Overview of the research activity of the CASCADE project

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EPSRC
Engineering and Physical Sciences Research Council

Mario Ferraro
M.Ferraro@soton.ac.uk


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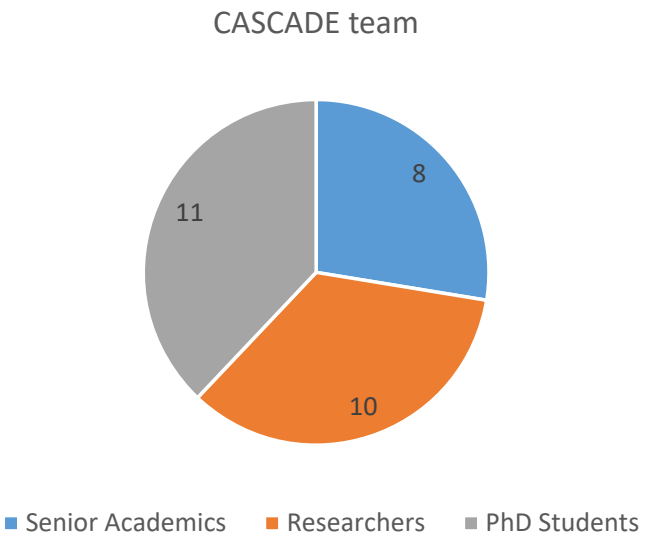
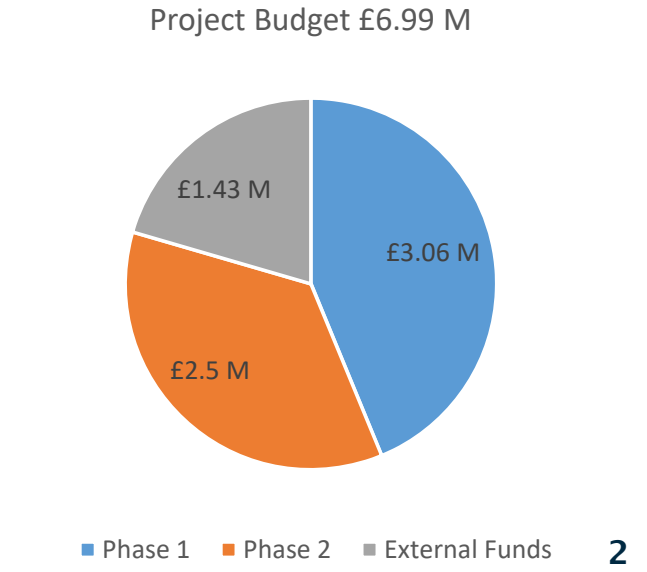
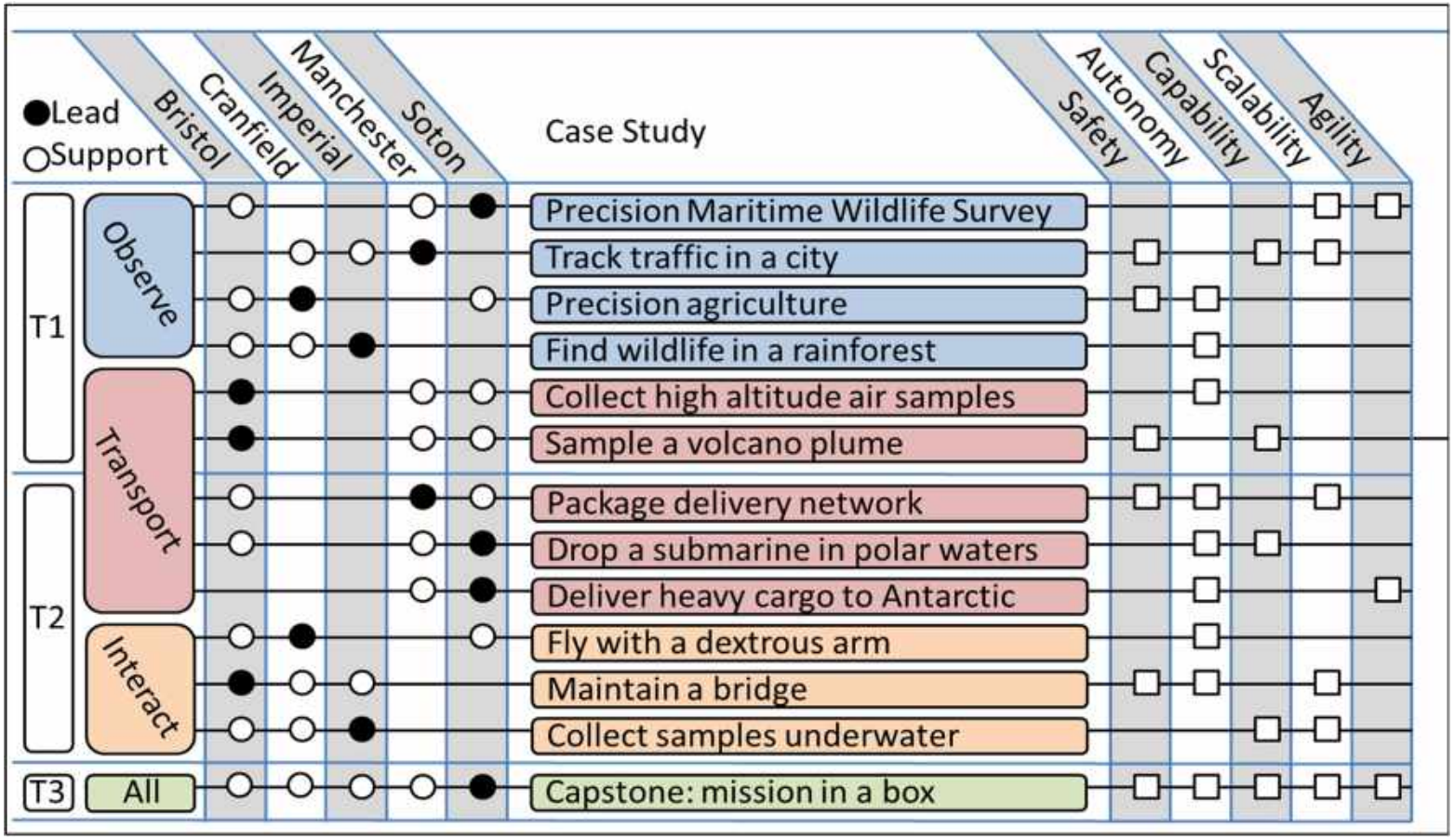

