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Atlantic City International Airport, NJ 08405

Assessment of the Visual Flight Rules Not Recommended Statement

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16. Abstract

Objective: We evaluated the weather conditions that pilots and Flight Service Station (FSS) specialists deem important to determine whether Visual Flight Rules (VFR) Not Recommended (VNR) conditions are/will be present or not. In addition, this effort began to define criteria for an online weather planning VNR service. **Background**: One of the FSS specialist responsibilities is to evaluate the weather along a proposed route of flight and decide if conditions warrant a VNR statement. Some pilots view the VNR statement unhelpful due to perceived over application. **Method**: We provided a group of FSS professionals and a group of general aviation pilots with a series of scenarios representing different weather categories to assess how GA pilots and FSS specialists determined flight conditions (VNR or VFR) using standard weather products. **Results:** Based on the correlation analysis, we cannot conclusively identify the specific standard weather products used to make a VNR or VFR determination or any differences between participant groups in making that determination, however, we identified certain common products that participants rated as having a "moderate impact" or above. **Conclusion**: Due to inconsistency and wide variation in weather product use, we find that there is a need for a procedure standardization. **Applications**: If we can define and train FSS specialists (and pilots) to adopt a procedural method of evaluating the weather products, we could apply that same methodology for an automated procedure that always follows the same steps and make consistent recommendations.

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EXECUTIVE SUMMARY

Flight Service Station (FSS) Specialists provide pilots with detailed weather briefings, available weather forecasts, and weather reports that describe weather conditions along the intended route of flight. One of the FSS specialist responsibilities is to evaluate the weather along a proposed route of flight and decide if conditions warrant a Visual Flight Rules (VFR) Not Recommended (VNR) statement. However, pilots do not always see the current statements by FSS specialists as helpful due to perceived conservative overuse and subjectivity (Duke & George, 2017). In addition, there is a need to develop a useful automated VNR service for online weather briefings.

We presented a group of FSS professionals and a group of general aviation pilots with a series of eight scenarios representing different categories of weather (VFR, Marginal VFR [MVFR], Instrument Flight Rules [IFR], Low IFR [LIFR]), and asked them to determine whether they would characterize flight conditions as VFR or VFR Not Recommended. We were also interested in which weather products participants used to make their determinations.

We present the outcome of Bayesian regression and correlation analyses using two dichotomous variables (i.e., Recommendation (VFR=0 or VNR=1) and FSS Pilot Experience (Non-pilot=0 or Pilot=1)) and five metric variables (i.e., Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views). We found that that the variables Age and Total Experience cannot predict the Time to Recommendation. None of the metric variables could reliably predict whether a participant made a VFR or VNR recommendation.

Based on the results of the study, we found that the pilot participants were slightly more conservative (i.e., they selected VNR) than the FSS participants. Participant justification of their selections varied widely. Based on user impact ratings, we identified common products, namely Meteorological Aerodrome Reports (METARs), Terminal Aerodrome Forecasts (TAFs), and Weather Cameras (when available), Aviation and En Route forecasts, that participants rated as having a “moderate impact” or above, however, we found a lack of consistency and procedural use of these products.

Given the inconsistency among the FSS specialists in their recommendation (for some scenarios) and a lack of a procedure for how to use the weather products before making a recommendation, there is a need for a procedure standardization. If we can define and train FSS specialists (and pilots) to adopt a procedural method of evaluating the weather products, we could apply that same methodology for an automated procedure that always follows the same steps and make consistent recommendations.

From the outcome of this study, we suggest further research to help define a procedural method for evaluating weather products using a focus group/cognitive walkthrough method to help define these procedures. We also find that we need to better define criteria so that obvious cases of VFR or VNR may be automated.

1. INTRODUCTION

This study is part of a larger project assessing the effect of weather information on General Aviation (GA) pilot performance and decision-making. In this study, we address the use of pre-flight weather information and weather assessments to reduce Visual Flight Rules (VFR) flights into Instrument Meteorological Conditions (IMC) by determining if conditions warrant a VFR Not Recommended statement (VNR). The goals are to improve the usefulness of the VNR statement and explore the potential for providing the VNR statement via automated systems.

1.1 Background

To prepare for a flight and to avoid encounters with hazardous weather, GA pilots can get a general overview of weather conditions by reviewing weather information on various internet or television weather sites. Pilots can acquire a more in depth weather briefing by contacting and speaking with a Flight Service Station (FSS) specialist. FSSs are air traffic facilities that communicate directly with pilots to conduct preflight briefings, flight plan processing, inflight advisory services, search and rescue initiation, and assistance to aircraft in emergencies. FSSs also relay Air Traffic Control (ATC) clearances, process Notices to Airmen (NOTAMs) and provide updates on aviation meteorological and aeronautical information.

At the FSS, flight service specialists can provide pilots with a detailed weather briefing, available weather forecasts, and weather reports that describe weather conditions along the intended route of flight. One of the FSS specialist responsibilities is to evaluate the weather along a proposed route of flight and decide if conditions warrant a VNR statement. When providing a VNR statement to the pilot, the FSS specialist also provides a rationale for why a VFR flight is not recommended.

However, pilots do not always see the current VNR statements by FSS specialists as helpful. The Aircraft Owners and Pilots Association (AOPA) believes that the issuance of a VNR statement may be overused (Duke & George, 2017; Namowitz, 2017). According to Namowitz: "…'VFR not recommended' has always had its critics who point out that the presence in a forecast of isolated or low-probability weather phenomena (mountain obscuration in low clouds or fog, or possible scattered thunderstorms on a sunny day in Florida, for example) can produce a 'VFR not recommended' statement even when widespread visual conditions are expected." Thus, VNR is often viewed as ineffective, overused, and too subjective, and cannot be provided to pilots through automated resources (Casner, Murphy, Neville, & Neville, 2012). In 2005, Canada discontinued the use of the phrase "VFR Not Recommended" in pilot briefings due to pilot complaints (Megginson, 2005). However, VNR can serve as an intervention for keeping pilots away from instrument meteorological conditions (IMC). A study by Prinzo (2006) found that in approximately 10% of the time FSS information impacted pilot decision-making and flight behavior, possibly keeping pilots from encountering IMC.

Presently, there is no automated equivalent of the 'VFR not recommended' statement within Flight Information Service-Broadcast (FIS-B) or other electronic sources of weather data. As part of the Automated FSSs (AFSSs), pilots could receive weather information from a continuous telephone recordings of meteorological information called the Telephone Information Broadcasting System (TIBS). TIBS, was a continuous recording of meteorological and aeronautical information, available by telephone. TIBS provided a limited VNR statement capability based on defined conditions that indicated "visual flight rules doubtful" (ceiling below 1000 ft., visibility less than 3 miles). However, TIBs was discontinued in 2018 due to low utilization. Pilots could use web- or phone-based services, such as the Direct User Access Terminal Service (DUATS II), which enabled pilots to receive online preflight briefings, file flight plans and get automatic notifications and alerts. Registering for these automatic notifications and alerts kept pilots informed when new or adverse conditions arise, such as a severe weather forecast or observation, an airport closure, NOTAM or temporary flight restriction. DUATS II was discontinued after May 2018; however, means of obtaining online information continue through the FAA's contracted website, www.1800wxbrief.com, and third party websites like the AOPA's Flight Planner. Therefore, one of the FAA's goals is to conduct research to improve the utility and availability of VNR statements.

During VFR flights, pilots acquire weather information by looking out-the-window and by receiving information from weather-reporting facilities and information from other pilots on the radio frequency. Pilots can also receive weather information and request *flight following* by contacting air traffic control (ATC). Similar to the weather preparation before a flight, pilots can also contact FSS to receive a weather-briefing while in flight. In addition, pilots can use cockpit-mounted weather displays (certified installed display systems) or portable weather displays (Ahlstrom, Ohneiser, & Caddigan, 2016). These weather displays allow GA pilots to receive important aircraft, terrain, and weather information while in flight (Zimmerman, 2013). Nevertheless, VFR flight into IMC where pilots inadvertently enter clouds or haze and can no longer see the horizon or the terrain is still a major safety hazard for GA pilots (Goh & Wiegmann, 2001). This dangerous situation can lead to spatial disorientation whereby pilots lose control of the aircraft (Wiggins, Hunter, O'Hare, & Martinussen, 2012; Wilson & Sloan, 2003). Some of the underlying causes of VFR-into-IMC are deficiencies in detecting, incorporating, and responding to cockpit and out-the-window information and understand the potential effect of forecasted weather conditions (O'Hare & Stenhouse, 2009; Wiegmann, Goh, & O'Hare, 2002; Wiggins, Azar, Hawken, Loveday, & Newman, 2014).

There is a need to assess in what ways FSS specialists and GA pilots potentially differ in their interpretation of weather factors (and their relative importance of those factors) and how the weather information is used to determine whether a flight can be safely and legally conducted under VFR (Namowitz, 2017). This information could help the FAA improve VNR statements for use by pilots and it could help the FAA to incorporate VNR information in electronic media (e.g., web-based information). This is particularly important since a large percentage of GA pilots never call FSS stations for their pre-flight weather briefings, but instead gather this information using the internet, and therefore never receive a VNR statement (i.e., 'self-briefers'; Casner, Murphy, Neville, & Neville, 2012).

1.2 Purpose

In this Weather Technology in the Cockpit (WTIC) effort, we evaluate the weather information that pilots and FSS specialist deem important to determine whether VNR conditions are/will be present or not with the goal of improving the usefulness of the VNR statement, and exploring the potential for including the VNR statement via automated systems. This data will help the effort to make the VNR statement more useful to GA pilots, and defines criteria that will enable the automation of a VNR statement.

2. GENERAL METHODS

In this section, we describe the methods used for the VNR study.

2.1 Participants

Twenty GA pilots and 20 FSS specialists participated in the study. The requirement for the FSS specialists were that they come from a variety of regions and that they were certified specialists.

2.3 Research Personnel

We (the research team) (see Appendix A) prepared briefings, collected data, and prepared the experimental systems for operation for the VNR study.

2.2 Informed Consent

We gave participants a copy of the informed consent form upon arriving at their scheduled participation time (Appendix B) and a Biographical Questionnaire (APPENDIX C) collecting basic background information.

Informed consent statements described the study, the foreseeable risks, and the rights and responsibilities of the participants, including that their participation in the study was voluntary and that the participant could withdraw from participation at any time without penalty. All the information that the participant provided, including Personally Identifiable Information (PII), was protected from release except as may be required by statute. Signing the form indicated that the participant understood his or her rights as a participant in the study and their consent to participate.

2.4 Facilities

We conducted the study at the William J. Hughes Technical Center Cockpit Simulation Facility (CSF), and utilized proctors for remote locations for other geographic region data collection. The Leidos Flight Service Center in Ashburn, Virginia; Civil Aerospace Medical Institute (CAMI); the Kenai FSS; and the Fairbanks FSS all served as remote locations for data collection.

2.5 FSS Workstation Simulator

For the VNR study, personnel from the CSF developed an emulation of the Aviation Weather Center (AWC) online service. We chose the AWC products as these are standard for both FSS specialists and pilots and both populations are trained and tested on these weather products when undergoing certification. While both groups commonly use other services for flight planning, the AWC serves as a back-up for FSS specialists and is available for pilots. Figure 1 is a reproduction of the AWC's landing page, which was emulated for this study. Figure 2 is an example of one of the scenario flight plan routes depicted on a regional map. Figure 3 is a depiction of the study toolbar, which participants could use to navigate to the various products (e.g. Figure 4) within the platform.

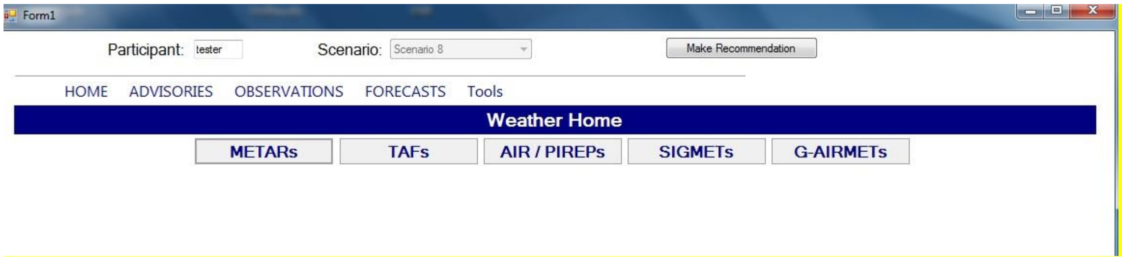


Figure 1. Aviation Weather Center Landing Page.

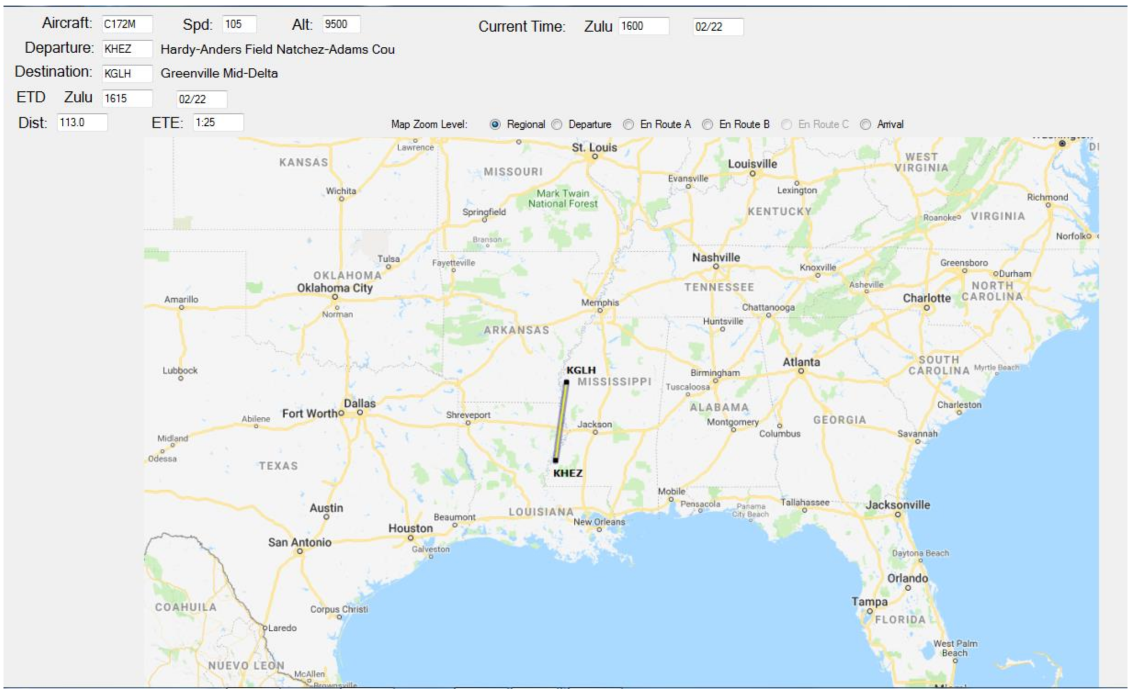


Figure 2. Example of Flight Plan Map.

Figure 3. Aviation Weather Product Toolbar.

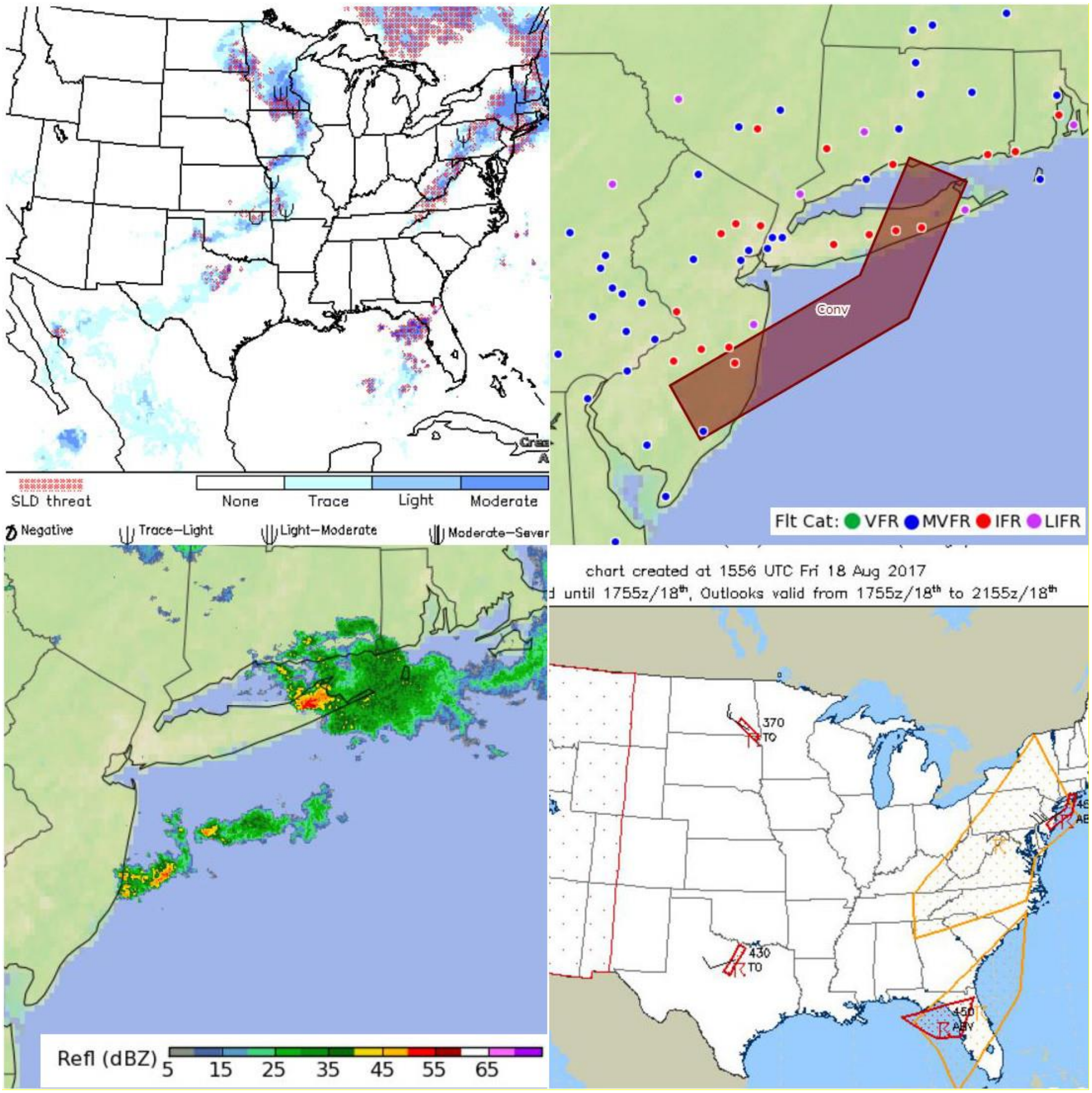


Figure 4. Example of weather information used in the VNR study (top left: icing; top right: Significant Meteorological information (SIGMET) and flight category information; lower left: precipitation; lower right: convective areas).

We used these tools to provide information to emulate weather conditions for eight flight scenarios. Data (i.e., participant's responses) was recorded automatically and written to a data file. At the CSF, the experiment software was installed on i5 HP desktop computers equipped with a Dell P2212H LCD monitor as shown in Figure 5.

Figure 5. The FSS Simulation Desktop Computer for the VNR study.

2.6 Data Handling Procedure

A coded identifier was assigned to each participant. The identifier did not appear on the Informed Consent Statement, because that is identified by the participant's signature. All other data collection forms, computer files, electronic recordings, video, storage media, etc., containing participant information, was tagged only with the coded identifier, not the name or personal identifying information of the participants. Original documents, recordings, and files were collected and securely stored. All data editing, cleanup, and analysis was performed on copies traceable to the original sources.

Members of the research team or designated proctors were present throughout the VNR study to observe participants and the data recording. Additionally, qualified researchers developed materials used to deliver instructions consistently, using appropriate terminology, to conduct briefings.

2.8 Data Analysis

The data from the present study was analyzed using descriptive statistics and Bayesian estimation as used in Ahlstrom and Suss (2014), Ahlstrom et al. (2015a; 2015b), and Ahlstrom et al. (2017).

2.9 Experiment

The study assessed how GA pilots and FSS specialists determined flight conditions (VNR: VFR not recommended, or VFR) using standard weather products. The overall study purpose was to evaluate pilot and FSS visibility assessment methodologies to ultimately enhance the process, and make the VNR statement more useful to GA pilots and enhance safety. This study did not evaluate FSS Specialist or pilot performance/knowledge. The results of this study provided data to show how each test group assessed the risk of encountering adverse weather and the level of risk that they use to determine VNR. The specific goals of the VNR study were:

(1) To identify the specific standard weather products and weather information used by FSS specialists to determine flight conditions.

(2) To assess differences in participants' determination of visibility flight conditions and the products/information used to make their determinations with the availability of the same standard weather.

(3) To assess the impact of the inclusion of an FSS briefing including the VNR/VFR determination on pilots' perspective of weather conditions.

(4) To assess the impact of an individual's age and experience-level on weather condition determination.

(5) To determine objective criteria used by each test group to determine VNR conditions and use these criteria to develop an automated VNR statement.

(6) To make the VNR statement more effective in supporting safe pilot decision making relative to adverse weather conditions.

(7) If VNR assessments between test groups (i.e., pilots and FSS specialists) are not consistent, identify potential options to make them more consistent. In particular, identify gaps in consistency among FSS and ways to improve consistency to ensure pilots have a common basis of understanding for the VNR statement.

2.10 Study Flight Plan Scenarios

The participant viewed a training presentation that explained the purpose and procedure of the study. We explained to the participant that the scenarios would be self-paced. After completing the training presentation, the participant viewed eight separate proposed flight plan scenarios (in random order) and used the available weather products to form an opinion as to whether or not VFR operations were recommended for each flight plan. Following the VFR or VNR decision, participants provided a rationale for their decision and rated the impact of each weather product for that particular scenario. Participants could take as long as necessary to evaluate the weather conditions before deciding whether conditions warranted a VNR statement.

Each scenario had aspects of visibility conditions that fell into one (possibly more) of four flight categories: VFR conditions, Marginal VFR conditions (MVFR), IFR, and Low IFR conditions as illustrated in Table 1. Each scenario is listed in Table 2, along with the scenario city pairs, estimated duration and distance of flight, proposed altitude, direction of flight, and weather category as defined by a Subject Matter Expert (SME).

Table 1. Scenario types for the VNR study participants

Weather data	Weather Category
Ceiling greater than 3000 feet AGL and visibility greater than 5 miles (includes sky clear).	VFR
Ceilings 1,000 to 3,000 feet AGL and/or visibility is 3-5 miles inclusive.	MVFR
Ceiling less than 1,000 feet AGL and/or visibility less than 3 miles.	IFR
Ceilings are less than 500 feet and/or visibility is less than 1 mile.	LIFR

Table 2. Description of study scenarios

Scenario	City Pairs	Time/Distance	Proposed Alt	Direction of Flight	Category

Scenario 1 (Washington)	KOLM-KALW	2:16/199nm	9500	E-SE	MVFR
Scenario 2 (Florida)	KPBI-KMCO	1:10/123	6500	N-NW	VFR
Scenario 3 (West Virginia - Pennsylvania	KLYH-KUNV	2:08/221	9500	N	MVFR
Scenario 4 (Florida – Georgia)	KSGJ-KABY	1:53/175	10500	NW	MVFR/IFR
Scenario 5 (Nevada - California)	KRNO-KCEC	2:46/248	10500	NW	MVFR
Scenario 6 (New York - New Jersey)	NY0-KBLM	1:30/174nm	10500	SE	MVFR/IFR
Scenario 7 (Alaska)	PAIL-PAEN	1:27/143	5500	NE E	VFR
Scenario 8 (Mississippi).	KHEZ-KGLH	1:25/113	9500	N	MVFR/LIFR

For pilots only, some scenarios included a VNR statement as part of their flight plan information. The FSS participants completed the study prior to the beginning of data collection for pilot participants. We used the results of the FSS VNR recommendations to determine which scenarios would include a VNR statement for pilots. The VNR statement provided to the pilots was derived from a cross-section of the FSS statements. Scenarios 1, 4, 6, and 8 always included a VNR statement to each participant. Scenarios 2 and 7 were VFR scenarios and never included a VNR statement. Scenarios 3 and 5 were the most split among the FSS participants, so to explore if the inclusion of the statement had an impact on pilot responses, half of the pilot participants received a VNR statement and the other half did not.

