Research – Weather Information from Departure to Destination

Tuesday, November 2, 2016 | 4:00 p.m. – 5:00 p.m.

PRESENTED BY FAA:
Steve Abelman – Weather Research Branch, Manager
Gary Pokodner – Weather Technology in the Cockpit (WTIC), Program Manager
Objectives of Educational Session

What will you learn?

• Increase knowledge of FAA/NOAA sponsored weather services and products
• Enhance decision making thru better understanding of weather capabilities
• Highlight key elements ADS-B and FIS-B
• Provide insight on research projects to enhance weather information that supports aviation
• Highlight recent FAA research accomplishments
• Provide guidance on weather information and products to support various flight operations
Objectives of Educational Session
What can FAA learn?

• What’s working out there today and what needs to improve
• Input into prioritization of future research
• Stakeholder challenges and hot issues
The FAA’s Aviation Weather Research Program (AWRP)

Applied research to minimize the impact of weather on the National Airspace System (NAS)

• The NextGen Implementation Plan contains specific initiatives to support NextGen weather Operational Improvements

• Collaborative, complementary initiatives with NWS to transition legacy capabilities to meet NextGen requirements

• Focused initiatives to help mitigate safety and/or efficiency issues associated with well-documented weather problems
Weather Technology in the Cockpit (WTIC)

Program Mission and Overview

• The Weather Technology in the Cockpit (WTIC) program is an FAA NextGen program that consists of a portfolio of research projects related to weather information and technology in the cockpit

• WTIC research projects develop, verify, and validate requirements recommendations to incorporate into Minimum Weather Service (MinWxSvc) standards and guidance documents

• MinWxSvc is defined as:
  – Minimum cockpit meteorological (MET) information
  – Minimum performance standards/characteristics of the MET information
  – Minimum information rendering guidance recommendations
  – Enhanced MET training
Weather Technology in the Cockpit (WTIC)

Program Objectives

• Enhance safety by identifying and resolving risks before they become accidents
• Incorporate MinWxSvc recommendations into standards and other guidance documents
  – Enables NextGen operations and benefits, and pilot roles
• Resolve operational (current and NextGen) inefficiencies associated with adverse weather
• Enhance pilot MET-training to enable effective and consistent adverse weather decision-making

WTIC is not building cockpit applications or hardware so outreach to industry is necessary for implementing the MinWxSvc(s)
Weather Technology in the Cockpit (WTIC)

MinWxSvc Recommendations - Description

• Detail gaps identified by gap analyses
• Recommendations aimed at providing information to selected stakeholders which include: consumers, guidance writers, industry, and standards writers
• Provide clear and compelling case for the recommendations to stakeholders
  – Benefits can only be realized by stakeholder *implementation* of recommendations
  – Recommendations aimed at reducing or resolving identified gaps
• Recommendations to include sufficient detail for stakeholder use/implementation
• Includes summary of overall research process and results, and references to associated reports with brief descriptions
WTIC In The Media - A Hot Topic!
Operational Shortfalls – Safety and Efficiency

Why this matters?

- Weather is a leading cause of fatal and non-fatal accidents and passenger/crew injuries
  - Advancements in weather information and weather technology are resolving/reducing weather information gaps to enhance safety
- Adverse weather is a primary cause of operational inefficiencies and flight delays
  - Convection
  - Turbulence Avoidance
  - Terminal and Enroute Winds
  - Winter Weather Conditions
  - Ceiling and Visibility
Operational Shortfalls – Safety and Efficiency

Part 135 Accident Causality

- 2013 accident data
- Highest # of fatalities associated with CFIT and LOC
  - Both of which may have a weather component

Sources: http://www.ntsb.gov/investigations/data/Pages/AviationDataStats.aspx
Operational Shortfalls – Safety and Efficiency

Part 135 Accident Rate

• Accident rate fluctuating around 15 accidents per million flight hours over this 10 year period

• NTSB reported in September 2016 that the FAR Part 135 accident rate for 2015 “was up, but only slightly”

Sources: http://www.ntsb.gov/investigations/data/Pages/AviationDataStats.aspx
Operational Shortfalls – Safety and Efficiency

