Integrated Fusion, Performance Prediction, and Sensor Management for Automatic Target Exploitation

Overview

MURI Annual Review Meeting

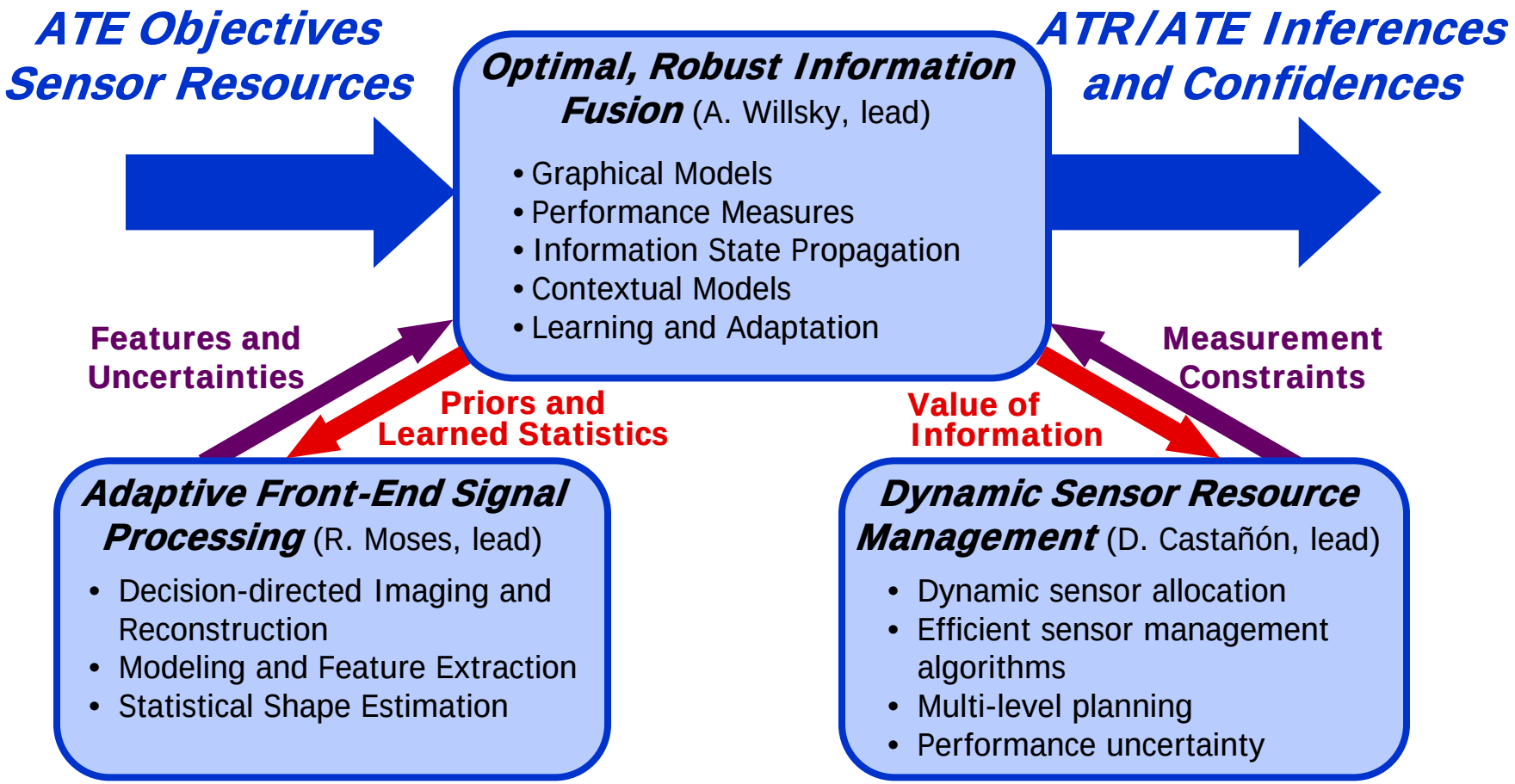
Randy Moses

September 14, 2007

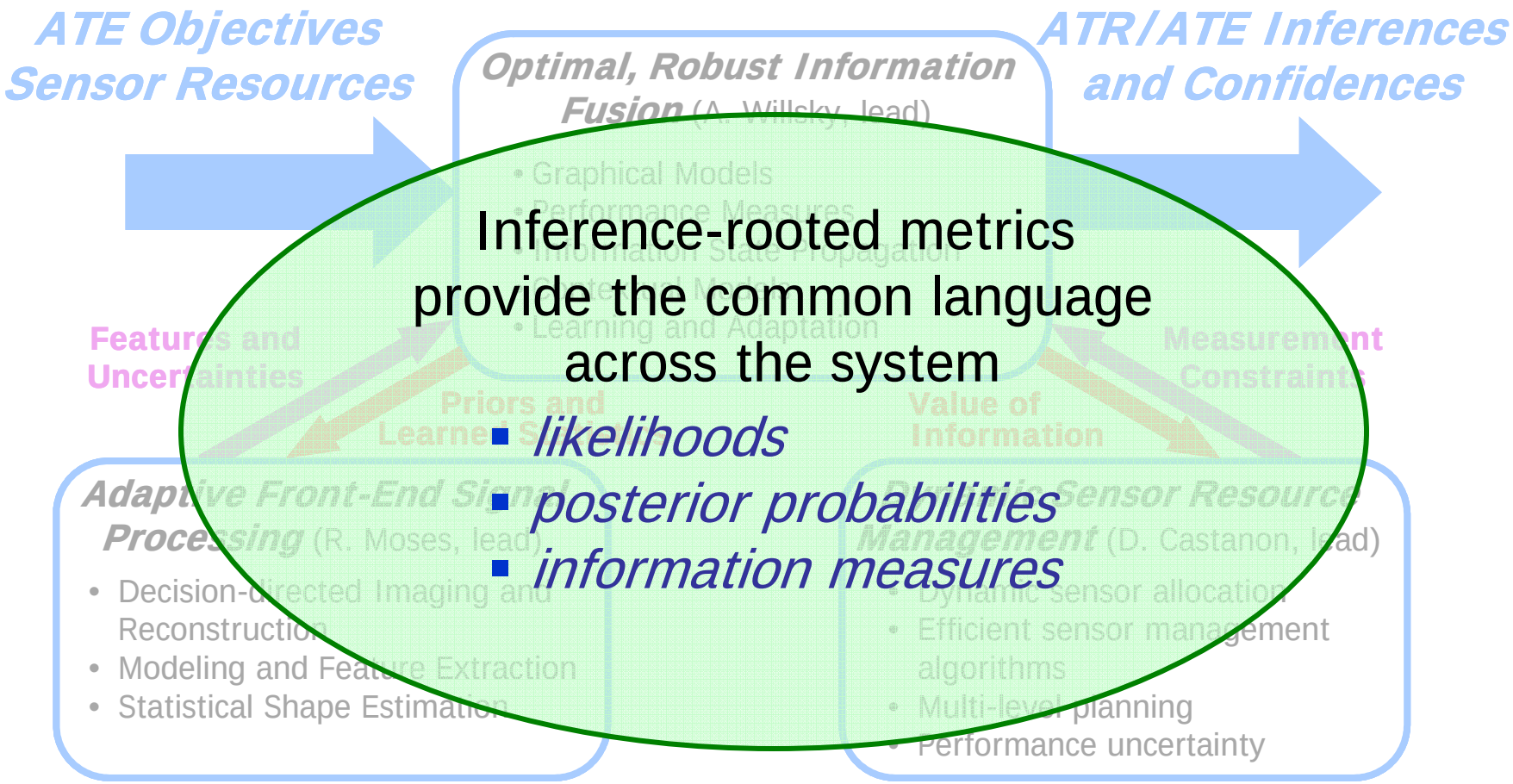
Research Goal

- *Develop an integrated systems theory that jointly treats information fusion, control, and adaptation for automatic target exploitation (ATE).*
  - Multiple, dynamic sensors
  - Multiple sensing modes
  - Resource-constrained environments

