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GOVERNANCE PRINCIPLES:

Towards an International Framework

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GOVERNANCE PRINCIPLES: Towards an International Framework

Hybrid Environmental Monitoring for Early Wildfire Detection

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The Challenge

Optimising a hybrid environmental monitoring system

Different sensor platforms, form satellite to unmanned aerial systems (UAS) or fixed sites, have different uses, characteristics and capabilities

Opting for one of them (at the exclusion of the others), or “mixing and matching” in an ad-hoc manner depending on availability, is ***suboptimal***

In order to maximise efficiency (performance *vs* cost), it is necessary to formulate a ***Concept of Operations*** that describes how different platforms may interact to compensate for each other’s limitations

It is advisable to test multiple hybrid configurations in a ***simulated*** environment prior to deployment

This is especially true for an ***autonomous*** or partially autonomous system that is expected to plan and execute reconnaissance missions without human input

→ We are not presenting a ***product*** but a ***method*** to achieve this...

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Proof-of-Concept

Numerical experiment: scenario

Two types of UAS:

- Fixed-wing: operates at a higher altitude, flies faster and furhter, carries sensors that cover a large area, is ***expensive*** (e.g., €80k per unit)
- Quadcopter**:** operates at lower altitude, is comparatively slow and has a shorter range, has a limited field of view, is ***cheap*** (e.g., €10k per unit)

Discrete space: a hexagonal mesh is superimposed onto the area of interest (itself a hexagon approximately 4,920 km^2 in size). The mesh width is 1 km, the fixed-wing UAS has a range of 256 km before landing/recharging, the quadcopter has a range of 32 km. All other parameter follow the same 1/8 ratio: 32 km/h *vs* 256 km/h etc.

Wildfire event detection and disambiguation:

- Fixed-wing fly at an altitude that allows them to detect possible fire events up to three cells away (2.5 km). Quadcopters only “see” inside their own cell (500 m radius)
- The world is populated with a fixed number of events (true and false positives). Detection and disambiguation are achieved with a probability P that decreases as the observation distance r (in km) increases: $P = k^{-r}$ with $k = 2$ for the former and $k = 4$ for the latter

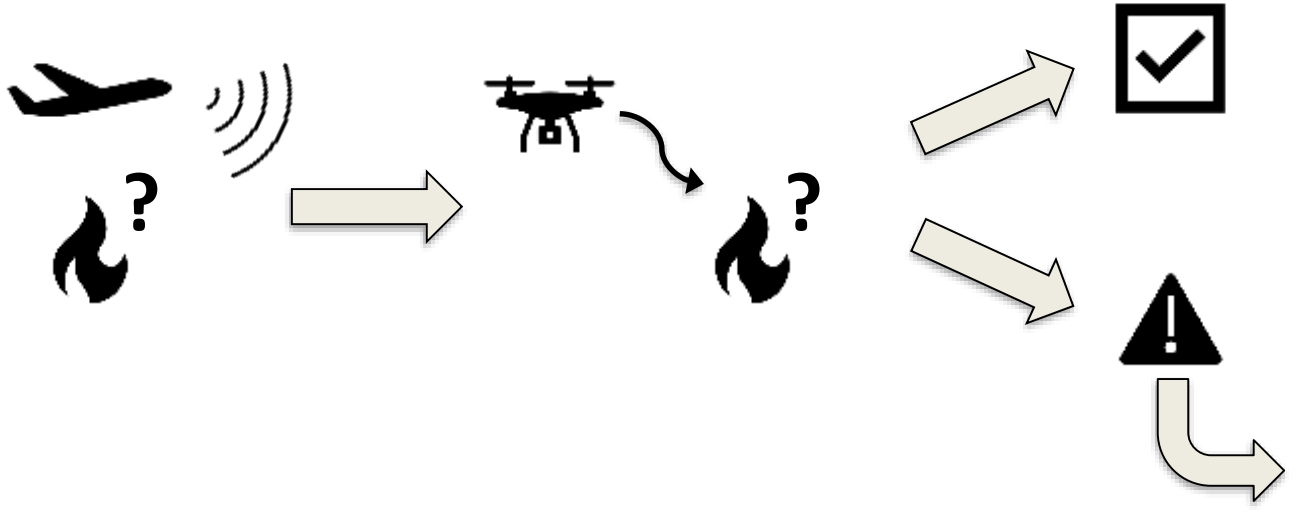
Proof-of-Concept

Numerical experiment: cooperation

A possible wildfire event that has been detected but ***not*** successfully categorised as either a true or false positive is marked as the target for a disambiguation mission, which overrides other autonomous navigation decisions

