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The Use of Weather Information in Aeronautical Decision-Making

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16. Abstract

An investigation was conducted of the values or worth functions pilots attribute to weather and terrain variables in making decision about flight in a single-engine aircraft under visual flight rules. The research employed a scenario-based judgment task designed to elicit pilot worth functions for visibility, ceiling, precipitation, and terrain features (specifically, flight over flat terrain, mountainous terrain, and over water).

Subjects were asked to consider a proposed cross-country flight of approximately one hour duration over each of the three terrain conditions. They were then given a deck of cards describing various combinations of ceiling, visibility, and precipitation and asked to first rank order the cards in descending order of comfort with flying under the described conditions over the specified terrain and then to assign a numerical rating to each card using a scale of 0 (least comfortable) to 100 (most comfortable). For each subject a linear model was constructed using the comfort ratings as the dependent variable and the visibility, ceiling, and terrain values as the independent variables. A separate linear model was constructed for each subject for each of the three terrain conditions. The regression weights associated with each terrain type were then subjected to hierarchical clustering to identify groups of weight sets differing significantly with respect to worth function emphasis.

Examination of the clusters indicated that pilots could be reliably grouped into four groups for the flat and mountainous terrain scenarios and two groups for the over-water scenario. These clusters are characterized primarily by the average degree of comfort which the subjects expressed in flying under the conditions described, by the nature of their efficiency of utilization of information (multiplicative models compared to simpler single variable models), and demographic characteristics such as age and aircraft ownership.

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Owen Russel
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Mr. Russel not only was responsible for locating and arranging for collection of data from the civilian pilots, but he participated as a proctor during group administration. His assistance made possible the generation of the research report.

Others contributed significantly to the development of data collection instruments and to data collection. We also express our sincere appreciation to the following persons and organizations with which they are affiliated:

Marvin G. Ledyard
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Finally, we are appreciative of the time and interest of the 152 anonymous pilots who provided the raw data employed in the analysis.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The body of this report details how 152 general aviation pilots were assessed to determine the weights (worth functions) they assigned to the variables of terrain, ceiling, visibility and precipitation. The obtained, analysis results were sufficiently clear to allow the identification (at least tentatively) of distinctly different worth functions. Specifically, four different worth functions were identified and characterized for non-mountainous and mountainous terrain types. Two different worth functions were identified and characterized for over-water terrain. Use of weather information was consistent with expert assessment of the safety risk associated with VFR flight under varying ceiling, visibility, and precipitation conditions over non-mountainous, mountainous, and water terrain. However, while use is consistent, pilots vary in their expressed degree of comfort in flying over the different terrain under different weather conditions. These differences in comfort level may occur, in part at least, because of:

- Differences of understanding of the risks associated with flying under differing above-minimum levels of visibility, ceiling, and precipitation and how terrain type impacts use of such information.

- Differences in their self-assessment and perception of their ability and/or skill in flying under the varying conditions.

In summary, this study found:

- It is possible to capture reliably pilots' "comfort" policies in terms of emphasis upon terrain, ceiling, visibility, and precipitation using a linear modeling approach.

- Pilots use compensatory judgment rules with sophisticated interactions.

- Pilots generally agree on how to prioritize the safety implications of terrain/weather conditions.

- Pilots' policies tend to fall cleanly into stable policy groups although the individual pilots who hold those views switch groups according to terrain.

- Pilots' policies vary based upon:
  1. General comfort level
  2. A mixture of age and general experience
  3. Number of hours flown in last 90 days
  4. Reasons for flying (employed as pilot versus pleasure flying)

IMPLICATIONS

- Pilots' use of weather information is consistent with expert assessment of the safety risk associated with VFR flight under varying ceiling, visibility, and precipitation conditions over non-mountainous, mountainous, and water terrain.

- While use is consistent, pilots vary in their expressed degree of comfort in flying over the different terrain under different weather conditions.

- Training or other interventions addressing risk assessment and self-perception would appear to be appropriate. Present use of the Five Hazardous Thought Patterns is one method of addressing self perception. Training directed at improving pilot understanding of the effects of terrain-type on interaction of meteorological conditions is another potential source. Increased emphasis on risk assessment and self perception training and exercises in initial training and in subsequent seminars (FAA-sponsored and otherwise) would seem to be warranted.

- Although the compensatory decison model is used by expert and by many other pilots as well, its use in all situations may not be advisable. Some care and consideration must be observed in training inexperienced pilots to use the decison models of expert pilots, as their injudicious use may be a threat to aviation safety.

THE USE OF WEATHER INFORMATION IN AERONAUTICAL DECISION-MAKING

INTRODUCTION

A National Transportation Safety Board report (NTSB, 1989) reviewed 361 general aviation accidents that occurred between 1983 and 1987 in which Visual Flight Rules (VFR) into instrument meteorological conditions (IMC) was listed as a probable cause or a related factor. (Most accidents have multiple causes/factors assigned as probable.)

Ninety-seven percent of the probable causes were attributed to the flight crew, and 42% of these cited the manner in which weather information was obtained (or not obtained), assimilated, and used. There were 276 fatal accidents, resulting in 583 fatalities.

An earlier review of aircraft accident data (Jensen, 1982) reported similar data and concluded that 80 to 85% of aircraft accidents can be assigned broadly to pilot error. The review also indicated that 51.6% of the fatal and 35.1% of the non-fatal accidents resulted from faulty decision-making. Because of the prominence of pilot error and flight from VFR into IMC as causes of general aviation accidents, the Federal Aviation Administration (FAA) sponsors training interventions on pilot decision-making which address both factors. The interventions focus on both cognitive and affective (or motivational) components of pilot decision-making (Brecke, 1981; Jensen, 1982; Jensen, Adrion, & Lawton, 1987). These two components differentiate among processes pilots employ in using and evaluating information available to them and making choices about actions to take. The cognitive component deals with the processes by which pilots establish and evaluate the alternatives in a decision-making situation. Jensen (1982) proposed that this component relates to pilot ability to search for and establish the relevance of all available information regarding a situation, to specify alternative courses of actions, and to determine expected outcomes from each alternative. This component invokes the intellectual, discriminative abilities which depend upon human capabilities to sense, store, retrieve, and integrate information.

From a cognitive perspective, according to Jensen (1982), pilots should *discriminate* among situational dimensions. He asserts that for discriminative judgment, these important questions must be addressed: 1) Do pilots consider all situational dimensions and do they assign proper weights to the data elements for each of these dimensions? 2) Do pilots efficiently integrate the relevant information from the data elements?

Cognitive training provides information designed to increase pilot awareness of flight safety under adverse conditions and to assist pilots in assigning and integrating proper weights to the data elements. Training consists of exercises demonstrating the risks associated with flying activities and the underlying behavioral causes of typical accidents. The effects of stress on decision-making and the management of stress are also important training elements. Informational materials include data about such factors as causes of accidents by phase of operation and pilot experience, the aeronautical decision-making processes, and weather forecast accuracy and use. Information about weights pilot attribute to flight data elements, however, is not available for use in training or other interventions.

According to Jensen et al. (1987), use of aeronautical decision-making interventions for instrument pilots produces substantial reductions in pilot error rates. Reduction in decisional mistakes attributed to the training ranges from 10 to 50%. Similar training exists for student, private, commercial, and multi-crew aircraft pilots.

A very limited amount of research on the cognitive processes of pilot decision-making has been reported. This research, however, has two important findings. First, the feasibility of investigating the intellectual processes in decision-making through assessment of pilot worth or values pilots attribute to flight data elements has been demonstrated. Second, pilots appear to weight flight data elements differentially, because of such factors as experience and training. Flathers, Giffin, & Rockwell (1982) presented pilots with a diversion-decision scenario requiring an in-flight decision to change destinations during a cross-country flight, because of equipment malfunction. Subjects were presented alternative landing sites varying according to weather conditions, air traffic control facilities, approach, and flight time to reach the sites. Two levels of each variable were represented. Subjects rank-ordered the sites according to their preference of diversion landing site. Conjoint analysis was employed to derive worth functions for each of the four variables. Comparisons of the worth functions among pilots with differing experience and training (e.g., flight hours, source of certification) revealed that pilots differentially weighted the variables. Interactions among the four variables were not found. Flathers *et al.* also referenced a study by Curry (1976) that reported similar results from a study of approach-to-landing decision making. These results suggest that pilot error in decision making, one of the two most frequently cited probable causes of general aviation accidents, may, in part, occur because pilots do not assign proper weights to the flight data elements that are available to them.

The present study sought to extend this area of research through an investigation of the values or worth functions pilots attribute to weather and terrain variables in making decisions. The specific objectives were as follows:

- Identify individual weights or worth functions pilots attribute to ceiling, visibility, precipitation, and terrain flight data elements in three representative cross-country flights in a small aircraft.
- Assess interaction effects on assignment of weights that may affect the worth functions of the data elements.
- Assess whether pilots differentially weight these data elements, because of such personal factors as age, flying hours, and source of certification.

METHOD

General Considerations

The research reported here employed a scenario-based judgment task designed to elicit pilot worth functions for visibility, ceiling, precipitation, and terrain variables. Behavioral decision research shows that task design is crucial for making consistent judgments. Depending upon the characteristics of a judgment task, individuals sometimes use a compensatory strategy and other times employ noncompensatory strategies in making decisions. A compensatory strategy is one which processes all relevant information and trades off the good and bad aspects of each alternative. Noncompensatory strategies avoid trade-offs among values by reducing information processing demands by ignoring potentially relevant problem information, such as selecting a single attribute and sorting on that alone.

A major concern was to design a task that would avoid use of noncompensatory cognitive strategies by the subjects when they were making their judgments. Subjects who employ cognitive decision strategies that are artifacts of the problem task, such as restructuring, application of simple heuristics (representativeness, availability, anchoring) and other more complex noncompensatory processes (e.g., elimination-by aspects, lexicographic) usually are trying to reduce cognitive effort. As a result, subjects frequently neglect information relevant to the decision problem (Payne, Bettman, & Johnson, 1988; Payne, Bettman, & Johnson, 1992).

The task was intended to facilitate consistent, compensatory decision strategy utilization by the respondents to make, using Jensen's (1982) terminology, rational judgments. Rational judgment implies that pilots should use weighted-additive strategy processes. In the weighted-additive process pilots should be expected to consider the values of each element or attribute; weight the values of each element by its importance for a safe flight; and sum the weighted values as a basis for overall evaluation of each flight scenario. In practice, however, some pilots may be expected to have developed mixed cognitive strategies (from their experience or training) for considering data elements. While some may have weighted-additive strategies which they consistently apply to judgments, other pilots may have developed rules which they apply to some of their judgments that give the appearance of some non-compensatory strategy or heuristic, such as elimination-by-aspects. For example, some pilots may have developed a simple heuristic that they will not make any flight over water regardless of weather conditions; however, weather conditions may have important values when flying over other kind of terrain. The possibility of multiple strategies was addressed in the analytic methodology (Appendix F) employed by providing for distinguishing between "real" multiple policies and those that may have been artifacts of the task itself.

Design Implications of Behavioral Decision Research

Design of the decision task was based on the results of behavioral decision research which indicates that differences in decision strategies within a problem task occur, according to Payne (1982), because "...information processing in decision making, as in other areas of cognition, is highly contingent upon the demands of the task" (p. 382). Different decision strategies can be thought of as different rules for conducting the search among the attributes and alternatives (Payne, Bettman, & Johnson, 1988). To reduce the likelihood of subjects in this study using strategy variations which are induced by the nature of task itself (versus using their own decision sets), careful attention was given to response mode and task and context characteristics (Einhorn & Hogarth 1981; Payne, Bettman, & Johnson, 1988; Payne, Bettman, & Johnson, 1992).

Judgment versus Choice Response Mode. Judgment and choice tasks require different cognitive processes. In a judgment task, subjects are provided successive presentations of alternatives to each of which a subject assigns a value reflecting its psychological worth. Sometimes the values are in terms of a rating scale; sometimes the psychological worth might be expressed in terms of the amount of money the subject would pay for the alternative. In a choice task, subjects are presented with two or more alternatives and asked to select the alternative most preferred or the order in which the alternatives are preferred.

Some of the clearest examples of decision reversals have been noted between judgment and choice tasks. Subjects reversed their decision in tasks containing identical information as a function of whether they were required to make judgments among the dimensions or make choices among the dimensions (Payne, 1982). Because of these findings, a judgment task was used in this research. In judgment tasks, subjects seem to select an attribute of an alternative as an anchor and then adjust that anchor based on information associated with other attributes. Such processing is more holistic. The choice mode seems to involve primarily dimensional processing by which dimensions of one alternative are compared with parallel dimensions of other alternatives.

