

# The Development of Magnetometer UAV Platforms for Geoscience

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**EAGE**



Since 1980  
Leading the World of Magnetism

- Since 1980, GEM has been providing quantum magnetometers (proton precession & Overhauser) for a variety of applications
- 1987 launched the model GSM-19, standard for portable and base station magnetometers
- Early 1990's commercialised "walking mag" concept

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# Applications of GEM magnetometers

- Late 1990's perfected the potassium alkali vapour magnetometer sensor for ground and airborne applications
- Best Sensitivity .0003nT @ 1Hz
- Sensors featured in a popular airborne tri-axial gradiometer

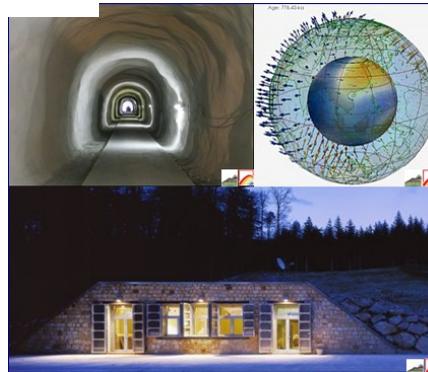


- data acquisition expertise AND experience with ancillary devices for the unmanned program, gained through our MANNED program





# Applications of GEM magnetometers



Archaeological and engineering investigations, and stationary magnetometers for studying the earth (volcanology, earthquake prediction research)



# Process of Implementation

## Summary :

- Couple of years assessing unmanned aerial vehicles
  - Affordability
  - Available payload
  - Range
  - Magnetic interference
  - UAV manufacturer's appetite for customization





# Selection

- The first vehicle selected was designed to study the harsh environment of super-cell thunderstorms and tornados
- designed to be customized for a variety of scientific payloads
- 58,000 feet – demonstrated ability to complete mission in harsh environments





# Testing

- UAV evaluation process sought out vehicles that would contribute a minimal amount of magnetic interference



- Testing involves the use of a high precision gradiometer system and measuring , not only the complete UAV but individual components as well
- Recommendations made to change any parts possible that can be made from non magnetic materials



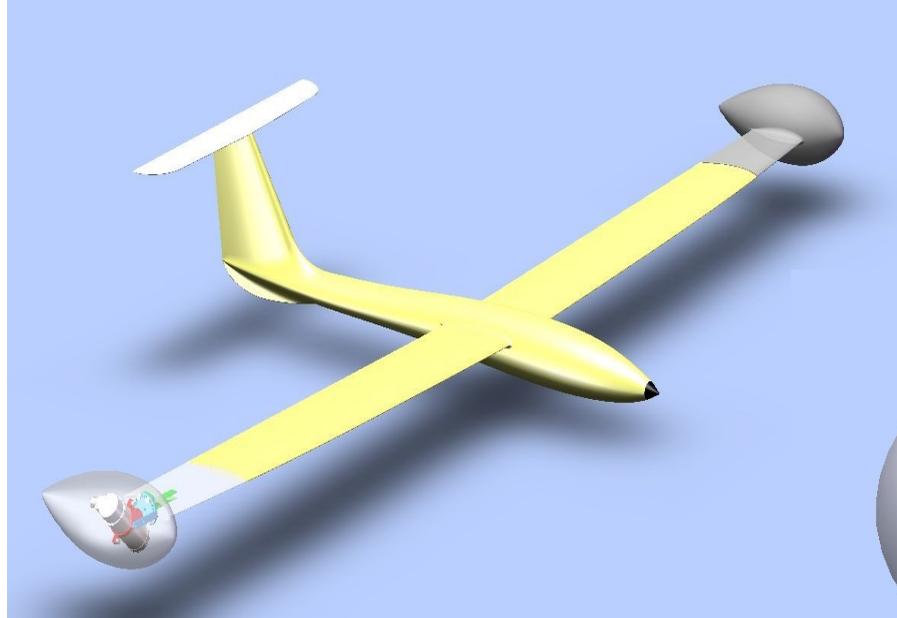
# Payload

- Light Weight GSMP-35U
- 1 Kg.
- Potassium Magnetometer
- .0003nT @1Hz sensitivity

