GLOBAL UNMANNED SYSTEMS

Use of Unmanned Aerial Vehicles (UAVs) in Impact Assessment

IAIA, Florence, Italy, April 2015

WWW.GUS-UAV.COM

EIA Context

- EIA is essentially a predictive process that informs decision–making
- Institutionalisation: 191 out of 193 member nations of the UN have national legislation or international obligations to EIA
- The scope of EIAs has continued to expand…..
- And so has the volume of material…..
- And cost and the time to prepare …….

Benefits?

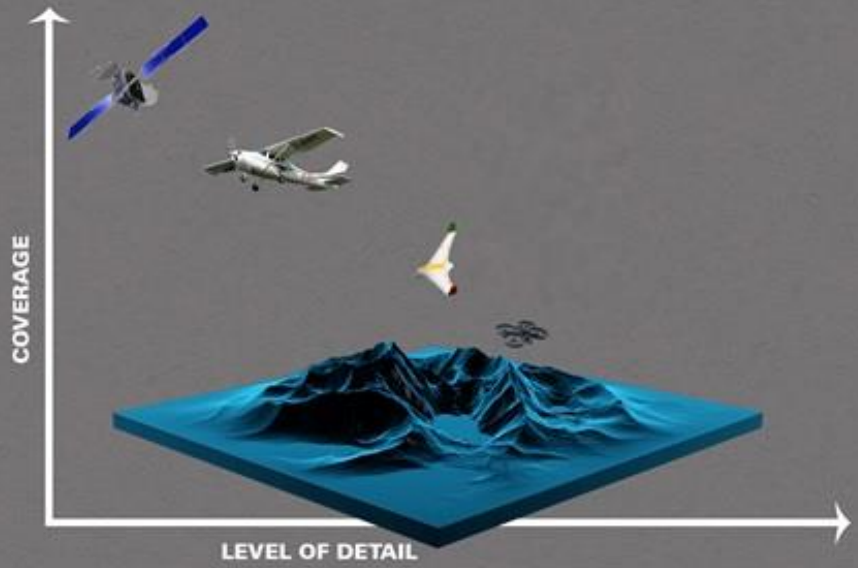
- But has this led to:
  - Better decisions?
  - More accurate predictions of impacts?
  - Better and more sustainable outcomes?
- Is there a link between the proliferation of EIAs and calls to ‘cut green tape’?

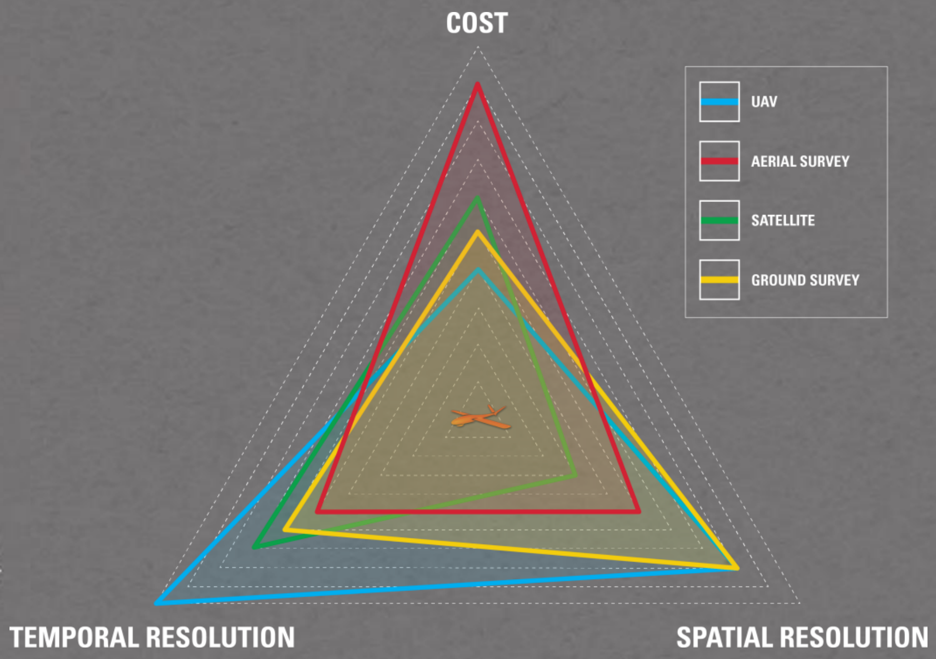
Opportunities for Improvement

- Some have argued for a return to basics, and specifically more focused and integrated assessments
- Two steps would make a big difference:
  - A more intuitive approach to **scoping**
  - A greater use of **innovative technologies**
- UAV systems have the potential to support both

Concept

- UAVs: platforms for positioning sensors in 3D space
- Supporting systems critical for data quality, efficiency, value and safety
- Complementarity with other technologies





Platform hierarchy

Increasing size /range /endurance /sensor capacity **but** corresponding increase in:

- Cost
- Operational complexity
- Operating logistics
- Import/export complexity
- License/permitting complexity
- Consequences in the event of an accident

GUS VTOL Multi-rotor

GUS Fixed Wing

Scheibel Camcopter

Boeing ScanEagle

Global Hawk

Small Unmanned Aerial Systems – represent cost-effective solution fitting perfectly into a historic “hole” in the remote sensing spectrum

Small UAV Systems – a convergence of technologies

GUS
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Autopilot and avionics:
Global Navigation Satellite System coupled with inertial navigation systems for precise autonomous 3D way-point navigation

Strong, light-weight components

Rapid development in sensor payloads:
- Miniaturisation
- Resolution
- Cost

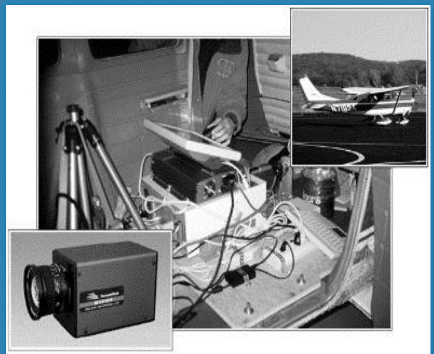
Advances in battery technology: lighter and greater life