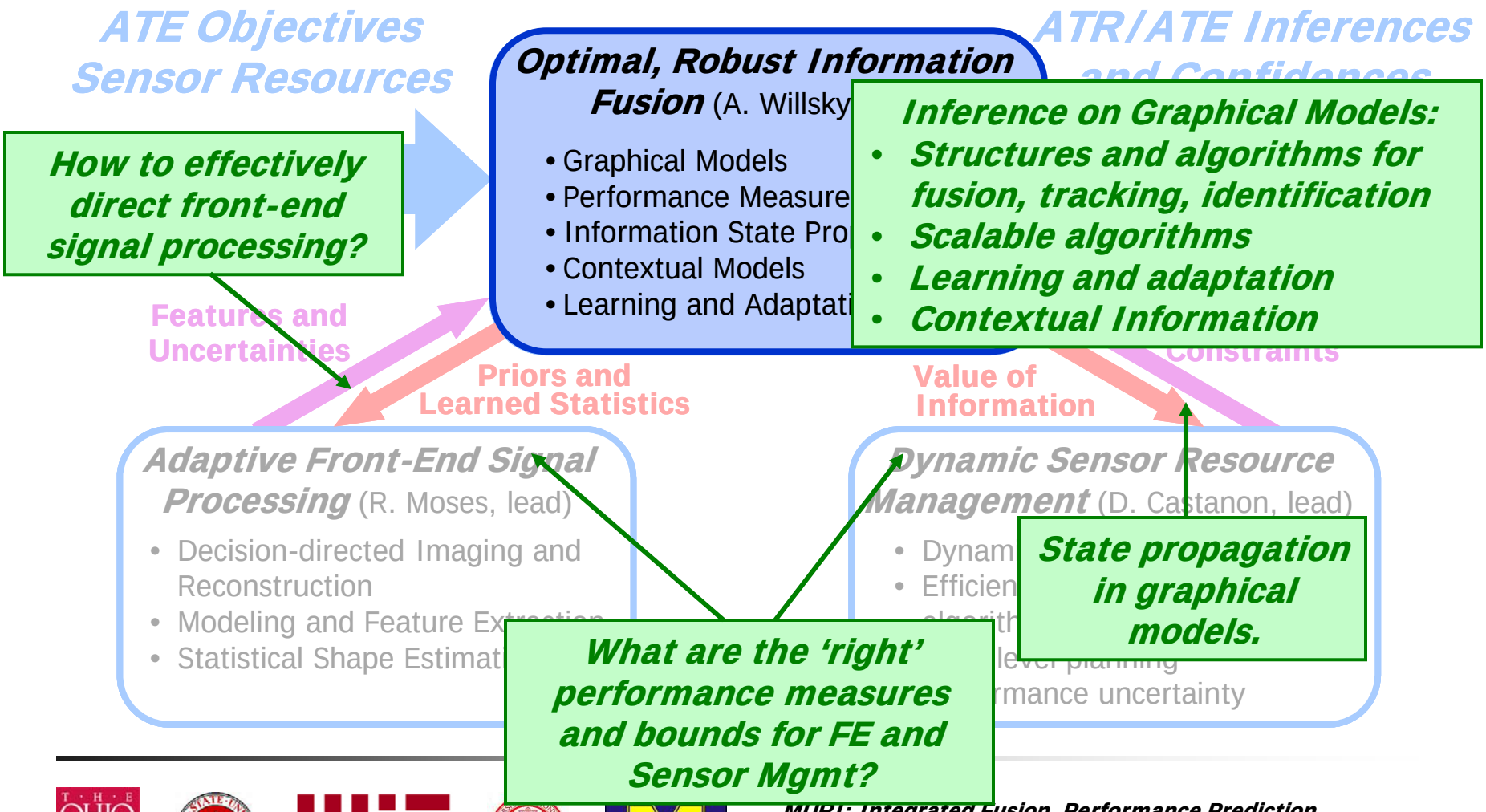
Research Framework



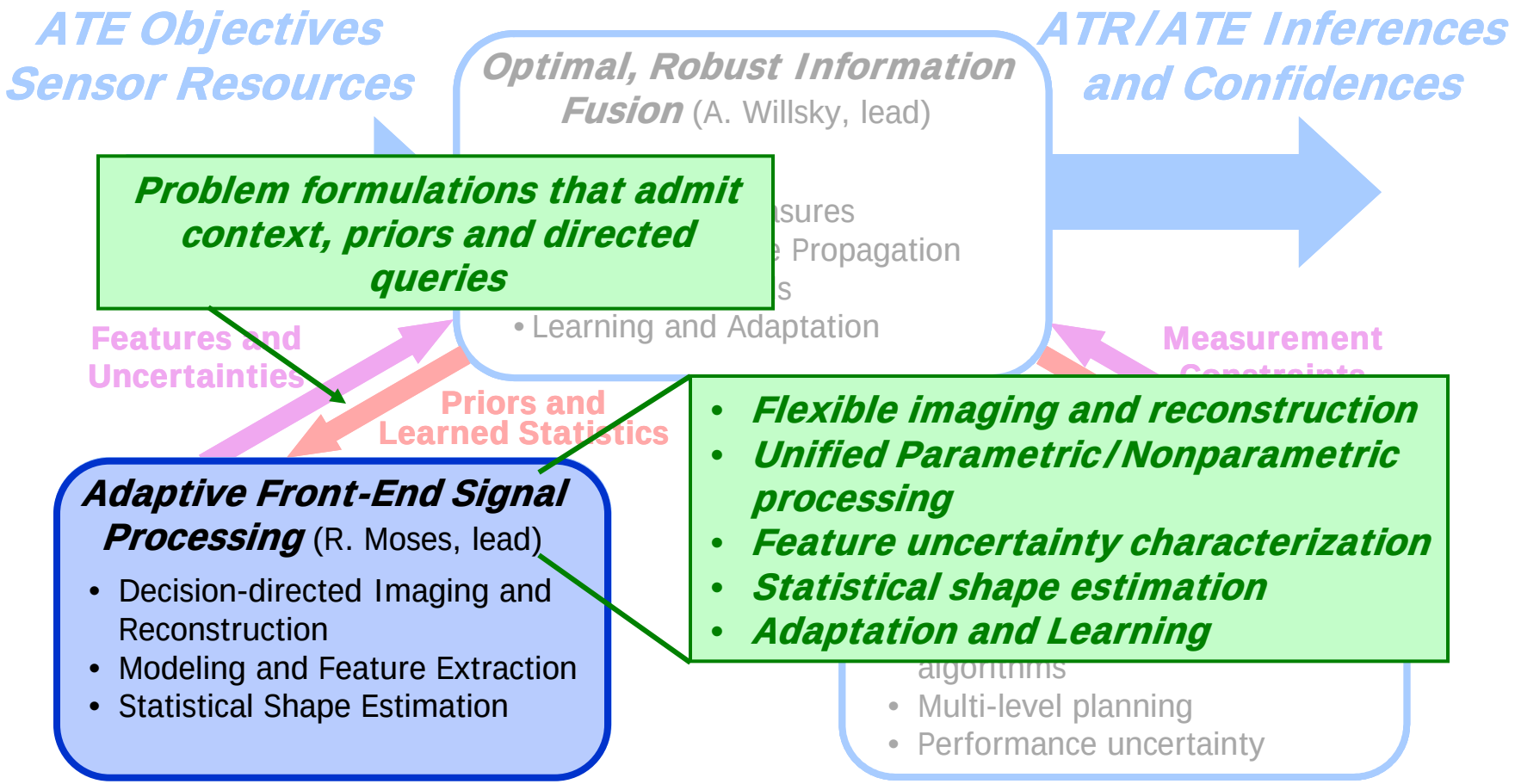
Research Framework



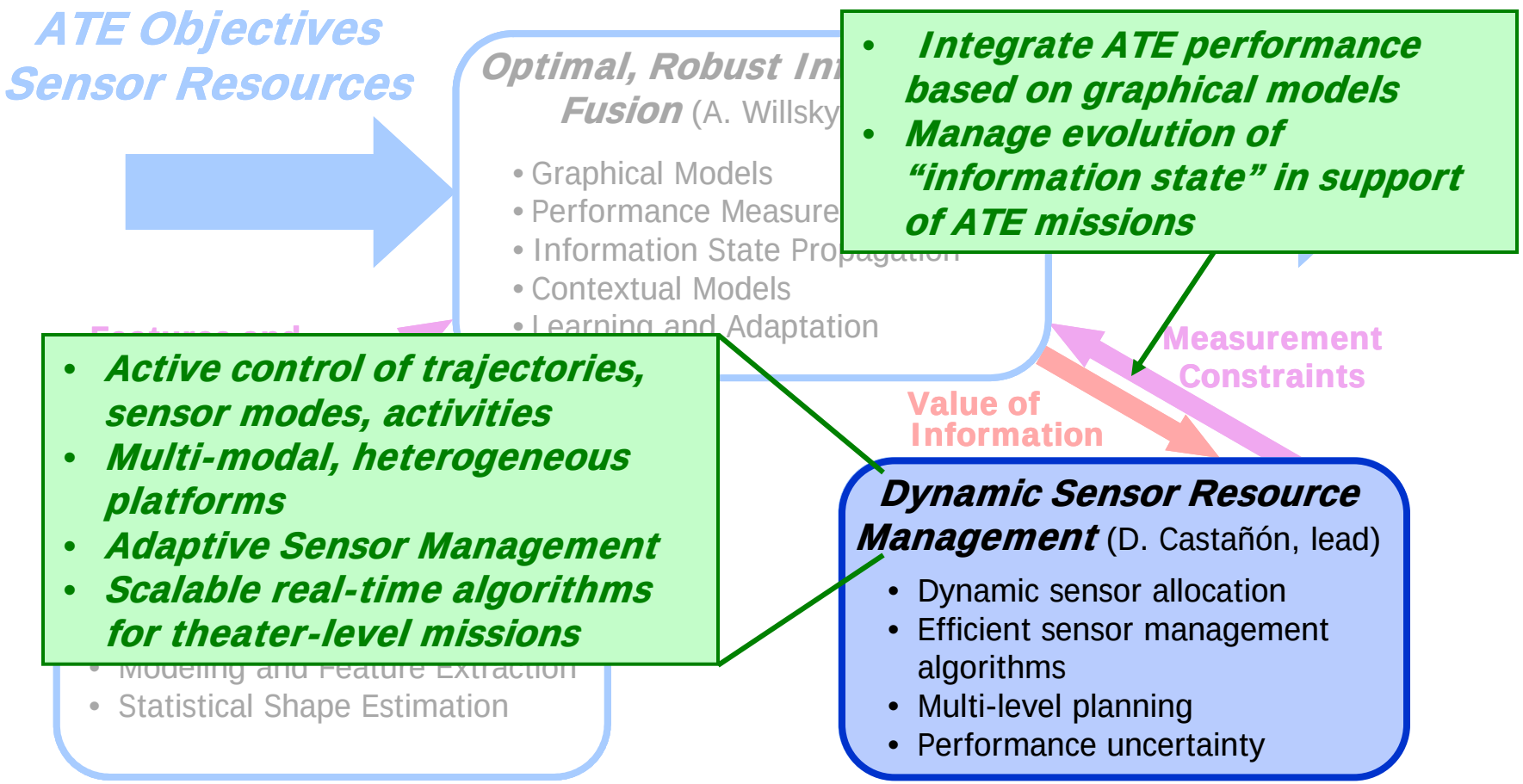
Information Fusion: Key Research Questions



Signal Processing: Key Research Questions



Sensor Management: Key Research Questions



MURI Payoff

Goal: Develop an integrated theory for ATE systems that combines information fusion, platform control, signal processing, and adaptation.

Research Outcomes:

- *An integrated theoretical framework for dynamic information exploitation systems.*
- *Theoretical foundations for adaptivity and learning in complex inference systems.*
- *New algorithms and performance metrics for coupled signal processing, fusion, and platform control.*

Payoff:

- *Systematic design tools for end-to-end design of multi-modal, multi-platform ATE systems.*
- *Active platform control to meet ATE objectives.*
- *System-level ATE performance assessment methods.*
- *Adaptive, dynamic ATE systems.*

MURI Team

UNIVERSITY TEAM:

- Ohio State University (lead)
  - Randy Moses (PI)
  - Lee Potter
  - Emre Ertin
- Massachusetts Institute of Technology
  - Alan Willsky
  - John Fisher
  - Mujdat Çetin (also Sabanici U.)
- Boston University
  - David Castañón
  - Clem Karl
- University of Michigan
  - Al Hero
- Florida State University
  - Anuj Srivastava

