A STUDY OF AN AVIATION SAFETY COURSE FOR COLLEGIATE AVIATION DEGREE PROGRAMS: CURRICULUM DEVELOPMENT AND RECOMMENDATIONS

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DEDICATION

This dissertation is dedicated to my parents,

Dr. H. J. Lee and B. S. Yoo,

who instilled in me the value of

a quality education on an individual's life.

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It is a solemn moment for a doctoral candidate to write the acknowledgements after fulfilling all required course work and finishing dissertation while recalling one's previous school years. I was told frequently that "You are not alone", which implied the importance of "team-play" in aviation, from many persons in the aviation field. This dissertation would not have been possible without the support of a number of individuals.

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CHAPTER I

INTRODUCTION

Background

In tracing American aviation history, the aviation world has shown resilience and resourcefulness in coping with challenges or adversities and ultimately making progress despite these forces. These challenges can be divided into two main streams. One is the technological advance for high speed and mass transportation, and the other is improvement in aviation safety. Nearly 100 years after the Wright brother's flight, aviation has changed the world in many ways. Beyond its importance to the national defense and a means of transportation, the aviation or aerospace industry has become the single most important factor leading technological advance among the various fields. Aviation contributed to a strong economic growth and promoted the standard of living.

Over the last decade, aviation played an integral role in sustaining the unprecedented economic growth. Thus, the aviation industry makes substantial contributions to the economic vitality of the U.S. The air transportation industry generates more than 775 billion dollars each year, which comprises approximately 9% of the U. S. gross domestic product (GDP). The aviation industry including manufacturers, operators, and airline passengers pays more than 30 billion dollars each year in federal tax portion alone (McKenna, 1999).

In the fiscal year 1998, eighty-six U.S. commercial airlines (both scheduled and unscheduled) reported financial and traffic data to the Bureau of Transportation Statistics (BTS) Department of Transportation. The commercial airlines comprised of sixty-two passenger airlines, operating aircraft with over sixty seats, and twenty-four all-cargo carriers. Among them, forty-two airlines provided scheduled passenger service. Owing to the prosperity of U.S. economy, the financial performance of the U.S. commercial airline industry was encouraging. FAA and other aviation analysts use the model of the U.S. GDP as the primary economic variable affecting the growth of air transportation. In the fiscal year 1998, the GDP estimated $7,474.5 billion (in 1992 $) with a growth rate of 3.9% (Figure 1). In 1998, all ten major U.S. carriers made an operating profit. The aviation industry operating profit in 1997 was $7.9 billion and that of 1998 was $9.2 billion, a seventeen percent increase compared to 1997 (FAA, 1999a).

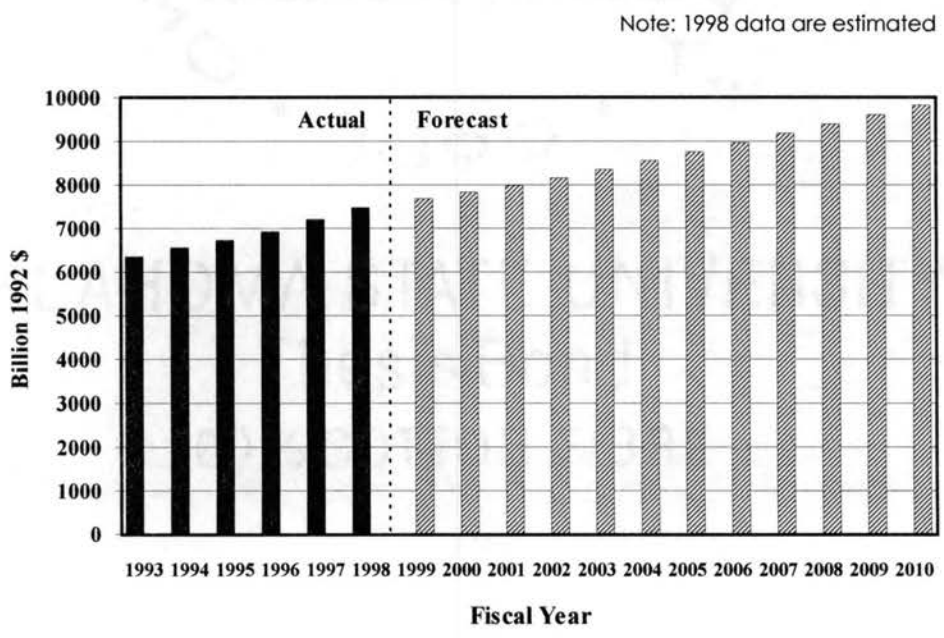


Figure 1. Forecast of Annual Gross Domestic Product (GDP)

Data from Aviation System Indicators, 1998 Annual Report Chap 3 p. 3
FAA, Assistant Administrator for System Safety, Safety Data Services Division

FAA's domestic economic forecast of aviation demand is mainly based on the Executive Office of the Present, Office of Management and Budget (OMB). The OMB's forecasts are optimistic and predict moderate growth throughout the forecast period. In the short-term, the U.S. GDP is estimated to increase by 2.7% in 1999, then slow to approximately 2.0% annual growth until 2001. The growth rate is expected to increase to 2.4% in 2002 and remain nearly stagnant throughout most of the remaining years of the forecast period. An average growth rate of GDP is forecast to 2.3% over the entire 12 year period from 1999 to 2010 (FAA, 1999b).

Every year Boeing Commercial Airplanes Group and Airbus Industrie published Current Market Outlook (CMO) and Global Market Forecast (GMF) respectively to assess the demand of world air travel. According to Boeing's 10-year outlook, the worldwide economic growth will average 2.7% a year. The world jet fleet will reach 19,100 airplanes in 2008 from an operating fleet of 12,600 airplanes at the end of 1998. Passenger traffic growth will average 4.7% per year. Cargo traffic growth will average 6% per year. The economic and traffic growth in a 20-year outlook illustrates a similar trend comparing with a ten-year outlook. The world commercial fleet will be 28,400 passenger and cargo jets in 2018 (Boeing, 1999).

Airbus' GMF also shows an optimistic forecast during the period 1999-2000. Passenger traffic will grow at an average annual rate of 5%, while cargo traffic growth will average 5.9% per year. The active passenger fleet will nearly double from some 10,000 passenger jets at the end of 1998 to 19,106 at the end of 2018 (Airbus, 1999).

The worldwide commercial aviation system is a huge complex structure composed of many factors. It includes approximately 745 airlines, more than 14,000 airplanes, and

1,350 major airports. Although the official aviation language is English, linguistic barriers still exist among the 190 countries and 150,000-plus flight crews. Various types of cultures play a great role in aviation safety around the world (Purvis, 1999).

In the previous decade, 1996 was recorded as the worst one in terms of aviation safety. Worldwide, there were 57 fatal accidents with 1,840 casualties. It was an extraordinary statistical numbers if we consider the previous decade's yearly average of 44 accidents and 1,084 casualties (Learmount, 1997). As we have seen the traffic forecast by Airbus and Boeing, worldwide jet fleet will be doubled within two decades. Under the forecast of air traffic condition, the actual number of accidents and the number of casualties are bound to increase while essentially the same rate of fatal accidents per million departures is maintained. The fatal accident rate has been nearly stagnant for over twenty years. It is probably not good enough to maintain current safety record owing to public perception of safety on catastrophic aircraft crashes. Daniel Maurino, the project manager of flight safety and human factors at International Civil Aviation Organization (ICAO), showed us his attitude toward aviation safety by saying that "the battle for safety is an endless quest against a relentless enemy having infinite resources, and who will never give up" (Maurino, 1997).

It is important to understand where we are and what we need in a collegiate aviation safety course. The following are sub-topics which are and will be impacting a prospective Aviation Safety course for the aviation degree programs in colleges and universities: (1) collegiate aviation programs and aviation supply and (2) some ramifications of aviation safety data.

Collegiate Aviation Programs and Aviation Supply

The University of Aviation Association (UAA) was founded in 1947 to promote non-engineering elements of higher education, providing degree programs in aviation education. Collegiate programs are housed at Associate, Baccalaureate, Master's, and Doctoral degree-awarding institutions. Usually, Associate degree programs take from two to three years to complete, with 60 to 70 semester hours of course work required. The Baccalaureate degree programs usually take four to five years to complete, with 120 to 140 semester hours of course work. The aviation degree programs are dealing with flight, aircraft maintenance, and avionics fields. A programs diversity depends upon the characteristics and philosophies of individual institutions. The majority of programs provide students with broadened aviation curricula that exceed FAA requirements for certificates and ratings. Some programs offer internships, providing experiences in the aviation industry, to bridge theory and practice (Crehan, 1995).

According to an UAA survey conducted in 1999, there has been a 15% decline in schools offering training in aviation careers. Besides, almost all universities are having difficulty retaining competent flight instructors owing to the increased hiring in the aviation industry (Tarver, 1999). In 1999, UAA published a Collegiate Aviation Guide (CAG) of institutions of higher education which number the institutions that offer programs in aviation. The total number of schools contacted was 280 and the number of institutions that replied to the survey were 109 UAA members and 10 non-members for total of 119. Among them, 95 institutions reported detailed aviation degree programs. By type of institution, 32 institutions had two-year programs and 61 institutions had four-year and upper level programs (see Figure 2).

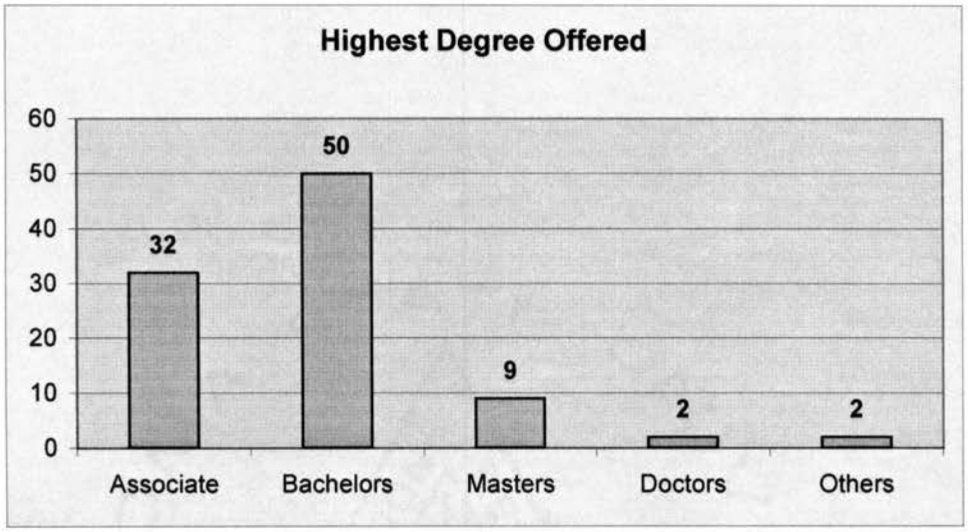


Figure 2. Number of Highest Degree Offered in Aviation Institutions

Source: Based on 1999 College Aviation Guide, UAA

These 95 out of 119 institutions reported a total enrollment of 19,087 students in aviation programs. The projected total enrollment of all 119 institutions are estimated to be more than 26,700 students. As the data shown in Figure 3, the UAA 1999 Collegiate Aviation Guide indicates that there are 10,165 students pursing programs in Flight Education; 3,827 students pursuing programs in Aviation Management or Airway Science Management; 1892 students pursing programs in Avionics or Electronics; 2414 students pursing programs in Aviation Maintenance or Aircraft Maintenance; and the remaining 364 students pursing programs in other related areas including Air Traffic Control and Aviation Computer Science (UAA, 1999).

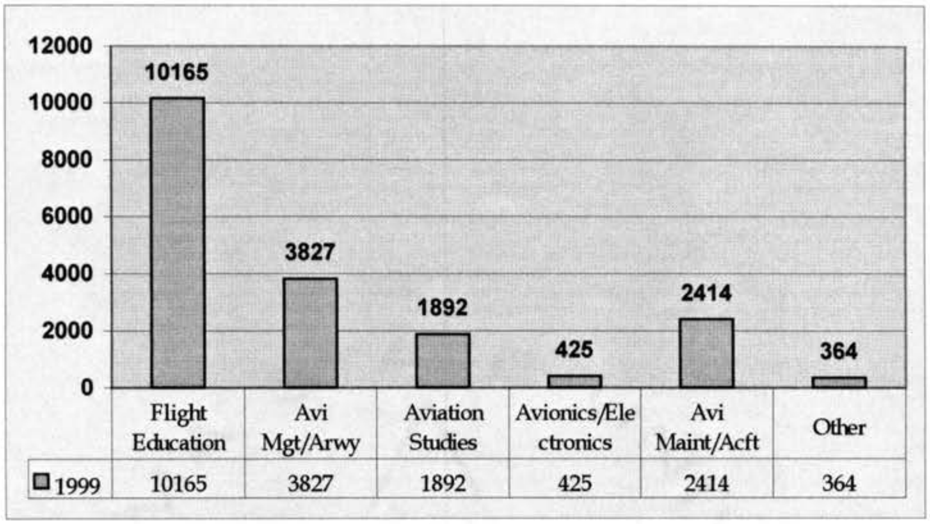
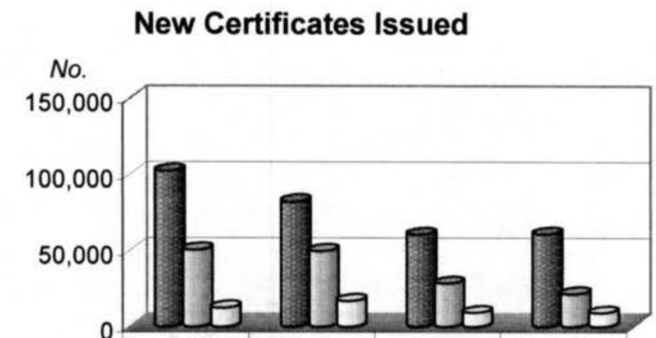


Figure 3. Aviation Enrollments by Program in 1999

Source: Based on 1999 College Aviation Guide, UAA

In 1993, a Blue Ribbon Panel launched by the FAA published a report titled "Pilot and Aviation Maintenance Technicians for the 21st Century – an Assessment Availability and Quality." The panel projected that there would be a national shortage of fully qualified pilots and Aviation Maintenance Technicians (AMT) for the period 1995 through 2010 unless positive action was taken. Not seeing any significant gains in the pool of aspiring commercial pilots and mechanics, the United States will see a shortage of pilots and AMTs (Tarver, 1999).

Data in Figure 4 indicates that student pilot certificates increased in 1997 but private and commercial pilot certificates continued to drop. We can assume a pessimistic picture regarding the future pool of commercial pilots. In the past, approximately 80% of major airline pilots were trained by the military. Currently, the ratio is down to 40-45%. The data shows a similar trend in the case of Aviation Maintenance Technicians. The FAA estimates that the United States will need approximately 16,000 AMTs each year but training programs are producing only 7,800 a year (Ibid.).



	1980	1991	1995	1997
Student	102,301	82,205	60,497	60,898
Private	50,458	49,580	28,333	21,552
Commercial	12,452	16,869	9,133	8,988

Figure 4. Number of New Certificates Issued by the Select Year
Source: Labor Pilot/Mechanic Supply, 24th Annual Commercial Aviation Forecast Conference proceedings, FAA, 1999

Some Ramifications of Aviation Safety Data

Aircraft accidents are rare events owing to the culmination of several concurrent failures. A description of aviation from the Flight Safety Foundation reads: "aviation in itself is not inherently dangerous, but like sea, is terribly unforgiving of any carelessness, incapacity or neglect" (Job, 1996, p. 7). An Australian proverb can be cited for conventional attitudes toward safety: "shutting the stable door after the horse has bolted" (Ibid., p. 8).