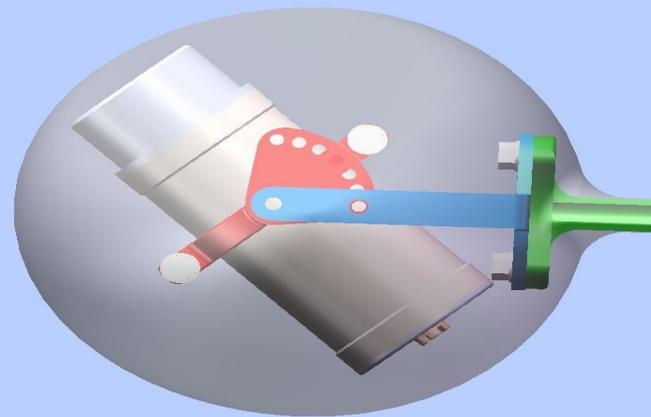




# Customizing the UAV vehicle



- Design wing tip payload bays
- Design gimbal for alkali vapour sensor as the sensor needs to be oriented
- Relocate servos for flight control surfaces





# Lightweight Sensor in the wing tip pod



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# Other Considerations

- Flight Control / Navigation
- using the PixHawk Flight Controller as it has unlimited waypoint navigation and is ideal for flying grid patterns/mapping missions.
- Regulations !
  - Practical large scale use will remain limited
  - 2005 Universal Wing launched (not much flying)
  - Times change – public pressure





# Specifications

## Autonomous Aircraft

### Speed

70 km/hr (Cruise)

160 km/hr (Max)

50 km/hr (Stall)

### Range (with gradiometer payload)

Up to 1.5 hours at cruise speed

### Production

100 linear km's per flight<sup>1</sup> (of high-res mag gradient data) with short ferry flights

<sup>1</sup> multiple flights per day are expected; changing aircraft batteries and re-launching the aircraft requires minutes

### Wingspan (sensor separation)

3.2 metres

### autopilot

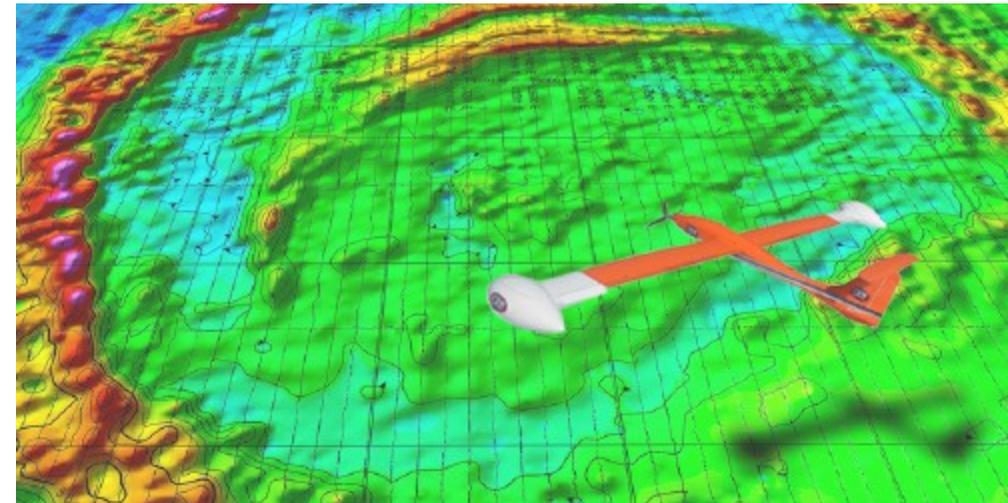
standard operation within 80.0 km of guidance base station for natural resource exploration





# Benefits

- 10 x faster than ground surveys
- Half the cost of a ground survey
- High resolution
- No line cutting required
- Quick Mobilization
- Fly over difficult areas
- Green Technology

