# Simulation Issues in the Design of Mini Unmanned Aerial Vehicles

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MAVs
Micro and mini-aerial-vehicles

**Different classes of aircraft, as a function of weight, dimensions, flight velocity**

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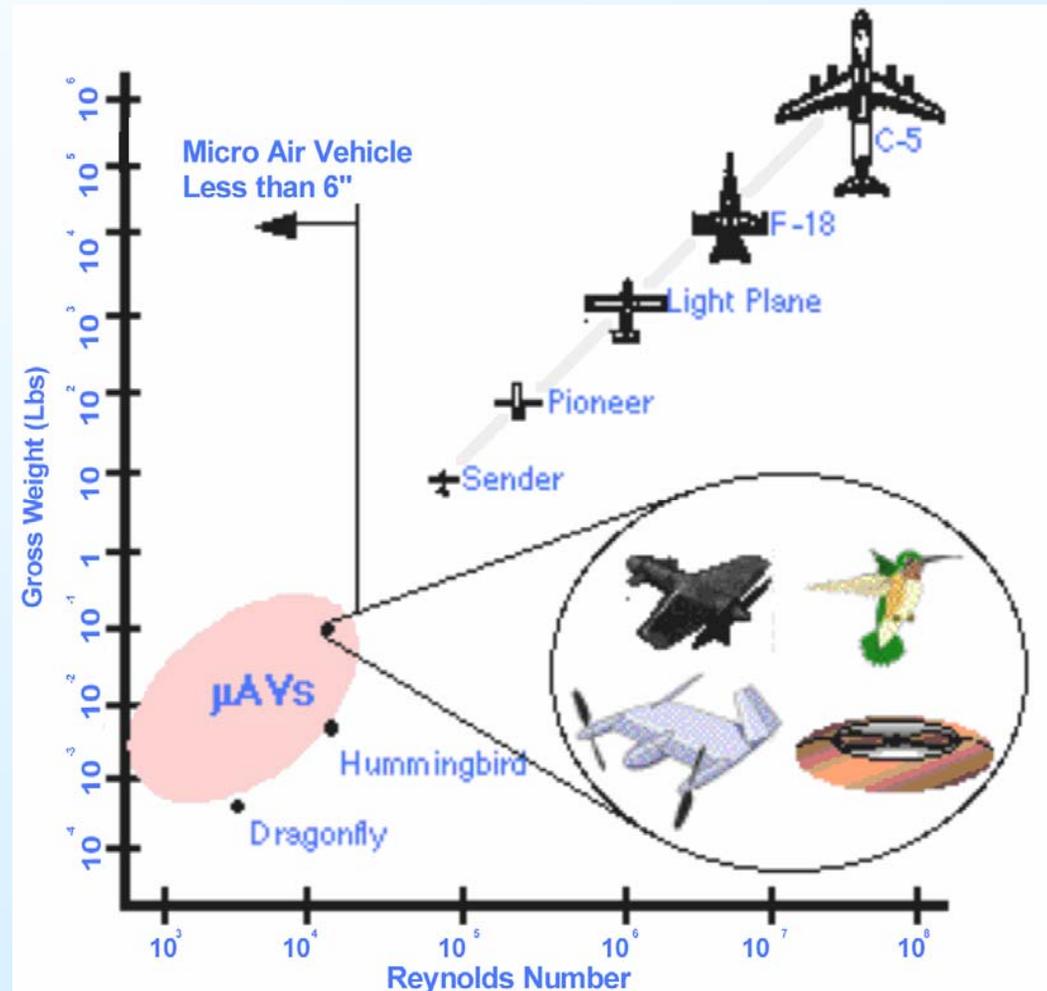
Micro/mini-aerial-vehicles

✓ **Fixed Wing Configurations**
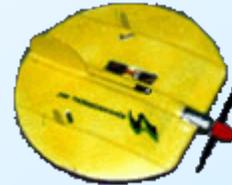
✓ **Rotary Wing Configurations**
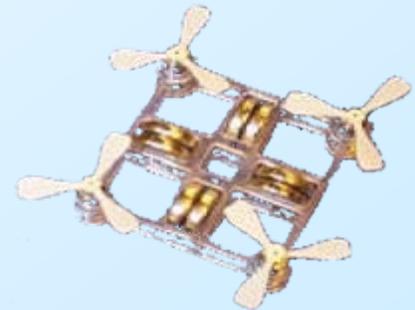
✓ **Flapping Wing Configurations**

