The Power of:

Dynamic Data Driven Applications Systems (DDDAS)

...a Transformative Paradigm for advanced applications/simulations and measurements methodologies

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ICCSE2011-DDDAS

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Component of a set of Transformation Inducing Directions

• Multidisciplinary Research
  Expanding Fundamental Research Opportunities

  Unification Paradigms - Multidisciplinary Thematic Areas
  ➢ InfoSymbiotic Systems
    The Power of DDDAS – Dynamic Data Driven Applications Systems
  ➢ Multicore-based Systems
    Unification of HEC w RT Data Acquisition & Control Systems
  ➢ Systems Engineering
    Engineering Systems of Information (design-operation-maintenance-evolution)
    ➢ Understanding the Brain and the Mind
      From Cellular Networks to Human Networks
  ➢ Network Systems Science (Network Science)
    Discover Foundational/Universal Principles across Networks

• The Aug2010 InfoSymbiotics/DDDAS Workshop
  -- multi-agency, jointly sponsored AFOSR-NSF,
  co-chaired by Profs: Craig Douglas, U-Wyo and Abani Patra, SUNY-Buffalo
  ➢ Report
  ➢ Possible Follow-up activities
Dynamic Data Driven Applications Systems (DDDAS)

DDDAS / InfoSymbiotics is the unifying paradigm

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

Software Architecture Frameworks
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 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

Interaction Level II: Tools and People Driving Observing Systems – Dynamic Adaptation

NWS National Static Observations & Grids

Mesoscale Weather

Experimental Dynamic Observations

Local Observations

“Sensor Networks & Computer Networks”

Slide courtesy Droegemeier
Why A Service-Oriented Architecture?

- Flexible and malleable
- Platform independence (emphasis on protocols, not platforms)
- Loose integration via modularity
- Evolvable and re-usable (e.g. Java)
- Interoperable by use of standards

LEAD Service-Oriented Architecture

Crosscutting Services
- MyLEAD
  - Authorization
  - Authentication
  - Monitoring
  - Notification

Resource Access Services
- Grid FTP
- Scheduler
- OPenDAP
- GRAM
- SSH
- LDM

Distributed Resources
- Computation

Portlets
- Visualization
- Workflow
- Education
- Browse
- Control
- Ontology
- Query
- Monitor
- Control

Client Interface

Configuration and Execution Services
- Application Resource Broker (Scheduler)
- Host Environment
- Execution Description
- Application Host
- Application Description
- GIPIR
- Geo-Reference GUI
- WRF, ADaM, IDV, ADAS

Configuration and Configuration Services
- Workflow Engine/Factories
- Workflow Monitor
- VO Catalog
- THREDDS
- Decoder/Resolver Service
- Transcoder Service/ESML

Data Services
- Stream Service
- Query Service
- Ontology Service
- Control Service
- Catalog Services
- Catalog Services
- RLS
- OGSA-DAI

Desktop Applications
- IDV
- WRF Configuration GUI

Slide courtesy Droegemeier
In 2000 NSF Workshop:
Examples of Applications benefiting from the new paradigm

- **Engineering (Design and Control)**
  - aircraft design, oil exploration*(*)
  - semiconductor mfg, structural eng
  - computing systems hardware and software design and runtime
    (performance engineering and runtime compiler systems)

- **Crisis Management and Environmental Systems**
  - transportation systems (planning, accident response)
  - weather, hurricanes/tornadoes, floods, fire propagation

- **Medical**
  - Imaging, customized surgery, radiation treatment, etc
  - BioMechanics /BioEngineering

- **Manufacturing/Business/Finance**
  - Supply Chain (Production Planning and Control)
  - Financial Trading (Stock Mkt, Portfolio Analysis)

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*(*) Darema 1980 (Gedenken Laboratory) & Darema 1987, 1990

“DDDAS has the potential to revolutionize science, engineering, & management 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) AF Chief Scientist (DDDAS Workshop, Aug 2010)
DDDAS: Beyond Grid Computing

