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Jayde King  
*Embry-Riddle Aeronautical University*

Yolanda Ortiz  
*Embry-Riddle Aeronautical University*

Nicholas DeFilippis  
*Embry-Riddle Aeronautical University*

Thomas A. Guinn  
*Embry-Riddle Aeronautical University - Daytona Beach, guinnt@erau.edu*

Beth Blickensderfer  
*Embry-Riddle Aeronautical University, blick488@erau.edu*

See next page for additional authors

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Jayde King, M.S
Yolanda Ortiz, M.S
Nicholas DeFilippis, M.S
Thomas Guinn, Ph.D.
Beth Blickensderfer, Ph.D.
Robert Thomas, Ph.D.

Friends & Partners of Aviation Weather, Orlando, FL, October 2018
PART 01  Background

Over the last 30 years, a large percentage of weather-related aviation accidents have occurred under General Aviation (GA) operations (FAA, 2010; Fultz & Ashley, 2016; AOPA, 2008).

- Novice Private Pilots VFR into IMC
- High Risk For Incurring Fatality

(Fultz & Ashley, 2016).
PART 02
Aviation Weather Challenges

1. Difficult to Interpret Aviation Weather Products
2. Pilot’s Decision Making Biases and Errors
3. GA Pilots’ Lack of Aviation Weather Experience
Difficult to Interpret Aviation Weather Products

- Weather products are crucial for preflight planning
- Poor usability weather products
- Inexperienced GA Pilots’ Lack of Aviation Weather Experience
Low experienced pilots may be incurring weather-related accidents due to their inability to:

- Access
- Interpret
- Apply

weather information (Blickensderfer et al., 2018).
New Weather Product Displays

- Aviation Weather Center (AWC) & Federal Aviation Administration (FAA) produce graphical and interactive weather products

- Improved products may be more confusing than helpful

(Latorella & Chamberlain, 2002; Yuchnovicz et al., 2001; Beringer and Ball, 2004).
Purpose

- Compare the usability of AWC and Foreflight weather information and displays.
- Highlight how weather product displays on AWC and Foreflight can hinder or assist with preflight planning processes.
  - Perceive
  - Process
  - Perform
Aviation Weather Knowledge Assessment

Blickensderfer et al. (2018) developed an aviation weather exam to evaluate GA pilots’ ability to interpret:

- Observation
- Analysis
- Forecast

Results indicated that, pilots’ product interpretation scores were quite low.
General Aviation Pilots scored the lowest on the following weather products:

**Forecast**
- G-AIRMET
- NCWF
- TAF

**Observation**
- METAR
- Satellite

<table>
<thead>
<tr>
<th>Product Type</th>
<th>n</th>
<th>Total M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite</td>
<td>204</td>
<td>54.04 (27.78)</td>
</tr>
<tr>
<td>METAR</td>
<td>204</td>
<td>46.14 (20.23)</td>
</tr>
<tr>
<td>TAF</td>
<td>204</td>
<td>50.00 (25.84)</td>
</tr>
<tr>
<td>G-AIRMET</td>
<td>204</td>
<td>48.82 (20.72)</td>
</tr>
<tr>
<td>NCWF</td>
<td>204</td>
<td>45.59 (28.79)</td>
</tr>
</tbody>
</table>

Table 2. Effect of Pilot Rating and Forecast Type on Interpretation Score. (Blick et al., 2018)
General Aviation Pilots scored the lowest on the following weather products:

- METARS
- TAF
- Radar
- Satellite

<table>
<thead>
<tr>
<th>Product Type</th>
<th>n</th>
<th>Total M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite</td>
<td>176</td>
<td>58.1 (29.4)</td>
</tr>
<tr>
<td>Radar</td>
<td>198</td>
<td>60.7 (17.7)</td>
</tr>
<tr>
<td>TAF</td>
<td>149</td>
<td>56.9 (24.8)</td>
</tr>
<tr>
<td>METAR</td>
<td>149</td>
<td>54.5 (19.0)</td>
</tr>
</tbody>
</table>

(Blick et al., 2018)
Usability and human centered design can assist with:

- Interpretability
- Product and System Transparency

Poor usability may actually encourage hazardous behavior rather than prevent it.

- i.e Radar

(Latorella & Chamberlain, 2002; Yuchnovicz et al., 2001; Beringer and Ball, 2004)
The National Convective Weather Forecast (NCWF) has been discontinued. Please use the links below to access replacement products.

Current Radar  MRMS Viewer
Aviation Weather Center

Pros:
• Issuance times
• Decoded option

Cons:
• Does not provide color coding based on interpretation (vfr/mvfr/ifr)
• Does not recommend METARS to check
Foreflight

Pros:
• Issuance times
• Multiple times before the requested METAR for trending
• Color Coded (VFR/MVFR/IFR)
• Recommended METARS along the flight route
• Provides graphical depiction of METARS

Cons:
• Does not provide the option for including TAFs with the METARs

METAR & TAF
Aviation Weather Center

Pros:
- Features Legend
- Allows users to easily transition between different time stamped G-AIRMET Products
- Allows users to overlay different G-AIRMET types

Cons:
- Confusing issuance times
- Ambiguity on the criteria for the weather phenomena to be reported is
- Does not include reference to the users flight route or location
G-AIRMET

Foreflight

**Pros:**
- Displays the G-AIRMET in plain text
- Allows users to easily transition between different time stamped G-AIRMET Products
- Allows users to overlay different G-AIRMET TYPES, satellite, radar
- Makes the issuance times easy to understand