Tracing the American aviation history, especially, with regard to establishing of safety agencies or Federal Aviation Acts, we can point out foremost the "blood priority" syndrome. For instance, the death of Senator Bronson M. Cutting of New Mexico in the 1935 TWA DC-2 crash aroused great public attention and triggered the establishment of the Civil Aeronautics Act of 1938, which repealed large portions of the Air Commerce Act and consolidated all aviation functions into an agency called the Civil Aeronautics Authority. The Federal Aviation Act of 1958 resulted from the midair collision between a TWA Constellation and a United Airlines DC-7 over Grand Canyon on June 30, 1956 (Ellis, 1984).

The official, professional definition of an aircraft accident is presented by International Civil Aviation Organization and National Transportation Safety Board (see "definition of terms" in this paper). Jerome Lederer, the founder of Flight Safety Foundation, described unique aircraft operations and the nature of accidents:

> The aircraft is continuously fighting the unrelenting law of gravity which instantaneously takes advantage of any failures or weakness in this struggle for survival. Human errors, carelessness and complacency are likely to be more catastrophic in air transportation than in any other means of transportation. Unlike surface traffic, an airplane cannot stop to attend to emergencies such as power plant failure, crew incapacitation or structural failure. It requires the coordinated cooperative efforts of a greater variety of associated technologies than any other system of transportation--air traffic control, airport management, weather, navaids, flight planning and dispatching, communications, ramp operations, et cetera. It is three dimensional, requiring navigation in three dimensions, subject to the variable hazard of the atmosphere, of terrain, and of air traffic threats from every direction. In the next century will be the problem of increased exposure of aircraft occupants to cosmic radiation in sub-orbital operations (Lederer, p. viii, 1995).

Statistical analysis shows that the accident rate has been at a plateau for almost 30 years. Although we understand that an accident does not occur by calendar according to previous statistical accidents, we can assume, in the worst case, that the projected increase in global traffic at 1996's accident rates would imply approximately one major crash per week by the year 2010. In turn, we readily conclude that we need to find new ways to improve aviation safety (Paries, 1996).

To get a bigger picture of safety, it is necessary for us to understand fundamental differences in safety paradigms between the aviation safety personnel and the public. There are two kinds of safety paradigms: one is professional and the other is public. Professionals tend to rationalize safety and regard the result as the concept of risk. Risk is by nature a predictive notion. However, the public version of safety in general does not seem to refer to risk. They tend to report disasters and record the fatalities. The result is a "feeling of safety" which is a level of trust and related to other social dangers. The relationship between "the feeling of safety" and the frequency of accident is not linear (Ibid.). The public tends to be sensitive about air disasters and are often mislead by accident and fatality rates from various sources.

The basic difference between accident and safety data can be summarized as accident data tells us what happened and safety data tells us why it happened. The aviation community consists of many members from various organizations. Each member has access to safety data that has been developed for his/her organization. It should be noted that there has not been a consensus among researchers and participants in the aviation community about what exactly constitutes safety data. One of the more important aspects of a safety database is the standardization of information. Without the standardized safety data tool, it is very hard to expect any improvements in accident prevention (Logan, 1999).

One endeavor for standardization of safety data can be found in the Global Analysis and Information Network (GAIN) movement envisioned by the Federal Aviation Administration (FAA). For worldwide safety data collection, the FAA proposed the

Global Analysis and Information Network in May 1996. GAIN was envisioned by the FAA as a voluntary privately owned and operated worldwide infrastructure to collect, analyze, and disseminate aviation safety information to the aviation community who can use it to assist in identifying emerging safety concerns. All facets of the aviation community are involved in this network including airlines, manufacturers, pilots, mechanics, flight attendants, dispatchers, regulatory authorities, the military, scholars, suppliers, and others. The GAIN organization is composed of the Steering Committee, Working Groups, Program Office, and a planned Government Support Team. Later, the Steering Committee changed the meaning of the GAIN to "Global Aviation Information Network" which more accurately defined the aviation centered program (GAIN, 1999).

Currently, the Federal Government makes a variety of aviation safety data available to the public by both the Federal Aviation Administration (FAA) and the National Transportation Safety Board (NTSB). The development of the National Aviation Safety Data Analysis Center (NASDAC) and the rapid growth in the internet make government safety data more accessible to the public. This increased availability offers new opportunities for educating the public on the use and interpretation of aviation safety data (FAA, 1997). The web address for NASDAC is http://nasdac.faa.gov. In addition to the FAA Internet Resources--A Quick Reference Guide can also be accessed through the FAA Mike Monroney Aeronautical Center Library at http://www.cami.jccbi.gov/AAM-400A/Library/faaweb.htm.

After the standardizing stage, normalization process of safety data should be followed as the next stage. The raw data on accidents and incidents should be converted to accident and incident rates before it is used for making reasonable comparisons for safety indicators. Selecting the appropriate measure of exposure to risk is another important decision to normalize event data including number of flights, hours flown, passenger enplanements, and passenger miles flown (FAA, 1997). Typically, transportation safety rates are based on either the distance traveled or the number of trips. However, the nature of risk differs across modes of transportation, which makes such comparisons difficult (Oster Jr., Strong, & Zorn, 1992). For instance, a commercial aircraft spends approximately six percent of its flight time in the events of take off, initial climb, final approach, and landing but around 70% of hull loss of accidents have occurred during these relatively short stages (Weener & Wheeler, 1992).

The data presented in Table 1 shows the formulas used for the aviation system indicators by the FAA, based on accident/incident rates both per 100,000 flight hours and per 100,000 departures.

Monthly/ 12–Mo Moving Avg:

$$\textit{Accident Rate (per 100,000 flt hrs/deps)} = \frac{\textit{No. of Accidents in Mo/Past 12 Mos}}{\textit{No. of Flt Hrs/Deps in Mo/Past 12 Mos}} \times 100,000$$

represents the following four separate equations:

$$\textit{Monthly Accident Rate (per 100,000 flight hours)} = \frac{\textit{No. of Accidents in Month}}{\textit{No. of Flight Hours in Month}} \times 100,000$$

$$\textit{Monthly Accident Rate (per 100,000 departures)} = \frac{\textit{No. of Accidents in Month}}{\textit{No. of Departures in Month}} \times 100,000$$

$$\textit{12-Month Moving Average Accident Rate (per 100,000 flight hours)} = \frac{\textit{No. of Accidents in Past 12 Months}}{\textit{No. of Flight Hours in Past 12 Months}} \times 100,000$$

$$\textit{12-Month Moving Average Accident Rate (per 100,000 departures)} = \frac{\textit{No. of Accidents in Past 12 Months}}{\textit{No. of Departures in Past 12 Months}} \times 100,000$$

Table 1. Formulas Used in the FAA System Indicators

Adapted from FAA Aviation System Indicators, 1998 Annual Report, Chapter 2 p. 2

Another formula to measure safety is based on "death risk" per one million departures. The measure was developed by Barnett, Abraham, and Schimmel, known as the Q statistic. This method is usually applied to aircraft carriers where reliable enplanement data is not available. Q is measured as:

$$Q = \frac{\sum_{i=1}^{n} X_i}{N}$$

N : the number of flights performed by airline i

X_i : the proportion of passengers on the i^{th} of the flight who do not survive it.

Therefore, in the formula, if a flight lands safety X_i equals zero. Here, Q can be considered as the odds of dying in one million flight (Oster Jr., Strong, & Zorn, 1992).

The death rate is often mentioned to dilute a negative public reaction on the safety of air transportation by comparing it with the other modes of transportation. For example, a person who randomly chose a U. S. domestic jet flight between 1967 and 1976 would have a one in two million chance of dying. Using data from 1990 to 1996, the death risk fell to one in eight million. Calculated somewhat differently, if a passenger facing a death risk of one in eight million chose one flight at random every day, the one would, on average, go for 21,000 years before perishing in a fatal accident (Hinson, 1996). However, among the discussion of various accidents and fatality statistics, NTSB remarked that "none of the statistics, taken alone, can be considered an accurate measure of airline safety and can be misleading" (NTSB, 1996).

Statement of the Problem

A cynicism of "blood priority" has been around for a long time in our aviation world. It is still used and still generally true in the aviation safety business in the U. S. Total safety of flight is no doubt an unattainable goal. At least, however, we should get rid of the "tombstone" attitude that waits for a repeat in similar types of accidents (Schiavo, 1998).

Safety has been a primary concern for the aviation business. For the past 30 years, the annual, global catastrophic aircraft accidents (hull-loss) rate has been one to three accidents per one million departures of large jets. In the United States, the annual rate has been consistently around one accident or less per million departures (NCARC, 1998).

In the United States, the year 1996 was the worst year both in airline fatal accidents and in fatalities on record which includes the Value Jet crash on May 11 and the TWA explosion on July 17. The total number of worldwide fatal accidents in 1996 reached was 57 with 1,840 casualties (Learmount, 1997). The FAA expects airlines in the U.S. alone to carry about 1.2 billion passengers by 2015, double today's level, on 40% more flights (Shifrin, 1996). This means more negative factors will affect aviation safety such as more operations, more use of aging aircraft, more maintenance, heavier use of already congested airport runways and ground facilities, further strains on an aging air traffic control system. The problem of air traffic congestion and delays become a serious issue in aviation safety with the growing of air transportation. However, if we fail to have innovation with regards to aviation safety while air travel doubles, the chance of fatal accidents could be increased in proportion to the size of air transportation. To avoid this outcome, we should do something for safer skies from the aviation schools where aviation safety begins. One of the most important pieces of that education effort is to provide proper instruction to enhance aviation safety. A major problem in aviation education is that no consensus exists regarding what should be included in a collegiate aviation safety course.

Purpose of the Study

The purpose of this study is to develop an Aviation Safety course suitable to collegiate aviation degree programs by identifying characteristics, scope, units, elements, and topics perceived to be included in a suggested Aviation Safety course. To date no analysis has been made of what universities and colleges currently cover and perceive should be taught with regard to an Aviation Safety course. To achieve the purpose of this study, the questionnaire developed by the researcher was utilized to answer the following questions.

1. What is the current involvement of University Aviation Association (UAA) schools concerning instructions for an Aviation Safety course?
2. What are the scope, depth and characteristics of a suggested Aviation Safety course?
3. What are the major recommended elements or units in a collegiate level Aviation Safety course?
4. What is appropriate credit hour for a suggested Aviation Safety course?
5. What is the respondents' preferred textbook for Aviation Safety instruction?
6. What is the indicated level of importance or necessity for formal instruction in an Aviation Safety course?

Assumptions

The following assumptions were made with regard to this study:

1. The UAA Institutional and Professional members are appropriate representatives who are experts in the aviation field.
2. The participants responded to the questionnaire in a sincere manner reflecting their professional, experiential, and educational knowledge.
3. The Aviation Safety course is a needed course for collegiate aviation degree programs.
4. The questionnaire was appropriately designed to address the purpose of this study.
5. The number of questionnaires returned were suitable for data interpretation.

Limitations of the Study

The population of the study was limited to the 111 University Aviation Association (UAA) institutional members and 202 professional members who were posted in the membership list in November 1999. The professional members are either full-time or part-time faculty members at collegiate aviation institutions in the United States. The UAA population was selected based on the charter and by-laws of its membership to develop and enhance aviation education.

Definition of Terms

The following definitions and aviation terminology will be used in this study:

Aircraft Accident. An aircraft accident involves some degree of damage or injury associated with the operation of an aircraft. The most widely accepted definition is the one developed by the International Civil Aviation Organization (ICAO), which does not apply to military and foreign government aircraft accidents (Wood & Sweginnis, 1999).

Accident defined by ICAO is that an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which:

a. a person is fatally or seriously injured as a result of :
    - being in the aircraft, or
    - direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or
    - direct exposure to jet blast,
    - EXCEPT when the injuries are from natural causes, self-inflicted, or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; or
    - the aircraft sustains damage or structural failure which:
    - adversely affects the structural strength, performance or flight characteristics of the aircraft and
    - would normally require major repair or replacement of the affected component,
    - EXCEPT for engine failure or damage, when the damage is limited to the engine, its cowlings or accessories; or for damage limited to propellers, wing tips, antennas, tires, brakes, fairings, small dents or puncture holes in the aircraft skin; or

b. the aircraft is missing or is completely inaccessible.
    - NOTE: A fatal injury is an injury resulting in death within thirty days of the date of the accident.

The NTSB's definition is similar to that of ICAO. The definition by NTSB reads: an occurrence associated with the operation of an aircraft that takes place between the time any person boards the aircraft with the intention of flight and all such persons have disembarked, and in which any person suffers death or serious injury, or in which the aircraft receives substantial damage. In 1997, the NTSB classified accident into 4 categories based on severity: major accident, severe accident, injury accident, and damage accident (Wood, 1997).

Air Carrier. Air carrier means a person who undertakes directly by lease, or other arrangement, to engage in air transportation (FAR Part 1).

Aircraft Incident. An occurrence, other than an accident, associated with the operation of an aircraft that affects or could affect the safety of operations and that is investigated and reported on FAA Form 8020-5 (FAA, 1999c, G-2).

Air Traffic Control. A service provided by the appropriate authority to promote the safe, orderly, and expeditious flow of air traffic (Nolan, 1994, p. 521).

Air Transportation. Air transportation means interstate, overseas, or foreign air transportation or the transportation of mail by aircraft (FAR, Part 1).

Airway Science. An educational program sponsored by the Federal Aviation Administration and provided by four-year degree-granting schools around the country (Nolan, 1994, p. 522).

Aviation /Aerospace Education. Broad aerospace information dealing with the social, scientific, and technological importance of aviation and space with special applications for the aviation educators who desire to utilize such information in the aviation related field.

Aviation Program. An academic program resulting in an earned certificate or baccalaureate aviation-related degree from an accredited institution. Usually, the program prepares the student for entry level positions in the air transportation industry including professional pilots, technicians, airport managers, aviation managers, air traffic controllers, and aviation safety personnel.

Aviation Safety. A definition of safety is the elimination of hazards, or their control to levels of acceptable tolerance as determined by law, institutional regulations, ethics, personal requirements, scientific and technological capability, experiential knowledge, economics, and the interpretations of cultural and popular practice (Grimaldi & Simonds, 1989, p. 181). In short, aviation safety refers to the utilization of all available resources of information, equipment, and people to achieve a safe and efficient operation in aviation.

Aviation Safety Course. A collegiate aviation course to develop within an individual knowledge of contributing factors affecting aviation safety and fostering control methods and techniques to reduce accidents related to aircraft and the aviation field (CMSU, 1999, p. 44).

Behaviorism. The school of psychological thought that rejects the validity of covert mental processes as useful concepts in the explanation of behavior, relying solely upon observable responses to stimuli (Green, 1995, p. 388).

Commuter Air Carrier. A scheduled passenger operation conducted under FAR Part 135 using one of the following types of aircraft with a frequency of operations of at least five round trips per week on at least one route between two or more points according to the published flight schedules: (i) airplanes, other than turbojet powered airplanes, having a maximum passenger-seat configuration of nine seats or less, excluding each crewmember seat, and a maximum payload capacity of 7,500 pounds or less; or (ii) rotorcraft (FAA, 1999c, G-2).

Cockpit or Crew Resource Management (CRM). The CRM is a training program developed to assist crew members to improve crew coordination.

Delay. Delays are incurred when any action is taken by a controller that prevents an aircraft from proceeding normally to its destination for an interval of 15 minutes or more. This includes actions to delay departing, en route, or arriving aircraft as well as actions taken to delay aircraft at departing airports due to conditions en route or at destination airports (FAA, 1999c, G-2).

Human Factors. Human factors are about people in their working and living environments, and it is about their relationship with machines, equipment and procedures. Just as important, is their relationship with other people. It involves the over-all performance of human beings within the aviation system.

