

The image features a dark blue vertical bar on the left side. Overlapping this bar is a stylized graphic of the Delta logo, consisting of two red triangles pointing towards each other to form a larger, irregular shape.

Airline Perspective on Turbulence

Evaluation of
Models, Automated Reports
and
Weather Delivery



What is Turbulence?

- A Potential Disruptor of:
 - Safety
 - Crew and passenger experience
 - Efficiency/Emissions
 - Airspace Capacity
- Solution for one might adversely impact other factors

**IMPROVED WEATHER DATA CAN DELIVER BETTER
SOLUTIONS FOR ALL DRIVERS**



Delta's History

- Delta's Role: 12+ Years with both NASA & FAA
 - Aircraft Installation of Automated Turbulence Reports
 - Use of Reports in the Ops. Control Center
 - 2013/14 FAA demo in the Cockpit (Windows OS)
 - Graphical Turbulence Guidance (GTG3) Forecast Model
 - Eddy Dissipation Reports (EDR)
 - Threat Based Weather App launched in 2016 (Windows OS)
 - Started Nowcast validation in 2017 (Windows OS)
- Delta's Current State
 - iOS version launched June 5, 2018
 - Unique concept for delivering Weather to the Cockpit



Turbulence – Ambiguity vs Objectivity

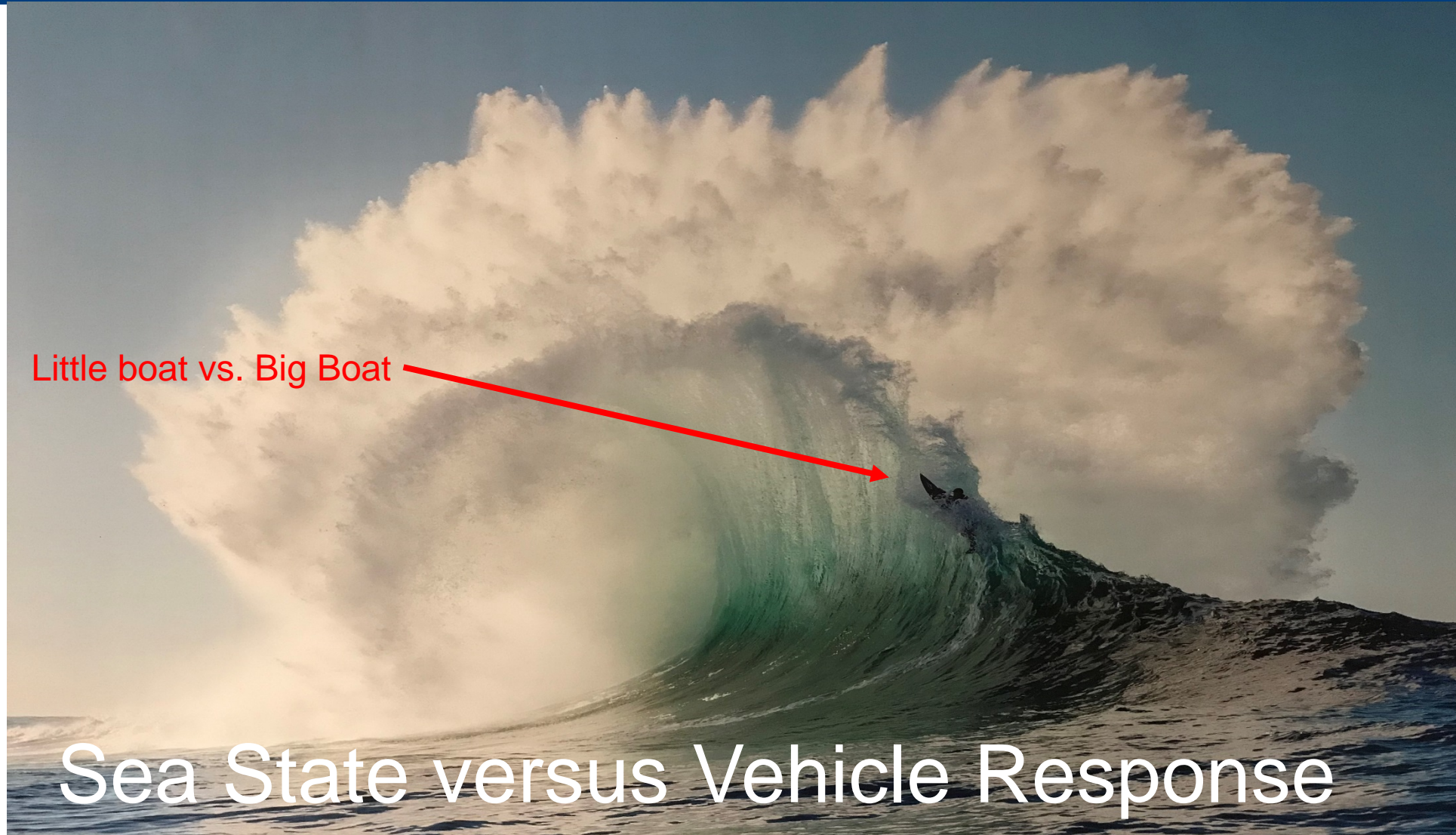
- Antiquated Processes
- Wright Brothers PIREPS
 - ATC Chat Room
 - Subjective inconsistent reports
- Convergence of Events for Paradigm shift
 - Objective Data – Automated turbulence reports (EDR)
 - Models using multiple sources of data, e.g. EDR, NEXRAD
 - Tablets and connectivity for delivery to the cockpit



