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Developing the Personal Minimums Tool for Managing Risk During Preflight Go/No-Go Decisions

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16. Abstract

This report describes the preliminary design of a structured method for pilots to construct personal minimums related to safety for use during preflight decision making. The design uses a three-step process by which individual pilots prepare personal minimums that apply to the scope of their routine flight activities. The approach encourages voluntary compliance with the self-generated personal minimums guidelines prepared in checklist form.

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INTRODUCTION AND OVERVIEW

As commonly employed, the term "personal minimums" represents an individual's set of operating criteria, procedures, rules, or guidelines used to assist that individual in making personal decisions. In this report, "personal minimums" pertains to the guidelines used by a pilot in making the preflight decision to go or to postpone the trip. The popular aviation literature contains many discussions of the benefits of personal minimums as a risk management tool to aid pilots in making this preflight go/no-go decision (e.g., Clausing, 1990). This literature offers anecdotal and narrative examples that suggest appropriate guidelines to minimize risks associated with aircraft flight. However, no accepted, structured method exists for compiling the guidelines into a usable tool. This report presents the results of a study to determine feasibility of providing such a tool. The results include a preliminary training program that provides pilots with a structured approach to generating their own personal minimums.

To introduce pilots to the idea of personal minimums as a risk management tool, this new approach emphasizes creating a set of self-selected, self-imposed minimums to guide the individual in making preflight decisions as opposed to relying solely on minimums imposed by others. The simplified training approach developed in this program uses a list of known risk factors to prompt pilots in selecting and writing guidelines that they expect will assist them in making successful future risk management decisions. To provide organization to the guidelines, a suggested taxonomy further aids pilots in placing their guidelines into an easy-to-use checklist so that each pilot may reference them quickly during subsequent use.

To introduce pilots to this new approach of self-imposed personal minimums and to provide an initial test bed to further evaluate the concepts incorporated, the research team designed a preliminary 90-minute training seminar. The seminar uses a flexible lecture-discussion format and incorporates both extensive examples as well as a case history to relate the program to real-world pilot decisions. Preliminary testing of the approach within the research group as well as discussions with potential users resulted in positive initial reactions.

To complete the training seminar design and to assure success in field introduction, the research team anticipates further testing and evaluation as prompted by four program goals. First, pilots with various flight experience, certifications, and flying time in various operational and geographic settings must perceive the approach as useful. Second, the Aviation Safety Program Managers, Safety Counselors, and other potential program instructors must input their program requirements to assure that this approach supports their efforts. Such instructor support will include providing easily used intervention materials as well as helping to reinforce the more general program efforts. Third, the preliminary nature of this seminar design requires further development., including input from pilots to assure successful implementation. Additional risk factors need to be identified, guideline examples written, and case histories found that are pertinent to a wider range of pilots. Fourth, formal evaluation will provide an avenue for enhancing and monitoring the success of this program. The evaluation process will provide useful data to modify the successful program.

This report is divided into three sections: background, product description, and future development. The *background* section describes the literature review that supports the development of personal minimums as a risk management decision support tool. Additionally, the background section contains the results and discussion of preliminary research tasks completed during the first year. This section may only be of value to teachers and researchers whose interest is in the program development process and rationale. The *product description* section describes the preliminary training intervention, its design, use, and intent. This section provides a detailed description of the training intervention and will be of interest to potential users such as pilots, instructors, Aviation Safety Program Managers, and Safety Counselors. The *future development* section outlines the next steps required to complete the development of the personal minimums concept and turn it into a program useful to pilots.

BACKGROUND

While the popular aviation literature has discussed personal minimums for some time, no rational, defensible method to generate these minimums has been established. In a search of the literature, no examples were found of a particular pilot's written personal minimums. On the other hand, several examples of organizational decision aids or job aids, such as the U.S. Forest Service Aviation's Go-No-Go Checklist (Figure 1) were found. Also, there are numerous standard operating procedures (SOPs) that can be found in most large flying organizations.

Three literature areas/sources were examined to provide the background for developing a personal minimums tool to manage risk during preflight. First, the basic aviation decision-making literature was examined for examples of ways to assist pilots in decision making tasks. Second, the general risk assessment and management literature was examined to provide the basis for teaching this aspect of preflight decision making. Third, because the target learners will be adults, an examination of the literature on the unique aspect of adult learning was examined for theory and approaches to teaching this population.

Pilot Decision Making Literature

The need for pilot judgment training was made clear in a taxonomy of pilot errors presented by Jensen and Benel (1977). Three broad categories of behavioral activities were identified: procedural, perceptual-motor, and decisional activities. Table 1 is a summary of fatal and non-fatal procedural, perceptual-motor, and decisional error proportions of pilot-caused accidents that occurred during the time period from 1970 through 1974 in U.S. Civil aviation. This finding has been reinforced in a recent study of ASRS incidents reported in airline operations in which cognitive errors accounted for almost half of the aviation incidents (McElhatton & Drew, 1993). It seems clear that pilot decision making errors result in aircraft accidents and incidents.

A practical model of pilot judgment was presented in Jensen and Benel (1977) with two parts: 1) an ability and 2) a motivation as shown below:

PART I: RATIONAL JUDGMENT

The ability to discover and establish the relevance of all available information relating to problems of flight, to diagnose these problems, to specify alternative courses of action, and to assess the risk associated with each alternative.

Table 1. Fatal and Non-Fatal Accident Proportions in Percent of Total for U.S. Civil Aviation Pilot Caused Accidents from 1970-1974 (Jensen and Benel, 1977).

Pilot Behavioral Activity	Fatal	Non-Fatal
Procedural	4.6	8.6
Perceptual-Motor	43.8	56.3
Decisional	51.6	35.1

GO/NO-GO CHECKLIST

If any one of the following situations is present cancel the trip. If already in flight ask to land until conditions warrant continuing.

1. **Visibility and Ceiling Requirements.**
   AIRPLANE—Two miles visibility and five hundred foot ceiling.
   HELICOPTER—One-half mile visibility and five hundred foot ceiling.
   You must always have these minimums.
2. **Foggy Weather**—Beware of fog, make certain ceiling and visibility minimums are present and you won't get caught in the fog.
3. **Snow Squalls**—Snow squalls develop very quickly in the spring and fall months. Maintain ceiling and visibility minimums and remember they can deteriorate extremely fast.
4. **Wind**—*Thirty knots of wind speed are the maximum allowable because of emergency water landing* conditions and turbulence.
5. **Mountain Passes**—If passes are partially obscured and appear marginal do not enter them for investigation. It may be too late to turn around.
6. **Pilots**—Watch for indications that the pilot's mental and physical condition are not conductive to safe flying, i.e., anger, tiredness, nervousness, or inattention.
7. **Aircraft**—Be concerned if you observe damage, dirt, fuel or oil leaks. Report it to the Aviation Officer.
8. ***In Flight Communications****—Make sure radio communications are maintained with dispatcher or FAA.*
9. **Loose Cargo and Overloading**—Never overload an aircraft. Make certain the pilot has all cargo secure.
10. **Passenger Briefing**—The pilot must give you a briefing before departure on where the emergency equipment is and how to use it.
11. **Personal Protection Equipment**—You must wear a FS inflatable vest with a survival kit in a helicopter over water. Although you don't have to wear them in an airplane they must be made available to you. We strongly urge you to wear them. A flight helmet, fire resistant coveralls, and gloves will be furnished to you and must be worn on all helicopter flights.
12. **Helicopter Foreman**—A qualified helicopter foreman is required to supervise each helicopter and is responsible for your safety around helicopters.

Figure 1. An example of an organizational go/no-go checklist used to guide pilots in making preflight decisions (United States Department of Agriculture, Forest Service, Alaska Region, 1987).

PART II: MOTIVATIONAL JUDGMENT

The motivation to choose and execute a suitable course of action within the available time frame.

The first part (rational judgment) is the mental ability of the pilot to detect, recognize, and diagnose problems, to establish available alternatives, and to determine the risk associated with each alternative. This part is purely rational, and if it could be used alone (which is not possible), would allow problem solving using mathematical functions in much the same manner as a computer. This does not mean it would be error free; it uses information that is probabilistic and therefore, predicts outcomes that are not certain. In addition, rational judgment depends upon the amount, type, and accuracy of the information stored in the pilot's memory as well as his or her learned capabilities to retrieve and process information. To optimize rational judgment requires high levels of knowledge, experience, organized mental structures, and systematic computational and problem solving abilities.

The second part is motivational judgment or the bias aspect of judgment. The emphasis is on the directional rather than the aspects of motivation dealing with intensity. This part of judgment says that humans (and pilots) base their decisions, in part, upon bias factors or tendencies to use less than purely rational (as defined by society) information. These factors include immediate gratification such as ego, adventure, commitment, duty, social pressure, and emotional arousal in the form of worry, fear, stress, anxiety, and euphoria, as well as more long term biases such as risk-taking attitudes, and personality factors, e.g., fear of failure and defensiveness. Optimizing motivational judgment requires both 1) an awareness of biasing factors and 2) a will (motivation) to suppress these error producing factors so that decisions can be made on the basis of relevant safety factors from the physical world.

At this time, the rational aspect of pilot judgment has received very little attention in aviator research. However, there is much in the literature outside of aviation, including studies related to stock brokers, livestock judges, and medical diagnosticians, indicating that this aspect of judgment, can be taught. In each of the areas studied, judgmental training occurs over a fairly long apprenticeship program in which the trainee observes the expert make decisions and learns by observation. Bill Rouse and his colleagues have performed a series of experiments to develop fault diagnosis training systems to be administered on computer (Rouse, 1979). One demonstration study at Ohio State (Jensen, Adrion, and Maresh, 1986) has shown the effectiveness of the DECIDE model in teaching rational judgment to pilots.

