Committee Information

• **Members:**
  — Ms. Marion Blakey, Chair (Aerospace Industries Association)
  — Mr. John Borghese (Rockwell Collins)
  — Dr. Karen Thole (Penn State University)
  — Dr. John Langford (Aurora Flight Sciences)**
  — Mr. Mark Anderson (Consultant)
  — Dr. John-Paul Clarke (Georgia Institute of Technology)
  — Dr. Mike Francis (UTRC)
  — Mr. Tommie Wood (Bell Helicopter)
  — Mr. Stephen Morford (Pratt and Whitney)

• Plans for next meeting: March 2015 at NASA Headquarters

** Not in Attendance
Areas of Interest Explored at Current Meeting

Topics covered at the Aeronautics Committee meeting held on December 4, 2014 at NASA Ames Research Center:

Ames Research Center Aeronautics Research Overview

Unmanned Aerial System (UAS) Air Traffic Management *

Federal Aviation Administration UAS Center of Excellence

Verification and Validation Research Update *

Aeronautics “Big Questions”

* These topics have related recommendations or findings provided by the Aeronautics Committee
Primary Research Areas:

- Next Gen – Air Traffic Management
- Verification and Validation of Flight Critical systems
- Data mining and human machine interface
- Rotorcraft Aeromechanics and Controls
- Sonic boom reduction, advanced CFD methods
- Systems Design and Mission Simulation
- UAS Operations
- Environmentally Responsible Aviation
- Large scale wind tunnel testing and flow visualization

Partners: Federal Aviation Administration, Department of Defense, Industry, Academia
ARC Technology Transfer Success

- Technology Transfer to FAA of Terminal Sequencing and Spacing (TSS), Precision Departure Release Capability (PDRC), Traffic and Atmospheric Information for General Aviation (TAIGA)

- Technology Transfer to American Airline of Dynamics Weather Routing (DWR)
ARC Highlighted Research


Data Mining Research and Development for Airspace Operations and Safety – POC: N. Oza

Loss of Control Prediction and Cueing Pilot in the Loop Motion-Based Simulation – POC: K. Krishnakumar
UAS Air Traffic Management

• Technical Challenge: Safely enable UAS operations at lower altitudes
• Missing: Infrastructure to support operations at lower altitudes
UTM – One Design Option

Multiple customers with diverse mission needs/profiles

Range of UAVs from disposable to autonomous

UAS 1

Low altitude CNS options such as:
- Low altitude radar
- Surveillance coverage (satellite/ADS-B, cell)
- Navigation
- Communication

Autonomicity:
- Self Configuration
- Self Optimization
- Self Protection
- Self Healing
- Operational data recording

UAS 2

- Authentication
- Airspace design and geo fence definition
- Weather integration
- Constraint management
- Sequencing and spacing
- Trajectory changes
- Separation management
- Transit points/coordination with NAS
- Geofencing design and adjustments
- Contingency management

UAS 3

Real-time Wx and wind

Wx and wind Prediction

Airspace Constraints

Other low-altitude operations

Constraints based on community needs about noise, sensitive areas, privacy issues, etc.

3-D Maps: Terrain, human-made structures

Transition between UTM and ATM airspace
Collaboration with External Partners

Request for Information:
- Focused on partnerships and collaborative tests
- Over 95 respondents from academia, industry, and other government agencies
- Novel partnerships: Vehicle manufacturers, test sites, DOI, insurance companies, communication, etc…

Other Government Agencies:
- FAA/NASA Research Transition Team focused on UTM
- FAA, NASA, UAS industry meeting
- NOAA: Weather service (wind, severe weather) at low altitudes
- DOI: UTM capability to manage national parks (largest landowner)

Academia:
- University of Massachusetts
- Duke University
- Stanford University
- University of California, Berkeley

International interest expressed by Korea, France, Poland, and Japan
Schedule

- UTM research and development driven by various “Builds”
- Each Build adds more services and capabilities
Build 1 Demo Description

• Two vehicles separated procedurally by staying in their own planned space

• Surveillance provided by operators: they report their own position

• UTM system accepts/rejects plans as they are submitted free of constraint intersection or not

• For testing/safety/post-operations analysis, maintain active surveillance of UAS

