UAS Automation & Intelligent Systems (A11L.UAS.61)

Research Project Description

- This research will develop a long-term automation strategy for approval of intelligent systems.
- The intent is to identify considerations for certification, including general human factors.
- The execution of this research requirement attempts to address both systems certification criteria and human factors considerations in coordination.

Approach

- ✈ Two consecutive 'Studies', which progressively validate certification testing criteria for Automation Systems.

Sponsor Anticipated Outcome

Research Sponsor is **AIR (POC Dave Sizoo)**; this research finishes in Q2 FY 23 and has the following anticipated benefits:

- Improve the regulatory processes and guidance for aircraft certification and operational approvals, especially for new technologies and operations (i.e. UAS):
  - Inform the development of STCs, TSO, etc…as well as the development of new operational procedures & guidance.
- Refine the flight deck design process & procedures (with human factors considerations in mind).

Critical Milestones

NOTE there have been substantial delays due to COVID

- Develop testing environment (at NASA) for validation of novel certification criteria **(10/2019)**
- Develop Initial Matrix of Test Maneuvers for interface concepts for initial pilot testing **(01/2020)**
- Conduct preliminary study ('Study 1') to validate Initial Matrix of Test Maneuvers **(06/2021)**
- Evaluate the integrated concept and provide feedback on preliminary test procedures **(12/2021)**

Research Accomplishments in FY22

- Refine the Initial Matrix of Test Maneuvers, based upon lessons learned from 'Study 1' **(05/2022)**
- Conduct follow-on study ('Study 2') to validated refined Matrix of Test Maneuvers **(06/2022)**

Final Report expected December 2022…

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PROJECT MANAGEMENT DETAILS:

- Sponsor
  - Sabrina Saunders-Hodge, AUS-300
- FAA Co-Sponsor:
  - AIR-714 (POC: David Sizoo)
- Research Partners:
  - ANG-E271 (POC: Robert McGuire)
  - NASA (POC: Michael Feary)
- Primary Technical Monitor
  - Evelina Bern, AUS-310
- Secondary Technical Monitor
  - John Miller, AUS-310
- ANG-C2 PM
  - Philip Maloney, ANG-C35
- *Expected level of Effort by Fiscal Year*
  - *$748,307 FY17*
  - *$856,930 FY19*

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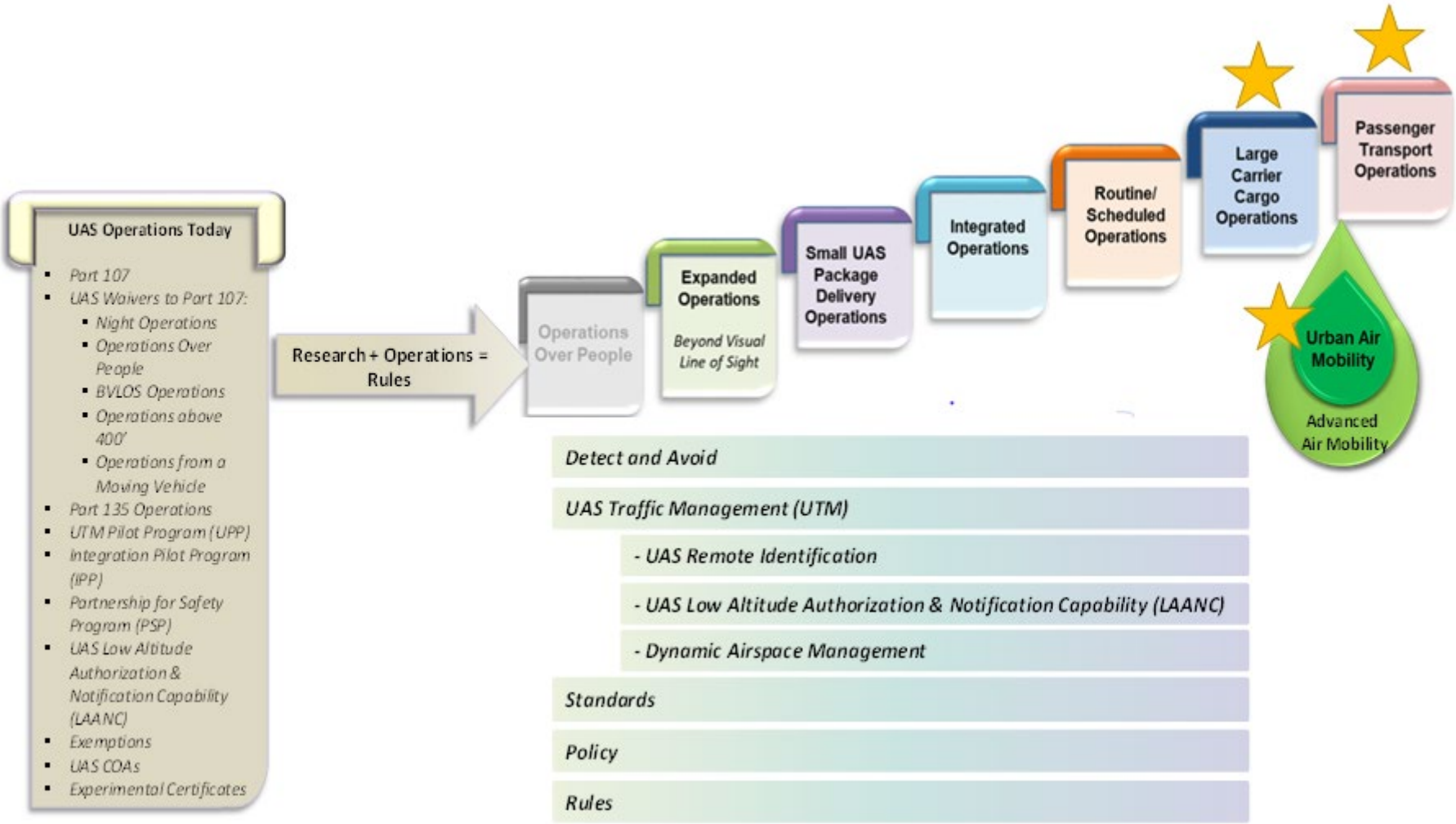

