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Holographic Radar™

Target-centric surveillance

Robust Detection of micro-UAS drones with L-band 3-D Holographic Radar™

Dr Mohammed Jahangir and Prof. Chris

Small UAV Detection and Tracking

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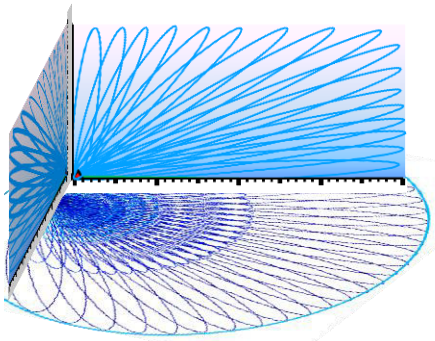
Rapidly escalating challenge & opportunity

- **Small UAV (e.g. DJI Phantom 2)**
- **CHALLENGE**
  - Proliferation in availability and capability
  - Threat to air safety, security, privacy
  - Difficult to reliably detect
    - Extremely small radar target
    - Standard radar unable to differentiate drone and birds
  - Complex detection environment
    - Low level, terrain and building shadows
- **OPPORTUNITY**
  - UAV have valuable applications
  - Solutions are needed to enable commercial adoption.
  - Solutions needed:
    - Detection – civil & military
    - Sense & Avoid

Staring (Holographic Radar) is the solution

A wide area persistent solution

Digitise the sky – search the data



Theia 64A HR

- **Single transmitter illuminates whole field of view**
  - Simple low cost transmitter
  - Not constrained to mono-static deployment
- **Multi-beam receivers continuously gather data**
  - Azimuth and elevation beams provide 3D coverage
  - 100% time-on-target yielding fine Doppler resolution
  - Tracking and analysis benefit from continuous dwell
- **Parallel processing allows real time target detection**
  - Software defined architecture
  - Increase performance through processing not through spectrum
  - Processing capacity determines the integrable range of target dynamics
- **The key principle is:**

IT's ALL ABOUT THE TARGET

Holographic Radar™ take on drone spotting

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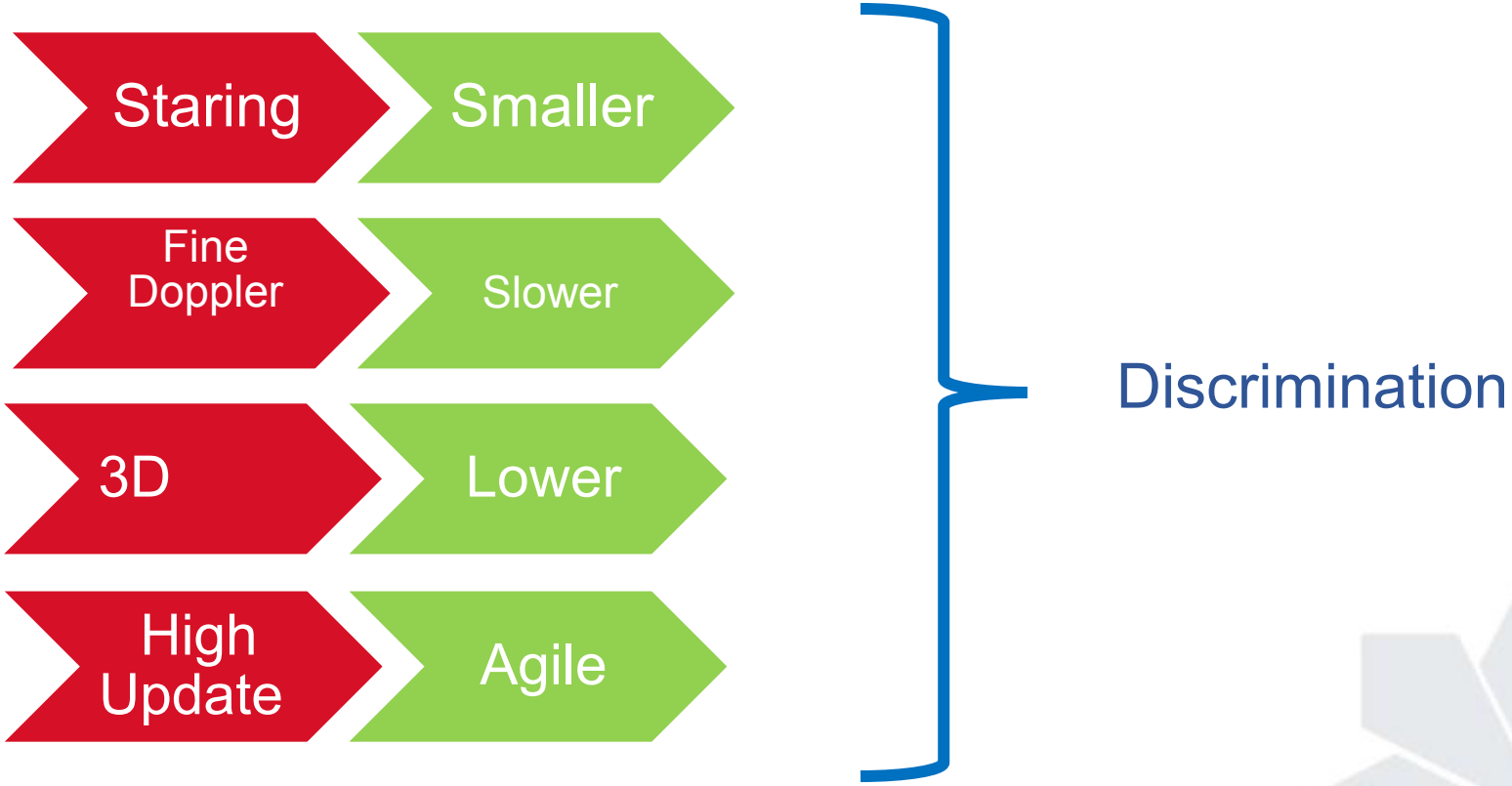
Stare not scan