Since quadcopters may only detect an event within 500 m ($r = 0$ km, rounded down), they are ***always*** successful at both detection and disambiguation

Accordingly, cooperation takes the form of a fixed-wing UAS flagging a possible event and triggering a disambiguation mission by a quadcopter (close inspection)



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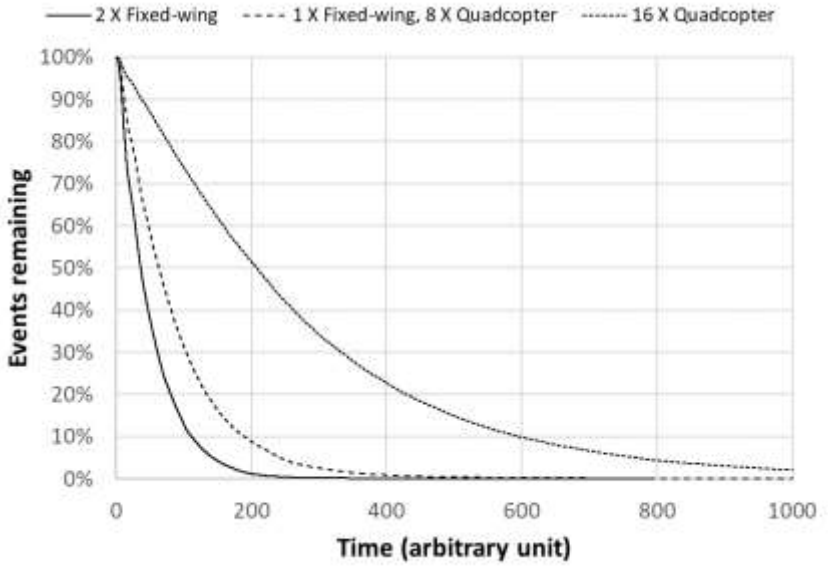
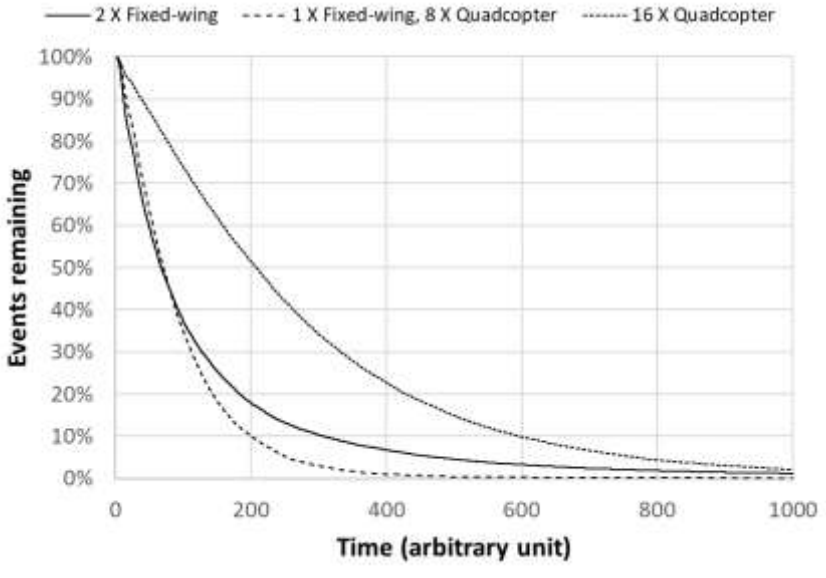
Proof-of-Concept

Numerical experiment: results

Tests were conducted for a variety of hybrid fleets, on a budget of €160k (i.e., 2 fixed-wing UAS, 16 quadcopters, or 1 fixed-wing and 8 quadcopters). Operational costs were not considered.

Results emphasise the advantages and disadvantages of each approach, with the "quadcopters only" option performing the worst. As anticipated, the "fixed-wing only"





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Conclusion and future work

Lessons learned and next steps

- Numerical experiments provide preliminary evidence that a hybrid fleet of UAS has ***significant advantages*** if considering the need to eliminate false positives
- Our performance evaluation method would allow for the identification of the ***optimal mix*** of platforms within arbitrary ***budget constraints***, given accurate parameter values (those used for the proof-of-concept were educated guesses)
- Additional simulations involving intermediate UAS types (flying at medium altitude/speed) emphasise the ***flexibility*** of the proposed approach (results not presented)
- Ongoing and future work will focus on refining the underlying flight and detection/disambiguation models

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FireMan

Thank you!

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