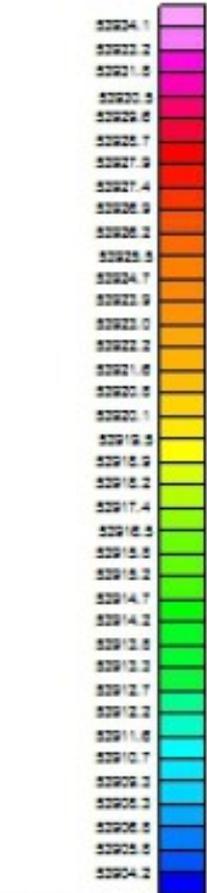
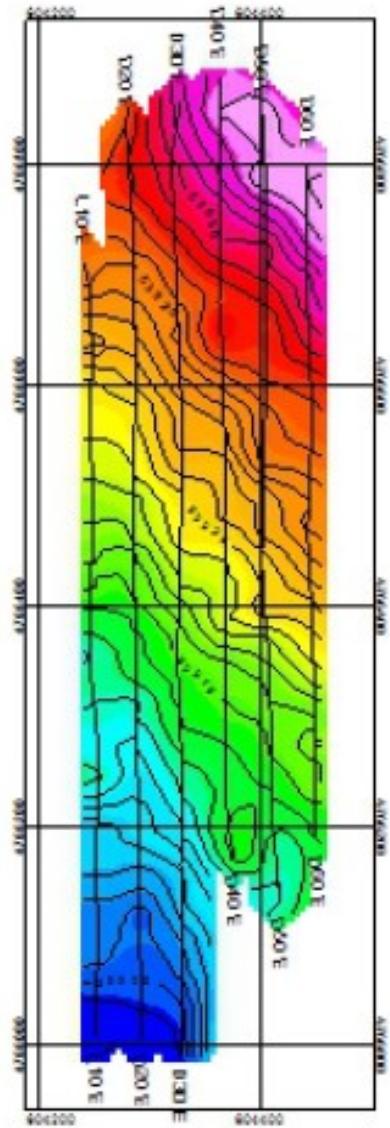


Possibilities





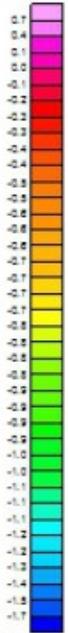
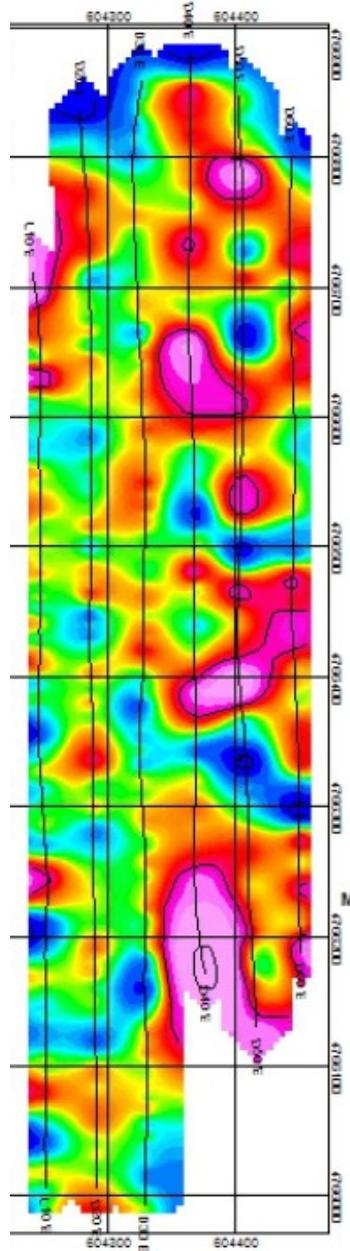




