



# **Coordination and Control of Cooperative Swarms of Unmanned Combat Aerial Vehicles via a Virtual Testbed Environment**

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- Michael J. Findler (Ph.D. candidate)
  - √ Controlling Swarms
- Mary E. Fendley (Ph.D. candidate)
  - √ Network-Centric Warfare
- Subashini Ganapathy (Ph.D. candidate)
  - √ Integrated Human-Algorithm Optimization
- Sriram Mahadevan (Ph.D.)
  - √ Control & Tracking Using Visual Feedback

# Student Research Team

- Rakesh Dave (Ph.D. candidate)
  - √ Integration of human with decision support
- Vijay Koppaka (MS)
  - √ Interface design and configurable simulations
- Rafael Aleman (MS)
  - √ Weapons-target time-based assignment planning
- Chaitr Hiremath (Ph.D. candidate)
  - √ Compilation of survey reports

- Introduction
- Domain Analyses
- Progress to Date
- Future Directions

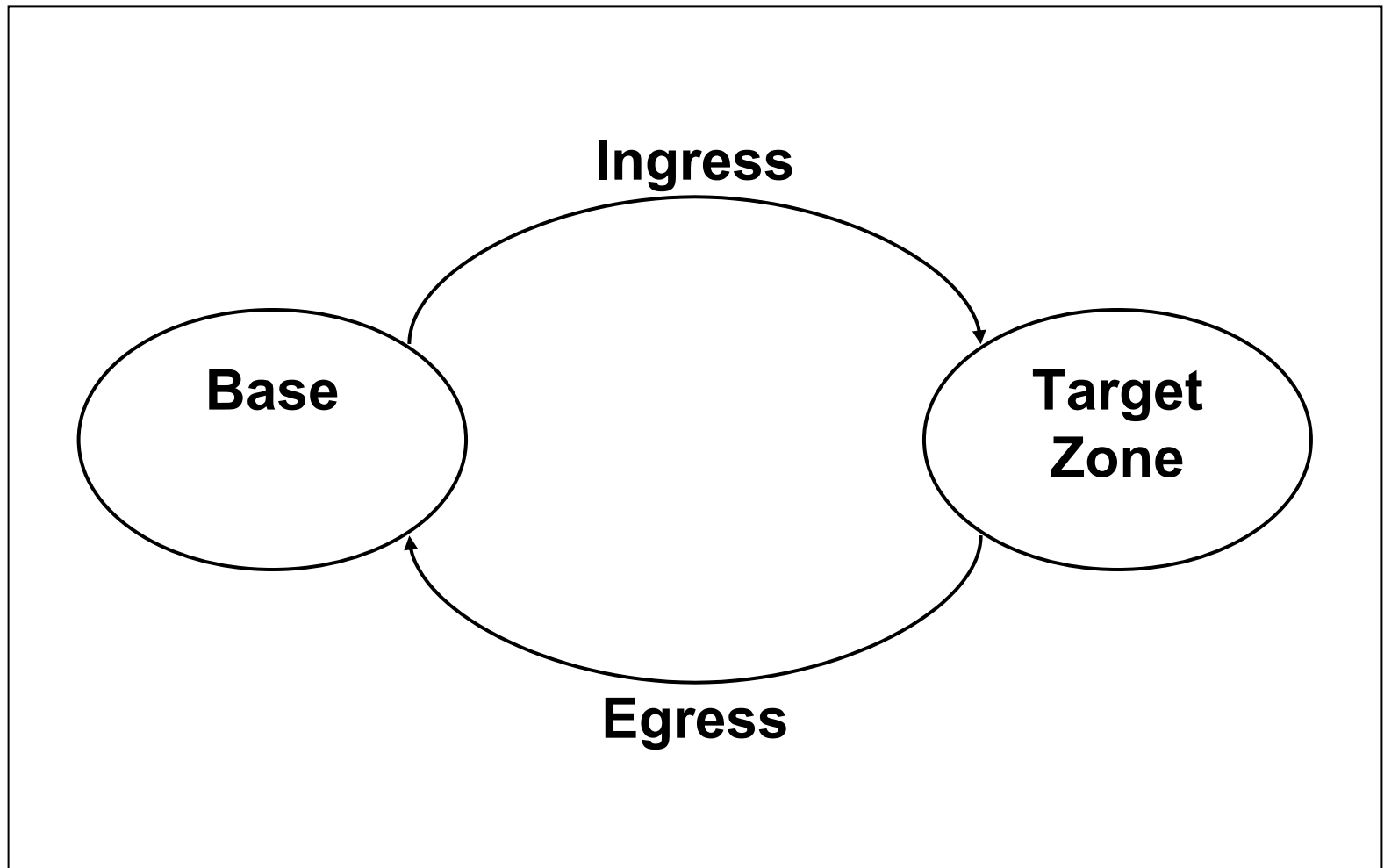
## ● MUAVES

- √ Multiple Unmanned Aerial Vehicles in a Virtual Environment System
- √ Architecture will provide an extensible research infrastructure to accommodate doctoral-level research
- √ A virtual test-bed for conducting research into human-based command and control issues with UAV/UCAV systems

# Domain Analyses

- Controlling swarms
- Human-algorithm integration
- Human integrated image analysis
- Network-centric warfare

# Controlling Swarms



# Controlling Swarms

- Target zone has four possible scenarios
  - √ search;
  - √ search and rescue (SAR);
  - √ search and destroy (SAD); and
  - √ suppression of enemy air defenses (SEAD)





- Can human-algorithm integrated optimization systems do better?
- Explicitly involve humans in generating alternatives
  - √ Leads to better coupling of human-computer systems
- Evaluate alternatives in a cognitively effective manner
  - √ Identify methods to reduce cognitive overload
  - √ Develop visual-based foundation for evaluating alternatives

- Identify baseline
  - √ Compare results of future studies in interactive modeling with the proposed framework
- Infrastructure support
  - √ Human-machine coupling
  - √ Different levels of supervisory control
  - √ Real-time decision making

- UAVs well established source of image
- Recent work examined use of UAV image for moving track indications
- Can color-based feature extraction from UAV imagery improve tracking
- Can this feature data then be combined with human input to create even better tracks?

# Network-Centric Warfare

*Information superiority-enabled concept of operations that generates increased combat power by networking sensors, decision makers, and shooters to achieve shared awareness, increased speed of command, higher tempo of operations, greater lethality, increased survivability, and a degree of self-synchronization*

