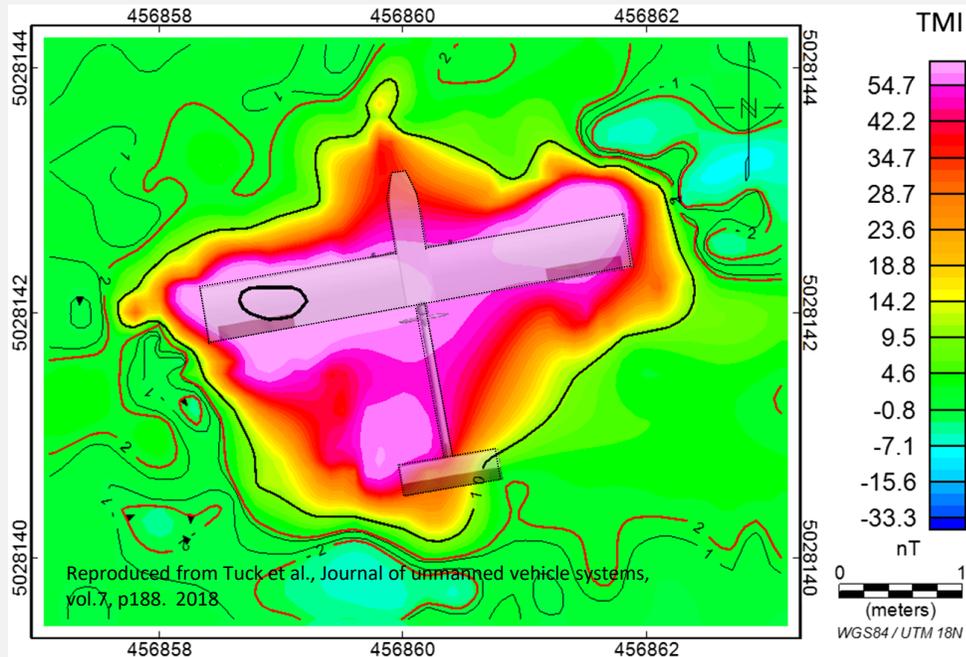
Challenges to resolve:

- Regulations
 - BVLOS regulations must be in place.
- Communications
 - Dedicated and reliable radio or satellite Command and Control (C2) link.
- Navigation
 - Robust automated Detect And Avoid (DAA) and terrain-follow technologies to support low-level flying.
- Logistics and crew management
 - Considerations for pilot's rotation and rest due to long flight endurance, night time flying?

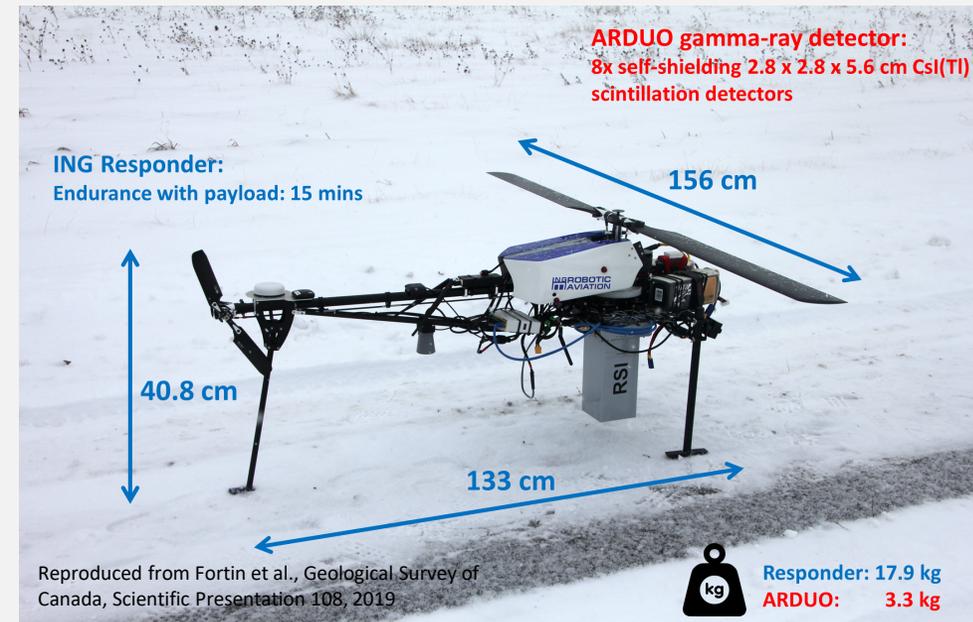


Toward RPA-borne geophysics: data quality and system integration challenges

Magnetic noise



Payload capacity for gamma-ray spectrometry



System integration is a critical step of system design to ensure data quality. The close proximity of magnetic sensors to the sources of noise from the RPA's air vehicle, and the limited payload capacity of RPAS for gamma-ray spectrometers are technical challenges that need to be analyzed and resolved.