Task and Context Task Factors. Task and context factors cause different aspects of the problem to be salient and evoke different processes for combining information (Payne, Bettman, & Johnson, 1992, p. 90; Payne, 1982; Einhorn & Hogarth, 1981). Task factors are general characteristics of a decision problem which do not depend upon the particular values of the attributes or alternatives, such as the number of alternatives, number of attributes, information display, and time limits. Context factors, such as similarity of alternatives, are associated with the particular values of the alternatives. The following task factors guided development of the experimental task:

- In general, cognitive effort in responding to a decision task seems to increase as the number of alternatives presented for each choice problem increases. Subjects tend to employ compensatory types of decision strategy when choices are made between only two alternatives. As alternatives are added, subjects tend to use choice strategies, such as the elimination-by-aspects rule. In the task employed in this research, judgments among the weather-terrain scenarios was not required. Subjects considered each weather-terrain scenario independently and judged their comfort level about flight under the conditions described.

- In general, increases in the number of attributes or dimensions (e.g., the amount of information) of alternatives increases the variability of strategy and decreases quality of judgments. Subjects are likely to use some decision rule (e.g., elimination by aspects) when faced with complex choices. The design of the problem task in this research limited each scenario to four attributes or dimensions.

- Time pressure seems to affect task complexity. Measures of information search showed that subjects tend to spend more time observing negative information under time pressure. Although no time limit was imposed, most subjects in the study reported here completed the task in less than 50 minutes (including time for administrative instructions).

- Information display also may affect judgment-choice behavior. Use of attribute information was reported as increased when this information was displayed in an organized manner and that information acquisition (about attributes) tends to proceed in a way consistent with the display format. Studies have demonstrated that displays designed to encourage alternative-based processing tended to produce more alternative-based information processing. Also, completeness of the information displayed is important. Subjects may tend to discount alternatives when there is missing information about one or more attributes. The judgment task presented dimension information consistently across all scenarios. Each scenario contained the same dimensions. Although values varied, dimensions appeared in the same order and format. Other data elements than those represented in the dimensions which could be important in making judgments about the scenarios (e.g., equipment status, time of day, pilot physical and psychological condition) were held constant across all scenarios for two reasons. First, the appearance of missing information was avoided. Second, variations in these elements would have introduced uncontrolled variables into the design.

- The only context variable that could have implications for the proposed research relates to the similarity of dimensions or attributes. It seems clear that in choice tasks where choices among alternatives is the task, similarity of attributes among alternatives increases the cognitive effort required to make choices. The effort required to make comparisons among alternatives essential to choice-making is increased, thus inducing some non-compensatory strategy, such as elimination-by-aspects (Payne, 1982). Since judgment of each scenario was made independently, the effects of similarity should have been eliminated or minimized.

Data Collection Instrument Development

Data collection instruments consisted of a) a test booklet (used to obtain pilot background and experience information), b) a set of laminated colored maps (one for each of three terrain types: water, non-mountainous, and mountainous), and c) three sets of en route weather scenarios (each set corresponding to a terrain type). Appendix A is a set of these data collection instruments.

Test Booklets. Booklets consisted of three separate parts. Part one contained instructions for assigning "comfort" ratings to the weather scenarios. Part two elicited demographic information such as certification source, age, total flying hours, total hours flown in the last 90 days. This demographic information paralleled that cited by the National Transportation Safety Board (NTSB, 1989) as being related to aircraft accidents the NTSB studied from 1983 to 1987. Part three of the booklet was designed to obtain the pilot-subject's degree of experience flying over each of the three types of terrain, and their experience flying into various levels of precipitation (light rain, moderate rain, heavy snow), visibility (1 NM, 4 NM, 8 NM), and ceiling (800 ft, 1800 ft, 4000 ft). A 5-point scale (0=I have never flown into these or highly similar conditions; 4=I have flown into these conditions numerous times (11+)) was used for these ratings.

Terrain Maps/Flight Routes. The terrain maps selected were for the Great Lakes (over water), North Texas (non-mountainous) and New Mexico (mountainous) areas and were clearly identifiable with respect to these terrain types. In the selection of the over-water terrain map, southern coastal areas were removed from consideration because of limitations imposed on the development of realistic weather scenarios (e.g., snow would not be a condition normally encountered over southern coastal areas). It was felt that local knowledge of terrain, if possessed by some subjects and not others, would act as an uncontrolled independent variable. The importance of minimizing this local knowledge was emphasized by the Shanteau and Nagy (1979) research which indicated that subjects' previous knowledge about a task to be performed influenced their choices in task performance. Since pilots were to be drawn from the San Antonio, Texas area, the route map selected (Great Lakes, North Texas, and New Mexico) minimized the potential impact of local knowledge.

Routes to be flown (City County to Delta County, Michigan for over water, Hereford to Dalhart, Texas for non-mountainous, and Las Vegas to San Juan Pueblo, New Mexico for mountainous) were laid out to minimize impact of restricted, special-use airspace, and low-level military training routes. These flight routes were clearly marked on the corresponding color terrain map. In addition to flight routes, maps were also annotated with local and destination weather and a description of the type and condition of the aircraft being flown (e.g., Cessna 172 without transponder and navigation radio out).

Scenario Development. En route weather scenario content was developed from the NTSB (1989) study of weather-related general aviation accidents from 1983 to 1987. In addition to a probable cause of VFR flight into IMC conditions, which was the criterion used by the NTSB to select accidents for analysis, 89% of these accidents were attributed to the following four factors:

Terrain conditions	225 (18.6%)
Low ceiling	216 (17.9%)
Poor visibility	448 (37.2%)
Precipitation	180 (15.3%)

As a result of these findings, scenarios were generated (using a multi-stage process) around variations in terrain, ceiling, visibility, and precipitation. Specifically, 81 scenarios were produced to accommodate three levels of each of these four independent attributes. Each scenario was printed on a 5 by 4 inch card, color coded with respect to terrain type, and described a combination of en route weather conditions (ceiling, visibility, and precipitation) encountered during the cruise phase of flight over each of the three terrain types.

The first stage of scenario development focused on the identification and validation of the three levels (low, medium, and high) of ceiling, visibility, and precipitation variables to be used in scenario development. Specifically, an Expert Pilot Safety Ratings Form (Appendix C) was developed and administered to 22 pilot-subjects. This group of pilots had an average of 3,700 hours of total flight time and had an average age of 42 years. Of the 22 pilots, 16 were certified flight instructors and 11 were employed as pilots. These 22 pilots used a 0-to-100 point scale (0=Absolutely unsafe/100=totally safe) to rate the relative safety of the three routes (over water, non-mountainous, and mountainous) and of levels of ceiling, visibility, and precipitation with respect to VFR flying by a pilot with 500 hours of flying experience.

These 22 pilot-subjects first provided safety ratings for 8 levels of precipitation (ranging from no precipitation to freezing rain), 12 levels of visibility (ranging from ½ NM to more than 8 NM), and 16 levels of ceiling (ranging from 600 feet to over 5000 feet). Interrater agreements for the obtained ratings (standardized to a mean of 5.0 and a standard deviation of 1.0) were computed using the GRPREL function of the Comprehensive Occupational Data Analysis Programs (CODAP; Christal, 1974; Staley and Weissmuller, 1981). (A brief description of CODAP and its components is provided in Appendix F.) The interrater agreements, shown in Table 1, were extraordinarily high. The interrater agreement (R_{11}) indicates the degree to which pilots within the policy group agreed on how to sort and rate the 81 weather scenarios with respect to comfort level. Values of 0.20 and above are considered "good agreement" (Staley

Table 1. Reliability of the Expert Pilot Safety Ratings.

Variable Levels	N Raters	R_{11}	R_{kk}
Routes	22	.67	.97
Precipitation Levels	22	.88	.99
Visibility Levels	22	.92	.99
Ceiling Levels	22	.92	.99
All Variable Levels	22	.82	.99

and Weissmuller, 1981). The policy stability measure (R_{kk}) indicates the expected correlation of this policy with the policy, which would be found in a re-survey of "k" subjects. Over all variables and levels, R_{11} was .82 and R_{kk} was .99.

To identify values associated with the three levels of precipitation, visibility, and ceiling, means and standard deviations were computed, standardized to a mean of 5.0 and a standard deviation of 1.0 for each of the three attributes, and then plotted. Sets of "High," "Medium," and "Low" values were then identified (by inspection) for each level. The results, shown in Table 2, represented a reasonable spread across the range of values. Appendix D contains the associated plots used.

Three sets of 27 weather scenarios were then generated (one set for each terrain type). Specifically, scenario sets were initially generated such that each scenario within a set was unique with respect to precipitation, visibility, and ceiling level combination (e.g., High/High/High, High/High/Medium, etc.). Within level, however, selection of the specific value was randomized i.e., selection of 5000 ft, 4000 ft, or 3500 ft within the high level of the ceiling variable was randomized. Each set of scenarios was then randomly numbered (600-to-626 for non-mountainous, 700-to-726 for mountainous, and 800-to-826 for water).

Prior to finalizing the three sets of scenarios, each set was evaluated with respect to plausibility. Subject-matter expert judgment was used for this purpose. Specifically, 12 weather experts (meteorologists and weather observers from the National Weather Service Forecast Office in San Antonio, Texas, and USAF Weather Detachments at Reese AFB, Texas, and Randolph AFB, Texas) were asked to rate the degree to which scenario weather combinations (precipitation, visibility, and ceiling values) could reasonably be expected to occur together (e.g., heavy snow, 5NM visibility, and a ceiling of 3500 feet would not be expected to occur simultaneously). Subjects rated each scenario on a 0-to-100 scale (0=Totally improbable/100=Very probable). Obtained interrater agreement was high — R_{11} was .63 and R_{kk} was .95.

Table 2. Standardized High, Medium and Low Levels of Safety Variables.

Variable	Benchmark value/Level
Precipitation:	
none	6.745/High
light rain	6.000/High
light snow	5.514/Medium
moderate rain	5.205/Medium
moderate snow	4.687/Medium
heavy rain	4.287/Low
heavy snow	3.975/Low
freezing rain	3.589/Low
Visibility:	
more than 8 NM	6.598/High
8 NM	6.410/High
7 NM	6.165/High
5 NM	5.446/Medium
4 NM	4.939/Medium
3 NM	4.639/Medium
1 1/2 NM	3.960/Low
1 NM	3.896/Low
1/2 NM	3.822/Low
Ceiling:	
5000 ft	6.419/High
4000 ft	6.244/High
3500 ft	6.081/High
2000 ft	5.393/Medium
1800 ft	5.010/Medium
1600 ft	4.702/Medium
900 ft	3.928/Low
800 ft	3.818/Low
600 ft	3.664/Low

Analysis of the resulting mean ratings led to the replacement of 12 of 81 draft scenarios. Scenarios with mean ratings (standardized to a mean of 5.0 and a standard deviation of 1.0) more than 1.5 standard deviations below the mean rating were considered improbable and replaced. Four scenarios from the non-mountainous set, three from the mountainous set, and five from the over water set were replaced because of low mean ratings. The replacement scenario within a given set was drawn from one of the other two sets. The scenario with the lowest acceptable mean value (of those scenarios not already used as replacements) was always selected as the replacement scenario. This process ensured that (to the extent possible) an equivalent level weather combination was substituted for the unrealistic weather combination.

Pilot-Subjects

A total of 152 pilots were tested from January to March 1994. Complete data were not available for two pilots who were subsequently dropped from the study. The remaining pilots (131 males and 19 females) ranged in age from 18 to 79 with a mean age of 42. Total flying hours ranged from 6 to 26,500 with a sample mean of 1,694 hours. Within this sample, 31 were certified flight instructors (CFI/CFII), 57 held private pilot certificates, and 9 were students. The remaining subjects were certified as either commercial or airline transport pilots. Table 3 contains the pilot-subjects self-reported mean experience levels (0=Never flown into condition/4=Flown into condition numerous times).

Table 3. Mean Experience Levels.

Attribute	Mean	Standard Deviation
Terrain		
Water	1.0	.95
Non-mountainous	3.6	.95
Mountainous	1.4	1.56
Precipitation		
Light rain	2.4	1.18
Moderate rain	1.6	1.35
Heavy snow	.4	1.00
Visibility		
1 NM	1.7	1.44
4 NM	2.7	1.29
8 NM	3.6	.84
Ceiling		
800 ft	1.7	1.55
1800 ft	2.9	1.23
4000 ft	3.6	.80

Data Collection Procedure

Introductory information was designed to be neutral. No reference was made to research into pilot error and pilot-subjects were allowed to respond anonymously. Subjects were motivated to give their personal judgments and to avoid "book" responses. It was emphasized that the only right answers were the responses a subject chose to make.

Data collection took place in group settings, with up to 25 pilots in a group. Pilots first read the instructions contained in part one of the test booklet, and then completed parts two (pilot information form) and three (attribute experience ratings). Pilots were then given the first of three sets of 27 weather scenarios and (using the corresponding terrain map) asked to sort the stack from least comfortable to most comfortable about completing the flight. Next, the pilots were asked to assign a 0-to-100 "comfort" rating (0=least comfortable about completing the flight/100=most comfortable about completing the flight) to each scenario in the set. Pilots wrote their rating on each scenario card in a clearly marked box. When pilots completed the ratings for a set of weather scenarios, they were given the next set to complete. The order of presentation of scenario sets to pilot-subjects was randomized.