Highly efficient brushless motors

Data links & communications

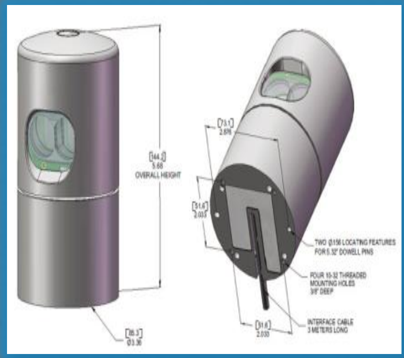
Image processing and presentation

1907



1990s

Multispectral
Currently useful



LiDAR– almost commercially viable

Governance

Where regulations exist, generally:

- Require some form of certification based on an external audit of companies operations manual and operating procedures

- Routinely able to fly over unpopulated areas, up to 400ft AGL or higher with special approvals and must operate within Visual Line of Sight (e.g. Australia/UK)

Where no certification framework exist, the operational concept is very much dependant on the local regulations

General Approach:

- Develop relationship with local partners
- Instigate safe working practices
- Seek approvals from relevant authorities

Sophisticated technology - despite what you might read

Australian company using UAVs to film triathlon without Operators Certificate and breaching regulations:

Sydney Morning Herald - 'River of blood' after drone 'hits' Australian athlete

BBC News - Australian triathlete injured after drone crash

Daily Mail - Australian triathlete injured by crashing drone as pilot loses control.

Avoidable by using responsible Certified companies with approved operators with CASA (or equivalent) audited safe working practices

UAV Systems: Potential Benefits

- High spatial resolution data
- Ability to target small areas at virtually any time
- Quantitative, geo-referenced data facilitates measurement of small changes over time-frames that take account of the 'target / question'
- Non-intrusive method of acquiring data
- Improved efficiency and effectiveness of ground surveys
- Access to remote / inaccessible areas
- Not impeded by cloud cover
- Reduced health and safety risk

Examples

Date Acquisition & Processing

High resolution imagery

Orthophoto

3D Models

Accuracy

Surveyor's feature and level survey derived from total station and real-time kinematic GPS measurements compared with UAV derived orthophoto.

Excellent planimetric accuracy: extremely good fit with total stations and RTK GPS survey

Orthophoto and RGB-colour point cloud allows for accurate cadastral and topographic mapping.

Data from within inaccessible areas ground-based teams are unable to reach

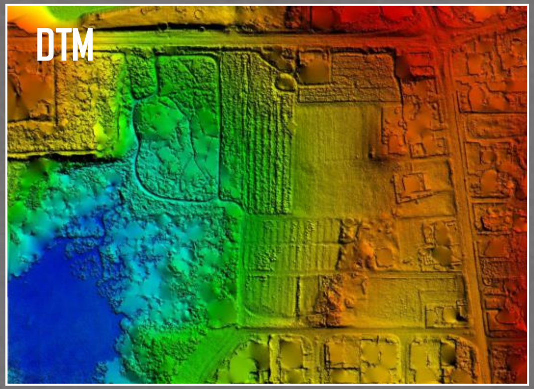
Complete richness of data: 72.2144 points per square meter. Does not require a surveyor to make subjective selections of features to survey. Richness of points allows for very high resolution DTMs and contours.

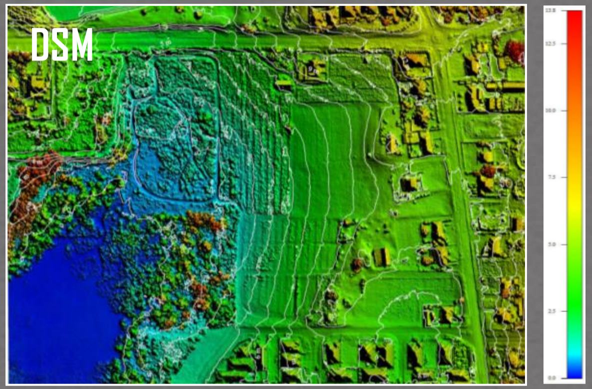
UAV data acquisition time: 30 minutes; processing: 24 hours. Surveying team acquisition time 2 days. Reduced data capture cost with vast increases in data quality and richness.

