Structured ISR Fusion

Walter S. Kuklinski

781-271-5778 • wskuklin@mitre.org

MSR

MITRE Technology Program

Problem

- **Many ISR performance requirements can only be satisfied by fusing data collected from multiple sensors and multiple platforms over extended periods of time with non-sensor evidence.**

MITRE

Background

- **Existing "classical" data fusion methods are not capable of meeting the demanding requirement of transforming data and evidence into actionable information and knowledge.**

Data & Information rec'd from the environment

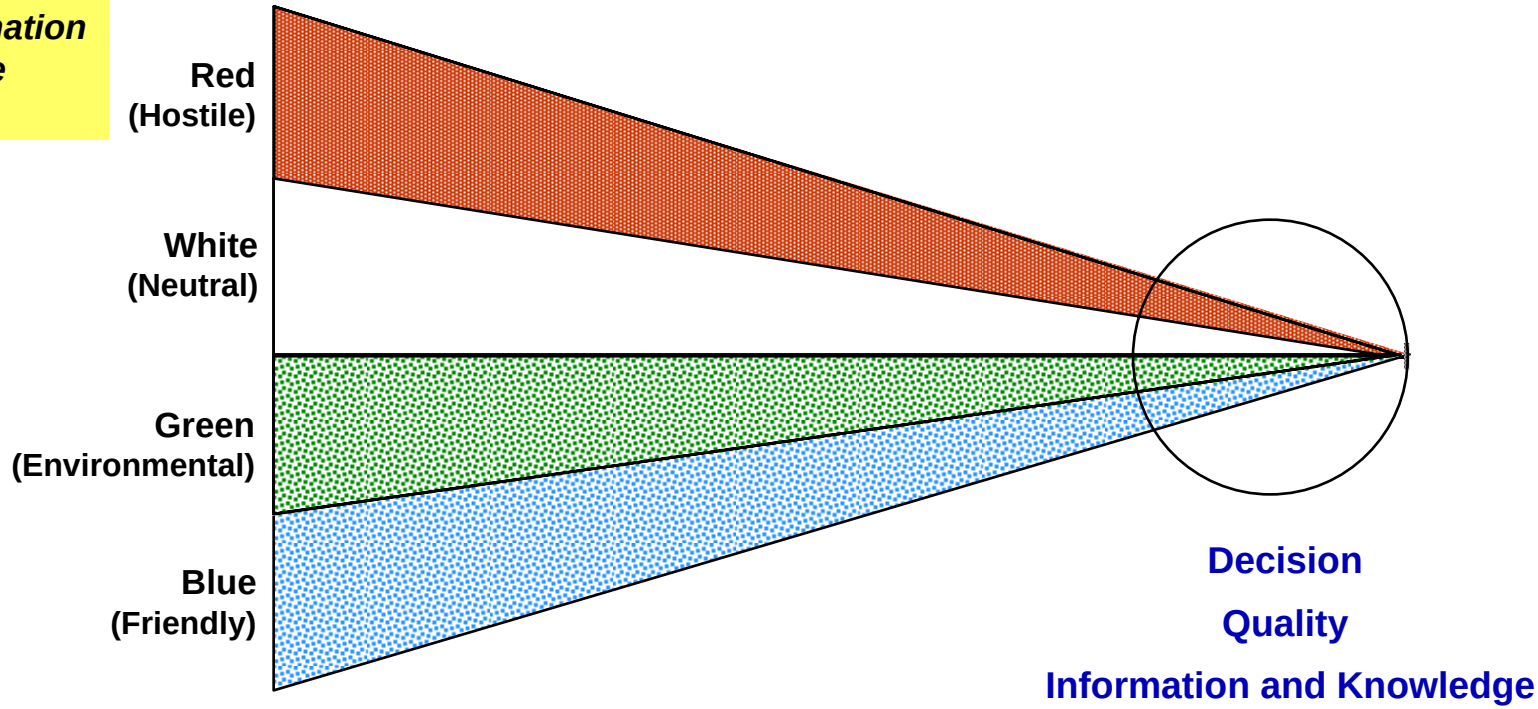
