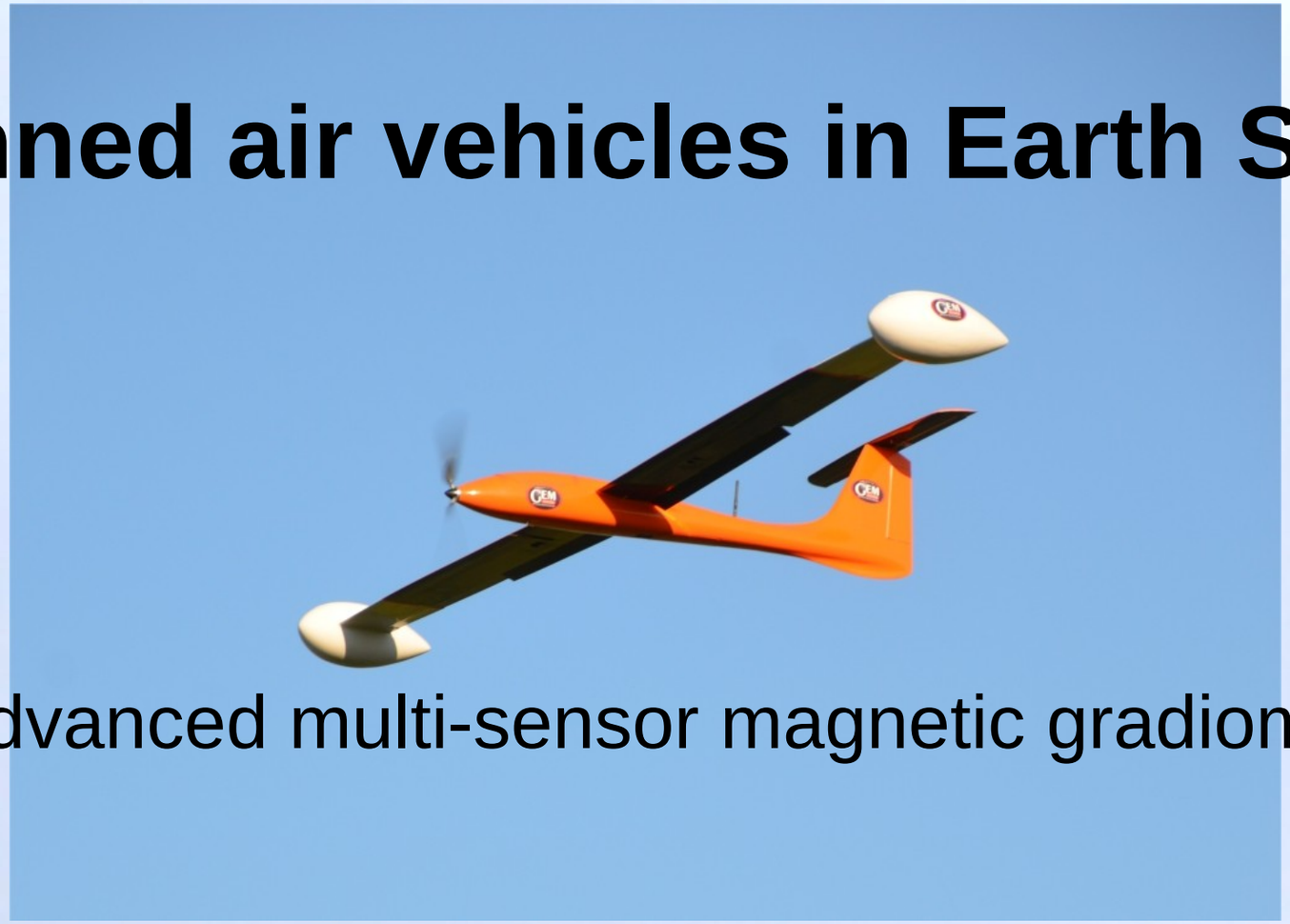
Unmanned air vehicles in Earth Science



An advanced multi-sensor magnetic gradiometer

Rob Gordon P. Eng., MBA., GEM Systems
Blair Walker B.Sc., GEM Systems

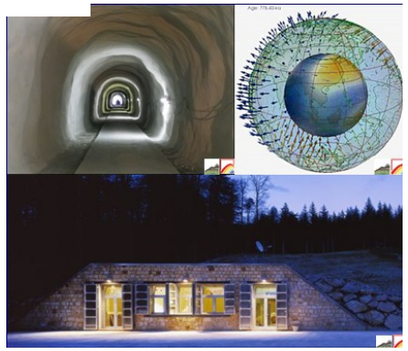
- Since 1980, GEM has been providing quantum magnetometers (proton precession & Overhauser) for a variety of applications
- 1987 launched the model GSM-19, standard for portable and base station magnetometers
- Early 1990’s commercialised “walking mag” concept

