

Aeronautics Committee Report to the NASA Advisory Council

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October 6, 2010





Areas of Interest Explored at Current Meeting

Topics covered at the Aeronautics Committee meeting held on Sept 1-2 and Ames Research Center:

Airspace Systems Next Generation Air Transportation System (NextGen) research and development activities

NextGen Technology Transfer

Verification & Validation of Flight Critical Systems (VVFCS) Research and Development*

Data Mining and Human Factors activities in Aviation Safety*

Planned National Research Council Flight Research Study*

* These topics have related observations provided by the Aeronautics Committee

Ames Research Center: Aeronautics & Aviation



- Environmentally Responsible Aviation
- Air traffic control & management
- Automation technologies to reduce emissions
- Optimal routing of flights, automated separation assurance, and advanced aircraft control systems
- Advanced aircraft concepts
- Simulators
- Improved propulsion systems
- Wind tunnels

Ames Research Center: Aeronautics & Aviation Success Story



Air Traffic Management/ Air Traffic Control

- Traffic Management Advisor (TMA) has had significant positive impact on the National Airspace System (NAS)
- Estimated annual savings of \$400M/year to airlines

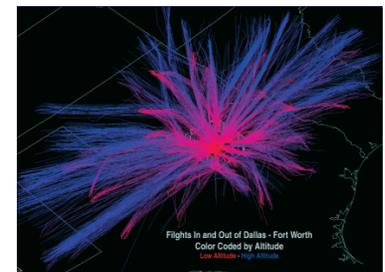


Airspace System Program (ASP)

Projects

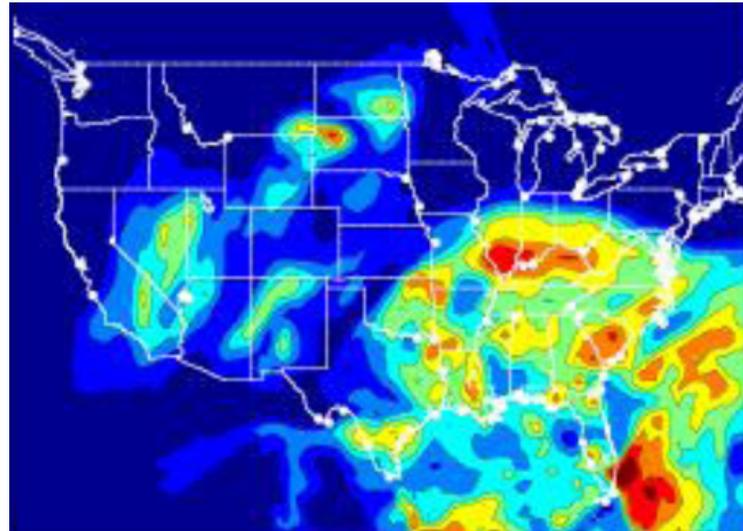
- NextGen Concept and Technology Development (CTD)
Project Goal:
 - Develop gate-to-gate concepts and technologies for NextGen to enable significant increases in capacity and efficiency

- NextGen Systems Analysis, Integration, Evaluation (SAIE)
Project Goal:
 - Facilitate the R&D maturation of integrated concepts through evaluation in relevant environments, provide integrated solutions, and characterize airspace system problem spaces, define innovative approaches, and assess potential system impacts and design ramifications of the program's portfolio



Specific ASP Research Example: Contrails

Contrails lead to increased earth temperature, but can be avoided.



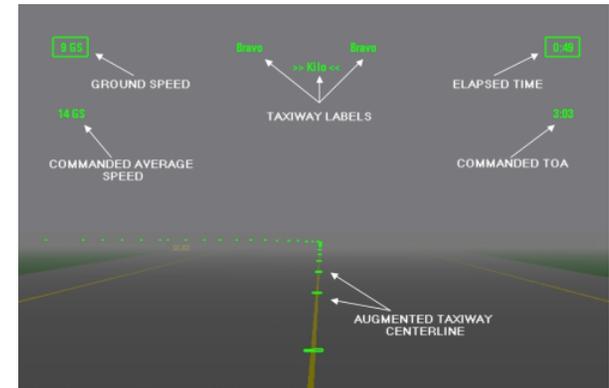
Research question:

But how is the extra fuel burn balanced against the environmental benefit?