Types of automated turbulence reports

- FAA NCAR Developed Eddy Dissipation Rate (EDR) - Open
- WSI Accelerometer Based Conversion to EDR – Proprietary
- Panasonic Horizontal Wind Based EDR - Proprietary
- Boeing (NCAR) & Airbus (???)
- Other solutions – iPad accelerometer based
- RTCA Effort
 - Guidelines not Standards
 - First Step

What is Eddy Dissipation Rate (EDR)?



Little boat vs. Big Boat

Sea State versus Vehicle Response



Data Concerns

- Data restrictions – Delta is concerned by any vendor’s potential to gain a monopoly on weather data particularly turbulence reports.
- Potential Sharing Solutions - IATA as a repository for **open source** data to be stored and made available to the industry members.
- Compatibility - Delta is working with the FAA to facilitate an operational correlation for turbulence reporting metric (EDR).
- Interim agreements – Peer to Peer



Turbulence Models

- NCAR Graphical Turbulence Guidance (GTG)
 - Forecast product – Updates every hour
 - Route Planning
- NCAR Domestic Nowcast – In Validation
 - Merged with short term GTG
 - NEXTRAD Convective inputs
 - Turbulence reports
- NCAR Global Nowcast – In Development



Next Steps ?

- Data - Availability and compatibility
- Connection to the cockpit - Band width and reliability
- Weather product selection
 - Many choices for multiple categories of threats
 - Delta's agnostic approach
- Distribution methodology – Quiet Dark Cockpit
- Coordination with Other Departments
 - AOC, Flight Ops, Safety, In Flight Service
 - Same data source with possible different presentations



Status Report?

- Injuries are trending down
 - Process improvements being implemented
 - Crew behavior changes required
 - Driven by confidence in tools
- Efficiencies/Emissions
 - Positive trends
 - Altitude decisions become more intuitive
- ATC Impact
 - Reduced number of inquiries needed for turbulence info
 - More data points reduces calls and altitude changes



