InfoSymbioticSystems/DDDAS

and Large-Scale-Big-Data & Large-Scale-Big-Computing for Smart Systems

Integrity ★ Service ★ Excellence

Frederica Darema, Ph.D., IEEE Fellow

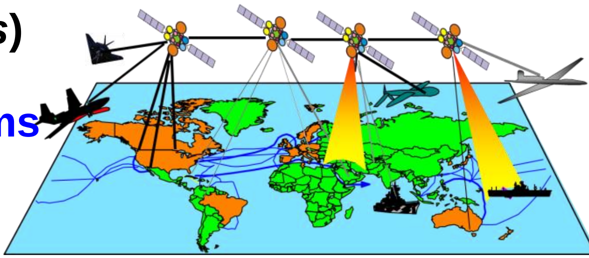
AFOSR

Air Force Research Laboratory

AF S&T Horizons – 10, 20, … 40 yrs + beyond

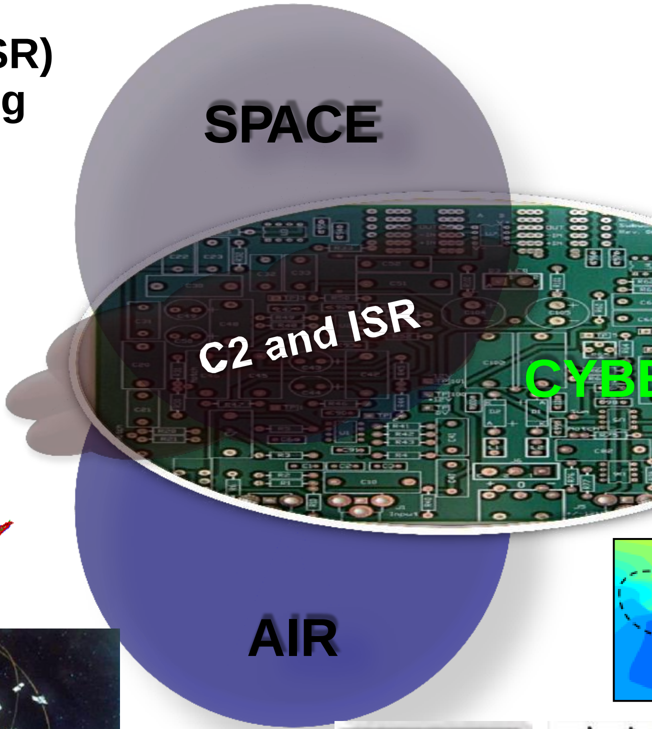
Technology Horizons

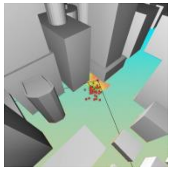
- Inherently Intrusion-Resilient Cyber Networks (*and Systems*)
- Trusted, Highly-Autonomous Decision-Making Systems
- Fractionated, Composable, Survivable, Autonomous Systems
- Hyper-Precision Aerial Delivery in Difficult Environments



Global Horizons

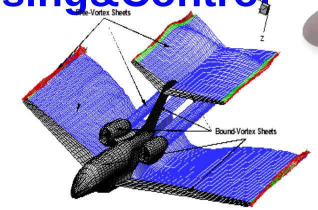
- Command & Control (C2); IntellSurveilRecon (ISR)
- C2&ISR "targeted as center of gravity threatening integrated and resilient global operations"





Autonomy Horizons

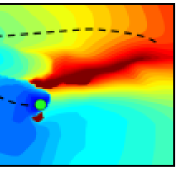
- Mission/Scenario Planning & Decision Making
- VHM, Fault /Failure Detection, Replanning
- SituationalAwareness, Multi-Sensing&Control

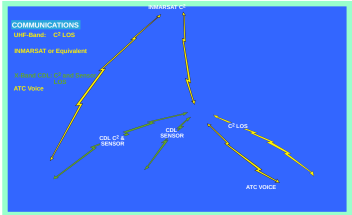


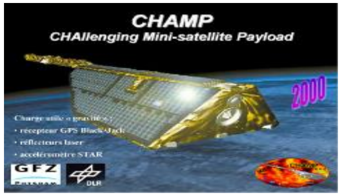
… (other) Horizons…

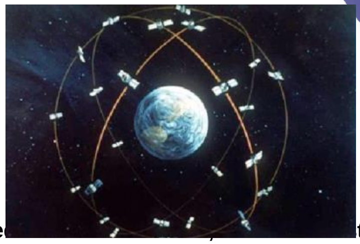
– *Energy Horizons*

– *Beyond Horizons*









DDDAS for new capabilities for Air Force Emerging Technological Horizons and Beyond

- **Increasingly we deal with *systems-of-systems*, and *systems/environments* that are *complex, heterogeneous, multimodal, multiscale, dynamic***

- **Need methods and capabilities**
  - **not only for *understanding*, *and (optimizing) design…***

… but also manage/optimize systems' operational cycle, evolution, interoperability

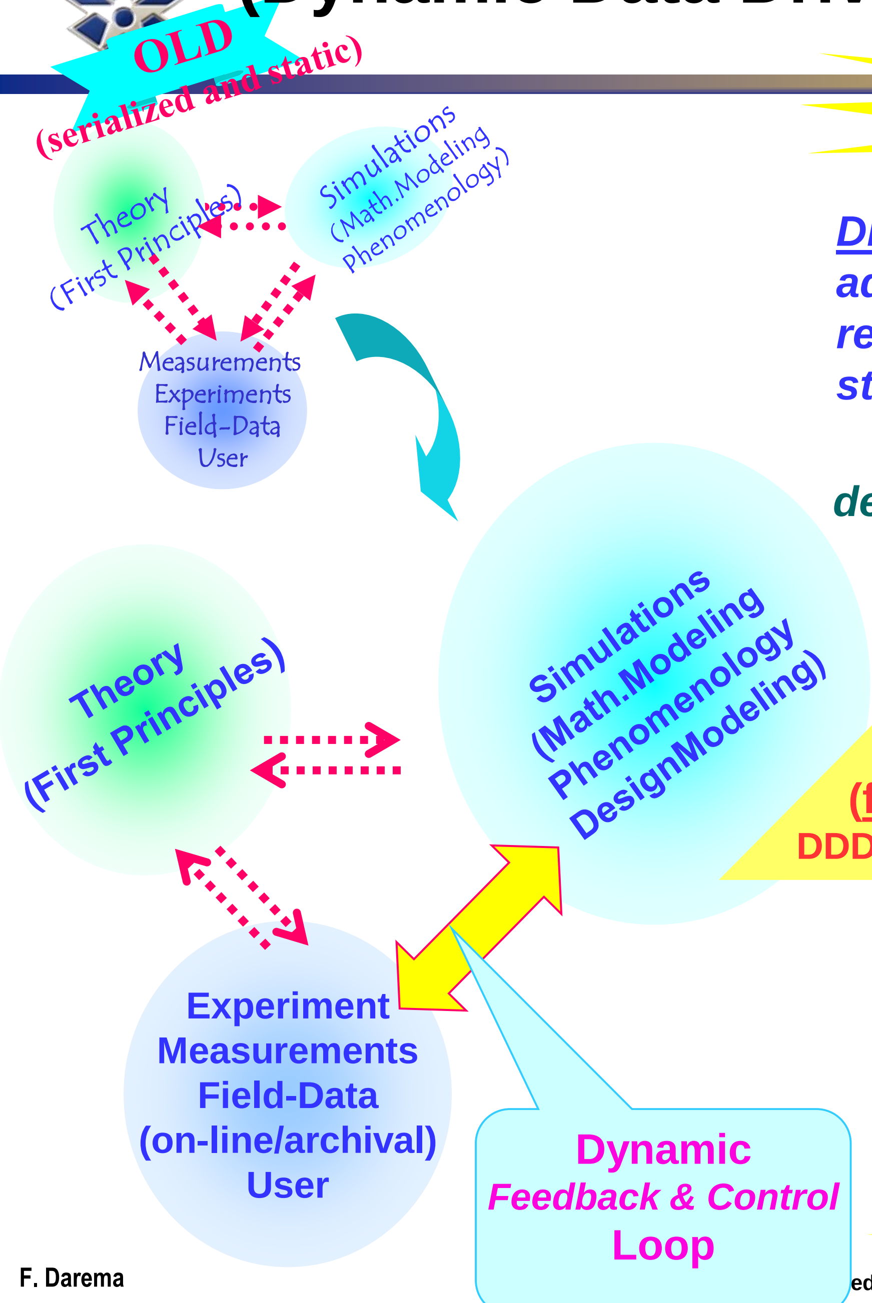
→ DDDAS-based methods for across the life-cycle of systems

- **DDDAS – *beyond traditional modeling/simulation approaches and use***

  – beyond the traditional instrumentation approaches and use
- ***DDDAS enables:***
  - ***more accurate and faster modeling capabilities for analysis and prediction***
  - ***decision support capabilities with the accuracy of full scale models***
  - ***dynamic/adaptive and more efficient/effective management of heterogeneous resources; ability to compensate for instrumentation faults***

- **Program Investment Strategy**
  - **Select key AF areas & apply DDDAS for end-to-end systems capabilities**
  - **"*Excellence in Science and Transformative Impact to the Air Force*"**

The DDDAS Paradigm
(Dynamic Data Driven Applications Systems)



InfoSymbiotic Systems

***DDDAS**: ability to dynamically incorporate additional data into an executing application, and in reverse, ability of an application to dynamically steer the measurement(instrumentation) processes*

"revolutionary" concept enabling
design, build, manage, understand complex systems

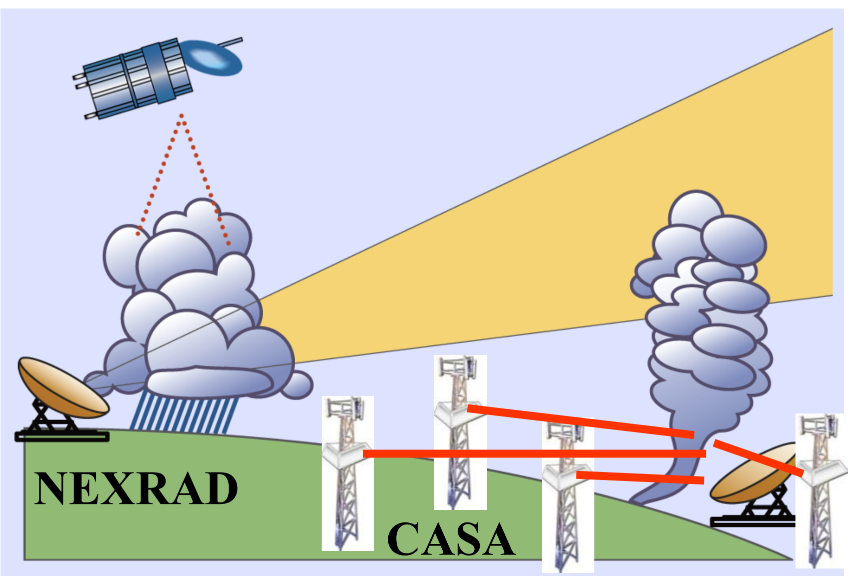
Dynamic Integration of
Computation & Measurements/Data
Unification of
Computing Platforms & Sensors/Instruments
(from the High-End to the Real-Time,to the PDA)
DDDAS – architecting & adaptive mngmnt of sensor systems

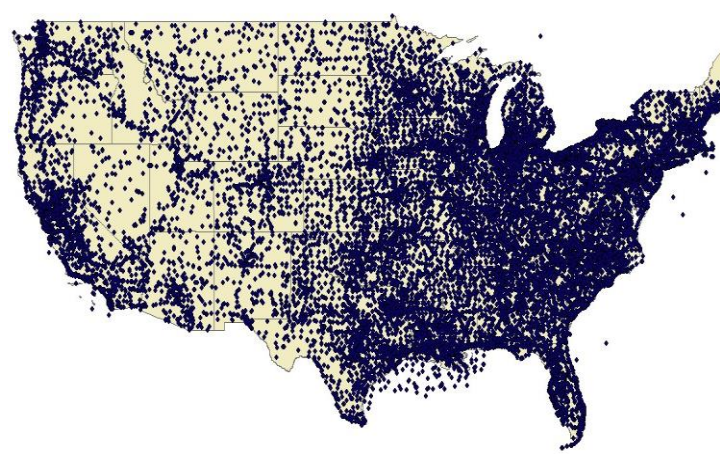
***Challenges*:**
Application Simulations Methods
Algorithmic Stability
Measurement/Instrumentation Methods
Computing Systems Software Support

Synergistic, Multidisciplinary Research

LEAD: Users INTERACTING with Weather
Infrastructure:
NSF Engineering Research Center
for Collaborative Adaptive Sensing of the Atmosphere (CASA)

- **Current (NEXRAD) Doppler weather radars are high-power and long range – Earth's curvature prevents them from sensing a key region of the atmosphere: ground to 3 km**
- **CASA Concept: Inexpensive, dual-polarization phased array Doppler radars on cellular towers and buildings**
  - **Easily view the lowest 3 km (most poorly observed region) of the atmosphere**
  - **Radars collaborate with their neighbors and dynamically adapt to the changing weather, sensing multiple phenomena to simultaneously and optimally meet multiple end user needs**
  - **End users (emergency managers, Weather Service, scientists) drive the system via policy mechanisms built into the optimal control functionality**

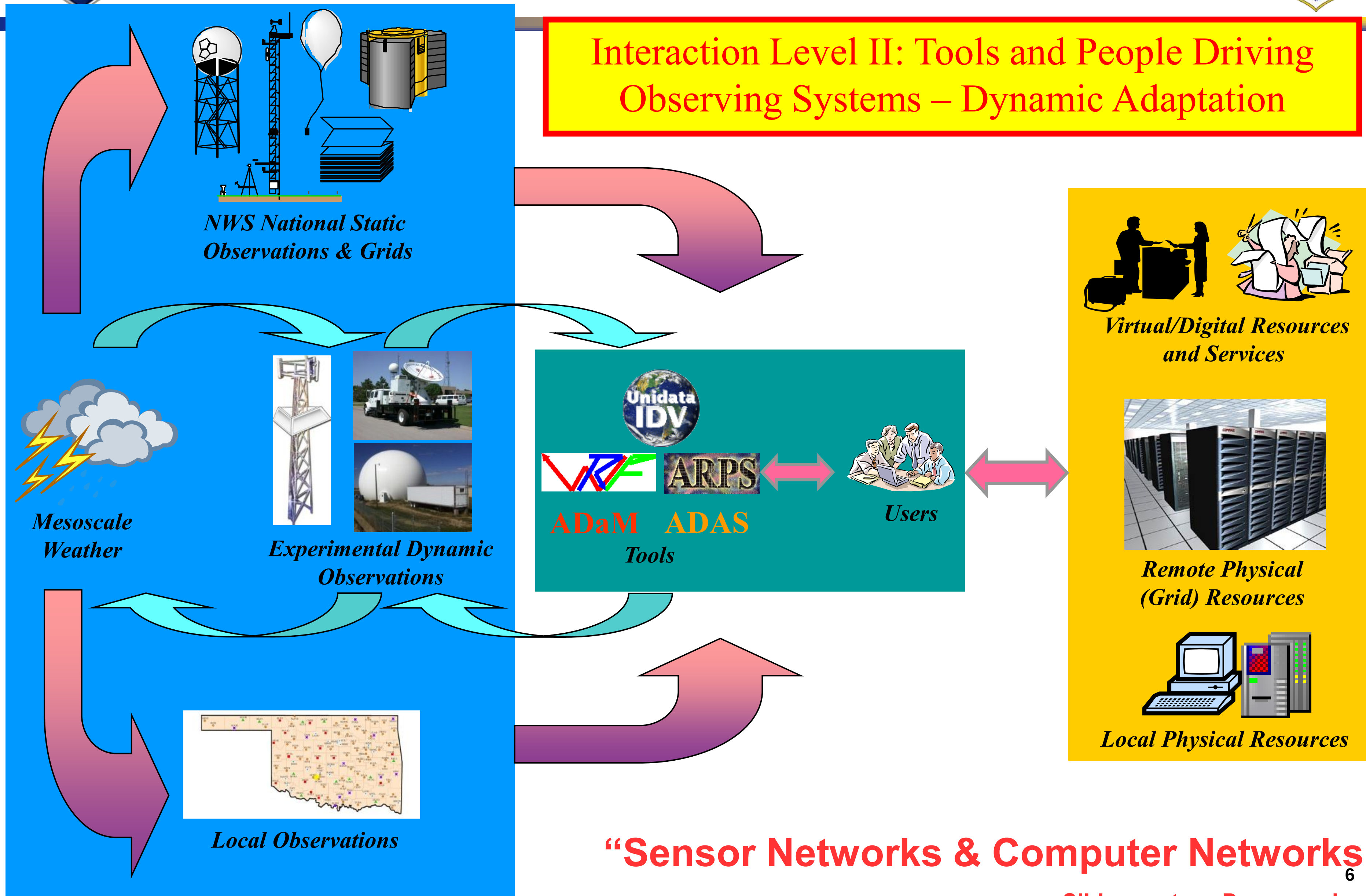




Slide courtesy Droegemeier

LEAD: Users INTERACTING with Weather

"The LEAD Goal Restated - to incorporate DDDAS " - Droegemeier



"Sensor Networks & Computer Networks"