“Extended Grid” – “SuperGRID”:
the Application Platform is
the unified computational & measurement system

Applications

- Instruments
- Sensors
- Controllers

- Archival/Stored Data

- Computational Platforms

Measurement Grids
Computational Grids

SuperGrids:
Dynamically Coupled Networks of Data and Computations
Fundamental Science & Technology Challenges in Enabling DDDAS

• Application modeling to support dynamic data inputs
  - interfacing applications with measurement systems
  - dynamically select appropriate application components
    • multi-modal, multi-scale – dynamically invoke multiple scales/modalities
  - switching to different algorithms/components depending on streamed data
    dynamic hierarchical decomposition (compt'n-sensor) and partitioning

• Algorithms
  - tolerant to perturbations of dynamic input data
  - handling data uncertainties, uncertainty propagation, quantification

• Measurements
  - Multiple modalities, space/time distributed, data management

• Systems supporting such dynamic environments
  - dynamic execution support on heterogeneous environments
    • Need new fundamental compiler advances (runtime-compiler)
  - extended Spectrum of platforms: Grids of Sensor Networks and Computational platforms
  - architect and manage heterogeneous/distributed sensor networks
  - GRID Computing, and Beyond (SuperGrids)!!! – DDDAS environments are the most important manifestation of Grids/SuperGrids!
Examples of Areas of DDDAS Impact

- 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, terrorist attacks
- Critical Infrastructure systems
  - Electric power systems, water supply systems, vehicles (air, ground, underwater, space), condition monitoring, prevention, mitigation
- Homeland Security, Communications, Manufacturing
  - Terrorist attacks, emergency response
- Dynamic Adaptive Systems-Software
  - Robust and Dependable Large-Scale systems
  - Large-Scale Computational Environments

List of Projects/Papers/Workshops in [www.cise.nsf.gov/dddas](http://www.cise.nsf.gov/dddas), [www.dddas.org](http://www.dddas.org)

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- ICCS/DDDAS Workshop Series yearly 2003 – todate
- other workshops – community organized
- August 30&31, 2010 Joint AFOSR-NSF Workshop (multiple agencies participation)
- [www.dddas.org](http://www.dddas.org) (maintained by Prof. Craig Douglas)
(1998 - precursor Next Generation Software Program)
SystemsSoftware - Runtime Compiler - Dynamic Composition - Performance Engineering

(2000 -Through NGS/ITR Program)
Pingali, Adaptive Software for Field-Driven Simulations

(2001 - Through ITR Program)
Biegler - Real-Time Optimization for Data Assimilation and Control of Large-Scale Dynamic Simulations
Car - Novel Scalable Simulation Techniques for Chemistry, Materials Science and Biology
Knight - Data Driven design Optimization in Engineering Using Concurrent Integrated Experiment and Simulation
Landsale - The Low Frequency Array (LOFAR) - A Digital Radio Telescope
McCanlind - An Ensemble Approach for Data Assimilation in the Earth Sciences
Patrikalakis - Poseidon - Rapid Real-Time Interdisciplinary Ocean Forecasting:
Adaptive Sampling and Adapting Modeling in a Distributed Environment
Pierrehumbert - Flexible Environments for Grand-Challenge Climate Simulation
Wheeler - Data Intense Challenge: The Instrumented Oil Field of the Future

(2002 -Through ITR Program)
Carmichael - Development of a general Computational Framework for the Optimal Integration of Atmospheric Chemical Transport Models and Measurements Using Adjoint
Douglas-Ewing-Johnson - Predictive Contaminant Tracking Using Dynamic Data Driven Application Simulation (DDDAS) Techniques
Eugene - A Framework for Environment-Aware Massively Distributed Computing
Farhat - A Data Driven Environment for Multi-physics Applications
Guibas - Representations and Algorithms for Deformable Objects
Karniadakis - Generalized Polynomial Chaos: Parallel Algorithms for Modeling and Propagating Uncertainty in Physical and Biological Systems
Oden - Computational Infrastructure for Reliable Computer Simulations
Trafalis - A Real Time Mining of Integrated Weather Data

