

Gulfstream

FLIGHT OPERATIONS

Turbulence Avoidance Technologies

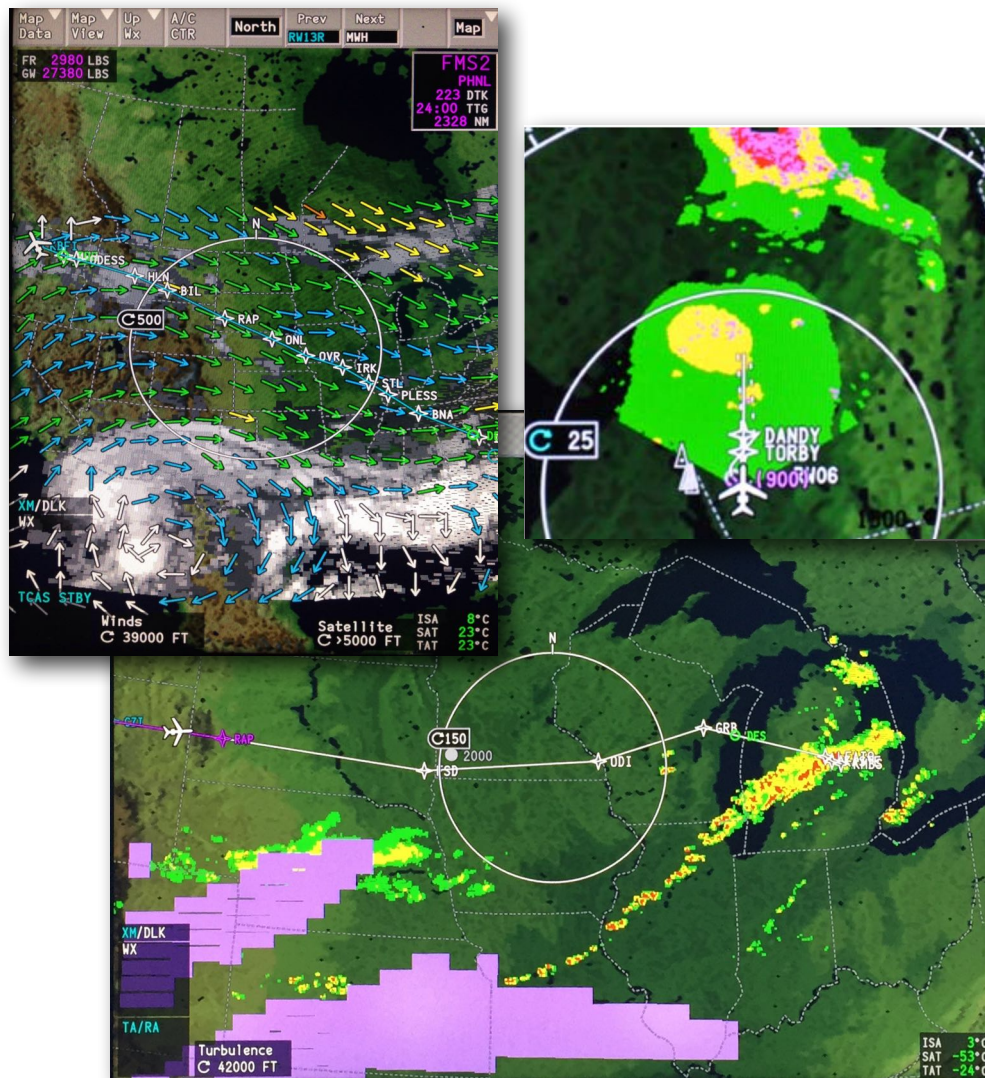
