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Multi-modelling of Cooperative Swarms

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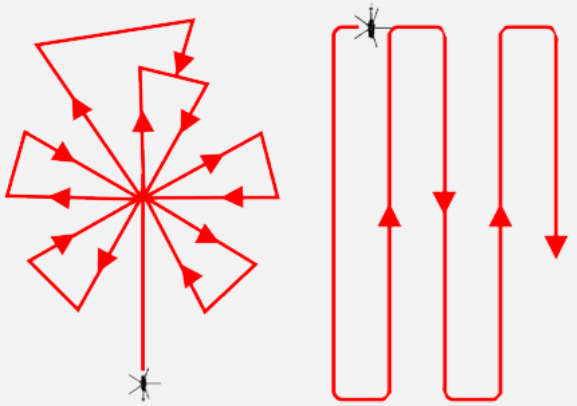
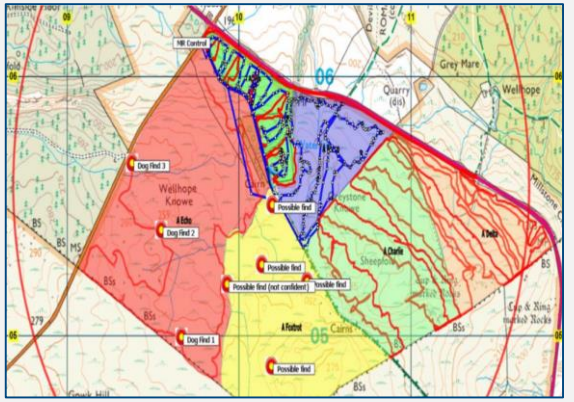
Overview

- Search and Rescue
- Drone Multi-model
- Controller and Results
- Conclusions and Future Work

Search and Rescue

- **Collaboration** between multiple agencies
- Increasing use of COTS drones **ad hoc**
  - Need for evidence, guidelines, and solutions
- Rare use of **expensive** field trials
  - UK 1987, 2008, 2017
- Working hypothesis: collaborative modelling can produce a viable and cost-effective **platform for virtual field trials**

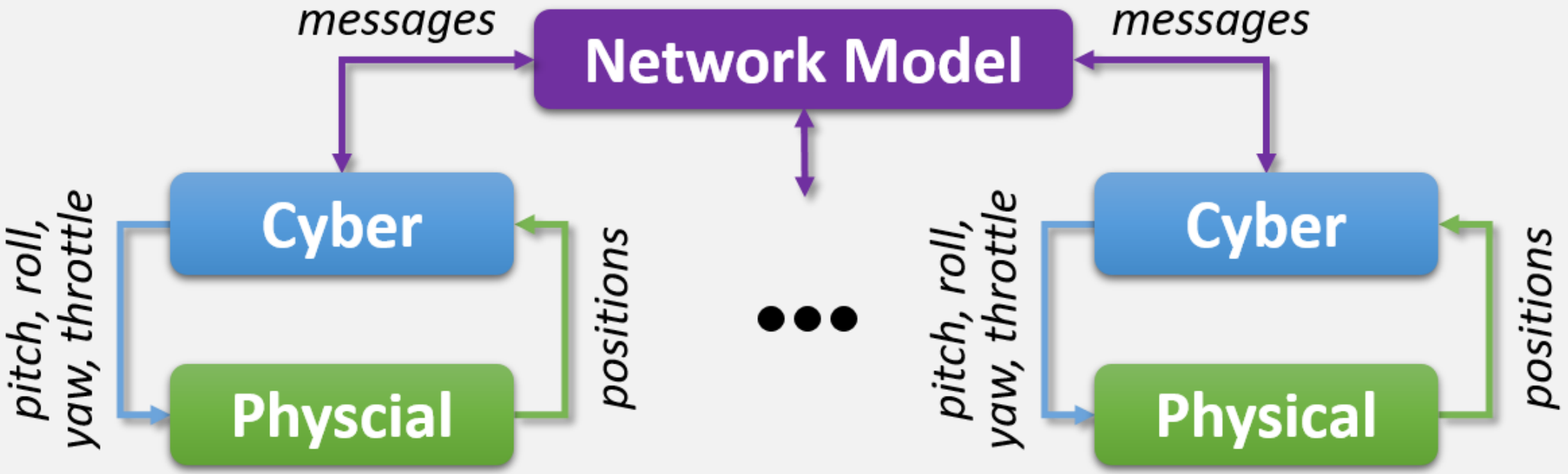




Hamilton et al., 2017.