For each scenario, the participant responded to whether or not they would issue a VNR statement, what weather products they used to make the determination, and provided a relative weighting of the weather products used (i.e., which weather product was the most important etc.). The participants responded to eight scenarios presented in random order. Each scenario contained a specific weather condition (convection, marginal VFR conditions, icing, and mountain obstruction) taken from archived real-weather data from the National Weather Service.

2.11 Experimental Stimuli

FSS specialists evaluated weather conditions using a suite of weather products available at their workstation. The FSS specialists have many weather products available to them in order to perform their tasks. The displays available to FSS specialists typically incorporate the following types of weather information:

Hazardous Weather Products:

• Center Weather Advisory	• Convective Watches	• Convective SIGMET*

• Graphical Airmen's Meteorological Information (G-AIRMETs)	• Volcanic Ash Advisory*	• AIRMET (WA)*
• SIGMETS (WS)	• Tropical Cyclone Advisory*	• Aviation Watch Notification (SAW)

Observed Weather:

• METARs	• Echo Tops	• Current Icing Product* (CIP)
• Pilot Reports (PIREPs)	• Weather Depiction	• Freezing Level Analysis*
• RADAR Summary	• Visible Imagery Satellite	• Graphical Turbulence Guidance (GTG)*
• Base Reflectivity	• Infra-Red Imagery Satellite	• 500mb height and vorticity Analysis*
• National/Regional RADAR Mosaics	• Surface Analysis Chart	• Lifted Index*
• Weather Cameras	• Barotropic Level Charts	• RADAR Velocity Azimuth Display (VAD) Wind Profiles*

Forecast Weather

• Convective Outlook (AC)	• Surface Prognostic Charts	• Freezing Level Forecast*
• High Level Significant Weather	• Barotropic Level Charts	• 500mb Heights and Vorticity Prognosis*
• Terminal Aerodrome Forecasts (TAFs)	• Winds Aloft	• GTG*
• Aviation Surface Forecast	• Low Level Significant Weather	• Forecast Icing Product-(FIP)*
• Aviation Clouds Forecast	• Min/Max Temperatures	• Tropical Cyclone Charts*

Not emulated for this study

While actual FSS workstations are comprised of multiple displays, for the purposes of this study, we used weather products and tools organized on one display.

2.12 Independent Variable

The independent variable in the VNR study was *weather condition*. There are eight scenarios, which contain a range of weather phenomenon including VFR, convection, mountain obscuration, marginal VFR, IFR, or LIFR conditions in areas along or adjacent to the intended route of flight.

2.13 Dependent Variables

During this study, we recorded key dependent variables to evaluate important factors relating to participants' evaluation of flight situation categories of VNR.

The dependent variables captured the following categories: a) the weather recommendation response (VNR or not), b) the weather information used to make the decision, and 3) the weighting of the relative importance of each weather information leading to the decision. In Table 3, we provide a list of the dependent variables and a short description.

Table 3. Dependent Variable List

Number	Dependent variable	Description
1	Weather recommendation response	VFR or VNR
2	Weather product usage	The number of times each product was accessed
		The duration of use for use for each weather product
3	Weighted importance rating	Participant rating of impact of each product on recommendation decision
4	Decision-making	Participant report justifications for recommendation

3. RESULTS

We analyzed data from this study using descriptive statistics and Bayesian estimation, as used in Ahlstrom and Suss (2014), Ahlstrom et al. (2015a; 2015b), and Ahlstrom et al. (2017).

3.1. VFR or VNR Selection

In this section we present a summary of FSS and pilot participants VFR or VNR selection results for all scenarios. After reviewing the flight information and weather products for each scenario, the participants made a selection of VFR or VNR for that particular flight (see Figure 6). In all scenarios, pilot participants were either equal to or more conservative (i.e. VNR in lieu of VFR) than FSS participants in their selection. All participants for Scenario 4 and Scenario 8 chose VNR, indicating that conditions for those scenarios were severe enough to eliminate any variability in the selections. For the remaining six scenarios, the participants were mostly in agreement for some scenarios (i.e., Scenario 1 and Scenario 6), while others, such as Scenario 5 are split for both FSS and pilot participants.

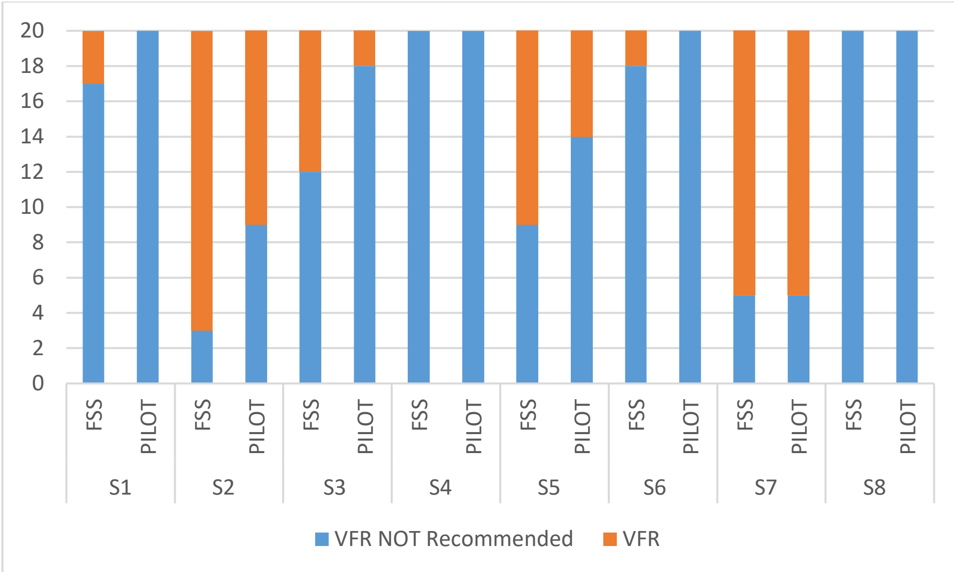


Figure 6. FSS and Pilot VFR and VNR Selection Summary

3.2. Justification Responses

In the following Section, we present the summary of participant subjective justification responses for both VFR and VNR selections. For these analyses, we present a summary of each scenario, a graphical representation of the scenario flight, the number of VFR and VNR responses for each group, and a summary of the justifications for each selection. We analyzed all participant's justification responses, identified and categorized key factors, and presented these factors as simple counts. Due to the wide variety of justification responses, we attempted to represent each factor with adequate detail, while condensing similar responses together. For example, separate participant responses such as "*AIRMETs IFR", "AIRMETs MVFR", "AIRMETs Mountain Obscuration*" are categorized as "*AIRMETs IFR, MVFR, MNT Obs*" and would be tallied as separate responses.

Some participant responses reference specific weather products as factors, while others did not. Responses also ranged from very general comments, such as, "conditions were IFR" to more specific responses such as "line of thunderstorms clearly visible on satellite imagery". While we specifically briefed all participants to select VFR or VNR solely on the proposed route, many participant responses included alternative reasoning, such as suggesting deviation around potential weather or an alternative altitude to get above/below a cloud layer.

We found some responses to be contradictory. For example, for Scenario 1, one FSS participant, who selected VFR, notes "departure field there will be *marginal VFR*, but as the flight continues the clouds begin to break up and lift giving him better conditions at his destination". Another participant uses the same factor "*MVFR at departure*" as part of the justification for a VNR selection.

3.2.1. Justification Responses

We present the flight information for Scenario 1 that was presented to each participant in Table 4. We also include a scenario summary description (not provided to the participants) to give a brief overview of scenario conditions as described by our SMEs. Figure 7 is one of several graphical map views available to the participants during the study.

Table 4. Scenario 1 Washington

Departure	KOLM	***Destination***	KALQ
Distance	199.3	***Est. Time En Route***	2:16
Est. Time of Departure	1715	***Proposed Altitude***	9500
Direction of Flight	E, SE		

Scenario Summary Description – Scenario 1
METARs show departure airport MVFR and destination airport VFR at the time of departure. There is an area of low pressure associated with moderate rain covering the western part of Washington and northern Oregon, with the low centered around Seattle and slowly moving eastbound. Light precipitation exists along the first 1/3 of the route. Forecasts show improving conditions ahead of the flight and worsening conditions behind.

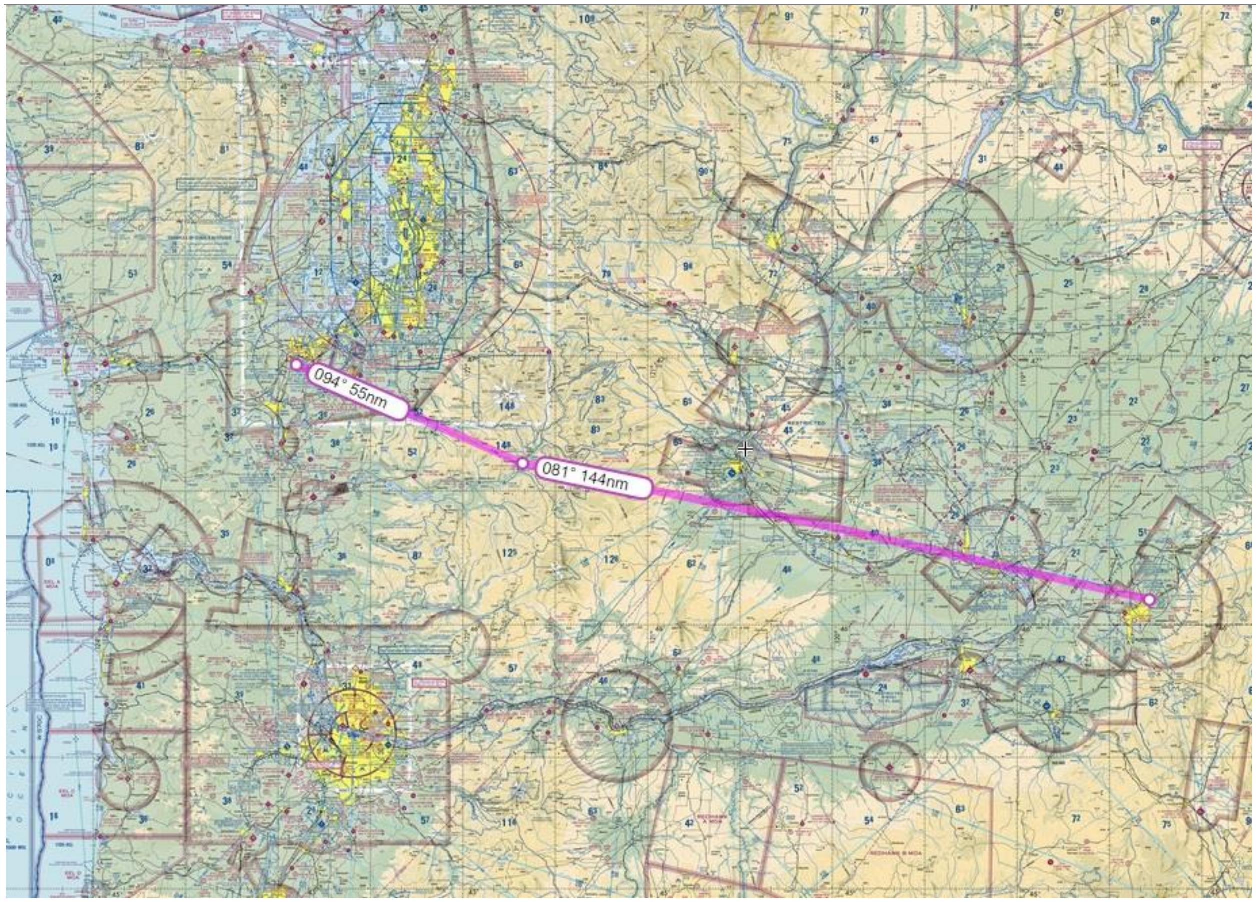


Figure 7. Graphical map depicting Scenario 1 proposed flight

Table 5. FSS and Pilot Recommendation Selections for VFR or VNR-Scenario 1

	VFR	**VNR**
FSS	3	17
PILOT	0	20

Table 5 shows the breakdown of VFR vs VNR selections for pilots and FSS participants. For Scenario 1, most FSS and all pilot participants selected VNR. Of the three FSS participants who selected VFR as their recommendation, two of them stated that the IFR conditions were outside of the proposed route as a justification for selecting VFR. Most of the participants who selected VNR sited the AIRMETs and IFR conditions as a reason for their selection. Many also noted that the pilot would have to climb through an overcast layer in order to get to the filed altitude. Figure 8 through Figure 10 shows the categories of responses from pilots and FSS participants.

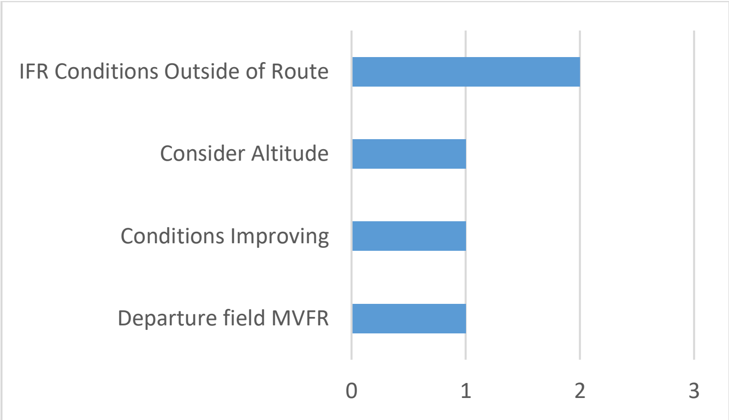


Figure 8. Scenario 1 FSS VFR Justifications

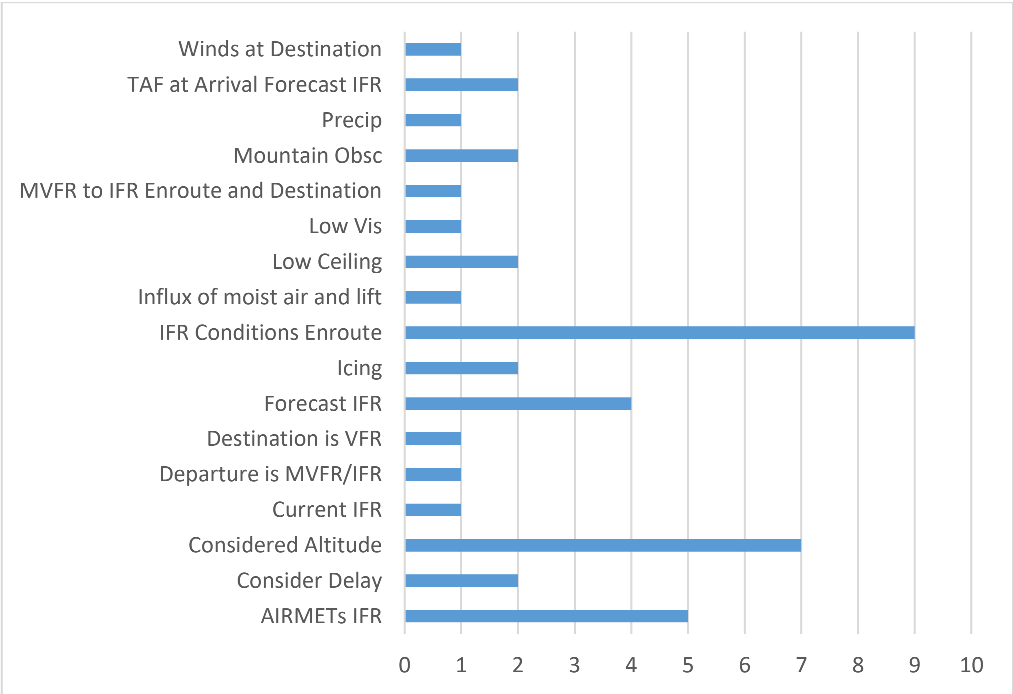


Figure 9. Scenario 1 FSS VNR Justifications

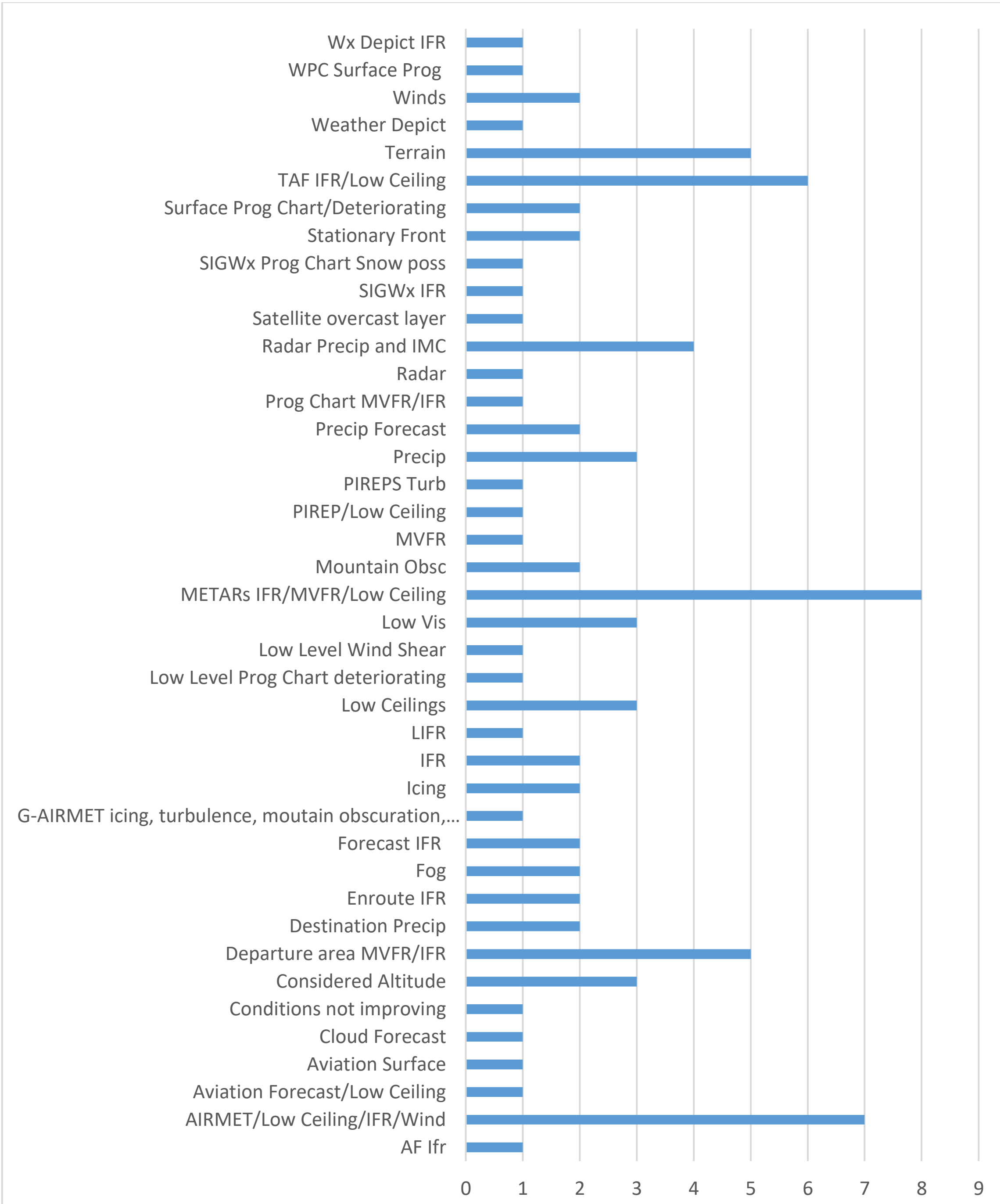


Figure 10. Scenario 1 Pilot VNR Justifications

3.2.2. <u>Justification Responses Scenario 2</u>

We present the flight information for Scenario 2 that was presented to each participant in Table 6. We also include a scenario summary description (not provided to the participants) to give a brief overview of scenario conditions as described by our SMEs. Figure 11 is one of several graphical map views available to the participants during the study.

Table 6. Scenario 2 Florida

Departure	KPBI	***Destination***	KMCO
Distance	122.9	***Est. Time En Route***	1:10
Est. Time of Departure	1415	***Proposed Altitude***	6500
Direction of Flight	N NW		

Scenario Summary Description – Scenario 2
Departure and destination airports show current and forecasted VFR conditions. Thunderstorms are present to the west, moving north and parallel to the route. En route weather shows only a minor possibility of small, localized areas of precipitation.

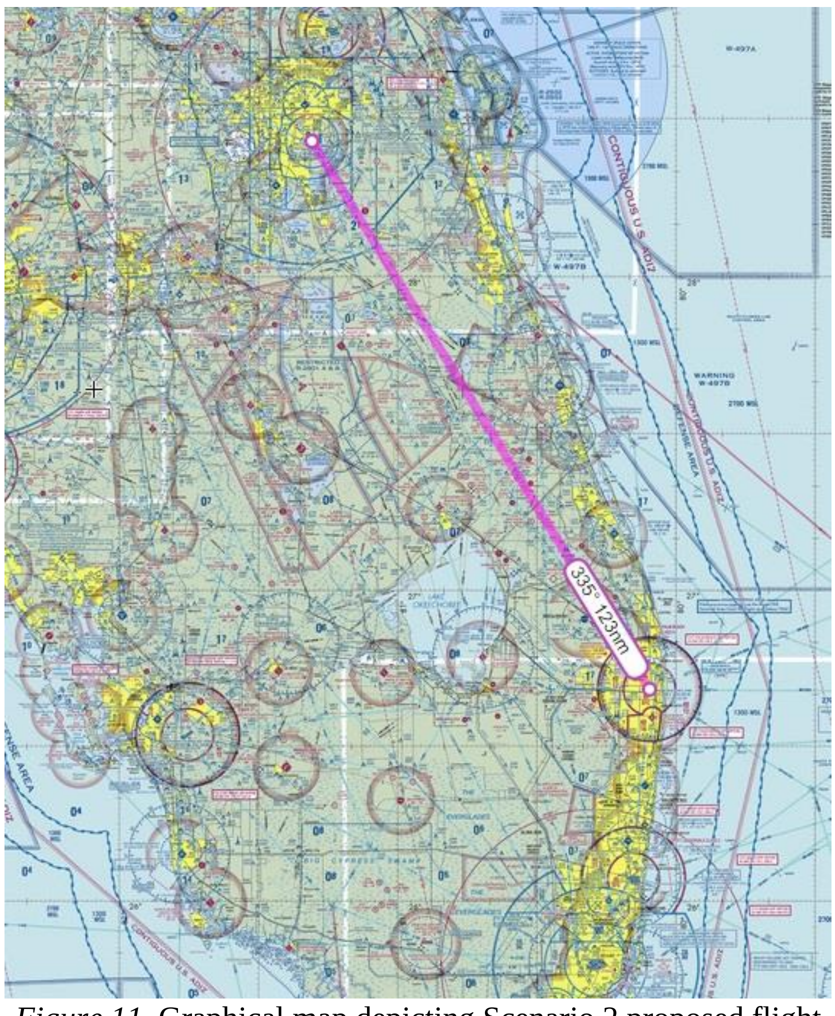


Figure 11. Graphical map depicting Scenario 2 proposed flight

Table 7. FSS and Pilot Recommendation Selections for VFR or VNR-Scenario 2

	VFR	**VNR**
FSS	17	3
PILOT	9	11

Table 7 shows the breakdown of VFR vs VNR selections for pilots and FSS participants. For Scenario 2, most FSS selected VFR while the pilots were split in their selections. FSS and pilots selecting VFR as their recommendation largely felt that the flight could be made at the designated time and that the thunderstorms were currently outside of the proposed route. Some comments indicted that they felt the thunderstorms could be avoided mid-flight if conditions changed. Pilots selecting VNR commonly cited potential weather movement as a contributing factor. Figure 12 through Figure 15 shows the categories of responses from pilots and FSS participants.