- Number of elements of the sensor come together to aid the surveillance of *small*, *slow*, *low* and *agile* micro-drones



Early drone development programme

32x8 receiver array Theia 64A Holographic Radar™

Parameter	Value
Frequency	L band
Bandwidth	<2MHz
Transmit Power	1kW
Receiver channels	256
Instrumented range	20 NM
Azimuth coverage	90 deg
Range accuracy	<50m
Azimuth accuracy	<250m
Doppler resolution	<0.5m/s
Update rate	~2Hz

Theia 64A HR tests against micro-light

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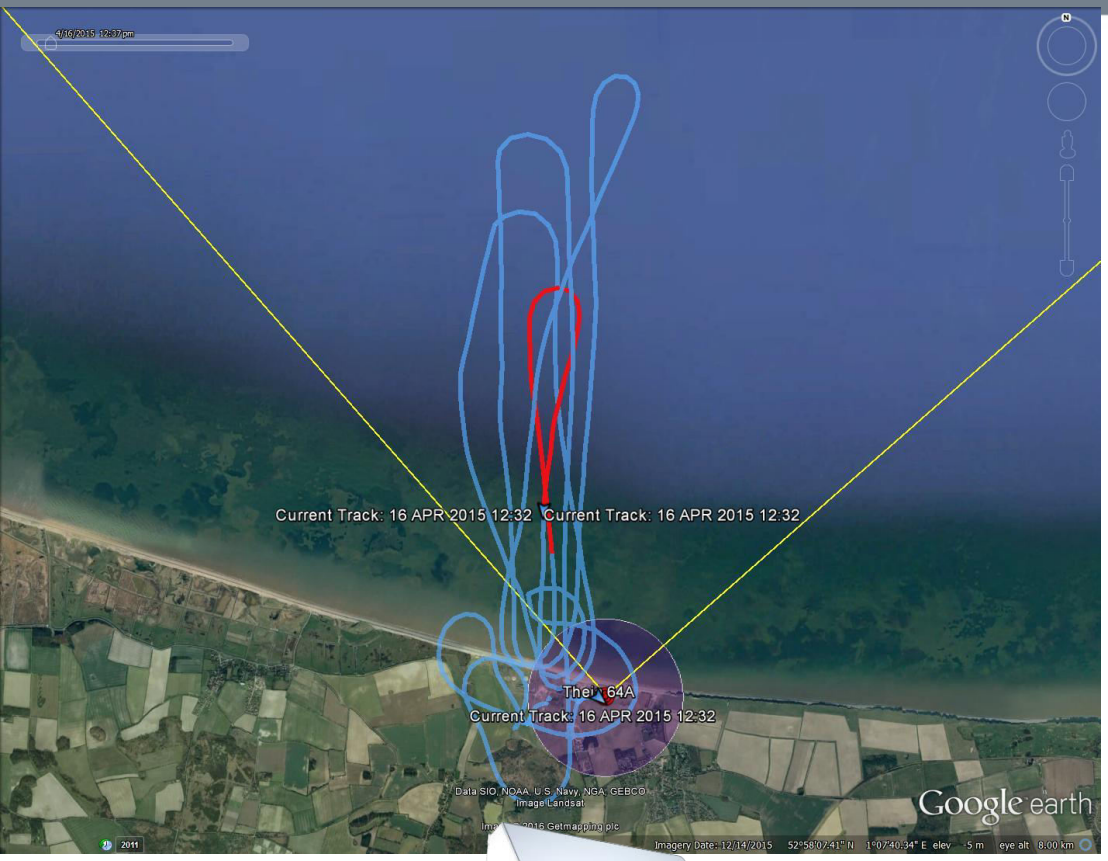
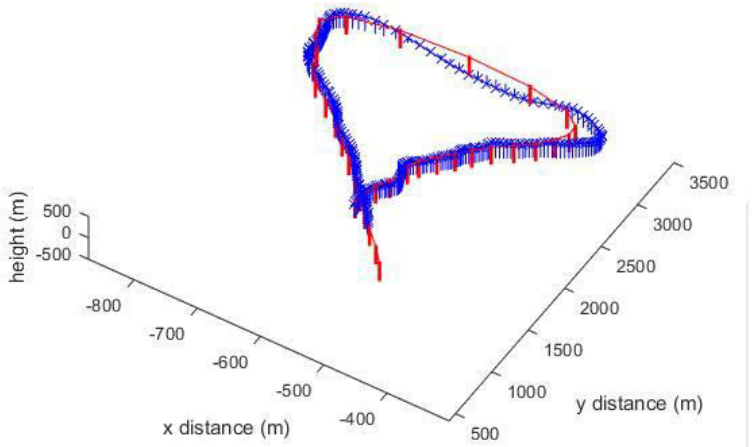
Separating very small targets from clutter