• Test various operation plan combinations of: planned, rejected, early ending, etc.
The Committee supports the approach that ARMD has taken toward establishing a research effort for Unmanned Aerial System (UAS) Traffic Management (UTM). In particular, ARMD efforts taken thus far to proactively engage the right stakeholders and partners in the process will be critical to reducing implementation barriers. The Committee encourages ARMD to broaden the scope of community engagement even further to enlist all stakeholders in being part of the solution and helping to enable a broader acceptance of this important area of aeronautics research.
H. R. 3547—574: CONSOLIDATED APPROPRIATIONS ACT, 2014

“Unmanned Aerial Systems (UAS). – The agreement includes funding [$1.144M] in the “Unmanned Aircraft Systems” activity to complete the establishment of a UAS center of excellence to provide recommendations for airspace designation for manned and unmanned flight operations, conduct research to support UAS interagency requirements, coordinate research and development activities with other agencies, and provide recommendations on aircraft certifications.”
UAS COE Technical Focus Areas

1. Air Traffic Control Interoperability
2. Airport Ground Operations
3. Control and Communication
4. Detect and Avoid (DAA)
5. Human Factors
6. Low Altitude Operations Safety
7. Noise Reduction
8. Spectrum Management
9. Unmanned Aircraft (UA) Crew Training and Certification, Including Pilots
10. Unmanned Aircraft Systems Traffic Management
11. UAS Wake Separation Standards for UAS Integration into the NAS
UAS COE Evolution

Timeline:

- FAA Administrator Signed Letter of Intent (03/13/14)
- Coordinated within FAA & with Gov’t Partners (03/14/14 - 05/27/14)
- Conducted Public Meeting (05/28-29/14)
- Released Final Solicitation (08/01/14)
- Received University Proposals (09/22/14)
- Conducted Technical, Mgt and Financial Evaluations (10/06/14 - 11/21/14)
- Deliver Final Evaluation Package to Administrator (Target - 1/15/15)
- FAA Administrator Selects UAS COE (TBD)
- Initiate Execution Phase (Target - 9/30/15)
FAQs

• What is the difference between the UAS COE and the UAS Test Sites?

**Center of Excellence (COE)** – Team of private and public U.S. colleges and universities that will conduct basic and applied research, education, training and related activities.

**UAS Test Sites** – Public airfield(s), associated airspace(s), and facilities available for flight and ground testing.

• Can a university participate in test site operations and be a COE member?  Yes.
Verification and Validation (V&V) Research
Motivating Problem

Complexity of current-day flight-critical systems already poses significant challenges to safety assurance:
  • difficult to confidently demonstrate safety in all operating conditions
  • costly and time-consuming V&V

Operational improvements proposed under NextGen will escalate complexity, inner-connectivity, and automation

Recent data from industry partner suggest comparable costs

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2. Winter, D. (VP, Engineering & IT, Boeing PW) Testimony to House Committee on Science and Technology, July 31, 2008 (http://cps-vo.org/node/253)
Balancing Nearer and Longer-Term V&V Research

• Prior NAC Aero Committee feedback
  – NASA should demonstrate incremental progress in applying new techniques to current certification problems while also developing more comprehensive solutions

• In 2014, Aviation Safety Program adopted additional program-level milestones to provide greater emphasis on V&V technology transfer with nearer-term benefits
  – New milestones leverage ongoing partnerships to support current needs of FAA and Industry customers.
  – Tech transfer complements ongoing work on longer-term, game-changing technologies needed to assure safety of highly complex future vehicles and operations (adjustments being made as part of new NASA program structure).
Near-Term V&V Research Stakeholder Coordination

• FAA Office of Aviation Safety (AVS)
  – In 2013, kicked off a formal collaboration in software and digital systems safety assurance research
  – Jointly developed a research transition roadmap to identify most crucial FAA certification needs and organize complementary cross-agency research activities
  – Two Research Transition Roadmap (RTR) teams initiated:
    • New Approaches for Software Assurance
    • Safety Assurance for Complex, Digitally Intensive Systems

• FAA Air Traffic Organization (ATO)
  – Apply NASA V&V tools to help FAA ATO with safety assurance of Airborne Collision Avoidance System (ACAS) X
  – NASA has developed Verification for Collision Avoidance (VeriCA) probabilistic model checking tool
  – Capabilities should be applicable to ACAS Xu follow-on that will accommodate UAS

• FAA Office of NextGen (ANG) /Industry
  – NASA has developed and matured IKOS (Inference Kernel for Open Static Analyzers) tool which reviewed embedded source code for errors without actually running the code, improving verification coverage and saving time/money
  – Discussions ongoing with FAA ANG and Lockheed Martin to consider application of IKOS to assist with software verification of advanced ground-based ATM systems
• Aviation Safety Program V&V research will transition to Airspace Operations and Safety Program (AOSP) as part of NASA Aeronautics re-structure

