Future Directions in Control for Unmanned Air Vehicles

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Outline

Introduction

UAV Issues

Control Challenges

Summary

Congressional Actions

"It shall be a goal of the Armed Forces to achieve the fielding of unmanned, remotely controlled technology such that –

(1) by 2010, one third of the operational deep strike aircraft of the Armed Forces are unmanned; and
(2) by 2015, one third of the operational ground combat vehicles of the Armed Forces are unmanned."

SASC Bill S.2549
12 May 2000

"[This is not intended] to replace pilots and manned aircraft with unmanned combat systems, but to provide added capabilities to manned combat aircraft -added capabilities that would provide alternatives to sending military personnel into the highest risk missions."

SASC Report 106-292
11 May 2000

Air Force Research Laboratory Organization

Commander
Major General Paul D. Nielsen

- Command Section (262/55)
  - Staff Offices
  - Plans & Programs
  - Air Vehicles (321/110)
  - Space Vehicles (593/275)
  - Information (812/338)
  - Munitions (337/130)
  - Directed Energy (578/260)
  - Materials & Manuf. (456/223)
  - Sensors (649/381)
  - Propulsion (489/465)
  - Human Effectiveness (573/411)
  - AFOSR (152/57)

Totals 5222/2905

* Total Government Authorized/Total Contractor

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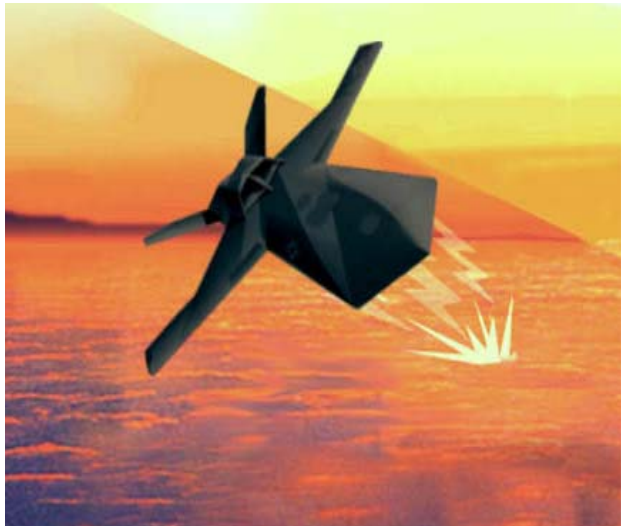


High Level UAV Issues

Concept of Operations

(How do we use UAVs in military operations?)

- Combat Intelligence Surveillance and Reconnaissance (Combat-ISR)
- Automated Air-Refueling/Re-Arming
- Persistent Area Denial

Manned Airspace

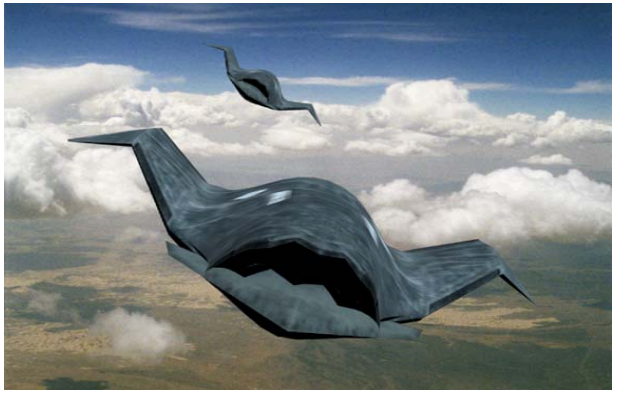
(How to integrate UAVs in a crowded airspace with a lot of people in it?)