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)

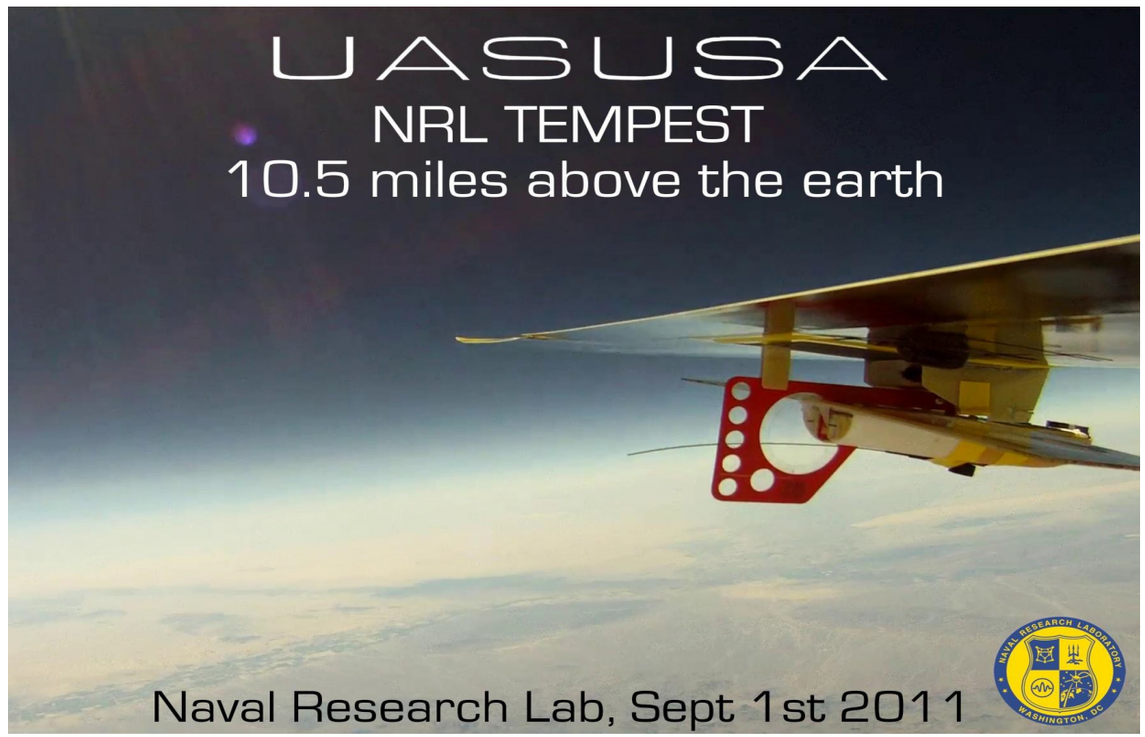
Process of Implementation

Summary :

