



Universitatea
Politehnica
Bucureşti



Facultatea de
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Catedra de
Calculatoare

Formation Flight for Unmanned Aerial Vehicles

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1. Domain
 2. Autonomous UAV
 3. Hirrus
 4. Platform Objectives
 5. Platform Simulation Architecture
 6. Autopilot Architecture
 7. Thesis Objectives
 8. Formation Flight
 9. Types of Formation
 10. Tested Formations
 11. Evaluation and Results
 12. Future Work
 13. Questions
-



UAV (*Unmanned Aerial Vehicle*)

- ▶ no pilot **on board**
- ▶ remote controlled or
- ▶ completely autonomous
- ▶ envisioned by N. Tesla in 1915
- ▶ used in military and civil missions
- ▶ rotor based or fixed-winged

[1] <http://aerosdb.com/uav-drone/>



Figure: Fixed-wing UAV with surmountable camera [1]



About:

- ▶ in collaboration with *Teamnet International S.A.*
- ▶ aims to build a management platform for a fleet of UAVs

Scope:

- ▶ development of autonomous flight modules for the Hirrus drone
- ▶ development of a software platform for programming, tracking and remote controlling of the drones



Figure: Hirrus UAV [2]

[2] <http://aft.ro/bro.pdf>



Destination law enforcement, reconnaissance, search and rescue, cartography

Dimensions Wingspan 2.35 m / Length 1.1 m / Weight 7 kg

Speed Max 130 km/h, Cruise 90 km/h

Payload 0.7 kg

Propulsion Electric

Endurance 180 m

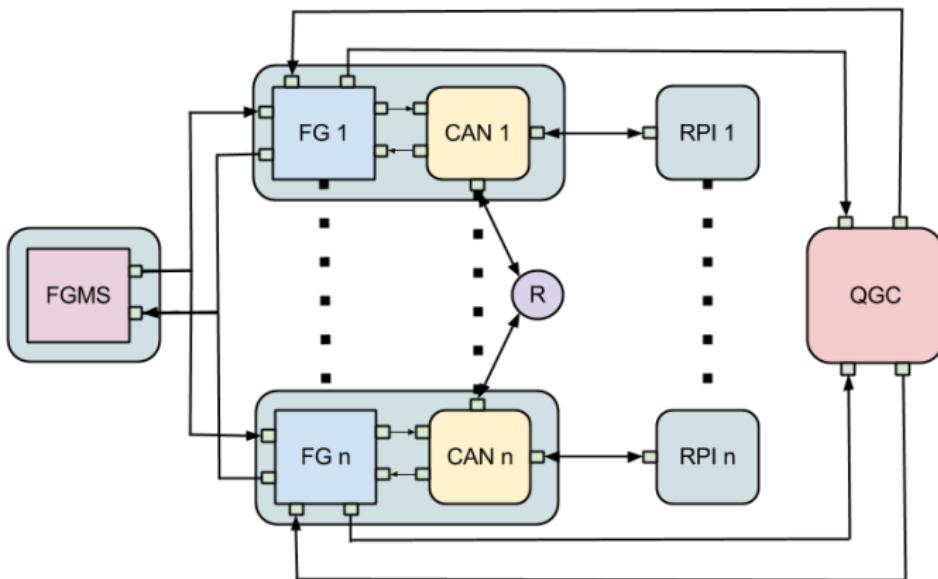
Range 15 km



- ▶ Ground Control System based on QGroundControl
- ▶ Mission Monitor System
- ▶ Remote Control Module for mission override and manual control
- ▶ Autopilot for Hirrus with *Collision Avoidance* and *Formation Flight* modules
- ▶ Artificial Intelligence Module for mission execution.