- Commercial Air Traffic Control Systems
- Military Air Traffic Control Systems

Positive Control

(How to get a group of semi-autonomous UAVs to *reliably* do what we want them to do)

- Decentralized Teams
- Information Systems
- Uncertainty



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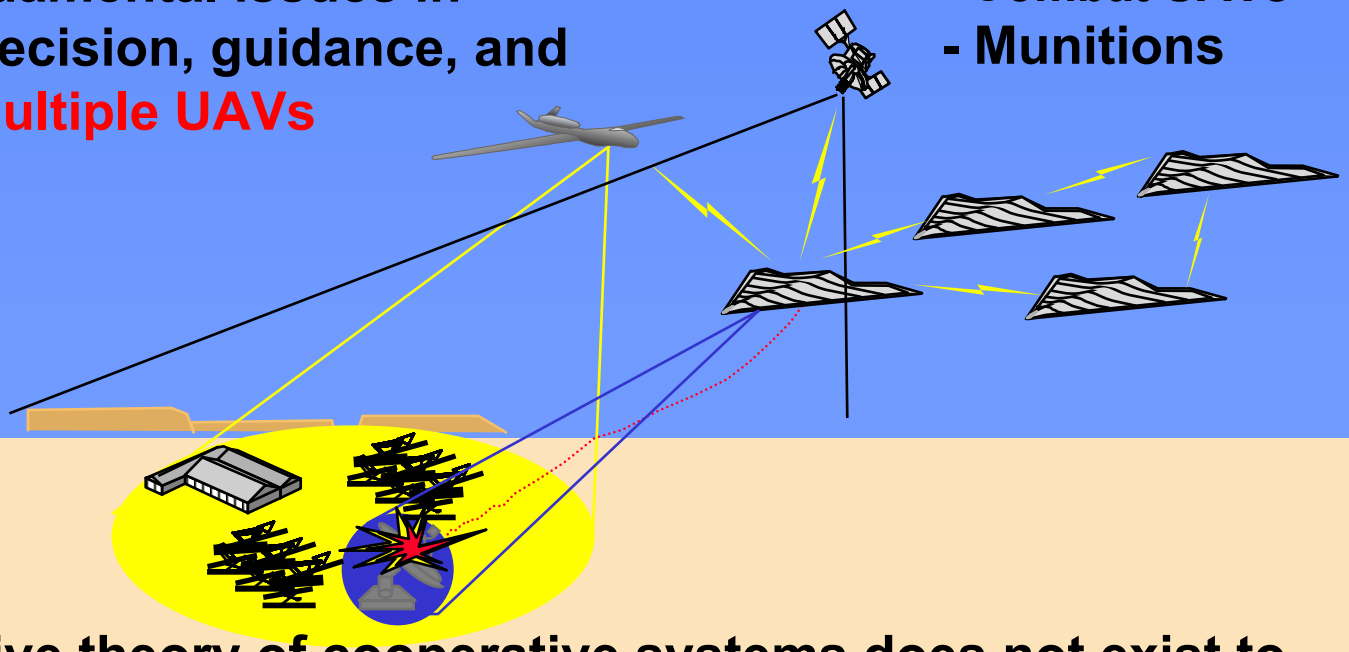
UAV Distributed Control

Objective:

Address fundamental issues in distributed decision, guidance, and control for multiple UAVs