NextGen Technology Transition

- NASA and the Federal Aviation Administration (FAA) have formed four *research transition teams* (RTTs) to facilitate successful transition of research technologies into an operational environment
 - Efficient Flow into Congested Airspace RTT
 - Integrated Arrivals/Departures/Surface Management RTT
 - Multi-Sector Planner (Trajectory Based Flow Management) RTT
 - Dynamic Airspace Configuration RTT

- Joint Achievement:
 - NASA/FAA joint field test at Denver for descent trajectory prediction accuracy
 - Results of field test showed that En Route Descent Advisor will increase fuel efficiency and meet-time accuracy
 - Technology transition package is in work





Summary of ASP NextGen Activities

- NextGen concepts and technologies are maturing
- Environmental research has been accelerated
- Research Transition Teams (RTTs) making progress toward initial technology product deliverables
 - Building appropriate level of management authorization and guidance on resources for RTT actions
- Actively engaged with Industry, academia, and government partners for both conduct and transition of research products
- Pursuing to engage broader joint activities with industry



Summary of VVFCS Research

- Four focal research areas
 - Argument-based safety assurance
 - Software Intensive Systems
 - Integrated Distributed Systems
 - Human/Automation Roles and Responsibilities
- Partnerships and collaboration with industry, FAA, JPDO, military and academia for coordinated and integrated research & development activities are essential
- Technology transfer at all levels
- Maintain relevancy by on-going communication with key players in community

Verification and Validation of Flight Critical Systems (VVFCS) Technical Challenge



Advance Safety Assurance to Enable Deployment of NextGen Systems

Develop safety assurance approach that unifies processes for ground based and airborne systems through a rigorous verification and validation process in a time and cost-effective manner.

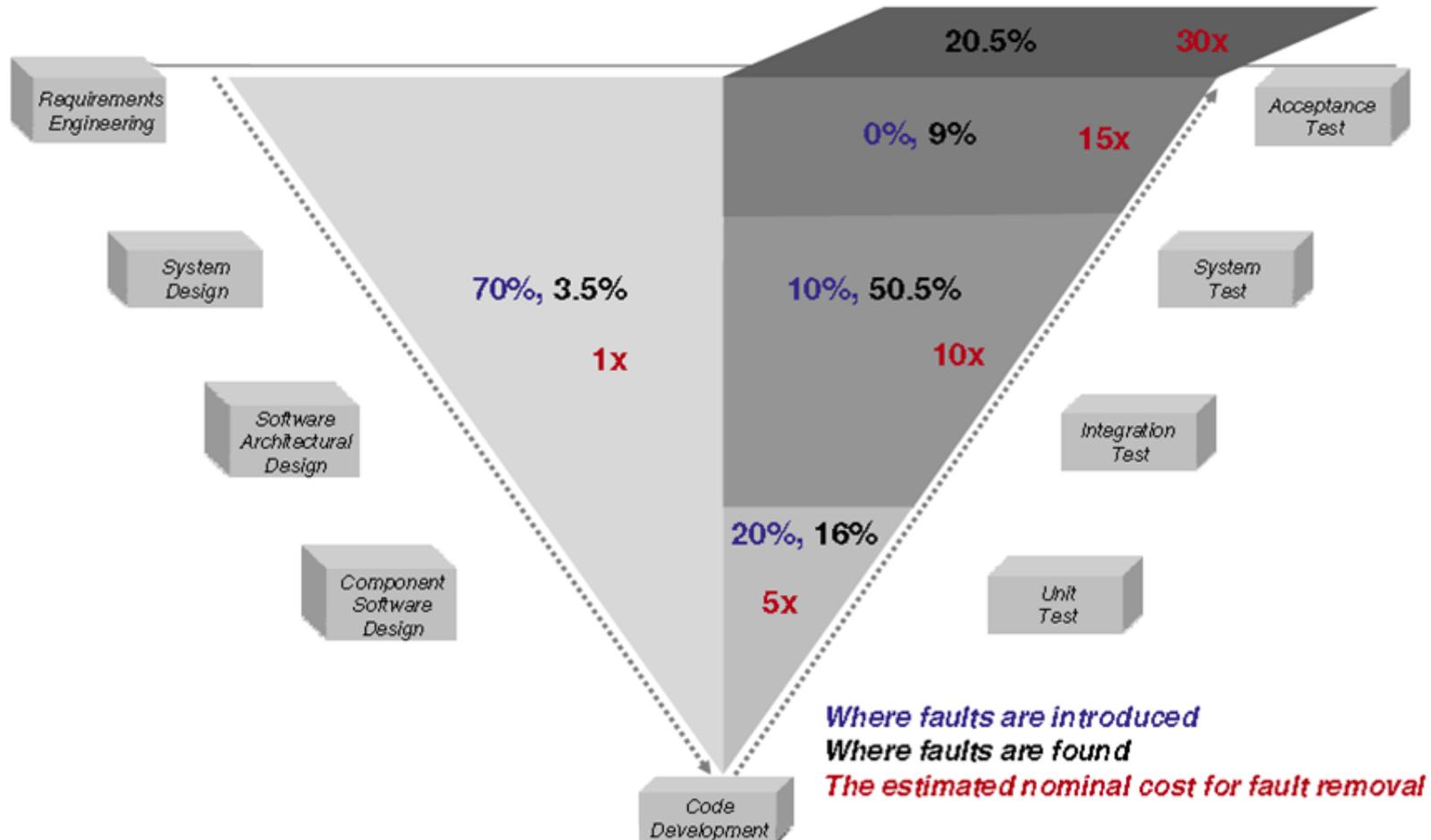
Goal:

