Taskable Agent Software Kit

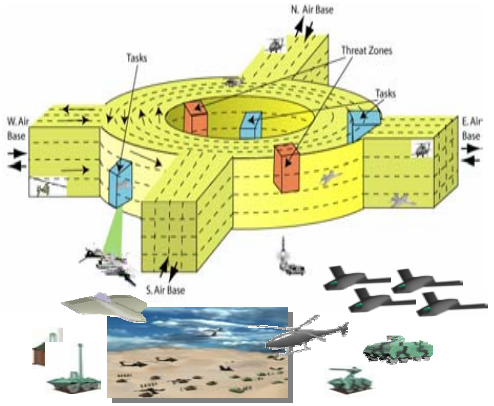
Program Objectives

Establish common infrastructure, mathematical foundations, and metrics for building, controlling, and understanding agent-based systems

Open Experimental Framework (OEF)

Enabling unmanned taskable resources to act autonomously and cooperatively to fulfill surveillance/targeting missions in highly dynamic dangerous environments

- Heterogeneous autonomous agents
- Complex tasks
  - Detection, tracking, ID
  - Constraints, cooperative tasking
- Continuous, evolving missions
- Cooperation required to achieve mission objectives
- Threats are dynamic & may adapt their behavior



Technical Challenges

- Design techniques for flexible, run-time distribution of control to regulate collective behavior without centralized design
- Adaptation strategies for recognizing and responding to unanticipated mission and environment dynamics
- Coordination methods for agreeing on group goals, assignments and shared situation assessment
- Multi-scale methods for analyzing, predicting, and controlling global behavior

Impact

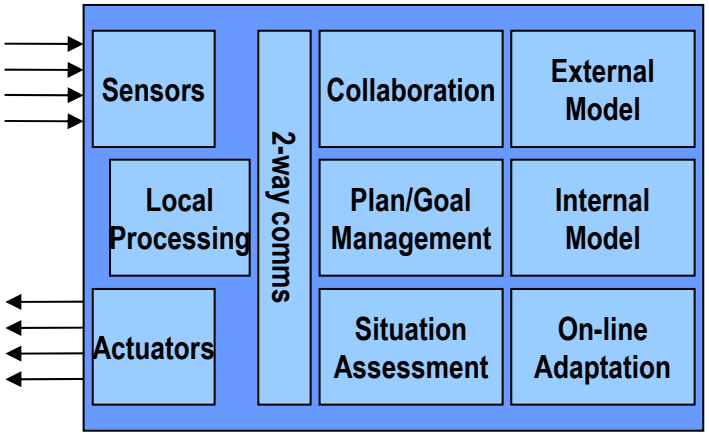
- Enable rapid construction of robust, highly decentralized agent-based solutions for military missions
- Prediction and engineering of global behavior for high confidence
- Increased autonomy reduces manpower requirements
- Establish Key foundational technologies for Cognitive Systems.

TASK Research Thrusts

Tools, Techniques for Agent-Based System Design

Agent Design Methodologies

- Control & decision frameworks
- Adaptation strategies
- Environment assessment
- Coordination algorithms



Establish core decision & control mechanisms and define metrics for appropriate use

Multi-Agent System Analysis

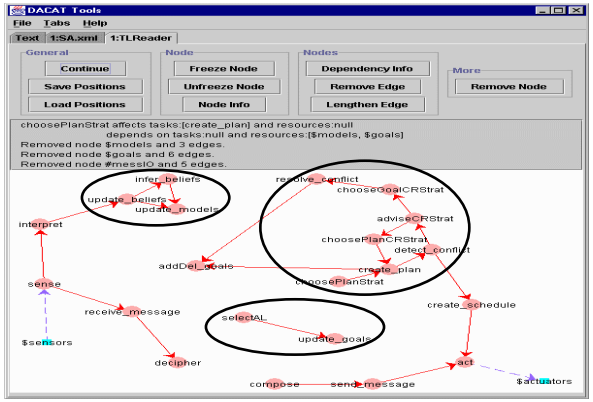
- Global behavior characterization
- Convergence and stability
- Global behavior
- Scalability and robustness

$$\frac{\partial P_m(v)}{\partial t} = -P_m(v)\sum_k \int_0^\infty dv' P_k(v')U + \sum_{k+j=m} \int_v^\infty dv' P_k(v')P_j(v)U$$
$$+\gamma\left[(m+1)P_{m+1}(v) - mP_m(v)\right] + \gamma P_0(v)\delta_{m,1} \quad m = 1,2,\ldots$$

