Update on FAA Turbulence Work

Friends and Partners of Aviation Weather (FPAW)
Summer 2018 Meeting
July 17, 2018
Tammy J. Flowe, Federal Aviation Administration
Update on FAA Turbulence Work

Overview

- Graphical Turbulence Guidance Nowcast (GTGN) Operational Evaluations
- Turbulence Reporting Standards Development
- September Turbulence Workshop
Turbulence
Why do we care?

pireps for 07 Jan 2009 0000 to 2400 UTC
flight levels (ft) = 1,000 to 65,000.
Motivations for FAA Turbulence Research

• **SAFETY:** In non-fatal accidents, turbulence is leading cause of injuries to passengers and flight crews for Part 121 Air Carriers\(^1\)
  - 1998-2013: 432 turbulence events; 225 serious injuries; 1,109 minor\(^2\)

• **CAPACITY:** Turbulence is the 2\(^{nd}\) leading cause of impact to NAS capacity

• **ECONOMY:** Cost to U.S. airlines $\sim$100 million/year\(^3\)

• **FUEL CONSUMPTION/EMISSIONS:** Turbulence related pilot initiated altitude deviations significantly increase airline fuel burn and carbon emissions
  - Estimates of fuel wasted by U.S. airlines as high as 160 million gallons/year\(^4\)

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\(^{1}\) [http://www.faa.gov/passengers/fly_safe/turbulence](http://www.faa.gov/passengers/fly_safe/turbulence)

\(^{2}\) NTSB Briefing to Turbulence Workshop, Washington DC, September, 2014

\(^{3}\) [http://news.delta.com/groundbreaking-app-helps-delta-pilots-avoid-turbulence](http://news.delta.com/groundbreaking-app-helps-delta-pilots-avoid-turbulence)


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FAA
Motivations
Shortfalls in Pilot Reports (PIREPS)

- Wright Brothers’ Technology?
- PIREPS are subjective in nature
- PIREP thresholds are aircraft-dependent
- Due to various reasons, manual turbulence PIREPs are often inaccurate in space and time:
  - A 2014 study by the NCAR found*:
    1. PIREPS, on average, have distance errors of 35-45 km
    2. Average PIREP timing error can range from a few seconds to a few minutes

Research and development by National Center for Atmospheric Research under FAA’s Aviation Weather Research Program (AWRP)

An algorithm in software loaded on the Aircraft Condition Monitoring System (ACMS)

- Uses existing sensors (accelerometer, winds, pressure, etc.) and inputs derived from sensors (angle of attack, roll angle, etc.) to calculate a measure of the turbulent state of the atmosphere

Aircraft independent, not a direct measurement of g-loads

Provides atmospheric turbulence metric: Eddy Dissipation Rate (EDR), actually $\epsilon^{1/3} \text{ (m}^{2/3}/\text{s})$, scaled 0.0-1.0

International Civil Aviation Organization (ICAO) standard metric for turbulence reporting
Government-Industry Collaboration Success
EDR Tech Transfer (EDR TT) Package Development

• Under funding from the FAA’s Weather Technology in the Cockpit (WTIC) program, NCAR developed an EDR TT package that allows airlines and airframe manufacturers to independently implement EDR reporting

• Development Approach: Modify the EDR algorithm to expand the capabilities of on-board and ground-based verification and tuning software

• The package then required evaluation and refinement to ensure it was complete and usable for new airframe types

• Key project participants: The Boeing Company, Teledyne Controls, Delta Air Lines, United Airlines
  - Others: Meteostar, Lufthansa, Swiss Air, AirDatTek, GoGo
U.S. Carriers: >1000 equipped aircraft (as of 7/16/2018)
  DAL: ~312, UAL: ~51, SWA: ~684
Foreign carriers joining program
  • Qantas, Lufthansa/Swiss Air, Air Lingus, Air France

Recent Accomplishments
  • Upgraded in-situ core ingest/QC software to accommodate additional airline data (e.g. A330) and added this capability to tech transfer package version.
  • Monitored calibrations of different fleets
  • In process of adding in situ data from several airlines
  • Improvements to tuning methodology
FAA Research
Graphical Turbulence Guidance (GTG) Forecast

- Based on NOAA’s RAP NWP model
- Publically available on [https://www.aviationweather.gov/turbulence/gtg](https://www.aviationweather.gov/turbulence/gtg)
- Forecast output in EDR [x100] with additional label of subjective intensity categories
- User selectable display for specific aircraft weight class (light, medium, heavy)
- Includes explicit forecasts for Mountain Wave Turbulence (MWT)
- Forecasts issued for Surface to FL 450
- Hourly forecasts extend out 0-18 hours, updated hourly
Graphical Turbulence Guidance Nowcast (GTGN) Operational Evaluations

• Designed for use as a tactical turbulence avoidance product
  ➢ Rapid update cycle of 15 minutes, valid for next 15 minutes

• Observation-centric:
  ➢ Nudges GTG3 to better agree with most recent turbulence obs
  ➢ Uses both airborne (PIREPS, in situ EDR) and ground-based (NEXRAD Turbulence Detection Algorithm-NTDA) observations

• Outputs all sources of turbulence – Low level, mountain wave, in cloud in a 3D map of EDR, same grid as GTG3

• Product received unanimous approval from a Technical Review Panel comprised of FAA, NWS, and airline met representatives in March 2016
Graphical Turbulence Guidance Nowcast (GTGN) Operational Evaluations

• GTGN available in real-time to AWC Testbed and Delta Air Lines to have flight crews and other users assess and evaluate the potential uses of the GTGN product in operations

• >12,000 DAL pilots with tablets containing “Flight Weather Viewer” application
  + Provides real-time graphics of GTG and EDR, along with company-specific products

• Crew reactions: “Industry game changer”; “…incredible leap forward in safety and customer comfort”

• If interested in helping evaluating GTGN, let us know and we will get you access to AWC Testbed.
Turbulence Reporting Standards Development

- RTCA DO-370 published in January 2018: Guidelines for Eddy Dissipation Rate (EDR) Algorithm Performance
  - Guidelines for developers to evaluate whether their algorithm performs as expected in strict testing environment
  - Actual operational implementations are much more complex
- Combined Surveillance Committee, Weather Surveillance Working Group (CSC WxS) - Determine which weather surveillance requirements and recommendations are to be implemented via ADS-B and/or Mode-S, and develop appropriate Minimum Operational Performance Standard (MOPS) requirements.
- Next step: Development of a Service Description for GTGN, to include inputs, update rates, etc, for use in the Minimum Aviation System Performance Standards (MASPS) for Aeronautical Information and Meteorological Data Link Services, RTCA DO-364A.
  - Will require harmonization with EUROCAE
  - Soliciting participation from industry – See Tammy Flowe or Eldridge Frazier
Turbulence Workshop III
September 5-6, 2018
Co-Sponsored by the MITRE Corporation and the National Center for Atmospheric Research (NCAR)
Location: MITRE, McLean, Virginia

For more information, contact
Tammy Flowe (Tammy.Flowe@faa.gov)
Dr. Bob Sharman (sharman@ucar.edu)