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Staring radar for Drone Tracking and Recognition

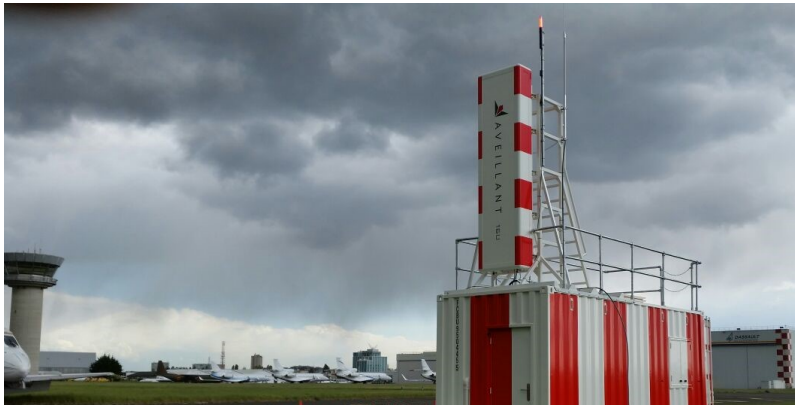
UDRC THEMED MEETING ON MULTIPLE OBJECT TRACKING AND DECENTRALISED PROCESSING
FRIDAY 14TH JANUARY 2022

Contents

Introduction: Background

Aveillant's Gamekeeper radar is the leading radar for long range drone detection, tracking and recognition.

- Deployed at several airports worldwide



Benefits from use of Holographic sensing

- Sometime called Staring or Ubiquitous

Advantages for tracking & recognition of drones

- 3D – discrimination of air & ground targets
- Fine Doppler resolution - Low MDV & Micro-Doppler discrimination
- Captures fleeting features, observes feature behaviour
- High track rates

However, like traditional radars, predominantly use standard sequential approaches to detection, tracking and recognition/identification (DTI).

Non-Cooperative UAS Challenges

Small

- 30cm+ diameter
- Radar Cross Section ~0.01m^2+

Slow

- Hovering – 30m/s+

Low

- Ground - ???m
- Above and around ground "clutter"

Agile

- Pop-up targets, VTOL
- High acceleration
- Signatures can be fleeting

Non-cooperative

- Remote controlled with datalink?
- Pre-programmed, GPS controlled

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Non-Cooperative UAS Challenges

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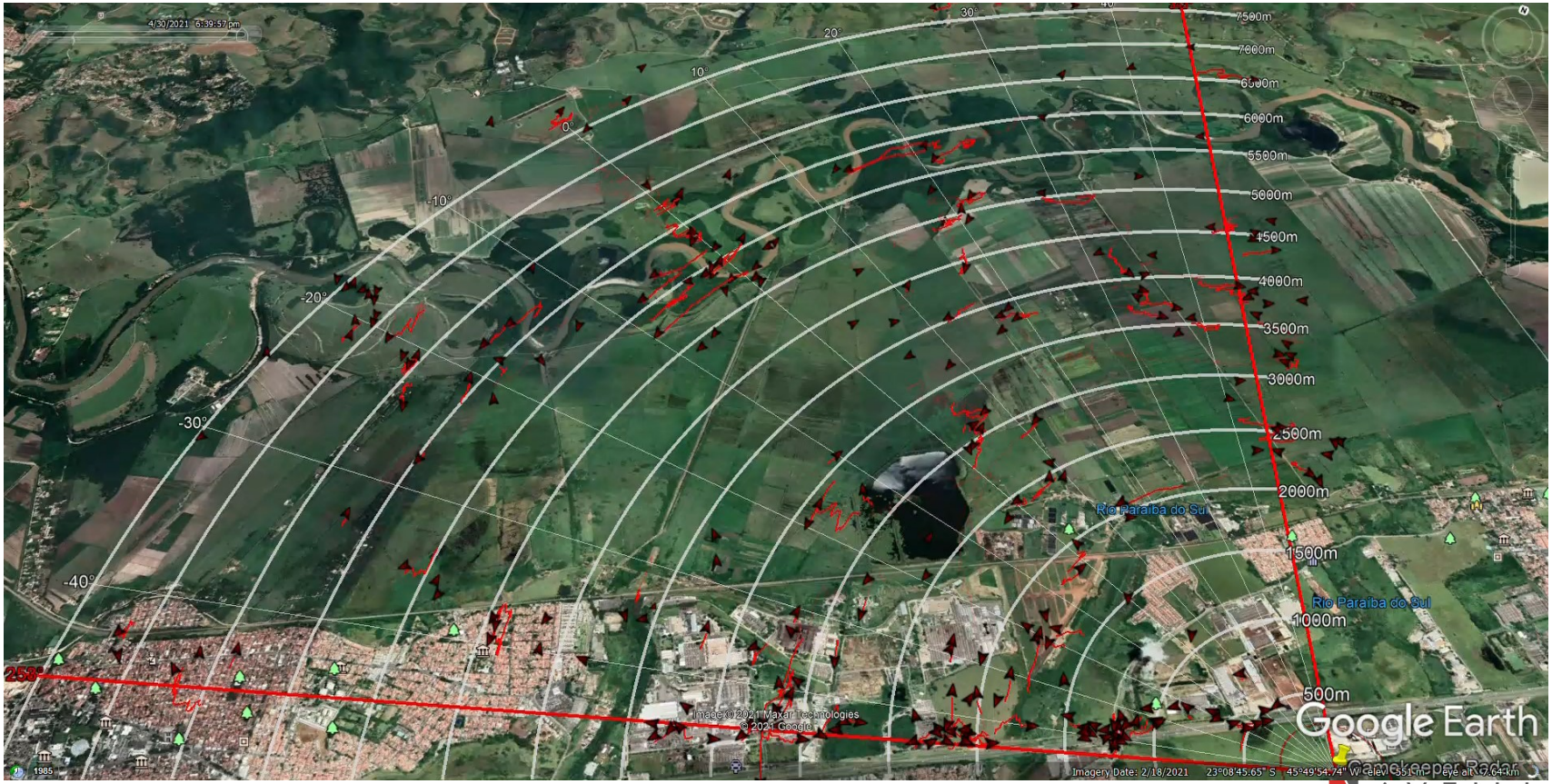
Challenges: Example