Theia 64A HR tests against micro-drone

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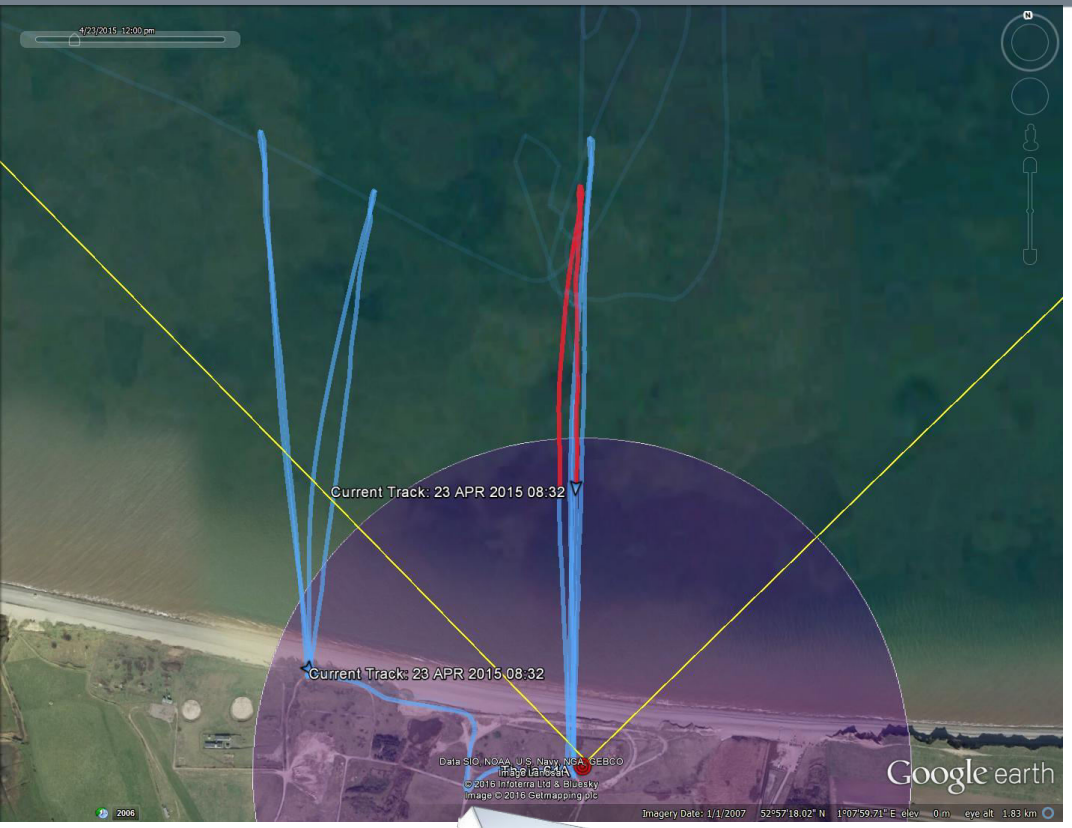
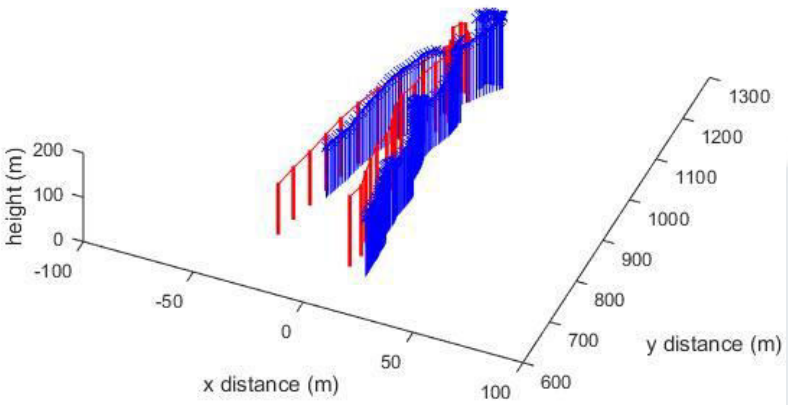
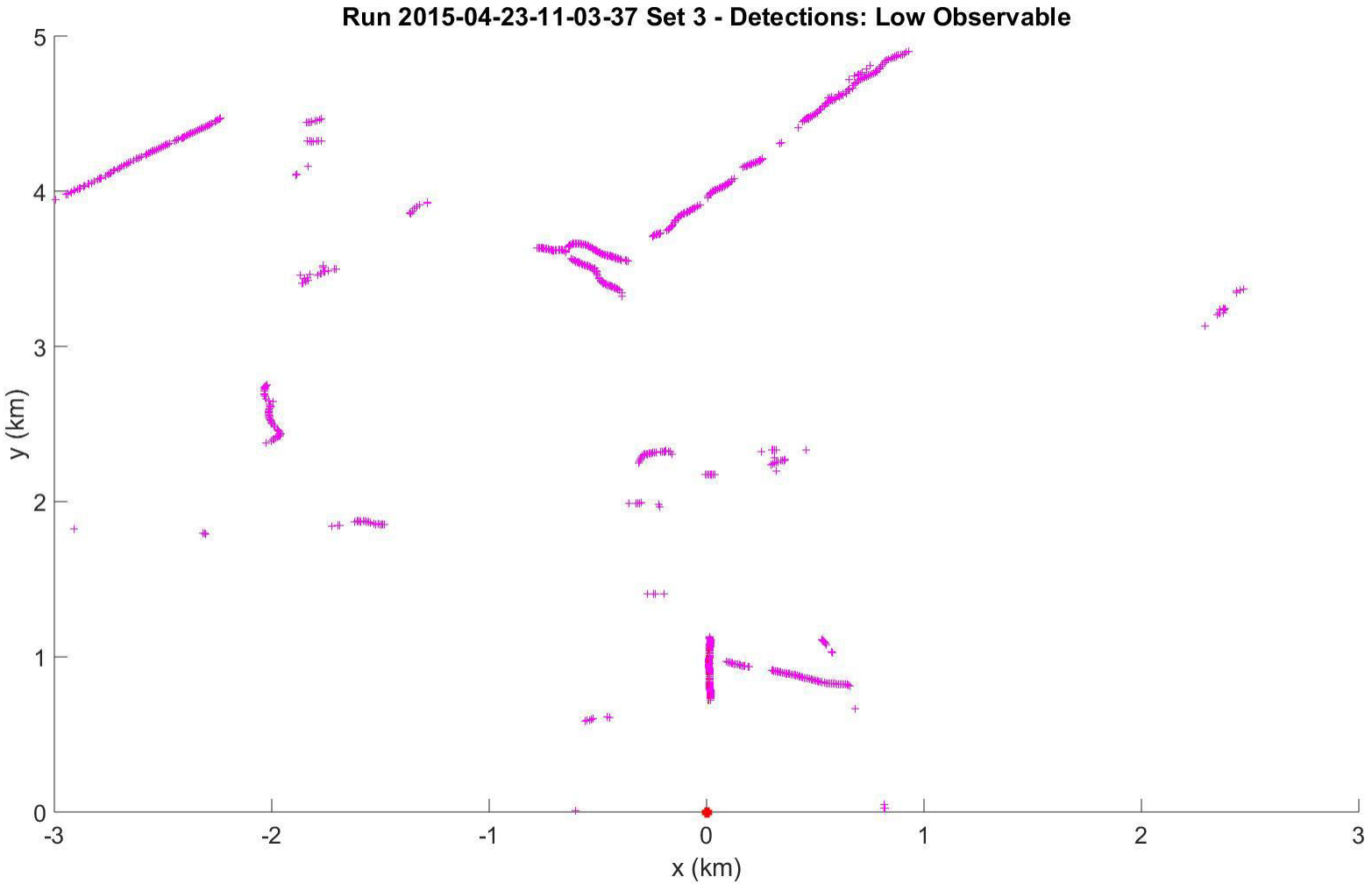
Separating very small targets from clutter