Total Magnetic Field nT



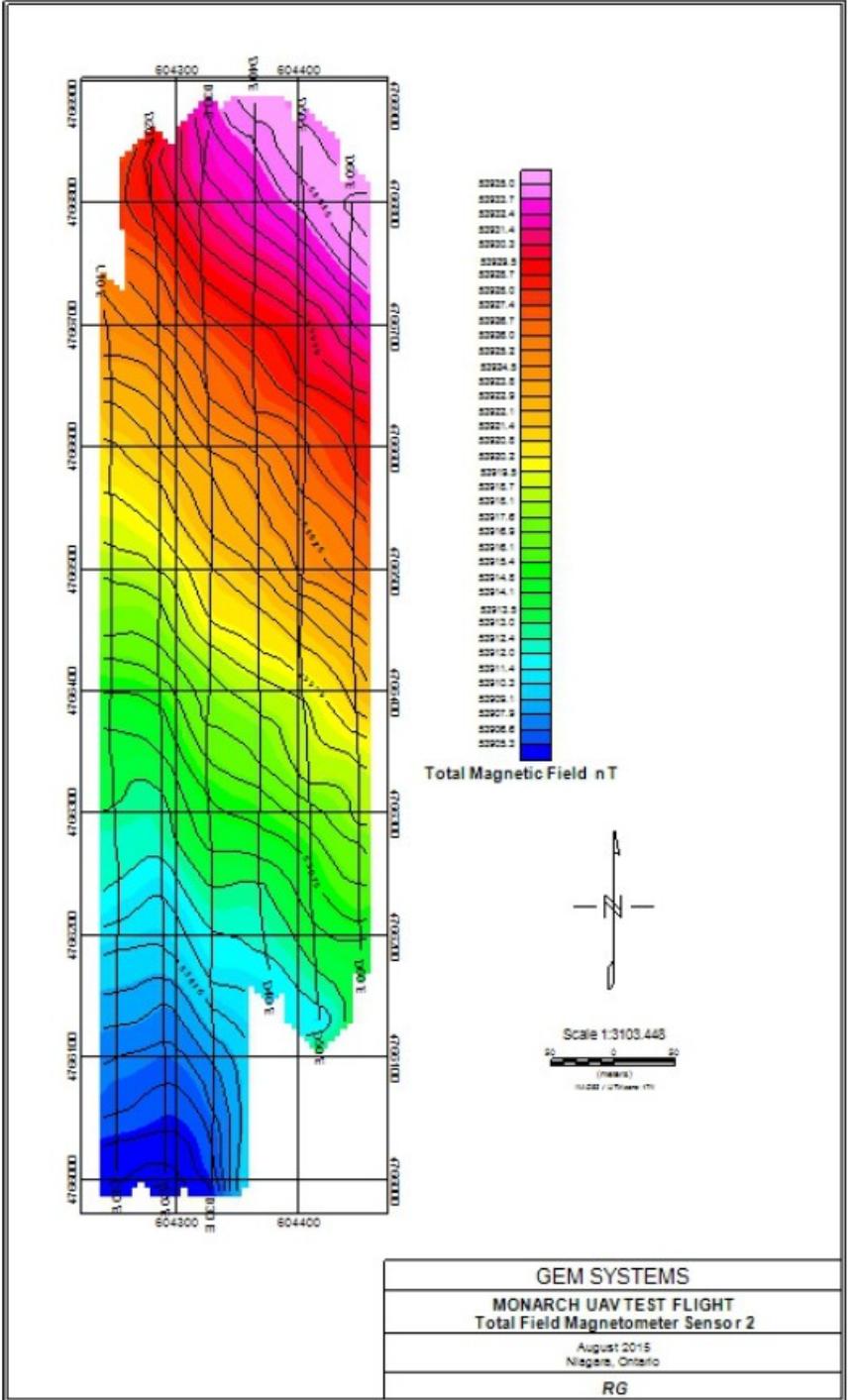
Monarch Test Flight  
August 2015  
Total Field Magnetometer Sensor 1