INTEL

Sensors

Context

Doctrine

Physics



Data → Information → Knowledge

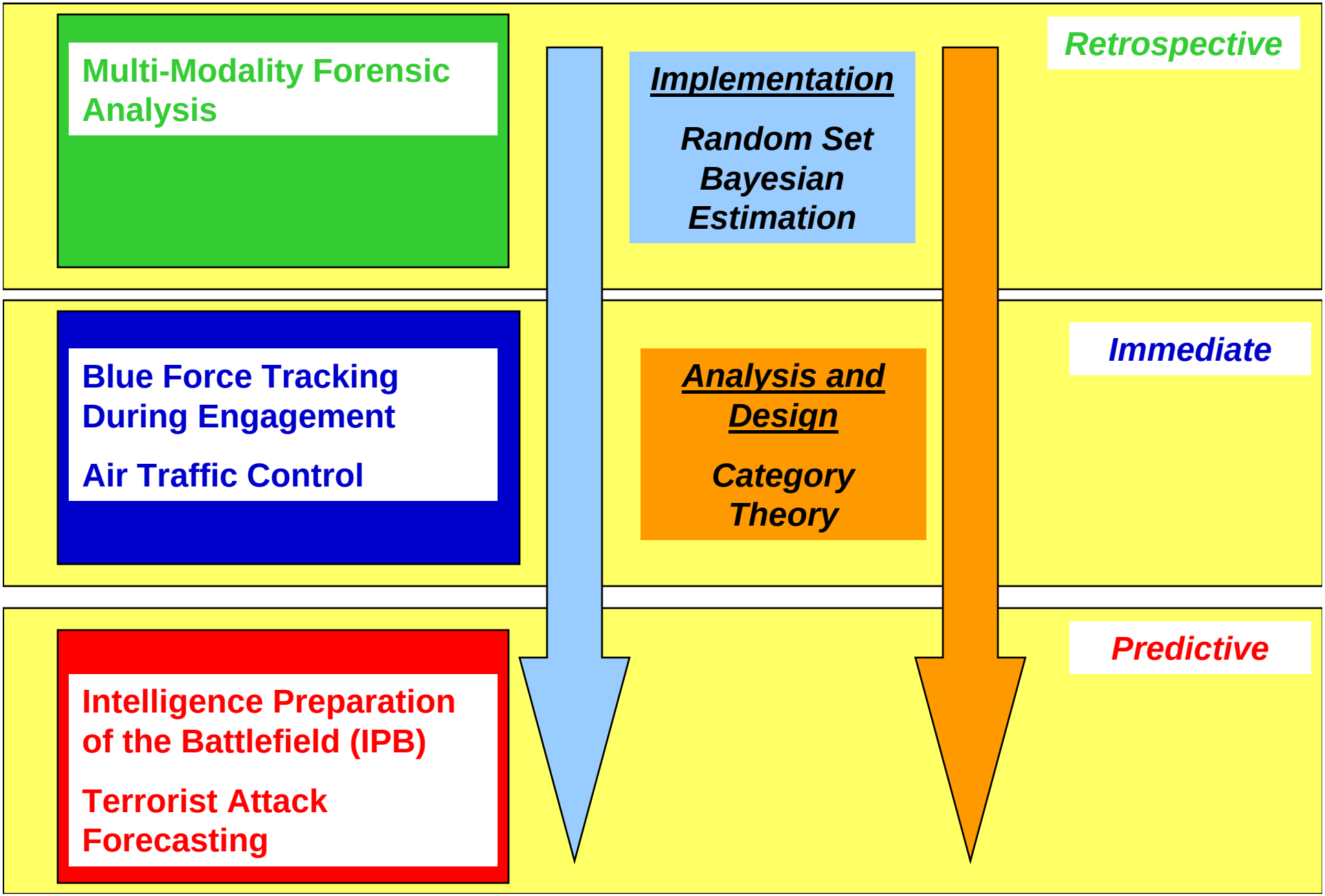
MITRE

Objectives

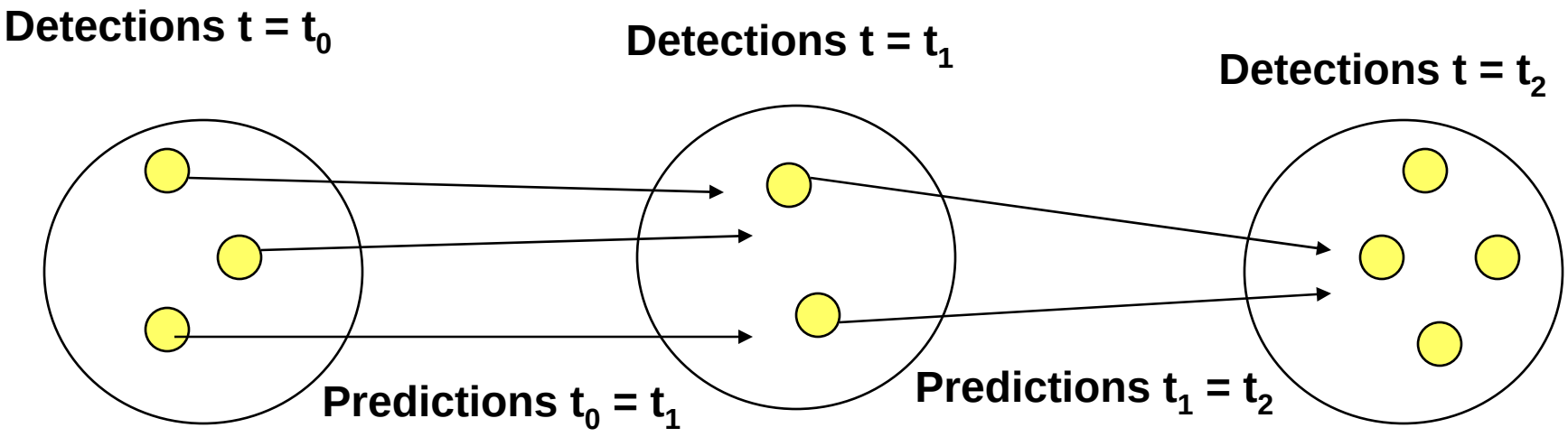
- Develop, implement, and evaluate the performance of structured ISR fusion systems using Retrospective, Immediate, and Predictive test cases
  - Retrospective = Batch smoothing problems
  - Immediate = Real-time filtering problem
  - Predictive = Prediction problems
- Quantify the performance gains that Random Set Theory methods yield in comparison with classical random vector methods for Bayesian state estimation (i.e., data fusion) problems
- Develop Category Theory representations of the three test case fusion systems and determine if formal proof methods can be used to
  - Confirm performance behavior over a wide range on conditions
  - Develop a design procedure for structured fusion systems

MITRE

Activities


Multi-Modality Forensic Analysis
Implementation
Random Set
Bayesian
Estimation
Retrospective
Blue Force Tracking During Engagement
Air Traffic Control
Analysis and Design
Category Theory
Immediate
Intelligence Preparation of the Battlefield (IPB)
Terrorist Attack Forecasting
Predictive