Conduct research on Verification and Validation (V&V) methods to ensure safe deployment of flight critical systems for NextGen. Verification and validation of complex civil aviation systems has been identified as a critical gap in life cycle development of complex systems for NextGen.

Benefits:

Rapid but safe incorporation of technological advances in avionics, software, automation, and aircraft and airspace concepts of operation and operating procedures.

Impacts of Inadequate Infrastructure for Software Testing



Source NIST Planning Report 02-3, "The Economic Impact of Inadequate Infrastructure for Software Testing", 2002

Additional System-Wide Safety and Assurance Technical Challenges



Data Mining and Knowledge Discovery Technical Challenge

Automated discovery of precursors to aviation safety incidents by mining massive heterogeneous data sets to enable proactive management of risk.

Human Systems and Solutions Technical Challenge

Enable the development of robust human-automation systems by incorporating known limitations of human performance into analysis tools

DASHlink Today

disseminate. collaborate. innovate.
<https://dashlink.arc.nasa.gov/>

DASHlink is a collaborative website designed to promote:

- Sustainability
- Reproducibility
- Dissemination
- Community building

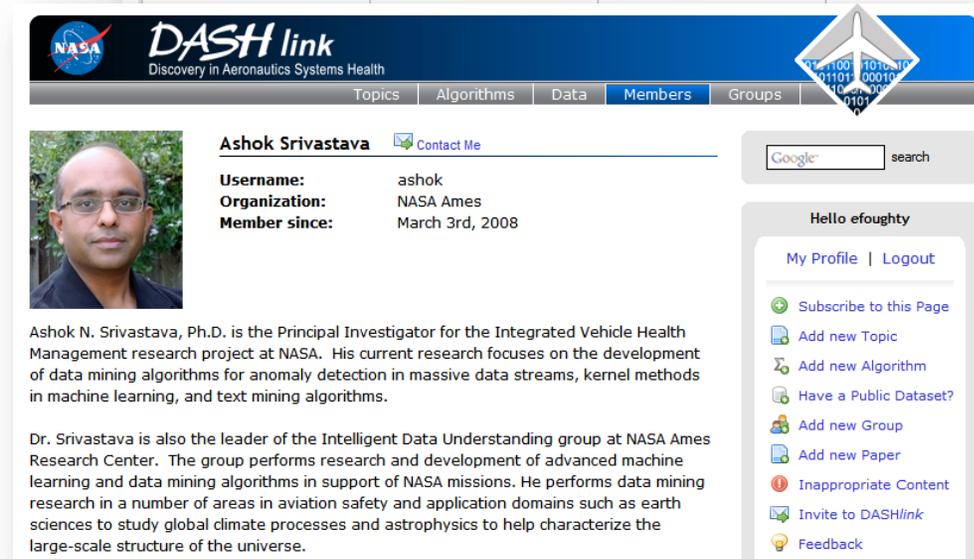
Over 400 users can :

