AFOSR

AFOSR Perspective on Integrating Analysis Tools

20 Jun 2007

Lt Col Rhett Jefferies

Program Manager

Aerospace, Chemical and Material Sciences Directorate

Air Force Office of Scientific Research (AFOSR)

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **JUN 2007**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**
4. TITLE AND SUBTITLE **AFOSR Perspective on Integrating Analysis Tools**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Aerospace, Chemical and Material Sciences Directorate Air Force Office of Scientific Research (AFOSR)**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release, distribution unlimited**		
13. SUPPLEMENTARY NOTES **Third International Symposium on Integrating CFD and Experiments in Aerodynamics, June 2007, The original document contains color images.**		
14. ABSTRACT		
15. SUBJECT TERMS		

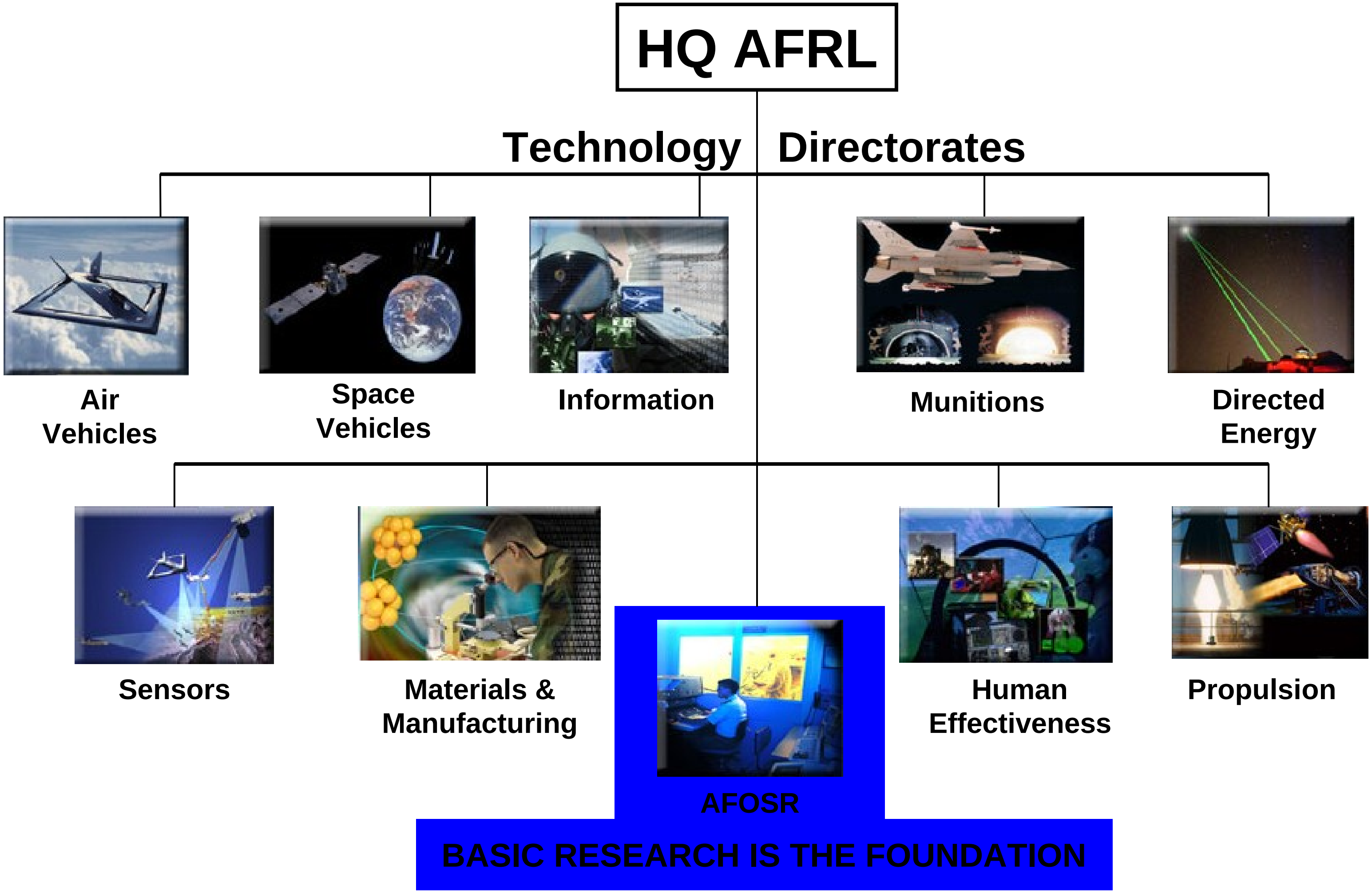
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**14**	