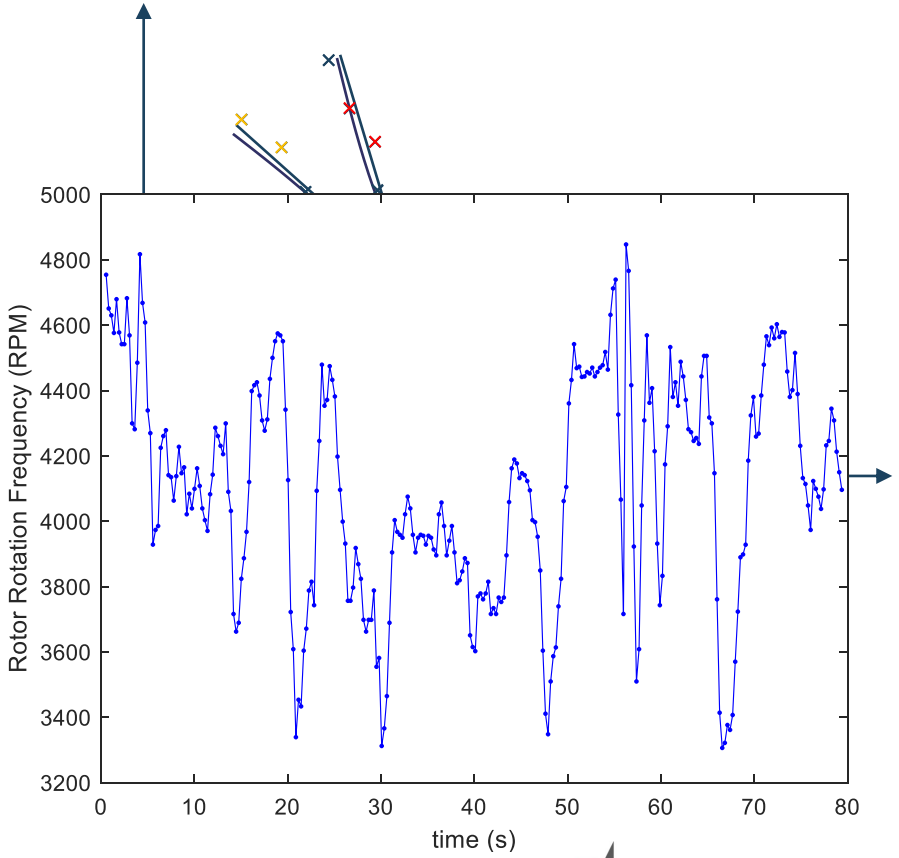
How drone recognition can improve drone tracking

Improved association

- Consider many targets in close proximity with similar trajectories
- Multiple Hypothesis trackers - assists effective decisions in tree/sets pruning
- Extended to track repair, increases track continuity