(2003 - Through ITR Program)
Boden - Asynchronous Execution for Scalable Simulation in Cell Physiology
Chaturvedi - Synthetic Environment for Continuous Experimental (Crisis Management Applications)
Draegemeier-Johnson - Linked Environments for Atmospheric Discovery (LEAD)
Kumar - Data Mining and Exploration Middleware for Grid and Distributed Computing
Machinju - A Framework for Discovery, Exploration and Analysis of Evolutionary Data (DEAS)
Mandel - DDDAS: Data Dynamic Simulation for Disaster Management (Fire Propagation)
Metaxas - Stochastic Multi-queue Tracking of Objects with Many Degrees of Freedom
Soma - Building Structural Integrity
(Sensors Program: Saltzer - Hourglass: An Infrastructure for Sensor Networks)

(2004 -Through ITR Program)
Brogan - Simulation Transformation for Dynamic, Data-Driven Application Systems (DDDAS)
Buldridge - A Novel Grid Architecture Integrating Real-Time Data and Intervention During Image Guided Therapy
Floyd's-In Silva De Novo Protein Design - A Dynamically Data Driven, (DDDAS), Computational and Experimental Framework
Grimshaw - Dependable Grids
Laudige - Computational simulation, modeling, and visualization for understanding unsteady bioflows
Metaxas - DDDAS - Advances in recognition and interpretation of human motion: An Integrated Approach to ASL Recognition
Wheeler - Data Driven Simulation of the Subsurface: Optimization and Uncertainty Estimation

(2005 DDDAS Multi-Agency Program - NSF/NIH/NOAA/AFOSR)
Ghattas - MIIPS: A Real-Time Measurement-Inversion-Prediction-Steering Framework for Hazardous Events
Howe - Coordinated Control of Multiple Mobile Observing Platforms for Weather Forecast Improvement
Bernstein - Targeted Data Assimilation for Disturbance-Driven Systems: Space weather Forecasting
McLaughlin - Data Assimilation by Field Alignment
Leisegang - Planet-in-a-Bottle: A Numerical Fluid-Laboratory
Oden - Multi-scale Data-Driven POD-Based Prediction of the Ocean
Urra - Dynamic Data Driven Integrated Simulation and Stochastic Optimization for Wildland Fire Containment
Allen - DynaCode: A General DDDAS Framework with Coast and Environment Modeling Applications
Douglas - Adaptive Data-Driven Sensor Configuration, Modeling, and Deployment for Oil, Chemical, and Biological Contamination near Coastal Facilities
Clark - Dynamic Sensor Networks - Enabling the Measurement, Modeling, and Prediction of Biophysical Change in a Landscape
Sobohaj - A Generic Multi-scale Modeling Framework for Reactive Observing Systems
Williams - Real-Time Astronomy with a Rapid-Response Telescope Grid
Gilbert - Optimizing Signal and Image Processing in a Dynamic, Data-Driven Application System
Liang - SEP: Integrating Multipath Measurements with Site Specific RF Propagation Simulations
Chen - SEP: Optimal interlaced distributed control and distributed measurement with networked mobile actuators and sensors
Oden - Dynamic Data-Driven System for Laser Treatment of Cancer
Roberts - Development of a closed-loop identification machine for biowires (CLIMB) and its application to nuclearide metabolism
Patterson - Dynamic Data-Driven Brain-Machine Interfaces
McClellan - Auto-Steered Information-Decision Processes for Electric System Asset Management
Downer - Autonomic Interconnected Systems: The National Energy Infrastructure
Sauer - Data-Driven Power System Operations
Ball - Dynamic Real-Time Order Promising and Fulfillment for Global Make-To-Order Supply Chains
Thiele - Robustness and Performance in Data-Driven Revenue Management
San - Dynamically-Integrated Production Planning and Operational Control for the Distributed Enterprise