On the other hand, the motivational aspect of pilot judgment has received the bulk of research. Early efforts following the Jensen and Benel study focusing on this part of the model have shown that motivational training can be effective. The model used in all of these studies may be called the attitude model or five hazardous attitudes, Anti-Authority, Impulsivity, Invulnerability, Macho, and Resignation. An awareness of these attitudes, that are found to some extent in everyone, can help to develop a more positive and rational approach toward flying decisions. Training studies using this model have demonstrated that pilot decision making improves anywhere from 13 to 100 percent as a result of attitude training (Buch and Diehl, 1982; Telfer, 1989; Telfer, 1987; Diehl, 1987; Diehl, 1992; Fox, 1991; Alkov, 1991). Even more impressive results have been provided by two helicopter operational training studies. Petroleum Helicopter Inc. (PHI) and Bell Helicopter have both offered the attitude method of judgment training to large numbers of helicopter pilots. PHI has reported a 54 percent reduction in accidents after giving this training to their pilots. Bell Helicopter in two studies reported a 36 percent decrease and a 48 percent decrease in accident rates after the training. Both organizations point to the judgment training as the most important tool now available to improve safety in helicopter flying. However, attitude training, as it has been tested in each of these research programs, has negative connotations and its benefits seem to have reached a plateau. Perhaps, greater emphasis needs to be placed on the rational side of the model emphasizing information processing.

Classical versus Natural Decision Making. The rational part of the judgment model is closely related to what has been called classical decision making (CDM). CDM is characterized by utility theory, Baysian approaches, and other normative models of human decision making. Beach and Lipshitz (1993) provide an extensive list of reasons why this approach may be inappropriate in natural settings, like flying. Orasanu and Connelly (1993) suggest naturalistic decision making (NDM) as an alternate conceptual framework. While CDM can prescribe what to do and help explain why, NDM is basically descriptive, not prescriptive. CDM recognizes that even a completely rational approach, even one aided by "perfect" mathematical models run on computers, would not result in error free flight since the information that pilots must use is probabilistic and contains errors. NDM includes aspects of motivational judgment mentioned in the model of pilot judgment. For a much more detailed description of CDM and NDM as they apply to aviator decision making, please see our sister report to the FAA (Jensen, et al., in preparation).

Risk Assessment and Management Literature

Recognizing that risks exist, pilots and managers of flight operations implement a variety of methods to assess and manage the risk. A common method involves providing a written set of SOPs. Many operations also use systems-based approaches including pilot selection methods, on-going safety programs, training of pilot and non-flying personnel, and other management support methods. None of these methods alone can be expected to eliminate accidents, but together, the more comprehensive systems-based approaches such as these improve safety significantly (Adams & Payne, 1992).

Risk and Uncertainty. Rowe (1977) defines risk as "the potential for realization of unwanted, negative consequences of an event" (p. 24). At the general level, Rowe further represents risk as involving two major components: (1) existence of a loss or unwanted consequence, and (2) uncertainty in the occurrence of the consequence expressed as a probability. Both components are important in risk assessment. In the absence of loss or unwanted consequence, there is no risk. And in the absence of uncertainty, risk does not exist.

Risk assessments can be performed using either the CDM or the NDM approach. Most of the risk assessment literature adopts the CDM perspective. Classic decision theory assumes that there is an optimal or best choice to be made in any decision and that models can be used in many situations to analyze and determine which alternative is best. Such an approach has been taken in military command and control, business management, and medical diagnosis. The second is an evaluation of risk at the time some situation warrants: In real-time risk assessment the NDM approach may be more relevant. In our context, both approaches seem to be relevant. While the CDM rational approach is likely to work best in establishing personal minimums in a setting apart from actual flight, the NDM approach may become more relevant when the pilot is attempting to apply the personal minimums in the context of actual flight preparation.

Uncertainty exists in the absence of information about past, present, or future events, values, or conditions (Rowe, 1977, p. 17-18). Two major types of uncertainty are involved: (1) *descriptive uncertainty*—absence of information relating to the identity of the variables that explicitly define a system (inability to describe the degrees of freedom of the system), and (2) *measurement uncertainty*—absence of information relating to the specific value of each variable in a system. This distinction suggests two ways to help pilots: a) identify relevant risk dimensions and b) determine the associated values for cost and probability.

Developing Takeoff Guidelines. Even when the relevant dimensions (factors or variables) are known, pilots rarely have tools that allow them to assess the probability of occurrence, to weigh the existence of unwanted consequences, or to manage uncertainty. Rarely do general aviation organizations offer risk assessment models to assist pilots in their analysis of preflight go/no-go decisions. Several organizations have approached the problem of making rational preflight go/no-go decisions by providing simple prescriptive decision tools. Generally these tools are checklists or operation manuals that say, "if these conditions exist, then do not fly." Other aviation organizations have approached the problem by applying more complex risk assessment techniques. The best examples have typically been for helicopter operations such as emergency medical evacuation or rescue where aircraft accident rates have been higher than desired. The usefulness of such methods have been shown to be highly dependent upon the type of operations or missions flown (Shively, 1990). A brief description of three such assessment tools follows.

The U.S. Army's ALERT (Aviation Litmus Evaluation Risk Test) is a paper and pencil based evaluation process intended to assist aviation operations commanders in assessing risk (Boley, 1985). ALERT gives its users a method to evaluate the probability and magnitude of flight risks for the following six elements: supervision, planning, crew selection, crew endurance, weather, and mission complexity. A set of matrices assigned a numeric risk value to each element (see Table 2). The linear element design of this approach produced a sum value for each element. The total was used to assign a qualitative risk value which was then rated as low risk (0-12), caution (13-23), or high risk (24-30) for each operation. The unit commander would then use the ratings to assist in preflight decisions concerning risk management. To decrease risk, the commander may change any of the six elements in order to achieve an appropriate or acceptable risk level.

The U.S. Coast Guard's REARM (Risk Evaluation and Aviation Resource Management) system consists of a modified and extended version of ALERT (Shively, 1988). Coast Guard applications were for helicopter medical evacuation operations. While the basic structure of ALERT is used in REARM, attributes and verbal descriptions of the variables were changed to accommodate representative Coast Guard missions (mission type was changed from "support", "nap of the earth", and "night vision goggles" to "site", "hospital", and "scene" mission) and two factors (crew experience and weather) were expanded to permit a further differentiation of variable effects (see Table 3). The risk value for wind in excess of thirty knots was increased by 1 for each 10 knots. Risk values for night were multiplied by 2.5. As with ALERT, REARM's values were summed to predict a relative level of mission risk. The scale was divided into four parts: normal (6-16), caution (17-25), coordination required (26-35), and danger (36-40). The matrices total provided the pilot with a risk assessment and recommendation of the level of supervision that should make the go/no-go decision.

The NASA Ames Research Center developed a risk assessment tool called, SAFE (Safety Assessment for Flight Evacuation). The SAFE approach is similar to ALERT and REARM but it uses a personal computer based expert system (EXSYS) model to predict risk profiles on civilian emergency medical services (EMS) helicopter operations (Shively, 1990). The computer increased speed, accuracy, and efficiency of the risk assessment. This approach permits factor interaction to be incorporated and variable weighting of factors. Five types of factors were investigated: mission, crew, organizational, environmental, and aircraft. These factors were further divided into subdivisions to allow rank ordering as to their influence on risk. The subdivisions for the crew factor are shown in Table 4. For example, weather received a higher weighting due to its greater correlation with EMS accidents. Interaction may be shown between level of supervision, weather, and crew experience. With pilot use, SAFE's automatic data collection feature aids the programs evaluation as well as its continuing research.

The extent to which any of the mentioned models are in routine use, as well as their acceptability to pilots and management, would provide guidance as to the efficacy of the approach and its potential applications in general aviation. Only limited field test data are available in the open literature. Further testing is needed.

Training Adults

It is important to consider two basic educational issues in our discussion of the preflight situation. The first issue concerns the most effective ways to train adults in applying advanced skills such as problem solving and decision making (Means, et al., 1993). Due to sociological and organizational factors, adults differ from children and adolescents in how and why they learn. The second issue involves the study of decision making training in real-world decision making situations (Klein & Calderwood, 1991). These two issues are briefly reviewed to provide background

Table 2. Examples of ALERT risk value matrices (Boley, 1985).

Weather Risk Value Matrix

Wind Velocity (Knots)	Ceiling/Visibility: Clear	VFR (>1000-3)	Minimums
30	3	4	5
20	2	3	4
10	1	2	3

Crew Endurance Risk Value Matrix

Quality of Rest	Length of Rest: Optimum	Adequate	Minimal
Tactical	3	4	5
Training	2	3	4
Unit	1	2	3

Supervision Risk Value Matrix

Command Control	Mission: Support	NOE*	NVG**
OPCON	3	4	5
Ground	2	3	4
Aviation	1	2	3

* Nap of the earth
** Night vision goggles

Table 3. Example of REARM risk value matrices (Shively, 1988).

Weather Risk Value Matrix

Wind Velocity (Knots)	**Ceiling/Visibility**		
	Clear	**VFR (>1000-3)**	**Minimums**
30	3	4	5
>20	2	3	4
>10	1	2	3
<10	3	4	5

Table 4. SAFE crew factors as rank ordered by expert panel (Shively, 1990).

Crew Factor Variables

(As rank ordered by subject matter experts from most to least risky)

1) EMS experience of pilot
2) IFR currency of pilot
3) Crew rest
4) Pilot's familiarity with area

   a) en route
   b) at site

5) Pilot's familiarity with aircraft
6) Number of pilots/aircraft
7) Hours since last meal
8) Commercial rating

for the design of an intervention program to train pilots in making preflight go/no-go decisions and risk assessments.