Safety Statistics

Part 135 – Accidents 2010 - 2014

Weather Event

- 33% Low CIG/VIS
- 29% Adverse Winds
- 13% Icing
- 12% Turbulence
- 8% Contaminated Runway
- 2% Lightning
- 2% Density Altitude
- 1% Carburetor Ice

Total Events: 253 Accidents, 64 Weather Related

Sources: Summer 2016 FPAW – NTSB Presentation
Operational Shortfalls – Safety and Efficiency

Safety and Efficiency Impact Examples

- Recent examples of shortfalls – safety and efficiency
  - Samples of weather related accidents
  - Loop of traffic with weather
  - Wind compression and/or wind-driven airport reconfiguration (Kevin’s video?)
  - Busjet runway excursions/overruns (primary issue for business jets?)
Operational Shortfalls – Safety and Efficiency

Weather Event Example

- ERA09FA389
  Cessna 421C, N4467D
  Gulf of Mexico
  July 8, 2009
  - IFR Part 135 flight from McKinney, TX (TKI) to Tampa, FL (TPA)
  - 3 AFSS Weather briefings
  - Anticipated deviating around weather
  - Equipped with airborne weather radar, StormScope, XM satellite
  - Fatal 5
Operational Shortfalls – Safety and Efficiency

2015 Part 135 Weather-Related Accidents

- CEN16LA076 – Gary, IN BE200 Dec 30
  LOC landing in icing conditions, substantial damage
- CEN16MA036 – Akron, OH HS125 Nov 11
  CFIT in LIFR conditions, fatal 9
- ANC15CA065 – Homer, AK C180 Aug 22
  LOC landing crosswinds, substantial damage
- CEN15LA334 – Chicago, IL C208 Aug 2
  High winds/microburst, substantial damage
- ANC15FA049 – Juneau, AK C207 July 17
  CFIT, fatal 1, 4 serious
- ANC15MA041 – Ketchikan, AK DHC3 June 25
  VFR into IMC, fatal 9

Sources: Summer 2016 FPAW – NTSB Presentation
Operational Shortfalls – Safety and Efficiency

2015 Part 135 Weather-Related Accidents [con’t]

- GAA15CA005 – Muckegon, MI C208 Mar 10
  Collision with approach lights, **LIFR conditions** 1/2SM FG OVC002

- CEN15LA144 – Denver, CO BE58 Feb 15
  LOC rejected takeoff on **contaminated runway**, substantial damage

- ERA15LA125 – Isla de Vieques, PR C402 Feb 10
  LOC landing **gusting crosswinds**, substantial damage

- 6 HEMS accidents with 7 fatal, 3 serious injuries
  Causes & weather factors undetermined at this time

Sources: Summer 2016 FPAW – NTSB Presentation
Operational Shortfalls – Safety and Efficiency

Safety Statistics

• Weather conditions to be a major contributing factor in all categories of aviation accidents
  – Turbulence
  – Loss of Control (LOC) in flight/ground
    • Adverse winds
    • Spatial Disorientation
    • Icing
    • Thunderstorms
  – VFR into IMC
Operational Shortfalls – Safety and Efficiency

Convection Impact

Here is a recent example of traffic impact by convection developing and moving into Orlando (Black arriving flights, blue departures)

Note the impact of how the weather north and south of MCO causes traffic to bunch up on approach

In an area like NY or Chicago with even more traffic and multiple airports, these problems are amplified
Operational Shortfalls – Safety and Efficiency
Wind Compression Impact

- Path-based wind shear present during sufficient arrival demand can create challenging wind compression situation in attempt to maintain spacing
  - 9 December 2014 particularly problematic wind compression event at EWR

Nor’easter located off East coast
Strong surface winds out of Northeast
Winds aloft out of South
Weather Information – Historical Perspective

Advances in aviation weather information and access

- Numerical Modeling Resolution
- Preparation for Winter vs. Convective Weather
Weather Information – Historical Perspective

Advances in aviation weather information and access

- Increased Numerical Modeling Resolution
- Realistic terrain with more features (land and water)
- Explicit prediction of thunderstorms and other phenomena
- Realistic physical processes
- Results in more accurate forecasts