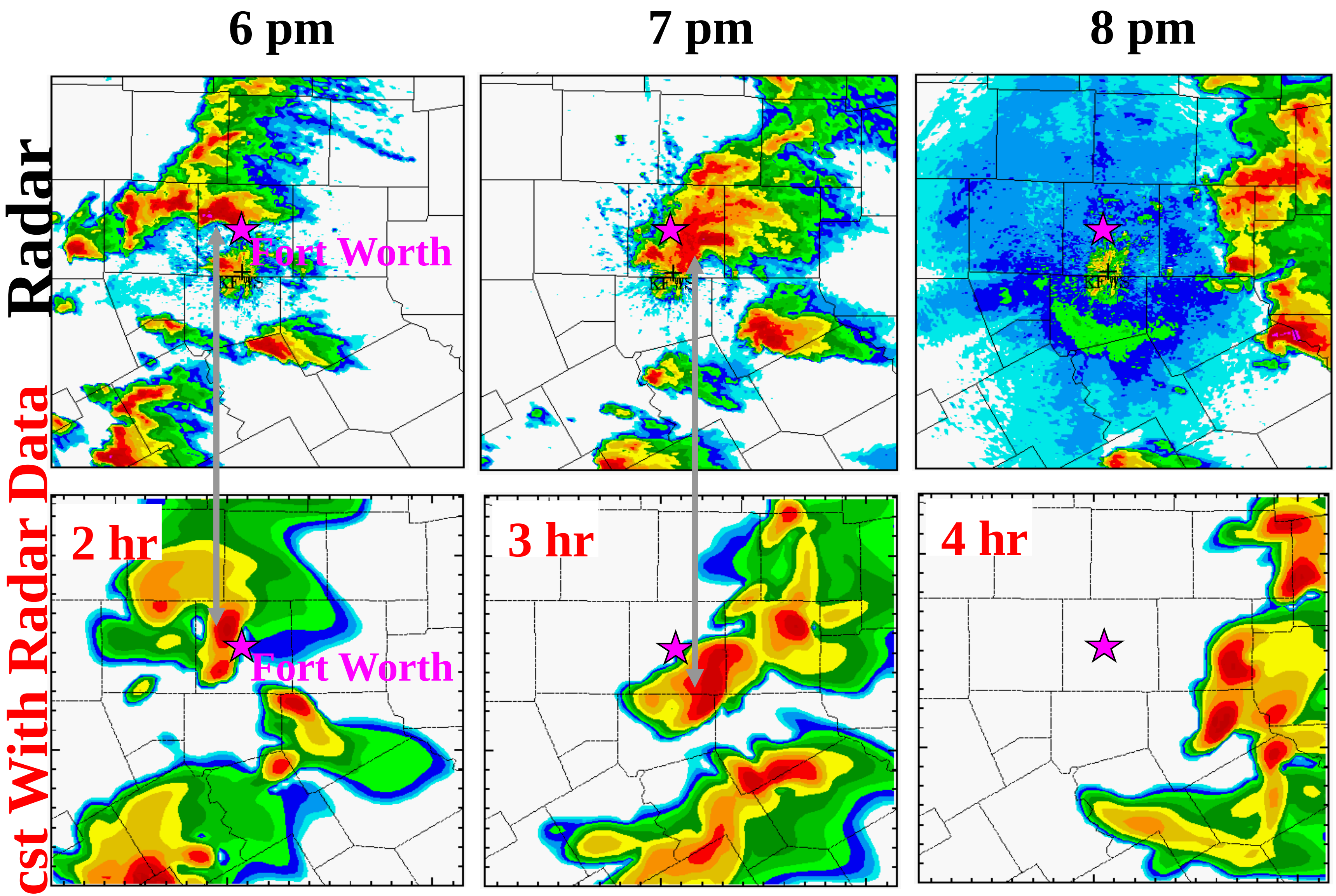
Slide courtesy Droegemeier

March 2000 Fort Worth Tornadic Storm
Local TV Station Radar

(Slide – Courtesy K. K. Droegemeier)

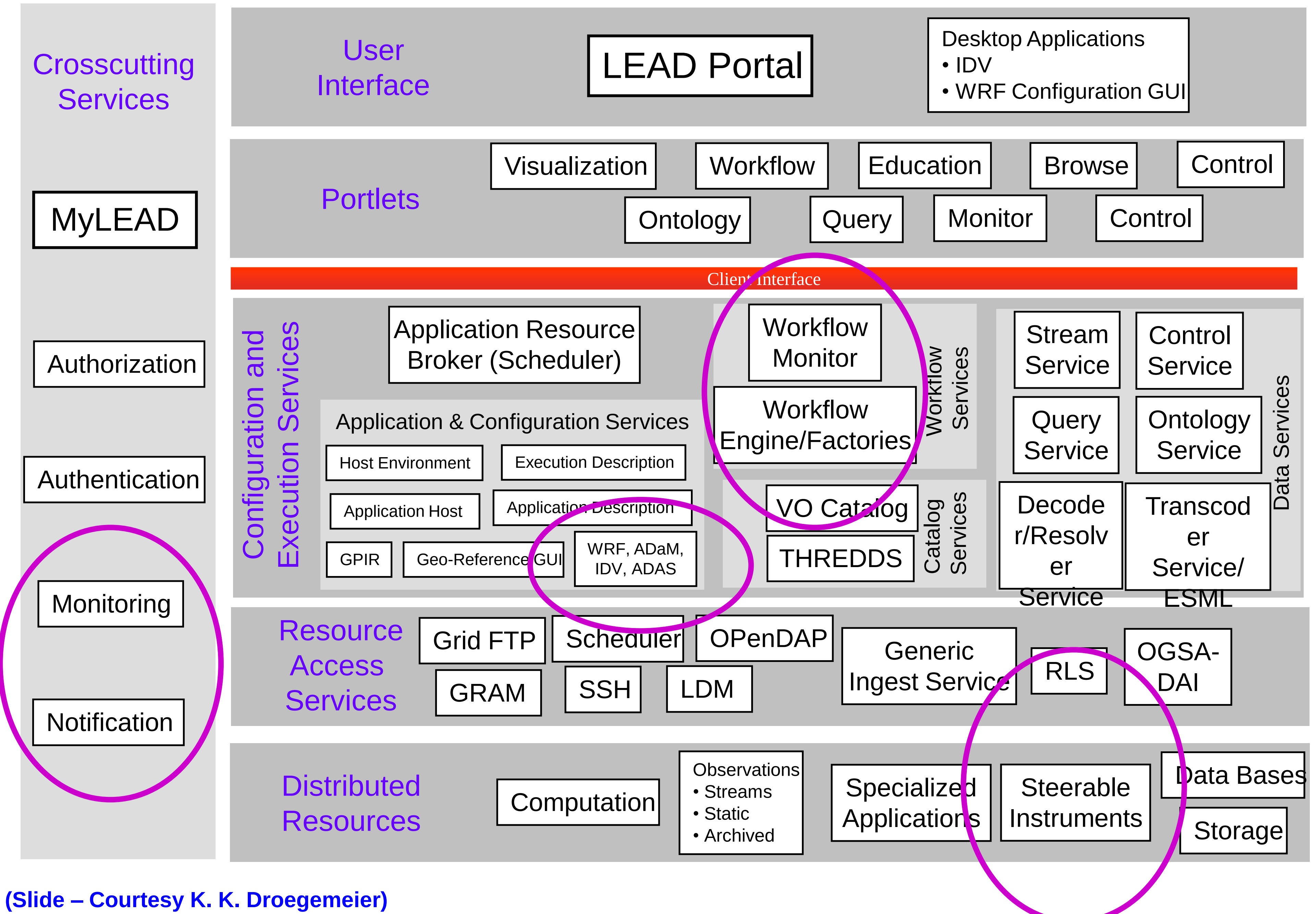
Corrected Forecast with LEAD(DDDAS)

(Slide – Courtesy K. K. Droegemeier)



Xue et al. (2003)

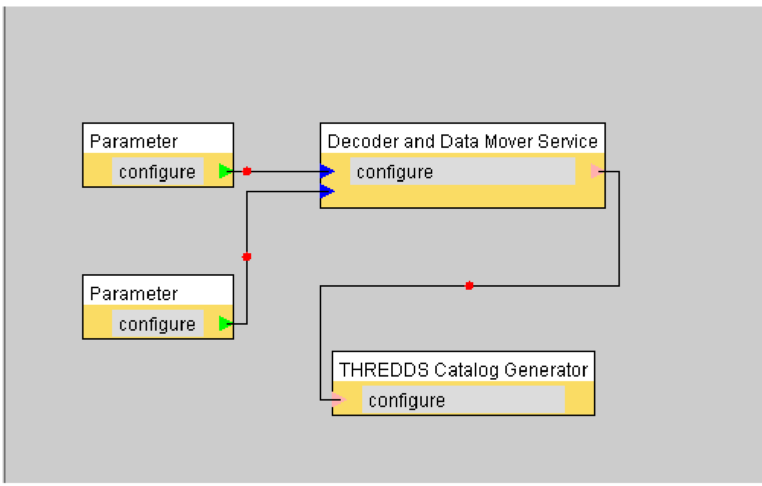
LEAD Architecture: adaptivity service interaction

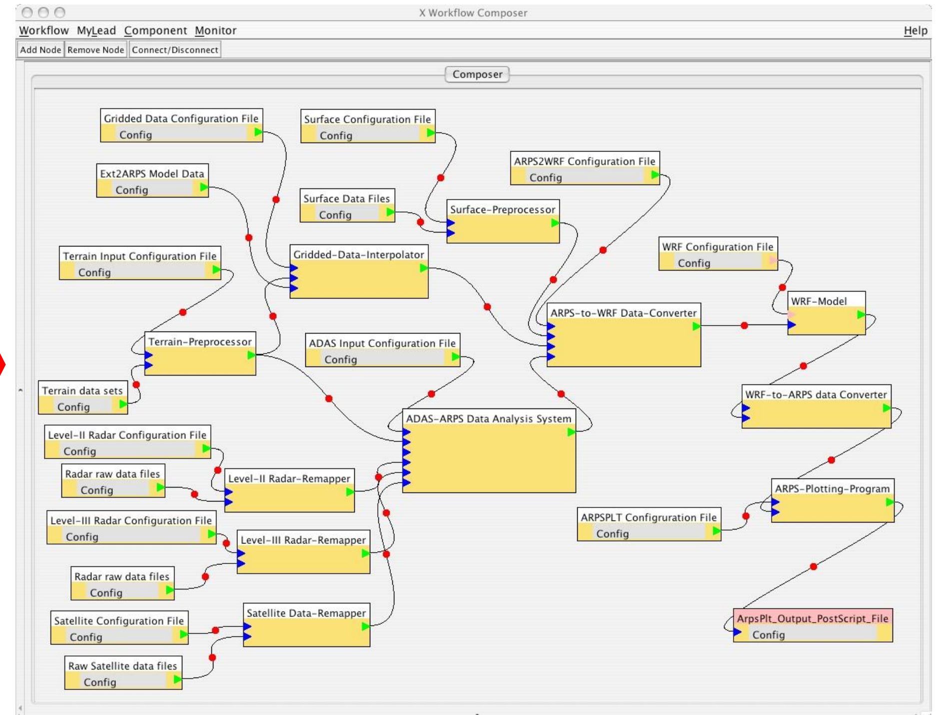


(Slide – Courtesy K. K. Droegemeier)

Dynamic Workflow: THE Challenge

(Slide – Courtesy K. K. Droegemeier)

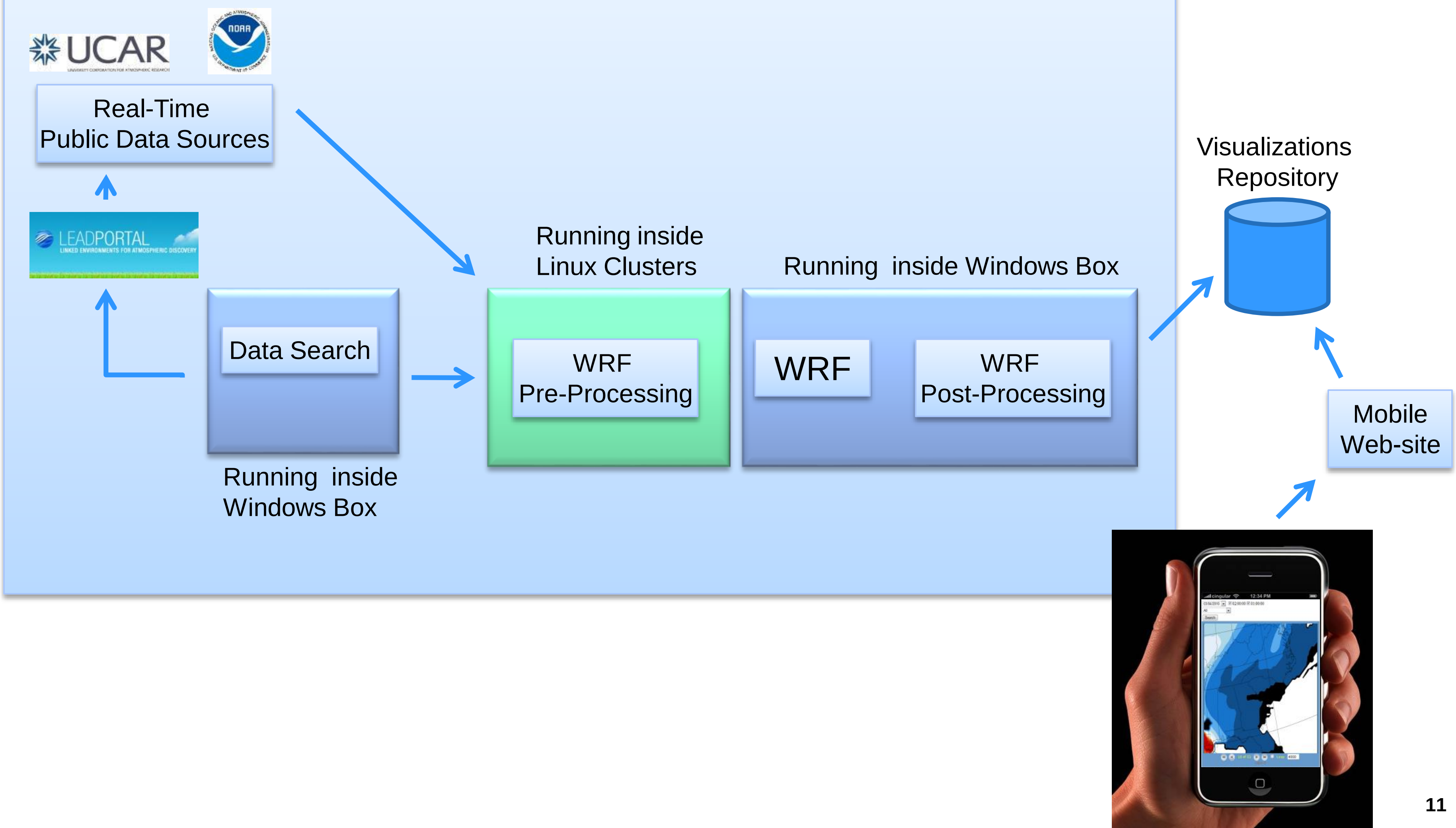




Automatically, non-deterministically, and getting the resources needed

Vortex2 Experiment with Trident

Vortex2 Workflow guided by Trident



Advances in Capabilities through DDDAS
and Fundamental Science and Technology

- **DDDAS: integration of application simulation/models with the application instrumentation components in a dynamic feed-back control loop**
  - **speedup of the simulation, by replacing computation with data in specific parts of the phase-space of the application**

    and/or
  - **augment model with actual data to improve accuracy of the model, improve analysis/prediction capabilities of application models**
  - **dynamically manage/schedule/architect heterogeneous resources, such as:**
    - **networks of heterogeneous sensors, or networks of heterogeneous controllers**
  - **enable ~decision-support capabilities w simulation-modeling accuracy**
- **unification from the high-end to the real-time data acquisition**
- **Increased Computat'n/Communic'n capabilities; ubiquitous heterogeneous sensing/control**

❖ **DDDAS is more powerful and broader paradigm than Cyber-Physical Systems**

DDDAS/InfoSymbiotics is the unifying paradigm

Fundamental Challenges and Timeliness

- **Application modeling methods to support dynamic data inputs**
  - **multi-modal, multi-scale, multi-fidelity models/simulations**
    - **dynamically invoke/select multiple scales/modalities/components**
    - **interfacing with measurement systems**
- **Algorithms tolerant to perturbations from dynamic data inputs**
  - **handling data uncertainties, uncertainty propagation, quantification**
- **Measurements**
  - **multiple modalities/fidelities, space/time distributed, data management**
- **Systems Software methods supporting such dynamic environments**
  - **dynamic/adaptive execution on heterogeneous/multi-hierarchical environments {from the high-end/mid-range to real-time platforms-- beyond Clouds(Grids) computation, communication, storage; programming models, run-time/OS, …}**

