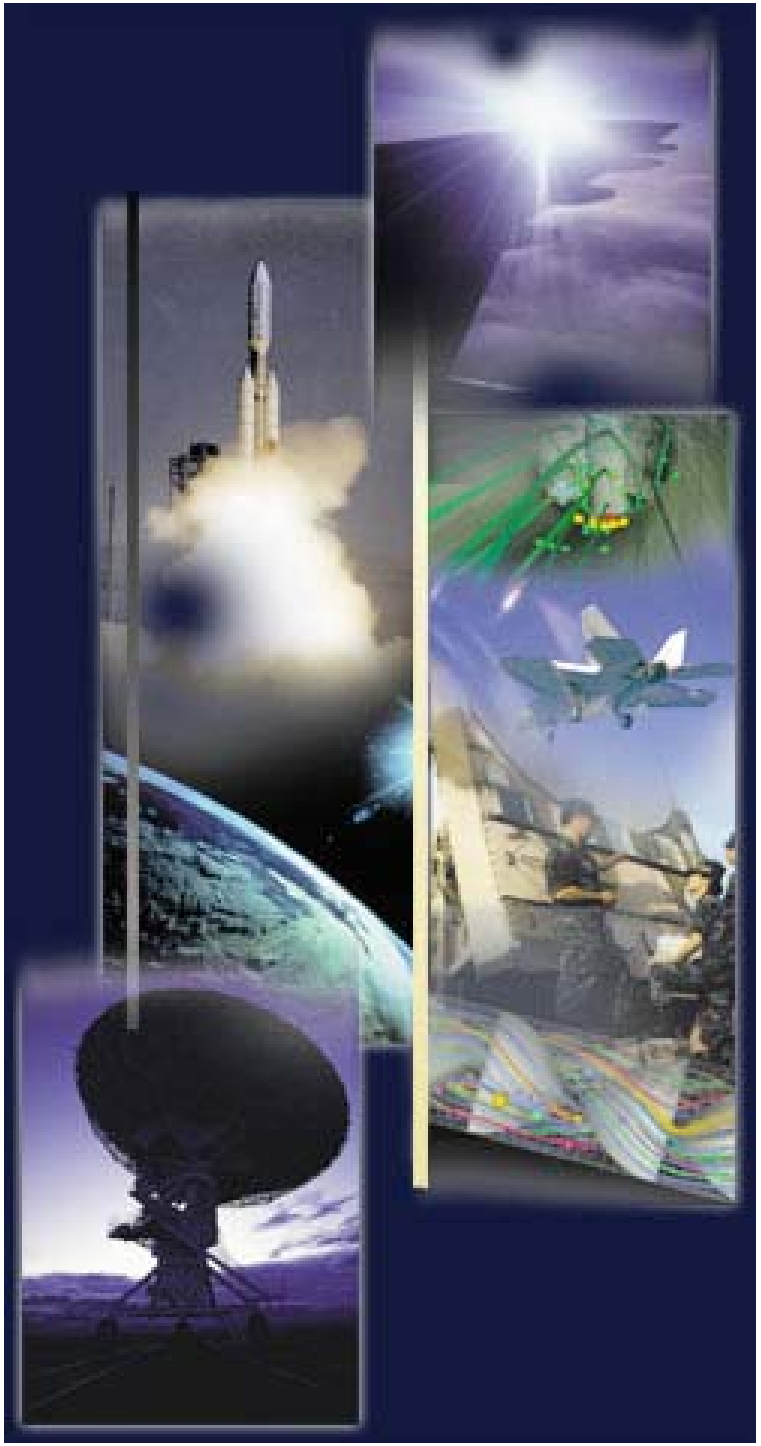


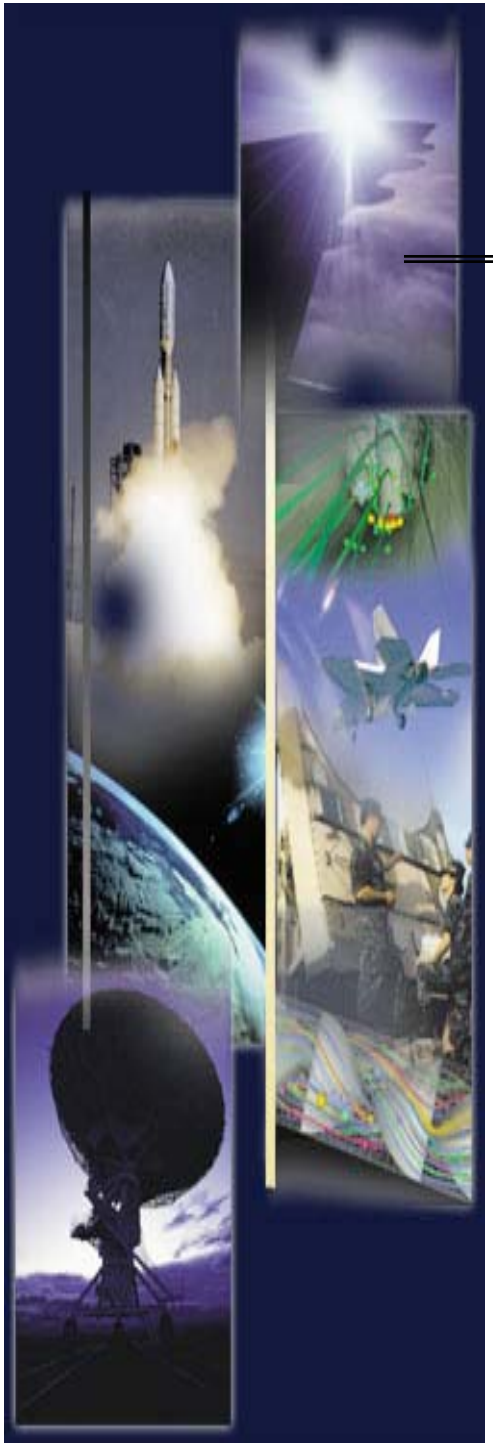
Challenges for Aeronautics in the U.S. and the Role of AIAA

