Status of DDDAS

InfoSymbiotics

2nd International Conference
Cambridge MA
August 7-9, 2017

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Air Force Office of Scientific Research

Integrity ★ Service ★ Excellence
Outline

• The DDDAS paradigm
• Back to the beginning… and forward
• Journey of demonstrating value in many areas
• Timely now more than ever
• Emerging drivers/opportunities
  ▪ Overarching
    • Autonomy, Test&Evaluation
  ▪ Targeted
    • Advanced Manufacturing
    • Smart -materials, -powergrids, -cities, -cars(self-driving), …-planet
    • …
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
Back to the Beginning...

- Physical, Chemical, Biological, Engineering Systems
  - materials, engineered systems health monitoring, oil exploration, molecular bionetworks, protein folding...
  - pollution transport (atmosphere/aquatic/subsurface), ecological systems, ...

- 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 systems, water supply systems, transportation networks and vehicles (air, ground, underwater), ...

- Homeland Security, Communications, Manufacturing
  - Terrorist attacks, emergency response; Mfg planning and control

- Dynamic Adaptive Systems-Software
  - Robust and Dependable Large-Scale systems
  - Large-Scale Computational Environments

List of Projects/Papers/Workshops in [www.1dddas.org](http://www.1dddas.org)
- 1st Workshop – NSF, March 2010
- many subsequent workshops – cross agencies, conferences,...
- as of 2 years ago, also standalone conference
(1998 - ... precursor Next Generation Software Program)

Systems Software - Runtime Compiler - Dynamic Composition - Performance Engineering

(2000 - Through NGS/ITR Program)

Biegler - Real-Time Optimization for Data Assimilation and Control of Large Scale Dynamic Systems

Car - Novel Scalable Simulation Techniques for Chemistry, Materials Science and Biology

Knight - Data Driven design Optimization in Engineering Using Concurrent Experimentation and Simulation

Lonsdale - The Low Frequency Array (LOFAR) - A Digital Radio Telescope

McLaughlin - An Ensemble Approach for Data Assimilation in the Earth Sciences

Patrikakis - Poseidon - Rapid Real-Time Interdisciplinary Ocean Forecasting

Adaptive Sampling and Adaptive Modeling in a Distributed Environment

Wheeler - Data Intensive Challenge: The Instrumented Oil Field of the Future

(2001 - Through ITR Program)

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Adaptive Sampling and Adaptive Modeling in a Distributed Environment

Wheeler - Data Intensive 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 Methods

Douglas-Ewing-Johnson - Predictive Contaminant Tracking Using Dynamic Data Driven Application Simulation (DDDAS) Techniques

Evans - 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

Trefethen - A Real Time Mining of Integrated Weather Data

(2003 - Through ITR Program)

Baden - Asynchronous Execution for Scalable Simulation in Cell Physiology

Chaturvedi - Synthetic Environment for Continuous Experimentation (Crisis Management Systems) Applications

Droegemeier - Linked Environments for Atmospheric Discovery (LEAD)

Kumar - Data Mining and Exploration Middleware for Grid and Distributed Computing

Machiraju - A Framework for Discovery, Exploration and Analysis of Evolutionary Data (DEAS)

Mandel - DDDAS: Data Dynamic Simulation for Disaster Management (Fire Propagation)

Metaxas - STochastic Multicue Tracking of Objects with Many Degrees of Freedom

Sameh - Building Structural Integrity

(Sensors Program: Seltzer - Hourglass: An Infrastructure for Sensor Networks)

(2004 - Through ITR Program)

Breazeal - Simulation Transformation for Dynamic, Data-Driven Application Systems (DDDAS)

Baldridge - A Novel Grid Architecture Integrating Real-Time Data and Intervention During Image Guided Therapy

Floudas-In Silico De Novo Protein Design: A Dynamically Data Driven, (DDDAS), Computational and Experimental Framework

Grishman - Dependable Grids

Hilligax: Computational simulation, modeling, and visualization for understanding unsteady biophysics