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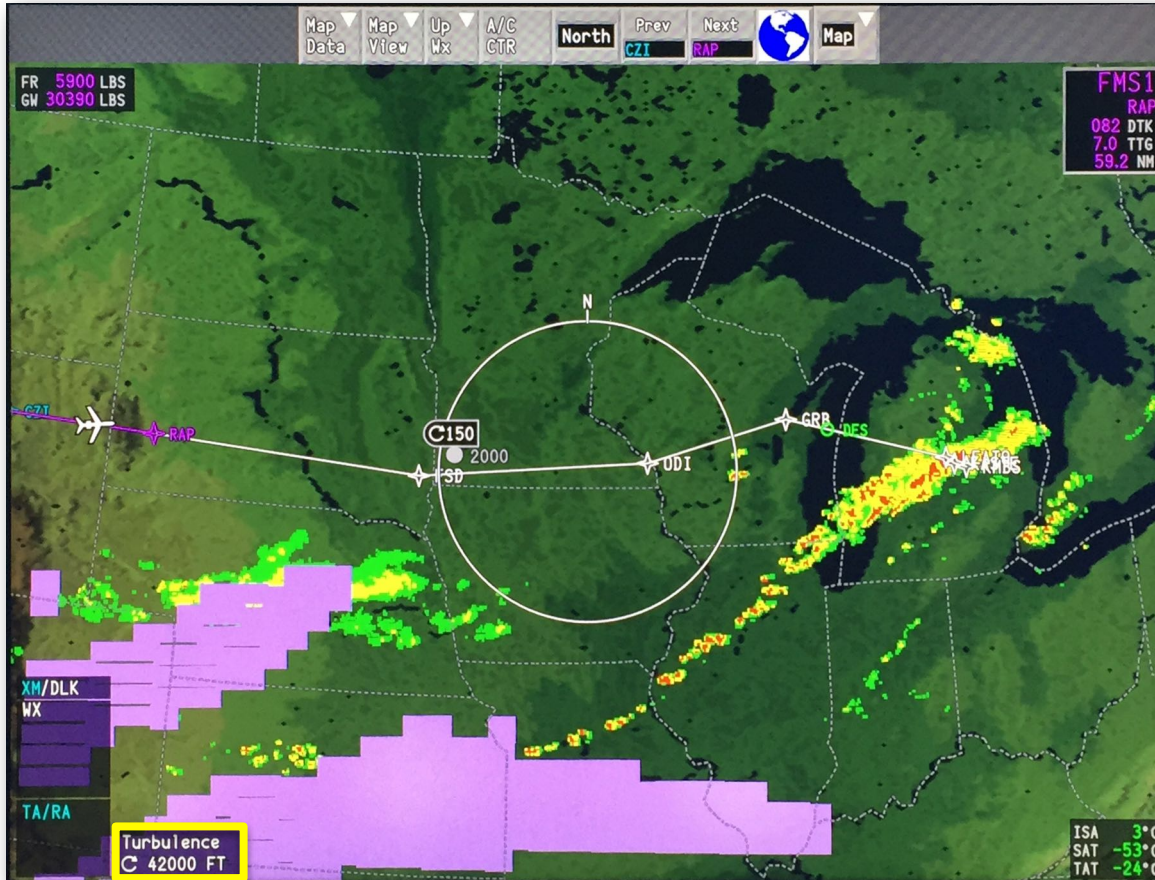


