

# The Aerospace Systems Design Laboratory

*Welcomes*

## The FAA and the CLEEN Consortium

Prof. Dimitri Mavris  
Boeing Endowed Professor in  
Advanced Aerospace Systems Analysis

Director

*Aerospace Systems Design Laboratory (ASDL)  
School of Aerospace Engineering  
Georgia Institute of Technology*

# Georgia Institute of Technology

---

- ❖ Founded in 1885 as an answer to the state's need to create change to enable the state's economy to benefit from the growth of new technology
- ❖ Georgia Tech is consistently ranked 3rd or 4th best college of engineering in the country based on US News & World Report
- ❖ Georgia Tech has 7 colleges offering 32 Undergraduate Degree programs, 49 Masters Programs, 28 Doctoral Programs
- ❖ FY2007 sponsored research awards: \$374 million, more than double the amount of a decade ago

	Georgia Tech	AE*	ASDL
Undergraduate	13,000+	696	50
Graduate	5,296	477	215
Total	19,000+	1,173	265



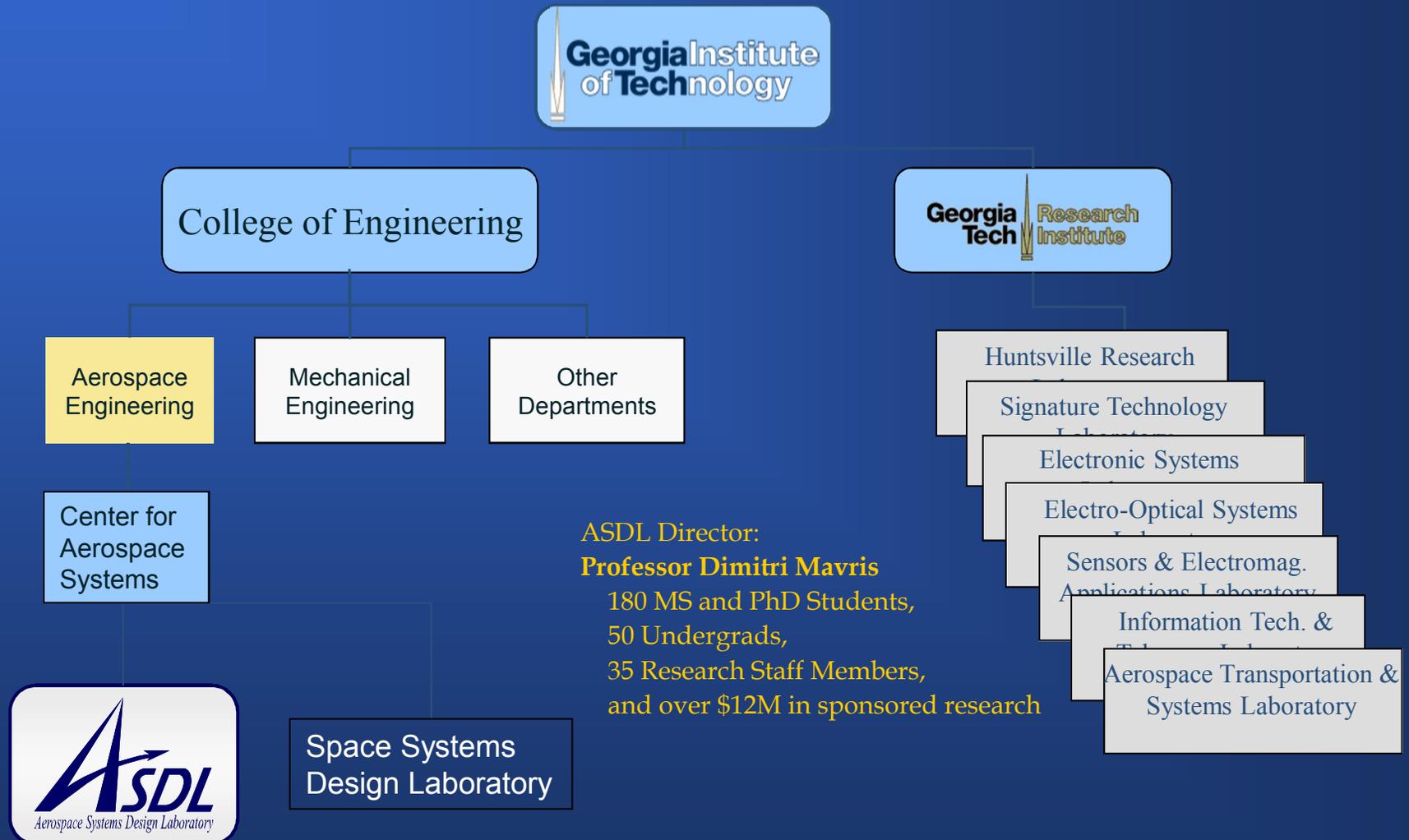
# School of Aerospace Engineering

---

- ❖ The Guggenheim School of Aerospace Engineering is one of the original 7 Aeronautical Schools created by the Guggenheim Foundation
- ❖ The school has been on the forefront of technology for Aerospace Engineering since inception in 1930