Predict & control global behavior in large scale systems

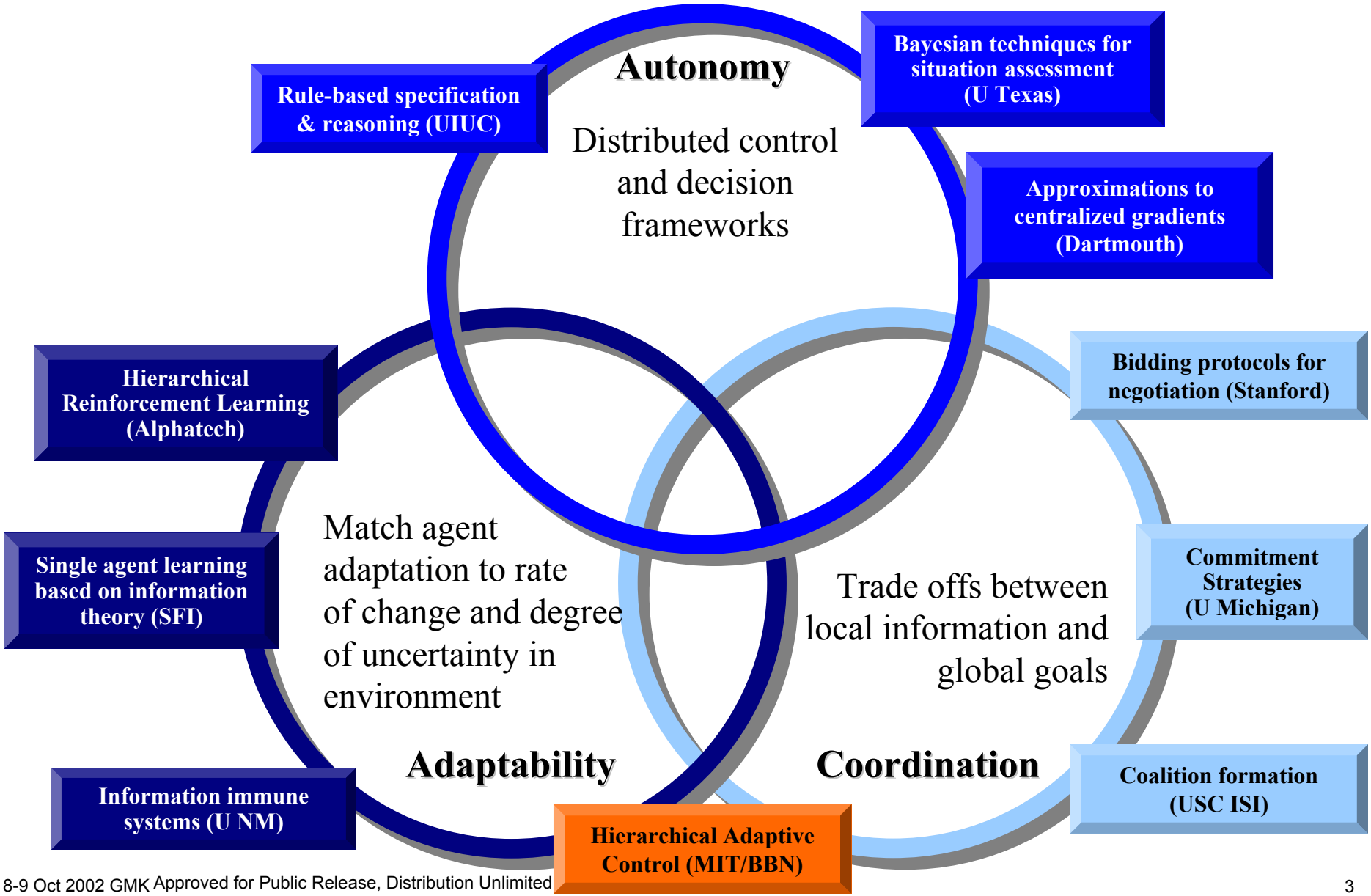
System Synthesis Toolkit

- Formal specification
- Composition of behaviors
- Generation and optimization
- Simulation