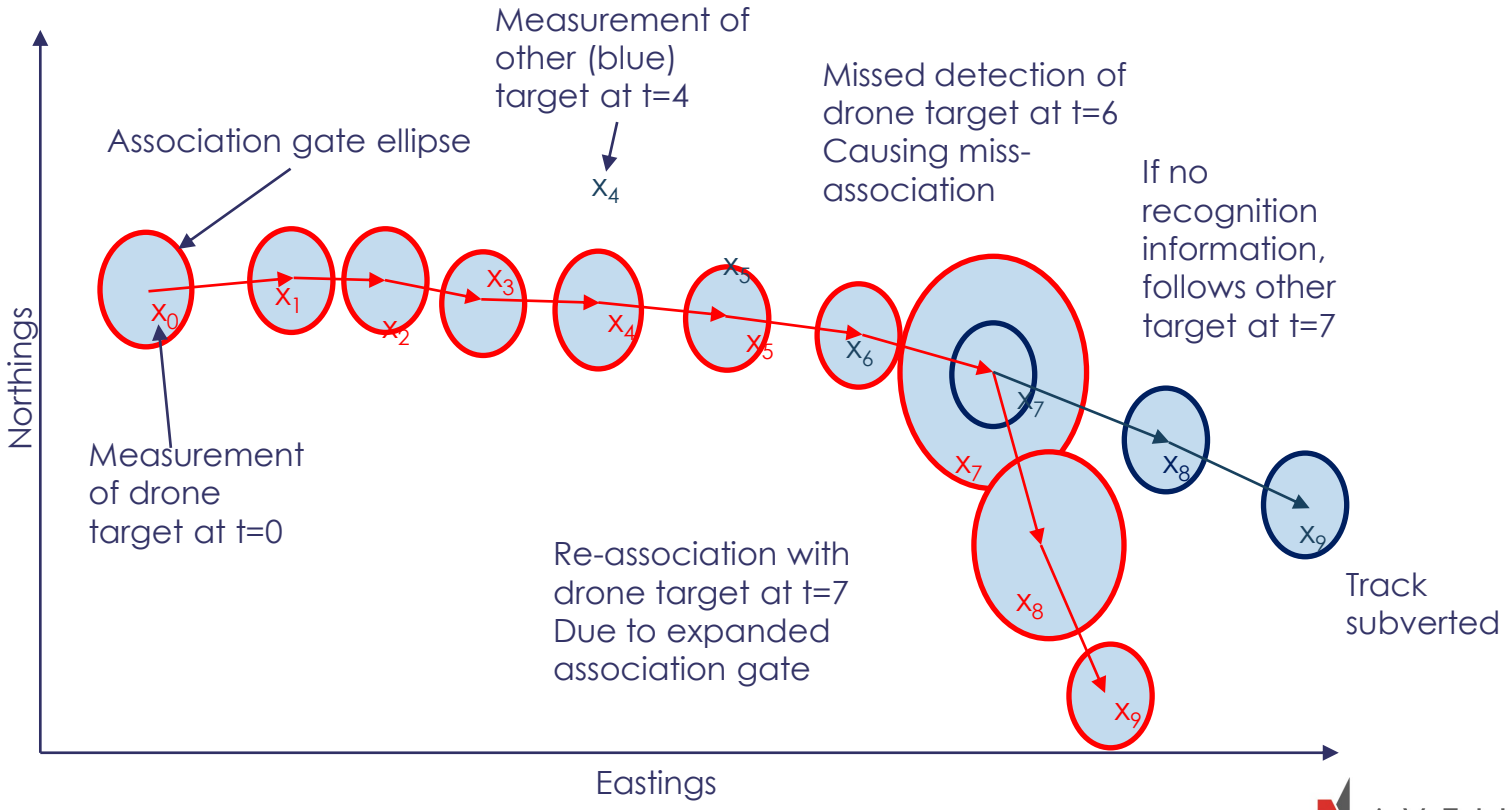
Tracking of recognisable features

- Staring radar advantage



How drone recognition can improve drone tracking

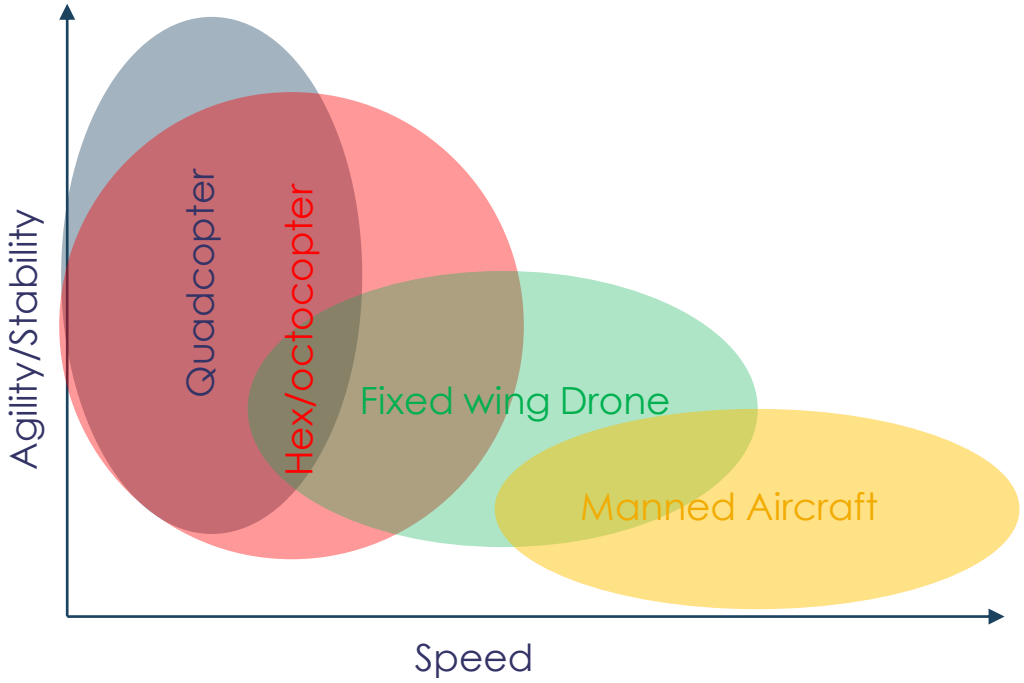
Reducing risk of track subversion



