Demonstrating Feasibility of Tactical Turbulence Alerts

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Tactical turbulence project objectives

- Tactical turbulence: A <u>rapidly-updated</u>, <u>high-resolution</u>
 view of the <u>current</u> turbulent state of the atmosphere
- FAA Weather Technology in the Cockpit (WTIC) Program
- Overall research project goals
 - Identify a recommended method for presenting tactical turbulence alerts in the cockpit
 - Demonstrate the feasibility of implementing the tactical turbulence alert (with the necessary latency) via an Aircraft Access to SWIM (AAtS) connection
 - Include tactical turbulence alerting function in the Minimum Weather Service recommendations
- Three Human-Over-The-Loop (HOTL) demonstrations at the NextGen Integration and Evaluation Capability (NIEC)

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Motivation for tactical turbulence alerts



- Current information available to pilots and dispatchers
 NCAR inadequate to accurately identify tactical turbulence hazards and can be misleading.
 - PIREPs, *in situ* EDR reports identify turbulence after encountered by other aircraft
 - GTG forecasts on ADDS currently do not include convective (CT) or convectively-induced (CIT) turbulence
 - Radar reflectivity is related to hydrometeor size and density, not turbulence intensity
 - Convective SIGMETs are large, long-lived, and non-specific
 - Turbulence SIGMETs don't include CT/CIT; only after severe PIREP
 - Airborne Doppler radar turbulence detection covers a limited region and is primarily for pilot use, not shared situational awareness
- Given the potentially rapid evolution of turbulence, latency of cockpit alerts must be minimized

NTDA-Graphical Turbulence Guidance Nowcast (NTDA-GTGNow)

- NTDA-GTGNow is a fusion of:
 - Graphical Turbulence Guidance (GTG-3)
 - Numerical weather prediction model
 - Diagnosis of Convectively-Induced Turbulence (DCIT)
 - MRMS 3D mosaic, lightning, satellite
 - NEXRAD Turbulence Detection Algorithm (NTDA)
 - PIREPs, in situ EDR measurements
- NTDA-GTGNow provides diagnosis of turbulence intensity
 - Outputs eddy dissipation rate^{1/3} (EDR)
 - Used to generate tactical turbulence alerts for inflight display
 - Updated at 15 min intervals
 - Includes turbulence sources for:
 - Clear air turbulence (CAT)
 - Convective (CT) and Convectively-induced turbulence (CIT)
 - Mountain wave turbulence (MWT)

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Human Over The Loop (HOTL) simulations and concepts



- Three stand-alone simulations in the NIEC Research Cockpit Simulator (RCS)
 - HOTL 1: End-to-end system component compatibility
 - Real-time alerts computed for all commercial aircraft in CONUS, including the RCS
 - Computational server load for generating TT product and alerts
 - Latency in delivering alerts to the NIEC/RCS
 - HOTL 2: Effectiveness of alert information in aiding pilot decision making for cabin management
 - Archived case studies for HOTL 2 and HOTL 3 with selected flights
 - HOTL 3: Efficiency/appropriateness of flight decisions with and without the TT alerts and NTDA-GTGNow product displays
- Simulations will occur February-July 2015

Meteorological scenarios for HOTL 2, 3

Scenario selection criteria

- Represent different turbulence sources
 - Clear-air (CAT)
 - Convective (CT)
 - Convectively-induced (CIT)
 - Mountain-wave (MWT)
- Different areas/depths of turbulence regions
- Different times of day, including nighttime convection



NIEC Research Cockpit Simulator (see ARAM poster 769A for more photos)

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Current alert parameters (adjustable) NCAR **60NM** Width: 60 NM **30NM** Length: 100 NM Middle: 30 NM **Position projection:** 100 NM ~3 minutes ~15 min of flight NTDA-GTGNow EDR thresholds: >0.15 Light >0.22 Moderate 3 minutes >0.34 Severe

Preliminary Text Alert Format

- Null example: NULL: No Alert for 18:18:00Z AIR007
- Light example:

ALERT: 13 Oct 2014 18:48:00Z AIR007 FL400 heading 188, Light Turbulence ahead

• Moderate example:

ALERT: 13 Oct 2014 19:03:00Z AIR007 FL400 heading 247, Moderate Turbulence ahead at JAN294021

JAN – Nearest Navaid

294 – Angle from Navaid to Moderate turbulence

021 – Distance in NM



CAT – Reflectivity mosaic





CAT – Satellite visible channel









NTDA-GTGNow gridded field shown with full range of EDR values 0-1





ALERT: 05 Nov 2014 18:33:00Z AIR007 FL300 heading 312, Moderate Turbulence ahead









NULL: Clear at 18:48:00Z AIR007

Summary



- NIEC Research Cockpit Simulator, WJHTC
- Three HOTL simulation studies:
 - HOTL 1: End-to-end realtime system test
 - HOTL 2: Pilot decision making for cabin management
 - HOTL 3: Pilot flight decisions w/wo alerts
- 2015 February July time frame
- If successful, next phase for WTIC program will be a future tactical turbulence demonstration with selected airlines

Thank you!