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 - MFPI: A Real-Time Measurement-Inversion-Prediction-Steering Framework for Hazardous Events

How - 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

Leiserson - Planet-in-a-Bottle: A Numerical Fluid-Laboratory

Chryssostomidis - Multiscale Data-Driven POD-Based Prediction of the Ocean

Ntimo - 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

Selbekch - 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 Multimodal Simulations 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

Rabitz - Development of a closed-loop identification machine for bio networks (CIMA) and its application to nucleotide metabolism

Forbes - Dynamic Data-Driven Brain-Machine Interfaces

McCalley - 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

...
• **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
  - 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
Fundamental Science and Technology
Challenges for Enabling DDDAS Capabilities

• Application modeling (in the context of dynamic data inputs)
  ➢ dynamically invoke/select appropriate application components (models/algorithms) depending on streamed data
  ➢ multi-modal, multi-scale – dynamically invoke multiple scales/modalities
  ➢ dynamic hierarchical decomposition (computational platform - sensor) and partitioning
  ➢ interfacing applications with measurement systems

• Algorithms
  ➢ tolerant to perturbations of dynamic data inputs
  ➢ UQ, uncertainty propagation

• Measurements
  ➢ multiple modalities, space/time-distributed
  ➢ heterogeneous data management

• Systems supporting dynamic runtime environments
  ➢ extended spectrum of platforms
    -- beyond traditional computational grids, beyond the “traditional” cloud, to include sensor/instrumentation grids
  ➢ dynamic execution support on heterogeneous environments
Fundamental Challenges and Timeliness

Timeliness -- Confluence across 4 emerging directions

**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
Research for New Air Force Capabilities
“excellence in science and transformative capabilities for the Air Force”

PROBLEM: Increasingly we deal with systems-of-systems and systems/environments that are complex | heterogeneous | multimodal | multiscale | dynamic

AFOSR INVESTMENT STRATEGY
Pursue excellence in science through disciplinary and multidisciplinary research, to develop new methods for end-to-end systems capabilities, applied to key Air Force challenges for transformative impact to the Air Force

NEW METHODS - Paradigm Changing
• enable more accurate and faster modeling capabilities for analysis, prediction, & operational support
• enable decision support capabilities with the accuracy of full scale models
• support adaptive multimodal instrumentation and fault tolerance in instruments/sensors failures
• exploit ubiquitous embedded sensing & control for new test & evaluation methods

AF CAPABILITY: understand, design, manage & optimize systems-of-systems across life-cycle
Example Highlights of Outcomes/Results/Achievements through DDDAS

Materials modeling - Structural Health Monitoring
- 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 (DDDAS model driven) mobile sensor vs 7 stationary sensors

... talks in this conference provide highlight other examples of new capabilities through DDDAS
Examples of Areas of DDDAS Impact
from the “nano”-scale to the “terra”&“extra-terra”-scale

• Physical, Chemical, Biological, Engineering Systems
  materials, engineered systems health monitoring, oil exploration, …
  molecular bionetworks, protein folding…
  pollution transport (atmosphere/aquatic/subsurface), ecological systems, …

• Medical and Health Systems
  MRI imaging, cancer treatment, seizure control, …

• Environmental (prevention, mitigation, and response)
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• Dynamic Adaptive Systems
  Robust and Dependable Large-Scale systems

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“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) AF Chief Scientist (2008-2010)
Large-Scale Computing Systems & Environments
DDDAS/AFOSR BAA -- Areas Covered

“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 – Cognition; Space Weather and Atmospheric Events – Modeling/Observations; CyberSecurity; Systems Software

Multidisciplinary Research
Focus of advancing capabilities along Key Areas identified in the AF Technology Horizons, the Energy Horizons, and the 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
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
- Situational Awareness, Multi-Sensing & Control

... (other) Horizons...
- Energy Horizons
- Beyond Horizons
AFOSR DDDAS Program (2011- ...)