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

Presentation Outline

- Brief overview of AFOSR
- Integration of Analysis Tools
  - Benefits
  - Methodology
- Future directions/emphasis

Air Force Research Laboratory (AFRL)

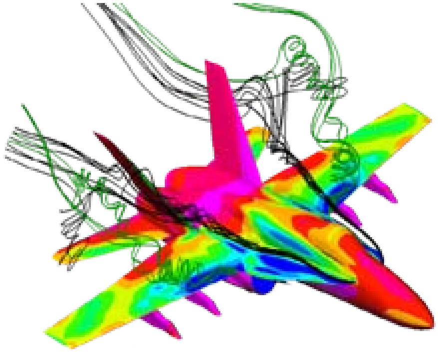


AFOSR is the Sole Manager of AF Basic Research

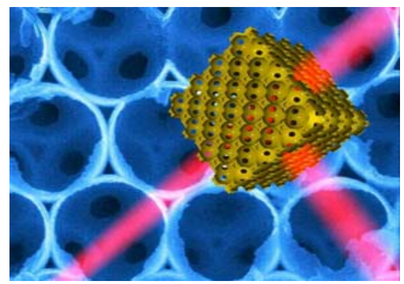
http://www.afrl.af.mil/

AFOSR Basic Research Areas

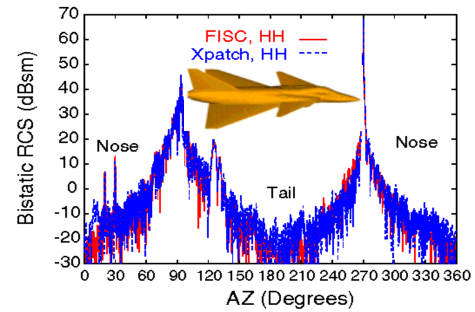
Aerospace, Chemical & Materials Sciences (NA)



Physics & Electronics (NE)



Mathematics, Information & Life Sciences (NL)



Sub-thrusts

- Structural Mechanics
- Materials
- Chemistry
- Fluid Mechanics
- Propulsion

- Physics
- Electronics
- Space Sciences
- Applied Math

- Info Sciences
- Human Cognition
- Mathematics
- Bio Sciences

Areas of Enhanced Emphasis

- Information Sciences
- Mixed-Initiative Decision Making
- Adversarial Behavior Modeling
- Novel Energy Technology
- Micro Air Vehicles
- Nanotechnology

UNSTEADY & ROTATING FLOWS

NAME: Rhett Jefferies **NO. OF YEARS AS OSR PM: 2**

BRIEF DESCRIPTION OF PORTFOLIO:

Advance fundamental understanding of complex time dependent flows, their interactions & control; develop physically-based models & novel concepts

SUB-AREAS IN PORTFOLIO:

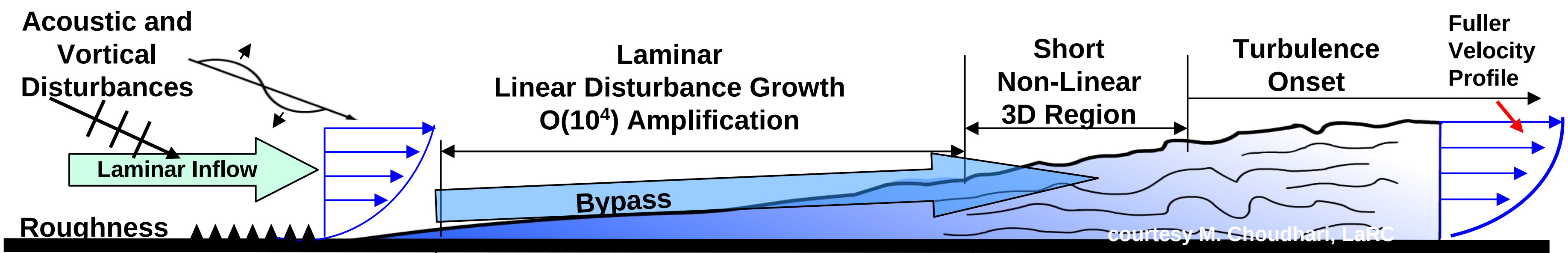
- **Active flow control effectors**
- **Low Reynolds number / Micro Air Vehicle aerodynamics**
- **Shear layers and vortex flows**
- **Micro-fluidics**

TECHNICAL APPROACH PRIORITIES:

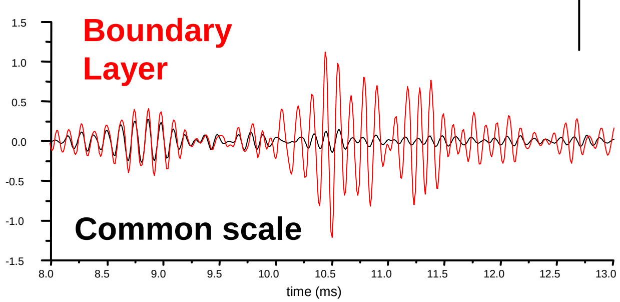
- **Integrated theoretical, numerical & experimental tools**
- **Multi-disciplinary innovation**
- **Technology transition**

The Science of Laminar to Turbulent Transition

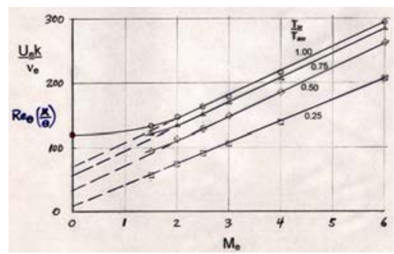
AFOSR-Sponsored Research Explores the Fundamental Physics of Transition



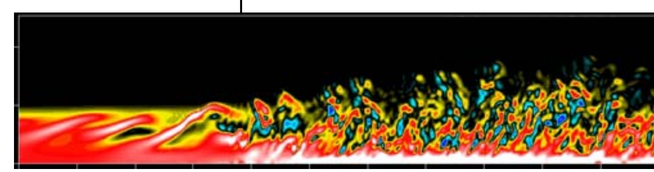
Receptivity	Stability Theory Transient Growth	Nonlinear Interactions	Turbulence Modeling



Receptivity Measurements
G. Brown, Princeton



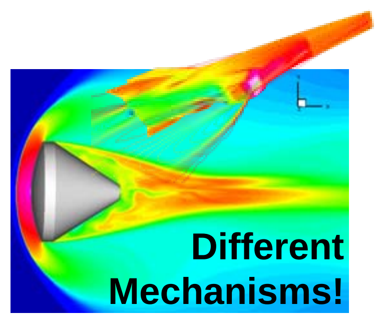
Transient Growth Theory Development – E. Reshotko, CWRU

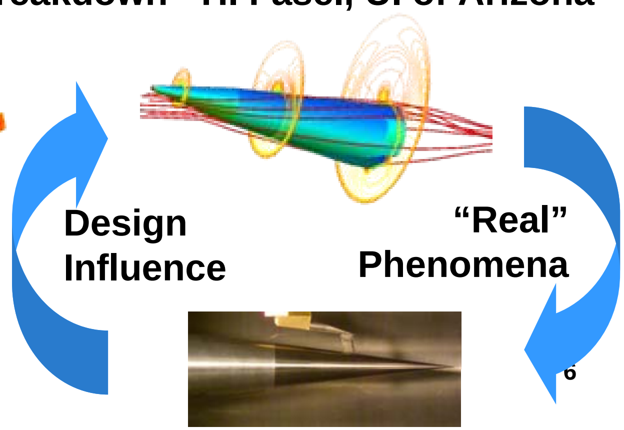


Direct Numerical Simulation of Breakdown - H. Fasel, U. of Arizona

Stability Theory Methods (15% of core):

