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C. Elaine McCoy, Ph.D.
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TRAINING CONSIDERATIONS FOR EXPERT PILOT DECISION MAKING

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Abstract

Extensive research since 1977 by the Federal Aviation Administration determined that the predominant underlying cause of "pilot error" accidents involved decisional problems or cognitive information processing. To attack these problems, Aeronautical Decision Making (ADM) training materials were developed and tested for ten years. Following this development, twelve training manuals were published covering the spectrum from student/private pilots, instrument pilots and commercial airline crews. The publication and use of these manuals has had a dramatic effect on the reduction of human performance error related accidents. These successes are documented for civil and military operations both in the U. S. and worldwide. However, shortcomings have been observed in the use of the ADM training for recurrency and in their relevance for more experienced pilots. This research identifies the differences between expert and novice decision makers from a cognitive information processing perspective and correlates the development of expert pilot cognitive processes with training and experience. This introductory material should provide an understanding of how to formulate expert pilot decision making training innovations and how to continue the record of improved safety through ADM training.

Introduction

Decision making training has made a significant impact on safety by reducing the human performance error related accidents in both civil and military aviation. Accident rate reductions of about 50% can be seen when comparing pilot groups with and without decision making training (Diehl, 1991). Yet, these large safety improvements have not reached the entire pilot community. In particular, there is a lack of acceptance of the linear decision making model by the more experienced pilots, a resistance to change in interpersonal skills in the multicrew environment and even a "boomerang" effect where the attitude toward the use of all crew resources deteriorates after training.

Extensive research and empirical testing in Aeronautical Decision Making (ADM) produced a series of ten Federal Aviation Administration manuals and reports on ADM (1986-1988). Although it is admittedly difficult to accurately assess the impact of all of the manuals throughout aviation,

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significant reductions in human performance error (HPE) accidents have been documented in specific areas:

- A 36% reduction in all HPE accidents for the *worldwide* B206 fleet (Fox, 1991).
- A 72% reduction in weather related HPE accidents for the *worldwide* B206 fleet (Fox, 1991).
- A 48% reduction in all HPE accidents for the U. S. B206 fleet (Fox, 1991).
- A 54% reduction in HPE accidents for the largest U. S. civil helicopter operator (more than two million takeoffs and landings annually, Fox, 1991)
- A 51% reduction in accidents/100,000 hours for USAF MAC crews (Diehl, 1991).
- A 20% reduction in USN helicopter air crew mishap rate and an 81% reduction by A6 and EA6 airplane pilots (Alkov, 1991)

These findings generated a request from many in the aviation community for advanced decision making and crew resource management material. They also have led the National Transportation Safety Board to recommend that the FAA pursue the implementation of ADM more vigorously following a fatal 1991 accident involving an airplane and a helicopter (NTSB 1991) However, as dramatic as the examples of improvements were, a more detailed examination of the accident rate reduction data disclosed that **the major positive impact has been on the less experienced pilots** (Albert, 1989). This finding led to two questions: Can we achieve the same impact in human error reduction with more experienced pilots? And, how can this be done?

The current research effort attempts to respond to these questions, questions which industry has also asked. The research is based upon parallel events occurring in the air carrier industry during the 1983-1989 timeframe. During this period, there were several extraordinary accidents involving multiple engine failures, explosive decompressions caused by structural failures, fuel starvation and in-flight fires. In each of these accidents, experienced pilots quickly responded to emergencies for which there was no handbook procedure or previous training. They assessed the situation and integrated airmanship skills, trained procedures and aeronautical knowledge into a quick, effective decision making process. Such dynamic cognitive behavior was in direct contrast to the more basic ADM training which stressed a linear, measured approach to situation analysis.

Expert Cognitive Processes

Research in the last twenty years has revealed that superior performance is most often the result of the interaction between **accumulated skill and experience**. The primary differences between a beginner and an expert can be attributed to **acquired knowledge** and problem solving skills: what we call *expertise* and which is demonstrated through performance. Expert performance can be defined as the selection of an appropriate response to situations or problems in a wide variety of domains. These include selecting the best move in a chess game, correctly diagnosing a medical problem, or using the proper emergency procedure in aviation. The relevant research on expert performance has focused on the basic understanding of *knowing how* to do something well rather than *knowing what* the underlying mechanism was for superior performance (Dreyfus & Dreyfus, 1986). Complex problem solving research assumed that the integration of the basic **human information processing** skills was required. This included the processes of **perception, memory, attention, and reasoning**. This research had real-world importance since performance/expertise obviously depended on learning how to do something well.

All human cognition is task dependent and purposeful (goal oriented). Humans use their knowledge, cognitive processing skills and the cues or stimuli of a situation or task to develop problem solving approaches. To accomplish this, two types of knowledge are used (Anderson, 1985). These are declarative knowledge and procedural knowledge. Declarative knowledge consists of knowledge that can be verbalized, some say knowledge about "facts and things". Procedural knowledge is knowledge about actions or how to perform various cognitive activities. These ordinarily cannot be completely or adequately verbalized, for example, how to ride a bike. Procedural knowledge is the basis for development of specific steps (also called production rules) to be used in problem solving situations. The study of **procedural learning** became a crucial area to be understood. The current (general) theory of acquiring expertise includes the following three stages:

1. Novice's solve problems by weak, domain general, heuristic methods (often working backwards from the goal).

2. Successful solutions (when repeated frequently) lead to the development of domain specific procedures or production rules. These rules specify actions that will achieve goals under particular conditions. Production rules form the beginnings of expertise.

3. As these rules are used more and more often, and applied to many situations in a domain, they result in fairly automatic generation of specialized productions which often use forward inferencing to progress from the initial problem state toward a solution or goal. Thus, relative to the novice, the expert is able to reach the correct solution more quickly and efficiently.

The status of these theories of expertise are presented in two references which provide 24 "Summary Propositions" pertinent to aviation. *Thoughts on Expertise* (Glaser, 1987) and *On the Nature of Expertise* (Glaser and Chi, 1988) provide the following relevant findings:

1. Expert performance is characterized by **rapid access to a well organized body of conceptual and procedural knowledge**. High levels of competence result from the interaction between knowledge structure and processing abilities.

2. The organization of knowledge used by experts can be thought of as **schemata or a modifiable information structure based upon knowledge that is experienced**. Schema theory assumes there are schemata for recurrent situations that expedite decisions in certain situations.

3. Expertise is domain specific. Within a domain, experts develop **the ability to perceive large meaningful patterns.** Furthermore, the expert's pattern recognition occurs so rapidly that it appears to take on the character of insight or intuition.

4. Expert **knowledge is highly procedural and goal oriented**. Individuals with extensive domain knowledge are much better at relating events in cause-and-effect sequences that relate to the goals and subgoals of a problem solution.

5. The capability of experts to **fast-access** their knowledge facilitates problem perception in a way that leads to the **reduction of the role of memory search and general processing**. The outstanding performance of experts is derived from how their knowledge is structured to accomplish: *Retrieval, Pattern Recognition, and Inference.*

6. Generalized thinking and problem solving skills may develop in individuals who acquire expertise in several domains (e. g., aeronautics, airplane systems, air traffic control procedures, emergency procedures, etc). **Continuous development of expertise in a field is based upon novel conditions that extend competence to novel situations.**

7. Experts develop specialized schemata that **match goals to demands of the problem**. Although both novices and experts can display good use of general problem solving process, experts use them primarily in unfamiliar situations.

8. The development of expertise is **influenced by task demands** encountered in the course of experience. In some domains, experts develop the capability for **"opportunistic planning"** which enables them to revise problem representations and to access multiple possible interpretations of a situation.

9. Experts also develop types of metacognition or self-regulatory capabilities that are not present in less experienced decision makers. Experts' **skilled self-regulatory processes** free their working memory for higher level conscious processing. These include: planning ahead, efficiently monitoring one's time and attentional resources, and monitoring and editing one's efforts to solve a problem.

10. An important point of distinction is that there are both routine and adaptive experts. Adaptive experts possess **the ability to creatively respond** to novel situations and develop an appropriate response with some reasonable chance for a successful outcome.

This distinction between routine and adaptive experts leads to the threshold of the next generation of expertise theory which relies on a cognitive psychology perspective. The current FAA sponsored R&D will examine applications to real world problems and the focus will be on *how* aviators respond to untrainable emergencies. A broad distinction between two classes of expertise is suggested in Sloboda (1991). His definition is that expert performance involves "the reliable attainment of specific goals within a specific domain." An extended definition is that "an expert is someone who can make an appropriate response to a situation which contains a degree of unpredictability."

In general, an expert will succeed in identifying and adapting to the inherent constraints of the task. If the task can be done most efficiently by forward search, the expert will search forward; if backward search is better, the expert searches backward. If certain patterns of cues are crucial to performing the task well, the expert will likely perceive and remember them; if patterns are not so important, the expert will not selectively process them.

Expertise and Training or Practice

Initially, expert performance and expertise involves the development of encoding processes which allow the situation to be fully represented and integrated cognitively. In this way, relevant actions can be retrieved from memory. The internal representation of external situations is also critical to planning and evaluation of possible courses of action as well as a means to represent a dynamically changing environment for the purposes of anticipation and prediction.

It seems that acquisition of expertise can be increased for most, if not all, relevant aspects of performance. Table 1 shows a phase or stage view of differing levels of expertise.