* projects, funded through other sources and "retargeted by the researchers to incorporate DDDAS"
* ICBS/DDDAS Workshop Series, yearly 2003 - to date
* other workshops organized by the community...
* www.dddas.org (maintained by Prof. Craig Douglas)
Mechanics
Fracture
Astrophysics
Electronic Structure
Condensed Matter
Dynamics
Chemical
Nanotechnology
Systems
Transportation
Logistics
Military
Dynamics
Chromo
Quantum
Prototypes
Steering
Genetics
Population
Actinide
Systems
Manufacturing
Scatterings
Atomic
Drug Design
Rational
Economics
Transport
Neutron
Modeling
Molecular
Control
Air Traffic
Visualization
Scientific
Dynamics / Biomolecular
Structure
Electronic
Chemistry
Quantum
Structure
Nuclear
Design
VLSI
Reality
Virtual
Crystallography CAD
Assimilation
Data
Collaboration
Multimedia
Tools
Problems
Inversion
Diffraction & Processing
Genome
Graphics
Discrete
N-Body Events
Raster
Monte Carlo
Reconstruction Tomographic Vision
Computer Databases
Data Mining
Large-scale Matching
Fourier MRI Imaging
Algorithms & Numerical Methods
Basic Agents Intelligent Processing Networks Distribution Symbolic Theoretic Search Intelligent Processing Flows Pipeline Cryptography Grids Electrical Reactors Algebra Computer Number Theory Dynamics Dynamics Multibody Processing Plasma Models Economics Electromagnetics Reaction-Diffusion Neural Networks Flow Multiphase Physics Cloud Structural Mechanics The University of Chicago Argonne National Lab and Source:
Rick Stevens, Mechanics Orbital Weather and Climate Astrophysics Ecosystems Geophysical Fluids Seismic Processing Aerodynamics Reservoirs Petroleum Porous Media Flows in Reactors Chemical CVD
Why Now is Timely for increasing efforts

Several agencies reports - over the ~recent & over the last 2 years:

- The 2005 NSF Blue Ribbon Panel headed by Prof. Tinsley Oden
  - characterized DDDAS as visionary and revolutionary concept.
- The 2006 Workshop on DDDAS convened in 2006
  - produced a report with comprehensive scope
  - covers scientific and technical advances needed to enable DDDAS capabilities
  - presents progress and wealth of examples where DDDAS has started making impact
- the “14 Grand Challenges” posed by the National Academies of Engineering
- A 2007 CF21 NSF Report and several more recent TaskForces
  - NSF CyberInfrastructure for the 21st Century (CIF21-NSF 2010) lays out
    - “a revolutionary new approach to scientific discovery in which advanced computational facilities (e.g., data systems, computing hardware, high speed networks) and instruments (e.g., telescopes, sensor networks, sequencers) are coupled to the development of quantifiable models, algorithms, software and other tools and services to provide unique insights into complex problems in science and engineering.”
- Set of recent TaskForces by NSF have reported-back with recommendations reinforcing the need for this thrust (DDDAS)
- The 2010 AirForce Technology Horizons 2010 Report (Dr. Werner Dahm -AF ChiefSci)
  - A Vision for transforming the Air Force in the next 20 years
Werner Dahm: 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

And some additional/starting opportunities

Optimized Aircraft Routing – Cognizant of Weather
Predicting spread of volcanic ash – Mitigating constraints/damage from event
InfoSymbiotics/DDDAS
Why Now More than Ever

• Scale/Complexity of Natural, Engineered and Societal Systems
  - the increasing complexity – and emphasis in complex systems multi-scale/multi-modal modeling and algorithmic methods