General Aviation (GA). That portion of civil aviation that encompasses all facets of aviation except air carriers (FAA, 1999c, G-3).

Large Air Carrier. A scheduled or nonscheduled aircraft operation conducted under FAR Part 121. Effective March 20, 1997, Part 121 includes:

(1) scheduled and nonscheduled operations of (i) all turbojet-powered airplanes; (ii) airplanes having a passenger-seat configuration of more than 30 passenger seats, excluding each crewmember seat; and (iii) airplanes having a payload capacity of more than 7,500 pounds; and (2) scheduled operations of aircraft with more than 9 and less than 31 seats, excluding each crewmember seat and with a payload capacity of 7,500 pounds or less (FAA, 1999c, G-2).

Near Midair Collision (NMAC). An incident associated with the operation of an aircraft in which a possibility of collision occurs as a result of proximity of less than 500 feet to another aircraft, or a report is received from a pilot or flight crew member stating that a collision hazard existed between two or more aircraft (FAA, 1999c, G-3).

Rotorcraft. A heavier-than-air aircraft that depends principally for its support in flight on the lift generated by one or more rotors (FAA, 1999c, G-3).

Safety Factor. A literal meaning of factor from English dictionary is one of the things that affect an event, decision, or situation (Sinclair et al., 1995, p. 595). A meaning from aeronautical term dictionary is the ratio of the maximum load a structure is designed to support, to the maximum load it will ever be required to support (Crane, 1991, p. 493). In the FARAMT, safety factor is mentioned in Part 23.303 and 27.303; unless otherwise provided, a factor of safety of 1.5 must be used (FARAMT). In this paper, safety factors indicate various things that affect an event, decision, or situation in aviation safety.

Significance of the Study

Safety begins with common sense. Safety is a very common word but this easy word often has complex concepts. How safe is safe? What constitutes aviation safety? Even for aviation safety specialists, it may not be easy to answer such questions. At least, we can acknowledge that a major component of a safety paradigm is the safety objective (Paries, 1996).

In 1996, the FAA issued a national safety plan aimed at zero-accident. Flight Safety Foundation (FSF) mentioned the goal of 50% reduction in the accident rate during the next 15 years (Ibid.). To successfully achieve a zero-accident rate is an ideal goal. However, we in the aviation world must wholeheartedly and unequivocally strive towards obtaining that mindset. Lowering accident rates can be done by a change of mindset that is beginning to take place. The word aviation safety must be synonymous with accident prevention (Duke, 1999). One approach that we can try is relying on an appropriate education to reinforce aviation safety concepts in aviation school. Rodney Slater, the Secretary of Transportation, mentioned that "developing a strong cadre of well-prepared students is essential to national economic success and will ensure that we are truly competitive in the global economy of the 21st century"(FAA, 1999d). Besides, Robert Francis Jr., Vice Chairman of NTSB, emphasized the importance of education which needs to enhance aviation safety:

> The final frontier here is education. Airline executives, government regulators and legislators, tort lawyers, the media, and the traveling public all need to understand that this is a critical component of enhanced aviation safety. And one of the most important pieces of that education effort is to ensure proper use of the data only to enhance aviation safety. We must proceed to a new era of trust, cooperation, and volunteerism to improve safe transportation worldwide (Francis Jr., 1997 p. 16).

Although there has always been a concern for safety throughout the airline industry, it appears that the lessons learned from past tragedies often go unnoticed or disregarded altogether. Safety recommendations from aircraft accident and incident investigations should be feedback if we intend to lower accident rates (Miller, 1999). The causes of accidents are frequently repeated, simply due to the common thread that entwines all accidents—human intervention. Studies of NTSB showed approximately 60% of the fatal accidents in the U. S. by scheduled passenger carriers are due to human error. Human error is a causal factor in more than 70% of these accidents. Human errors are defined as problems of personnel capabilities that include attention, judgement, perception, knowledge, and motor skills (Wells, 1997).

Although it is not easy to identify human errors owing to privacy, sensitivity, and morality, human capabilities can be improved to an extent by better training or education methods. Here, we can find the role of an aviation education. We should apply such valuable insights and important lessons from previous errors to our aviation community. If we are to successfully apply positive or better input to our students for safety, we can have chance break at least one ring in the chain of events leading to an accident. Hence, an Aviation Safety course will be a good background course to give whole safety concepts to students in aviation degree programs. For the instructors or faculty members at aviation institutes who teach aviation courses, the results of the study can give an opportunity for them to compare their versions of aviation safety with those of other aviation safety specialists in the aviation education community.

Organization of the Study

The remainder of this work contains the following topics. Chapter II is a review of the literature which includes various issues covering from collegiate aviation education to aviation safety. Chapter II includes the historical review of aviation education; recent studies of aviation education and aviation safety; general aviation safety; commercial aviation safety; a theoretical framework of aviation education; and a theoretical framework of aviation safety. Chapter III, which gives the methodology, comprises introduction, selection of subjects, instrument, collection of data, and compilation and analysis of the data. Chapter IV is the result of the study. Chapter V is the summary, findings, conclusions, and recommendations.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Questions concerning safety in aviation attract a great deal of attention owing to worldwide fatal accidents in recent years. It is indubitable that the aviation community has always been deeply concerned with "the permanent prevention of accidents and conscientious safeguarding of all imaginable critical factors surrounding the organization of processes in aeronautical technology" (Soekkha, 1997, p.xiii).

Conventional methods of aviation safety are called piecemeal approaches focusing on individual factors in aviation fields. Ironically, controllers, designers, engineers, pilots, researchers and other aviation specialists which advocated fixed solutions to safety deficiencies were biased by their professional backgrounds. Such attitudes made us neglect looking at the big picture of aviation safety, and conveying the notion that abnormal activities within aviation take place in isolation (Maurino, 1997).

In this chapter, several areas concerning both aviation education and aviation safety will be reviewed and discussed to understand the nature of aviation safety. The following area are addressed:

- Historical Review of Aviation Education
- Recent Studies of Aviation Education and Aviation Safety

- General Aviation Safety
- Commercial Aviation Safety
- A Theoretical Framework of Aviation Education
- A Theoretical Framework of Aviation Safety

Historical Review of Aviation Education

Humans were known for their great desires to fly the sky in numerous mythologies and historical descriptions about aviation. Manned flight actually began in lighter-than-air balloons filled with hot air. Wright brother's made a historic heavier-than-air flight with their Flyer I installed with a twelve-horsepower gasoline engine at 10:35 a.m. on December 17, 1903 (Christy, 1994).

The first record about aviation education in the U. S. was that of H. Lavonne Twining of Los Angeles Polytechnic High School which he discussed aviation in his physics classes in 1908 (Strickler Jr., 1968). The first post-secondary courses in aviation were started by the Massachusetts Institute of Technology in 1914 (Rollo, 1990). World War I triggered interest in pioneering aviation in the United States. According to the various documents in the 1920's, many schools offered aviation education programs throughout the country. In 1925, the Galt school system of California established the first public school flight-training program at the high school level. In 1926, The Galt Schools added a two-year junior college level aviation education program (Strickler Jr., 1994). Other records show the beginning of collegiate level aviation education. On August 1, 1927, Oliver Parks started Parks Air College with two biplanes and rented facilities at Lambert Air field in St. Louis. On July 1, 1929, Parks Air College became the first federally certified flight school in the U. S. (Parks College, 1995).

Prior to World War II, commercial schools conducted major roles in teaching aviation programs in the U. S. Among them, a few colleges and universities had aviation programs combined with aeronautics and engineering. In 1939, the Civil Pilot Training Program (CPTP) was established under government sponsorship. The program continued until it became the War Training Service (WTS) after Japan's attack on Pearl Harbor. The large-scale war aviation program was performed by over 1,000 institutions including private aviation contractors, schools and colleges. Under this war program, over four hundred thousand students were trained as military pilots (Strickler Jr., 1994).

After World War II, some commercial private schools became part of colleges or universities, or were accredited as universities of themselves. From the early 1950's, under the government suggestion, collegiate aviation started the Reserve Officers' Training Corps (ROTC) and flight orientation programs for preparing future military flight officers. With the advent of the jet age in the 1960's, collegiate aviation programs needed improvement to meet the challenges presented by new technologies. Thus, initial aviation curricula included management, flight, maintenance, avionics, and other options to come later (Kiteley, 1996).

According to "Post-Secondary Aviation & Space Education Reference Guide" by the FAA in 1994, more than 400 institutions of higher learning offer the aviation and space (or aerospace) study and flight education programs in the United States (Schukert, 1994). Presently, approximately 580 certified flight schools exist in the U.S. Some of these schools have formal classes for college credit for the required aviation subjects whereas some require only home study. UAA's College Aviation Guide comprise 118 post secondary institutions which offer non-engineering aviation programs in the United States, Puerto Rico, and Canada (UAA, 1999).

Recent Studies of Aviation Education and Aviation Safety

The dissertation database of University Microfilms International (UMI) is an authoritative, academic source for information about doctoral dissertations and master's theses. The database comprises academic work from over 1,000 institutions including almost all North American universities and many European universities. The digital library of UMI has more than 1.5 million records from the first American dissertation in 1861 to the present day (UMI, 2000).

Presently (January 7, 2000), the data related to aviation is filed under 674 topics. The first dissertation concerning aviation is titled "The Nature and Development of Aviation Insurance" written by Stephen Sweeney in 1925 (UMI, 2000). A couple of analyses of dissertation topics illustrate that a majority of aviation studies were presented in the 1990's. The data in Figure 5 shows that 368 (54.6%) dissertations related to aviation topics have been presented in the 90's.

Among the dissertations about aviation, 57 topics are categorized into aviation education and 75 topics into aviation safety according to the UMI database, January 2000. As illustrated in the Figure 6, approximately 47% (27) of aviation education topics were presented in the 1990's. The pioneering studies about aviation education are "Teacher Training in Aviation Education" by Cecil Lewis in 1948, "The Air Center As Means of Implementing Aviation Education" by Mervin Strickler Jr. in 1951, and "A Study of Aviation Courses and Facilities in Higher Education in the United States with

Predictions of Future Trends" by Lewis Jackson in 1951 (UMI, 2000).

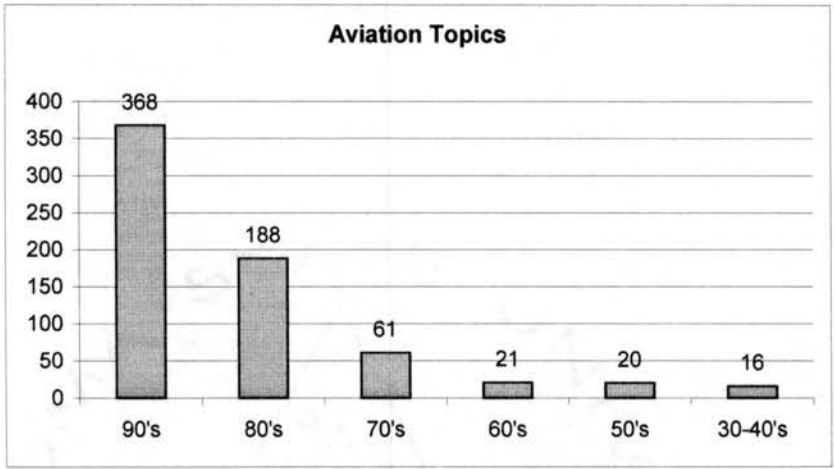


Figure 5. Number of Aviation Topics Posted in the UMI Dissertation Database
Source: UMI's digital library on January 7, 2000, http://wwwlib.umi.com/dissertations

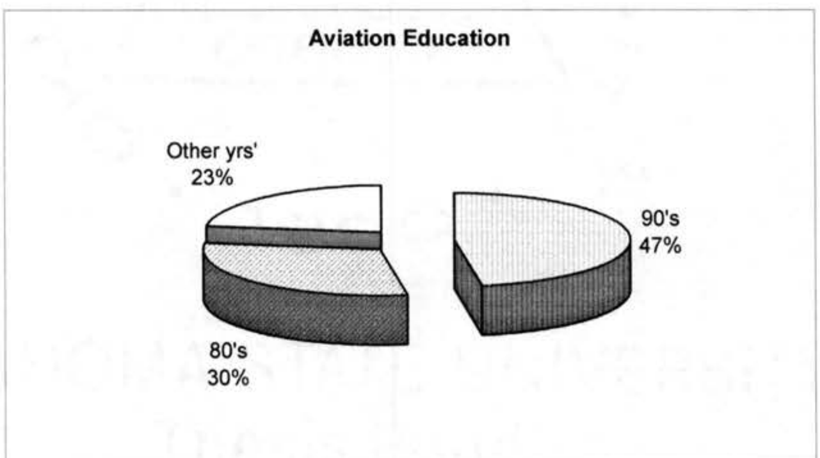


Figure 6. The Aviation Education Topics Posted in the UMI Dissertation Database
Source: UMI's digital library on January 7, 2000, http://wwwlib.umi.com/dissertations

In the1960's, "An Introduction to Aerospace Education" was edited by Mervin Strickler Jr. to help curriculum planners and educational practitioners for aerospace education. The book consists of 20 chapters including a definition of aerospace education, aerospace curriculums, enrichment techniques, sources of aerospace education, and aerospace education background (Strickler Jr., 1968).

As we have seen in Figure 5 and 6, a comprehensive list of dissertations dedicated exclusively to aviation grew during the 1990's. However, published literature addressing aviation safety course for collegiate level is not prevalent. Among the numerous aviation textbooks used for collegiate aviation, only a few books directly or exclusively address aviation safety. They are:

- Aircraft Safety: Accident Investigations, Analyses, & Applications (by Shari Stamford Krause)
- Air Travel: How safe is it? (by Laurie Taylor: BSP Books)
- Aviation Safety Programs: A Management Handbook (by Richard H. Wood: Jeppesen)
- Commercial Aviation Safety (by Alexander Wells: Tab Books)
- Flight Safety: A Primer for General Aviation Pilots (by Alexander Wells: Tab Books)

Of the studies identified, 15 dissertations have been identified for contemporary review of literature and they are listed in Table 2. The resources used in this study include the UMI ProQuest Digital Dissertations database and Dissertation Abstracts International.

Among the authors, Lehrer, Bogue, Bowen, Conway, and Weitzel were concerned with topics relating to aviation curriculum development. One study by Henry Lehrer (1985) was conducted to determine and compare the responses of public airport managers. The study was limited to the 298 public airport managers in the state of Arizona, New York, North Carolina, and Ohio. The objective of the study was to determine what course should be included in an airport manager education program. The findings of the study indicated that there was agreement among the managers as to what academic courses should be included in the program for a potential airport manager. The suggested academic courses were Airport Operation, Airport Internship, Airport

Planning, Aviation Law, Aviation Safety, Management, Finance, Economics, Accounting, and Labor Relations (Lehrer, 1985).