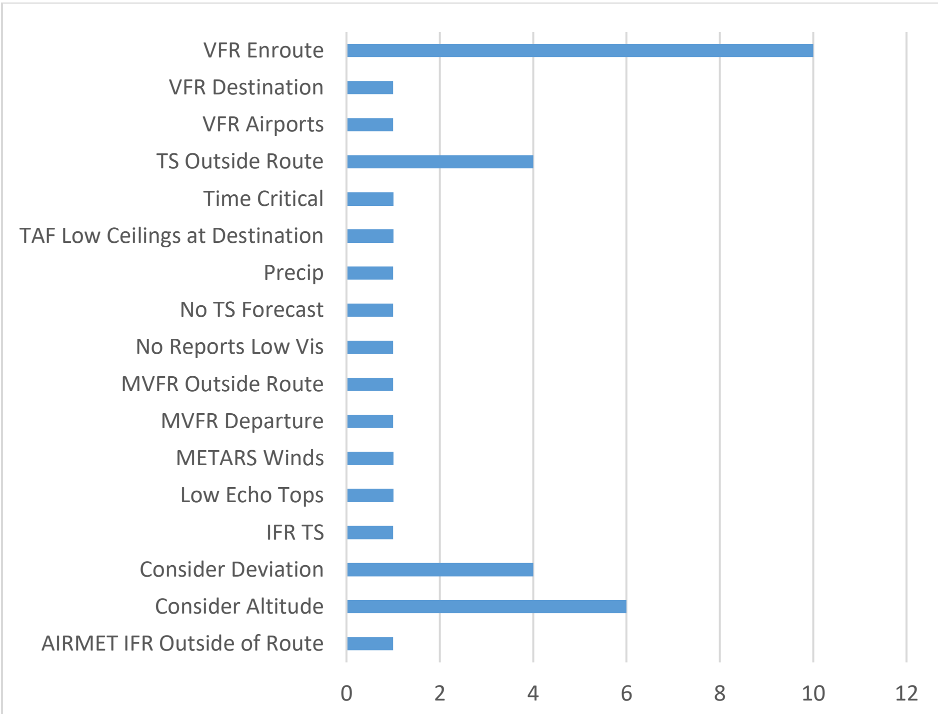


Figure 12. Scenario 2 FSS VFR Justifications

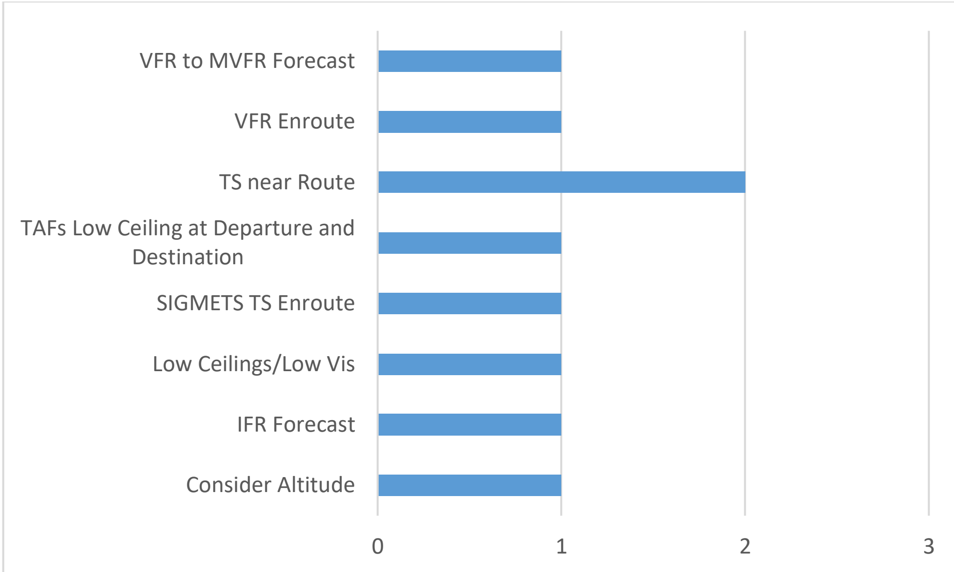


Figure 13. Scenario 2 FSS VNR Justifications

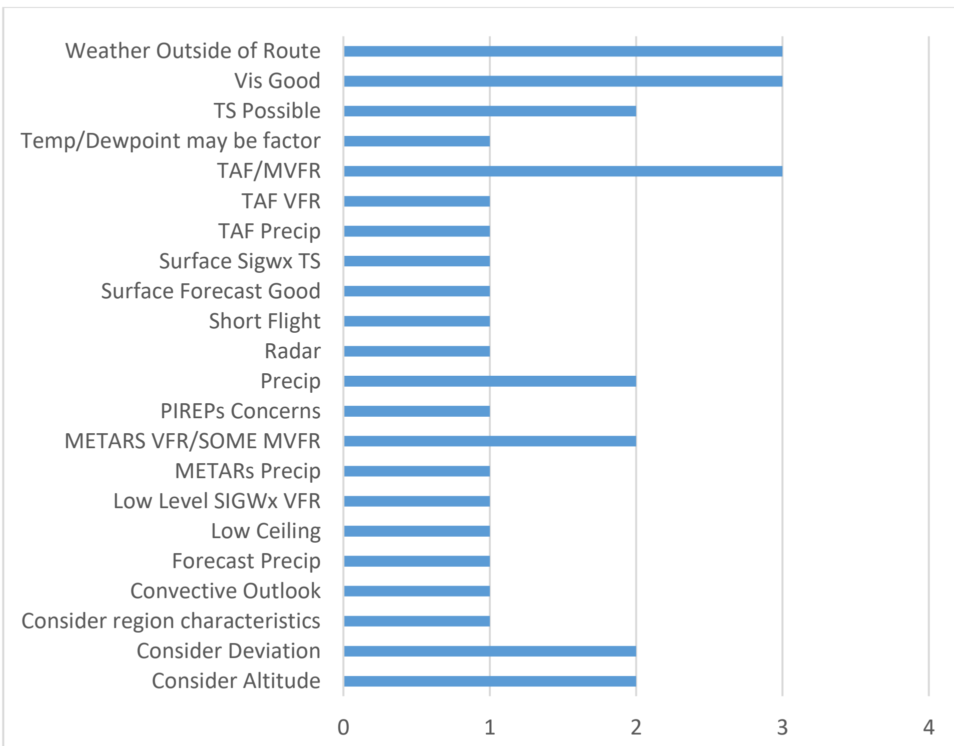


Figure 14. Scenario 2 Pilot VFR Justifications

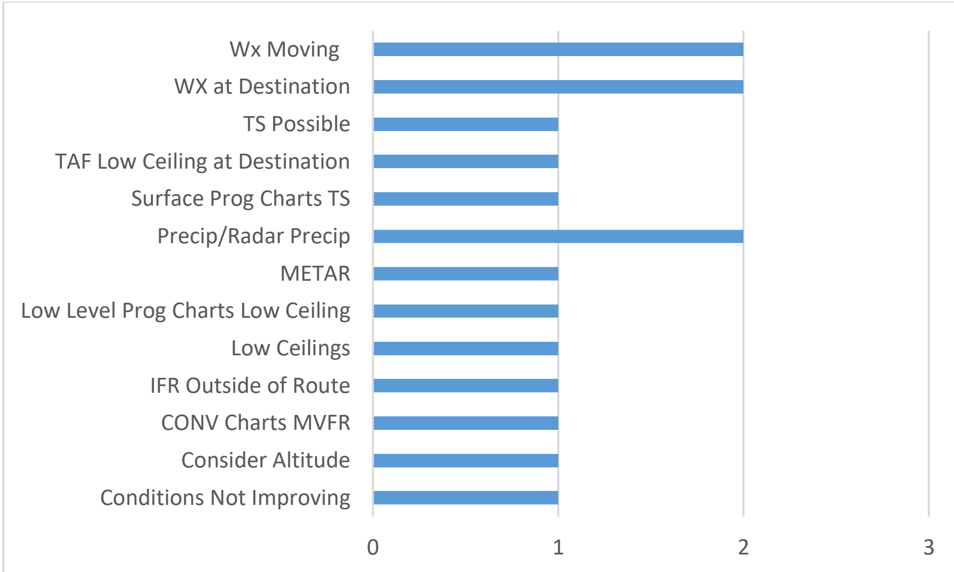


Figure 15. Scenario 2 Pilot VNR Justifications

3.2.3. Justification Responses Scenario 3

We present the flight information for Scenario 3 that was presented to each participant in Table 8. We also include a scenario summary description (not provided to the participants) to give a brief overview of scenario conditions as described by our SMEs. Figure 16 is one of several graphical map views available to the participants during the study.

Table 8. Scenario 3 West Virginia – Pennsylvania

Departure	KLYH	***Destination***	KUNV
Distance	220.5	***Est. Time En Route***	2:08
Est. Time of Departure	1415	***Proposed Altitude***	9500
Direction of Flight	N		

Scenario Summary Description – Scenario 3
Departure and destination airports both show VFR conditions at the time of departure. There is no precipitation along the route of flight, although there are areas of MVFR with the possibility of mountain obstruction. Forecasts show destination airport VFR, but degrading to MVFR one hour after arrival.

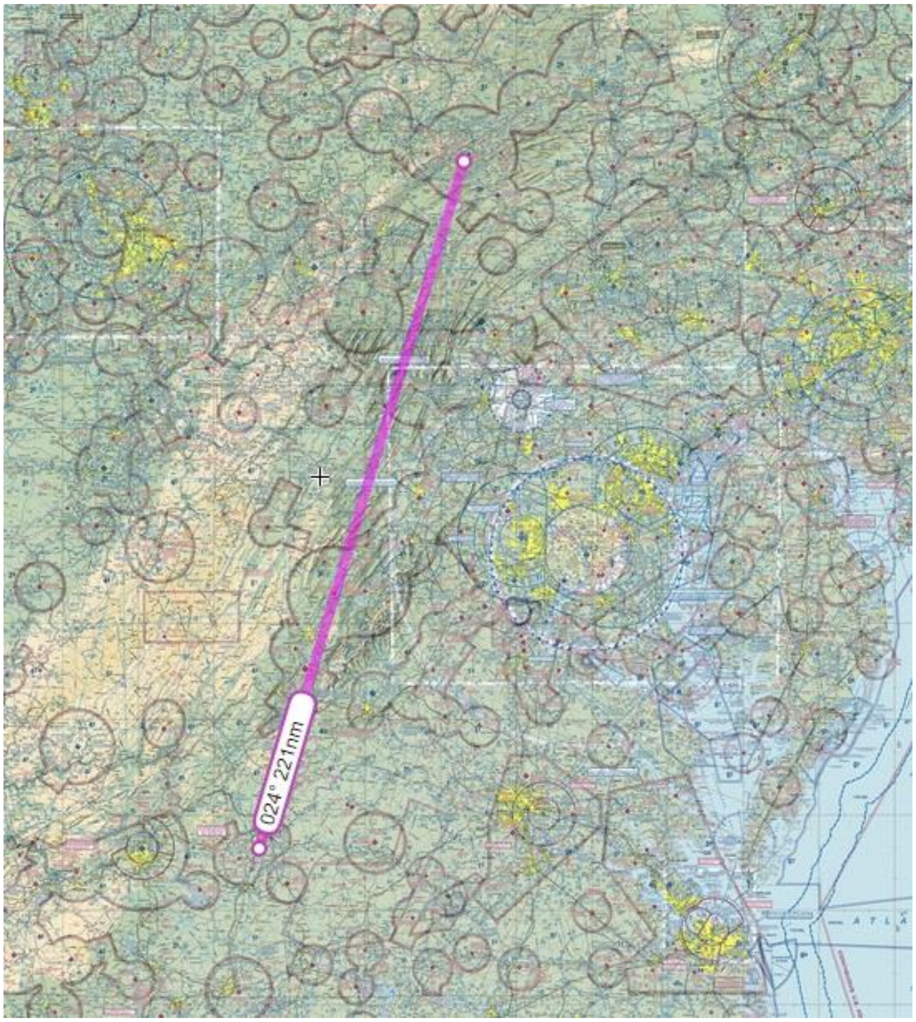


Figure 16. Graphical map depicting Scenario 3 proposed flight

Table 9. FSS and Pilot Recommendation Selections for VFR or VNR-Scenario 3

	VFR	VNR
FSS	8	12
PILOT	2	18

Table 9 shows the breakdown of VFR vs VNR selections for pilots and FSS participants. For Scenario 3, FSS participants were somewhat split in their selection, while the majority of pilots selected VNR. FSS and pilots selecting VFR as their recommendation largely felt that the flight could be made at the designated time as long as the proposed flight was not delayed. Both FSS and pilots cited Mountain Obscuration and low ceilings as a common justification for the VNR selection. Figure 17 through Figure *20* show the categories of responses from pilots and FSS participants.

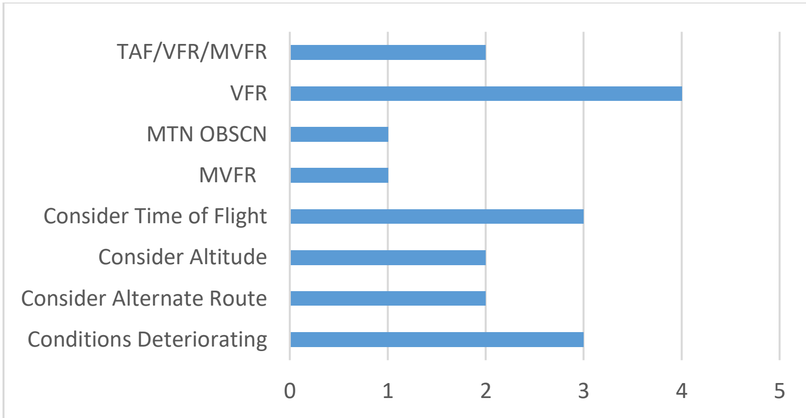


Figure 17. Scenario 3 FSS VFR Justifications

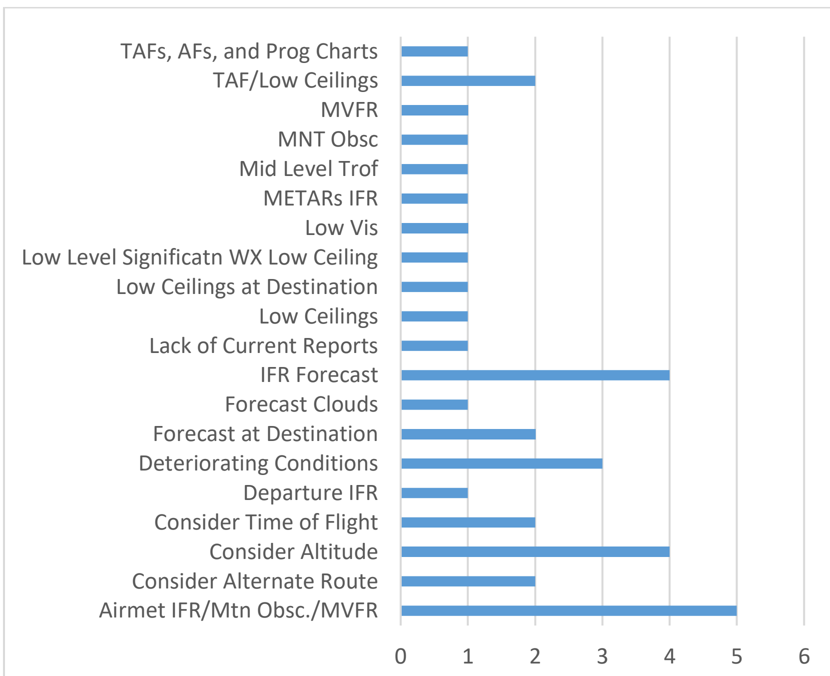


Figure 18. Scenario 3 FSS VNR Justifications

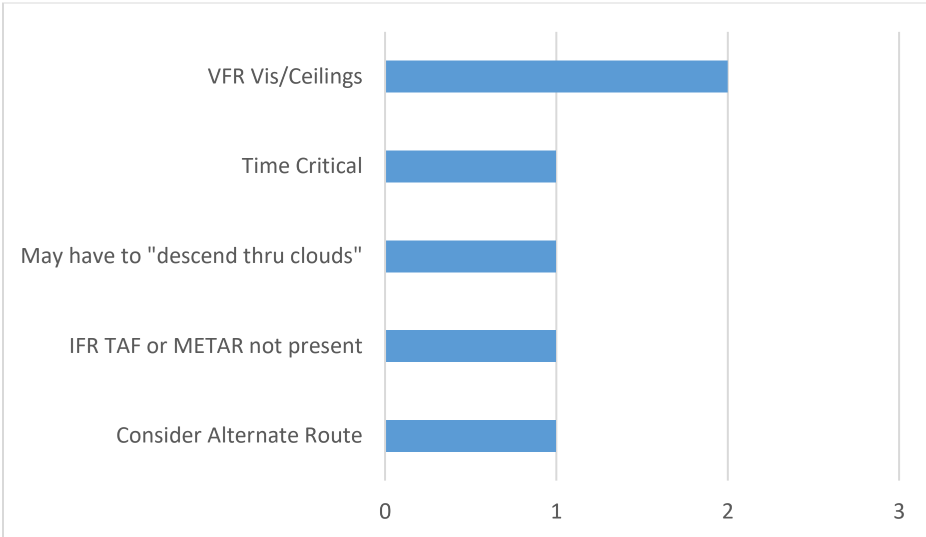


Figure 19. Scenario 3 Pilot VFR Justifications

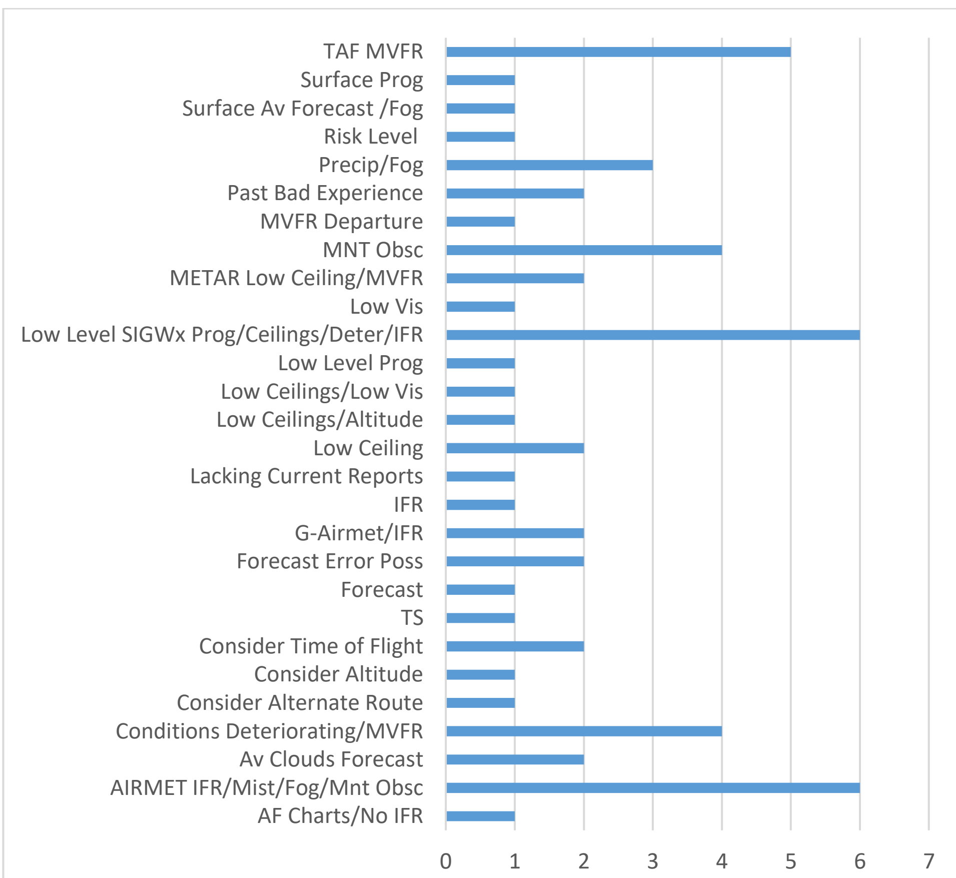


Figure 20. Scenario 3 Pilot VNR Justifications

3.2.4. Justification Responses Scenario 4

We present the flight information for Scenario 4 that was presented to each participant in Table 10. We also include a scenario summary description (not provided to the participants) to give a brief overview of scenario conditions as described by our SMEs. Figure 21 is one of several graphical map views available to the participants during the study.

Table 10. Scenario 4-Florida - Georgia

Departure	KSGJ	***Destination***	KABY
Distance	175.2	***Est. Time En Route***	1:53
Est. Time of Departure	1415	***Proposed Altitude***	10500
Direction of Flight	NW		

Scenario Summary Description – Scenario 4
Departure and destination airports both show MVFR conditions at the time of departure with potential areas of IFR along the route. There are areas of extreme precipitation to the west of the route moving NE. Forecasted conditions at the destination airport show MVFR at the time of arrival.

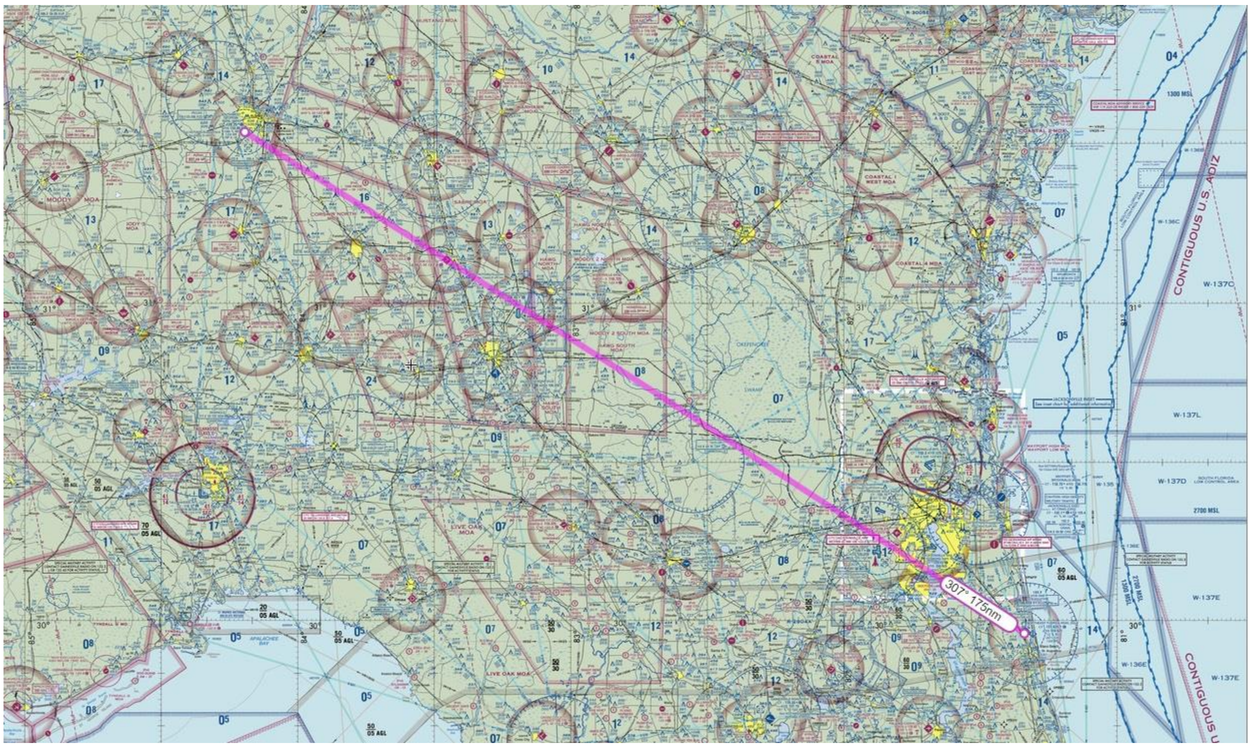


Figure 21. Graphical map depicting Scenario 4 proposed flight

Table 11 shows the breakdown of VFR vs VNR selections for pilots and FSS participants. For Scenario 4, all FSS and pilots unanimously selected VNR for their recommendation. Participants still had a wide variety of responses as shown in Figure 22 and Figure 23. Participants frequently mentioned thunderstorms (TS) and convective activity. FSS overwhelmingly mentioned IFR conditions, in particular around the departure and arrival airports. The pilot responses included a wide variety of weather products, such as Prognostic Charts, Daily Weather, and Area Forecast, used to help them reach their conclusion.