- ❖ Graduate students generally specialize in one or two of the following research areas:
  - Structural Mechanics and Material Behavior
  - Aerodynamics and Fluid Mechanics
  - Aero-elasticity and Structural Dynamics
  - Flight Mechanics and Controls
  - Propulsion and Combustion
  - **Systems Design and Optimization**



# Georgia Tech Program Organization



# Current ASDL Organization and Staff: 2010

**Director**  
Prof. Dimitri N. Mavris

## Affiliated Academic Faculty

Prof. Robert Loewy  
Prof. Dan Schrage  
Prof. Mark Costello  
Prof. Vitali Volovoi  
Prof. Brian German  
Prof. Massimo Ruzzene

## Research Staff

Dr. Bruce Ahn	VTOL Analysis
Dr. Santiago Balestrini	Naval Systems
Dr. Simon Briceno	Game Based Decision Support
Mr. Graham Burdette	Technology Assessment
Dr. Kyle Collins	Rotorcraft MDO
Mr. Russell Denney	Propulsion Methods
Mrs. Rebecca Douglas	Military Systems of Systems
Dr. Stephane Dufresne	Requirements Analysis
Dr. Scott Duncan	Energy Systems
Dr. Elena Garcia	Affordability and Mobility
Dr. Hernando Jimenez	Operational-Environmental Analysis
Mr. Carl Johnson	Design, Build, Fly-UAVs
Dr. Brian Kestner	Propulsion Design and Optimization
Dr. Michelle Kirby	Strategic Technology Planning
Dr. Young -Ki Lee	Aircraft Design and Performance

