

Collaborate Sensing, Tasking, Collection, and Mission Management

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Air Force MOIE

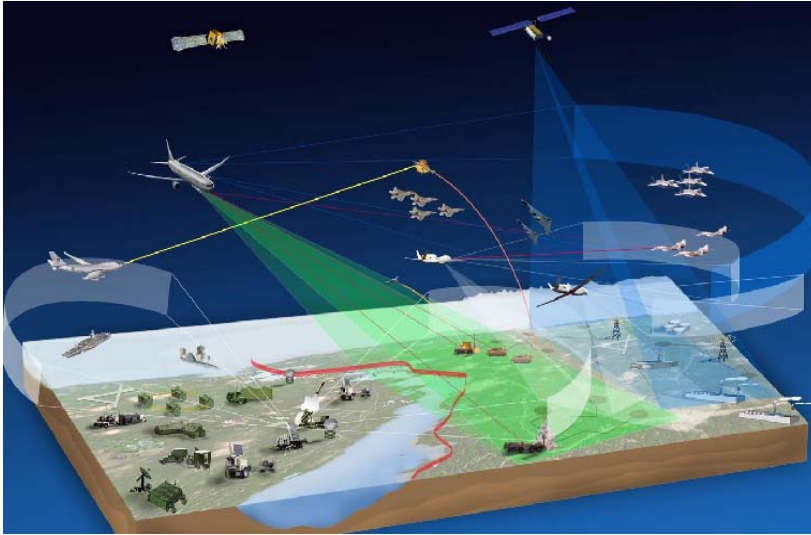


Problem



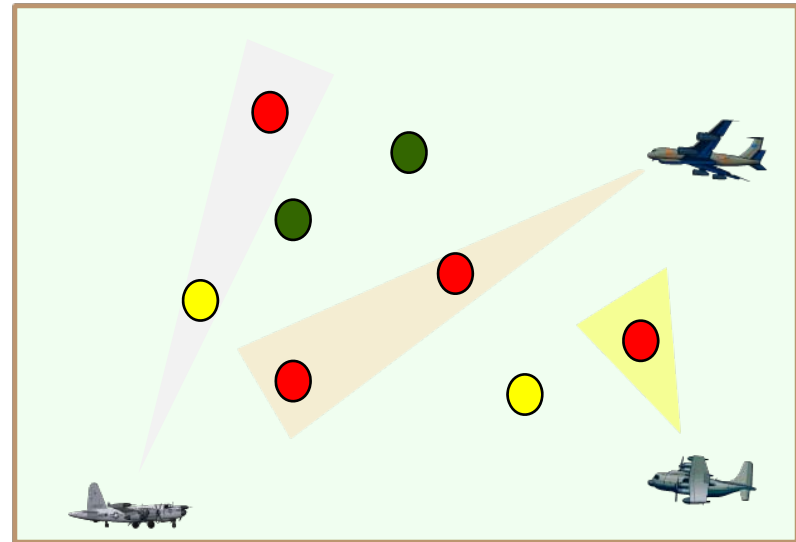
- **Battlespace sensing is currently:**
 - **Conducted to satisfy unit-specific and tactical goals**
 - **Does not include collaboratively-based data collection and analysis**
 - **Is not focused on overarching operational objectives.**
- **This approach precludes synergies that could enhance overarching operational effectiveness without sacrificing tactical imperatives.**
- **Overcoming these limitations will require coordination across hierarchical and functional lines, as well as a sound technical approach.**

Background



- **Coordinated Constellation Resource Management is historically a planning phase function. Real-time management during dynamic operations is largely *ad hoc*.**

- **Sensing should be tactically *reactive*, rather than operationally *proactive*.**