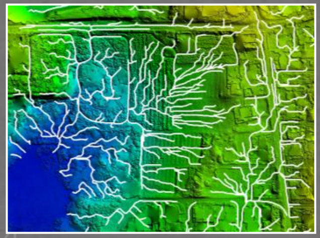
Value-added Stream

High resolution imagery

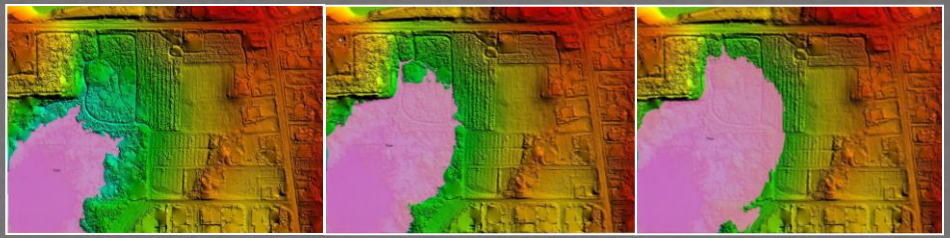
3D Models





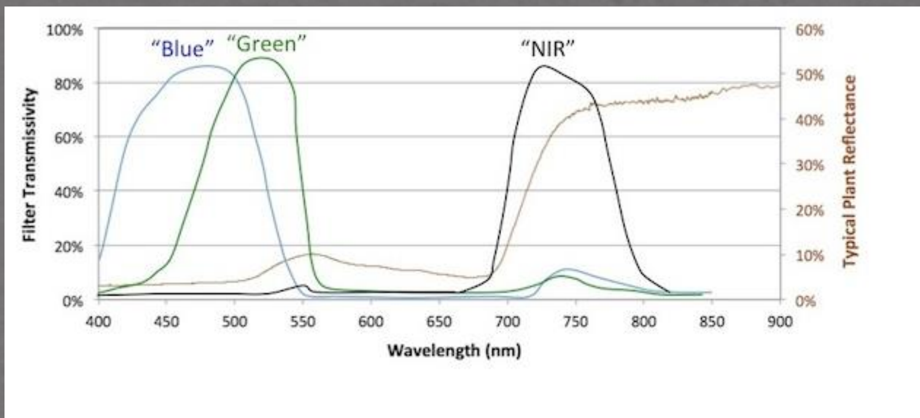


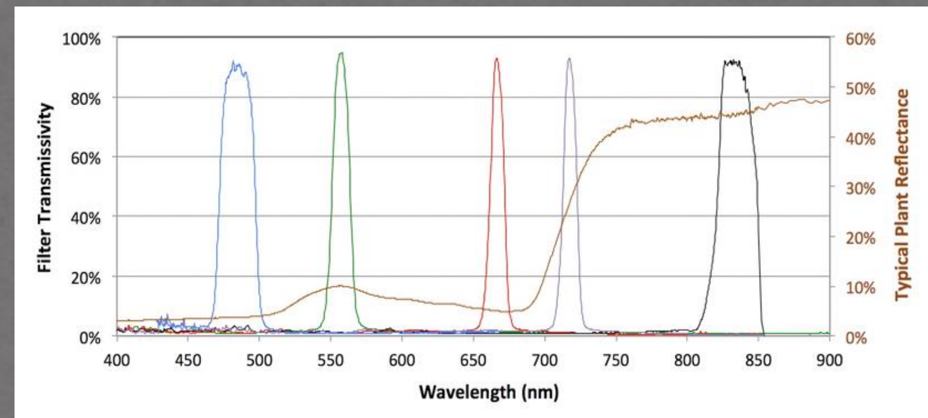
Watershed analysis (left) & Flood analysis (right)

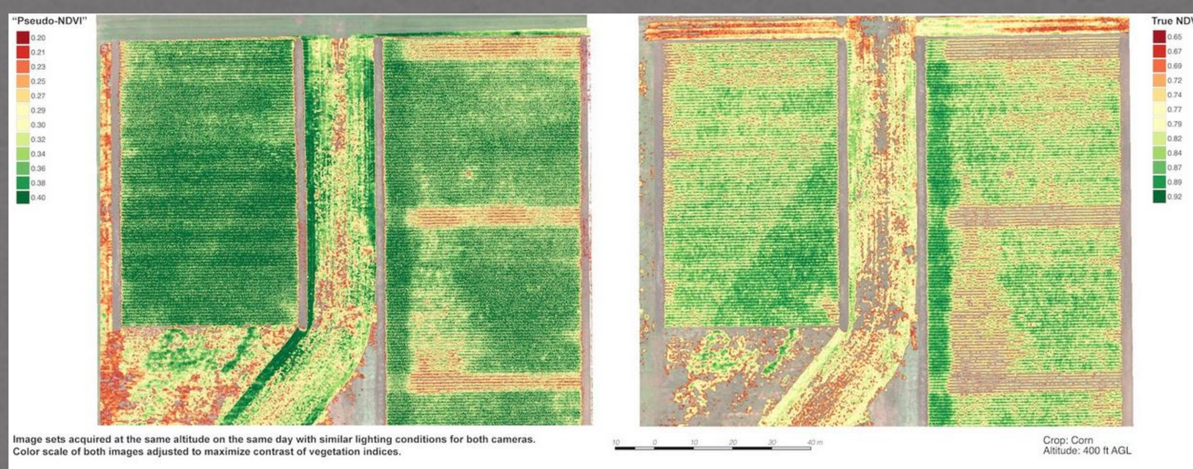


Dredge-Plume Monitoring

- Local scale i.e. near source validation of plume models and verification of satellite remote sensing data.
- Working to develop algorithms to convert remotely sensed information into monitoring parameters e.g. suspended sediment concentration (SSC) / nephelometric turbidity units (NTU).
- Eventually aim to integrate with AUV data for high temporal frequency plume monitoring tool able to be deployed from vessel.