Darkenwald and Merriam (1982) describe adult learning as a "complex phenomenon" that has commonalties with childhood learning, but also substantial differences. Among the differences, an adult has an independent self-concept, has the ability to be a self-directed learner, exhibits readiness to learn, and has a well established orientation to learning. Adults become more differentiated from each other as they age. Their psychosocial and physical development differ. They possess differing abilities to employ complex problem-solving strategies. They possess a rich and varied set of life experiences upon which to draw. As a result, "an adult's ability to acquire new information may have more to do with lifestyle, social roles, and attitudes than with innate ability to learn" (Darkenwald & Merriam, 1982, p. 75). Furthermore, all these factors combine to challenge any individual who is attempting to develop training for adults.

Knowles' (1980) concept of "andragogy", the art and science of helping adults learn, offers four points that have influenced many successful adult training programs. First, most adults have moved from being a dependent personality to that of a self-directed individual. As a result, adults tend to want to influence what they learn and how they learn it. Forcing an unwanted or unacceptable approach on adults may not work well. Second, adults have a growing wealth of experiences that is a rich resource for learning. These experiences provide self-identity and are highly valued. The challenge is to use this experience without negatively challenging an individual's attitude, social role, or lifestyle. Third, an adult's readiness to learn is closely related to the tasks or social roles in which the adult participates. Adults with children may be interested in parenting classes. Pilots may be interested in aeronautical decision making (ADM) interventions. But pilots without children are unlikely to be interested in parenting, while parents who are not pilots are less likely to be interested in ADM. Thus, successful training must be pertinent to how they see their roles. Fourth, time perspectives change in adults. Adults take an immediacy of application perspective. This means what they learn must have an immediate application or they are unlikely to pursue the learning activity. Additionally, adults take a problem-centered approach. They tend to seek learning experiences that offer solutions to what they see as their immediate or anticipated problems.

The implications of these approaches to adult training are that interventions must address all of these issues to be effective. They must account for a wide range of experience and multiple social roles. A program should actively involve the adult learners in the training program at many levels. That is, from planning to participation. Learning should draw upon the experience of the participants. Such learning is often implemented in the form of group discussion so that experiences can be shared and valued. Finally, the training must be clearly useful and applicable to the anticipated tasks or social roles of the participants.

Real-World Decision Making Training

The literature is quite clear that in designing a decision making training program, one must give careful consideration to the real-world context in which the decision are being made. Klein and Calderwood (1991) reviewed field research and laboratory studies which show that people, especially experts in a domain, do not conform to the normative decision making model in natural settings. Actually, normative models more accurately describe what beginners do (Orasanu and Connelly, 1993). Beach and Lipshitz (1993) argue that the classical decision theory is an inappropriate standard for evaluating and aiding most decision making and cite four points. First, they argue that real-life decision tasks often differ markedly from those for which classic decision theory was designed. Second, professional decision makers seldom rely upon classical theory to make their decisions. Third, classical decision theory's reliance upon gambles as an all-purpose analogy for decisions does not apply in many natural settings due to the fundamental role of control. Fourth, the classical decision theory assumption (that use will improve decision success) is empirically unproved and questionable.

Means, Salas, Crandall, & Jacobs (1993) argue that decision making training needs "to take into account the specific characteristics of the task and of the social and organizational context within which it is performed" (p. 326). Orasanu and Connolly (1993) characterize decision making in real-world or naturalistic settings as including some or all of the following features: (1) ill-structured problems, (2) uncertain dynamic environments, (3) ill-defined, competing, or shifting goals, (4) action/feedback loops, (5) time stress, (6) high stakes. (7) multiple players, and (8) organizational goals and norms. Such characteristics exist in preflight decisions.

Means et al. (1993) offer three reasons why ignoring context creates problems. The first basic argument is that, "decision training based on classical decision theory has not been shown to transfer to natural tasks outside the classroom" (p. 326). Studies "suggest that formal models taught in professional programs do not get used on the job by business managers, financial analysts, or medical diagnosticians" (p. 307). This training approach is not effective because the circumstances under which the model is taught and practiced, and the model's view of decision making are inconsistent with real-world decision making. Inconsistency may be attributed to ill-defined problems, information that resists quantification, or decision tasks that are embedded in other activities, goals, or emotions. Furthermore, when decisions must be made under time pressure, normative models require too much time. Heuristic choices, such as using rules of thumb, may be more accurate than a truncated normative model in a particular domain. Finally, many formal models require more effort than they are worth. Some are too complex, difficult, or time consuming. Therefore, under time pressure, the added cognitive processing load may be too much.

The first argument raised by Means et al. (1993) supports the distinction made between analysis and evaluation as different kinds of risk assessments that most likely need to utilize different approaches. The second argument they raise, points to the fact that evaluation must always consider time constraints, but analysis can occur in a more relaxed environment. However, their third argument suggests that pilots should *not* be turned into amateur decision analysts. If decision analysis supports risk assessment, pilots should be shown the results, rather than expecting them to perform any analysis themselves. Decision analysis would require an extensive knowledge of the probability theory that few pilots have, and it is unreasonable to expect they would want to learn about decision theory just so they can assess risk on a logical basis.

An argument for including decisional characteristics and context is that bias training transfers only marginally to natural settings (Means et al., 1993, p. 326). Bias reduction or elimination training is aimed at biases such as overconfidence, representativeness, hindsight, and confirmation. Such designs try to inhibit natural or intuitive ways of thinking. Inhibiting said ways is difficult to do in a single seminar or short-time-frame training program. The "five hazardous thoughts" is a form of bias training which may be the reason such training may have reached a plateau. Means et al. (1993) recognized that bias reduction training has some reduction effect within a task but that limited generalization of the bias extends outside the task. They conclude that with only minimal effects being shown in an experimental evaluation of these training programs, it is unlikely that the real-world effects would be long lasting.

Another basic argument for including decisional characteristics and context is that, "in real world settings, experts and novices differ in *how they use* their domain knowledge, *not in their ability* to use particular problem-solving methods or decision rules" (Means et al., 1993, p. 326). As individuals know more, they begin to understand things differently and often have the ability to frame the problem better. They develop abilities to reorganize information, to recognize familiar patterns, and to attend to critical indicators. These skills are domain specific and the expert's knowledge is highly proceduralized. These factors require differentiating *what experts know* from *how experts use their knowledge*. The critical point is that in many real-world decision making tasks, cognitive overload separates the novice from the expert.

Fundamental Training Evaluation

To measure training effectiveness in real-world environments, both formative (process) and summative (product) evaluation have value. Formative evaluation provides feedback to those developing training programs during the development process. Summative evaluation provides additional feedback at the completion of the development and following training program implementation. An efficient, effective training program requires appropriate evaluation of both the process and its products.

A fundamental and useful evaluation approach commonly used in training divides evaluation of effectiveness into four basic levels (Kirkpatrick, 1959). These levels are reaction, learning, behavior, and results. In practice, these levels are described as:

1) *Reaction* Did the learners like the training?
2) *Learning* Did the learners learn the objectives?
3) *Behavior* Did the learner's behavior change on the job as a result of the training?
4) *Results* Did the change in behavior make any difference in job performance?

Evaluation on these levels provide useful data to training program developers, instructors, sponsors, and others. Results for the first three levels could be expected for most programs addressing personal minimums. However, data on the fourth level, the results level, may be difficult and expensive to obtain.

INTERVENTION DEVELOPMENT

In the development of a preliminary methodology for teaching pilots to develop personalized minimums for preflight decisions, three primary tasks were accomplished, 1) a list of risk factors for preflight decisions were generated, 2) pilots were interviewed to develop prototype guidelines for personalized minimums, and 3) a preliminary training program to assist pilots in creating personal minimums was developed and tested. The following is a brief description of these tasks and their results.

Checklist of Preflight Factors

To compile a taxonomy of preflight go/no-go risk factors that contribute to flight safety for routine general aviation activities, the scientific and popular aviation literature relating to decision making, risk management, and related aviation areas was reviewed. Particular emphasis was placed on pilot characteristics, aircraft characteristics, environmental conditions, and operational activities. Some examples of risk factors identified by these sources are visibility, cloud ceiling, cross-wind component, precipitation, daylight, night, topography, and total and recent flight.

Given the list of risk factors, the question remains, can pilots use them to assess risk levels for any particular flight? The literature offers mixed findings on pilot abilities to identify risk factors and assign priorities, particularly multiple factors using multiple criteria. Research shows that pilots can assign values to risk factors (Flathers, Giffin, & Rockwell, 1981; Curry, 1976), when making flight related decisions such as diverting from a flight plan or in landing situations. However, these decisions are related to technical flight decisions, not preflight choices to minimize risk.

On the other hand, some of the literature suggests that pilots do not analyze risks well. Collins (1986), using informal interviews concluded that "the risks perceived by the five pilots queried turn out to be not significant" (p. 67) when compared to accident statistics. Collins further states that "pilots insulate themselves from reality, imagining risks where none exist and ignoring those that are real." Robb (1984) suggests that any such approach must provide guidance on key factors and on the appropriate weights given to those factors.

Initial Pilot Interviews

To obtain information from pilots on preflight decisions, an interview guide was developed and administered to six pilots at a large southern fly-in. Most of those interviewed routinely flew single-engine airplanes, and two of those interviewed had instrument ratings. These semi-structured interviews consisted of general questions concerning preflight actions, guidelines or rules used to make the go/no-go decision, risk factors in aviation, and examples of risky situations from their past flying. The interviewer identified himself as a researcher studying pilot decision making, particularly go/no-go decisions. At no time was the individual pilot's name requested, but most interviewees offered at least their first name.

An attempt was made at the start of each interview to establish trust between the interviewer and the pilot. The most common initial question asked by the interviewee was, "Do you represent the FAA?" The concern was that the interview was a trick to get them to admit to violating FARs and that enforcement action would follow. The interviewer's response was that the research was in support of a FAA funded project. They were told that the interviewer did not represent the FAA and that any information collected could not be traced to the pilot. That trust was maintained and no data were recorded that could be linked to the pilot.

