NAS Ops Subcommittee Review

Weather Technology in the Cockpit (WTIC)

By: Gary Pokodner, Program Manager, Weather Technology in the Cockpit (WTIC)

Date: August 11, 2015
Weather Technology in the Cockpit (WTIC) - Program Description

- Research projects to develop, verify, and validate requirements for incorporation into Minimum Weather Service (MinWxSvc) standards
  - FAR Part 121, OPERATING REQUIREMENTS: DOMESTIC, FLAG, AND SUPPLEMENTAL OPERATIONS (i.e. commercial operations)
  - FAR Part 135, OPERATING REQUIREMENTS: COMMUTER AND ON DEMAND OPERATIONS AND RULES GOVERNING PERSONS ON BOARD SUCH AIRCRAFT (i.e. commuter, on demand, and air taxi operations)
  - FAR Part 91, GENERAL OPERATING AND FLIGHT RULES (includes General Aviation operations)

- The MinWxSvc is defined as:
  - Minimum cockpit meteorological (MET) information
  - Minimum performance standards (e.g. accuracy) of the MET information
  - Minimum information rendering standards
  - Enhanced weather training
  - Minimum cockpit technology capability recommendations
WTIC Program Overview

Purpose

- Identify causal factors for weather-related General Aviation (GA) safety risks/hazards
- Identify causal factors for Part 121/135 adverse weather safety risks/hazards and NAS operational inefficiencies (current and NextGen)
- Recommend MinWxSvc(s) to resolve/reduce identified safety risks and NAS inefficiencies
- Recommend enhancements to pilot MET-training to resolve training shortfalls

Budget

<table>
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<tr>
<th>Year</th>
<th>FY14</th>
<th>FY15</th>
<th>FY16</th>
<th>FY17</th>
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<td>funded</td>
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<td>Budget</td>
<td>$3.4M</td>
<td>$3.1M</td>
<td>$3.1M</td>
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WTIC Program Overview

Benefits

• Enhanced safety by resolving/reducing adverse-weather safety risks before they result in an accident/incident

• Enhanced NAS efficiency and increased capacity resulting from consistent and predictable pilot adverse weather decision making due to established cockpit minimum weather service(s)
  – Reduced emissions due to enhanced efficiency
  – Reduction in flight delays

• Enhanced safety resulting from the resolution of pilot MET-training shortfalls

Tracking

• Developing spreadsheet to track gaps, operational shortfalls, and MinWxSvc(s) recommendations
<table>
<thead>
<tr>
<th>Gap Identification</th>
<th>Gap Resolution</th>
<th>Input Sponsor / Output Beneficiary</th>
<th>Future Research (if necessary)</th>
<th>WTIC Program Output</th>
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<tbody>
<tr>
<td>Research Activity</td>
<td>MinWxSvc Category</td>
<td>Current / Past Research</td>
<td>Research Reference Document</td>
<td>Participant / Sponsor</td>
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<td>Operator input</td>
<td>Lack of objective turbulence information in the cockpit</td>
<td>NCAR Tactical Turbulence</td>
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<td>Information - Content</td>
<td>MIT Adverse Weather-Alerting</td>
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<td>AFS</td>
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<td>Recommendation</td>
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<td>EDR Uplink Demonstration Final Report</td>
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<td>Airlines</td>
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<td>WTIC Mid-Term</td>
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<td>EDR Benefits Quantification Final Report</td>
<td>-</td>
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<td>ConOps Development</td>
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<td>WTIC Mid-Term ConOps</td>
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<td>NCAR</td>
<td>Safety Hazard / Risk</td>
<td>Current rendering of METAR information on commercially available cockpit applications results in inconsistent recognition of change of state of information</td>
<td>-</td>
<td>PEGASAS</td>
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<td>Safety Hazard /</td>
<td>Information - Content</td>
<td>PEGASAS Project C Final Report</td>
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<td>AFS</td>
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<tr>
<td>Risk</td>
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<td>HF Standardization Final Report</td>
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<td>SAE G10</td>
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<td></td>
<td></td>
<td>ATSC Final Report to Initial Study</td>
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Open NAS Ops Recommendations and Action Items

• No NAS Ops Open Action Items or Recommendations
Recent and Upcoming Accomplishments

