AFOSR Spring Review 2013

Test and Evaluation (T&E)

4 March 2013

Dr. Michael Kendra
Program Officer
AFOSR/RTA
Air Force Research Laboratory

Integrity ★ Service ★ Excellence

Report Documentation Page

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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

3002T PORTFOLIO OVERVIEW

NAME: Dr. Michael Kendra

BRIEF DESCRIPTION OF PORTFOLIO:

The T&E program supports basic research which will build the foundation for future revolutionary capabilities that address the identified needs of the T&E Community.

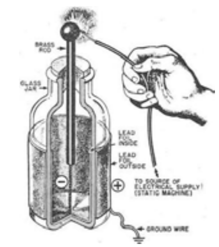
LIST SUB-AREAS IN PORTFOLIO:

The T&E Program encompasses five broadly-defined, overlapping thrust areas:

- Hypersonics
- Aerodynamics
- Sensors and Electromagnetics
- Information and Data Fusion
- Enabling Materials.

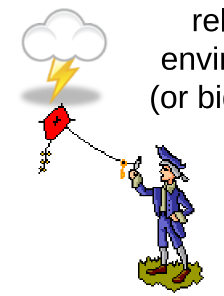
T&E Spring Review Summary

T&E: The Science of Test



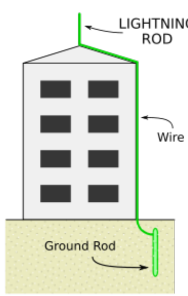
lab

- **2009 – Last T&E Spring Review**
- **AFOSR Technical Strategic Plan**
- **Technology push versus pull – role of PM's and TD's**
- **AFRL role – LRIR, STTR, tech transition**
- **T&E Thrust Teams – strengthen and expand**
- **TCTTA – Test Center Technology Transition Advisors**



relevant environment (or bigger lab)

Partnerships and Collaborations



system integration

- **AFTC, 412th TW, 96th TW, AEDC, RCC**
- **AFRL RY, RW, RX, RI**
- **OSD TRMC T&E/S&T Program**
- **UK DSTL T&E**
- **Ultra High Performance Concrete – HSST, AFRL/RW, Army ERDC, DTRA, AFOSR IO**
- **DoD Environmental Security Technology Certification Program (ESTCP)**

AFOSR Test and Evaluation Overview

MOTIVATION

- Future air, space and cyber platforms will have integrated materials, sensors and information systems that will exceed present day T&E capabilities
- AF Test Centers will require new technologies to fulfill their mission –
  - The speed at which data must be processed and exploited has dramatically increased.
  - T&E capabilities must now interweave computational tools into traditional physical testing and analysis capabilities.

5 Thrust Areas focused on Test Center Missions

STRATEGY

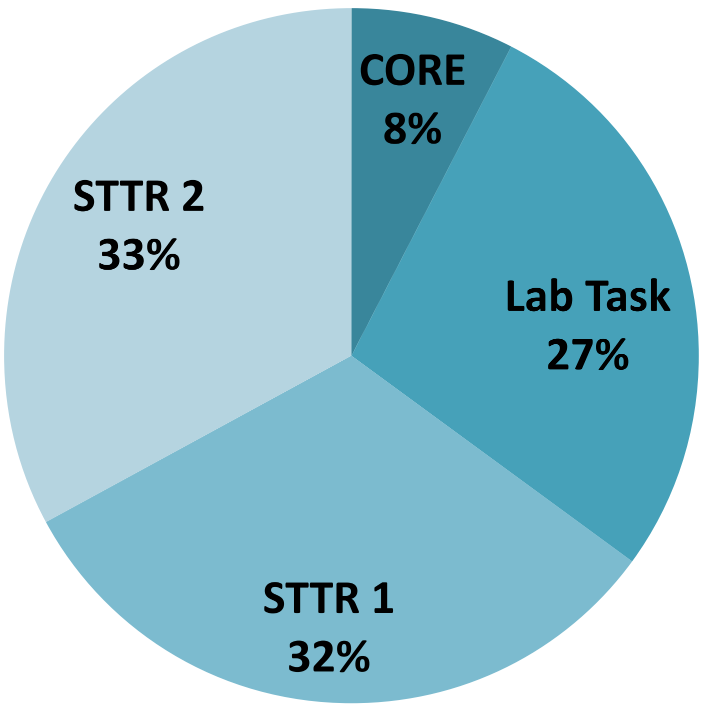
- **Creation of a network of AFRL S&E partners to support T&E future requirements.**
  - Exploration of parallel scalable computing/quantum computing using advanced fluid flow algorithms
  - Transition of new materials that run hotter and last longer to enhance existing test facilities.
  - Implementation of techniques for nano-scale machine, sensor, and electronics measurement and quality assessment

PAYOFF

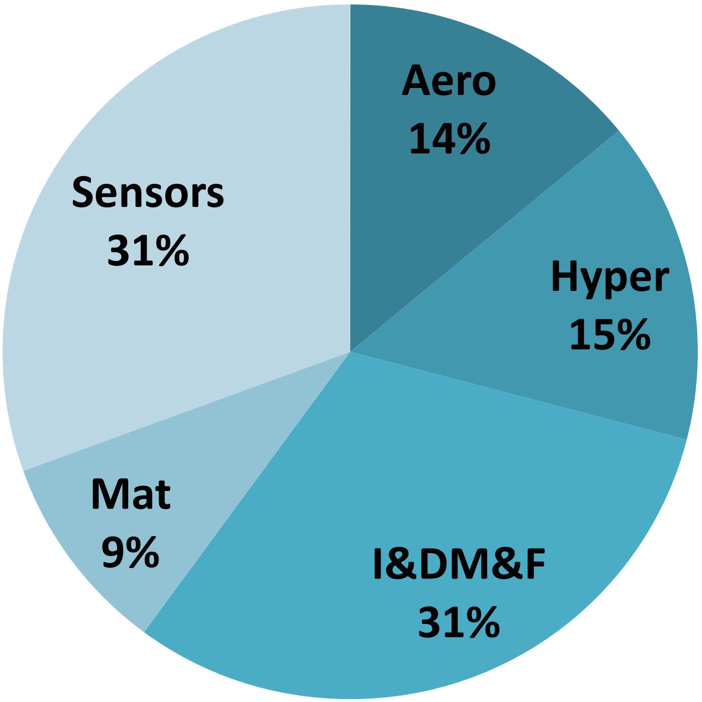
- Advanced Test Center capabilities for better, faster, more effective T&E
- Superior intramural T&E capabilities to support future AF systems
- Opportunity to recruit and train the next generation T&E workforce

AFOSR T&E FY12 Investment

T&E FY12 Investment



T&E FY12 Thrust Area Investment



<u>T&E FY13 Investment</u>

3 CORE	**11 STTR Phase 1**
8 LRIR	**13 STTR Phase 2**

CORE – University Grant
STTR – Small Business Technology Transfer
LRIR (Labtask) – Laboratory Research Independent Research

AFOSR Mission and Strategic Plan

AFOSR discovers, shapes, and champions basic science to profoundly impact the future Air Force

