NextGen Collision Avoidance Human Factors Research Program

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Working paper prepared for routine scientific interchange; material not cleared for public release



- NextGen Collision Avoidance Human Factors Research Needs
- Research Sponsors/Supported Standards
- Research Questions
- Current Research Activities/Findings
- Planned Research



- Three sources of human factors research needs
 - Experiences with existing Traffic alert and Collision Avoidance System (TCAS)
 - Pilot response does not match design assumptions
 - Potential issues with displays/annunciations
 - Training issues
 - New TCAS functions/integration
 - Autopilot Resolution Advisories (RAs)
 - Head Up Display (HUD) guidance, Vertical Situation Display (VSD)
 - Airbus' TCAS Alert Prevention (TCAP) functionality
 - New collision avoidance systems
 - Current TCAS users Airborne Collision Avoidance System (ACAS Xa) Integration with ADS-B in applications (ACAS Xo)
 - New user classes

ACAS Xp (General Aviation/Helicopter collision avoidance)

ACAS Xo (procedure specific collision avoidance)

Traffic Situation Awareness with Alerts (TSAA) - traffic alerts for General Aviation



Issue - TCAS RA Response

Major Air Carrier Does Not Respond to RA



 <u>Scenario</u>: Major air carrier leveled (by ATC) 500' below an initially level GA aircraft. GA aircraft maneuvered vertically toward TCAS aircraft.

Correct, timely pilot response to TCAS guidance is essential to ensure adequate vertical miss distance



Future Collision Avoidance



The FAA's Next Generation Air Traffic Control System incorporates:



Future collision avoidance must safely support and integrate new surveillance, users, and reduced separation procedures with minimal nuisance alerts



ACAS X Variants/New User Classes

		User Group	Surveillance Technology	Advisories				
Initial	ACAS X _A	Current ACAS II users (large aircraft)	Beacon Surveillance supplemented with ADS-B	Same set as current TCAS II				
Implementation	ACAS X _o	Users of specific operations (e.g., closely- spaced parallel operations)	Active radar supplemented with passive	Procedure- specific alerts for selected aircraft, global alerting against all others				
Longer term	ACAS X _P	General aviation	Passive only	Reduced advisory set				
research	ACAS X _u	Unmanned aircraft	Potentially radar, EO/IR, etc.	Vertical and horizontal advisories				
X _A – Active Surveillance X _o – Operation Specific X _P – Passive Surveillance X _U – Unmanned Aircraft								
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- Sponsors
 - AIR 130 Steve Plummer
 - AFS 430 Wayne Gallo
- Guidance Material
 - FAA AC 120-55C Air Carrier Operational Approval and Use of TCAS II
 - FAA AC 20-151A Airworthiness Approval of Traffic Alert And Collision Avoidance Systems (TCAS II), Versions 7.0 & 7.1 and Associated Mode S Transponders
 - RTCA DO- 185B Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance System (II)
 - Operational approval of Airbus Auto-RA functionality

• RTCA

- Special Committee 147 Will begin new ACAS Xa/Xo MOPS Oct 2013 - 2018
- Special Committee 228 Unmanned Aircraft Systems (UAS) MOPS July 2013 – July 2016



NextGen HF Collision Avoidance General Research Topics

- Automated RA response
 - Information needs, mode issues, operational procedures
- Pilot RA response
 - Factors associated with observed pilot response
 - Training and displays to improve RA response
- Future collision avoidance
 - Displays to support collision avoidance in NextGen operations
 - Human Capabilities and limitations with respect to future collision avoidance systems/concepts



FY 10-13 Collision Avoidance Research Topics

- Performers: Dr. Amy Pritchett, Georgia Tech; Steve Estes, MITRE
- Developed medium fidelity simulation capability
 - Implemented TCAS logic
 - Flight deck crew stations/displays
 - Traffic Generation/Psuedo-pilots
 - Air Traffic Control
- GA Tech Studies
 - Factors associated with pilot interaction with TCAS
 - Pilot interaction with TCAS Auto-RA capability
 - Training mitigations to improve pilot interaction with TCAS
 - Display concepts to improve pilot understanding of TCAS guidance
- MITRE Studies
 - Pilot and ATC acceptability of horizontal RAs



GA Tech TCAS Medium Fidelity Simulator

- Medium fidelity ATC/Flight deck simulation capability to support future collision avoidance Human Factors research
 - Traffic generation, psuedo pilot aircraft, ATC communications, TCAS guidance and traffic displays, Reconfigurable Flightdeck Simulation (RFS)
- Tools to reliably generate specific TCAS resolution Advisory types