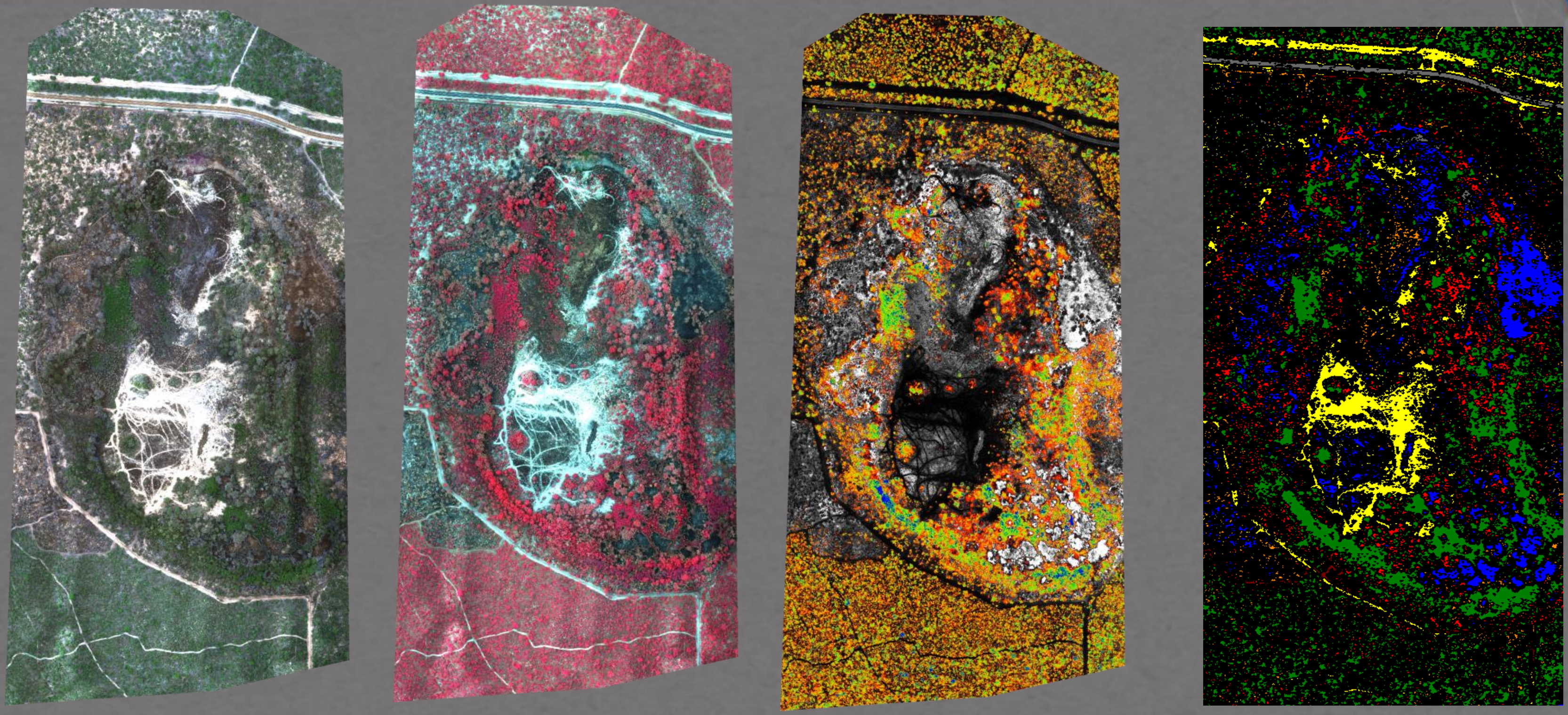




"Converted" single-imager camera

GUS's 5-narrowband multispectral camera

Multispectral Imaging - Ecology



Narrow-band optical filters – known characteristics and calibration parameters enable accurate measurements of reflectance across 5 bands: Red, Green, Blue, Red-Edge and Near-infrared.

Ground measurements allows for relationships to be established to calculate metrics for "plant health" in environmentally sensitive areas

Sandalwood Image Analysis

Orthoimagery

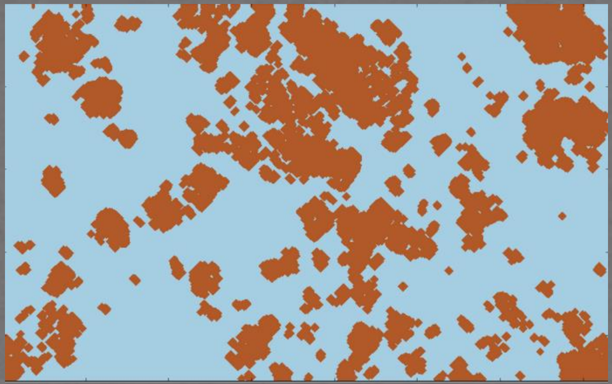
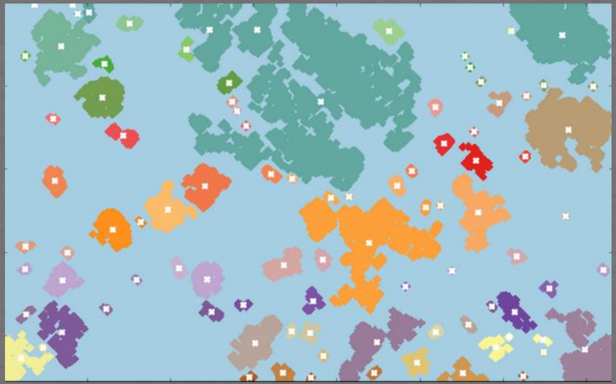
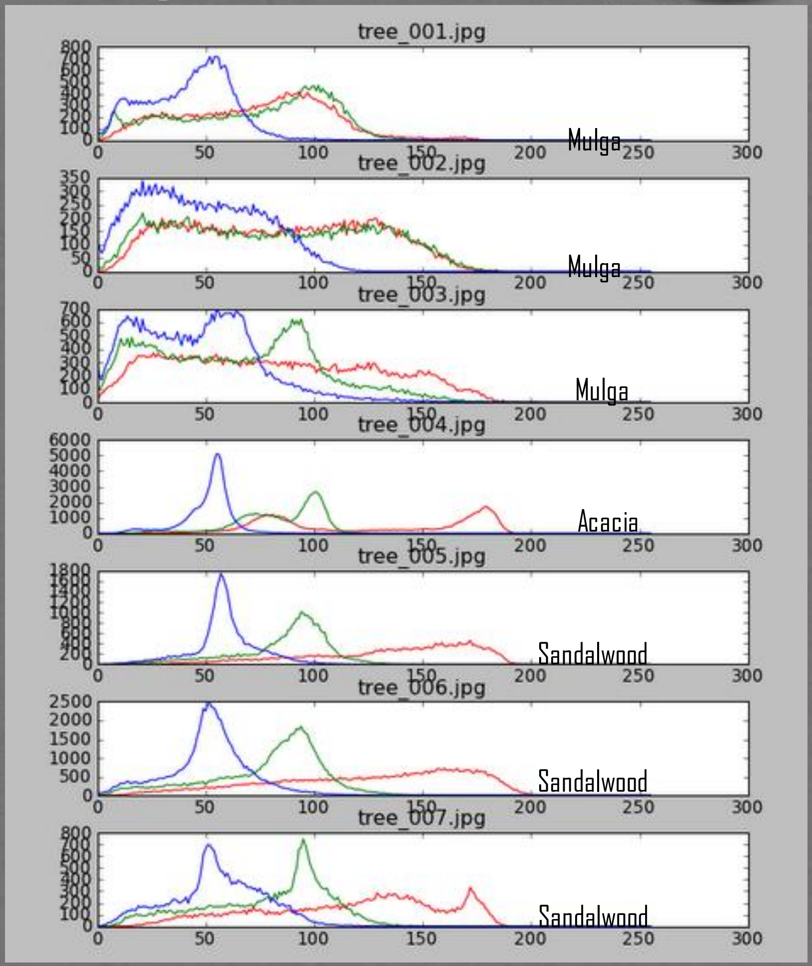


Image Segmentation:
Veg. vs Bare Earth



Index of Individual
Plants

RGB Histograms

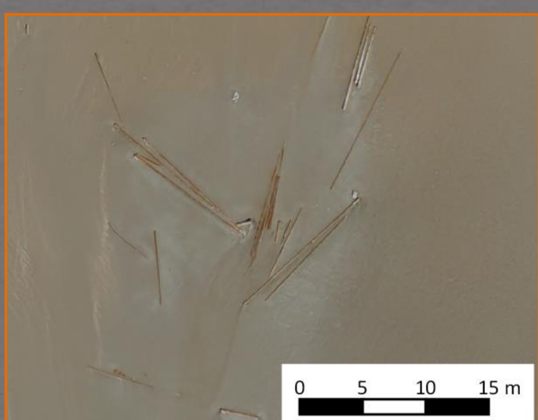


Ongoing project: aims to build an automated classification programme that accurately speciates and counts tree species in a given area. System could be applied elsewhere e.g. weed mapping.