How drone recognition can improve drone tracking

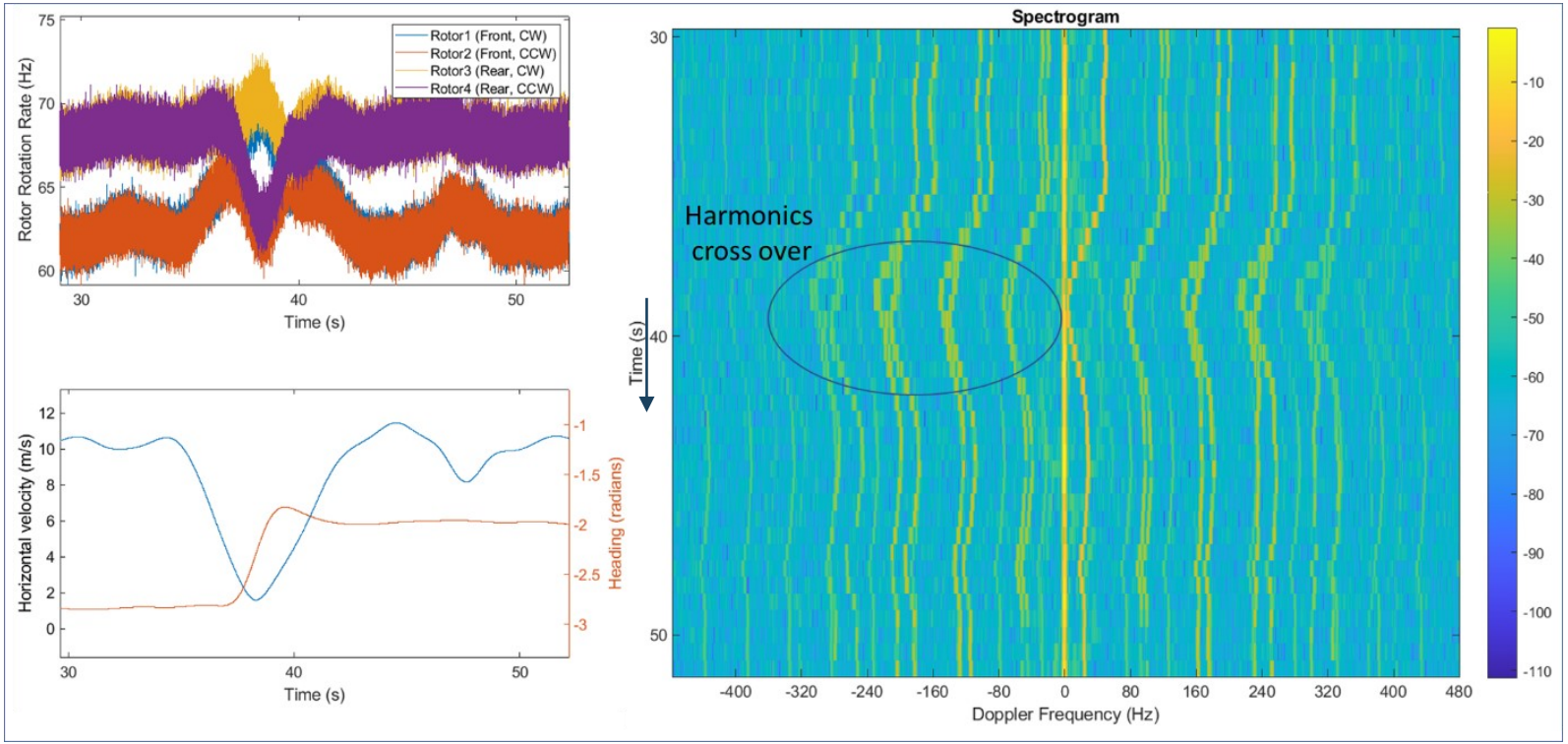
Tracker parametrisation

- Motion model choice
- Tailoring Innovation



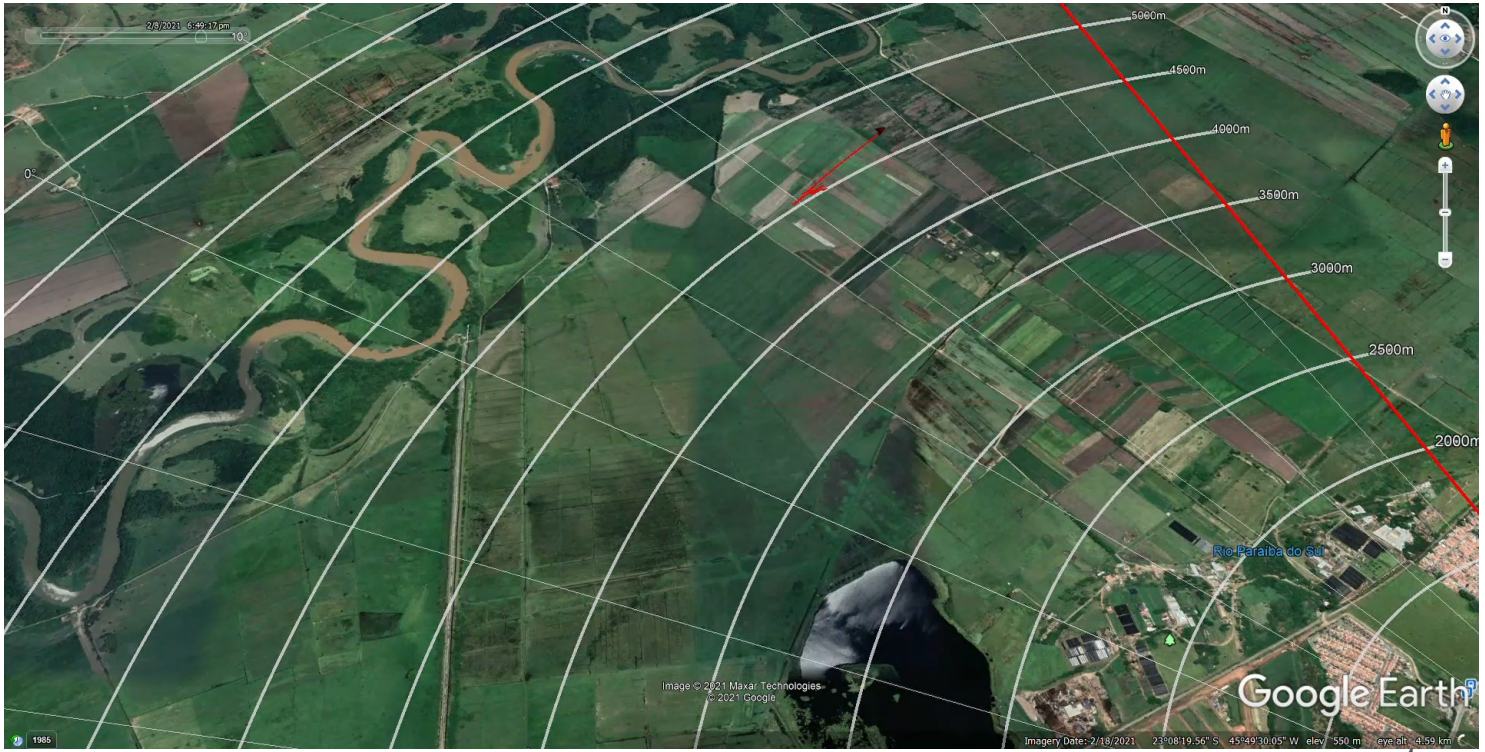
How drone recognition can improve drone tracking