Table 1 **PHASES AND CATEGORIES OF EXPERTISE**

PHASES OF EXPERTISE	CATEGORY OF EXPERT
Beginning Phase (Acquisition of declarative knowledge and domain general problem solving skills)	Beginner, Student, or Novice
About 1-2 years of active experience and training	Intermediate
Many years of active experience and training (Full time - 40-80 hours per week)	Routine Expert (or "Journeyman")
More than 10 years of full time experience and training	Master or Adaptive Expert

At this time, knowledge about how experts attain the base for their expert performance is relatively limited. Generally speaking, the current view is that the novice should have acquired all basic knowledge in less than one year. Continuing beyond this basic knowledge leads to the acquisition of problem solving skills where the knowledge is organized to effectively produce efficient performance. That is, there is an acquisition of the **procedural knowledge** of complex patterns occurring in specific situations. At this Intermediate level, differences in expertise appear to be related to the **cued recall** ability and the number and complexity of those patterns available for use. Finally, in both the routine expert and adaptive expert categories, an accepted, domain specific vocabulary (or jargon) is developed to allow efficient communication among experts in a given domain. This is obvious in aircraft operations (from flight planning to air traffic control) where experts have developed an extensive jargon which is formalized in the "Pilot-Controller Glossary" of the Airman's Information Manual.

Pilot Cognition & Information Processing

Thus far, we have characterized the performance of experts from a cognitive psychology perspective. We have tried to show that the development of expertise relies heavily on training and requires considerable amounts of experience in a specific field. Further, experts rely on a wide variety of different processing skills and unique problem solving capabilities. As summarized in Gordon (1990):

- Experts have more detailed, better organized knowledge structures.
- Experts perceive and organize problems on a more abstract level than novices.
- Experts perceive problems in large meaningful patterns related to the context.
- Experts are much faster than novices because of their use of procedural knowledge and forward inferencing techniques.

These characteristics are equally applicable to the expert pilot domain and all have been observed and documented. We will now attempt to show how the cognitive psychology perspectives and understanding of the development of expertise apply to pilot development, training and aeronautical decision making.

Cognitive psychology recognizes three stages in the development of expert problem solving skills (Anderson 1985). These are *cognitive, associative and autonomous* . During the first, *cognitive* stage, pilots commit to memory a set of facts relevant to a desired skill. They typically rehearse these facts as they first perform the skill. For example, novice pilots learning stall recovery will memorize: recognize the stall, lower the nose, apply full power, level the wings and minimize altitude loss. In this stage, they are using their general aeronautics knowledge (domain-general) to guide their solution to loss of lift over one wing, and solve a domain specific problem, how to keep the aircraft flying. The problem solving capabilities and level of expertise in this stage are very basic. Novices spend a lot of time searching and moving around factual knowledge.

The second, or *associative* stage, has two important characteristics. First, errors in the initial understanding and performance are detected and gradually eliminated. That is, the novice pilot learns to coordinate the nose drop, power application and rudder application for a smooth stall recovery. Second, the connections between the various elements required for successful performance are strengthened. The pilot does not sit for a few seconds trying to decide which action to perform first after lowering the nose. Basically, the outcome of the *associative* stage is a learned procedure for performing a desired response to a known situation.

The third cognitive stage occurs when the problem solving procedures become faster and more automatic. The *autonomous* stage evolves from the repeated application of known patterns and their associative use to achieve solutions. The use of declarative knowledge or "verbal mediation" often disappears during this stage of cognitive processing, at least for some tasks. Expert cognitive process development gradually improves in a specific area or domain. Ultimately, the skill can be extended to the ability to respond to cues not previously encountered and to develop new solutions or production rules applicable to novel situations.

In aviation, training is highly procedure oriented both in developing flying skills (psychomotor) and in decision making skills (cognitive and informational) for normal and emergency operation of the aircraft. These procedures and skills provide the foundation for the development of more sophisticated production rules (procedural knowledge) as experience is gained. Novice aviators develop flying and decision making skills through 1-5 years of experience. This experience allows pilots to expand their procedural knowledge base using encounters with real-world problems and operational constraints. The low time pilot is at the second stage of cognitive process development; he has begun to develop the speed and quality of processing of the Routine Expert. Finally, the Expert Pilot mainly relies on automatic cognitive processing abilities. Just as in the other domains of sports, games, music, and medicine, the Expert Pilot has achieved a tremendous base of procedural knowledge and skills applicable to normal day-to-day flying problems, trained emergencies (such as an engine failure) and novel or untrainable emergencies.

Figure 1 illustrates the relationships between levels of pilot experience, types of knowledge used for problem solving and the three stages of development of cognitive processing ability. As shown in the figure, one main characteristic of the development of expert cognitive processes is the continual **increase in decisional speed and accuracy** as experience is gained in a specific area, e.g., aviation. In fact, these two characteristics are precisely the areas of decision making and problem solving most affected by experience and training or "practice."

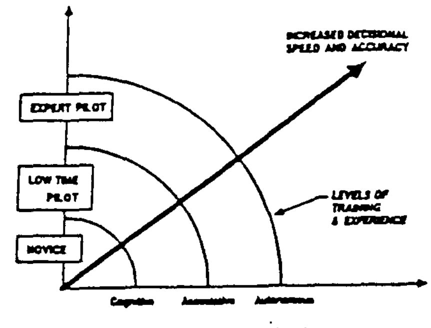

Figure 1 EXPERT PILOT JUDGMENT DEVELOPMENT

To summarize, novice pilots respond (cognitively) to stimuli or external cues based upon an understanding of a complex, declarative knowledge base. Their decisions, whether normal or critical, are typically based on a linear problem solving approach (some type of checklist). Their capabilities are generally limited to the procedures learned and expedited by the use of rules-of-thumb (or heuristics). The intermediate pilot is becoming an associative problem solver and has the capability for an enhanced decision making. As a result of experience and additional flight training, this pilot has the capacity for more dynamic cognitive processing. At the associative level, pilots store information in terms of schemata which are modifiable information structures based upon experience. This "associative pilot" uses pattern recognition and dynamic interrelationships among objects, situations and events to integrate and interpret related knowledge instead of the static, linear thinking of the novice. This pilot's level of cognitive processing is in the process of evolving into a Routine expert.

In addition to having all the decision making skills gained through experience and training, the Expert Pilot is **"adaptive."** Expert's can alter procedures in real time (modify, delete or expand); can create new rules and patterns based upon unique, previously unencountered problem characteristics. This capability to creatively respond to unique problems or novel task demands identifies the highest level of expert pilot cognitive processes.

This "adaptive" capability is referred to as "KNOWING WHEN" (Dreyfus and Dreyfus, 1986). That is, the Adaptive Expert Pilot can perceive the necessity to alter ingrained procedures based upon the parameters and dynamics of the problem or situation encountered. When necessary, the expert is able to plan and set goals required to accomplish a successful solution. It is believed that this "KNOWING WHEN" (an almost direct perception of the proper course of action) may provide the key to the next generation of ADM training. As in the general field of expertise, isolating and quantifying the cues that experts use to either trigger a routine response or the mechanism to adapt remains a challenge.

Training Considerations

Two issues must be considered when teaching decision making to experienced pilots. These are non-linear decision making and cognitive dissonance.

Non Linear Decision Making: Currently there are a large number of both competing and complementary decision making models and procedures (Maher, 1991). A few of these either were aviation developed, modified for aviation use or applied to aviation. These include the DECIDE model; the PASS model; and, the SAFE model. However, no definitive research exists which allows for the identification of **one** optimum decision making theory -- either for the pilot or crew. All theories have positive aspects and drawbacks; all have difficulty in meeting all the unique and stringent requirements that aviation imposes. However, a great deal is known about establishing and promoting a set of environmental conditions which foster optimal crew decisional processes and strategies (Lofaro, 1992).

One of the newest areas that holds promise for the development of ADM comes from Mathematics/Artificial Intelligence; it is Chaos theory (Gleick, 1988). All current models of ADM are essentially linear. Some models have branching (decisional "trees") aspects, but all involve a linear series of steps/choices. The causal chain model used in accident analysis is an example of an essentially linear view of a complex event. It is true that a linear chain of prior events can be reconstructed for an accident. But, such a chain is not sensitive to the fact that small changes (in the environment, in time-pressure, in the crew composition, etc.) can make large—and unpredictable by any linear model— differences in the actions and consequences as time passes.

Since many ADM models are based on accident analysis (on breaking the causal chain), once again the linear DM paradigm is used. It is becoming apparent that, especially under time pressure, we make decisions in a non-linear fashion; this holds also for group decisions (Lofaro, 1991). Another short-fall of ADM models based on accident data is that they rely on an analysis of one (or a statistical representation of many) prior event(s). They then are either so general as to not be helpful in a particular situation or so complex and specific that they only apply to one situation which will never re-occur in exactly the same way. Chaos theory deals with non-linear systems and the corresponding beginnings of the realization that the human mind does not typically use linear steps to decide. Rather, cognitive processes go forward and backward, sideward and into many layers simultaneously. Insight and direction for expert decision making training may be available from this field.

Cognitive Dissonance. The psychological phenomena of cognitive dissonance may, in part, help to explain why some high-time aviators show less acceptance of ADM --- as well as less attitudinal change after exposure to ADM and/or CRM training materials. An analogy may clarify this statement:

> Consider if you will the baseball, a small hard core wrapped with layers of varying types of twine and covered with an outer shell of stitched-on horsehide. The core is well protected by the layers of twine and the cover. The twine layers themselves are of different strength and they may be wound or wrapped with more or less tension. The core can be considered our basic, deepest values and beliefs; the twine windings are less tightly held beliefs and attitudes; and, the cover is what holds it all together and what must be penetrated to access the interior of the baseball--- the biases and slants and filters by which we initially process new data.

Following this analogy, it would seem that the attitudes and beliefs of high time aviators are closer to the core and therefore less amenable to change. Or, looked at another way, their flying habits and attitudes are more embedded, therefore, challenges may trigger a cognitive dissonance based "protection". The initial reaction of such pilots to ADM information and strategies which run counter to their own are typical cognitive dissonance mechanisms by which people do not change their attitudes and beliefs when confronted with new, unsettling data.

