UAV Technology Challenges and Opportunities: a University Perspective

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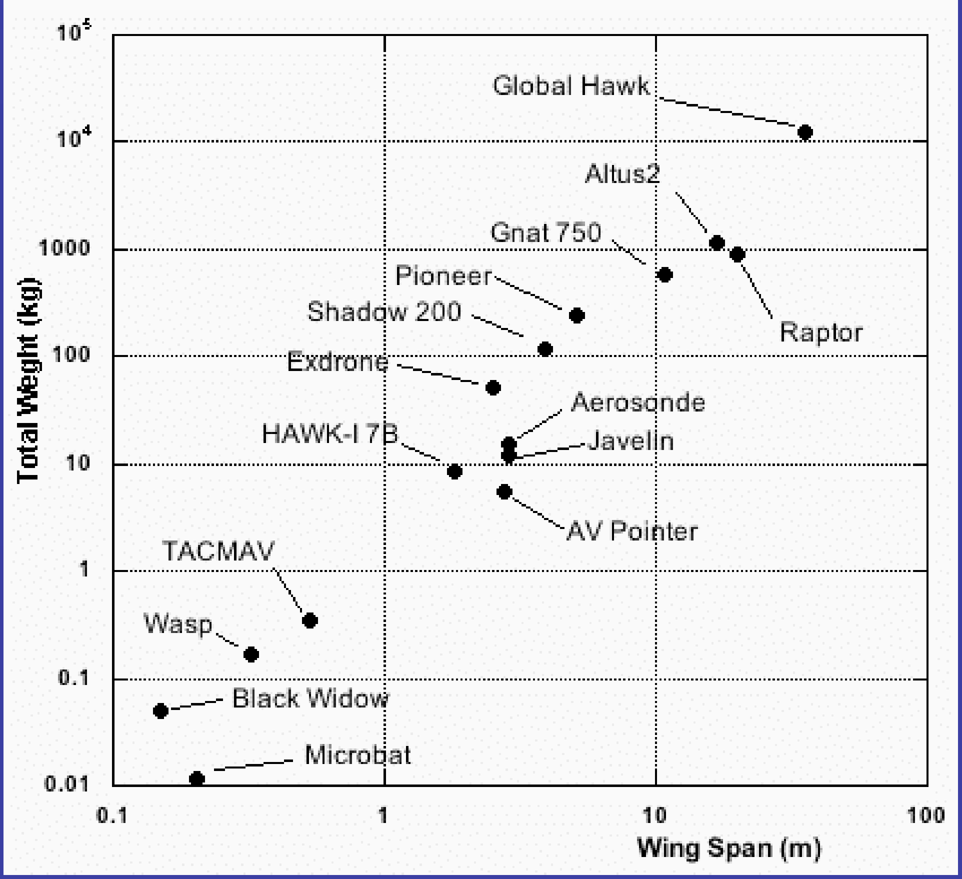
Outline

- Trends in UAV development
- MAV requirements
- Technology Challenges
- Current Projects at Glasgow
- Concluding Remarks

Trends in UAV Development

- UAVs have been developed for a wide range of military and civilian missions
- They come in a range of sizes
- In the last 10 years, the potential for very small scale UAVs has been recognised and this is now a major focus for research