Drone raw detections

False targets dominating the output



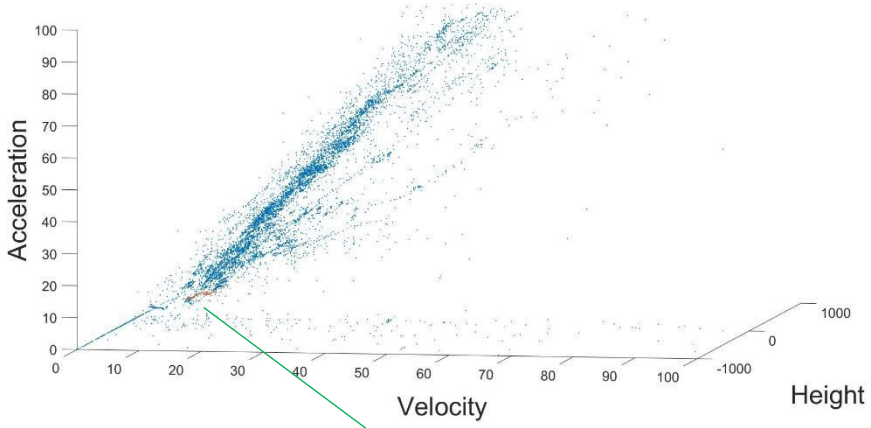
Drone raw detections

False targets dominating the output

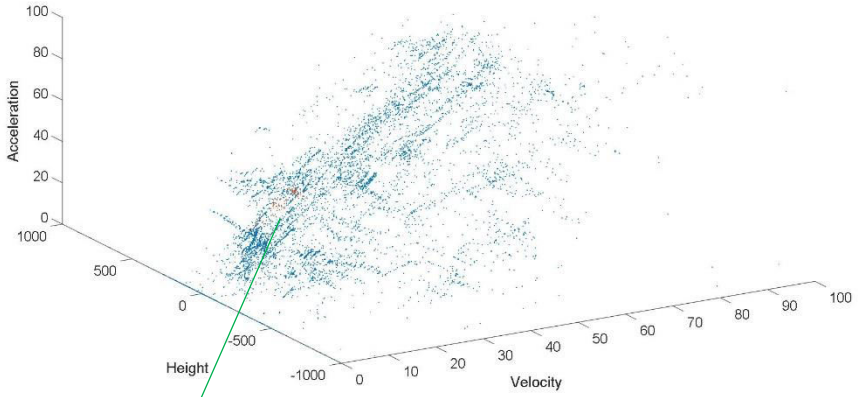
Identifying distinguishing features

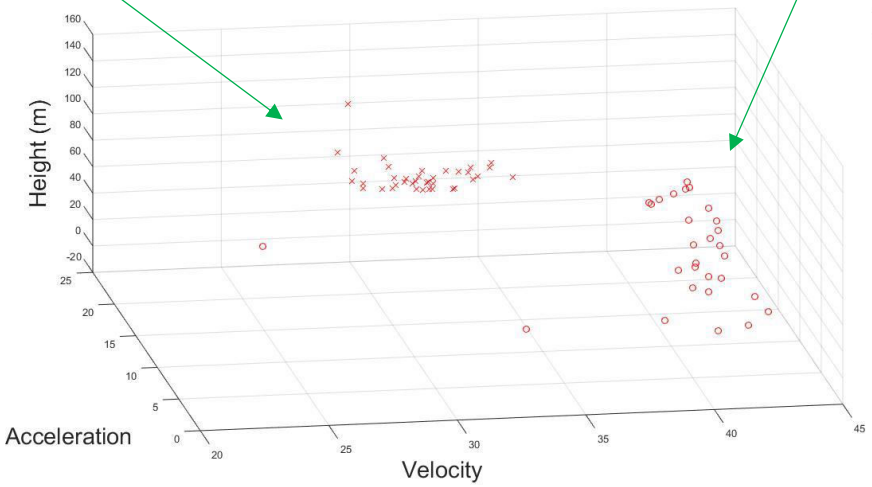
Drone discrimination using features relating to flight profile