• **WTIC Wind Study**
  – Completed Phase 4 research planning
  – Co-Chair SG7 of RTCA SC-206, outlined “Guidance of Data Linking Forecast and Real Time Wind Info to Aircraft”
  – Upcoming activities – implement research plan
    • Produce trade spaces with Boeing models
    • Develop trade spaces with A320 SESAR FMS (10 altitude wind levels and limited interval management) (Need SESAR approval)
    • A-IM trade spaces with lead aircraft as active participant
    • Lead SG7 of RTCA SC-206 deliverable completion
    • Investigate potential sources of truth wind data for HRRR accuracy comparison
  – No phase 5 research currently planned
Guidance for Data Linking, Forecast and Current Wind Information to Aircraft

1 Introduction
   1.1 Purpose
      1.1.1 Problem Statement(s)
      1.1.2 Goals
      1.1.3 Use of this Document
   1.2 Scope and Approach
      1.2.1 TOR Information
      1.2.2 Other Guidance
   1.3 Background
      1.3.1 Documents Review/Information Gathering Process and Findings
      1.3.2 Need for Wind/Temperature data
   1.4 Stakeholders
   1.5 Assumptions and Considerations
   1.6 Disclaimer
   1.7 Reference Documents
   1.8 Glossary
   1.9 Acronyms and Abbreviations
   1.10 Document Overview

2 Interval Management
   2.1 Advanced-Interval Management
      2.1.1 A4M Overview
      2.1.2 Impact of Winds/Temperatures
   2.2 Flight Interval Management
      2.2.1 FIM Overview
      2.2.2 Impact of Winds/Temperatures
   2.3 Operational Weather Requirements
   2.4 Supporting Research Results

3 4D Trajectory Based Operations
   3.1 4D TBO Overview
      3.1.1 Impact of Winds/Temperatures

3.2 Required Time of Arrival
   3.2.1 RTA Overview
      3.2.1.1 Impact of Winds/Temperatures
   3.2.2 Departure RTA
      3.2.2.1 Overview
      3.2.2.2 Impact of Winds/Temperatures
   3.2.3 Arrival RTA
      3.2.3.1 Overview
      3.2.3.2 Impact of Winds/Temperatures
   3.2.4 Cruise RTA
      3.2.4.1 Overview
      3.2.4.2 Impact of Winds/Temperatures

3.3 Operational Weather Requirements

3.4 Supporting Research Results

4 Wake Vortex Mitigation
   4.1 Wake Mitigation Overview
      4.1.1 WM Overview
      4.1.2 Impact of Winds/Temperatures
   4.2 T&D --- (Clark to provide operations/areas per AI-13)
   4.3 Operational Weather Requirements
   4.4 Supporting Research Results

5 Conclusions and Recommendations
   5.1 Methodology of Reporting
   5.2 Quality
   5.3 Synchronized Winds among Stakeholders
   5.4 Recommendations for Future Work

5 Membership
   6.1 SC-206 Co-chairs
   6.2 RTCA Program Director
   6.3 SG7 Co-chairs
   6.4 SG7 Key participants
   6.5 SC-206 Membership

Appendix A 4D Trajectory Based Operations Example/Scenario(s)
Appendix B Wake Vortex Example/Scenario(s)
Appendix C Interval Management Example/Scenario(s)
Recent and Upcoming Accomplishments

• Mobile MET
  – Completed demonstration of updated Mobile MET prototype tool
    • Credibly increased weather situational awareness
    • Credibly larger distances from hazardous weather (30dBZ)
    • Both groups were much closer than recommended 20 Nmi
    • Low performance in discriminating change-detection
    • No degradation observed on safety-related flight tasks
  – Upcoming activities – final phase
    • Identify content and capabilities to support pilot workflow by phase of flight
    • Finalize MinWxSvc recommendations and prepare recommendations for developers
Recent Accomplishments – Mobile MET

Figure 4. Illustration of the weather application menus.

Figure 6. An example of the out-the-window view during Scenario A.