CASCADE team
8
11
10
Senior Academics
Researchers
PhD Students


Project Budget £6.99 M
£1.43 M
£3.06 M
£2.5 M
Phase 1
Phase 2
External Funds

CASCADE

Complex Autonomous Aircraft Systems Configuration, Analysis and Design Exploratory



- The goal of CASCADE is to accelerate the exploitation of aerial robotics across a wide range of science and industry applications
- Five-year project (currently in year two)
- It has already produced 13 scientific publications (5 journal papers and 8 conference papers) and several conference talks
- It has attracted £1.43 M of external funding, £800 k of which in monetary contribution from industrial sponsors

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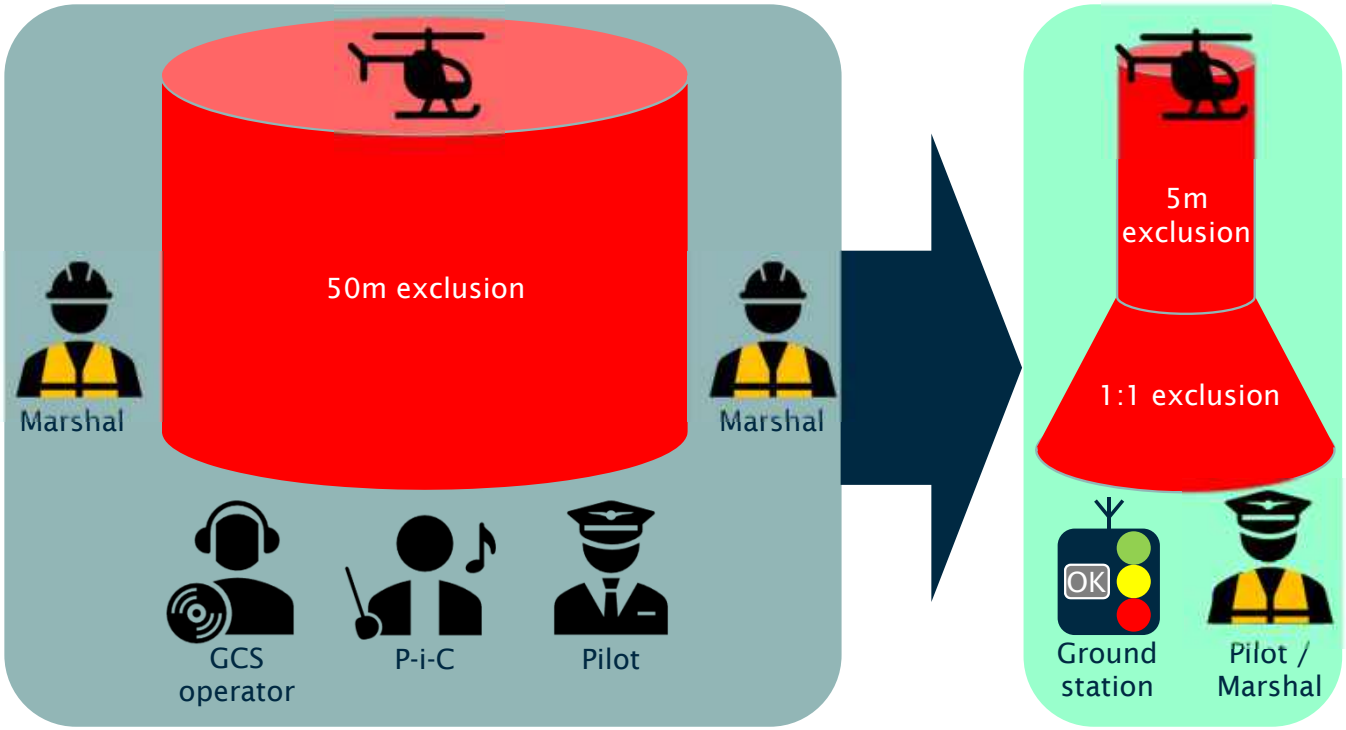
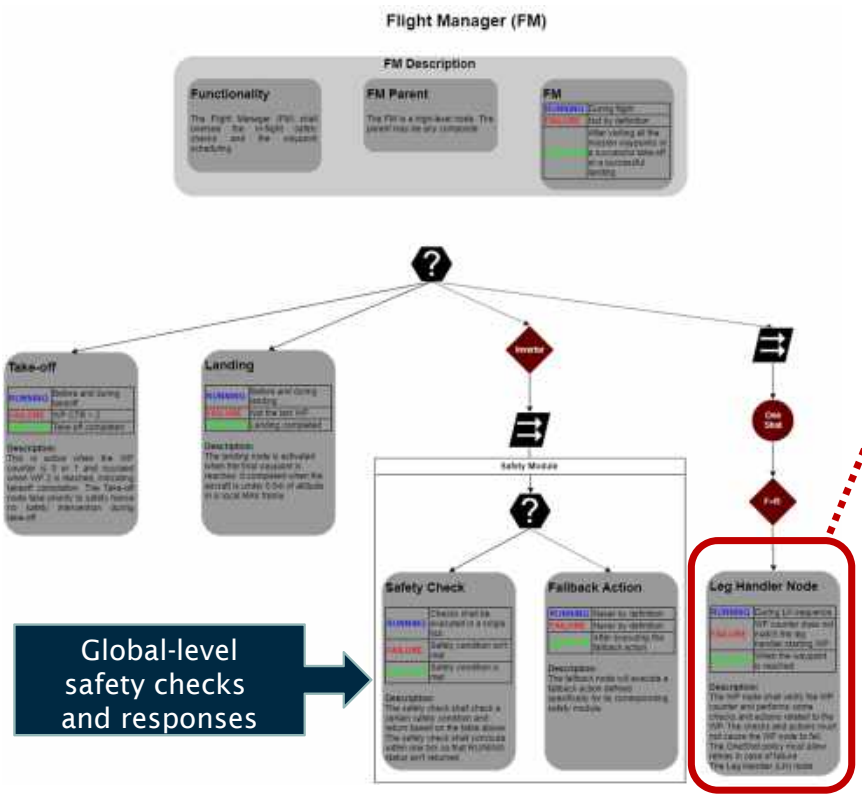
Single-Operator Infrastructure Inspection