Radar output for inbound track



Radar output for outbound track





Holographic Radar™ view of the world

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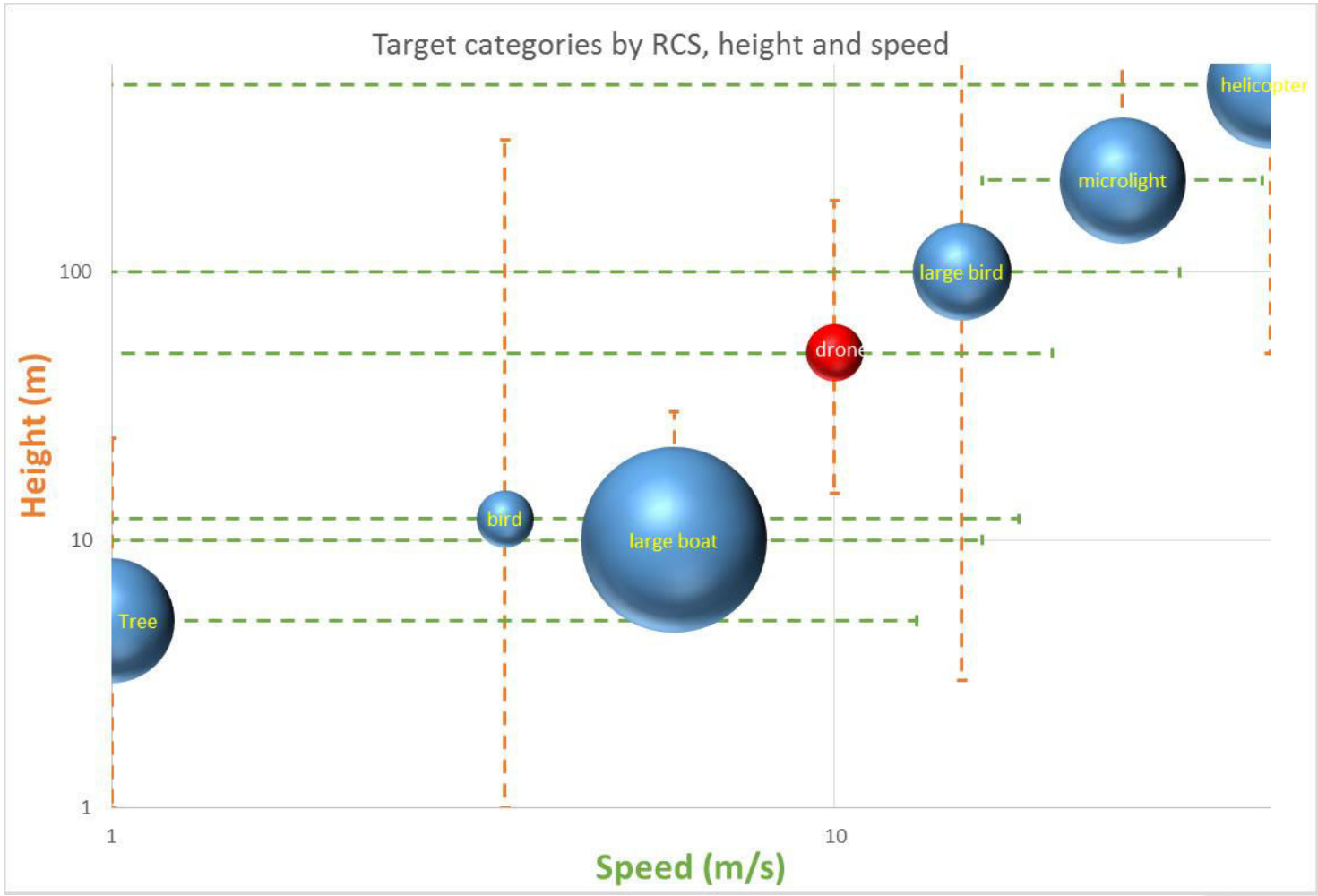
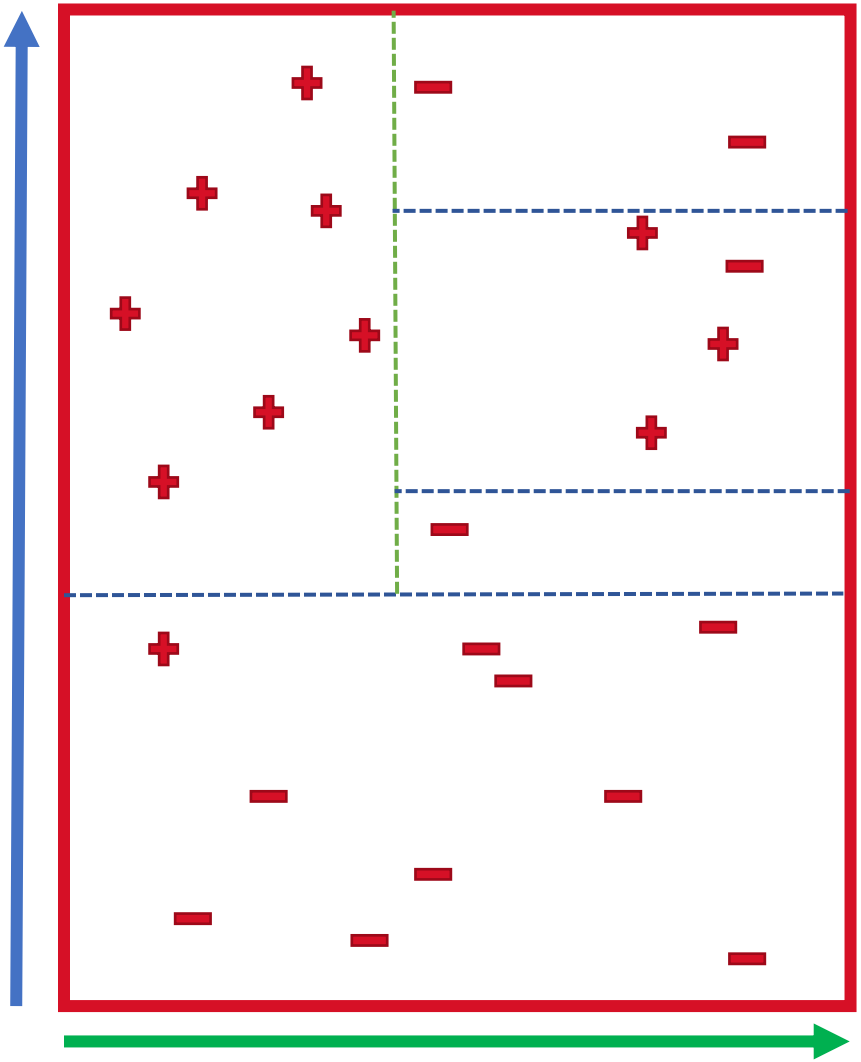
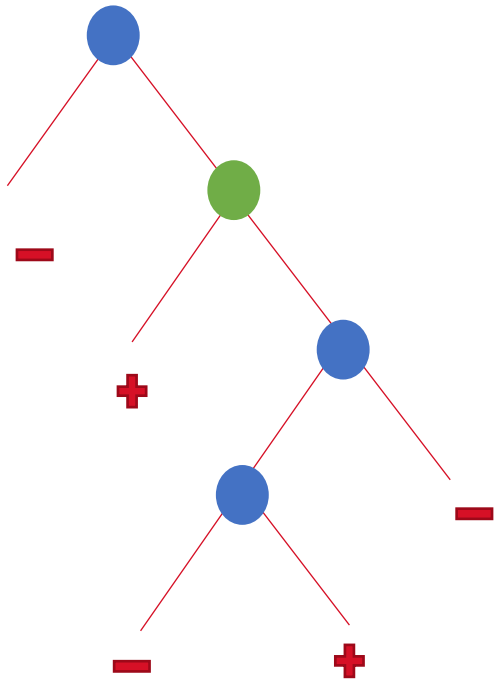
Understanding the object categories