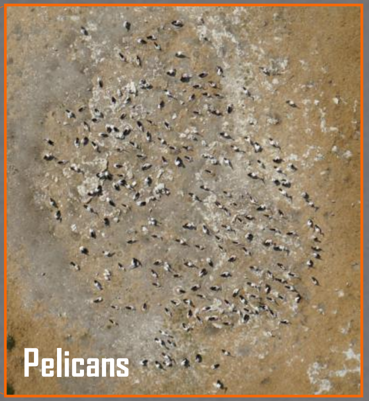
Baseline survey: magnetic anomaly verifivation

UAV utilised to map 85 km^2 over 10 days:

1. Magnetic survey – anomalies identified
2. Co-incident with archival record of exploratory drilling
3. UAV reconnaissance survey identifies and spatially maps anomalies
4. Safely leads field teams to anomalies for visual inspection



Bird census

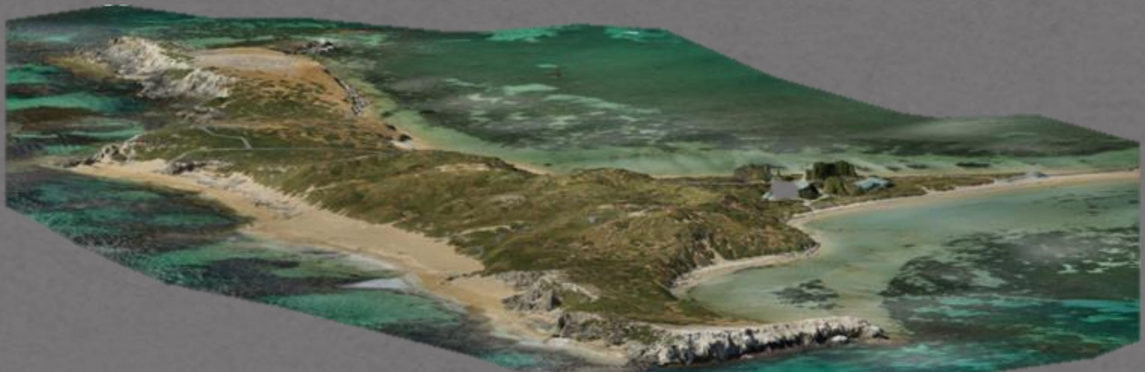


Data Specifications

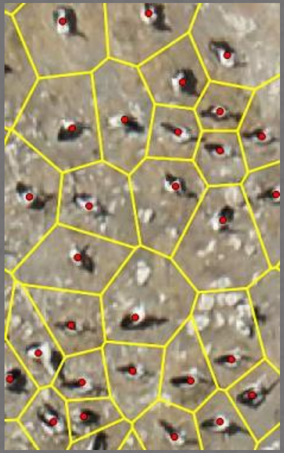
- Flying height: 80m
- Acquisition time: 20 minutes
- On-ground Pixel Resolution: 2.7cm/pixel
- Processing time: <1 Day

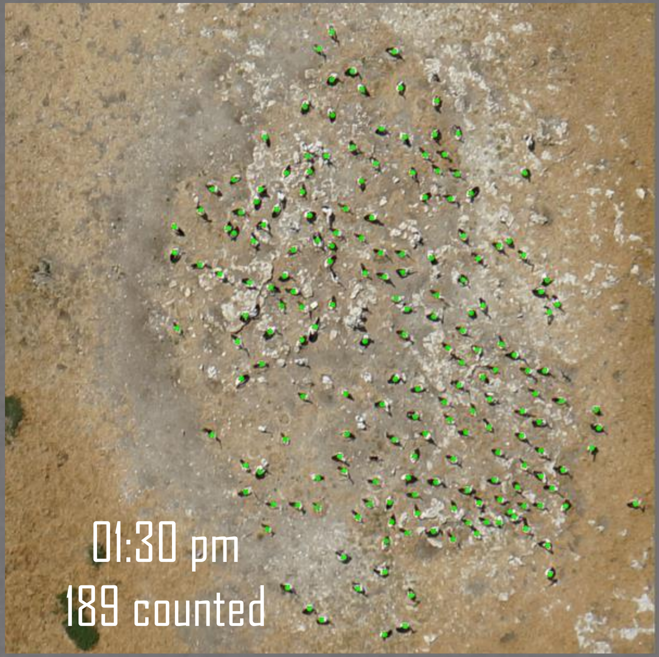
Benefits

- Unimpeded access to remote site
- No disturbance to target
- Resolution tailored to resolve individual birds
- Timely
- Cost-effective
- Minimal H&S risk