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Working Scenarios

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MAV Platforms
for Surveillance and Reconaissance

Mobile platform

Wireless communication

Mobile and wearable technologies

Territorial monitoring

Remote ground operator/control station

Wireless communication

Storage architecture

Internet

Coordination station

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Working Scenarios I

wood fires

Industrial Areas Recce

Natural Disasters Recce

ground control station

Operations coordination station

Volcanic areas Recce

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Working Scenarios II

surveillance of natural parks

release from UAV *carrier*

traffic monitoring

cellular antenna

cartographics

monitoring of sports events

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MAV Typical Mission

```
                    ┌─────────────────────┐
                    │  Launching by hand  │
                    └─────────────────────┘
                               │
                    ┌─────────────────────┐
                    │   Manual Take Off    │
                    └─────────────────────┘
```

Remote piloting   *Autonomous flight*

Climb to operative flight altitude	Climb to operative flight altitude
Arrival at observation zone (loitering)	Arrival at observation zone (loitering)
Trajectory chosen by operator	Trajectory controlled by autopilot
Return to chosen descent point	Return to chosen descent point
Descent	Descent

Manual landing

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# MicroHawk (POLITECNICO DI TORINO - Dipartimento Ingegneria Aeronautica e Spaziale)

Project EU–IST/FET: MARVEL (Micro Air Vehicles for Multi-purpose Remote Monitoring and Sensing)
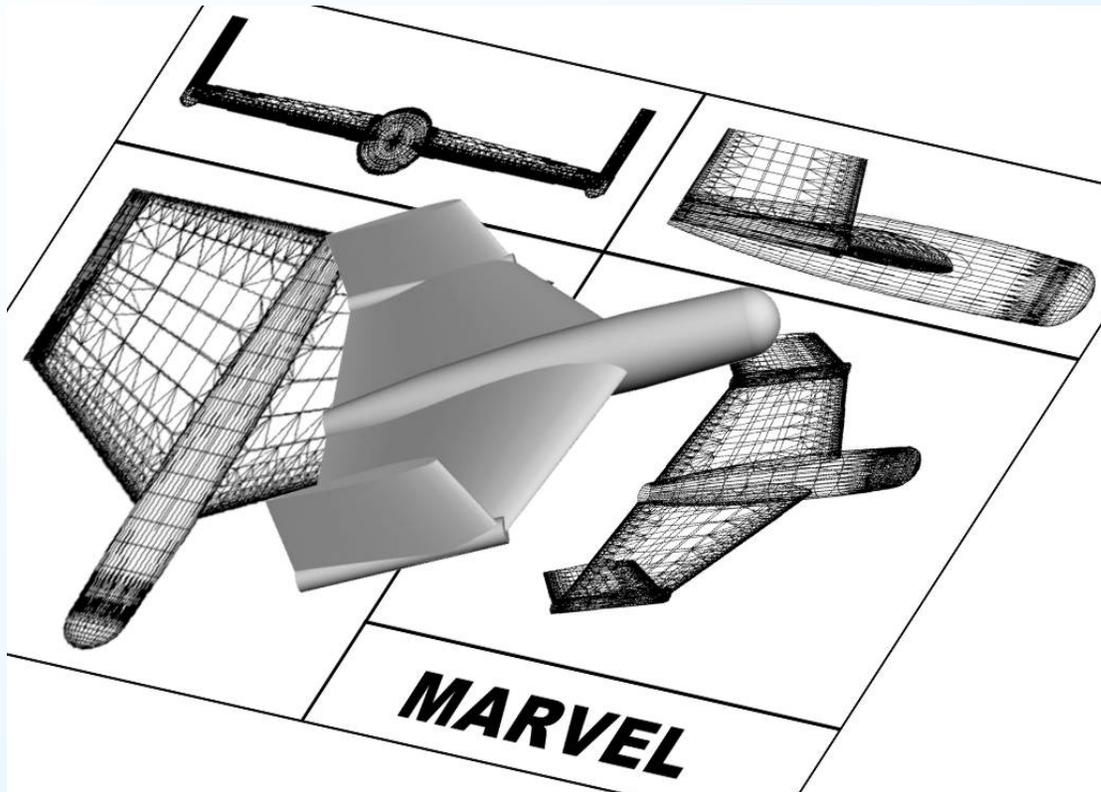
Engine: electric DC
Maximum dimension: 150 mm
Gross weight: 70 g
Stall speed: 7 m/s