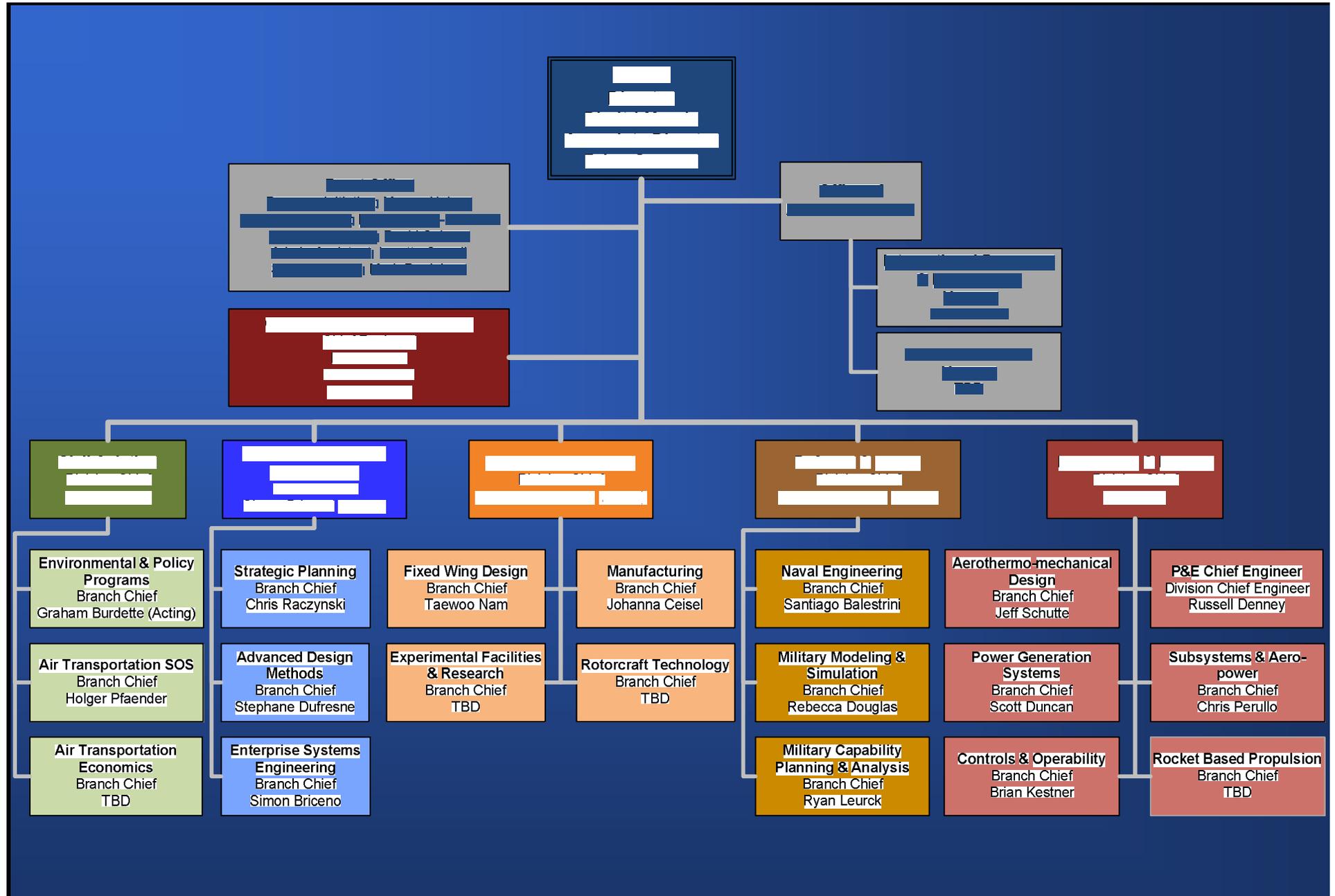
## Research Staff

Dr. Ralph Latham	Computational Specialist
Mr. Ryan Leurck	Missile Systems
Dr. Jung-Ho Lewe	Agent Based Modeling
Dr. Yongchang Li	MCDM, Rotorcraft Design
Dr. Dongwook Lim	Family of Systems
Dr. Zhimin Liu	Structural Reliability
Dr. Taewoo Nam	Aircraft Sizing and Synthesis
Mr. Chris Perullo	Propulsion Design
Dr. Holger Pfaender	System Dynamics
Dr. Chris Raczynski	Strategic Portfolio Planning
Dr. Hongjun Ran	MDO/MDA, Propulsion Simulation
Dr. Jeff Schutte	Civil Aviation Technology Evaluation
Dr. Jimmy Tai	Propulsion Systems Design
Dr. Neil Weston	Structural Design
Dr. Ping Yang	Combustion

## ASDL Administration

Mrs. Loretta Carroll	Administrative Assistant
Mr. Mark Danielson	System Administration
Ms. Marisol Haulthaus	ASDL Program Manager
Ms. Megan Halsey	Program Initiation Manager
Mr. David Selman	Financial Manager

**180 Graduate Research Assistants    50 Undergraduate Researchers**



# ASDL Affiliated Academic Faculty



❖ Prof. Robert Lowey  
Senior Technical Advisor

❖ Prof. Mark Costello  
Sikorsky Associate Professor

- Flight Mechanics & Controls
- Autonomous Control
- Rotorcraft Design

❖ Prof. Brian German  
Assistant Professor

- Propulsion Design
- Design Theory



❖ Prof. Daniel Schrage  
Professor, CASA Director

- Rotorcraft Design
- Certification

❖ Prof. Massimo Ruzzene  
Associate Professor

- Smart Structures
- Structural Health Monitoring
- Vibration & Noise Control

❖ Prof. Vitali Volovoi  
Assistant Professor

- Reliability & Safety
- Certification



## Strong Enrollment & Quality Graduates

---

### ASDL incoming class enrollment (Fall 2010)

- ❖ Median undergraduate GPA 3.82.
- ❖ 250 applicants. 40 students with a 4.0 GPA, 35 with a 3.9 GPA.
- ❖ 55 students accepted
- ❖ 50 US citizens and 5 international students