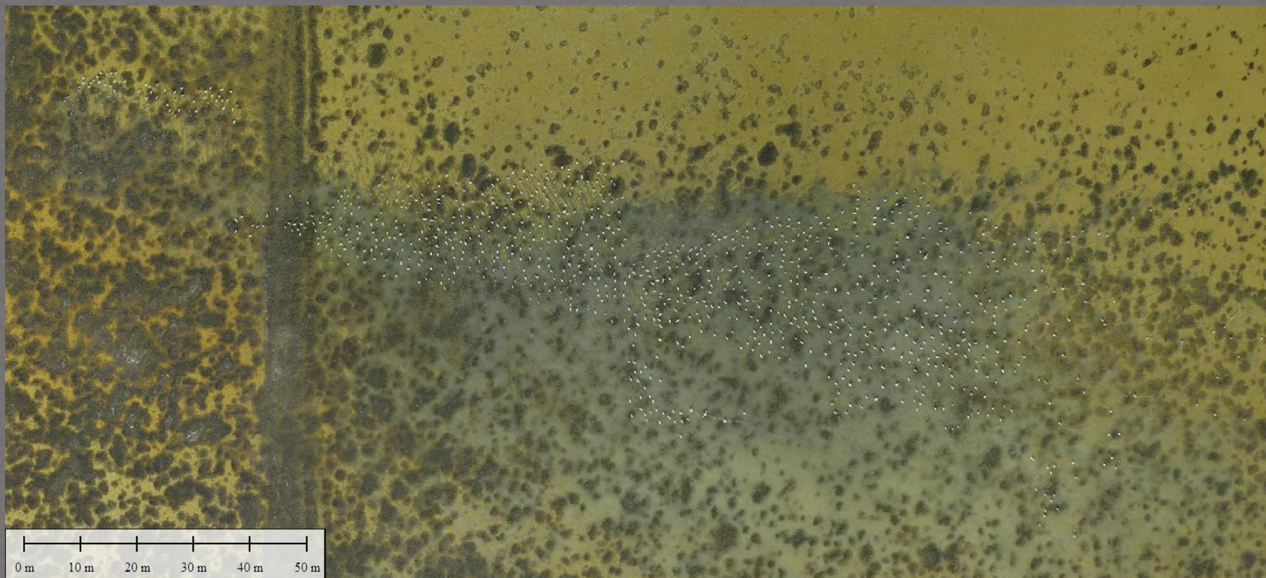
Bird census: temporal analysis



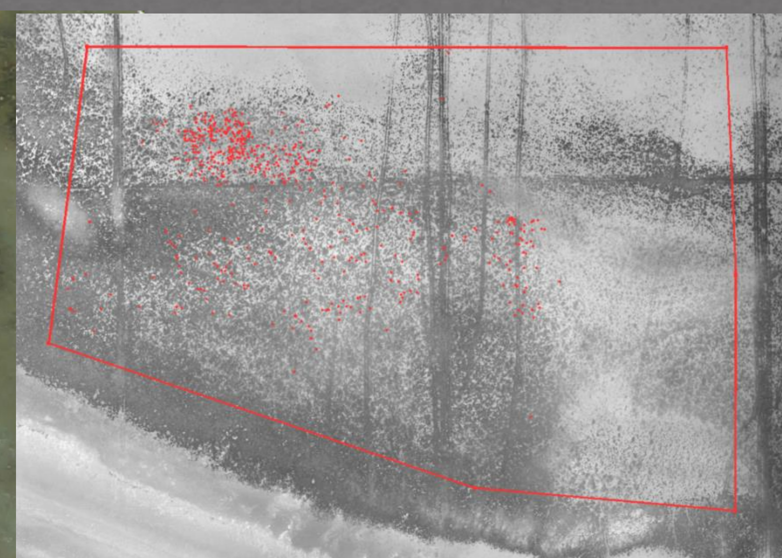


- Particularly effective for nesting species
- Potential to automate with image analysis
- Temporal capability increases scope for population and behavioural assessments

Bird Census: Feeding Flamingo Colony



- Ability to rapidly cover colony in low number of passes to avoid double counts.
- Utilisation of image analysis techniques provides rapid inventories.



Habitat mapping

Data specifications

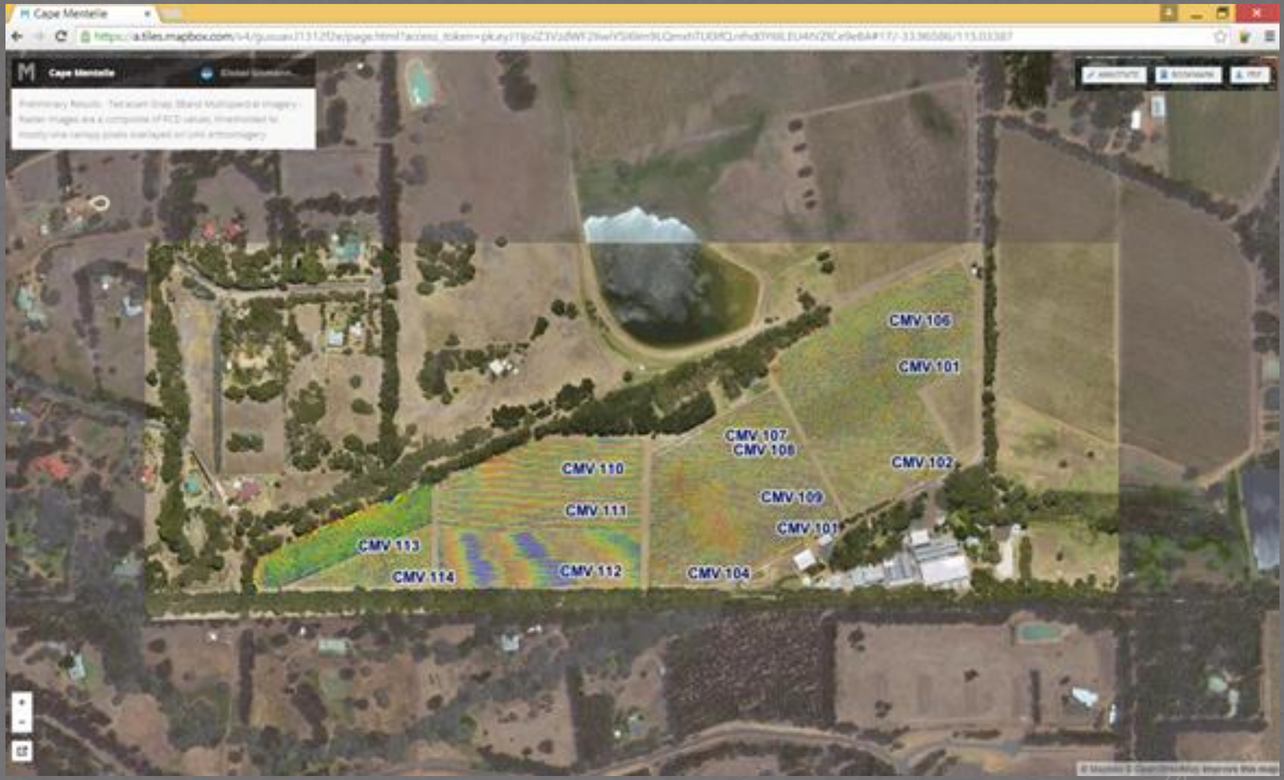
- Flying height: 80m
- Acquisition time:
- 20 minutes
- On-ground Pixel Resolution: 2.7 cm/pixel
- Processing time: <1 Day