Author	Year	Dissertation Title
Robb, D. O.	1984	Development of Relative Risk Information for General Aviation Safety Education (Decisions, Pilot, Training)
Lehrer, H. R.	1985	A Study of College Level Academic Courses for Airport Management Personnel (Aviation, Aerospace, Flight)
Bogue, N. E. F.	1986	Developing a Resource Unit in Aerobatics to Improve Aviation Education (Flight Instruction, Collegiate, Innovation, Flight)
NewMyer, D. A.	1987	An Analysis of the Perceptions of Aviation Educators Concerning Non-engineering Master's Degrees in Aviation with Implications for a First Professional Degree
Bowen, B. D.	1989	The Federal Aviation Administration's Airway Science Program as Perceived by Program Coordinators in Participating Colleges and Universities
Rollo, V. A.	1990	Aviation Programs in the Post-secondary Schools of the United States: 1950 and 1985
Routledge, G. L.	1991	A Paradigmatic Framework for Flight Safety (Aviation, USAF, Safety Paradigm)
Conway, D. M.	1995	Aviation Physiology in General Aviation: A Study of College and University Curricular Requirements and Recommendations
Kaps, R.	1995	Perceptions of Aviation Educators Concerning Aviation Practitioner's Concepts of Curricular Need in an Aviation Doctoral Program: A Modified Delphi
Lindseth, P. D.	1996	Identifying Indicators of Program Quality in United States Baccalaureate Aviation Programs
Johnson, J. A.	1997	An Analysis of Curriculum Design in Developing a Doctor of Philosophy Program in Aeronology (Aviation)
Rodriguez, C. L.	1997	The Establishment and Development of Aviation and Aviation Education from Its Earliest Forms through World War I
Sellers, J. L.	1997	A Descriptive Analysis of Partnership, Alliance, Consortium, and Articulation Agreements Currently Existing in Post-Secondary Aviation Education Programs (University Aviation Association)
Weitzel, T. R.	1997	Fatigue: Investigation of a Human Factor for Aviation Curricula
Curtis, A. T.	1999	An Investigation of the Role of Politics in the Safety Recommendation Process of the National Transportation Safety Board (Aviation)

Table 2. Selected Dissertations Concerning Aviation Curricular Studies and Aviation Safety

A study conducted by Ninita Bogue in 1985 was to develop through cooperative curriculum planning a resource unit on teaching aerobatics to student pilots for the Private Pilot Course. The results of the study showed that what was needed in an aviation teacher education was to make teacher managers of learning. The specific competencies needed for an aviation instructor are philosophy of education, creativity, and an understanding of pupil-teacher planning (Bogue, 1985).

An aviation curriculum study by Brent Bowen in 1989 analyzed the perceptions of program coordinators of the 33 institutions that offer an Airway Science program. A problem identified in the study was that the FAA had not adhered to the hiring goals for graduates of the Airway Science program (Bowen, 1989).

David Conway (1995) conducted research concerning aviation physiology requirements for collegiate aviation programs. The subjects of the study were Institutional members of the University Aviation Association (UAA). Results of the survey revealed that the majority of the UAA member institutions recommended aviation physiology as a formal training course. The desired educational level to instruct aeromedical factors showed most frequency at the junior level. The educational background of an instructor for the course largely favored the military trained physiologist (Conway, 1995).

A descriptive study by Thomas Weitzel in 1997 investigated the impending problem of human fatigue as an operational consideration among U. S. air carriers and the status of fatigue as content within aviation education curricula. The findings of the study revealed that fatigue is perceived as an operational consideration on the flight decks of U.S. air carriers and the subject of fatigue is revealed as content within aviation curricula. It was determined that teaching the concepts and management of fatigue is important for flight crews (Weitzel, 1997).

Vera Rollo (1990), Paul Lindseth (1996), Jackie Sellers (1997), and Charles Rodriguez (1997) took broad approaches in both the selection of topics and scope of study concerning aviation education. A comparative study by Rollo identified the pressures, influences, and trends of post-secondary aviation schools in the United States between 1950 and 1985 (Rollo, 1990).

Lindseth's study identified indicators of program quality and ranked the quality of aviation programs offered by institutions studies. Data was collected from 70 collegiate aviation program administrators and 89 aviation industry experts. Findings from the study revealed that aviation program quality is multi-dimensional, with the curriculum, faculty, students, and program activities accounting for a majority of the criteria designated as indicators of quality (Lindseth, 1996).

A descriptive study by Sellers analyzed partnership, alliance, consortium, and articulation agreements of aviation education programs among post-secondary institutions and other education institutions. The population of study was the 108 institutional members of UAA (Sellers, 1997).

A historical approach by Rodriguez traced and documented the evolution of aviation and aviation education from the earliest through World War I. The study focused on educational programs in flight, maintenance, manufacturing, and engineering. His study indicated that the United States experienced a conspicuous need for aviation education during the World War I (Rodriguez, 1997).

A series of studies concerning the need for non-engineering aviation Master's or doctoral degrees have been made since 1987. Those studies were conducted by David NewMyer (1987), Robert Kaps (1995), and Jeffery Johnson (1997). Currently, in the United States, there are two universities offering non-engineering doctoral aviation degrees: one is the University of Nebraska conferring as Public Administration and the other is Oklahoma State University conferring as Aviation Education (UAA, 1999).

The exploratory study by NewMyer identified the perceptions of UAA members concerning a common set of guidelines for the development of non-engineering Master's degrees in aviation. Besides, the study examined the concept of the first professional degree as it related to the aviation industry (NewMyer, 1987).

A delphi study conducted by Kaps identified the perceived content of an aviation doctoral degree program by aviation professionals and obtained some consensus among aviation professionals and educators (Kaps, 1995).

Jeffrey Johnson conducted a study about a non-engineering based aeronautical or aerospace science Ph.D. program. To describe the nature and aspects of aeronautical or aerospace program, he coined a new terminology term called "Aeronology" which was derived from combining various learning theories and Webster's definitions. The purpose of Johnson's study was to propose a doctoral curriculum model based on two models: one was research/practitioner model and the other was practitioner model. The findings of the study showed that preference for each of the two curriculum models was nearly equal and a majority of scholars support several aspects of curriculum design in developing a new Ph.D. program. The proposed curriculum design included computer science, a core requirement, global education awareness, and an oral communication (Johnson, 1997).

Seventy-five dissertations relating to aviation safety are listed in the UMI ProQuest Digital Dissertation data from 1955 to 1999. Among them, dissertations of Donald Robb (1984), Garry Routledge (1991), and Aaron Curtis (1999) were chosen for review in this study.

Robb (1984) conducted a study on the development of relative risk information for general aviation safety education. The study focused on the prior-to-flight decisions made by general aviation pilots flying for non-business purposes. The information developed for the study included relative risk reference values for several representative decision issues. The reference values were determined from previous aircraft accident data, activity data, and safety expert opinions. The conclusions and recommendations of the study were based on comparisons of questionnaire responses with the reference values (Robb, 1984).

One study done by Routledge (1991) was included a paradigm for aviation safety. He pointed out the problem that traditional methods were not enough for a full understanding of aviation safety because they seldom explained adequate context of aviation safety. In general, a framework for explaining the context of accidents and safety is synthesized from four paradigms such as the cognitive paradigm, the paradigm of normal accidents, the paradigm of technology, and the paradigm of organizational complexes. The development of the framework was based on diverse literature from philosophy, psychology, sociology, and engineering (Routledge, 1991).

In 1999, Aaron Curtis conducted a study on the role of politics in the safety recommendation process of the National Transportation Safety Board (NTSB). He determined that there was evidence to support the notion that the safety recommendation process was influenced by many political motivations. The study included data from interviews, NTSB accident reports, NTSB safety recommendations, and correspondence between the FAA and NTSB related to safety recommendations. The findings of the study showed a relationship between higher media visibility accidents and disagreements between the FAA and NTSB (Curtis, 1999).

General Aviation Safety and Some Environmental Indicators

General aviation is an important transportation system. Economy in the U. S. general aviation encompasses all facets of civil aviation except air carriers. These public, private, and corporate aircraft provide a variety of services such as aerial application, student training, fire fighting, law enforcement, news coverage, industrial work, corporate transportation, personal and recreational flying.

According to FAA system indicators of 1998, the total number of certified pilot holders are 618,298 and that of non-pilot airmen holders are 549,588. The certified pilots comprise 247,226 Privates, 122,053 Commercials, 97,736 Students, 134,612 Airline Transports, 134,612 Rotorcraft certificates only, 9,402 Glider certificates only, and 305 Recreationals. The non-pilot airmen certificate holders consist of 336,670 Mechanics, 70,334 Ground Instructors, 63,700 Flight Engineers, 10,459 Parachute Riggers, 14,804 Dispatchers, 712 Flight Navigators, and 52,909 Repairmen (FAA, 1999c). The FAA expects an annual increase of 1.5% by 2010. Among the pilot pool, about 78% are general aviation (Tarver, 1999). The registered total number of aircraft in 1997 was recorded at 290,242 including 243,036 Fixed Wing Pistons, 12,886 Fixed Wing Turbojets, 8,921 Fixed Wing Turboprops, 6,643 Rotorcraft Pistons, 6,164 Rotorcraft

Turbines, 7,592 Balloons, 4,951 Gliders, and 49 Blimps (FAA, 1999c).

The "total system flight hours" data in the U. S., depicted in the Figure 7, had been increasing over the seven-year period ending in 1998. The flight hours of general aviation in 1998 is 26,796,000 hours out of 46,354,000 per the total system hours (FAA, 1999c). Aviation accidents overall are about 1,000 casualties per year in recent years, being about 70% of the total general aviation. As in the Figure 8, average annual fatalities of general aviation was 735 from 1988 to 1997 (Matthews, 1998). Between 1982 and 1997, general aviation fatal accident rate declined 29%. However, the elements of general aviation have potential risks and the level of risk is inherently higher in some fields. They operate in hazardous environments such as agricultural application, external heavy load carriage, fire fighting, power line patrol and rescue operations in harsh conditions (FAA, 1999e).

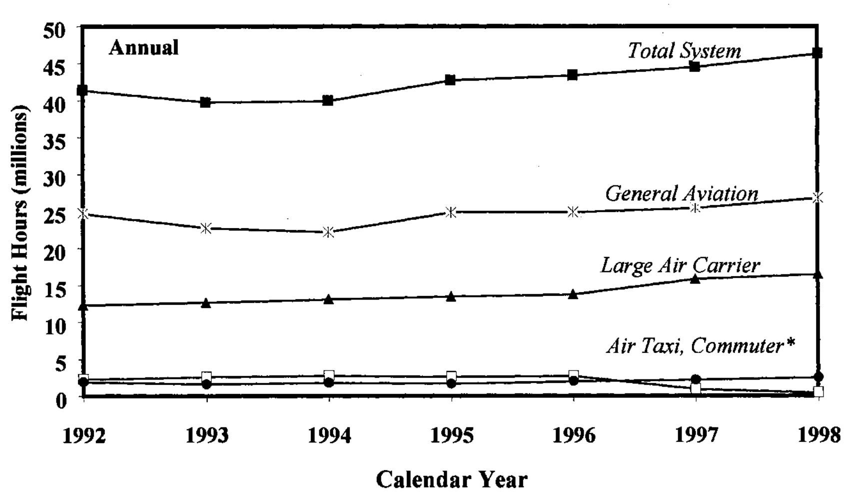


Figure 7. Total System Flight Hours

Data from FAA Aviation System Indicators, 1998 Annual Report, Chapter 3 p. 19

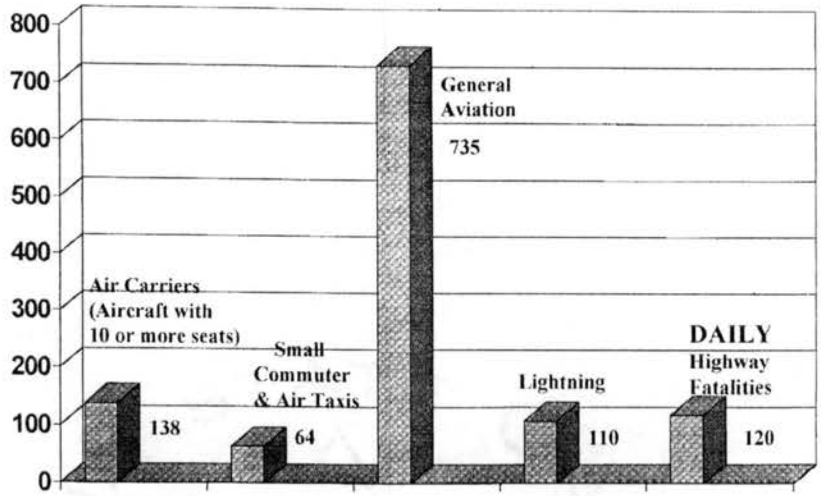


Figure 8. Average Annual Aviation Fatalities in the U. S. (1988-1997)
Source: FAA, Office of Accident Investigation (Matthews, 1998 p. 8)

FAA Administrator Jane Garvey announced General Aviation is one of the three primary focus areas of the "Safer Skies Initiative." Some areas needing improvements are in the following:

- Decision making about a flying or non-flying situation
- Loss of control due to pilot's distraction, Visual Flight Rules (VFR) flight into Instrument Meteorological Conditions (IMC)
- Controlled Flight into Terrain, Survivability in the event of an accident
- Runway incursions involving an aircraft, vehicle, person or object on the ground (FAA, 1999e)

The safety record of general aviation in the United States over a seven year period ending in1998, described in Table 3, shows each year's number of accidents, number of flight hours, and accident rates per 100,000 flight hours. The average number of accidents annually is 1,976 and the average rate per 100,000 flight hours for total accidents is 8.08 for the seven-year period.

Calendar Year	No. of Accidents	No. of Flight Hours	Accident Rate Per 100,000 Flt. hrs
1992	2,073	24,780,000	8.37
1993	2,039	22,796,000	8.94
1994	1,995	22,235,000	8.97
1995	2,053	24,906,000	8.24
1996	1,907	24,881,000	7.66
1997	1,858	25,473,000	7.29
1998	1,907	26,796,000	7.12
Average	**1,976**	**24,552,429**	**8.08**

Table 3. GENERAL AVIATION ACCIDENT DATA

Data from Aviation System Indicators, 1998 Annual Report Chapter 2, p.12
FAA, Assistant Administrator for System Safety, Safety Data Services Division

Information presented in Table 4 shows that the average number of annual incident is 1876 and the average rate per 100,000 flight hours for all incidents is 7.79 in the United States for the six-year period from 1992 to 1997 (FAA, 1999c).

Calendar Year	No. of Incidents	No. of Flight Hours	Incident Rate per 100,000 Flt. hrs
1992	2,308	24,780,000	9.31
1993	2,025	22,796,000	8.88
1994	1,863	22,235,000	8.38
1995	1,824	24,906,000	7.32
1996	1,673	24,881,000	6.72
1997	1,565	25,473,000	6.14
Average	**1.876**	**24,178,500**	**7.79**

Table 4. GENERAL AVIATION INCIDENT DATA

Source: Aviation System Indicators, 1998 Annual Report p. 2, 28
FAA, Assistant Administrator for System Safety, Safety Data Services Division

According to the FAA's annual report in 1998, over the seven-year (1992-1998) period, the record of the air carriers is approximately 35 times better than that of general aviation. This is reflected in a seven-year average accident rate per 100,000 flight hours; the rate of air carriers is 0.23 and that of general aviation is 8.08 (FAA, 1999c).

Commercial Aviation Safety

The worldwide commercial aviation system is a complex structure including approximately 745 airlines, more than 14,000 airplanes, and about 1,350 qualified, major airports. Linguistic barriers exist among the 150,000-plus flight crews from 190 countries. Also various regional and national cultures play a great role in safety among the regions of the world. Such cultures are often worked as negative factors with latent problems in safety. Aviation safety is to be shared among three big elements composed of operators, governments, and manufacturers (Purvis, 1999).

There are several reliable accident databases. In the United States, the NTSB is responsible for maintaining and publishing all modes of transportation safety data including aircraft accidents. The Aviation System Indicators as an annual report, published by FAA Data Services Division, is a domestic safety database. The system indicators report contains data for 24 aviation systems (including accidents) and incidents and 12 aviation environmental indicators. As for worldwide commercial aviation safety data, frequently cited databases are "Statistical Summary of Commercial Jet Airplane Accidents" published by Boeing almost annually and "IATA Safety Record" issued by the International Air Transport Association (IATA).