Typically, the person experiencing cognitive dissonance responds by challenging or rejecting the data which has caused the dissonance. This is done by forgetting it, by questioning the source, and/or by finding others of similar beliefs and attitudes. This serves to reinforce the original beliefs and attitudes of all concerned. This can be a partial explanation of what Dr. Robert Helmreich has found in some CRM trainees and what he terms the "boomerang effect" (Helmreich, 1989). Dr. Helmreich has found that some pilots receiving CRM training not only resist attitudinal change, but also experience either a hardening or "negative increase" of their initial attitudes, as well as sometimes attempting to proselytize others in the CRM class.

Conclusions

A review of aviation examples where expert pilots "saved the day" either in whole or in part, documented that pilot's making decisions under stress exhibit five basic characteristics (Adams and Ericcson, 1992):

Reversion to basic airmanship skills
Instantaneous recall of training
Reasoned approach in emergencies
Positive in approach & expectations
Self-assured and optimistic.

This research effort has identified the characteristics of expert pilot decision making and identified the differences between expert and novice pilot cognitive processing skills. This is the initial step in the development of expert pilot decision making training. However, additional research is required in three areas to further our understanding of how the adaptive expert pilot functions and how to train novice and intermediate pilots this "adaptiveness."

The first area is to acquire a better understanding of the adaptive expert's perception of information and the decision related actions. This can be done by analysis of the different interpretations of task demands between novice and expert pilot's when faced with the same cues and context, i. e., their sensing and filtering cognitive processes. This analysis should also include a more detailed examination of differences between novice and expert pilot's in setting goals and taking action on the available information.

The second task should be a closer examination of how experienced pilot's have applied their cognitive abilities in both trainable and untrainable emergency situations. This empirical data base coupled with current efforts in modeling chaotic systems and the importance of knowing <u>when</u> to "adapt" cognitive processing to meet novel task demands may provide enough information to postulate an initial expert pilot decision making model.

The third area to explore is the importance and impact of cognitive dissonance in experienced pilot decision making training. An analysis of the possible differences in the expert and novice psychophysiological attitudes including kinesthetic, affective and cognitive components should be performed. The importance of affective components and characteristics in problem solving should be analyzed to determine what relationships might exist between these characteristics and decision making. These issues should be addressed in expert decision making training which provides analogous affective states to reinforce the development of analytical relations between the training environment and what is perceived as the operational environment.

If a new level of understanding of expert pilot cognitive processes in these three areas can be achieved, then safety could be further improved through more advanced, tailored training. Again, teaching judgment or decision making skills (of a more advanced nature) avoids the pitfalls of learning totally from the expensive school of accident/incident experience.

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ASSESSING EDUCATIONAL OUTCOMES: ANOTHER HURDLE IN THE ACCREDITATION PROCESS?

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Abstract

Universities and colleges that have aviation programs have a unique mission; such programs have a primary purpose of providing graduates for productive careers in aviation and aerospace. In addition, many if not most programs are approved by the Federal Aviation Administration (FAA) and are specifically taught to meet performance objectives contained in the appropriate Federal Aviation Regulations (FARs). But meeting such performance objectives may not be sufficient to meet the future demands of regional accreditation agencies. This paper is an overview of the institutional effectiveness movement, preparing for an accreditation visit, academic change, assisting faculty members to prepare performance objectives, and integrating academic programs that embrace the FARs, the academic traditions of the aviation program, and the unique and highly technical background of the faculty.

Background

What skills, knowledge, and values does or possibly should a well educated college graduate possess? Does a college education make a difference in obtaining these attributes or could an individual prepare just as well for the demands or entry requirements of the work place in another manner? Such issues have become more important in the past few years as the question of outcomes assessment or institutional effectiveness has emerged as a critical issue in academe.

Regional accreditation associations are also becoming increasingly interested in not only assessment procedures and the administration of such procedures, but are also placing considerable emphasis on the use of assessment findings for program evaluation. North Central Association of Colleges and Schools Executive Director Patricia Thrash (1991) stated that "the time has come for regional accreditation to assume a more active, visible role [and the director would] . . . . like to see more recognition of the substantial efforts the regionals are making to provide increased assurance of educational quality and a greater assurance to institutions for their improvement (pp. 6-7)." Stephen Weiner (1991), Executive Director of the Western Association of Schools and Colleges, stated that "regional accreditors look both at how well each college or university accomplishes its proclaimed purposes and whether each institution meets the general standards of the community of higher education" (p. 7).

As early as 1973, at Alverno College or in 1976 with the American Assembly of Collegiate Schools of Business (AACSB) Outcomes Measurement Project, educators have become increasingly concerned with whether students have mastered the basic information, attitudes, and skills inherent in a college curriculum (Paskow, 1988). To this end, the American Association for Higher Education (AAHE) has been in the outcomes assessment and institutional effectiveness vanguard. AAHE has played a pro-active part in this movement by hosting their Annual Conference on Assessment (the seventh of which took place this summer in Miami), publishing both *Change* and the *AAHE Bulletin*, and supporting numerous related conferences and projects each year.

One might ask then should collegiate aviation programs be concerned with the increased emphasis on outcomes assessment by the regional associations? Won't the accreditation, or the reaffirmation of accreditation of the other academic programs on the campus insure that the aviation program, which is not usually very large in comparison, will be impervious to the regional review? Furthermore, since many of collegiate academic programs have been approved by the Federal Aviation Administration (FAA) and such programs are specifically taught to meet performance objectives contained in the appropriate Federal Aviation Regulations (FARs), won't that suffice? Well, Kiteley (1991) perhaps stated the issue best:

> Assessment now is a way of life in higher education in that we must not only deliver the appropriate content to our students, we must measure the learning outcomes to ensure that the students that are leaving our campuses have the necessary knowledge and skills to meet industry and society expectations. We need to strengthen networking with industry through advisory committees, formalized graduate follow-up surveys that ensure that we not only have a current and relevant curriculum today, but one that stays current and relevant to the needs of a dynamic changing industry. (p. 3)

The new thinking then appears to be how are we going to make such changes and how are we going to insure that collegiate aviation programs can pass the scrutiny of the regional accreditation associations now and in the future.

Accreditation Requirements

Traditionally, most collegiate aviation programs have blended a highly technical academic program into a somewhat acceptable academic major. Although on many campuses, the convincing of academic peers that aviation is a viable collegiate pursuit has not come easy. As if these forays haven't been enough, there is another fight just over the horizon for colleges and universities in the Southern United States. The issue of institutional effectiveness is an extremely important one to the Southern Association of Colleges and Schools (SACS) and is so critical to the accreditation process that a *Resource Manual on Institutional Effectiveness* (SACS, 1989) was developed by the association to assist colleges and universities in interpreting Section III of the *Criteria for Accreditation* (SACS, 1991) of the Commission on Colleges of SACS. Although James T. Rogers stated that the ". . . inclusion of the section on 'Institutional Effectiveness' is a very modest first step" (p. ii), this document provides institutions with a comprehensive, thought provoking treatise on how to effective interpret the five "must" statements concerning institutional effectiveness. These five statements indicate that institutions that wish to be accredited or reaccredited must:

1. Establish adequate procedures for planning and evaluation.
2. Define [the institution's] expected educational results.
3. Describe how the achievement of these results will be ascertained.
4. Engage in continuing study, analysis and appraisal of their purposes, policies, procedures, and programs.
5. Evaluate the institutional research function.

In addition, there are eight "should" statements that should be considered advisory and not prescriptive in nature. Included among these are suggestions that relate to the planning and evaluation process that institutions may employ in addressing the issue of institutional effectiveness.

Now, does this impact collegiate aviation programs? Yes, quite significantly since when the parent institution is being evaluated for accreditation, so is the flight line, the aerospace classroom, and the repair station. It will be virtually impossible to escape the view of the visiting team. While this may not sound like too much of a chore for those who are comfortable with outcomes assessment already, others that are just getting into the institutional effectiveness arena may be facing some difficult times. In addition, on those campuses where the aviation program has to virtually fight for academic recognition every step of the way, there will be many exciting days ahead.

Developing an Institutional Effectiveness Program

How best to prepare and proceed with developing an institutional effectiveness program? Since such a program will usually be a campus-wide program, it would seem appropriate to become heavily involved with your institution's institutional effectiveness efforts right from the beginning. However, if you are in a leadership role in the process or wish to develop an effectiveness program solely for the benefit of your academic unit, a review of the assessment process is appropriate.

The Assessment Process

The central questions in the assessment process are (a) what body of knowledge is required to adequately convey a specific academic program, (b) how can that knowledge be delivered in the most appropriate instructional package, and (c) how do educators know that they are educating students effectively? Fitzgibbons (1981) and Telfer and Biggs (1988) refer to these three questions respectively as the matter, the manner, and the outcomes of education. If we then set out overtly to improve the matter, manner, and outcomes by using such a model (Mentkowski & Loacker, p. 49, 1985), we have a very embryonic but effective assessment model. Figure 1 illustrates two concepts that are central to the assessment process, involvement of faculty as well as students and a goal oriented decision making model. The decision making section shows that the learning experience has several distinct components - goals, criteria, performance, observation, judgment, and feedback. The learning event encompasses the first three of these components followed by observation which culminates in a decision about goal achievement and possible modification.

