Hazard Perception & Avoidance (HPA)

Technical Work Overview

July 11, 2022

Project Background

- Hazard Perception and Avoidance (HPA) is a technical area under Advanced Air Mobility's (AAM) Automated Flight and Contingency Management (AFCM) sub-project
  - Collecting human-in-the-loop simulation and flight test data to inform standards development for a tactical avoidance system for UAM
  - Building toward UML-4; our testing assumes an **onboard** pilot with increased automation support
- Using the FAA's Airborne Collision Avoidance System for Rotorcraft (ACAS Xr) as our tactical conflict detection and resolution technology
- Completed first HPA simulation – Part Task 1 (PT1) – in late April
  - Plan to brief TCAS PO in late July and SC-147 at the November F2F meeting

Human-in-the-Loop Simulations

- Part Task 1 Simulation – completed in April 2022
  - Performed in fixed-base eVTOL simulator at NASA Ames Research Center
  - Utilized ACAS Xr v2
    - Did **not** exercise airspeed DAA guidance or Ground Point Obstacle Avoidance (GPOA)
  - Limited scenarios to *en-route* portion of flight
  - Manipulated whether or not Resolution Advisories were executed manually or automatically
    - Also included a DAA condition where pilots responded to DAA alerting and guidance
  - Recruited 12 pilots with private helicopter licenses, who flew sim under VFR

- Full Motion Simulation – data collection planned for August 2022
  - Expansion of Part Task sim:
    - Increasing overall fidelity – full motion, out-the-window visual traffic, moderate winds & turbulence
    - Incorporating traffic conflicts while in terminal area & in hover
    - Integrating Ground Point Obstacle Avoidance (GPOA) logic & airspeed-based DAA guidance
  - Testing different ACAS Xr Modes:
    - **Collision Avoidance System (CAS) Mode**: provides Traffic Advisories (TAs) & Resolution Advisories (RAs)
    - **Detect and Avoid (DAA) Mode**: provides Remain Well Clear alerting/guidance & Resolution Advisories

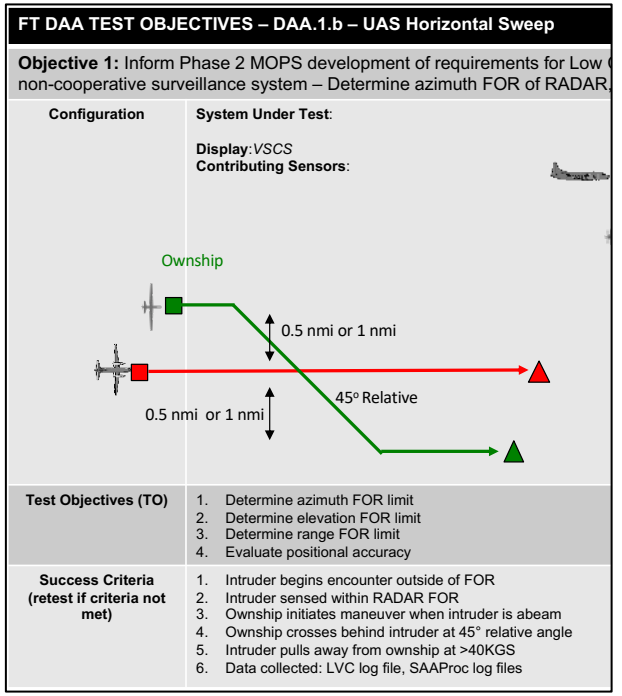
General Flight Test Plans

- Coordinating with AAM's National Campaign for the parallel Integration of Automated Systems (IAS) Flight Series
  - IAS-1 (2023) focusing on HPA and Flight Path Management (FPM) technologies
    - FPM is another tech area under AAM-AFCM, focusing on strategic flight path creation and modification
    - Testing these technologies independently
  - IAS-2 (2025) will focus on additional NASA AAM technologies and their integration

- IAS-1 will be flown with the Sikorsky Autonomous Research Aircraft (SARA)
  - Highly modifiable single-piloted S-76B with Variable Stability In-flight Simulation (VSS)
  - Configured for a safety pilot (left seat) and research pilot (right seat)
  - A live intruder (type TBD) will be utilized to generate scripted traffic conflicts
    - Intruder will be equipped with ADS-B Out & ownship with ADS-B In

IAS-1 Plans

- Objectives:
  - Assess the effectiveness and acceptability of ACAS Xr v2 in live flight
    - May attempt to integrate v3 if the additional capabilities are essential
  - Test plan will reflect upcoming full-motion simulation:
    - Fly ACAS Xr against scripted intruders in en-route, terminal, and hover flight phases
    - Test both the TA/RA & DAA modes
    - Automate the RA and return-to-course maneuvers
    - Assess low-altitude/GPOA behavior
  - New research questions identified in full-motion sim will (if feasible) be incorporated into test plan

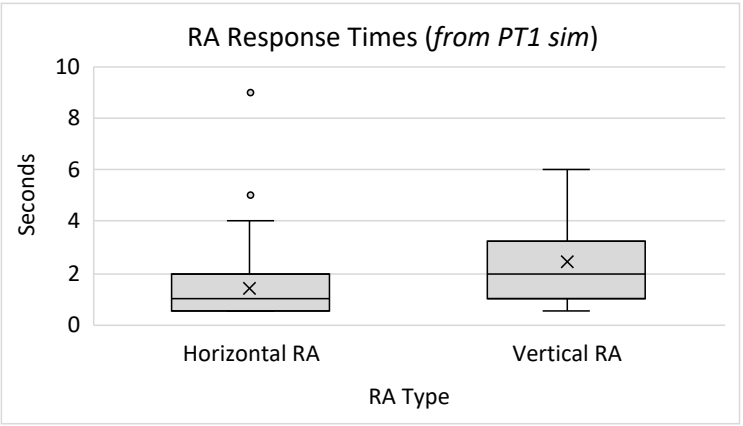


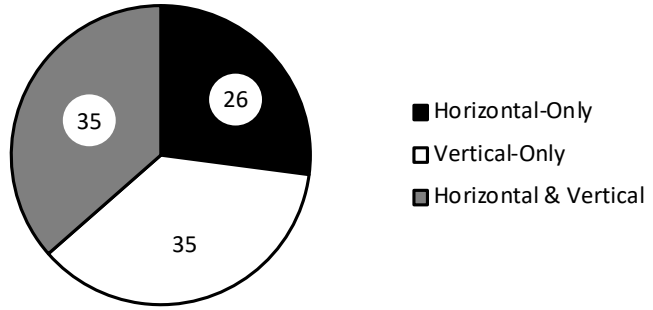
DAA Flight Card

IAS-1 Plans

- Approach
  - NASA test pilots will fly prescribed scenarios under VFR
    - *Manually* maneuver during DAA encounters
    - *Monitor* the automated maneuvers during RA encounters
  - Compare pilot and system performance to simulation results

- Primary Metrics:
  - Objective:
    - Response times
    - Losses of DAA well clear & NMACs
    - DAA maneuver preferences
    - Instances of non-compliance with RAs
  - Subjective:
    - Acceptability of DAA and RA maneuver guidance
    - Utility of DAA Mode
    - Acceptability of automated RA and RTC functions





DAA Maneuver Preferences (*from PT1*)

Remaining Plans

- Execute a human-in-the-loop simulation in 2024
  - Integrate Xr v3 or v4
  - Focus on highest-priority research questions
  - Model higher-fidelity AAM airspace
- IAS-2 flight test in 2025
  - Specific objectives TBD
  - Focus likely on integration of a variety of AAM technologies