Table 11. FSS and Pilot Recommendation Selections for VFR or VNR-Scenario 4

	VFR	VNR
FSS	0	20
PILOT	0	20

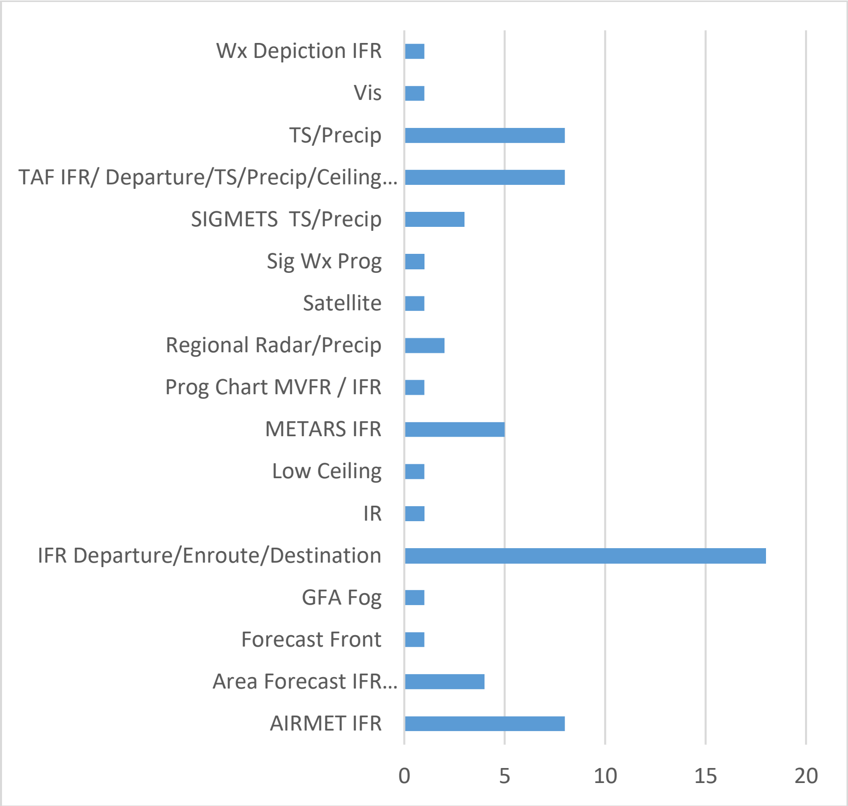


Figure 22. Scenario 4 FSS VNR Justification

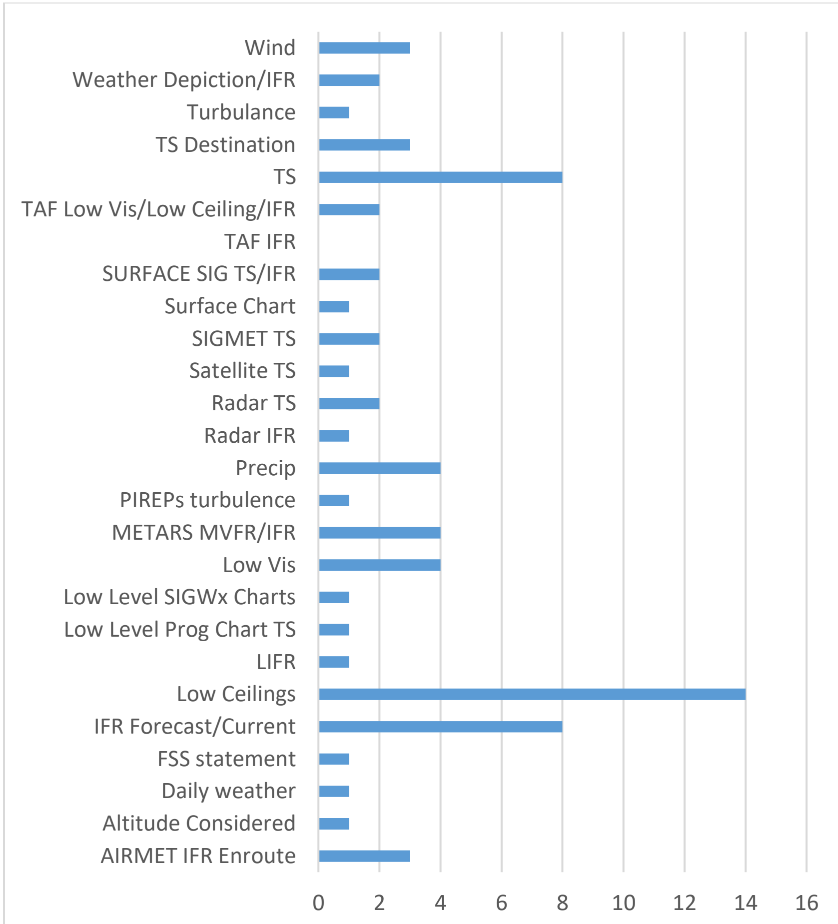


Figure 23. Scenario 4 Pilot VNR Justifications

3.2.5. Justification Responses Scenario 5

We present the flight information for Scenario 5 that was presented to each participant in Table 12. We also include a scenario summary description (not provided to the participants) to give a brief overview of scenario conditions as described by our SMEs. Figure 24 is one of several graphical map views available to the participants during the study.

Table 12. Scenario 5 Nevada – California

Departure	KRNO	***Destination***	KCEC
Distance	247.8	***Est. Time En Route***	2:46
Est. Time of Departure	1915	***Proposed Altitude***	10500
Direction of Flight	NW		

Scenario Summary Description – Scenario 5
Departure and destination airports both show current and forecasted VFR conditions. En route weather shows an area of MVFR midway through the flight.

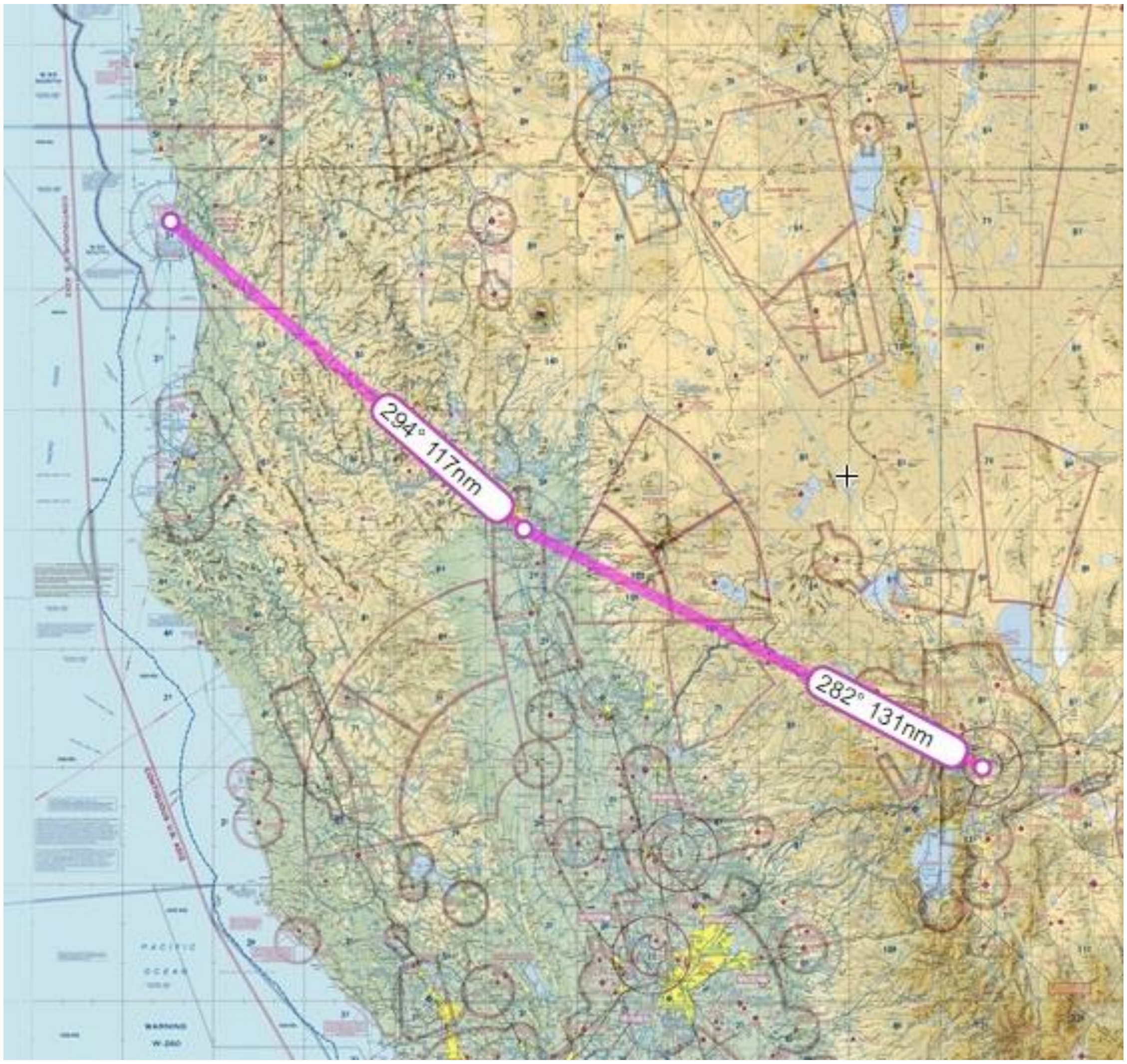


Figure 24. Graphical map depicting Scenario 5 proposed flight

Table 13 shows the breakdown of VFR vs VNR selections for pilots and FSS participants. For Scenario 5, FSS and pilot participants were again somewhat split in their selection. FSS and pilots selecting VFR as their recommendation largely felt that the flight was mainly VFR with some MVFR possible. Several mentioned mountainous terrain as a concern, but largely agreed that the flight could be maintained clear of weather, with a possible deviation if needed. Another interesting note, participants mentioned "MVFR" in both the VFR and VNR selection responses. This indicates, at least to some degree, that individuals have different comfort levels encountering marginal weather during a VFR flight. Both FSS and pilots selecting VNR commonly mentioned 'low ceilings' as a factor in their recommendation, however, here again we see a wide variety of factors represented in the responses. Figure 25 through Figure 28 shows the categories of responses from pilots and FSS participants.

Table 13. FSS and Pilot Recommendation Selections for VFR or VNR-Scenario 5

	VFR	VNR
FSS	11	9
PILOT	6	14

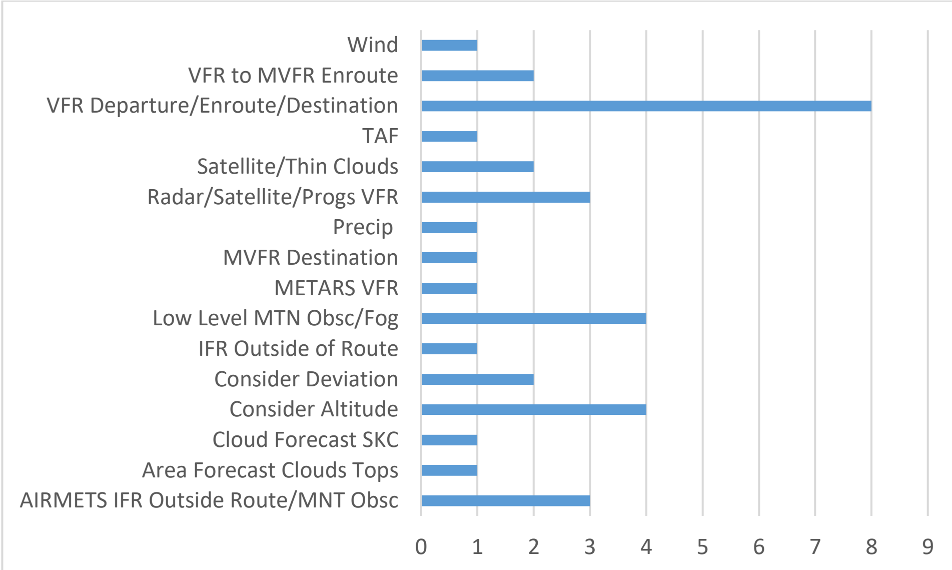


Figure 25. Scenario 5 FSS VFR Justifications

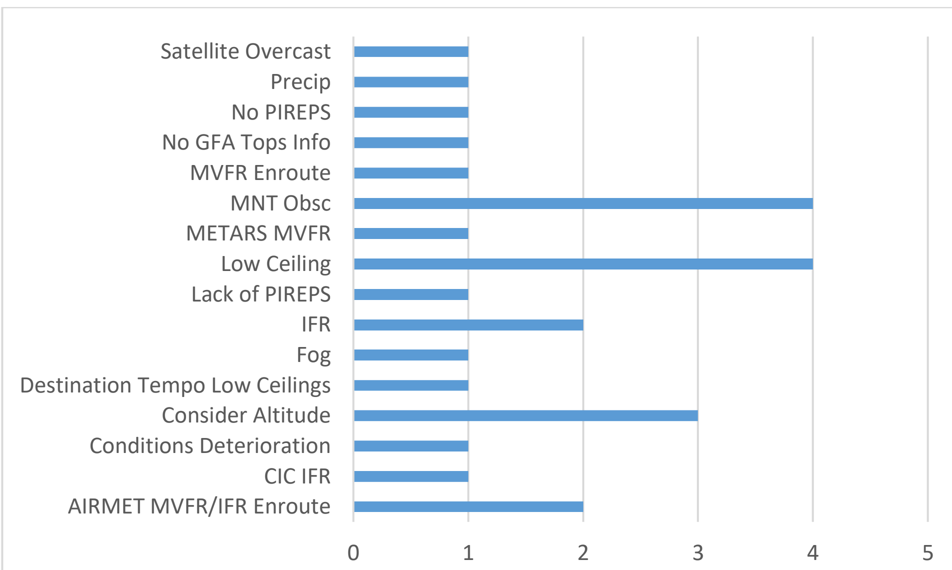


Figure 26. Scenario 5 FSS VNR Justifications

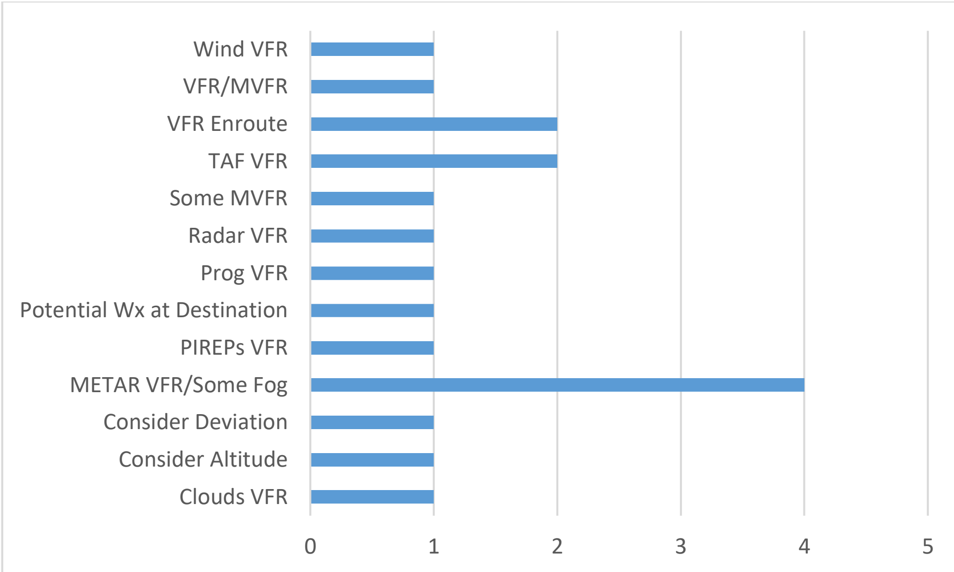


Figure 27. Scenario 5 Pilot VFR Justifications

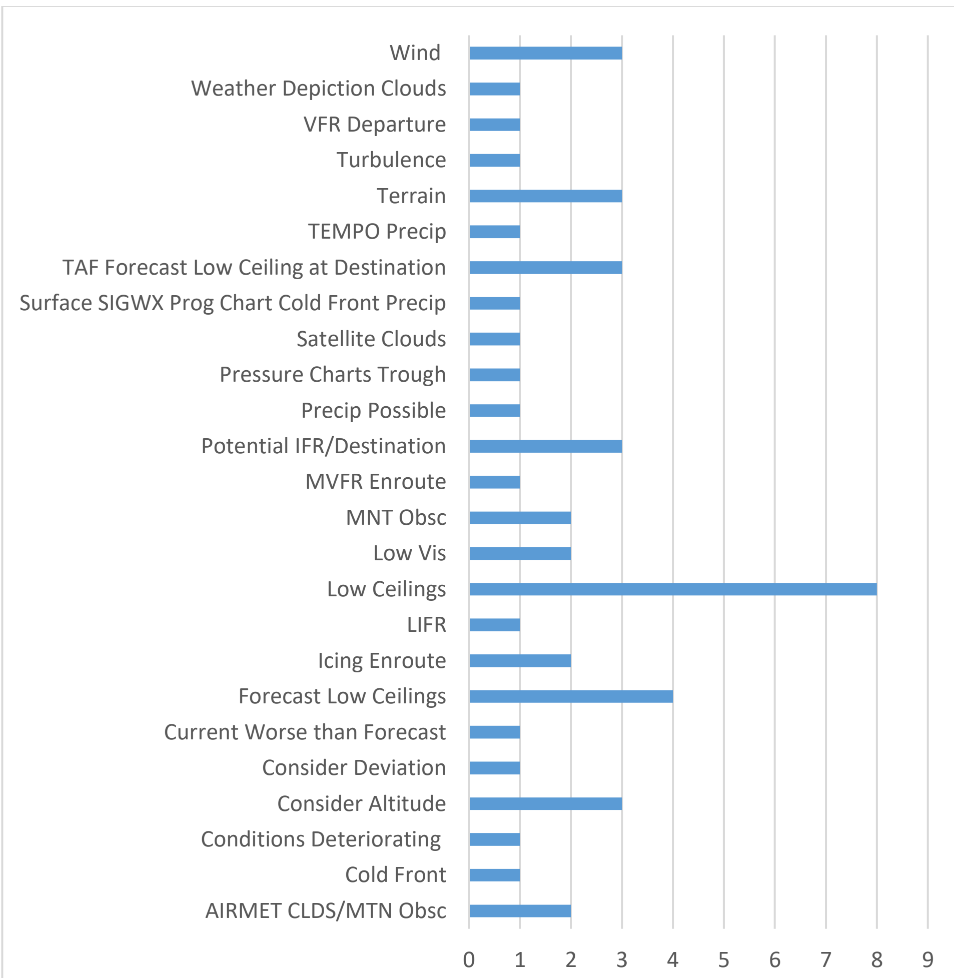


Figure 28. Scenario 5 Pilot VNR Justifications

3.2.6. Justification Responses Scenario 6

We present the flight information for Scenario 6 that was presented to each participant in Table 14. We also include a scenario summary description (not provided to the participants) to give a brief overview of scenario conditions as described by our SMEs. Figure 29 is one of several graphical map views available to the participants during the study.

Table 14. Scenario 6 - New York – New Jersey

Departure	NYO	***Destination***	KBLM
Distance	173.9nm	***Est. Time En Route***	1:30
Est. Time of Departure	1500	***Proposed Altitude***	10500
Direction of Flight	S, SE		

Scenario Summary Description – Scenario 6
Departure and destination airports both show current MVFR conditions. A large area of precipitation is west of the route and moving east. Forecasts show conditions at the departure airport and most of the en route portion of the flight improving. Forecasts also show the destination airport remaining the same (MVFR) with surrounding areas degrading.

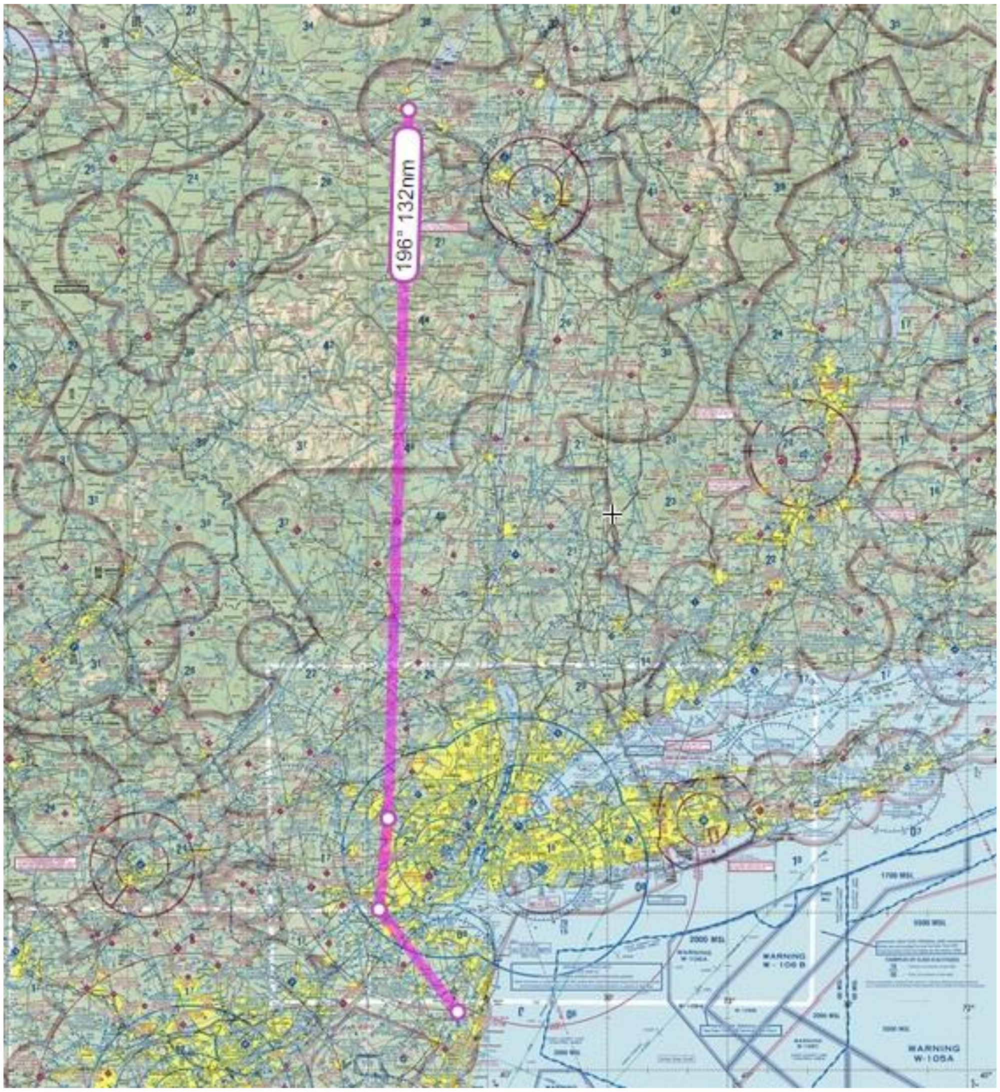


Figure 29. Graphical map depicting Scenario 6 proposed flight

Table 15. FSS and Pilot Recommendation Selections for VFR or VNR-Scenario 6

	VFR	VNR
FSS	2	18
PILOT	0	20

Table 15 shows the breakdown of VFR vs VNR selections for pilots and FSS participants. For Scenario 6, most FSS and all pilot participants selected VNR. Of the two FSS participants who selected VFR as their recommendation, one of them stated that there was a very narrow window for which the pilot could fly VFR. The other stated that conditions were improving. As with other scenarios, the participants included a wide variety of factors as justifications for their selections. However, a large number of participants noted that 'low ceilings' and 'Mountain Obscuration' was a concern. Figure 30 through Figure 32 shows the categories of responses from pilots and FSS participants.