- Horizontal RA acceptability (MITRE CAASD)
 - Method: Pilots and controllers observe video representation of scenarios reflecting horizontal Resolution Advisories during operations in NY Class B airspace
 - Main Finding: Horizontal Resolution Advisories are generally acceptable to pilots and controllers, but design must consider ATC and pilot goals/objectives to ensure operational acceptability
 - Supports RTCA ACAS X MOPS development
- Factors affecting pilot response to TCAS Resolution Advisories (GA Tech)
 - Method: Air Carrier pilots flying RFS simulator experience TCAS RAs across various traffic conditions, RA types and ATC communications
 - Main Findings
 - Pilot compliance to RAs found to vary significantly with traffic event, also affected by ATC traffic callouts some (but not all!) measures also found pilot effects
 - Time to achieve first commanded RA vertical rate correlated strongly with compliance
 - Supports future updates to pilot procedures and training in FAA AC 120-55C



- Pilot interaction with automated TCAS RA response (GA Tech)
 - Method: Air Carrier pilots flying RFS simulator experience automatic
 TCAS RAs across various traffic conditions and RA types
 - Main Findings
 - Pilots generally left autopilot engaged (83% of encounters) but did disengage autopilot in some circumstances
 - Most pilots rated auto-RA capability acceptable
 - Unexpected observations of mode confusion following termination of RA
 - Supports:
 - Future updates to pilot procedures and training in FAA AC 120-55C
 - AFS decisions on approval of Airbus autopilot RA functionality
 - Future ACAS X MOPS



- TCAS training improvements (GA Tech)
 - Method: Air Carrier pilots provided 45 minute training session based on observed issues
 - Main Findings
 - Significant improvements in compliance and reduction in aggressive response
 - Supports:
 - Future updates to pilot procedures and training in FAA AC 120-55C
- TCAS displays to improve understanding of TCAS guidance
 - Method: Air carrier pilots flew mix of scenarios using alternate prototype TCAS displays developed using human centered design approach
 - Main Findings:
 - Displays did not affect compliance, but did alter pilot scan across displays
 - Supports:
 - ACAS X MOPS







- Four planned simulator studies at Georgia Tech
 - Human Factors considerations for implementation of horizontal RAs
 - Informs development of concepts, displays, annunciations and procedures for use of horizontal RAs in future collision avoidance systems
 - Supports ACAS X MOPS
 - Identification of performance issues/mode potential mode confusion associated with auto-RA function
 - Previous research identified areas of potential mode confusion
 - Supports guidance for operations approval of autopilot RA functions; updates to FAA AC 120-55C
 - Factors associated with designation/de-designation of traffic to support collision avoidance function
 - Procedure-specific alerting in future collision avoidance will require traffic designation on CDTI
 - Supports ACAS X MOPS
 - Issues associated with coupling autoflight guidance to ADS-B in applications
 - Supports updates to procedures and training in FAA AC 120-55C as well as development of future DO-317MOPS



- Collision Avoidance human factors research supports issues with existing TCAS, integration of TCAS with other aircraft systems and implementation of new collision avoidance systems
 - AIR 130, AFS 430
 - RTCA SC-147, SC-228
- Ongoing research topics include:
 - Automated RA response
 - Horizontal RA issues
 - Understanding/improving RA response
 - Interaction with ADS-B in applications
- Research findings directly support updates to:
 - FAA AC 120-55C; FAA AC 20-151A
 - ACAS X MOPS





Observed TCAS Pilot Response Climb and Descend RAs



- In many cases flight crews do not respond to Climb/Descend RAs
 - Often likely due to visual acquisition with TCAS threat
 - Pilots may also respond less to Climb RAs when close to arrival airport at low altitudes
- Following TCAS RA guidance increases miss distance from threat
 - Non-response is often a factor in low separation encounters
 - Following "weakening" guidance if provided also minimizes altitude deviation and airspace impact
 - Over-response is less common, but can result in secondary conflicts and increased workload



Program Timeline



	2013	2014	2015	2016	201	7 2018	2019	2020	2023
ACAS X _U	2013 Con develo	-2014 cept opment	14 2014-2017 ot Requirements development/design			2018-2021 Standards development & safety assessment			2023 X _u MOPS Complete
Late 2014 Proof-of-concept Flight Test			i (Target date: 2018 for initial operational system (Certifiable UAS Collision Avoidance Capability)			Formalized Civil MOPS Approved		