Toronto, Ontario, Canada

June 6, 2005

Roger L. Simpson

President



Topics To Be Covered

- **Economic and Competitiveness Issues**
- **US Government Proposals and Response**
- **Nature of Basic Research**
- **Some Technical Areas for Research**
- **Role of AIAA**
- **AIAA Strategic Plan**
- **What you can do**

Challenge for Researchers

A principal challenge for the U.S. aeronautics endeavor is to have sufficient R&D resources sustained over the short and long terms to remain competitive in the global marketplace.

Nothing can be taken for granted. Engineers cannot be passive. We must communicate the proper course of action.

Without R&D funding, the research and innovation endeavor shrinks, US technologies become obsolete, our economy shrinks, and the standard of living declines.

"The U.S. will not be a fun place without R&D funding."

Economic and Competitiveness Issues

Floyd Norris, NY Times, January 14, 2005:

"U.S. Tech Exports Slide, but Trash Sales Are Up."

Change in U.S. Exports for most recent 12 months versus 1999:

Advanced technology products: -21%

Scrap and waste: +135%

- **U.S. Trade Deficit is now $650 Billion per year.**
- **U.S. Aerospace Industries Trade Surplus is $32 Billion per year, but shrinking. Less than 50% world market share.**
- **U.S. Federal Budget Deficit is about $520 Billion per year.**

IT MAKES ECONOMIC SENSE TO INVEST $1B IN AERONAUTICS R&D EACH YEAR TO MAINTAIN THE AERO TRADE SURPLUS AND REDUCE THE LONG-TERM TRADE AND FEDERAL BUDGET DEFICITS.

- **Over half of aerospace students in U.S. are non-U.S. citizens. Many cannot find jobs in U.S. because of ITAR and/or US Citizenship issues – have to go home – or the EU. US loses talent.**

"If you are holding on for dear life, the left hand and the right hand had better well be doing their parts."

Economic and Competitiveness Issues

Multiple studies have linked over 50% of US economic growth over the past 50 years to technological innovation.

"Thriving in a World of Challenge and Change"

National Innovation Initiative Report - Dec. 2004

Developed by over 200 national leaders from universities, industry, and government. Basically, the U.S. must either "Innovate or Abdicate".

"Over the next quarter century, we must optimize our entire society for innovation."

"Stimulate high-risk research; restore DoD commitment to basic research by directing 20% of S&T budget to long-term research."

Recommends scholarships, educational opportunities to develop TALENT.

Recommends R&D INVESTMENTS, tax incentives, reductions in tort litigation.

Recommends INFRASTRUCTURE development.

"You can't expect to hit the jackpot if you don't put a few nickels in the machine." Flip Wilson on his TV Show, Oct. 28, 1971.

Economic and Competitiveness Issues

National Academy of Engineering Report (Preliminary) 2005

Assessing the Capacity of the U.S. Engineering Research Enterprise

"… worrisome trends are adversely affecting the U.S. capacity for innovation. These trends include:

- ***A disciplinary skewing of the nation's research priorities away from engineering and physical sciences and toward the life sciences;***

- ***continuing erosion of the engineering research infrastructure;***

- ***a relative decline in the interest and aptitude of American students in engineering and other technical fields;***

- ***and growing uncertainty about our ability to attract and retain gifted science and engineering talent from abroad at a time when foreign nationals constitute a large and productive fraction of the U.S. R&D workforce."***

European Vision 2020 (Jan. '01)

- **Focused on world aerospace leadership over U.S.**

  "In 2020, European leadership will be evident on aircraft throughout the world. The industry in Europe is (will be) the leading developer and supplier of avionics systems and its engines and systems."

  -- Aircraft

  -- Power Plants

  -- Systems

  -- Air Traffic Management

  "Such has been (will be) the success of the 'European solution' for ATM, that a defacto world standard has been created."