**Thematic Areas:**

- Materials modeling; Structural Health Monitoring for Decision Support; Propulsion/Combustion;
- 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

What makes DDDAS(*InfoSymbiotics*) TIMELY, NOW MORE THAN EVER?

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

- 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 micros(*sensors*) – wave # 2”
  - Dr. Frederica Darema, AFOSR (2011, LNCC)
  - challenge: how to deal with heterogeneity, dynamicity, large numbers of such resources
  - Ubiquitous sensoring is important component of BIG DATA (BigData – Wave #2!)
Integrated Information Processing Environments
from Data-Computation-Communication to Knowledge-Decision-Action

Multicores EVERYWHERE !!!

Adaptable Computing and Data System Infrastructure spanning the high-end to real-time data-acquisition and control systems manifesting heterogeneous multilevel distributed parallelism system architectures.

Large-Scale-Big-Computing: From the ExaScale to the SensorScale
Large-Scale-Big-Data: Traditional BigData + Ubiquitous Sensing & Control
AFOSR Science and Technology Strategy

**Mission:** Discover, shape, and champion basic science that profoundly impacts the future Air Force

- Identify breakthrough research opportunities here & abroad
  - 30 Arlington-based Program Officers and 18 International Program Officers interacting with leading scientists and engineers across the globe
  - 3 International offices (London, Tokyo, Santiago)

- Transition technologies to DoD and industry
  - AFRL is the principal technology transition path
  - 38 SBIR/STTR contracts funded with FY16 funds
  - Entrepreneurial impact: >1600 patents; 74 spin-off companies

- Foster revolutionary basic research for Air Force needs
  - 1166 research projects in FY16
    - 190 U.S. institutions
    - 46 States
  - 293 intramural projects at AFRL, USAFA, and AFIT in FY16
  - In FY16 384 international efforts in 43 countries in 5 continents
36 Programs in Basic Research Division and 20 Programs in International Office

“excellence in science and transformative capabilities for the Air Force”

Basic Research Division

Mathematics, Engineering and Information Sciences Branch

- Computational Cognition & Machine Intelligence
- Information Operations and Security
- Dynamic Data Driven Applications Systems
- Systems and Software
- Trust and Influence
- Science of Information, Computation, Learning and Fusion
- Computational Mathematics
- Dynamics and Control
- Complex Networks

Information and Networks Team

Physical and Biological Sciences Branch

- Atomic and Molecular Physics
- Quantum Information Science
- Ultrafast Pulse Laser-Matter Interactions
- Remote Sensing and Imaging Physics
- Optoelectronics and Photonics
- Aerospace Materials for Extreme Environments
- Quantum Electronic Solids
- Electromagnetics
- Plasma and Electro-Energetic Physics
- Laser and Optical Physics
- Space Sciences

Chemical and Biological Science Team

- Natural Materials & Systems
- Mechanics of Multifunctional Materials and Microsystems
- Human Performance and Biosystems
- Organic Materials Chemistry
- Molecular Dynamics and Theoretical Chemistry
- Biophysics

Engineering and Complex Systems Team

- Multi-Scale Structural Mechanics and Prognosis
- Science for Test and Evaluation
- Unsteady Aerodynamics and Turbulent Flows
- Energy Conversion and Combustion Sciences
- GHz-THz Electronics
- Dynamic Materials and Interactions
- Low Density Materials
- Space Propulsion and Power
- High-Speed Aerodynamics

International Office (AFOSR/IO)

- Asian Office of Aerospace R&D (IOA – Tokyo)
- European Office of Aerospace R&D (IOE - London)
- Southern Office of Aerospace R&D (IOS - Santiago)
- North America (ION – Arlington, VA)
International Outreach

- Identifying research of AF interest
- Engaging with collaborators
- Building relationships
- Leveraging foreign resources
- Transitioning S&T to the U.S.