### High quality graduates (1992-2010)

- ❖ 550 students have graduated through the program
- ❖ 80 PhDs awarded
- ❖ 180 students currently in the program, 70 PhDs within 1-2 years of graduation

## ASDL External Advisory Board 2009 - 2010

Dr. Gary Seng*	EAB Co-Chair, NASA Glenn
Mr. Bob McKinley	
Mr. Brett Anderson	Boeing St. Louis
Dr. Kevin Bowcutt	Boeing-Long Beach
Mr. David Brown	AFRL
Ms. Kelly Cooper	Office of Naval Research
Mr. Vinod Philip	Siemens
Mr. David Eames	Rolls Royce
Mr. Yuri Gawdiak	JPDO
Mr. John Griffith	Boeing St. Louis
Mr. Bill Kimmel	EAB Co-Chair, NASA Langley
Dr. Viren Kumar	GE Energy
Mr. Dale King	Airbus
Mr. James MacLeay	BAE Systems, Inc.
Dr. Lourdes Maurice	FAA AEE
Dr. Mike McCoy	Boeing, St. Louis
Mr. Jim Phillips	Lockheed-retired

Mr. Lou Cerone	General Electric Energy
Mr. Anthony Maiello	GE Energy Services
Mr. Denis Mrozinski	AFRL-MDTC
Mr. Robert Nelson	Raytheon Missile Systems
Mr. Om Sharma	UTRC
Dr. David Parekh	United Technologies
Mr. Robert Plencner	NASA Glenn RC
Mr. Tony Seman	ONR
Mr. Phil Fahringer	Lockheed Martin Aeronautics
Mr. Richard Shaw	Boeing, Phantom Works
Dr. Joe Shaw	NASA Glenn RC
Dr. Shiva Shivananda	Northrop Grumman
Mr. Larry Schneider	Boeing Commercial
Mr. Brent Staubach	Pratt & Whitney UTC
Mr. Casey Litaker	Vought Aircraft
Mr. James Williams	FAA Systems Engineering
Mr. Rob Wolz	Gulfstream (Gen. Dynamics)
Ms. Christine Zemsky	GE Energy

# ASDL's Unique Mission

---

## ❖ **ASDL Mission**

- Produce well trained System Analysts, Engineers and Technologists for immediate deployment in academia, industry, and government
- Develop strong strategic partnerships with counterparts in Industry and Government
- Use these relationships to study problems of fundamental interest to both
- Promote student participation in IPT and IPPD teams, internships with industry/government, and national design competitions

## ❖ **Focus of the Research Program:** Formulation, development, and implementation of comprehensive approaches to the design of affordable and high quality complex systems, emphasizing:

- Interdisciplinary research, both within the schools at Georgia Tech and through the formation of alliances with other universities, industry, and government
- Technology research, development and integration
- Disciplinary breadth and depth while accounting for uncertainty and risk
- Multi-disciplinary analysis, optimization and design
- Reduction of analysis, design process cycle time
- Physics-based analysis and design of unconventional vehicles
- Systems of systems, architecture-based systems engineering

# Cultural Changes in Academia

---

## Organizational

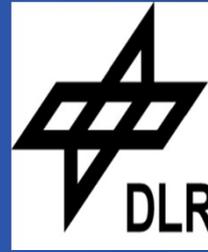
- ❖ Research done under strict proprietary and non-disclosure agreements
- ❖ Formation of separate proprietary labs for each partner
- ❖ Negotiating intellectual rights with industry
- ❖ Emphasis on U.S. citizen recruitment
- ❖ Utilization of company owned tools, methods, and best practices
- ❖ Transition from primarily grants to a mix of grants and contracts

## Education and Research

- ❖ Balance between breadth and depth in Ph.D. graduate research
- ❖ Economics & Manufacturing treated side-by-side with traditional disciplines
- ❖ Creating a new curriculum that transcends traditional boundaries
- ❖ Transition from single-discipline to multi-discipline, integrative research (to break down the barriers between university “stovepipes”)
- ❖ Transition from a reliance on historical data to physics-based formulations
- ❖ Move from deterministic, single-point to probabilistic, parametric solutions
- ❖ Transition from single-objective to multi-objective optimization