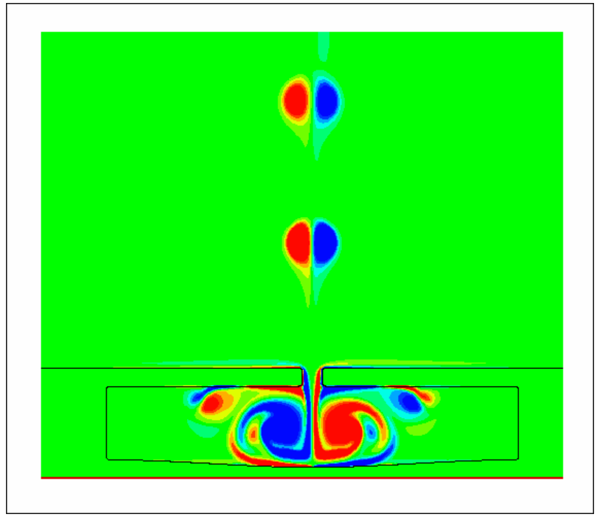
- Analysis of relevant configurations helps identify which mechanisms are most critical
- Major opportunity to transition methods to industry and advanced programs





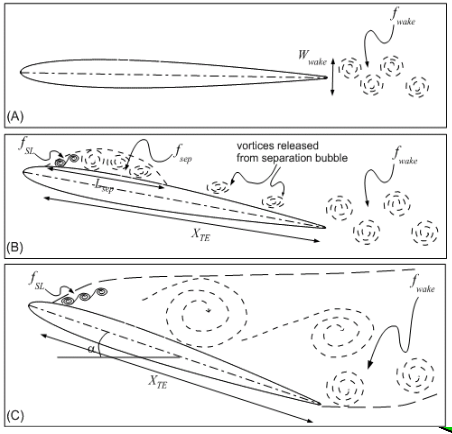
Integrated Analysis Tools

CFD



Numerical

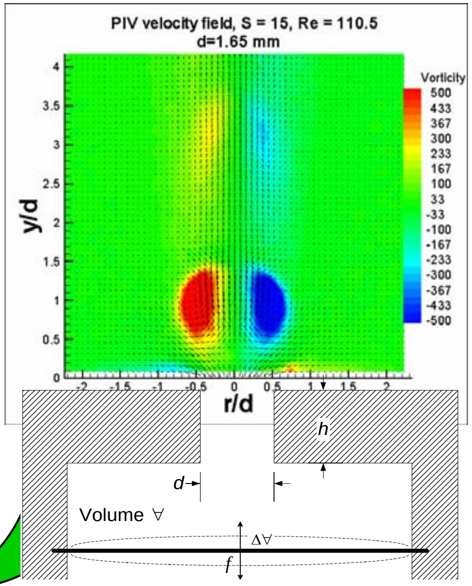
TFD



Theoretical

IFD

EFD



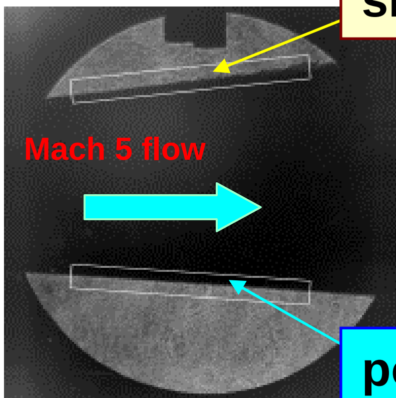
Experimental

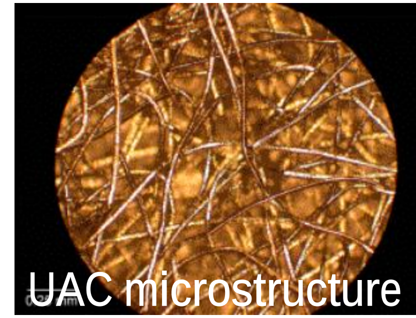
Integrated Fluid Dynamics (IFD): Benefits

