Mission Support for Drones: A Policy Based Approach

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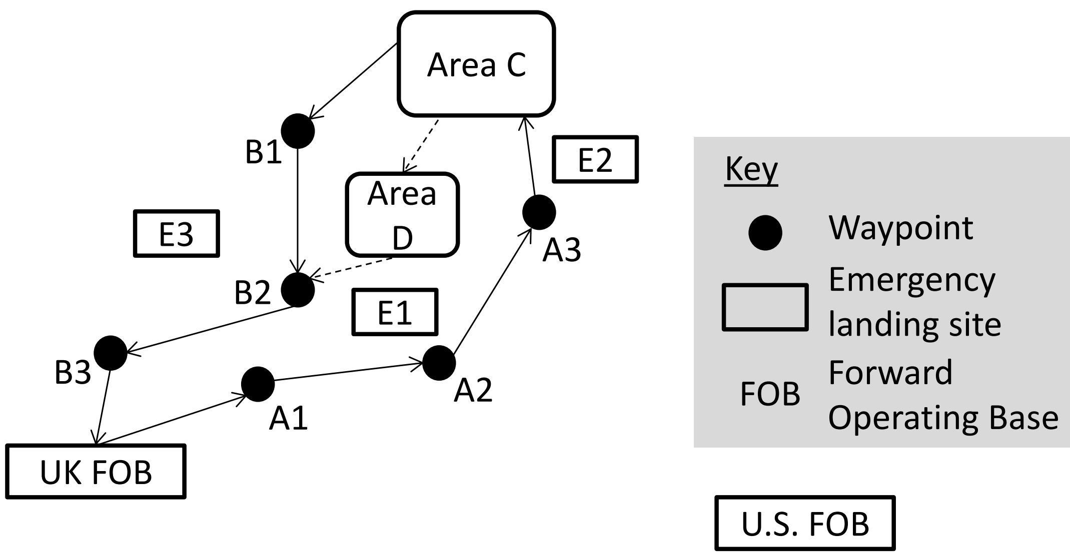
Overview

- Motivation: Research into generative policies to facilitate coalition operations

- Introduce a coalition scenario with drones
- Summarise challenges in drone operations
- Introduce policy as a concept
- Introduce generative policies with examples
- Conclusions

Scenario (1 of 2)



UK and U.S. forces are operating in a hostile environment

The UK commences a surveillance operation in area C

- Routes and emergency landing sites planned
- Plans shared with U.S.
- Drones operating in a swarm

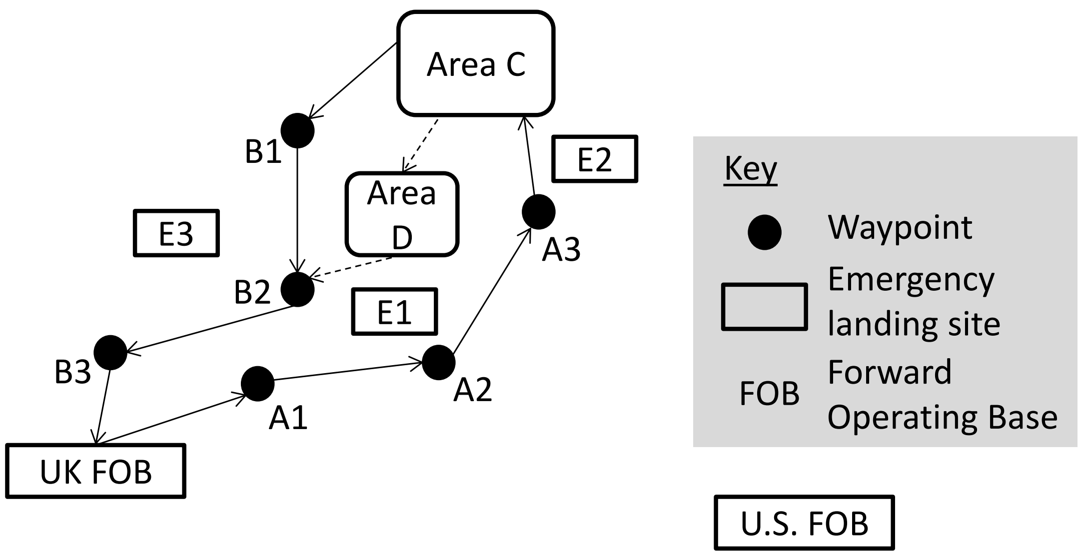
The U.S. loses a manned aircraft in area D, and wishes to extract the crew who have survived

- Imagery is required *urgently* to select a safe landing site for their rescue helicopters

How should this imagery be obtained?