# ASDL Strategic Partnerships

---



- ❖ Strategic Partnership with Boeing for 21<sup>st</sup> Aerospace Manufacturing
- ❖ University Strategic Alliance (USA) partner with General Electric Energy for Systems Design and Optimization
- ❖ Member of the Partnership for AiR Transportation Noise and Emissions Reduction (PARTNER) consortium under the FAA
- ❖ DLR Cooperation agreement for Civil Aviation Research
- ❖ Pratt & Whitney Center of Excellence in aero-propulsion and power

## Centers of Excellence

---



University Strategic Alliance (USA) in partnership with General Electric General Electric Aircraft Engines and presently Energy in Systems Design and Optimization



Partner in the Partnership for Air Transportation Noise and Emissions Reduction (PARTNER) under the FAA



National Aeronautics and Space Administration University Research Engineering Technology Institute (URETI) on Aero-propulsion and Power Technology (UAPT)



Pratt & Whitney Center of Excellence in Aero-propulsion



Boeing Strategic Partnership for 21<sup>st</sup> Century Aerospace Manufacturing.

# Our Sponsors – Worldwide Support



## Strategic Alliances – Software Development

---



Georgia Tech School of Interactive Computing  
Graphics, Visualization, Usability (GVU) Center

# Advanced Method Development Scale

In a breakdown analogous to NASA/DoD's Technology Readiness Levels (TRLs), the following Advanced Methods Readiness Levels (AMRLs) hierarchical approach to research has emerged as a useful construct at ASDL:

## Method Implementation

- Full System Prototype
- Actual System in Application Domain
- Real World, Industrial Applications
- Stakeholder Involvement
- Utilization, Integration and Automation of Actual Tools and Processes

## Method Development

- Application Formulation
- Proof-of-Concept Implementation
- Unification of Theory
- Automation, Tool Development
- Creation of Tutorial Material

## Formulation Phase

- Basic Principles, Fundamentals
- Analytical Formulation
- Cross-Fertilization of Elements
- Method Initial Formation
- Initial Testing



# Introducing the Concept of Visual Analytics

---

- ❖ **Challenge:** How to analyze overwhelming, disparate, and dynamic information
- ❖ **Analytics** is the “science of analysis” to discover and understand patterns
  - Uses statistical tools and methods
  - Primary goal is to understand the past to predict the future
- ❖ **Visual Analytics** is “the science of analytical reasoning facilitated by interactive visual interfaces”\*
  - Provides a mechanism for a user to see and understand large volumes of information at once
  - The brain can best process information received through visual channels
  - Facilitates discovery of unexpected trends and highlights transparency of underlying physical phenomena
  - Used to synthesize information and derive insight from unmanageable data sets
  - Leveraged by:
    - Analytical Reasoning
    - Visual Representation and Interaction Techniques
    - Data Representations and Transformations