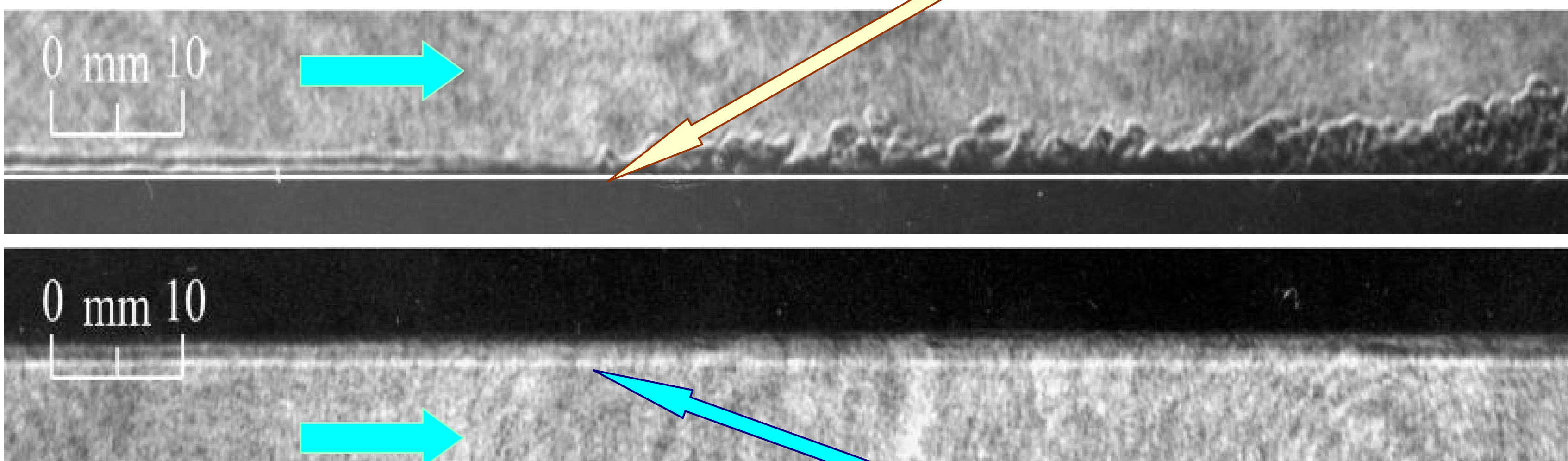
- **Gain new insights into flow physics**

Boundary Layer Laminarization by Ultrasonically Absorbing Coating (UAC)

Premature transition reduces efficiency of propulsion system and aerodynamic control surfaces







By increasing the laminar run from 20% to 80% it is feasible to decrease gross vehicle take-off weight by factor of 2

Laminarization initially predicted using variant of Orr-Sommerfeld stability theory