Toward RPA-borne geophysics: new Concept of Operations

New capability: localized survey



Existing capability replaced by RPAS: regional survey



Toward RPA-borne geophysics: candidate air vehicles



In Situ
ScanEagle

Piston engine, 1.5hp

MTOW: 26.5 kg
Payload: 5 kg
Speed: 30.8 m/s
Endurance: 18 hr
Wingspan: 3.1 m



UAV Factory
Penguin B

Piston engine, 2.5hp

MTOW: 21.5 kg
Payload: 10 kg
Speed: 22.1 m/s
Endurance: 20 hr
Wingspan: 3.3 m



Brican
TD100E

Electrical, 4.5 hp

MTOW: 25.0 kg
Payload: 5.0 kg
Speed: 41.1 m/s
Endurance: 2.3 hr
Wingspan: 5.0 m



Nasa
Sierra-B

Piston engine, 25.0 hp

MTOW: 217.7 kg
Payload: 49 kg
Speed: 29.3 m/s
Endurance: 10 hr
Wingspan: 6.3 m



Griffon Aerospace
SeaHunter

Piston engine, 17.0 hp

MTOW: 136.0 kg
Payload: 20+ kg
Speed: 20.0 m/s
Endurance: 8 hr
Wingspan: 4.9 m

RPA specifications as reported from manufacturers website and information sheets.

Pictures are credited to manufacturers.

'MTOW' is the maximum take-off weight.

'Speed' represents quoted optimal cruise speed.

Toward RPA-borne geophysics: flight operations

New Concept of Operations:

- Pilots at remote location?
- Reduced field crew, for maintenance and recovery of vehicle and data management ?



Production with a typical fixed-wing RPA



King Air A100



ScanEagle RPA

<i>Ferry speed (m/s)</i>	85.0	41.2
<i>Survey speed (m/s)</i>	85.0	30.8
<i>Endurance (hr)</i>	6	18
<i>One-way ferry (hr)</i>	00:27:30	00:57:00
<i>Survey line time (hr)</i>	00:23:23	01:04:12
<i>Whole FLT 029 (hr)</i>	05:13:21	12:57:00

By optimizing survey operations to the RPAS expected flight endurance, the ScanEagle could achieve to fly 14 flight lines in 17:23:24.

Toward RPA-borne geophysics: fuel consumption

New Concept of Operations:

- Pilots at remote location?
- Reduced field crew, for maintenance and recovery of vehicle and data management ?



Fuel consumption with a typical fixed-wing RPA



King Air A100



ScanEagle RPA

Fuel Type	Jet A	JP-5 or JP-8
Fuel consumption	270 L/hr	-
Fuel for flight 029	1408.5 L	4.35 L (5 Kg ?)
Cost (\$0.61/L IATA)¹	\$859.19	\$2.65

¹ Price of Jet A fuel reported by the International Air Transport Association (IATA) at the time this presentation was prepared. JP-5 cost is usually very similar to that of Jet A.

Satellite imagery credit: ESRI

Conclusion

- The capacity for large-scale trials currently exists in industry and the R&D community. Live trials will contribute in quantifying more precisely performance and integration challenges.
- RPAS manufacturers and regulators have to be informed about this type of operations and its requirements for optimized platform to be designed and for the development of regulations that considers long-range low-level flight operations.
- The geophysics community has to resolve the specific geophysical sensors integration challenges.
- Guidelines and 'standardized' technical specifications will support industry and end-users and ensure data quality.





Thank You

Web: nrcan.gc.ca/GEM-GeoNorth

E-mail: gem-geonorth-gem-geonord@nrcan-rncan.gc.ca

NRCan twitter: twitter.com/NRCan?lang=en

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