Patent n. TO2003A000702
PCT/IB2004/002940
Politecnico di Torino

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MicroHawk Platform Design
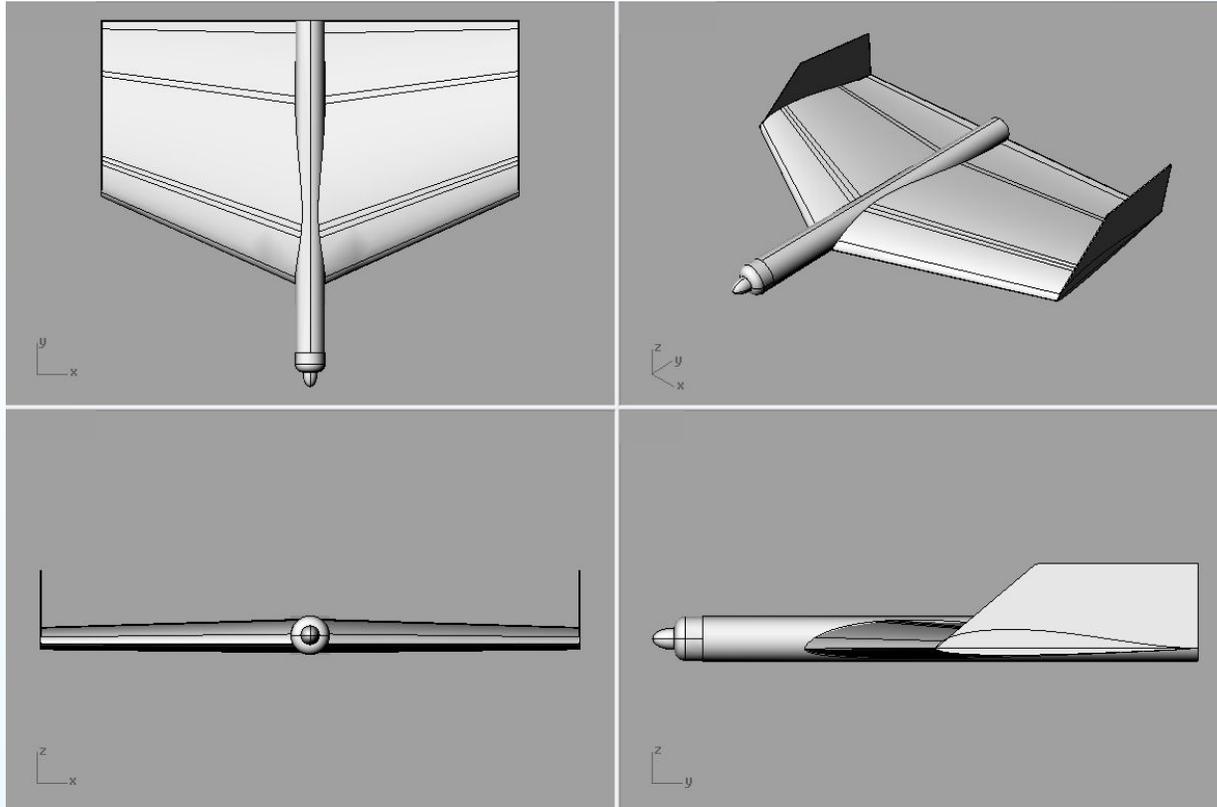
- ✓ Fixed wing
- ✓ Tail-less configuration
- ✓ Double vertical fin
- ✓ Electric propulsion system
- ✓ Tractor propeller

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MicroHawk Platforms(I)

MH150

- ✓ Wing span 150 mm
- ✓ Weight 35 g
- ✓ Engine: electric DC
- ✓ Remote piloting
- ✓ Endurance 5 min
- ✓ Limited range
- ✓ Maximum payload 5 g
- ✓ Take off: manual

B/W Image acquisition

Narrow places surveillance

MH300

- ✓ Wing span 338 mm
- ✓ Weight 130 g
- ✓ Engine: electric (brushless)
- ✓ Remote piloting
- ✓ Endurance 15 min
- ✓ Range 300 m
- ✓ Maximum payload 25 g
- ✓ Take off: manual