Timeliness -- Confluence across 4 emerging

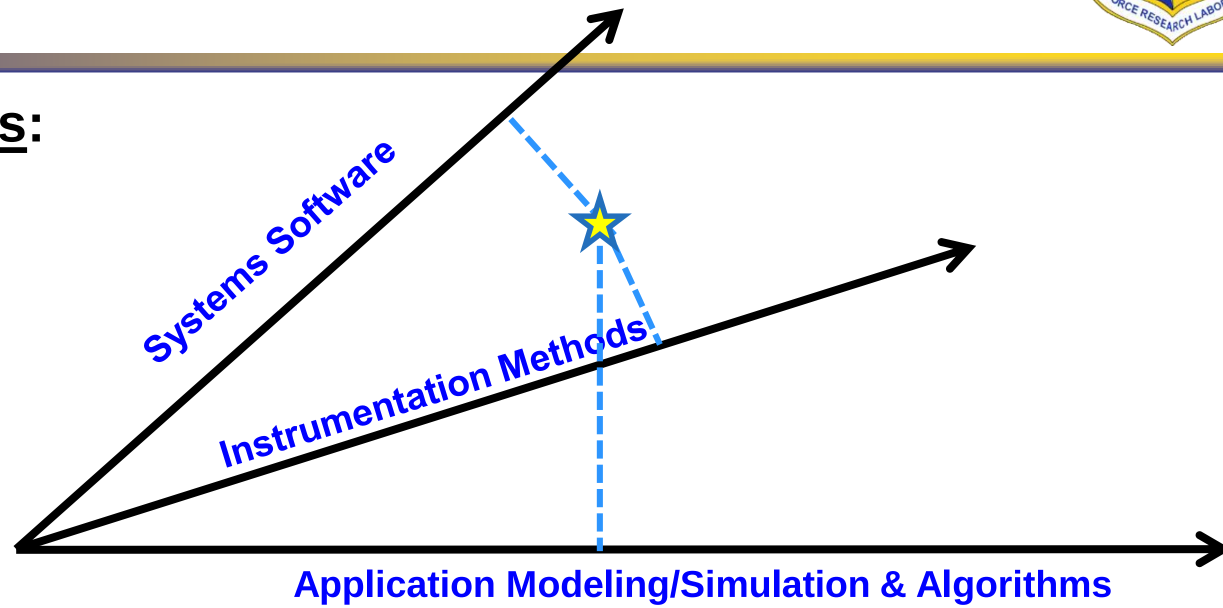
DDDAS-Dynamic Data Driven Applications Systems
- **Unifying High-End with Real-Time/Data-Acquisition&Control**

Large-Scale-Big-Data (Large-Scale-Dynamic-Data)
- **"Big Data" + Ubiquitous Sensing&Control (2nd Wave of big-data)**

Large-Scale-Big-Computing
- **From the exa-scale to the sensor-scale/controller-scale**

Multi-core Technologies
- **Will be driven by sensor/controller and mobile devices**

Program Portfolio organization



<u>Program Research Axes</u>:

{Program Sub-Areas}

AFOSR DDDAS Program (2011- …)

***<u>Thematic Areas</u>*:**

Materials modeling; Structural Health Monitoring for Decision Support;
Environment Cognizant Operation; Energy Efficiencies;
Autonomic Coordination of U(A/G)S Swarms;
Co-operative Sensing for Surveillance - Situational Awareness
Space Weather and Adverse Atmospheric Events;
CyberSecurity; Systems Software

NSF-AFOSR DDS Initiative (2014) - Large-Scale-Big-Data & Large-Scale-Big-Computing

(Planned) Expanded Multi-Agency (2016): InfoSymbioticSystems (DDDAS)

Areas Covered in Portfolio

"from the nanoscale to the terra- and extra-terra-scale"

Key Strategic Approaches of the Program

Materials modeling; Structural Health Monitoring – Environment Cognizant - Energy Efficiencies; Autonomic Coordination of U(A/G)S Swarms;

Co-operative Sensing for Surveillance - Situational Awareness

Space Weather and Adverse Atmospheric Events;

CyberSecurity; Systems Software

Multidisciplinary Research

Drivers: advancing capabilities along the Key Areas identified in Technology Horizons, Autonomy Horizons, Energy Horizons, Global Horizons Reports

DDDAS … key concept in many of the objectives set in Technology Horizons

- **Autonomous systems**
- **Autonomous reasoning and learning**
- **Resilient autonomy**
- **Complex adaptive systems**
- **V&V for complex adaptive systems**
- **Collaborative/cooperative control**
- **Autonomous mission planning**
- **Cold-atom INS**
- **Chip-scale atomic clocks**
- **Ad hoc networks**
- **Polymorphic networks**
- **Agile networks**
- **Laser communications**
- **Frequency-agile RF systems**
- **Spectral mutability**
- **Dynamic spectrum access**
- **Quantum key distribution**
- **Multi-scale simulation technologies**
- **Coupled multi-physics simulations**
- **Embedded diagnostics**
- **Decision support tools**
- **Automated software generation**
- **Sensor-based processing**
- **Behavior prediction and anticipation**
- **Cognitive modeling**
- **Cognitive performance augmentation**
- **Human-machine interfaces**

Impact to Civilian Sector Areas of prior and present Multiagency DDDAS Efforts

- **Physical, Chemical, Biological, Engineering Systems**
  - **Chemical pollution transport (atmosphere, aquatic, subsurface), ecological systems, molecular bionetworks, protein folding..**
- **Medical and Health Systems**
  - **MRI imaging, cancer treatment, seizure control**
- **Environmental (prevention, mitigation, and response)**
  - **Earthquakes, hurricanes, tornados, wildfires, floods, landslides, tsunamis, …**
- **Critical Infrastructure systems**
  - **Electric-powergrid … ms, water supply systems, tra … works and vehicles (air, ground, u…**

"revolutionary" concept enabling to design, build, manage and understand complex systems

NSF/ENG Blue Ribbon Panel (Report 2006 – Tinsley Oden)

"DDDAS … key concept in many of the objectives set in Technology Horizons"

Dr. Werner Dahm, (former/recent) AF Chief Scientist

… syst…

  - **Large-Scale Con… …ronments**

List of Projects/Papers/Workshops in www.cise.nsf.gov/dddas, www.1dddas.org

(+ Planned DDDAS Conference - August2016)

Large-Scale-Big-Data

- **Emerging scientific and technological trends/advances**
  - *ever more complex applications – systems-of-systems*
  - increased emphasis in complex applications modeling
  - increasing computational capabilities
  - increasing bandwidths for streaming data
  - increasing sources of data

Large Volumes of Data
(heterogeneous, distributed, multi-time-scales)

- **Sensors– Sensors EVERYWHERE…** *(data intensive Wave #2)*
  - *Swimming in sensors and drowning in data* - LtGen Deptula (2010)

Analogous experience from the past:

- *"The attack of the killer micros(microprocs)"* - Dr. Eugene Brooks, LLNL (early 90's)

about microprocessor-based high-end parallel systems

then seen as a problem – have now become an opportunity - advanced capabilities

Back to the present and looking to the future:

- *"Ubiquitous Sensing – the attack of the killer micro (sensors) – 2nd wave"*

Dr. Frederica ... AFOSR (2011, LNCC)

challenge: ... such resources

oppo... capabilities

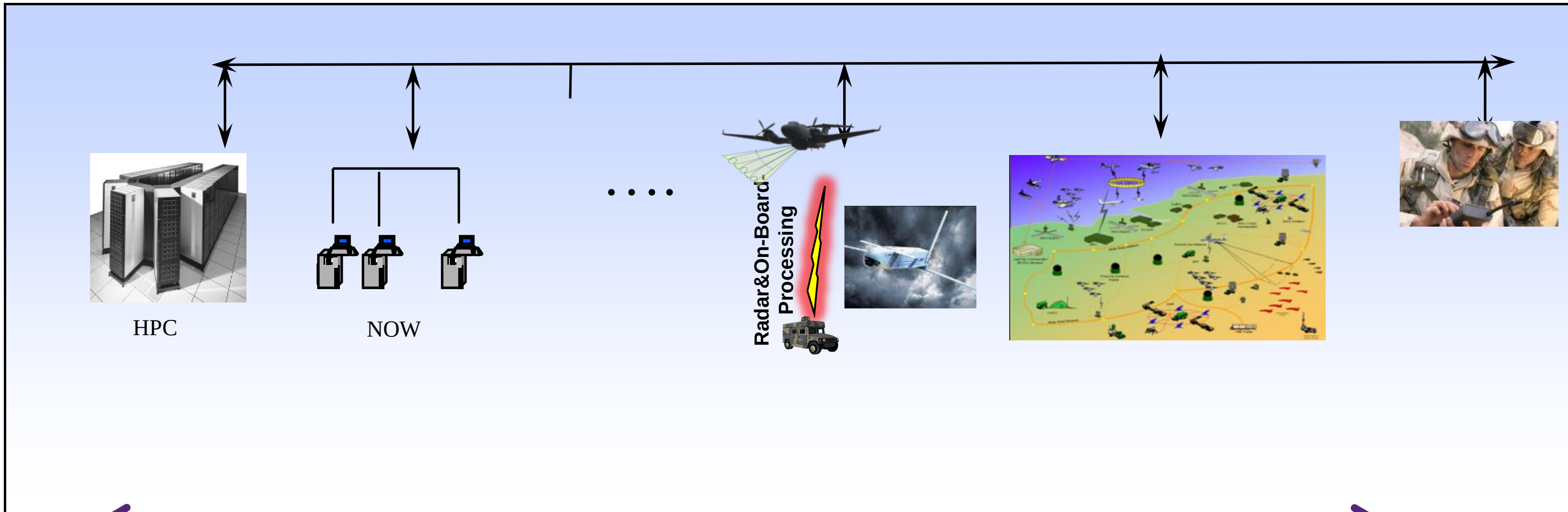
Ubiquitous Sensing
important component of BIG DATA -- Wave #2! -
→ Large-Scale-Big-Data

Integrated Information Processing Environments

from Data-Computation-Communication to Knowledge-Decision-Action

Multicores EVERYWHERE !!!

End-to-End Methods Across System Layers/Components



DDDAS - Integrated/Unified Application Platforms

Adaptable Computing and Data Systems Infrastructure spanning the high-end to real-time data-acquisition & contro
manifesting heterogeneous multilevel distribut
system architectures – softw

Technological Advances for exascale

es

overlapping multicore needs – pow t-tolerance

Large-Scale Big-Computing

Areas Covered in DDDAS Portfolio

"from the nanoscale to the terra- and extra-terra-scale"

***Materials modeling**; Structural Health Monitoring – Environment Cognizant - Energy Efficiencies;*
Co-operative Sensing for Surveillance - Situational Awareness;
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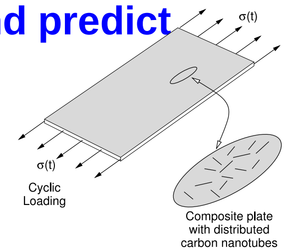
Development of a Stochastic Dynamic Data-Driven System for Prediction of Material Damage

J.T. Oden (PI), P. Bauman, E. Prudencio, S. Prudhomme, K. Ravi-Chandar - UTAustin

Goal: **Dynamic Detection and Control of Damage in Complex Composite Structures**

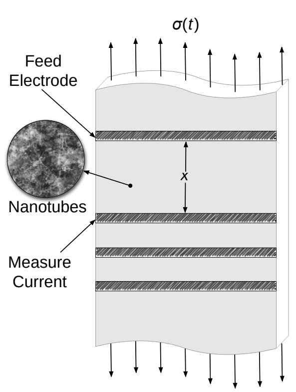
Results achieved:

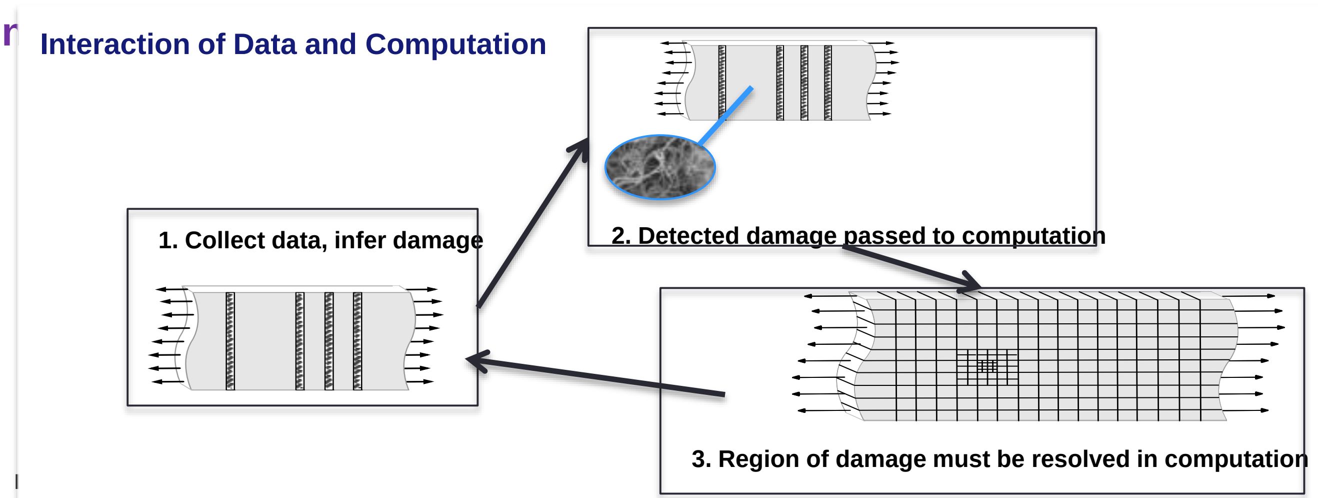
- **Through DDDAS new capabilities have been developed for prediction of material damage**
- **For example can predict on-set of damage before is observed experimentally and predict the evolution of the damage.**



Methodology:

- **Dynamic Data: direct and indirect measurements of damage in materials**
- **Reliable predictive computational models: Finite element solution of continuum damage models**
- **Handling uncertainties: Bayesian framework for uncertainty quantification and Bayesian Model Plaucibilities to dynamically choose damage models based on evolving data; and**
- **Real Time Damage Monitorir**





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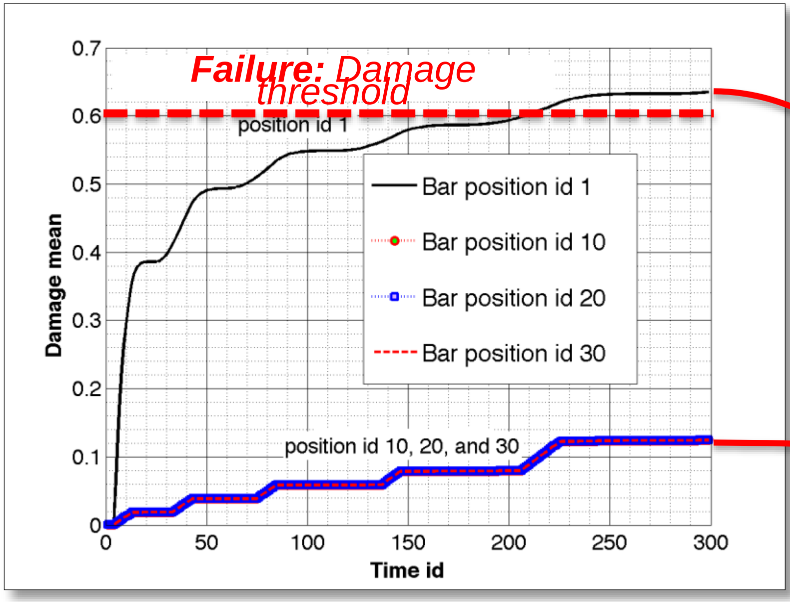
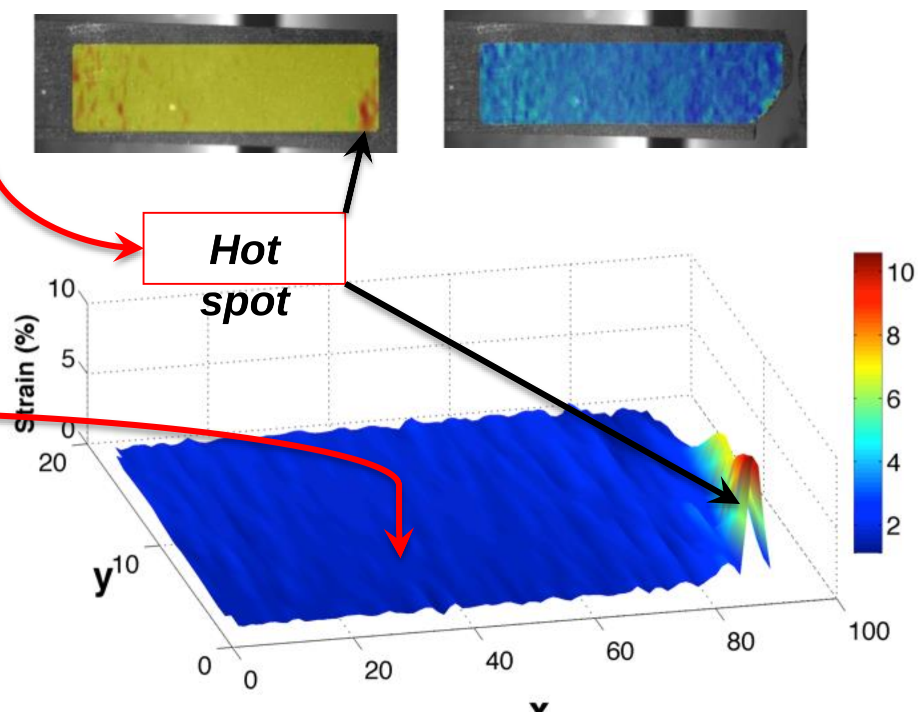
Prediction using Dynamic Data



Experimental Observation



2 (s) before failure

Example Results:

- **Experimental Data: shows the spatial variation of strain 2(s) before the failure**
- **Prediction Using Dynamic Data: shows the computed evolution of the damage variable with time at various position**
- **“hot spot”: is the dangerous point leading to system failure**
- **From the test results the hot spot can be observed few second before failure**