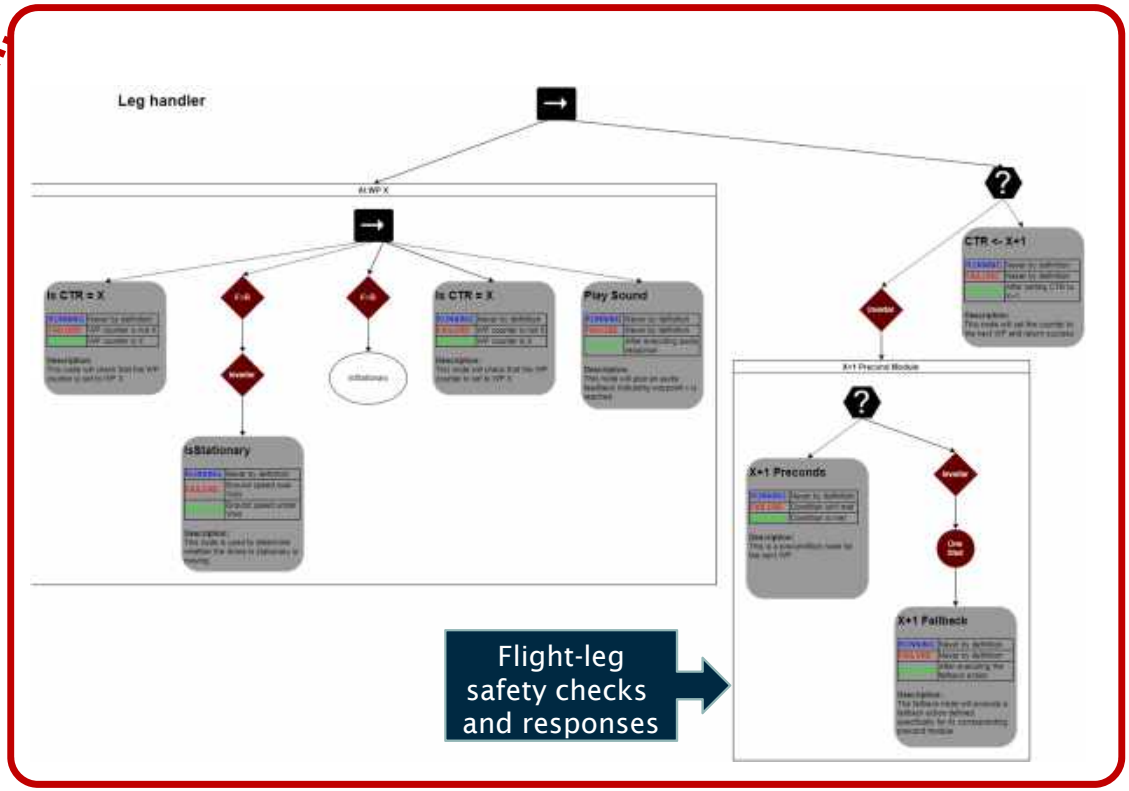
Use of advanced mission planning and automation to reduce the personnel necessary for inspection in high risk environments



Behaviour-tree-based mission planning

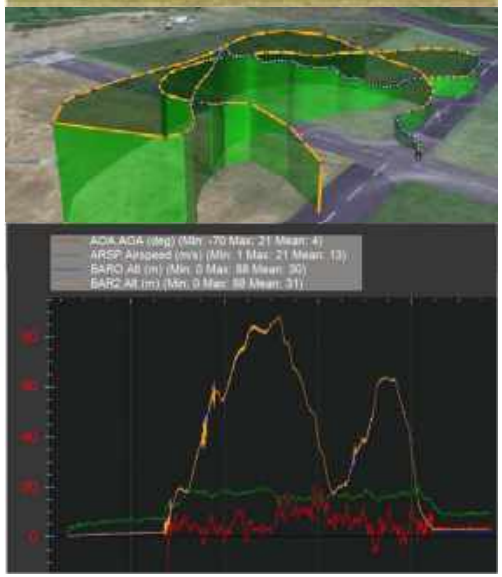
Use game AI concepts to realise a ***standard command system*** for various drone missions