AFOSR Technical Strategic Plan

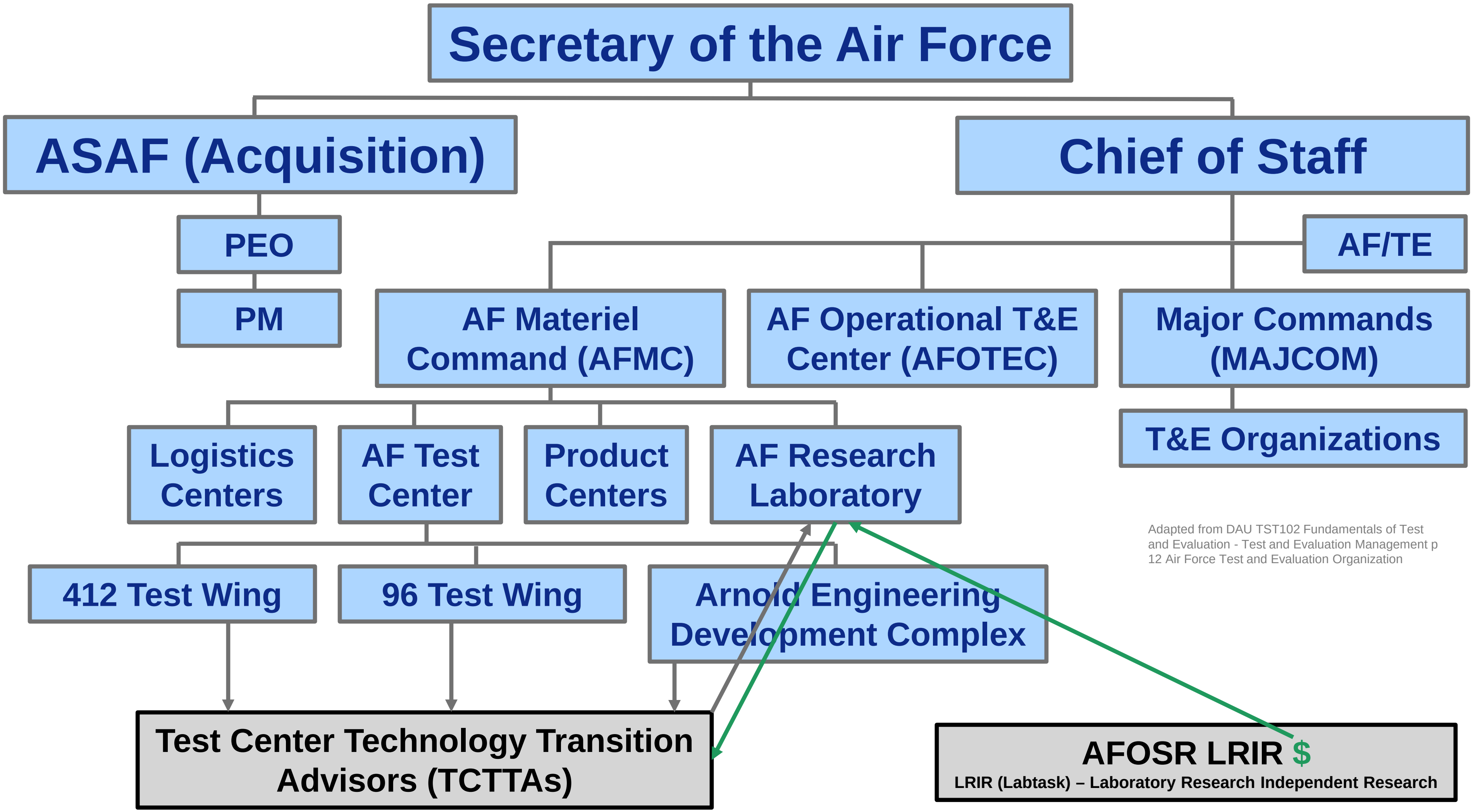
Strategic Goal 1: ***Identify opportunities*** for significant scientific advancements and breakthrough research here and abroad

Strategic Goal 2: ***Rapidly bring to bear*** the ***right researchers and resources*** on these opportunities in the interest of fostering revolutionary basic research for Air Force needs

Strategic Goal 3: ***Enable*** the Air Force to exploit these opportunities at the appropriate time ***transitioning revolutionary science*** to DoD and industry

TODAY'S BREAKTHROUGH SCIENCE FOR TOMORROW'S AIR FORCE

Air Force T&E Organization



Adapted from DAU TST102 Fundamentals of Test and Evaluation - Test and Evaluation Management p 12 Air Force Test and Evaluation Organization

AFOSR I 61-7 revised to allow AFRL TD collaborative funding to USAFA, AFIT, and AFMC Test Centers

AFOSR Test & Evaluation Portfolio

Management Structure

STAKEHOLDERS

David Stargel - AFOSR

Joan Fuller- AFOSR, Robert Arnold- 96TW, Ed Kraft - AEDC, Eileen Bjorkman - AFTC

Guidance

Plan Execution and Coordination

AFOSR	96TW	AEDC	AFTC
Michael Kendra	Jeong (Min) Kim	Scott Waltermire	Jim Deckert

Reporting

Thrust Teams

Information & Data Management & Fusion

Tristan Nguyen, AFOSR/RSL
Bob Bonneau, AFOSR/RSL
Andy Noga, AFRL/RI
Jim Deckert, AFFTC
Misty Blowers, AFRL/RI
Min Kim, 96TW
Stanley Borek, AFRL/RI

Aerodynamics & Aeroelasticity

LEAD Doug Smith, AFOSR/RSA
David Stargel, AFOSR/RSA
Scott Morton, 96TW
Stan Cole, NASA
Chuck Harris, 812 TSS
Jason Lechniak, 812 TSS
Crystal Pasiliao, AFRL/RW

Hypersonics

LEAD John Schmisseur, AFOSR/RSA
Charles Jones, AFTC
John Lafferty, AEDC
Chris Leone , AEDC
Alex Henning, AEDC
Ed Tucker, OSD TRMC T&E/S&T
Tony Schauer, HSTT

Sensors & Electromagnetics

LEAD Arje Nachman, AFOSR/RSE
Greg Czarnecki, 96TW
Michael Johnson, 96TW
Andy Keipert, 96TW

Enabling Materials

Les Lee, AFOSR/RSA
Scott Waltermire, AEDC
John Jones, AFRL/RX
Clint Hooser, Holloman High Speed Test Track
Michael Bohun, 96TW

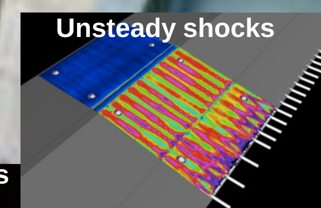
Thrust Area Teams

- Comprised of subject matter experts from each agency
- Develop and regularly assess the scientific objectives in each Thrust Area

Hypersonics Workforce Revitalization
UMd and AEDC Tunnel 9
PI Professor Ken Yu University of Maryland

- **Multi-year effort supported by AFOSR T&E and Hypersonics Programs, OSD T&E/S&T HSST**
- **3+ faculty, 10-12 students (grad and undergrad)**
- **Offices and lab co-located at Tunnel 9 in White Oak MD**
- **Take advantage of unused capacity and piggybacking**
- **Focus on hypersonics workforce revitalization**
- **Students starting to exit pipeline**
  (DARPA, Naval Air Warfare Center)


Focused Schlieren


Unsteady shocks


Temp-sensitive paints


Best Poster Award

Faculty Workshops

- **Research Opportunities Workshops**
  26-28 June 2012 AFFTC Edwards Air Force Base, CA
  24-26 July 2012 46 TW Eglin Air Force Base, FL

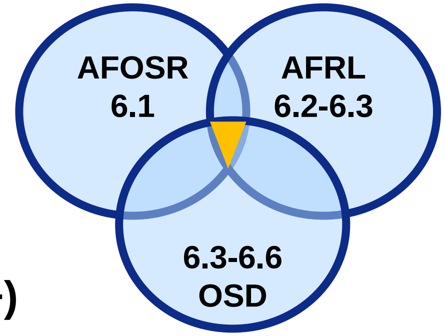
- More than 70 research professors and 5-10 students