Using machine learning for classification

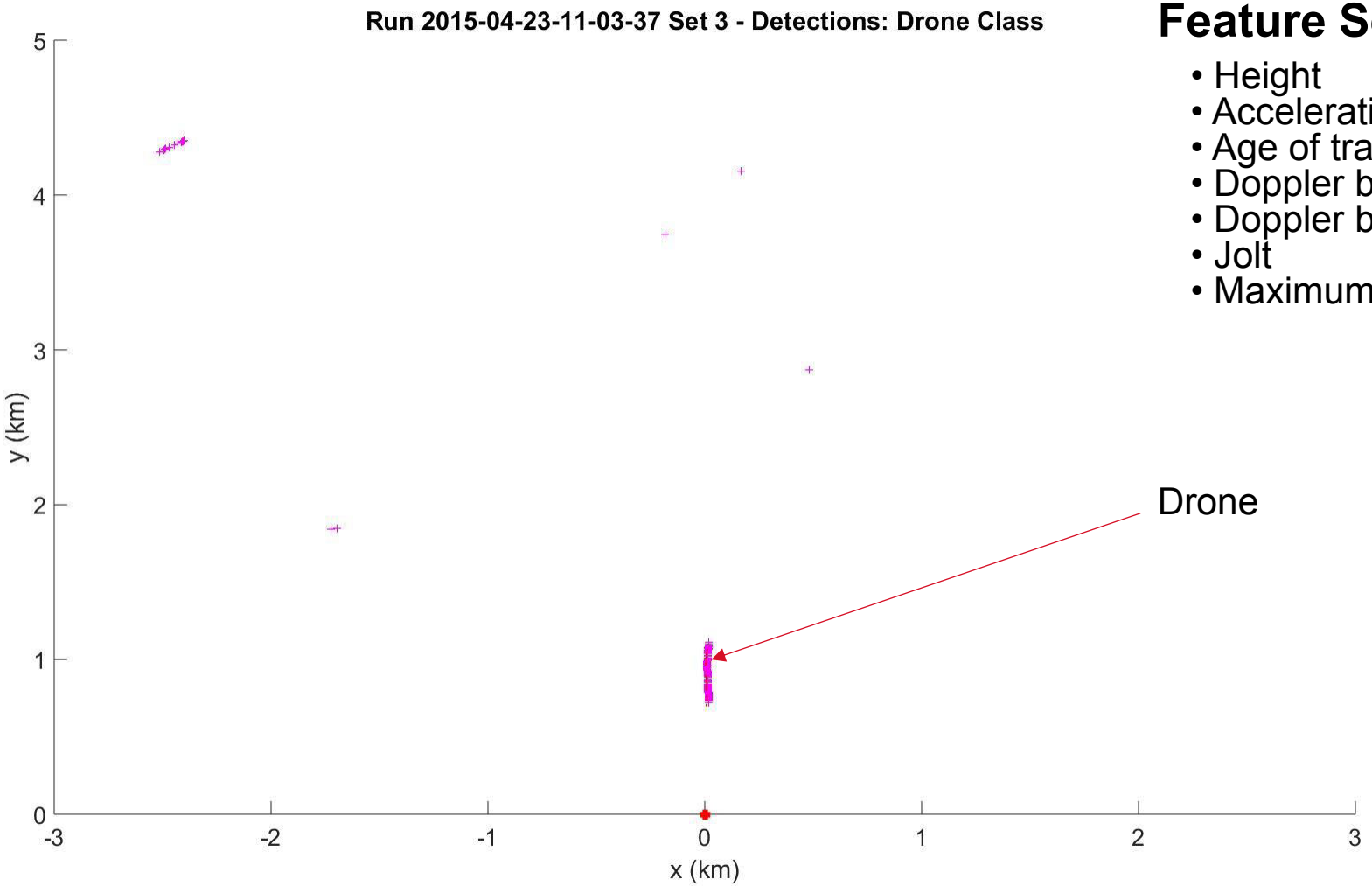
Decision Tree





Drone discrimination

Result obtained with Decision Tree



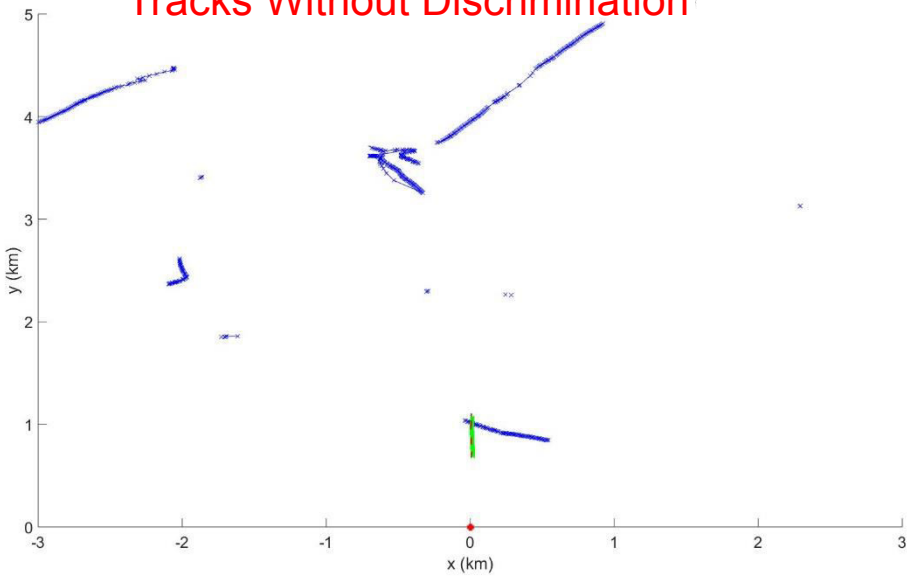
Feature Set

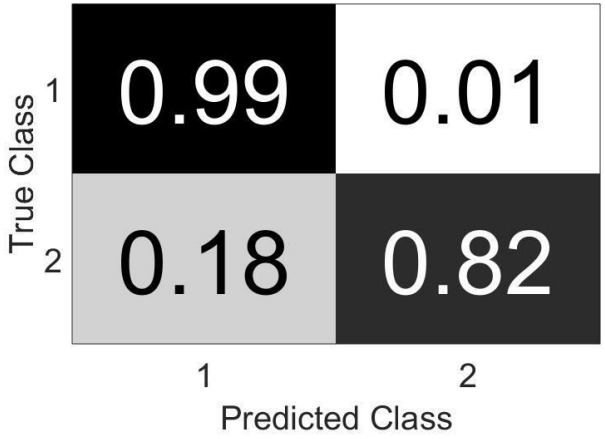