Tracker parametrisation – reactivity, model evolution



How drone recognition can improve drone tracking

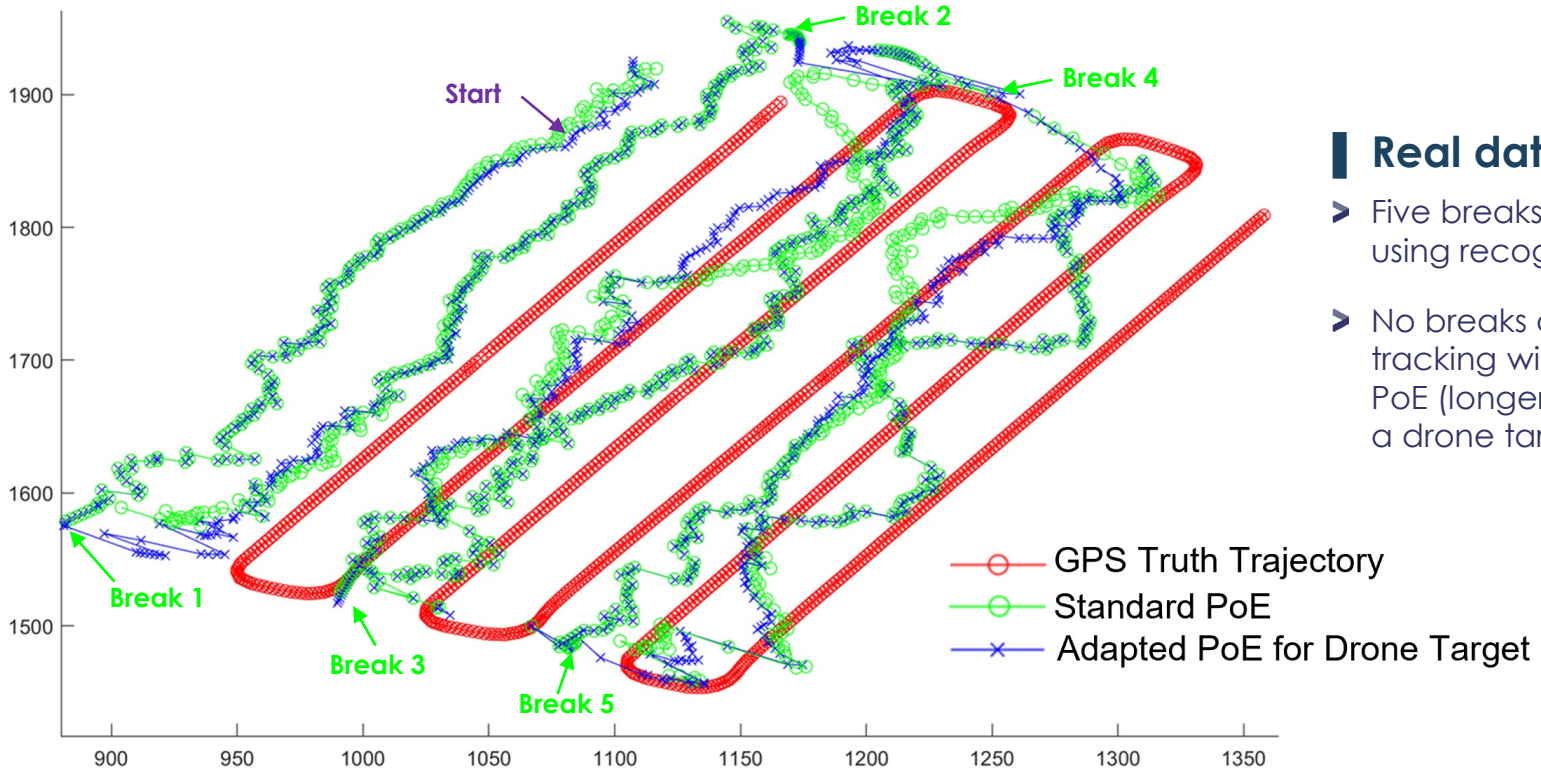
Reduction of the effects of multi-target track persistence