- Combat UAVs
- Munitions

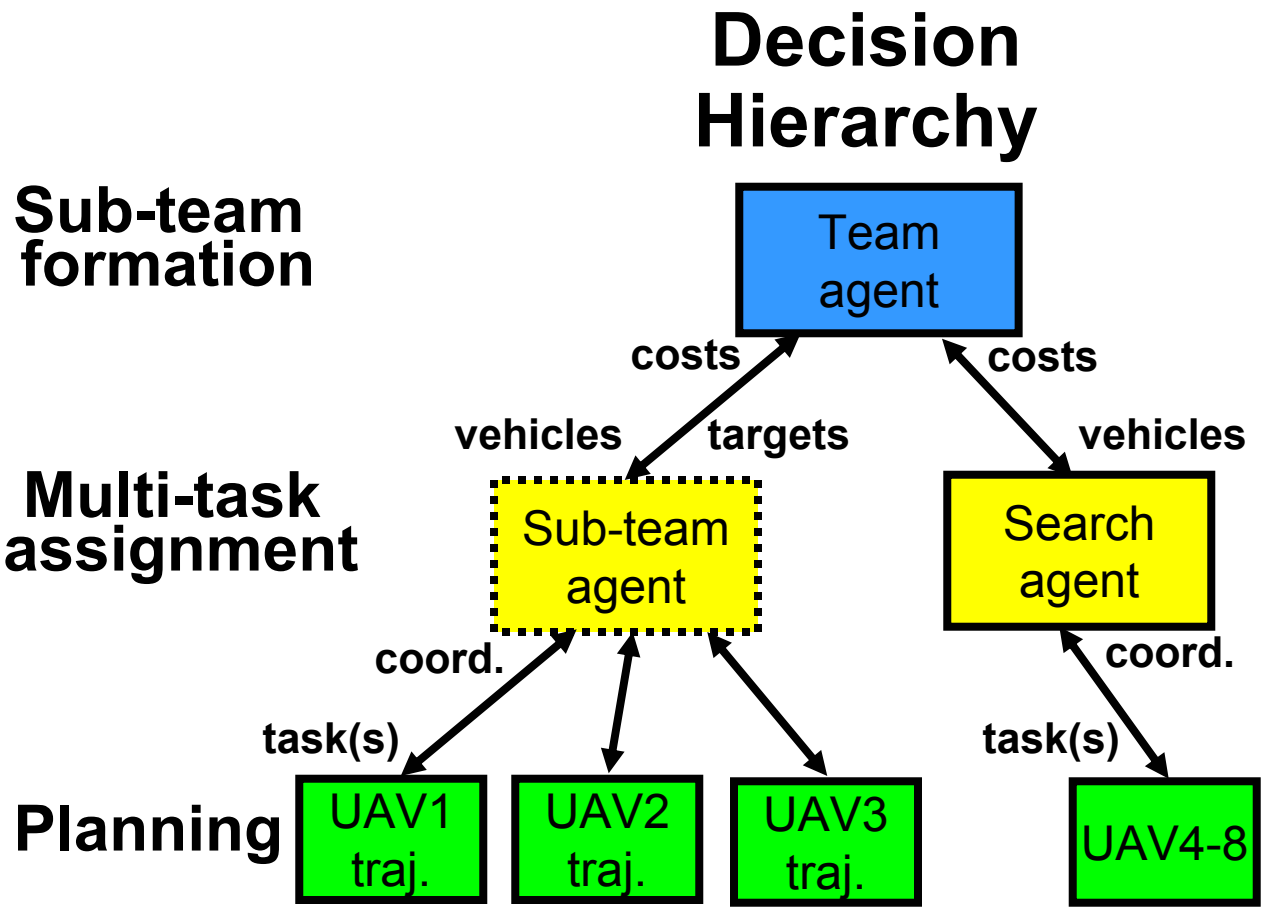


Challenge:

Comprehensive theory of cooperative systems does not exist to coordinate objectives under high complexity, uncertainty and partial information