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RESEARCH APPROACH:

- Research was originally split into three tasks, but the project was re-scoped in FY19 to include only one task:

  - **Task 1**: Investigate automated system certification challenges on electric propulsion Vertical Take-off and Landing (eVTOL) aircraft with augmented/automated control functions. Specifically, investigate and develop methods for evaluating industry representative pilot vehicle and control station interfaces while performing tasks designed to expose expected potential aircraft control deficiencies based on expected operational tasks. This includes the development and execution of one or more related experiments.

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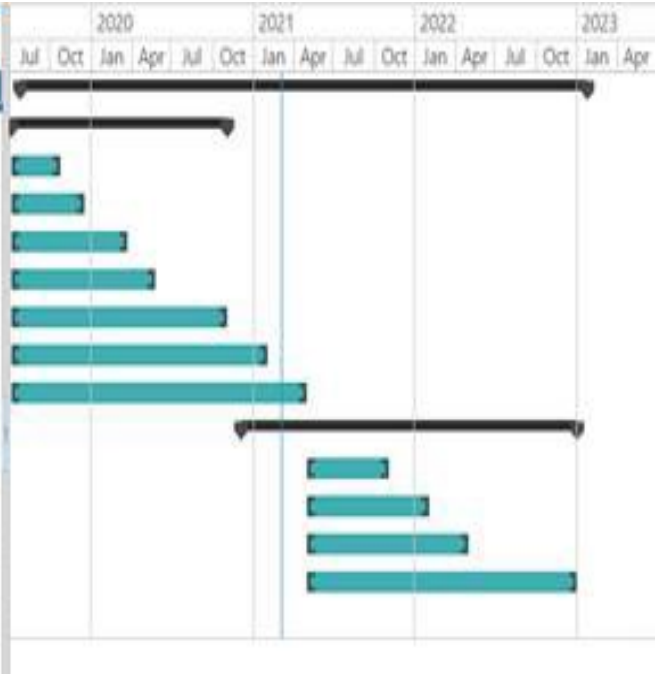
MASTER SCHEDULE:

Name
▪ Automation and Autonomy
▪ Project Phase 1
Prototype novel V/STOL aircraft pilot interface integrated into a Flight Deck Z part task simulator software
Initial Matrix of Test maneuvers for interface concepts for initial pilot testing.
Refine the V/STOL aircraft pilot interface test matrix for pilot usability testing in the Vertical Motion Simulator (VMS).
Evaluate the integrated concept and provide feedback after successful integration of V/STOL simulation with representative display, control and interceptor concepts.
Report on collection and analysis of data from the VMS Pilot Usability study.
Draft technical report at the completion of Phase 1
Deliver final technical report after comment and review.
▪ Project Phase 2
Novel V/STOL aircraft pilot interface in medium fidelity simulator for industry representative eVTOL aircraft.
Study 2 maneuver, vehicle and interface concept test matrix
Implementation of novel V/STOL aircraft pilot interface concept(s) in Vertical Motion Simulator (VMS)
Draft Technical Report and a Final Technical Report including summary of Study 2 data collection and analysis



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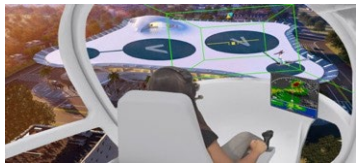
PROJECT STATUS:

- **Phase I of Research is complete:**
  - Develop prototype novel V/STOL aircraft pilot interface integrated into a Flight Deck Z part task simulator software (10/25/2019)
  - Develop initial Matrix of Test Maneuvers for interface concepts for initial pilot testing. (12/20/2019)
  - Refine the V/STOL aircraft pilot interface test matrix for pilot usability testing in the Vertical Motion Simulator (03/25/2020).
  - Conduct Study 1 and report on collection & analysis of data (06/30/2021).
  - Evaluate the integrated concept and provide feedback on preliminary test procedures (12/14/2021).
- **Phase II of research nearing completion; Phase II Includes:**
  - Develop novel V/STOL aircraft pilot interface in medium fidelity simulator for industry representative eVTOL aircraft (05/27/2022).
  - Conduct Study 2 and report on collection & analysis of data (06/29/2022).
  - Delivery of Final Report (expected December 2022).

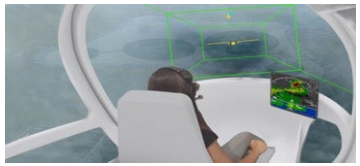
Automation Command Concept (ACC) Roadmap

ACC-0	ACC-1	ACC-2	ACC-3	ACC-4	ACC-5	ACC-6	ACC-7
Conventional Stability and Control Augmentation "Rotorcraft-ish"	Vector Control with Inceptors e.g. "Unified"	Target Control with Inceptors	Tactical Autoflight	Resilient Autoflight Capabilities	Operational Contingency Management Functions	Mission Management Functions	Full Aircraft Automation

Control Commands
(Human-Within-the-Loop)



Autopilot
(Human-On-the-Loop)



Autoflight
(Human-Over-the-Loop)

m:n Remote Operations

SAE-0	SAE-1	SAE-2	SAE-3	SAE-4	SAE-5
No Automation	Automation Assistance	Partial Automation	Conditional Automation	High Automation	Full Automation

Foundation: Adapting US Military Advanced VTOL Evaluation Standard

US Army Aeronautical Design Standard-33 (ADS-33)

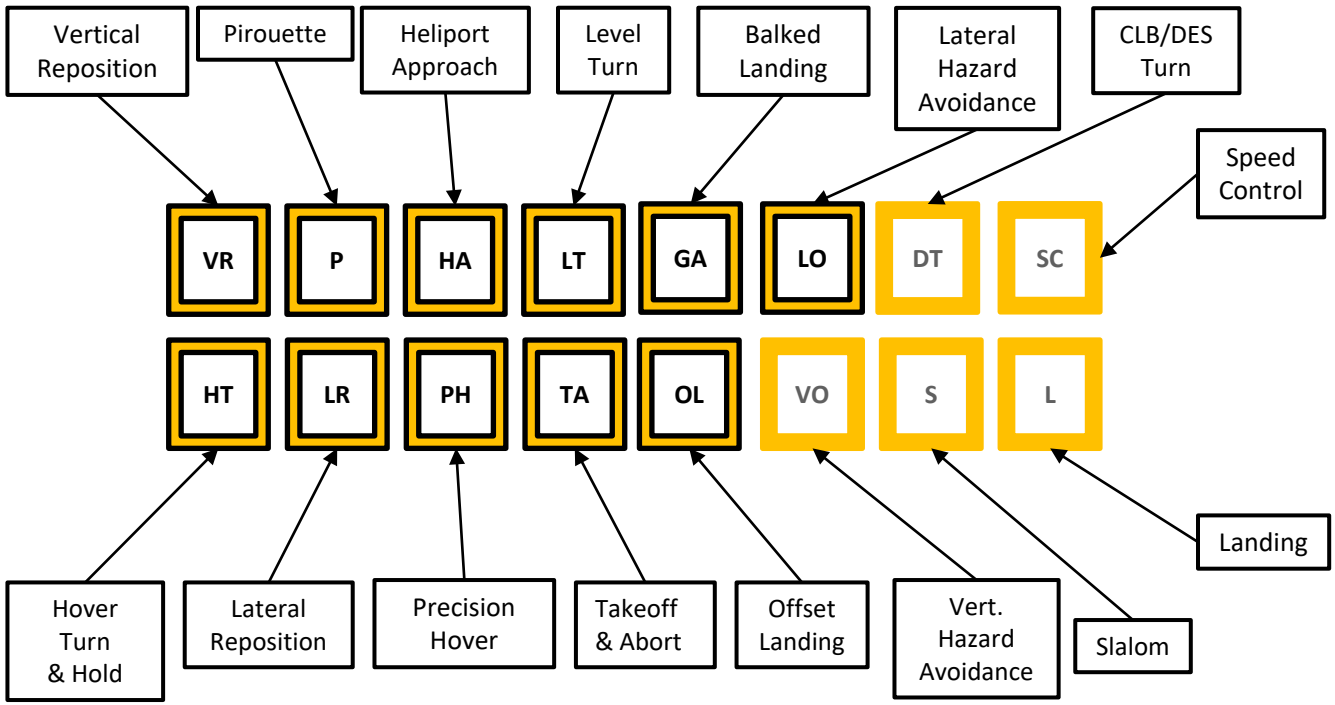
- US Army and NASA for started research on VTOL Aircraft with Indirect Flight Controls and Advanced Automation, later developed into Aeronautical Design Standard (ADS-33) by:
  - US Army
  - US Navy
  - NASA
  - US Air Force
  - FAA
  - Industry
  - International partners
- Specifically designed for US military reference mission tasks, referred to as Mission Task Elements (MTE)
- MTE are based on missions, independent of aircraft configuration and automation level (e.g. pilot on-board or off-board)