What on-board turbulence avoidance technologies do Gulfstreams employ?

- Gulfstreams are equipped with both strategic and tactical turbulence avoidance equipment.
- This briefing will discuss both types, as well as a deeper dive into Eddy Dissipation Rate “nowcasting.”

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Strategic Turbulence Avoidance

- The XM graphical weather interface provides a graphical depiction of turbulence for North America.
- Clear air turbulence is included in this depiction.
- Magenta outlines on the image to the left signify moderate turbulence.
- Using the Cursor Control Device (CCD), various altitudes may be transposed onto the Map display (altitude window outlined in yellow).

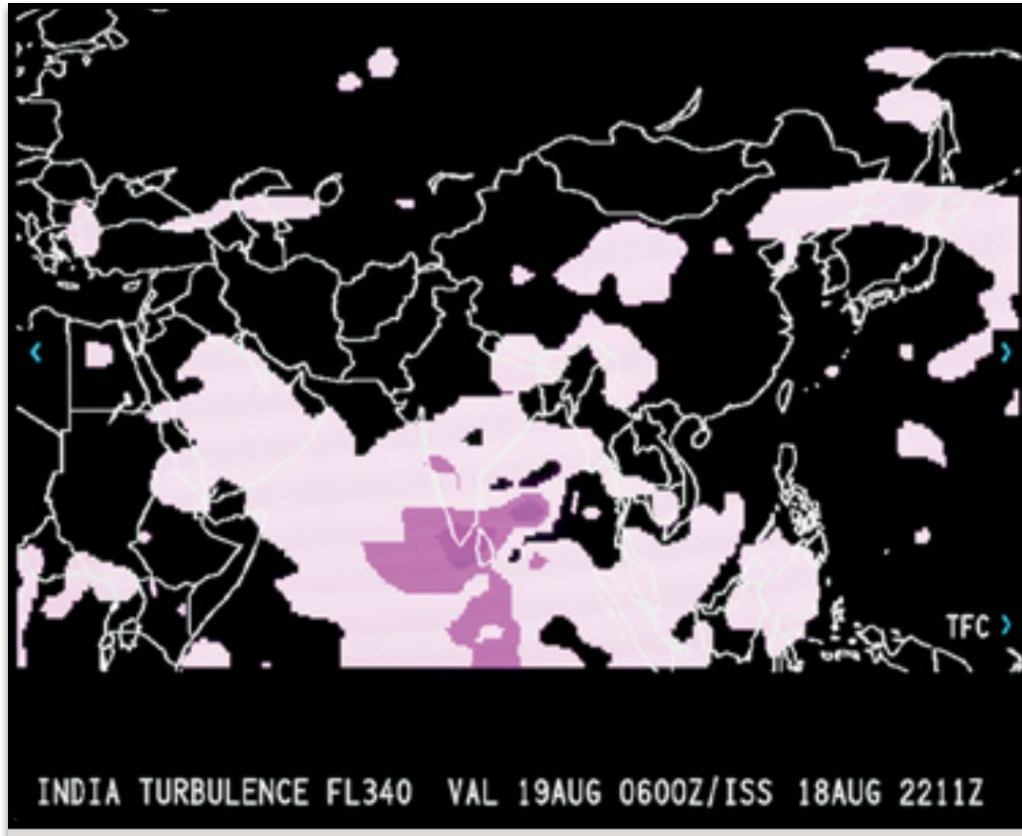
Light

Moderate

Severe

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Strategic Turbulence Avoidance

- Universal Datalink graphical weather provides worldwide turbulence coverage.
- The image to the left shows turbulence depiction centered over India on a Multi-Function Window.