Objective



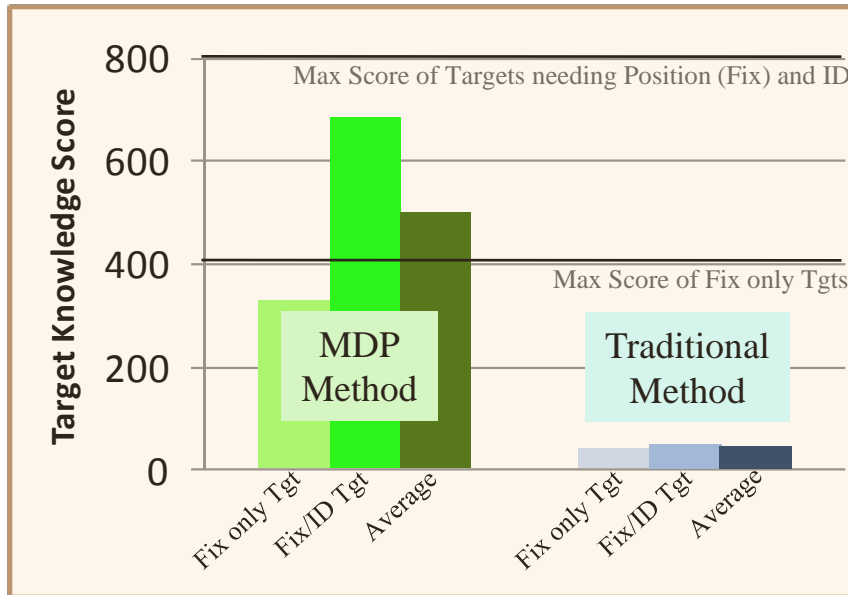
- **Develop an analytically sound, robust, and scalable, technical approach to manage a constellation of tactical sensors so that operational goals are satisfied.**
- **Conduct both simulation and live fly demonstrations to quantitatively assess the value of the dynamic and coordinated sensor tasking methods we develop.**

Activities



- **We have developed a leading-edge, dynamic tasking/re-tasking algorithm for multiple platforms, sensors, and modes using combined linear and integer programs (LP/IP).**
 - **LP/IP provides the engine for a Markov Decision Process (MDP).**
- **We are currently designing a real-time automated UAV mission management demonstration using MDPs and ordinal optimization.**
 - **We are working in collaboration with the USAF Academy.**

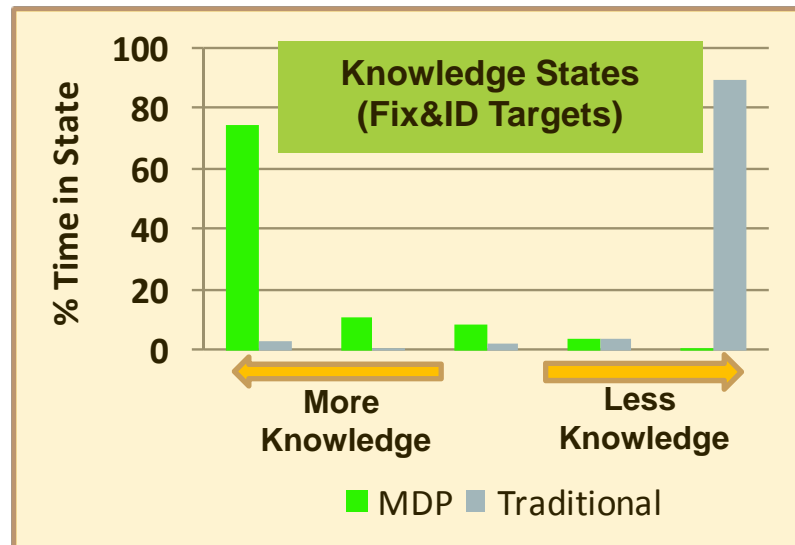
Highlight



- Results show 10x improvement in target knowledge “scores” over traditional uncoordinated, reactive sensing...