In 1996-97, there were ten major U. S. carrier accidents comprised of aircraft hull-loss or more than one casualty. The year 1998 was a relatively safe year with no major accidents in the United States (Duke, 1999). According to the FAA aviation safety indicators of 1998, large air carriers were involved 48 accidents in the United States. However, none of these were classified as "major" accidents by the NTSB's definition and only three were defined as "serious" accidents. The accident rate for the large air carriers in 1998 was 0.465 accidents per 100,000 departures (FAA, 1999c).

On February 25, 2000, the NTSB released the 1999 Aviation Accident Statistics, showing an increase in scheduled airline and commuter accident rates, but a slight decrease in the rates for general aviation aircraft in the United States. The Airline Accident Report for 1999 by the NTSB showed that there was 12 fatalities including the 11 persons who died in the crash of American Airlines flight 1420 in Little Rock, Arkansas on June 1, and a ground crew worker killed by a rotating propeller in July. The accident rate for Part 121 scheduled carriers was 0.430 accidents per 100,000 departures. The NTSB reported 12 fatalities from five commuter airline accidents, 38 deaths in 12 air-taxi accidents and 628 fatalities in 342 general aviation accidents. Overall 690 people died in 2,049 accidents in the United States (NTSB, 2000).

According to Boeing's statistical data, since the introduction of jet passenger aircraft in the late 1950s, aviation has made remarkable improvement in safety. The accident rate, hull loss accidents per million departures, has dropped from 30 per million in 1950s to 1.4 per million by the end of 1997. The accident rate of 1997 equates to over 714,000 departures between hull loss accidents. Over 99% of the fatalities in worldwide aircraft accidents is categorized into the hull-loss type of accident, which is generally used as a statistical indicator of safety (Purvis, 1999).

The Boeing Statistical Summary of Commercial Jet Airplane Accidents from 1959 to 1997 shows that worldwide scheduled commercial jet operations had 1,155 accidents involving 69 fatal accidents without hull loss, 215 hull losses without fatalities, and 384 hull losses with fatalities resulting in 22,402 onboard fatalities. During this period, it is estimated that there were approximately 328.2 million cumulative departures and 510.3 million cumulative flight-hours (Boeing, 1998). If we look at the accident rate from 1959 to 1997 as shown in Figure 9, one can see that the rate has been fairly level for more than two decades.

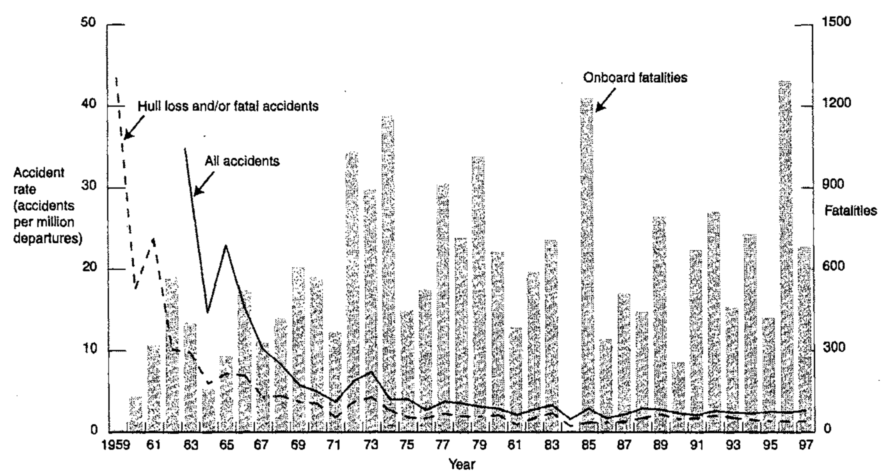


Figure 9. Accident Rates and Fatalities by the Year

Source: Boeing Statistical Summary of Commercial Jet Airplane Accidents, Worldwide Operations 1959 – 1997, p. 13, Boeing Commercial Airplane Company, 1998.

Data presented in Figure 10 illustrates that the accidents and on-board fatalities from 1959 to 1997 occurred during the phase of flight, based on a flight duration of 1.5 hours. After the combined *final approach* and *landing* phases (30%), the next greatest number of hull-loss accidents occurred during the *takeoff* and *initial climb* phase (21%).

Although the *cruise* phase accounted for a majority of the flight time (57%), the portion of fatal accidents amounted to only nine percent.

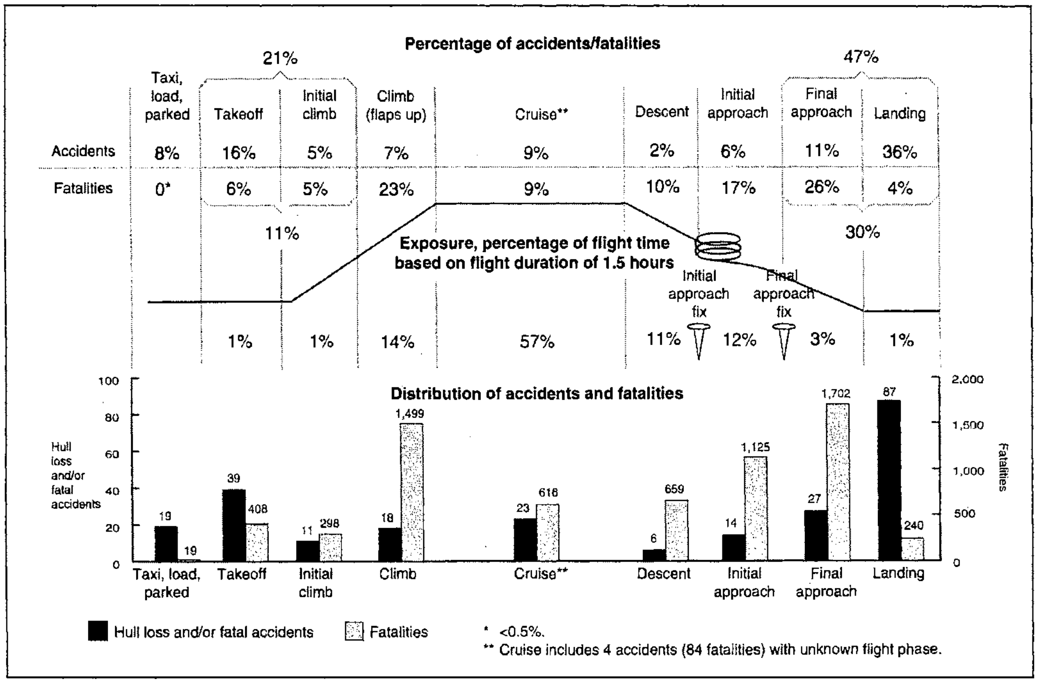


Figure 10. Accidents and Onboard Fatalities by Phase of Flight
Source: Boeing Statistical Summary of Commercial Jet Airplane Accidents, Worldwide Operations 1959 – 1997, p. 20, Boeing Commercial Airplane Company, 1998.

Boeing's statistical analysis has addressed the issue of human error. Boeing's statistical summary shows that the human factor is consistently the most frequent cause of incidents and accidents from the worldwide commercial jet fleet. Information presented in Figure 11 shows that approximately 70% of accidents with known causes are due to the flight crew in worldwide commercial jet accidents from 1988 to 1997. According to Boeing's data, other causal factors are: airplane (10%), maintenance (6%), weather (5%), airport/air traffic control (3%), and miscellaneous factors (5%).

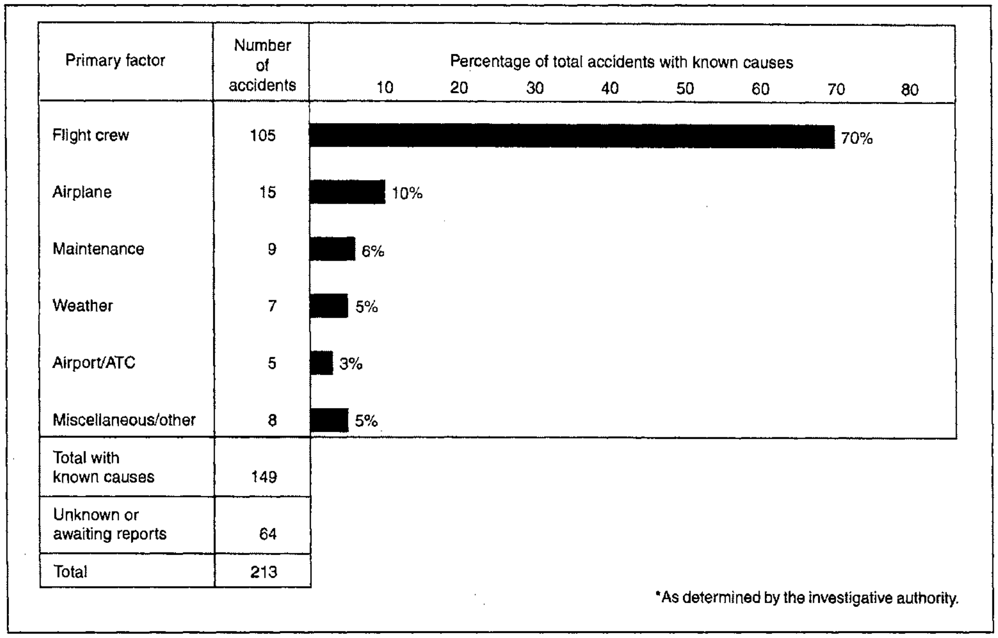


Figure 11. Worldwide Accidents by Primary Cause of Hull Loss Accidents
Source: Boeing Statistical Summary of Commercial Jet Airplane Accidents, Worldwide Operations 1959 – 1997, p. 21, Boeing Commercial Airplane Company, 1998.

However, data in Figure 11 shows only a kind of superficial human error problem because flight crewmembers are not the sole source of error in an aviation system. Including human discrepancies in other categories, we can assume that human error is a major contributing factor to incidents and accidents. This is why estimates of the total contribution of human error to aviation incidents and accidents can range far higher than 70% even up to 90% (Wells, 1997). Similar statistical figures concerning human factors apply to most other socio-technical systems such as the nuclear industry, chemical plants, railways, and offshore industries. Therefore, the increased safety effort is focusing on this area to reduce human error contributing to incidents or accidents (Amalberti & Wioland, 1997).

Considering fatalities by accident categories, *controlled flight into terrain* (CFIT) and *loss of controll in flight* have been two major problem areas throughout the world. As the data indicates in Figure 12, there were 36 *controlled flight into terrain* and 31 *loss of control in* *flight* accidents out of a total of 126 accidents with 2,806 and 1,932 fatalities respectively out of total 6,792 fatalities between 1988 and 1997 (H. Orlady & L. Orlady, 1999).

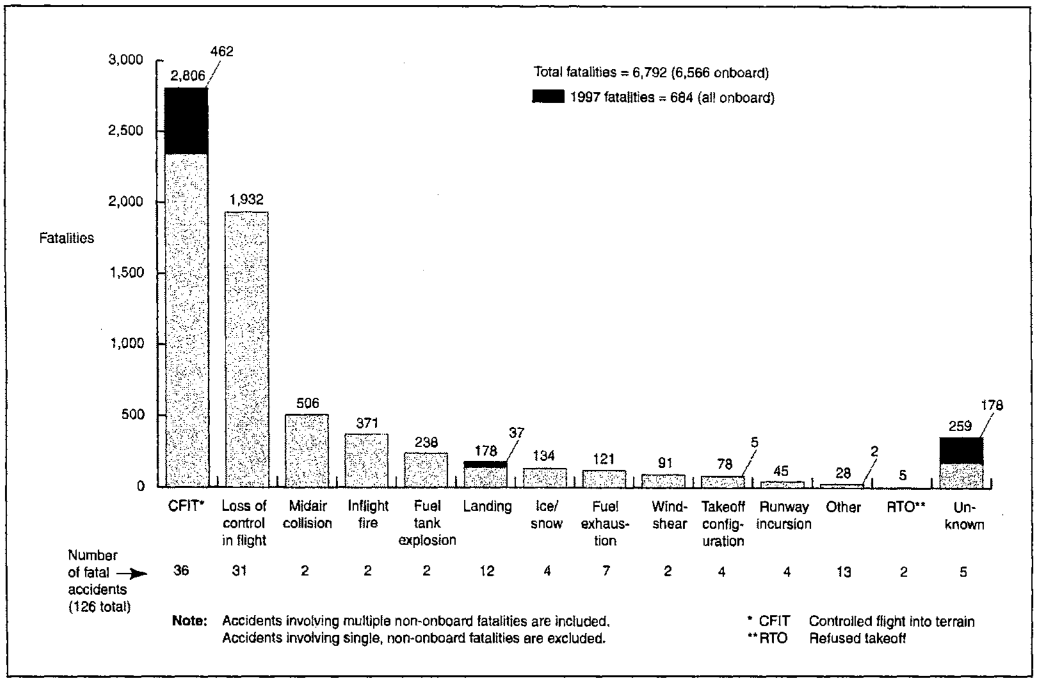


Figure 12. Worldwide Fatalities by Accident Categories of Commercial Jet Fleet

Source: Boeing Statistical Summary of Commercial Jet Airplane Accidents, Worldwide Operations 1959 – 1997, p. 19, Boeing Commercial Airplane Company, 1998.

A noticeable accident of 1998 was in one of Western Europe's airlines which had their first fatal jet accident since 1993. On September 2, Swissair MD-11 crashed near the coast of Nova Scotia in Canada and took 229 lives (Ibid.).

The International Air Transport Association (IATA) offers a reliable source of worldwide aviation safety data. According to the IATA's safety data analysis, the worldwide safety record in1998 was not very encouraging. As the data indicates in Table 5, the number of jet operational total losses decreased from 21 to 18 in 1998. Although the number of fatal accidents remained approximately the same from 1997, the number of total fatalities increased from 682 to 848. The trend for turboprop was optimistic with a significant decreases in operational total losses, fatal accidents and fatalities (IATA, 1999).

	JET		*TURBOPROP*	
	1998	1997	1998	1997
Number of Aircraft Operating	12,648	12,061	5,363	5,267
Operational total losses	18	21	21	34
Accidents Involving Fatalities	9	8	12	17
Passenger Fatalities	768	630	107	141
Crew Fatalities	80	52	25	41
Total Fatalities	848	682	132	182

Table 5. Worldwide Commercial Jet Accidents Data (1997-1998)
Source: Annual Report 1999, IATA for the 55th Annual General Meeting

Flight delays due to air traffic congestion become a critical issue that affects safety. In 1998, excessive flight delays have occasionally disrupted airline schedules, assessing severe economic penalties and causing an increase in passenger inconvenience. As the data in Table 6 shows the number of delays reported in 1998 was 314,471 cases giving a delay rate of 195.8 per 1000,000 facility activities (FAA, 1999c). According to International Air Transport Association, U. S. airlines and passengers are losing $4.5 billion a year due to delays (Hughes, 1999). In 1999, schedule delays in Europe are averaging 30 minutes, affecting a half-million flights. By 2008, passenger traffic will increase 43%, adding 2,500 aircraft in the U. S. commercial airline fleet (Ott, 1999). The factors affecting capacity and delay can be grouped into five categories: airfield characteristics, airspace characteristics, air traffic control, meteorological conditions, and demand characteristics (Wells, 1992). As data shows in Table 6, the overall delay rate and number of delays fluctuated from 1992 to 1998, but data from 1998 shows an increase compared to previous years.

