NAS Ops Subcommittee Review

Weather Technology in the Cockpit (WTIC)

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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

FY14 (funded)	FY15 (funded)	FY16 (funded)	FY17 (request)
$3.4M	$3.1M	$3.1M	$3.3M

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

•WTIC Gap Tracking / MinWxSvc Spreadsheet (excerpt)

Gap Identification				Gap Resolution		Input Sponsor / Output Beneficiary		Future Research (if necessary)	WTIC Program Output	
Research Activity	Shortfall	Gap	MinWxSvc Category	Current / Past Research	Research Reference Document	Participant / Sponsor	Stakeholder(s)	Required Research	MinWxSvc Element(s)	Delivered On
•Operator input •NTSB Safety Recommendation •WTIC Mid-Term ConOps Development •EDR Uplink Demonstration •NCAR	Inefficiency	Lack of objective turbulence information in the cockpit	Information - Content	•NCAR Tactical Turbulence		•AVS •AFS •Delta Airlines •NCAR •WJHTC / NIEC	•AVS •AFS •Airlines		•EDR Technical Transfer Package	
	Safety Hazard / Risk								•Objective turbulence information (i.e. EDR/GTG) in the cockpit	
				•MIT Adverse Weather-Alerting						
				•EDR Uplink Demonstration	•EDR Uplink Demonstration Final Report					
				•EDR Quantification of Benefits	•EDR Benefits Quantification Final Report					
				•WTIC Mid-Term ConOps	•WTIC Mid-Term ConOps					
•Tech Center HF Study •PEGASAS •ATSC Initial Report	Safety Hazard / Risk	Current rendering of METAR information on commercially available cockpit applications results in inconsistent recognition of change of state of information	Information - Content	•PEGASAS	•PEGASAS Project D Final Report	•AFS •AVS •PEGASAS •SAE •ATSC •WJHTC	•AFS •AVS •Operators		•Recommended set of airport visibility alerting functions	
					•PEGASAS Project C Final Report					
				•Tech Center HF Standardization	•HF Standardization Final Report					
					•SAE G10					
				•ATSC Uncertainty Study	•ATSC Final Report to Initial Study					

Open NAS Ops Recommendations and Action Items

- No NAS Ops Open Action Items or Recommendations

Recent and Upcoming Accomplishments

- **WTIC Wind Study**
  - Delivered Phase 3 final report to RTCA SC206. Positive feedback from the committee (spring 2015).
  - 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

RTCA SC-206, SG7 Deliverable Outline

Guidance for Data Linking Forecast and Current Wind Information to Aircraft

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

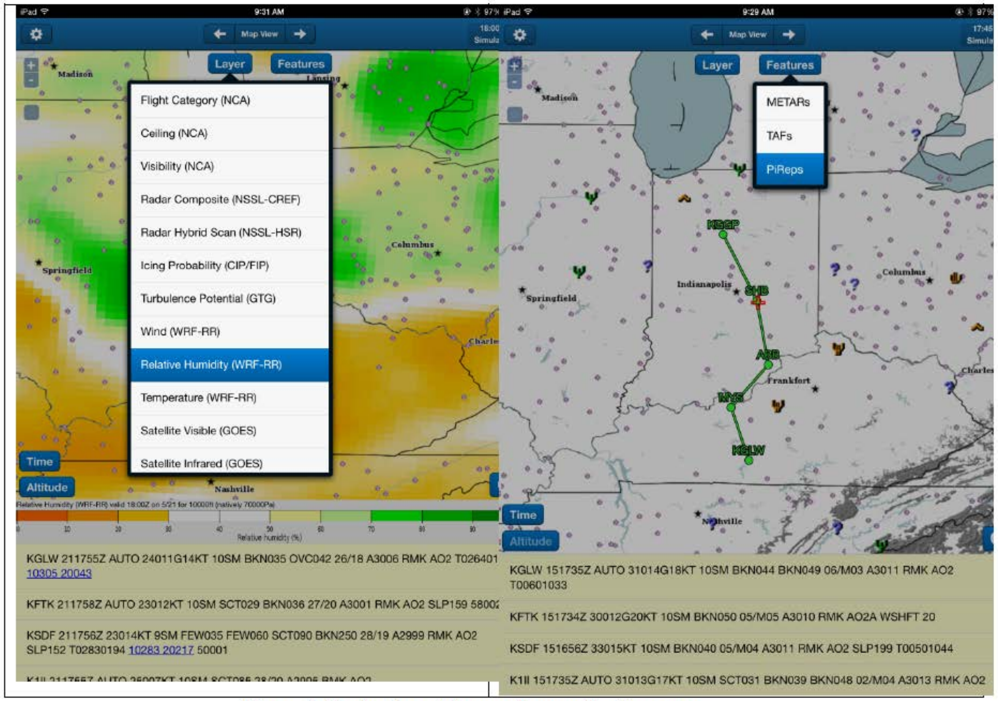


Figure 4. Illustration of the weather application menus.