Delta Pilot Feedback

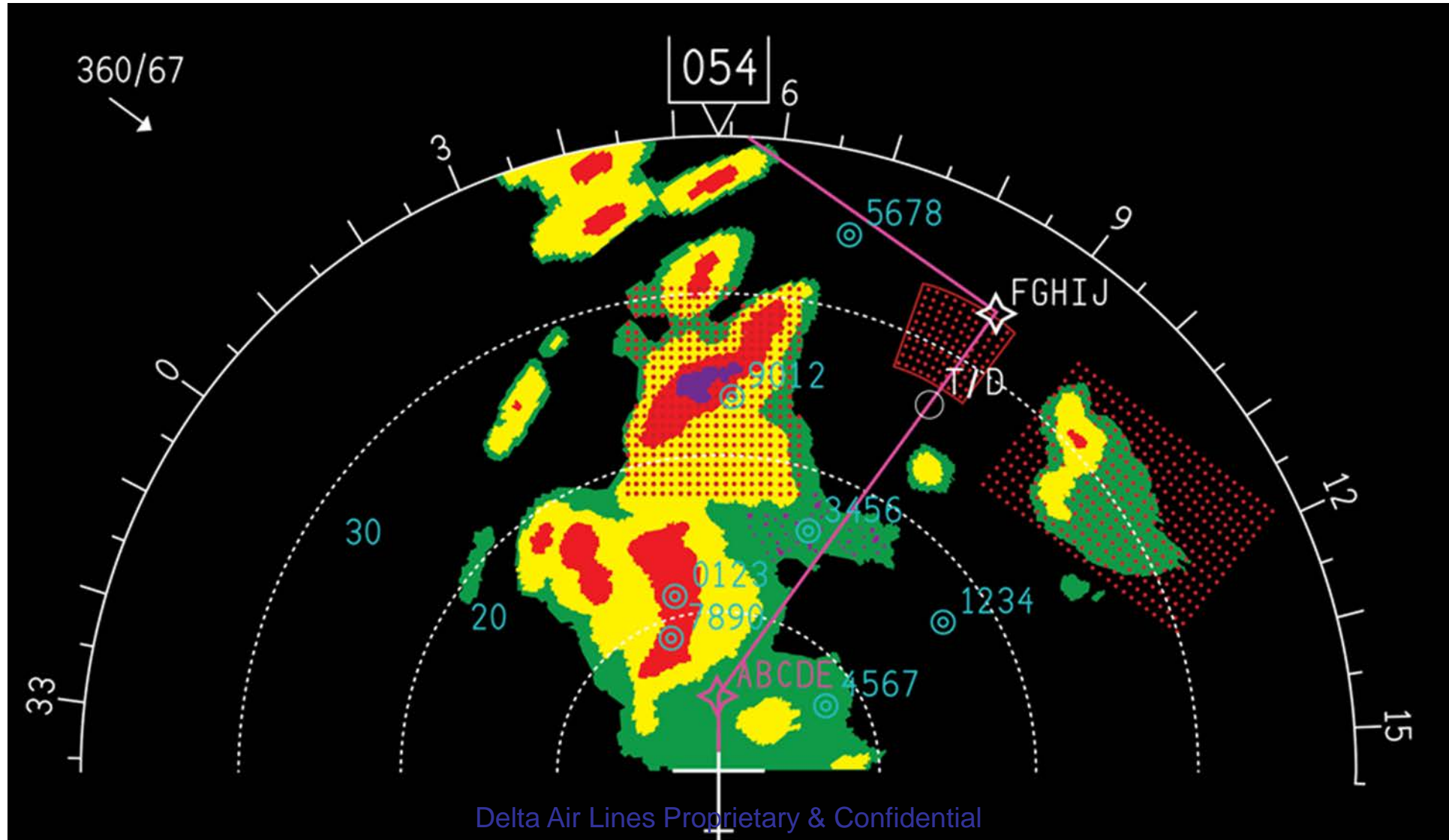
- “Overall, this tool was awesome!! We were like **magicians of the sky** as we seemed to always know where the best rides were and when to turn on the seatbelt sign.”
- “In summary, this was my first time using the weather app but it was great. Not just from a comfort standpoint, but also safety. I am **highly impressed and excited to use it again** in the future.”
- “The app worked GREAT on the previous three days and proved its worth several times. **I LOVE the product!!!** Your team is amazing.”
- “Functionality was spot on.....used it the entire trans con flight both ways and the app was spot on every time. We **never even needed to query the controller about the "rides ahead"**...we already knew them.”
- “Again, love the app, really think it can be a **game changer** for us.”
- “This is going to be one of the **greatest aviation revolutions**. Congrats.”