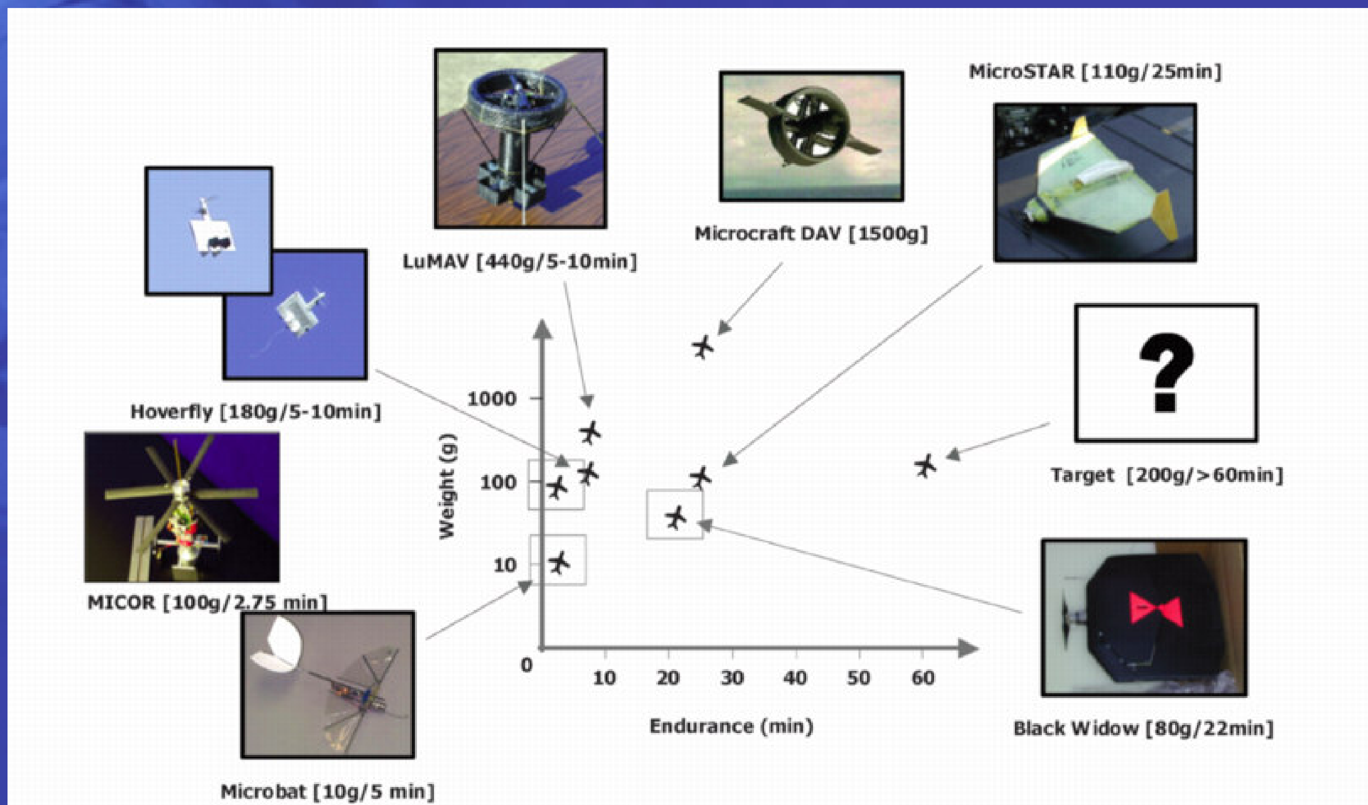
MAV Requirements

Guidelines for a typical MAV urban mission could be

Specification	Requirement
Size	<15cm
Weight	-100g
Range	1 to 10km
Endurance	60min
Altitude	<150m
Speed	15m/s
Payload	20g
Cost	$1500

Taken from: "Challenges facing future micro air vehicle development", D.J. Pines & F. Bohorquez AIAA Journal of Aircraft, April 2006

MAV Requirements - Are we there yet?



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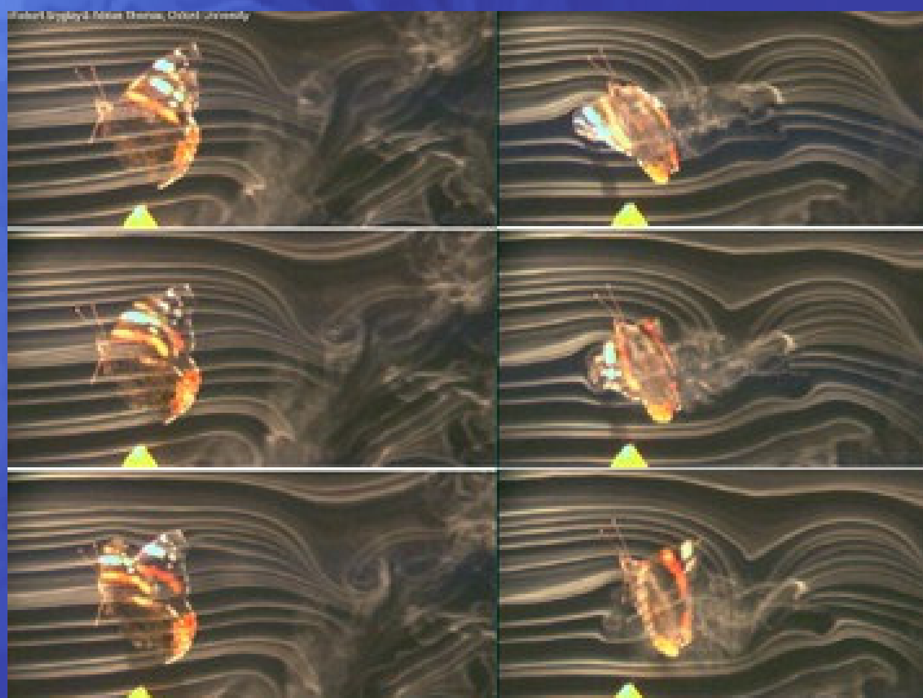
Technology Challenges

