

Drone Based Autonomous Antenna Swarms

Communications and Control
Aspects for Manned-Unmanned
Teaming

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 - Erion Plaku – Swarm motion planning, optimization
- University of Tennessee, Knoxville
 - Aly E. Fathy – Radar system design, synchronization and localization

Interdisciplinary Collaboration

- Develop an **autonomous, distributed system** to remotely sense, image, or monitor an activity or a particular property of interest in a difficult to reach/hostile environment
- Use **microwave technology** (high penetration of barriers, night time use, privacy)



Objectives

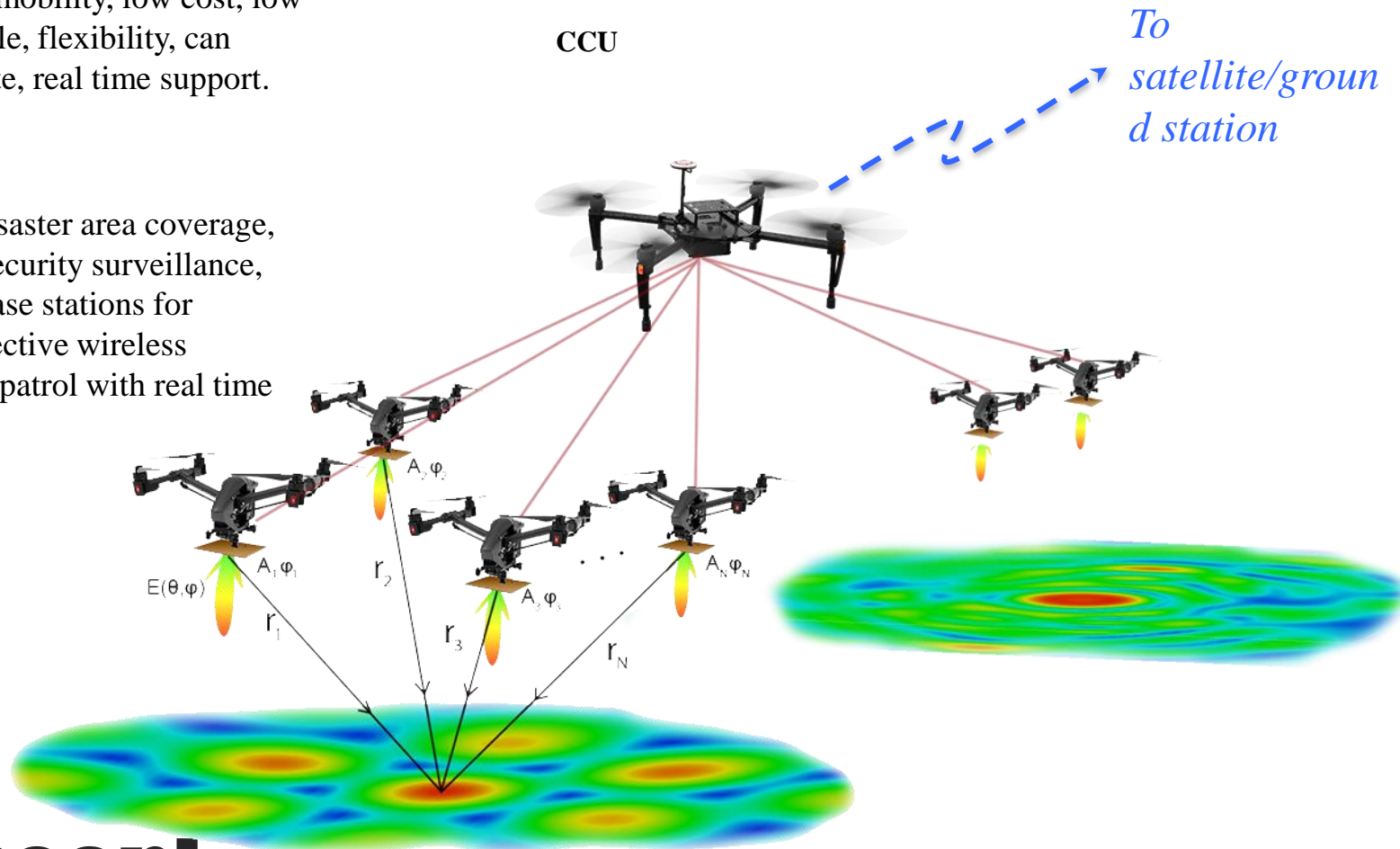
Drones provide platform for beam switching between satellites/base stations on the ground.