RESULTS

Data analysis was designed to address two primary issues. The first focused on the identification and description of weights (worth functions) that pilots attribute to ceiling, visibility, and precipitation with respect to terrain type. This analysis included an assessment of the relationship between pilots' worth functions and associated personal factors such as age, total flying hours, source of certification, etc.. The second and more narrow issue involved data analysis designed to detect the extent to which noncompensatory strategies were used by pilot-subjects. Analysis methodology and analysis results associated with the first issue (identification of worth functions) will be described first.

Identification of Worth Functions

Separate sets of analyses were conducted for each terrain type. Specifically, each pilot-subject's worth function (i.e., the relative emphasis given to ceiling, visibility, and precipitation with respect to the assigned "comfort" ratings) was computed using the following regression equation:

$$CF = A + B + C + AB + AC + BC + ABC$$

where CF was a vector of a pilot's 27 weather scenario "comfort" ratings for a given type of terrain; and A, B, and C (and their interactions) were vectors of benchmark values (of the corresponding scenarios) for ceiling, visibility, and precipitation, respectively. A total of 150 sets of regression weights (one set for each pilot-subject) were computed with respect to each terrain type. These individual sets of regression weights were considered to be a pilot-subject's worth function with respect to the given terrain type.

R^2 values associated with these weight sets were relatively high. For mountainous terrain, 78% of the 150 equations had R^2 values equal to or greater than .70. For the non-mountainous and over water terrain, 60% of the equations had R^2 values equal to or greater than .70. These R^2 values indicate the degree to which pilots' comfort ratings are explained by their worth functions and scenario benchmark values.

The 150 sets of regression weights associated with each terrain type were then subjected to hierarchical clustering (HIER-GRP) to identify groups of weight sets differing significantly with respect to worth function emphasis. Within both mountainous and non-mountainous terrain types, four significantly different policy groups were detected. Within the over water terrain type, two significantly different policy groups were detected. Tables 4, 5, and 6 display, for the non-mountainous, mountainous, and over water scenarios, respectively, the worth functions for significant policy groups by showing the average standard regression weights which were greater than or equal to .25. The average R^2, inter-rater agreement (R_{11}), policy stability (R_{kk}), and average comfort level (CF) are also reported for each group and terrain.

Tables 7, 8, and 9 contain the background data for pilots in each subject identified policy group for the non-mountainous, mountainous, and overwater scenarios, respectively. In addition, Appendix E lists the results of a series of pair comparisons of demographic and comfort level values for policy groups in each of the three scenarios. Since the purpose of these pair comparisons was to assist in developing an understanding of the critical differences among these groups, only those comparisons that were found to be statistically significant are listed.

Table 4. Non-mountainous Group Average Weights.

	GP1	GP2	GP3	GP4
A (Ceiling)	—	—	—	—
B (Visibility)	—	—	—	—
C (Precipitation)	—	—	0.51	—
AB (Ceiling/Visibililty)	1.5	—	0.34	—
AC (Ceiling/Precipitation)	0.8	—	—	0.25
BC (Visibility/Precipitation)	—	—	—	—
ABC (Ceiling/Visibility/Precipitation)	—	2.1	—	0.37
Average R^2	0.79	0.77	0.66	0.58
Rater Agreement, R_{11}	0.57	0.53	0.40	0.35
Policy Stability, R_{kk}	0.98	0.98	0.95	0.95
Average Comfort Level	32.0	28.0	50.0	17.0
Number of subjects	34.0	52.0	27.0	37.0

Table 5. Mountainous Group Average Weights.

	GP1	GP2	GP3	GP4
A (Ceiling)	—	—	—	—
B (Visibility)	—	—	—	—
C (Precipitation)	—	—	—	—
AB (Ceiling/Visibililty)	—	—	0.51	—
AC (Ceiling/Precipitation)	—	—	1.1	0.29
BC (Visibility/Precipitation)	0.91	—	—	—
ABC (Ceiling/Visibility/Precipitation)	0.53	2.3	—	0.58
Average R^2	0.83	0.80	0.75	0.60
Rater Agreement, R	0.49	0.53	0.44	0.35
Policy Stability, R^{11}	0.93	0.99	0.96	0.95
Average Comfort Level	36.0	29.0	46.0	17.0
Number of subjects	14.0	69.0	31.0	36.0

Table 6. Over Water Group Average Weights.

	GP-A	GP-B
A (Ceiling)	—	—
B (Visibility)	—	—
C (Precipitation)	—	—
AB (Ceiling/Visibility)	—	—
AC (Ceiling/Precipitation)	—	0.98
BC (Visibility/Precipitation)	—	0.45
ABC (Ceiling/Visibility/Precipitation)	1.9	—
Average R^2	0.69	0.67
Rater Agreement, R	0.43	0.35
Policy Stability, R^{11}	0.99	0.95
Average Comfort Level	27.0	40.0
Number of subjects	112.0	38.0

Table 7. Mean Demographic Variables and Comfort Levels for Non-Mountainous Scenario Groups.

Background Variable	Non-mountainous Groups			
	GP1 S-N	GP2 J-N	GP3 J-B	GP4 S-C
Number of Subjects	34	52	27	37
Flying History				
Total Hours	1942	1516	1869	1679
Last 90 Days	51	37	47	25
Average Age	44	41	38	46
Percent Instrument Rated	53%	38%	48%	42%
Percent Owning Aircraft	32%	44%	19%	41%
Percent Female	12%	17%	4%	14%
Mean Terrain Experience	3.50	3.65	3.41	3.49
Mean Precipitation Experience				
Light Rain	2.62	2.50	2.41	2.11
Moderate Rain	1.79	1.71	1.63	1.27
Heavy Snow	.38	.33	.67	.38
Mean Visibility Experience				
1 NM	1.62	1.79	1.85	1.38
4 NM	2.74	2.92	3.00	2.24
8 NM	3.38	3.77	3.70	3.30
Mean Ceiling Experience				
800 ft	1.65	1.75	1.78	1.62
1800 ft	2.88	3.13	2.93	2.46
4000 ft	3.56	3.81	3.67	3.38
Percent Using Weather Source				
FAA/FSS	74%	66%	56%	68%
TV/Radio	33%	32%	35%	26%
Other	0%	12%	7%	13%
None	0%	4%	3%	1%
Percent Filing Flight Plan*	58%	55%	45%	57%
Percent Certificated Held				
PP	53%	58%	56%	70%
COM/ATP	32%	37%	22%	24%
CFI/CFII	21%	21%	26%	16%
Percent Flying				
Job-employed as Pilot	21%	17%	23%	3%
Business/Work Related	11%	7%	11%	6%
Pleasure	61%	74%	60%	85%
Average Comfort Level	32	28	50	17
Average R^2	.79	.77	.66	.58

* Letter choices were converted to a 0-to-100 range: a=100, b=75, c=50, d=25, e=0.

Table 8. Mean Demographic Variables and Comfort Levels for Mountainous Scenario Groups.

Background Variable	Mountainous Groups			
	GP1 S-N	GP2 J-N	GP3 J-B	GP4 S-C
Number of Subjects	14	69	31	36
Flying History				
Total Hours	1969	1963	561	2140
Last 90 Days	47	49	34	21
Average Age	51	41	34	48
Percent Instrument Rated	51%	36%	50%	39%
Percent Owning Aircraft	43%	39%	16%	44%
Percent Female	7%	10%	6%	25%
Mean Terrain Experience	1.57	1.58	1.10	1.36
Mean Precipitation Experience				
Light Rain	2.50	2.59	2.10	2.31
Moderate Rain	2.00	1.81	1.19	1.42
Heavy Snow	.36	.43	.19	.58
Mean Visibility Experience				
1 NM	1.86	1.90	1.35	1.39
4 NM	3.14	2.94	2.61	2.25
8 NM	3.57	3.72	3.55	3.28
Mean Ceiling Experience				
800 ft	2.43	1.84	1.19	1.58
1800 ft	3.50	3.10	2.52	2.50
4000 ft	3.86	3.77	3.58	3.28
Percent Using Weather Source				
FAA/FSS	58%	68%	69%	64%
TV/Radio	24%	32%	28%	35%
Other	7%	11%	5%	17%
None	2%	1%	3%	3%
Percent Filing Flight Plan*	44%	55%	54%	56%
Percent Certificates Held				
PP	36%	59%	68%	61%
COM/ATP	36%	33%	16%	33%
CFI/CFII	29%	22%	16%	19%
Percent Flying				
Job-employed as Pilot	18%	22%	12%	5%
Business/Work Related	12%	8%	9%	7%
Pleasure	66%	62%	76%	86%
Average Comfort Level	36	29	46	17
Average R^2	.83	.80	.75	.60

* Letter choices were converted to a 0-to-100 range: a=100, b=75, c=50, d=25, e=0.

Table 9. Mean Demographic Variables and Comfort Levels for over-Water Scenario Groups.

Background Variable	Over-Water Groups	
	GP-A T-N	GP-B T-B
Number of Subjects	112	38
Flying History		
Total Hours	1896	1187
Last 90 Days	39	39
Average Age	43	40
Percent Instrument Rated	46%	39%
Percent Owning Aircraft	39%	26%
Percent Female	12%	16%
Mean Terrain Experience	1.04	.89
Mean Precipitation Experience		
Light Rain	2.49	2.18
Moderate Rain	1.71	1.29
Heavy Snow	.43	.37
Mean Visibility Experience		
1 NM	1.74	1.42
4 NM	2.80	2.50
8 NM	3.62	3.37
Mean Ceiling Experience		
800 ft	1.77	1.50
1800 ft	2.80	2.68
4000 ft	3.65	3.53
Percent Using Weather Source		
FAA/FSS	67%	65%
TV/Radio	33%	24%
Other	12%	7%
None	1%	5%
Percent Filing Flight Plan*	56%	50%
Percent Certificates Held		
PP	58%	63%
COM/ATP	33%	21%
CFI/CFII	21%	18%
Percent Flying		
Job-employed as Pilot	14%	19%
Business/Work Related	9%	6%
Pleasure	72%	67%
Average Comfort Level	27	40
Average R^2	.69	.67

* Letter choices were converted to a 0-to-100 range: a=100, b=75, c=50, d=25, e=0.

With respect to non-mountainous terrain (Table 4), four worth functions could be interpreted. The most obvious of these were those associated with GP1 and GP2, which we have chosen to designate as the Senior-Nominal Group and Junior-Nominal Group, respectively, based upon an inspection of the significant differences among demographic characteristics and comfort levels of the groups, as shown in Table 7 and Appendix E. The worth function associated with GP1 seemed to be related to pilots who emphasized the interactive relationship of ceiling and visibility in their assessment of flight completion comfort. The function associated with GP2 appeared to represent pilots who interactively related ceiling, visibility, and precipitation. The remaining functions for GP3 (Junior-Bold) and GP4 (Senior-Cautious) were less distinct (i.e., did not have standard weights greater or equal to 1.0). All mountainous terrain worth functions (Table 5) appeared to involve the interrelationship of pairs of weather attributes or all three weather attributes. With respect to over-water terrain (Table 6), there were two relatively distinct functions. The function for GP-A (Total-Nominal) was similar to the previously cited GP2 (Junior-Nominal) functions. Significant differences in background variable values among non-mountainous, mountainous, and over-water groups are listed in Appendix E.

Noncompensatory Strategy Detection

To determine the extent to which noncompensatory strategies were used by the subject-pilots in assigning weather scenario comfort ratings, the relationships (correlations) between comfort ratings and sets of compensatory and noncompensatory models were examined and compared. Specifically, the standardized scenario benchmark ratings (which had been standardized to a mean of 5.0 and a standard deviation of 1.0 for all scenarios) were first transformed (using sets of transformations designed to simulate compensatory and noncompensatory policies), and then correlated with pilot-subjects' scenario mean comfort ratings for each terrain type. The compensatory model set consisted of additive, multiplicative, and worst-factor cut-off models. The noncompensatory set consisted of sets of single-factor, continuous, and cut-off models (one set for each factor — ceiling, visibility, and precipitation).

Within the compensatory model set, the additive model summed the three benchmark factors, and implied equal weights for the three factors. The multiplicative models (both two and three factor models) cross-multiplied benchmark values, implied a policy in which one or more factors may introduce a dampening effect which can overpower the level of the other factors. The worst-factor cut-off models used the lowest of the three benchmark values, and implied a policy in which the poorest of the three factors became the only focus. Within the noncompensatory set, models representing policies associated with continuous single factors and single-factor cutoffs (ceiling, visibility, or precipitation) were used.

Table10 lists the compensatory and noncompensatory models used, and their respective correlations with pilot-subject mean comfort ratings. It may be seen that in almost all instances, the highest correlations (across terrain types) were always associated with the compensatory models. Of these compensatory models, the three-factor additive and multiplicative models consistently showed the strongest relationships with assigned comfort ratings. Overall results tend to support the contention that compensatory strategies were widely used by pilot subjects.