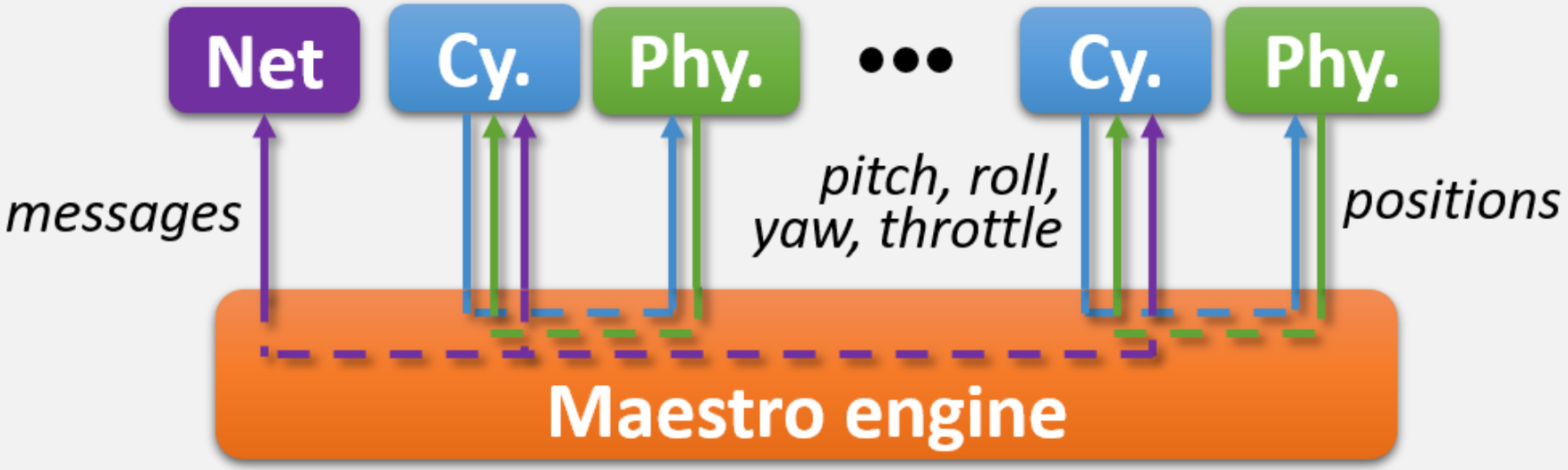
Multi-model (Logical View)

- Cyber-physical pairs representing each drone
- Cyber models connect via network model



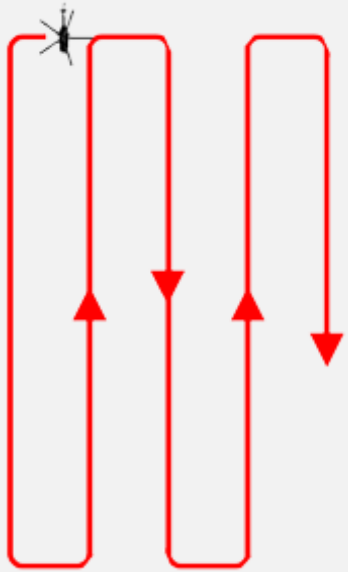
Multi-model (FMI View)

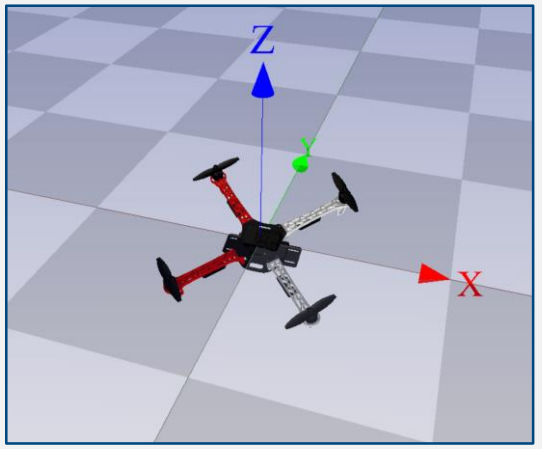
- Cyber, physical and network FMUs
- Connected through Maestro engine

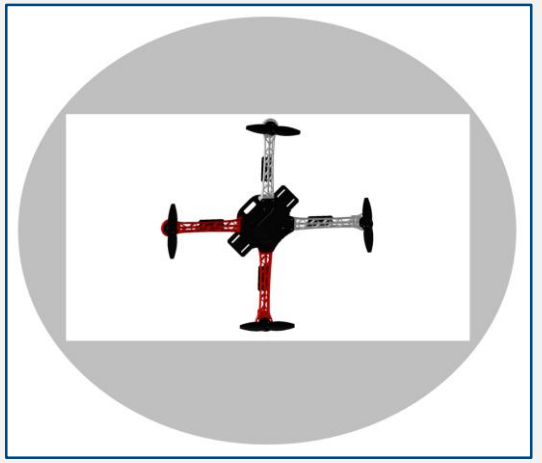


Scenario

- Initial virtual field trial
  - Grid search using Parallel Track Search
  - Multiple drones
  - Coordinated searching
  - Return-to-base for refuelling
  - Resilience to failed drones
- Drone
  - Quadcopter
  - Dual camera (infrared and visual)