Table I. Mission-Task-Elements (MTEs)

MTE	REQUIRED AGILITY	ROTORCRAFT CATEGORY				EXTERNALLY SLUNG LOAD
		ATTACK	SCOUT	UTILITY	CARGO	
Tasks in GVE						
Hover	L	✓	✓	✓	✓	✓
Landing	L	✓	✓	✓	✓	
Slope Landing	L	✓	✓	✓	✓	
Hovering Turn	M	✓	✓	✓	✓	
Pirouette	M	✓	✓	✓	✓	
Vertical Maneuver	M	✓	✓	✓	✓	✓
Depart/Abort	M			✓	✓	✓
Lateral Reposition	M			✓	✓	✓
Slalom	M	✓	✓	✓	✓	
Vertical Remask	A	✓	✓			
Acceleration and Deceleration	A	✓	✓			
Sidestep	A	✓	✓			
Deceleration to Dash	A	✓	✓	✓		
Transient Turn	A	✓	✓	✓		
Pullup/Pushover	A	✓	✓	✓		
Roll Reversal	A	✓	✓	✓		
Turn to Target	T	✓	✓			
High Yo-Yo	T	✓	✓			
Low Yo-Yo	T	✓	✓			
Tasks in DVE						
Hover	L	✓	✓	✓	✓	✓
Landing	L	✓	✓	✓	✓	
Hovering Turn	L	✓	✓	✓	✓	
Pirouette	L	✓	✓	✓	✓	
Vertical Maneuver	L	✓	✓	✓	✓	✓
Depart/Abort	L			✓	✓	✓
Lateral Reposition	L			✓	✓	✓
Slalom	L	✓	✓	✓		
Acceleration and Deceleration	L	✓	✓			
Sidestep	L	✓	✓			
Tasks in IMC						
Decelerating Approach	L	✓	✓	✓	✓	✓
ILS Approach	L	✓	✓	✓	✓	
Missed Approach	L	✓	✓	✓	✓	
Speed Control	L	✓	✓	✓	✓	

Notes: ✓ = Suggested maneuvers to apply with appropriate performance standards.
L = Limited agility
M = Moderate agility
A = Aggressive agility
T = Target Acquisition and Tracking

Sample Achievements/Products
Catalog of initial Mission Task Elements, referred to as Handling Quality Task Elements (HQTEs) Developed and Tested



* Current snapshot
Others in development

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SAMPLE ACHEIVEMENTS/PRODUCTS:

Scale point description	Rating
Excellent, highly desirable	1
Good, pleasant, well-behaved	2
Fair; some mildly unpleasant characteristics. Good enough for mission without improvement.	3
Some minor, but annoying, deficiencies. Improvement is requested. Effect of performance is easily compensated for by pilot.	4
Moderately objectionable deficiencies. Improvement is needed. Reasonable performance requires considerable pilot compensation.	5
Very objectionable deficiencies. Major improvements are needed. Requires best available pilot compensation to achieve acceptable performance.	6
Major deficiencies which require mandatory improvement for acceptance. Controllable. Performance inadequate for mission, or pilot compensation required for minimum acceptable performance in mission is too high.	7
Controllable with difficulty. Requires considerable pilot skill and attention to retain control and continue mission.	8
Marginally controllable in mission. Requires maximum available pilot skill and attention to retain control.	9
Uncontrollable in mission.	10

Parameter
Longitudinal Characteristics
Lateral Characteristics
Directional Characteristics
Trim Characteristics
Speed Control

Description	Rating
Entirely unrelated to task performance	1
Moderately related to task performance	2
Related to task performance	3
Important for successful task performance	4
Critical for task performance	5

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CHALLENGES & RISKS:

- **Laboratory Availability**
  - NASA laboratories have limited access during the COVID-19 pandemic and scheduling time for Study 1 one has been challenging.
  - Study 1 & Study 2 were delayed; however, overall period of performance remains unaffected.

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Questions?

Thank you

Backup Slides

Concept Approach Mission Based Evaluation of Increasingly Automated Aircraft