How drone recognition can improve drone tracking

Track initiation-maintenance can be improved by using recognition results

- Ensure drone track continuity, albeit missing detections, by adjusting the applied Probability of Existence (PoE) - using a higher survival prior or termination threshold



Real data

- Five breaks when not using recognition data
- No breaks and better tracking with class-aware PoE (longer coasting for a drone target)

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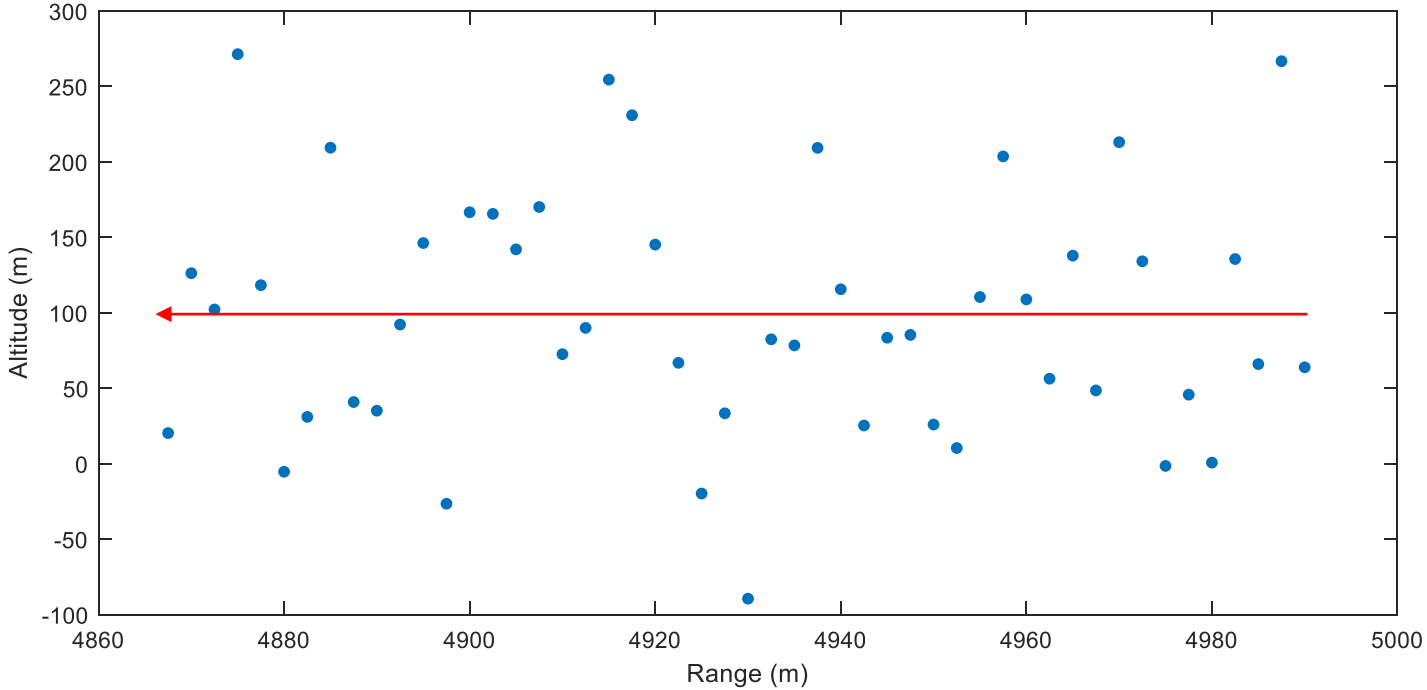
How effective drone tracking can improve drone recognition