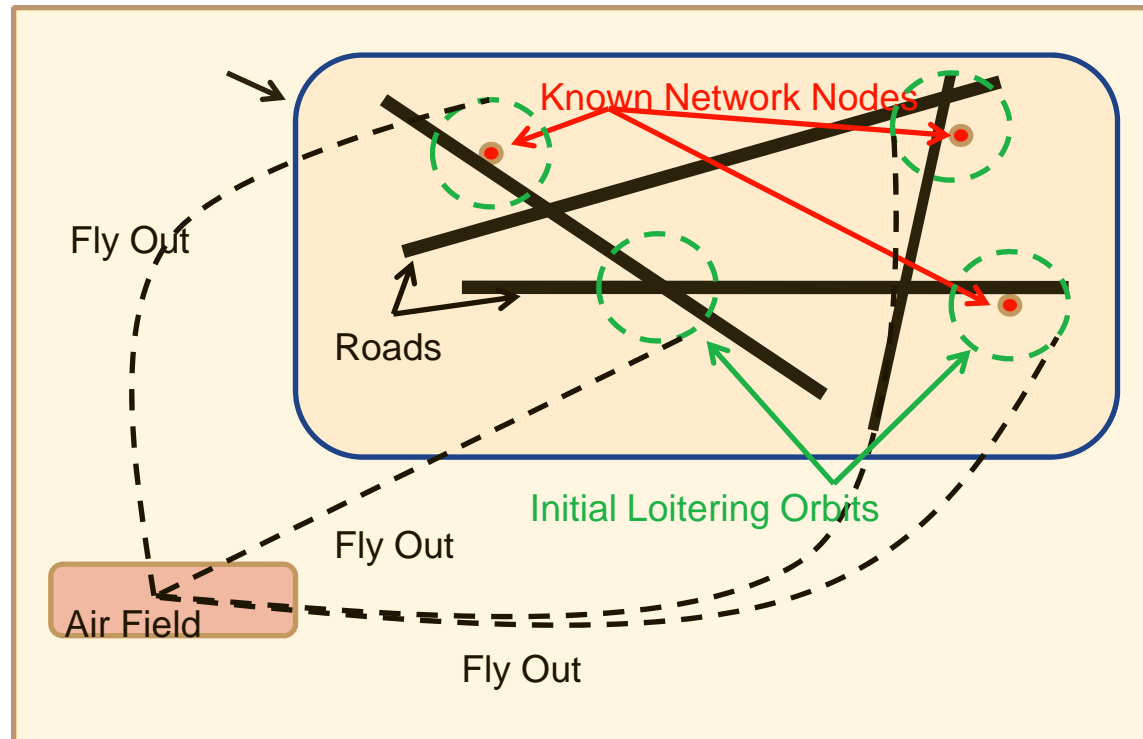


- ...because the state of our knowledge is maintained through proactive (MDP) sensing.



Demonstration

- **USAF Academy Live-fly will map mission level objectives to tactical level taskings.**



- **Mission control at MITRE Bedford**
- **SOA-based simulation at MITRE Colorado Springs Site**
- **SOA-based UAV Ground Station at USAFA**

Impacts



- **Will provide a framework to integrate disparate air-breathing platform sensors**
 - **Facilitates synthesis of tactical and operational objectives**
 - **Battlespace knowledge improvements are potentially many fold**
- **Pushes the research envelope with use of Markov Processes to assign sensors to targets**
 - **Work submitted to SIAM conference; Mathematics of Operations Research (pending)**
- **Applicability to existing and developmental sensing programs**
 - **MIST, UAVs, JSTARS, others**

Future Plans

- Continued refinement of sensor assignment algorithm
- Develop simulation to demonstrate results
- USAF Academy Live-fly: June 2009
- Explore transition opportunities

Maximize:

$$\sum_{n \in N} \sum_{a \in A} (\gamma_{n0} - \gamma_{na}) \cdot \text{ACTIVATE}_{na}$$

Subject to:

$$\sum_{c \in C} Y_{ac} \leq 1 \quad \forall a \in A$$
$$\sum_{c \in C_a: n \in N_c} Y_{ac} \geq \text{ACTIVATE}_{na} \quad \forall n \in N, \forall a \in A$$
$$\sum_{a \in A} \text{ACTIVATE}_{na} \leq 1 \quad \forall n \in N$$
$$\sum_{a \in A_s} \sum_{c \in C_a} Y_{ac} \leq 1 \quad \forall s \in S$$
$$Y_{ac} \in \{0,1\} \quad \forall c \in C, \forall a \in A$$
$$0 \leq \text{ACTIVATE}_{na} \leq 1 \quad \forall n \in N, \forall a \in A$$