**Cons:**
- Does not feature legend
- Ambiguity on what the criteria for the reported weather phenomena

**IFR**
Oct 16, 10:45 PM - Oct 17, 5:00 AM EDT
Active, Surface - 1,000' AGL
WAUS42 KKCI 170245
MIAS WA 170245
AIR MET SIERRA FOR IFR AND MTN OBSCN VALID UNTIL 170900
AIRMET IFR...GA FL AND CSTL WTRS FROM 40W AMG TO 50NNE CTY TO 70SSW TLH TO 40ESE SJI TO 40W AMG CIG BLW 01 0N I S BLW 3SM BR. CONDS DVLPG 06-09Z. CONDS CONTG BYD 09Z ENDG 09-12Z.
OTLK VALID 0900-1500Z
AREA 1...IFR NC SC GA MD VA AND CSTL WTRS BOUNDED BY SBY-110SE SIE-50E ECG-70SE SAV-50N AMG-50SSW RDU-30NE GSO-20SSE CSN-SBY CIG BLW 01 0N I S BLW 3SM BR. CONDS DVLPG...
Satellite

Aviation Weather Center

Pros:
• Allows users to overlay different Satellite types, regions, and times

Cons:
• Features legend that is difficult to link the weather phenomena
• Does not indicate cloud height
• Does not easily display valid times and issuance times
Satellite

Aviation Weather Center

Foreflight

Pros:

• Allows users to overlay satellite data over various map types such as aeronautical sectional charts

• Also allows users to overlay METAR & TAF information on the display

• Allows users to access different Satellite types, regions, and times

Cons:

• Features legend that is difficult to link the weather phenomena

• Does not indicate cloud height

• Does not easily display valid times and issuance times
Aviation Weather Center

Pros:

• Features a limited legend without all the symbols from the weather product.
• Allows users to switch between different types of reflectivity and regions

Cons:

• Does not easily display valid times and issuance times
• Does not display a legend that easily relates to the reported weather phenomena
Radar

Foreflight

Pros:
• Allows users to switch between different types of reflectivity and regions
• Allows users to overlay radar over the aeronautical sectional chart

Cons:
• Does not easily display valid times and issuance times
• Does not display a legend that easily relates to the weather phenomena that relates the the legend
Graphical Forecast for Aviation (GFA)

- New, Web-based weather display
  - Covers the continental U.S., ground up to 42,000 feet
  - Observations (current weather data)
  - Forecasts
  - Updated hourly

- Three major components:
  - Satellite (low ceiling and visibility)
  - Radar (presence of precipitation)
  - Station Plots (symbols used to represent wind speed, rain and other precipitation)
## Results - Mean Percentage Correct

<table>
<thead>
<tr>
<th></th>
<th>Radar M(SD)</th>
<th>Station Plots M(SD)</th>
<th>Satellite M(SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private</td>
<td>54.01 (17.11)</td>
<td>36.30 (22.83)</td>
<td>56.83 (26.81)</td>
</tr>
<tr>
<td>Private w. Instrument</td>
<td>60.82 (18.63)</td>
<td>35.77 (21.59)</td>
<td>64.81 (28.05)</td>
</tr>
<tr>
<td>Commercial w. Instrument</td>
<td>67.22 (15.15)</td>
<td>43.68 (22.89)</td>
<td>59.61 (28.33)</td>
</tr>
<tr>
<td>CFI/CFII</td>
<td>67.06 (19.27)</td>
<td>50.00 (22.92)</td>
<td>55.36 (30.36)</td>
</tr>
<tr>
<td>Total</td>
<td>60.53 (18.22)</td>
<td>39.44 (22.67)</td>
<td>59.76 (27.89)</td>
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</table>

- 3 separate 2x4 ANOVAs were conducted to compare the effect of Product and Pilot Certificate/Rating on the Interpretation score
  - Station Plots and Satellite
  - Radar and Satellite
  - Radar and Station Plot
- Scores were quite low!
Results – Station Plots and Satellite Radar

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- Mixed between and within-subjects ANOVA was conducted to assess impact of Product type and Pilot Certificate/Rating on scores
  - No interaction between Product type and Pilot Certificate/Rating
  - Main Effect for Product, partial eta squared = 0.21
  - *Suggests that pilots interpret Satellite products better than Station Plot*
Radar M(SD) Station Plots M(SD) Satellite M(SD)

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- Two-way between groups ANOVA was conducted to assess impact of Product type and Pilot Certificate/Rating on scores.
  - No interaction between Product type and Certification and/or Rating
  - No Main Effects for Product OR Rating
  - Pilots interpreted Satellite and Radar at about the same level regardless of skill level.
## Results – Radar and Station Plots

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</table>

- Two-way between groups ANOVA was conducted to assess impact of Product type and Pilot Certificate/Rating on scores.
  - No interaction between Product type and Certificate/Rating
  - Significant Main Effect for Product on score, Partial Eta Squared = .194
  - Significant Main Effect for Certificate/Rating on score, Partial Eta Squared. = .06
- *Pilots interpreted Radar better than Station Plots*
A major contributing factor in the weather accidents may be Pilots’ inability to interpret weather displays.

New technology is *reusing* existing display formats and symbology that *Pilots may not understand*.

The products are not discriminating: Pilots of ALL ratings and certificates are struggling.

Improving usability could help with product interpretability.