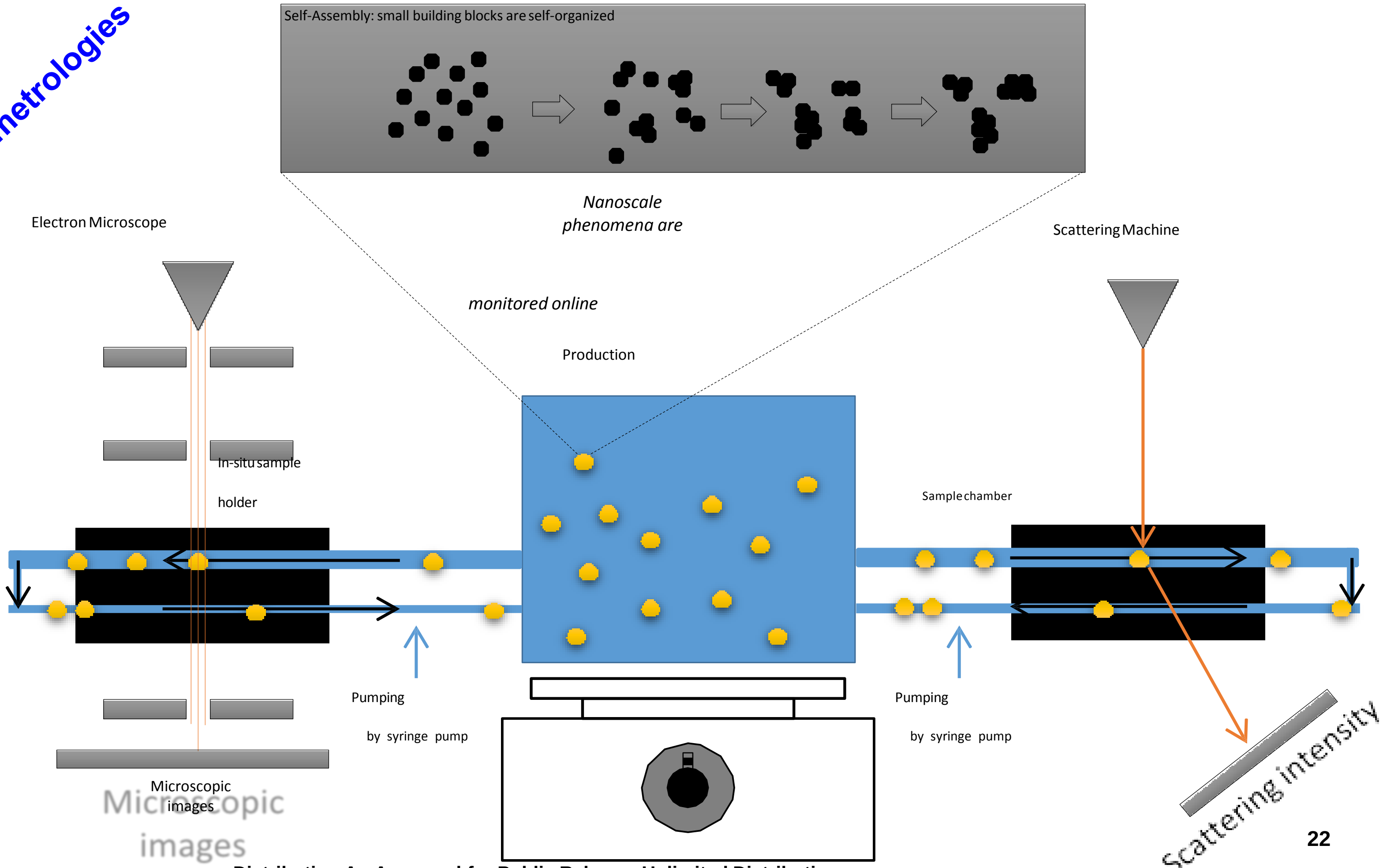
Dynamic, Data-Driven Modeling of Nanoparticle Self-Assembly Processes

Team: Ding, Park, Huang, Liu, Zhang

Many applications require nanoparticle products of precisely controlled sizes and shapes, because the functionalities of the nanoparticles are determined by their sizes and shapes.

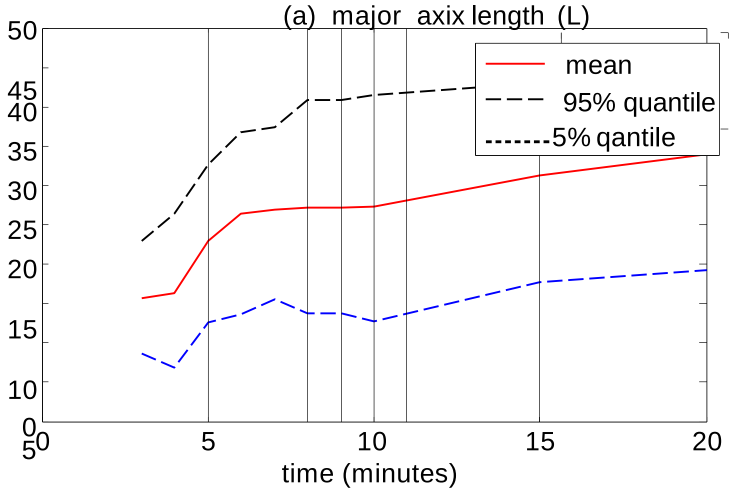
- **Nanoparticles as propellants of satellites and space craft propulsion;**
- **Nanocomposites with special mechanical and electrical properties;**
- **Photovoltaic catalyst for solar cell; and Sensing toxic biological weapons**

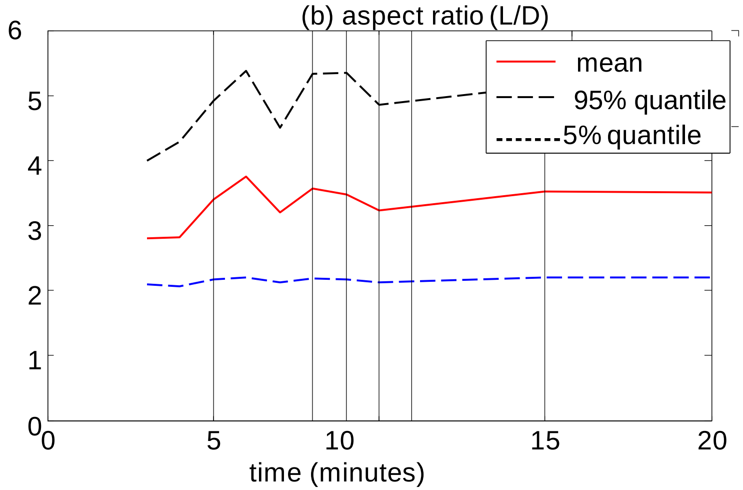
Combining multiscale metrologies

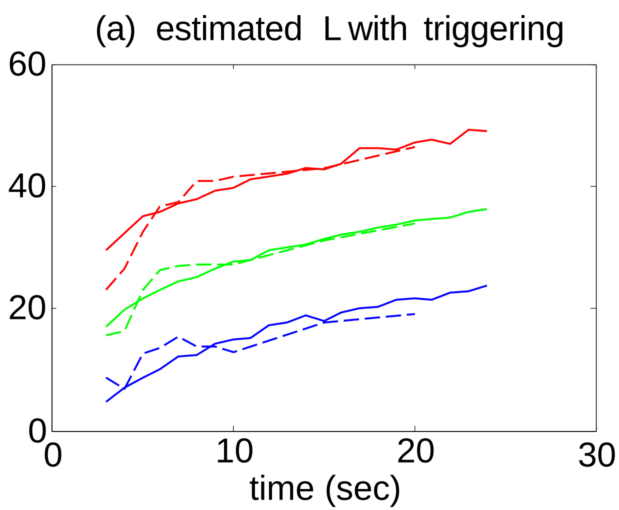


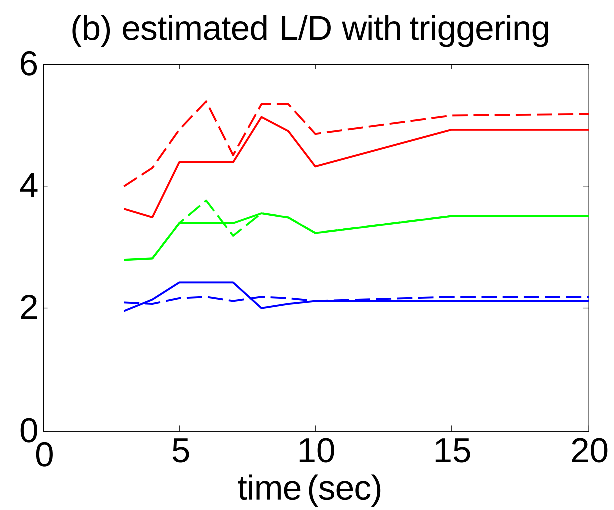
Controlled TEM Triggering

TEM triggering process initiated after *t* = 5 mins, controlled per the (DDDAS-based) approach. Additional TEM operations are triggered (DDDAS model driven) in between 5 and 20 minutes.









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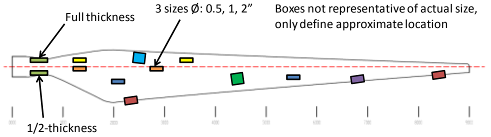
Y. Bazilevs, A.L. Marsden, F. Lanza di Scalea, A. Majumdar, and M. Tatineni (UCSD)

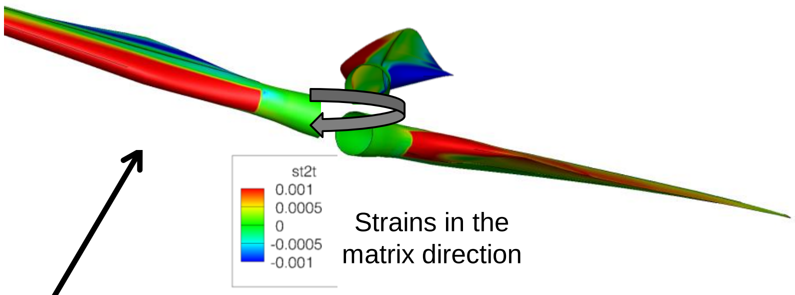
DDDAS Loop for Detected In-plane Waviness



SENSOR DATA/ MEASUREMENTS

Request for additional or refined sensor data

IGA SIMULATION



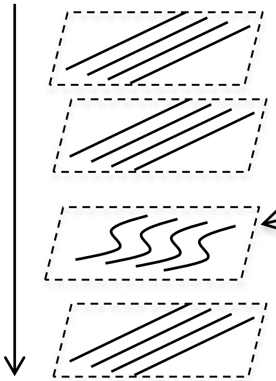
Strains in the matrix direction

Defect detection, geometry and type

Input for analysis, data for mesh refinement based on error indicators

IGA MESHING AND PREPROCESSING

Through-thickness homogenization



Ply 1

Ply 2

…

Ply i - Wavy

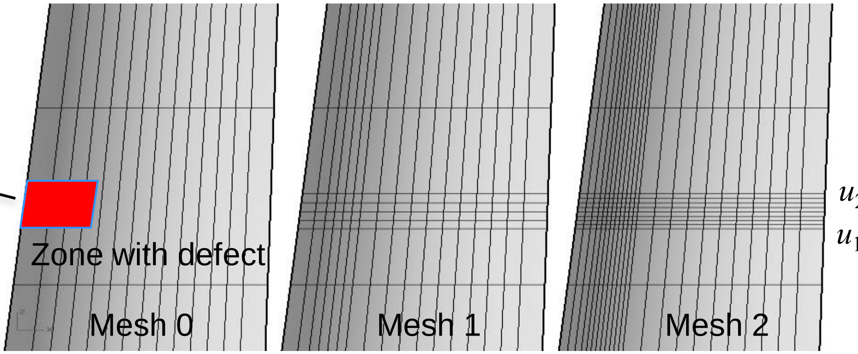
…

Ply N

Parametric description of fiber waviness

$$\bar{\theta} + \theta_{dev} \sin(2\pi \frac{u - u_1}{u_2 - u_1})$$

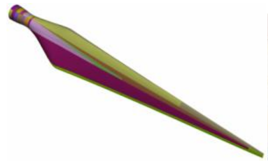
Waviness zone and ply identification on the model (Rhino 3D), and mesh refinement

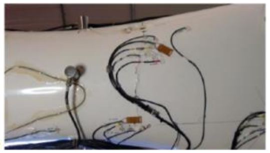


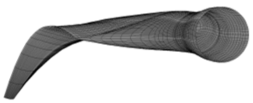
Advanced Simulation, Optimization, and Health Monitoring of Large Scale Structural Systems

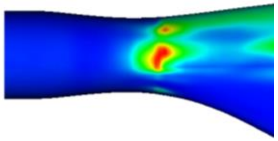
Y. Bazilevs, A.L. Marsden, F. Lanza di Scalea, A. Majumdar, and M. Tatineni (UCSD)

Fatigue damage prediction for full-scale structure in a lab setting

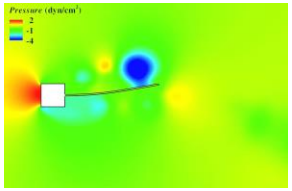


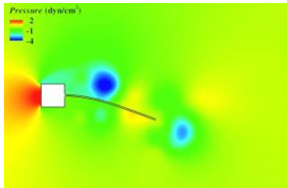


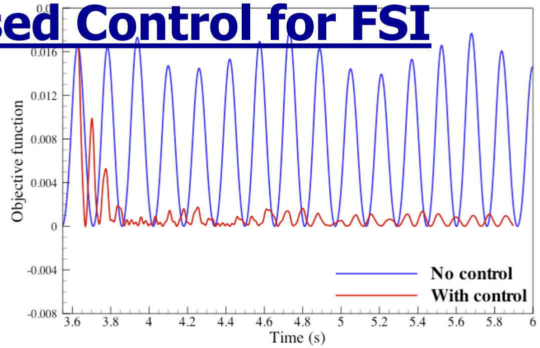


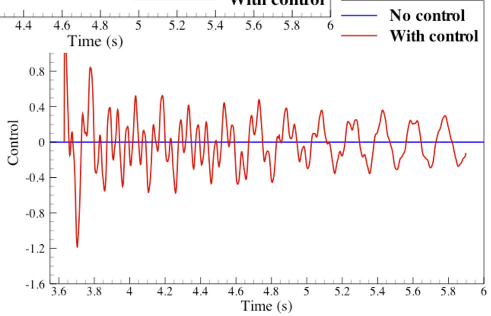


Adjoint-Based Control for FSI

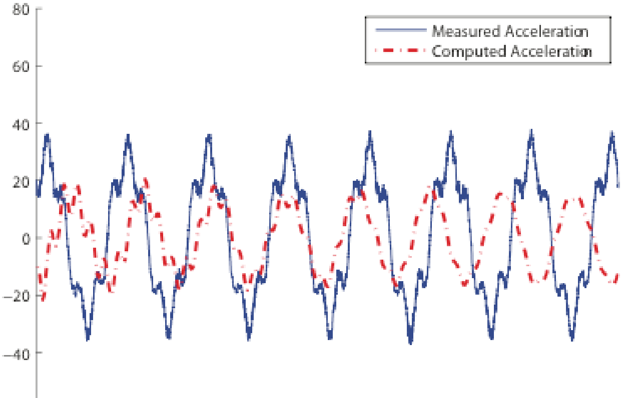




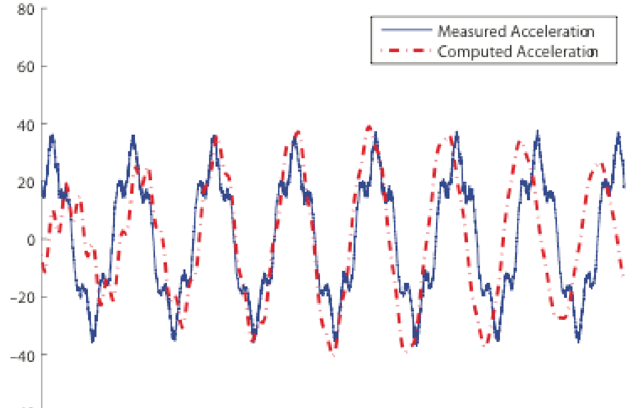




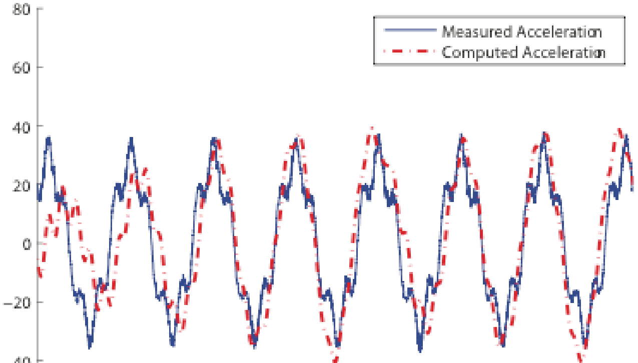
Acceleration



(a) No DDDAS



(b) With DDDAS



(c) Further calibration

Advanced Simulation, Optimization, and Health Monitoring of Large Scale Structural Systems

Y. Bazilevs, A.L. Marsden, F. Lanza di Scalea, A. Majumdar, and M. Tatineni (UCSD)

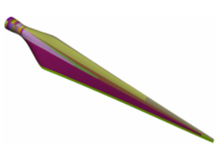
Using the DDDAS paradigm the project has developed :

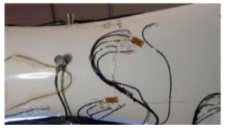
- new **multiscale** laminated-composite **fatigue damage model** data-based dynamic calibration
- new algorithm for numerical **fatigue testing and failure prediction** for laminated composite structures driven by dynamic accelerometer data
- new formulation and algorithm for **adjoint-based control** in coupled **fluid-structure interaction**
- new software based on **isogeometric analysis** for modeling **complex geometry** and material layout, including measured defects, for large-scale composite structures

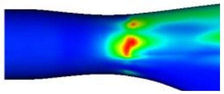
Results:

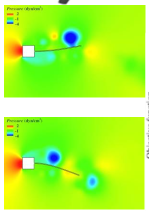
- new capability to dynamically update advanced fatigue damage models in full-scale structural simulations with the goal to predict the remaining fatigue life of a structure

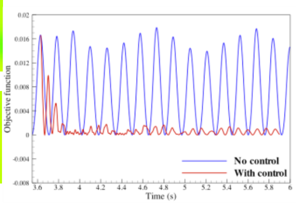
Fatigue damage prediction for full-scale structure in a lab setting

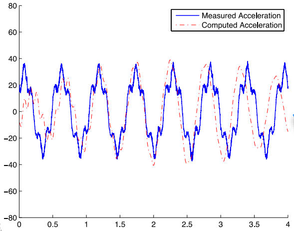




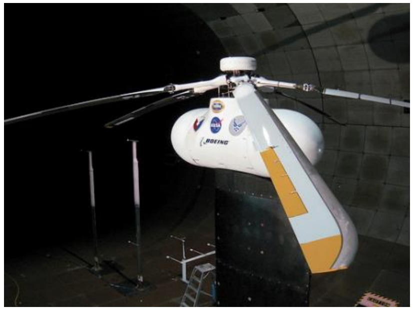








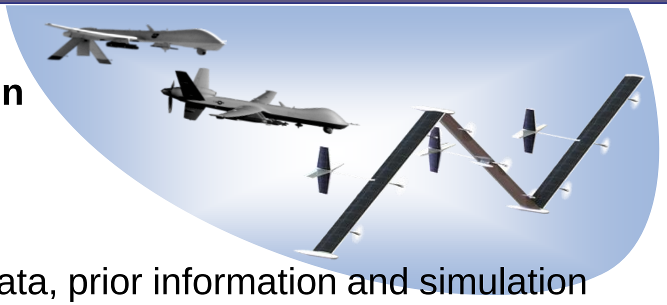
Prediction of fatigue damage in real operating conditions…



… and **sheltering of structures from excessive damage**

Dynamic Data-Driven Methods for Self-Aware Aerospace Vehicles

D Allaire, L Mainini, F Ulker, M Lecerf, H Li, K Willcox (MIT); G Biros, O Ghattas (UT Austin); J Chambers, R Cowlagi, D Kordonowy (Aurora)



A self-aware aerospace vehicle; dynamically adapt to perform mission cognizant of itself and its surroundings and responding intelligently.