Be Wary of the Holy Grail



10 Different Weather Apps
Is this the Answer?

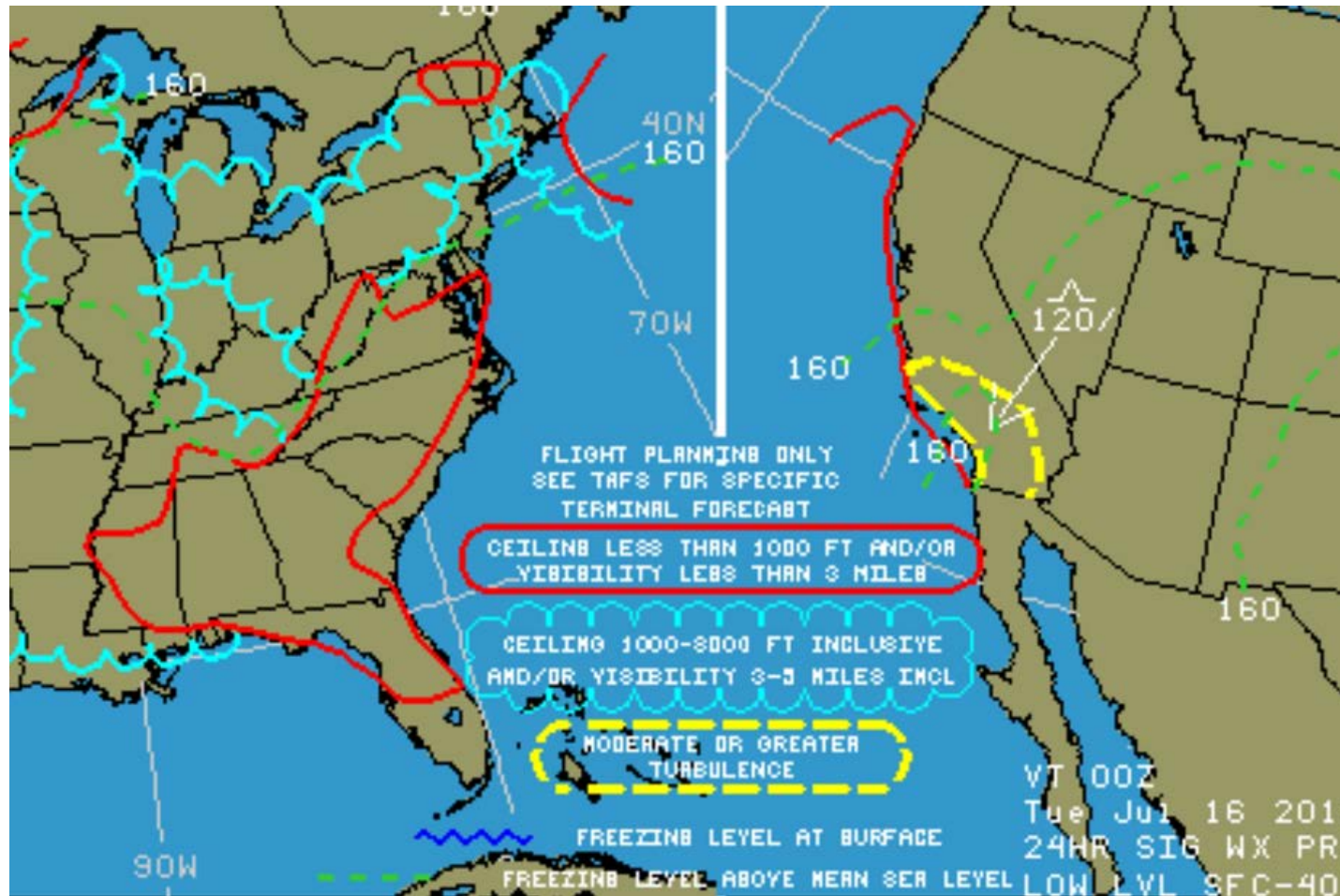
Reflectivity vs. Threat



Teletype Weather with Decoder Ring

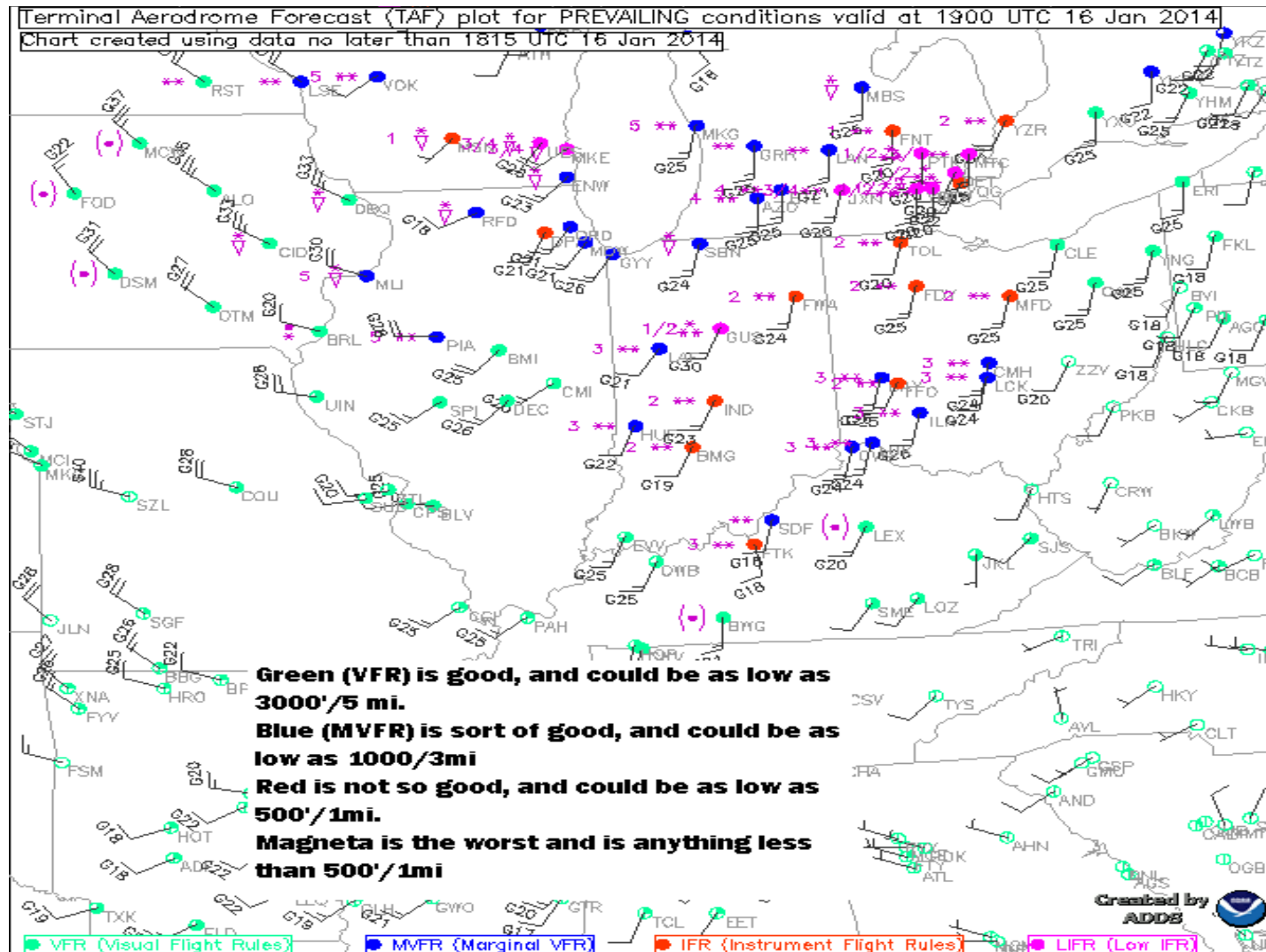
- FAUS42 KKCI 171745 FA2W MIAC FA 171745 SYNOPSIS AND VFR CLDS/WX SYNOPSIS VALID UNTIL 181200 CLDS/WX VALID UNTIL 180600...OTLK VALID 180600-181200 NC SC GA FL AND CSTL WTRS E OF 85W . SEE AIRMET SIERRA FOR IFR CONDS AND MTN OBSCN. TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR CONDS. NON MSL HGTS DENOTED BY AGL OR CIG. . SYNOPSIS...CDFNT NRN ME. CDFNT SC CSTL WTRS WWD TO SRN GA. 06Z CDFNT GA CSTL WTRS TO EXTRM SWRN GA. 12Z CDFNT NERN ME-EXTRM NWRN PA. CDFNT NRN FL CSTL WTRS TO FL PNHDL CSTL WTRS.
- What is “PY”?