DISCUSSION AND CONCLUSIONS

First, let us note that the results of this study must be considered tentative in that the worth functions were derived from a subject-pilot sample primarily experienced in flying over non-mountainous terrain. Because of the terrains used and the experience base of the pilots sampled, this study may produce unstable weights for the "water" and "mountain" terrains as experience levels were very low. In particular, low experience levels over water may account for the fact that only two policies were detected. Additional studies (in other parts of the country using subjects with higher levels of mountainous and over-water flying experience) will be required to assess the stability of the obtained worth functions. These studies will also allow us to evaluate the degree to which the compensatory and noncompensatory models are used by pilot in these settings.

Table 10. Comparison of Compensatory and Non-Compensatory Models.

Models Used	Obtained Correlation (r)		
	Non-mountainous	Mountainous	Water
Compensatory Models			
A + B + C (Additive)	.94	.93	.83
A * B * C (Multiplicative)	.96	.96	.89
A * B (Multiplicative)	.86	.84	.65
A * C (Multiplicative)	.76	.82	.79
B * C (Multiplicative)	.79	.86	.73
Worst Factor Models			
Worst Factor (X > 5.0)	.69	.71	.54
Worst Factor (X > 4.5)	.80	.82	.78
Worst Factor (X > 4.0)	.76	.79	.74
Noncompensatory Models			
A	.48	.53	.46
A (X > 5.0)	.44	.55	.46
A (X > 4.5)	.38	.42	.35
A (X > 4.0)	.38	.42	.35
B	.67	.62	.48
B (X> 5.0)	.56	.53	.41
B (X > 4.5)	.62	.46	.46
B (X > 4.0)	.62	.46	.46
C	.60	.73	.62
C (X > 5.0)	.60	.67	.57
C (X > 4.5)	.53	.56	.50
C (X > 4.0)	.35	.55	.41

A = Ceiling
B = Visibility
C = Precipitation

Subject to that caveat, the obtained analysis results were sufficiently clear to allow the identification (at least tentatively) of distinctly different worth functions. Specifically, four different worth functions were identified and characterized for non-mountainous and mountainous terrain types. Two different worth functions were identified and characterized for over-water terrain. Pilot use of weather information was consistent with expert assessment of the safety risk associated with VFR flight under varying ceiling, visibility, and precipitation conditions over non-mountainous, mountainous, and water terrain. However, while use is consistent, pilots vary in their expressed degree of comfort in flying over the different terrain under different weather conditions. These differences in comfort level may occur, in part at least, because of:

- Differences of understanding of the risks associated with flying under differing above-minimum levels of visibility, ceiling, and precipitation and how terrain type impacts use of such information.
- Differences in their self-assessment and perception of their ability and/or skill in flying under the varying conditions.

Training or other interventions addressing risk assessment and self-perception would appear to be appropriate. The use of training directed at the Five Hazardous Thought Patterns is one method of addressing self perception. Training directed at improving pilot understanding of the effects of terrain-type on interaction of meteorological conditions is another potential source. Increased emphasis on risk assessment and self perception training and exercises in initial training and in subsequent seminars (FAA-sponsored and otherwise) would seem to be warranted. Careful consideration must be given, however, to the desired outcome of this training. The present study has shown that many pilots use a compensatory model for evaluating weather information, however no data have been collected to demonstrate that the use of a compensatory model is appropriate for all or even the majority of pilots.

Consider the implications of a compensatory model in which a high value for one variable (say, visibility) can compensate for a low value on another variable (say, ceiling) in making the determination of the suitability of the weather conditions for flight. From the standpoint of information processing, this may be an efficient use of information, however it may also lead pilots to make poor decisions under some circumstances. It may be argued that in many situations (for example, in mountain flying) a noncompensatory model should be used. One such model might set a minimum value for ceiling values (sufficient to clear all mountain peaks, for example) which must be met, regardless of the visibility. That is, in such a model, having a very high visibility does not compensate for ha[illegible]g a low ceiling. Under those circumstances, training inexperienced pilots to use the compensatory model used by experts might be inappropriate and could, in fact, lead to a decrease in safety. Indeed, the dominance of the compensatory models held by central-Texas pilots might partially account for accidents involving these pilots when they fly into mountainous areas.

Thus, the use of a compensatory model, even though it is the favored mode, may be hazardous under some circumstances. Training might therefore be developed that would allow pilots to assess their personal decision making model, and which would train them in the use of non-compensatory models where such models might reduce risk.

In summary, this study found:

- It is possible to capture reliably pilots' "comfort" policies in terms of emphasis upon terrain, ceiling, visibility, and precipitation using a linear modeling approach.
- Pilots use compensatory judgment rules with sophisticated interactions.
- Pilots generally agree on how to prioritize the safety implications of terrain/weather conditions.
- Pilots' policies tend to fall cleanly into stable policy groups although the individual pilots who hold those views switch groups according to terrain.
- Pilots' policies vary based upon:

1. General comfort level
2. A mixture of age and general experience
3. Number of hours flown in last 90 days
4. Reasons for flying (employed as pilot versus pleasure flying)

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APPENDIX A

DATA COLLECTION PACKAGE

Rate your comfort level about proceding given the following weather update (100 = The MOST comfortable; 0 = the LEAST comfortable):

____

ENROUTE: A weak cold front has stalled along a line from Sturgeon Bay to Manistique. Ceilings are reported at 5000 ft with visibility of 1½ NM and light rain.

ROUTE 1

Card Number 801

Rate your comfort level about proceding given the following weather update (100 = The MOST comfortable; 0 = the LEAST comfortable):

____

ENROUTE: A weak cold front has stalled along a line running west from Amarillo into New Mexico.. Ceilings are reported at 4000 ft with visibility of 1 NM and light rain.

ROUTE 2

Card Number 601

Rate your comfort level about proceding given the following weather update (100 = The MOST comfortable; 0 = the LEAST comfortable):

____

ENROUTE: A weak cold front has stalled along a running from Santa Fe northeast into Colorado. Ceilings are reported at 600 ft with visibility of 5 NM and freezing rain.

ROUTE 3

Card Number 701

Weather Combinations: Route 1— Delta County to City County.

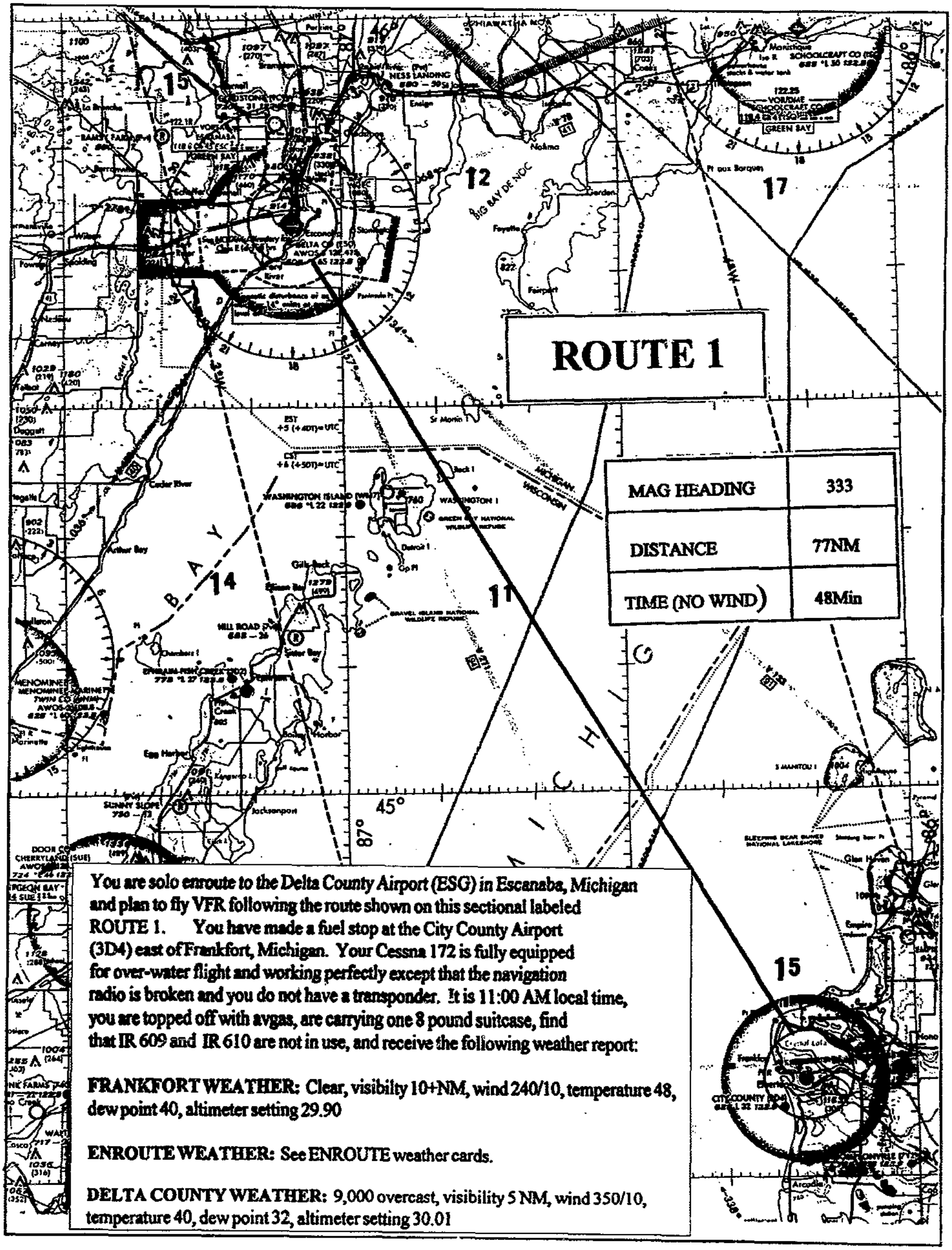
Scenario	Ceiling	Visibility	Precipitation
800	4000	7	moderate rain
801	5000	1.5	light rain
802	4000	4	none
803	5000	8+	none
804	2000	3	none
805	1800	3	heavy rain
806	1800	7	light snow
807	3500	1	heavy rain
808	900	1.5	moderate rain
809	1800	7	moderate rain
810	800	1.5	none
811	1600	8	none
812	1600	3	heavy snow
813	4000	5	light snow
814	900	0.5	heavy snow
815	1600	1.5	heavy rain
816	5000	0.5	moderate rain
817	600	8	moderate rain
818	600	7	none
819	1600	1.5	moderate snow
820	5000	8+	freezing rain
821	900	5	none
822	800	4	moderate rain
823	1600	4	moderate snow
824	1800	5	moderate rain
825	1800	0.5	none
826	900	4	heavy rain

Weather Combinations: Route 2— Dalhart Airport to Hereford Airport.

Scenario	Ceiling	Visibility	Precipitation
600	5000	8	light snow
601	4000	1	light rain
602	1600	3	heavy snow
603	4000	3	light rain
604	2000	7	light snow
605	4000	8+	light rain
606	3500	0.5	heavy rain
607	1800	0.5	moderate snow
608	600	0.5	light snow
609	1800	4	none
610	800	8+	light snow
611	800	8	none
612	1800	5	moderate rain
613	600	8	moderate rain
614	900	4	heavy rain
615	5000	1.5	moderate rain
616	1800	7	moderate rain
617	900	5	light snow
618	900	0.5	heavy rain
619	2000	1.5	none
620	1800	3	heavy rain
621	2000	0.5	freezing rain
622	1600	4	moderate snow
623	800	3	none
624	900	1.5	light rain
625	2000	8+	light rain
626	4000	5	light snow

Weather Combinations: Route 3— San Juan Pueblo Airport to Las Vegas Airport.