- Create profiles and contact other users
- Share papers, upload and download open source algorithms
- Find NASA data sets

Coming Soon... **DASHlink 2.0.**



The screenshot shows the DASHlink website homepage. At the top is the NASA logo and the text "DASH link Discovery in Aeronautics Systems Health". Below this is a navigation bar with links for "Topics", "Algorithms", "Data", and "Members". The main content area features a large image of an airplane and a text box stating: "DASHlink is a virtual laboratory for scientists and engineers to disseminate results and collaborate on research problems in health management technologies for aeronautics systems." Below the image is a "Discover..." section with four tabs: "Topics" (View and discuss), "Algorithms" (Find and download), "Data" (Browse and use), and "Members" (Meet the DASHlink).



The screenshot shows a user profile page for Ashok Srivastava. The profile includes a photo, a "Contact Me" button, and the following information: Username: ashok, Organization: NASA Ames, Member since: March 3rd, 2008. Below the profile is a bio: "Dr. N. Srivastava, Ph.D. is the Principal Investigator for the Integrated Vehicle Health Management research project at NASA. His current research focuses on the development of data mining algorithms for anomaly detection in massive data streams, kernel methods in machine learning, and text mining algorithms." Below the bio is another bio: "Dr. Srivastava is also the leader of the Intelligent Data Understanding group at NASA Ames Research Center. The group performs research and development of advanced machine learning and data mining algorithms in support of NASA missions. He performs data mining research in a number of areas in aviation safety and application domains such as earth sciences to study global climate processes and astrophysics to help characterize the large-scale structure of the universe." To the right of the profile is a search bar and a sidebar with the text "Hello efoughty" and a list of actions: "My Profile | Logout", "Subscribe to this Page", "Add new Topic", "Add new Algorithm", "Have a Public Dataset?", "Add new Group", "Add new Paper", "Inappropriate Content", "Invite to DASHlink", and "Feedback".

Real World Impact: Flight Operations at Southwest Airlines



- NASA has **open-sourced** many of its key data mining algorithms for analysis of data from flight data recorders through **DASHlink**, our Web 2.0 portal for the world.
- **Southwest Airlines** obtained copies of sequenceMiner and Orca, two advanced anomaly detection techniques.
- Early results indicate that **operationally significant** events have been discovered by these algorithms that would not be triggered by their existing methods.

National Aeronautics and Space Administration



Atypicality Analysis Tool Applied to Flight Operations Quality Assurance (FOQA) Data

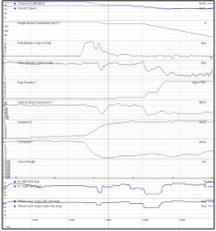
Bryan Matthews (SGT), Rodney Martin (NASA), and Ryan Nurnberger (Southwest Airlines)



Southwest Airlines analyzes approximately 1600 flights per day from 305 aircraft (of a fleet of 544 aircraft).

The data is analyzed using a 3rd party analysis tool to determine threshold exceedances based on Flight Operations Manual limits and other coordinated parameter limits.

Most discovery analysis is done while performing daily exceedance review or through voluntary pilot reporting

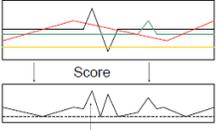


ORCA



A program for mining outliers in large multivariate data sets using distance-based outliers

Bay, S. D. and Schwabacher, M. (2003). [Mining Distance-Based Outliers in Near Linear Time with Randomization and a Simple Pruning Rule](#). Proceedings of The Ninth ACM SIGKDD International Conference on Knowledge Discovery and Data Mining.



Score

0 = typical



- Southwest Airlines plans to incorporate algorithms into **daily operations**.

NRC Flight Research Study

ARMD is developing a task for the National Research Council (NRC) to perform a study to assess and make recommendations about how to integrate flight research into the current ARMD's fundamental research activities and integrated research activities.