Questions concerning the pilot's preflight actions produced frequent mention of the aircraft preflight and the weather. Preflight actions also included fuel and oil checks, draining the sumps, and checking instruments and avionics. Some pilots reported that working with the weather information caused problems. One pilot complained of "too much information" and that the DUAT (Direct User Access Terminal) system was "confusing". He preferred to talk with someone. Another stated that "FSS (Flight Service Station) doesn't want us to fly, there is always bad news from flight service." Most of the pilots interviewed used both the FSS and the DUAT system as a routine part of all their cross-country flights. However, one pilot did state that he often would "go up to see how it is, then come back" if he did not like the weather.

When asked about the guidelines or limits that they placed on themselves, some provided good suggestions while others were reluctant to make such statements or to put risk values on situations. Marginal visual flight rule (MVFR) conditions (ceiling 1000-3000 AGL, visibility 3-5 statute miles) tended to be the point at which pilots started to draw the line on visual flight rules (VFR) cross-country flights. Particular concern was noted as the ceilings approached 1000 feet above ground level (AGL). One instrument rated pilot did not fly in what he termed hard IMC (instrument meteorological conditions) and described as ceilings below 1000 feet, any icing, or thunderstorms. This pilot offered the comment that flight following was an "excuse to violate the rules." Another rule offered was that VFR over-the-top was "not smart."

All pilots were asked the question, "in the context of piloting an airplane, what does 'risk' mean to you." While no good definitions were provided, every pilot made some statement acknowledging that risk existed in aviation. One pilot put it simply, you are "crazy if you don't think it (risk) exists." Another added that there is "never a time of no risk." Most pilots however, offered situations that they consider risky. These included cross country flights, quickly deteriorating weather, being low on fuel, rain showers, lowering ceilings, turbulence that is uncomfortable, mountainous terrain, extended over-water flights, single engine flight at night, being hurried to be on time, being too optimistic about one's pilot capabilities, and lack of proficiency. A few pilots made comparisons to other activities. One compared single-engine flying to the risk of riding motorcycles, which he also enjoyed. Another stated that the risk in flying general aviation aircraft was "less than driving a car."

To assist in generating risk factors and guidelines used to manage them, pilots were asked about situations in the past that concerned them in any way. Although some of the pilots were initially reluctant to talk about their own situations, all eventually recounted a specific situation. Two such examples were given by two pilots who had each accidentally run a fuel tank dry causing the engine to quit. One of these was as a student pilot with an instructor on-board. A second pilot had run a tank dry on a high performance aircraft. He said it took 15-20 seconds to get the engine restarted. The same pilot had a retractable gear stick in the "up" position. Another recounted a strong gust that resulted in a go-around in California. An eastern U.S. pilot told of trying to get home from a fly-in by flying through a valley with the tops of the mountains obscured. Flight service had said the weather would be "OK" but rain showers quickly developed and visibility dropped. The only escape had been to turn around and follow a set of railroad tracks out of the valley. The factors that had generated concern in these past situations represent possible learning experiences for pilots about preflight decisions.

When asked to supply suggestions about training pilots to reduce risk, several examples were offered. Some simply stated that a pilot must maintain proficiency for whatever type of flying she or he planned (such as taildraggers, instrument conditions, or in marginal weather). One pilot recommended extensive reading, then went on to provide a short list of specific things to read that included some popular aviation magazine to read that included some popular aviation magazine columns, training manuals, and some classic piloting texts such as *Stick and Rudder* (Langewiesche, 1944). A unique suggestion was a game in which several pilots went on board the same airplane. After they had flown out of the local area, one pilot was placed under the hood for several minutes and given vectors to fly by another pilot. The pilot under the hood then took it off and started to find his exact location while still flying the aircraft. The pilots took turns. The winner was the one who found his location in the shortest time. They varied the rules on what methods could be used to identify their location.

These pilot interviews produced several findings useful to our approach to assisting pilots in making preflight decisions. (1) Pilot awareness of the range of decisions needed during preflight should be increased. (2) This awareness should expand the number of factors considered, the extent of risk involved in these factors, and provide guidelines for evaluating the factors that apply to their individual flight operations. (3) Pilots need to understand that risk exists and have reasonable ideas for managing that risk. (4) Pilots need help using current forms of weather information to make decisions. (5) Pilots are interested in training interventions that assist them in making decisions, if they meet their learning needs and are easily available to them.

Guideline Development and Intervention Testing

Following the interviews, the project moved into two areas: (1) identifying guidelines that pilots use in making their decisions, and 2) intervention initial testing. The guidelines developed are not an exhaustive set, but examples of guidelines that pilots consider usable in their environment. The training intervention product is expected to be a test bed for evaluating the feasibility of using a flexible strategy for helping pilots to establish preflight personal minimums.

Guideline Development. The review of the literature, the pilot interviews, and the experience of the project staff produced numerous examples of guidelines used by pilots when making their preflight decisions. This preliminary list of guidelines is intended to show the range and types of examples of guidelines that pilots use in making preflight decisions. It is not an exhaustive list, but it does contain key elements to help stimulate discussion and generate guidelines applicable to particular pilots.

For purposes of the pilot interviews, "guideline" was defined as, "A statement, such as a policy or rule, for conduct." Guidelines include acronyms, rules of thumb, regulations, standard operating procedures, and so forth that assist pilots in preflight decisions.

During this task, many pilots often agreed on the general nature of a guideline, but they often disagreed over the specific quantities or qualities that should be placed in any particular one. An example would be a guideline to define minimum currency. Some pilots stated that the minimum FAR requirement of three takeoffs and landings in the last ninety days was sufficient. Another suggested that if a pilot with only a few hundred hours total time, did not fly at least fifty hours per year, she or he might not be safe, but if a pilot had five thousand hours total time, then five hours a year might be sufficient.

These discussions highlight the fact that pilots consider similar guidelines but often disagree on the specifics within a guideline. Of particularly concern to the pilots is whether they set their own standards or have limits imposed on them. However, some pilots, usually the less experienced ones, tended to prefer more assistance from instructors in setting their own limits. The more experienced pilots preferred to set their own limits. These results could be interpreted to mean that, with varying amounts of assistance, most pilots who set their own limits would be more likely to comply voluntarily with those self-set limits than those whose limits are imposed on them.

Intervention Initial Testing. A preliminary training intervention was then developed to teach pilots to set personal minimums. The instructor's guide for this training intervention is presented in Appendix A. The research team wanted answers to several questions concerning the intervention. How would pilots respond to the personal minimums concept? Could pilots identify factors influencing preflight decisions? Could pilots write guidelines that pertained to their routine flight activities. Could pilots evaluate guidelines written by other pilots? Finally, how would pilots evaluate the training intervention?

To test the preliminary intervention, seven individuals from our research group participated in a ninety minute program conducted by a pilot/flight instructor facilitator using the preliminary instructor's guide. Six of the seven were pilots. Among them were airline transport, instructor, commercial, private, and student pilot certificate holders. One rated pilot was no longer actively flying. The student pilot had soloed. Pilot ages ranged from approximately twenty to fifty. All participants were college graduates.

The results of this test were useful to the further development of the program confirming several of our ideas concerning the approach taken. Pilots responded favorably to the concept of personal minimums. They participated actively in the discussions, completed each exercise, and offered numerous comments during the evaluation following the training seminar. They recognized the benefits of establishing personal minimums as illustrated by statements such as, "standard operating procedures are not enough by themselves", "knowing your own limits is important", and "admitting that one has limits takes away some anxiety of not knowing where those limits end." A comment was also made that, like the FARs, personal minimums are intended to "protect us rather than restrict us."

The pilots participating were able to identify factors influencing preflight decisions. When asked for examples, the pilots were able to provide them orally in the discussions and written in the exercises. However, the number of factors they could generate in the time provided (approximately 5-10 minutes) was limited. More experienced pilots tended to have more factors than did those with less experience. Group listing and discussion of risk factors tended to generate interest and additional factors.

Pilots were able to write guidelines that pertained to their routine flight activities. However, the list generated by each pilot consisted of three to five guidelines. During the portion of this activity when pilots wrote sample guidelines, the list of factors provided as samples was used extensively. This would indicate that pilots need to be prompted as to which factors are involved in their activities. The list was helpful in expanding the number of guidelines they might be able to produce under time pressure. The list of risk factors could be used as prompts for pilots in training seminars to generate their own guidelines. These individually produced guidelines generated both additional examples, as well as modified existing ones during the group discussion.

The evaluation of the seminar consisted of a group discussion of the pros and cons of this approach. Generally, the comments were favorable and expressed enthusiasm for an approach to generate personal minimums. The flexibility of the format to generate a useable set of personal minimums was favored because the opportunity to add or delete items gave the individual pilot "control." General encouragement was offered to try the intervention on a wider group of participants. The case history used was well received because it gave a related problem to solve and generated ideas for risk factors. The pilot in the case history had a difficult go/no-go decision to make. The pilots studying the case history wanted to know "what they could do to help" the troubled pilot in the case history to more easily make his preflight go/no-go decision.

The evaluation of a sample set of personal minimums illustrated the potential problems. A sample guideline for thunderstorm clearance contained a non-standard number for the distance from thunderstorms that the pilot would maintain. Questions were asked, where did you get that number and how do you know if it is right. Since the sample was only a dummy one to generate discussion, no one's feelings were damaged and the discussion could continue. If the guideline had been identifiable with someone in the seminar, such questions could have made the individual defensive or ended discussion in general so as to avoid embarrassment. A method to generate discussion is important to increasing the learning potential, but embarrassment in front a peer should be avoided or minimized.

