



# *ICCS'05 WORKSHOP*

*on*

# *Dynamic Data Driven Application Systems (DDDAS)*

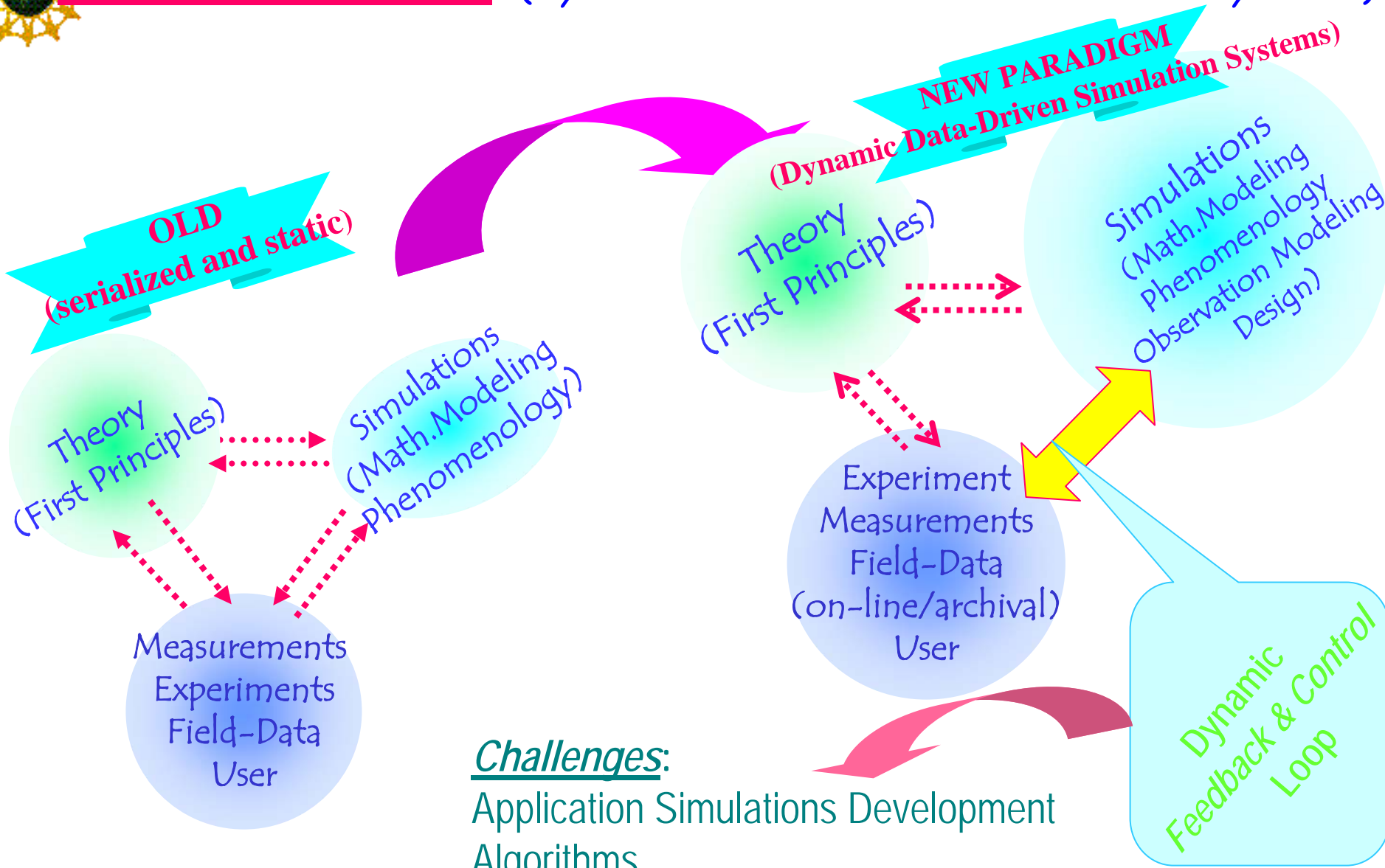
*A new paradigm for  
applications/simulations and measurements methodology*