Approach and objectives

- **infer** vehicle health and state through dynamic integration of sensed data, prior information and simulation models
- **predict** flight limits through updated estimates using adaptive simulation models
- **re-plan** mission with updated flight limits and health-awareness based on sensed environmental data

Research Goal: multifidelity framework using DDAS paradigm

- draws on multiple modeling options and data sources to evolve models, sensing strategies, and predictions
- dynamic data inform online adaptation of structural damage models and reduced-order models
- dynamic guidance of sensing strategies
- dynamic, online multifidelity structural response models&sensor-data, for predictions w sufficient confidence

Results: dynamic health-aware mission re-planning with quantifiable benefits in reliability, maneuverability and survivability.

Methodologies

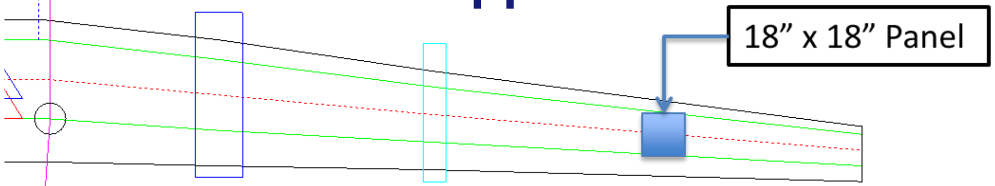
- statistical inference for dynamic vehicle state estimation, using machine learning and reduced-order modeling
- adaptive reduced-order models for vehicle flight limit prediction using dynamic data
- on-line management of multi-fidelity models and sensor data, using variance-based sensitivity analysis
- quantify the reliability, maneuverability and survivability benefits of a self-aware UAV

Dynamic Data-Driven Methods for Self-Aware Aerospace Vehicles

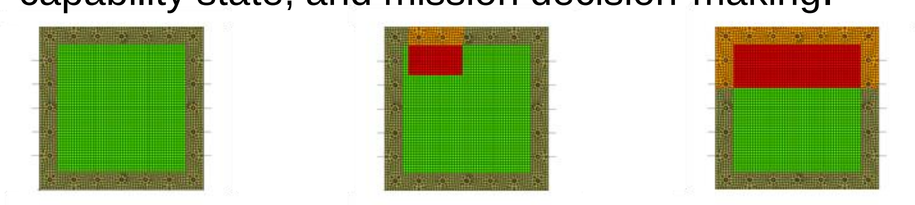
D Allaire, L Mainini, F Ulker, M Lecerf, H Li, K Willcox (MIT); G Biros, O Ghattas (UT Austin);
J Chambers, R Cowlagi, D Kordonowy (Aurora)

An offline/online DDDAS approach

- **Test case: composite panel on a UAV**



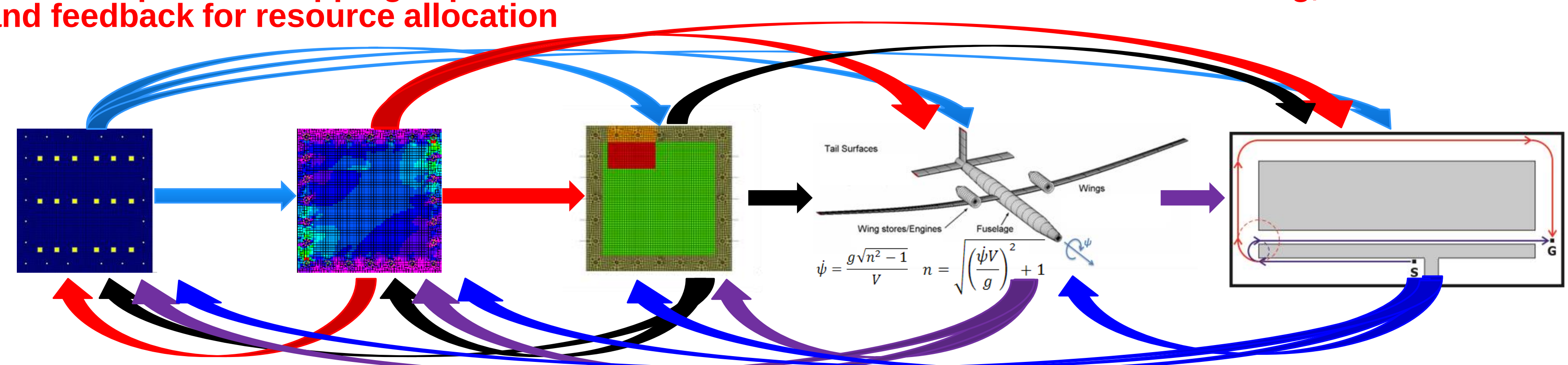
- **Offline:** develop libraries of panel strain information, under different load/damage scenarios under uncertainty. Develop data-driven reduced-order models to map from sensed strain to damage state, capability state, and mission decision-making.



Example damage scenarios caused by ply delamination. Red and orange indicate delamination sites.

- **Online**: information management strategy for dynamic sensor and model-based data acquisition, damage and capability state updates, and dynamic mission re-planning.

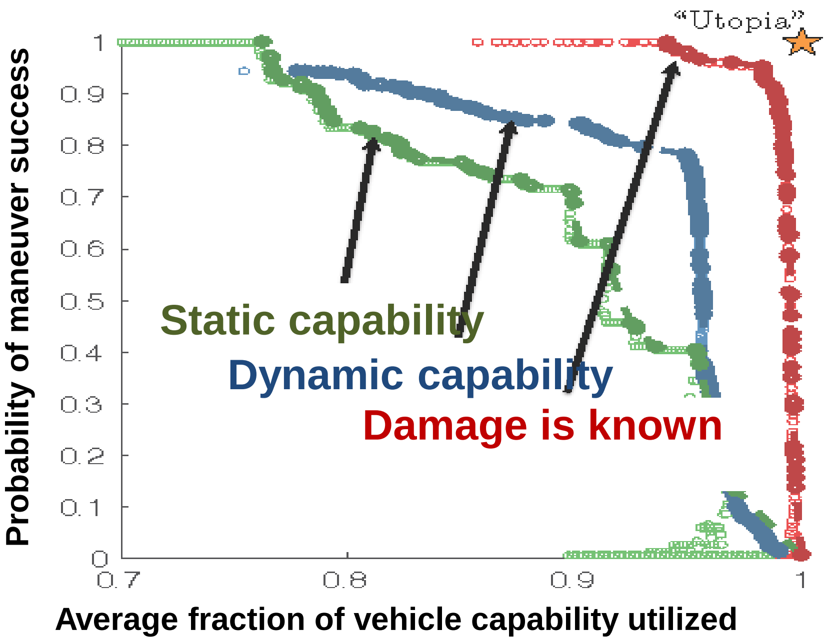
Arrows represent mapping capabilities from sensor data to mission decision-making, and feedback for resource allocation



Sensor information | **Strain field estimation** | **Damage state estimation** | **Capability state estimation** | Mission decision-making

D Allaire, L Mainini, F Ulker, M Lecerf, H Li, K Willcox (MIT); G Biros, O Ghattas (UT Austin); J Chambers, R Cowlagi, D Kordonowy (Aurora)

Trade-off curves for evasive maneuver flight scenario decision strategies



Using the dynamic data through the DDDAS approach increases both vehicle utilization and probability of maneuver success

Highlights of improvements achieved in this project:

- **High-fidelity offline evaluation takes ~5-10 seconds per maneuver per damage case. To evaluate a flight envelope over 100 damage cases and 50 maneuvers takes ~7-14hrs**
- **Online classification using the damage library takes ~100-300 microseconds The DDDAS method yields a speed up of a factor of ~50,000-100,000**
- **Decision support for maneuver**
- **Work transitioned to Aurora Flight Sciences**

Areas Covered in Portfolio

“from the nanoscale to the terra- and extra-terra-scale”

Materials modeling; Structural Health Monitoring – Environment Cognizant - Energy Efficiencies;

Co-operative Sensing for Surveillance - Situational Awareness;

Autonomic Coordination of U(A/G)S Swarms; Cognition

Space Weather and Adverse Atmospheric Events;

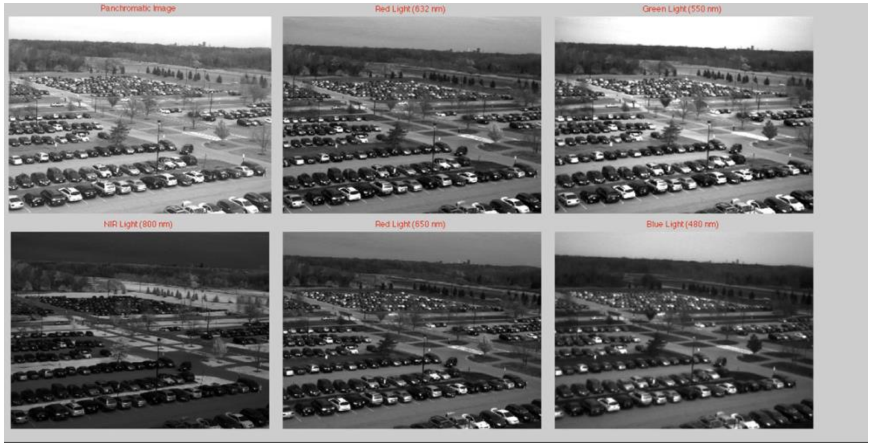
CyberSecurity; Systems Software

Dynamic Modality Switching Aided Object Tracking using an Adaptive Sensor

Matthew Hoffman , Anthony Vodacek (RIT)

- Create capabilities to ***enhance persistent aerial vehicle tracking in complex environments where single imaging modality is insufficient, and full spectral imaging yields inordinate amounts of data***
- **Approach and objectives**
  - *Use the DDDAS framework to allow the tracker to dynamically control the sensor to specify modality and location of data collection and this data to reduce uncertainty in target location*
  - *Develop algorithms to optimize the use of small amounts of hyperspectral data and evaluate performance in simulated scenes using realistic noise and a moving platform*
  - *Begin development of real data testing scenes*
- **Methodology**
  - Tracker leverages DOTCODE framework from previous AFOSR funding
  - Simulation study leverages existing Digital Imaging and Remote Sensing Image Generation (DIRSIG) scenes of a cluttered urban area
  - Real data collection leverages multispectral WASP Lite sensor at RIT

(left) Simulated DIRSIG image and (right) Google maps image of same area



Multispectral Wasp Lite scene with moving vehicles

Dynamic Modality Switching Aided Object Tracking using an Adaptive Sensor

Matthew Hoffman , Anthony Vodacek (RIT)

- **Object tracking** through particle filtering approach – uses **Gaussian Sum Filter** (GSM needed to handle noise in observing turning vehicles – uses an ensemble of vehicle models)
- **New adaptive image processing methods** for **both the targets and the background**

Introduced new cascaded target detection, combining:

Target Detection/ Background Modeling
- NDVI vegetation detection
- Nonlinear SVM roads classifier
- Spectral matching to target
- Linear SVM/HoG vehicle classifier

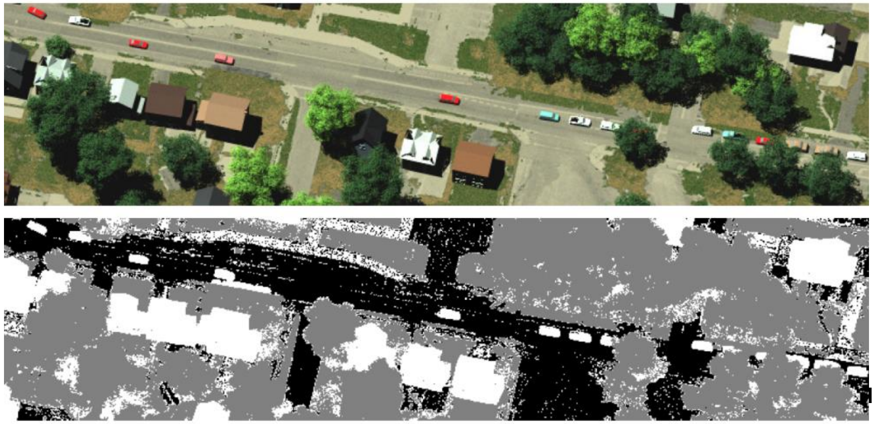
Data Acquisition & Filtering
- MHT Data Association
- Gaussian Sum Filer

Target Movement Model
- Adaptive, multi-model ensemble

Sensor Control & Data Acquisition
- Modality Selection
- Region of interest determination

Processing
- SIFT Keypoint Registration
- Homography Estimation

Vegetation and **road** classification (bottom) of image



Object tracking through targeted feature matching

DDDAMS-based Surveillance and Crowd Tracking via (*combination*) UAVs and UGVs

Young-Jun Son, Jian Liu, University of Arizona; Jyh-Ming Lien, George Mason University

Motivation: TUS 1- Project (23-mile long area of US/Mexico border)Sasabe, AZ)

Problem: Highly complex, uncertain, dynamically changing environment

Goal: Develop a simulation-based planning and control system for surveillance and crowd control via collaborative UAVs/UGVs

Approach:

Hardware-in-the-Loop **Dynamic Data Driven Adaptive Multi-scale Simulation (DDDAMS)**

Incorporates real UAVs/UGV

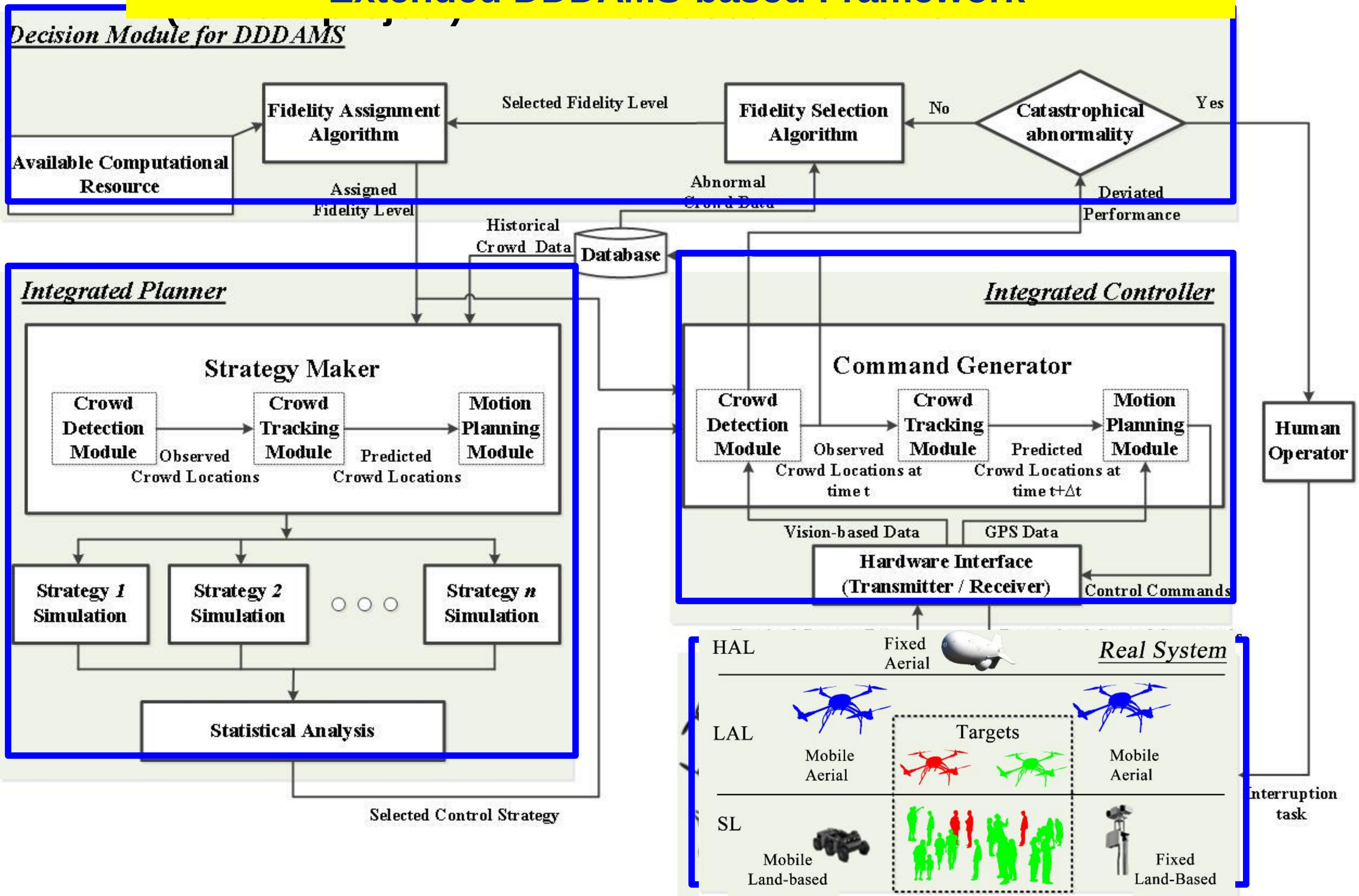
Adopts Dynamic Data Driven Application System (DDDAS) paradigm