AFOSR: David Luginbuhl

AFRL POC: Greg Arnold

Kickoff Meeting Feedback

- Strongly positive on team expertise and interactions.
  - Already up to speed
- Strongly supportive of research plan
- Maintain emphasis on fundamental research.
- Maintain research continuity
  - Interactions among the MURI PIs
  - Interactions with government labs and industry

Year 1 Advances

- Regularized Tomography for Sparse reconstruction
  - Sparse apertures
  - Sparse ‘objects’ (targets or scenes)
  - Anisotropy characterization
  - Reconstruction for wide angle and circular SAR
  - Decision-directed reconstruction
  - Lots of cross-pollination, especially OSU, BU, MIT
- Shape Statistics for Curves and Surfaces
  - Shape Analysis
  - Bayesian Classification from Shapes

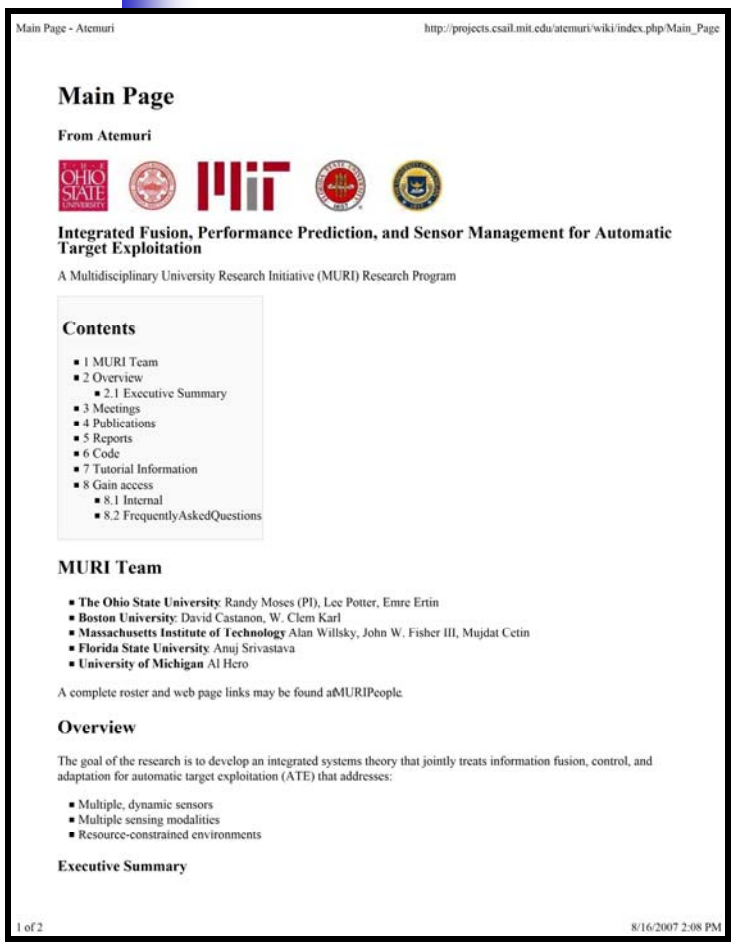
Year 1 Advances II

- Distributed Estimation and Management
  - MIMO radar fusion with calibration errors
  - Distributed estimation with unreliable communications
- Sensor Management:
  - Adaptive data fusion
  - Adaptive waveform scheduling
  - Real-time SM algorithms and performance bounds
- Scalable, flexible inference
  - Low-rank uncertainty estimation in graphical models
  - GM-based Tracking
  - Learning Model structure

MURI Students

- 11 graduate students and 1 postdoctoral fellow fully supported by the MURI.
- 10 graduate students working on the MURI team with outside support (e.g. fellowships).
- 3 PhD and 3 MS degrees awarded in Year 1

ATE MURI Web Page



Main Page - Atemuri http://projects.csail.mit.edu/atemuri/wiki/index.php/Main_Page

Main Page

From Atemuri

Integrated Fusion, Performance Prediction, and Sensor Management for Automatic Target Exploitation

A Multidisciplinary University Research Initiative (MURI) Research Program

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MURI Team

- **The Ohio State University**: Randy Moses (PI), Lee Potter, Emre Ertin
- **Boston University**: David Castanon, W. Clem Karl
- **Massachusetts Institute of Technology** Alan Willsky, John W. Fisher III, Mujdat Cetin
- **Florida State University**: Anuj Srivastava
- **University of Michigan** Al Hero

A complete roster and web page links may be found at MURIPeople.