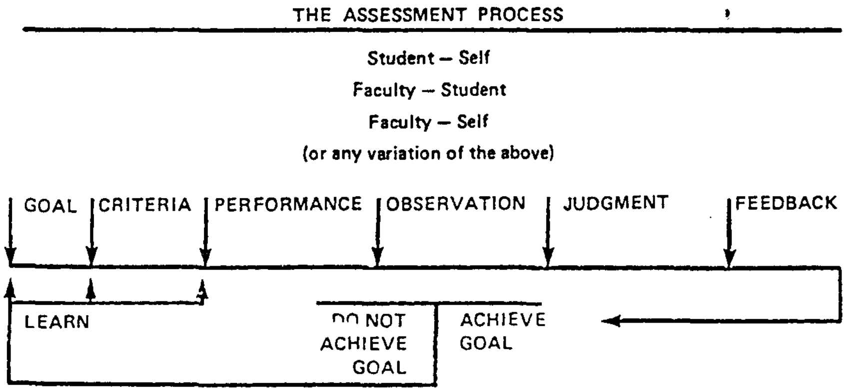

Figure 1. Components of the Assessment Process

Additionally, there are also several recommendations of a non-instructional nature that must be considered in assessment plan development. The North Central Association of Colleges and Schools (1991) has defined the assessment process as possessing ten distinct characteristics. These ten characteristics indicate that the assessment program:

1. Flows from the institution's mission.
2. Has a conceptual framework.
3. Has faculty ownership/responsibility.
4. Has institution-wide support.
5. Uses multiple measures.
6. Provides feedback to students and the institution.
7. Is cost effective.
8. Does not restrict or inhibit goals of access, equity, and diversity established by the institution.
9. Leads to improvement.
10. Has a process in place for evaluating the assessment program.

While the steps outlined in Figure 1 and included in the 10 characteristics of assessment offered by North Central above seem to encompass most of the components of a rudimentary assessment program, collegiate aviation programs have some unique attributes that must be accounted for in establishing any institutional effectiveness paradigm. The most significant of those attributes is that there may be a number of major academic programs within an institution that are approved by the FAA. Such programs might be the FAR 141 flight instruction curriculum, an aviation maintenance technician school certificate issued under FAR 147, or a certified repair station with associated ratings. Most of these certificates specify the manner in which certificates are issued and maintained, what facilities and equipment are required as part of the instructional program, the minimum experience levels and certification of instructional personnel, the curriculum, and the minimum measurable performance level for each flight, ground, or repair operation. However, such a level of performance may not be in and of itself totally acceptable for accreditation. Just meeting FARs or complying with the Practical Test Standards may not suffice; you may have to, in the process of self-study in preparation for accreditation, set out on a course of having to re-evaluate your whole academic program from the bottom up.

Performance Objectives. If you must proceed from the beginning, one fundamental activity that is germane to the education process is the development of performance objectives for all courses, any instructional sequences, and the academic major(s) that are part of the aviation program. A performance objective (be it called a learning or behavior objective or even an intended learning outcome) is "an educational goal that specifies the learned behavior a student is to exhibit after a learning episode (lesson or series of lessons). The objective usually details the conditions under which the learning is to occur and the level of performance expected" (Telfer & Biggs, 1988, p. 152). Most performance objectives take the form of: At the completion of the course (lesson, task, or even term), the student should be able to do a specific things under a certain regime and to such a level of performance.

To write a performance objective the first step is to determine in which domain of learning the activity is centered, the cognitive domain (knowledge), the affective domain (values), or the psychomotor domain (skills). Specific references for the cognitive domain may be found in Bloom (1952), for the affective domain in Krathwohl (1964), and in Simpson (1972) for the psychomotor domain. The second step is to determine the major category within each domain that best indicates the level of performance expected for the objective. Once the level has been determined, the third step is to select the action verb that best exemplifies the type of activity the learner will pursue. Finally, the action verb is combined with criteria and condition that relate to the specific activity.

Many faculty members may need assistance in preparing such performance objectives. A hands-on, user-friendly, and step-by-step method of developing performance objectives using action verbs, criteria, and conditions could be an appropriate direction. Perhaps a series of inservice workshops on an institution wide basis could accomplish the preparation of such objectives in a uniform format.
Course Syllabi and Outlines. Additionally, this may be an appropriate time to review each academic offering, prepare uniform course syllabi, and do a general housecleaning in the paperwork department. The accreditation teams will be very interested in whether there is uniformity within the institution. The process of accreditation at institutions that have branch campuses, foreign campuses, or programs housed at military bases and taught by adjunct faculty can be somewhat difficult. In addition, if there are multiple sections of a class taught by different instructors, syllabi and course outlines should be as consistent as possible. There is need for the institution to integrate horizontal communication among wide spread academic entities since the accreditation associations view their efforts as being directed at one institution no matter how many different sites are involved.

Conclusions

It seems clear that the assessment of educational goals, particularly as part of the accreditation process by the regional association is now a fact of academic life. In fact, it is an integral part of the process in the SACS region and will surely become more important in all areas of the country. At the core of the issue, however, is still the questions of what skills, knowledge, and values does a well educated graduate possess and does a college education make a difference. Addressing such concerns must be done sooner rather than later, at least in the minds of the regional accrediting associations.

Many of the problems associated with the development of assessment procedures to meet the criteria for accreditation may seem almost insurmountable in the beginning but these challenges are not impossible. Faculty will soon begin to talk about outcomes assessment; most individuals will begin to see ways that will improve their teaching, provide their students with a more meaningful educational experience, and better prepare graduates for the future. Hemphill (1991) perhaps illustrates the point best in that:

> faculty actually have the most to gain from assessment for two reasons. First, assessment emphasizes the academic mission if the institution. As a result of the planning that must precede assessment, academic needs emerge in the forefront of the institutional decision-making process. Second, assessment focuses attention on the qualitative dimension that is normally given heavy emphasis due to enrollment-driven funding formulas. It is possible that, through assessment, the interest of faculty and the need of the public to improve the quality of higher education will merge into one unified effort. Faculty members have a common interest in supporting and funding assessment as a promising way to achieve our primary goal of the providing education of the highest quality. (p. 13)

Outcomes assessment will then benefit not only the student but the faculty as well. Additionally, the institution will profit by providing a more meaningful and relevant educational experience. Perhaps then assessing educational outcomes as a component of the accreditation process is not a hurdle after all but what we really want to do anyway!

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COCKPIT CRISES AND DECISION MAKING: IMPLICATIONS FOR PILOT TRAINING

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Abstract

This paper presents the theoretical foundations and a description of a research study designed to examine pilots' attitudes about cockpit crises and the processes used to make decisions in crises. The findings suggest that a "high crisis perception/low urgency/low rigidity" pattern may be an optimal approach to crisis decision making. In other words, the decision maker recognizes the situation as a crisis and is motivated to act, but the low sense of urgency encourages flexibility with respect to roles, responsibility, participation, and procedures. Suggestions for both ground training and simulator instruction are offered which expand situational awareness to include the concepts of crisis and available decision time.

Introduction

Crisis situations in the cockpit occur in a relatively complex, often ambiguous, sometimes hostile environment. However, the high achievement and task orientations of crew members seem to produce optimal responses in most situations that would be described as crises. Extensive technical training and highly structured emergency procedures provide pilots a means for diagnosing and responding to critical situations. Nevertheless, the history of commercial aviation is marred with many accounts of mismanaged crises.

The aviation community has long realized that the effective performance of cockpit crews is essential to aviation system safety. Early research in the area of flight crew performance focused primarily on skills acquisition and retention, perceptual requirements, and physical stress. Much less attention was given to the psychosocial aspects of the cockpit environment. Air transport accident analyses and related research during the past decade have, however, produced convincing evidence that pilot training and evaluation systems must address the crucial dimension of crew interaction and decision making in the cockpit (Foushee 1984; Ruffell Smith 1979; Sears 1986; Wheale 1984).

In recent years many airlines have initiated training programs to encourage effective cockpit resources management (CRM). Although CRM programs vary, they are essentially designed to educate pilots (and, more recently, cabin and ground crews) about the importance of interpersonal relations, communication skills, synergistic activity, and participatory decision making to safe flight operations--training quite in contrast to the traditional focus on the technical means of accomplishing the goals of flight operations rather than the process.

Subsequent, evaluative research has supported the notion that CRM training can improve cockpit performance and, further, suggests that performance-related attitudes are significant predictors of crew coordination in line operations (Helmreich, Foushee, Benson, and Russini 1986). However, research also indicates that crewmembers lack awareness of the deleterious effects of stress and have unrealistic attitudes about their personal vulnerability to stress (Helmreich 1984). Some researchers caution that during a crisis situation the crew is likely to revert to prior well-learned behaviors rather than the concepts espoused by CRM (Hackman 1987b).

It is expected, however, that over a period of time CRM training--if an accepted and customary component of initial and recurrent training programs--will encourage behaviors which lead to more effective coordination and decision making in critical or crisis situations (Hackman 1987b; Helmreich 1984; Helmreich and Wilhelm 1987).

Crisis and Group Decision Making

A crisis is triggered by incremental or radical changes in the environment. A crisis threatens the goals of the decision unit and involves risks with the potential for substantial losses. There is a relatively short time in which to make a decision before loss occurs. The crisis is further exacerbated by the lack of a contingency plan and of decision-relevant information. Not surprisingly, the psychological and physiological manifestations of stress accompany the crisis situation. In sum, the crisis situation is characterized by threat, uncertainty, limited information, time pressure and tension (Billings, Milburn and Schaalman 1980; Hermann 1969; Milburn 1972; Miller 1963; Staw, Sanderlands and Dutton 1981).

The psychological and physiological responses to crisis as well as individual differences in personality predispositions and perceptions affect the processes employed by the group, and, ultimately, decision outcomes. The evidence suggests that individual cognitive flexibility is restricted in a crisis. Decision makers may overemphasize similarities between the past and the present (Milburn 1972), gravitate toward simple decision rules (Janis and Mann 1977; Nagel 1988), rely on well-learned, dominant behavior (Zajonc 1965), suffer from a foreshortened time perspective (Milburn 1972) and be indiscriminate in the search for information or, conversely, ignore relevant information (Janis and Mann 1977).