Scenario (2 of 2)

Option	Benefits	Drawbacks
1) Commence special U.S. drone mission	High security	Long flight time from U.S. FOB Risk of alerting opposition forces
2) Task U.S. special forces operating near D	High security	Delay before secure comms Puts further lives at risk
3) Ask UK to retask a drone at C	Fast response Low risk of alerting opposition forces	Sharing information about a critical mission



U.S. selects option (3)

UK confirms that it can accept the mission without compromising safety

UK drones select best suited member of the swarm to go to D

UK drones undertake additional task: check for the possibility of opposition forces moving towards D

Challenges in Drone Mission Planning

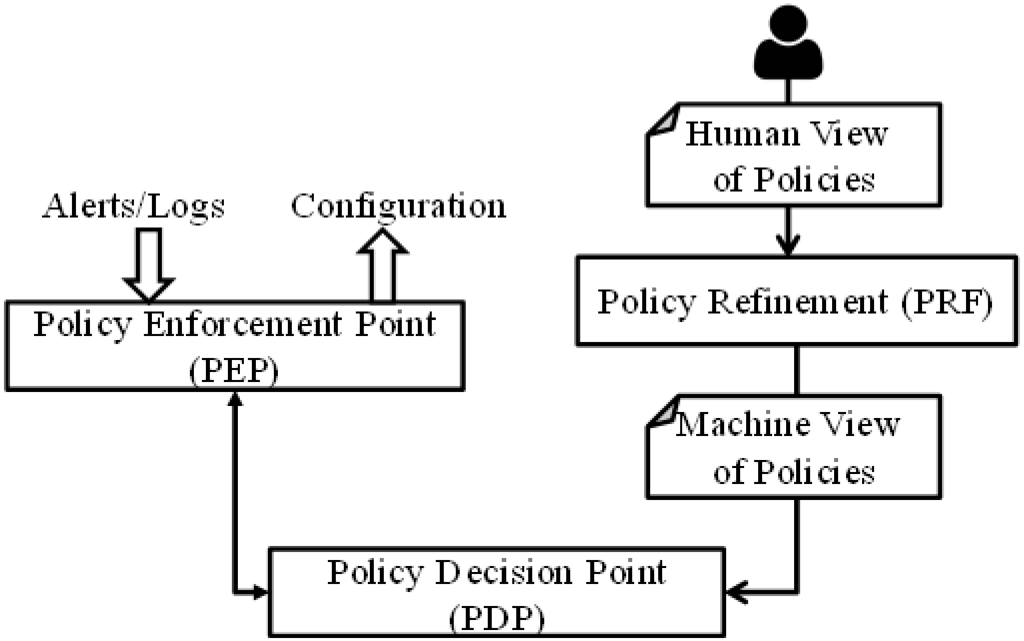
- From the scenario
  - Adapting to unexpected events and/or changing priorities
  - Being observed by opposition forces
- Other challenges
  - Operation in congested or contested airspace
  - Airspace segregation for operation with manned aircraft
  - Communications with congested or contested spectrum
  - GPS denial
  - Hazardous weather conditions, daylight dependencies
  - Platform limitations, e.g. range
  - Etc.

Introduction to Policy

- Policies influence the behaviour of a system or person
- Obligations vs constraints
- Grouped into domains for management

Policy Example	Policy Domain
Fly above 10,000 feet in area X	Navigation
Do not take photographs in area Y	Sensor management
Return to FOB if fuel less than required plus 20% margin	Navigation
Photographs must be encrypted with AES 256	Data management