![Diagram showing different modeling resolutions over time](image-url)
Weather Information – Historical Perspective

Winter Weather versus Convective Weather

• 20 years ago this image…
• Produced this impact…
• But now often produces this…
• So what has happened…
Weather Information – Historical Perspective

Winter Weather versus Convective Weather

• 20 years of steady improvement in numerical modeling forecasting has led to smarter, more proactive cancellations and operational decision by airlines, business jet operations and even GA during winter storms (and tropical weather as I am making this slide during impact of Hurricane Matthew)

• Even FAA air traffic management statistics are often “fooled” by seemingly smooth operations during winter storms

• However, while our thunderstorm forecasts have improved dramatically, airlines much less willing to make similar operational decisions with similar lead times.

• So what’s a common result…
Weather Research

What’s working:

• GTG - Steve
• FIP/CIP - Steve
• EDR - Gary
Weather Research

What’s working:

- Graphical Turbulence Guidance (GTG)
  - Operational on NWS aviationweather.gov website
  - Includes CAT, Mountain Wave and Low Level Turbulence from Sfc-FL450 to 18 hours out
  - Displays EDR (Eddy Dissipation Rate) with option to convert to aircraft size impact
  - Future considerations include Global Expansion, 15 minute “nowcast” product, and probabilistic component.
Weather Research

What’s working:

- Current and Forecast Icing Product (CIP and FIP)
  - Operational on NWS aviationweather.gov website
  - Includes Icing Probability, Severity, and SLD from Sfc-FL290 to 18 hours out
  - Future considerations include global expansion, increased resolution, and forecasts of icing components for airframe specific applications
Weather Research

What’s working:

- Eddy Dissipation Rate (EDR)/Graphical Turbulence Guidance (GTG) Uplink and EDR Technical Transfer Package
  - 2013-14: FAA successfully demonstrated EDR/GTG uplink in collaboration with Delta Air Lines
  - FAA sponsored benefits assessment showed a substantial reduction in altitude changes. Total benefits via simulation shown to be $414M with 50% sector use*
  - Technical transfer package is being refined and tested to ensure usability with new aircraft types
    - Includes software for on-board calculations and ground-based quality control system
  - Delta Airlines excited about benefits of implementing EDR/GTG uplink—They have outfitted <12,000 DAL pilots with a tablet-based weather application for use in real-time decision-making (altitude adjustments, cabin management, reduction in fuel burn/emissions)

*Reference EDR Quantitative Benefits Analysis Final Report
Dated: 9 December 2014, by AvMet Applications Inc.
Weather Research

What’s working: EDR

- Eddy Dissipation Rate (EDR)/Graphical Turbulence Guidance (GTG) Uplink and EDR Technical Transfer Package

Graphical Turbulence Guidance (GTG) forecast product with automated turbulence reports

On the left: Atmospheric profile view
On the right: Route of flight
Cockpit Applications Research
WTIC Current Research

• ADS-B / FIS-B
• Tactical Turbulence Notification
• Wind Information Accuracy, Fidelity, and Integration with Avionics
• Active Reminder – Distance From Convection and Low Visibility
• Cloud Tops
• Latency Training
• Mobile meteorological (MET) applications
Cockpit Applications Research
Current Research – ADS-B/FIS-B

• Automatic Data Surveillance Broadcast (ADS-B) and Flight Information Service Broadcast (FIS-B) – FIS-B Service
  – Aircraft equipped with ADS-B transceiver receives the FIS-B service
  – Provides NAS users with accurate, reliable, and timely data on weather conditions in the NAS
  – Non-control near real-time aeronautical information regarding the status of NAS systems and resources
  – Data linked via Universal Access Transceiver (UAT)
  – Includes graphical and textual weather reports and forecasts, Special Use Airspace (SUA) information, NOTAMs, and pilot reports (PIREPS)
### Cockpit Applications Research