Figure 8. Illustration of the out-the-window view during start-up for Scenario B.
Recent and Upcoming Accomplishments

• **GA MET Rendering Standardization**
  – Completed demonstration of impacts of state-change notifications (tactile) in GA cockpit simulator
    • Credibly higher recognition of weather state-changes and weather situational awareness
    • No credible difference in distance from 30dBZ cells
    • No credible difference in inadvertent IMC encounters though experimental group had 20% less (33 vs 27)
    • Poor recognition of symbol changes on topological, IFR and VFR map backgrounds
  – Upcoming Activities being considered for follow-on include
    • Assess performance with more simplistic renderings than symbols
    • Define MinWxSvc recommendations for luminance contrast
    • Follow-on notification demonstration with larger sample of pilots
    • Investigate “safe distance” from severe convection
Recent and Upcoming Accomplishments

• PEGASAS (GA Center of Excellence) GA Projects
  – Completed Phase 1 final reports (Spring 2015)
    • Identified numerous safety related gaps
    • Notification assessment found prioritized tone/tactile with brief text yielded best results
    • Briefed GA stakeholders (AOPA, GAJSC, NTSB, AFS) on July 21
  – Completed Phase 2 planning and began research efforts
    • Research focused on 15 gaps identified in Phase 1 (see backup slides)
    • Mitigating latency related issues a primary goal
  – Upcoming activities
    • Collaborating with FRASCA to develop trainer that implements adjustable weather latency for training
    • HITL demonstration to assess benefits/impacts of focused training on avoiding inadvertent flight into IMC
    • HITL demonstration to assess effects of display factors (i.e., encoding severity in tactile notifications) on pilot decision making
Recent and Upcoming Accomplishments

• **Shortfall analyses in oceanic and remote regions**
  - Completed shortfall analyses and delivered draft report
    • Convection - Lack of information to depict the vertical profile and horizontal extent of convective weather results in extra flight time and communication
    • Turbulence - Lack of accurate turbulence forecasts and sharing of turbulence encounter information results in unanticipated turbulence encounters or unnecessary avoidance maneuvers
    • Icing (Engine Core) - Incidents of ice accretion inside the core of an engine inflight at higher cruise altitudes have resulted in thrust loss or engine flameout
    • Icing (Structural) - Ice crystals accumulated on the pitot tubes causing several aircraft systems to degrade or malfunction
  - **Upcoming Activities**
    • Identify current MET sources/technologies to resolve shortfalls
    • Complete final report and gap spreadsheets
<table>
<thead>
<tr>
<th>Shortfall: Information Gap</th>
<th>Frequency</th>
<th>Impact</th>
<th>Current Met Sources / Technology</th>
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</thead>
<tbody>
<tr>
<td>Inefficient rerouting to avoid convective activity due to a lack of: • Vertical profile of convective weather • Lateral extent of convective weather • Graphical depiction of weather satellite data</td>
<td>• 9 respondents mentioned this MET element • Commonly encountered throughout warmer latitudes</td>
<td><strong>Safety</strong>&lt;br&gt;Limitations of onboard radar:&lt;br&gt;• Difficulty depicting weather behind the weather (radar shadows) hindering pilot decision-making to deviate through or around weather&lt;br&gt;• Relative lack of radar reflectivity of oceanic convection (particularly dry storm tops) compared to that over land.&lt;br&gt;• Time/effort required to coordinate/approve a deviation with ATC can result in limited options to deviate.&lt;br&gt;• Lack of uplinked current graphic-based depiction of convective weather to aid in decision-making.</td>
<td>• Maintaining adequate separation for deviating aircraft in non-radar environment (primarily lateral deviations)</td>
</tr>
<tr>
<td><strong>Efficiency</strong>&lt;br&gt;Higher fuel burn due to:&lt;br&gt;• Lateral deviation resulting in longer route&lt;br&gt;• Vertical deviation away from optimum altitude</td>
<td></td>
<td><strong>Workload</strong>&lt;br&gt;• Additional communications with ATC for route adjustment to avoid convection&lt;br&gt;• Additional communications with dispatch for fuel burn/flight time adjustments based on revised route/altitude which impacts fuel reserves for destination and alternate(s)&lt;br&gt;• Cockpit/Cabin coordination with Flight Attendants for seat belt sign/cabin service adjustments</td>
<td><strong>Increased workload/comm in coordinating routing/altitude changes with pilots/other ATC sectors</strong></td>
</tr>
<tr>
<td>Environmental Impact</td>
<td>• Lateral deviations and/or holding resulting in longer flight times and increased emissions</td>
<td></td>
<td></td>
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<tr>
<td>Passenger</td>
<td>• Comfort - Avoid turbulence&lt;br&gt;• Schedule - Longer flight time due to deviations</td>
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Recent and Upcoming Accomplishments