• Ubiquitous sensoring
  - networks of large collections of heterogeneous sensors and actuators; other complex instruments
    • dynamically manage such sets of resources in optimized ways through adaptive control executing application-model
    • improve over traditional static/ad-hoc ways of resource management

• Big Data
  - “swimming in sensors and drowning in data” (Lt Gen Deptula)

• Transformational Computational and Networking Capabilities
  - increased in networking capabilities for streaming large data volumes remotely
  - emerging multicore-based transformational computational capabilities at the high-end and in real-time data acquisition and control systems
    • unprecedented computational capabilities
    • multicores across – simplify one of the dimensions in the challenge of unification of high-end with real-time data-acquisition and control
Multicore-based Systems

**Multicores in High-End Platforms**
- Multiple levels of hierarchies of processing nodes, memories, interconnects, latencies

**Multicores in “measurement/data” Systems**
- Instruments, Controllers, Networks, Storage

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### Multidisciplinary Research and Technology Development for:
Adaptable Computing Systems Infrastructure
from the high-end to real-time data-acquisition & control systems
supporting applications adaptive mapping and optimized runtime
heterogeneous multilevel distributed parallelism
system architectures - software architectures

**SuperGrids: Dynamically Coupled Networks of Data and Computations**
Emerging Computational Platforms

Landscape on Multicores:

- **multicore processing unit (MPU) – system on a chip (SoC)**
  - Heterogeneity within the multicore processing unit
    - each MPU will most likely include *scalar*, *vector*, *GPU*, and *FPGA*
    - role of memristors in the evolution of MPUs, in particular
  - interconnections among MPUs
    - “printed on the chip”, optical
    - multistage, combining networks, architectures

- **multicores in high-end and mid-range platforms**
  - globally-distributed, meta-computing, heterogeneous, assemblies
  - workstations, networked supercomputing clusters, networked and adaptive platforms, together with their associated peripherals such as storage and visualization systems e.g. *Grids, Clouds* (*Clouds are not sufficient solutions!*)
  - Hexascale range – multi-level hierarchies in processors, memories, networks, mem & nets architectures [*“grids-in-a-box”* (Paul Messina) - GiBs (Darema)]

- **multicores in sensors, instrumentation, data acquisition, control systems** ...
  - & integrated with mid/high-end → unified platforms

*Challenges and Opportunities through such systems*
Need for New Programming Environments and Runtime support technologies (FD - 1997; NGS-1998)

Emerging and future hardware platforms will have
- multiple levels of processors, and multiple levels of interconnecting networks
- multiple levels of memory hierarchies (cache, main memory and storage levels)
- with multiple levels of bandwidths (variable at inter-node and intra-node levels) and latencies (differing for different links, differing based on traffic)
- exascale domain: prospects of addressing billion-way concurrency, and in the presence of heterogeneity of processing units

The questions range from:
- how to express parallelism and optimally map and execute applications on such platforms
- how to enable load balancing, in the presence of multiple levels of the platform architecture, and at what level (or levels) is load balancing applied

becomes evident that static parallelization approaches are inadequate
- one needs programming models that allow expressing parallelism so that it can be exploited dynamically
- for load balancing and hiding latency
- for expressing dynamic flow control and synchronization possibly at multiple levels

Need new systems software approaches (articulated in programs I started)
- new programming models (in ~'97-'98 I explicitly said, “let’s go beyond SPMD”)
- dynamic runtime compiler
- dynamic application composition (application analytics, UQ)
- “systems engineering”
Dynamic Runtime Support needed for DDDAS environments

Runtime Compiling System (RCS) and Dynamic Application Composition

Dynamic Analysis Situation

Launch Application(s)
Interacting with Data Systems
(archival data and on-line instruments)

Application Model

Application Program

Application Intermediate Representation

Dynamically Link & Execute

Distributed Programming Model

Compiler Front-End

Compiler Back-End

Application Components & Frameworks

Performance Measurements & Models

Distributed Computing Resources

Distributed Platform

Adaptable Computing Systems Infrastructure

MPP NOW SP

F. Darema
Systems Engineering
(Engineering Systems of Information)

- System-level methods to design, build, and manage the operation, maintenance, extensibility, and interoperability of complex systems in ways where the systems' performance, fault-tolerance, adaptability, interoperability and extensibility is considered throughout this cycle 

(limiting component level, design level approaches - not sufficient!)