Benefits

- Unimpeded and unobtrusive access sensitive habitat
- Synoptic view of area of interest
- Complete spatial coverage vs ground-based sampling
- Cost-effective

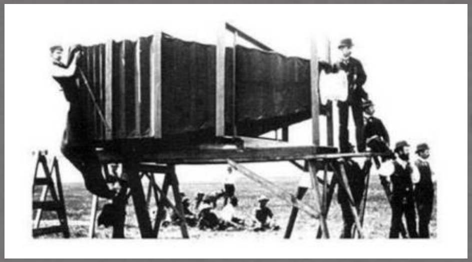
Data : User interface - critical element

- Cloud-based Interface that allows secure access and visualisation of spatial data – imagery, photos, sampling points etc. for non-GIS users.
- Allows decision-makers to rapidly access data from anywhere in the world with an internet connection.
- Quickly switch between image sets from different dates.
- Annotate, measure and flag (areas, lines, points) as issues/items for discussion.
- Export scaled PDF Maps for meetings, presentations etc.



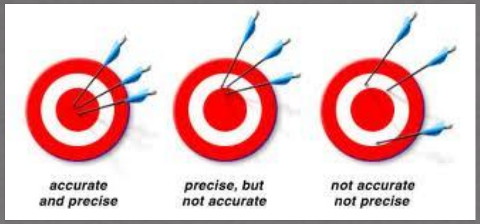
Foreseeable developments

Sensors:



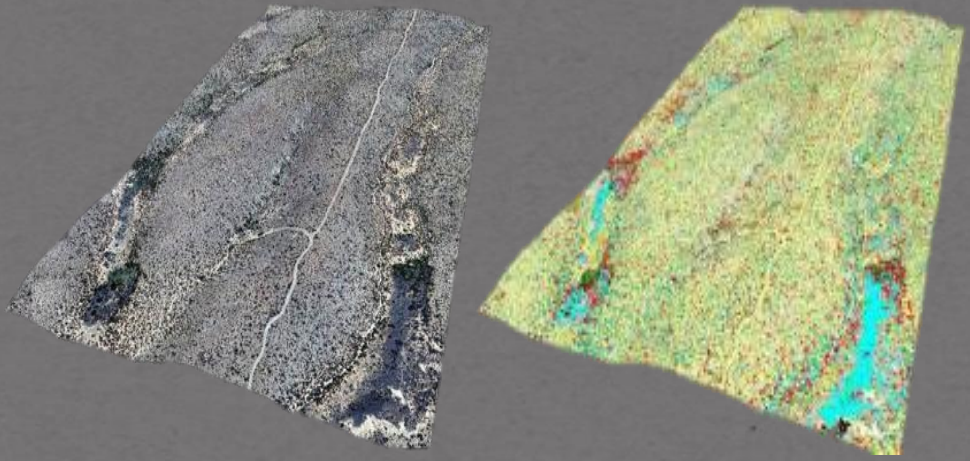
Continued miniaturisation and improvement

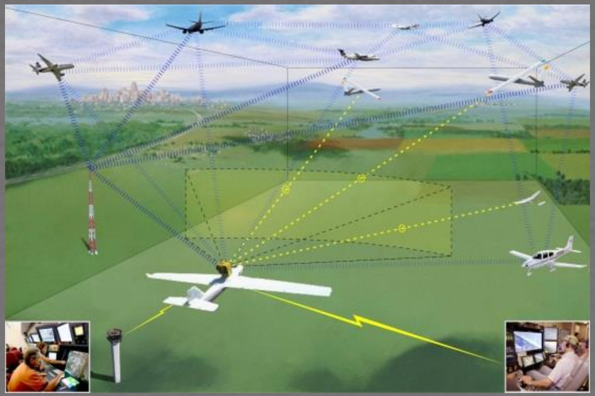
Guidance systems:



Increased accuracy/precision from miniaturisation and affordability of GPS technology – ability to directly geo-reference orthoimagery without ground control

Image processing & automated feature recognition:





Evolution of regulatory space to allow safe and cost-effective use of an extended range of capabilities

Back up

Platforms

Vertical take-off and landing

- **Endurance:** up to 15 minutes
- **Range/coverage:** 500 m (0.25 km^2)
- **Navigation:** manual and semi-autonomous
- **Sensors:** Digital SLR camera, HD video, thermal infrared, and multispectral imagery – all mounted on a stabilised tilt-roll gimbal
- **Uses:** High resolution, discrete area mapping and monitoring

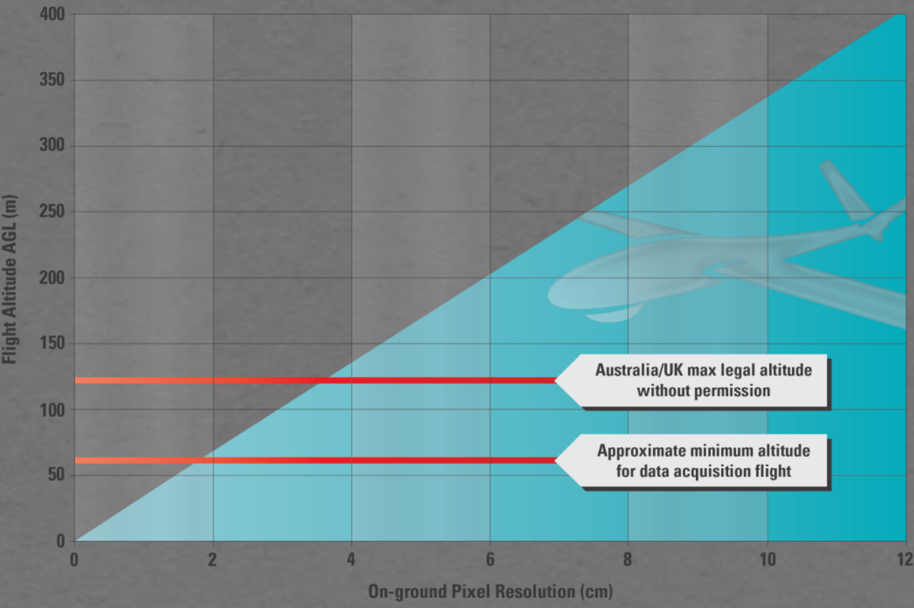
Platforms

Short-range fixed wing

- **Endurance:** 45 minutes
- **Range/coverage:** <2km (LOS), (~10km2)
- **Navigation:** fully autonomous with auto take-off and pilot-assisted/manual mode
- **Sensor:** SLR camera, and multispectral imager
- **Take-off:** catapult/hand launched
- **Landing:** belly landing (flat terrain: 20x50m), net capture or parachute deployment
- **Uses:** land inventory, mapping and monitoring