- **Estimated funding of 95B Euros ($120B) over 20 years**
- **Significant competition to U.S. industry**
- **Congressional awareness**
- **The EU is already even or ahead in some areas, including Basic Research**

Federal R&D Budgets - FY 2006

- **Stated Goals by Administration and Congress for DoD Science and Technology Budgets – 3% of overall DoD Budget or $13.4B for FY06**

- **Administration FY 2006 request for DoD S&T is $10.52B**
  $2.55B or 19.5% less than FY 2005 appropriation
  Covers 6.1 (basic research), 6.2 (applied research), 6.3 (advanced technology development)

"The first essential of Air Power is pre-eminence in research."
- Gen. Hap Arnold

- **Dept. of Energy Basic Energy Sciences FY 06 Budget – ZERO**

- **National Science Foundation Budget – FY06 3% increase,**

BUT, many current researchers that are cut off by DoD, DoE and NASA have little chance for funding – only about 1 of 15 worthy proposals are currently funded! 70% of funds go to special programs.

Administration NASA Aeronautics Budgets

PROJECT	FY04	FY05	FY06	FY07	FY08	FY09	FY10	Project Total
Safety and Security	183.1	185.4	192.9	173.5	170.5	176.2	176.3	**1,257.9**
Airspace Systems	232.3	152.2	200.3	180.5	174.6	177.9	175.7	**1,293.5**
Vehicle Systems	641.4	568.6	459.1	373.6	385.5	373.5	365.6	**3,167.3**
FY TOTAL	**1,056.8**	**906.2**	**852.3**	**727.6**	**730.6**	**727.6**	**717.6**	**5,718.7**

Aviation Safety and Security and Airspace Systems proposed funding is about flat.

Vehicle Systems Reductions: $109.5M (19.3%) for FY06; $195M (34.3%) for FY07.

Some Impact of Adm. NASA Aero Budgets

NASA Langley Research Center – from $616M for FY05 to $557M for FY06 and $479M for FY07. Advanced designs and use of composites in aviation construction could be shut down. About 700 jobs to be eliminated.

NASA Glenn Research Center - from $640M for FY05 to $520M for FY06. Leader in developing quieter, cleaner, more fuel-efficient engines. About 700 jobs to be eliminated.

NASA Ames Research Center - leader in air traffic management technology. Buyout offered to 1400 of 1470 employees.

Research activities to be terminated – ZERO BUDGET: Hypersonics, rotorcraft, improvements to engine efficiency.

14 Facilities, including 10 wind tunnels to be closed. (Rand Report, Nov. 2004, only recommended 2 out of 31 facilities be closed.)

Damaged morale, early retirements, loss of promising young people

Some Congressional Testimony, March 16, 2005

Dr. John Klineberg, Chair, Comm. to Review NASA's Aeronautics Technology Program, National Research Council, The National Academies. Commissioned by NASA and OMB.

12 key recommendations from the Nov. 2003 report supporting aeronautics. "… full-cost accounting will have an unintended effect on certain facilities and infrastructure that are national assets and will compromise the research program…."

Dr. Philip S. Antón, The RAND Corp., PI for "Wind Tunnels and Propulsion Test Facilities. An Assessment of NASA's Capabilities to Serve National Needs," 2004 (www.rand.org/publications/MG/MG178)

"Closing facilities needed for strategic reasons cuts off the country's options for R&D of current and future concepts and vehicles."

"It would be detrimental to close 29 of 31 NASA test facilities that serve national needs."

"Relying on foreign facilities incurs serious security risks, and unclear access and availability risks."

Recommends that NASA: develop an aero. test technology vision and plan, stop full-cost accounting of WT/PT facilities, and very selectively consolidate and broadly modernize existing facilities.

Comments on Capabilities

As mentioned by Dr. Antón: Computational capabilities and modeling have not yet achieved sufficient reliability for all practical cases in order to totally replace wind tunnel results.

Some conclusions are too early to make, e.g.:
"I have solved the problem of the turbulent boundary layer."
Guest Seminar Lecturer, Stanford University, 1965.
"Wind tunnels will be used to store printouts." A&A, 1975.

Some proposed NASA facility reductions are premature.
Boeing quote (Nov. '04):
"We are outsourcing a significant part of the wind tunnel testing of our new aircraft designs to overseas facilities because our domestic facilities are not adequate as regards power and Reynolds Number."

We need better wind tunnel facilities & instrumentation – NOT LESS!

National Institute for Aerospace (NIA) Report –April 2005

Congress asked NIA to lead the development of a 5-year Aeronautics Research Plan and Budget for NASA.

Involved over 250 experts from academia and industry.