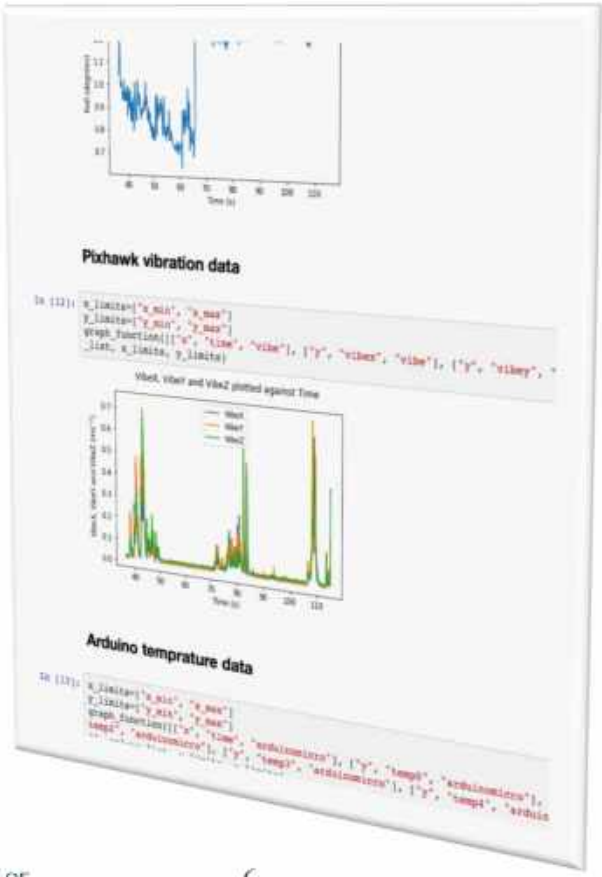


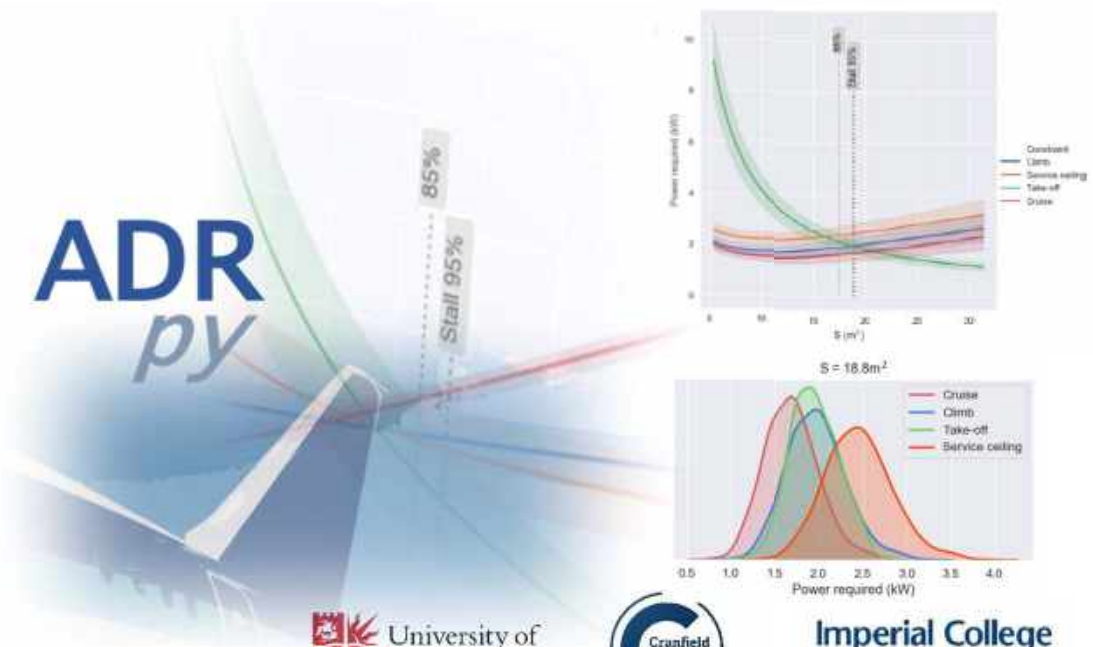


Agile design space exploration

- Open source aircraft conceptual sizing tool for rapid trade-off analysis and uncertainty quantification
- Rapid design-build-test cycles
- Automatic flight test reports that fuses relevant weather data, autopilot logs, electronic checklists, etc.



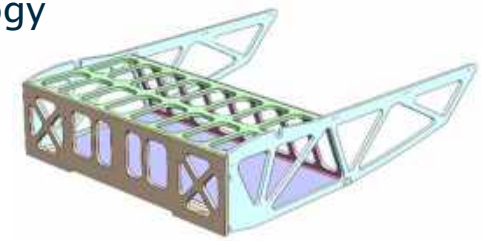
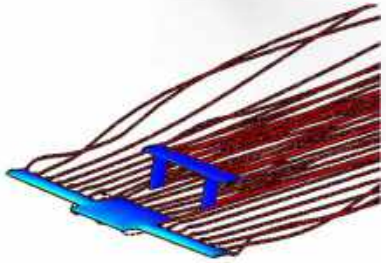