## **INTRODUCTION and AGENDA**

Dr. Frederica Darema  
Senior Science and Technology Advisor  
NSF



# What is DDDAS *(Symbiotic Measurement & Simulation Systems)*



## Challenges:

- Application Simulations Development Algorithms
- Measurement Instruments Interfaces
- Computing Systems Support



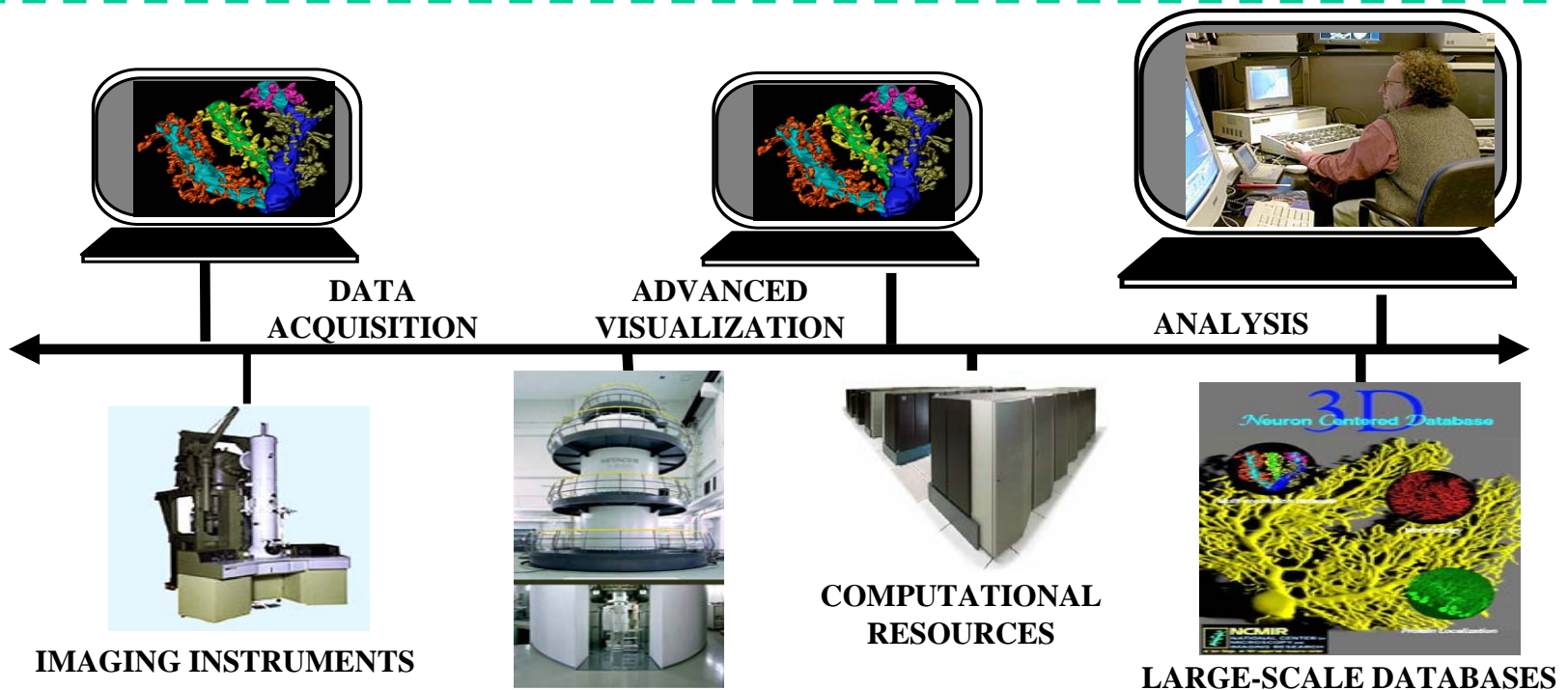
# Some Technology Challenges in Enabling DDDAS

- **Application development**
  - interfaces of applications with measurement systems
  - dynamically select appropriate application components
  - ability to switch to different algorithms/components depending on streamed data
- **Algorithms**
  - tolerant to perturbations of dynamic input data
  - handling data uncertainties
- **Systems supporting such dynamic environments**
  - dynamic execution support on heterogeneous environments
  - Extended Spectrum of platforms: assemblies of Sensor Networks and Computational Grid platforms
  - GRID Computing, and Beyond!!!