National needs addressed:

Competitiveness

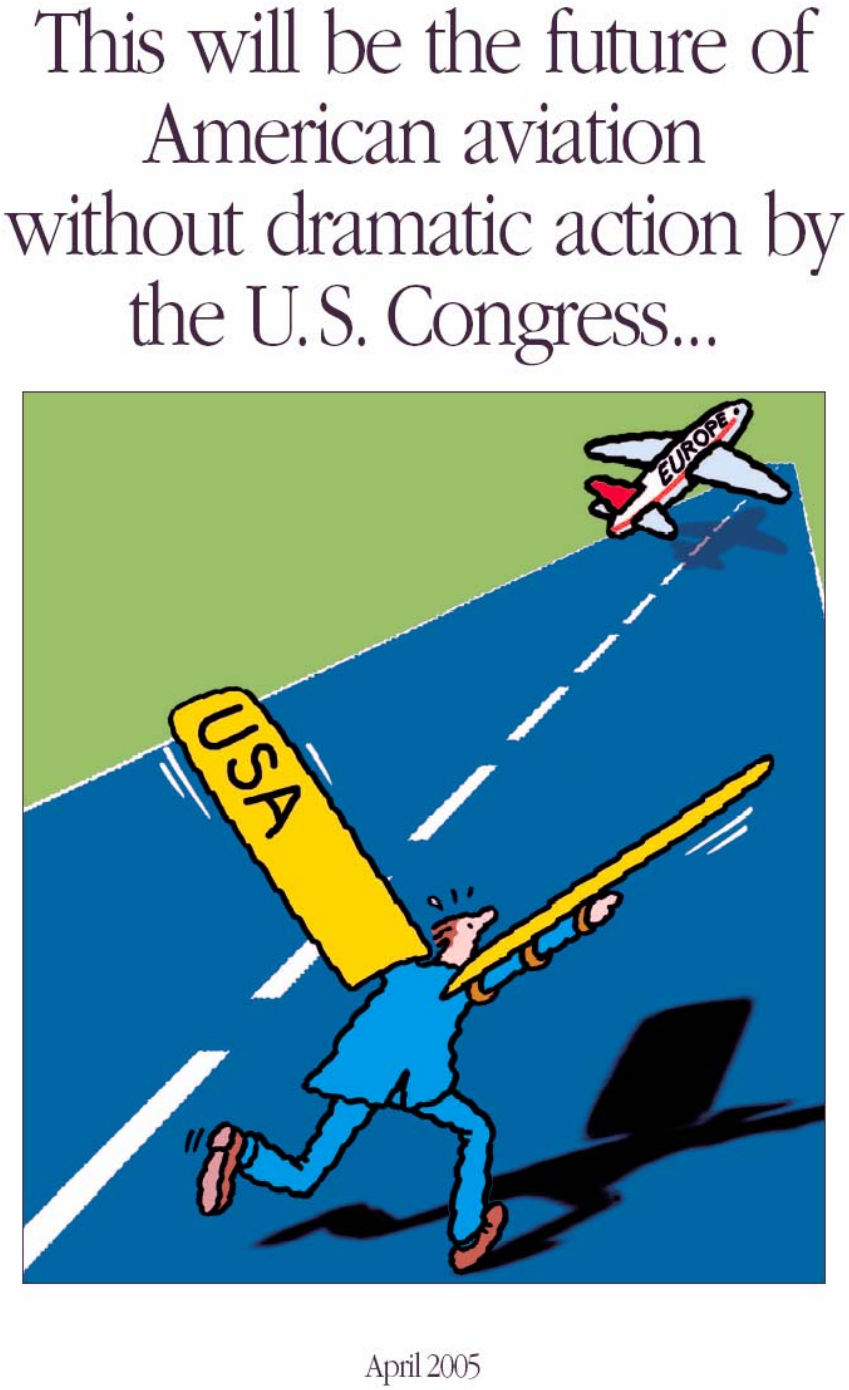
Freedom of air travel

Flight safety

Secure and defend the nation

Protect the environment

Educate the future workforce



National Institute of Aerospace Report –April 2005

www.aiaa.org; → Public Policy; →Policy Watch

"Due to a lack of significant and stable funding in long-term research, the centroid of aviation technical and market leadership is shifting outside the United States."

"Why NASA? Aviation research requires unique national facilities, and world-class researchers that cannot be resident in any one company. The fruits of this research add to the nation's wealth, not that of any individual company."

Budget reductions "… mean that universities may well become the only repositories of domestic aeronautics research. Therefore, it is imperative that U.S. research universities have the resources necessary to train U.S. citizens so that they are able to make fundamental discoveries that will define the future course of aeronautics. … proposes… to support 400 graduate students per year. "

RLS Comment : UNLESS FACULTY AND THEIR LABS ARE SUPPORTED TOO, THEN THE UNIVERSITIES WILL NOT BE REPOSITORIES OF AERONAUTICS RESEARCH EITHER!