During the initial test, the pilot and the aircraft categories tended to follow a conventional line of thought. The pilot category attracted guidelines that addressed the experience, capabilities, physiological health, psychological health, and so forth of the pilot. Similarly, the aircraft category contained conventional preflight items such as fuel load, performance characteristics, number of engines, maintenance conditions, equipment, and so forth. The remaining three categories tended to consist of less defined items, and the same guidelines were often included in various categories by different pilots. The environmental category usually contained the meteorological guidelines. Additional items included airport lighting, navigational aids, terrain features, and others. Operational/mission categories tended to include not only the types of flight operations such as night, over-water, personal, fun flight, training, but other items including towing gliders and banners, aerobatics, aerial applications, emergency medical flights, business meetings, family trip, high altitude flight, and so forth. The organizational/sociological category tended to include items that characterized the pressures that are placed on the pilot-in-command and alternate ways to manage such pressures. The examples included the need to get to a meeting or home, how to handle a higher ranking or executive passenger, pilot briefing statements concerning alternate plans, and so forth.

General comments suggested that an initial introduction of the concept of personal limits was necessary, but it should be shorter, faster moving, and harder hitting. Pilots suggested the need for a short video or slide presentation as opposed to an oral presentation. This comment was also emphasized during program management review of the approach at the FAA. Participants also wanted to have an opportunity to prioritize the risks so that the most threatening could be addressed. Further consideration should be given to this question. The interaction of two or more factors also needs to be considered. Interaction effects will be more complicated to address.

Intervention Design Concepts

The design concepts for the preliminary training seminar developed for using personal minimums as a risk management tool during preflight decisions are based on four major concept features. These features include:

1) aiding pilots in the identification of risk factors,
2) building commitment to support use of personal minimums,
3) providing credible examples to a wide range of pilots, and
4) providing an easy-to-use format for generating personal minimums.

Identifying risk factors. Risk factors form the basis for personal minimum development as an approach to managing risk associated with flight. Three reasons support this approach. First, the approach allows pilots to identify and highlight major risk factors that many pilots recognize and might classify as "high risk" or "killer" factors. These include thunderstorms, icing, lack of currency, poor preflight planning, and so forth. The intervention uses these factors as a way for pilots to describe actions they deem useful and are willing to follow to prevent or reduce the effects these factors could potentially have on their flight. From these risk factors flow guidelines for personal minimums. For example, pilots may state (as their personal minimum) that they will do a complete preflight prior to each cross-country flight. They may define what their complete planning entails as well.

Second, the training intervention offers group discussions and examples that widen the range of factors that an individual pilot might consider for her or his own personal minimums. These discussions provide exposure to new factors as well as expand the pilot's knowledge base. For example, a pilot may not file a flight plan because no immediate safety benefit is recognized. However, during the group discussion, benefits may be recognized that go beyond providing a place for rescuers to start the search for a downed aircraft. Hence, filing the flight plan may take on more practical meaning and importance to the pilot (e.g., flight planning). As a result, the pilot may do both the flight planning and filing of a flight plan in the future as her or his minimums.

Third, the identification of key factors allows the pilot to customize or individualize the risk factors into guidelines developed for the types of flying that are done on a regular basis. By excluding items that are irrelevant to the pilot, time and effort are not expended on unimportant items and the time can be focused on those of optimum importance. If a large general list of personal minimums is generated, many pilots would be expected either to not use the list or to modify it by eliminating those items that do not pertain to them.

Building Commitment. Building commitment is another major feature of the preliminary intervention. It involves the development of an individual pilot's commitment to the use of personal minimums as a risk management tool. Three mental forces are at work to bring about commitment: voluntary generation of personal minimums, generation of personal minimums in written form, and peer reinforcement for personal minimums use. The key is to gain commitment that is sufficiently strong that it has a positive effect in unsupervised flights.

The preliminary training intervention starts with a blank form upon which a pilot can produce his or her own set of guidelines. There is no preset list of imposed guidelines. There is instead a wide range of examples that pilots can use to assist them in writing their own set. The examples they do generate are their own and while the pilots may be asked to voluntarily share them with the group, they are never forced to let another pilot see them or evaluate them. Results of the initial field test reinforced this aspect. Pilots were reluctant to share any but their best or least controversial guidelines.

Writing down a set of personal minimums increases the commitment of an individual to his or her own set of minimums. When pilots are asked if they have personal minimums, most will answer that they do, but many have difficulty listing more than a few such limits. Generating a list tends to develop commitment to that list. The review, updating, and maintenance of a list is expected to further that commitment. To assist in generating an initial list, the intervention provides a simple place to start a list of personal minimums. Additionally, the pilots are specifically asked to make a commitment to these personal minimums in the form of a signed statement that the personal minimums reflect their best judgment as a pilot.

Peer pressure is a strong influence on any individual operating within a group. This is especially true among pilots. This pressure can be both negative and positive. As previously discussed, being embarrassed in the training seminar would be an undesirable example of the negative effects of peer pressure. In the intervention, positive pressure is used to build continued support for personal minimums. During the intervention the facilitator provides positive reinforcement throughout the program. Additionally, pilots are asked to have the personal minimums they develop reviewed by a trusted peer, confidant, or favorite flight instructor. The basic concept is that, for personal minimums to be an accepted practice within the pilot community, generating and using personal minimums depends upon the development of positive reinforcement by the community.

Identifying Credible Examples. Utilizing examples is a fundamental approach in learning. The preliminary intervention depends heavily upon providing and generating a wide range of useful examples of personal minimum guidelines for pilots. The range of experience levels and types of flight operations in which pilots participate are extensive for general aviation pilots. Creating a generic set of minimums applicable to all is impossible. However, the general aviation population provides a rich set of examples for an individual pilot to review when generating her or his own personal minimums.

Inexperienced pilots, particularly student pilots may not have sufficient knowledge or experience to develop their own personal minimums. During the preliminary field testing of this intervention, student pilots expressed confusion and lack of confidence in the personal minimums they developed. They suggested that more generic examples of minimums are necessary for the various stages of their learning. Specifically, they suggested that these examples be provided in a form that they could review and revise with their instructors during their training. Future developments in personal minimums interventions should directly address the specific needs of students by providing more specific examples for them to use with their instructors.

Ease of Use. The program is designed to be easy to use and to gain early and long term acceptance within the pilot community. Minimums must be easy not only to generate, but to use as well. Checklists are readily accepted and used by the pilot community. The checklist format promotes the collection of memory aids (GUMP, I AM SAFE, etc.), rules of thumb, and other materials into one place where they can be maintained in a logbook or flight bag and accessed easily. The checklist was designed for easy updating and revision.

A long list of guidelines could be difficult to sort through before preflight planning or during use. To provide an organizing principle, a set of six categories was suggested, but not dictated for organizing the guidelines. However, pilots are encouraged to define and use these categories in ways that have meaning to them, as opposed to rigid definitions. The six suggested categories of guidelines are, pilot, aircraft, environment, operation/mission, organizational/sociological, and miscellaneous.

THE PERSONAL MINIMUMS TRAINING PRODUCT

The primary product of this initial research program is a preliminary training intervention that assists pilots in constructing a personal minimums checklist tool for managing risks in their preflight go/no-go decisions. An instructor's guide, entitled "Using Personal Minimums as a Risk Management Tool for Preflight Decisions" is provided in Appendix A. The guide is designed to be used by the instructor in preparation for conducting the seminar. The seminar is designed, not only to assist in risk assessment, but students are encouraged to learn from each other through sharing personal flying experiences. Instructors/facilitators are expected to use their own experiences to stimulate and motivate pilots to set and follow personal minimums.

The seminar is divided into four stages. In the first stage students are given an introduction to personal minimums presenting the basic concepts and showing the need for pilots to use them. The second stage provides a knowledge base of preflight risk factors for GA pilots. In the third stage, students actually compose personal minimum guidelines with assistance from the facilitator. In the fourth stage, students evaluate their product through review and sharing of ideas with each other. The following is a detailed description of the instructor guide stage by stage.

STAGE 1: INTRODUCING PERSONAL MINIMUMS

The introductory section highlights the reasons for using personal minimums as a tool for managing the risks associated with preflight go/no-go decisions. The instructor must use this time to provide background concepts, instill motivation for the pilots to learn, and show what level of participation will be expected of them in the seminar. Finally, the instructor should point out that some behavior change is expected following the seminar regarding their use of personal minimums in preflight decision making. This introductory stage focuses on five basic questions:

1) What are preflight decisions?
2) Why are these preflight decisions important?
3) What are personal minimums?
4) Why are personal minimums important?
5) Why should an individual pilot establish personal minimums?

Defining Preflight Decisions

When asked about preflight decisions, pilots often limit their answers to inspection of the aircraft, weather evaluation, and flight navigation planning. While preflight decisions include all of these activities, other factors such as experience and social pressures may contribute to possible errors in judgment. For our purposes, preflight decisions are defined as: "Any and all decisions made prior to taxiing the airplane onto a runway with the intent to takeoff." In aircraft other than airplanes, preflight decisions are any and all decisions made prior to the first task to make the aircraft airborne (i.e., gliders—giving the initiate/launch signal; balloons—giving the command to launch; helicopters—advancing the throttle). Under this broad definition, preflight starts with the first idea that a pilot generates about a possible flight until the pilot initiates the first action to make the aircraft airborne or until that possibility no longer exists.

This definition of preflight decision making includes many factors (perhaps considered months ahead of the flight) often overlooked in a pilot's preparation for flight, including, for example:

- the initial motivation to fly the family to the beach for vacation;
- a decision to forego maintenance items on the aircraft;
- a decision to take the BFR or instrument competency;
- a decision to install navigation, communication, anti-icing, or weather detection equipment.

This definition also includes short-term factors such as:

- assuring the fuel reserve is sufficient;
- concluding that you have to get the boss/family there on time;
- recognizing I might disappoint them by not going now.

It should be noted that this definition excludes some decisions that are usually considered go/no-go decisions (e.g., the rejected takeoff decision).