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

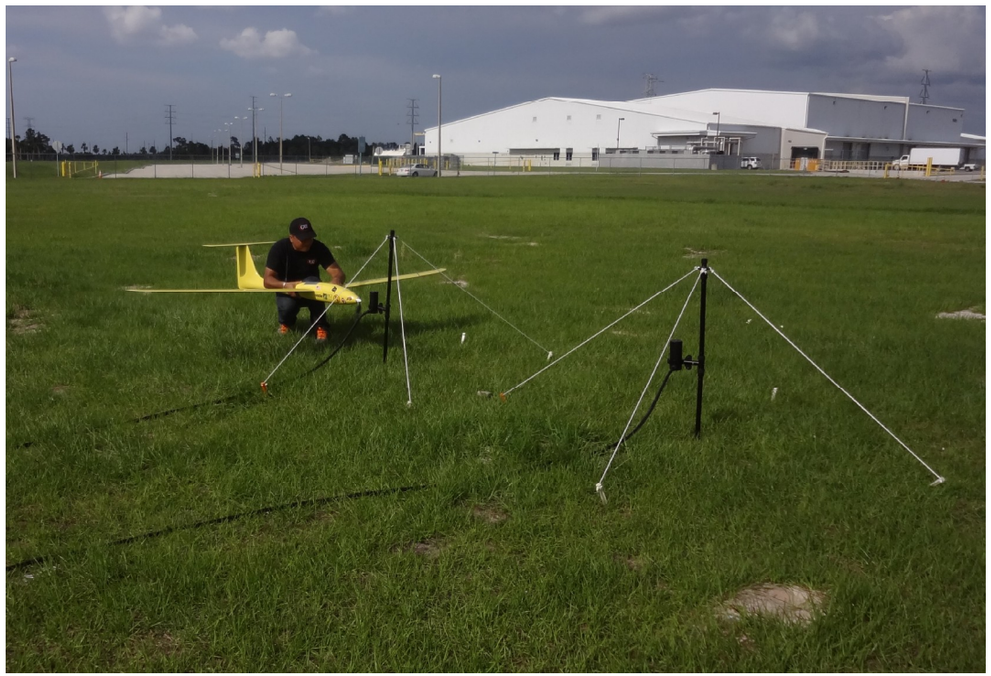
Selection

- 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



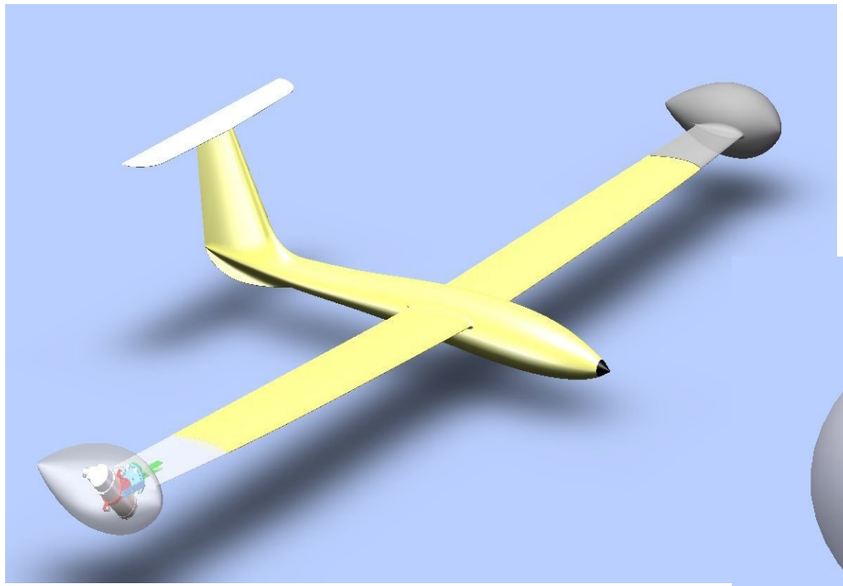
- Testing involves the use of a high precision gradiometer system and measuring , not only the complete UAV but individual components as well

- Recommendations made to change any parts possible that can be made from non magnetic materials

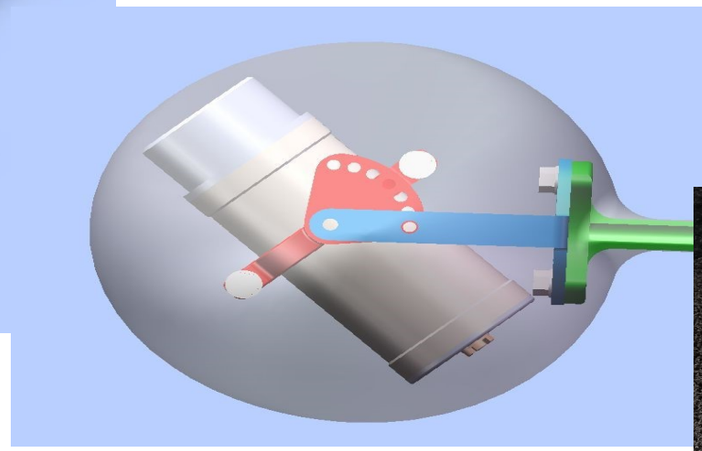
Payload

- 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

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


GEM
SYSTEMS

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[1] (of high-res mag gradient data) with short ferry flights

[1] multiple flights per day are expected; changing aircraft batteries and re-launching the aircraft requires minutes

Wingspan (sensor separation)