ADVANTAGES:

Adjustable altitude, mobility, low cost, low infrastructure, reliable, flexibility, can provide high data rate, real time support.

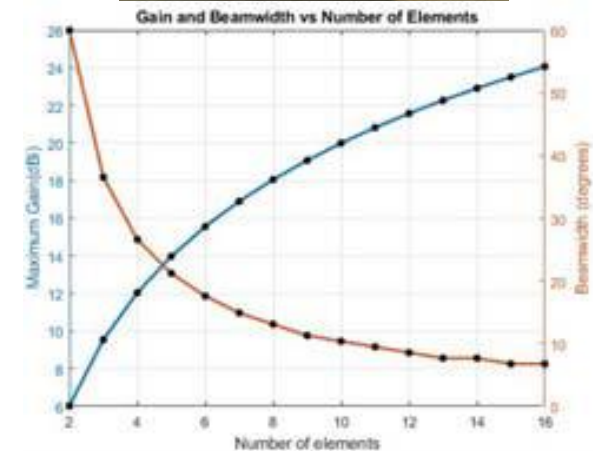
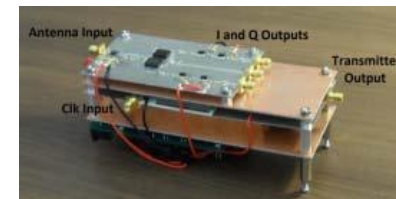
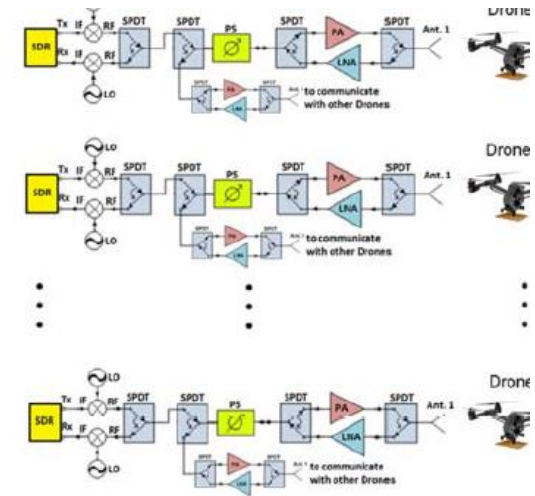
APPLICATIONS:

Communications, disaster area coverage, search and rescue, security surveillance, agriculture, flying base stations for reliable and cost effective wireless connectivity, border patrol with real time support



Concept

- The antenna array system is composed of multiple single-antenna drones
- Reconfigurable using relative spacing, number of elements, and phase shifters.
- Not limited by space constraints
- Gain along a given direction is controlled via relative drone positioning and/or phase are adjustments.



Antenna System

- CCU – satellite/ground station →

The connection to ground is the bottle neck of drone technology, and needs to be done in real time. Improving the connection would improve RF link budgets

- Swarm – CCU

- Inter-swarm

for coordination, interference mitigation, relaying, routing in the air

- Swarm – ROI (region of interest)

- *Multiple drones can be used as an aerial antenna array and can effectively provide wireless service to ground users.*
- *Service time is minimized by optimizing the wireless transmission time and control time needed for movement and stabilization of drones.*
- *Transmission time can be minimized by increasing the array gain upon optimizing the drone spacing.*
- *A tradeoff needed to minimize control time, transmission time, serving multiple users by adjusting number and location of drones*
- *Synchronization with GPS would allow precise localization*

Communications

- Interference
- Handover and movements
- Resource management
- Security and privacy
- Energy efficiency
- Path planning
- Drone antennas – small, light weight, robust

Challenges and Limitations

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- Use of electronically scanned antennas: Maximize: range, persistence, data rate, and lifetime.
- Better solution when fixed beam or mechanically gimbaled apertures not viable.
- Advantages: low mass, mechanical simplicity, directing energy into a spot, higher efficiency, better autonomous flight duration.
- A ground station can follow a planned route of the drone, steering its own beam, or the drone can maintain connectivity to one or various ground stations that are located in fixed or known positions.