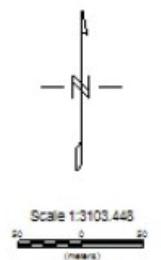
Magnetic Gradient nT



GEM SYST  
MONARCH UAV TEST  
Magnetic Gradient  
August 2015  
Niagara, Ontario  
RG



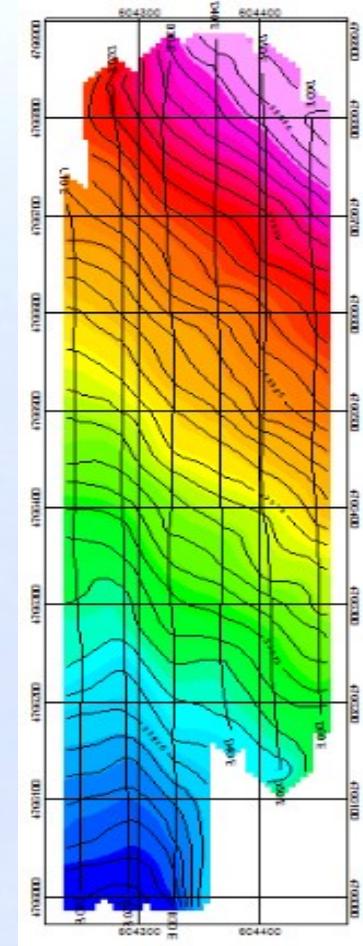
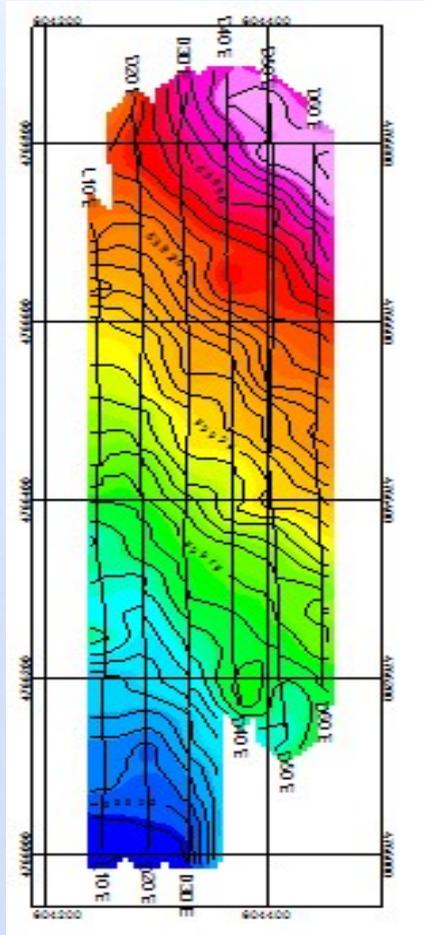
Total Magnetic Field nT



GEM SYSTEMS  
MONARCH UAV TEST FLIGHT  
Total Field Magnetometer Sensor 2  
August 2015  
Niagara, Ontario  
RG