- **Presentations**
  AF T&E leadership and workforce,
  OSD TRMC T&E/S&T,
  AFRL, AFIT, U Md, NASA,
  HR

- Site and facility visits

T&E Collaboration - Rapid Prototyping and Risk Sharing (RAPARS)

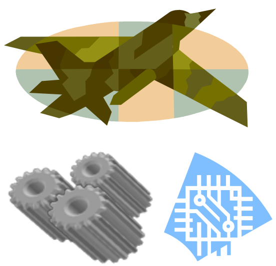
Goal – rapid tech transition to Test Centers



- Early basic research risk assumed by AFOSR (6.1)
- Early applied research risk assumed by AFRL (6.2-6.3)
- Advanced applied research risk assumed by OSD T&E/S&T (6.3+)

Tunable Diode Laser Absorption Spectroscopy (TDLAS) Temperature Sensor for High Pressure and High Temperature Air
- PI Professor Ron Hanson (Stanford U)
- Dr. Mike Brown AFRL/RQHS
- Ed Tucker, Wade Burfitt, Carrie Reinholtz AEDC

AFOSR Proposal	AFOSR Proposal		OSD TE/ST Proposal	Test Center Tech Transition
Mini CORE Grant 6.1	Mini LRIR 6.1 (not seedling)	AFRL 6.2-6.3	BAA 6.3-6.6	
University	AF Labs	AF Labs	AF Labs	
AFOSR $ 1 yr overlapping	AFOSR $ 1+ yr overlapping	AFRL $ overlapping as needed	OSD TE/ST $	



Mathematical Model Based Control System for Wind Tunnels

Dr. Alan Cain, Innovative Technology Applications Company, abcain@itacllc.com
PI Dr. Mark Rennie, University of Notre Dame, rrennie@nd.edu

iTAC

UNIVERSITY OF NOTRE DAME

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH UNITED STATES AIR FORCE

Objective

To develop accurate mathematical models for improved control and simulation of wind tunnels.

Approach

> Formulate mathematical models to simulate the wind-speed and temperature behavior of wind tunnels by applying the conservation equations for 1-D constant-property flow.

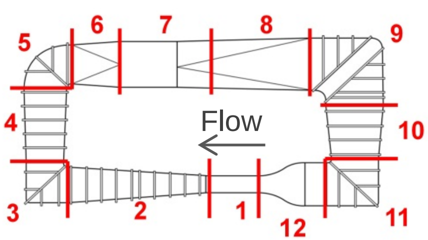
> Acquire a database of wind-tunnel operating conditions, and develop methods to compute parameters required by the mathematical model from the database.

> Use neural networks to organize and manipulate the database

> Develop error-management methods to protect against noise and signal failure, and integrate the approach into the control system of a wind tunnel.

Mathematical Modeling

1) Divide wind-tunnel circuit into sections.
2) Apply conservation of mass, momentum, energy, head-loss, plus auxiliary equations to each component.



3) Combine equations in the sense that the flow exiting each section is equal to the flow entering the section downstream.
4) Time step through the solution, or eliminate time-derivative terms and compute steady-state solution directly.

Neural Networks (NN)

> NN are ideal for organizing large databases and for "extracting" complicated relationships from those databases.

> e.g., a NN is used to compute the model drag area C_DS from routinely-measured data. This idea was developed in Phase I and will be experimentally validated in Phase II.

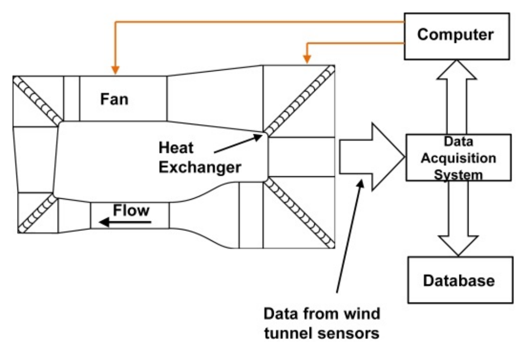
> In Phase II, NN will also be used to test for signal failure, and to compute all data required by the mathematical model for model-based control of the wind tunnel.

Phase II Progress (to April 2012)

> Mathematical models for wind speed and temperature behavior have been completed and the test-bed wind tunnel has been instrumented for good control.

> A control demonstration is tentatively planned for the mid-term review at the end of 2012.

Model-based Control



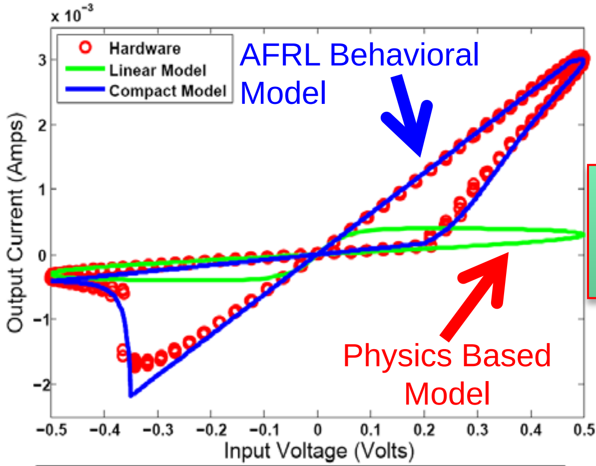
> Mathematical model is used to predict required control inputs (i.e. to fan and heat exchanger in this case) for improved control of test-section flow conditions.

> Data from wind tunnel sensors are continually acquired during testing and stored in a database, which is used to update neural networks and monitor tunnel performance.