Overview

The goal of the research is to develop an integrated systems theory that jointly treats information fusion, control, and adaptation for automatic target exploitation (ATE) that addresses:

- Multiple, dynamic sensors
- Multiple sensing modalities
- Resource-constrained environments

Executive Summary

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- People
- Publications
- On-line research collaboration space
- Code
- Data resources

Intra-team Interactions

- MURI research meeting in Boston Dec07
  - 30 participants, 25+ posters,
- Sensor Management Book Collaboration
  - *Foundations and Applications of Sensor Management*; Springer 2007; Editors: A. Hero, D. Castañón, D. Cochran, K. Kastella
- Student Committees
  - D. Castañón (BU) on Jason Williams' (MIT) dissertation committee
  - J. Fisher (MIT) on Shantanu Joshi's (FSU) dissertation committee
- Numerous Research Interaction Visits
  - A. Hero → MIT sabbatical Au06
  - Fisher → FSU; Joshi Ph.D. committee
  - Moses → 3 visits to MIT Summer 2006
  - Fisher → UMich July07
  - Çetin → OSU Aug07 (video-conference)

Publications and Students

- 54 Publications
  - 13 Journal publications
  - 41 Conference proceedings papers
- Student Graduate Degrees
  - Jason Williams (MIT) PhD
  - Raghuram Rangarajan (UMich) PhD
  - Shantanu Joshi (FSU) PhD
  - Christian Austin (OSU) MS
    - PhD on this MURI
  - Kush Varshney (MIT) MS
    - PhD on this MURI
  - Subhojit Som (OSU) MS
    - PhD on this MURI