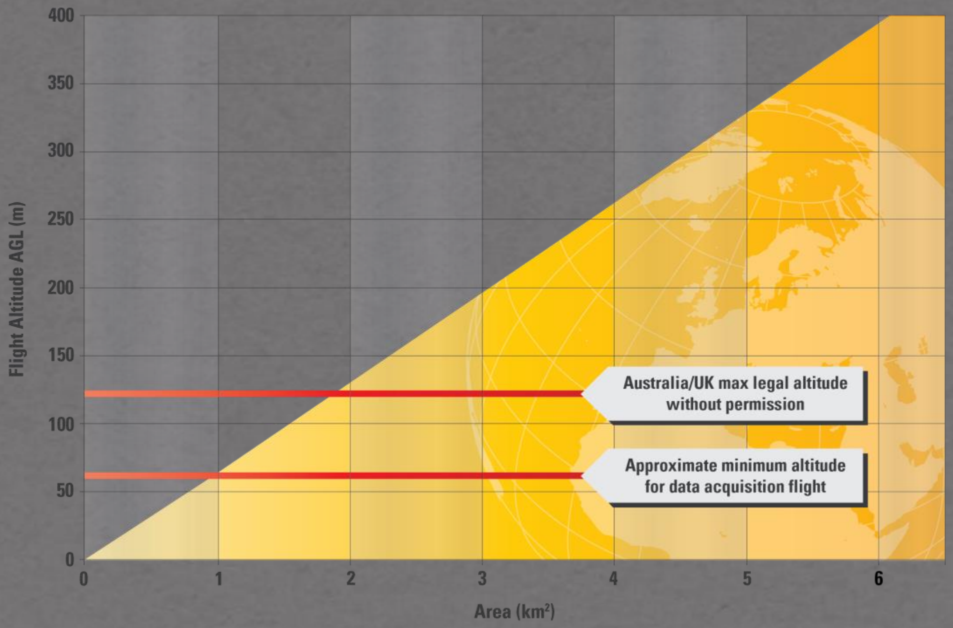
Platforms

Short-range fixed wing



On-ground pixel resolution vs. altitude

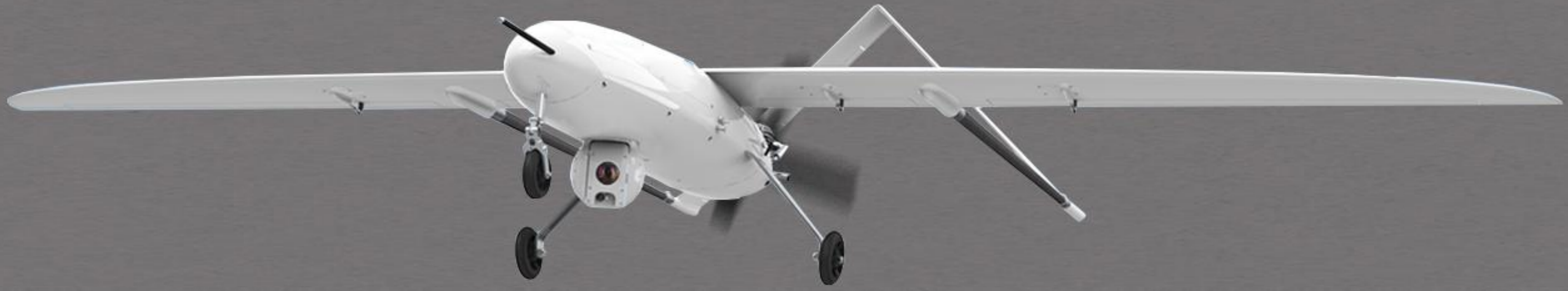
Aerial coverage per flight in optimum conditions vs. altitude



Platforms

Long Endurance UAV (business case under review)

- **Endurance:** >10 hours
- **Range and coverage:** theoretically up to 40km and 5000km^2
- **Sensor:** optional; DSLR, video camera gimbal, hyperspectral sensor, multispectral sensor
- **Take-off:** Catapult/unimproved airstrip
- **Landing:** unimproved/unprepared airstrip or rough field – anticipated requirement ~120m
- **Uses:** Large area mapping , security and surveillance



Sensors

Digital SLR

Currently using
16.1MP DSLR

HD Video

Currently using
24MP HD Camera

Multispectral

Thermal /Infrared
(proposed)

LiDAR (potential)

SAR (potential)

Operations Workflow

1. Definition of Project: coverage area and desired accuracy to be achieved

2. Project Design: coverage area and nature of the terrain dictates which UAV type and specification will be utilised

3. Mission planning, GCP siting, flight execution and data acquisition

4. Processing: ortho/geo-rectified mosaic & DEM – highly automated but requires user input for optimal results.

5. Analysis: pre-construction surveys, resettlement census and surveys, vegetation assessments, erosion and sedimentation analysis, etc.

6. Data integration and information management

Data Acquisition & Image Processing

Data Acquisition:

- Integrated autopilot: relies on gyroscopes, accelerometers, pressure sensors and GPS to compute and control the state of the UAV.
- UAV follows a pre-determined path in 3D space (defined by waypoints)
- Repeatable workflow.

Image Processing:

- Required to generate geo-referenced orthomosaics and DEMs
- Two broad options:
  - Direct geo-referencing – simplest but least accurate - computes an estimate of the geo-location using the UAVs on-board navigation GPS measurements. No ground control points (GCPs). Geo-referenced orthomosaic can be generated in minutes
  - Semi-automatic GCP geo-referencing – GCPs can be utilised in the imagery to improve accuracy to <10cm