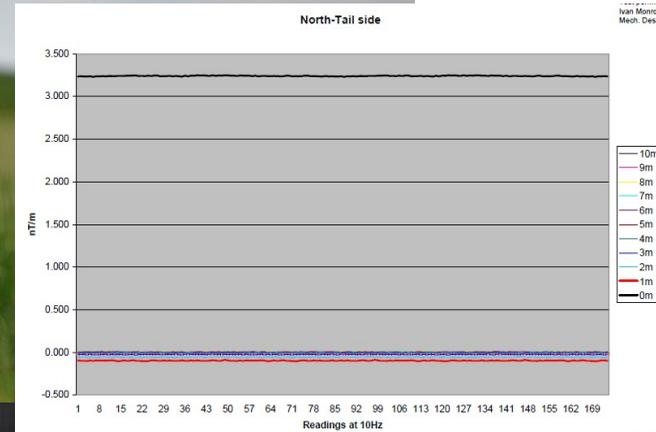
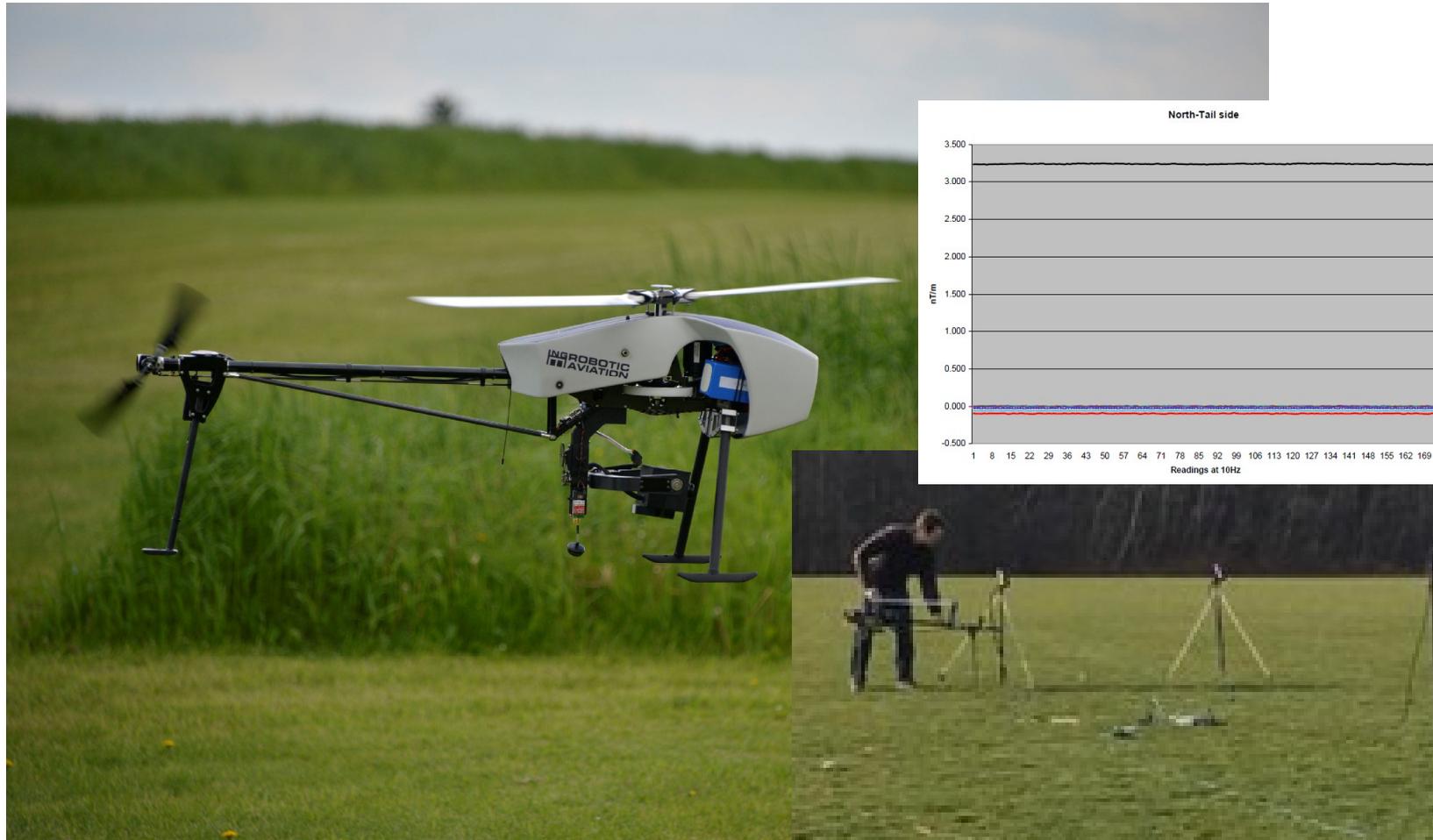