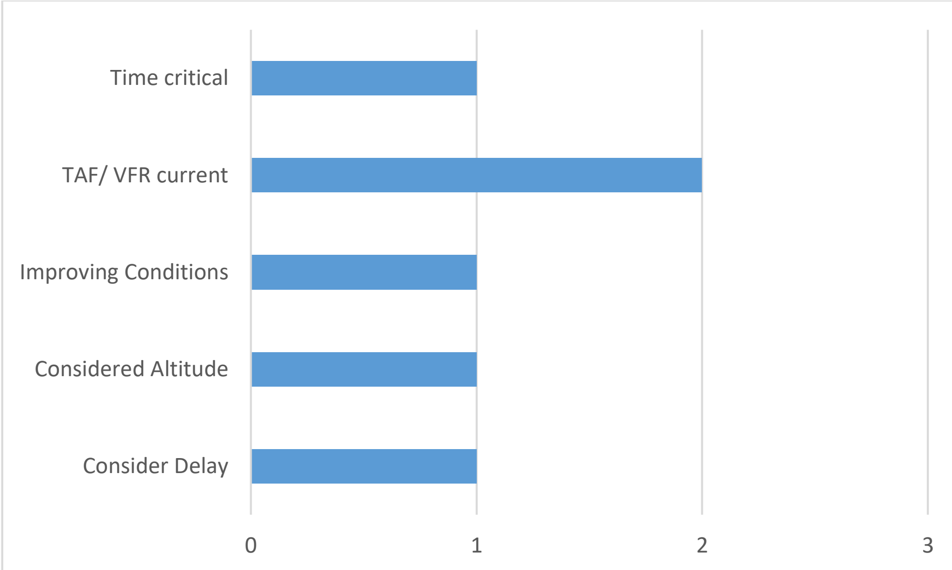


Figure 30. Scenario 6 FSS VFR Justifications

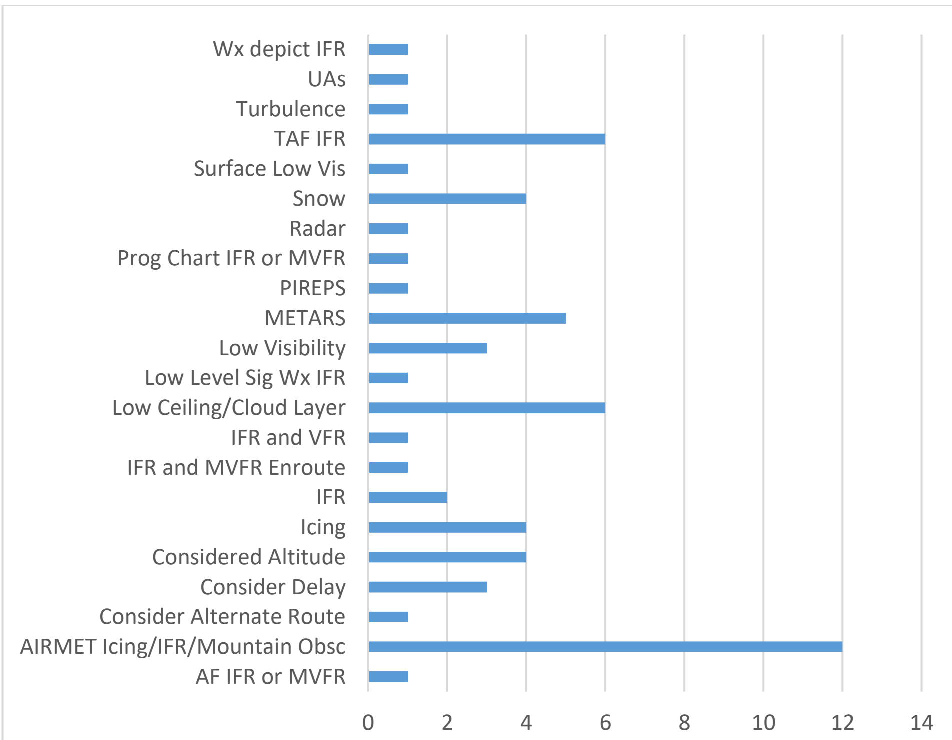


Figure 31. Scenario 6 FSS VNR Justifications

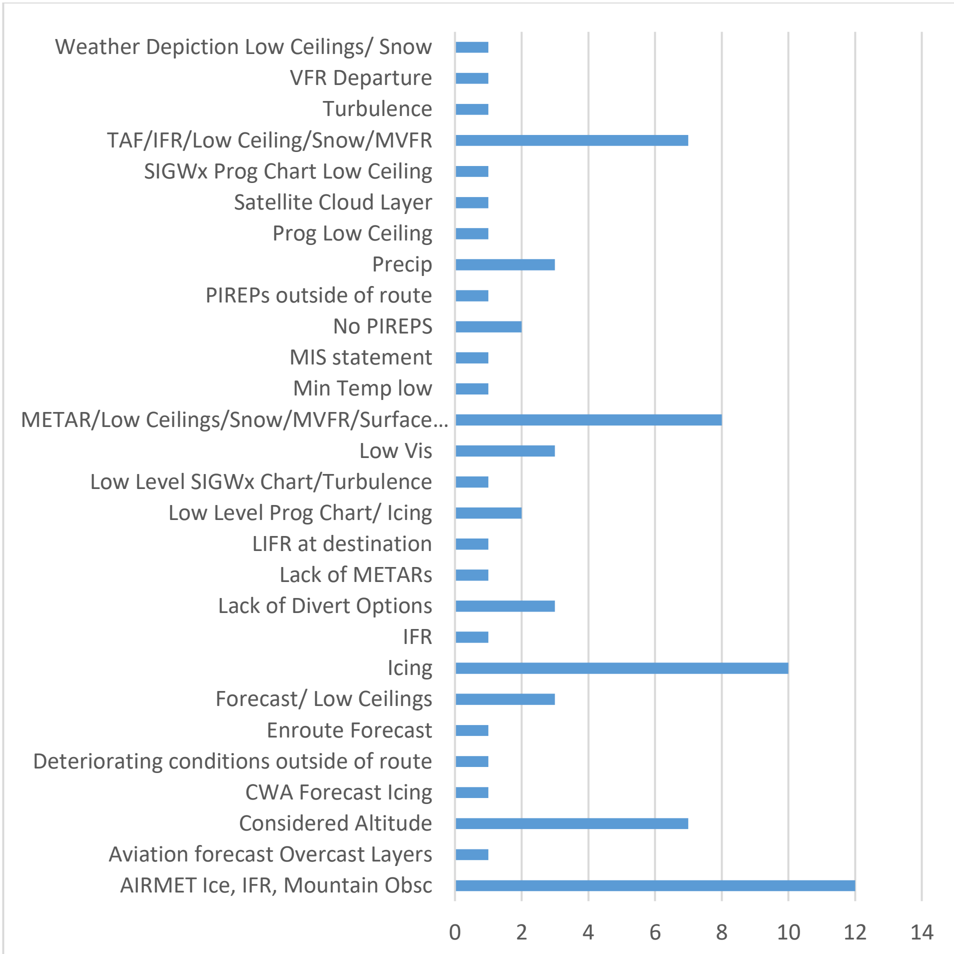


Figure 32. Scenario 6 Pilot VNR Justifications

3.2.7. Justification Responses Scenario 7

We present the flight information for Scenario 7 that was presented to each participant in Table 16. We also include a scenario summary description (not provided to the participants) to give a brief overview of scenario conditions as described by our SMEs. Figure 33 is one of several graphical map views available to the participants during the study.

Table 16. Scenario 7 Alaska

Departure	PAIL	***Destination***	PAEN
Distance	142.5	***Est. Time En Route***	1:27
Est. Time of Departure	1915	***Proposed Altitude***	5500
Direction of Flight	NE, E		

Scenario Summary Description – Scenario 7

Departure and destination airports both show current and forecasted VFR conditions. The weather cameras are showing mountain obstruction with improving cloud coverage and ascending bases 15 minutes prior to departure.

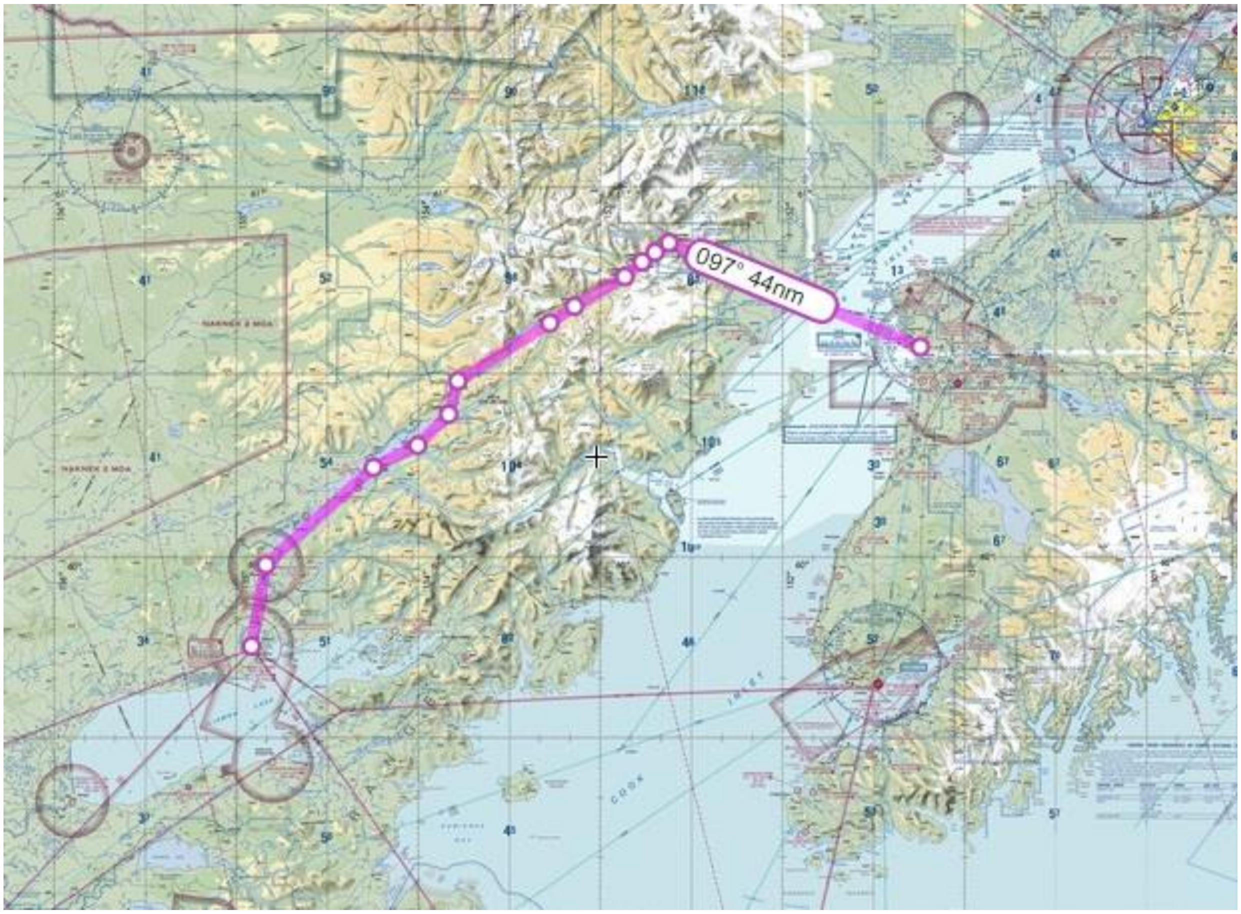


*Figure 33.*Graphical map depicting Scenario 7 proposed flight

Table 17. FSS and Pilot Recommendation Selections for VFR or VNR-Scenario 7

	VFR	**VNR**
FSS	15	5
PILOT	15	5

Table 17 shows the breakdown of VFR vs VNR selections for pilots and FSS participants. For Scenario 7, FSS and pilot groups broke out the same with 15 selecting VFR and 5 selecting VNR. In Alaska, pilots and FSS specialists use camera views where available along routes. For Scenario 7, we used video to show conditions for the Lake Clark Pass. Both FSS and pilot participants selecting VFR responses indicate that they generally felt that IFR conditions were outside the proposed route and were improving. They generally agreed that camera views at Lake Clark Pass verified that clouds were clearing. The participants who selected VNR were uncomfortable with the current conditions (specifically, relating to the filed altitude and mountain obscuration), and were not confident the conditions would be clearing for the time of flight. They also cited that they were either unfamiliar with the territory, or there was an insufficient amount of information. Figure 34 through Figure 37 shows the categories of responses from pilots and FSS participants.

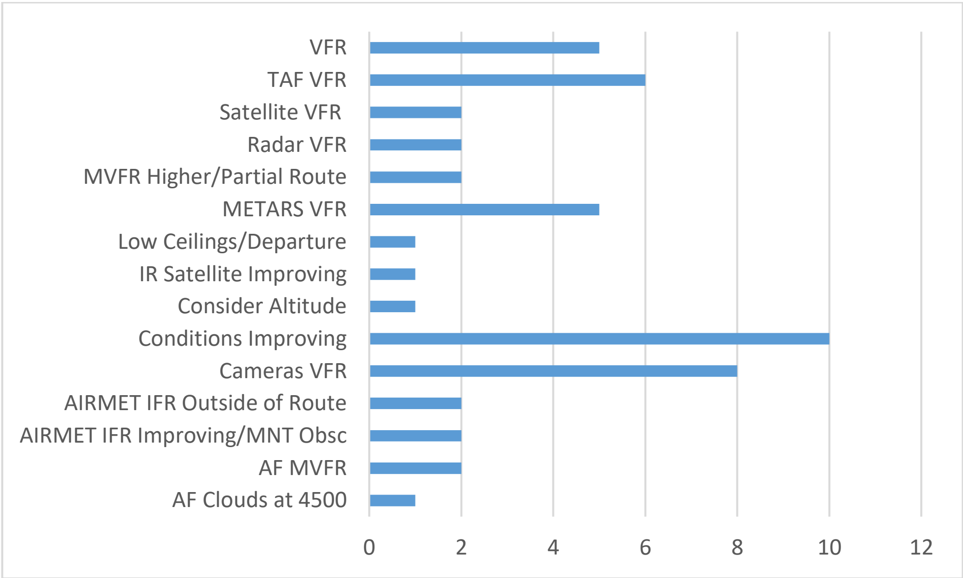


Figure 34. Scenario 7 FSS VFR Justifications

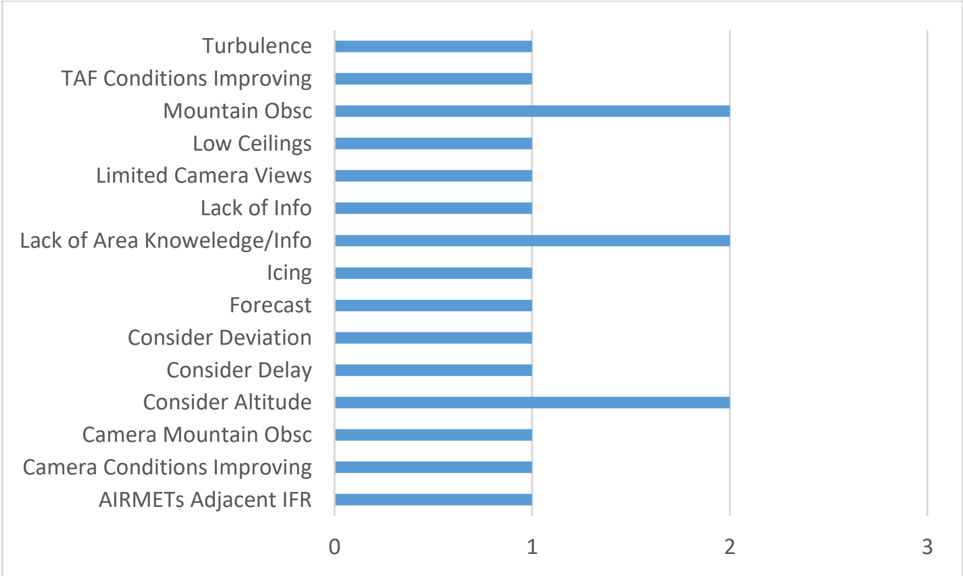


Figure 35. Scenario 7 FSS VNR Justifications

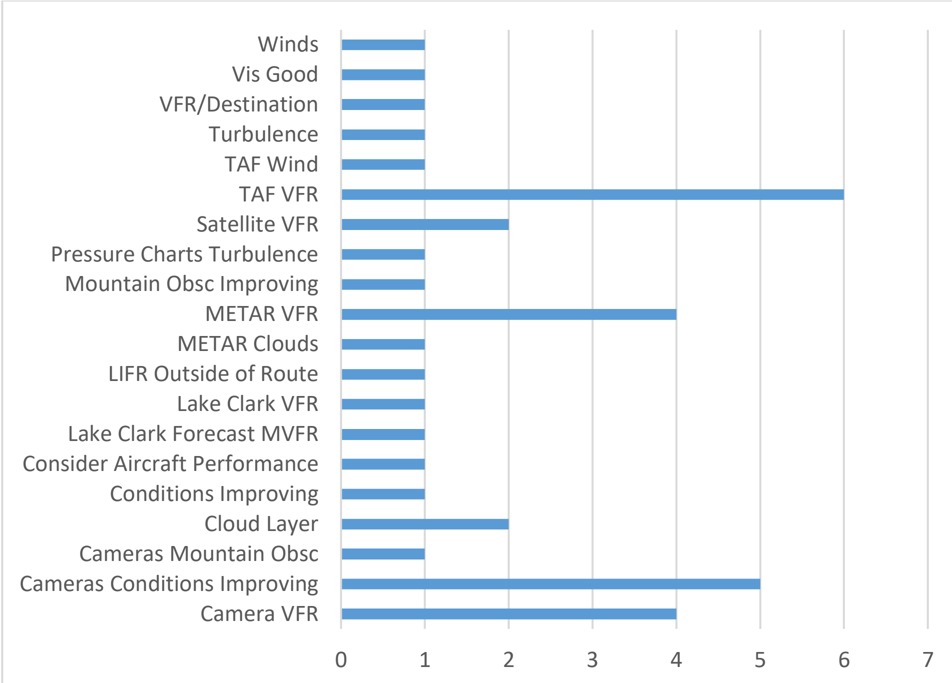


Figure 36. Scenario 7 Pilot VFR Justifications

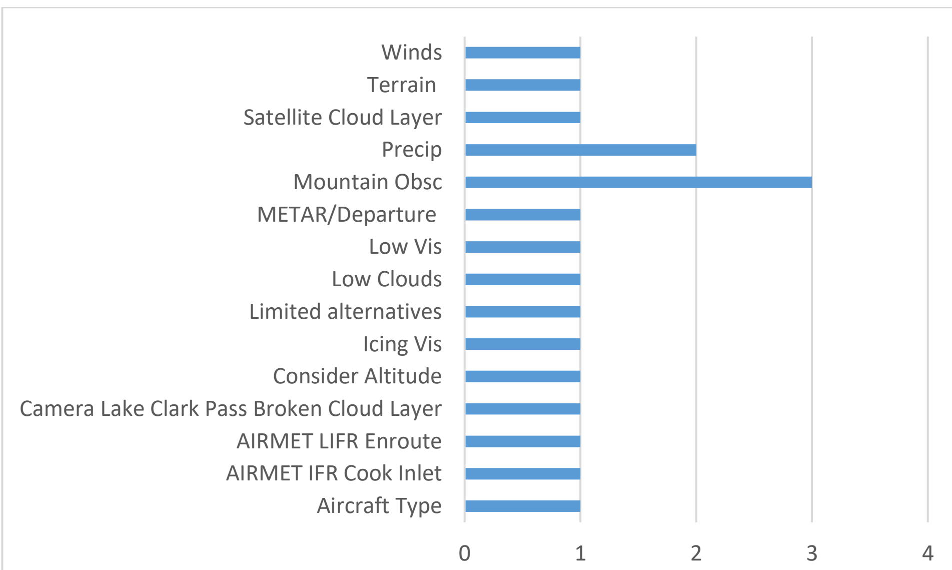


Figure 37. Scenario 7 Pilot VNR Justifications

3.2.8. Justification Responses Scenario 8

Table 18 shows the flight information for Scenario 8 that was presented to each participant . We also include a scenario summary description (not provided to the participants) to give a brief overview of scenario conditions as described by our SMEs. Figure 38 is one of several graphical map views available to the participants during the study.

Table 18. Scenario 8 Mississippi

Departure	KHEZ	***Destination***	KGLH
Distance	113.0	***Est. Time En Route***	1:25
Est. Time of Departure	1615	***Proposed Altitude***	9500
Direction of Flight	N		

Scenario Summary Description – Scenario 8
Departure and destination airports both show current MVFR conditions. Forecasts for the destination airport show a gradual change to LIFR. The flight crosses a warm/cold front boundary associated with squall line thunderstorms.

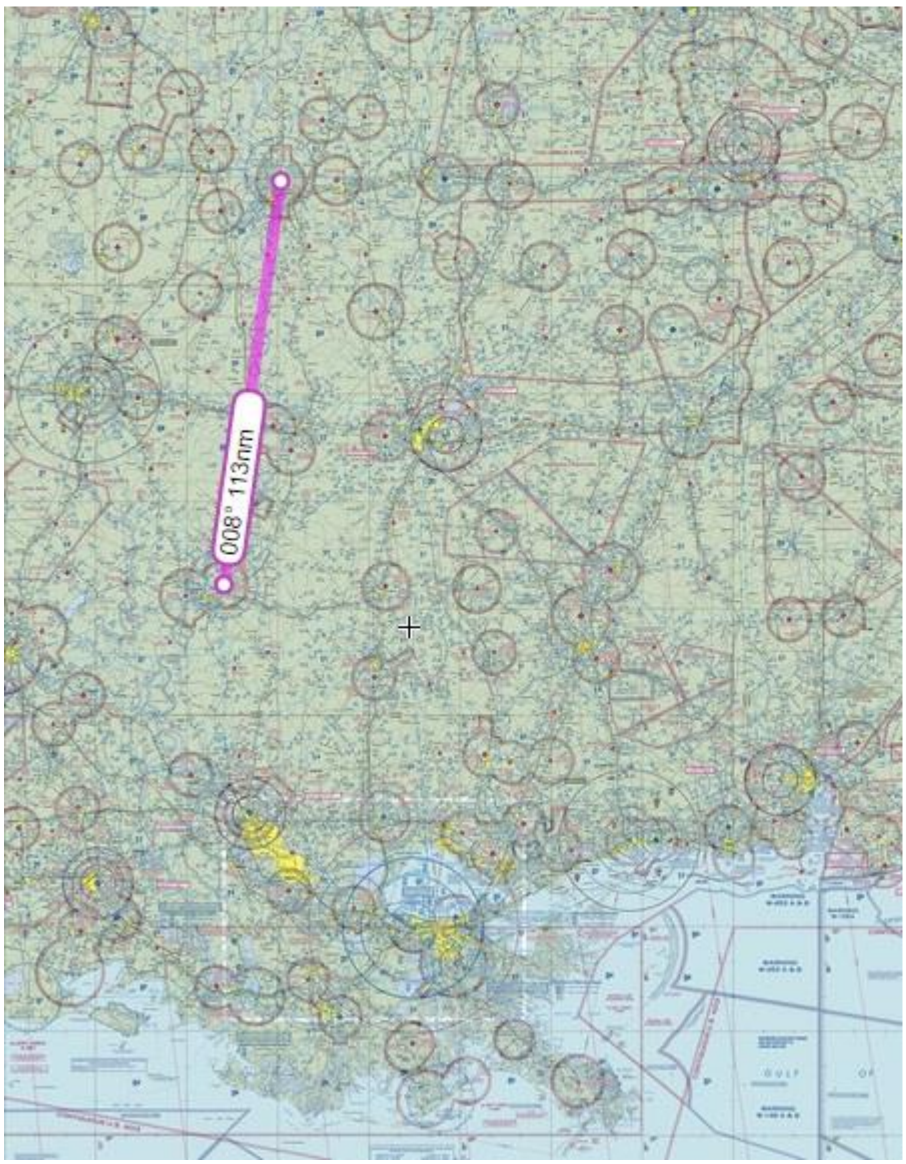


Figure 38. Graphical map depicting Scenario 8 proposed flight

Table 19. FSS and Pilot Recommendation Selections for VFR or VNR-Scenario 8

	VFR	VNR
FSS	0	20
PILOT	0	20

Table 19 shows the breakdown of VFR vs VNR selections for pilots and FSS participants. For Scenario 8, all participants unanimously selected VNR. While the selections were unanimous, it is still interesting to note the range in justification. Also note, that some responses could be further combined, but were reported separately if the participant indicated a specific weather product (e.g. Upper Level Charts or SIGMETs etc.) or a specific aspect of the flight (i.e. TS at destination). For example, the FSS responses have nine different categories that include reference to thunderstorms. *Figure 39* through *Figure 40* shows the categories of responses from pilots and FSS participants.