Policy Based Management: Reference Architecture



Policies are initiated by humans

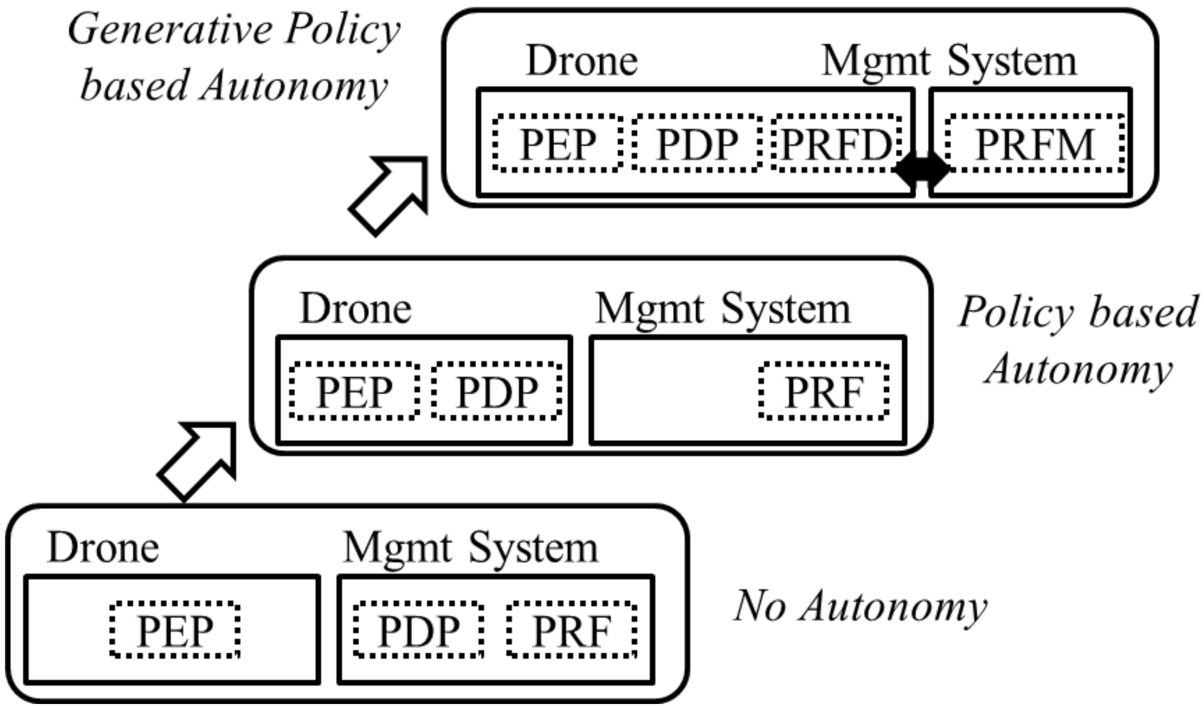
- Commanders
- Legislation
- Owners of platforms
- Suggested by manufacturers
- Etc.

Architecture

- Refinement into machine understandable statements
- Enforcement points
- Decision points

Diagram from D. Verma, S. Calo, S. Chakraborty, E. Bertino, C. Williams, J. Tucker and B. Rivera, "Generative Policy Model for Autonomic Management," in 1st Int. Workshop Dist Analytics Infrastructure & Algorithms, IEEE Smartworld Congress, 2017 (to appear), 2017.

Policy Based Management: Evolution of Architecture



In general wireless communications are not dependable
Low autonomy and lost communications => risk of mission failure
Autonomy is facilitated by moving policy framework to platforms

Diagram from D. Verma, S. Calo, S. Chakraborty, E. Bertino, C. Williams, J. Tucker and B. Rivera, "Generative Policy Model for Autonomic Management," in 1st Int. Workshop Dist Analytics Infrastructure & Algorithms, IEEE Smartworld Congress, 2017 (to appear), 2017.

Generative Event/Condition/Action Policy Rule - Example

Event	Request-to-Emergency-Land (X: landing site)
Condition	Secure(X) MOD
Action	Land(X)

Condition predicate: True, False, or Unknown
MOD => predicate can be substituted via refinement
Generative policy

- Policy supplied to drone is partially specified
- Drone allowed to make its own policy decisions

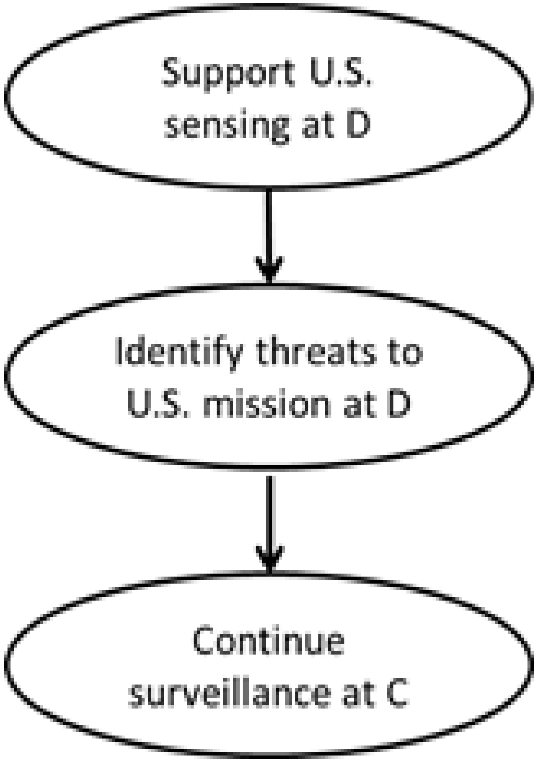
Instantiated Event/Condition/Action Policy Rule - Example