- Low Reynolds Number Aerodynamics, analytical and computational models
- Lightweight, adaptive and biologically inspired multifunctional materials and structures
- Micropropulsion/power sources
- Robust flight navigation and control using insect-like optic flow vision
- Miniaturised navigation and control electronics
- System engineering tools

Low Reynolds Number Aerodynamics, analytical and computational models

How do you model this?



- In addition to being at low Reynolds number, flow is unsteady
- Modelling of unsteady vortex dominated flows for helicopters is a specialisation at Glasgow
- Technology is transferable but requires validation by wind tunnel testing

Lightweight, adaptive and biologically inspired multifunctional materials and structures

- Structure from a plastic Lithium Ion Battery Material?
- Flapping-Winged MAVs: stimulation of bio-mimetic materials and new flexible materials for wing surfaces
- Synthetic muscles are evolving but will need control via Functional Electrical Stimulation strategies like those being used in research on rehabilitation of spinal injuries patients at Glasgow.
- Research on composite fabrics has clear potential applications for wing surfaces

Micropropulsion/power sources

- Flapping wing propulsion may hold the key to major performance enhancements
- Synthetic muscles could provide the flapping mechanism
- Micro jets that burn solid fuel also have potential to enhance fixed wing capabilities

- Actuation via miniature electric motors is likely to be the preferred choice for some time - the SPEED group at Glasgow has transferable expertise in this area

Robust flight navigation and control using insect-like optic flow vision

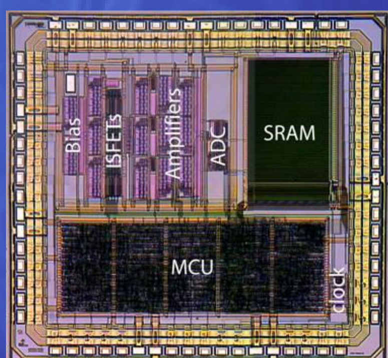
This requires joined up thinking that will pull expertise from a range of disciplines across Engineering. These include

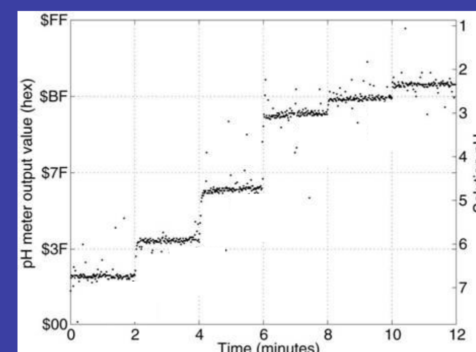
Air Traffic Management
Control
Flight Dynamics
Image Processing
Remote sensing

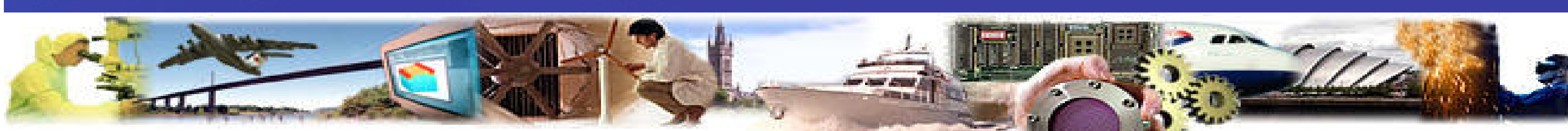
All these capabilities exist….integration is the key

Key Technologies - Remote Sensing

Distributed Wireless Sensor Technologies - Sensor/System on a Chip….ideal for harsh environments







Key Technologies - Sightline Control

Control of all pointing, stabilisation and tracking subsystems in remote sensing / directed energy weapons systems.