X-1 1947
Mach 1



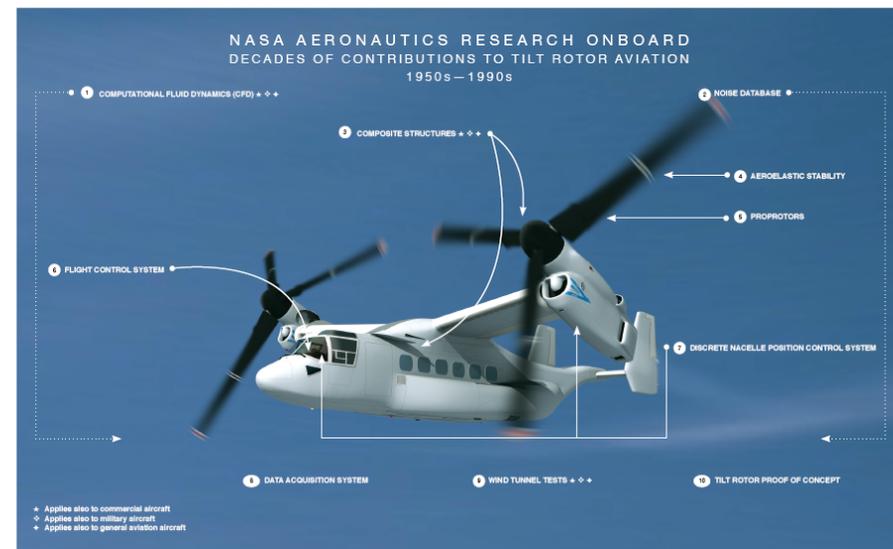
X-15 1959
Mach 5+



Xv-15 1977
Preceded V-22 Opsry

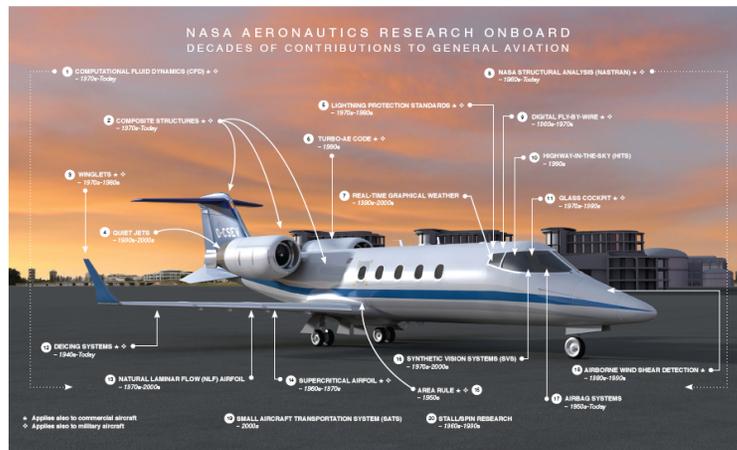


X-29 1984
Forward Wing
New Composites



NRC Flight Research Study (cont.)

- Flight testing has been used to validate and evaluate low Technology Readiness Level (TRL) technologies in actual flight (relevant) environments.
- Resource constraints often result in limited or no flight research being performed. This can add risk to the otherwise successful completion of a research task or project and effectively limit the ability to explore complex system-level and component interactions in realistic flight environments.



- The scope of this evaluation includes all ARMD research, including vehicle and vehicle subsystem/component technologies, next generation air traffic management (NextGen) technologies and technologies related to the safety of flight.



Considerations for Flight Research

- Exposure of the Unanticipated Down Side
- Costs
- Real-World training for the Next Generation
- Variety of Flight Research Opportunities



Committee Observations

- 1) The Committee believes that within the V&V project planning, the scope is very broad and would benefit from a more focused approach. The Committee suggests ARMD continue to engage the external V&V community to obtain suggestions for paring down the current research scope.
- 2) The Committee strongly endorses continued research in data mining concepts for aviation research. In particular, the Committee recognizes the difficulty and importance of human factors research in collaboration with industry and other government agencies.
- 3) The Committee strongly endorses planned National Research Council flight research study that NASA is initiating with the NRC . The Committee would like to receive regular updates of the study's progress in order to provide continued advice on ARMD planning in regards to flight research.



Committee Information

- Members:
 - Ms. Marion Blakey (Chair)*
 - Dr. Ilan Kroo*
 - Dr. Mark Lewis**
 - Mr. Preston Henne*
 - Dr. R. John Hansman**
 - Mr. Mark Anderson*
 - Dr. Harry McDonald
 - Mr. Paul Adams*
 - Dr. Ray Colladay (ex-officio)*
- Plans for next meeting: Face-to-face Committee Meeting at NASA Headquarters in early February 2011.

*In attendance at meeting **
Participated remotely