Event	Request-to-Emergency-Land(E1)
Condition	False
Action	Land(E1)

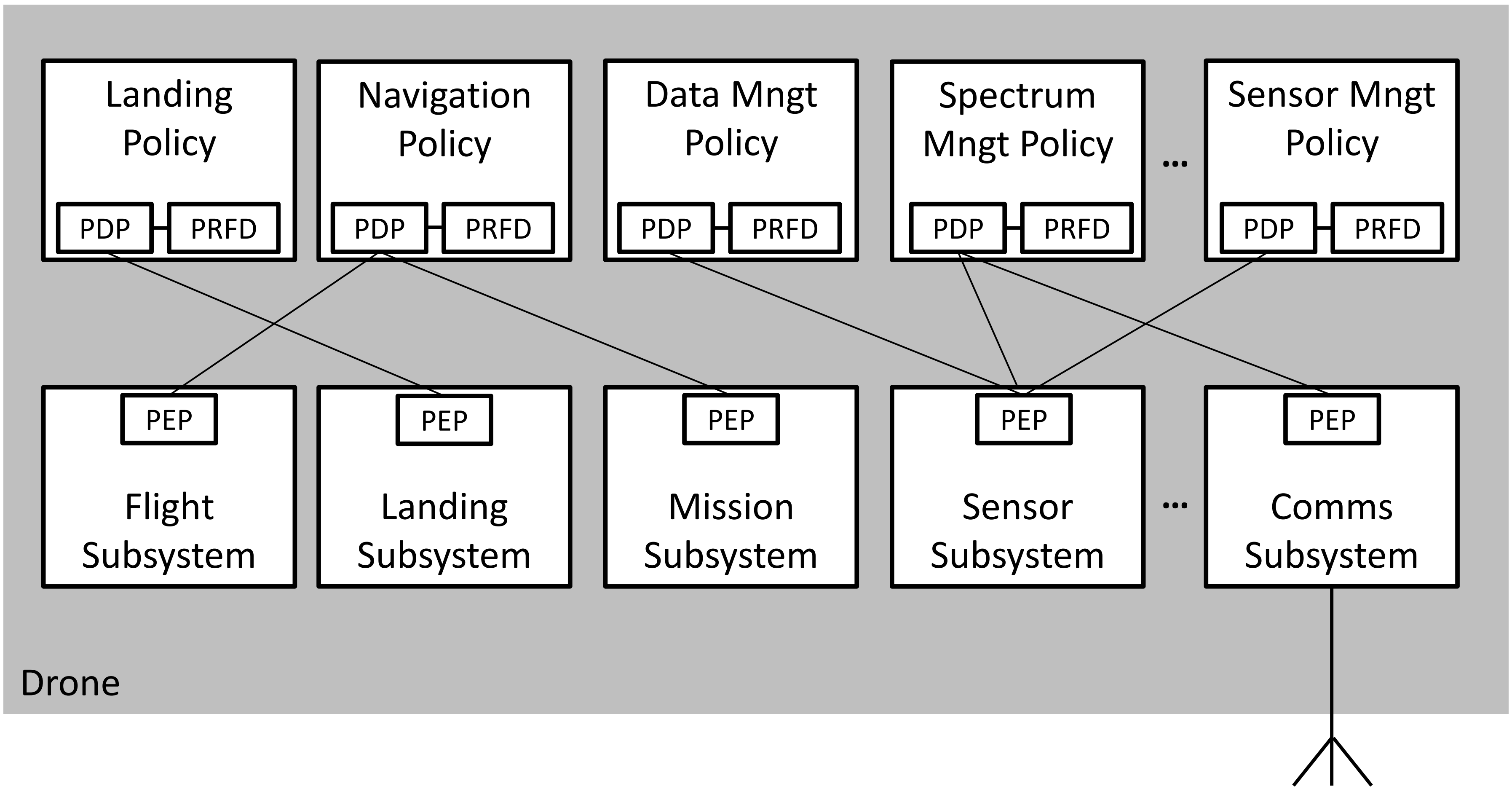
Event	Request-to-Emergency-Land(E2)
Condition	True
Action	Land(E2)

Event	Request-to-Emergency-Land(E3)
Condition	E3.SecStaus = OK AND CURRENTTIME - E3.SecStatus.NotifT <10m AND E3.SourceNotif.Trust = High
Action	Land(E3)