- Height
- Acceleration
- Age of track
- Doppler bin
- Doppler bin rate
- Jolt
- Maximum height

Drone discrimination

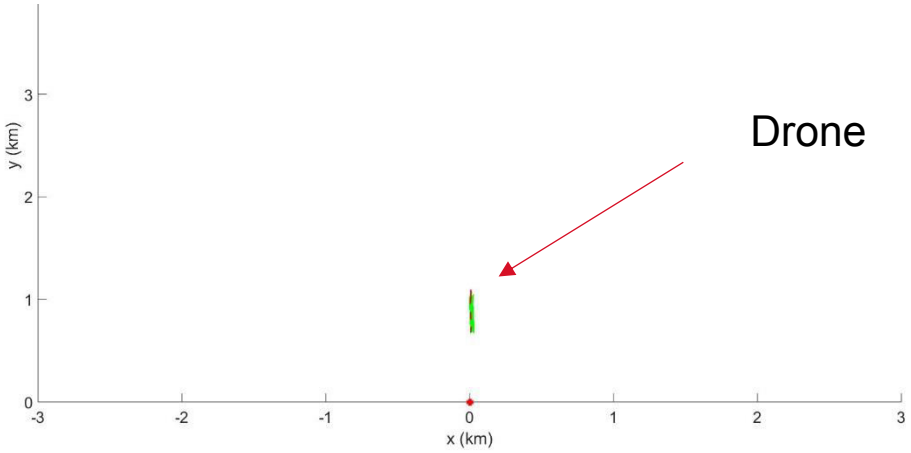
Training and testing on same target using different data from same trial