In addition, the strategies utilized by the crew and the control structures within which decisions are made are determined to varying degrees by leadership--the leader's abilities, style, influence, and orientations toward the task and relational aspects of group performance. The evidence suggests that, in a crisis, leaders often tend to restrict information, participation and shared responsibility. These strategies are designed to reduce error, losses, and uncertainty and to encourage quick and decisive action. However, such strategies often result in information overload, omission, or distortion; role overload; and reducing the number of decision participants (Billings, Milburn and Schaalman 1980; Dutton 1986; Smart and Vertinsky 1977; Staw, Sanderlands and Dutton 1981).

Alternatively, decision making is likely to be more successful in cockpit crises if (1) group norms encourage shared information and responsibility for decision making (Foushee 1984; Foushee and Helmreich 1988); (2) the crew has confidence that a satisfactory solution exists and believes that there is sufficient time available to search for and evaluate alternative courses of action (Janis and Mann 1977); (3) the crew evaluates and utilizes available resources to develop alternatives, strategies or new resources, rather than relying upon existing strategies and resources to resolve the situation (Hackman 1987a); and (4) individuals are trained for cognitive flexibility under adverse conditions (Dutton 1981).

Description of the Research

The purpose of the study was to examine pilots' perceptions about three constructs central to decision making in cockpit crisis situations--the perception of crisis, sense of urgency, and response rigidity. The survey materials included a crisis scenario, a two-part, nineteen-item questionnaire and a background information sheet. The scenario and questionnaire items had been pre-tested during personal interviews conducted with twenty-four Denver-based line pilots employed by a major airline.

Subjects. The subjects of the study were Los Angeles-based line pilots from three major airlines. Six hundred and fifty-seven surveys were distributed. One hundred and eighty-five usable surveys were returned and used in the analysis. The subjects represented a relatively broad cross-section of the pilot population (i.e., 46% were captains, 33.5% were first officers, and 20% were second officers; 38% were not yet forty years old, the other 62 were; 67% had no formal CRM training while the other 33% had).

The concept of crisis was measured in two ways. The perception of crisis was determined by asking pilots if they believed that this crew was in crisis situation (Question 1, Part I). They were asked to respond on a Likert-type scale numbered 1 (strongly agree) through 7 (strongly disagree). In Part II of the questionnaire pilots were asked to rate five crisis characteristics of the scenario on a Likert-type scale numbered 1 (low) to 9 (high). The second measure of crisis is a combination of the mean ratings of four crisis characteristics--level of threat to the safety of the flight, level of situational uncertainty, availability of decision-relevant information, and the level of tension.

The perception of urgency--the perceived time available in which to search for and evaluate alternative courses of action--was measured by combining the responses to three questions in Part I in addition to the rating of the fifth crisis characteristic, level of time pressure, in Part II of the questionnaire.

Response rigidity is characterized by the restriction of participation, limiting the search for and evaluation of viable alternatives, and adherence to/reliance on authority and procedures. Nine questions in Part I of the questionnaire were used to determine response rigidity.

It was hypothesized that (1) the perception of crisis would have a positive correlation to the ratings of the crisis characteristics, (2) the higher the rating of the situation as a crisis, the higher the response rigidity, and (3) a high sense of urgency would result in high rigidity.

Results of the Study

Ninety percent of the pilots surveyed indicated, at some level of agreement, that the crew in the scenario was in a crisis situation. This crisis perception positively correlated with their ratings of the level of threat, uncertainty, information availability and tension--characteristics commonly attributed to crisis situations.

It was anticipated that the effects of the pilot personality, hierarchical task/role structures in the cockpit, and pilot training procedures--which have, traditionally, emphasized individual, mechanistic responses to emergencies-- would lead to a high response rigidity when the perception of crisis was high. Response rigidity is characterized by reluctance to engage in participatory decision making or to search for and evaluate alternative courses of action, and reliance on the captain's capabilities, deference to his or her authority, and reliance on standard operating procedures.

The hypothesis that a higher perception of crisis would result in higher response rigidity was not supported by the data. The results indicated that a higher perception of crisis resulted in a lower rigidity score (r=-.18). Further, pilots had, overall, a lower rigidity score than expected.

It was also expected that a higher sense of urgency would result in higher response rigidity. Previous studies of decision making suggest that a high sense of urgency (the belief that there is little time to search for and evaluate alternative courses of action) may evoke dysfunctional decision making behavior characterized by the restriction of information, authority, and participation. The hypothesis that high urgency would result in high response rigidity was supported by the data. The higher the sense of urgency the higher the response rigidity (r=.25).

The findings indicate that the perception of crisis and response rigidity are negatively related (high crisis/low rigidity, low crisis/high rigidity) and the sense of urgency and response rigidity are positively related (low urgency/low rigidity, high urgency/high rigidity). Rigidity scores were not significantly different as a result of a high or low perception of crisis, however, pilots with a low sense of urgency had significantly lower rigidity scores than pilots with a high sense of urgency. These results suggest the interpretation that sense of urgency--the time component of crisis--drives decision making behavior, more so than the perception of crisis.

While the results of this study were not conclusive, they strongly suggest the possibility that the high crisis perception/low urgency/low rigidity pattern may be an optimal approach to crisis decision making. First, the decision maker recognizes the situation as a crisis. As a result of this awareness the decision maker experiences mild but "helpful" stress and is, consequently, motivated to act on the situation. The low sense of urgency--the belief that there is sufficient time to search for and evaluate alternative courses of action--encourages flexibility with respect to roles, responsibility, participation, and procedures.

Conversely, pilots exhibiting the high crisis/high urgency/high rigidity pattern may be behaviorally similar to people who suffer from the high, debilitating stress which ultimately inhibits performance. They may resemble the hypervigilant decision maker described by Janis and Mann (1977) whose high arousal state results in impaired cognitive functioning and narrowed time perspectives. The study similarly suggests (although less conclusively) that a high, or at least moderate, perception of crisis is antecedent to the low urgency/low rigidity response pattern. The present research makes a stronger case for low sense of urgency as antecedent to flexible, participatory decision making.

Implications for Pilot Training

The research lends additional support to the findings that cockpit resource management training improves attitudes toward crew coordination and decision making (e.g., Helmreich 1989). Pilots who had attended formal CRM training programs exhibited a significantly lower sense of urgency and significantly lower response rigidity than pilots who had no formal CRM training.

The results of this study also provide some possibilities for expanding or modifying content in pilot training programs in industry and those used in colleges and universities. While there are implications for several concepts central to most CRM training programs--decision making, communication, stress management (U.S. Federal Aviation Administration 1989)--the concept of situational awareness is most relevant to the present discussion.

It has been argued that an accurate assessment of crisis is a necessary first step toward crisis resolution (Billings, Milburn and Schaalman 1980). In aviation, this notion is embodied in the concept of situational awareness. Situational awareness is generally considered to be the accurate perception of the factors and conditions that affect the aircraft. In other words, a pilot who is situationally aware has made an accurate assessment of reality. However, the concept of situational awareness as currently conceived focuses primarily on information processing and communication (e.g., Nagel 1988) with little reference to temporal structure or awareness.

The results of this study suggest that it would be beneficial to expand the concept of situational awareness to include (a) the concept of crisis and (b) the accurate assessment of decision time available in critical situations (as opposed to relying on an internally-perceived time frame). Pilots should be aware that in a crisis time perspectives are constricted and short-term goals and consequences tend to be overemphasized.

One means of accomplishing this in a ground training session is the use of the critical incident technique. Flannagan (1954) used this technique successfully in the 1940s to collect observations of flight crew behavior (incidents) which significantly contributed to a specified outcome (were critical). The critical incident technique can be used to sensitize pilots to the importance of an accurate perception of time to situational awareness and informed decision making. For example, the instructor might ask pilots for a factual, detailed account of the behavior of the flight crew in a situation which could be considered--by them or by someone else--a crisis. The resulting list of behaviors could then be categorized along behavioral dimensions normally associated with CRM, but with special emphasis on temporal perceptions and errors. The criteria used to establish the situation as a crisis could be similarly examined.

An expanded concept of situational awareness is applicable to simulator training as well as ground training. Debriefing sessions could include evaluation of how the crew assessed the decision time available, the accuracy of that assessment, and how time perspectives affected the processes used to resolve the crisis. This approach is not limited to the full-motion, high-fidelity simulators utilized by major airlines. Such training might be accomplished just as effectively in low-fidelity simulators or using interactive video workstations and video recordings of behavior (e.g., Foushee and Helmreich 1988).

The roles, the skills, and the training required of pilots are changing. The successful pilot of the next century will advance based not only on technical skills and total experience but on his or her management skills as well. Cockpit resources management is designed, as the name implies, to improve the management of resources in the cockpit. These resources are commonly categorized as people, information, and equipment. The present paper suggests that the concept of time should be added to this list of interrelated resources, especially in critical or crisis situations. Further research is also needed to clarify how patterns of information exchange and processing might encourage the accurate perception of crisis and assessment of decision time. The findings could contribute a great deal to understanding crew performance in crisis situations and provide valuable information relevant to CRM and other pilot training programs.

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PROBLEMS AND PROSPECTS OF RELIEVER AIRPORTS

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Introduction

In recent years, one of the most critical and misunderstood national airport funding and policy challenges has centered on the reliever airport - a growing and ever important general aviation facility normally located within the surrounding metropolitan city area.

Officially recognized in the mid 1960's as a means of reducing delays at larger air carrier airports, reliever airports subsequently expanded and took on additional congressional support. However, even with the special funding considerations set forth in the Airport Improvement Program (AIP) Legislation of 1982, several formidable areas of legislative, administrative and operational deficiencies remain. Without appropriate changes to these consequences, a number of challenges may be insurmountable for many publicly and privately owned reliever airports in the years to come.