AFRL Memristor Research

PI Clare Thiem and Dr. Bryant Wysocki AFRL/RI

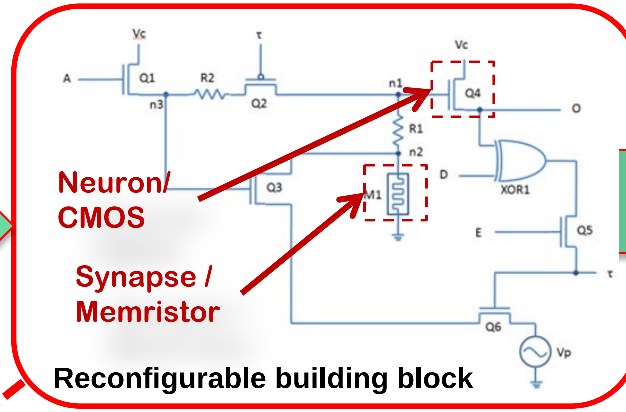
Most accurate model in literature



AF Patent 8,249,838

Building blocks for neuromorphic computing

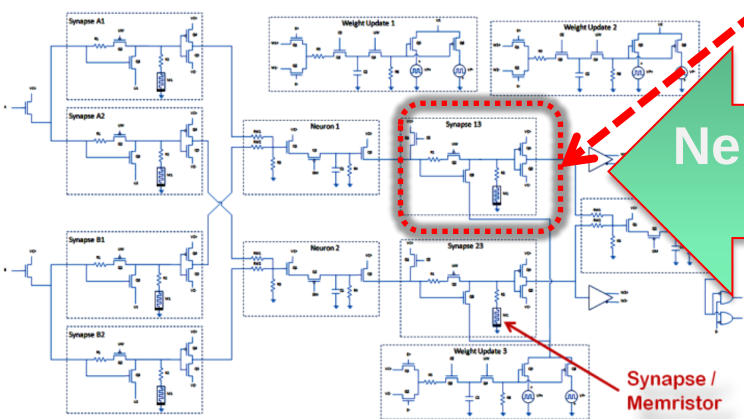
Models for Simulation



AF Patent 7,902,857

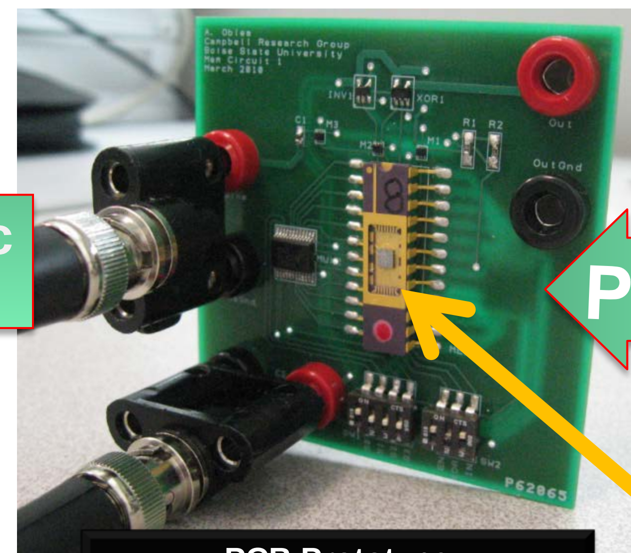
Design To Prototype

Trainable neuromorphic circuit



Neuromorphic Systems

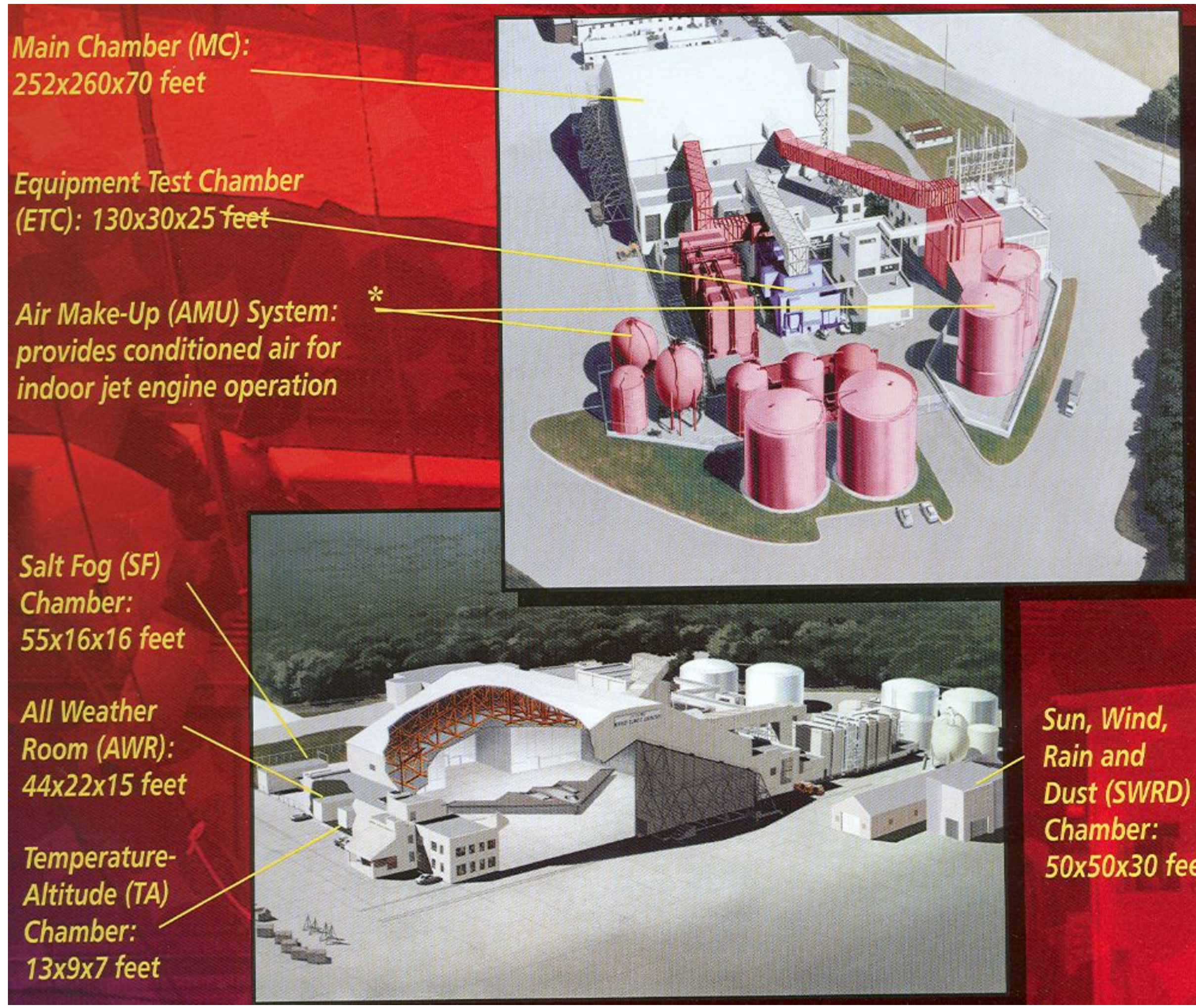
AF Patent 8,275,728



PCB Prototype

Model Development for a Solid State Neural Device Based Energy Management System

McKinley Climatic Laboratory, Eglin AFB



Operates 24/7/365
-65 F to 165 F
Manual Control Room Ops
Rotating Shifts
Largest Power Consumer
Last Major Upgrade 1990's

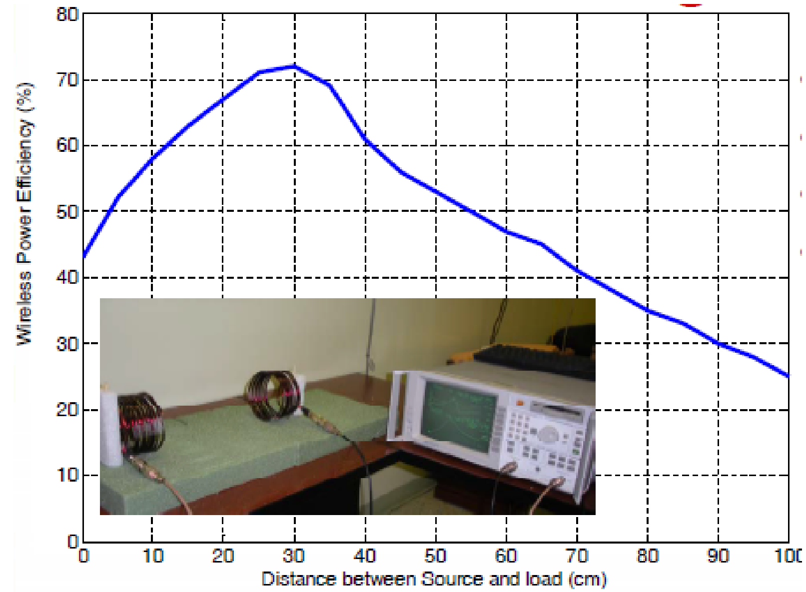
Push from AFOSR
Push from STTR contractor
Push from Norte Dame
Push from AFRL/RI
Pull from Eglin