Importance of Preflight Decisions

The importance of decisions made prior to flight is underscored by studies that have shown that a significant number of pilot decisions (or lack of decisions) made during the preflight phase led directly to accidents and incidents much later in flight (McElhatton & Drew, 1993). Of the 125 Aviation Safety Reporting System (ASRS) incident reports reviewed in their study, ninety percent of all time-related human errors occurred in the preflight or taxi-out phase of operation (See Figure 2). General aviation examples of such errors might include:

- Knowingly overloading the airplane and failing to clear an obstacle at the end of the runway on takeoff.
- Running out of fuel enroute because of poor flight planning (e.g., insufficient fuel reserve).
- Deciding that the high ranking passenger (boss or family member) must get there despite the weather, resulting in premature contact with the ground on approach.
- Flying with a known medical condition then becoming disoriented (e.g., in haze).

On a fundamental level, a flight is a sequence of events that are related and influenced by the previous events. So it should be no surprise that preflight

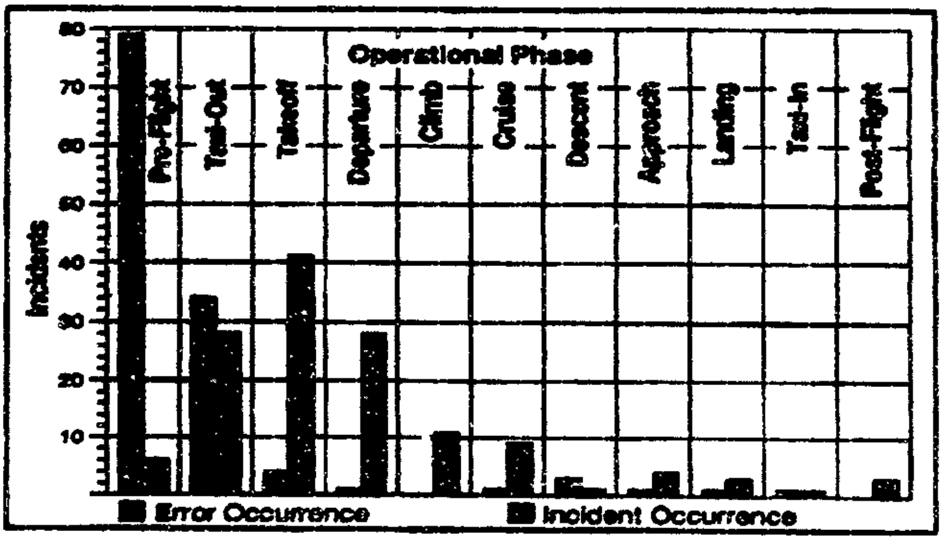

Figure 2. Operational phase vs. error and incident occurrence (after McElhatton and Drew, 1993).

decisions affect subsequent flight phases. Once the commitment to flight is made, a strong force exists in the pilot's mind to continue to the intended destination. Social or peer pressure may make admitting an error difficult or seemingly impossible and time pressures may seem insurmountable. Furthermore, once airborne, certain options disappear, including the option to add more fuel. Recognizing and dealing with factors such as these could improve the quality of preflight decisions and improve safety.

In preflight decision making, the Federal Aviation Regulations (FARs) require a pilot to "become familiar with ALL available information concerning the flight" (FAR 91.103) and the pilot is "directly responsible for" and "the final authority as to the operation of the aircraft" (FAR 91.3a). Furthermore, FAR 91.13 requires that the aircraft be operated in a way that does not endanger the life or property of others. Nevertheless, in setting these limits, the FAA still places most of the responsibility for risk management in the hands of the individual pilot. The FAA limits are based on the capabilities of ideal pilots and equipment because, in addition to regulating for safety, they are tasked to promote aviation. Before each flight the individual pilot must determine whether his or her currency and aircraft meet this ideal level of skill and capability. If ideal levels are not met, pilot judgment is expected to produce more conservative operational minimums for that situation.

Personal Minimums

Pilots possess a wide range of experience, capabilities, and training that makes each one unique. Physiological and psychological states vary from one day to the next adding to the uniqueness of each flight. On a particular day, or even at various times during the day, a pilot may be tired or rested, stressed or unstressed about a personal or professional situation, or any combination of other possibilities. These sources of variability suggest the need to conduct an analysis of the risks that individuals and situations bring into a proposed flight prior to the decision to takeoff.

Personal minimums are defined as an individualized set of decision criteria (standards) to which the pilot is committed as an aid to preflight decisions. Theories in psychology suggest that people are more likely to follow standards that they have made themselves than those imposed upon them by someone else (Festinger, 1957). Therefore, the emphasis should be placed on personally set minimums that may differ from those offered by someone else in authority such as the FARs or SOPs (Standard Operating Procedures). Personal minimums have two characteristics that should be recognized: 1) they are unique to the individual pilot and 2) they can be changed with time and situation.

Importance of Personal Minimums to GA Pilots

There are three reasons why personal minimums are important in general aviation: 1) there is a minimum level of outside supervision in most flights, 2) many pilots have very little awareness of risk factors, and 3) general aviation safety depends upon voluntary compliance. Robb (1984) states an old adage that the "less the supervision, the less the safety" (p. 120). NTSB accident data combined with FAA activity estimates clearly show that the accident rate for pleasure flying has remained consistently about twice that of general aviation as a whole, ten times that of corporate or executive aviation, and about one and a half times that of aerial application (Robb, 1984, p. 120). The most prevalent cause of pleasure flying accidents is inadequate preflight preparation or planning (McElhatton & Drew, 1993; Robb, 1984)!

While some pilot operations take place under the direct supervision of regulators, management, supervisors, or others in authority, many flights in general aviation remain unsupervised. Pilots know that compliance with regulations, SOPs, or rules (and even personal minimums) depend upon voluntary observance by the pilot. Flying is not unique as an enterprise of trust. In automobile driving, the actions of the driver are not observed by the police at every corner. Instead, the safety of the driver mainly depends upon voluntary compliance with the 'rules of the road' and setting some personal standards which vary depending on the situation.

In business aviation, commercial flight operations, flying clubs, and other situations, operational limitations or sets of rules define what the operational minimums include. In these types of operations, pilots with less experience must operate with higher ceilings, higher approach minimums, lighter winds, and lower crosswind components. In airline and military operations, an extensive set of SOPs provide tools to assist pilots in making critical preflight go/no-go decisions. Flights may be canceled by dispatchers, chief pilots, or supervisory personnel even before the pilot has an opportunity to address the go/no-go decision. Such supervision remains effective in improving safety if it is maintained over an extended period of time and appears to be one reason for a better safety record.

Personal assignment of minimums requires an awareness of the risk factors involved before one can attempt to manage them. Risk awareness is an effective tool to increase safety, but requires experience and knowledge. Insurance companies demand higher rates from lower time pilots, pilots with limited experience in high performance or complex aircraft, and from pilots without upgrade training in advanced aircraft. Some pilots may think that their responsibility ends with understanding their own safety risk. "Allowable risk" understood by passengers may be quite different from that of the pilot. The pilot has a responsibility to be sensitive to the level of understood risk acceptable to his or her passengers and company. Therefore, some study may be required by the pilots to establish both their personal risk factor knowledge base and that of others who may be affected by the flight.

The popular flying literature has discussed the idea of personal minimums for years. Numerous articles describe accidents, incidents, and near misses in attempts to offer an awareness of these issues to pilots without exposure to the consequences. The following reasons are often offered for the establishment of a written set of personal minimums:

- Promotes safer flight operations
- Heightens awareness of risk factors and provides techniques to manage risk
- Highlights the effects of pressure (commitment, peer, supervision, passenger, time, destination, financial, etc.)
- Fosters "good practice"
- Encourages competent or professional image and behavior
- Assists in legal requirement compliance
- Provides a rational, defensible method to support a "no-go" decision to passengers, employers, and others

Most pilots, especially more experienced and well trained pilots, limit the conditions under which they will fly. Thus most already possess a preliminary set of personal minimums. However, few have a written set that they can reference. A personally developed and written set of minimums can carry the psychological force needed for a pilot to resist a tempting risk in unsupervised aviation when there may be pressures to take it.

STAGE 2: IDENTIFYING RISK FACTORS

The objective of the second stage is to develop in the students a knowledge base of risk factor awareness. The activities in this stage include a short facilitator discussion of risks, a case study with the whole class, and a longer small group exercise to generate a taxonomy of preflight risk factors.

Risk factors are defined as, "something that actively contributes to the production of a negative result" (in this case, with regard to the expected flight). Numerous examples of preflight risk factors can be offered including, icing, thunderstorms, a questionable magneto drop, an inoperative communication radio, no flight in type for more than 30 days, family pressure to get home, or getting only four hours of sleep in the last 24. Research has shown that when people make decisions, they usually consider only a very small number of factors and they tend to make these decisions based on a few basic rules discovered in previous experiences, and/or on their "gut feeling" about the situation. This activity stage is designed to expand the pilot's knowledge base of risk factors that go into preflight decision making and to classify them into categories that are easily recalled when they are needed.

Students are asked to relate examples from their own experiences in which they decided not to make a flight for safety reasons, and examples of situations in which they decided to go but later regretted the decision or had to abort the flight. The instructor draws parallels between the examples offered and the three points listed above. In the rare case in which the pilots cannot provide examples, the instructor should use her or his own experiences. Instructors must be careful not to dominate the seminar with their own "war stories." Instead, they should make the examples real for the participants using their experiences.

A Case Study

To stimulate thinking about risk factors and how they apply to preflight decisions the instructor can offer one or more case studies in the form of "trigger tapes" of situations developed in the FAA's "Back to Basics" program or stories found elsewhere. One excellent example was published in *Flying Magazine's*, "I Learned About Flying From That" (McCutcheon, 1991). In this case, a pilot feels pressure to make a medical evacuation flight in a Cessna 210 with inoperative radios, in questionable weather, with night approaching. After arriving for the pick up, he finds that there is both a child and a mental patient to transport, plus families and other cargo, causing the plane to be overloaded. Despite the child's condition, because of the numerous risk factors, he decides not to takeoff. As students read this story, they are asked to identify the risk factors facing the pilot including the subtle psychological factors such as the condition of the child. When all have listed these factors individually, the class is opened for discussion, and all are invited to share their discoveries. The same could be done with any aviation preflight scenario, including those from individuals in the class, presented either in front of the whole class or in small groups.