- EPSRC Grant – Nonlinear Sightline Control.
- Nadir control
- Image-based stabilisation
- Industrial Consultancy (SELEX SAS)
- High-bandwidth laser tracking

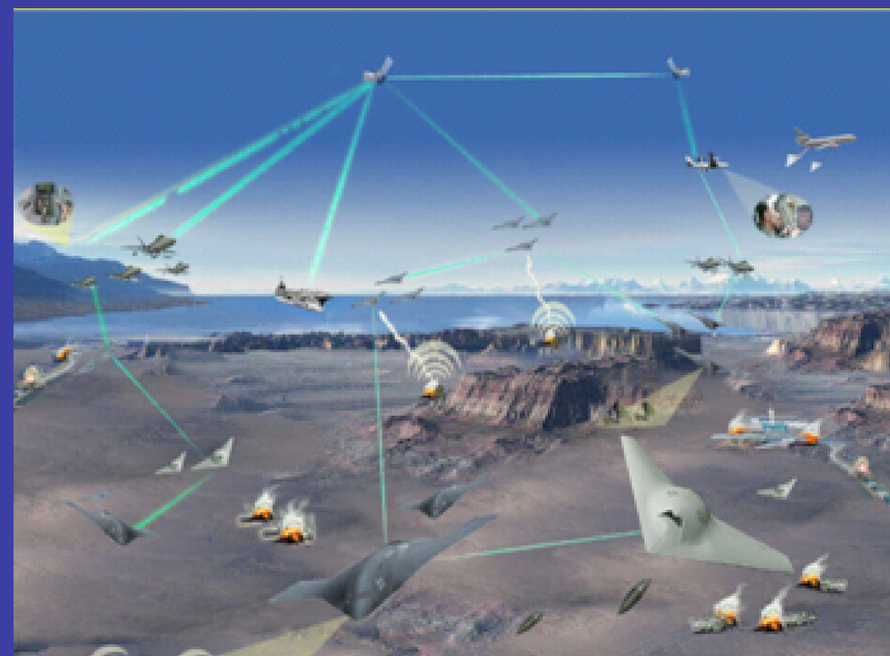
Key Technologies - UAV Flight Control

- **Single Platform Flight control**
  - -Inverse methods
  - -Predictive methods
- **Trajectory Generation**
  - -‘Feasible’ trajectory generation for capability and mission parameters
- **Cooperative/Distributive control**
  - -Optimal path planning (Graph Theory)
  - -Distributed Artificial Intelligence (DAI)

Key Technologies - MAVERIC Simulation (in development)

Multi Agent Vehicle Environment for Research in Instrumentation & Control (MAVERIC).

- Intelligent Multi-resolution modelling engine
- Generic UCAV architecture (rotary/fixed wing & missile)
- Accurate variable-fidelity sensor modelling
- Investigations into cooperative control, data & sensor fusion and operational analysis



System Engineering Tools

- Integration of technologies into the UAV platform must pervade the design process

- The methodology for this exists in, for example, the Concurrent Design Facility, used by the Space Systems Engineering group at Glasgow

Current AV projects - Remotely Operated Vehicles

Activities Involving the Seaker ROV

- Modelling
- Optimisation
- Autonomous Control
- Safety Critical Systems
- Current Tank Trials

Robosalmon-Biomimetic Autonomous Underwater Vehicle

RoboSalmon - EPSRC Studentship

- Modelling
- Autonomous Control
- Biologically inspired Propulsion and Navigation Systems
- Current Tank Trials