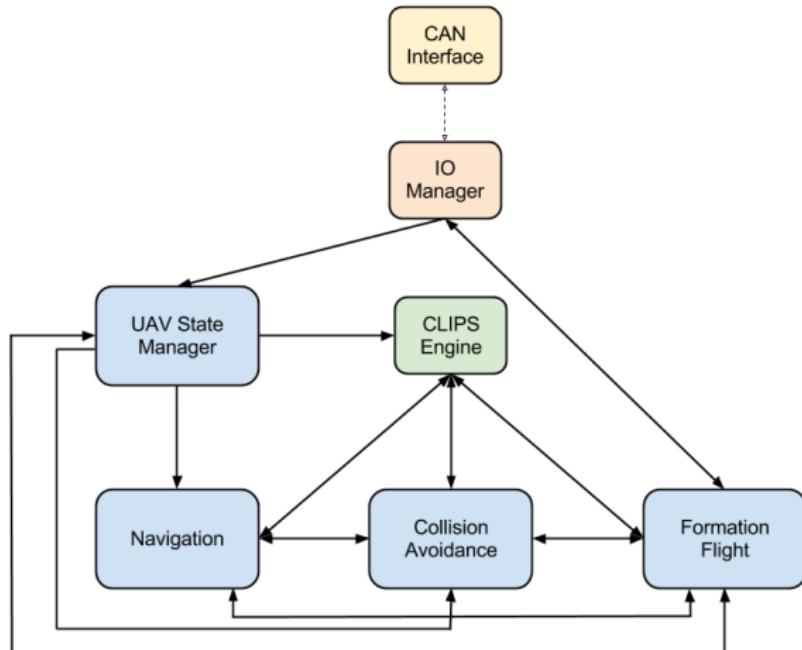


Platform Simulation Architecture





Autopilot Architecture



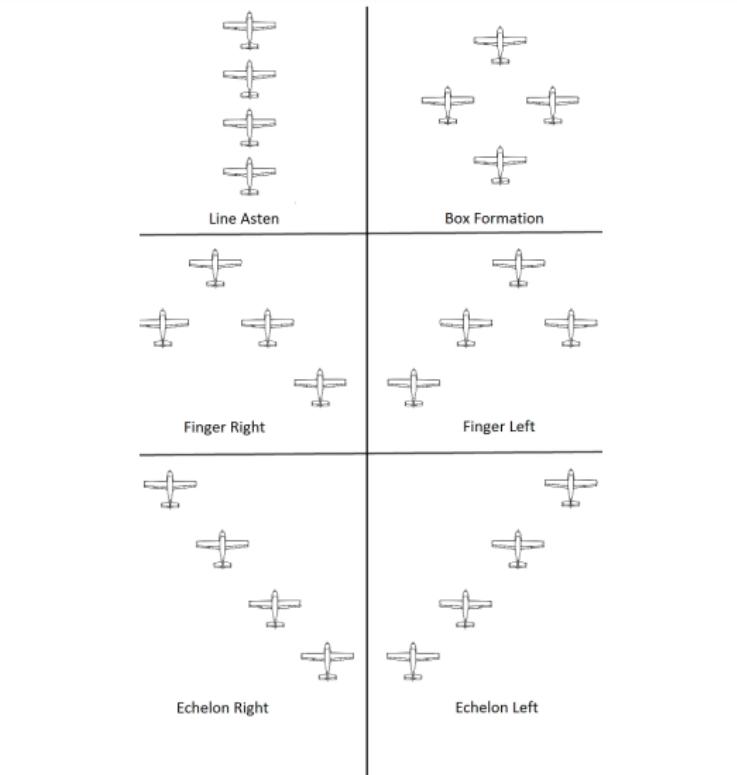


- ▶ close range formation flight module
- ▶ decentralized communication
- ▶ reactive agents
- ▶ inspired by real life animal swarms



- ▶ 3 or more UAVs flying in formation
- ▶ simulated using Flight Gear Flight Server
- ▶ close range
- ▶ follow the leader algorithm
- ▶ GPS and ECEF coordinates based on WSG84 ellipsoid

Types of Formation





Tested Formations

3 UAVs Formations

- ▶ Line Astern
- ▶ V Formation





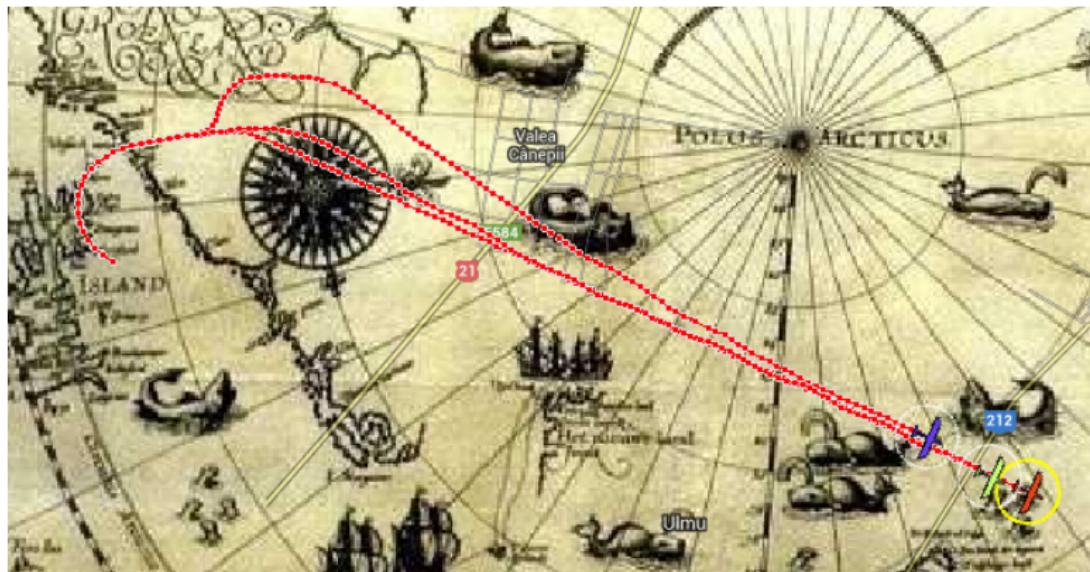
- ▶ tested with dedicated leader
- ▶ leader with it's own mission
- ▶ other UAVs have a *follow the leader*
- ▶ 9% to 25% of time spend for maintaining the formation
- ▶ 60% to 70% of time spend for entering the formation
- ▶ 15% to 20% of time relieving control for collision avoidance



- ▶ communication delay can decrease the time spent in formation maintaining
- ▶ communication delay can induce formation detachment
- ▶ 300 feet (> 100 m) distance between UAVs
- ▶ for tighter result another coordinate system is needed
- ▶ computational errors are induced by the ellipsoid model while converting coordinates



Evaluation and Results





- ▶ formations based on a virtual leader (geometrical center of formation)
- ▶ simulating with Flight Gear instances running on dedicated machines
- ▶ communication between AI modules and Hirrus via CAN bus
- ▶ PID controllers for speed and steering



Q&A