# High Sensitivity Magnetometers for Unmanned Aircraft

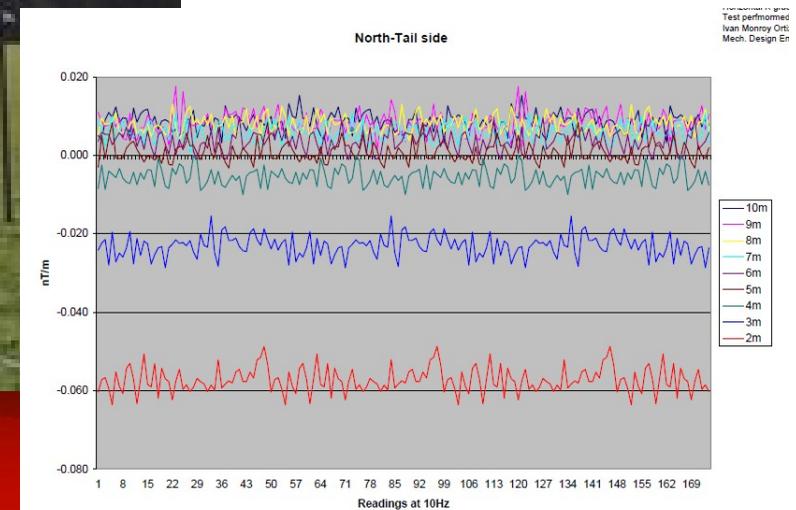




# Unmanned Helicopters



- Optimal distance away typically > 2 metres
- Balance practicality and tolerance for noise
- $.06\text{nT/m}$  @ 2m –off the tail

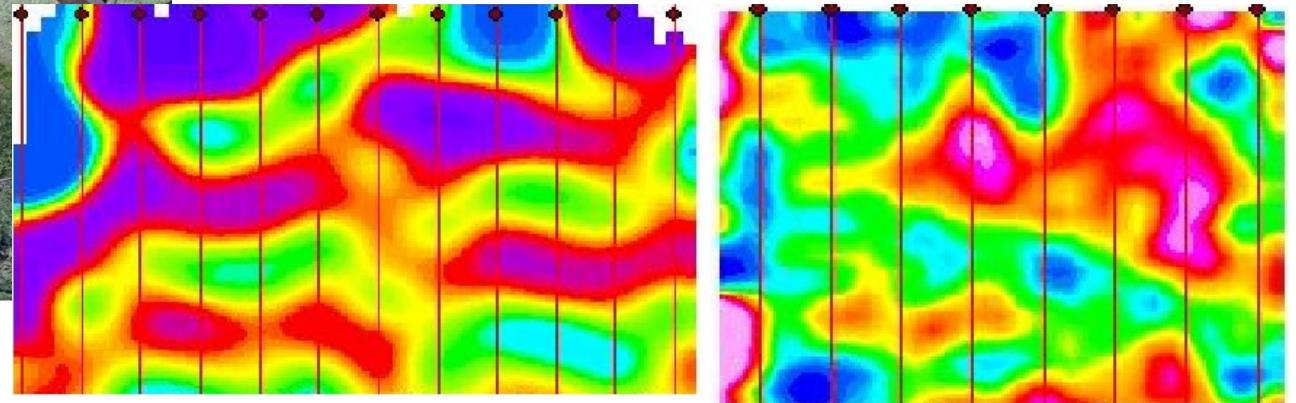




# Multi copters



**Preliminary flight testing with “dangling” magnetometer seemed to work.**



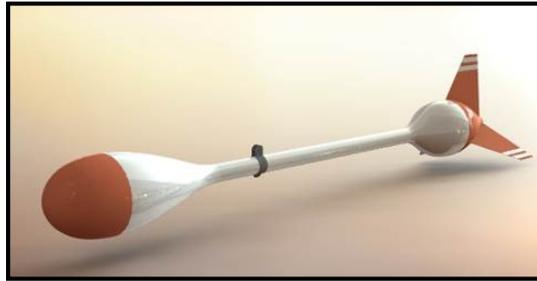
sensor HEAD is suspended by a 2.0 metre signal cable; the other instrumentation is installed in a stand alone chassis between the skids of the UAV, which can be quickly disconnected if the UAV is to be used for other applications





