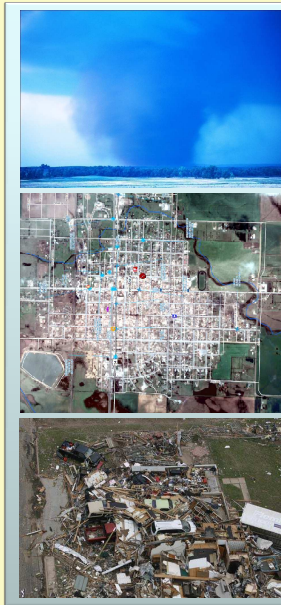


## Project Description

- **Security Scenario:** Tornadoes struck the United States 1691 times in 2008
  - Distributed sensing can provide key first response and damage assessment
  - Storm categorization must be made by assessing damage to natural and man-made structures
  - Existing methods of manned helicopter assessment are costly (\$5000-\$10000 per incident) and introduce a single point of failure
  - Using distributed agents exposes them to adverse, unknown environmental conditions and malicious attacks
- **Objective:** Use task-to-resource reallocation to allow execution of distributed system objective despite intrusions or environmental factors
  - Identify problems proactively with IDS
  - Perform reallocation to allow continued distributed execution



## Mobile Test-Bed

- Radio-controlled UAV platform with onboard autonomous navigation
  - Hangar 9 Alpha 40 trainer aircraft
    - Large loading capacity, stable flight
    - Onboard internal combustion engine and fuel source for up to 40 minutes of flight
  - Onboard navigation computer and servo management
    - Features GPS for waypoint navigation
    - Multi-axial thermopiles for altimetry and orientation management
  - Mountable distributed sensing (photo/video)
  - Two-way telemetry and inter-aircraft comm
  - \$800 total unit system cost
- Autonomous flight characteristics can model actual assessment flight patterns
- In-field results provide accurate 3-space mobility data for intrusion-tolerance simulation and algorithm development



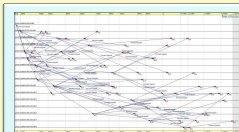
Aircraft with side-mounted camera, manual-control radio, and reported GPS tracklog



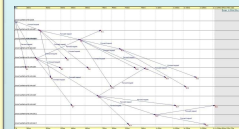
Video still from aircraft BellyCam at 2400 feet above ground – approx. 600m viewing width

## Task Re-Allocation Mechanisms

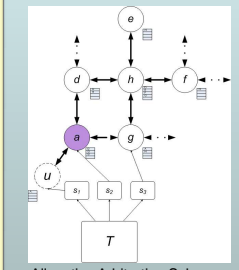
- Capitalizing on network resource redundancy to find replacement resource(s) in case of a discontinuity due to environmental or malicious interference
- Service Discovery Protocols assess suitability (fitness) of resources on each MANET node
- Modified intelligent flood algorithm limits search based on cached neighbor interactions
  - Neighboring nodes, through interaction, know resources available to their peers
  - If a resource query is received and a neighbor is aware of another neighbor's suitability, further search propagation is halted and a result returned
- Arbitrator nodes handle reallocation initialization and execution duties
- Non-reallocatable tasks are suspended until resources are once more available



Baseline Flooding Search Times



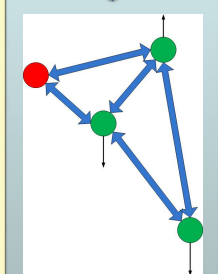
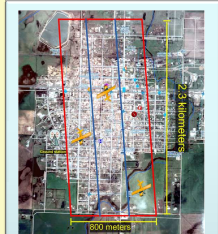
Improved Propagation Algorithm



Allocation Arbitration Scheme

## IDS Triggering and Simulation

- Proactive Intrusion Detection System technologies can reduce downtime
  - Detection of adverse conditions (e.g., jamming, spoofing, RF interference) can spawn reallocation processes prior to node failure
  - Reallocated network active before distributed task operation is threatened with discontinuity
- Flight models and system activities simulated in Omnet++ v4.0 + MiXiM mobility and wireless networking framework
- IDS triggering methods applied as Java modules that can be directly integrated into the existing Java + C++ heterogeneous simulation environment
- Resultant simulations can demonstrate mobility-aware task-to-resource reallocation for intrusion tolerance on a distributed sensing application targeted at tornado disaster assessment and response



Allocation Arbitration Scheme