Case histories make identifying risk factors seem meaningful because they are placed in the context of real-world situations. The use of specific case histories helps to add flexibility to the program by allowing various audiences to be addressed with the same basic program. For example, if the students are balloonists, balloon case histories mean much more to them than airplane examples.

Students are asked to divide into small groups and generate a more comprehensive list of preflight risk factors. After generating the list, the students are asked to organize them into a taxonomy with six suggested categories: pilot, aircraft, environment, operation/mission, organization/social, and miscellaneous. A format for the students to use (Table 5) is provided as a handout. The first three categories are those normally used to represent the pilot's world. The operation/mission category is added as a place to put factors regarding the operational aspects of that particular flight. The organization/social category is included as a place to put risk factors that organizations can add to the pilot's decision process including subtle pressures to complete flights on schedule. Finally, the miscellaneous category is included to underscore the emphasis on personal freedom in the construction of this tool in anticipation that some may not wish to identify a particular risk factor with one of the given categories. The structure presented is offered as a starting point, not a required set of categories. What is placed under any category will be a function of each pilot's mental model of how these factors are classified.

By grouping risk factors into these categories they are more easily remembered and hence applied to the decision process than they would be if unorganized. This categorizing process also helps to establish decision rules or guidelines for future use. After completing these tasks, the students will have the skills necessary to identify risk factors that pertain to preflight decisions and to place them into categories that have the most self-meaning. Students will also become aware of the general methods that other pilots use to make decisions and the risk factors involved for them.

STAGE 3: COMPOSING GUIDELINES

The third stage is the most important because students develop their own personal minimum guidelines into an easy-to-use checklist format. The three activities of this stage are:

1) defining guidelines,
2) generating examples, and
3) generating guidelines on a checklist form.

Table 5. Examples of preflight risk factors.

Factors in Airplane Preflight Go/No-Go Decisions				
Pilot	**Aircraft**	**Environment**	**Operation/Mission**	**Sociological/ Organizational**
Certificate level	Horsepower	Visibility	Terrain	Time constraints
Recency of flight	Engine number	Ceiling height	Night	Destination importance
Total flight time	Weight and balance	Wind velocity	Special operations	Supervision level
Recurrent training	Speed	Crosswind	Low/High altitude	Operational guidelines
Knowledge	Systems complexity	Icing	Towing banners	Club rules
Skill	Performance envelope	Thunderstorms	Towing gliders	Family commitments
Illness	Anti/deicing equipment	Turbulence	Passengers	Pilot seniority/position
Medication	Navigational system(s)	Fog/dust	Higher ranking/VIP	Financial constraints
Stress	Oxygen/pressurization	Severe temperatures	Max. performance	FAR compliance
Alcohol/drugs	Turbocharger	Mountain waves	Airport systems	Legal operations
Rest	Fuel availability	Rain/freezing rain	Lighting	
Nutrition	Redundant systems	Weather report availability	Runway(s)	
Physical condition	Communication system(s)		Braking action	
	Maintenance discrepancies		Airspace complexity	
	Aircraft preflight status		Airway/ATC traffic	
	Weather detection equipment		Alternate airport	
	Autopilot		Known delays	
	Gear type		Approach(es) available	
	Lighting		Runway length	
	Category/class		Emergency procedures	
			Chart currency	

Guideline Definition

The dictionary definition of a guideline is "a line or rule by which one is guided: as an indication of or outline of policy or conduct." Intended for use in a checklist, guidelines are simple rules of thumb, sayings, if-then statements, or memory aids. Guidelines are used frequently in aviation to help remember checklist items and to cause you to think before acting impulsively. For example some guidelines used by GA pilots are:

- "Dead foot, dead engine"
- "Never fly single-engine at night in the mountains"
- "GUMP: Gas, Undercarriage, Mixture, Prop"
- "On final approach, always check first and then say aloud, 'Gear indicates down and locked'"
- "The three most useless items in aviation: The runway behind you, the altitude above you, and the fuel that's not in your tank"

A longer list of guideline examples is shown in Table 6. Care should be taken to provide samples of risk factors and guidelines that match the certification levels, flight activities, and other variables of the students in that class. Particular items on the checklist can be used or changed to reinforce subjects from other training efforts or the newest "hot" topic in aviation safety. The facilitator may request examples of guidelines from the students to be sure they understand the concept.

Composing Personal Minimum Guidelines

After the presentation of the guideline definition and examples, the students are asked to work individually on their own guidelines using the blank checklist shown in Figure 3. The taxonomy headings or categories on the checklist provide an initial organizing structure that the pilot is encouraged to change to fit his or her individual way of organizing the guidelines. Each pilot is given sufficient time to generate at least one guideline in each category. The most important category and the most difficult to handle is the "Pilot." Special attention may be needed in that category to be sure the students provide several items before setting it aside. Students should also be encouraged to consider the risk factors identified in their previous exercise in the development of guidelines.

This exercise can be used to reinforce risk factors and direct discussion toward voluntary exchange of ideas about personal minimums. The success of the personal minimums approach depends upon building a personal commitment to writing and to the use of these minimums in preflight decision situations. The final step in this stage is to ask students to commit to the process by signing a statement of commitment to use minimums, also provided in Figure 3.

Table 6. Examples of personal minimums guidelines in six categories.

Pilot	Aircraft	Environment
Current experience— __ takeoffs & landings within __ days	Recent experience in type— __ takeoffs and landings within __ days	VFR Ceiling—greater than ____ ft. AGL for cross country flights
Well rested	Reviewed emergency procedures within last __ days	VFR flight visibility—greater than __ mi. for cross country flights.
Eaten at normal interval	Minimum fuel reserve—__ hrs	Avoid all thunderstorms by __ mi.
Illness free	VOR receiver operational	Crosswind component less than maximum aircraft crosswind component.
Medication/drug free	Use ALL checklist	Weather reports & forecasts—most current available
Alcohol free—no drink within ____ hrs		Get a standard weather briefing from FSS or NWS for each cross country flight
Drinking water available in aircraft when hot or flight longer than two hours		

Operational	Sociological/Organizational	Miscellaneous
Night operations restricted to greater than marginal VFR requirements	Alternate plans available for later than expected arrival or not being able to reach destination	Miscellaneous items include: items to be added at next revision, limited use items, one-time items, etc.
Runway length ___ % better than determined from POH tables	Phone credit card & phone numbers available to call affected parties	Review AIM quarterly
Flight plan filed for all cross country flights	In compliance with club rules	
Notams checked	All passengers briefed on existence of minimum operating procedures—particularly those factors nearing limits which may change planned flight	
Runway lighting at destination operational for all night flights		
No flight above _____ ft. MSL without oxygen		
Current sectional charts used for navigation		

Pilot

☐ ____
☐ ____
☐ ____
☐ ____
☐ ____
☐ ____
☐ ____

Aircraft

☐ ____
☐ ____
☐ ____
☐ ____
☐ ____
☐ ____
☐ ____

Environment

☐ ____
☐ ____
☐ ____
☐ ____
☐ ____
☐ ____
☐ ____

Operation/Mission

☐ ____
☐ ____
☐ ____
☐ ____
☐ ____
☐ ____
☐ ____

Sociological/Organizational

☐ ____
☐ ____
☐ ____
☐ ____
☐ ____
☐ ____
☐ ____

Operational Minimums

Pilot: ____

Revised: ____

Reviewed with: ____

Purpose: I have set these Operational Minimums as guidelines for the safe operation of the aircraft for the benefit of all individuals that can be affected on each intended flight. These standards reflect my best judgment as the pilot in command.

Signed ____

Miscellaneous

Miscellaneous items include: items to be added at next revision, limited use items, one-time items, etc.

☐ ____
☐ ____
☐ ____
☐ ____

Figure 3. Sample persona. minimums checklist with categories.

STAGE 4: EVALUATING AND BUILDING ON PERSONAL MINIMUMS

The fourth stage consists of the evaluation of guidelines written in Stage 3 for the purpose of further developing personal commitment and to gain additional ideas for building and modifying the checklist over the long term. This evaluation stage can be highly rewarding (i.e., changing behavior) because it offers opportunities for verbal expression and public commitment. However, the instructor/facilitator must be very sensitive to students who may not wish to share their ideas, or those who might consider them too personal to share. Suggested steps in this evaluation are:

1) Check for missing, unclear, and duplicate items.
2) Ask general questions such as:
   — Are the personal minimums flexible?
   — Do they cover the range of intended activities?
   — Do they address flying currency questions?
   — Do they cover the range of equipment and aircraft routinely used?
3) Will the pilot understand the intended purposes for each item when used at a later date?
4) Is a general statement included about how the pilot will approach "non-routine" activities not covered by this set of minimums?

Seminar leaders should consider encouraging students to suggest other evaluation methods. These inputs can be used as examples in future seminars.

Due to time limitations, most pilots will not complete a set of personal minimums during the training period. In addition, critical evaluation of an incomplete personal minimums checklist by another pilot within the class could potentially embarrass some pilots and thus discourage them from completing and using the method. To avoid this problem, the instructor should provide a sample personal minimums checklist (such as Table 2) for each individual to review critically and to discuss.

The instructor may use the discussion summary to reinforce the requirement for review and revision of any personal minimums checklist. This includes the regular inspection/revision of one's checklist during biennial flight reviews, instrument currency checks, safety program participation, or other recurrent training. A personal minimums checklist should be considered a flexible document that develops and changes with time and experience.