National Institute of Aerospace Report –April 2005

- Seven critical aviation sectors:
  - Airspace systems
  - Aviation safety & security
  - Hypersonic flight technologies
  - Advanced rotorcraft technologies
  - Subsonic aviation
  - Supersonic technologies
  - Workforce and education
- More on technical areas later

Congressional Response for FY 2006

Bi-partisan support for aeronautics R&D

"The overall concern that I have is that, more and more, there are those who are trying to make NASA a single-mission agency, and that is not acceptable to people like me and others in Congress."
Congressman Sherwood L. Boehlert (NY), House Science Comm. Chair, March 16, 2005, Washington Post.

"There is a lot of concern that the investment in aeronautics R&D by this nation has been limping along for several years, and that there is a lack of a national strategy."
Congressman Ken Calvert (CA), Chair, Space and Aero. Subcomm., March 16, 2005, from Opening Statement of Congressional Hearing on NASA Aeronautics.

"It concerns me deeply that while we – the United States – are reducing our federal investment in aeronautics research, our competitors are increasing their aeronautics budgets."
Congressman Frank Wolf (VA), April 14, 2005, Press Conference.

Congressional Response for FY 2006

On May 12, 2005 Congressman Mark Udall (CO) introduced the "Aeronautics Research and Development Revitalization Act of 2005" HR 2358 with 8 bi-partisan co-sponsors.

Among other things it proposes for universities, industry and government:

- **R&D to reduce noise, energy use, emissions, including supersonic flight and rotorcraft.**
- **A Fundamental Research and Technology Base program that is not tied to specific development projects.**
- **An Airspace Systems Research program.**
- **An Aviation and Security Research program.**
- **Research programs directed towards developing and testing concepts for zero-emissions aircraft and unmanned aircraft for Mars.**
- **A broad program of research in hypersonics.**

Congressional Response for FY 2006

- A program of aeronautics scholarships for U.S. citizens to pursue graduate work in aeronautical engineering.
- Collaborative research with NOAA directed at significantly improving the reliability of two- to six-hour aviation weather forecasts.
- University-based centers for research on aviation training.
- An independent assessment of the Nation's wake turbulence R&D program.
- Relieves "Full Cost Accounting " for operation of NASA's aeronautical test facilities.

Provides a five-year funding plan for NASA's aeronautics program. Restores aeronautics funding to its FY 2004 level for FY 2006 ($1.057 billion) and increases funding by 3 percent per year through FY 2010 (to a level of $1.19 billion).

House Subcommittee on Science, State, Justice Appropriations - NASA Mark-Up on 5/24/05:

Proposed NASA funding at $16.5 billion, $275M above FY05, and $15M above the President's FY06 request.

- **Funds the President's Vision for Space Exploration at $3.1 billion.**
- **Restores the aeronautics research program to enacted level of $906M.**
- **Provides $40M over the request to partially restore NASA's science programs.**
- **Provides full request for the Space Shuttle program.**
- **Directs the President to develop a national aeronautics policy.**

The Bill is expected to go the full Committee on Tuesday, June 7, 2005.

Principles of Innovation and Research

Researchers need to emphasize the nature of Basic Research to the U.S. Government in order to restore an understanding that apparently has been lost .

Basic research should not be viewed as an optional national luxury that is funded sporadically and can be reduced or eliminated and then restored with the erroneous expectation of instantaneous positive results. (In earlier times, basic research budgets were respected.)

"The more advanced a technology and the more competitive the market, the more R&D resources that are required to stay in the business." Contrary to the idea that "mature areas" don't need R&D!

The country that does the basic research will be the country that reaps the benefits for its workforce and applications to competitive products.
"Don't look back. Something may be gaining on you."
Leroy (Satchel) Paige, 1953.

Principles of Innovation and Research

Individual visionary investigators are important.

"…someone who has been around the whole problem many times and thus acquired an overview which goes deeper than any other worker. That kind of overview is in my experience the real key to solid technical progress." Prof. S.J. Kline, Stanford University, personal letter, 1990, on "Values, Technology and Society".

Experience is important. Early retirements of the most experienced and productive researchers is a bad idea.