Graphics?



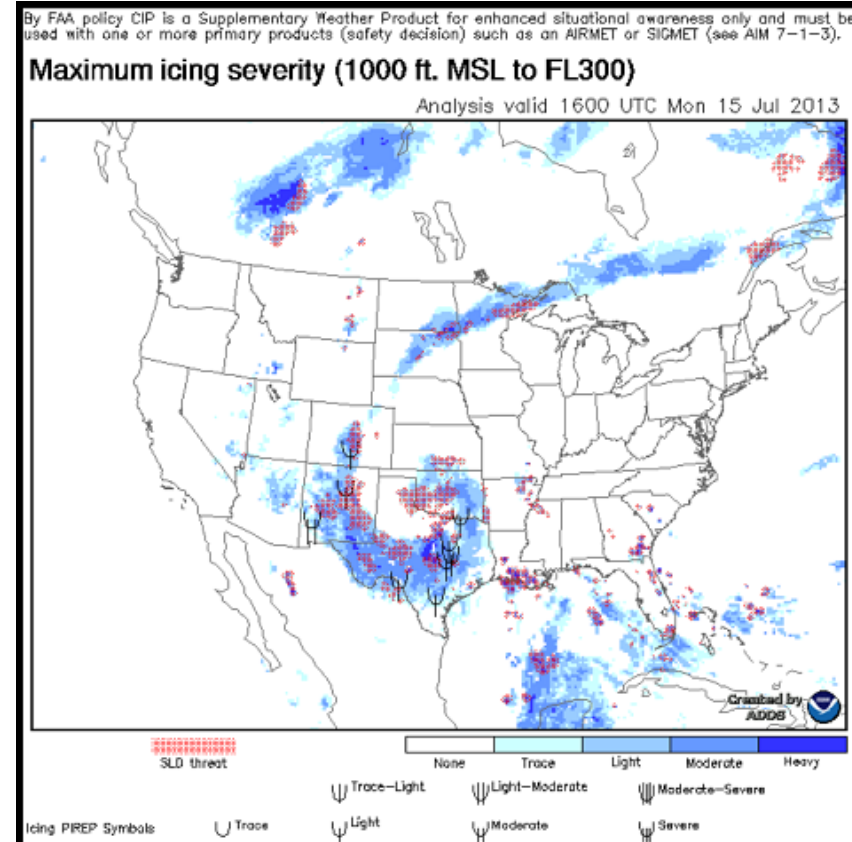
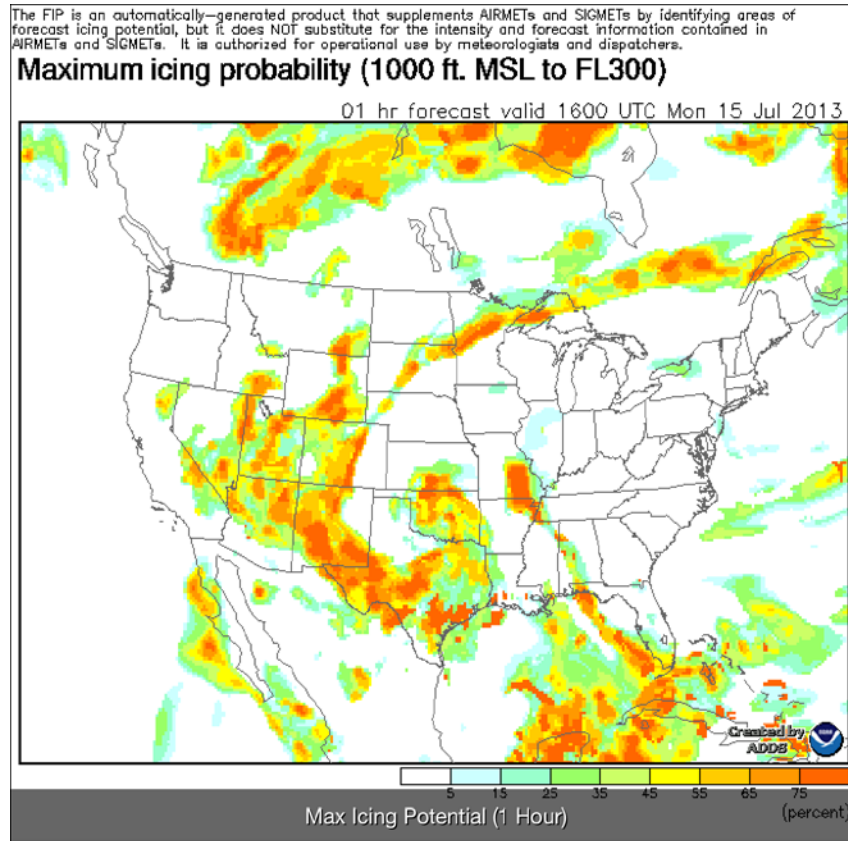
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Better or Worse? Same Data