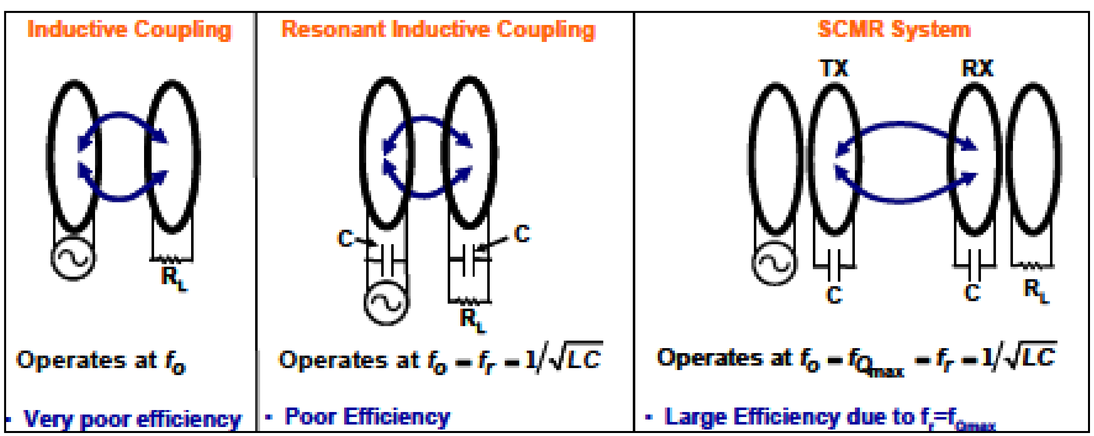
Potential partners include the Environmental Security Technology Certification Program (ESTCP)

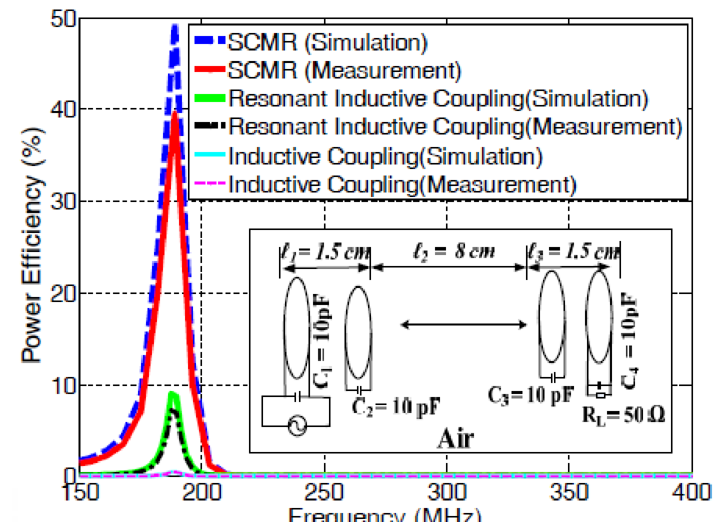
Highly Efficient Powering of Embedded Sensors

PI Professor Stavros Georgakopoulos, Florida International University

- **Highly Efficient Powering of Embedded Sensors**
  - Professor Stavros Georgakopoulos, Florida International University
  - AFOSR HBCU/MI Program
- **Strongly Coupled Magnetic Resonance (SCMR) Challenges**
  - Model development
  - Antennae geometry for maximum efficiency
  - Conductor material selection
  - Frequency
  - Scaling and miniaturization
- **T&E Payoff**
  - Wireless powering of instruments during test
  - Transmission through most materials (metals, composites, concrete)
  - Control signal and data transmission
  - Weight – potential to eliminate miles of wiring during test
  - Time - potential to reduce test preparation time

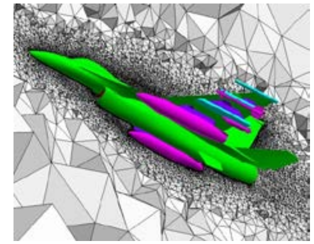


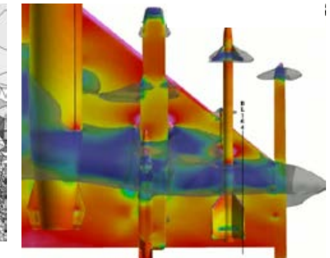




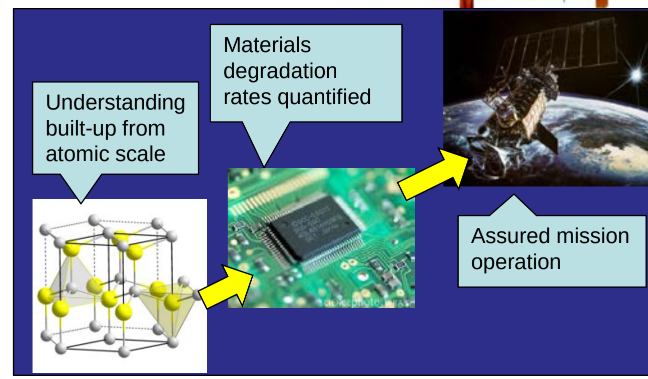
AFRL PI and Test Center Technology Transition Advisor Collaboration

PI Dr. Crystal Pasiliao AFRL/RW
TCTTA Jason Lechniak 412 TW Edwards AFB
Characterization Of Aero-Structural Interaction (CFD)
Expanded: technical contribution

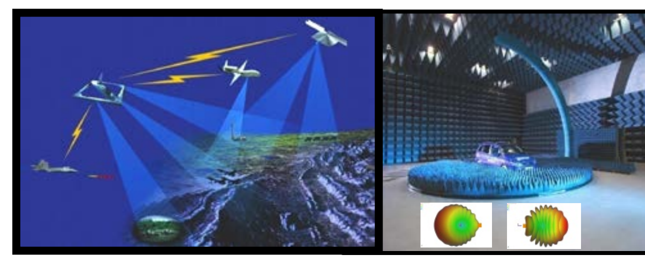




PI Dr. Don Dorsey AFRL/RX
TCTTA Dr. Jim Nichols AEDC
Tools for Nanoelectronics T&E
Space Environment Chamber test
Andy Keipert 96 TW Eglin AFB – EMP test



PI Dr. Kris Kim AFRL/RY
TCTTA Jim Deckert 412 TW Edwards AFB
Bistatic Radar Cross-Section
Benefield Anechoic Chamber test



PI Tony Quach AFRL/RY
TCTTA Ed Utt 96 TW Eglin AFB
High Power & Efficient Waveform-Agile Transmitter
Tom Young 412 TW Edwards AFB - T&E/S&T Spectrum Efficiency

Thank You!

?

2013 AFOSR SPRING REVIEW
3002T PORTFOLIO OVERVIEW

- **Novel measurement techniques, materials, and instruments** that enable accurate, rapid, and reliable test data collection
- Accurate, fast, robust, integratable **models** of the aforementioned that reduce requirements to test or help provide greater understanding of test results
- Advanced **algorithms and computational techniques** that are applicable to new generations of computers
- Advanced **algorithms and test techniques** that allow rapid and accurate assessment of devices and software to **cyber vulnerability**
- New processes and devices that **increase bandwidth utilization** and allow rapid, secure transfer of test data to control facilities during test
- Advanced **mathematical techniques** that improve **design of experiment** or facilitate confident **comparison of** similar but disparate **tests**
- Advanced models of test equipment and processes that improve **test reliability and efficiency**
- **Basic research** in other T&E technical areas that advances the **science of test** and contributes to the development of knowledge, skills, and abilities (**KSA**) of the established or emerging AF T&E **workforce**

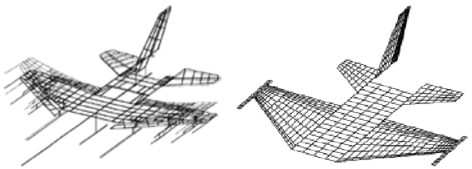
Characterization Of Aero-Structural Interaction Flow-Field Physics

PI Dr. Crystal L. Pasiliao AFRL/RW

STATUS QUO

Existing theories are insufficient to provide analytical means for direct characterization of aero-structural-induced interactions, such as Limit Cycle Oscillation (LCO).