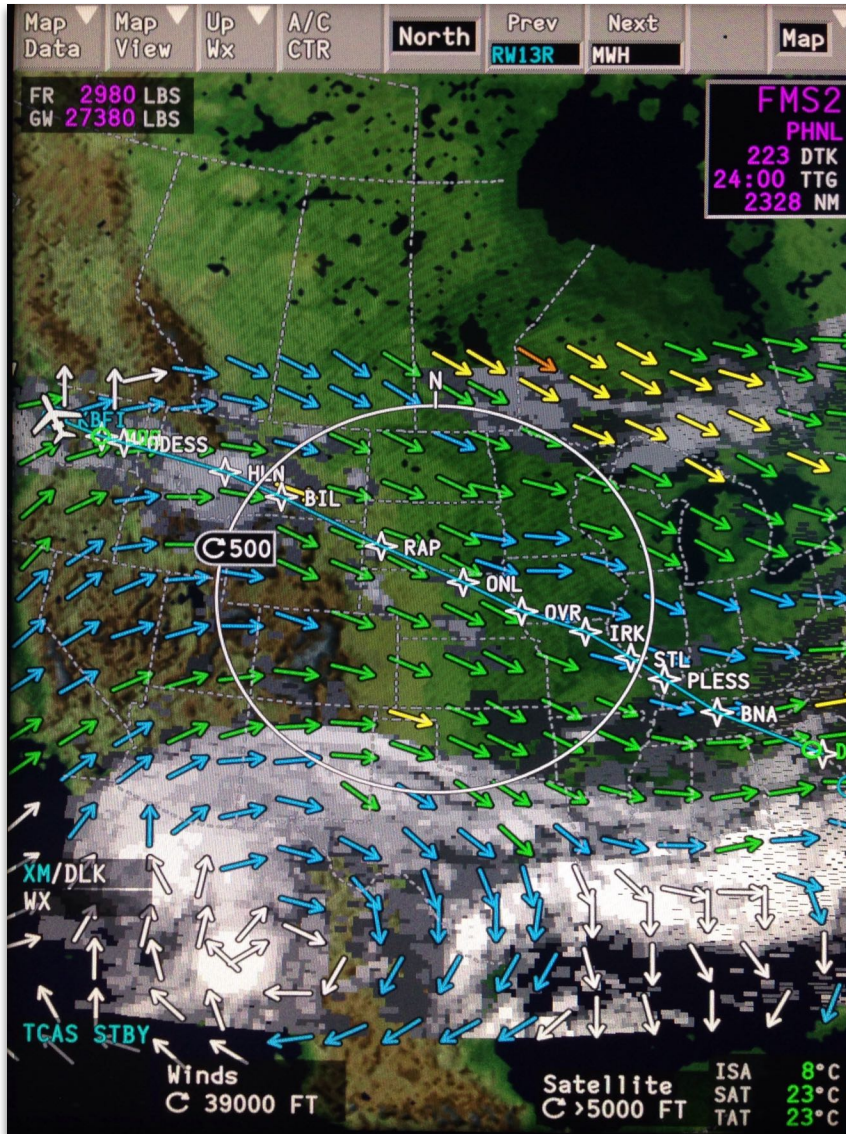
Light

Moderate

Severe

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Strategic Turbulence Avoidance

- In addition to graphical turbulence, winds aloft and satellite imagery may also be viewed.
- Evaluating large shifts in wind direction/velocity and cloud height will aid in ride-planning.

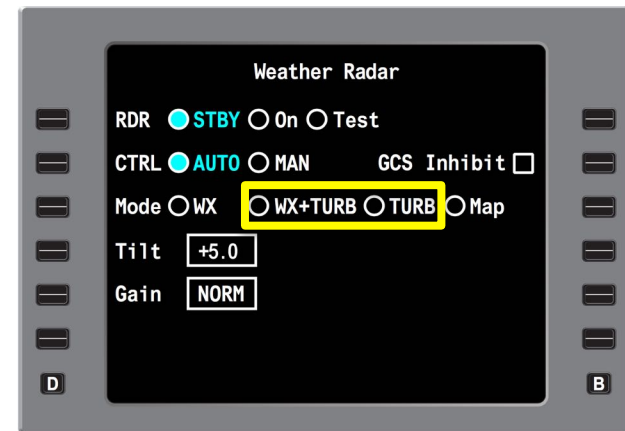
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Tactical Turbulence Avoidance

- Gulfstream on-board radar provides precipitation-related turbulence detection modes.
- Enhanced Turbulence measures severe and ride-quality turbulence out to 40 NM. When the new FAA standards for severe turbulence are met, solid magenta is displayed. When the radar detects less severe ride-quality turbulence consisting of light to moderate chop, then speckled magenta is displayed.



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Turbulence - EDR

The Telegraph

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News

16 injured as severe turbulence forces United Airlines flight to make emergency landing at Shannon Airport in Ireland

share



A United Airlines plane CREDIT: PRESS ASSOCIATION

By Our Foreign Staff

31 AUGUST 2016 • 1:02PM

A United Airlines flight bound for London has made an emergency landing at Shannon Airport in Ireland after severe turbulence that left 16 passengers needing hospital treatment.

[Select to view article](#)

Overview

- Turbulence, especially Clear Air Turbulence, continues to pose a major hazard to aircraft in cruise flight.
- Eddy Dissipation Rate (EDR) is a relatively new technology that assists in both turbulence forecasts and nowcasts.
- This briefing provides an overview of EDR and how Gulfstream Flight Ops can access this information to strategically and tactically mitigate the threat of turbulence.

$$\varepsilon = 15 \nu \left\langle \left(\frac{du}{dx} \right)^2 \right\rangle = 7.5 \nu \left\langle \left(\frac{du}{dy} \right)^2 \right\rangle$$

Formula for EDR from a [Deep Dive](#). See following pages for a pilot-friendly overview.