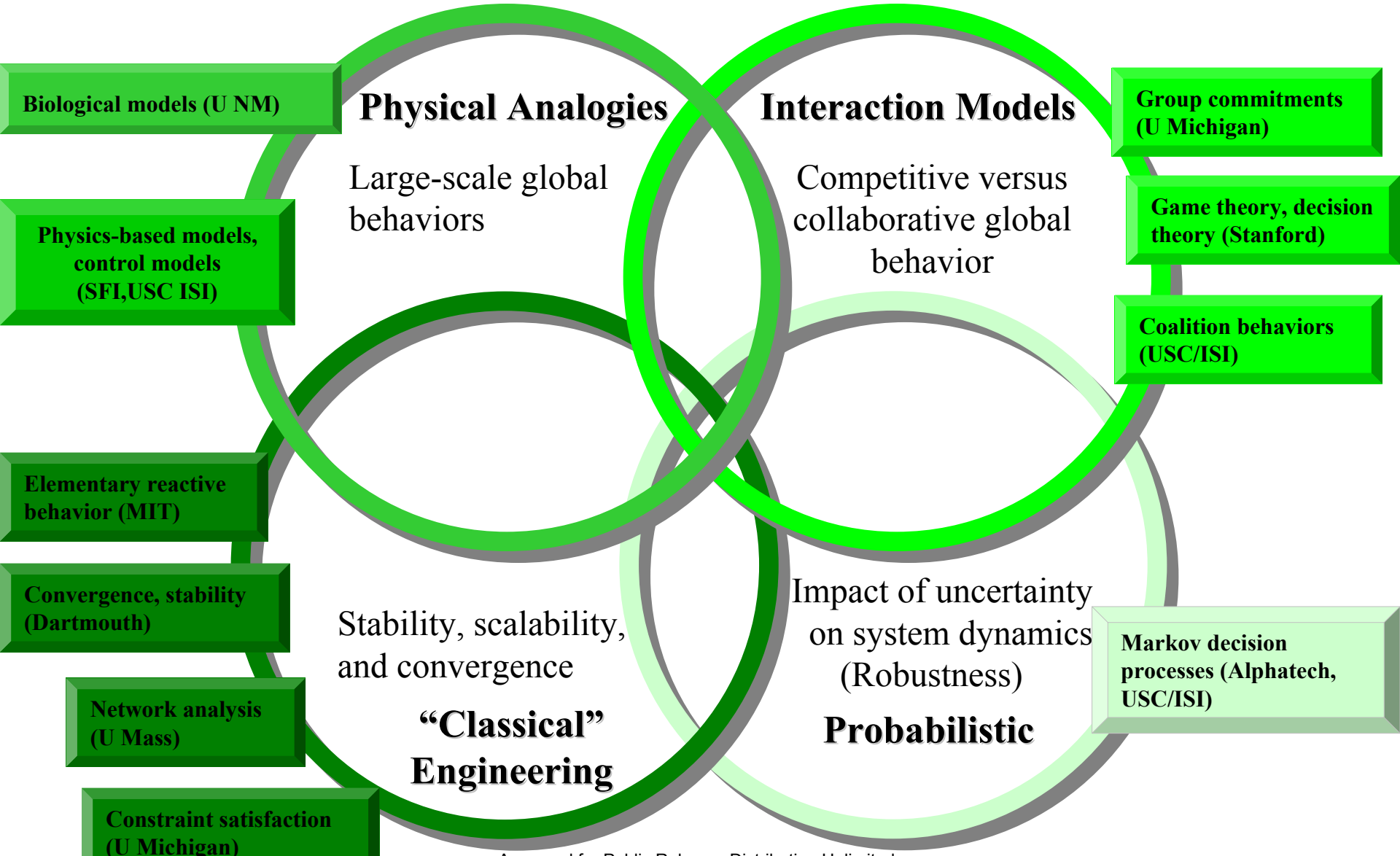


Provide software tools for synthesis & analysis of next-generation multi-agent systems