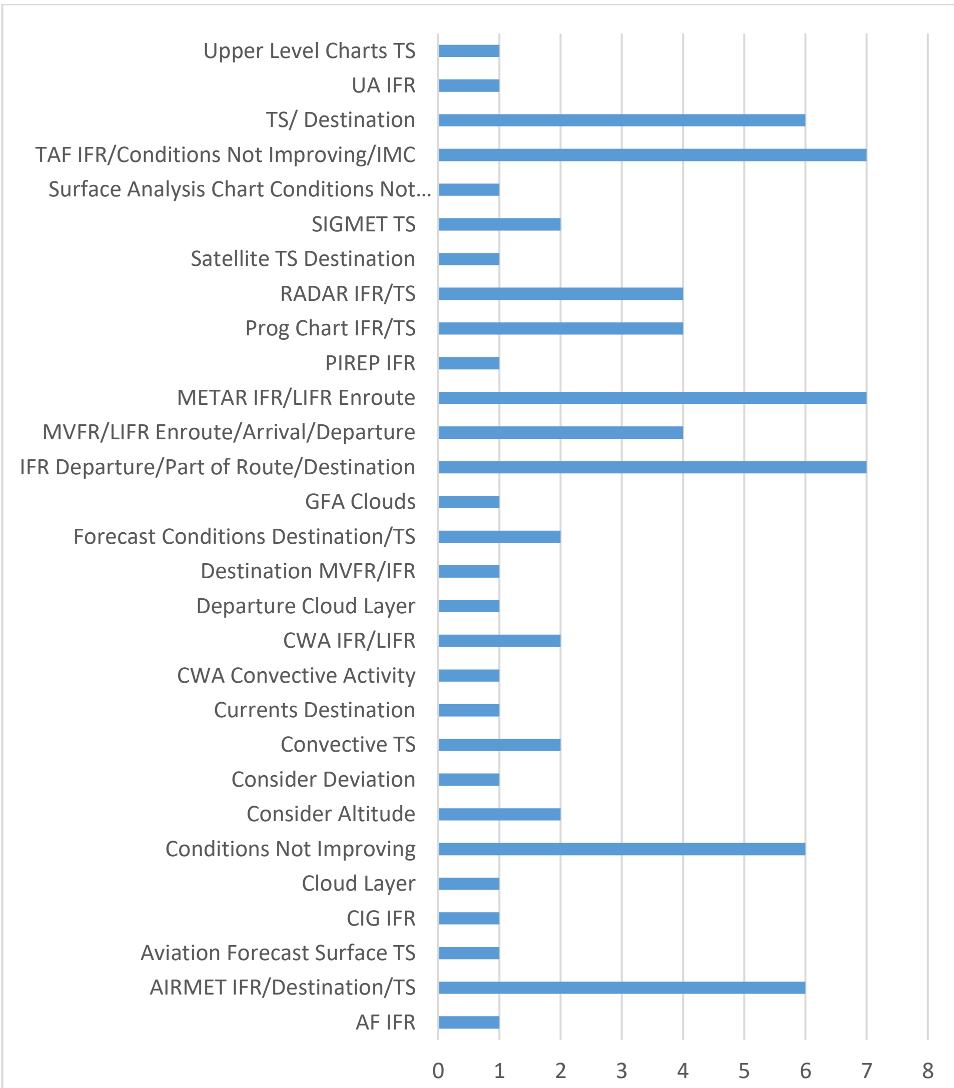


Figure 39. Scenario 8 FSS VNR Justifications

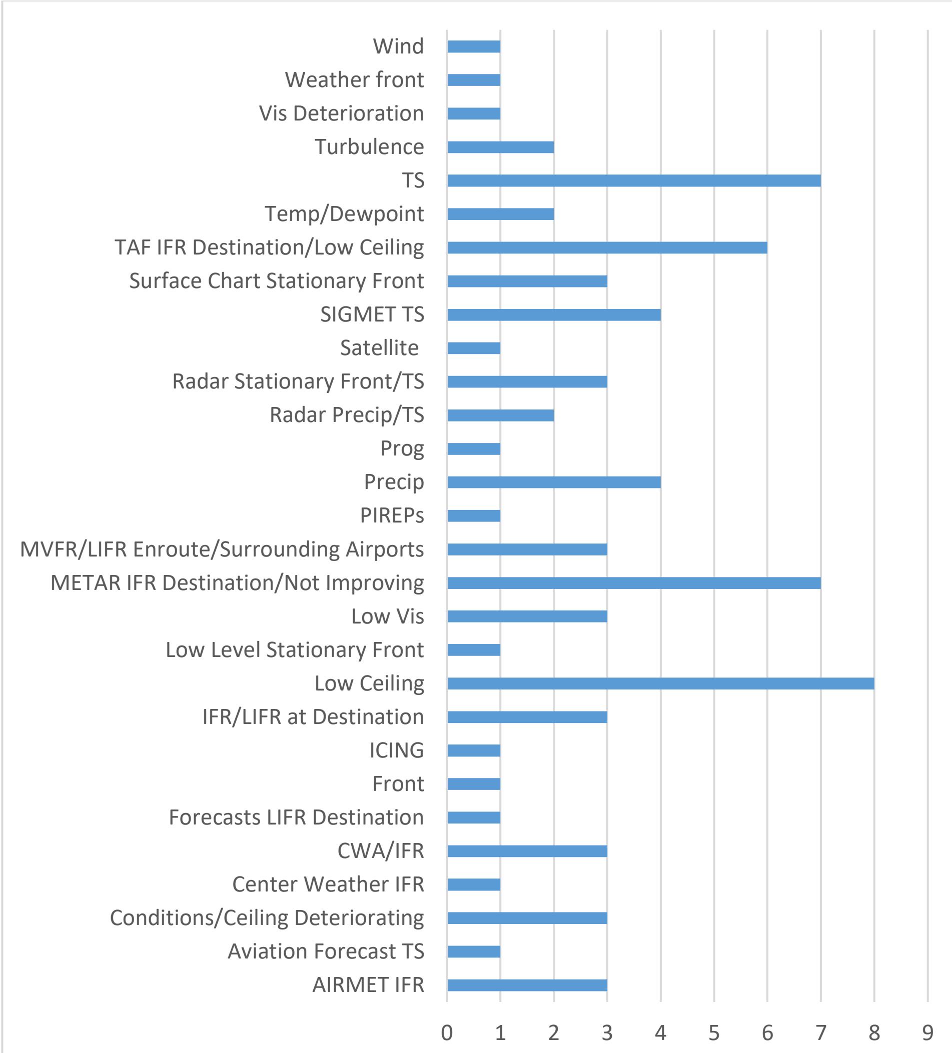


Figure 40. Scenario 8 Pilot VNR Justifications

3.3. Recommendation Analysis

3.3.1. Recommendation Analysis – Scenario 1

In the following section we present the outcome of Bayesian regression and correlation analyses. For these analyses, we used two dichotomous variables (i.e., Recommendation (VFR=0 or VNR=1) and FSS Pilot Experience (Non-pilot=0 or Pilot=1)) and five metric variables (i.e., Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views). We also computed a sixth metric variable: Weather Product Display Time. However, due to the preponderance of very long display times we determined that this variable might not correlate well with the actual time that participants viewed a given weather product. Therefore, we decided not to use this variable for our analyses.

In a first multivariate regression analysis (Kruschke, 2014), we assessed if the metric variables Age and Total Experience could predict the Time to Recommendation. However, as is shown in

Figure 41, the model probability is only 0.15, which means that the variables Age and Total Experience cannot predict the Time to Recommendation.

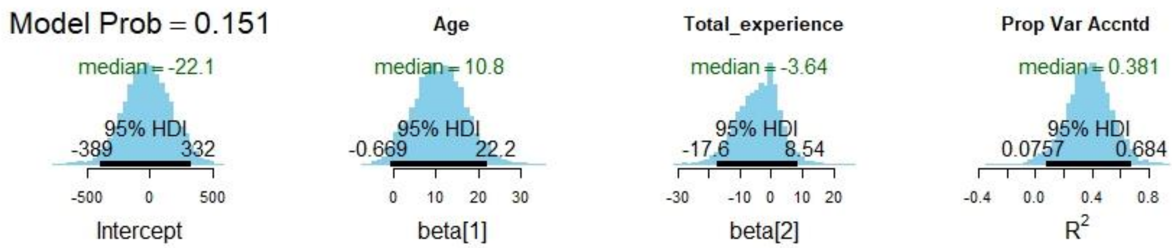


Figure 41. Multivariate model using Age and Total Experience to predict the Time to Recommendation.

In a second analysis we used logistic regression (Kruschke, 2014) to assess whether the metric variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views could predict whether the participant made a VFR or VNR recommendation. However, none of the metric variables could reliably predict whether a participant made a VFR or VNR recommendation. In the example (Figure 42), we illustrate the non-predictive outcome of using the Number of Weather Products Used to predict whether participants made a VFR (0 on the y-axis) or VNR (1 on the y-axis) recommendation.

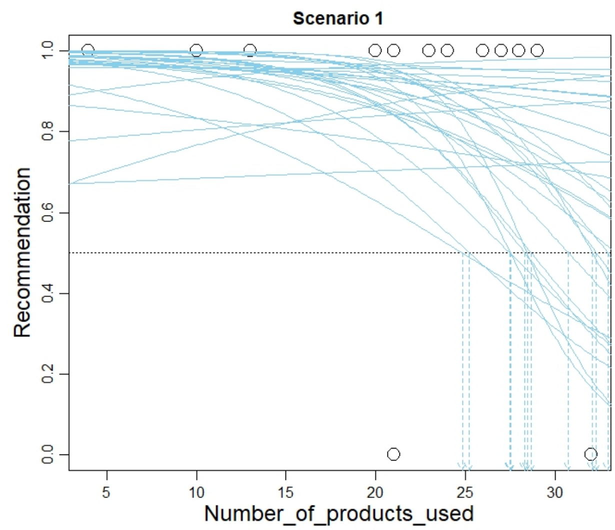


Figure 42. Logistic regression using the Number of Weather Products Used to predict the Recommendation (VFR=0 and VNR=1).

We also assessed whether the Recommendation differed between FSS Specialists that had a private pilot certificate and FSS Specialists that had no private pilot certificate. Using the dichotomous variable FSS Pilot Experience (Non-pilot=0 or Pilot=1) and five metric variables (i.e., Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views), we assessed whether a logistic regression could predict if participants were a pilot or not. In essence, this analysis assessed whether there were any differences between pilots and non-pilots regarding the five metric variables. However, the analysis showed that none of the five metric variables could predict whether the participant was a pilot or not, meaning that pilots and non-pilots were similar on all five variables. In the example (*Figure 43*), we illustrate the non-predictive outcome of using the Number of Weather Products Used to predict whether a participant was a non-pilot (0 on the y-axis) or a pilot (1 on the y-axis).

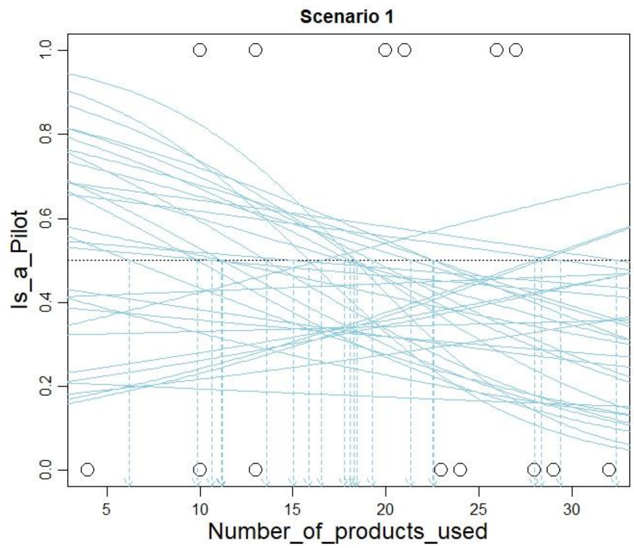


Figure 43. Logistic regression using the Number of Weather Products Used to predict whether a participant was a private pilot or not (Non-pilot y-axis=0 and Pilot y-axis=1).

In a third analysis we computed the correlation between the variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views. The closer the correlations are to +1.0 (positive correlation) and -1.0 (negative correlation) the stronger the relationships are between the variables. In Figure 44, we present some of the outcomes that have moderate to strong correlations.

First, there is a moderate correlation (0.51) between an FSS participant's total experience and the number of weather products used to make a recommendation (Figure 44, top). That is, the more experience a participant had the more weather products they used. Second, there is a strong correlation (0.65) between the time to the recommendation and the number of weather products used (Figure 44, second from top). As the time to the recommendation increases, there is a corresponding increase in the number of weather products used. Third, there is a moderate correlation (0.44) between the time to the recommendation and the total experience (Figure 44, second from bottom). That is, with an increasing time to the recommendation there is a corresponding increase in the FSS participant experience. And, finally, there is a strong correlation between participants' total experience and the number of weather display views (0.64). That is, the more experienced the participants were the more they viewed the weather product displays.

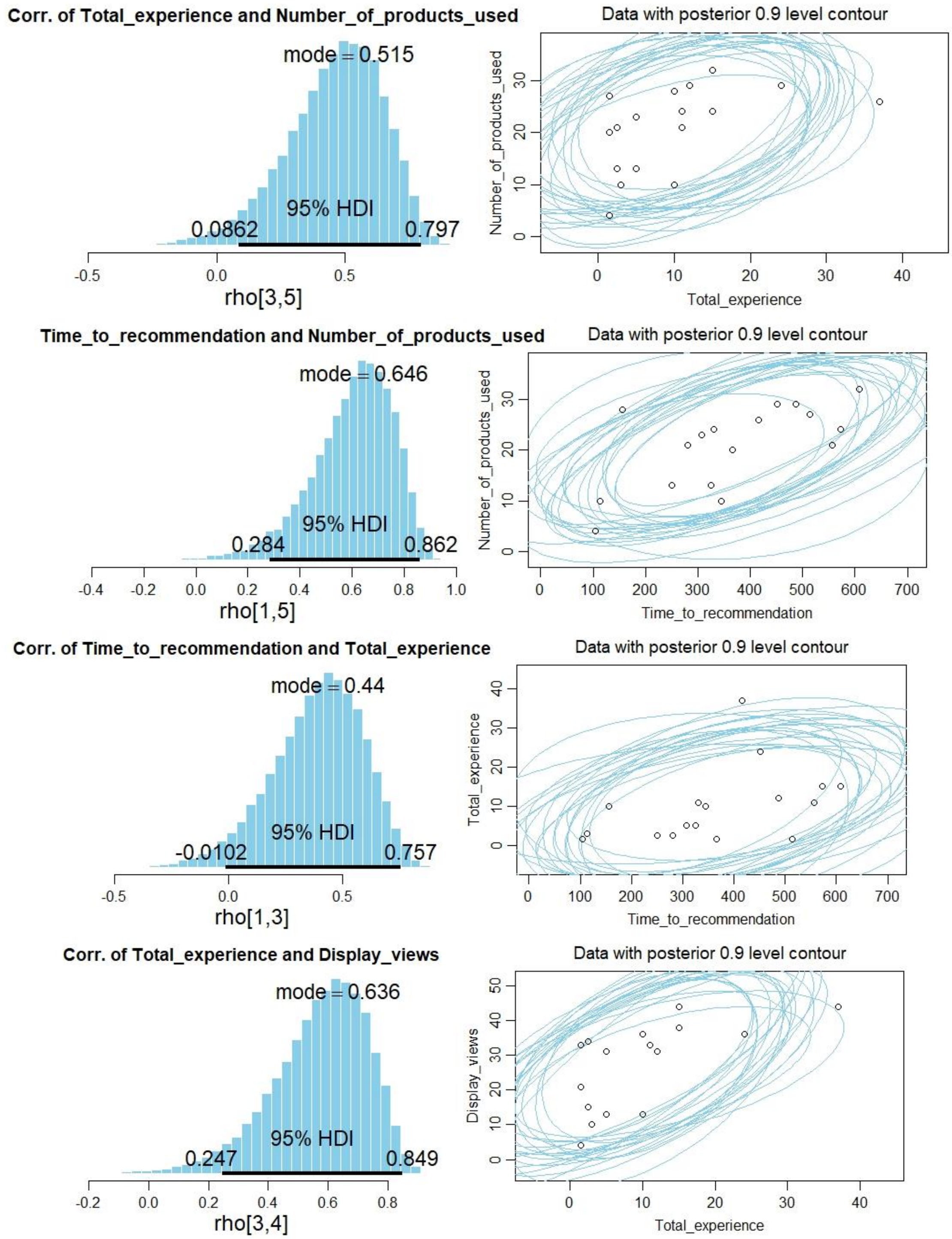


Figure 44. Correlations between Total Experience and the Number of Products Used (top), Time to Recommendation and the Number of Products Used (second from top), Time to Recommendation and Total Experience (second from bottom), and Total Experience and Display Views (bottom).

3.3.2. Recommendation Analysis – Scenario 2

Similar to the analysis for Scenario 1, we used Bayesian regression and correlation analyses with two dichotomous variables (i.e., Recommendation (VFR=0 or VNR=1) and FSS Pilot Experience (Non-pilot=0 or Pilot=1)) and five metric variables (i.e., Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views).

In a first multivariate regression analysis (Kruschke, 2014), we assessed if the metric variables Age and Total Experience could predict the Time to Recommendation. However, the model probability was only 0.03 which means that the variables Age and Total Experience cannot predict the Time to Recommendation for Scenario 2.

In a second analysis we used logistic regression (Kruschke, 2014) to assess whether the metric variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views could predict whether the participant made a VFR or VNR recommendation. However, none of the metric variables could reliably predict whether a participant made a VFR or VNR recommendation.

We also assessed whether the Recommendation differed between FSS Specialists that had a private pilot certificate and FSS Specialists that had no private pilot certificate. Using the dichotomous variable FSS Pilot Experience (Non-pilot=0 or Pilot=1) and five metric variables (i.e., Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views), we assessed whether a logistic regression could predict if participants were a pilot or not.

Figure 45 shows the regression outcome for the metric variable Time to Recommendation. As we can see in the figure, there was a tendency for FSS Pilots (y-axis=1) to make their recommendation quicker compared to FSS participants that were not pilots (y-axis=0).

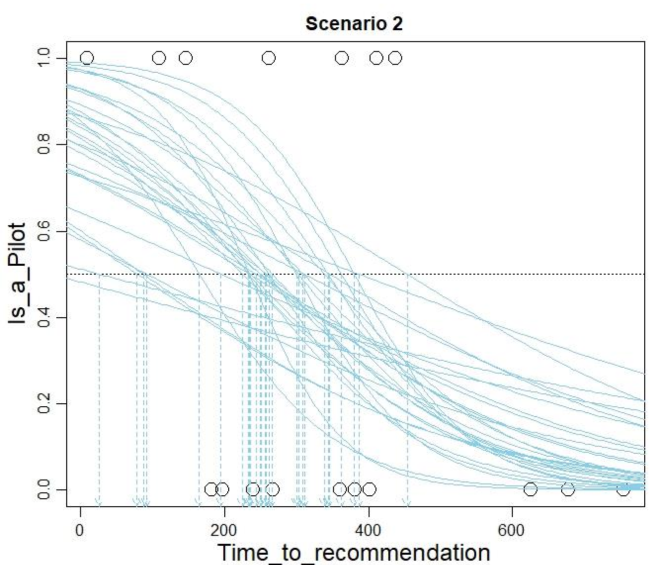


Figure 45. Logistic regression using the Time to Recommendation to predict whether a participant was a private pilot or not (Non-pilot y-axis=0 and Pilot y-axis=1).

Figure 46 shows the regression outcome for the metric variable Display Views. As we can see in the figure, FSS non-pilots (y-axis=0) had more weather display views than FSS pilots (y-axis=1).

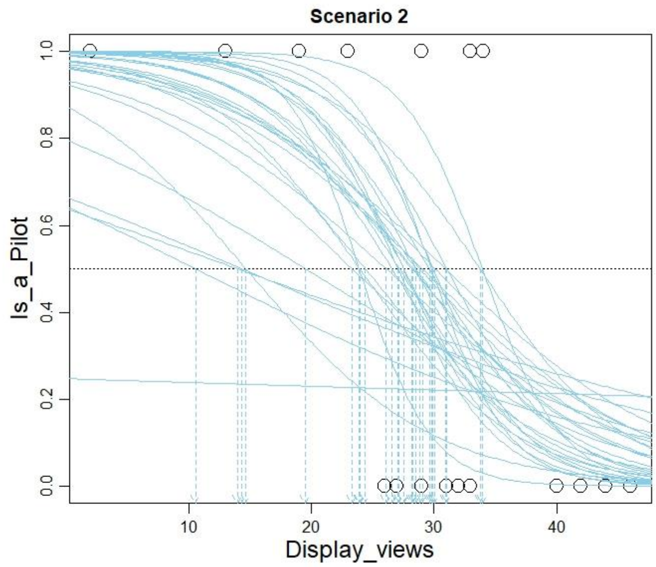


Figure 46. Logistic regression using Display Views to predict whether a participant was a private pilot or not (Non-pilot y-axis=0 and Pilot y-axis=1).

In a third analysis, we computed the correlation between the variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views. The majority of the analysis outcome showed no moderate or strong correlations between any of the five metric variables as the correlations ranged between 0.07 and 0.25. However, there was a moderate correlation (0.40) between the Time to Recommendation and the Number of Products Used and a strong correlation (0.66) between the Time to Recommendation and the number of Display Views. This implies that with an increasing time to recommendation, there was a corresponding increase in the number of weather products used and the number of weather display views.

3.3.3. Recommendation Analysis – Scenario 3

Similar to the analyses for Scenario 1-2, we used Bayesian regression and correlation analyses with two dichotomous variables (i.e., Recommendation (VFR=0 or VNR=1) and FSS Pilot Experience (Non-pilot=0 or Pilot=1)) and five metric variables (i.e., Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views).

The logistic regression models could not predict the Time to Recommendation using the metric variables Age and Total Experience, nor could it predict whether the participant made a VFR or VNR recommendation or predict if participants were a pilot or not using the five metric variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views.