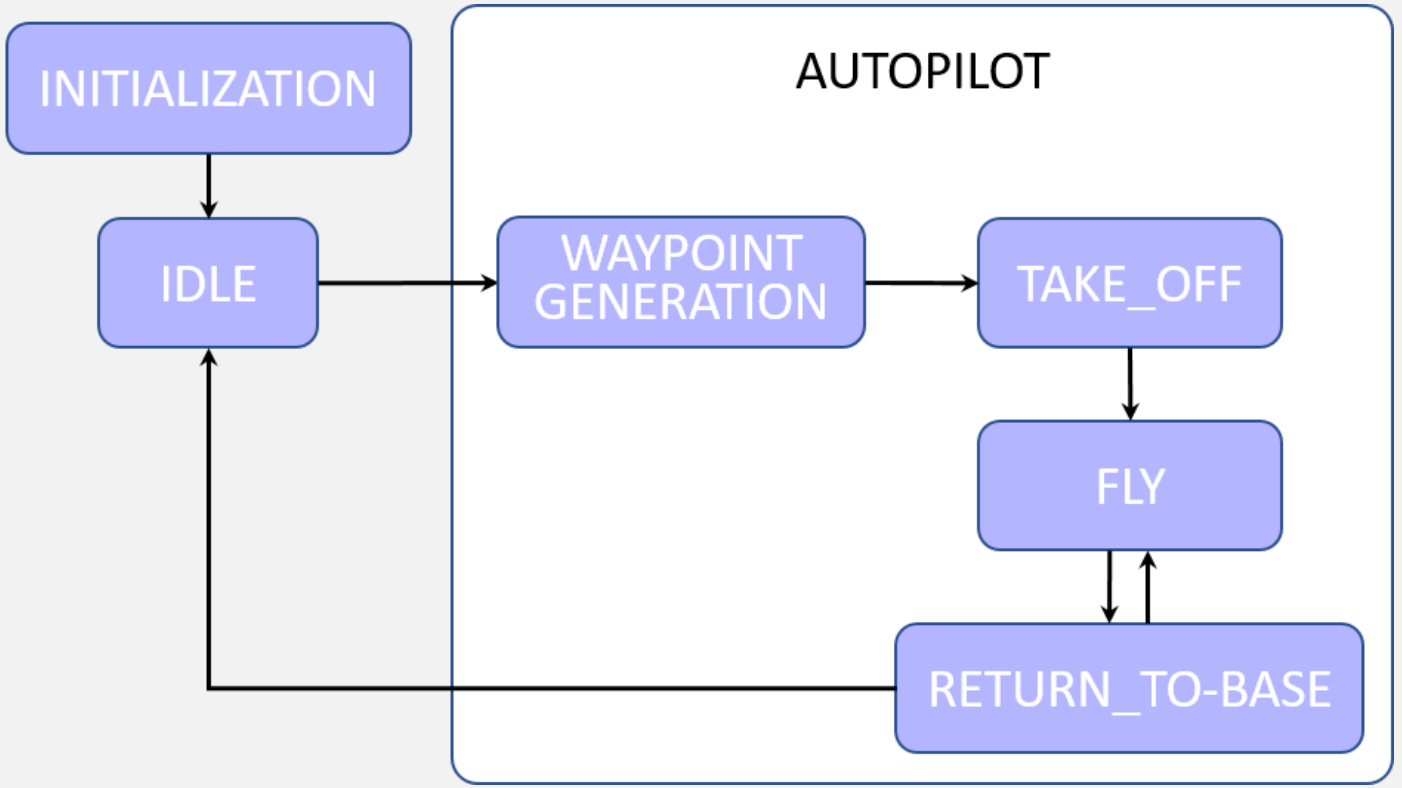




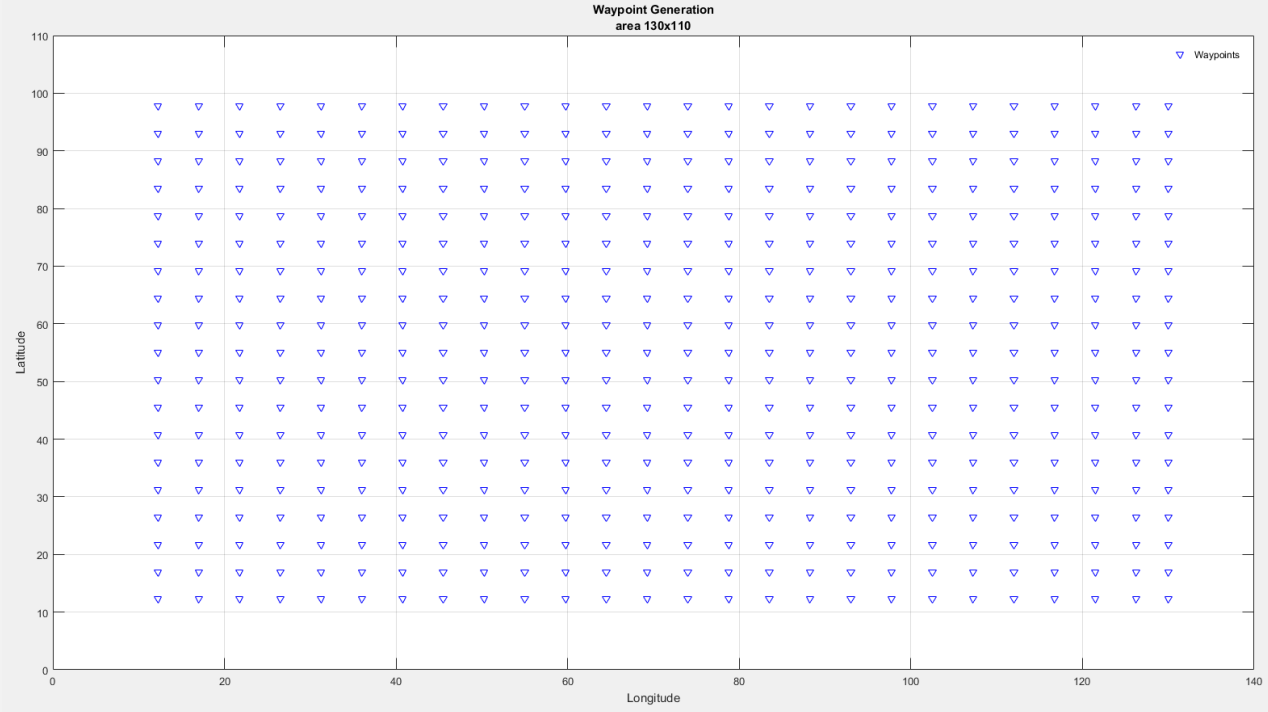


Controller Model

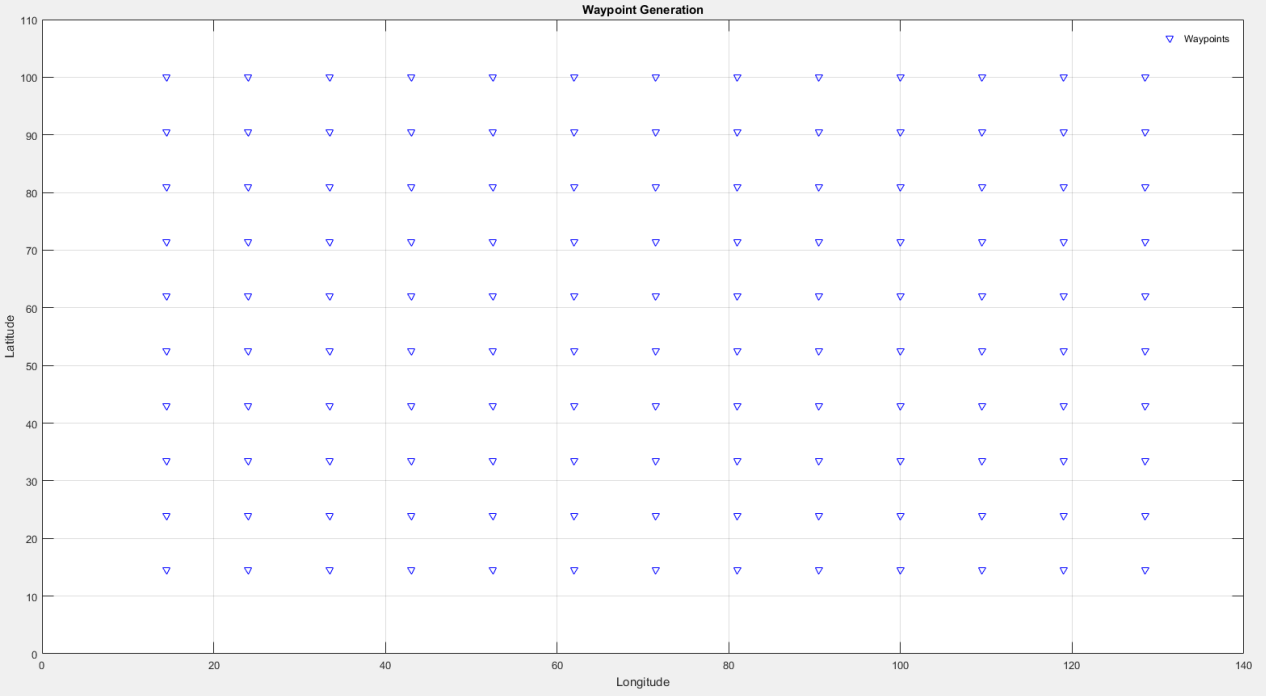
- Modal control
- Flight control
  - Pitch
  - Roll
  - Yaw
  - Throttle
- Messaging
  - Send / receive position
  - Leader election