For relievers, the "legislative" part of the problem focuses on the evolving definition and criteria of relievers under changing aviation laws and re-authorization acts. The "administrative" inadequacies pertain to the level of funding available for relievers during the former Airport Development Aid Program (ADAP) Legislation and continued under the present AIP Legislation. The "operational" dilemma concerns an expressed need for airport expansion as a result of increasing levels of aircraft activity amid the complex operating constraints of their own metropolitan service area. These three areas (legislative, administrative and operational) are the focus of this article and are reviewed as part of a survey conducted in December 1989 of 110 reliever airports (mainly in the Chicago, New York, San Francisco, Los Angeles and Phoenix areas) in which airport manager's were asked key "reliever" airport issues.

Role of Reliever Airports

Essentially, a reliever airport's primary benefit is to allow greater capacity to one or more commercial airports (generally air carrier airports) while serving as a gateway for general aviation aircraft into metropolitan districts. Since their establishment, not only has their functional role been redefined, but the airport itself is the focus of increasing activity for which new standards and criteria have been developed (particularly at the state and regional planning level). Today, reliever airports appear to be facing more than operational changes; they are also challenged with many of the same political, economic and environmental considerations facing the primary airports that they are designated by the Federal Aviation Administration (FAA) to relieve.

Evolution of the Reliever Airport Definition

When viewed from the perspective of its definition, the overall contribution, significance and application of the reliever airport's role has changed significantly without a corresponding response in legislative, administrative and operational action. The changing role of relievers during the last ten years *and* the emphasis placed on their specific purpose has demanded an alteration of the original intent to include new ways of identifying general aviation airports as relievers. Although the reliever category did not change much in name from the 1982 legislation, the definition of relievers was broadened - so much in fact that it now allows for the inclusion of a number of additional general aviation airports which provide relief, but were previously not able to meet the earlier reliever criteria. This issue singularly raises the question of how relievers will grow in a controlled and equitable manner within the national airport system.

To describe only the current definition of relievers would be unjust without a comparison made to the historical progression of its original definition and established criteria. This following section traces the major historical reliever definitions used by the FAA and then contrasts them with the present definition supplied by the National Plan of Integrated Airport Systems, 1990 (NPIAS).

Reliever Airport Definitions and Criteria

1. National Airport Plan Fiscal Years 1962 - 1966 (April, 1961)

"Large and medium hubs need separate general aviation airports because of the very great air carrier activity and the excessive time it takes to get to an air carrier airport from many parts of a metropolitan area. Important segments of general aviation tend to desert air carrier airports when air carrier operations have reached 30,000 to 50,000 operations annually. In metropolitan areas, a neighborhood with 10 aircraft owners usually justifies an airport if no suitable one exists within 10 miles or 30 minutes driving time".

2. National Airport System Plan Fiscal Years 1972-1992 (January, 1973)

"Reliever airports, either existing or new, must meet all of the following:

a. It must primarily serve general aviation which is defined as an annual level of general aviation activity equal to at least 75 percent of the airport's total annual operations.
b. It must have reached a current activity level (or be officially forecast to reach such a level within the appropriate NASP period) of either:
   1. 50 based aircraft, or
   2. 25,000 annual itinerant operations, or
   3. It must be located such that it clearly functions as a reliever to the major airport being relieved.

In order for a major airport to qualify for relief (relieved airport), it must meet simultaneously all of the following criteria:

a. It must be served by a certificated scheduled air carrier.
b. It must serve a recognized Standard Metropolitan Statistical Area (SMSA) having, or forecast to have, either a population of 500,000 persons or a scheduled airline enplaned passenger level of at least 250,000.

c. It must be classed, or forecast as an S-2 (or 100,000 to 250,000 operations per year), or higher airport.

d. It must either:

1. Be operating, or officially be forecast to operate at 60 percent of its planned annual or peak hour capacity for the National Airport System Plan (NASP) period under consideration; or

2. Have operated at such a level in the past and have been previously provided with relief through designation of one or more reliever facilities qualified as indicated in this section.

3. <u>Airport and Airway Improvement Act of 1982, Sec. 503, (a)18, (August, 1982)</u>

"Reliever Airport means an airport designated by the secretary as having the function of relieving congestion at a commercial service airport and providing more general aviation access to the overall community".

4. <u>"Interim Criteria for Designating Reliever Airports," FAA Order 5090.3A National Plan of Integrated Airport Systems Criteria (January 25, 1983)</u>

Reliever airports shall meet the following criteria:

1. The reliever airport provides substantial capacity or instrument training relief, as evidence by:

a. A current activity level (or in the case of a new airport or airport that is slated for major improvement, a forecast activity level) of at least 50 based aircraft, or 25,000 annual itinerant operations, or 35,000 annual local operations, or;

b. The installation or proposed installation of a precision instrument landing system (ILS or MLS) when the FAA Regional Director has determined that the airport is a desirable location for instrument training activity.

2. The relieved airport:

a. Is a commercial service airport that serves a Standard Metropolitan Statistical Area (SMSA) with a population of at least 250,000 persons or at least 250,000 annual enplaned passengers, and -

b. Operates at 60 percent of its capacity, or operated at such a level before being a relieved airport, or is subject to restrictions that limit activity that would otherwise reach 60 percent of capacity.

Airports not meeting all of the above criteria may be included in the plan as reliever airports if they are so designated in a state, regional, or metropolitan system plan, and the FAA concurs in that portion of the plan.

As demonstrated by these definitions, the 1960's criteria for relievers was loosely defined in comparison to later reliever criteria. Conversely, the 1970's criteria was more detailed, providing several different qualifying guidelines for reliever airports in terms of the type and amount of activity as well as with the location of the airport within a Standard Metropolitan Statistical Area (SMSA). However, the 1980's criteria, in comparison to the 1970's criteria, has become less stringent. An example is the lowering of the SMSA size which qualifies for reliever status. Also, the 1980's criteria has been changed to include discussion of relief from instrument operations based on training activity.

Finally, the concluding qualifier on the 1980's criteria allows for the designation of reliever airports outside the national planning criteria under the contention that a state, regional and/or metropolitan area system plan calls for a reliever that has been concurred by means of FAA determination.

Furthermore, the 1990's definition of reliever airports has essentially remained unchanged from that of the 1980's. The National Plan of Integrated Airport Systems (NPIAS) 1990-1999 offers this basic definition. "Reliever airports are general aviation airports in metropolitan areas which are intended to reduce congestion at large commercial service airports by providing general aviation pilots with alternative landing areas, and providing more general aviation access to the overall community."

A Status Report on the Reliever Airport System

According to the National Plan of Integrated Airport System (NPIAS) 1990-1991, there are approximately 17,451 airports in the United States. Of the 3,385 airports included in the NPIAS, 285 (8%) are reliever airports (National Plan of Integrated Airport Systems 1990-1999). It is clear that a fairly small number of reliever airports have been identified for special attention in the national airport planning system. However, without examining several individual reliever airport cases, it is difficult to understand why this category of airports should receive special attention as a consequence of its metropolitan status.

In reviewing reliever airport situations in fifteen metropolitan areas, several key areas of needs were identified which helped to consolidate and summarize the primary issues surrounding the current developments of these airports. These areas included the following:

1. **System Preservation:** Wherein the current system needs to be protected from airport closures (usually indicates that a large number of privately-owned relievers are in the area);
2. **Existing System Development:** Wherein one of the best options for obtaining new reliever capacity is the further development of the existing reliever system;
3. **Public Relations:** A key problem in these cases is the image of the reliever system in the minds of the area's citizenry. This public relations problem stands in the way of other options, especially existing system development; and
4. **New Relief:** This option means that new reliever airport sites need to be developed to supplement the existing reliever system. When this option is indicated, it usually means that such efforts are either underway or are at least possible.

Historical Funding Levels for Relievers

As the various definitions for relievers evolved, placing greater emphasis on its system-wide role, the amount of federal funding allocated to this category of airports generally increased. Funding authorizations for relievers from the Federal Aid to Airports Program (FAAP) hovered between $2 to $5 million per year during the 1960's (National Airport Program 1960-1979). In the first five years of the Airport Development Aid Program (ADAP), an average of just over $12 million per year was spent on relievers, for a total of $61.5 million from 1970 through 1975. During this period, there were three new reliever airports constructed and a total of 149 projects at 81 reliever airports. The $61.5 million amounted to 4.7 percent of the total money spent under ADAP and 28.9 percent of the total money spent on general aviation airports during these years (AIP Annual Report of Accomplishments 1970-1975).

With the change of reliever money classification in an amendment to the federal law from discretionary sources during 1970-1975 to specific allocations in 1976-1981, reliever airports saw even more improvement in their federal funding levels. The annual amount authorized to relievers during 1976 (plus the "transition quarter" in the change-over to new federal fiscal years) was $18.75 million. While far better than the allocations during the 1960's, this equated to $15 million per year from 1977 through 1979 and $20 million a year during 1980 and 1981 (AIP Annual Report of Accomplishments 1980-1990).

The Airport Improvement Program (AIP) formulated in 1982 mandated an even higher annual allocation for relievers. The law specified that a minimum of 10 percent of the basic authorization for all airports be spent on relievers (set aside under discretionary funds). This equated to $45 million spent in FY 1982. In the first two years of AIP, the amount of money allocated to relievers exceeded the amounts allocated from 1970 through 1981. Approximately $138 million was spent during FY 1990, however by then, there were over 285 relievers included in the NPIAS; 82 more than in 1982 with an additional 71 planned (NPIAS 1990-1999).

The funding levels previously discussed suggest that there has been a definite increase in the apportionment of federal funds made available to a greater number of relievers. However, will it be enough as new relievers are added and existing relievers require greater capital development?