Calendar Year	No. of Delays	No. of Facility Activities	Delay Rate
1992	280,821	144,167,634	194.8
1993	275,759	144,427,234	190.9
1994	247,719	147,019,869	168.5
1995	236,794	147,497,917	160.5
1996	271,509	147,916,934	183.6
1997	245,453	152,800,008	160.6
1998	314,471	160,570,789	195.8

Note: rate per 100,000 facility activities

Table 6. Delay Rate Data in the United States

Source: Aviation System Indicators, 1998 Annual Report p. 2,28
FAA, Assistant Administrator for System Safety, Safety Data Services Division

Asian countries such as Hong Kong, Japan and Korea have constructed new international airports in order to reduce congestion and schedule delays. Airbus Industrie projects a need for high capacity aircraft called A3XX within a decade. Airbus forecasts that worldwide airlines need more than 1,200 passenger aircraft in size categories above 400 seats by 2018 (Airbus, 1999).

However, the U. S. delay problem is focusing on the outdated Air Traffic Control (ATC) system. The Air Transport Association warns that delays will rise 250% if problems with the ATC system are not fixed. Although the FAA is focusing on modernization of the U. S. ATC system, the system is still outdated. In 1999, the FAA was in the 17th year of the modernization program, a $26.5-billion project through 2004.

The General Accounting Office reported that the progress of the project was eight years behind the original schedule (Ott, 1999). One of the most critical problems of congestion is that the margin for pilot error is shrinking.

A Theoretical Framework of Aviation Education

Aviation is a specialist application requiring an eclectic selection of general educational theories. It is often perceived as having a narrow and inconsistent scientific base with supporting theories for aviation instruction and training. In view of social responsibility, aviation instruction is a professional activity in which instructors use specialized, technical knowledge and skills (Telfer, 1997). A number of theories from various fields support aviation education. Aviation education almost invariably involves interaction with adult learners in the subject of instruction. Therefore, in terms of an appropriate learning theory, it is closer to *andragogy* (adult learning) than *pedagogy* (child learning). An understanding of aviation education can begin with reviewing comprehensive adult learning theories based on adult characteristics, adult life situation, and changes in consciousness. A study of adult characteristics was propagated by Knowles. Knowles' theory of *andragogy* is an attempt to seek an appropriate theory base for adult learning. *Andragogy* is based on the following assumptions:

> As a person matures, his or her self-concept moves from that of dependant personality toward one of a self-directing human being. An adult accumulates a growing reservoir of experience, which is a rich resource of learning. The readiness of an adult to learn is related to the developmental tasks of his or her social role. An adult is more problem-centered than subject-centered in learning (Knowles, 1980, pp. 44-45). Adults are motivated to learn by internal factors rather than external ones (Knowles, 1984, p. 12).

Another theory relating to adult education is Cross' characteristics of adults as learners (CAL) model. The CAL model consists of two classes of variables: personal and situational characteristics. Personal characteristics include physiological (aging), socio-cultural (life phase), and psychological (developmental stages) dimensions. Situational characteristics comprise part-time, versus full-time learning, and voluntary versus compulsory learning. The CAL model offers guidelines for adult education programs (Cross, 1981). One of the criticisms about this model is that the variables are too broadly defined. For instance, it is not easy to divide neatly between children and adults with the situational characteristics. Although the CAL model is frequently mentioned in adult education, it has yet to be empirically tested (Merriam & Caffarella, 1991).

Theories based on an adult's life situation are proposed by McClusky's theory of margin, Knox's proficiency theory, Jarvis's model of the learning process. These theories focus on changes in consciousness and are supported by Mezirow's perspective transformation and Freir's conscientization (Ibid.). There is no single theory that explains adult learning with all of its complexity. Merriam and Caffarella (1991) extracted four components of adult learning from the previous theories:

- Self direction or autonomy as a characteristic or goal of adult learning
- Breadth and depth of life experiences as content or triggers to learning
- Reflection or self-conscious monitoring of changes taking place
- Action or some other expression of the learning that has occurred (Merriam & Caffarella, 1991, pp. 264-265).

As to aviation crew training, Roscoe (1980) identified three major categories of skills including procedures, decision-making, and perception. Procedures comprise of aircraft operation, communication, emergency, navigation, and battle management for military personnel. Decision-making comprises of flight planning, crew functions, hazard assessment, and mission priorities. Perception comprises of aircraft controls, geographic orientation, target identification, and weapon system control (Roscoe, 1980).

As an instructional theory of aviation, Ross Telfer, an Australian scholar, presents a 3-P model which comprises of presage, process, and product. Telfer arrive at the 3-P model from behavioral and cognitive theories. Behavioral theory links *presage* stage and *product* stage through instructional objectives and evaluation. The presage stage includes task analysis, lesson planning, and preparation of the second stage, the process of instruction. In the process stage, instructors apply various teaching methods by providing students with rules, principles, and concepts to store the new knowledge. In addition to instructors providing problems, simulations or decisions, which require the student to apply new knowledge or skills and reinforce trainee's self concept, are emphasized. The product stage evaluates and identifies the areas where the training has been or has not been successful. This information has implications to both the trainee's learning and the course of instruction (Telfer, 1997)

To describe the nature of post-secondary aviation studies, many terms had been tried interchangeably by scholars of aviation institutions. The terms frequently used in aviation field are aviation (or aeronautical) science, aviation (or aeronautical) technology, and aviation (or aeronautical) education. By using syntax to describe the aviation learning theory, Jeffery Johnson (1997) developed a new term called "Aeronology" to describe the non-engineering aeronautical or aerospace field (Johnson, 1997).

A Theoretical Framework of Aviation Safety

Aviation system safety responsibilities are shared by three major elements: governments, manufacturers, and operators. A proper balance among these three elements leads to a safe aviation system (Purvis, 1999). Besides, technology, training, and regulatory compliance are three pillars of aviation safety. More technology, training and regulations have been introduced to improve safety after aircraft accident investigations identified critical safety breakdowns and hazards. Daniel Maurino described a phenomenon of aviation safety history as "escalating the commitment to technology and its supporting cast of training and regulations for more than 50 years" (Maurino, 1996, p. xxi).

A number of studies on motivation are laboratory-based and psychology-oriented. Information concerning motivation can be found in many human factors related books: Evans in 1975; Murell in 1976; Vroom et al. in 1970; and Warr in 1971. However, a classical theory frequently mentioned in aviation safety is Maslow's theory of human motivation. Motivation is a complex component of behavior and central to behavior. Motivation incites the will, which leads to a requisite action whether expressed as purpose or motive (Maslow, 1943).

Maslow developed a hierarchy of needs and defined motivation as the drive to fill an open need. According to the theory, as shown in Figure 13, the hierarchy is composed of physiological needs, safety needs, social needs, ego needs, and self-fulfillment needs from the bottom to the top (Wood, 1997).

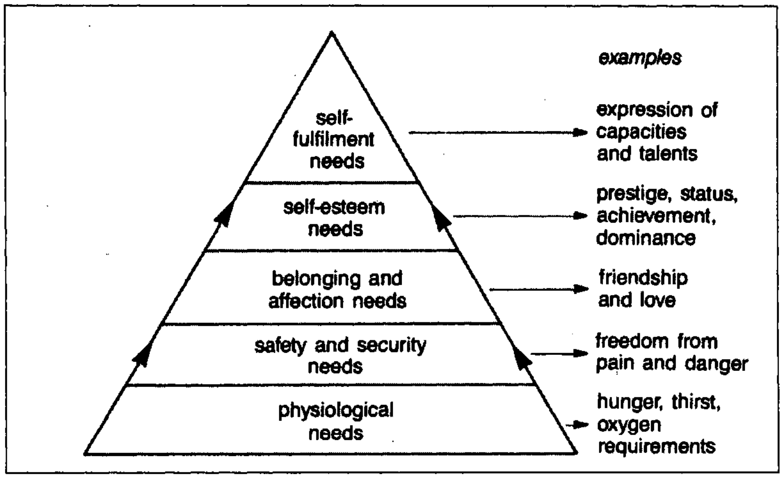


Figure 13. Maslow's Hierarchy of Needs

Source: Adapted from Human Factors in Flight, F. H. Hawkins, 1997, p. 138

To describe the nature of accidents, some scholars have tried to seek some casual factors that lead to aircraft accidents. The endeavors have been conceptualized into 5-*M* system safety factors (see Figure 14). T. P. Wright first introduced the triad of man-machine-environment (medium) into the aviation society during the late 1940s and follow-on instructors defined the factors as the 3-*M* terminology. The last two *M*s of the 5 *M*s, including management and mission, were introduced by the scholars at the University of Southern California (USC). The forth *M* (management) was added in 1965 when USC established the courses concerning safety management and system safety. The fifth *M* (mission) was originally discussed at military-oriented USC courses but was not added into M-factors until 1976 at the suggestion of E. A. Jerome (Miller, 1988).

Various psychological approaches or methods have been tried in providing aviation safety with a theoretical background. From the early 1940s to the mid-1970s, clinical, behavioral, and cognitive psychologists made significant contributions in studying human capabilities and limitations for safe operations (Maurino, 1997).

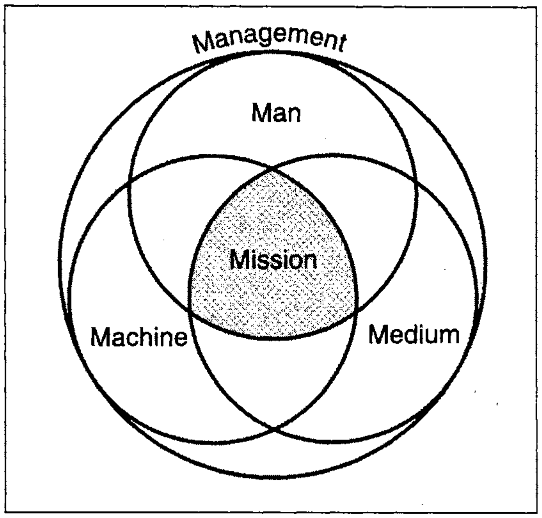


Figure 14. 5-M Diagram of System Safety Factors

Source: Adapted from Human Factors in Aviation, C. O. Miller, 1988, p. 63

Behavioral theory provides "a functional account of behavior, focusing on the functions served by acts and the conditions under which those functions are served" (Fuller, 1997, p. 174). The behavioral model is described as representing a three-term contingency with Antecedent event, Behavior, and Consequences, yielding the A-B-C of the behavioral model (Fuller, 1997).

From the late 1970s to the 1980s, social psychology was prevailing and dedicated an attention to small group dynamics while cognitive and behavioral psychology still continued to provide the data on how humans make decisions, on the capabilities of human cognition, and on how to improve the process of learning. Hence, the aviation community began to understand how small groups make decisions about issues involving members of small teams (Maurino, 1997).

Crew/Cockpit Resource Management (CRM) is an offspring of the social psychology. Although the term CRM was first used by J. K. Lauber in 1977, a similar concept was already being applied among the airlines. For instance, Pan Am incorporated crew concepts into its training programs; Northwest developed coordinated crew training (CCT); KLM and Lufthansa touched the problem of flight coordination and discipline (Lauber, 1993). The CRM approach recognized the importance of intra-team communications, workload management, informed decision-making, and leadership/ followership skills. Although initial training focused on the cockpit crew, many people recognized that the concept of team was applicable to the cabin crew and eventually extended to include dispatchers, mechanics, and ramp personnel. Thus, the CRM evolved from "Cockpit" to "Crew" and became an application of human factors in the aviation system (Hemreich & Foushee, 1993).

According to Maurino's classification, based on a 20 year history, CRM has remarkably evolved and developed into four generations of training based on two perspectives: one is the European and the other is North American. Paries and Amalberti, scholars of European perspective, seek to establish a connection between changes in the understanding of aviation safety, prevention strategies and the evolution of CRM training. They proposed that prevention and management in "cockpit crisis" should be gradually shifting toward a macro-system of education, and CRM corresponds to a revolution in accident causation models. Helmreich, on the North American side, practically agreed with Paries and Amelbert but with slight differences in milestones and emphasis reflected by American empiricism. While Pareis and Amalberti insisted that CRM was the prevailing safety paradigms, Helmreich seemed less concerned about this conceptual preference. By virtue of globalization of CRM, Helmreich put more value on cross-cultural issues as they affect CRM training (Maurino, 1999). In 1997, Helemreich presented the article titled "*Managing Human Error in Aviation*" in Scientific American.

In 1998, Helemreich and Merritt proposed a fifth generation of CRM training that has a manifest goal of managing human error in their book "*Culture at Work in Aviation and Medicine*." The concept of "managing human error" is based on the fact that the error is ubiquitous and inevitable. The key point of the training is to change the professional culture by fostering a more realistic awareness of personal limits and capabilities (Helmreich & Merritt, 1998).

The most current psychological method applied in aviation is organizational psychology or system approach. The first non-conventional system approach was tried in investigating the crash of Air Ontario flight 1363 in Dryden, Ontario on March 10, 1989 by the Royal Commission of Inquiry (Maurino et al. 1995). Accident investigations increasingly take macroscopic approaches rather than microscopic approaches. Issues like corporate culture, unsafe culture, and organizational design have been discussed in both accident reports and international forums. Currently the organizational perspective provides a framework of aviation safety, allowing it to be viewed within the goals of aviation organizations (Maurino, 1995).

Human errors or human factors have been in 60% to 80 % of both civil and military aviation accidents. Although the overall rate of aircraft accidents has declined and remained constant during the past two decades, reductions in human factor related accidents have not paralleled those related to mechanical and environmental factors (Wiegmann & Shappell, 1997).

The issues of human factors have been an essential part of research, development, test, and evaluation cycle in aviation. Although the elements of human factors are not clear, the observation seems on target. The unique problems of human factors have been approached from the human perception, physiology, and cognition, and consequences of human errors in the human-machine systems. As a result, a science of human factors has contributed significantly to the safety and growth of aviation.

In the United States, the term Human Factors is more common than the term Ergonomics. Murrell introduced the term ergonomics in 1949. The term was derived from the Greek words *ergon* (work) and *nomos* (natural law) and used as the title of his textbook on the subject published in 1965. Murrell defined it as the study of man in his working environment (Hawkins, 1997).

Various definitions have been employed to describe the subject matter of human factors. According to Weimer's research, 74 definitions were used to describe such terms as human factors, ergonomics, human factors psychology, human factors engineering, applied ergonomics and industrial engineering (Orlady, 1999). The term Human Factors is hard to define in one paragraph because humans are multi-faced subjects by nature. One definition by Elwyn Edwards reads:

> Human factors (or Egonomics) may be defined as the technology concerned to optimize the relationships between people and their activities by the systematic application of human sciences, integrated within the framework of system engineering (Edwards, 1988, p. 9).

ICAO states that human factors is the study of how the physical, physiological, psychological, and psychosocial variables affect a person's ability to perform in Human Factors Digest, Number 7 (Sumwalt, 1998). A concise definition of human factors, in view of the applied technology, is the 5-P definitions including psychological, physiological, physical, psychosocial, and pathological factors (Braden, 1998). Another definition states that "human factors is a multidisciplinary field that draws on the methods and principles of the behavioral and social sciences, engineering, and physiology to optimize human performance and reduce human error" (Chesterfield, 1997a, Chapter 1, p.1).

Concerning current trends and issues in a human factor study, David Meister mentioned that technological practice or psychological concept was not any more a sole approach to human factor study but the cultural concept should be recognized as going well beyond its origin. Human factors should be considered not only a reaction to the dominance of technology but also a means of trying to control the dominance (Meister, 1999). In practice, based on theory, Helmreich applied cultural concepts into the aviation field to further CRM study. He conducted studies in the fields of professional culture, national culture, and organizational culture (Helmreich & Merritt, 1998).