The Sun Never Sets on AFOSR
AFOSR Programs
Supporting Basic Research in AFRL Technical Directorates

- RI – Assured command & control
- RX – Multifunctional materials
- RV – Space science
- RH – Neural stimulation
- AFOSR
- RD – Fiber lasers
- RQ – Hypersonics
- RY – Printed electronics
- RW – Nature-inspired flight
Scientific Partnerships

- Hypersonics Research
- Non-equilibrium flow
- Digital Twin
- Nanocomposites
- Living With a Star Steering Committee
- Ultracold atoms, Quantum sensor-magnetometry
- Microplasma for counter HPM
- Plasma-based logic circuits for rad-hard applications
- Photonics, High-power energy,
- Many more...

- Quantum computing, transducers project
- Info ops and security
- Complex Networks
- OSTP/NITRD committee member
- Cognition

- Nanophotonics
- Partnership for Research in Optical Technology
- Multi-agency Materials Genome Initiative
- Nanoenergetics: co-crystallization
- Combustion Chemistry

- Combustion Working Group
- Multi-Agent Sys.

- Origami Structures, aero
- Solar and heliospheric physics
- Decision Making, Social and Behavioral Science, plasma chemistry, and others
- Many joint reviews
- Metamaterials research
- Laser propagation
- Graphene research
- Alt Navigation
- Other areas

- Alternative energy
- Interagency
- Pulse Power Energy
- High temperature superconductors

- Working with many industry and international teams on various research topics
Vehicles for Executing our Mission

- Extramural programs (academia and industry)
  - Grants
  - Young Investigators
  - Contracts

- Intramural program (AFRL, USAFA, AFIT)
  - Lab tasks
  - Academic connections
  - International opportunities
  - Windows on the World
Factors Underlying AFOSR Investment Decisions

- **Search for transformational opportunities**
  - We take on informed relevance risk

- **Comprehensive search**
  - Relevance: across the spectrum of potential future Air Force applications
  - Opportunity: throughout the world

- **Investment balance across technology areas**

- **What other agencies are funding**
  - Awareness, collaboration

- Each Program convenes yearly Principle Investigators meeting
  - Meeting is attended by Program Officials by other Agencies, DoD Services
  - Most such reviews can also be attended by the broader community (need to pre-arrange with PO)

- Each Program Portfolio is reviewed yearly by AFOSR & AFRL management

AFOSR program officer autonomy is a key component of our success
How To Do Business With AFOSR

General Proposal Submission Process
- Researchers review broad agency announcement and submit white papers to program officers
- Promising white papers lead to requests for full proposals

- Program officers weigh several factors in selecting proposals for funding
  - White paper process to identify overlap with program interests
  - Encourage proposals with high potential for breakthroughs
  - Peer review to gauge scientific merit
  - Programmatic issues
    • Strategic directions
    • Portfolio coverage
    • Budget realities

Broad Agency Announcement (BAA) open at all times to innovative ideas
http://www.wpafb.af.mil/afrl/afosr/
### Open Broad Agency Announcements (examples)

More information at [https://www.grants.gov/](https://www.grants.gov/)