Visualization aids decision making on otherwise insurmountable problems

# Collaboration and Integration in Design

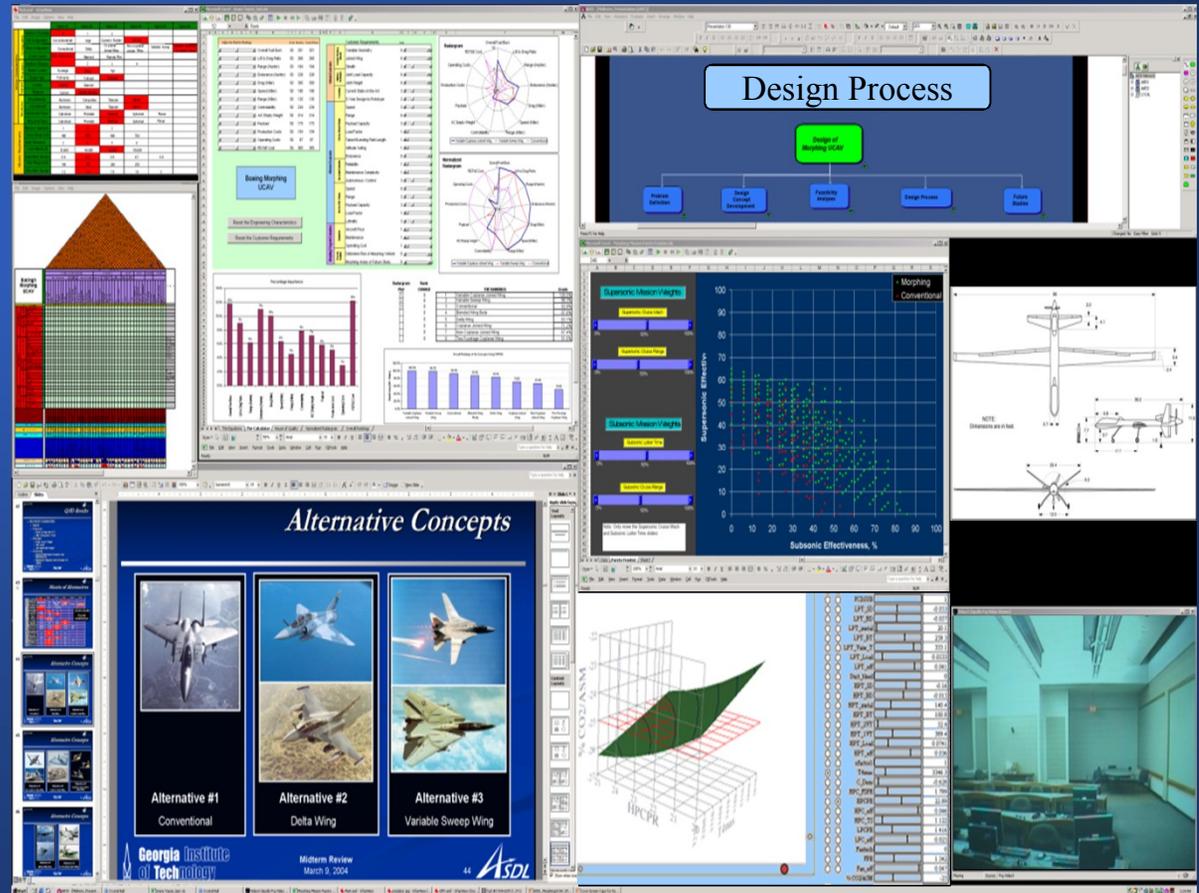
- ❖ Design is, by nature, a collaborative endeavor
- ❖ Facilities to support integrated design and visualization are becoming more affordable
- ❖ Courses that encourage collaboration and the use of new web technologies are needed
- ❖ Design competitions are a good way to foster education in collaborative design methods



Collaborative Visualization Facilities are Becoming Affordable and Widespread

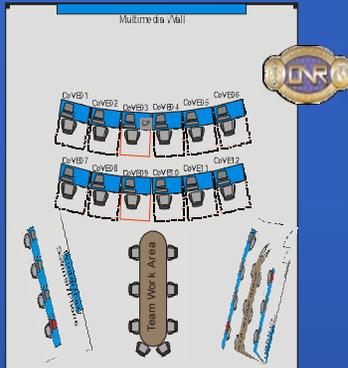
# Interactive Electronic Design Reviews

- ❖ Interlinking data on a large format visualization wall allows decision makers to interact with engineers
- ❖ Surrogate models, probabilistic techniques, and defined interface standards are required
- ❖ The speed of the decision-making/design process is dramatically enhanced

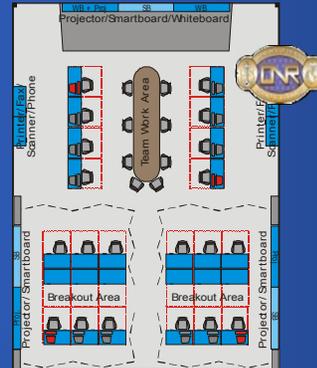


Interactive Design Reviews Allow Instantaneous Trade Studies

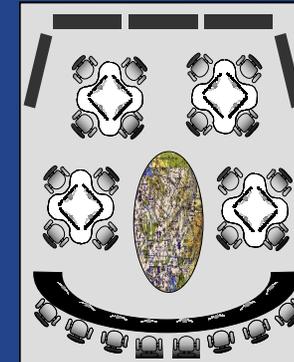
# GT ASDL Infrastructure and Design Facilities



**Collaborative Visualization Environment (CoVE) 2004**  
Electronic and Interactive Design Reviews



**Collaborative Design Environment (CoDE) 2009**  
Collocated Subject Experts



**Technology and Environmental Policy Trade-offs**  
Operations Planning, Real Time Analysis, 2010



**High Powered 256 Processor Computing Cluster - 2005**



**Classified CoVE Facility In GCATT Building (Atlanta) 2006**



**CoVE Capability Linked to all GTRI Field Offices 2006-2008**