Alberts et al., 1999

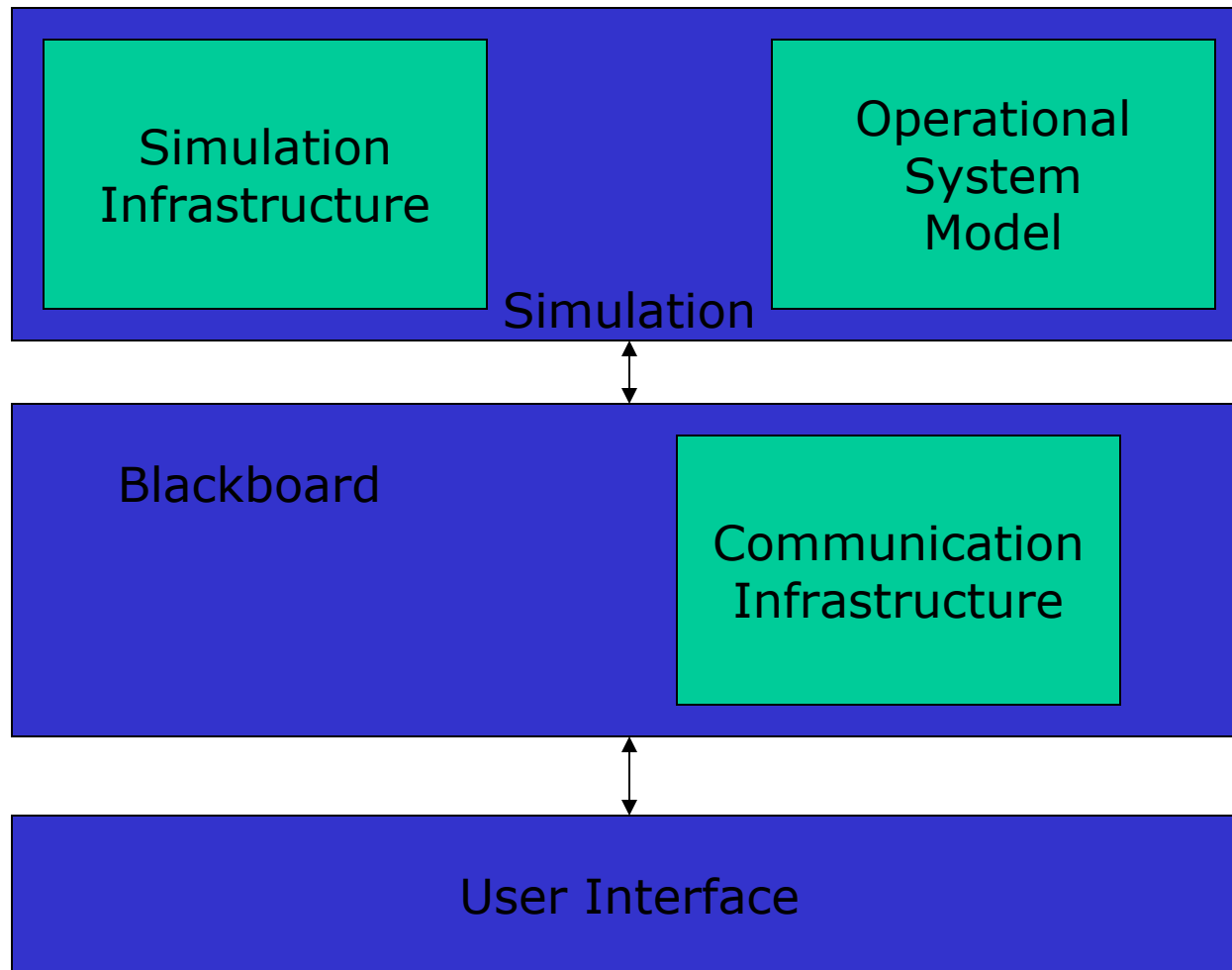
# Network-Centric Warfare

- Design, implement, and evaluate model-based visual interfaces
  - √ Enable image analysts to interpret images
  - √ Large amounts of information
  - √ Network-centric operations environment
- Interdisciplinary approach
  - √ Information fusion from multiple sensors
  - √ Human factors research on model-based display design
  - √ Network-centric environment
  - √ Image processing
- Decisions made in a time-critical manner

# Progress to Date

- Scenario designer for creating simulations
- Distributed thread-based simulation infrastructure
- Distributed communication infrastructure
  - √ Multiple levels of interconnection
  - √ Interprocess and interagent
- Different methods of communication
  - √ Standalone (<10)
  - √ Synchronous (Pull ... 10-20)
  - √ Asynchronous (Push ... >20)

# Progress to Date – MUAVES Architecture





# Progress to Date – MUAVES Simulation Architecture

- **Serialization / Deserialization**

- √ Stores state of the object / reading the object from where it is stored

- **Multi-threaded architecture**

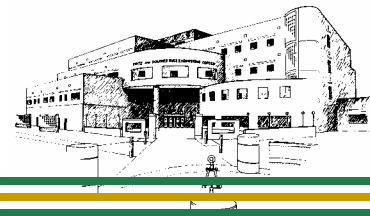
- √ Each simulation object controlled by a unique thread

- **Delegates**

- √ Capability to use user assigned function names at runtime

# Future Work

- The MUAVES architecture provides a common basis for extending the individual research efforts
- Individual research efforts
  - √ Focus is on the PhD work
  - √ At least two M.S. theses will result
- Further extend components of MUAVES for greater common use



# Questions?

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