• **Functional analysis of WTIC ConOps**
  – Completed functional analysis of WTIC ConOps
    • Developed WTIC Functional Architecture Document (FAD) (Sample outputs in backup slides)
    • Developed SV-1 (Systems/Services Interface Description), SV-2 (Systems/Services Communication Description), and SV-4 (Systems/Services Functionality Description) views
    • FAD details the set of functions, requirements, and architecture of necessary Data Link Weather (DLW) capabilities to implement/enable NextGen weather benefits
  – Upcoming activities and uses of functional analysis
    • Identification of minimum DLW services
    • Identification of internal and external service interfaces for DLW
    • Assess gaps in existing functions and data for DLW
    • Derivation of service level requirements that can be allocated to enabling systems
BACKUP SLIDES
Knowledge Gaps
- **Gap 1**: Lack of training (mainly due to little opportunity) for student pilots to fly in and experience different weather patterns and their associated visual and other cues.
- **Gap 2**: GA pilots often do not understand the limitations of the technology in the cockpit.

Skill Gaps
- **Gap 3**: There is a perceived gap in skills related to VFR-into-IMC decision-making.
- **Gap 4**: Lack of Situational Awareness relating to VFR-into-IMC.
- **Gap 5**: Retention of weather knowledge was identified as a gap.

Ability Gaps
- **Gap 6**: Lack of ability of pilots to correlate, interpret and apply weather information related to VFR-into-IMC Weather Factors, specifically convection, icing, lowered ceilings, quickly emerging weather events, precipitation, or pilot-reported turbulence.
PEGASAS Phase II Research

• Training Gaps
  – **Gap 7**: Existing pilot training activities do not provide pilots with adequate exposure to the impact of adverse weather events, information latency, or information resolution on the hazards of flying VFR-into-IMC or adverse weather conditions. (Source: Survey / Focus Groups / Past Literature).
  – **Gap 8**: Existing pilot training activities to not sufficiently develop or improve KSAs regarding adverse weather events, information latency, or information resolution on the hazards of flying VFR-into-IMC or adverse weather condition

• Assessment Gaps
  – **Gap 9**: Pilot applicants taking written knowledge certification examinations can fail all weather questions but still pass the examinations.
  – **Gap 10**: No specific guidance on weather knowledge assessment in the Flight Review FAR §61.56.
Technology Gaps

- **Gap 11**: Identification of adverse weather event triggers (and impact on pilot planning efforts) differs between out the window and mobile device / software application presentations of weather conditions; differences in awareness of trigger severity and potential impact affects pilot planning task and time sequences.

- **Gap 12**: Existing, commercially available aviation training device (ATD) simulators, regardless of certification level, do not present NEXRAD or other weather information with the latencies commonly experienced during actual flight.
• **Information Presentation Gaps**
  
  – **Gap 13**: The effectiveness of available mobile device and software application tools is affected in unknown ways due to timely availability of tool features and high-salience alerts. (Source: Past Literature / Technology Evaluation).
  
  – **Gap 14**: Information presentation and interface design in some mobile devices and software applications may limit or prevent pilot planning activity in potentially degrading ways during adverse or degrading weather conditions. (Source: Past Literature / Survey / Technology Evaluation).
  
  – **Gap 15**: Updates to flight conditions after a pilot obtains a flight briefing may not be communicated in a timely manner to pilots.
Functional Analysis – Sample High Level Requirements

• Establish Crew Connection to WTIC Service
  • DLW Service shall provide capability for FAR 121 crew to connect to WTIC services.
  • DLW Service shall provide capability for FAR 135 crew to connect to WTIC services.
  • DLW Service shall provide capability for FAR 91 crew to connect to WTIC services.

• Transform to Textual Format
  • DLW Service shall convert aggregated Weather data into pre-established textual reporting format.
  • DLW Service shall convert aggregated Weather data into crew-requested textual reporting format.