In a last analysis we computed the correlation between the variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views. The majority of the analysis outcome showed no moderate or strong correlations between any of the five metric variables as the correlations ranged between 0.04 and 0.30. However, there were two moderate correlations between the Time to Recommendation and the Number of Products Used (0.47) and a strong correlation between the Time to Recommendation and the number of Display Views (0.58). This implies that with an increasing time to recommendation, there was a corresponding increase in the number of weather products used and the number of weather display views.

3.3.4. Recommendation Analysis – Scenario 4

For the Scenario 4 data, the logistic regression models could not predict the Time to Recommendation using the metric variables Age and Total Experience, nor could it predict whether the participant made a VFR or VNR recommendation. Furthermore, the model could not predict if a participant was a pilot or not using the five metric variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views.

We also computed the correlation between the variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views. The majority of the analyses showed low correlations between the five metric variables as the correlations ranged between 0.18 and 0.30. However, there were two noteworthy correlations between the Time to Recommendation and the Number of Products Used (0.80) and a strong correlation between the Time to Recommendation and the number of Display Views (0.88). This implies that with an increasing time to recommendation, there was a corresponding increase in the number of weather products used and the number of weather display views.

3.3.5. Recommendation Analysis – Scenario 5

For Scenario 5, the logistic regression models could not predict the Time to Recommendation using the metric variables Age and Total Experience. However, the modelling showed that it took participants longer time to make a VNR recommendation compared to a VFR recommendation (Figure 47). Furthermore, the modelling showed that it took FSS Pilots longer time to make a recommendation compared to FSS non-pilots (Figure 48).

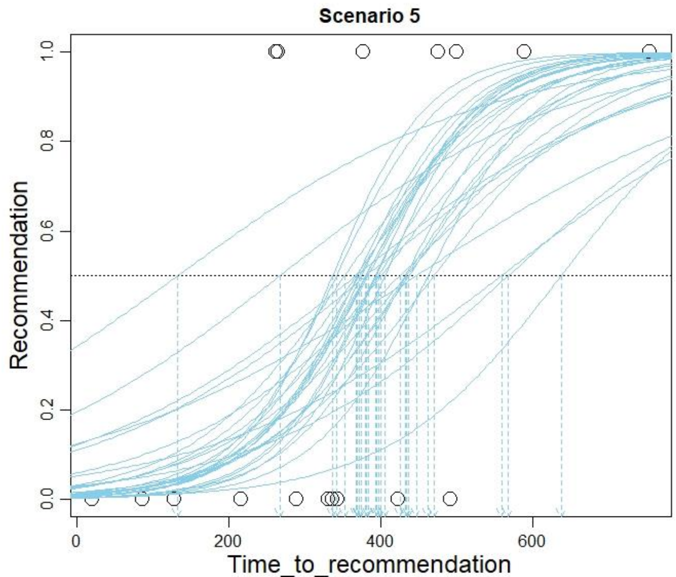


Figure 47. Logistic regression using the Time to Recommendation to predict the Recommendation (VFR=0 and VNR=1).

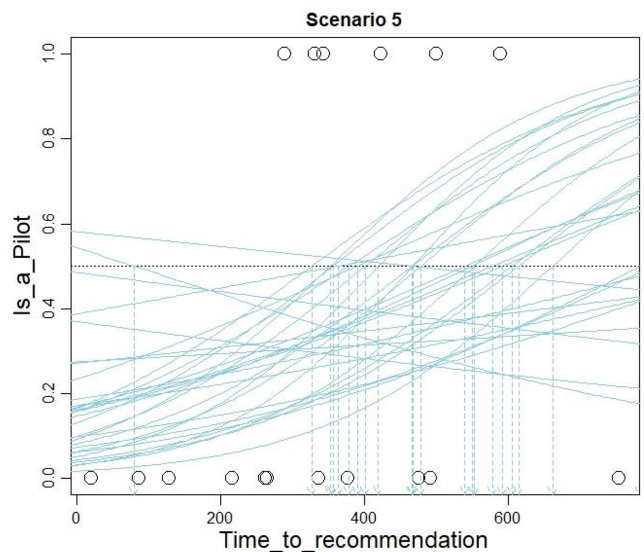


Figure 48. Logistic regression using the Time to Recommendation to predict whether the FSS participant was a pilot or not (non-pilots=0 and pilots=1).

We computed the correlation between the variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views. The majority of the analyses showed low correlations between the five metric variables as the correlations ranged between -0.008 and 0.30. However, there were two noteworthy correlations between Display Views and the Number of Products Used (0.82) and between the Time to Recommendation and the Number of Products used (0.43). This implies that as the number of weather products used increased there was a corresponding increase in the number of weather display views and the time to recommendation.

3.3.6. Recommendation Analysis – Scenario 6

Similar to the analyses for Scenario 1-5, we used Bayesian regression and correlation analyses with two dichotomous variables (i.e., Recommendation (VFR=0 or VNR=1) and FSS Pilot Experience (Non-pilot=0 or Pilot=1)) and five metric variables (i.e., Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views).

The logistic regression models could not predict the Time to Recommendation using the metric variables Age and Total Experience, nor could it predict whether the participant made a VFR or VNR recommendation. Furthermore, the model could not predict if participants were a pilot or not using the five metric variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views.

We also computed the correlation between the variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views. The majority of the analyses showed low correlations between the five metric variables.

However, there were two strong correlations between the Time to Recommendation and Display Views (0.64) and between the Time to Recommendation and the Number of Products Used (0.61). This implies that with an increasing time to recommendation, there was a corresponding increase in the number of weather products used and the number of weather display views.

3.3.7. Recommendation Analysis – Scenario 7

For the regression and correlation analyses we used two dichotomous variables (i.e., Recommendation (VFR=0 or VNR=1) and FSS Pilot Experience (Non-pilot=0 or Pilot=1)) and five metric variables (i.e., Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views).

The logistic regression models could not predict the Time to Recommendation using the metric variables Age and Total Experience, nor could it predict whether the participant made a VFR or VNR recommendation. However, the logistic regression modelling showed that FSS pilots made the recommendation in less time than FSS non-pilots (Figure 49).

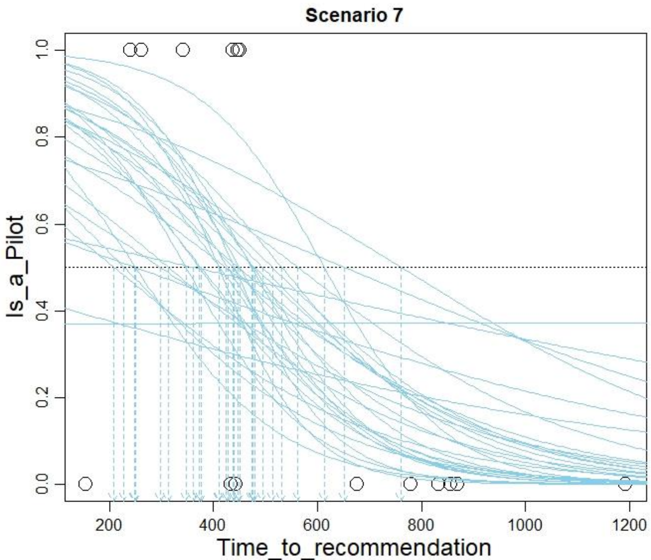


Figure 49. Logistic regression using the Time to Recommendation to predict whether a participant was a private pilot or not (Non-pilot y-axis=0 and Pilot y-axis=1).

We also computed the correlation between the variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views. The majority of the analyses showed low correlations between the five metric variables.

However, there was a strong correlation between the Time to Recommendation and Display Views (0.63) and a moderate correlation between the Time to Recommendation and the Number of Products Used (0.42). This implies that with an increasing time to recommendation, there was a corresponding increase in the number of weather products used and an increase in the number of weather display views.

3.3.8. Recommendation Analysis – Scenario 8

For the regression and correlation analyses we used two dichotomous variables (i.e., Recommendation (VFR=0 or VNR=1) and FSS Pilot Experience (Non-pilot=0 or Pilot=1)) and five metric variables (i.e., Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views).

The logistic regression models could not predict the Time to Recommendation using the metric variables Age and Total Experience, nor could it predict whether the participant made a VFR or VNR recommendation or predict if participants were a pilot or not using the five metric variables Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views.

We also computed correlations between the five metric variables. The majority of the analyses showed low correlations between variables. However, there was a moderate correlation between the Time to Recommendation and Display Views (0.52) and a moderate correlation between the Time to Recommendation and the Number of Products Used (0.49). This implies that with an increasing time to recommendation, there was a corresponding increase in the number of weather products used and an increase in the number of weather display views.

3.3.9. <u>Recommendation and the Number of Weather Products</u>

The Y-axis shows the dichotomous variable ‘Recommendation’ where 0=VFR and 1=VNR. The X-axis shows the metric variable ‘Number of products used’ by the FSS specialists.

Figure 50 is a (fake) Scenario 3 example of what it would look like if we had an effect. In this case, all FSS specialists that used very few weather products all said “VNR” whereas all specialists that used a large number of products said “VFR” (and any other example where the VNR and VFR recommendations are well separated and clumped together at their respective locations). As we can see for the real data (Figure 51) there are no effects.

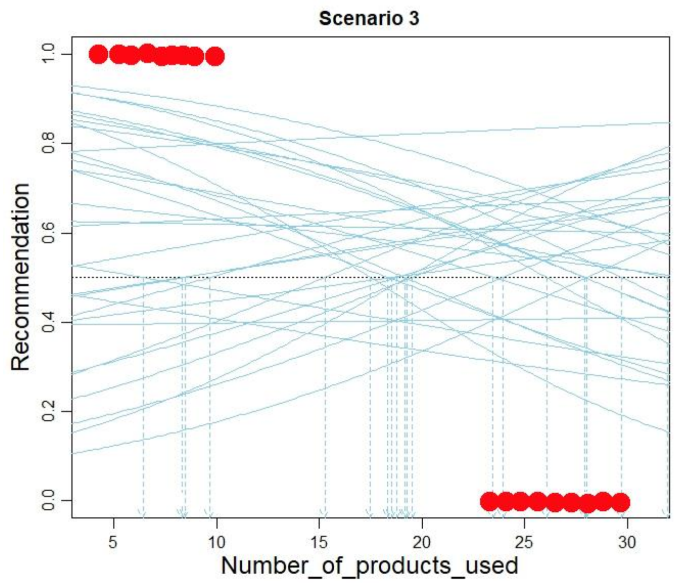
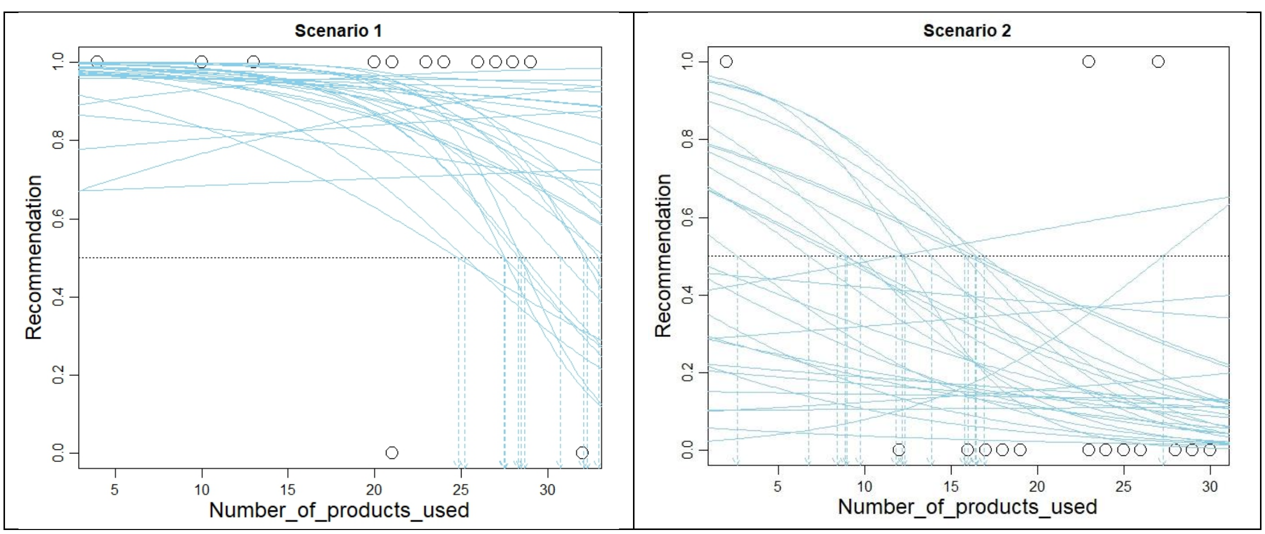


Figure 50. Example of a dummy logistic regression with an effect for Recommendation and Number of Products used.



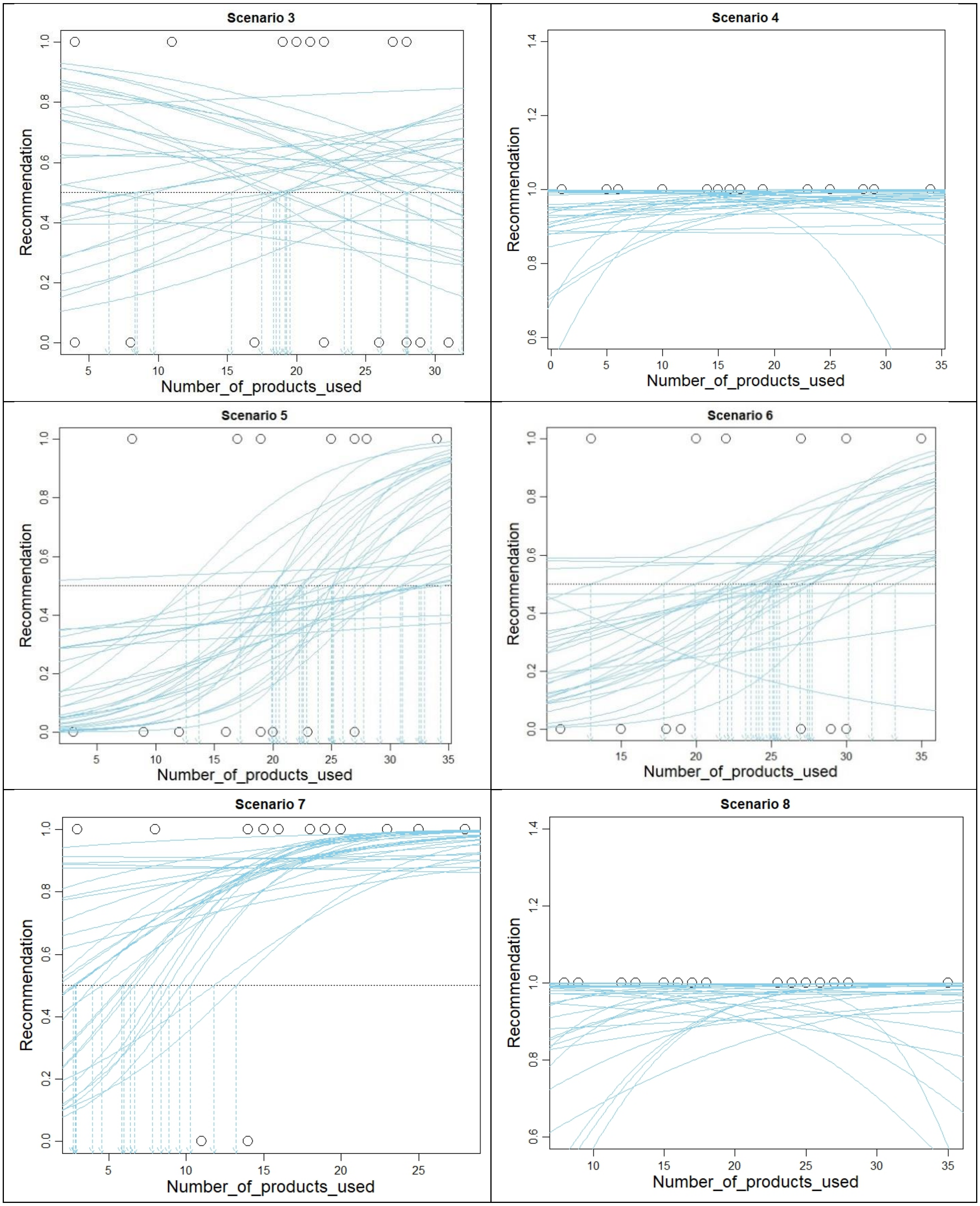


Figure 51. Logistic regression for Scenarios 1-8 using Recommendation and Number of Products showing no effect.

3.4. Post Scenario Questionnaire

At the end of each scenario, participants completed a *Post Scenario Questionnaire* (APPENDIX D). The questionnaire was primarily comprised of weather product impact ratings, but also contained questions on the participant decision-making process. In this section, we present the outcome of the post scenario questionnaire descriptive analysis.

3.4.1. Weather Product Impact Ratings

In order to identify specific standard weather products used to determine flight conditions and the risk of a flight experiencing adverse weather, we asked participants to rate each weather product in terms of how much it impacted their decision to select VFR or a VNR recommendation. The rating scale ranged was: *1-no impact, 2-minor impact, 3-moderate, 4-high impact, and 5-very high impact*. Figure 52 presents the FSS and pilot mean ratings across all eight scenarios. Pilots and FSS participant ratings for the top three weather products were METARs, TAFs, and Weather Cameras (cameras were available for Scenario 7 only), followed by Aviation and En route forecasts. FSS participants rated 14 weather products as "moderate impact" or above; pilot participants rated a total of 13 weather products (11 in common with the FSS participants) as having "moderate impact" or above.

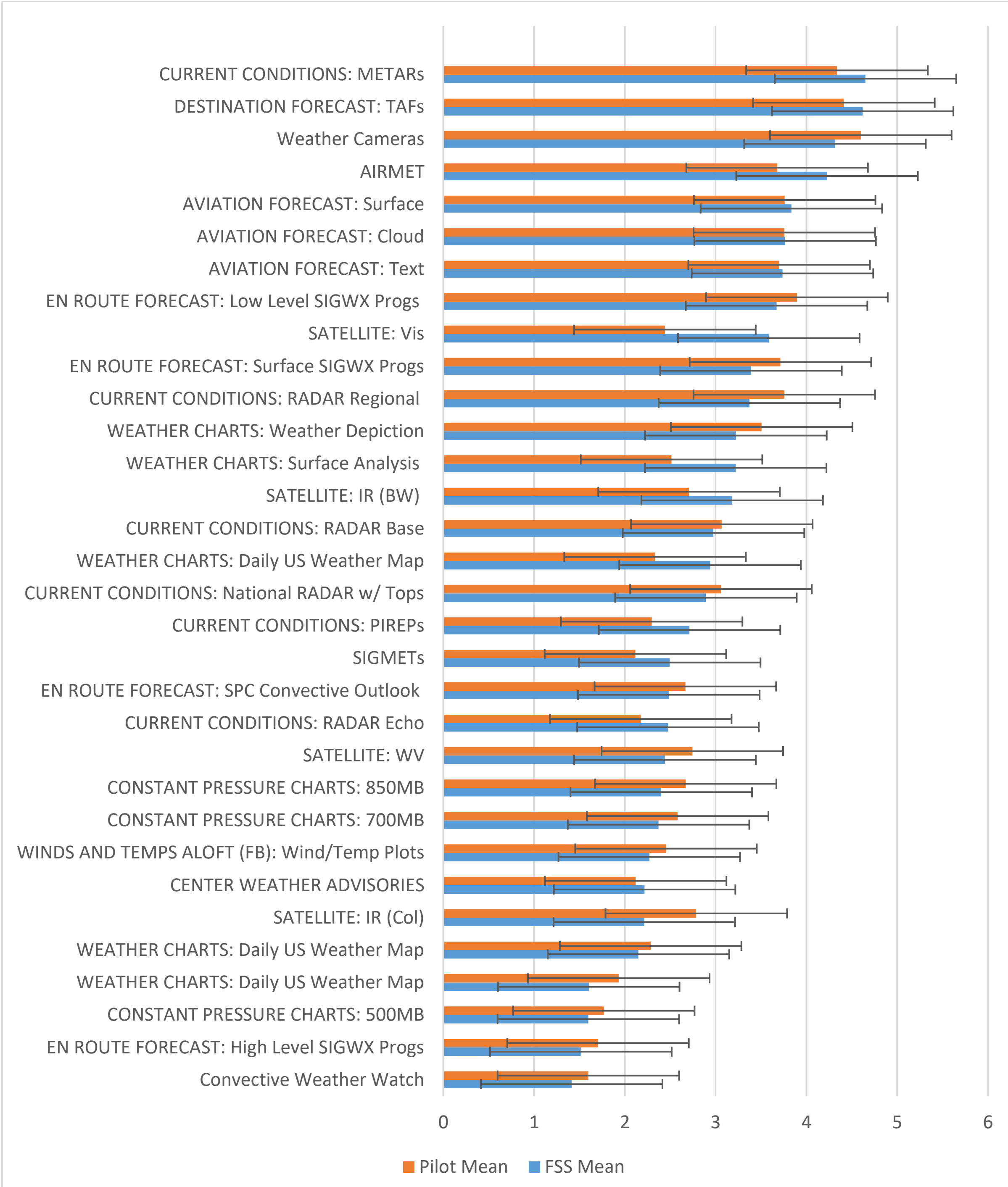


Figure 52. Mean FSS and Pilot Weather Product Impact Ratings (w/ error bars) across Scenarios

We also used Bayesian estimation with Markov chain Monte Carlo (MCMC) sampling to determine the posterior distribution of predicted means and standard deviations (*SD*) as outlined in Kruschke (2014). Table 20 summarizes the credibly different mean ratings (and *SD*) for each product for pilot and FSS participants.

Table 20. Model fit mean impact rating for 15 weather products by Pilot and FSS Specialist

Weather Product	Pilots	FSS Specialists
1. RADAR Regional	**3.46 (SD=1.41)**	2.17 (SD=1.66)
2. Scenario 6 Satellite Col	**3.15 (SD=1.49)**	1.8 (SD=1.45)
3. Scenario 6 National Weather with Tops	**3.02 (SD=1.24)**	1.89 (SD=0.99)
4. Scenario 4 Surface Analysis	2.25 (SD=0.91)	**3.86 (SD=1.32)**
5. Scenario 4 Satellite Vis	2.38 (SD=1.95)	**4.78 (SD=2.47)**
6. Scenario 4 Daily US Weather Maps	2.05 (SD=1.31)	**3.57 (SD=1.51)**
7. Scenario 3 Surface Analysis	2.08 (SD=0.76)	**3.33 (SD=1.78)**
8. Scenario 3 Satellite Vis	1.74 (SD=1.3)	**3.55 (SD=1.58)**
9. Scenario 3 Daily US Weather Map	1.85 (SD=0.84)	**2.84 (SD=1.16)**
10. Scenario 2 Satellite Vis	2.36 (SD=1.63)	**3.83 (SD=1.82)**
11. Scenario 2 Satellite BW	1.98 (SD=2.09)	**3.57 (SD=1.52)**
12. Scenario 6 Satellite Vis	2.34 (SD=1.35)	**3.64 (SD=1.58)**
13. Scenario 5 Satellite Vis	2.46 (SD=1.08)	**4.39 (SD=2.65)**
14. Scenario 6 TAFs	3.61 (SD=1.8)	**5.0 (SD=3.98)**
15. Scenario 6 Surface Analysis	1.81 (SD=0.51)	**3.27 (SD=1.79)**

3.4.2. Go/No Go

After each scenario, we asked pilot participants, "If you selected VFR Not Recommended, how likely would you be to fly VFR in this scenario?" using the rating scale *1-not at all likely, 2-somewhat likely, 3-moderately likely, 4-likely, 5-highly likely*. In most cases, pilots who selected VNR also rated their likelihood of flying VFR as low with a mean rating of 1.20 (*SD* 0.55).