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

Shortfall Analysis – Sample Spreadsheet

Shortfall: Information Gap	Frequency	Impact			Current Met Sources / Technology
		Operational Parameter	Cockpit	ATC	
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	• 9 respondents mentioned this MET element • Commonly encountered throughout warmer latitudes	Safety	Limitations of onboard radar: • Difficulty depicting weather behind the weather (radar shadows) hindering pilot decision-making to deviate through or around weather • Relative lack of radar reflectivity of oceanic convection (particularly dry storm tops) compared to that over land. • Time/effort required to coordinate/approve a deviation with ATC can result in limited options to deviate. • Lack of uplinked current graphic-based depiction of convective weather to aid in decision-making.	• Maintaining adequate separation for deviating aircraft in non-radar environment (primarily lateral deviations)	• Weather Briefing Packet (preflight) - Graphical depiction of current and forecast convective polygons (coverage, cloud tops) • Online resources (preflight-print copy) - Graphical depiction of satellite imagery; lightning data; "synthesized" depiction of convection based on satellite imagery and high resolution model data; convective forecast polygons • Onboard radar • Pilot-to-Pilot VHF comm • AOC updating convective info textually via satellite datalink • Visual "out-the window" deviation - Difficult to impossible at night/IMC - Relative lack of lightning in tropical regions
		Efficiency	Higher fuel burn due to: • Lateral deviation resulting in longer route • Vertical deviation away from optimum altitude	• Lateral airspace constraints with aircraft funneling through gaps in weather • Vertical airspace contraints with aircraft at same altitude resulting in potential lateral separation issues	
		Workload	• Additional communications with ATC for route adjustment to avoid convection • Additional communciations with dispatch for fuel burn/flight time adjustments based on revised route/altitude which impacts fuel reserves for destination and alternate(s) • Cockpit/Cabin coordination with Flight Attendents for seat belt sign/cabin service adjustments	• Increased workload/comm in coordinating routing/altitude changes with pilots/other ATC sectors	
		Environmental Impact	• Lateral deviations and/or holding resulting in longer flight times and increased emissions		
		Passenger	• Comfort - Avoid turbulence • Schedule - Longer flight time due to deviations		

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

PEGASAS Phase II Research

- **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.

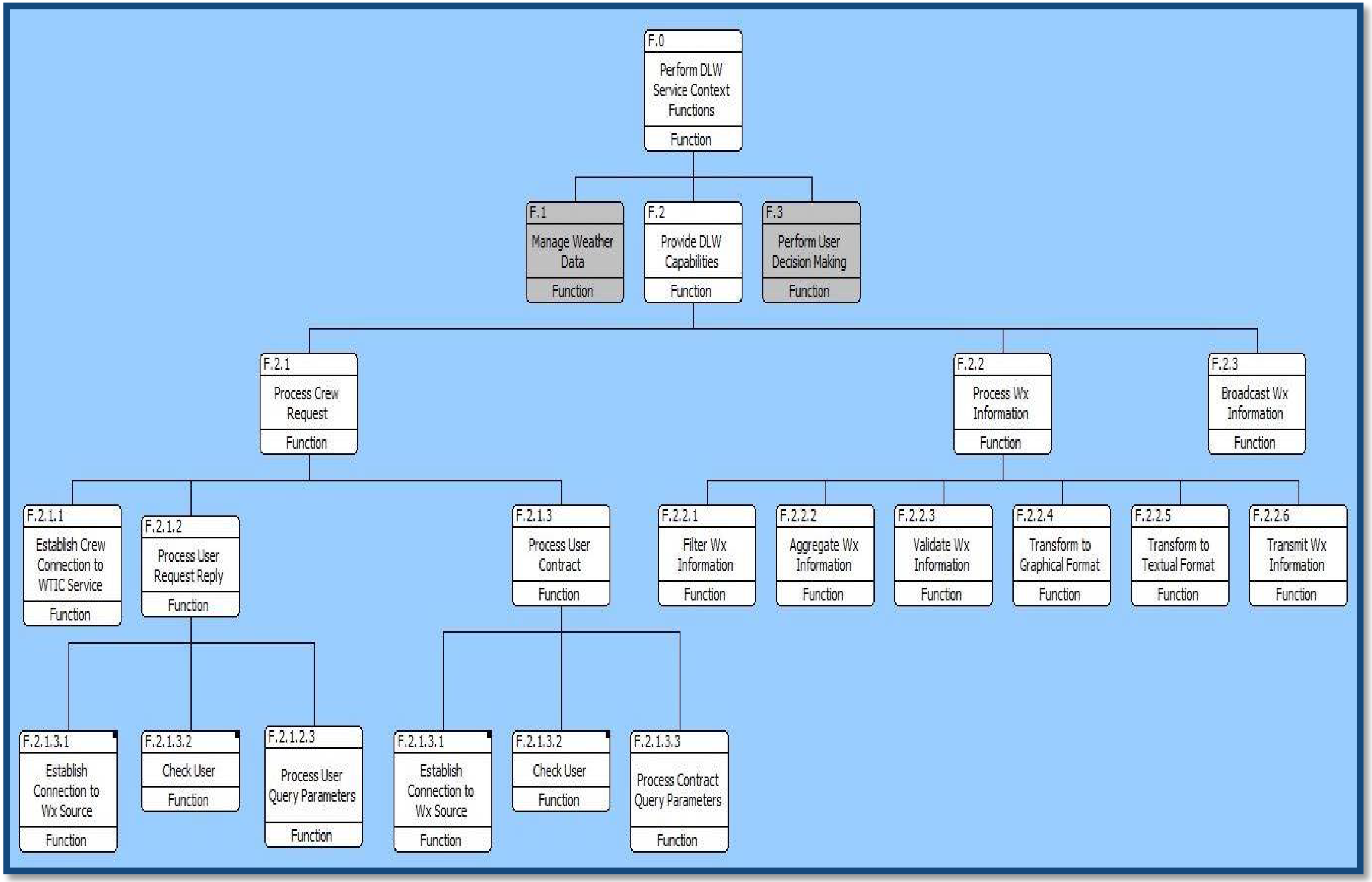
PEGASAS Phase II Research

- **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

PEGASAS Phase II Research

- **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 – DLW Hierarchy



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.*