Utilizes different fidelities into the simulation

DDDAMS-based Surveillance and Crowd Tracking via UAVs and UGVs

Young-Jun Son, Jian Liu, University of Arizona; Jyh-Ming Lien, George Mason University

Extended DDDAMS-based Framework



DDDAMS-based Surveillance and Crowd Tracking via UAVs and UGVs

Young-Jun Son, Jian Liu, University of Arizona; Jyh-Ming Lien, George Mason University

1. Crowd Joining

2. Crowd Splitting

3. Out of Detection Range

4. Random Movements

DDDAMS-based Surveillance and Crowd Tracking via UAVs and UGVs

Young-Jun Son, Jian Liu, University of Arizona; Jyh-Ming Lien, George Mason University

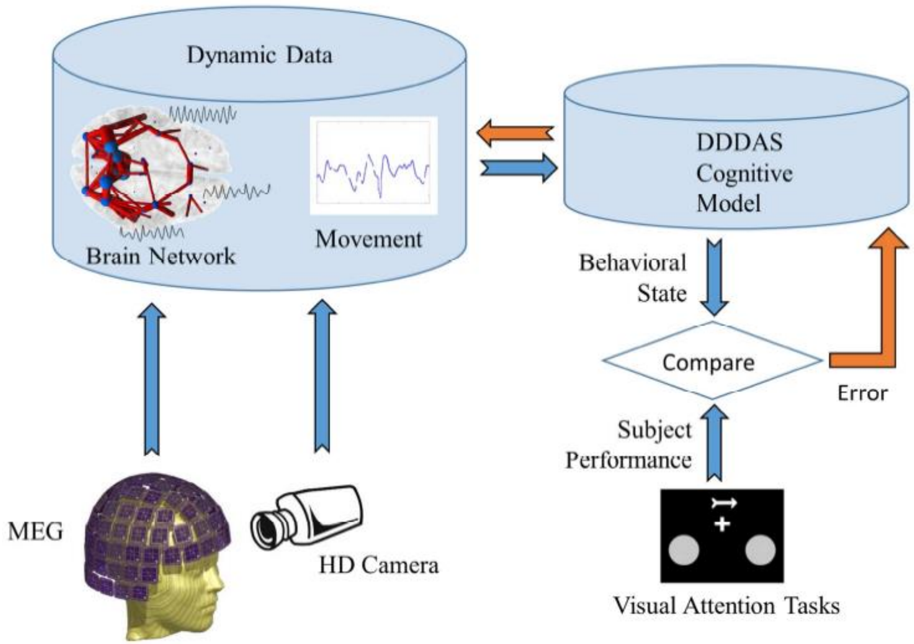
- **A DDDAMS-based planning and control framework has been refined to devise robust, multi-scale, and effective surveillance and crowd control strategies using UAVs/UGVs**
- **Under the DDDAMS framework, the algorithms based on UAV/UGV information aggregation for crowd tracking was demonstrated with real videos from UAVs/UGVs. Using the proposed algorithm, 79% coverage was achieved as opposed to 60.3% w/o involving aggregation**
- **Under the DDDAMS framework, an abrupt motion change detection (AMCD) module was developed based on particle filtering and sequential importance resampling. The intent was to help detect crowds' abrupt changing of dynamics, such as sudden turning, stop, or acceleration. According to the simulation study, prediction accuracy was increased by 24% via the proposed AMCD module**
- **Under the DDDAMS framework, a team formation approach was developed, and for a simulation study involving crowd splitting into two clusters, it took 30 seconds to form new teams, compensating the 38% reduction of the coverage.**
- **Under the DDDAMS framework, a motion detection module was developed based on optical flow for crowd detection via UAV, and a human detection module based on histogram of oriented gradients for individual detection via UGV. In the experiment, the crowd coverage can reach up to 100% when combining with the UAV, while is 75% with only the UGV.**
- **The ability to localize the UAVs and UGVs in outdoor environments is an essential step in solving the problem of visibility-based pursuit. Semantic segmentation of images for labeling of man-made structures allows to obtain proper feature weighting and improve the overall location recognition accuracy.**
- **An integrated simulation test-bed has been refined, involving hardware (UAVs and UGVs), software (agent-based system-level model in Repast; GIS), and human components**

Areas Covered in Portfolio

"from the nanoscale to the terra- and extra-terra-scale"

Materials modeling; Structural Health Monitoring – Environment Cognizant - Energy Efficiencies;
Co-operative Sensing for Surveillance - Situational Awareness;
Autonomic Coordination of U(A/G)S Swarms; Cognition
Space Weather and Adverse Atmospheric Events;
CyberSecurity; Systems Software

Dynamic Integration of Motion & Neural Data to Capture Human Behavior
D. Metaxas (Rutgers), D. Pantazis (MIT), K. Michmizos (Harvard)



New Capabilities for:

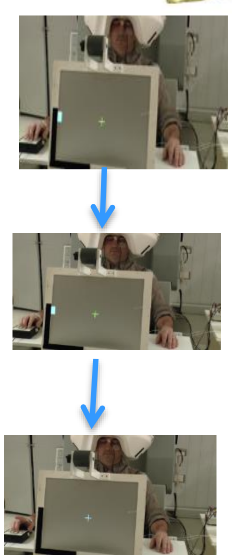
- *Understanding processing in human brain at neuronal & functional levels to create realistic models for each subject*
- *Detect: Pilot-fatigue (simulator to test periodically mental stamina); air-traffic controllers; unmanned vehicles operators; veterans (PTSD, depression, anxiety, memory loss, in/ability to process information, aberrant behavior)*

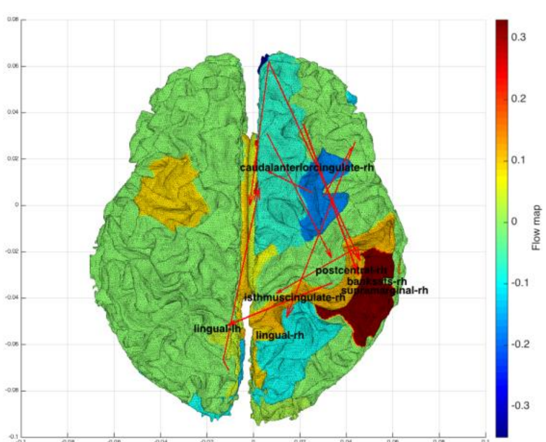
Methods: *Combinatorial optimization methods* to quantify the <u>functional connectivity</u> of human brain in **attention tasks** that demand **action**
Stochastic and Sparse Multivariate Methods for multimodal/scale, heterogeneous&dynamic data analysis and sparse/multimodal data reduction

- ❑ Find activity of sources inside the brain by solving the ill-posed inverse problem
- ❑ Construct a network with capacities being differences in signal strength of sources for every pair of consequent time points
- ❑ Solve maximum flow (MF) problem to find possible paths and directions of signal transfer during tasks
- ❑ Couple the MF activity with movement characteristics from video recordings analysis

Instrumentation (Data)

- *Magnetoencephalography (MEG) – a technique to record noninvasively the electro-magnetic activity in the brain with high temporal resolution (equal to neurons' firing)*
- *MRI – brain anatomy images to create realistic brain models for each subject*





Max Inflow to a region: Red

Max outflow from a region: Blue

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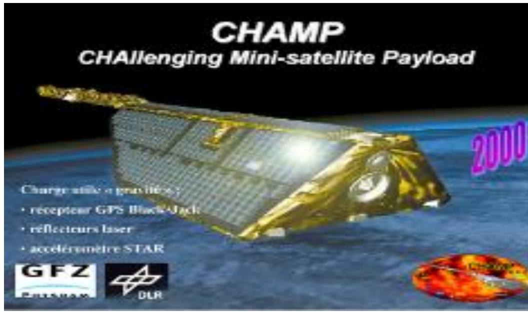
CyberSecurity; Systems Software

Transformative Advances in DDDAS with Application to Space Weather Modeling

Dennis Bernstein (PI), Amy Cohn, James Cutler, Aaron Ridley – U of Michigan



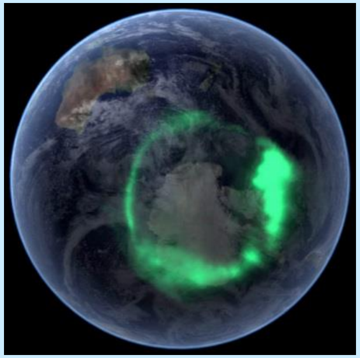
Scientific Motivation

- Unknown changes to the atmospheric density degrade the accuracy of GPS and impede the ability to track space objects

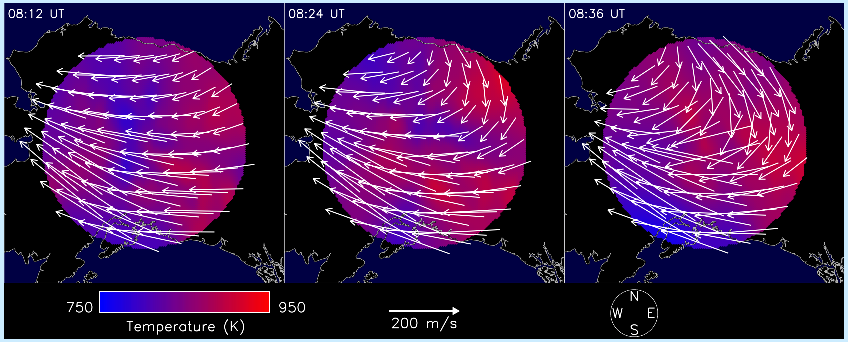
Project Scope and Objectives

- Apply DDDAS concepts and methods to space weather monitoring
- Key goals are input estimation and model refinement to facilitate higher-accuracy data assimilation
- Input reconstruction is used to estimate atmospheric drivers that determine the evolution of the ionosphere-thermosphere
- Model refinement is used to improve the accuracy of atmospheric models
- DDDAS supported by space physics modeling and mission planning and analysis
- DDDAS-based accurate prediction of important quantities: NO, Neutral Density, PhotoElectron Heating, Eddy Diffusion Coefficient Estimate

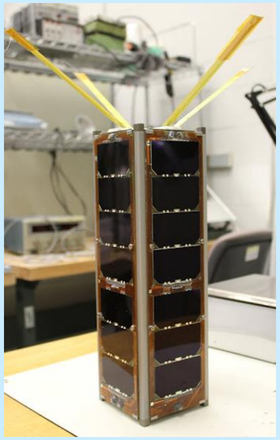
Space Debris



Auroral Heating



Wind Field Estimation



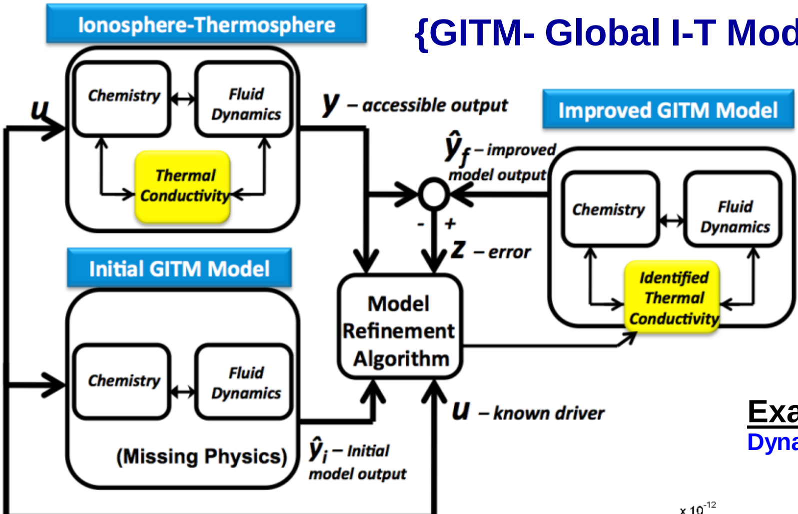
RAX-2 CubeSat

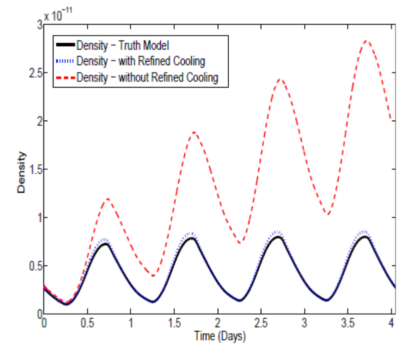
Transformative Advances in DDDAS with Application to Space Weather Modeling

Dennis Bernstein (PI), Amy Cohn, James Cutler, Aaron Ridley – U of Michigan

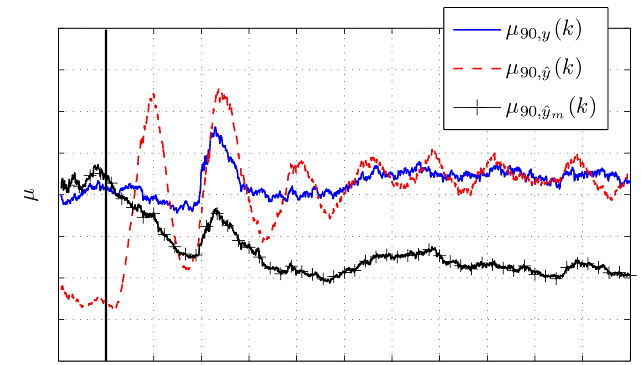
DDDAS Approach: *Model Refinement to Enable Enhanced Data Assimilation*

{GITM- Global I-T Model}

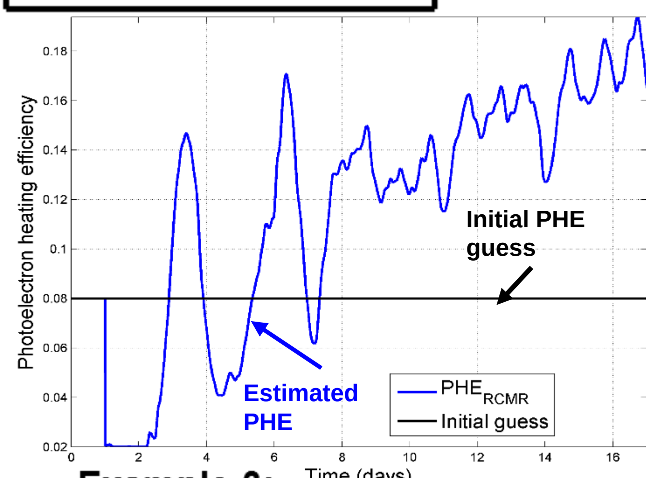




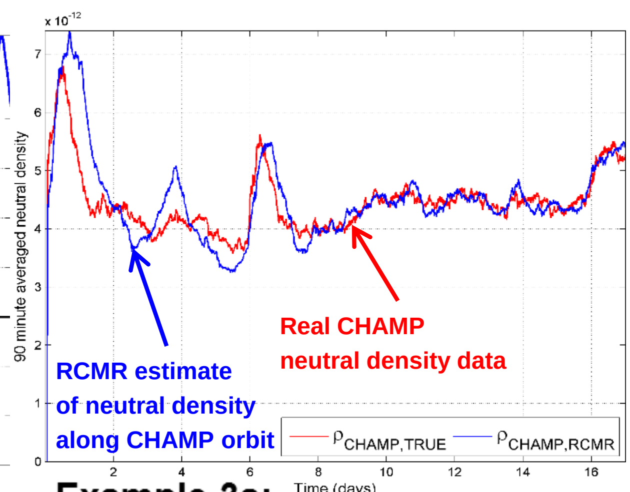
Example 1:
Dynamic estimation of Nitrous-Oxide Density



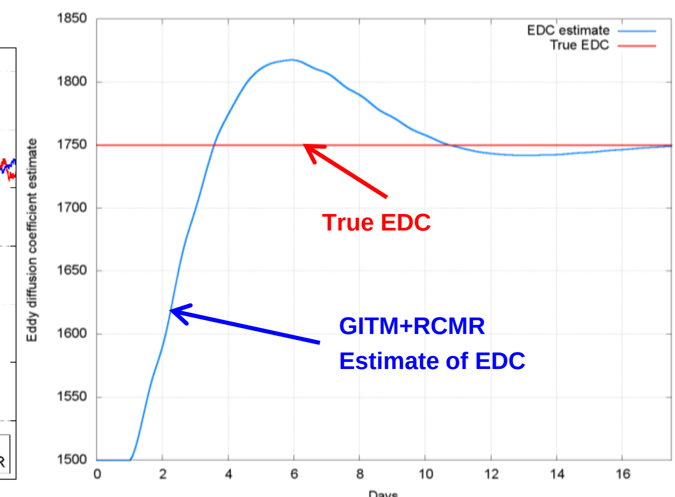
Example 2: Neutral Density



Example 3:
Dynamic estimation of Photoelectron Heating Efficiency using neutral density