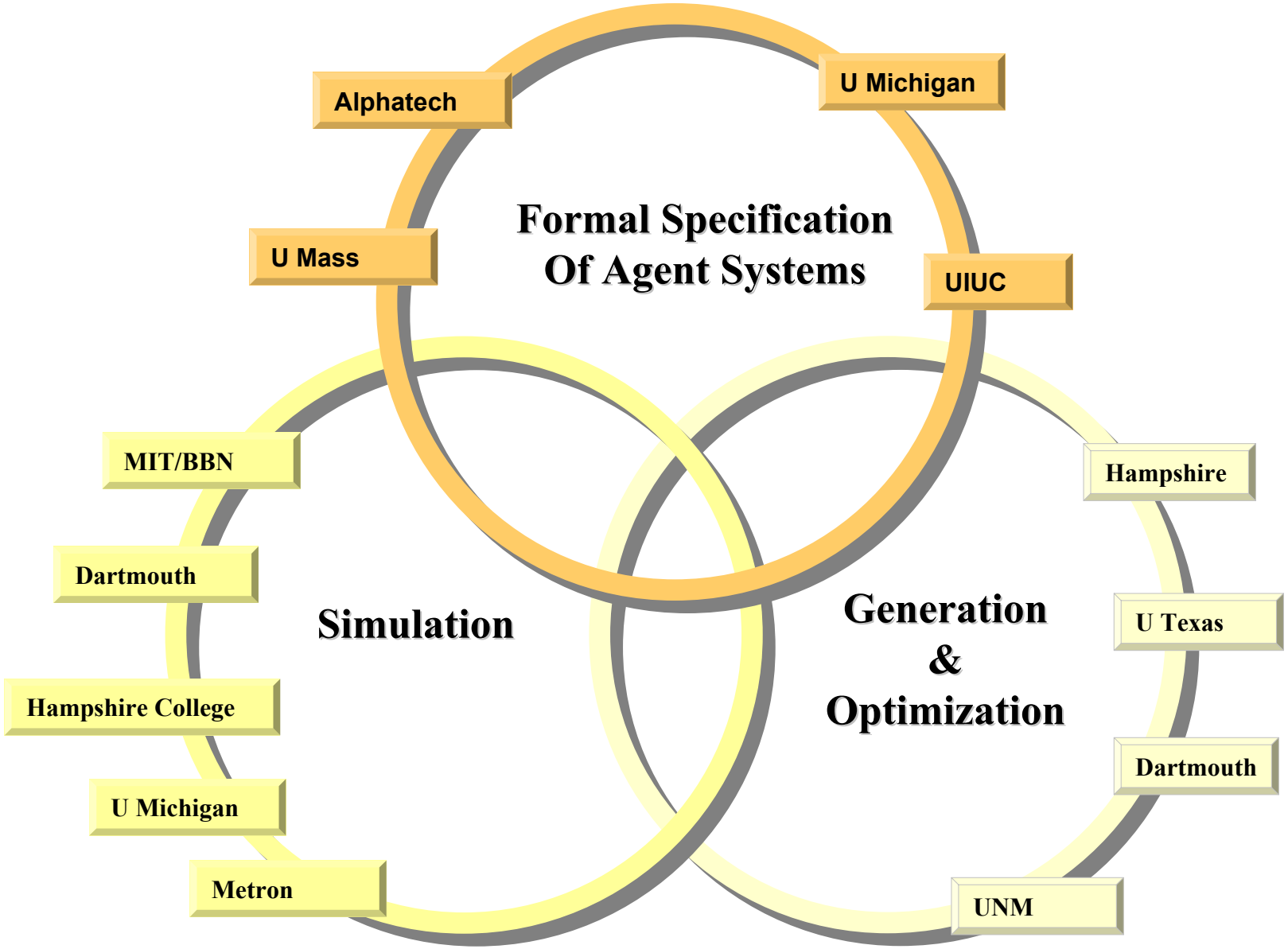
Agent Design Methodology



Multi-Agent System Analysis



System Synthesis Toolkit



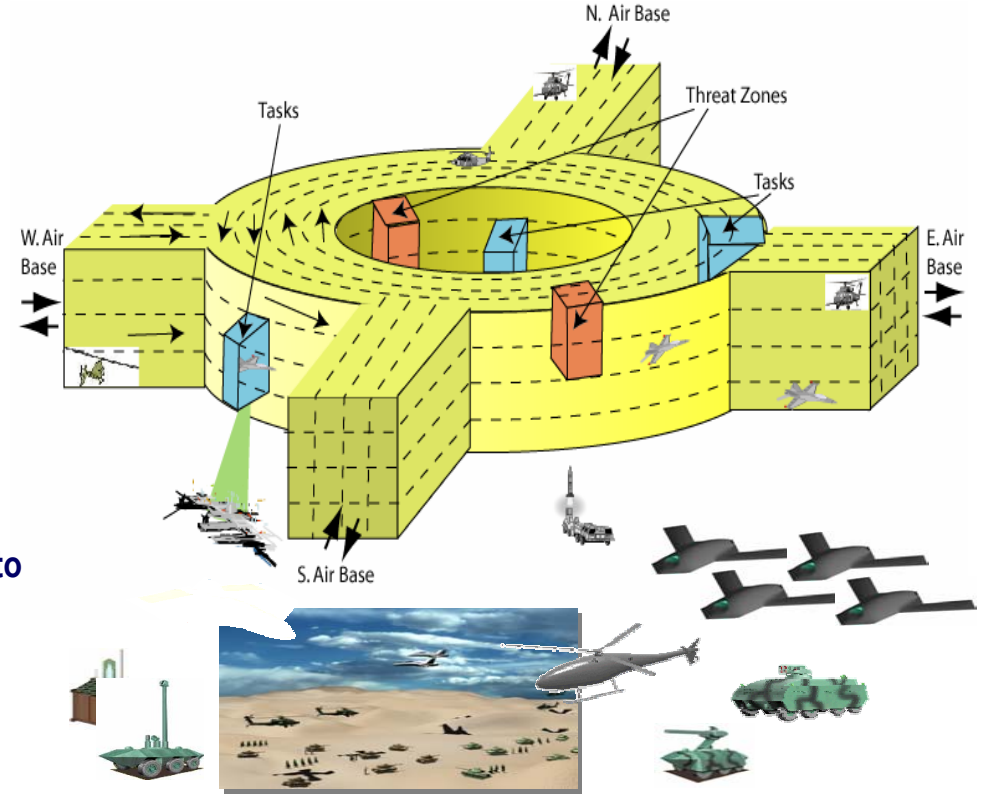
TASK Open Experimentation Framework (OEF)

Enabling unmanned taskable resources to act autonomously and cooperatively to fulfill surveillance/targeting missions in highly dynamic dangerous environments

…to search for, identify, and destroy hostile (e.g. al-Qaeda) operatives, equipment, bases, …

BASIC OEF Problem:

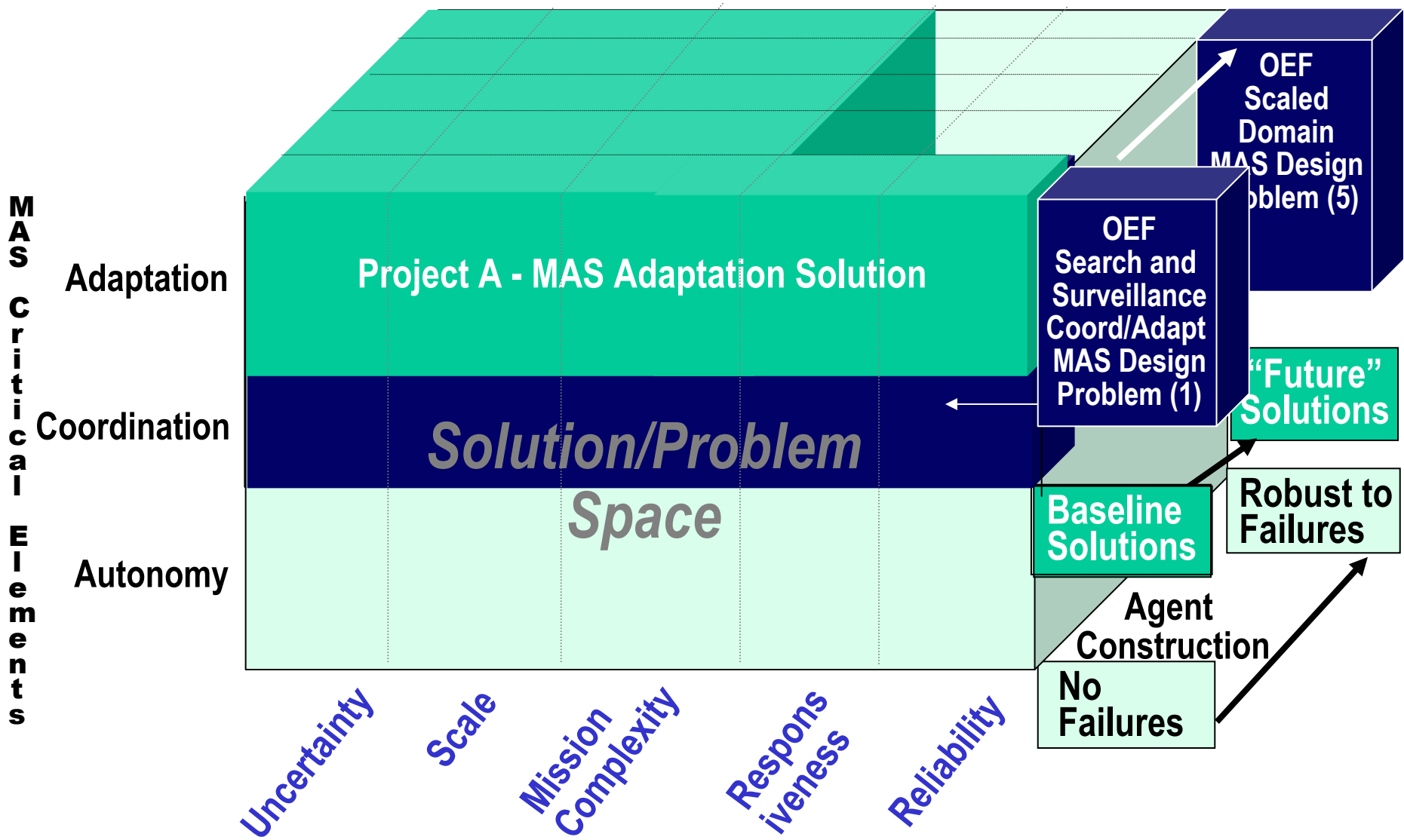
M air vehicles cooperate to service N tasks



- **Heterogeneous autonomous agents**
  - Vehicles have local objectives *and* must distribute control for cooperative missions
- **Tasks**
  - Complex: I.e. heterogeneous, require detection, tracking, ID, constraints, cooperative tasking
- **Continuous, evolving missions**
- **Cooperation**
  - Agents must coordinate and share information to achieve mission objectives
- **Threats: dynamic & may adapt their behavior**
- **Unanticipated dynamics**
  - Agents need to be able to recognize new situations, find "similar" past experience, adapt past experience for current response, remember new experiences and responses
- **MAS behavior must be robust and predictable**
  - reliable predictable behavior, scale to large #s of AVs, extreme stresses/uncertainty (environ/threats), etc.