3.4.3. FSS VNR Statement Impact

After each scenario, we asked pilot participants, "If an FSS VNR statement was included in this scenario, how did it impact your evaluation of the weather situation?" *1-no impact, 2-minor impact, 3-moderate, 4-high impact, 5-very high impact.* Ratings indicated that pilots felt that the VNR statement had a moderate impact on their evaluation with a mean 3.64 (*SD* 1.21). Four pilots gave a rating of *1-no impact*; of these, two stated in their comments that they agreed with the FSS VNR Statement. In these two cases, we conclude that the pilots gave a low rating because they came to the same conclusion without FSS input.

The questionnaire asked the pilots that disagreed with the VNR statement to provide details why they disagreed. Only two pilots selected VFR when a VNR statement was provided. Of these two, only one pilot (with an impact rating of 3) provided a response to explain why they disagreed, responding "The TAFs".

Of interest is one pilot's inclusion of the following statement: "We have been given VNR [statements] and drove it rather than fly. The time and destination ended up being clear and beautiful, on more than one account. Likewise, VNRs given and the weather truly was MVFR if not even IFR. It's weather - much like predicting the future. Better to have [availability] to monitor the progress as the flight progresses as well."

3.4.4. VNR Decision Process

We asked, "In deciding on a VNR statement, did you use a systematic (specific, identifiable factors and criteria) or intuitive process (general perception)?" Using a rating scale of *1-used only systematic process, 2-used mostly a systematic process, 3-used equal systematic and intuitive process, 4-used mostly intuitive process, 5-used only intuitive process*", pilots gave a mean rating of 2.53 (*SD* 0.76), and FSS participants gave a mean rating of 2.64 (0.70). For both pilot and FSS participants, these mean ratings fell between the *mostly systematic* and *equal systematic and intuitive process* ratings.

We also asked, "Could your decision-making process for this scenario be documented, such that others could follow it and arrive at the same decision?" Pilot participants responded "Yes" 88% of the time, and the FSS participants responded "Yes" 94% of the time.

3.5. Post Study Questionnaire

Following the completion of all eight scenarios, participants answered a short Post Study Questionnaire. Table 21 presents a summary of rating responses to the question of how the participants felt regarding the use of a computer generated VNR (along with a rationale) statement using the rating scale: *1- not at all, 2- somewhat uncomfortable, 3- neutral, 4- somewhat comfortable, 5- very comfortable*. The mean FSS rating was 2.25, which is in the somewhat uncomfortable range, and the mean pilot participant rating was 3.60 in the neutral range.

Table 21. Comfort level using a computer generated VNR statement (with rationale)

	FSS	*Pilots*
Mean	2.25	3.60
StDev	1.16	0.99
Min	1	2
Max	5	5

We then asked participants to explain why they would be uncomfortable or comfortable with a computer generated VNR statement. The responses are summarized as follows.

FSS participants responses:

- Would be helpful for unfamiliar regions
- Could become comfortable after a time
- Might be redundant with FSS services
- Too many factors/factors vary with each situation
- Small portions of affected route many be circumvented
- Briefer can evaluate pilot experience level
- Degree of MVFR condition subjective
- Time of flight evaluation
- Trust in automation issues
- Inability to automate potential alternatives to pilots
- Area knowledge
- Liability concern with automation recommendation
- Potential lack of rationale transparency

- Variablity in VNR “threshold triggers”
- Reduced human input

Pilot participant responses:

- Comfortable because the automation would have all the current info
- Good info in addition to actual FSS briefer
- Could indicate areas to further evaluate
- Automation could process more info/Humans better at nuance
- Would like VNR statement to include potential alternatives
- Trust in automation issue
- Would be a potential tool
- Would prefer FSS briefer
- Technology could work/Usually self brief
- Comfortable with own training/Foreflight briefings

Of the three FSS participants who entered a rating of 4 or 5, two stated that they would like to use an automated VNR statement as a tool. This indicates that although they see potential use for automating the VNR statement within the FSS environment, they prefer it as an augmentation to their current services. The majority of FSS participants expressed a variety of concerns with the potential for automating a VNR statement, citing that many factors require nuanced and agile reasoning.

The pilot participants were more positive in their comfortability ratings, with 13 of the pilots selecting a rating of 4 or 5. Of these 13 participants, seven stated that they would like the automation as an ‘extra check’ or in addition to talking to a briefer. Others indicated they would use the VNR statement as an added cue to look more closely at specified information. A few participants did feel that the automation would be able to process vast amounts of information (better than a human), while acknowledging that the human might be better at interpreting nuanced information.

4. CONCLUSION

To prepare for a flight and to avoid encounters with hazardous weather, GA pilots can get a general overview of weather conditions by reviewing weather information either via various internet or automated services or by contacting a FSS briefer. The FSS briefer, based on their evaluation of the weather products, will provide a VNR recommendation if they deem conditions are not favorable for a VFR flight. However, the VNR determination process as it exists today needs improvement to address criticisms (e.g., those raised in the AOPA 2017 survey) that it may be unnecessary, over used, used for liability reasons, or too subjective (pilots and FSS use different criteria). In addition, given that many GA pilots today use online services to procure their weather information, there is a need to develop an effective means to present an automated VNR component to those services.

In the present study, we presented two groups (FSS specialists and GA pilots) with eight scenarios with various weather conditions in various regions of the country. We provided them with a suite of weather products to evaluate conditions for each proposed flight, and asked them to select either ‘VFR’ or ‘VNR’ depending on whether or not the flight conditions were appropriate for a VFR flight or not, along with an explanation for their selection. We then asked them to rate each weather product in terms of how much impact that product had on their decision.

To identify the specific standard weather products and weather information used by FSS specialists to determine flight conditions and the risk of a flight experiencing adverse weather, we recorded the number and duration of each product viewed, and we asked participants to rate the impact of the weather products on their decision making process. We identified common products, namely METARs, TAFs, and Weather Cameras (when available), Aviation and En Route forecasts, that participants rated as having a "moderate impact" or above.

We also examined the correlation between the VFR/VNR recommendation and five metric variables (i.e., Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views). Based on the correlation analysis, we cannot conclusively identify the specific standard weather products used to make a VNR or VFR determination or any differences between participant groups in making that determination.

To assess the impact of the inclusion of an FSS briefing including the VNR/VFR determination on pilots' perspective of weather conditions, we included an FSS VNR statement to a select number of scenarios. We asked pilots to rate the impact of the FSS VNR statement, if one was included, on their own decision making process. We found that while pilots rated that the FSS VNR statement as having a moderate impact on their evaluation of the weather situation, there were only two instances where the pilot indicated disagreement with the VNR statement.

In our assessment of the impact of an individual's age and experience level on weather condition determination, we find that "Experience (in years as an FSS)" is not highly correlated with the "Recommendation (VFR or VNR)". That is, more experienced FSS participants were neither more nor less likely to select VNR for any of the scenarios. Furthermore, there is no consistent use of the weather products among the FSS for both the number of products used and how they viewed them.

One of the criticisms revealed in the AOPA's 2017 survey, is that the FSS VNR recommendation is given to cover liability. In this study, however, we find that the FSS were less likely to make a VNR selection than the pilot group. This may have more to do with the pilot group's reluctance to fly in marginal weather than the FSS participants erring on the side of caution. From the results of this study, despite explicit instructions to assess weather conditions, we see that FSS often times sought ways for the pilot to proceed with the flight (using alternative altitudes and course deviation) when areas of MVFR were present. As one FSS participant stated "…as a briefer I can discuss my findings with the pilot and offer alternatives". The FSS participants' attempts to assist pilots in this manner in this study demonstrates how they commonly include this as a part of the service they provide to pilots.

One of our goals was to determine objective criteria used by each test group to determine VNR conditions, and then to use these objective criteria as inputs to develop an automated VNR statement and to make the current VNR statement more effective in enhancing safety. However, we find that claims that the VNR statement may be too subjective are substantiated in the results of this study. Specifically, we see that given the same set of information, individuals vary widely for both FSS and pilots on not only whether they would recommend VNR or not, but also in the reasons why they would justify their recommendation. Of particular interest, Scenario 5 was the most split of all of the scenarios, with 11 FSS and 6 pilots selecting VFR, and 9 FSS and 14 pilots selecting VNR. This scenario had a number of factors that highlight issues that lead to subjectivity providing a VNR rating including mountain obscuration, MVFR conditions along a portion of the route, and the potential for deviating around problematic weather areas. It also underscores the variable of the risk/comfort level of the pilots.

Another goal was that, if VNR assessments between test groups (i.e., pilots and FSS specialists) were not consistent (and we find that they are not), to identify methods to make them more consistent. Based on the inconsistency in recommendations found in our study, in particular, for scenarios that had highly subjective conditions, we find that there is a need for a procedure standardization.

Another concern among pilots is that the FSS briefers use different criteria than they would as pilots. To address this, we examined whether or not actual pilot experience would be a factor for the FSS recommendations. An analysis of five metric variables (i.e., Age, Total Experience, Time to Recommendation, Number of Weather Products Used, and the Number of Weather Display Views) found that we could not predict whether the FSS participant was a pilot or not, meaning that pilots and non-pilots were not notably different on all five variables.

The overall goal of this study was to make the VNR statement more useful to GA pilots. VNR does have an impact and serves as an important intervention for unintentional VFR flight into IMC. While we fell short of achieving the overall goal, we feel that we have made progress in understanding why the VNR process is not effective and identifying the next steps/roadmap to solve this issue. If we can define and train FSS specialists (and pilots) to adopt a consistent procedural method for evaluating the weather products, we could apply that same methodology to an automated procedure.

5. <u>RECOMMENDATION</u>

From the outcome of this study, we recommend:

1. Further research to help define a standardized procedural method and training for evaluating weather products to achieve a more consistent determination of flight visibility and to develop an automated version of the VNR service. We suggest first using a focus group/cognitive walkthrough method to help define these procedures.

2. Develop a more standardized response format for the VNR justification statements to reduce variation and identify specific risks. This would improve pilot understanding of the VNR service and ensure a consistent level of information.

3. Develop clear criteria for the obvious cases of VFR and VNR conditions. For automation purposes, develop and define thresholds between obvious VFR and obvious VNR conditions, which may result in a “call an FSS briefer” status to automation users when the thresholds make a definitive determination difficult. The rationale for this ‘status’ would be to catch weather situations that require human interpretation, while allowing the potential for more timely automation of the VFR and obvious VNR conditions.

4. Conduct research on pilot risk assessment of adverse weather and the impact on pilot decision-making. Subjective comments suggest that pilot evaluation of weather conditions is influenced by individual comfort level with the risk of flying into adverse weather. Understanding risk would be beneficial for the development of recommendation 5.

5. Create a process so pilots can identify their ability, such as VFR only, to FSS or to a computer, so a tailored/customized discussion and statement could be provided to that pilot.

6. Address the nomenclature for VNR to more accurately reflect the informative nature (as opposed to using the term ‘recommended’) of the service. Modification of the VNR terminology may help to clarify the FSS role and reduce subjectivity.

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APPENDIX A: Research Team

Name	Role	Responsibility
Ahlstrom, Ulf	Test Lead	Lead developer of test plan, test conductor, data analysis.
Ahlstrom, Ulf	Data Analysis	Analyze data for Quick Look and Final Report.
Doucett, Scott	Cockpit Simulator Laboratory Manager	Identify and provide resources for study development and data collection.
Hallman, Kevin	Human Factors Specialist	Co-developer of test plan, test conductor, data analysis.
Johnson, Ian	WTIC Human Factors Lead	Coordinate on test plan and test effort, technical review of test products and deliverables.
Kukorlo, Matt	ATC and Pilot Subject Matter Expert	Flight Scenario Developer. Simulation SME.
Pokodner, Gary	WTIC Program Manager	Track project, conduct interim reviews, final acceptance of Deliverables.
Racine, Nicole	Human Factors Specialist	Co-developer of test plan, test conductor, data analysis.
Vary, Kimberly	Software Engineer	Developer of Aviation Weather Center test platform. Implements workstation system, routes, weather conditions, and data recordings.

APPENDIX B: Informed Consent Statement

Consent Form

I, ______________________________, understand that this study, entitled "weather information and weather-related decision making", is sponsored by the Federal Aviation Administration (FAA) and directed by Andrew Cheng.

Nature and Purpose:

I volunteered as a participant in this study where my task is to determine flight conditions (VFR not recommended (VNR), or VFR) using standard weather products and flight plans. I will make these assessments while operating a computer workstation. The overall study purpose is to make VNR statement more useful to GA pilots and to make VNR statements compatible with digital presentations (i.e., web services).

Research Procedures:

A total of forty participants (GA pilots and FSS Specialists) will participate as volunteers during a half-day (4 hours) session. The participants will be engaged from 8:00 AM to 12:00 PM (or from 12:00 PM to 16:00 PM) with short breaks.

The first part of the session will encompass a briefing to review project objectives and participant rights and responsibilities. This briefing will also include familiarization training on the experimental software and response menus. After this briefing participants will complete a brief biographical background questionnaire.

The participant will evaluate different flight plans and weather data to determine whether a given flight route is under VFR or not (approximate duration: 30-50 minutes). During this evaluation, an automated data-collection system will record responses from the participant. When the task is completed, each participants will fill out a post-task questionnaire.

Anonymity and Confidentiality:

The information that I provide as a participant is strictly confidential and I shall remain anonymous. I understand that no Personally Identifiable Information [PII] will be disclosed or released, except as may be required by statute. I understand that situations when PII may be disclosed are discussed in detail in FAA Order 1280.1B "Protecting Personally Identifiable Information [PII]." A copy of the FAA Order 1280.1B will be available during the Consent briefing.

Benefits:

Participants may benefit from participation in this research in the form of improved weather assessment skills (from the weather and flight assessments performed during the task). The information obtained from the study may suggest ways to make VNR statements more useful to GA pilots.

Participant Responsibilities:

I am aware that to participate in this study I must be a GA pilot or a FSS Specialist.

I will (a) perform the evaluation task and (b) answer questions asked during the study to the best of my abilities. I will not discuss the content of the study with other potential participants until the study is completed.

Participant Assurances:

I understand that my participation in this study is voluntary and I can withdraw at any time without penalty. I also understand that the researchers in this study may terminate my participation if they believe this to be in my best interest. I understand that if new findings develop during the course of this research that may relate to my decision to continue participation, I will be informed. I have not given up any of my legal rights or released any individual or institution from liability for negligence.

The research team has adequately answered all the questions I have asked about this study, my participation, and the procedures involved. I understand that Andrew Cheng or another member of the research team will be available to answer any questions concerning procedures throughout this study. If I have questions about this study or need to report any adverse effects from the research procedures, I will contact Andrew Cheng at (609) 485-4904.

Discomfort and Risks:

Risks encountered in this study will be minimal - similar to regular office computer work. Nevertheless, I agree to immediately report any injury or suspected adverse effect to Andrew Cheng at (609) 485-4904.

Signature Lines:

I have read this informed consent form. I understand its contents, and I freely consent to participate in this study under the conditions described. I understand that, I may request a copy of this form.

Research Participant:____ Date:__________

Investigator:____ Date:__________

Witness:____ Date:__________

<u>APPENDIX C: Biographical Questionnaires</u>

Pilot Biographical Questionnaire

This questionnaire is designed to obtain information about your background and experience as a pilot and flight instructor. Researchers will only use this information to describe the participants in this study as a group. Your identity will remain anonymous.

Demographic Information and Experience

1. What pilot certificate and ratings do you hold? (circle as all that apply)	Private Commercial ATP Glider SEL SEA MEL Airship Instrument CFI CFII MEI Helicopter A&P IA

2. What is your age? _____ Years

3. . Approximately, what is your total time? _____ Hours

4. . Approximately, how many total hours have you logged in the last 12 months? _____ Hours

5. Approximately how many actual instrument hours do you have? _____ Hours

6. Approximately how many instrument hours have you logged in the last 6 month (simulated and actual)? _____ Hours

7. List all (if any) in-flight weather presentation systems you have used during a flight to make actual weather judgments (not including onboard radar or Stormscope).

____

____

8. Have you had any additional training in weather interpretation since receiving your pilot certification (for example, courses in meteorology)? If so, to what extent?

____

____

9. How often *do you provide/did you provide* pilot reports (PIREPs) during actual GA flights?

____

____

<u>Thank you very much for participating in our study, we appreciate your help.</u>

FSS Biographical Questionnaire

This questionnaire is designed to obtain information about your background and experience as a Flight Service Specialist. Researchers will only use this information to describe the participants in this study as a group. Your identity will remain anonymous.

Demographic Information and Experience

1. What is your age? _____ Years

2. What is your total experience as a Flight Service Specialist? _____ Years

3. What regions have you served as a Flight Service Specialist? ____________________

4. What is your total experience as an Air Traffic Control Specialist

Tower	_____	Years
TRACON	_____	Years
En Route	_____	Years
FSS	_____	Years

5. How many of your years of flight service experience has been worked as a:

   Federal employee? ___________________ Contract employee?_______________________

6. List all current certifications.

____

____

7. Have you had any training in weather interpretation (for example, courses in meteorology)? If so, to what extent?

____

____

Thank you very much for participating in our study, we appreciate your help.

APPENDIX D: Post-Scenario Questionnaires

Post Scenario Questionnaires

Based on the information available, how would you classify the weather conditions for this scenario?

☐ VFR ☐ VFR NOT RECOMMENDED

Weather products: please place a check mark for each product you used to determine the VFR/VNR recommendation. Then, rate each product in terms of how much each product impacted your decision. (1-no impact, 2-minor impact, 3-moderate, 4 high impact, 5-very high impact)

	How much impact did this product have?					
CONVECTIVE						
Convective SIGMETs (WST)	1	2	3	4	5	n/a
Convective Watches (WW)	1	2	3	4	5	n/a
SIGNIFICANT METEORIOLOGICAL INFORMATION (SIGMETs)						
Domestic SIGMETS (WS)	1	2	3	4	5	n/a
CENTER WEATHER ADVISORIES						
Center Weather	1	2	3	4	5	n/a
AIRMET						
Graphical AIRMETs	1	2	3	4	5	n/a
WEATHER CHARTS						
Surface Analysis	1	2	3	4	5	n/a
Weather Depiction	1	2	3	4	5	n/a
RADAR Summary	1	2	3	4	5	n/a
Daily US Weather Map	1	2	3	4	5	n/a

	How much impact did this product have?					
CONSTANT PRESSURE CHARTS						
850MB (~5,000')	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
700MB (~10,000')	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
500MB (~FL 180)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
300MB (~FL 300)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
200MB (~FL 390)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
CURRENT CONDITIONS						
METARs	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
PIREPs	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
National RADAR w/ Tops	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
SATELLITE						
Vis	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
IR (BW)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
IR (Col)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
WV	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
En Route Forecast						
Low Level SIGWX Progs	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
High Level SIGWX Progs	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a

	How much impact did this product have?					
Surface SIGWX Progs	1	2	3	4	5	n/a
SPC Convective Outlook	1	2	3	4	5	n/a
AVIATION FORECAST						
Surface	1	2	3	4	5	n/a
Cloud	1	2	3	4	5	n/a
Destination Forecast						
TAFs	1	2	3	4	5	n/a
Winds and Temps Aloft (FB)						
Wind/Temp Plots	1	2	3	4	5	n/a

How familiar are you with the region for this particular route of flight in this scenario?

Not at all Familiar	Somewhat Familiar	Very Familiar
1	3	5

If you selected **VFR NOT RECOMMENDED**, please provide a statement describing why you are not recommending VFR flight. Please be as specific and detailed as possible.

If you selected **VFR NOT RECOMMENDED**, how likely would you be to fly VFR in this scenario?

Not at all Likely	Somewhat Likely	Moderately Likely	Likely	Highly Likely
1	2	3	4	5

If you selected **VFR** please provide a rationale for your decision. If weather was present along your route, please describe why you felt this would not impact the flight enough to warrant a VNR recommendation.

If an FSS VNR statement was included in this scenario, how did it impact your evaluation of the weather situation?

No Impact	Minor Impact	Moderate Impact	High Impact	Very High Impact
○ 1	○ 2	○ 3	○ 4	○ 5

If you disagreed with the VNR statement included in this scenario, please detail why in the space provided. Please be as specific as possible.

In deciding on a VNR statement, did you use a systematic (specific, identifiable factors and criteria) or intuitive process (general perception)?

Used only systematic process	Used mostly systematic process	Used equal systematic and intuitive process	Used mostly intuitive process	Used only intuitive process
○ 1	○ 2	○ 3	○ 4	○ 5

Could your decision-making process for this scenario be documented, such that others could follow it and arrive at the same decision?

○ Yes	○ No

Post-Scenario Questions – FSS

Based on the information available, how would you classify the weather conditions for this scenario?

☐ VFR ☐ VFR NOT RECOMMENDED

Weather products please place a check mark for each product you used to determine the VFR/VNR selection. Then, rate each product in terms of how much each product impacted your decision.
(1-no impact, 2-Minor impact, 3-moderate, 4 high impact, 5-Very high impact)

	How much impact did this product have?					
CONVECTIVE						
Convective SIGMETs (WST)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
Convective Watches (WW)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
SIGNIFICANT METEORIOLOGICAL INFORMATION (SIGMETs)						
Domestic SIGMETS (WS)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
CENTER WEATHER ADVISORIES						
Center Weather	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
AIRMET						
Graphical AIRMETs	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
WEATHER CHARTS						
Surface Analysis	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
Weather Depiction	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
RADAR Summary	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
Daily US Weather Map	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a

	How much impact did this product have?					
CONSTANT PRESSURE CHARTS						
850MB (~5,000’)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
700MB (~10,000’)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
500MB (~FL 180)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
300MB (~FL 300)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
200MB (~FL 390)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
CURRENT CONDITIONS						
METARs	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
PIREPs	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
National RADAR w/ Tops	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
SATELLITE						
Vis	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
IR (BW)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
IR (Col)	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
WV	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
En Route Forecast						
Low Level SIGWX Progs	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
High Level SIGWX Progs	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a

	How much impact did this product have?					
Surface SIGWX Progs	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
SPC Convective Outlook	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
AVIATION FORECAST						
Surface	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
Cloud	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
Destination Forecast						
TAFs	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a
Winds and Temps Aloft (FB)						
Wind/Temp Plots	○ 1	○ 2	○ 3	○ 4	○ 5	○ n/a

If you selected **VFR** please provide a rationale for your decision. If weather was present along your route, please describe why you felt this would not impact the flight enough to warrant a VNR recommendation.

If you selected **VFR NOT RECOMMENDED**, please provide a statement describing why you are not recommending VFR flight. Please be as specific and detailed as possible.

How much did you base your VNR decision on current condition information versus forecast information?

Used only current information	Used mostly current info	Used equal current and forecast info	Used mostly forecast info	Used only forecast info
○ 1	○ 2	○ 3	○ 4	○ 5

In deciding on a VNR statement, did you use a systematic (specific, identifiable factors and criteria) or intuitive process (general perception)?

Used only systematic process	Used mostly systematic process	Used equal systematic and intuitive process	Used mostly intuitive process	Used only intuitive process
○ 1	○ 2	○ 3	○ 4	○ 5

Could your decision-making process for this scenario be documented, such that others could follow it and arrive at the same decision?

○ Yes	○ No

APPENDIX E: Post Study Questionnaires

Pilot Post Study Questionnaire

If you were using 1800wxbrief.com, DUATS, ForeFlight, or similar and it provided a computer-generated VNR statement (along with rationale), how comfortable would you feel using that statement in place of a specialist statement?

Not at all Comfortable	Somewhat Uncomfortable	Neutral	Somewhat Comfortable	Very Comfortable
◌ 1	◌ 2	◌ 3	◌ 4	◌ 5

Please explain why you would be uncomfortable or comfortable with a computer generated VNR statement.

FSS Post Study Questions

If a new support tool on FS21 or similar provided computer-generated VNR recommendations (along with rationale), how comfortable would you feel using it to decide whether or not to issue a VNR statement?

Not at all comfortable	Somewhat uncomfortable	Moderately comfortable	Moderately comfortable	Very Comfortable
○ 1	○ 2	○ 3	○ 4	○ 5

Please explain why you would be uncomfortable or comfortable with a computer generated VNR statement.