Image acquisition
and/or sensors transport
for short distances
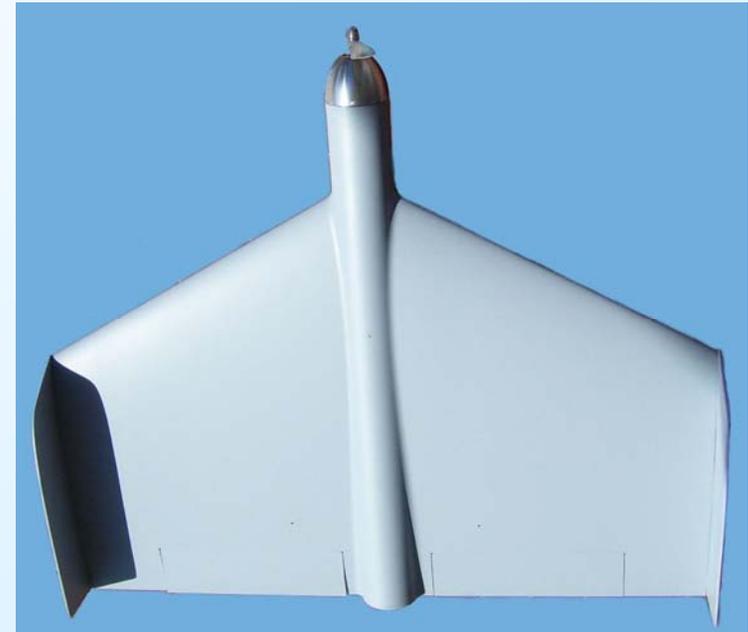
MH600

- ✓ Wing span 600 mm
- ✓ Weight 575 g
- ✓ Engine: electric (brushless)
- ✓ Remote piloting
- ✓ Autonomous flight
- ✓ Endurance 35 min
- ✓ Range 300/2500 m
- ✓ Maximum payload 100/25 g
- ✓ Take off: manual

Image acquisition
and/or payload
transport for medium
distances

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MicroHawk Platform (II)

MH1000

✓ Wing span 1000 mm
✓ Weight 1400 g
✓ Engine: electric (brushless)
✓ Remote piloting
✓ Autonomous flight
✓ Endurance 35 min
✓ Range 300/2500 m
✓ Maximum payload 500g
✓ Take off: manual

Image acquisition and/or payload transport for medium distances

MH2000

✓ Wing span 2000 mm
✓ Weight 9000 g
✓ Engine: electric (brushless)
✓ Remote piloting
✓ Autonomous flight
✓ Endurance 40 min
✓ Range 300/7500 m
✓ Maximum payload 2500 g
✓ Take off: traditional landing gear

Image Acquisition and/or payload transport for medium distances

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Mathematical modeling

AIRCRAFT AERODYNAMICS
- aerodynamic data base

AIRCRAFT STATES
- A /C math modeling
- atmospheric turbulence modeling
- actuator dynamic modeling

FEEDBACK
- gain synthesis
- control laws implementation

CONTROL SURFACES

THRUST
- blade element theory

COMPENSATOR

THROTTLE INPUT

STICK INPUT

POWER PLANT
- motor modeling

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Flight Simulator

HEXAGON

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# Flight Simulation for MAVs D&D

- ✓ MicroHawk flight performances

- ✓ Capability to perform a standard mission profile

- ✓ Propulsive system sizing

- ✓ Propeller effects on maneuvering behaviour

- ✓ Flight dynamics characterization

- ✓ Configuration scalability effects

- ✓ Autonomous flight demonstration

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Flight Simulation I

time domain response characterization
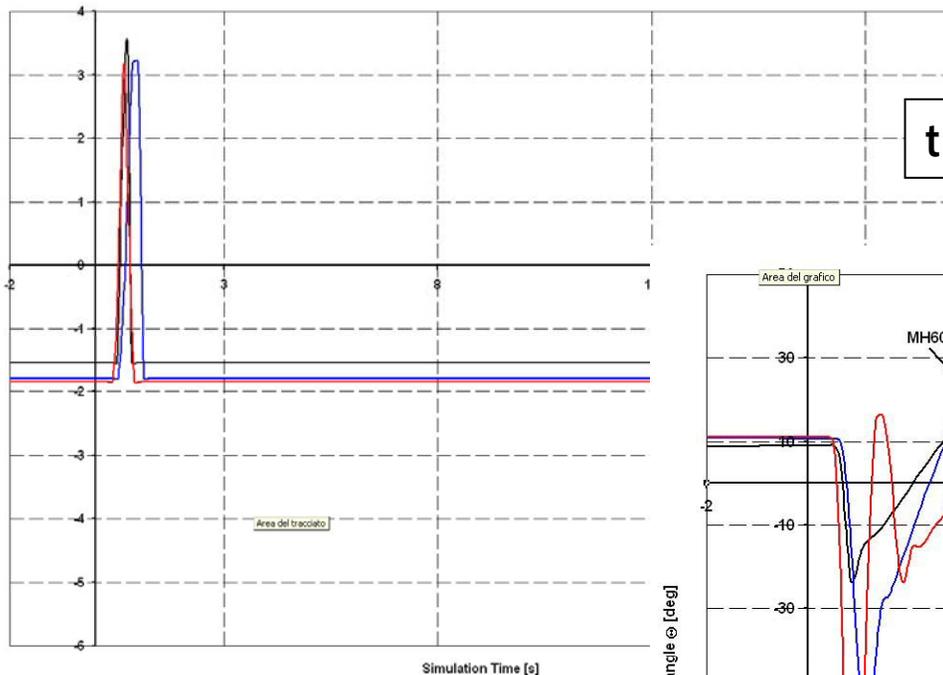
elevator impulse maneuver