<table>
<thead>
<tr>
<th>Name</th>
<th>Description</th>
<th>Eligibility</th>
<th>Opening/Closing dates</th>
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<tbody>
<tr>
<td>Funding Interests of the Air Force Office of Scientific Research</td>
<td>Supports AFRL’s basic research program including engineering, complex systems, information and networks, physical sciences, chemistry, and biological sciences</td>
<td>Applicants from academia and industry are eligible to apply. Small businesses encouraged.</td>
<td>Ongoing</td>
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<tr>
<td>BAA-AFRL-AFOSR-2016-0007</td>
<td></td>
<td>U.S. institutions of higher education or nonprofit organizations, including foreign entities and foreign organizations operated primarily for scientific, educational, service, charitable, or similar purposes in the public interest.</td>
<td>Ongoing</td>
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<tr>
<td>Air Force Defense Research Sciences Conference and Workshop Support</td>
<td>Provides partial support for conferences and workshops as defined in the DoD Joint Travel Regulations in special areas of science that bring experts together to discuss recent research or educational findings, or to expose other researchers or advanced graduate students to new research and educational techniques in our areas of research interest.</td>
<td>U.S. institutions of higher education or nonprofit organizations, including foreign entities and foreign organizations operated primarily for scientific, educational, service, charitable, or similar purposes in the public interest.</td>
<td>Ongoing</td>
</tr>
<tr>
<td>BAA-AFRL-AFOSR-2016-0008</td>
<td></td>
<td>U.S. institutions of higher education with degree-granting programs in science and/or engineering are eligible to apply</td>
<td>Mar 20 – Nov 1, 2017</td>
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<tr>
<td>DoD Multidisciplinary University Research Initiative (MURI)</td>
<td>Supports basic research focused on multidisciplinary research efforts where more than one traditional discipline interacts to provide rapid advances in scientific areas of interest</td>
<td>U.S. institutions of higher education with degree-granting programs in science and/or engineering are eligible to apply</td>
<td>Mar 20 – Nov 1, 2017</td>
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</table>
Examples of Yearly Program Reviews

- Jul 24-28: **AFOSR High Speed Aerodynamics Portfolio** and ONR Hypersonics Portfolio, Drs. Ivett Leyva and Knox Millsaps, Hampton, VA
- Jul 24-26: **Cyber Security**, Dr. Tristan Nguyen, Arlington, VA
- Aug 14-18, **Computational Mathematics**, Dr. Jean-Luc Cambier, Arlington, VA
- Aug 28-Sep 1, **Mechanics of Multifunctional Materials and Microsystems (M^4)** and The 4th Multifunctional Materials for Defense Workshop, Dr. B.-L. ("Les") Lee, Arlington, VA
- Sep 6-8, **Dynamic Data Driven Applications Systems (DDDAS)**, Dr. Erik Blasch, Arlington, VA
- Sep 11-14, **Dynamics and Controls**, Dr. Frederick Leve, Arlington, VA

Complete list and registration information at [https://community.apan.org/wg/afosr/p/workshops_and_reviews](https://community.apan.org/wg/afosr/p/workshops_and_reviews)
• AFOSR executes the Air Force’s basic research program, effectively and with notable accomplishments & outcomes
  – Range of Programs available to discover, shape, and champion the world’s best science
  – Relevant to Air Force priorities and AFRL tech needs
  – Highly-qualified Program Officials
  – Healthy (but uncertain) budget

• Strong collaborations with other funding agencies (US&abroad)

• Excellence in science - accomplished through fostering in the U.S and abroad, for transformative capabilities for AF & Nation
60th Anniversary Monograph

Technical Strategic Plan

2016 Broad Agency Announcement (BAA)

AF S&T Horizons – 10, 20, … + beyond
Technology Horizons; Global Horizons; Energy Horizons; ... Autonomy Horizons

https://community.apan.org/wg/afosr/
AFOSR invites proposals in broad research areas through the general BAA and other broad agency announcements. Proposals submitted under the BAAs are evaluated using a peer or scientific review process and selected for award on a competitive basis.

To apply for AFOSR funding opportunities listed in the BAA, visit www.grants.gov. All application forms and instructions are provided on the site. You can search grants.gov by CDFA numbers 12.800, 12.630 and 12.910. There you can also search for opportunities by all grant issuing agencies.

Quick Links:
- 2015 AFOSR BAA
- AFOSR Funding Opportunities
- Search for other opportunities on Grants.gov
Social Media

www.facebook.com/afosr

www.twitter.com/afosr

www.youtube.com/TheAFOSR
Questions
Entrepreneurial Impact

- AFOSR has sponsored research resulting in more than 1600 patents
- Most citations for AFOSR funded patents come from industry
- AFOSR funding has resulted in or significantly contributed to the establishment of 74 cutting-edge startup companies

Europe
- Denmark
- Czech Republic