Waypoint Generation

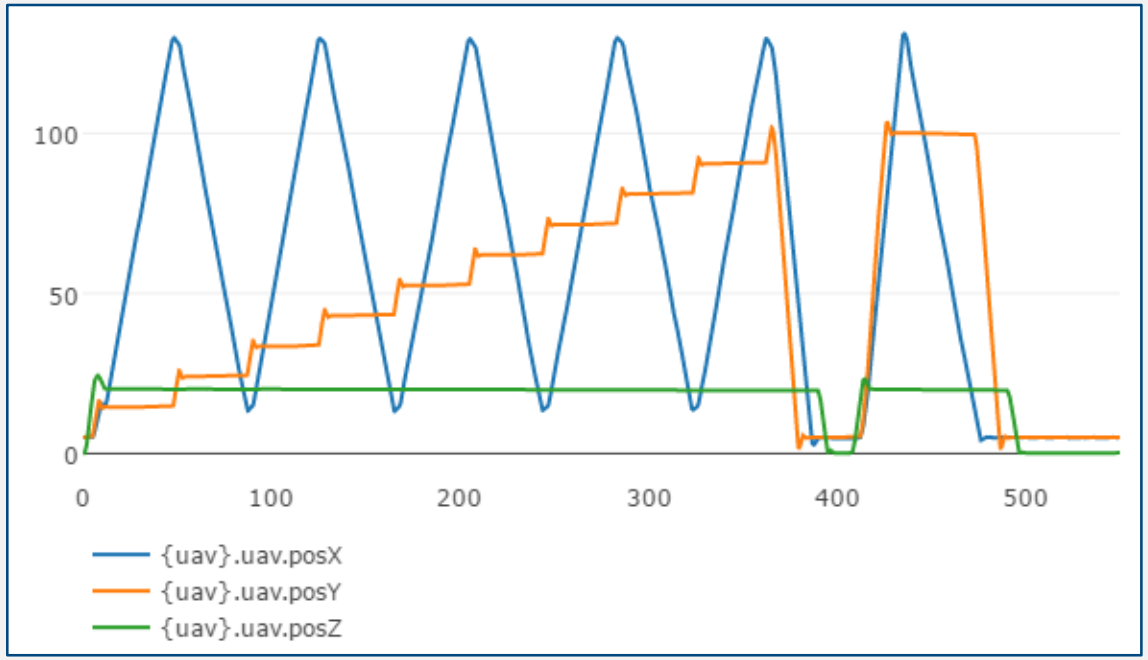


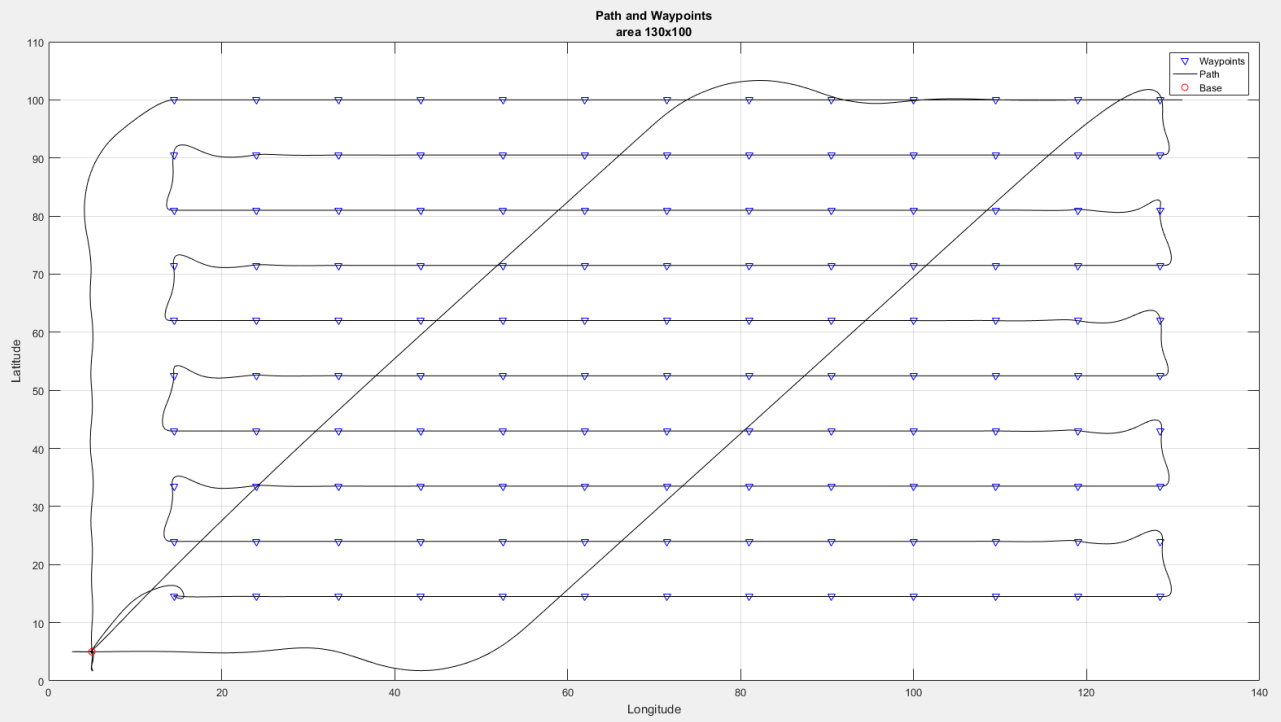
Camera: 5x5
Waypoints: 494



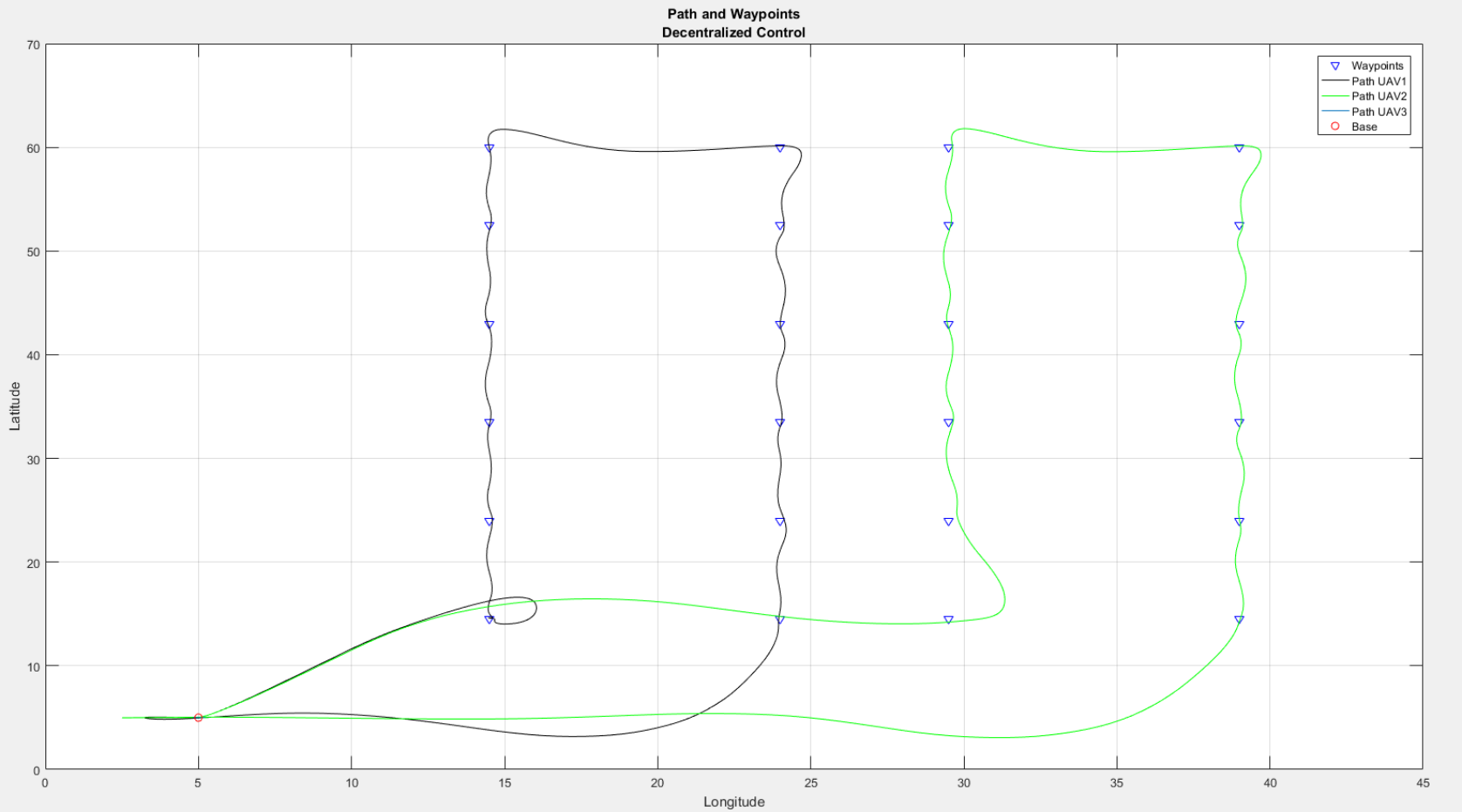