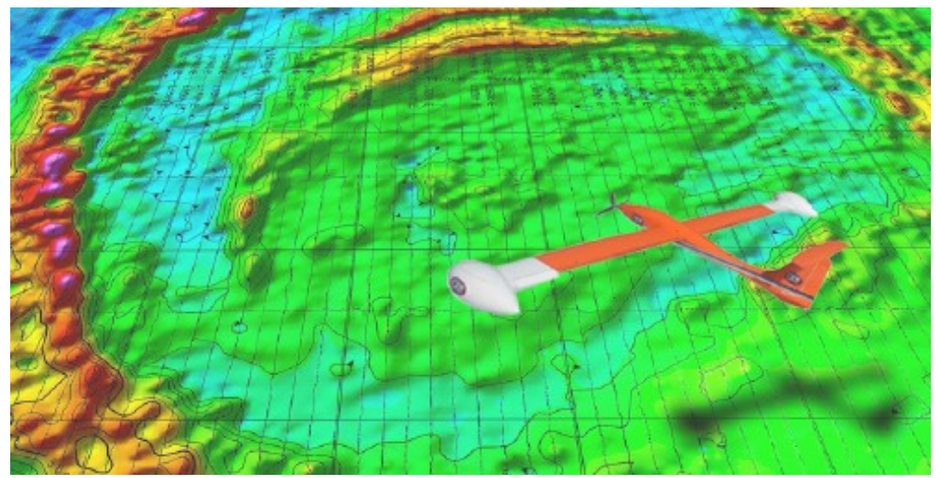
3.2 metres

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



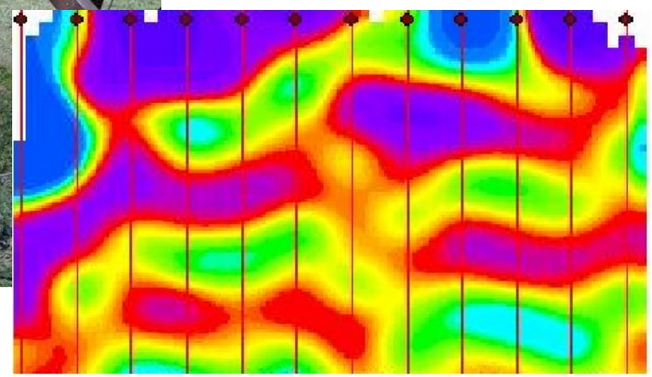
Possibilities

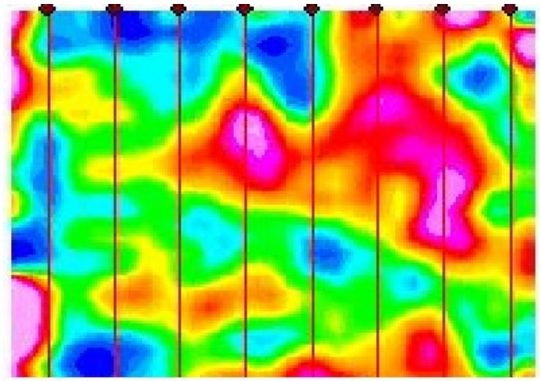
Unmanned Helicopters

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

Multi copters

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

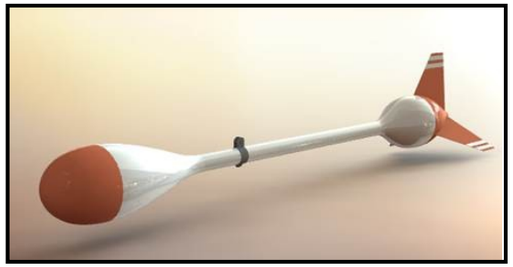




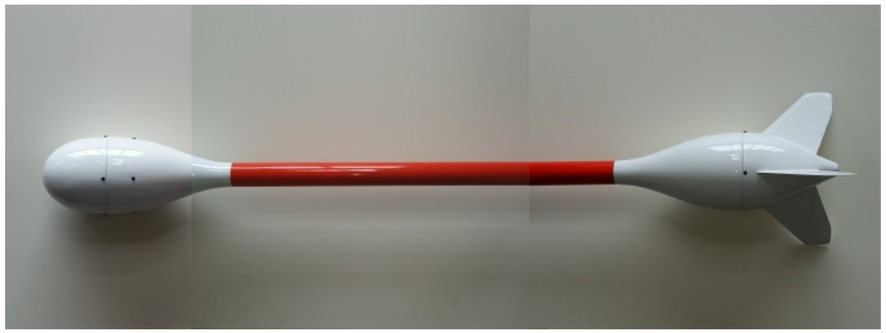
sensor HEAD is suspended by a 2.0 metre signal cable; the other instrumentation is installed in a stand alone chassis between the skids of the UAV, which can be quickly disconnected if the UAV is to be used for other applications

