REDAAC Slides

P&I UAS and Innovative Technology Discussion
Wes Ryan – AIR-600 P&I
Using Innovation To Enhance Safety

• History of finding ways to bring new technology into the National Airspace System safely
  • GPS, ADS-B, Glass Displays, Envelope Protection, AOA, Small UAS

• Transformational Flight & Automation Concepts are the Next Logical Progression/Evolution in Technology/Safety
  • Innovation from UAS will work into Small Aircraft, Future UAM, Part 25
  • Culture in FAA is Shifting to Risk-based Innovation & Safety

• Must Foster Innovation While Addressing Current Challenges
  • Further UAS Integration
  • Greater Automation
  • UAM/SVO/EVTOL/ESTOL

• Use Methodical Approach
  • Low risk introduction 1st
  • Build to Higher Risk Uses

GA Fatal Accidents per 100,000 Hours

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FLAT (NO CHANGE)
DECLINING TREND FROM TECHNOLOGY
Future?
Future Vision for Innovation/Safety

• Integration of UAS Will Mature Key Technology Enablers
  • Application Will Improve Access To Personal Aviation
  • Attract More Pilots – Automation Will Simplify Flight

• Shared Integration & Future “Traffic Management”
  • UTM Concepts Will Continue To Mature
  • Build to Manage all Trajectories Leveraging UAS Tech

• Prompt Agility Of Airworthiness/Collaboration
  • Part 23 Rewrite, Industry Standards Development, Others

• Related R&D Must Quickly Feed Policy: Key Enablers – Electric Propulsion, 4D Flight Path Control, Automation
Electric Propulsion

• Flying Pipistrel Alpha Electro in California
  • Experimental data collection – performing simulated training missions
  • Core lessons learned feeding standards – ASTM & Battery Standards
  • Operational Challenges for a “Pilot of Average Skill” – Suitable for LSA?
  • Energy Management and Indication of Remaining Flight Time (40 min)

• Collaborating with NASA on X-57
  • Part of NASA Design Reviews, Flight Readiness Reviews, and Tests
  • Participation in ASTM Electric Propulsion Standard Development/Validation

• Working with UAS and UAM TC Applicants:
  • Standardized Battery, Motor, Motor Controller Design and Operational Requirements with Methods of Compliance
Flight Controls & Simplified Ops

- Working R&D for 10+ years to bring affordable augmented flight path control to GA
  - Modern sensors, actuators, processors enabling new systems – UAS provide safe prototyping
  - Real Results - Envelope Protection Autopilots – Certified and in flight for 5+ years
  - Targeting Simplified Vehicle Operations – “Pilot on the loop” simplified flight – Reduce pilot error

- Methodical Buildup from Component to Full System Level R&D Projects Feeding Policy
  - Yielding Real-World Test Results and MOC
  - AOA, Advanced Autopilots, Full Flight Path Management, Resilient Automation, “EZ-Fly” system being tested at Embry Riddle.
NASA Collaborations

• UAM - Grand Challenge
  • Advance Maturity of UAM Aircraft/Applicants
  • Leverage Combined Expertise of NASA, FAA, Industry

• UAS Integration - SIO – System Integration Operationalization
  • Large UAS Initiative under UAS in NAS program
  • Detect and Avoid and NAS Integration Technology Demonstrations

• Automation - Resilient Autonomy – DOD, NASA, FAA
  • Prove Specific Architecture Can Safely Automate Critical Tasks
  • Robust Autonomy for UAS and Manned Aircraft
  • Run-time Assurance – Key to Safe Automation With Less Human Involvement
  • Dynamic Consistency Checks (Avoid Issues like 737 Max)
Supporting Materials
Cyber Security

• Risk-based Approach to Requirements
  • Exposure of software/system to threats
  • Risk of aircraft to public

• Systems with no connectivity present lower risk
  • Spoofing of GPS sensors still a potential threat

• Greater connectivity = greater exposure
  • Requires partitioning of critical systems from exposed system
  • Procedural and strategic mitigations can be as powerful as design aspects
Safety From Experience in Innovation

• Using a well-proven risk-based approach to safety
  • Balance FAA Rigor vs. Safety Improvement – Drives cost, time for project

• UAS Certification and our targeted R&D to drive policy to technology benefit all aviation – Urban Mobility and Retrofit/Fwd-fit

• Traditional Certification has primary/secondary, or primary/backup mentality, with human as the safety net – Need New Proven Approach

Gov, Industry + Market Driven Evolution

Notional Structure

Key:

- = Critical R&D Policy Change

- = Tech Transfer

Future eVTOL Safety & Technology


Commercial Aircraft Technology


GA Safety & Technology


UAS Safety & Technology

Technology Enablers, Forward Fit EVTOL

Low Cost Technology Enablers, UAS

Future eVTOL Safety & Technology

POLICY ENABLES Tech Transfer
Ongoing Research Threads

- Flight Profiler Project
- Advisory Circular for AFCS based on Performance Specs
- EZFly FBW Project
- DA-42 FBW VSS Project
- GA AFCS MOCs Project
- AOA Displays Project – FAA/CAMI
- Adaptive Controllers & Autopilot Streamlining Projects
- Run Time Assurance
- Energy Management Displays
- Low-Cost Stick Shaker Project
- AGCAS & RTA Prioritization Projects
- Flight Test Scale Model to Conduct Mock Cert. using RTA – NASA
- Low-Cost AOA Feedback Project
- eVTOL & AFPC MOC Project
- Augmented Flight Path Controller
- Adaptive Controllers & Autopilot Streamlining Projects
- GCAS/ACAS
- Weather Avoidance
- Nz Protection
- Speed Protection
- Bank Angle Protection
- AOA Protection
- PVI
- AOA Displays Project – FAA/CAMI
Research for Policy Development

- Research Projects can be started early focusing on Tech
  - Before applicants apply
- Get Empirical Data to Support Means of Compliance (MOC)
  - Develop first draft of guidance
  - Provide feedback to Industry Stds Committees
- Many advanced VTOL concepts are highly integrated
  - Blend Propulsion, Flight Controls, Autonomy

- Research And Policy Integration Team (RAPIT) Standards Staffs:
  - Rotorcraft
  - Engine/Propeller
  - Small Airplane
  - Transport
Our Shared Challenge for Automation

• Discuss Ways to Purposefully/Safely Move from Concept, to Design, to Operation & Integration of Pilotless, Passenger Carrying Aircraft
  • We have the means for conceptual design and sub-scale or full-scale development in flight test of prototypes, BUT
  • We do not have requirements for pilot/automation performance for “autonomous” operations, or automated integration with air traffic
Challenge - Humans/Machines Safely Trading Roles

- Reduced Pilot Error/Operational Error
- Future Safety Gain?
  - Automation Replacing Humans
  - Automation May do More Than Human Capability
  - What Will Residual Future Roles Be?
- Human as Safety Monitor
Is Evolution or Revolution the Right Methodology?

• Some are Convinced they can jump straight to full automation without a human pilot in the loop “flying” the aircraft.
• Others recognize the challenge of replacing the pilot on board with an automated system that is reliable enough to handle all actions typically done by the pilot and the controller for all phases of flight.

Low Risk to High Risk (Safety Risk, Financial, Time, Certification, etc.)
Automation Certification Path

- Logically reduce/replace functions of pilot/controller
  - Deconstruct functions of the pilot and controller to design functions into automation

- Developing “Assured” Automation
  - Bounded Behavior – Safe limitations of authority
  - Expected outcomes – architecture is key – human intention is built into bounded behavior
  - Fault Tolerant, Fail-Safe – Continue to function after a failure
Deconstruction of Intended Tasks/Functions

• Concentrate on major functions
  – Pilot:
    • Aviate – Flight Path Management of the aircraft states – flying the aircraft
    • Navigate – Flight Path Management of the flight path in national airspace – telling it where to go
    • Communicate – Flight Path Management in context of other aircraft and air traffic expectations
  – Controllers:
    • Locate – Is the aircraft where it is supposed to be?
    • Separate – Is the aircraft avoiding others?
    • Communicate – Can Air Traffic “talk to the airplane” to manage its course?

• Assess Readiness of automation to perform each set of functions – Air and Ground Operations
Deconstruction of Pilot/Controller Functions

- Planning & Decision Making
- Systems Management
- Basic Airmanship
- Takeoff & Landings
- Terminal Procedures
- Navigation
- Communication
- Detect & Avoid
- Emergency Procedures

Notional
Piloted vs. Pilotless – Must Design in Functions For All Phases of Flight
Keys To “Trusted” Automation

- **Modular Architecture**
  - Top down architecture hierarchy with clearly specified interfaces

- **Partitioned Functions & Criticality**
  - Software/Hardware Isolation
  - Each module limited to a single safety function – Ease of Testing

- **Dynamic Consistency Checks**
  - Compare Derived and Measured Parameters
  - Measure real time behavior of the system