#### Current Research

- Current FIS-B Texts/Graphics Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
<th>SBSS-Required Update Interval</th>
<th>SBSS-Required Transmission Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONUS NEXRAD</td>
<td>Contiguous United States Next Generation Radar</td>
<td>~5 minutes (10 minutes for clear air mode)</td>
<td>15 minutes</td>
</tr>
<tr>
<td>Regional NEXRAD</td>
<td>Regional Next Generation Radar</td>
<td>~5 minutes (10 minutes for clear air mode)</td>
<td>2.5 minutes</td>
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</table>

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</thead>
<tbody>
<tr>
<td>AIRMET</td>
<td>Airman's Meteorological information: mountain obscuration, icing, or turbulence</td>
<td>As Available</td>
<td></td>
</tr>
<tr>
<td>CONVETIVE SIGMET</td>
<td>Significant Meteorological Information: severe, extensive, or prolonged thunderstorm</td>
<td>As Available, then 15 minute intervals for 1 hour</td>
<td>5 Minutes</td>
</tr>
<tr>
<td>SIGMET</td>
<td>Significant Meteorological Information: turbulence, icing, or IMC conditions</td>
<td>1 hour</td>
<td></td>
</tr>
<tr>
<td>NOTAM-D</td>
<td>Distant Notice to Airmen: Information requires wide dissemination</td>
<td>As Available</td>
<td>10 Minutes</td>
</tr>
<tr>
<td>NOTAM-FDC</td>
<td>Flight Data Center Notice To Airmen: Information that is regulatory</td>
<td>As Available</td>
<td>10 minutes</td>
</tr>
<tr>
<td>SUA Status</td>
<td>Special Use Airspace Status</td>
<td>As Available</td>
<td>10 minutes</td>
</tr>
</tbody>
</table>
Cockpit Applications Research

Current Research – ADS-B/FIS-B

• FIS-B Improvements and Additional FIS-B Products
  – Lightning – Lighting Strokes on Display Map, 5 min updates, assist pilots in identifying most severe areas of convection
  – Turbulence – Intensity, receives data from NWS GTG (available in CONUS only)
  – Icing – NOWcast, 8 raster images updated every hour, displays most severe icing level in altitude band, indicates presence of Supercooled Large Droplet formation
Cockpit Applications Research

Current Research – ADS-B/FIS-B

- FIS-B Improvements and Additional FIS-B Products
  - Cloud Top Heights – Useful for GA pilot to understand sky conditions and how high the tops of clouds extend. Updated every 30 minutes from GOES satellite.
  - One-Minute Automated Weather Observing System (AWOS) – More frequent updated airport weather. FIS-B updates every 5 minutes, this data normally changes hourly.
Cockpit Applications Research

Current Research – ADS-B/FIS-B

• RTCA Special Committee 206 Subgroup 5
  – Modify DO-358 – Minimum Operational Performance Standards (MOPS) for Flight Information Services Broadcast (FIS-B) data using Universal Access Transceiver (UAT)
  – Include 5 new weather products in the MOPS
    • Define the minimum operational performance for the display of FIS-B data
    • Define testing requirements for the display of FIS-B data
  – Modify FIS-B data display testing requirements for some of the existing products
Cockpit Applications Research

Current Research

• Tactical Cockpit Turbulence Notification
  – Demonstration using NEXRAD Turbulence Detection Algorithm (NTDA)
  – Low latency
  – Primarily a tactical notification to secure cabin, but enabled some reroute decisions
  – Concept is to notify proximity aircraft to detected turbulence
  – Graphical Turbulence Guidance (GTG) on viewer to assist with request for new altitude
Tactical Turbulence Notification and GTG Display on iPad

Notification includes:
- Text message
- Polygon of turbulence
Tactical Turbulence Video
Cockpit Applications Research

Current Research

- Adverse Weather Active Reminder
  - Implementation tested for convection and low visibility
  - Provides visual notification of preset distance to adverse condition
  - Addresses shortfalls of pilots flying too close to convection and inadvertent IMC
  - Demonstration scenarios set reminder to 20 nmi from convection and visibility
  - Initial results showed credible impact reducing flights into 1 nmi visibility from 15 to 7
  - Data analysis of demonstration still ongoing
  - Preliminary analysis showing active reminder assists pilots in determining distance to adverse weather conditions
Active Reminder (AR) Demonstration Video