Camera: 10x10
Waypoints: 130

Single UAV

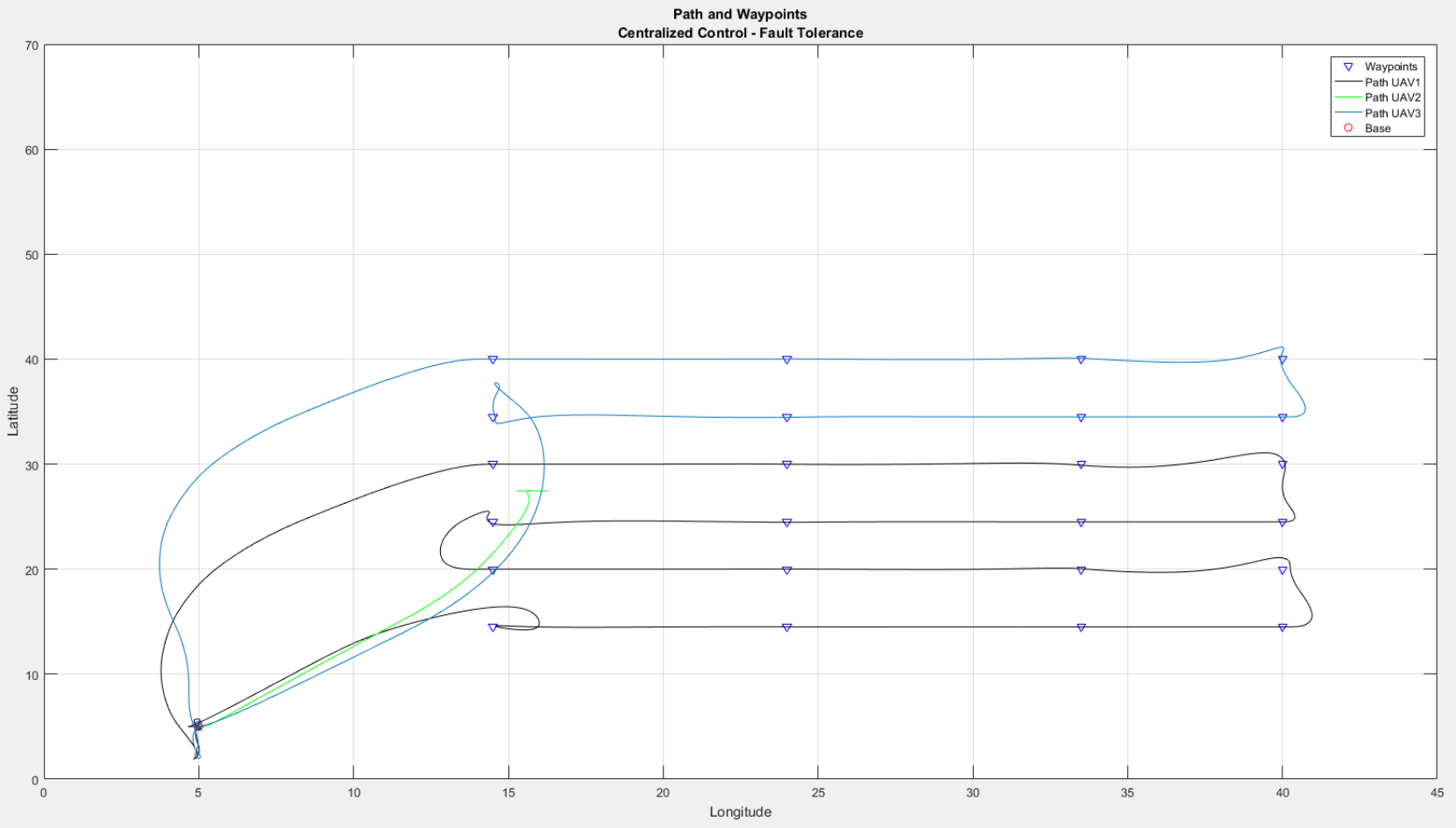

100
50
0
0
100
200
300
400
500
{uav}.uav.posX
{uav}.uav.posY
{uav}.uav.posZ


Path and Waypoints
area 130x100
Waypoints
Path
Base
Latitude
Longitude
0
10
20
30
40
50
60
70
80
90
100
110
0
20
40
60
80
100
120
140