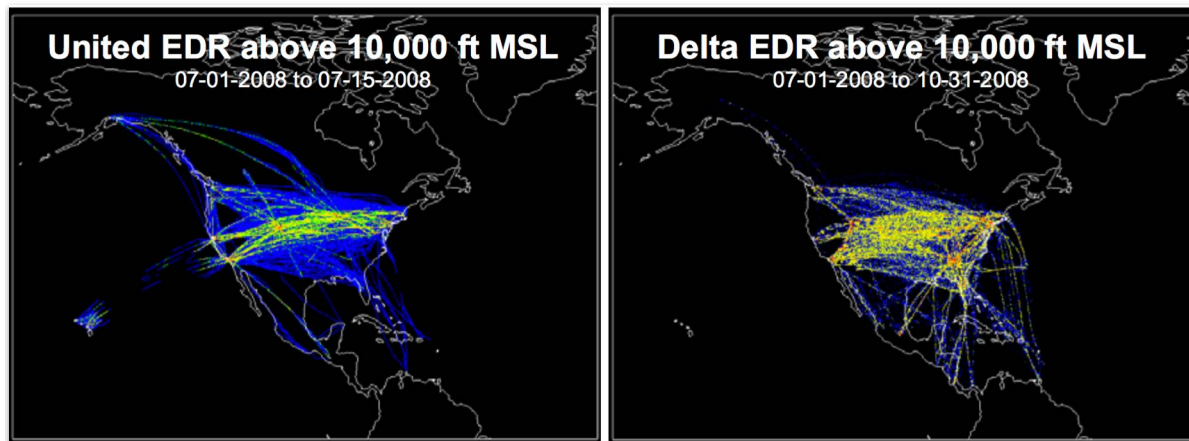
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Turbulence - EDR

What is EDR?

Objective, aircraft-independent, universal measure of turbulence. ICAO and NEXTGen Standard

- Based on rate at which energy dissipates in the atmosphere: using aircraft sensors/avionics, EDR value will be the same across aircraft types. Removes PIREP subjectivity.
- *In situ* calculation (determined by an aircraft while in flight): Delta Air Lines and United Airlines have outfitted **a portion of their fleets** with this automatic reporting capability (this is where the data actually comes from). 44,000+ reports a day with 10km average certainty versus 300-500 pireps/day with only 50km average certainty. Can be converted into root mean square of aircraft loads (**RMS-g**). Generally only reporting data from above FL200 (equipment limitations).
- Image below depicts EDR data for the described dates (EDR scale discussed on next page):



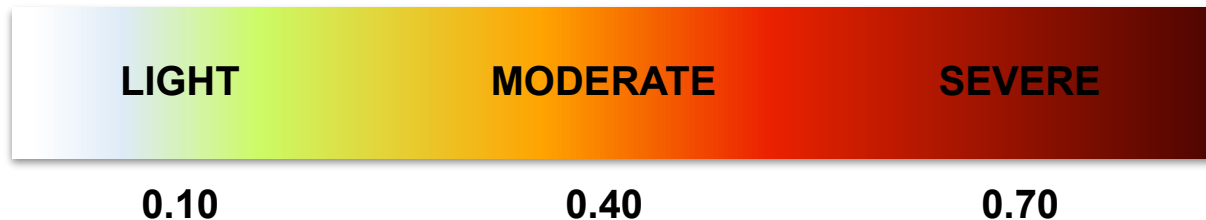
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Turbulence - EDR

EDR Scales

- The ICAO-accepted EDR scale ranges from 0 to 1.
- A simplified medium-weight (15,500 - 300,000lbs) aircraft scale is below. Specific sources of information are on the next page.

Eddy Dissipation Rate (EDR)