# Multicopters : Towed Bird concept

Design



Manufacture



## Turnkey Solution to include;

- Light Weight GSMP-35U (1.0kg)
  - Potassium Magnetometer
  - .0003nT @1Hz sensitivity
- GPS, Laser Altimeter, IMU and GEMDAS data acquisition with radio link
- LiPo Battery in bird to run system for 1 hour
- Light weight bird (1.5 kg)

**TOTAL WEIGHT ON HOOK = 3.3 KG**



# Multi-Copters

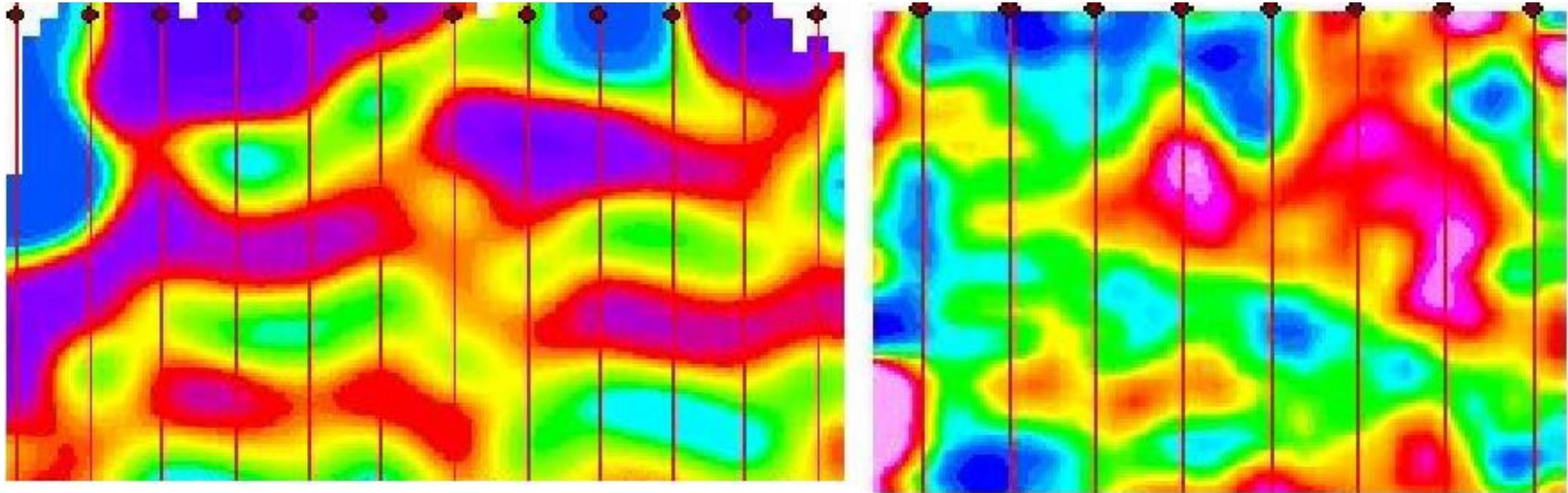


**Preliminary  
Flight testing  
with Payload**



**Test Flight with AirBird**





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# UAV SOLUTIONS

- Fixed Wing **Monarch** Gradiometer UAV
- Light Weight High Sensitivity Sensor
- **AirBird** – Lightweight Turnkey complete Magnetometer Geophysical BIRD designed for UAV
- Rotary Wing Magnetometer UAV



# Conclusions

- Turnkey UAV AirBIRD delivers data quality comparable to today's manned airborne systems yet at lower height and tighter line spacing for increased resolution
- Functioning magnetic UAV gradiometer is available today
- Increased use and application is expected in the next several years
- Logistical operating challenges exist for the various potential UAV platforms (including regulatory)

Wish I had a UAV!





Since 1980

Leading the World of Magnetics