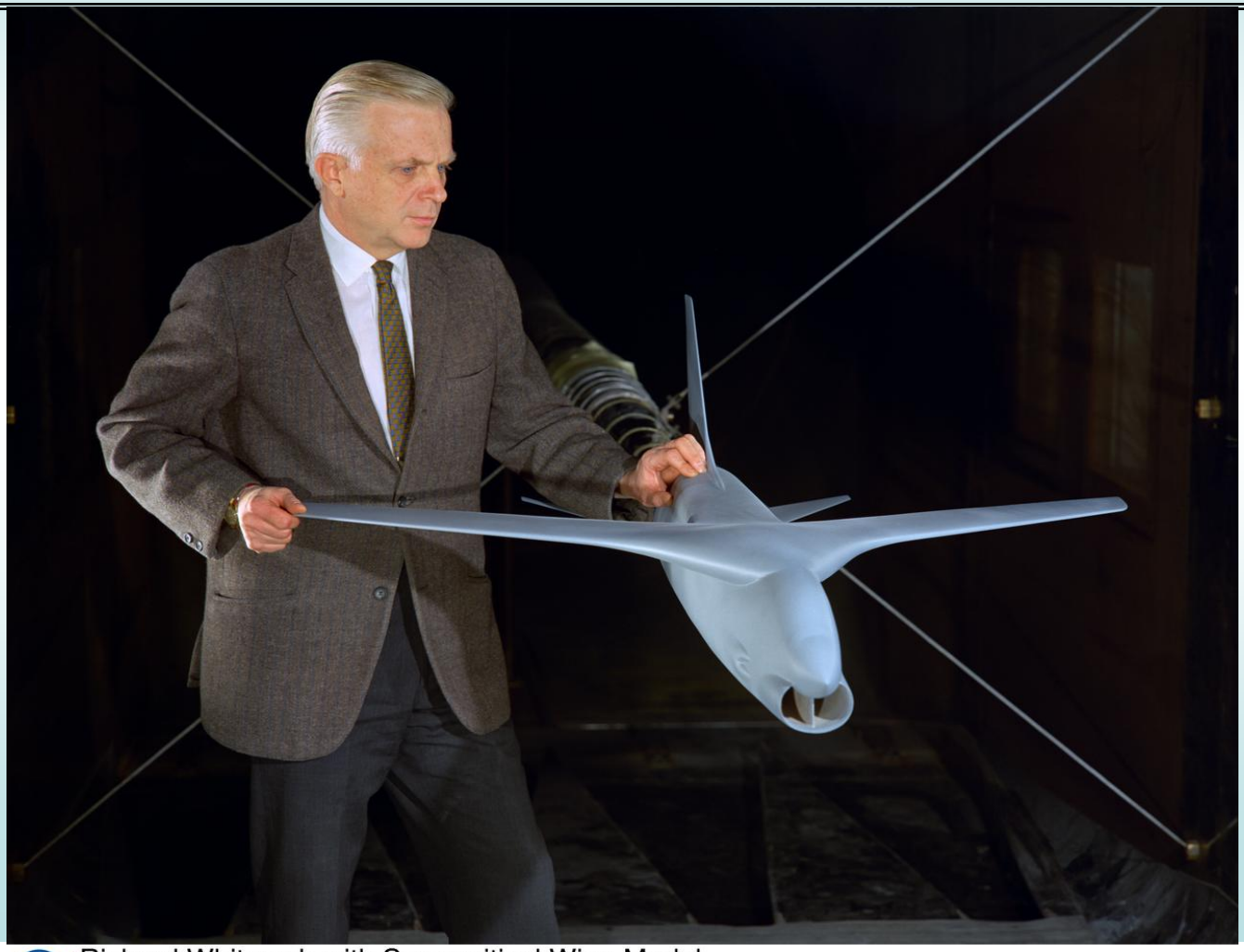
A great wealth of knowledge, experience, understanding, wisdom, and ideas for future innovations from individual investigators will be lost if U.S. Basic Research is not properly funded.

"In the high jump, we need one person who can jump 7 feet, not seven people, each of whom can jump 1 foot." Terman's Law (Frederick E. Terman, late Stanford University provost)

Richard T. Whitcomb – 37 years at NASA Langley

- Personal qualities that led to Innovations:
  - •Drive to find a better way to do everything.
  - •Intuitive abilities developed from years of experience.
  - •Lifelong dedication to his work.
  - •Vision to reach goals.
- Conceived of area-rule for transonic aircraft design around 1951
  - •Implemented in 1952 on F-102.
  - •Collier Trophy in 1954.
- Supercritical airfoil to reduce transonic airfoil drag 1965
  - • Iterative wind tunnel testing –"It's just easier that way."
  - • Filed model shape and retested model till it achieved goal.
- Probably not allowed to do this in today's environment of "Full Cost Accounting" of wind tunnels

Richard T. Whitcomb & Supercritical Wing Model



Richard Whitcomb with Supercritical Wing Model
NASA Langley Research Center 1/19/1970 Image # EL-2001-00478

Principles of Innovation and Research

Steady continuously funded programs based on merit and a competition of ideas are the most productive with new innovations.

It takes at least 10 times as long and 10 times the cost to recover a lost research area, than to keep it going for one more year.

Intense "crash" efforts over short periods are less likely to produce true innovations than steady programs with the same funding over a longer period.

Example: How many times has "hypersonics research" been funded and deemphasized in the past 40 years? Which researcher in his or her right mind, who worked hard to get up to speed and was cut off in the last funding cycle, would get involved in this again?

"Let's get 9 women on this and we will have that baby in 1 month."
Example of a crash program doomed to failure.

Principles of Innovation and Research

Interactive computations and experimental testing are required to more precisely define designs.

Elimination of some intermediate steps in the research and development process to save time and money is risky and often foolish. (Recall "Faster, better, cheaper.")

Optimization is best at the time when all systems are being designed and low uncertainty information is available.

"If you have time and money to do a job a second time, you have the time and money to do it correctly the first time."