CONCLUDING SUMMARY

In summary, the instructor reviews the three primary learning activities and reinforces the specific learning elements which occurred in each. 1) The pilots find and list important preflight factors associated with risk, 2) each pilot transforms risk factors into guidelines to place in a usable checklist format, 3) each pilot generates a preliminary set of evaluation criteria with which to judge any self-generated personal minimums or to review those generated by a peer.

In closing, the instructor reminds each pilot that the personal minimums checklist is unique to her or him. Other pilots' minimums will be different. The checklist need only have meaning to its user. Furthermore, it represents only a starting point for pilots to consider. As new risk factors are discovered, each pilot must consider how they might by incorporated into his or her minimums checklist. Finally, the checklist must continuously be reviewed and changed as required to accommodate the pilot's changing flight activities and capabilities. To provide each pilot with further sources of information, additional references are listed. Presently identified references include, advisory circulars, magazines, books, newsletter (IFR Refresher, FAA Safety Review, etc.), and standard pilot references (Airman's Information Manual, FARs, etc.).

FUTURE DEVELOPMENT

This program produced a new concept for aiding pilots in generating personal minimums to manage flight risks during preflight go/no-go decisions. It is believed that this approach to personal minimums training for preflight decisions has a great deal of face validity; however, it is a new idea that has a certain risk of failure if it is not fully developed and presented to pilots properly. Training programs often fail if their approach is not fully developed. Furthermore, strategies for the assessment of the approach need to be developed to show its effectiveness. The authors think that this tool to aid pilots in preflight decision making has so much potential for improving aviation safety that it deserves to be fully developed and implemented with a proper assessment tool.

It is recommended that further efforts to support the program's use proceed in two directions simultaneously. The first uses field testing to refine the training intervention into a turn-key training tool for use by Aviation Safety Program Managers, Safety Counselors, and flight instructors. The second completes the study of the feasibility and effectiveness of personal minimums as a risk management tool through laboratory studies. The research team sees these two approaches as mutually supporting and occurring simultaneously.

FIELD TESTING AND TRAINING REFINEMENT

To refine adequately the preliminary personal minimums training intervention program into a turn-key training tool, the design team recommends a series of field tests and instructional system design activities. The field tests provide both a subject pool for the experiments described subsequently and evaluation opportunities for the training intervention refinement. The field test series is expected to be offered to the following audiences:

1) University aviation students,
2) Local flying clubs,
3) Local Aviation Safety Seminars taught by the investigators,
4) Regional Safety Seminars using Aviation Safety Program Managers and research team members as instructor teams,
5) Regional Safety Seminars using Aviation Safety Program Managers as instructors,
6) Various other target communities of pilots representing a diverse sample of pilots from across the country. (e.g., pilots in mountainous terrain, high-traffic areas, routine over-water operation areas, Alaska, etc.).

In these field tests, an evaluation program will be administered at three levels: reaction, learning, and behavior. At the reaction level, each participant will complete an evaluation questionnaire at the end of the training seminar to provide immediate feedback on the acceptability of the training program. During the training seminars, the research team will collect observational data and sample participant responses to assess learning or knowledge acquisition during the seminar. The behavioral level assessment will occur approximately six weeks following each training seminar to assess use of the training in actual flight operations. This assessment will use a short questionnaire, administered by mail, and selected telephone interviews for non-respondents.

These evaluations will provide both formative and summative evaluations of the training materials at each level of the field tests as described above. The objectives are to make the training seminar and its support materials useful and effective to participants while providing an acceptable and efficient program to expected instructors. Additionally, the program evaluation will address the applicability of this approach to pilots of various skill, experience, and certification levels operating in a variety of flight operations, special environments, and target populations.

EXPERIMENTS

To investigate further the feasibility and effectiveness of personal minimums in risk management, a series of experiments is recommended. The objective of these experiments is to compare the approaches of self-generated, voluntary minimums (such as personal minimums) to those of imposed minimums (i.e., SOPs, rules, regulations, etc.) as tools in changing pilot risk management behavior and to determine whether pilots can be taught effectively to assess relative risk. In these experiments, two types of variables would be tested, (1) types of training (personal minimums, imposed minimums, or no training) and (2) experience and certification levels. Experimental subjects will come from those individuals who participate in field testing of the intervention as described previously. Control subjects will come from an available pool of pilots similarly qualified, but untrained in risk assessment and management using personal minimums. The experimental protocol will use ground-based realistic flight scenarios to collect data. Verbal protocols will be used to collect data during the preflight planning and go/no-go decision making stages. Data analysis will be by standard verbal protocol analysis techniques. The analysis will focus on (1) awareness of risk factors available during preflight activities, (2) methods used to manage recognized risks, and (3) outcome decisions made about the proposed flights.

Finally, a test is recommended of whether or not pilots trained in preflight decision making can make better relative risk assessments than those not comparably trained. If the results are positive, we may have a valid tool to offer. Controversy exists on the ability of pilots to assess relative risk. If pilots can assess relative risk, then they may be able to use that knowledge to implement appropriate risk management techniques. If experienced pilots can make better relative risk assessments, then the possibility exists that training may offer a surrogate for experience in developing relative risk assessment and management techniques beyond making the simple go/no-go decision. For example, can a change of aircraft, avionics, autopilot, destination airport, or other factors, implemented singularly or in combination reduce the relative risk so the flight can be made at an acceptable risk level. However, if experienced pilots are not better able to assign relative risk values, then simple training interventions may not be appropriate due to strongly-held but erroneous individualistic opinions or other causes. As a starting point, two primary questions should be addressed. (1) Can a group of general aviation pilots be identified that possess significantly better abilities to assign relative risk values to those risk factors that can be evaluated at the preflight phase? (2) If such a pilot group can be identified, then is it possible to identify the characteristics of that group that contribute to such a capability? Suggested characteristics offered include: flight time, initial training, recurrent training, education, or other life experiences.

EXPECTED RESULTS

Two types of results are expected. The field testing is expected to result in a refined, production quality personal minimums training program that is proven successful with both pilots and potential instructor personnel. The experimental results are expected to provide a scientific basis for using personal minimums and new ideas for the development of the product.

Field Testing Results

The series of field tests and a structured instructional systems design approach will result in a refined production quality personal minimums training program for pilots to use as a risk management tool during preflight takeoff decisions. The program provided will have been proven effective and can be handed over to flight instructors and the FAA's Aviation Safety Program Managers and Safety Counselors with confidence that it will succeed. It will have been evaluated using assessment tools, some of which could be used continuously in the training setting to provide continued assessment data during the life of the training seminar. The field testing also will serve to instruct some of the Aviation Safety Program Managers and Safety Counselors in how to facilitate this program.

Throughout both the field testing and experimental programs, the research team expects to introduce the ideas of personal minimums to the FAA Aviation

Safety Program Managers, Safety Counselors, and flight instructors to obtain feedback from them on the concepts, methods, materials, and evaluation techniques that work for them individually and their pilot learners in actual field settings. Such insights will contribute to the successful implementation of the personal minimums program.

Experimental Results

We expect that both personal minimums and imposed minimums will achieve positive results because both offer an effective refresher on risk factor awareness. However, we believe that the personal minimums approach will be significantly more effective in changing behavior, especially in the long term. SOPs are effective, but often they are opposed by other organizational or group policies (such as, always accomplishing the mission) or in economic terms. Pilots may be inclined to balance one organizational or group policy against another. Furthermore, some people are not highly motivated enough to follow the restrictions set down by others. Personal minimums, on the other hand, have a personal commitment attached. These commitments are powerful psychological forces that have been proven effective in deciding human behavior in many settings. We believe that they will be effective in aviation as well.

Experiments in determining the capabilities of pilots to assign relative risk values are expected to show that some pilots have significantly better capabilities than other pilots. However, the number of factors that a pilot can integrate into such an evaluation is expected to be small and on the order of seven factors, plus or minus two. If such limits exist, then the risk management approach also must include a risk assessment aspect to assist the pilot in identifying the key factors involved in an intended flight. An additional result of these experiments is expected to be the identification of factors pilots identify as key in selected missions. Such missions may include VFR flight in marginal VMC (visual meteorological conditions), flight in known icing conditions, flight in areas of known windshear, flight in mountainous terrain, extended flight over open water, or others.

FURTHER RESEARCH QUESTIONS

Several research questions have been identified to guide the development of risk management approaches in preflight go/no-go decisions. Answers to these questions are expected to lead to a better understanding and to refinements in such approaches:

1) What types (self-generated or imposed) of preflight minimums are pilots more likely to follow when making actual preflight decisions?
2) Are techniques that rate risk levels (i.e., SAFE, REARM, ALERT, etc.) effective for positively influencing a pilot's go/no-go decisions?
3) How effective is increasing the pilot's knowledge of risk in a general aviation operation in causing pilots to act on that knowledge?
4) What risk levels are acceptable to pilots in various situations and how do pilots decide the acceptability of that risk?
5) How far can we push pilots into risk assessment and management? Can they be taught to make assessments of relative risk levels?

REFERENCES

Adams, R. J. & Payne, B. (1992). Administrative risk management for helicopter operations. *The International Journal of Aviation Psychology, 2* (1), 39-52.

Alkov, R.A. (1991). U.S. Navy aircrew coordination training: A progress report. In R.S. Jensen, *Proceedings of the Sixth International Symposium on Aviation Psychology*, Columbus, OH: OSU Department of Aviation.

Beach, L. R. & Lipshitz, R. (1993). Why classical decision theory is an inappropriate standard for evaluating and aiding most human decision making. In G. A. Klein, J. Orasanu, R. Calderwood, and C. E. Zsambok (Eds.), *Decision making in action: Models and methods* (pp. 21-35). Norwood, NJ: Ablex Publishing Corporation.

Boley, K. O. (1985, September). ALERT: Aviation litmus evaluation risk test. *U. S. Army Digest*, p. 17-19.