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Color Confusion- Is blue bad or good?



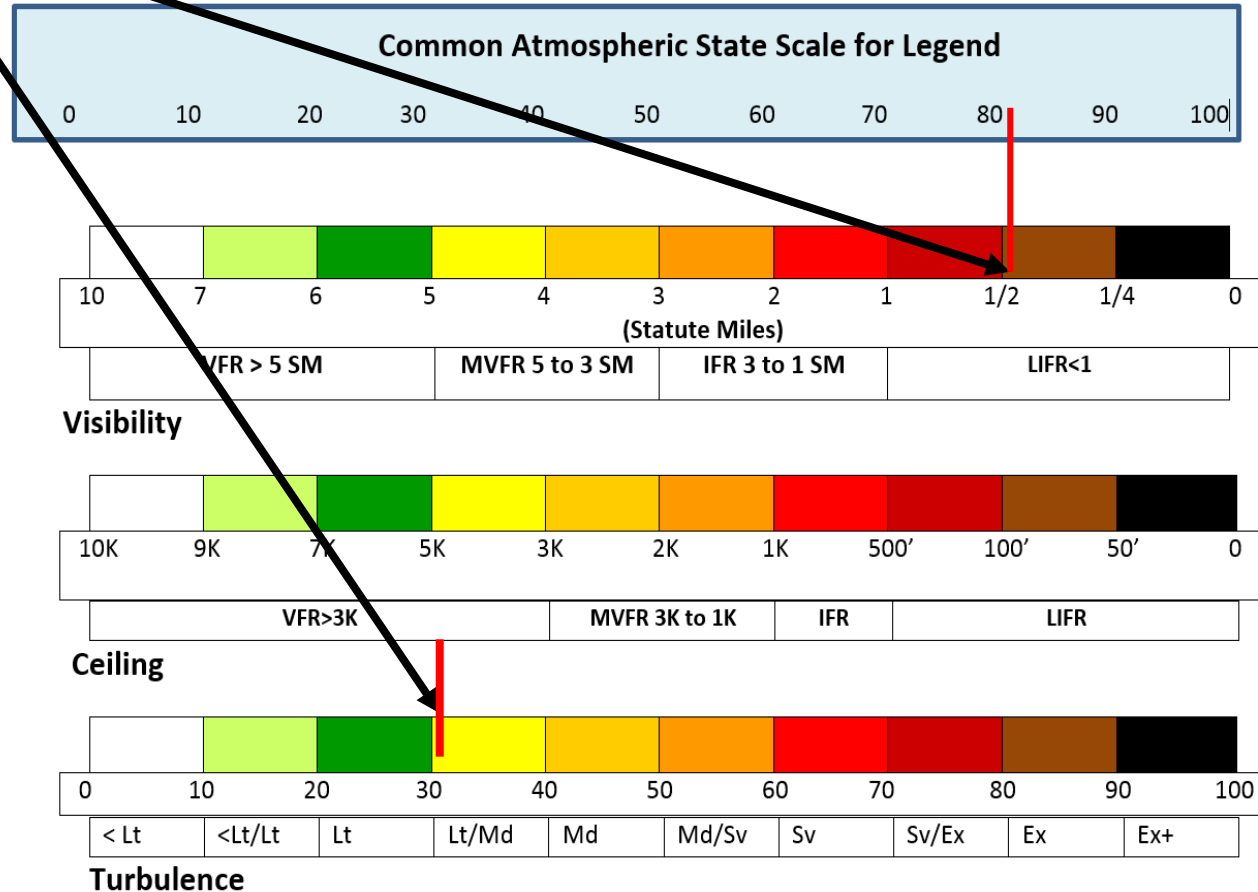
Color Confusion - 3 Examples

Weather product	XM	WSI	WxWorx
Wind	green	blue	Color legend
AIRMET sierra (IFR)	purple	red	green
AIRMET tango (Turbulence)	orange	green and yellow	orange
AIRMET Zulu (icing)	blue	blue	blue
SIGMET	yellow	magenta	red
METAR	VFR: cyan	VFR: cyan	VFR: white
	MVFR: green	MVFR: green	MVFR: blue
	IFR: yellow	IFR: yellow	IFR: red
	LFR: red	LFR: red	LFR: purple

Standardized Presentation of Threats

Alert Thresholds – Threat vs Capability

Key enabler: Operator (Company) defined thresholds which drive operational decisions



Quiet Dark Cockpit Notification

Notification occurs
when threat index
is exceeded

What does
integration really
mean?

The screenshot displays a flight weather viewer interface for a route from KSFO to KJFK. The map shows various airports and flight paths across the United States. A notification overlay is visible in the bottom right corner, circled in red, with the following text:

Flight Weather Viewer Alert
2016-10-17 19:06 Z
Turb: 44, 42K, 19Z
Dismiss

The interface includes a top navigation bar with icons for home, list, settings, search, and lock. The left sidebar contains a dropdown menu with 'High' selected and a 'Wx' button. The bottom of the screen shows the Windows taskbar with the time 3:06 PM and date 10/17/2016.

Intuitive Display





Lessons Learned

- Pilots are not meteorologists
- Weather compilation is not intuitive
- Information overload is common
- New technologies can work and be cost effective
- Delta Flight Weather Viewer is improving safety
- Outstanding Feedback from Crews - **GAME CHANGER**
- Education requirements need to be understood

- Say Goodbye to the Wright Brothers' Expertise
- Maximize New Sensors and Technology
- Reduce confusion in Weather Delivery Systems
- Determine Weather Knowledge Requirements
- Embrace Digital Weather



Research Emphasis

- Focus on processes which identify threats
- Educational limitations in weather knowledge
 - Need to know vs. meteorology degree
 - Threat detection with digital tools
- Speed to market
 - EDR Correlation
 - Weather products i.e., Nowcast and Global Nowcast
- Facilitation of improved regulatory guidance