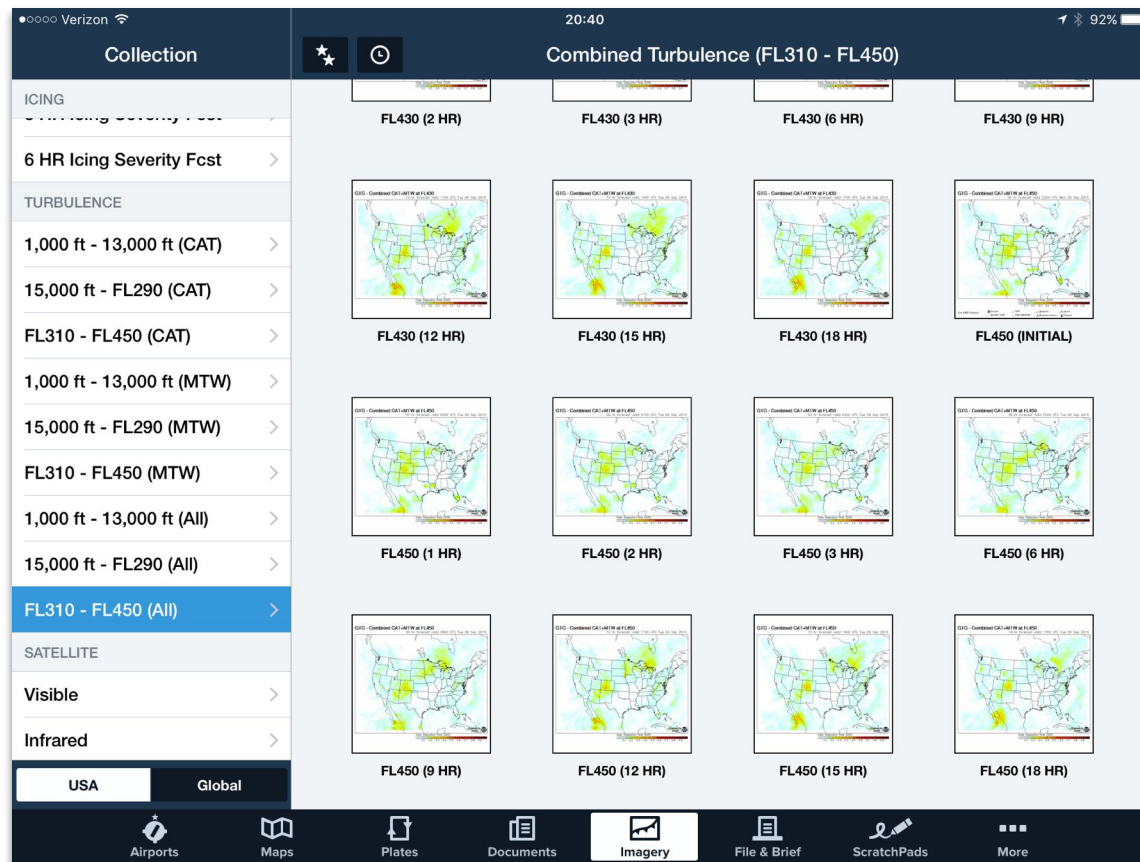


- **NOTE:** some academic papers have claimed that a business jet may experience severe turbulence with EDRs *as low as 0.40*. Practically-speaking, it may be wise to avoid all areas of turbulence above 0.40.

Turbulence - EDR

Products

ForeFlight: IMAGERY > TURBULENCE (Provides both current and forecast data).



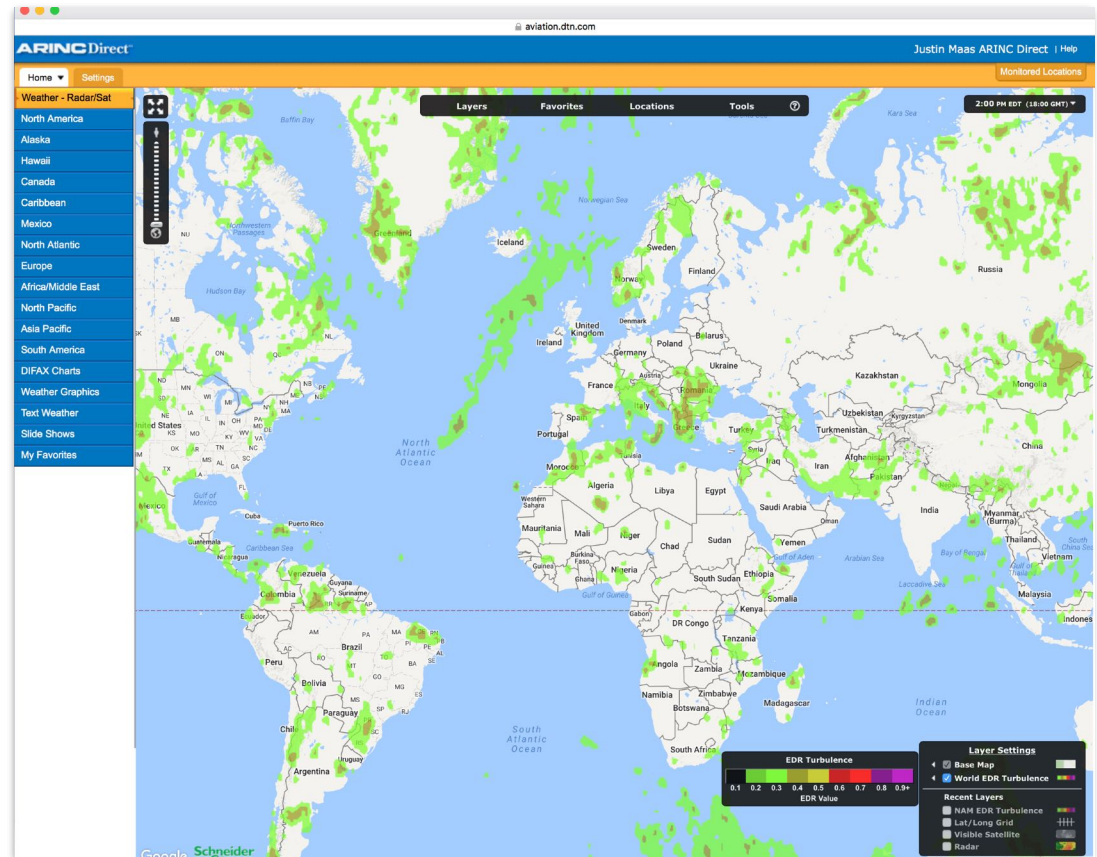
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Turbulence - EDR