Unmanned Air Vehicles - Swarms

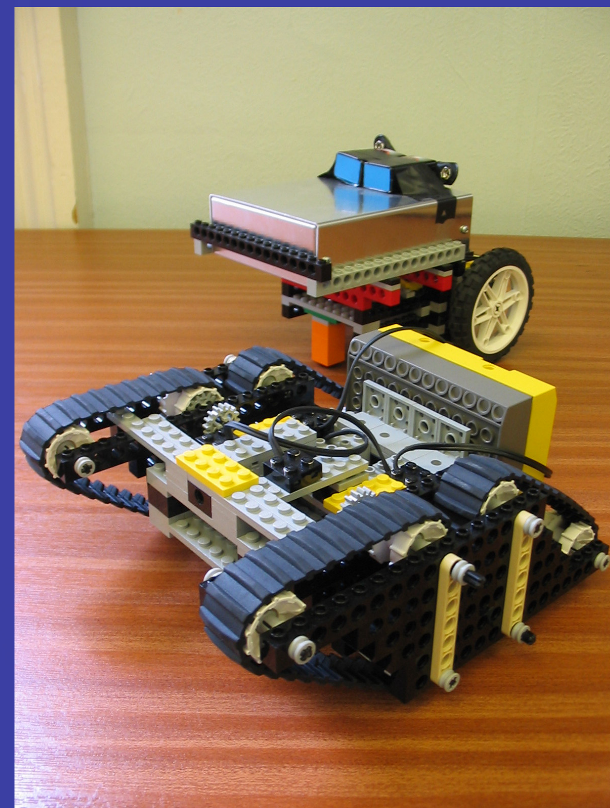
Draganflyer Quad-rotor

- Multi-Agent Mini-UAVs
- Modelling
- Autonomous Control
- Coordinated Swarms – Migration and Search

Urban Search and Rescue – Swarms

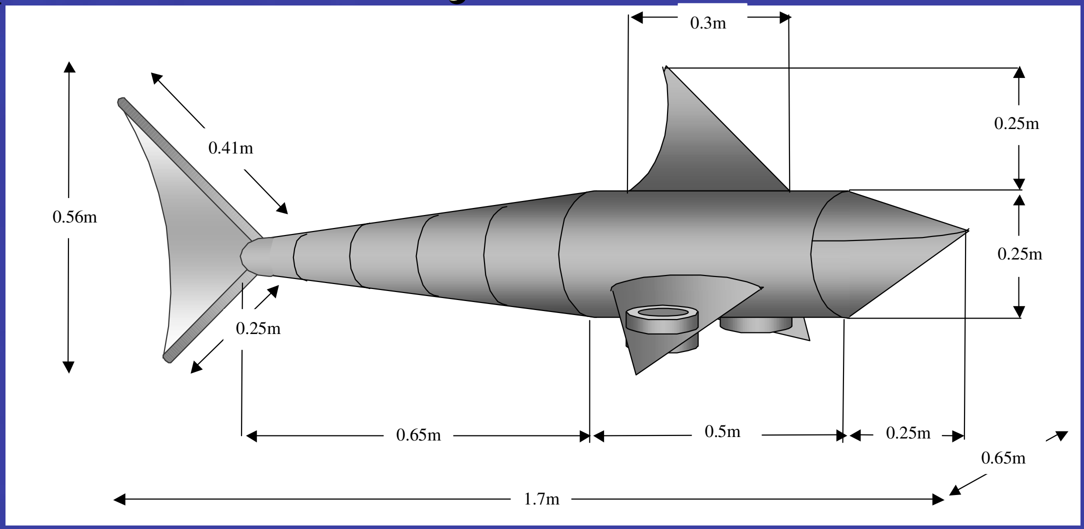
Autonomous Ground Vehicles

- Modelling
- Optimisation
- Autonomous Control
- Search Algorithms
- Initial Prototyping using Lego Mindstorms



DSTL Unmanned Underwater Vehicle Competition Entry

'SHARC' – Submersible Hybrid Autonomous Rover Craft



- Autonomous Control
- Biologically inspired Propulsion
- Vision Based Navigation

Concluding Remarks

- Micro UAVs are possibly the only type of aircraft, in today's markets, that can be designed and manufactured by small-scale enterprises anywhere in the world.
- The technologies underlying the development of these vehicles either exists or is emerging
- Universities are well placed to look at complete system solutions

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