# What is Grid Computing?

*coordinated problem solving  
on dynamic and heterogeneous resource assemblies*

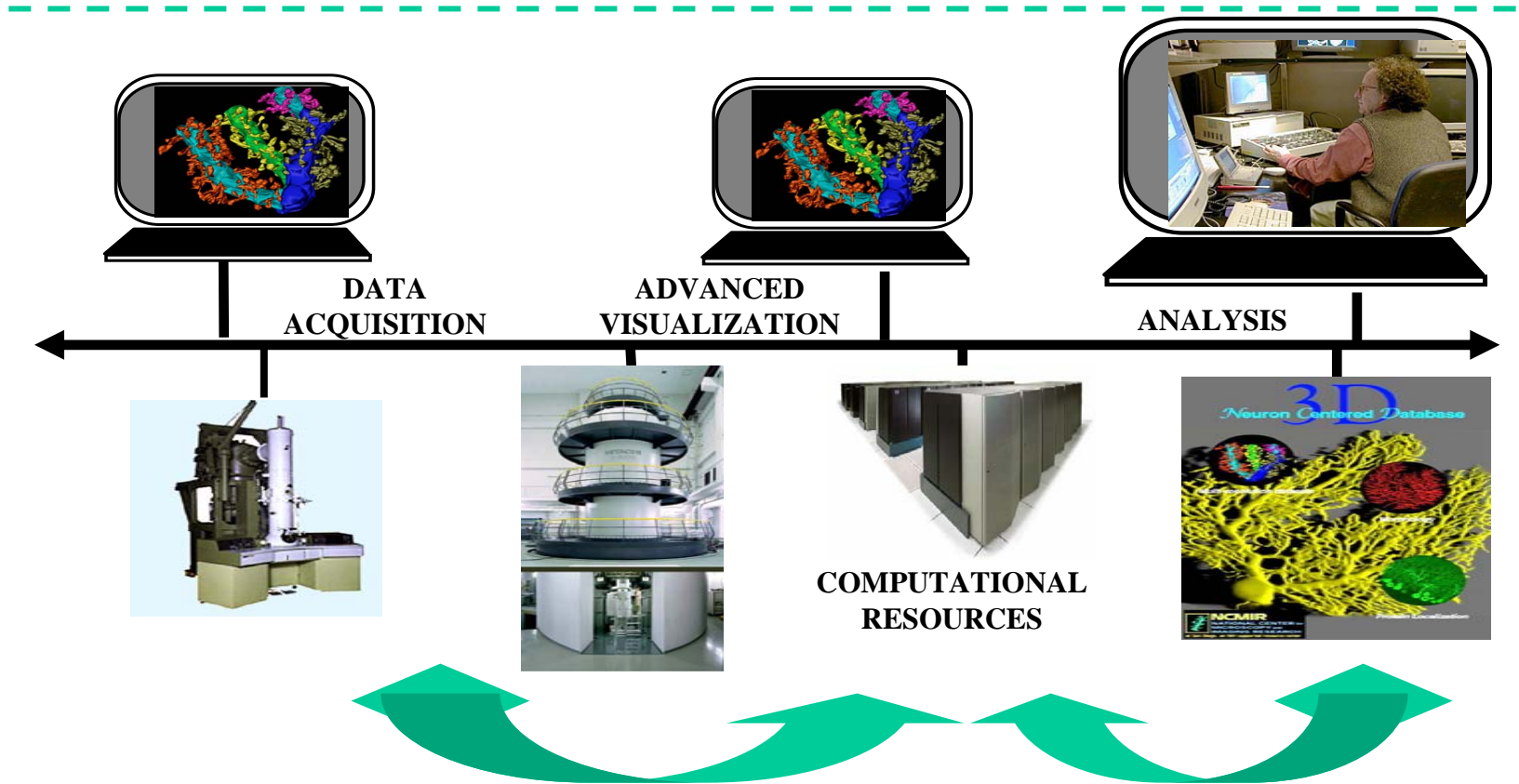


**Example:** "Telescience Grid", Courtesy of Ellisman & Berman /UCSD&NPACI



# DDDAS: Beyond Grid Computing

## New Capabilities in Applications and Measurements



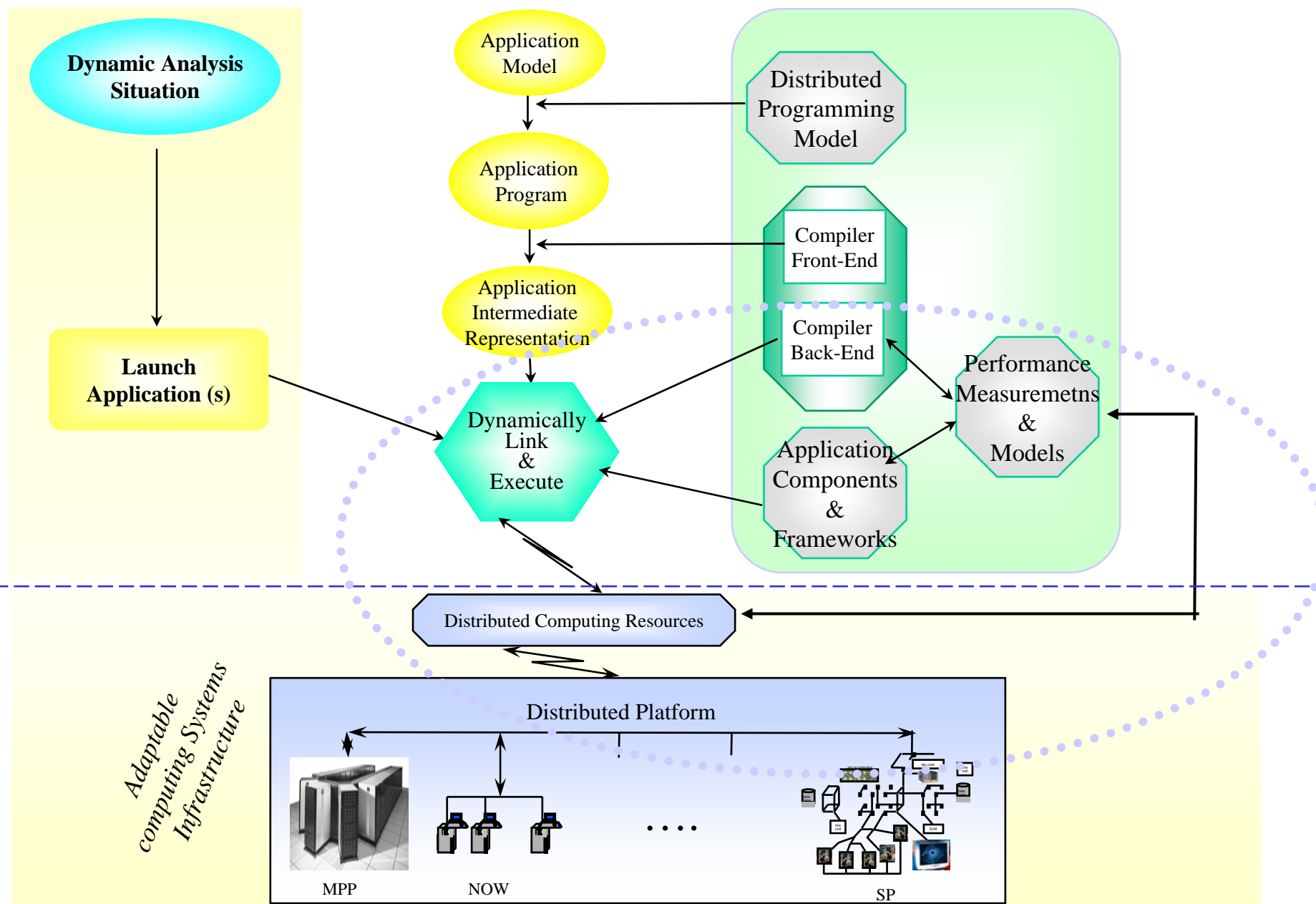


# Why Now is the Time for DDDAS

- Technological progress has prompted advances in some of the challenges
  - Computing speeds advances (uni- and multi-processor systems), Grid Computing, Sensor Networks
  - Systems Software
  - Applications Advances (parallel & grid computing)
  - Algorithms advances (e.g.: parallel & grid computing, numeric and non-numeric techniques: adaptive, asynchronous algorithms, dynamic meshing, data assimilation, 3DVAR/4DVAR, chaotic Monte-Carlo)
- Ongoing DDDAS project make advances in:
  - Applications, Algorithms, Instrumentation, Systems Software