Products

Schneider Electric (via [Arinc Direct](#)): WEATHER > GRAPHICAL WEATHER > LAYERS > ENH FLIGHT HAZARDS > WORLD EDR TURBULENCE

NOTE: This provides global data unlike ForeFlight.

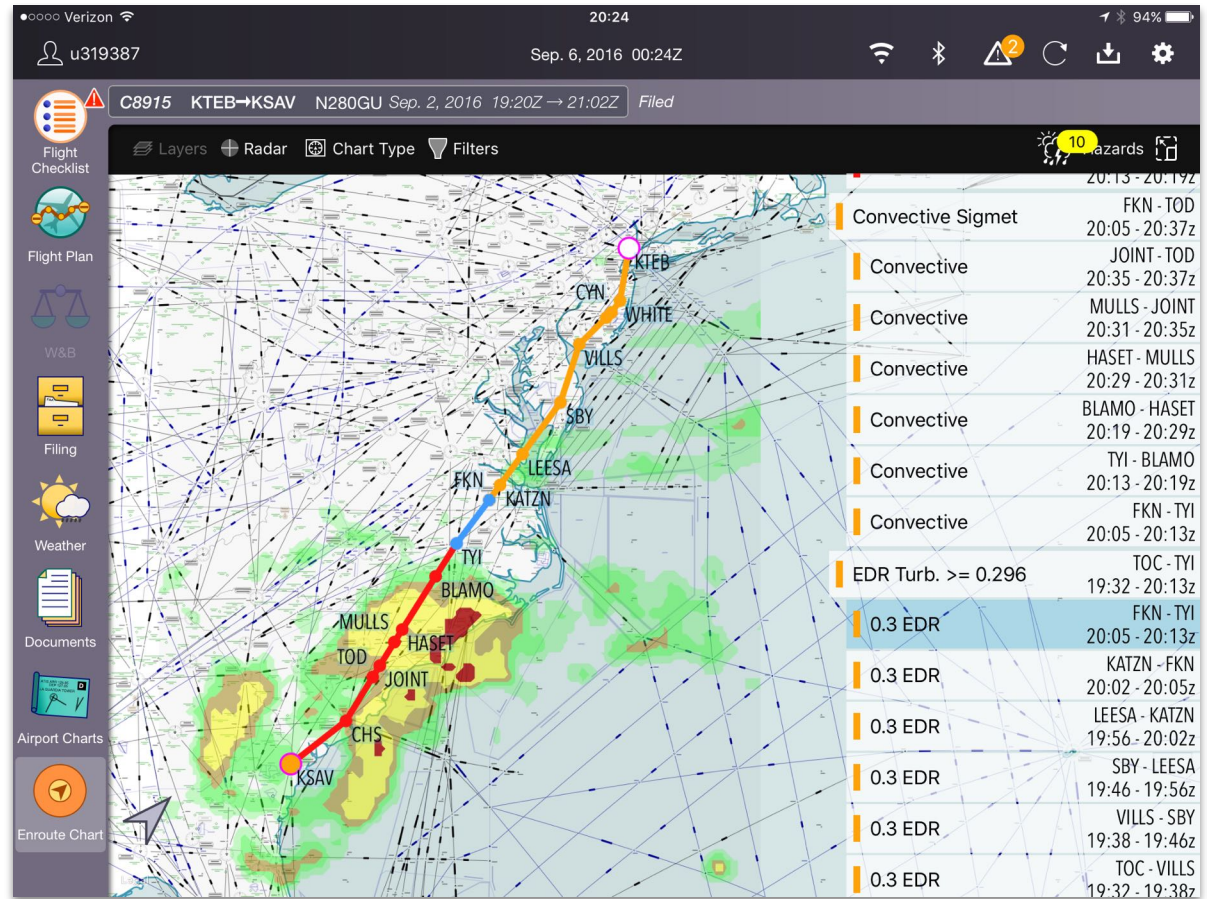


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Turbulence - EDR

Products

ArincDirect iPad App: if you were filed via Arinc (mostly for domestic operations), your route of flight and EDR hazards will appear:

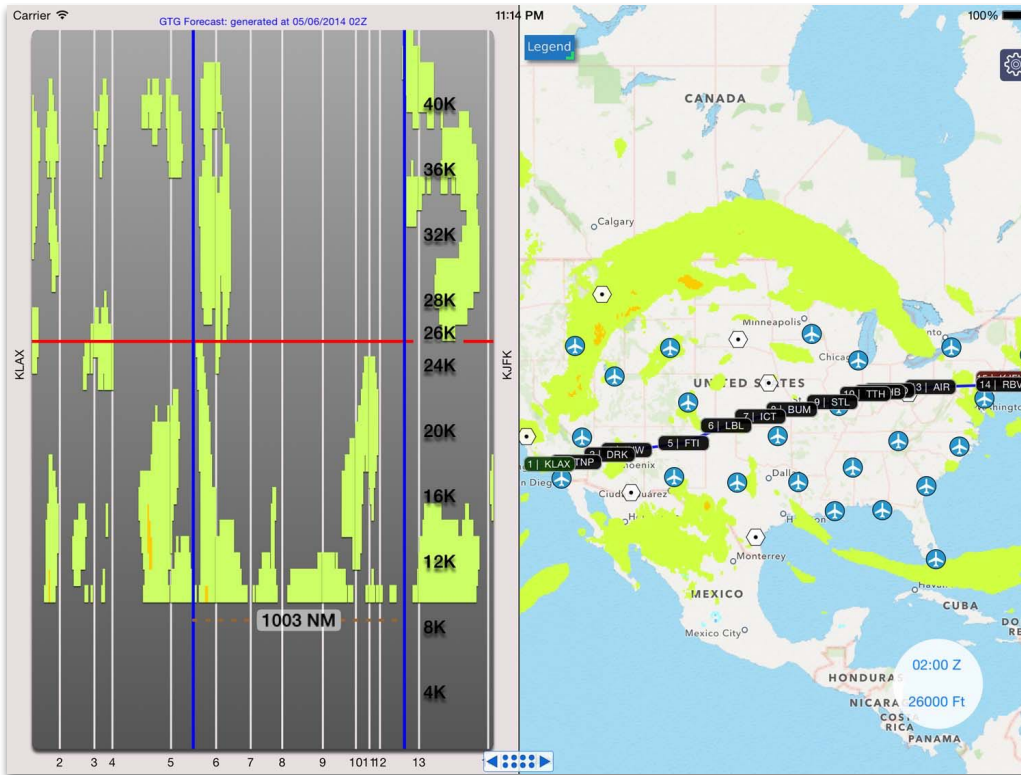


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Turbulence - EDR

Products - Future Development

Flight Situational Awareness Viewer (FSAV) iPad App: Delta Air Lines currently utilizes an iteration of this subscription-based application to provide a profile view of EDR data.



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