Two video segments; first is convection and second is low visibility. Blue line popping up is the active reminder.
Cockpit Applications Research

Current Research

• Weather Information Latency Trainer (WILD)
  – Developed by PEGASAS, the FAA Center of Excellence for General Aviation
  – Capability to vary NEXRAD latency versus out-the-window view incorporated into demonstrator
  – Provides enhanced training on the impacts of latency and decision making skills
  – Baseline design can be easily incorporated into commercial training devices
  – PEGASAS collaborating with trainer manufacturers to incorporate design
  – Currently PEGASAS is developing associated immersive skills based training to be used with WILD and potentially an online video version
WILD Demonstration Video
Weather and Application Research

Futuristic Research

- **Crowd Sourcing – Processing and Sensors**
  - Weather Radar
  - Wind Information
  - Ceiling and Visibility
- **Automated Weather**
- Translated Weather
- Probabilistic Forecasts and Uncertainty Information
- **Nulling Out Latency (Latent vs Forecast)**
Weather and Application Research

Crowd Sourcing

• Crowd Sourcing as Processor
  – Visibility
• Crowd Sourcing as Sensor
  – Wind
  – Forward Looking Radar
  – Turbulence
Crowd Sourcing

Visibility - Current

Current Synoptic View of FAA Alaska Web Cams
http://avcams.faa.gov

Clicking on camera location provides current cam image
Crowd Sourcing
Visibility - Current

FAA Alaska Web Cams – Camera View
http://avcams.faa.gov/

Camera views at same location, camera direction noted.
Crowd Sourcing

Visibility - Current

• Webcams provide current view
• Some distance markers on clear day view
• Need to look at multiple cameras to determine visibility along flight route
• Additional clicks required to view looping for trending information
• High bandwidth images
• High workload not compatible for in-flight use, high work load for flight service stations
Crowd Sourcing
Visibility – Crowd Sourced Information

- Objectives of crowd sourced visibility information include:
  - A low bandwidth synoptic view (Alaska for demonstration) of visibility that provides at least an equivalent level of information (goal is to provide additional information) and accuracy
  - Easier to interpret and less workload
  - Enable trending view and route information in synoptic view
  - High reliability and availability
  - Potentially enhance data inputs to weather models
Crowd Sourcing
Visibility – Crowd Sourced Information

• Methodology and Objectives:
  – Use human evaluators to assess visibility by completing short Human Intelligence Tasks that consist of comparing a distance annotated clear day view to a current still image
  – Use crowd sourcing to develop desired level of confidence
    • More evaluators, higher rated evaluators, edge detection sensors, and prevalence, can be used to increase confidence
    • Algorithm determines when “crowd” has converged on a solution
  – Potentially use hybrid system that includes edge detection software for quality assurance and/or simple clear day assessments
  – Use crowd sourced information to develop low bandwidth synoptic views that provide assessment of visibility and trends
  – Synoptic view provides visibility information along route as well as destination
A display showing an active Human Intelligence task will allow an evaluator to login and input visibility assessment into the system.

Clear day view has distances marked.
Crowd Sourcing

Visibility – Crowd Sourced Information

The notional results summary picture shows the current visibility at two camera locations based upon the crowd sourcing. Colors indicate visibility distances, arrow direction will indicate trend, and mouseover will provide additional details.

Notional display of site with multiple camera views. Green is VFR, yellow is marginal VFR, and red is IFR.
Weather Research

Challenges

• Using latent products vs. high resolution short term forecasts
  – Can a pilot trust the uncertainty in a 15 minute forecast instead of a 15 minute old NEXRAD image?
• Does the “High Definition”, “Highly Accurate” cockpit weather device make pilots complacent?
  – Is weather information designed for strategic applications being used tactically?
• Limits of Science
  – Forecasts of turbulence, icing, C&V and more continue to improve, but we have a long way to go!
  – Forecast information using uncertainty quantification (e.g. probability, risk, confidence, etc…) is the latest craze, but do users get it?
• Are users trained adequately to use the latest cockpit applications or to understand meteorological advancements?
Contact Information
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