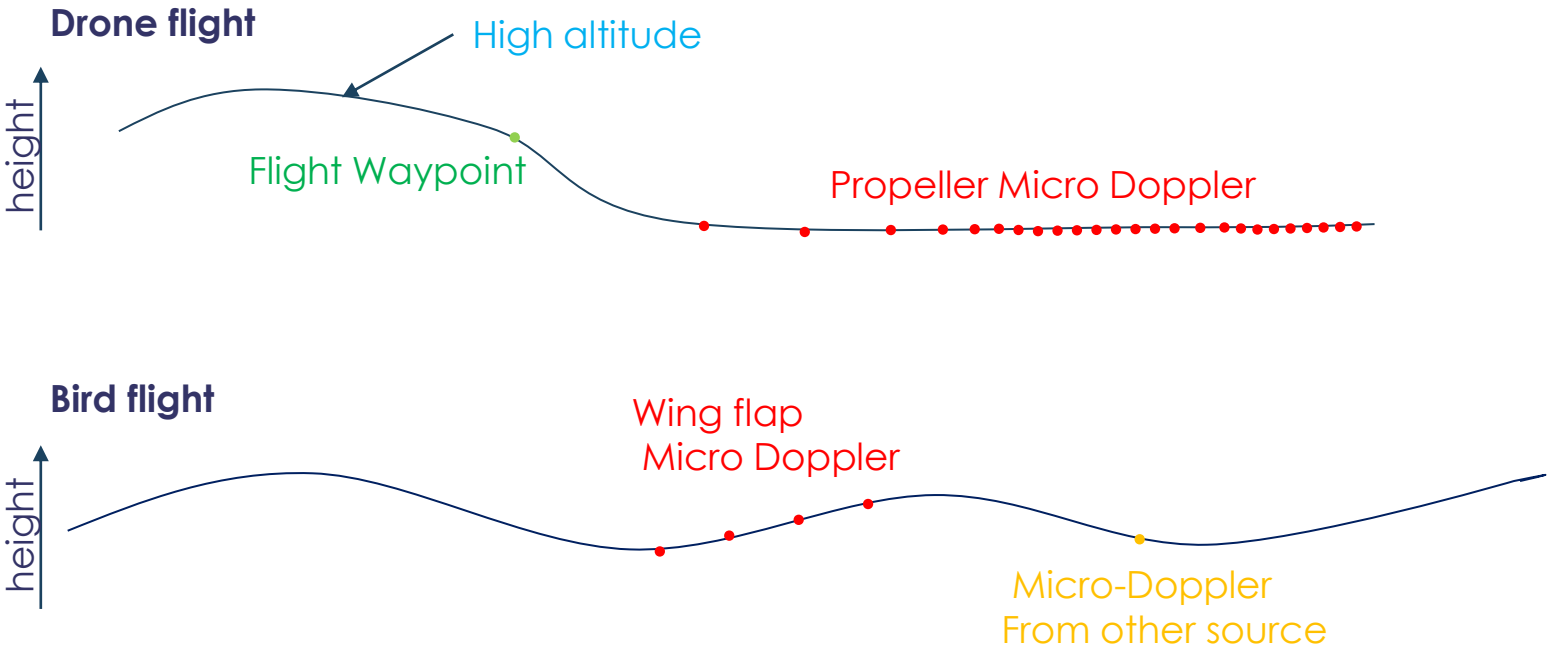
Improved accuracy of critical parameters – Airborne target?

- eg altitude given 1° accuracy



How effective drone tracking can improve drone recognition

Accumulation of recognitions cues



How effective drone tracking can improve drone recognition

Short target kinematics

- Speed, Altitude, flight stability

long term

- Flight pattern
  - Straight & level, weigh point flying, racetracks
- Association with environmental features (e.g. roads)
- Long term statistics of flight pattern or features