Multicopters : Towed Bird concept

Design



Manufacture



<u>Turnkey Solution to include;</u>

- 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

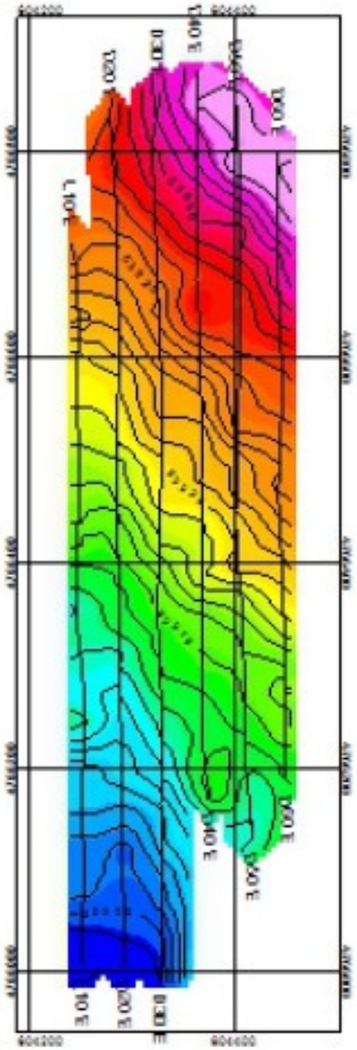
Test Flight with AirBird

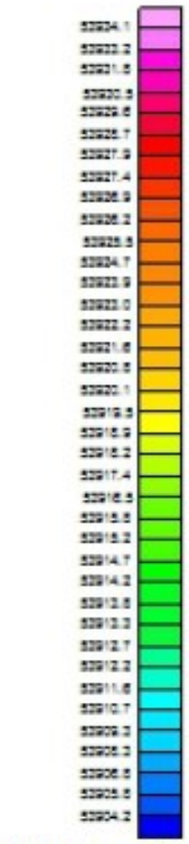
UAV SOLUTIONS

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

Monarch Gradiometer UAV

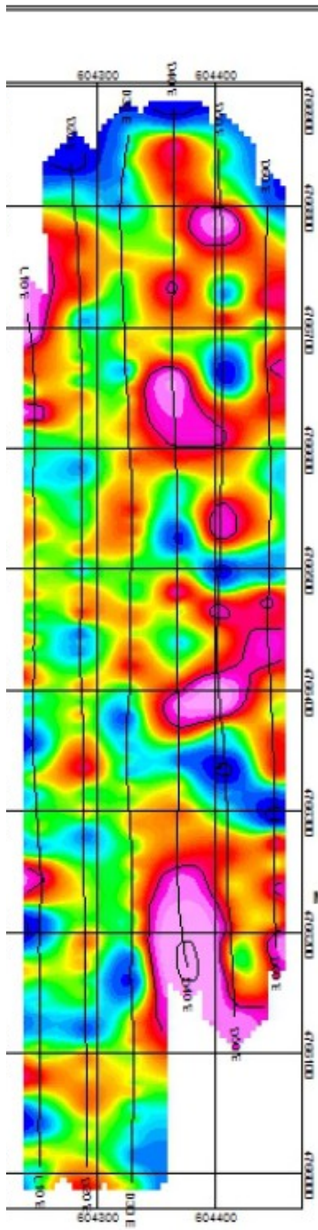
Monarch UAV Gradiometer

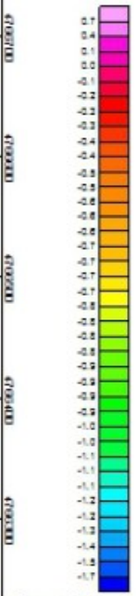




Total Magnetic Field nT

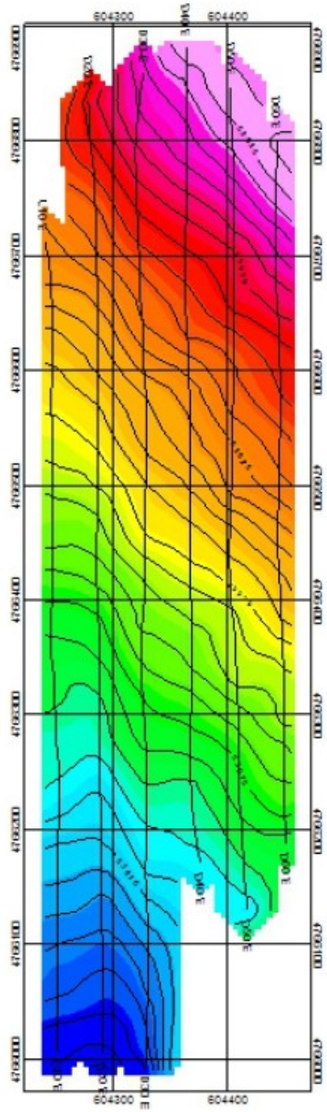
Monarch Test Flight
August 2015
Total Field Magnetometer Sensor 1

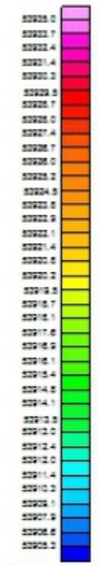




Magnetic Gradient nT

GEM SYST
MONARCH UAV TE
Magnetic Gradien
August 20
Niagara, Ont