- Methods do not account for aerodynamic and stiffness nonlinearities; therefore missing the fundamental physics bounding the flutter mechanism.



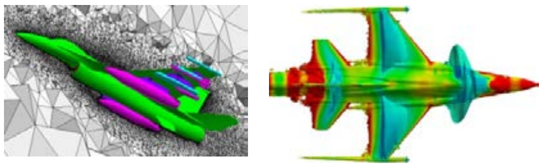
NEW INSIGHTS

Limit Cycle Oscillations (LCO's) are self-sustained oscillations of an airframe that achieve a constant amplitude for stabilized flight conditions.

- The fundamental physics of LCO cannot be characterized by direct theoretical methods.
- Nonlinear behavior requires development of pertinent nonlinear analysis methods.
- Classical linear flutter analyses fail to provide insight into LCO behavior (e.g. onset speed and response amplitude).
- Cannot account for aerodynamic and structural nonlinearities (bounding mechanisms).
- Flight testing is only way to assess LCO characteristics.

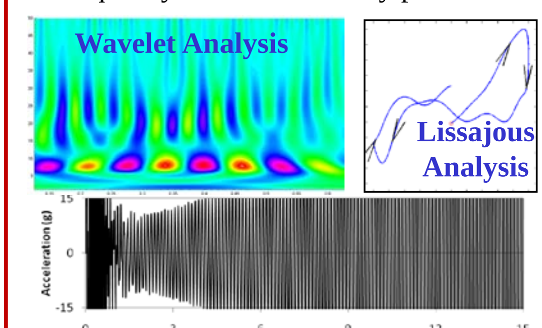
HOW IT WORKS:

- Utilize high fidelity unsteady fluid-structure reaction/ interaction (FSR/FSI) CFD solutions of full-scale airframes on HPC resources.



MAIN ACHIEVEMENTS:

- Unsteady, viscous, rigid-body FSR sims show evidence of shock oscillations, shock-induced separation, & phase lags.
- Unsteady, Euler, FSI sims predict accurate LCO onset speeds with "slowly diverging flutter" behavior.
- Lissajous illustrates non-sinusoidal tracking of C_p w.r.t. A/C motion.
- Wavelets key in identifying localized frequency differences at any point in time



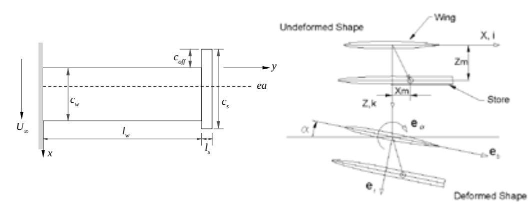
Structural Response

Planned Impact

- Successful development of advanced numerical technologies to progress the fundamental understanding of physics associated with and driving aero-structural interactions (ASI).
- Use of high fidelity aerodynamic characterization to quickly, robustly and accurately predict ASI driven events.
- Increased agility, maneuverability, and lethality for weapon development.

Research Goals

- New computational-based method capable of characterizing nonlinear ASI phenomena induced by weapons configurations on fighter aircraft.
- Characterization of flow physics that interact with the structure and contribute to aeroelastic mechanism.
- Feedback into the design of weapons to either avoid or exploit the mechanism.
- Provide the ability to "virtually fly" missions before actual tests.



QUANTITATIVE IMPACT

END-OF-PHASE GOAL

Tools for Test and Evaluation of Emerging Nanoelectronics

PI Dr. Donald L. Dorsey AFRL/RX

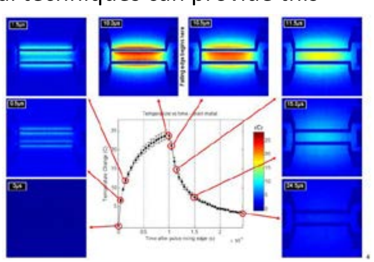
Future military systems will depend on high density electronics with sub 100nm feature size (nanoelectronics) Current NDE techniques will not be adequate due to:

• Limited spatial resolution • Lack of physical understanding of materials degradation behavior in operating devices • Relevant defects not always known (structure, properties, behavior); hard to measure (buried under multiple layers)

NEW INSIGHTS

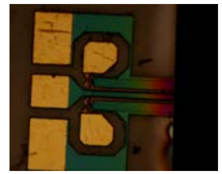
Tools exist to develop NDE approach to assess emerging nanoelectronics:

• Electronics operational models exist but don't include degradation mechanisms
• Can use these models to correlate NDE measurements to damage buried inside nanoelectronic devices (not accessible to direct measurement)
• Missing piece: nanoscale damage detection to discover & model degradation mechanisms
• *Scanning Probe Microscopy* (SPM) and micro-optical techniques can provide this

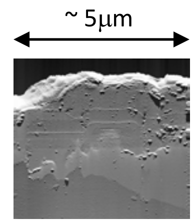


NDE – Thermoreflectance-based thermal transient imaging of an operating GaN power transistor with 50ns temporal resolution

MAIN ACHIEVEMENTS:



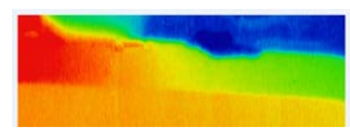
GaN Transistor cross-section created by a combination of polishing and 3-beam Ar ion milling



AFM Topology of GaN Transistor

• Routinely cleaving devices by multiple methods (mechanical, polishing, 3-beam ion milling) to surface qualities adequate for useful SPM imaging • Preliminary surface potential measurements made including impact of electrically biasing the device • Preliminary microRaman measurements made on device cross-sections

Surface Potential map for biased GaN transistor



SHORT TERM GOALS:

• Optimize cleaving technique for surface quality – *Challenge: smearing of metal contacts across the surface*
• Explore further surface optimization using low-energy argon ion mill
• Validate surface quality using surface potential and electrostatic force microscopy (EFM)
• Use EFM to test for evidence of charge build-up in the GaN buffer layer as suggested in some models as a potential device degradation mechanism
• Solve issues with the thermal stability of the cross-sectioned sample for micro-Raman and micro-PL measurements

Current Impact

• Availability of device cross-sections and nanoscale characterization techniques are sparking joint studies of degradation mechanisms with U. Florida, Ga.Tech, UC Santa Cruz/Purdue and others
• Sample preparations techniques developed are broadly applicable for other electronic device and materials technologies (beyond GaN High Electron Mobility Transistors (HEMTs)

Long Term Goals

• Extend work to other SPM modes (Scanning Microwave Microscopy, Kelvin Probe Microscopy)
• Perform systematic studies of damage accumulation during device operation and model the mechanism
• Incorporate damage models into in-house device simulator
• Correlate experimental and model results with NDE measurements
- Electrical (I-V curves, transconductance, etc.)
- Thermal (Raman, IR Camera)
- Optical (Photoemission, Photoluminescence)

Planned Impact

•Detailed, physically & chemically accurate models combined with NDE measurements to enable real-time state assessment of remaining useful lifetime of nanoelectronics
• Eliminate/dramatically reduce anomalies in fielded electronics; Improve logistics

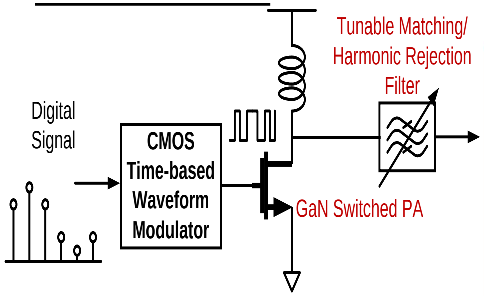
END-OF-PHASE GOAL

High Power/Efficient Waveform Agile Transmitter Technology for Multi-Function Apertures

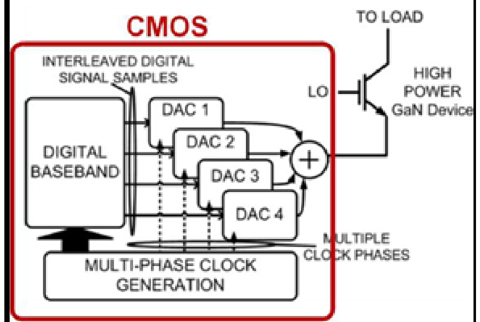
PI Tony Quach AFRL/RY

Multi-Function Transmitter **Architecture**

Test Case I
Pulse Width Modulated
Switch-mode **PA**



Test Case II
Power RF-DAC



- Objective:
  - To take advantage of waveform diversity and power scaling technologies required for next generation sensor needs.
  - Fundamental investigation of the foundational theory and limitations governing adaptive and efficient control of high power/efficient transmitter technology.