"Take calculated risks. That is quite different from being rash."
Lt. Gen. George S. Patton in a letter to his son, Geo. S. Patton, IV, June 6, 1944 (D-Day), 61 years ago today.

Principles of Innovation and Research

Seasoned researchers and students alike need time and adequate resources to achieve results in high risk research. The period of funding must be greater than the gestation period.

One cannot always predict *a priori* which researcher will make great breakthroughs. Competition of ideas and approaches among researchers will lead to more sound results.

RLS Comment from first-hand experience: The EU has funded multiple independent groups to work on the same problem. The U.S. seldom does this anymore. Now it seems:

"If only 8% of the funded research produces innovations, then let's only fund those." From a newspaper Opinion/Commentary letter.

"If we knew what we were doing, it wouldn't be research."

Some Basic Research Technical Areas

Progressive Improvements in Basic Research Areas are needed to achieve goals of Seven Critical Aviation Sectors discussed in the NIA Report.

From personal experience and knowledge, the following are some timeless Basic Research areas with still a large potential to contribute to aeronautics innovations:

- **turbulence modeling and simulations for high Reynolds number flows, 3-D flows, separated flows, transonic, supersonic, and hypersonic flows.**
- **advanced flow field diagnostics for these flows.**
- **advanced instrumentation and signal processing.**
- **unsteady flows.**

Much advanced work in these areas is underway in the EU and elsewhere, so we have no time to waste.

Industry Concerns

- Every airplane that has made it to flight has had surprises of one kind or another. We need to be able to identify the potential problem and design it out before the vehicle ever flies. This requires a lot of wind tunnel test time and affordable high quality CFD analysis during the design phase. We can't do it today.
- The fundamental issue remains one of increasing vehicle performance under an increasing list of multi-disciplinary performance metrics or constraints. Survivability concerns drive complexity of design & analysis .
- High altitude surveillance requires airfoils that produce high lift coefficients at high transonic Mach numbers, and preferably support sustained laminar flows at the same time. Airfoil design using current high-end CFD tools would be…a fertile area for advancements.
- The development of capability to address the above concerns has been falling behind. Three aspects are particularly limiting: turbulence modeling, geometric complexity, and turnaround time for solutions.
- Long time between programs, retreat from supersonic and near-sonic airliners, poor ties between industry and universities, slow development pace for manned aircraft
- Long Development Cycle. F-22—20 years, JSF—12 years. Difficult to respond rapidly to changing threats

Industry Concerns

- Multidisciplinary optimization capabilities are required to facilitate design of complex configurations. Far more work is needed in integrating codes across various disciplines.
- Coupled Aero Technologies—aero-optics, aero-structural, aero-thermal—require improved simulation & optimization techniques
- Improved validation and verification of simulations is imperative for Simulation Based Acquisition and Capabilities Based Planning. Accurate models are essential to achieve credible results.
- Personnel: There is a need for an aggressive means to replenish and sustain the pool of technical talent required to maintain an industry that continues to find a multi-billion dollar a year market for its products and services.
- Infrastructure: It will soon be difficult to keep the current inventory of transonic/supersonic large scale wind tunnels open. Within a few years, we may be down to AEDC 16T and Ames 11 ft. Industry no longer has several on-going efforts to spread the business among several facilities. Having fewer facilities and qualified people to staff them creates an inability to respond in a timely manner to testing requirements, resulting in slipped schedules. This is happening right now.

Industry Concerns

- High Reynolds number testing: The DERA 15 Meter low speed facility would be closed if [US industry] were not paying to keep it open—and it's the only one of its kind outside Russia. For transonic/supersonic high Reynolds number testing, the NASA LaRC NTF productivity is essentially at a research level, so database construction testing is not feasible.
- It is easier to justify "focused" programs through budgetary cycles. However, we should strive to balance research efforts between aligning with the focused programs and the basic core development efforts. No matter what the product decisions are, the core R&T should not waiver from its directions and goals.
- CFD has become accepted for attached flows but is unreliable for determining the hinge moment and control surface characteristics in highly separated flows. LES and DNS do not seem capable of producing good engineering answers. Research in this area is mandatory.
- Basic aero research is important. Constraints on vehicle design have made it increasingly difficult to achieve performance increases. Furthermore, performance is demanded in a far larger part of the flight envelope. Research into new, innovative aero techniques for meeting demands under these constraints is significantly less in terms of real dollars than it has been.