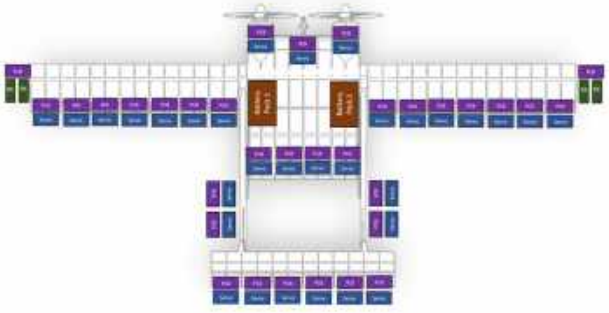
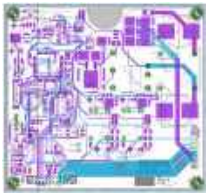
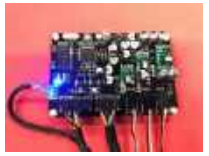


Low-cost high-reliability long-range cargo

- 350 kg MTOW
- 100 kg of cargo
- 1000 km range
- Low-cost construction technology
- Over-actuated fault-tolerant architecture
- Masterless distributed flight controllers
- No single point of failure
- From concept design to flying prototype in 12 months
- Currently undergoing BVLOS flight trials

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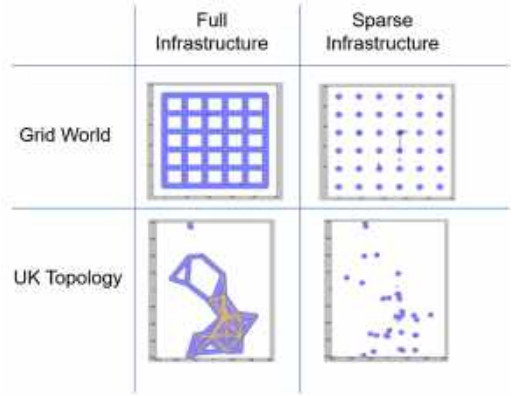
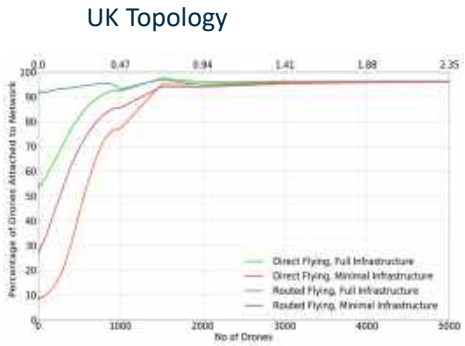
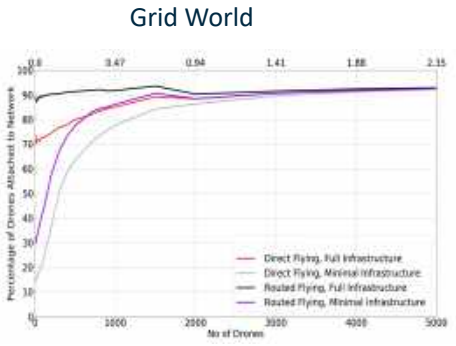
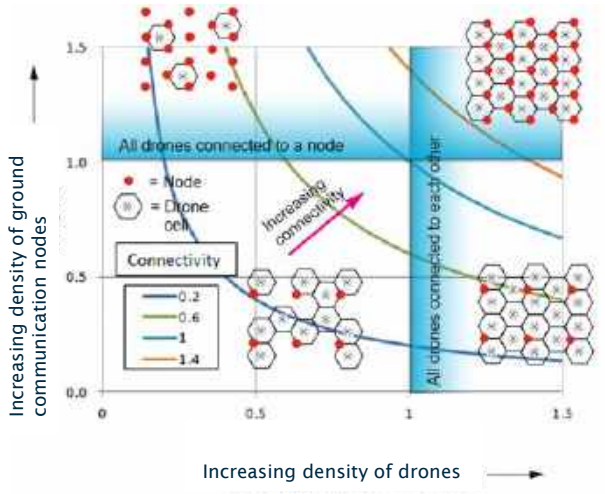
Drone networks for scalable operations and comms backup

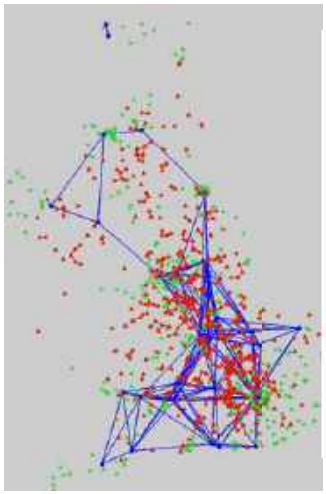
- Demonstrate and evaluate enabling technologies for routine and ubiquitous BVLOS operations.
- Research context: understanding of how choice of communication strategy impacts cost and complexity of achieving required levels of safety.
- Research method: multiagent simulation, flight demonstration.
- Example outcome: Demonstration of mesh networking to allow full connectivity of a UK wide drone distribution system