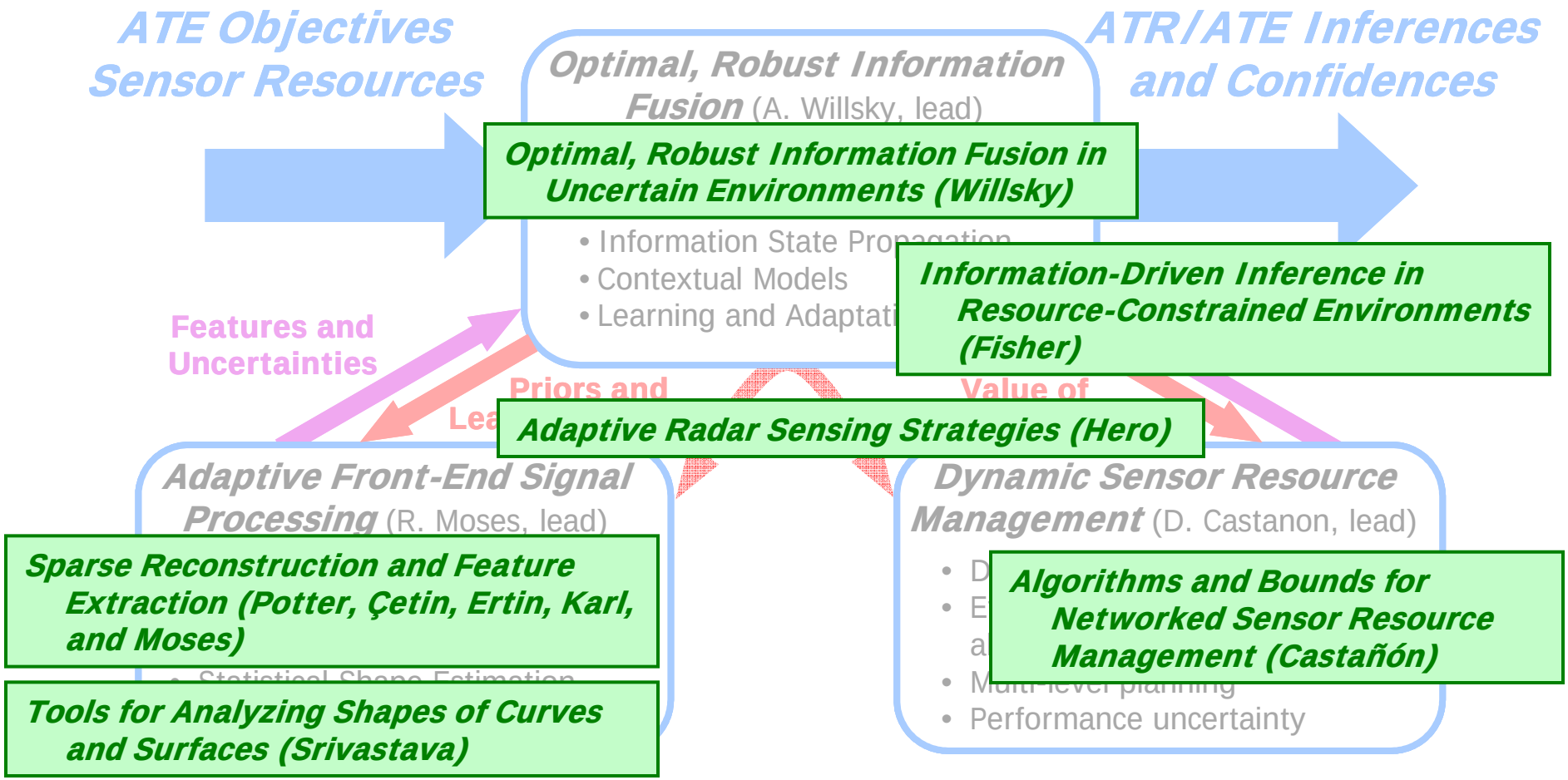
Interactions and Transitions I

- Presentations at 15 conferences
- Scientific Advisory Boards
  - Castañón: Air Force SAB
  - Hero: ARL TAB
  - Willsky: DARPA POSSE;
  - Willsky: Chief Scientific Consultant to BAE-AIT
  - Hero: National Research Council
- Research Formulation Workshops
  - Srivastava organized ARO Workshop on Challenges and Opportunities in Image Understanding
    - Moses, Fisher, Hero, Arnold presented
  - Hero organized ARO Workshop on Signal and Information Processing
    - Moses, Fisher, Castañón presented
  - Ertin: AFRL ATR Modeling Workshop

Interactions and Transitions II

- Transitions:
  - Sparse aperture research -> AFRL GREP program
  - Srivastava statistical shape analysis to Northrup-Grumman via Innovation Alliance Award
  - A. Hero directed Mike Davis (GD-AIS) research on MIMO radar networks
  - MURI LADAR model identification and radar scheduling provided to Lincoln Laboratory
  - Summer internships
    - Julie Jackson: AFRL Dayton, Summers 06 and 07
    - Kerry Dungan: AFRL Dayton, Summer 07
    - Ahmed Fasih, SET Corp. Dayton, Summers 06 and 07
    - Christian Austin: SET Corp. Dayton, Summer 06
    - Kyle Herrity: FAAC, Inc Ann Arbor MI, Summer 07

Today's Presentations



Agenda

9:00 - 9:25	Intro and Overview (Moses)
9:25 - 10:00	Optimal, Robust Information Fusion in Uncertain Environments (Willsky)
10:00 - 10:30	Adaptive Radar Sensing Strategies (Hero)
10:30 - 10:50	Break
10:50 - 11:30	Sparse Reconstruction and Feature Extraction (Potter-includes Çetin, Ertin, Karl, and Moses)
11:30 - 12:00	Tools for Analyzing Shapes of Curves and Surfaces (Srivastava)
12:00 - 1:00	Lunch (and Government mini-retreat) ***Blackwell Ballroom***
1:00 - 1:30	Algorithms and Bounds for Networked Sensor Resource Management (Castañón)
1:30 - 2:00	Information-Driven Inference in Resource-Constrained Environments (Fisher)
2:00 - 2:30	Summary (Moses)
2:30	Break and Government caucus
~3:30	Feedback and Discussion