Our Approach

- Illustration of how the proposed system could be used in a disaster-recovery scenario
 - Approach partitions UAVs into smaller groups, assigns tasks, and plans motions
 - Objective is to quickly inspect the entire area
 - System actively communicates with the human supervisor providing critical feedback and responding to new instructions



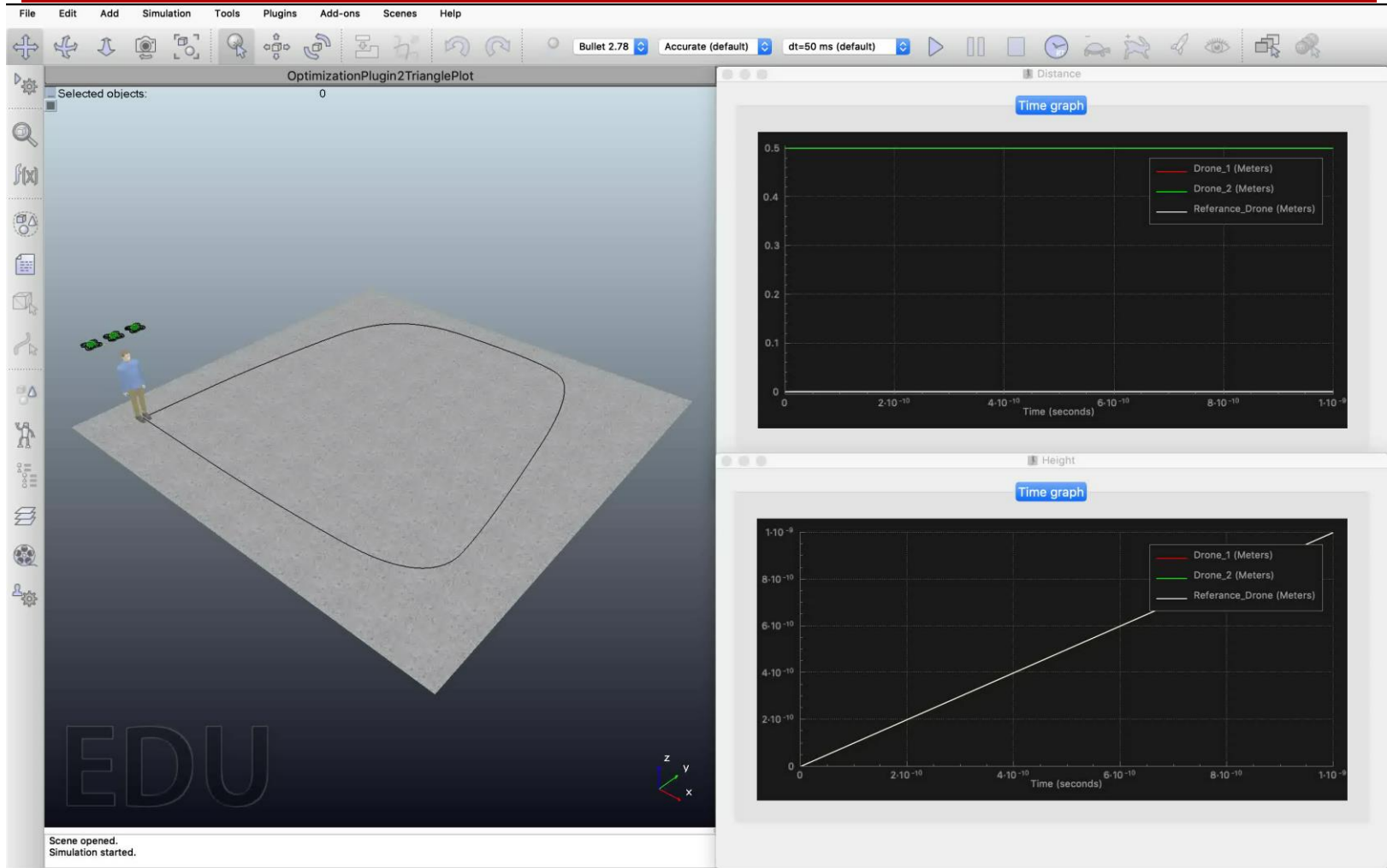
Application – Disaster Rescue

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Application - Defense

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Real Time Coverage