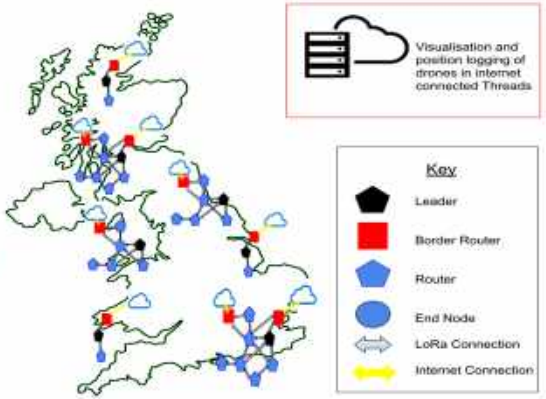












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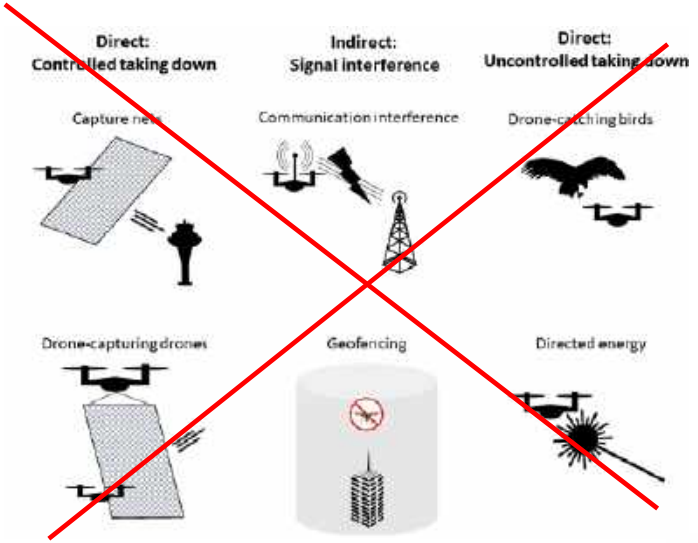
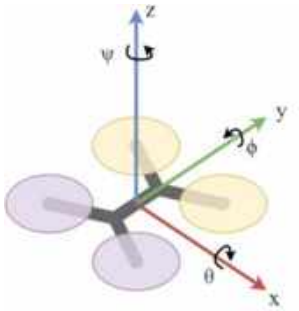
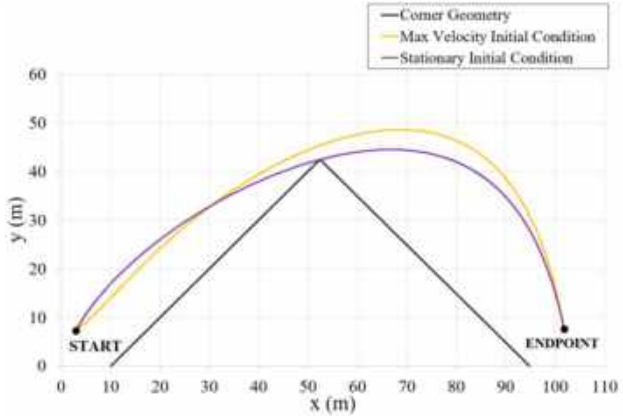
Emerging security threats

- Goal: To evaluate the emerging security threat from small high performance drones and demonstrate innovative means of physical interdiction
- Background: drone regulation encourages good behaviour but a small number of nefarious users have a disproportionate negative impact on wider society.
- Technical challenge: Geofencing, jamming and existing physical interdiction methods can easily be bypassed by criminals
- Research method: Dynamic simulation and flight test
- Example outcome: prediction of drone extreme performance capabilities