Example 3a:
Dynamic estimation of Photoelectron Heating Efficiency using neutral density



Example 4:
Dynamic estimation of Eddy Diffusion Coefficient using total electron content

Areas Covered in Portfolio

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Materials modeling; Structural Health Monitoring – Environment Cognizant - Energy Efficiencies;
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Autonomic Coordination of U(A/G)S Swarms; Cognition
Space Weather and Atmospheric Events – Modeling/Observations;
CyberSecurity; Systems Software

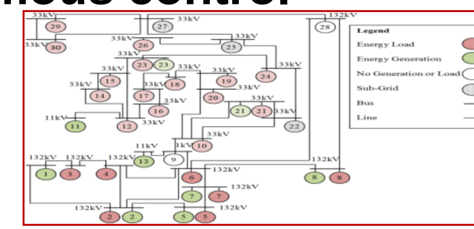
Real-time Assessment and Control of Electric-Microgrids
(YIP – Project)

Nurcin Celik, University of Miami

Motivation: predict/mitigate power outage (case study: effects in an AF Base)

- *How should a real-time diagnosis and forensics analysis be performed automatically?*
- *Did it occur because of an accidental failure or malicious and possibly ongoing attack?*
- *A wide spread disturbance or just a localized outage of a few minutes?*
- *How should the AFB microgrid respond to this abnormality (or catastrophe)?*
- *What actions should be taken to secure the AFB power supply?*

→ **quick responsive and corrective actions via autonomous control**



Approach:

→ *Dynamic Data Driven Adaptive Multi-scale Simulations framework (DDDAMS)*

- *new algorithms and instrumentation methods for RT data acquisition and timely control*

Challenges:

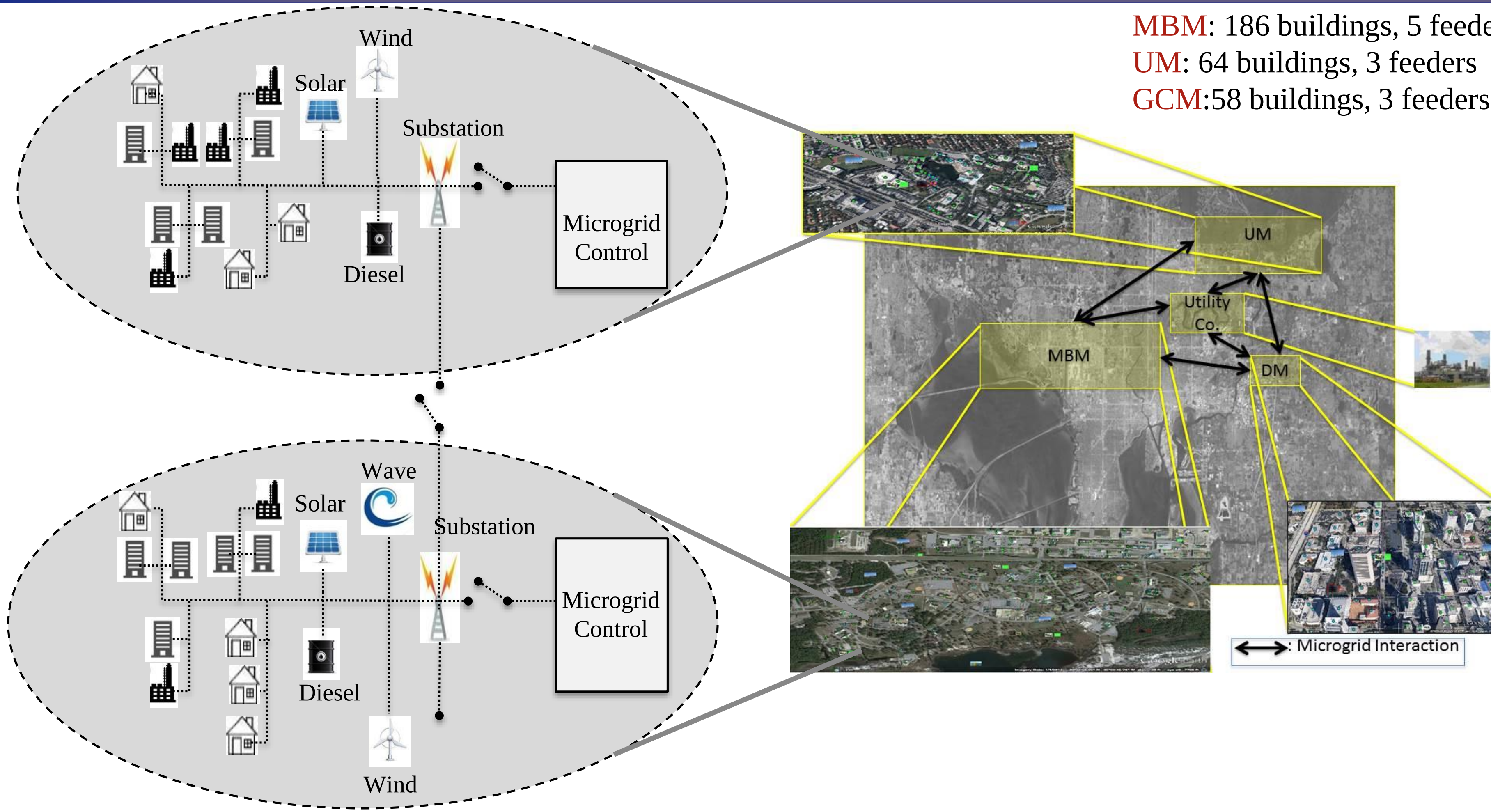
- Large number of variables, nonlinearities and uncertainties
- Intense and time-critical information exchange
- High processing requirements for massive information loads
- Synchronization between the distributed sensor and decision networks

Real-time Assessment and Control of Electric-Microgrids

(YIP – Project)

Nurcin Celik, University of Miami

MBM: 186 buildings, 5 feeders
UM: 64 buildings, 3 feeders
GCM:58 buildings, 3 feeders



- To ensure that primary electrical needs are satisfied while total cost is minimized
- To maintain MGs' stability and security by
  - Meeting requested demands within each individual MG
  - Searching for neighboring MGs for back-up

Experiments on Self-Healing Microgrids

The proposed DDDAMS approach is tested on MGs that do not share energy in the following cases:

- **Scenario A:** A major hurricane completely wipes out power to GCM for 48 hrs
- **Scenario B:** A terrorist attack within the borders of UM forces MBM to isolate from the local utility for 2 hrs until the threat is cleared (damage on UM link will require 6 hrs to repair)

Demand Satisfaction

	Scenario	**MBM Loads**			**UM Loads**			**GCM Loads**		
		Cr	**Pr**	**NCr**	**Cr**	**Pr**	**NCr**	**Cr**	**Pr**	**NCr**
No Sharing	A	100%	100%	100%	100	100%	100%	46%	0%	0%
	B	97.6%	79%	66.4%	45.2%	4%	0%	100%	100%	100%
Sharing	A	100%	100%	95.7%	100%	93.2%	27.9%	100%	0%	0%
	B	98.6%	94%	66.4%	97%	41.1%	6%	99%	52.1%	26%

Cr: Critical Pr: Priority NCr: Non-critical

Areas Covered in Portfolio

"from the nanoscale to the terra- and extra-terra-scale"

Materials modeling; Structural Health Monitoring – Environment Cognizant - Energy Efficiencies;
Co-operative Sensing for Surveillance - Situational Awareness;
Autonomic Coordination of U(A/G)S Swarms; Cognition
Space Weather and Adverse Atmospheric Events;
CyberSecurity; Systems Software

DDDAS-based Resilient Cyberspace

PIs: Salim Hariri, Youssif Al-Nashif, Ricardo Valerdi – UofAZ;
Stacy Prowell – ONRL; ***Collaborator: Erik Blasch - AFRL***

- **Motivation- Resilience**
  - **Human endpoint devices are the most vulnerable - easy to penetrate and exploit.**
  - **Software, hardware, websites, cloud services all will have errors, vulnerabilities that can be exploited.**
    - **DDDAS paradigm provides the ability for resilient cyberspace operations by continuous monitoring, analysis, diagnosis and response in a timely manner**

Moving Target Defense Strategies

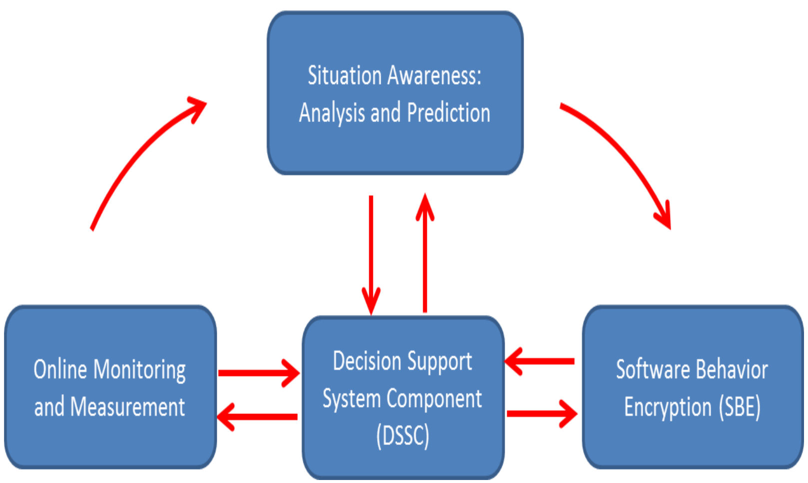
Traditional/Static utilize:

- **Space Randomization**
- **Instruction Set Randomization**
- **Data Randomization**

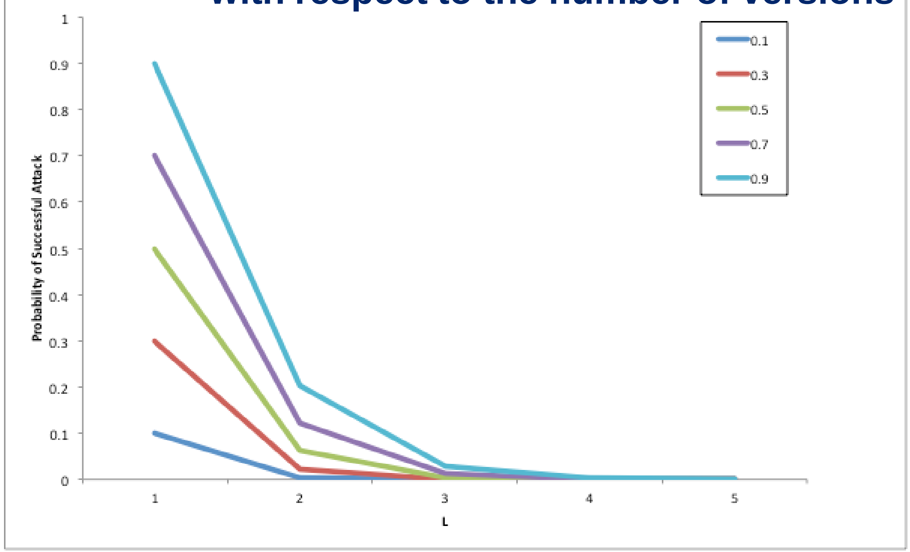
DDDAS-based

- **Execution Environment Randomization**
  - **Change Programming Language**
  - **Change OS and Middleware**
  - **Change Resources**

rDDDAS: DDDAS-based Resilient Cyberspace



Probability of Successful Attack with respect to the number of versions



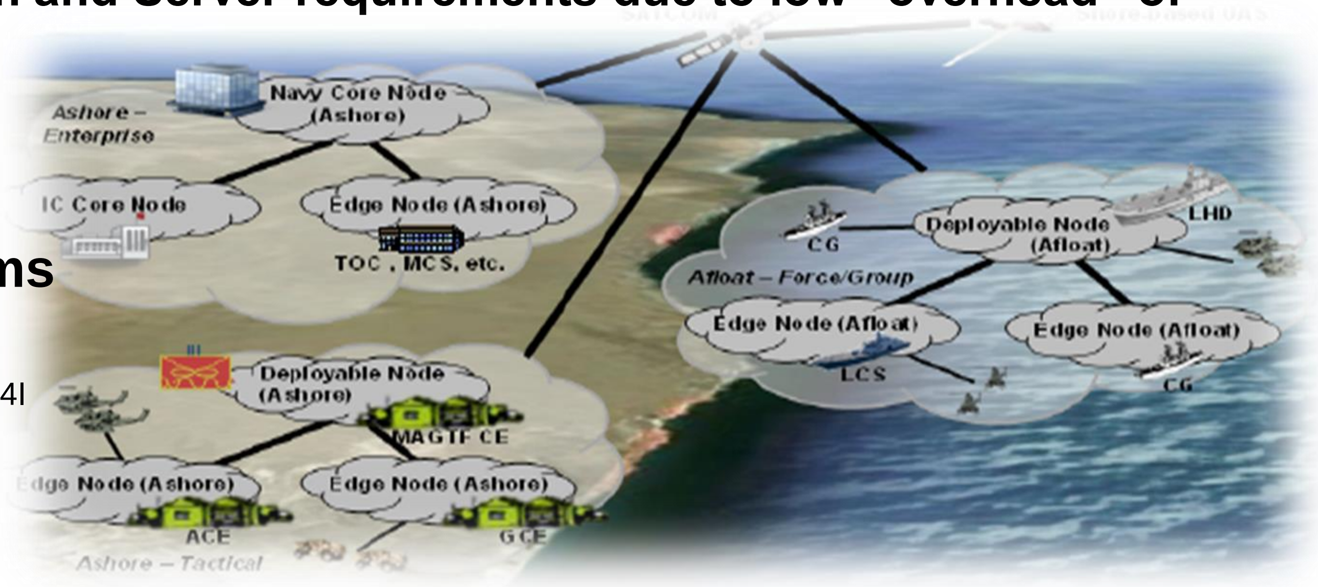
DCRA chosen for the Navy Tactical Cloud also transition to Raytheon

DCRA--- Secure, Agile, Scalable, and Available

❖ **Navy Tactical Cloud Prototype**

- Simplifies content distribution management of different levels of access among pre-established groups
- Protects data at rest, even when devices / networks don't have SRK devices
- Reduces bandwidth and Server requirements due to low "overhead" of SRK process

- Ashore
- Afloat
- Sensors&Platforms



Graphic Source
Charlie Suggs, PEO C4I

❖ **Raytheon/Energies and AVIRTEK collaborative effort and transition**

Examples of Sci&Tech Highlights of Outcomes/Results/Achievements through DDDAS

Materials modeling - Structural Health Monitoring

- Demonstrated that DDDAS-based materials modeling can model regions of instabilities leading to exploitation of new properties in materials
- Have demonstrated that DDDAS models can predict the onset of damage prior to being detected experimentally

Self -Cognizant and Environment -Cognizant UAS Mission Planning

- Demonstrated that DDDAS methods allow decision support in real-time with accuracy of large scale simulation – e.g.: DDDAS method yields a speed up of a factor of ~50,000-100,000 - online classification using the damage library takes ~100-300 microseconds.

Algorithmic Advances in UQ

- Demonstrated effectiveness of PCQ in a broader class of systems than gPC; developing further improved UQ methods based on the DDDAS paradigm

Improved sensing approaches

- Demonstrated that intelligent deployment of mobile sensors provides improved efficiencies – e.g. one mobile sensor (DDDAS model driven) vs 7 stationary sensors

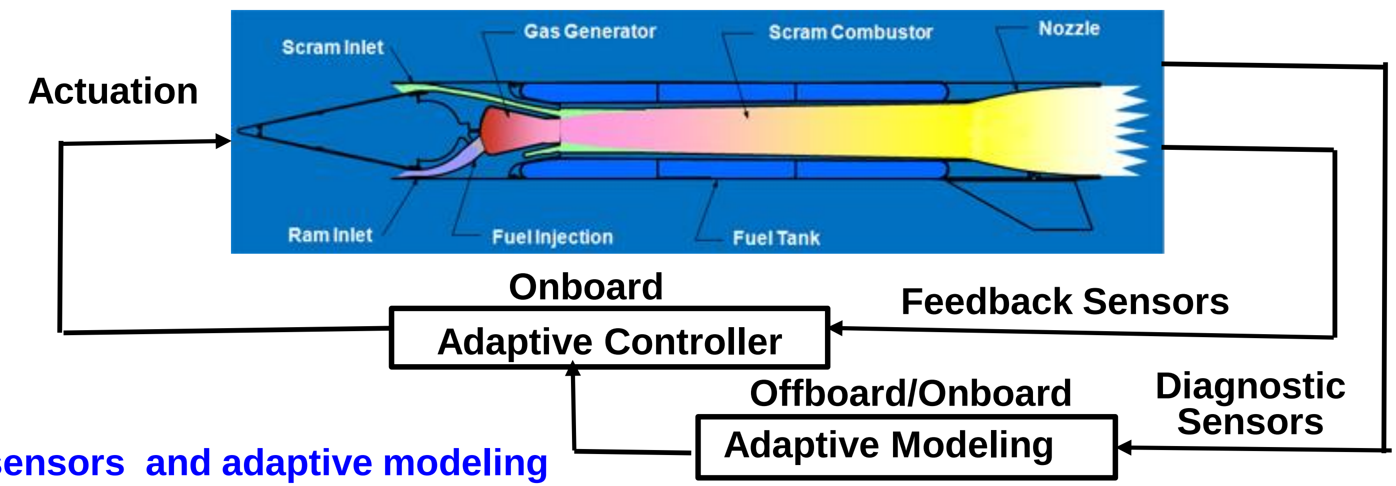
Cybersecurity

- Demonstrated theoretical basis for resilient software security.