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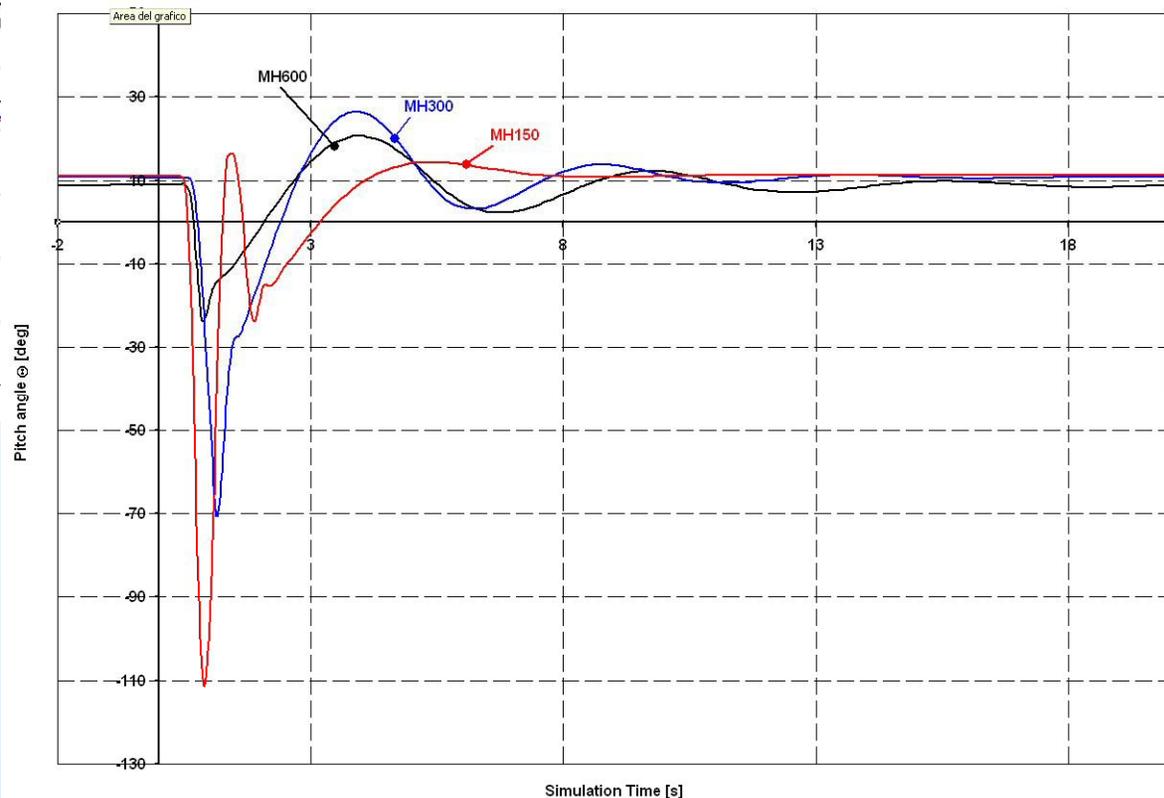
Flight Simulation II
Dynamic Analysis