The concept of the "error chain" is frequently mentioned by many aviation safety experts as a theory of accident/incident causation. This concept proposes that most accidents/incidents consist of a series of errors or the chain of the events leading to a mishap. Under the concept, if we can find and correct one error in a series of errors, we can prevent the accident. The theory seems to be plausible but the concept has a weak background according to a theory for aviation safety. Orlady H. and Orlady L. (1999) point out problems in the concept of error chain:

> We should note that there are both internal and external causes of errors. Clear definition and precise identification of the elements in the 'error chain' and of the practical aspects of how the likelihood of the accident could have been prevented are not always a conspicuous part of many accident analyses (Orlady, 1999, p. 415).

Errors in individuals, design, and management of crew tasks can degrade the performance and safety in a system or an organization and sometimes lead to accidents. An error is defined as unintended and inappropriate physical or mental operations.

Several types of errors in the aviation field include adjustment errors, forgetting errors, reversal errors, substitution errors, unintentional activation errors, habit pattern substitution errors, and procedural errors (Chesterfield, 1997a).

Multiple definitions and classifications of human error have also been discussed among European scholars. These definitions can be summarized into three dimensions: comprehensive approach vs. descriptive approach; individual error recognition vs. collective definition of errors and norms; and definition of error as individual and individual lapses vs. definition of error only by their consequences on system safety (Amalberti & Wioland, 1997).

The system approach became main stream to examine human factors. Two major human factor models are currently being discussed among the aviation society: one is SHELL (or SHEL) model and the other is Reason's model. In the 18th century, German philosopher Hegel mentioned a basic concept of system theory; he argued that the whole is greater than the sum of the parts and parts can not be understood in isolation from the whole (Beringer, 1997). The system approach is derived from a philosophical point of view, having been applied to operation research and engineering before human factors scholars adopted it as a model. This concept can be traced back to the ideas of various philosophers such as Lao-tzu, Heraclitus, Vico, and Marx (Meister, 1999).

The original SHEL model was first introduced by Elwyn Edwards in 1972 to explain man and machine system interfaces in aviation. The original SHEL concept was named after the initial letters of the four components: Software, Hardware, Environment, and Liveware. The 'building block' model was used by Hawkins (1997). However, both models are based on the same concepts (Harle, 1997). The SHEL concept was further developed into the SHELL model by Frank H. Hawkins with the publishing of "Human Factors in Flight" in 1987. He added another L of *Liveware-Liveware* to describe the interface among people. The SHELL model has been widely accepted in CRM training programs around the world (Chesterfield, 1997b). The presentation in Figure 15 shows the SHELL model which includes Software, Hardware, Environment, and Liveware.

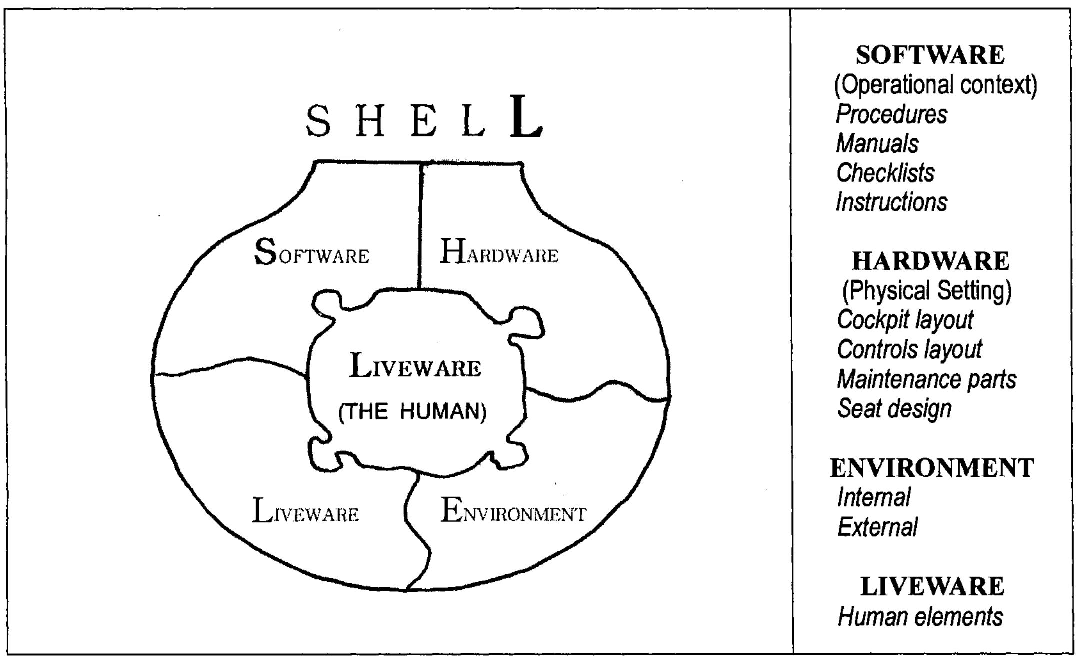


Figure 15. Modified Version of SHELL Model

Source: Adapted from TSI Human Factors in Accident Investigation, 1997, Chapter 2, p. 2

In 1990, James Reason presented a pioneering organizational framework that involved a total system approach to accident investigation. His organizational approach further develops the concept of the "error chain" and extends the scope of analysis from not only individuals but also to all of the people or organization that could have been involved. One of the significant contributions has been the identification of "latent errors" in the system that may have lain dormant for some period until combined circumstances trigger an incident or an accident (Orlady, 1999).

In general, active failures are associated with the performance of the person in direct contact with the system such as pilots, control room crews, and air traffic controllers. The factors of active failures are relatively easy to identify. On the other hand, latent failures are derived from those whose activities are removed in both time and space from the front line such as designers, managers, and high-level decision makers. An organizational culture can be considered as latent conditions (Reason, 1998).

Figure 16 illustrates the steps that active failures and latent conditions in the overall defense system can interact to result in an accident. The position of the holes depicts the time and conditions of active and latent failures. In the real world, a fatal aircraft accident is a rare event and only occurs when the holes line up and none of the defenses can block fallible decisions, deficiencies, and unsafe acts. The size of the limited window of accident opportunity at the last stage depends on the effectiveness of total system management (Maurino et al., 1995).

Reason's system approach has been officially adopted by several organizations including the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA), the International Federation of Air Line Pilot Associations (IFALPA), the International Federation of Air Traffic Controllers Associations (IFATCA), the NTSB, the Bureau of Air Safety Investigation of Australia (BASI), the Air Line Pilots Association (ALPA), and many airlines (Orlady, 1999).

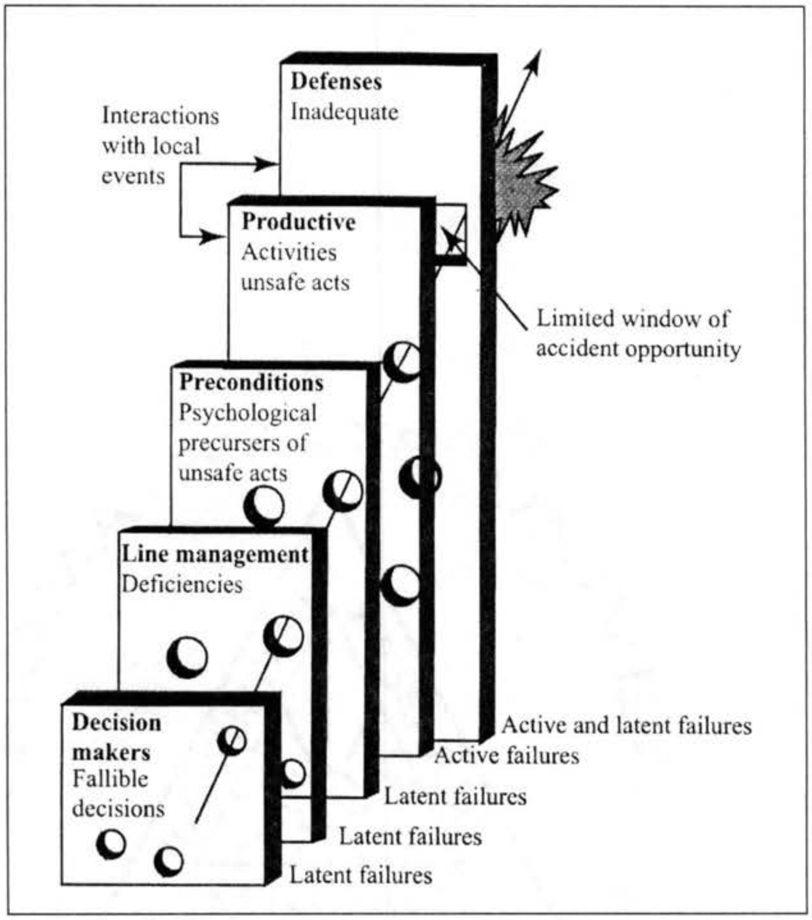


Figure 16. Modified Version of Reason's Model of Accident Causation
Source: TSI Human Factors in Accident Investigation, 1997, Chapter 1, p. 3

According to Maurino, the system approach based on organizational psychology becomes a reliable framework for aviation safety, allowing it to be interpreted as a macroscopic approach focusing on the entire system. However, Maurino point out his perception of where we are in aviation safety:

> Is organizational psychology the new last frontier in aviation safety? I think not. Furthermore, I think that such a mythical frontier does not exist. The passage of time will bring unforeseen challenges which will demand new solutions. The real issue is that we should never sit back, assuming that once and forever we have found the solution for aviation safety. The notion of such a magical solution was implicit in presenting Human Factors as the last frontier of aviation safety, and it was preached in a thousand-and-one opportunities during the past fifty years (Maurino, 1995, p. 15).

There may not be a perfect theory or magical word on how to prevent accidents in the human world. However, to enhance safety, we should not neglect critical lessons learned from previous accidents. We can improve accident prevention by reflecting better and corrected input at various levels in the system requiring appropriate feedback. The struggle for safety is an endless, tedious task against a relentless enemy inside and outside of the involved systems.

CHATPER III

METHODOLOGY

Introduction

The major purpose of this study was to develop an Aviation Safety course suitable to collegiate aviation degree programs. A questionnaire was utilized to obtain participants' perceptions or opinions with regard to the characteristics, scope, depth, curriculum elements and topics for a prospecting Aviation Safety course. The questionnaire was also used to identify the current curriculum of aviation safety being presented to students in aviation degree programs such as Aviation Education, Aviation Sciences, Aviation Management, and Aviation Technology in the U. S. colleges and universities. This chapter includes the following:

- Selection of subjects
- Instrument
- Collection of data
- Compilation and analysis of the data

The need for this study was that there was no summary or analysis of what UAA member institutions presently cover or perceive should be taught with regard to an Aviation Safety course in an aviation degree program. This information is needed to assist curriculum designers and developers.

Selection of Subjects

This is a descriptive study and a questionnaire was used to obtain the needed data. The population of the study included all *Institutional* members and *Professional* members of University Aviation Association (UAA) in the United States. UAA classifies membership into five classes including *Institutional*, *Professional*, *Associate*, *Corporate*, *Student*, and *Honorary*. Among them, *Institutional* members and *Professional* members were chosen for this study because they were designated by the researcher's advisory committee as the appropriate groups to survey with regard to aviation safety education. The UAA membership list of November 1999 indicated that there were 114 *Institutional* members and 258 *Professional* members. Each Institutional member represents a technical, associate or baccalaureate level institution that offers an aviation/aerospace program. The *Professional* members are composed of a college or university faculty or staff engaged in or interested in the furtherance of any form of aviation.

Instrument

The questionnaire was developed by the researcher with assistance from the faculty of the Department of Aviation Education at Oklahoma State University. No standardized instruments were available to obtain the data required to achieve the purpose of the study. The validation of the questionnaire was conducted for content and consistency by a review from the following eight individuals, each an expert in his/her specialty in aviation safety:

- An instructor in U. S. Air Force Academy

- A former FAA and NTSB safety specialist in accident investigation
- The aviation division manager and a course manager in Transportation Safety Institute of Department of Transportation in Oklahoma City, OK
- A senior accident investigator in Bell Helicopter Textron Inc, Fort Worth, Texas
- Three faculty members in the Department of Aviation Education at Oklahoma State University

The majority of the questions were developed based upon information obtained in the current literature related to the subject of aviation safety. The questionnaire was composed of three parts: Part I (Setting of Safety in the Curricula), Part II (Instruction), and Part III (Curricula). Part I (Setting of Safety in the Curricula) consisted of 7 question items. Among them, item 3 measured the necessity of an Aviation Safety course. A value was assigned to each response, developing a weight value scale from one to ten, with ten representing "absolutely necessary". Part II and III were composed of 16 and 19 question items respectively. Part II related to the characteristics and scope of an aviation safety course. Part III dealt with the topics and safety factors in an aviation safety course. To determine what an individual believes, perceives, or feels, an attitude scale was used for the research (Gay, 1996). For this study, a Likert scale was utilized for Part II and III question statements in the questionnaire. In the questionnaire, the phrase, "Not Applicable (NA)" was used to provide the respondents a suitable means to respond if they were unsure about what the statement meant, or if it was outside their area of expertise. The following designations were utilized:

1. Strongly Agree (SA)
2. Agree (A)

3. Neutral (N)
4. Disagree (D)
5. Strongly Disagree (SD)
6. Not Applicable (NA)

The value of each designation (i.e., 1 for Strongly Agree, 2 for Agree) was applied for analyzing responses from each respondent in order to formulate results. The last question was optional. It asked for comments concerning aviation safety education and the issues or topics not covered by the questionnaire.

The Part I, Setting of Safety in Curricula, concerned with:

1. Whether respondents' institutions provided formal work in Aviation Safety.
   a. Level of instruction
   b. Semester credit hours
   c. Type of instructors who taught the course
2. The courses closely related to Aviation Safety.
3. Indicated level of necessity for instruction in an Aviation Safety course
4. The optimum collegiate level to include an Aviation Safety course.
5. Appropriate credit hours for an Aviation Safety course
6. The best person to provide instruction in an Aviation Safety course
7. A preferred or recommended textbook for an Aviation Safety course

The objective of Part II was to find the characteristics, the depth and scope, of an Aviation Safety course. The questionnaire items in Part II were used to determine whether a prospective Aviation Safety course should:

a. be a flexible course not relying on certain texts or topics.
b. be an advanced course for junior or senior standing in the course works.
c. focus on case studies of aircraft accidents and safety.

d. focus on current trends and issues of aviation safety.
e. focus on developing a sample Aviation Safety program or accident prevention program.
f. focus on enhancing flight skills/maneuvers and safety operation.
g. focus on frameworks of strengthening safety concepts.
h. focus on human factors.
i. focus on narrowing gaps between real aviation world and school works.
j. focus on theoretical frame works of safety.
k. have extra laboratory hours or field work.
l. include experimental aircraft safety.
m. include rotorcraft safety.
n. require prerequisite courses (e.g. Aviation Psychology or Human Factors).
o. take a macroscopic approach focusing on whole system safety.
p. take a microscopic approach focusing on individual safety elements.