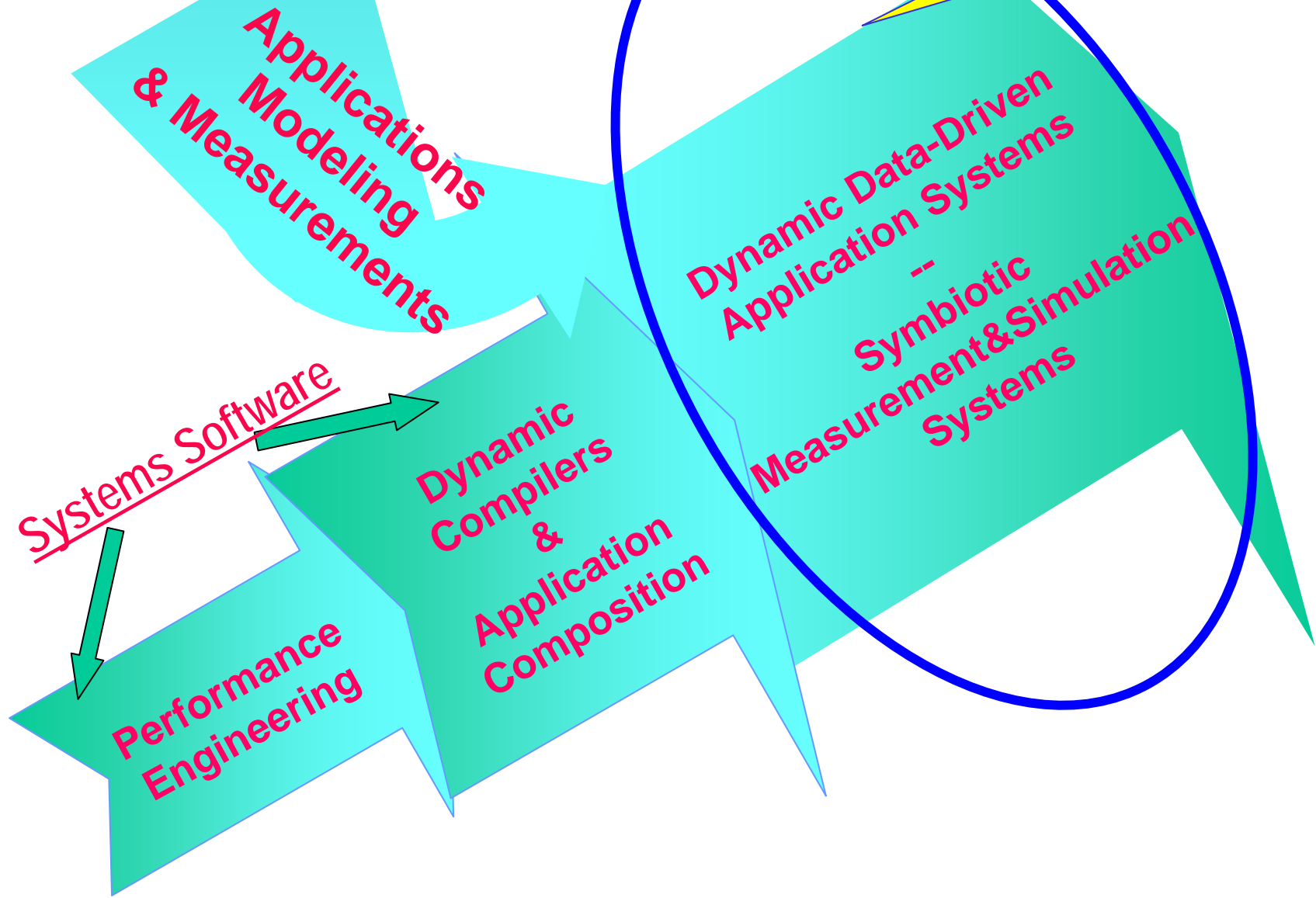
# The NGS Program develops Technology for integrated feedback & control