• Many nearer-term applications and most longer-term V&V research will address
  – Thrust 5: Real-Time System-Wide Safety Assurance
  – Thrust 6: Assured Autonomy for Aviation Transformation

• AOSP projects hosting V&V research:
  – Shadow Mode Assessment using Realistic Technologies for the NAS (SMART NAS): Explore and Develop Technologies, Concepts and a Test Bed for Safe, Integrated Gate-to-Gate Trajectory Based Operations
  – Safe Autonomous System Operations (SASO) - Identify justifiable and optimal combination of autonomous characteristics for management of future airspace operations
Constant Evolution of Assurance Elements

- Support V&V and certification of ATM systems throughout the lifecycle, i.e.,
  - from design to and throughout operations
    - fast
    - agile
    - dynamic
    - support evolutions
  - system-wide: interactions with
    - environment,
    - hardware assets
    - compositional analysis
  - should imply system resilience
    - fault isolation
    - on-the-fly repair
    - incremental assurance
The Committee endorses the current ARMD program restructure, but stresses that critical areas of aviation safety research need to be maintained as the former Aviation Safety Program elements are transitioned in the new structure. The Committee finds that it is especially imperative for ARMD to maintain its commitment to research in verification and validation since this is a critical national need and an important area of work for NASA.
Aeronautics “Big Questions”

Focus on Big Questions
Focus on major system level questions and challenges that require NASA and the aviation community to think beyond current concepts, architectures and relationships.

Maximize Economic Benefit of UAS
Can we safely and unobtrusively integrate UAS’s into urban environments?

Develop Questions and Challenges with the Aviation Community

Conceive New Multi-Disciplinary Solutions
Multi-disciplinary NASA teams develop proposed new “convergent” solutions focused on proving feasibility and value of concepts.

Convergent Electric Propulsion Technology
Proposal for Significant Reduction in Energy Consumption

Fund Rapid Feasibility
ARMD funds 1 – 3 year feasibility R&D for the most promising and innovative solutions that have the potential to be game-changers for the aviation community.

Proposed Convergent Solutions

Partnerships, Experimentation & Analysis for Feasibility

Review with Aviation Community / Transfer or Terminate
Each project will be reviewed in depth initial and criteria for success will be established. Efforts are transferred into Mission Programs, out to the aviation community or are documented and terminated based on how well the criteria were met.

Demonstration, Dissemination and Transfer
• Strong desire to change how we look at our research questions.
  – Otis Elevator example: How do we get rid of the equipment room at the top of the shaft? *vs* How do we design a more efficient elevator?

• How do we make the change?
  – By encouraging the re-conceptualization of solutions to aviation challenges
  – By looking at our aviation challenges from a different perspective
  – By changing the scope of the challenge
    • Integrate or converge domains
  – By enforcing constraints rather than trying to remove them.
    • Can we solve the problem within the current constraints by looking at the problem differently?
FY 15 Big Questions

• **BQ:** Can we create an aviation system with maximum efficiency and minimal environmental impact?

• **Big Question solution idea generators:** Here are some examples (proposals should not be limited to just these – these are here to help open thoughts, not given as focused solution paths) of how to potentially think about this question.
  – Think cradle to grave, not just flight ops.
  – Consider different vehicles, operations, and missions, such as cargo, surveillance, EMT, etc.
  – Consider whether we can impact or modify existing aircraft and infrastructure
  – Consider all angles of cost when looking at new environmental technology.
  – Explore ways to increase the value of air travel to companies providing travel/transportation services and to the consumers (both passengers and users of shipping).

• **Associated Thrusts:**
  - Ultra-efficient Commercial Vehicles

• **BQ:** Demonstrate the feasibility for urgent medical transportation from the wilderness of Alaska to the Mayo Clinic without human interaction.

• **Context:** An aviation system that utilizes the power of convergent technologies to fundamentally create new S curves for mobility and safety.

• **Associated Thrusts:**
  - Autonomy for Aviation Transformation
Big Questions for FY16 and Beyond

• Process for Big Question development being defined
  – Steering group being stood up to develop and execute

• Potential process components:
  – Use a focused brainstorming workshop to develop several candidate questions
    • Questions tied to thrusts
    • Include strategic risks as material to spawn questions
  – Workshop participants to include NASA workforce as well as external representatives, inside and outside aviation
  – Use crowdsourcing tools to garner broader feedback on workshop results and input on other potential questions