Scenario	Ceiling	Visibility	Precipitation
700	5000	5	none
701	600	5	freezing rain
702	3500	8	moderate rain
703	900	1	heavy snow
704	2000	0.5	moderate rain
705	900	4	heavy rain
706	4000	8+	none
707	600	3	moderate snow
708	1800	7	moderate rain
709	800	1	none
710	4000	0.5	heavy snow
711	600	1	moderate snow
712	4000	4	light snow
713	3500	1	light snow
714	1600	3	heavy rain
715	2000	8+	light rain
716	2000	1.5	none
717	1600	1	freezing rain
718	600	8	moderate rain
719	3500	3	freezing rain
720	2000	5	light snow
721	900	5	light rain
722	900	8	light rain
723	1600	3	heavy snow
724	2000	4	none
725	5000	1.5	light rain
726	1800	5	moderate rain

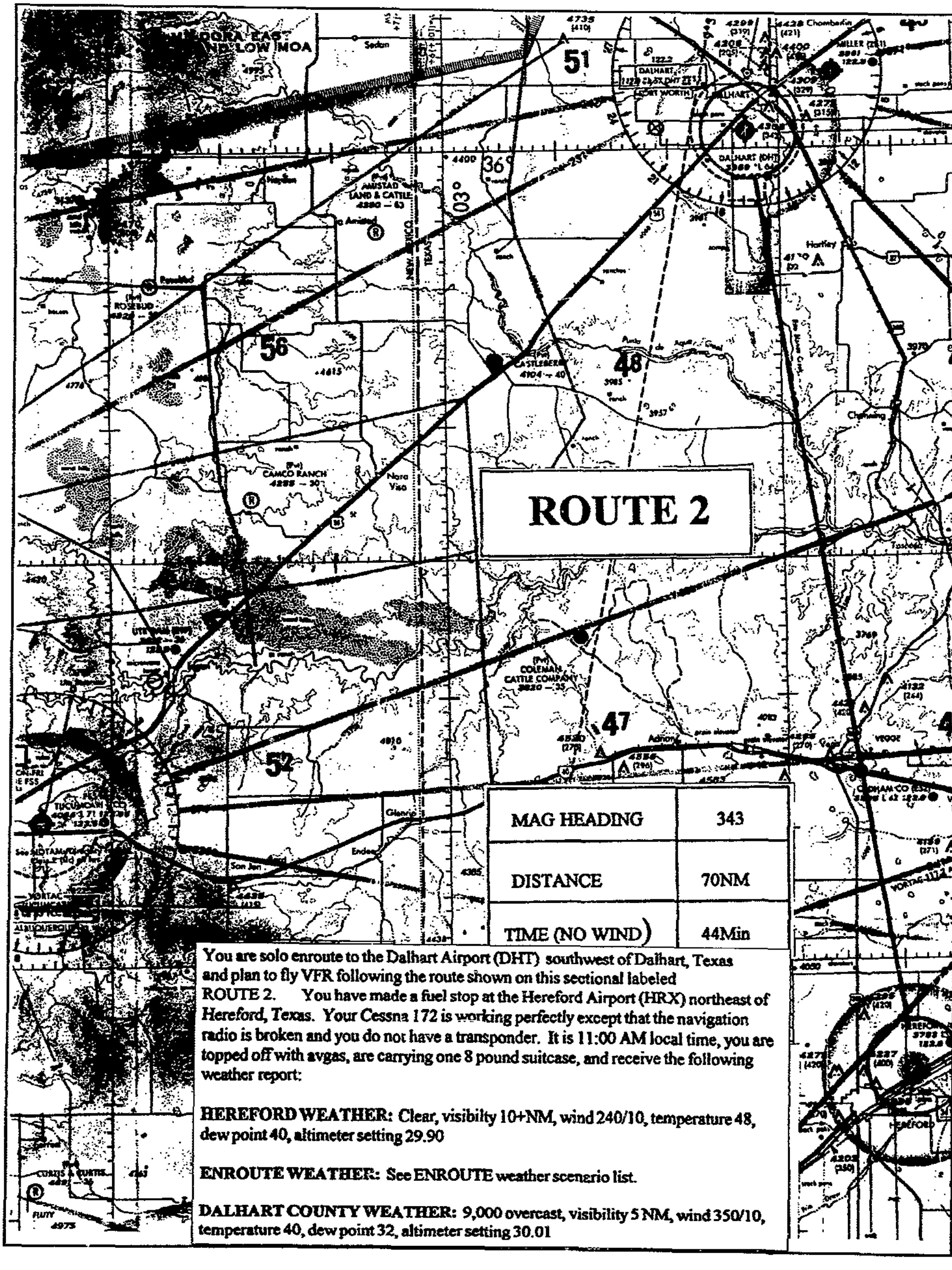


You are solo enroute to the Delta County Airport (ESG) in Escanaba, Michigan and plan to fly VFR following the route shown on this sectional labeled ROUTE 1. You have made a fuel stop at the City County Airport (3D4) east of Frankfort, Michigan. Your Cessna 172 is fully equipped for over-water flight and working perfectly except that the navigation radio is broken and you do not have a transponder. It is 11:00 AM local time, you are topped off with avgas, are carrying one 8 pound suitcase, find that IR 609 and IR 610 are not in use, and receive the following weather report:

FRANKFORT WEATHER: Clear, visibilty 10+NM, wind 240/10, temperature 48, dew point 40, altimeter setting 29.90

ENROUTE WEATHER: See ENROUTE weather cards.

DELTA COUNTY WEATHER: 9,000 overcast, visibility 5 NM, wind 350/10, temperature 40, dew point 32, altimeter setting 30.01



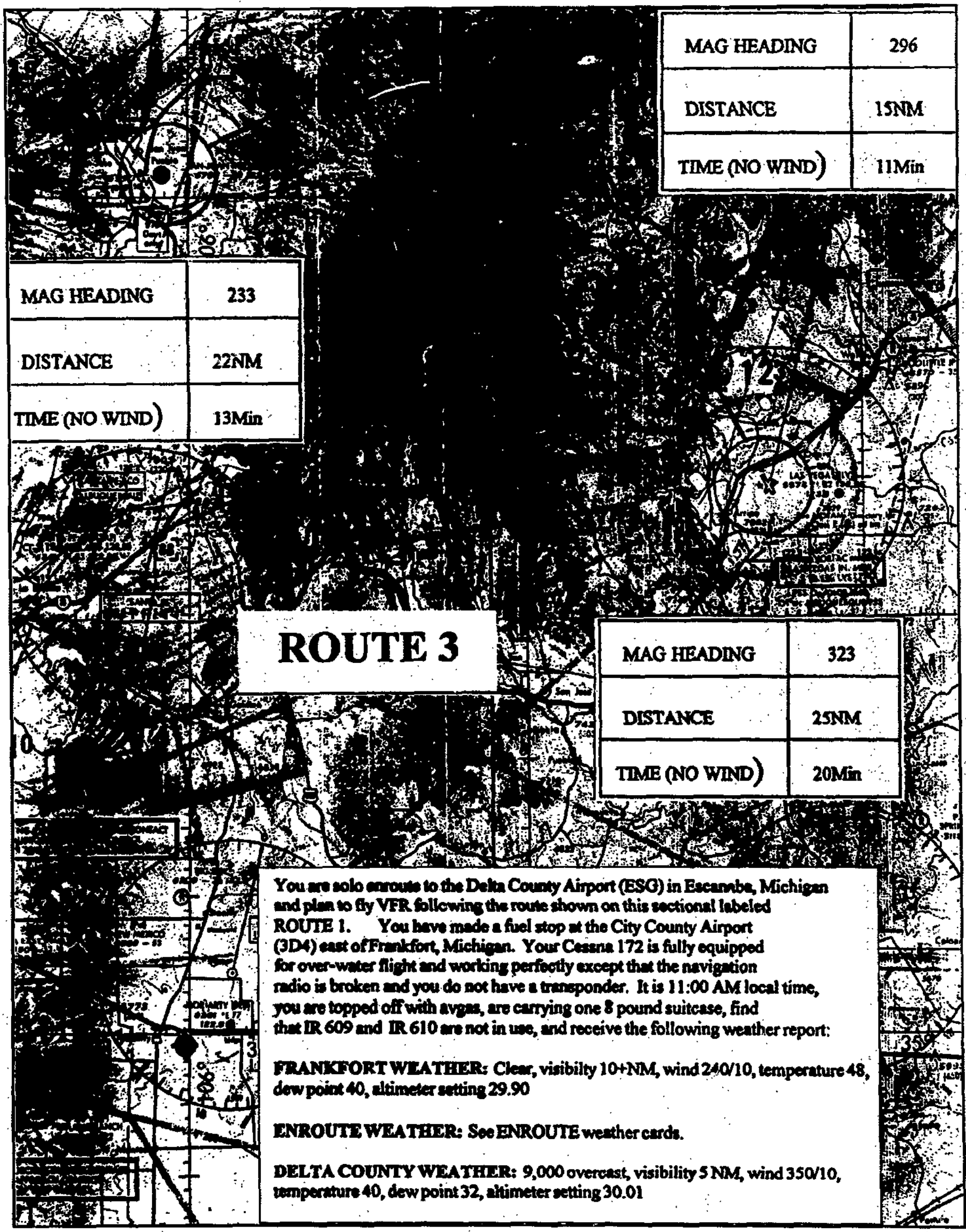
MAG HEADING	343
DISTANCE	70NM
TIME (NO WIND)	44Min

You are solo enroute to the Dalhart Airport (DHT) southwest of Dalhart, Texas and plan to fly VFR following the route shown on this sectional labeled ROUTE 2. You have made a fuel stop at the Hereford Airport (HRX) northeast of Hereford, Texas. Your Cessna 172 is working perfectly except that the navigation radio is broken and you do not have a transponder. It is 11:00 AM local time, you are topped off with avgas, are carrying one 8 pound suitcase, and receive the following weather report:

HEREFORD WEATHER: Clear, visibilty 10+NM, wind 240/10, temperature 48, dew point 40, altimeter setting 29.90

ENROUTE WEATHER: See ENROUTE weather scenario list.

DALHART COUNTY WEATHER: 9,000 overcast, visibility 5 NM, wind 350/10, temperature 40, dew point 32, altimeter setting 30.01



MAG HEADING	296
DISTANCE	15NM
TIME (NO WIND)	11Min

MAG HEADING	233
DISTANCE	22NM
TIME (NO WIND)	13Min

ROUTE 3

MAG HEADING	323
DISTANCE	25NM
TIME (NO WIND)	20Min

You are solo enroute to the Delta County Airport (ESG) in Escanaba, Michigan and plan to fly VFR following the route shown on this sectional labeled ROUTE 1. You have made a fuel stop at the City County Airport (3D4) east of Frankfort, Michigan. Your Cessna 172 is fully equipped for over-water flight and working perfectly except that the navigation radio is broken and you do not have a transponder. It is 11:00 AM local time, you are topped off with avgas, are carrying one 8 pound suitcase, find that IR 609 and IR 610 are not in use, and receive the following weather report:

FRANKFORT WEATHER: Clear, visibilty 10+NM, wind 240/10, temperature 48, dew point 40, altimeter setting 29.90

ENROUTE WEATHER: See ENROUTE weather cards.

DELTA COUNTY WEATHER: 9,000 overcast, visibility 5 NM, wind 350/10, temperature 40, dew point 32, altimeter setting 30.01

APPENDIX B

PILOT INFORMATION FORM

Table B-1. Pilot Demographic Information.

	Count	Percent
CERTIFICATES HELD:		
Private Pilot	89	59%
Commercial Pilot	35	23%
Airline Transport Pilot	12	8%
Certified Flight Instructor	13	9%
Certified Flight Instructor Instrument	24	16%
INSTRUMENT RATED:		
Yes	67	45%
No	83	55%
STATE OF RESIDENCE:		
Colorado	1	1%
Maryland	1	1%
New Mexico	1	1%
Texas	144	96%
Wisconsin	1	1%
Other	2	1%
AGE[1]:		
16 - 20	10	7%
21 - 40	59	39%
41 - 50	28	19%
51 - 60	30	20%
61 - 70	18	12%
71 +	5	3%
SEX:		
Female	19	13%
Male	130	87%
Blank	1	1%
ENGINE RATING:		
Single	108	72%
Multi	37	25%
Other	5	3%
MEDICAL CERTIFICATE:		
Class 1	30	20%
Class 2	49	33%
Class 3	69	46%
EVER BEEN A MILITARY PILOT?		
No	135	90%
Yes	15	10%

Note 1 : Age Mean = 42.64; S.D. = 15.44

Table B-2. Flying Categories.

	Count	Percent
PERCENT OF FLYING AS: PRIMARY JOB-EMPLOYED AS A PILOT		
0%	120	80%
1 - 20%	2	1%
21 - 40%	1	1%
41 - 60%	3	2%
61 - 80%	4	3%
81 - 100%	20	13%
PERCENT OF FLYING AS: BUSINESS SUPPORT-WORK RELATED		
0%	116	77%
1 - 20%	15	10%
21 - 40%	3	2%
41 - 60%	9	6%
61 - 80%	3	2%
81 - 100%	4	3%
PERCENT OF FLYING AS: PLEASURE		
0%	15	10%
1 - 20%	20	13%
21 - 40%	5	3%
41 - 60%	7	5%
61 - 80%	6	4%
81 - 100%	97	65%

Table B-3. Flight Plan Use.

HOW OFTEN DO YOU FILE A FLIGHT PLAN WITH THE FAA?

	Count	Percent
All of the time	22	15%
Most of the time	44	29%
Some of the time	43	29%
Seldom	23	15%
Never	9	6%
(Invalid/No response)	9	6%

Table B-4. Weather information sources

PERCENT USE OF: FAA/FSS

	Count	Percent
0%	14	9%
1 - 20%	16	11%
21 - 30%	9	6%
41 - 60%	19	13%
61 - 80%	15	10%
81 - 100%	77	51%

PERCENT USE OF: TV/RADIO

	Count	Percent
0%	46	31%
1 - 20%	38	25%
21 - 40%	12	8%
41 - 60%	22	15%
61 - 80%	11	7%
81 - 100%	21	14%

PERCENT USE OF: OTHER

	Count	Percent
0%	110	73%
1 - 20%	17	11%
21 - 40%	6	4%
41 - 60%	5	3%
61 - 80%	6	4%
81 - 100%	6	4%

PERCENT USE OF: NONE

	Count	Percent
0%	139	93%
1 - 20%	7	5%
21 - 40%	1	1%
41 - 60%	1	1%
61 - 80%	0	0%
81 - 100%	2	1%

Table B-5. Flying History - Total Hours.