## Runtime Compiling System (RCS) and Dynamic Application Composition





# Towards Enabling DDDAS





# Research and Technology Roadmap

*(emphasis on multidisciplinary research)*

## Application Composition System

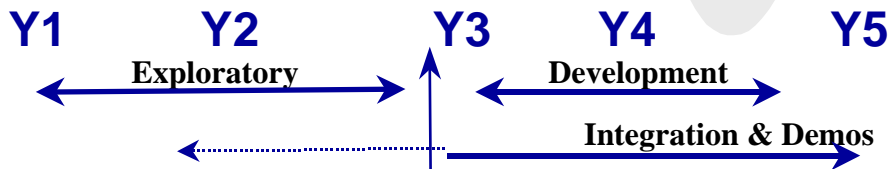
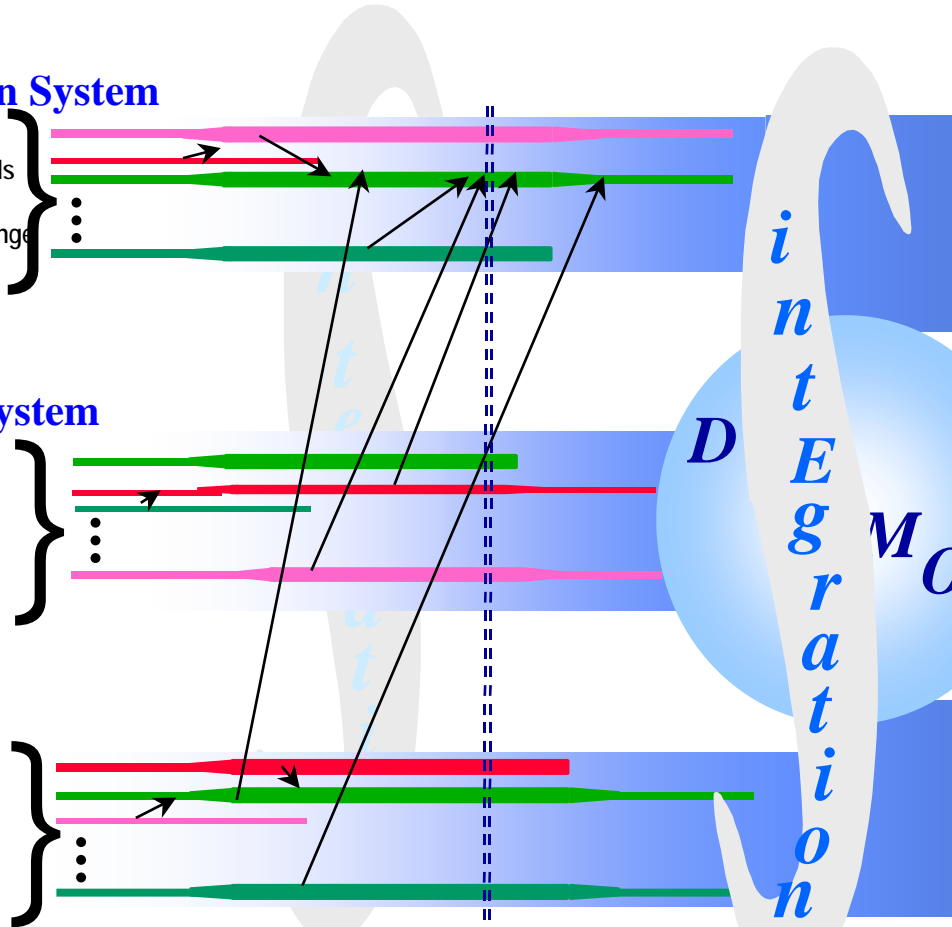
- Application multi-resolution models
- Automatic selection on solution methods
- Modeling languages
- Interfaces, data-representation & exchange

## Application RunTime System

- Distributed programming models
- Application performance interfaces
- Dynamic compiler optimized mapping'
- Debugging tools

## Measurement System

- Measurement instrumentation
- Application interfaces
- Measurement data formats/models





# Tally Points

- ITR Program was initiated to start new research, not previously funded by existing NSF programs
- ITR was used to spawn a significant number on ~DDDAS projects
- majority of funds for DDDAS from ITR - additional funding sources for other programs: NGS, SES, Sensors, BITS, etc
- About 40 projects
- Project sizes: \$400K-\$12M, majority \$1-3M, one: \$12M
- ITR funds on DDDAS: ~\$60M (cumulative)
- Funded projects are the success record for follow-on program
- Workshops: NSF/2000; ICCS'03, ICCS'04; ICCS05