Problems and Prospects

In order to provide a better understanding of the challenges facing this category of airports, a questionnaire was distributed to a 157 reliever airports designated in the 1987 National Airport System Plan update. The relevance of these questions was to determine the most significant problems facing the respondent's airport in order to identify how individual concerns compare with system-wide reliever problems. In all, a total of 110 responses (70 percent) were received. Of these responses, 94 were from publicly-owned airports and 16 were from privately-owned airports. Overall, the surveyed airports had an average of 131,396 operations per year (106 to 110 respondents), 263 based aircraft (108 of 110 respondents) and 19 based jets (106 of 110 respondents).

The following six questions were asked of each respondent. Each question is summarized by the total number of responses and its corresponding percent table ranking.

Question #1: "What is the greatest problem faced by your facility?" Each airport was limited to one response.

Problem	Number	Percent
Airspace/Traffic Congestion	3	11.8
Obstructions	2	1.8
Land Use Encroachment/Lack of Zoning	14	12.7
Needed Capital Improvements	41	37.3
Operating Costs	14	12.7
Community Opposition	13	11.8
Other	11	10.0
No Response	2	1.8
Total Responses	110	100

Based on the 110 responses, an overwhelming 41 (37.3 percent) indicated that needed capital improvements is the most crucial problem. The next largest problem included a split between airport operating costs and land-use encroachment/lack of zoning, which was specified by 14 respondents respectively. Following closely behind are problems associated with community opposition and airspace/traffic congestion - indicated by 13 respondents each. As detected in the comment space provided for this question, many of the community opposition comments involved a lack of support for expansion purposes (runway extensions and additional land acquisition privileges).

Question #2: "To what extent do you feel it has been an advantage to be designated as a reliever airport in the National Plan of Integrated Airport Systems (NPIAS)?" The response to this question are:

Problem	Number	Percent
Large Advantage - attracted money our airport would have otherwise not received.	64	58.2
Moderate Advantage - financial help has been good but very difficult to obtain	24	21.8
Small Advantage - support has been barely enough to warrant special designation as a reliever	8	7.3
None - it has not helped at all.	11	10.0
No Response	3	2.7
Total Responses	110	100

Nearly 80 percent of the respondents indicated that it has been either a moderate (21.8%) or large (58.2%) advantage to be designated as a reliever airport. On the negative side, only a combined 17.3 percent of the respondents felt it was of "small" or "no" advantage to be designated a reliever.

Question #3: "What is the most important advantage of a reliever airport?" The tabulated responses to this question are as follows:

Advantages	Number	Percent
Geographic location near or in metropolitan area	46	41.8
High demand levels	4	3.6
Role in serving corporate users	35	31.8
Role in serving suburban areas	6	5.5
Other	17	15.5
No Response	2	1.8
Total Responses	110	100

The responses to this question indicate that geographic location advantages (e.g. being located within or surrounding a metropolitan area) are the most important advantage of being a reliever airport. A similar response, the role of serving suburban areas, adds to this general trend. A response of secondary importance is the advantage of the role of serving corporate users - with 31.8 percent of the total responses.

Question #4: Solutions to reliever problems were also covered in the questionnaire. Respondents were asked which type of the following environmentally related measures were in place at their airport.

Measures	Responses
Curfews	7
Jet aircraft ban or limits	12
Noise monitoring	15
Land acquisition, easement acquisitions	46
Others (abatement procedures, etc.)	24
None in use	41
No Response	0
Total Responses (*)	145

(*) The total is greater than 94 because a number of airports have more than one measure in use.

Besides the 41 (28%) who use no related environmental measures, a total of 46 of the 110 respondents used acquisition of land or easements as the primary measure to control environmental circumstances. The use of noise abatement procedures was reported by 24 of the 110 respondents. Next came noise monitoring use by 15 of the 110 respondents. In a corresponding survey question pertaining to the noise issue, respondents were asked if they thought government regulation would help improve the airport noise situation. The outcome was split with 57 responding yes, 52 no and 4 undecided. Many of those answering yes provided comments which clarified the need for a national *general aviation noise policy* to reduce airport liability for compatible land-use and zoning requirements. Next, following noise monitoring, a total of 12 of 110 respondents selected a ban or limit on jet aircraft operations and 7 of 110 reported selecting curfews.

Question #5: When the respondents were asked "do you view such a metropolitan airport authority (or similar arrangement) an advantage," a 110 replied:

Attitude	Number	Percent
Clear advantage	48	43.6
Clear disadvantage	25	22.7
No change in our airport's situation	29	26.4
No Response	8	7.3
Total Responses (*)	110	100

It seems that a significant percentage of (but not a majority of) respondents viewed metropolitan airport authorities as a clear advantage. The comments received pertaining to this question typically underscored the economic and political advantages associated with region and community control in solving local aviation issues. Others felt that such an authority was far removed from the obligations necessary for corporate and general aviation pilots and that an authority is too involved in multi-agency politics. Another sizeable group (26%) - many of whom may already be included in such authorities - saw no change in their airport's situation. Many of those in this category of response expressed the viewpoint that the primary airport would automatically receive the majority of financial support due to the funding priority. Additionally, they fell that regional political and economic representation was of little consideration to the smaller general aviation/reliever type airports.

Question #6: Finally, respondents were asked if the 1987 AIP Legislation has been better for their airport than the old ADAP or AIP laws. Their responses were as follows:

Attitude	Number	Percent
It will provide significantly higher funding	4	3.6
No change - about the same	35	31.8
It will provide significantly lower funding	6	5.5
Not sure	17	15.5
No Response	2	1.8
Total Responses (*)	110	100

In the two years since the 1987 AIP Legislation, 50 percent of the respondents felt that there had been no change in the way their airport was affected by the 1987 Law. While very few (2.7%) maintained that the new law would provide significantly lower funding, nearly a third (30.9%) were not sure how the new legislation affected them in terms of federal funding. This response may imply that many were still not fully aware of the funding implications and did not understand the genuine differences between the 1982 and 1987 AIP Legislation for reliever airports. Not many more than a narrow margin (10.9%) agreed that they had experienced significantly higher funding advantages with the 1987 AIP Legislation.

Concluding Remarks

As evidence of this survey, it appears reliever airports are not only perceived by the respondents as achieving an important role within their own metropolitan area, but are also viewed as a significant contribution within the National Plan of Integrated Airport Systems (NPIAS). This is illustrated by 80 percent of the respondents who felt it was a large to moderate advantage to be included in the NPIAS.

In consideration of these benefits, there are also apparent disadvantages of being designated as a reliever airport - the most pressing of which coincides with the shortage of federal funds required for needed capital improvement projects. This survey further reveals that there are important opportunities for relievers in terms of attracting federal money and being able to carry out a defined and specific federal planning role. Nevertheless, it does not appear that the overall conditions faced by these airports will improve under current AIP Legislation.

While reliever airport problems are somewhat unified, their solutions are not. From this survey we see that there are clearly specific legislative, administrative, and operational areas which should be addressed in subsequent aviation legislation. This is especially true at the federal level so as to ensure a more clear, unambiguous stance which can be used system-wide for developing reliever airports. Overall, comments from the questionnaire pointed towards the need for better legislative guidance to uniformly help solve local issues that tend to be universal in nature (maintaining federal standards at general aviation airports, zoning requirements for airspace, environmental compliances and funding availability) but nevertheless require national attention, direction and solutions.

With FAA forecasts projecting worsening traffic congestion at the nation's top commercial service airports, it is paramount that relievers do more than just compliment the primary and general aviation airports in their area. This challenge comes at a time when over half of our respondents feel that there have been no noticeable changes in AIP Legislation in comparison with prior AIP or ADAP Legislation. All of this falls under more progressive constraints which may well be the most painful attempt to expand without reconciliation of federal assistance.

When collectively constrained from participating in a manner that optimizes their ability to operate effectively, planning for the future is made more difficult when based on the decision galvanized from the 1987 AIP legislation. Overall, future legislation may need to more aggressively pursue NPIAS criteria and development with respect to the specific needs of the relievers themselves.

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RELATIONSHIPS BETWEEN TECHNICALLY-ORIENTED SECONDARY SCHOOL COURSES AND A COLLEGE PRIVATE PILOT GROUND SCHOOL

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Abstract

This study was undertaken to determine if there is a relationship between final grades received in secondary school technically-oriented courses and the final grade received in a college private pilot ground school course. Ninety-six first-year students enrolled in the ground school course comprised the sample, with data for 51 aviation pre-major students and 45 non-aviation pre-major students examined both as two separate samples and as a single sample. Final grades earned by these students in secondary school elementary algebra, geometry and advanced algebra, the mean of the three mathematics final grades, the mean of the secondary science final grades and the mean of the secondary English final grades were used as independent variables. The final grades earned in Technology 101, Private Pilot Ground School, were used as the dependent variable.

From the analysis, it may be concluded that, when grades earned by aviation pre-major students and non-aviation pre-major students were analyzed as one sample, there was a relationship for all students between the private pilot ground school course and all of the secondary school technically-related courses. When the grades earned by aviation pre-majors were analyzed alone, there were relationships between only the ground school course and geometry and the mean of the final grades earned in secondary mathematics courses. The analysis of the grades earned by non-aviation pre-majors revealed relationships between the ground school course and all of the secondary school technically-related courses. There was no relationship between the ground school course and the mean of the final grades earned in secondary English courses for any of the three samples studied.

This study suggests that secondary school mathematics plays a role in preparing all students for a college private pilot ground school course. Secondary school geometry appears to play a particularly significant role in preparing pre-aviation majors who are taking a private pilot ground school course as an initial professional course.