✓ **Dynamic Behaviour Analysis**

✓ **Scale Effects Analysis**
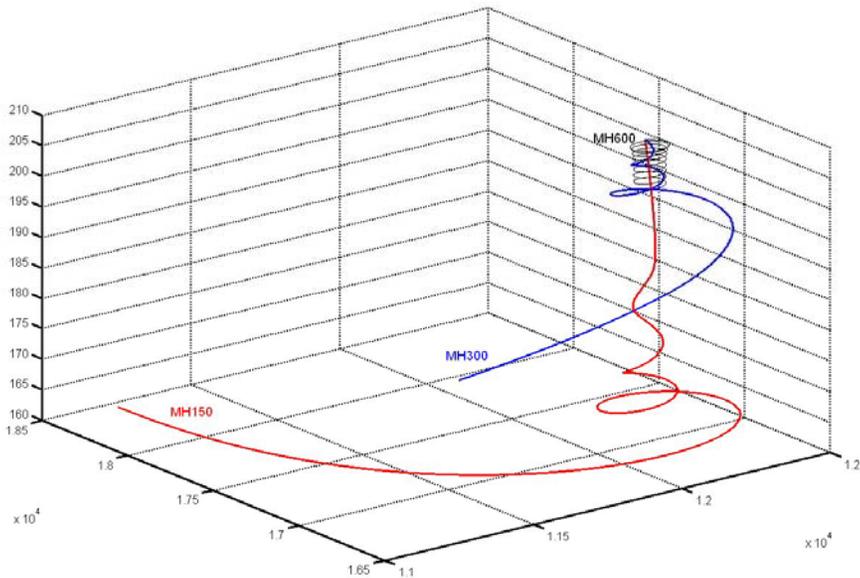
Aileron Unit- Impulse Maneuver

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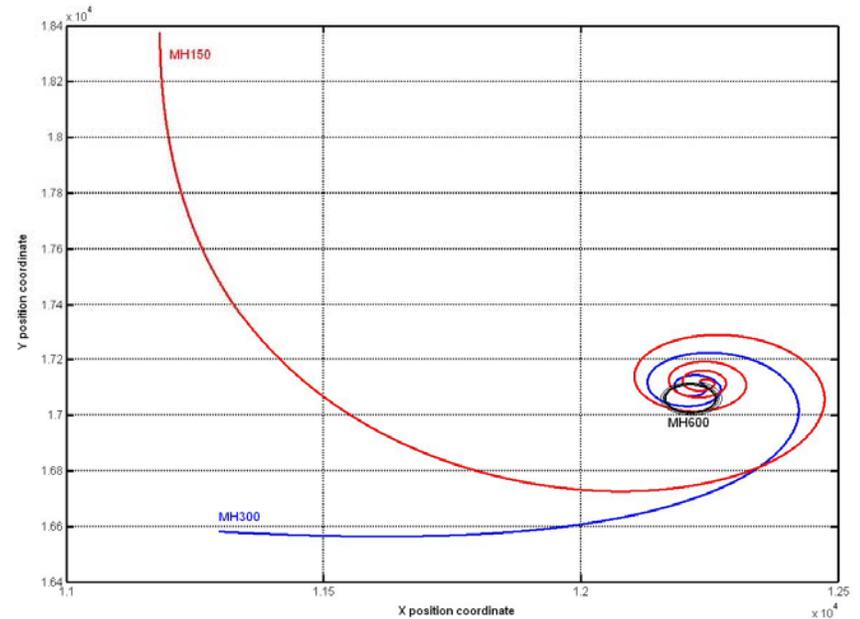
Flight Simulation III

✓ MicroHawk flight performances
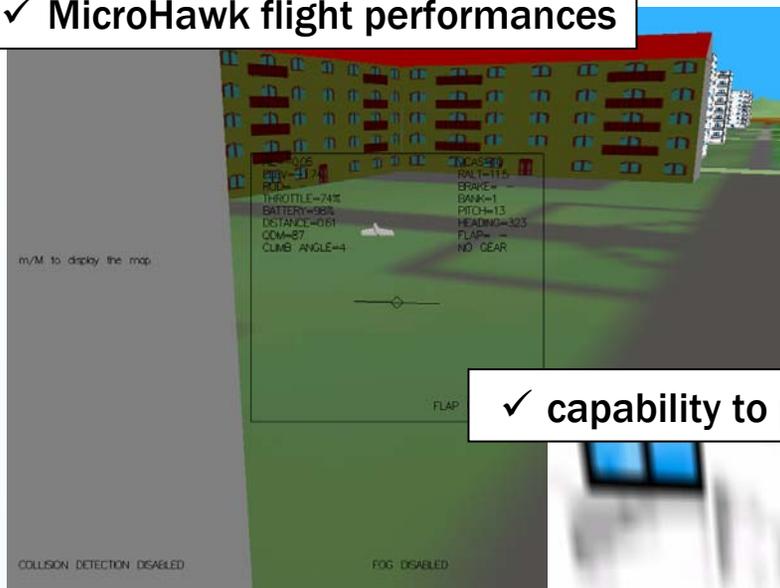
✓ control effectiveness