An example of other possible future scope of work
Estimation and Control of Highly Inaccessible Dynamics in Complex Systems

- **Major challenges for understanding, characterization, performance optimization, adaptive control in real-world natural&engineered systems and their applications are due to a combination of:**
  - **high degree of non-linearity; very high dimensionality of the parameter space;**
  - **epistemic and aleatoric uncertainty; and hard constraints on states and control inputs**
- **Examples include: turbulent flows for complex and adaptive aircraft configurations; combustion in jet engines and scramjets; instabilities in structures; and programmable metamaterials (e.g. solitons/breathers; quantum information devices)**
- **Measurements are difficult to attain, and models alone do not afford the fidelity needed, in highly unstable (&inaccessible) regions**
- **Dynamic Data-Driven Application Systems (DDDAS) based methods**
  - **combine estimation and control techniques with real-time computation and data**
  - **dynamically couple an executing model with the instrumentation, allow targeted collection of data and compensate for data sparsity in the measurement or the solution phase space**

Highly Complex System (Scramjet)



DDDAS uses diagnostic sensors and adaptive modeling to provide crucial information for controller adaptation

Interactions & Outreach

- **Publications by DDDAS PIs: over 250 (Journals, Conferences, Books)**
- **Presentations by PIs: over 200 talks (Conferences, Academe/Industry/Gov't Agencies&Labs)**
- **PIs Recognized: Over 36 awards (in 2015); e.g.:**
  - **Bazilevs: (2015) Elected Fellow of USACM**
    2015 (&2014) Thomson Reuters Highly Cited Researcher (Computer Science)
    2015 Thomson Reuters Highly Cited Researcher (Engineering)
    2015 (&2014) ScienceWatch list of The World's Most Influential Scientific Minds
  - **Blasch: AFRL Research Award**
  - **Willcox: Distinguished Alumni Award – UofAuklandNZ (was selected NASA Astronaut Training)**
  - **…**

- **Interactions with AFRL Technical Directorates and MAJCOMs**
  - **The Program has started engaging AFRL researchers – launched 3 new Lab Tasks**
  - **Several PIs have connected with AFRL, ONR, ARL/ARO; e.g.:**
    - **Varela (RPI); Phoha (Upenn); Hariri (UAZ); Gokhale (Vanderbilt) -- Erik Blasch (RI)**
    - **Karaman (MIT) -- David Casbeer (RY); Fox (Uof Indiana) -- Alex Aved (RI)**
    - **Bernstein (UMich) -- AFRL/Kirtland; Madey (NotreDame) - AFRL/RB and AFIT**
    - **Celik (Umiami) – TyndallAFB; Balachandran – ONR; Bhattacharrya – ARL/ARO**
    - **… (& NSF, NASA, DOE, …)**

- **Additional Transition Activities**
  - **AirVehicle Health Aware Mission Planning (PI: Willcox) –> Aurora Flight Sciences**
  - **rDDDAS-Resilient Cyberspace (PI: Hariri) –> Raytheon, US Navy**
  - **Adaptive Stream Mining Systems (PI: Bhattacharya) –> Cisco Systems Inc**
  - **…**

Additional Interactions & Outreach

Community Websites: www.1dddas.org; dddas wiki page

Other Forums (involving/organized by DDDAS Pis; presentation slides, papers, etc, in websites above)

- **ICCS/DDDAS Yearly Workshop – Reykjavic/Iceland June 2015; organized by Blasch(AFRL)&Tian(GMU**
- **Bernstein: DDDAS Panel / Workshop at the 2015 American Controls Conference; also June 2016**
- **Blasch: FUSION Conference; July 2015**
- **Henderson: IEEE Multisensor Fusion and Integration (MFI) Conference Conference; September 2015**
- **Zhou: INFORMS Conference; November 2015**
- **Gokhale/Hariri/Sandu/Sunderam: HiPC (High Performance Computing) Conference; December 2015**
- **Ravela: DyDESS (DDDAS for Environmental Systems) Nov 2014; DDDAS Conference August 2016**
- **Fujimoto: Research Challenges in M&S; January 2016 (AFOSR/NSF cosponsored)**
- **Jin&Fujimoto: DDDAS Workshops at ACM-SIGSIM PADS Conference; May 2016**
- **Willcox: DDDAS Special Session at Multidiscipl Anal&Optim, 2016 AIAA Aviation Meeting; June2016**
- **Mohseni: DDDAS Mini-Symposium at SIAM Annual Meeting; July 2016**
- **Fujimoto: Winter Simulation Conference; December 2016**

Journals

Special Issue on DDDAS in the Journal of Signal Processing Systems; organizers Blasch, Son, Phoha

Darema Invited Presentations/Forums (keynotes, speaker, panels) to disseminate Program Activities

- **Next Generation Modeling&Simulation Perspectives: Dynamic Data Driven Applications Systems (DDDAS)", National Modeling and Simulation Coalition (NMSC), Feb 2015**
- **DDDAS and Large-Scale-Big-Data and Large-Scale-Big-Computing" at *CCDA, May2015;* SIMUTools, Sept2015; and MFI, Sept2015**
- ***"Smart Transportation – Emergency Response", DHS, June2015***
- **Panel Organizer: (&Chair) InfoSymbioticSystems/DDDAS, SC2014; Co-Chair/organizer - panel multiagency programs at SC15. Panelist: Big Data: Challenges, Practices and Technologies" at the IEEE Big Data Conf. Oct2014, Washington, DC**
- **Member of the cross-Agencies HECWG (High-End Computing) of the NITRD**

DDDAS Program Reviews
Cross-Agencies Program Solicitations

- **Joint AFOSR and NSF Initiative on Dynamic Data Systems (DDS)**
  - **DDDAS-based, and Large-Scale-Big-Data and Large-Scale-Big-Computing**
  - **DDS MOU**
  - **112 Letters of Intent (Sept 2014)**
  - **86 Proposals (Sept 2014) – Reviewed in Dec 2014**
  - **18 Awards - Recommendations/Notifications Summer 2015**

  AFOSR & NSF planning for follow-up solicitation which will include additional organizations from NSF and DOD, as well as other Agencies (NOAA, NIH, NASA, ...)

- **Yearly PI meeting, January 2016** **(presentations slides posted in 1dddas.org)**
  - **Meeting brings the quorum of all PIs; update on advances of the funded projects; *vertical and horizontal* leverage across projects; coordination for end-to-end capabilities**
  - **This year**
    - **the meeting brought together the AFOSR supported PIs and the PIs supported by the joint AFOSR/NSF solicitation of 2014**
  - **Last year**
    - **the meeting was invited/hosted by IBM at the T. J. Watson Research Center (following Darema presentation of DDDAS Program at IBM Res in June 2014)**
    - **Opportunity to interact with IBM Management and Researchers**
    - **IBM interested to select DDDAS Projects/PI to collaborate**

Summary and QUO Vadimous

Key strategies and directions in the AFOSR DDDAS Program

- Transformational Research - Dynamic Data-Driven methods for Adaptive, Agile, Autonomic systems; end-to-end capabilities
- Responsive to AF needs, Transformational Impact to the AF and other sectors
- Impact to civilian sector applications

Expansion Opportunities

- Expanding interactions with AFRL, ONR/NRL, ARO/ARL
- Expanding collaborations and leverage other Agencies' efforts
- Expanding international collaborations
- Expanding/leveraging industry partnerships

BACK-UP Slides

AFOSR DDDAS and NSF/AFOSR DDS Program Review
Agenda for January 27-29, 2016 PI Meeting
DAY – 1: January 27, 2016 --Morning

7:30-8:00am – Registration/Badge pick-up
8:00am-8:30am –Introduction -- Frederica Darema and Chengshan Xiao
8:30am-10:00am Air Vehicle Structural Health Monitoring – Environment Cognizant
Advanced Simulation, Optimization, and Health Monitoring of Large Scale Structural Systems
PI: Yuri Bazilevs (UCSD)
Dynamic Data-Driven Methods for Self-Aware Aerospace Vehicles
PI: Karen Willcox (MIT)
Progressive Fault Identification and Prognosis in Aircraft Structure Based on Dynamic Data Driven Adaptive Sensing and Simulation
PI: Shiyu Zhou (U. Wisconsin)
10:00am-10:15am –Break
10:15am -11:15am
Robust Data-Driven Aero-elastic Flight Envelope Tailoring
***PI: Balachandran (*University of Maryland)**
Dynamic Data-driven Prediction, Measurement Adaptation, and Active Control of Combustion Instabilities in Aircraft Gas Turbine Engines
PI: Asok Ray (PennState)
11:15am -12:15noon
An Integrated approach to the Space Situational Awareness Problem
PI: Suman Chakravorty (TAMU)
Cloud Computing Based Robust Space Situational Awareness
PI: Raktim Bhattacharya (TexasA&M)
12:15-1:00pm –Lunch (Lunch Boxes pick-up)

AFOSR DDDAS and NSF/AFOSR DDS Program Review
Agenda for January 27-29, 2016 PI Meeting
DAY – 1: January 27, 2016 --Afternoon

1:00pm-3:15pm *Spatial Situational Awareness (UAV Swarms + Ground Systems Coordination)*

Dynamic Data-Driven Motion Planning and Control for Pervasive Situational Awareness Application Systems

PI: Sertac Karaman (MIT)

EAGER- Adaptive Ensemble-Based Uncertainty Prediction for Satellite Collision Avoidance

PI: Adam Ridley (University of Michigan Ann Arbor)

EAGER- Management of Dynamic Big Sensory Data

***PI:* Zhipeng Cai (Georgia State University)**

EAGER- Subspace Learning From Binary Sensing

PI:* Yuejie *Chi (Ohio State University)

Dynamic Data Driven Adaptation via Embedded Software Agents for Border Control Scenario

PI: Shashi Phoha (Penn State)

Multiscale Analysis of Multimodal Imagery for Cooperative Sensing

PIs: Erik Blasch (and Guna Seetharaman) (RI Directorate, AFRL)

3:15pm -3:30pm --Break

3:30pm -5:15pm *(UAV Swarms + Ground Systems Coordination)*

Energy-Aware Time Change Detection using Synthetic Aperture Radar on High-Performance Heterogeneous Architectures: A DDDAS Approach

PI: Sanjay Ranka (UofFlorida)

An adaptive distributed approach to DDDAS for surveillance missions with UAV swarms

PI: Rajiv Gupta (U of NotreDame)

Cloud-Based Perception and Control of Sensor Nets and Robot Swarms

PI: Geoffrey Fox (U of Indiana, Bloomington)

EAGER- Generative Statistical Modeling for Dynamic and Distributed Data

***PI:* Jia Li (Pennsylvania State Univ)**

***EAGER- Real-time Discovery and Timely Event Detection from Dynamic and Multi-Modal Data Streams**

***PI: Mihaela vander*Schaar,(UCLA)**

5:15pm - 6:00pm – Discussion of all projects discussed in Day 1

AFOSR DDDAS and NSF/AFOSR DDS Program Review
Agenda for January 27-29, 2016 PI Meeting
DAY – 2: January 28, 2016 - Morning

7:30am-10:00am

Dynamic Data Driven Information Fusion For Situational Awareness

PI: Biao Chen (Syracuse University)

Collaborative Image Processing in Vehicle Ensembles via Probabilistic Graphical Models and a Self-optimizing Support System

PI: Jose Martinez (Cornell U.)

Dynamic Modality Switching Aided Object Tracking using an Adaptive Sensor

PI: Matthew Hoffman (RIT)

Software for Data Streaming Analytics and its Application to Safer Flight Systems

PI: Carlos Varela (RPI)

DDDAMS-based Urban Surveillance and Crowd Control via Aerostats & UAVs and UGVs

PI: Young-Jun Son (University of Arizona)

10:00am-10:15am –Break

10:15pm -12:15pm 10:15pm -2:00pm Energy Efficiencies

(YIP) DDDAMS-based Real-time Assessment and Control of Electric-Microgrids

PI: Nurcin Celik (University of Miami)

EAGER- A Scalable Framework for Data-Driven real-Time Event Detection in Power Systems

PI: Dominguez-Garcia (UIUC)

EAGER- A Hierarchical Approach to Dynamic Big Data Analysis in Power Infrastructure Security

PI: Mohsenian-Rad (UCRiverside)

EAGER- Data-Driven Operation and Maintenance of Wind Energy Systems under Uncertainty

PI: Perez (Texas State University - San Marcos)

EAGER- Machine Intelligence for Dynamic Data-Driven Morphing of Nodal Demand in Smart Energy Systems

PI: Lefteri Tsoukalas (Purdue U.)

EAGER- Power Aware Data Driven Distributed Simulation on Micro-Cluster Platforms

***PI: Richard* Fujimoto (GeorgiaTech)**

EAGER- Collaborative Research: Dynamically Data-driven Morphing of Reduced Order Models and the Prediction of Transients

PI: Themis Sapsis (Massachusetts Institute of Technology)

12:15-1:00pm –Lunch (Lunch Boxes pick-up)

AFOSR DDDAS and NSF/AFOSR DDS Program Review
Agenda for January 27-29, 2016 PI Meeting
DAY – 2: January 28, 2016 --Afternoon

1:00pm -3:15pm *Space Weather and Atmospheric Events – Modeling/Observations*

Fluid SLAM and the Robotic Reconstruction of Localized Atmospheric Phenomena

PI: Sai Ravela (MIT)

Retrospective Cost Model Refinement and State Estimation for Space Weather Modeling and Prediction

PI: Dennis Bernstein (UMich)

Dynamic Data-Driven UAV Network for Plume Characterization

***PI: Kamran* Mohseni (U. of Florida)**

EAGER - Dynamic Data-Driven Random Sampling and Consensus for Large-Scale Learning Algorithms

PI: Georgios Giannakis (University of Minnesota)

EAGER- Novel Approaches for Optimization, Control, and Learning in Distributed Multi-Agent Networks

PI: Wotao Yin (UCLA)

EAGER- A New Scalable Paradigm for Optimal resource Allocation in Dynamic Data Systems via Multi-Scale and Multi-Fidelity Simulation and Optimization

PI: Jie Xu (George Mason U.)

3:15pm -3:30pm --Break

3:30pm -4:30pm *Sensing&Tracking*

Optimized Routing of Intelligent, Mobile Sensors for Dynamic, Data-Driven Sampling

***PI: Derek* Paley (UMD)**

A Distributed Dynamic Data Driven Applications System (DDDAS) for Multi-Threat Tracking

PI: Ioannis Schizas (UTArlington)

4:30pm-5:00pm Materials modeling

Dynamic, Data-Driven Modeling of Nanoparticle Self Assembly Processes

PI: Yu Ding (TAMU)

****EAGER- Transforming Wildfire Detection and Growth Forecasting with Smart Sensing***

PI: Janice Coen (NCAR)

5:00- 6:00pm – Discussion of all projects discussed in Day 2

AFOSR DDDAS and NSF/AFOSR DDS Program Review
Agenda for January 27-29, 2016 PI Meeting
DAY – 3: January 29, 2016 - Morning

8:00am-10:00am Cognitive and Networked Systems

Dynamic Integration of Motion and Neural Data to Capture Human Behavior

PI: Dimitri Metaxas (Rutgers U)

Stateless Networking: Principles, Architectures, and Codes

PI: Gregory Wornell (MIT)

Statistical Models and Graphs

PI: Pablo Parrilo (MIT)

Universal Laws and Architectures

PI: John *Doyle (CalTech)*

10:00am-10:15am –Break

10:15am-12:15pm Distributed Systems

Using Trajectory Sensor Data Stream Cleaning to Ensure the Survivability of Mobile Wireless Sensor Networks in Cyberspace

PI: Niki Pissinou (Florida International University)

Adaptive Stream Mining: A Novel Dynamic Computing Paradigm for Knowledge Extraction

PI: Shuvra Bhattacharyya (U. Of Maryland)

Data-Adaptable Modeling and Optimization for Runtime Adaptable Systems

PI: Roman Lysecky (UAZ)

Cloud support for Surveillance

PI: Alex Aved (AFRL/RI)

12:15noon-1pm – Lunch – (Lunch Boxes) - Discussion of all projects discussed in Morning of Day 3

AFOSR DDDAS and NSF/AFOSR DDS Program Review
Agenda for January 27-29, 2016 PI Meeting
DAY – 3: January 29, 2016 --Afternoon

1:00pm-2:00pm *Systems Software CyberSecurity*

Data-Driven and Real-Time Verification for Industrial Control System Security

***PI:* Kevin Jin (Illinois Institute of Technology)**

DDDAS-based Resilient Cyberspace (DRCS)

PI: Salim Hariri (University of Arizona. Tucson)

2:00pm-3:00pm *Systems Software*

Performance Analysis and Diagnosis of Cloud-based DDDAS Applications

PI: Mohammad Khan (Uconn)

(YIP) From Sensor Data to High-value Information: ultra-low-energy platforms for deriving inferences from complex embedded signals

PI: Naveen Verma (Princeton U.)

3:00pm-3:15pm–Break

3:15am-4:45pm – *Systems Software (cont'd)*

Amorphous Polyhedral Model for Stochastic Control of Autonomous UAVs

***PI: Sanjay* Rajopadhye (Colorado State)**

Architecture and Programming Models for High Performance Interactive Computation

***PI: XiaoMing Li* (U of Delaware)**

Hybrid Systems Modeling and Middleware-enabled DDDAS for Next-generation US Air Force Systems

PI: Aniruddha Gokhale (Vanderbilt U.)

4:45pm-6:00pm Discussion of all projects – Collaborations, Directions in the Program

6:00pm Meeting Concludes