- PI: Tony Quach (937) 528-8903

  AFRL/RYDI, Tony.Quach@wpafb.af.mil
- Co-PI: Christopher Bozada (937) 528-8685

  AFRL/RYD, Christopher.Bozada@wpafb.af.mil

- Approach:
  - Develop the theoretical understanding for multi-phase digital signal reconstruction with multi-phase LO mixing in power DAC/Mixer architecture to cancel nonlinearity, enable wide bandwidth and digital phase shifting
  - Develop the theoretical understanding for pulse-width modulated switch-mode power amplifier to enable highly efficient / linear transmitter technology
  - Develop models for reconfigurable GaN devices to enable power scaling for waveform agile operation
  - Transition knowledge and designs to AFRL's complementary 6.2 funded demonstration of a waveform agile transmitter

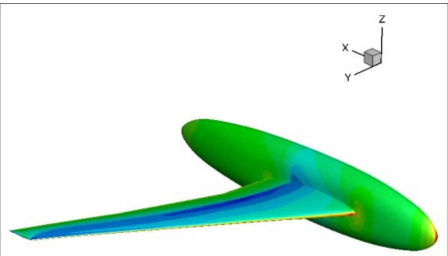
Funding: for 3-Years

Task Definition:

Task 1	**Multi-phase digital signal reconstruction theoretical exploration**
Task 2	**Pulse width modulated switch-mode PA theoretical exploration**
Task 3	**Reconfigurable GaN transistor core models for power scaling**
Task 4	**Waveform Agile transmitter demonstration**

Highly Scalable Computational-Based Engineering Algorithms for Emerging Parallel Machine Architectures

- ***PI Dimitri Mavriplis and Jay Sitaraman***
- ***University of Wyoming and Scientific Simulations LLC***



HIRENASD Model
AIAA Aeroelastic Prediction Workshop (April 2012)

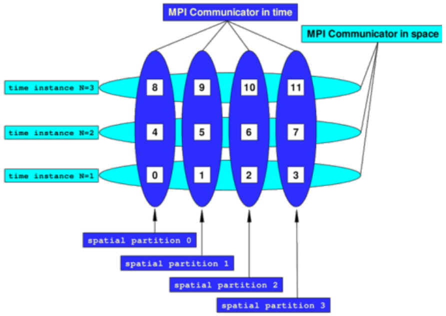
Task 1: Investigate hierarchical parallel partitioning strategies

Task 2: Demonstrate combined space-time parallelism (time-spectral or other)

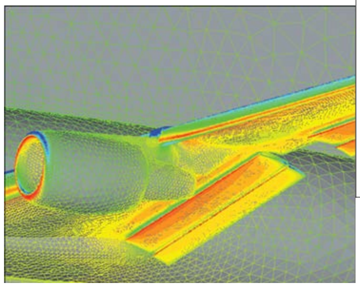
Task 3: Implement parallel CSD approaches

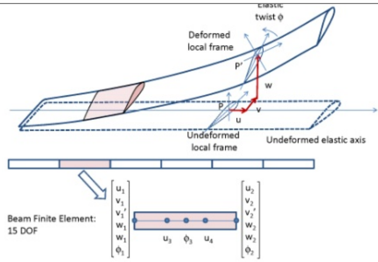
Task 4: Demonstrate efficient parallel scalability for fully coupled CFD/CSD problem

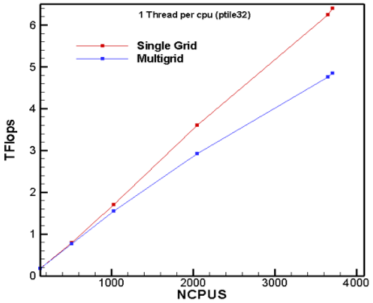
Task 5: Unified programming model for GPU/CPU architectures



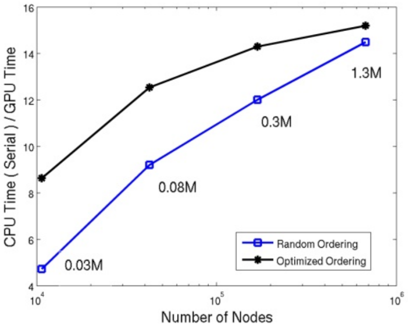
Space-time MPI for time spectral method



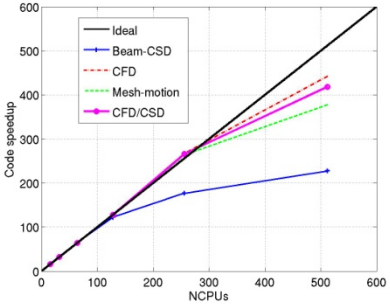




Scalability of CFD solver @4000 cpus



GPU speedup for unstructured mesh solver



***Scalability of CFD/CSD solver using beam model on AePW model** (HIRENASD)*

Distribution A: Approved for public release; distribution is unlimited

Nonintrusive Diagnostics for Off-Body Measurements in Flight Experiments

Dr. Alan Cain, Innovative Technology Applications Company, abcain@itacllc.com
PI Dr. Mark Rennie, University of Notre Dame, rrennie@nd.edu

Objective

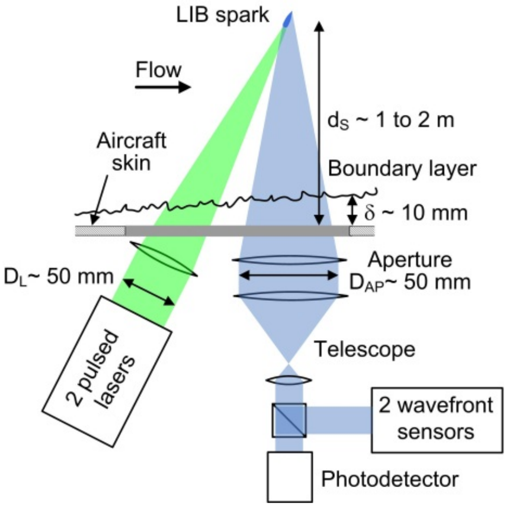
Develop new methods for in-flight, nonintrusive measurements of off-body, aerothermodynamic flow parameters.

Approach

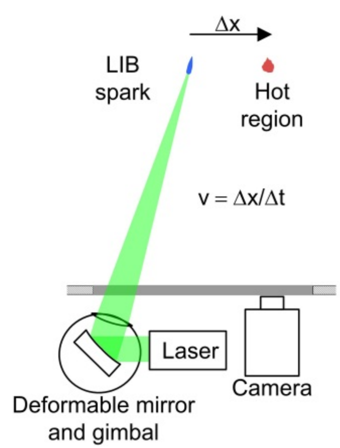
Determine flow parameters from the optical aberrations produced by density variations in the flow, i.e. from "aero-optic" measurements. Generate a reference light source using the emitted light from a laser-induced breakdown (LIB) spark for a fully nonintrusive method. The region of high-temperature air generated by the LIB spark is also used for computation of detailed flow velocities using a "thermal tufting" approach.