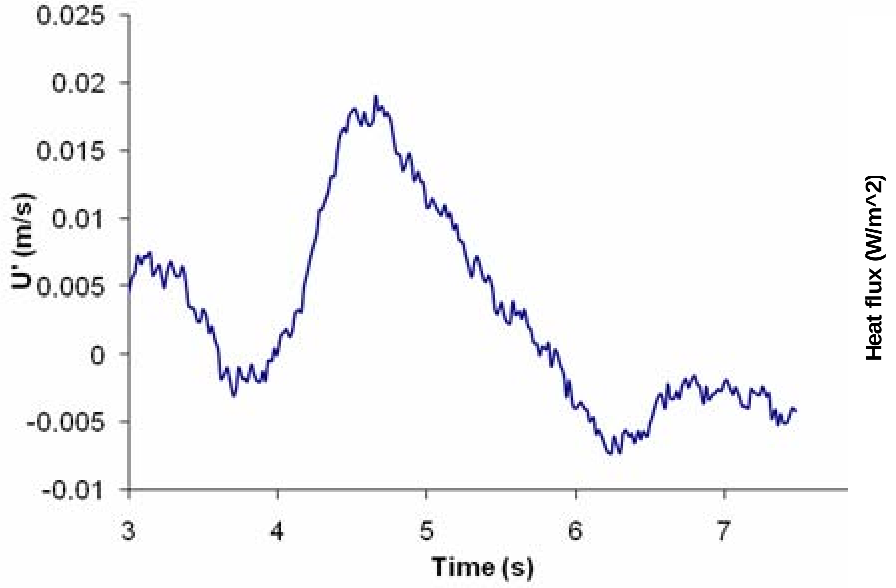
Dr. N. Malmuth, Teledyne

Integrated Fluid Dynamics (IFD): Benefits

- **Gain new insights into flow physics**
  - **Example: Ultrasonically Absorbing Coating (UAC)**
- **Develop novel integration methodologies**
  - **Low order model representation**
  - **Incorporate PIV as initial condition in CFD**

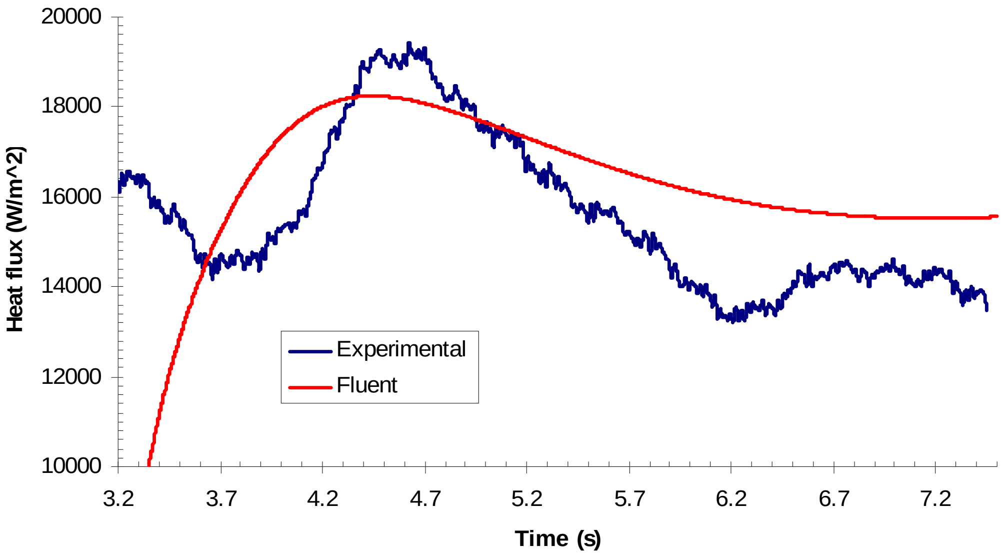
Study of Heat Transfer Augmentation under Large-Scale Freestream Turbulence*

Time-Resolved DPIV Measurements of 2-D Velocity Field Normal to a Plate



Vlachos, VA Tech (2007)

Time-Resolved Simulation of Experimental Heat Transfer



Experimental velocity used as initial condition for CFD model to predict the time-resolved wall heat flux

*Supported by NSF

Integrated Fluid Dynamics (IFD): Benefits

- Gain new insights into flow physics
  - Example: Ultrasonically Absorbing Coating (UAC)
- Develop novel integration methodologies
  - Low order model representation
  - Incorporate PIV as initial condition in CFD
- Cut time & cost for technology development/transition
  - Use TFD, CFD for parameter sweep to refine EFD reqmts
  - Incorporate UAV flight test data
- Enable multi-scale analysis and design
  - Move from low to high Re#
  - Incorporate lower order techniques for design

Integrated Fluid Dynamics: Methodology

- Integration can occur on many levels
- Goal is to move beyond CFD-EFD data comparison
- Take advantage of strengths of TFD, EFD, CFD
  - TFD seems under-utilized but may provide great insight
  - Once validated, CFD can be used for numerical “experiments”
  - Flight test
- Low Re# flows allow max use of analysis tools
- Innovation key for successful integration

Future Directions/Emphasis

- Encourage PIs to creatively integrate analysis tools
  - Funded efforts must address IFD
  - Collaboration crucial for success
- Establish successful case studies for methodology
  - Emphasize IFD process used to get results
  - Organize focused reviews/workshops/conferences
  - Adopt standard procedures for successful IFD
- Utilize national data repository to enable IFD analysis