## W16a: Dynamic Data Driven Application Systems I

Mon, May 23; 1:40 PM - 3:20 PM; Room: MSC W301

- Data Driven Applications Systems: New Capabilities for Application Simulations and Measurements

Frederica Darema, National Science Foundation, USA

- Dynamic Data Driven Methodologies for Multiphysics System Modeling and Simulation

by John Michopoulos, Charbel Farhat, Elias Houstis, Panayota Tsompanopoulou, Haiping Zhang, Thomas Gullaud

- Towards Dynamically Adaptive Weather Analysis and Forecasting in EAD

by Beth Plale, Dennis Gannon, Dan Reed, Sara Graves, Kelvin Droegemeier, Bob Wilhelmson, Mohan Ramamurthy

- Towards a Dynamic Data Driven Application System for Wildfire Simulation

by Jan Mandel, Lynn S. Bennethum, Mingshi Chen, Janice L. Coen, Craig C. Douglas, Leopoldo P. Franca, Craig J. Johns, Minjeong Kim, Andrew V. Knyazev, Robert Kremens, Vaibhav Kulkarni, Guan Qin, Anthony Vodacek, Jianjia Wu, Wei Zhao, Adam Zornes

- Multiscale Interpolation, Backward in Time Error Analysis for Data-Driven Contaminant Simulation

by Douglas, C.C., Yalchin Efendiev, Richard Ewing, Victor Ginting, Raytcho Lazarov, Martin J. Cole, Greg Jones, Chris R. Johnson



## W16b: Dynamic Data Driven Application Systems II

Mon, May 23; 3:40 PM - 5:40 PM; Room: MSC W301

- Ensemble-Based Data Assimilation for Atmospheric Chemical Transport Models  
by Adrian Sandu, Emil M. Constantinescu, Wenyuan Liao, Gregory R. Carmichael, Tianfeng Chai, John H. Seinfeld, Dacian Dăescu
- Towards Dynamic Data-Driven Optimization of Oil well Placement  
by Parashar, M., Matossian, V., Bangerth, W., Klie, H., Rutt, B., Kurc, T., Catalyurek, U., Saltz, J., Wheeler, M.
- High-Fidelity Simulation of Large Scale Structures  
by Christoph Hoffmann, Ahmed Sameh, Ananth Grama
- A Dynamic Data Driven Grid System for Intra-operative Image Guided Neurosurgery  
by Majumdar, A., A. Birnbaum, D. Choi, A. Trivedi, S. K. Warfield, K. Baldrige, P. Krysl
- Structure-based Integrative Computation and Experimental Approach for the Optimization of Drug Design  
by Morikis, D., Floudas, Ch.
- Simulation and Visualization of Air Flow Around Bat Wings During Flight  
by Pivkin, I.V., Hueso, E., Weinstein, R., Laidlaw, D.H., Swartz, S., Karniadakis, G.E.



## W16c: Dynamic Data Driven Application Systems III

Tue, May 24; 3:40 PM - 5:40 PM; Room: MSC W301

- Integrating Fire, Structure and Agent Models  
by Chaturvedi,R., S.A. Filatyev, J.P. Gore, A. A. Mellema
- A Dynamic, Data-Driven, Decision Support System for Emergency Medical Services  
by Gaynor,M., Margo Seltzer, Steve Moulton
- Dynamic data Driven Coupling of Continuous and Discrete Methods in 3D Tracking  
by Metaxas,D., Tsechpenakis, G.
- Semi-Automated Simulation Transformation for DDDAS  
by Brogan,D., Reynolds, P., Bartholet, R., Carnahan, J., Loitiere, Y.
- The Development of Dependable and Survivable Grids  
by Andrew Grimshaw, Marty Humphrey, John C. Knight, Anh Nguyen-Tuong, Jonathan Rowanhill, Glenn Wasson, Jim Basney
- On the Fundamental Tautology of Validating Data-Driven Models and Simulations  
by John Michopoulos, Sam Lambrakos



backup slides