Cooperative Control

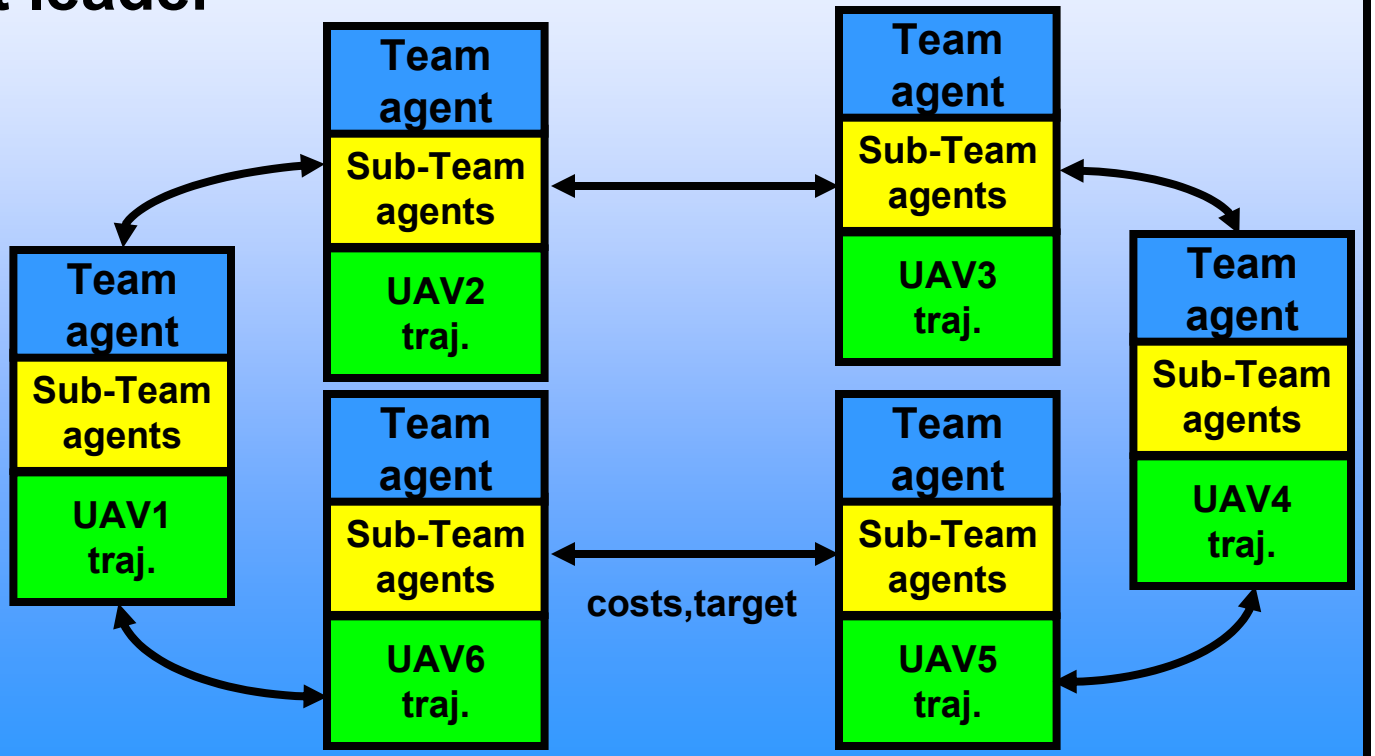
Decomposition



Cooperative Control

Team Information Structure

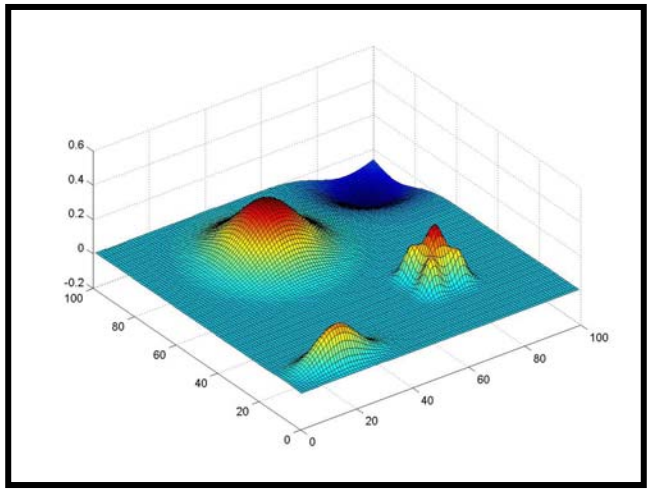
- Decentralized decisions
- Distributed sensing
- Partial state information
- No explicit leader