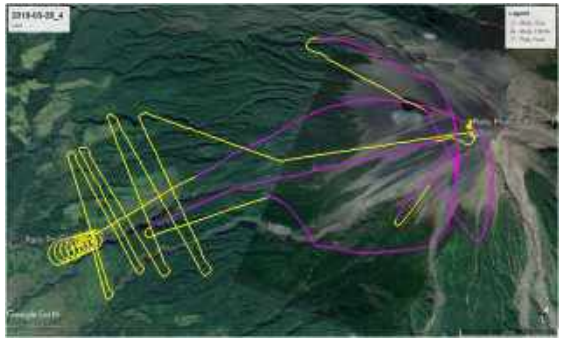




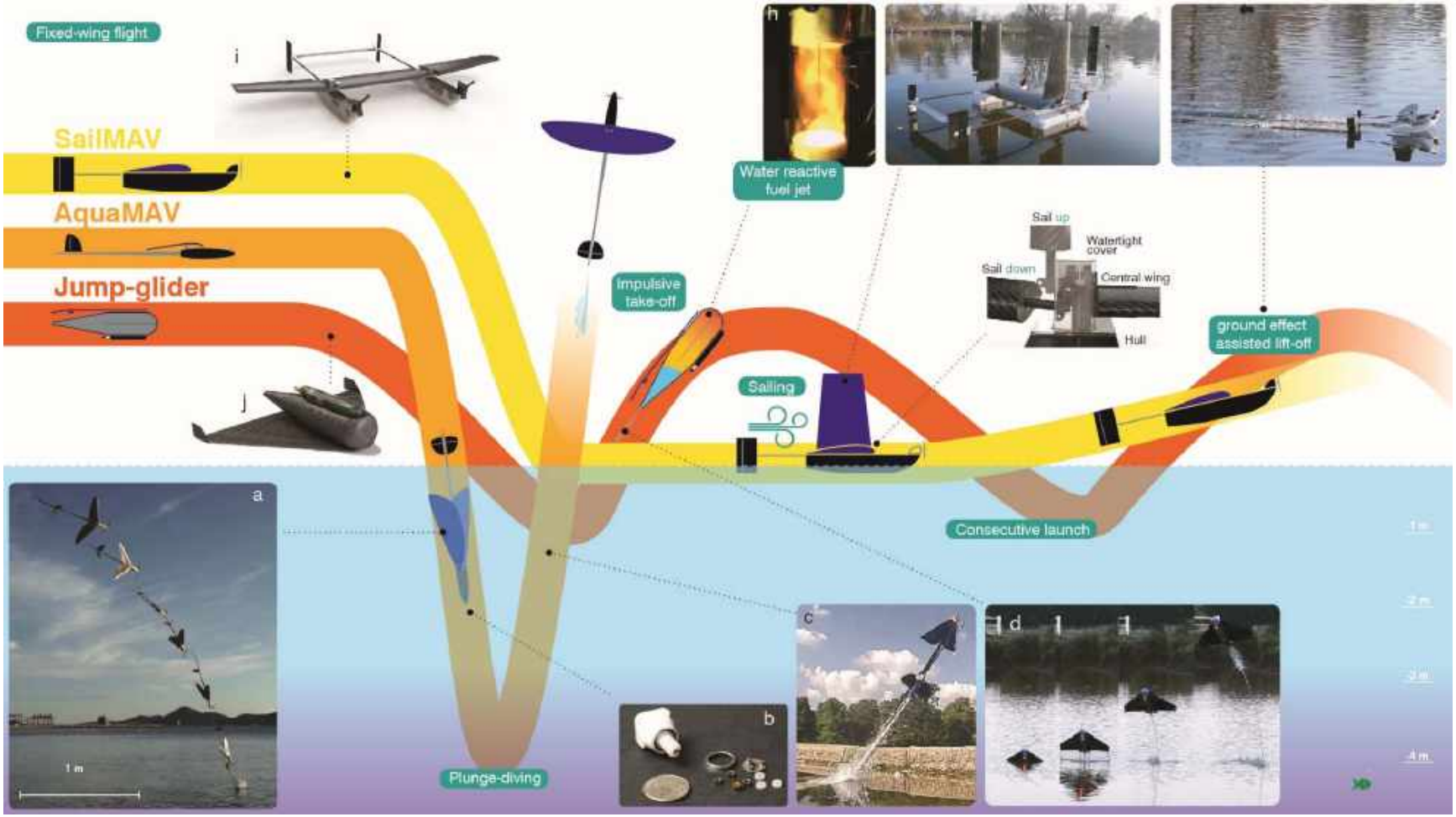


BVLOS remote sensing in extreme environments

- Repeated ash collection from Fuego, Guatemala at >10,000 ft AGL
- Repeated plume and fumarole gas measurement in Papua New Guinea
- Automated plume detection and real-time onboard re-routing

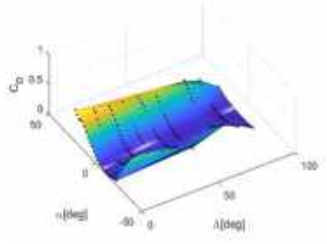


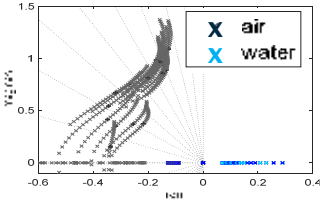
Aerial-aquatic robot concepts

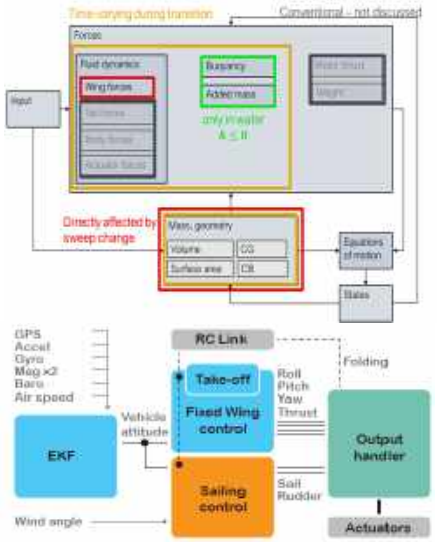


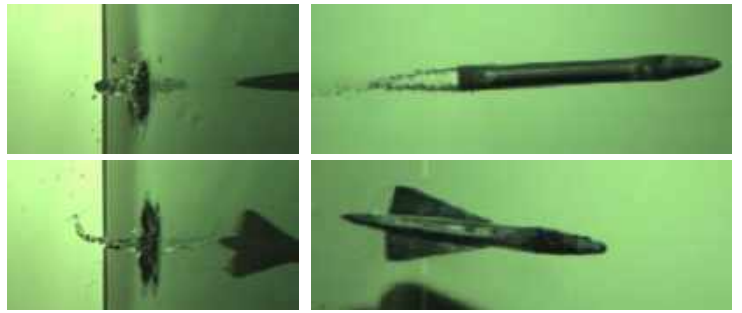
Aerial-aquatic robot concepts

- New solutions for aerial-aquatic mobility
  - Flying-diving
  - Flying-sailing
- Development of multi- configuration winged robots
  - Hybrid structure and control
  - Ultralight composite design
  - Autonomous operation framework
- Mathematical models
  - Multi-modal: flight, diving, sailing, morphing, phase transitions
  - Validated experimentally
- Simulation & control
  - Stability & dynamics
  - Multi-modal control
- Water impact experiments
  - Multi-phase aerodynamics
  - Design study: geometry & surface coating