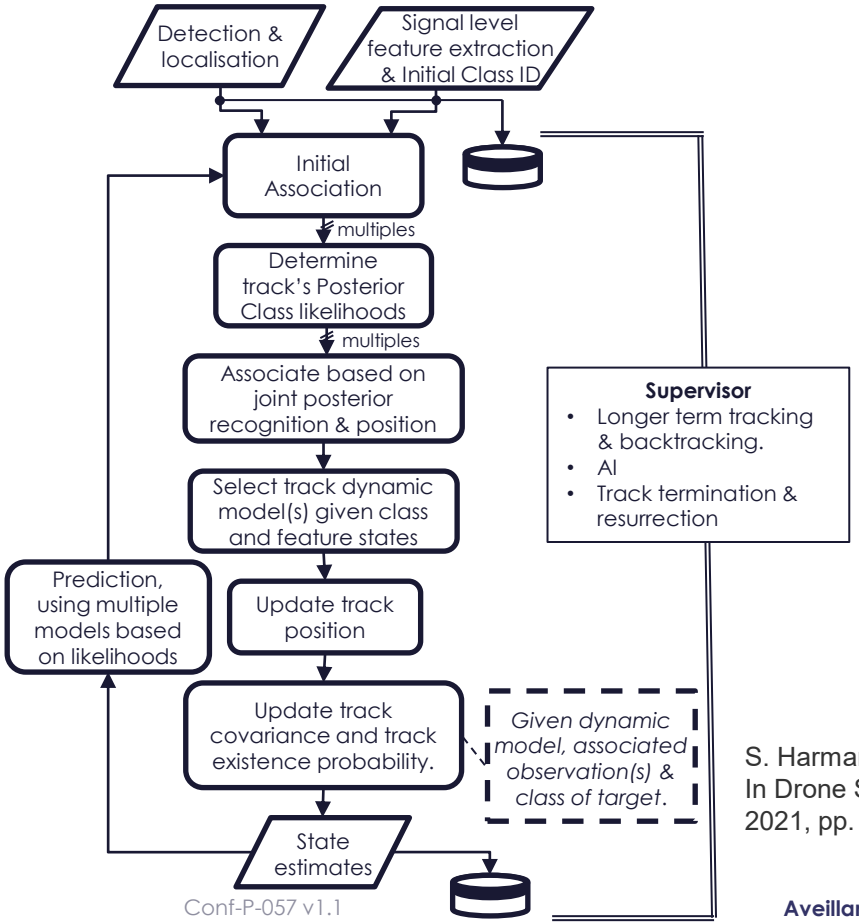
Retrospective classification

- e.g. Backward tracking,
  - improves early accuracy
  - repairs tracks increasing total information on a target

Features of Simultaneous Tracking and Recognition (STaR) of drones

- **STaR benefits tracking & recognition jointly,**
- **Desirable features of a STaR algorithm for drones**
  - A recognition hierarchy (tentative to consolidated)
  - Class tracking & likelihood
  - Feature tracking & feature values (e.g. rotor frequencies)
  - Multiple tracking & classification models with choice based on kinematics, features & determined classifications
  - Retrospective decision making (longer term)
  - Improved supervision
    - Not just for track existence
    - E.g. for track reconstitution
    - For determining long term track behaviours

Proposed framework for STaR of drones algorithm

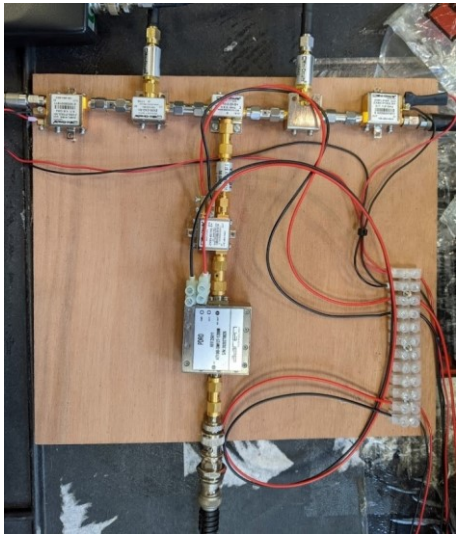


- **Initial association of multiple candidates**
- **Calculation of Joint posterior recognition and track likelihoods for each**
- **Selectable track dynamic models**
- **Supervisory 'agents' improving longer term tracking and overall track quality**

S. Harman and B. I. Ahmad, "The Need For Simultaneous Tracking And Recognition In Drone Surveillance Radar," *2021 21st International Radar Symposium (IRS)*, 2021, pp. 1-10, doi: 10.23919/IRS51887.2021.9466222.

Multistatic (“Polygraphic”) radar

- Multi-static Gamekeeper development for robust detection & sensing
- Low cost bistatic receiver development



Cranfield Defence and Security

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Ongoing development

Internally (PV) funded and customer funded R&D

- Merging elements & additional features of signal processing into trackers
- Multistatic holographic radar developments

University of Cambridge PhD

- "Bayesian Learning for Object Recognition from Noisy Time Series"

Sorbonne Centre for AI (Abu Dhabi) PhDs

- "Collaborative Multi-Agents Tool for meta-Sensors – Radar & Auxiliary sensors for AI"
- "Hybrid AI for the design of Intelligent radars, Joint recognition and tracking of drones in complex environments"

Cranfield University PhD

- "Target Detection and Classification with the Aveillant Holographic Radar" (multistatic)

Concluding remarks

- **The need and benefits of simultaneous tracking and recognition approach for drone surveillance radar (and potentially other sensors) was highlighted**
  - good target recognition in order to provide effective tracking and good tracking to provide effective recognition
- **A framework for a STaR algorithm is provided and the merits of staring radar for this application is discussed.**
- **A software-defined Holographic radar such as the Gamekeeper is particularly suited to exploit STaR algorithms given**
  - Persistent sensing
  - its ability to adapt its applied processing or revisit processed data to improve performance, including in real-time.
- **Next generation multi-static Holographic radar introduced**

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Thank you

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