Concept Instruments

Aero-optic measurements



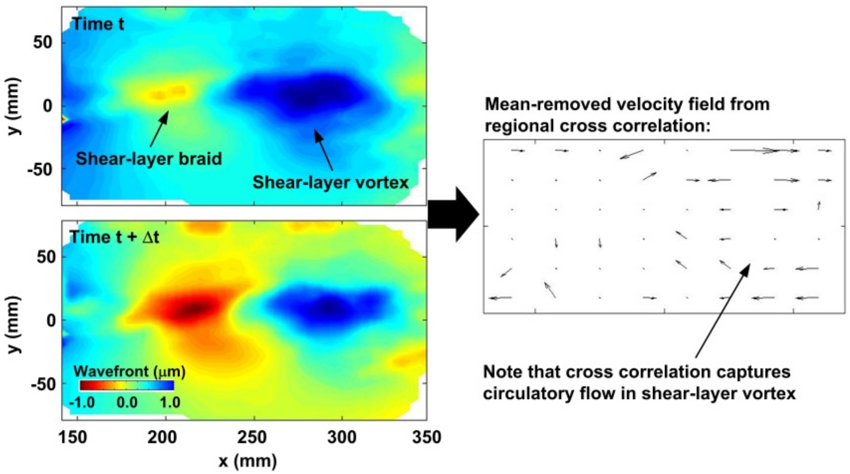
"Thermal tufting"



Sampling rate using LIB spark is ~200 Hz, but optical measurements up to ~100 kHz or more can be achieved using a continuous LED beacon.

Detailed Flowfield Measurement Example

Determined from regional cross-correlation of sequential wavefront measurements through a compressible shear layer



Features

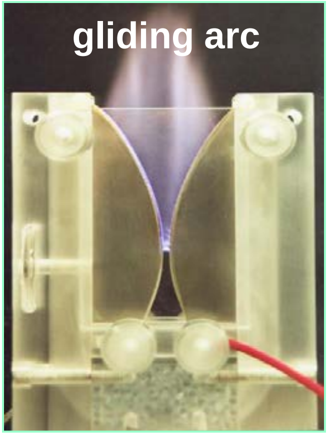
Measurement		Flow Parameter
Aero-optic measurements of boundary layer	⇒	Boundary-layer thickness, freestream density, mean freestream velocity
Regional cross-correlation of two sequentially-measured aero-optic wavefronts	⇒	Detailed velocity flow field (for primarily 2-D flows)
Convection of high-temperature air created by LIB spark	⇒	Local flow velocity
Intensity of LIB spark	⇒	Local air pressure
Spectrum of LIB spark	⇒	Chemical composition of flow

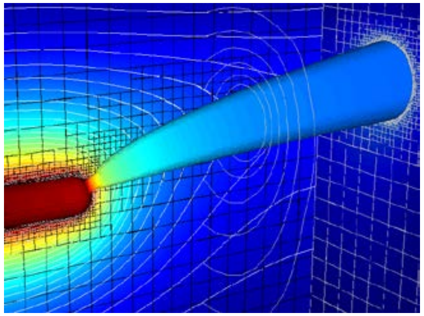
AFOSR STTR Phase I Project FA9550-12-C-0045 (topic AF11-BT25)
Computational Model for Electrode Erosion by High-Pressure Moving Arcs

PI: Dr Vladimir Kolobov: CFD Research Corporation – 215 Wynn Drive, Suite 501, Huntsville, AL 35805
Academic Partner: Dr A.Fridman, Dr A.Rabinovich, Drexel Plasma Institute

Problem & Technical Objectives

- Arc heaters provide high-temperature airflows needed for simulating extreme conditions for space vehicles and hypersonic weapon systems
- This project aims to develop theory and validated computational model of electrode erosion by high-pressure moving arcs
- Understand effects of different factors on material removal rates to help increasing lifetime of arc heaters by improved electrode design





Simulation of moving arc with dynamically adaptive Cartesian mesh

Challenges & Innovations

- Physics of arc attachment and electrode erosion by high-pressure moving arcs is poorly understood
- Existing models and computational tools do not take into account all the important factors
- CFDRC Solution: high-fidelity physical models and dynamically adaptive mesh technology for accurate and efficient simulations of arc motion and electrode erosion by the plasma
- Unified multi-phase solver for solid, liquid, gas, and plasma using different physical models for different phases
- Validate and fine-tune models vs experiments

Commercialization

- New tool will help better understand electrode erosion process by high-pressure moving arcs
- Help AEDC extend the run time and increase usable lifetime of arc heaters in hypersonic facilities
- Market new tool's capabilities to DoD and NASA facilities using arc heaters for hypersonic testing and other applications
- Offer improved capabilities for simulating multi-phase processes involving gas, plasma, solid and liquid, proven difficult to measure and control experimentally.

Mission

AFOSR's mission is to **discover, shape**, and champion **basic science** that profoundly impacts the future Air Force.

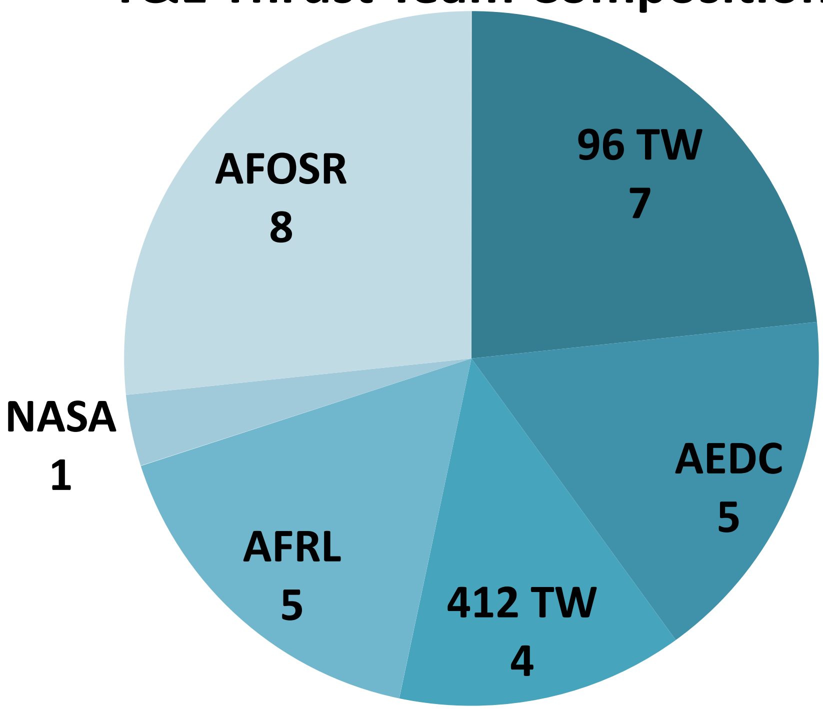
Air Force Test Center's mission: "conduct and support **research, development**, test and evaluation of aerospace **systems** from concept to combat."

AEDC mission "**Develop**, test and evaluate weapon, propulsion, aerodynamic and space **systems** at realistic conditions for the nation through modeling, simulation and ground test facilities"

The 96th TW executes **developmental** test and evaluation enabling the warfighter to put **weapons** on target in all battlespace media.

AFOSR T&E Thrust Teams

T&E Thrust Team Composition



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AF Workforce Pipelines