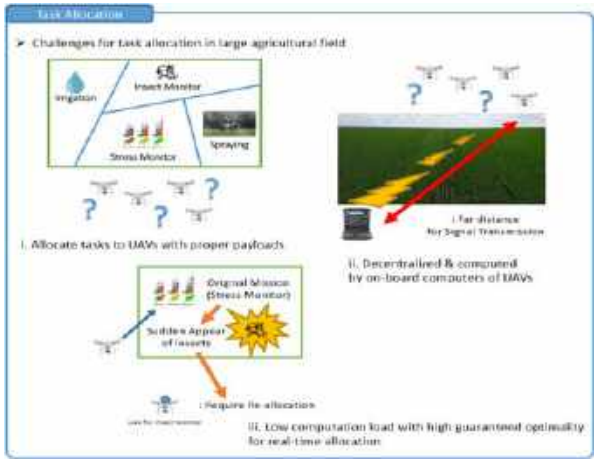




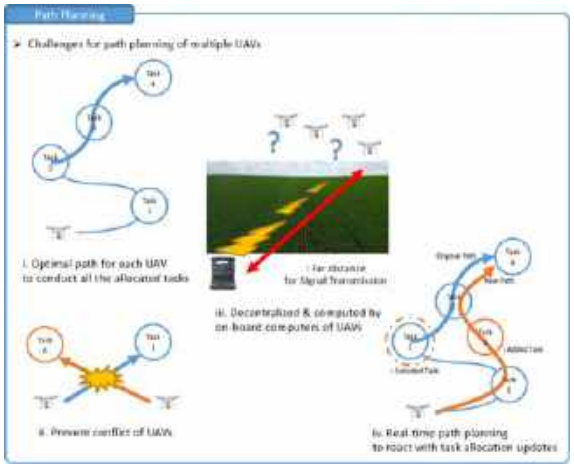


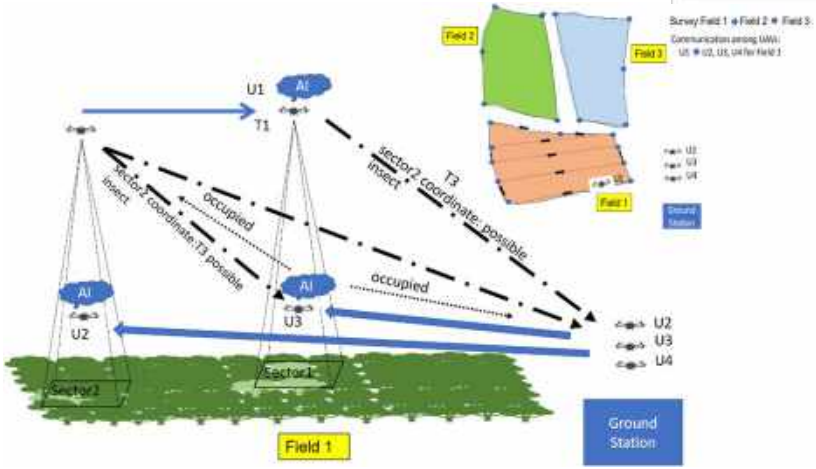


Autonomous Fleet Task Allocation



- Decentralised task allocation for agricultural applications
- High-level drone with image processing and task allocation capabilities
- Low-level drones receiving updated flight plans through SMS messages





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CASCADE Collaboration Workshop

Snowdonia Aerospace Centre, Llanbedr, June 2019

- 75 people
- 40 UAVs and 1 manned aircraft
- up to 8 aircraft airborne from 5 different operators simultaneously

Snowdonia Aerospace Centre, Llanbedr, June 2020

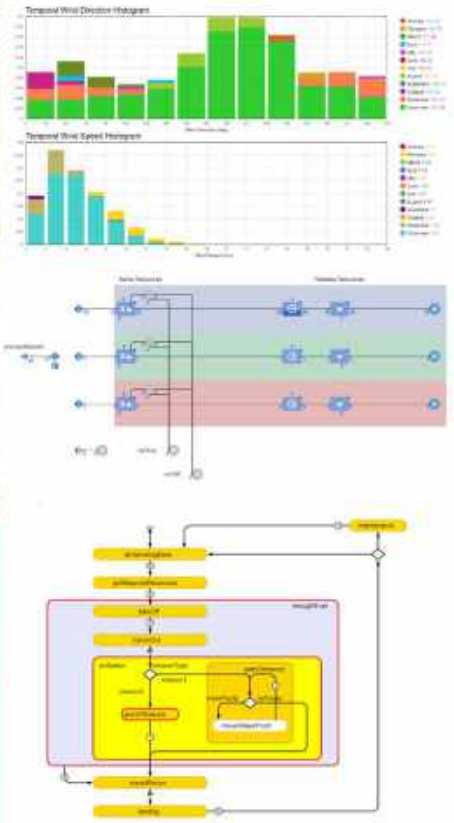
- BVLOS trials!

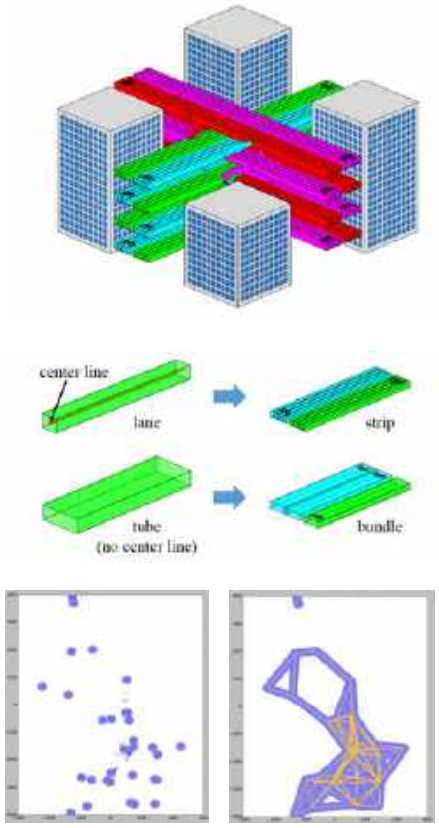
SEEDPOD

Simulation Environment for the Evaluation of Drone Policies and Optimal Deployment rules

Decision Variables
Airspace rules
Separation rules
Zone limits
Number of operators/ drone
Flight Patterns and routes
Maintenance and health monitoring policies
Airworthiness rules
Operator approvals

Inputs
Model boundaries
Weather models
Traffic patterns and density (Manned and unmanned)
Platform types
Zone categories
Map (GIS) data
Communications infrastructure and limitations
Systems reliability data
Position uncertainty scenarios





Questions?

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