TOTAL FLYING HOURS

	Count	Percent
0 - 99	20	13%
100 - 299	48	32%
300 - 599	24	16%
600 - 899	13	9%
900 - 1199	7	5%
1200 - 1499	5	3%
1500 - 1799	4	3%
1800 - 2099	4	3%
2100 - 2399	1	1%
2400 - 2699	1	1%
2700 - 2999	2	1%
3000 - 30000	21	14%
Mean:	1716.89	
S.D.	3742.17	

DAY HOURS

	Count	Percent
0 - 99	29	19%
100 - 299	44	29%
300 - 599	25	17%
600 - 899	9	6%
900 - 1199	7	5%
1200 - 1499	7	5%
1500 - 1799	4	3%
1800 - 2099	1	1%
2100 - 2399	1	1%
2400 - 2699	2	1%
2700 - 2999	2	1%
3000 - 30000	19	13%
Mean:	1418.14	
S.D.	3036.35	

NIGHT HOURS

	Count	Percent
0	4	3%
1 - 19	53	35%
20 - 49	31	21%
50 - 99	16	11%
100 - 299	24	16%
300 - 599	7	5%
600 - 899	3	2%
900 - 1199	3	2%
1200 - 1499	2	1%
1500 - 15000	7	5%
Mean:	293.01	
S.D.	1054.43	

Table B-5. *(Continued)*

ACTUAL INSTRUMENT HOURS

0	47	31%
1 - 19	49	33%
20 - 49	12	8%
50 - 99	14	9%
100 - 299	12	8%
300 - 599	4	3%
600 - 899	2	1%
900 - 1199	3	2%
1200 - 1499	2	1%
1500 - 15000	5	3%
Mean:	220.09	
S.D.	995.52	

ACTUAL PLUS HOOD HOURS

0	24	16%
1 - 19	38	25%
20 - 49	22	15%
50 - 99	31	21%
100 - 299	16	11%
300 - 599	7	5%
600 - 899	2	1%
900 - 1199	0	0%
1200 - 1499	2	1%
1500 - 15000	8	5%
Mean:	276.26	
S.D.	1181.99	

NIGHT INSTRUMENT HOURS

0	72	48%
1 - 19	6	31%
20 - 49	13	9%
50 - 99	3	2%
100 - 299	10	7%
300 - 599	2	1%
600 - 899	1	1%
900 - 1199	1	1%
1200 - 1499	0	0%
1500 - 15000	2	1%
Mean:	105.28	
S.D.	767.16	

TOTAL INSTRUMENT APPROACHES FLOWN

0	60	40%
1 - 24	16	11%
25 - 49	16	11%
50 - 99	16	11%
100 - 299	22	15%
300 - 599	6	4%
600 - 899	1	1%
900 - 9999	13	9%
Mean:	291.67	
S.D.	964.28	

Table B-6. Flying Experience in the Last 90 Days.

TOTAL HOURS

	Count	Percent
0	12	8%
1 - 24	70	47%
25 - 49	36	24%
50 - 99	13	9%
100 - 299	18	12%
300 - 9999	1	1%
Mean:	39.45	
S.D.	54.69	

DAY HOURS

0	15	10%
1 - 24	74	49%
25 - 49	34	23%
50 - 99	12	8%
100 - 299	14	9%
300 - 9999	1	1%
Mean:	36.95	
S.D.	54.52	

NIGHT HOURS

0	69	46%
1 - 24	79	53%
25 - 49	1	1%
50 - 99	0	0%
100 - 299	1	1%
300 - 9999	0	0%
Mean:	3.99	
S.D.	9.41	

ACTUAL INSTRUMENT HOURS

0	87	58%
1 - 24	58	39%
25 - 49	3	2%
50 - 99	2	1%
100 - 9999	0	0%
Mean:	3.55	
S.D.	9.39	

Table B-6. (Continued)

TOTAL INSTRUMENT HOURS

0	81	54%
1 - 24	62	41%
25 - 49	6	4%
50 - 99	1	1%
100 - 9999	0	0%
Mean:	4.94	
S.D.	8.98	

ACTUAL NIGHT INSTRUMENT HOURS

0	118	79%
1 - 24	31	21%
25 - 49	0	0%
50 - 99	1	1%
100 - 9999	0	0%
Mean:	1.06	
S.D.	6.61	

NUMBER OF INSTRUMENT APPROACHES FLOWN

0	81	54%
1 - 24	54	36%
25 - 49	11	7%
50 - 99	3	2%
100 - 299	1	1%
300 - 9999	0	0%
Mean:	7.02	
S.D.	13.93	

Table B-7. Characteristics of Aircraft Most Frequently Flown.

NUMBER OF ENGINES

	Count	Percent
One Engine	136	91%
Two Engines	8	5%
(Other/No Response)	6	4%

IFR CAPABLE?

Yes	119	79%
No	30	20%
(Other/No Response)	1	1%

AUTO-PILOT EQUIPPED?

Yes	40	27%
No	108	72%
(Other/No Response)	2	1%

WEATHER RADAR EQUIPPED?

Yes	14	9%
No	134	89%
(Other/No Response)	2	1%

TRANSPONDER EQUIPPED?

Yes	145	97%
No	3	2%
(Other/No Response)	2	1%

HOURS OF CRUISE CAPABLE

3 Hours	16	11%
4 Hours	55	37%
5 Hours	48	32%
6 Hours	15	10%
7 Hours	8	5%
(Other/No Response)	8	5%

DO YOU OWN THIS AIRCRAFT?

Yes	54	36%
No	94	63%
(Other/No Response)	2	1%

Table B-8. Attribute Experience - Terrain.

FLOWN OVER LARGE BODY OF WATER

	Count	Percent
I have NEVER flown into these or similar conditions	88	59%
I have flown into these conditions ONCE or TWICE	19	13%
I have flown into these conditions SEVERAL times (3-5)	15	10%
I have flown into these conditions MANY times (6-10)	11	7%
I have flown into these conditions NUMEROUS times (11+)	17	11%

FLOWN OVER NON-MOUNTAINOUS TERRAIN

	Count	Percent
I have NEVER flown into these or similar conditions	7	5%
I have flown into these conditions ONCE or TWICE	3	2%
I have flown into these conditions SEVERAL times (3-5)	11	7%
I have flown into these conditions MANY times (6-10)	11	7%
I have flown into these conditions NUMEROUS times (11+)	118	79%

FLOWN OVER MOUNTAINOUS TERRAIN

	Count	Percent
I have NEVER flown into these or similar conditions	67	45%
I have flown into these conditions ONCE or TWICE	21	14%
I have flown into these conditions SEVERAL times (3-5)	22	15%
I have flown into these conditions MANY times (6-10)	11	7%
I have flown into these conditions NUMEROUS times (11+)	29	19%

Table B-9. Attribute experience - Precipitation

LIGHT RAIN

	Count	Percent
I have NEVER flown into these or similar conditions	3	2%
I have flown into these conditions ONCE or TWICE	39	26%
I have flown into these conditions SEVERAL times (3-5)	42	28%
I have flown into these conditions MANY times (6-10)	25	17%
I have flown into these conditions NUMEROUS times (11+)	41	27%

MODERATE RAIN

	Count	Percent
I have NEVER flown into these or similar conditions	34	23%
I have flown into these conditions ONCE or TWICE	51	34%
I have flown into these conditions SEVERAL times (3-5)	31	21%
I have flown into these conditions MANY times (6-10)	8	5%
I have flown into these conditions NUMEROUS times (11+)	26	17%

HEAVY SNOW

	Count	Percent
I have NEVER flown into these or similar conditions	122	81%
I have flown into these conditions ONCE or TWICE	11	7%
I have flown into these conditions SEVERAL times (3-5)	6	4%
I have flown into these conditions MANY times (6-10)	5	3%
I have flown into these conditions NUMEROUS times (11+)	6	4%

Table B-10. Attribute Experience - Visibility.

ONE NAUTICAL MILE

	Count	Percent
I have NEVER flown into these or similar conditions	42	28%
I have flown into these conditions ONCE or TWICE	36	24%
I have flown into these conditions SEVERAL times (3-5)	32	21%
I have flown into these conditions MANY times (6-10)	11	7%
I have flown into these conditions NUMEROUS times (11+)	29	19%

FOUR NAUTICAL MILES

	Count	Percent
I have NEVER flown into these or similar conditions	12	8%
I have flown into these conditions ONCE or TWICE	19	13%
I have flown into these conditions SEVERAL times (3-5)	24	16%
I have flown into these conditions MANY times (6-10)	38	25%
I have flown into these conditions NUMEROUS times (11+)	57	38%

EIGHT NAUTICAL MILES

	Count	Percent
I have NEVER flown into these or similar conditions	4	3%
I have flown into these conditions ONCE or TWICE	4	3%
I have flown into these conditions SEVERAL times (3-5)	11	7%
I have flown into these conditions MANY times (6-10)	17	11%
I have flown into these conditions NUMEROUS times (11+)	114	76%

Table B-11. Attribute experience - Ceiling

800 FEET

	Count	Percent
I have NEVER flown into these or similar conditions	45	30%
I have flown into these conditions ONCE or TWICE	38	25%
I have flown into these conditions SEVERAL times (3-5)	20	13%
I have flown into these conditions MANY times (6-10)	11	7%
I have flown into these conditions NUMEROUS times (11+)	36	24%

1800 FEET

	Count	Percent
I have NEVER flown into these or similar conditions	8	5%
I have flown into these conditions ONCE or TWICE	17	11%
I have flown into these conditions SEVERAL times (3-5)	27	18%
I have flown into these conditions MANY times (6-10)	32	21%
I have flown into these conditions NUMEROUS times (11+)	66	44%

4000 FEET

	Count	Percent
I have NEVER flown into these or similar conditions	3	2%
I have flown into these conditions ONCE or TWICE	3	2%
I have flown into these conditions SEVERAL times (3-5)	8	5%
I have flown into these conditions MANY times (6-10)	20	13%
I have flown into these conditions NUMEROUS times (11+)	116	77%

APPENDIX C

EXPERT PILOT SAFETY RATINGS

EXPERT PILOT SAFETY RATINGS

You have been selected as a Subject Matter Expert (SME) in the field of aviation safety due to your personal flying experience and/or your FAA job experience.

Place yourself in this scenario: Kelly (a new pilot VFR-only qualified with around 500 flying hours) asks you, "How safe would it be for me to fly this route VFR?"

Use this scale from 0 to 100 to indicate your expert safety assessment where:

0	=	Absolutely unsafe for Kelly to fly VFR.
100	=	Totally safe for Kelly to fly VFR.

Note 1: Use your total experience (VFR and IMC) to evaluate the conditions on the following pages. NONE of the choices shown may deserve a "0" for "Absolutely unsafe" or a "100" for "Totally safe."

Use any numbers in the range from 0 to 100 to indicate your expert opinion, but you MAY NOT use the same number more than once on one page. If you feel that two choices are "Absolutely unsafe," rate one as "0" and the other as "1".

You and we know that evaluating conditions for determining the safety of any flight involves interaction between all weather, aircraft, pilot and terrain variables. Yet each of us has developed benchmarks for certain values of each variable on which we make flight planning decisions. We ask you to consider each variable (i.e., TERRAIN, PRECIPITATION, VISIBILITY and CEILING) separately and give us your opinion on the relative safety of each value for VFR flying. Treat each page as a separate and unrelated rating assignment.

Read each of the following pages in turn, and give us your opinion on the safety of each value using the scale at the top of the page and using each number only once on each page.

Note 2: Values are not necessarily presented in order of "worst-to-best" or "best-to-worst." The order is simply to help us ensure that all target values are covered. Remember, you are evaluating each of the variables against the safety for a VFR qualified pilot with around 500 hours of flying time to fly in a reliable single engine VFR only aircraft.

Turn the page and begin.

TERRAIN

Rate each route on how safe you think it would be for a VFR only pilot with around 500 flying hours experience to encounter. Use the following scale and each number no more than once:

0 = Absolutely unsafe.
100 = Totally safe.

ID	Rating	Destination
a.	_____	Route "1" (City County to Delta County, MI)
b.	_____	Route "2" (Hereford to Dalhart, TX)
c.	_____	Route "3" (Las Vegas to San Juan Pueblo, NM)

PRECIPITATION

Rate each item on how safe you think it would be for a VFR only pilot with around 500 flying hours experience to encounter. Use the following scale and each number no more than once:

0	=	Absolutely unsafe.
100	=	Totally safe.