✓ capability to perform a standard mission profile

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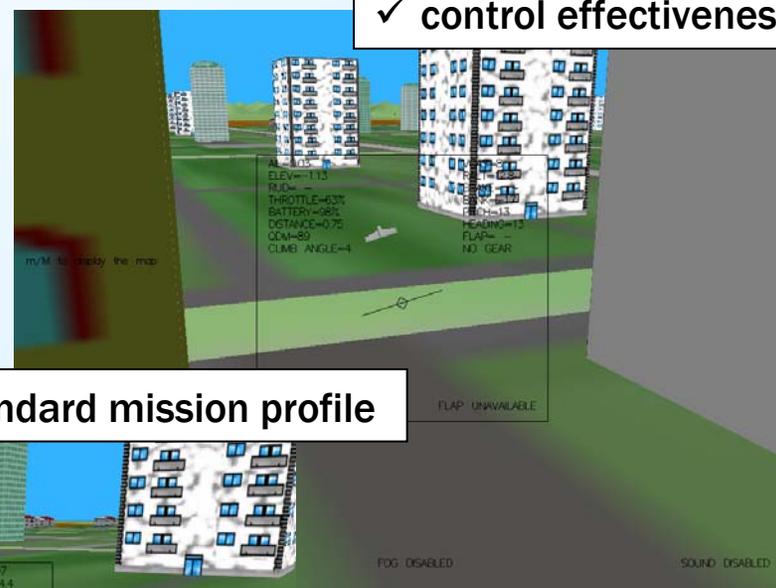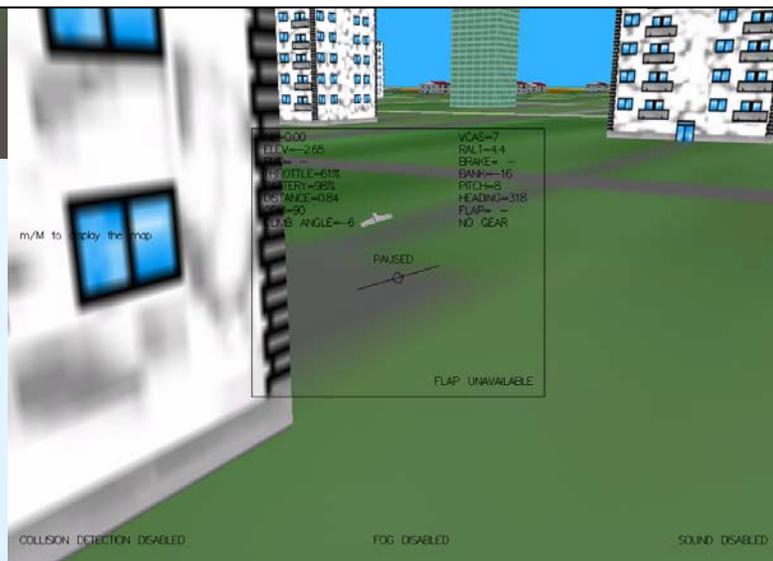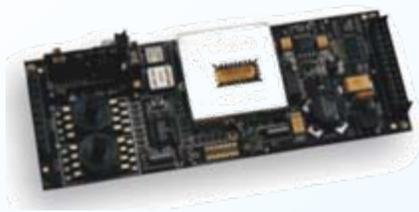
Autonomous Flight

Dimensions:

100 x 40 mm

Weight: 28 g

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MAV Autonomous Flight Simulation

Why include autopilot functions into the simulator?

✓ For autopilot tuning...