Tracks Without Discrimination





Tracks With Discrimination



Discrimination aided by continuous dwell-

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Why it helps having a staring system

- Drones are highly manoeuvrable
- 100% time on target provides two key advantages

1. Continuous estimation of the flight trajectory
   - High update rate provide very good information on position of the target
   - Helps to identify subtle difference between drone and non-drone targets' flight profile
2. Longer integration means very fine Doppler resolution
   - Enables the detection of Micro-Doppler characteristics such as that from rotating blades which are a powerful discriminant

Gamekeeper Holographic Radar™

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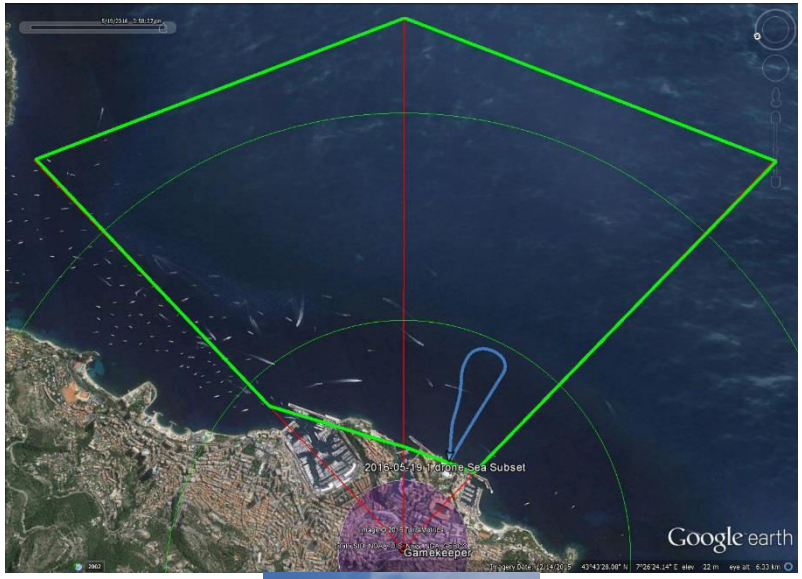
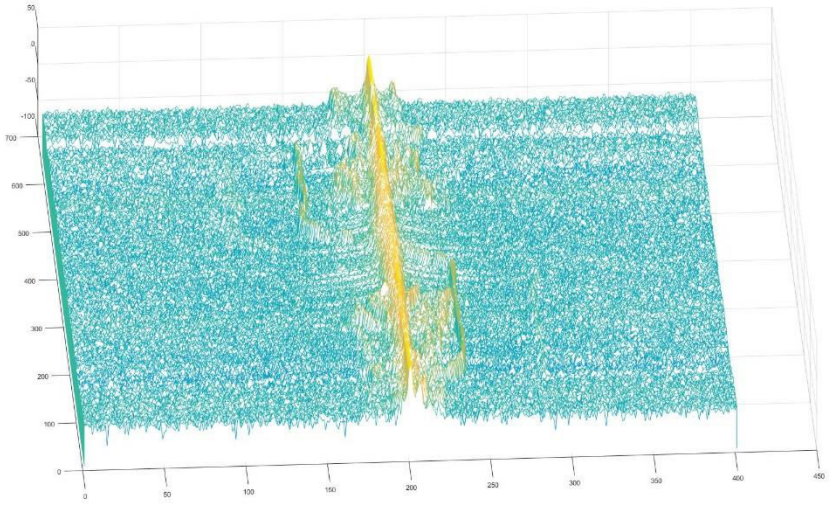
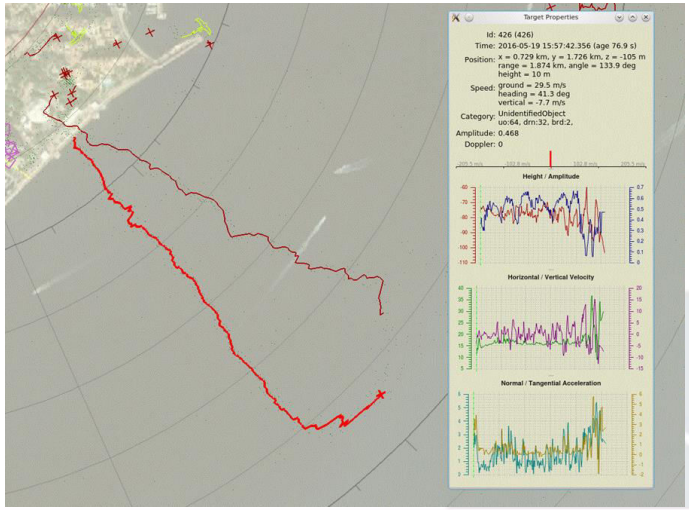
Monaco deployment







Summary

- Staring Holographic Radar provides sufficient sensitivity to detect micro-Drones (0.01 m^2) out to 5km range
- Staring, 3-D Height, Fine Doppler and Rapid Update enables reliable drone discrimination from birds and similar confuser targets
- Decision Tree machine learning provided good discrimination based on features derived from flight profile
- Micro-Doppler offers potential for more robust discrimination
- Aveillant radar selected for world's first complete civil drone protection system in Monaco

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Contact details:

Aveillant Ltd
300 Science Park, Milton Road
Cambridge CB4 0XL
United Kingdom

Tel: +44(0)1223 226290
Email: enquiries@aveillant.com
Web: www.aveillant.com