ID	Rating	Description
a.	_____	No Precipitation
b.	_____	Light Rain
c.	_____	Moderate Rain
d.	_____	Heavy Rain
e.	_____	Light Snow
f.	_____	Moderate Snow
g.	_____	Heavy Snow
h.	_____	Freezing Rain

VISIBILITY

Rate each item on how safe you think it would be for a VFR only pilot with around 500 flying hours experience to encounter. Use the following scale and each number no more than once:

0	=	Absolutely unsafe.
100	=	Totally safe.

ID	Rating	Description
a.	_____	1/2 NM
b.	_____	1 NM
c.	_____	1 1/2 NM
d.	_____	2 NM
e.	_____	2 1/2 NM
f.	_____	3 NM
g.	_____	4 NM
h.	_____	5 NM
I.	_____	6 NM
j.	_____	7 NM
k.	_____	8 NM
l.	_____	More than 8 NM

CEILING

Rate each item on how safe you think it would be for a VFR only pilot with around 500 flying hours experience to encounter. Use the following scale and each number no more than once:

0	=	Absolutely unsafe.
100	=	Totally safe.

ID	Rating	Description
a.	_____	600 ft.
b.	_____	700 ft.
c.	_____	800 ft.
d.	_____	900 ft.
e.	_____	1000 ft.
f.	_____	1200 ft.
g.	_____	1400 ft.
h.	_____	1600 ft.
i.	_____	1800 ft.
j.	_____	2000 ft.
k.	_____	2500 ft.
l.	_____	3000 ft.
m.	_____	3500 ft.
n.	_____	4000 ft.
o.	_____	5000 ft.
p.	_____	over 5000 ft

Personal Experience Profile

Thank you for your expert ratings. Your data will be combined with data from other experts to form the foundation for studying safety judgment of General Aviation (GA) pilots.

Now, please fill out the PILOT INFORMATION and four EXPERIENCE Forms which ask for your personal flying history. These forms are intended only for use in this study of GA pilots. Notice neither your name nor any personal identifying information is requested.

Please feel free to write suggestions or comments on these sheets regarding problems we may expect within the GA community with these forms.

The PILOT INFORMATION sheet requests personal flying history information which may be important in explaining the decision making process used by different subgroups within the GA pilot community.

The ATTRIBUTE EXPERIENCE forms appear similar to the four rating sheets you just completed. Instead of rating "HOW SAFE?" you are asked to indicate how much experience you have had under specific conditions. Because these forms are designed for the GA pilot community, you, as a senior expert, may well be responding level "5" to all these items -- and that is OK.

Here is the scale used on all four Attribute Experience forms:

0 = I have NEVER flown into these or highly similar conditions.
1 = I have flow into these conditions ONCE or TWICE
2 = (same as above)
3 = I have flown into these conditions SEVERAL times.
4 = (same as above)
5 = I have flown into these conditions MANY times.

COMMENTS and/or SUGGESTIONS

EXPERIENCE: TERRAIN

How much personal expeience (VFR and IMC) do you have with these conditions:

0 = I have NEVER flown into these or highly similar conditions.
1 = I have flow into these conditions ONCE or TWICE
2 = (same as above)
3 = I have flown into these conditions SEVERAL times.
4 = (same as above)
5 = I have flown into these conditions MANY times.

ID	Exper.	Destination
a.	_____	Route "1" (City County to Delta County, MI)
b.	_____	Route "2" (Hereford to Dalhart, TX)
c.	_____	Route "3" (Las Vegas to San Juan Pueblo, NM)

EXPERIENCE: PRECIPITATION

How much personal expeience (VFR and IMC) do you have with these conditions:

0 = I have NEVER flown into these or highly similar conditions.
1 = I have flow into these conditions ONCE or TWICE
2 = (same as above)
3 = I have flown into these conditions SEVERAL times.
4 = (same as above)
5 = I have flown into these conditions MANY times.

ID	Exper.	Description
a.	_____	No Precipitation
b.	_____	Light Rain
c.	_____	Moderate Rain
d.	_____	Heavy Rain
e.	_____	Light Snow
f.	_____	Moderate Snow
g.	_____	Heavy Snow
h.	_____	Freezing Rain

EXPERIENCE: VISIBILILTY

How much personal expeience (VFR and IMC) do you have with these conditions:

0 = I have NEVER flown into these or highly similar conditions.
1 = I have flow into these conditions ONCE or TWICE
2 = (same as above)
3 = I have flown into these conditions SEVERAL times.
4 = (same as above)
5 = I have flown into these conditions MANY times.

ID	Exper.	Description
a.	_____	1/2 NM
b.	_____	1 NM
c.	_____	1 1/2 NM
d.	_____	2 NM
e.	_____	2 1/2 NM
f.	_____	3 NM
g.	_____	4 NM
h.	_____	5 NM
I.	_____	6 NM
j.	_____	7 NM
k.	_____	8 NM
l.	_____	More than 8 NM

EXPERIENCE: CEILING

How much personal expeience (VFR and IMC) do you have with these conditions:

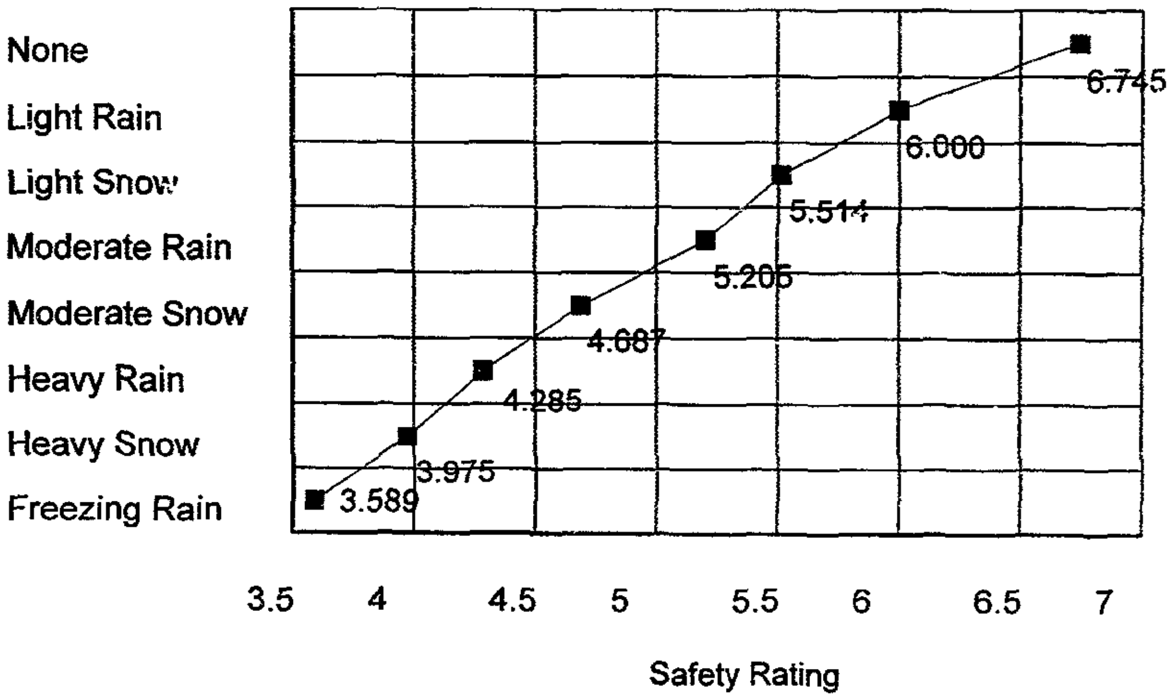
0 = I have NEVER flown into these or highly similar conditions.
1 = I have flow into these conditions ONCE or TWICE
2 = (same as above)
3 = I have flown into these conditions SEVERAL times.
4 = (same as above)
5 = I have flown into these conditions MANY times.

ID	Exper.	Description
a.	_____	600 ft.
b.	_____	700 ft.
c.	_____	800 ft.
d.	_____	900 ft.
e.	_____	1000 ft.
f.	_____	1200 ft.
g.	_____	1400 ft.
h.	_____	1600 ft.
i.	_____	1800 ft.
j.	_____	2000 ft.
k.	_____	2500 ft.
l.	_____	3000 ft.
m.	_____	3500 ft.
n.	_____	4000 ft.
o.	_____	5000 ft.
p.	_____	over 5000 ft

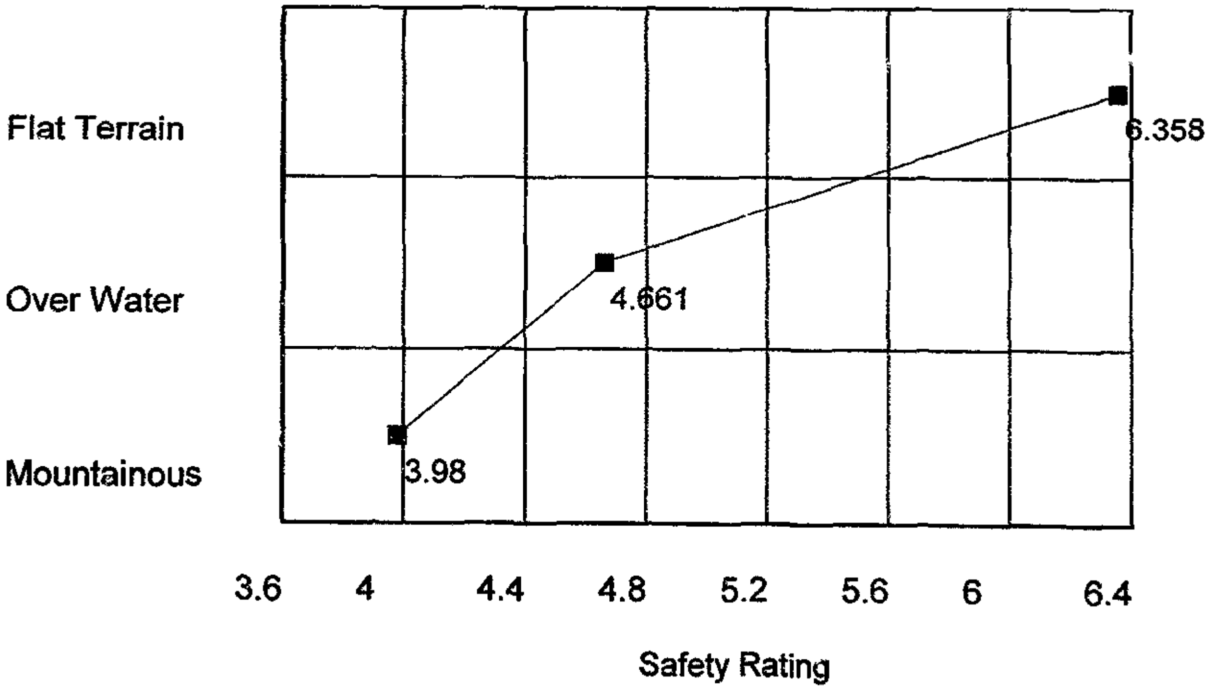
APPENDIX D

PLOTS OF EXPERT PILOT SAFETY RATINGS

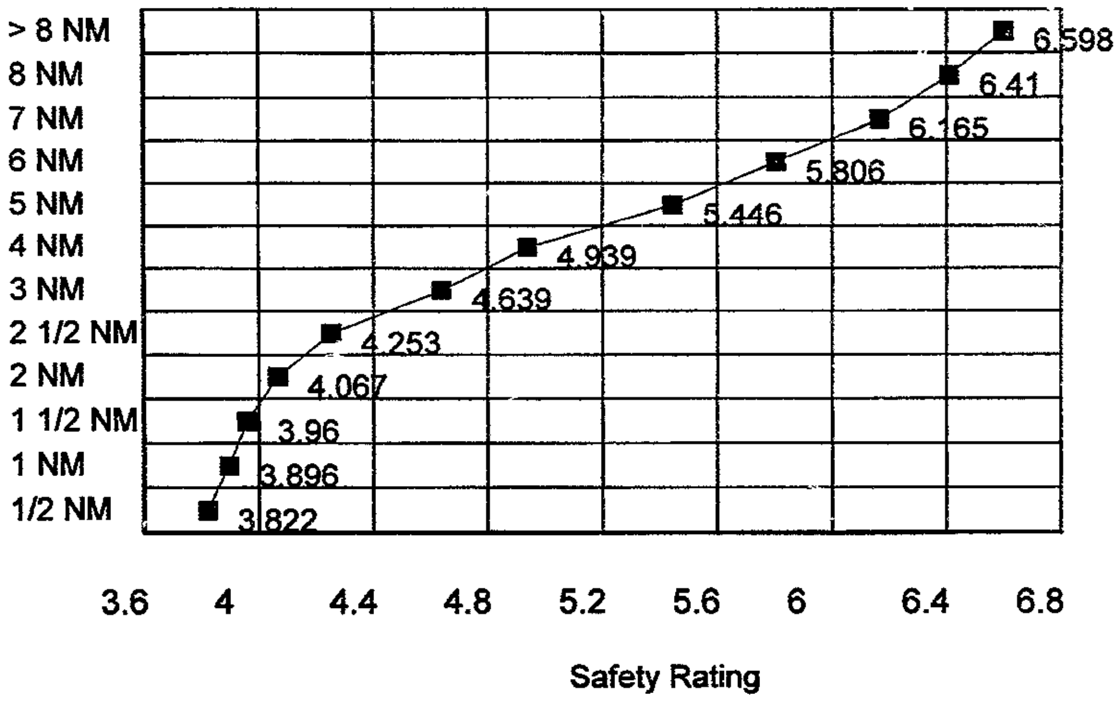
Safety Ratings of Precipitation by Expert Pilots