- **Computational Agility**
  - Rapid assessment of system/situational hazards with quick and decisive response to those hazards
Proposed NASA & FAA Process Relationship for Challenge

Grand Challenge “Scenario Roadmap” Rosetta Stone

NASA

Design Readiness
- NASA 7900.3D CH1

Design Robustness
- NASA 7900.3D CH2

Operational Suitability
- NASA 7900.3D CH3 & 4

Operational Approval

Aircraft Evaluation Group

Type Certification & Operational Readiness

FAA

Basic Airworthiness
- FAA Order 8130.34D

Design Certification
- FAA Order 8110.4C

Operational Approval

Outcome: Identify Design Issues, Airworthiness Requirements, Means of Validating Design + Performance (ie. Subpart B)

Outcome: Identify Operational/Performance Issues, Pilot Training Requirements, Suitability for Real World Use

Outcome: Determination of Condition for Safe Flight – “Crew Rated”

Outcome: Type Certification & Operational Readiness

NASA Data, Lessons Learned, SME Expertise
FAA Steps for Certification

Conceptual Design
- Process Orientation
- Pre-Project Guidance
- Familiarization Briefing
- Top Level Safety Requirement
- Potential Policy Items to Address
- Airspace Integration Challenges

Requirements Definition
- UAS Conceptual Design*
- CONOP*
- Risk Classification*
- Certification Plan*
- Conformity
- Interim TCBM
- ATO/AFS Coordination*

Compliance Planning
- FAA Involvement
- Applicant’s Responsibility
- Oversight and Delegation*
- Conformity
- Preliminary TCBM
- ORA*
- Proposed Certification Basis *
- Acceptable Means of Compliance
- Detailed Method of Compliance

Implementation
- Compliance Data Generation
- Compliance Substantiation
- Compliance Finding

Post Certification Activities
- Type Inspection Report
- Data Retention
- Required Documents at Delivery
- TC Holder Info
- Continued Airworthiness
- ICA Changes
- Post Certification Evaluation

Red Items = Steps Where NASA Resilient Autonomy Will Focus
* Denotes items that are specific to UAS Type Certification, or items that are tailored for UAS certification
Identify aircraft level functions to be certificated (included piloted and/or autonomous)

Decompose Aircraft level functions into system item functions.

Identify system safety requirements

Apply JARUS SORA Guidance

Can this be met under current 14 CFR Rules

Conceptual Design

Requirements Definition

Compliance Planning

Implementation

Post Certification Activities

Concept: Aircraft, CONOP (AC 21.17 Section 10)

Aircraft/System(s) Function Development

Development of System(s) Architecture

System(s) Implementation

Implementation & Verification

Production

Software & Hardware

Safety Assessment (SRP4761)

Identify aircraft level functions to be certificated (included piloted and/or autonomous)

Decompose Aircraft level functions into system item functions.

Identify system safety requirements

Task at Hand Decompose Aviate, Navigate, and communicate

Apply JARUS SORA Guidance

Design and Development

Activities
Mission Task Elements

• Identify what the aircraft is going to do (Concept of operation/mission) and break into mission elements
• Identify tasks automation is intended to do for each mission element
• Identify expected behavior and pass/fail criteria for the automated functions
• Create mission task element testing procedures to validate/verify proper function and behavior

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Grand Challenge Mission Task Elements

Creating Standard Test Procedures, Maneuvers
• Design Basic Airworthiness
• Design Robustness
• Operational Readiness
• GAMA Publication 16 Mission Profile

Goal: Tests and Methods of Compliance for Unique Aircraft Not Currently Covered by our Rules.
Notional Steps for Certification of Automation

• Identify the aircraft, its intended use, and area of operation
• Identify the functions that are expected to be automated without human backup
• Evaluate risks and severity of those risks based on that CONOP (What if document) (SORA)
• Evaluate mitigations for those risks and whether they are by design, operational limitation, or geographic/airspace limitation
• Evaluate the integrity/assurance needed for the risk mitigations that are by design
• Create certification requirements for the design aspects, and pass fail for those requirements for showing compliance
• Identify functions, definition of expected performance of that function, pass/fail evaluation criteria for the function, and a means to test that functionality to verify reliability, accuracy, availability, and what happens if it fails. (contingencies without human intervention)
• From pass/fail and expected performance for function/design features, identify cert/safety requirement and means to test to show it has been met.
• Collect data, and demonstrate compliance by test, inspection, analysis