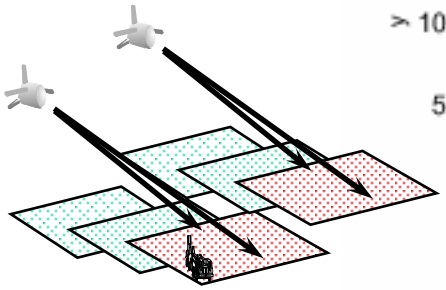
Cooperative Control

Search Uncertainty

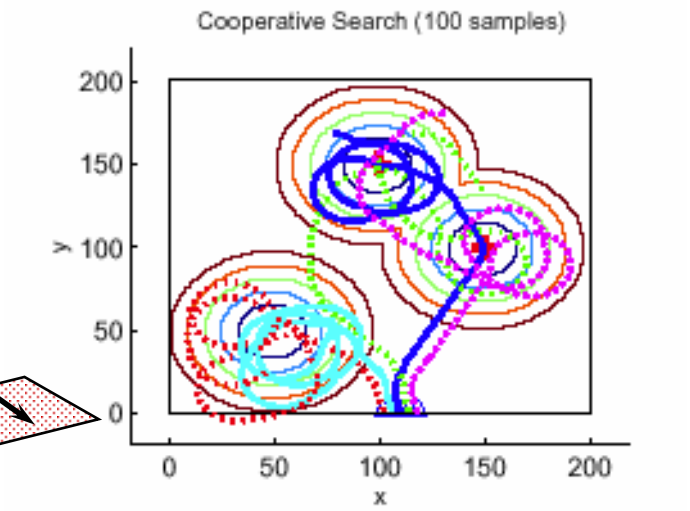
No Target Data



- Build cognitive maps of threats, targets, terrain
- Maximize coverage



Possible Targets



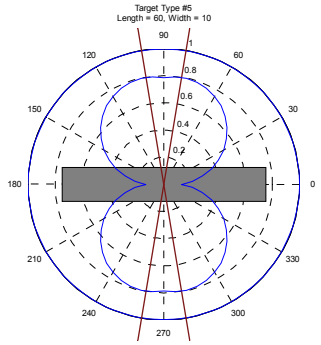
- Search theory
- Relocatable targets
- Hidden targets

Cooperative Control

Classification Uncertainty

Combine views to maximize probability of correct classification

- Aspect angle dependence
- Multiple views needed
- Correlated views



Aspect Angle Template

Objective

- find 2nd heading to view target
- optimal vehicle to perform 2nd view

Rendezvous Control Challenges

- survivable trajectories
  - multiple target
  - time phased team attack
  - minimum team ETA

Cooperative Attack Control Challenges

- task sequencing
- sensor–shooter allocation
- false target attack rate
- team coordination with decoys & ISR

Challenges on Cooperative Munitions

Cooperative Search

- optimal search strategy
- situational map building
- time critical targets
- coupling with other tasks

Multi-Vehicle Sensing

- target state estimation
- threat state estimation
- sensor fusion
- passive triangulation

UAV Networks

Communication limitations

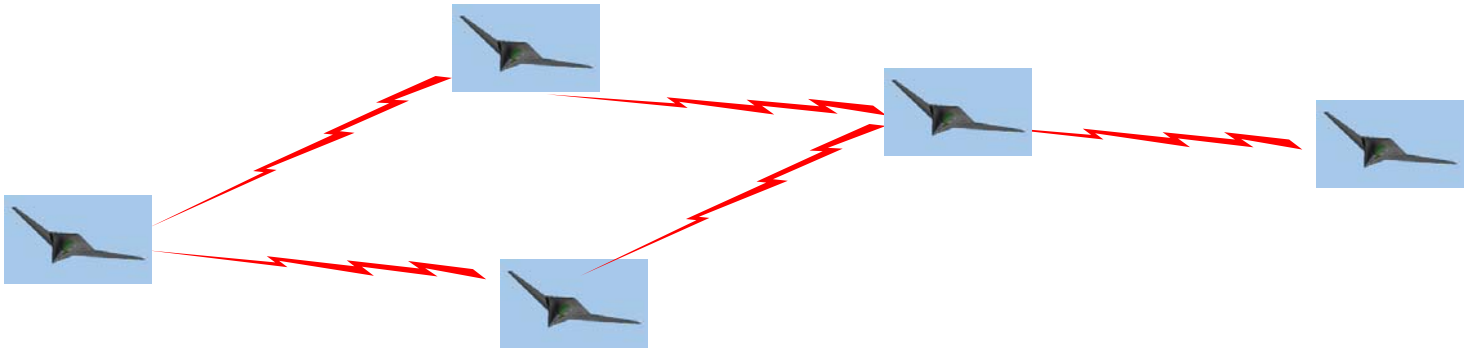
-Noise
-Delays
-Bandwidth
-Range
-Network topology

Functionality

–Synchronization
–Timing & stability
–Highly coupled tasks
–Multiple assignments
–Limit cycle “churning”

The challenge is

cooperative control over networks



Summary

Distributed UAV control problem is dominated by

- ✓ **Complexity**
- ✓ **Uncertainty**
- ✓ **Partial information**
- ✓ **Communications**