Industry Concerns

- Specific Research Areas:
  - Turbulence modeling for separated flows
  - Transition prediction tools for wind tunnel & full scale
  - Rapid geometry parameterization
  - Plume flow field methods
  - CFD for S&C and control effectiveness predictions
  - Nonlinear CFD based Configuration Shape Optimization Methods
  - Sensitivity derivative methods
  - Integrated multidisciplinary optimization tools
  - Scale & Reynolds number effects on predictions
  - Prediction of separation point onset
  - Prediction of aero elasticity & separated flow induced unsteady aerodynamics
  - High fidelity prediction of high-lift aerodynamics
  - Low sonic boom configuration design process
  - Supersonic Laminar flow—prediction tools & control maturation
  - Active Flow Control, tools, actuators, closed loop control and large scale flight validation

Industry Concerns

- Specific Research Areas:
  - Morphing feasibility assessments & systems integration
  - Hypersonic aerothermodynamics
  - Hypersonic aerodynamic heating, transition, test techniques, multi-stage separation, real gas effects, propulsion
  - High fidelity sensors for wind tunnel and flight testing, including MEMS based & embedded sensors, transition sensors, unsteady loads sensors
  - Nanotechnology applications—flow physics, surface interactions, nano-molecular definitions of friction, transition, separation, etc.
  - Control devices for hypersonic weapons
  - Innovative approaches to Drag reduction
  - Accurate, fast prediction of unsteady flow
  - Accurate prediction of turbulence in all flow regimes
  - Problems associated with Abrupt Wing Stall, Tail Buffet, Download in Hover work but reduce range
  - CFD for Flow Control with small high frequency actuators is not available with current CPU power

Role of AIAA –The Forum for Aerospace

- **Mission - "To advance the arts, sciences, and technology of aeronautics and astronautics, and to promote the professionalism of those engaged in these pursuits."**
- **To achieve this mission, AIAA**
  - **encourages original research …**
  - **furthers dissemination of new knowledge …**
  - **fosters the professional development of those engaged in science and engineering …**
  - **improves public understanding of aerospace and its contributions … Public Policy Activities**
  - **fosters education in engineering and science …**
  - **promotes communication among engineers, scientists, and other professional groups …**
  - **and stimulates outstanding professional accomplishments.**

AIAA Aeronautics-Related Technical Activities

Technical Committees…

Aircraft Operations
Air Transportation Systems
Flight Testing
Aircraft Design
General Aviation Systems
Balloon Systems Technologies
Lighter-Than-Air Systems
V/STOL Aircraft Systems
Air Breathing Propulsion
Aero acoustics
Aerodynamic Measurement Technology
Atmospheric Environment
Fluid Dynamics
Aerodynamic Decelerator Systems
Applied Aerodynamics
Atmospheric Flight Mechanics
Guidance, Navigation & Control
Digital Avionics
Modeling & Simulation
Ground Testing
Structural Dynamics
Structures
Sensor Systems
New Emerging Technologies

Program Coordinators…

Aerospace Traffic Management
Unmanned Systems
HYTASP
Network-Centric Operations

AIAA Strategic Plan

- **3 Year, Institute-wide plan, updated annually**
- **Four core missions:**
  - **Communication / Advocacy**
  - **Products and Programs**
  - **Membership Value – AIAA is a members oriented organization**
  - **Market / Workforce Development**
- **Current Annual Funding -- $1.8M**

Samples of AIAA Activities

COMMUNICATIONS and ADVOCACY

- Coalitions – "Crisis in Aviation," et. al.
- Roundtables / Outreach
- AIAA Congressional Visits Day
- AIAA Public Policy Committee
- Testimony before Commissions
- Interactions with Congress
- Legislative Alerts, Policy E-News
- Alliances with other groups – Larger combined groups have greater impact on Public Policy
- Public Policy Sessions in Major Symposia

Samples of AIAA SP Contributions

PRODUCTS and PROGRAMS

- **New Committees**
  - **Emerging Technologies Committee**
  - **Network Centric Operations PC**
- **New Technical Journal – JACIC**
  (Journal of Aerospace Computing, Information and Communication)
- **Standards and Guidelines – UAV, RLV**
- **AIAA Electronic Library (Journals and Papers Archives)**
- **Redesigned AIAA Web site**
- **International Relationship Building**

What can you do?

Become active in the AIAA in one of the Mission areas.

Enlist other aerospace professionals to join our efforts within AIAA.

Contribute to the formulation of Public Policy recommendations to aid the future R&D efforts of the aerospace endeavor.

"We should all be concerned about the future because we will have to spend the rest of our lives there!"
Charles F. Kettering, CEO, General Motors Corp., "Seed for Thought," 1949.

What can you do?

Contact your Congressman and Senators and the Chairs of relevant Congressional Committees with your concerns NOW. The House Comm. on Science acts on June 7, 2005. – the full Congress has not yet acted.

Instructions with links to Congressional addresses, Sample letters, the "NIA Executive Summary", and the HR 2358 "Aeronautics Research and Development Revitalization Act of 2005" are located at

www.public.iastate.edu/~tomshih/NIA

I appreciate Prof. Tom Shih of Iowa State University for posting these items on his website.

Conclusions

There are many basic advancements to be made, if we are given the opportunities and sufficient R&D funding is spent on merit-based competitive programs.

"America always does the right thing – after it has tried everything else."

Sir Winston S. Churchill

Acknowledgements

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The views expressed here in this presentation are those of the author and have not been reviewed or endorsed by AIAA.