RG





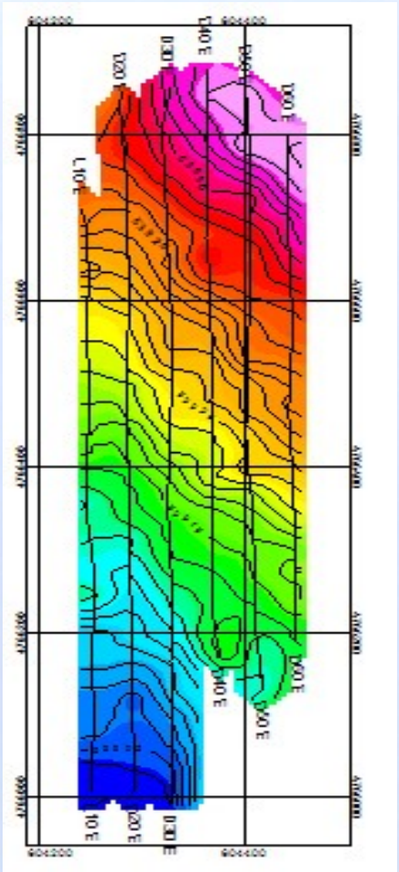
Total Magnetic Field nT

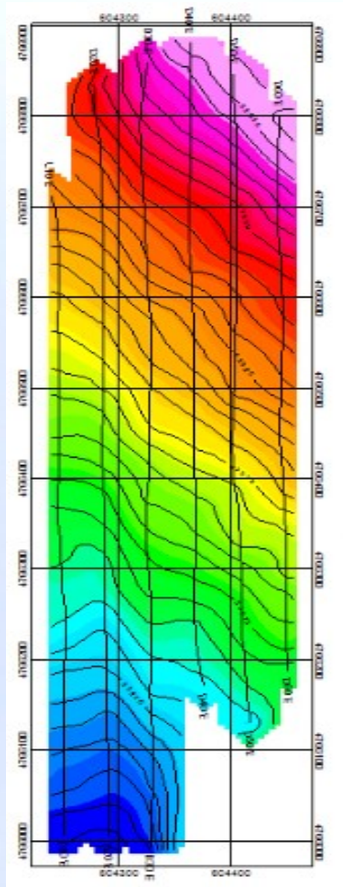
GEM SYSTEMS
MONARCH UAV TEST FLIGHT
Total Field Magnetometer Sensor 2
August 2015
Niagara, Ontario
RG

Conclusions

- Functioning magnetic UAV gradiometer is available today
- Logistical operating challenges exist for the various potential UAV platforms (including regulatory)
- Turnkey UAV borne gradiometer delivers data quality comparable to today's manned airborne systems
- Increased use and application is expected in the next several years

High Sensitivity Magnetometers for Unmanned Aircraft





Celebrating 35 Years

Leading the World of Magnetics

35 Years

Innovation

Reliability

Our World is Magnetics