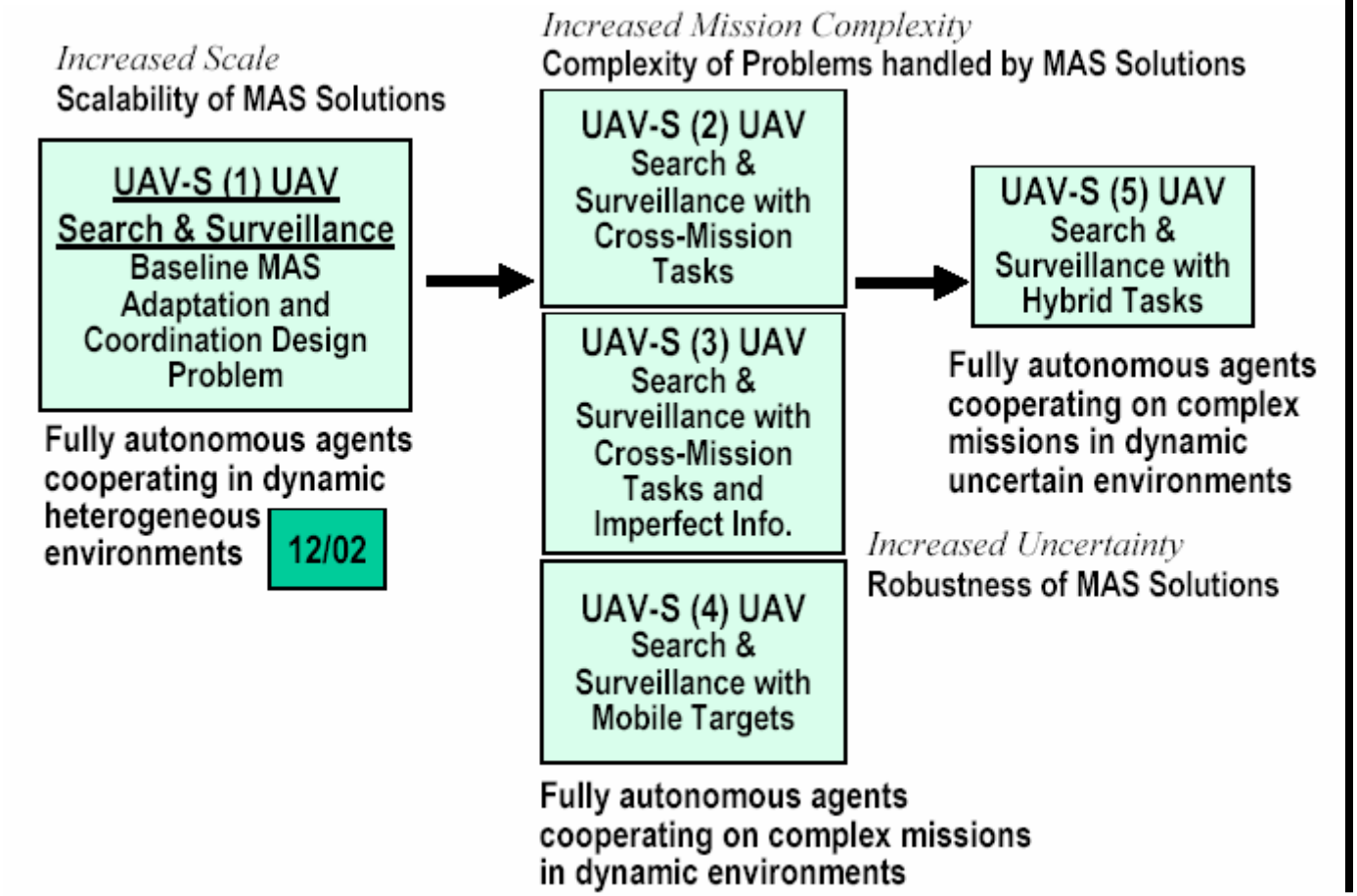
MAS Problem/Solution Space:

Characterized by MAS Critical Elements and Problem Parameters



UAV Adaptation & Coordination Roadmap

Problem UAV-S: Simple cooperative search and surveillance problem



- **Define Problem Series**
- **Define Experiments**
- **Identify Metrics**
- **Demonstrate Solutions**
- **Document Methodologies**
- **Compile TASK Toolkit**