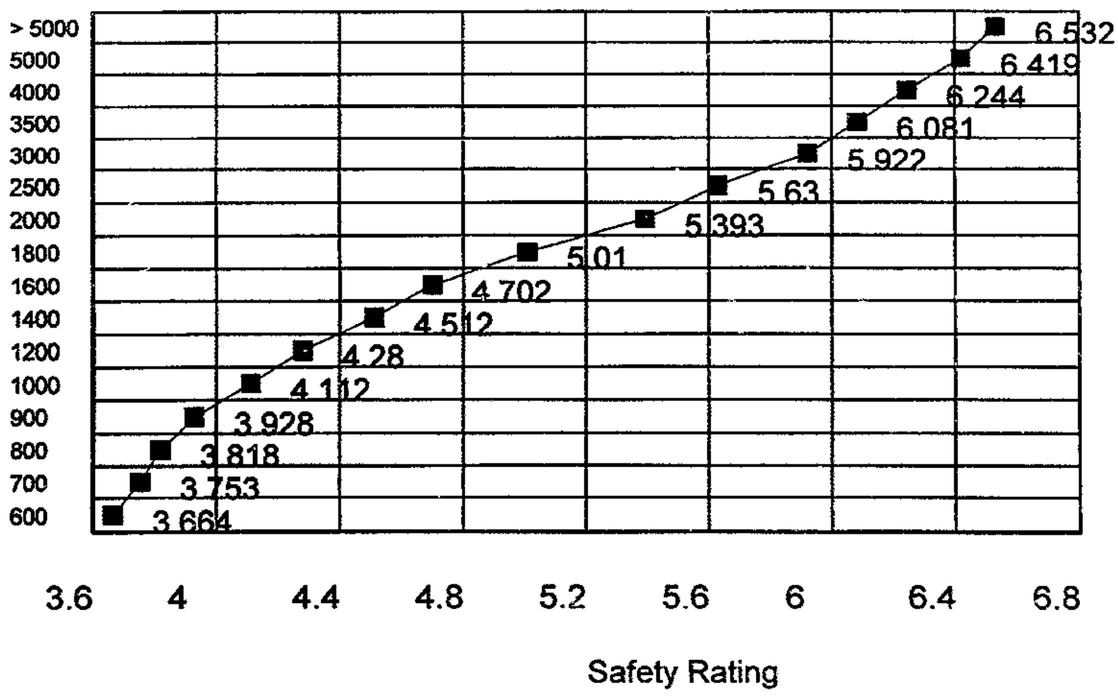
Safety Ratings of Terrain by Expert Pilots



Safety Ratings of Visibility by Expert Pilots



Safety Ratings of Ceiling by Expert Pilots



For all ratings, Mean = 5.00; Standard Deviation = 1.00

APPENDIX E

SELECTED PAIR COMPARISONS AMONG POLICY GROUPS FOR EACH SCENARIO

(All mean differences statistically significant for $p < .05$)

Highlights of Characteristics for Mountainous Terrain Groups:

GP1	S-N:	Senior-Nominal Policy Group: (Mountainous)
S-N	J-N	Compared to the Junior-Nominal group, this Senior-Nominal group has:
51	41	Higher average Age
36%	59%	Lower percentage report PP as highest certification
S-N	J-B	Compared to the Junior-Bold group, this Senior-Nominal group has:
51	34	Higher average Age
2.43	1.19	Higher experience with Ceiling 800 FT
3.50	2.52	Higher experience with Ceiling 1800 FT
36%	68%	Lower percentage report PP as highest certification
2.00	1.19	Higher experience with Precip Moderate Rain
43%	16%	Higher percentage own aircraft
1969	561	Higher average Total Hours Flown
S-N	S-C	Compared to the Senior-Cautious group, this Senior-Nominal group has:
.83	.60	Higher average R-Squared (Use of Expert Info)
47	21	Higher average Hours Flown Last 90 days
3.50	2.50	Higher experience with Ceiling 1800 FT
36	17	Higher average Comfort Level
3.14	2.25	Higher experience with Visibility 4 NM
3.86	3.28	Higher experience with Ceiling 4000 FT
66%	86%	Lower percentage fly for Pleasure
36%	61%	Lower percentage report PP as highest certification
2.43	1.58	Higher experience with Ceiling 800 FT
GP2	J-N:	Junior-Nominal Policy Group: (Mountainous)
J-N	S-N	Compared to the Senior-Nominal group, this Junior-Nominal group has:
41	51	Lower average Age
59%	36%	Higher percentage report PP as highest certification
J-N	J-B	Compared to the Junior-Bold group, this Junior-Nominal group has:
29	46	Lower average Comfort Level
41	34	Higher average Age
39%	16%	Higher percentage own aircraft
3.10	2.52	Higher experience with Ceiling 1800 FT
10%	6%	Higher percentage Female
1963	561	Higher average Total Hours Flown
1.81	1.19	Higher experience with Precip Moderate Rain
1.84	1.19	Higher experience with Ceiling 800 FT
2.59	2.10	Higher experience with Precip Light Rain
1.90	1.35	Higher experience with Visibility 1 NM
33%	16%	Higher percentage report COM/ATP as highest cert.
.80	.75	Higher average R-Squared (Use of Expert Info)

J-N	S-C	Compared to the Senior-Cautious group, this Junior-Nominal group has:
29	17	Higher average Comfort Level
.80	.60	Higher average R-Squared (Use of Expert Info)
62%	86%	Lower percentage flying for Pleasure
3.72	3.28	Higher experience with Visibility 8 NM
3.77	3.28	Higher experience with Ceiling 4000 FT
22%	5%	Higher percentage Primary Job as Pilot
49	21	Higher average Hours Flown Last 90 days
2.94	2.25	Higher experience with Visibility 4 NM
3.10	2.50	Higher experience with Ceiling 1800 FT
41	48	Lower average Age
1.90	1.39	Higher experience with Visibility 1 NM
GP3	J-B:	Junior-Bold Policy Group: (Mountainous)
J-B	S-N	Compared to the Senior-Nominal group, this Junior-Bold group has:
34	47	Lower average Age
1.19	2.43	Lower experience with Ceiling 800 FT
2.52	3.50	Lower experience with Ceiling 1800 FT
16%	36%	Lower percentage report COM/ATP as highest cert.
68%	36%	Higher percentage report PP as highest certification
1.19	2.00	Lower experience with Precip Moderate Rain
16%	43%	Lower percentage Own Aircraft
561	1969	Lower average Total Flying Hours
J-B	J-N	Compared to the Junior-Nominal group, this Junior-Bold group has:
46	29	Higher average Comfort Level
16%	39%	Lower percentage Own Aircraft
34	41	Lower average Age
2.52	3.10	Lower experience with Ceiling 1800 FT
561	1963	Lower average Total Flying Hours
1.19	1.81	Lower experience with Precip Moderate Rain
1.19	1.84	Lower experience with Ceiling 800 FT
2.10	2.59	Lower experience with Precip Light Rain
1.35	1.90	Lower experience with Visibility 1 NM
16%	33%	Lower percentage report COM/ATP as highest cert.
.75	.80	Lower average R-Squared (Use of Expert Info)
J-B	S-C	Compared to the Senior-Cautious group, this Junior-Bold group has:
46	17	Higher average Comfort Level
34	48	Lower average Age
16%	44%	Lower percentage Own Aircraft
.75	.60	Higher average R-Squared (Use of Expert Info)
6%	25%	Lower percentage Female
5%	17%	Lower percentage use Weather Source: Other
16%	33%	Lower percentage report COM/ATP as highest cert.
561	2140	Lower average Total Flying Hours

GP4	S-C:	Senior-Cautious Policy Group: (Mountainous)
S-C	S-N	Compared to the Senior-Nominal group, this Senior-Cautious group has:
.60	.83	Lower average R-Squared (Use of Expert Info)
21	47	Lower average Hours Flown Last 90 days
2.50	3.50	Lower experience with Ceiling 1800 FT
17	36	Lower average Comfort Level
2.25	3.14	Lower experience with Visibility 4 NM
3.28	3.86	Lower experience with Ceiling 4000 FT
86%	66%	Higher percentage flying for Pleasure
61%	36%	Higher percentage report PP as highest certification
1.58	2.43	Lower experience with Ceiling 800 FT

S-C	J-N	Compared to the Junior-Nominal group, this Senior-Cautious group has:
17	29	Lower average Comfort Level
.60	.80	Lower average R-Squared (Use of Expert Info)
86%	62%	Higher percentage flying for Pleasure
3.28	3.72	Lower experience with Visibility 8 NM
3.28	3.77	Lower experience with Ceiling 4000 FT
5%	22%	Lower percentage Primary Job as Pilot
21	49	Lower average Hours Flown Last 90 days
2.25	2.94	Lower experience with Visibility 4 NM
2.50	3.10	Lower experience with Ceiling 1800 FT
25%	10%	Higher percentage Female
48	41	Higher average Age
1.39	1.90	Lower experience with Visibility 1 NM

S-C	J-B	Compared to the Junior-Bold group, this Senior-Cautious group has:
17	46	Lower average Comfort Level
48	34	Higher average Age
44%	16%	Higher percentage Own Aircraft
.60	.75	Lower average R-Squared (Use of Expert Info)
25%	6%	Higher percentage Female
17%	5%	Higher percentage use Weather Source: Other
33%	16%	Higher percentage report COM/ATP as highest cert.
2140	561	Higher average Total Flying Hours

Highlights of Characteristics for Over-Water Terrain Groups:

GP-A	T-N:	Total-Nominal Policy Group: (Over Water)
T-N	T-B	Compared to the T-B group, this T-N group has:
27	40	Lower average Comfort Level
1%	5%	Lower percentage use Weather Source: None
1.71	1.29	Higher experience with Precip Moderate Rain

GP-B	T-B:	Total-Bold Policy Group: (Over Water)
T-B	T-N	Compared to the T-N group, this T-B group has:
40	27	Higher average Comfort Level
5%	1%	Higher percentage use Weather Source: None
1.29	1.71	Lower experience with Precip Moderate Rain

APPENDIX F

COMPREHENSIVE OCCUPATIONAL DATA ANALYSIS PROGRAM (CODAP)

Comprehensive Occupational Data Analysis Program (CODAP)

CODAP is a suite of software products developed by the US Air Force for the analysis of large bodies of occupational data, commonly obtained from job analyses and other studies of elements of the Air Force personnel system. In addition to its use by the Air Force, CODAP has also been adopted for use by foreign and domestic governmental units, including the Australian government and the state of Maryland. One use of CODAP which is particularly relevant to the current study is its application in studies of promotion boards. The linear modeling capabilities of CODAP components allow for the identification of the worth functions used by promotion boards in the evaluation of individuals for promotion. This process, which is often termed "policy-capturing" allows for the explication of the relative weighting which the board and the constituent members have applied to the available demographic, training, performance, and other data which are provided for each individual eligible for promotion in arriving at their global promote versus do-not-promote decision. In some ways this is highly similar to the decision process undertaken by pilots in evaluating the many elements of weather information prior to making their go versus no-go decision. A similar technique (conjoint analysis) has been used in previous studies of aviator decision making (Flathers, Giffin, and Rockwell; 1982).

GRPREL: (pronounced "Group" "Rel") A standard interrater reliability program in the CODAP system. For a given list of items rated by a set of Subject Matter Experts (SMEs), this program reports two measures of interrater agreement (R_{11} and R_{kk}). The R_{11} value indicates the reliabilitly of the observed set of ratings — while 0.10 is considered a minimum for usable rater agreement, a value of 0.20 or greater is desired. The R_{kk} value is driven by the number of raters acutally used. Although an R_{kk} of 0.90 is usually desired, it may not be practical in a particular study because of a small number of raters (SMEs) that may be subdivided even further into smaller groups based on policy differences. The GRPREL program also computes means and standard deviations for each item in the list. Item-level reports are printed in three orders: original sequence, ordered descending y mean value, and ordered descending on standard deviation. GRPREL computes each rater's correlation with the full-group mean vector and uses a probability evaluation to recommend the removal of deviant (non-cooperative or reversed scale) raters. The program can automatically iterate and remove flagged raters until either a sufficient level of agreement ($R_{kk} = 0.90$) is reached or no raters can be found with a probability (of deviant rating) above 0.95.

An overview of the CODAP system is provided by Christal (1974), and a complete description of the interrater reliability components is given in Staley and Weissmuller (1981). The interested reader is directed to those sources for a more complete technical description of these software analytic tools.

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