Introduction

Collegiate aviation educators often are asked by secondary school counselors and teachers for recommendations regarding secondary school courses which provide the best preparation for college aviation courses, particularly pilot ground schools and other technically-oriented aviation courses. Collegiate aviation faculty frequently recommend that secondary school courses having a similar orientation, i.e., mathematics and science, provide the best preparation for technically-oriented college aviation courses. While a relationship has not been established between these secondary school technically-oriented courses and college technically-oriented aviation courses, it might be theorized that, based upon similar orientation, such a relationship could exist.

Gimmestad (1989) reported that a relationship exists between a college engineering design course and secondary school mathematics, student spatial visualization skills and a combination of drafting, shop and solid geometry courses. Of these three variables, spatial visualization is the most significant, mathematics is second and drafting, shop and solid geometry third. She suggests that students who are weak in these skills will be less likely to succeed in a college engineering design course than students who are strong in these areas.

Oman (1986) found mathematics proficiency to be correlated with successful completion of college computer science courses. Marsh and Anderson (1985) reported that achievement on a Biomathematics Skills Pre-test as well as secondary school grade point average were found to be predictors of success in a college introductory biology course.

Purpose of the Study

This study had three general purposes:

1. To determine if there is a relationship between secondary school technically-related courses, i.e., mathematics and science, and a college private pilot ground school course.

2. To determine if there is a relationship between secondary school non-technically related courses, i.e., English courses, and a college private pilot ground school course.

3. To determine if relationships between secondary school technically related courses and a college private pilot ground school course and secondary school non-technically related courses and a college private pilot ground school course differ between those students planning to major in aviation and taking the college course as the initial professional course and those not planning this major and taking the course as general education.

Methodology

The samples used in the study were 51 first-year pre-aviation major students (Group A), 45 first-year students who were not pre-aviation majors (Group B) and Group A and Group B students combined (N=96) for whom secondary school academic records were available. The students were enrolled in seven sections of Technology 101, Private Pilot Ground School, taught during fall and winter quarters, 1990-91, at St. Cloud State University. The curriculum for this course has been approved by the Federal Aviation Administration under Federal Aviation Regulations, Part 141. The sections were taught by three different instructors, all using this curriculum, the same text, work books, visual aids and the same four unit examinations and final examination.

The final grades earned by Group A and Group B students in Technology 101 were used as the dependent variable for each group in this study. These data were collected from instructor end-of-quarter grade reports for fall and winter quarters, 1990-91.

Quantitative data were collected from Group A and Group B student secondary school academic records. The final grades earned by the students in elementary algebra, geometry and advanced algebra were used as independent variables for each group in this study. Secondary school final letter grades were converted to numbers with A=4, B=3, C=2 and D=1.

While not all students in the two groups had taken all three secondary mathematics courses, all had taken at least two and the mean of the final grades earned in these courses was used as an independent variable. The least number of students in either group enrolled in any one of the three mathematics courses was 36, with the majority of students having taken all three courses. The mean of the final grades earned by the students in secondary science courses was used as an independent variable as was the mean of the final grades earned by the students in secondary English courses. In Group A, 50 of 51 students had taken at least two science courses and two English courses. In Group B, all 45 students had taken at least two science courses and two English courses.

Analysis of Data

The null hypothesis that each of the independent variables (x) was unrelated to the dependent variable (y) was tested using a T-test and a confidence interval of 95 percent was constructed. A simple regression equation was derived for each of the relationships. From this data, correlation (r) was used to examine the extent to which each of the independent variables, the final grades earned in secondary elementary algebra, geometry and advanced algebra courses, the mean of final mathematics grades, the mean of final science grades and the mean of final English grades, were related to the dependent variable, final grades earned in Technology 101, Private Pilot Ground School.

The analysis of the six independent variables of all students (Group A and Group B) and the dependent variable, Technology 101, of all students revealed that the null hypothesis can be rejected in the relationship between the final grades earned in Technology 101 and the final grades earned in elementary algebra, geometry, advanced algebra, the mean of the final grades earned in the three mathematics courses and the mean of the final grades earned in secondary science courses. The null hypothesis cannot be rejected in the relationship between Technology 101 and the mean of the final grades earned in secondary English courses. Refer to Table 1.

The analysis of the six independent variables of Group A and the dependent variable of Group A revealed that the null hypothesis can be rejected in the relationship between the final grades earned in Technology 101 and the final grades earned in geometry and the mean of the final grades earned in the three mathematics courses. Refer to Table 2.

The null hypothesis cannot be rejected for Group A in the relationship between the final grades earned in Technology 101 and the final grades earned in elementary algebra, advanced algebra, the mean of the final grades earned in secondary science courses and the mean of the final grades earned in secondary English courses. Refer to Table 2.

The analysis of the six independent variables of Group B and the dependent variable of Group B revealed that the null hypothesis can be rejected in the relationship between the final grades earned in Technology 101 and the final grades earned in elementary algebra, geometry, advanced algebra, the mean of the final grades earned in secondary mathematics courses and the mean of the final grades earned in secondary science courses. The null hypothesis cannot be rejected in the relationship between final grades earned in Technology 101 and the mean of the final grades earned in secondary English courses. Refer to Table 3.

Table 1

Independent	Dependent	Correlation(r)	Null Hypothesis
Variables	Variable	All Students	B = 0
Elem Algebra	TECH 101	0.23	0.0210484 < B < 0.4274236
Geometry	TECH 101	0.36	0.1711000 < B < 0.5869000
Adv Algebra	TECH 101	0.28	0.0590633 < B < 0.4619577
Math Mean	TECH 101	0.35	0.1736482 < B < 0.5673118
Science Mean	TECH 101	0.27	0.0968825 < B < 0.6083995
English Mean	TECH 101	0.16	-0.0428354 < B < 0.4673234

Table 2

Independent	Dependent	Correlation(r)	Null Hypothesis
Variables	Variable	Group A	B = 0
Elem Algebra	TECH 101	0.22	-0.0669070 < B < 0.4646300
Geometry	TECH 101	0.41	0.1402174 < B < 0.6581080
Adv Algebra	TECH 101	0.28	-0.0144477 < B < 0.4972939
Math Mean	TECH 101	0.36	0.0955700 < B < 0.6304500
Science Mean	TECH 101	0.21	-0.0829830 < B < 0.6010970
English Mean	TECH 101	0.19	-0.1041820 < B < 0.5515500

Table 3

Independent	Dependent	Correlation(r)	Null Hypothesis
Variables	Variable	Group B	B = 0
Elem Algebra	TECH 101	0.33	0.0218779 < B < 0.5988101
Geometry	TECH 101	0.34	0.2718060 < B < 0.3430444
Adv Algebra	TECH 101	0.36	0.0390967 < B < 0.6750533
Math Mean	TECH 101	0.41	0.1389460 < B < 0.7139940
Science Mean	TECH 101	0.36	0.0982990 < B < 0.8499750
English Mean	TECH 101	0.19	-0.1395580 < B < 0.6612100

From this analysis, one may conclude that, when grades earned by aviation pre-major students (Group A) and non-aviation pre-major students (Group B) are analyzed as one sample, there is a relationship for all students between the dependent variable, Technology 101, and five of the six independent variables. Refer to Table 1.

One also may conclude that there is a relationship for Group A between the dependent variable and two of the six independent variables: geometry and secondary mathematics courses. The relatively high correlation (r= 0.41) for the relationship between geometry and Technology 101 may indicate that the regression equation may have some value as a predictor of success in a private pilot ground school course for aviation pre-majors who are prepared in secondary school geometry. While this analysis does not suggest that relationships exist between Technology 101 and elementary algebra or advanced algebra, there is a relationship between Technology 101 and the mean of final grades earned in secondary mathematics courses. Refer to Table 1. Further, relationships are present between the dependent variable and both elementary algebra and advanced algebra in the analysis of data for all students. Refer to Table 1.

It may be concluded further from this analysis that there is a relationship for Group B between the dependent variable and five of the six independent variables: elementary algebra, geometry, advanced algebra, secondary school mathematics courses and secondary school science courses. However, none of the correlations for the relationships between Technology 101 and the three mathematics courses is as high for this group as is the correlation for the relationship between Technology 101 and geometry for Group A. The relatively high correlation ($r= 0.41$) for the relationship between Technology 101 and the mean of final grades earned in secondary school mathematics may indicate that the regression equation may have some value as a predictor of success in a private pilot ground school course for non-aviation pre-majors who are prepared in secondary mathematics.

An independent t-test was conducted to determine whether there was a statistically significant difference between the mean scores for Group A students, aviation pre-majors, and Group B students, non-aviation pre-majors, in TECH 101, Private Pilot Ground School. There was no significant difference between the mean score for Group A ($Ya = 2.4$) and Group B ($Yb = 2.1$).

Conclusion

This study suggests that secondary school mathematics plays a role in preparing all students for a college private pilot ground school course. Secondary school geometry appears to play a particularly significant role in preparing pre-aviation majors who are taking a private pilot ground school course as an initial professional course. It further suggests that secondary school science courses play a role in preparing students for a college private pilot ground school course, non-aviation pre-major students to a greater extent than aviation pre-major students. While English courses do not appear to play a role in preparing students for a technically-oriented course such as private pilot ground school, it must be emphasized that representatives of the aviation industry have indicated that the ability to communicate verbally and in writing is essential for success in all facets of the industry.

The study also suggests that achievement in geometry may be useful in predicting success in a college private pilot ground school course for those students taking this course as an initial professional aviation course. It further suggests that overall achievement in mathematics may be useful in predicting success in a college private pilot ground school course for those students taking this course for general education. Further research should include multiple regression analysis to rank the significance of each of the independent variables examined in this study in relation to the dependent variable, a private pilot ground school course, and to determine if relationships exist among these independent variables.

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