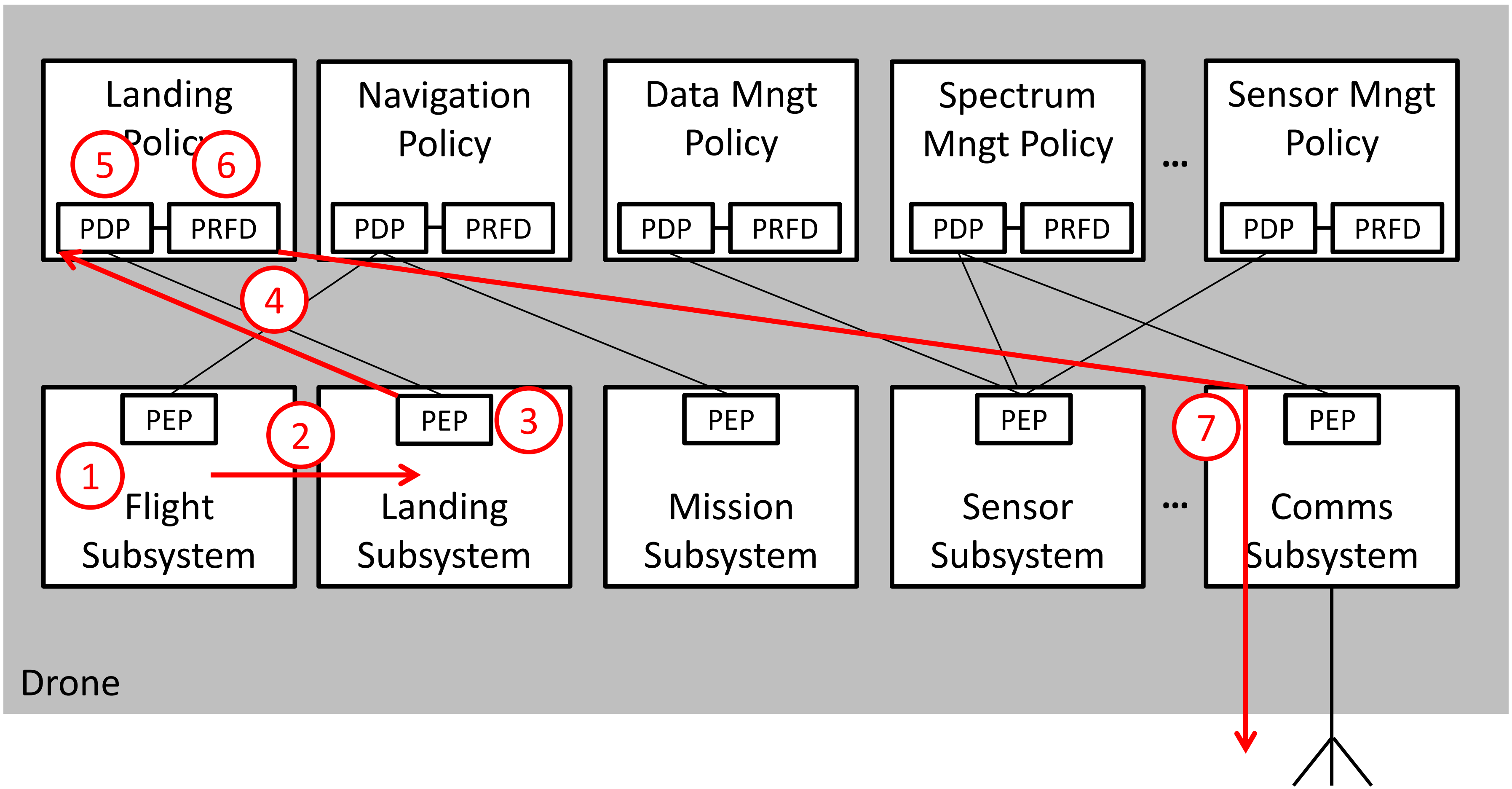
Policy Preference Graph



Hypothetical Implementation



Emergency Landing Example



Conclusions

- Vision of autonomous drones facilitated by a generative policy framework
- Benefits
  - Reduced manpower => improved scalability, lower cost, lower risk to lives
  - Avoids dependency upon communications
  - Agility, e.g. a drone could be acting as a sensor, communications relay and processing platform concurrently
- Future work
  - Detect and resolve policy conflicts, especially in coalition operations
  - Policy framework: languages, security, etc.
  - Assurance of a complex system of systems

Acknowledgements

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