Highlight: Single Target vs. Multi-Target Tracking



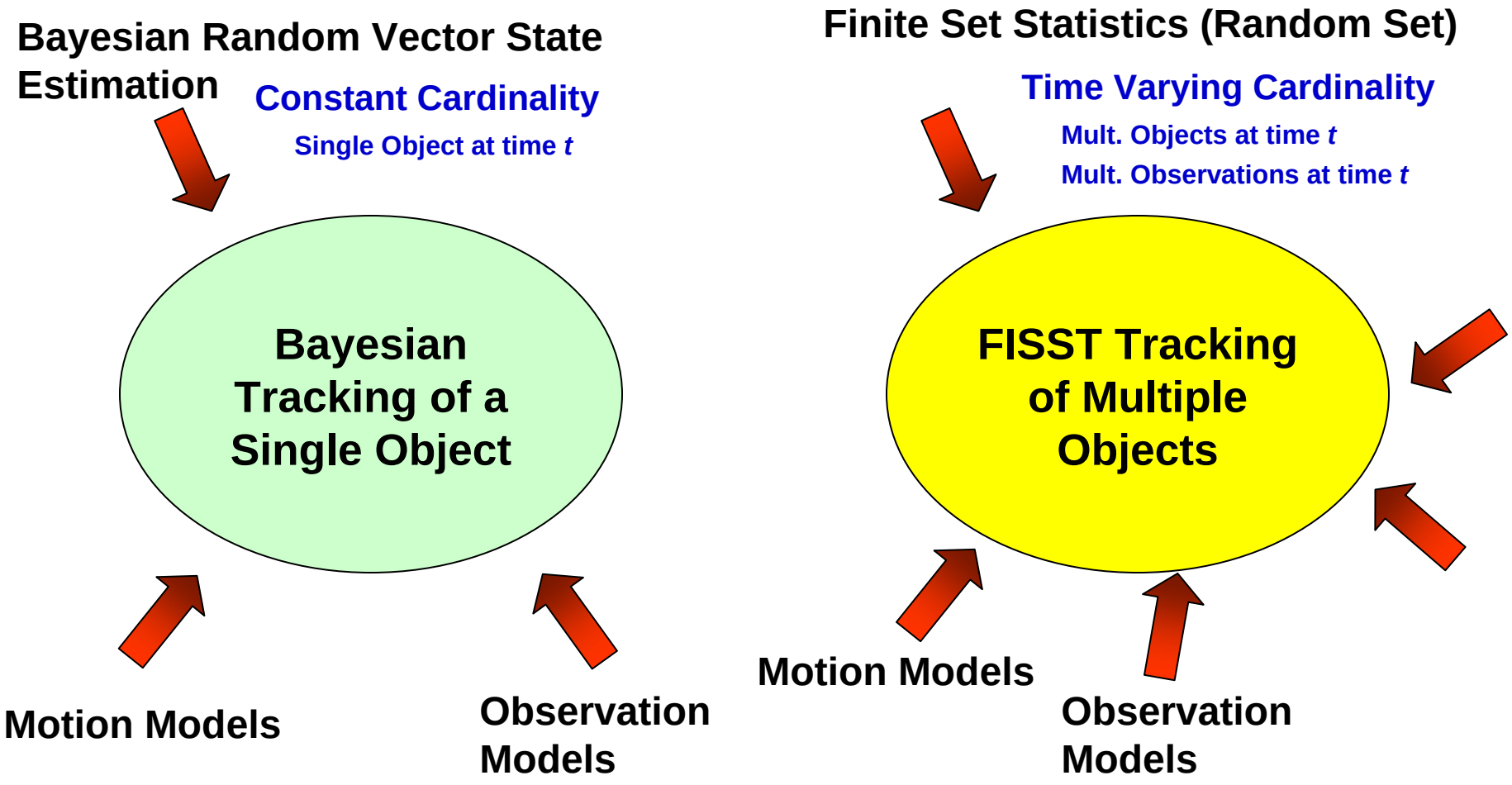
At each time step we have a vector state estimation problem of possibly time varying cardinality.

The object we need to estimate is a random set, not a random vector.

For optimal performance we also need to use all available knowledge of correlations that may exist between target motion, target detection characteristics, target birth and death behavior, … at each time step.

MITRE

Highlight: Single Target vs. Multi-Target Tracking



MITRE

Impacts

- A number of MITRE sponsors including the DoD, intelligence agencies, FAA, and law enforcement agencies have multi-source fusion requirements to
  - Provide data for fusion processing,
  - Perform data and information fusion operations, or
  - Make effective decisions based on the results of fusion processing.
- While an active data fusion research community exists, open questions still remain regarding
  - Developing a unified framework for analysis of fusion performance, and
  - Developing formal methods of using non-sensor data and prior information to structure the statistical signal processing operations used in sensor data fusion systems.
- This MSR will allow MITRE to make significant contributions toward resolving these open questions and enable MITRE to provide expert advice and support to our sponsors' data fusion needs.

MITRE

Future Plans

- Simulation/ Demonstration
  - Multiple modality forensic analysis
  - Scatter subset selection for 3D ATR applications
- Analytical Studies
  - Quantify limitations of classical Bayesian random vector methods
  - Implement a multiple modality forensic fusion system based on Random Set Theory
  - Implement 3D ATR scatter subset selection algorithm
  - Map resulting algorithm into a Category Theory-based representation and begin study of Category Theory analysis tool

MITRE