- Such complex systems include (examples):
  - heterogeneous and distributed sensor networks
  - large platforms & other complex instrumentation systems & collections thereof which need to satisfy/exhibit:
    - adaptability and fault tolerance under evolving internal and external conditions
    - extensibility/interoperability with other systems in dynamic and adaptive ways

- Systems engineering requires novel methods that can:

  New Directions:
  Systems Level Modeling and Analysis <-> Performance Frameworks
  Performance Models & Resource Monitoring <-> Operation Cycle, System Evolution
InfoSymbioticSystems/DDDAS
Multidisciplinary Research

• applications modeling
• mathematical and statistical algorithms
• systems software

and

• measurement (instrumentation and control) systems
Multidisciplinary Research in applications modeling mathematical and statistical algorithms measurement methods dynamic, heterogeneous systems support
Where we are ... & QUO VADIMUS

- **DDDAS/InfoSymbiotics**
  - high pay-off in terms of new capabilities
  - need fundamental and novel advances in several disciplines
  - well-articulated and well-structured research agenda from the outset

- **Progress has been made - it's a “multiple S-curves” process**
  - experience/advances cumulate to an increasing rate of progress in the future
  - we have started to climb the upwards slope of each of these S-curves
  - need the trust of sustained, concerted, synergistic support

  - DDDAS/InfoSymbiotics broad impact - Multi-agency interest
  - can capitalize on past/present progress through projects started
  - timely in the landscape of: ubiquitous sensing/instrumentation, big-data, multicore-based high-performance systems, multiscale/multimodal modeling, uncertainty quantification, ...
  - the present landscape enriches the research agenda and opportunities
Executive Summary

1. Introduction - InfoSymbiotics/DDDAS Systems
2. InfoSymbioticSystems/DDDAS Multidisciplinary Research
3. Timeliness for Fostering InfoSymbiotics/DDDAS Research
   3.1 Scale/Complexity of Natural, Engineered and Societal Systems
   3.2 Applications’ Modeling and Algorithmic Advances
   3.3 Ubiquitous Sensors
   3.4 Transformational Computational and Networking Capabilities
4. InfoSymbiotics/DDDAS and National/International Challenges
5. Science and Technology Challenges discussed in the Workshop
   5.1 Algorithms, Uncertainty Quantification, Multiscale Modeling
   5.2 Large, Complex, and Streaming Data
   5.3 Autonomic Runtime Support in InfoSymbiotics/DDDAS
   5.4 InfoSymbioticSystems/DDDAS CyberInfrastructure Testbeds
   5.5 InfoSymbioticSystems/DDDAS CyberInfrastructure Software Frameworks
6. Learning and Workforce Development
7. Multi-Sector, Multi-Agency Co-operation
8. Summary

Appendices
Appendix-0 Workshop Agenda
Appendix-1 Plenary Speakers Bios
Appendix-2 List of Registered Participants
Appendix-3 Working Groups Charges

Report posted on www.dddas.org & AFOSR, NSF websites
Follow-up Activities

• DDDAS included in the new AFOSR BAA
• Discussions with NSF and other agencies for joint efforts
• The Aug2010 InfoSymbiotics/DDDAS workshop

  included representation by several agencies:
  DOD(AFOSR&AFRL, ONR&NRL, NRO&NRL)
  NSF (MPS, OCI, ENG, CISE, …)
  NASA
  NIH
  DTRA
  DOE(Labs)

  (other agencies have expressed interest)

Industry participation & interest

  ... more updates forthcoming....