Decentralized Control Strategy

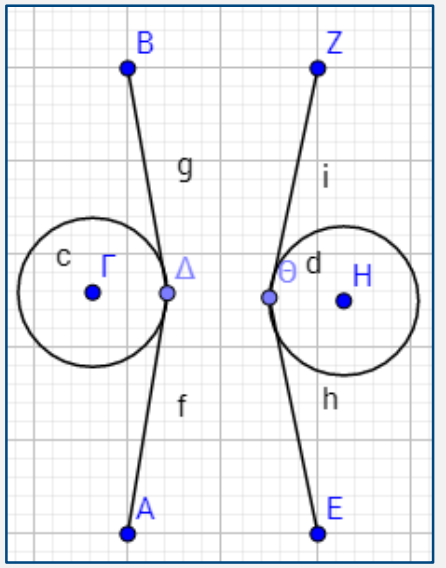


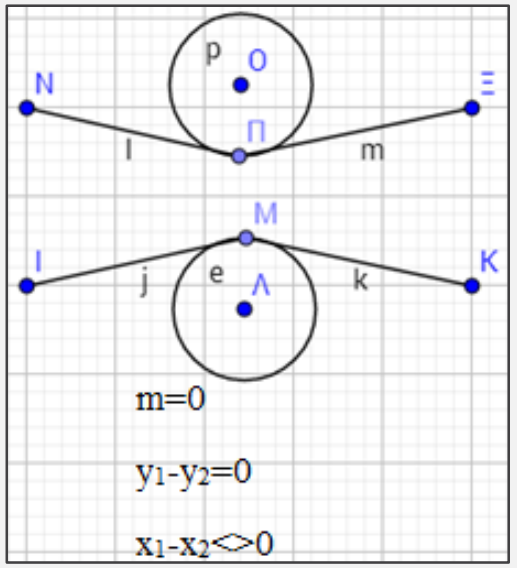
Fault Tolerance

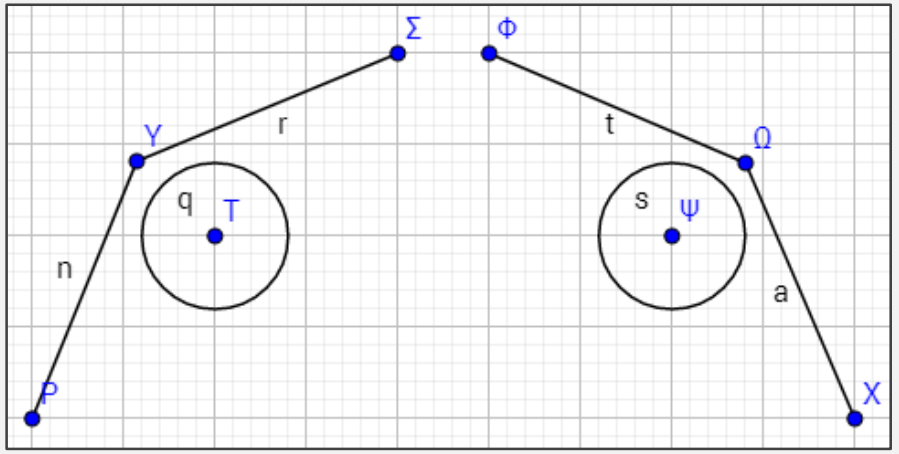


Avoidance Action

- Generation of intermediate points to avoid obstacles
- For line (x_1, y_1) and (x, y)
  - Slope is $m = \frac{y-y_1}{x-x_1}$
  - Diagonal line
    $m \neq 0, x - x_1 \neq 0, y - y_1 \neq 0$
  - Vertical line
    $m = \infty, x - x_1 = 0, y - y_1 \neq 0$
  - Horizontal line
    $m = 0, x - x_1 \neq 0, y - y_1 = 0$







Conclusions

- Application of collaborative MBSE produced a viable platform for **virtual field trial** in a limited study.
- Simulations aid **communication** with non-experts.
- Multi-modelling permits **concurrent engineering** by domain experts and flexibility, extensibility.

Future Work

- Improved models
  - Add environment / terrain models
  - Add human / dog team models
  - Improve network model
- Trade-space analysis / design space exploration
  - Search patterns, make-up of search teams, etc.
- Further scenarios, guidelines
- Multi-agency search, SoS aspects

References

Carl Hamilton, Dave Perkins, Pete Roberts, and Steve Hughes, *Exercise Northumberland Research Report*, Centre for Search Research, 2017.

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