     ... avoiding risky situations

     ... saving experimental costs

     ... reducing time-to-flight

✓ For autonomous flight
     operator training

MicroHawk MH600

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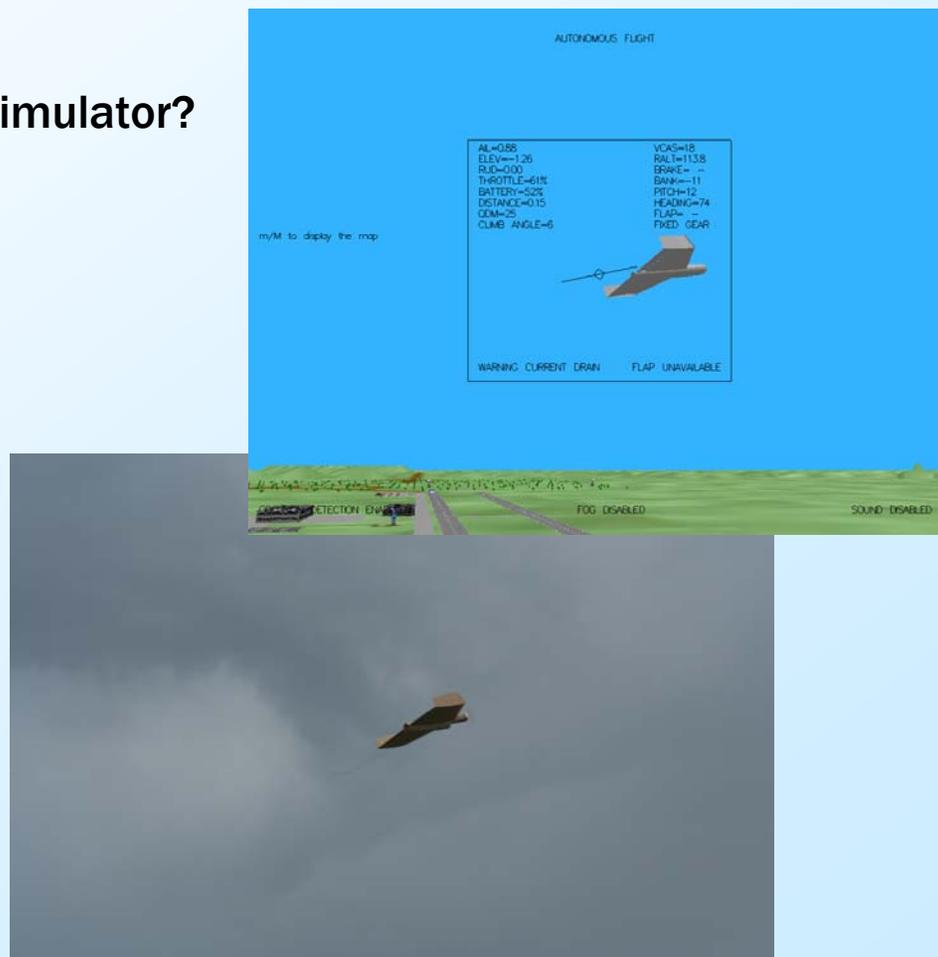
Autonomous Flight
Simulation vs Real Flight

MicroHawk MH2000

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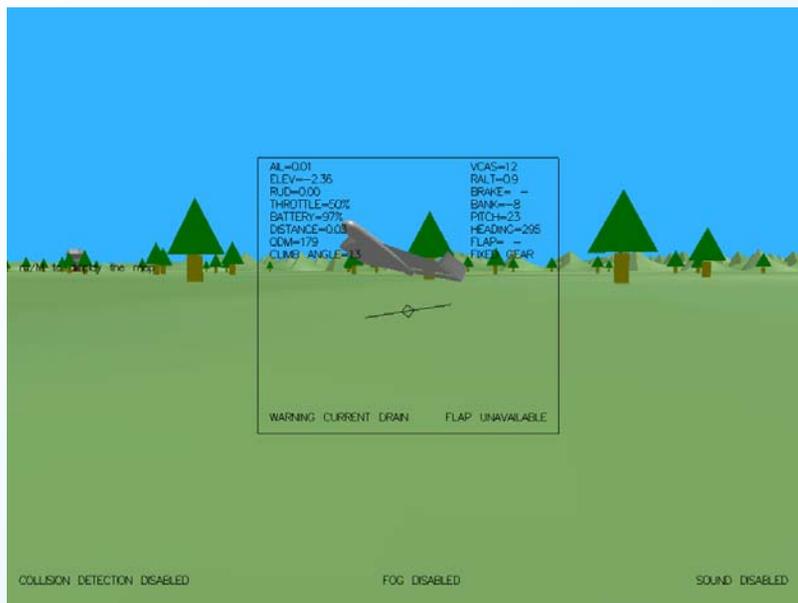
MAVs Operator Training

On the field training

Flight Simulator

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Future Developments & Research Projects

- ✓ *Autonomous flight*

- ✓ *Autonomous formation control and trajectory management for multiple MAVs applications*

- ✓ *Payload definition, design & development for different MAVs applications*

- ✓ Cost effective design

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MAVs are small, but they have many seats available on board for research scientists and engineers!

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