Items in Part III were designed to find appropriate topics and safety elements that should be discussed in a prospective Aviation Safety course. The item details were:

a. Accident investigation process and technology
b. Aircraft performance including takeoff, climb, landing, crosswind components, and weight and balance
c. Aviation history in safety perspective
d. Aviation law, FAR, and AIM
e. Aviation security including bomb detection, baggage and passenger screening, and hijacking
f. Aviation theoretical frame work in safety (e.g., SHELL/SHEL model, cognitive theories, behavioral theories, and Reason's system approach)
g. Basic physics including aerodynamics
h. Ethics in safety including bogus parts
i. Case studies of catastrophic aircraft accidents
j. Computer skills including database, spreadsheet and internet access

k. Establishing an aviation safety program including prevention methodology and risk management
l. Familiarization of aircraft systems including airframe, powerplants, instruments, and avionics
m. Flight operations including airport facilities, air traffic control, airspace and communication procedures
n. Flight safety including collision avoidance, CFIT, near misses, runway incursions and inflight fires
o. Management of safety data (e.g., data collection and selection, data analysis, and statistical analysis)
p. Meteorology and atmospheric phenomena including thunderstorms, microbursts, lightening, windshears, and icing conditions,
q. Physiological human factors including hypoxia, hyperventilation, spatial disorientation, decompression sickness, motion sickness, vision in flight, and fatigue
r. Psychological human factors including CRM, human error, and stress alertness management
s. The aviation safety community including FAA, NASA, NTSB, IATA, and ICAO

Collection of Data

A list of University Aviation Association (UAA) members was obtained from the University Aviation Association, 3410 Skyway Drive, Auburn, AL 368430 in December 1999. According to the UAA membership list of November 1999, there were 114 Institutional members and 258 Professional members. Through the analyzing and sorting process, three Institutional members and 56 Professional members were excluded from the mailing list because they were located outside the United States or listed on both the

Institutional and Professional membership lists. Finally, a total of 313 questionnaires were sent by first class mail on February 7, 2000. The population of the UAA members was identified as 111 Institutional members and 202 Professional members who were instructors, adjunct faculty or faculty at 131 institutions. Each questionnaire was accompanied by a cover letter of introduction outlining the purpose and importance of the survey. Respondents were asked to return the completed questionnaires in the enclosed, self-addressed stamped envelopes. A total of 137 questionnaire were returned for analysis from 72 institutions by March 10, 2000. The data in Table 7 shows the return rate of the questionnaires:

MEMBERSHIP TYPE	RETURNED / MAILED	RATE
Institutional	46 / 111	41.44%
Professional	91 / 202	45.05%
Total	137 / 313	43.77%

Table 7. Return Rate of the Questionnaire

In the questionnaire, any personal questions concerning the participants' private profiles were not asked because confidentiality was an important factor in obtaining reliable data from the population. In the initial analysis, some different perspectives were revealed among the participants owing to their types of institutions. Especially, question 1a and 4 were affected by a particular kind of variable. To better interpret and present data, the participating institutions were classified into three types according to the level of granting degrees. The classification was based on the aviation program information listed in "1999 Collegiate Aviation Guide (CAG)". Fourteen out of seventy-two institutions' information was not available in the CAG. However, the required information for analysis was obtained from each school's internet web site. The data in the Figure 17 shows the type of institution that participated in the survey. The post-graduate program reported in Figure 17 is an Air Traffic Control Training Program. The post-graduate program was titled because one of the requirements of an applicant for the program should have a two or four year college degree.

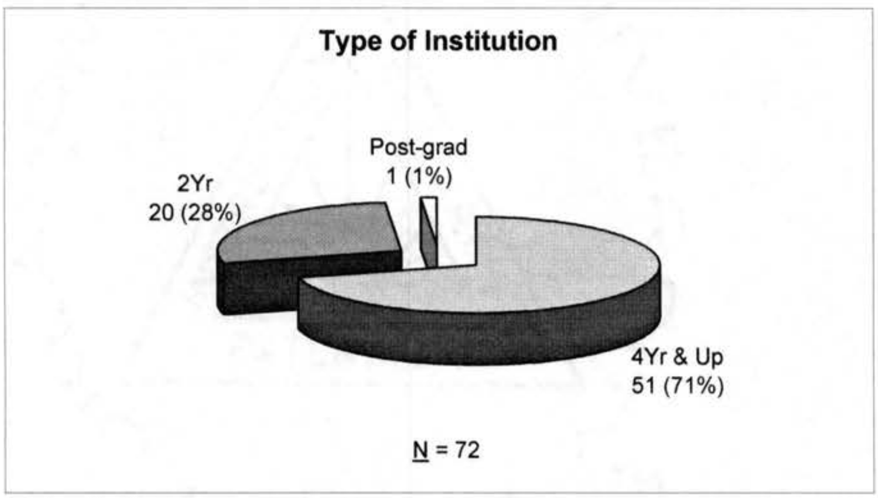


Figure 17. Type of Institution that Participated in the Survey

The main objective of question one and two of the questionnaire was to find how the University Aviation Association member schools teach an Aviation Safety course to their students. However, only 46 out of 111 Institutional members returned the questionnaire. In addition to analyzing data from institutional members, the researcher also utilized input from professional members whose Institutional member did not participated in the survey. The Institutional members joined the UAA on behalf of their institutions but they were from faculty or adjunct faculty members like Professional members. Required information with common factors could be obtained by comparisons of each Professional member's respond from same institution.

For precise interpretation and analysis of data, Professional members selected in surveying questionnaire items 1 and 2 was classified into two groups: one was Institutional-Professional whose institution was affiliated to the UAA and Non-Institutional Professional whose institution was not affiliated to the UAA. The data in Figure 18 shows the membership profile of respondents who offered information on their current Aviation Safety course.

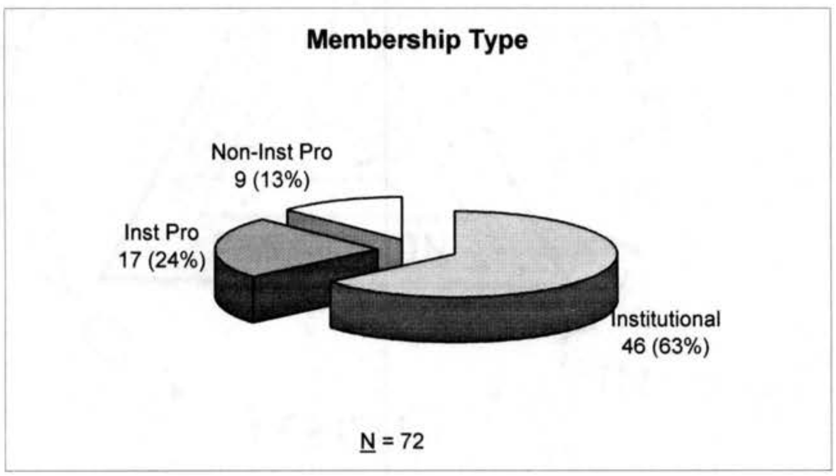


Figure 18. Membership Type of Respondents

Compilation and Analysis of the Data

The data from the 137 usable questionnaires was recorded with the aid of database and spreadsheet software. In addition to data entry, respondent errors were examined. Several participants inadvertently marked more than one designation given in Likert scale or skipped the responses in some of questionnaire items. For instance, questionnaire item 7 asked participants' opinions concerning an appropriate textbook for a prospective

Aviation Safety course under a given condition that "please choose one book or specify other choice in the blank". However, fourteen respondents chose more than one text. Although total respondents who returned questionnaire was 137 persons, the total number of responses in each questionnaire item was not constant owing to missing or double responses. These errors were not counted in the result for a fair treatment and interpretation of data.

Finally, a database was utilized to yield frequency data for each questionnaire item. The frequency data is presented in either histograms or pie charts. The graphs included the total number of respondents, the frequency, and the percentage of each Likert type designation. The comments from an optional question 10 were summarized in Appendix C.

CHAPTER IV

RESULTS OF THE STUDY

Introduction

This chapter summarized the findings of the study. The questionnaire included in Appendix A was used to obtain the required data from the respondents. The data is presented in either histograms or pie charts. The graphs included the total number of respondents (N), the frequency, and percentage of each Likert type designation.

The results of the study are presented in three parts and a response to an optional question is included. The first part is concerning aviation safety curricula setting. The items in Part I were designed to find the current involvement of the University Aviation Association schools concerning instruction in an Aviation Safety course. Responses to questionnaire (Appendix A) items from 1 to 7 are reported under this part. Part II addressed the instruction characteristics in depth and scope of an Aviation Safety course. Responses to questionnaire (Appendix A) item number 8 are reported in this part. The item number 8 are composed of 16 detailed sub-questions. Part III asked opinions concerning contents of Aviation Safety curricula. Responses to questionnaire (Appendix A) item number 9 are reported in this part. The item number 9 is composed of 19 sub-questions. The last question, number10, asked for any comments concerning aviation safety education, not mentioned in the questionnaire.

Many participants submitted comments including criticism, recommendations, and their viewpoints about collegiate level safety instructions. Select recommendations from the participants are discussed in Chapter V. The comments are summarized in Appendix C.

Part I. Setting of Safety in the Curricula

Questionnaire item 1 asked if a participant's institution provided a formal course work in Aviation Safety. To obtain supporting data to this question, sub-items were utilized. The results show that forty-nine institutions offered formal course work in Aviation Safety: forty-one schools among the fifty-one Bachelor's degree granting institutions, eight schools among the twenty Associate degree granting institutions and one post-graduate program (Figure 19). Data from the questionnaire also indicated that 80% of 4-year degree granting schools and 40% of 2-year degree granting schools provided formal course work in Aviation Safety (Figures 20 and 21).

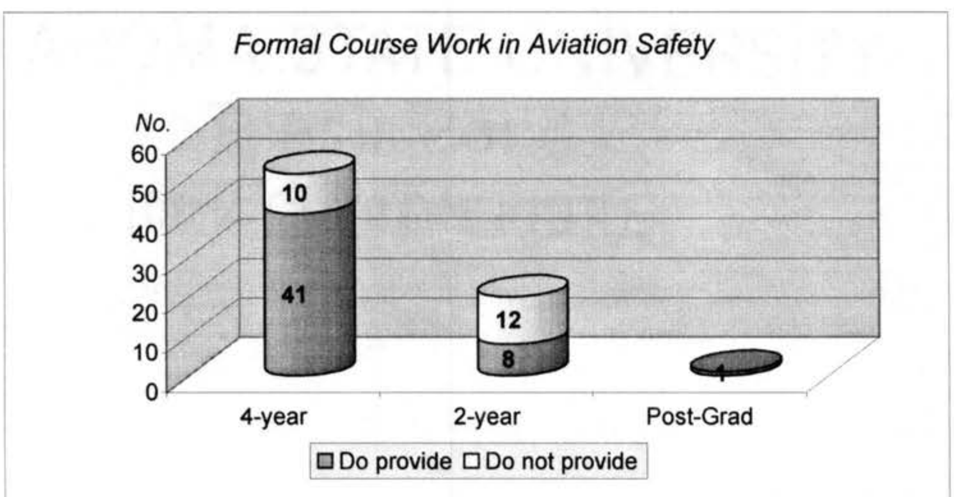


Figure 19. UAA Schools Providing Formal Aviation Safety Course

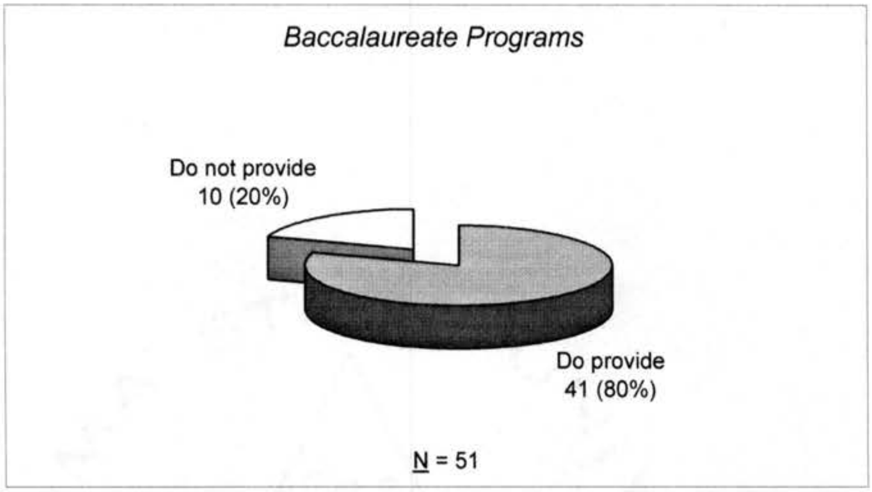


Figure 20. 4-year Schools Providing Formal Aviation Safety Course

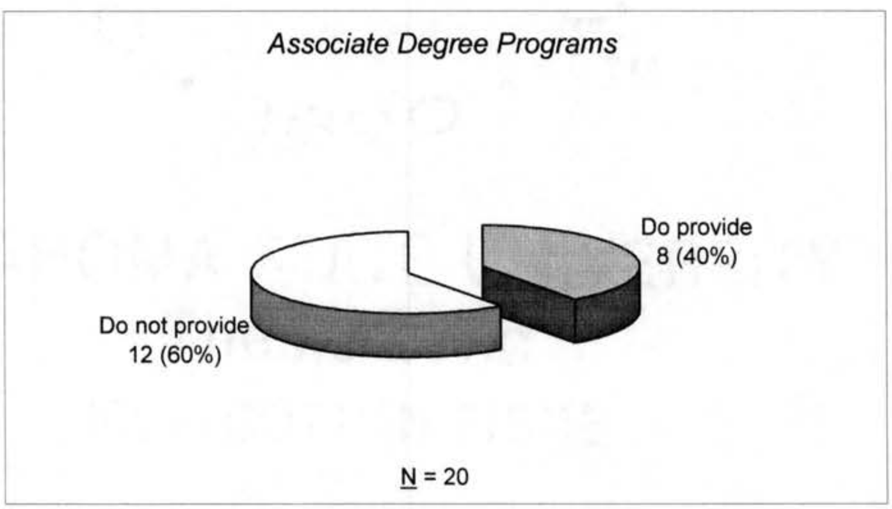


Figure 21. 2-year Schools Providing Formal Aviation Safety Course

Data from questionnaire item 1a, the level at which Aviation Safety course was taught, is revealed in Figure 22. The majority of respondents marked more than one level. The post-graduate program as described in Figure 19 was not included in Figure 22.

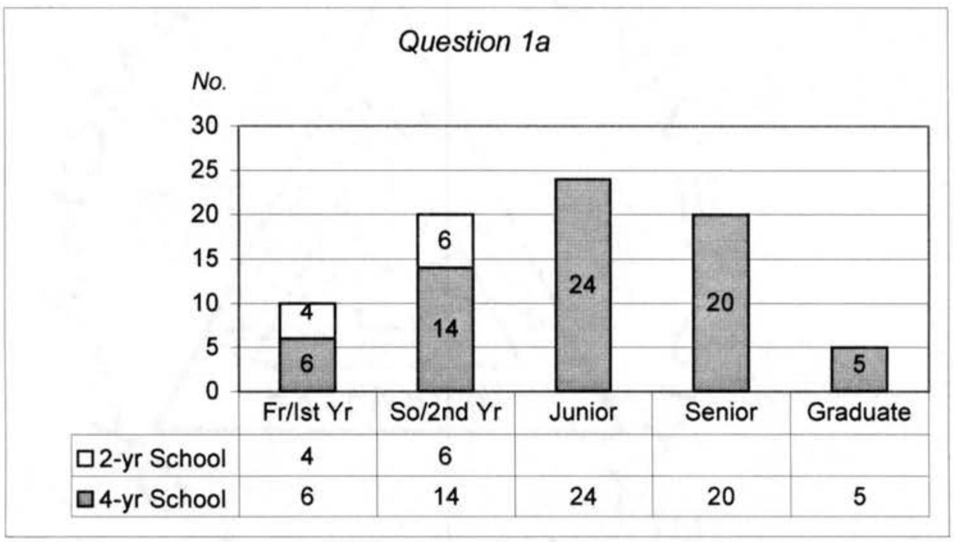


Figure 22. Level at Which Aviation Safety Course Is Taught

In questionnaire item 1b, the respondents were asked how many semester credit hours are granted for the Aviation Safety course offered by their institutions. The result shown in Figure 23 revealed that a majority of institutions (92%) granted three semester hours, six percent of institutions granted six semester hours, and two percent of institutions granted two semester hours among the 50 institutions that offer a formal course work in the Aviation Safety course. The Post-graduate program was counted in Figure 23.

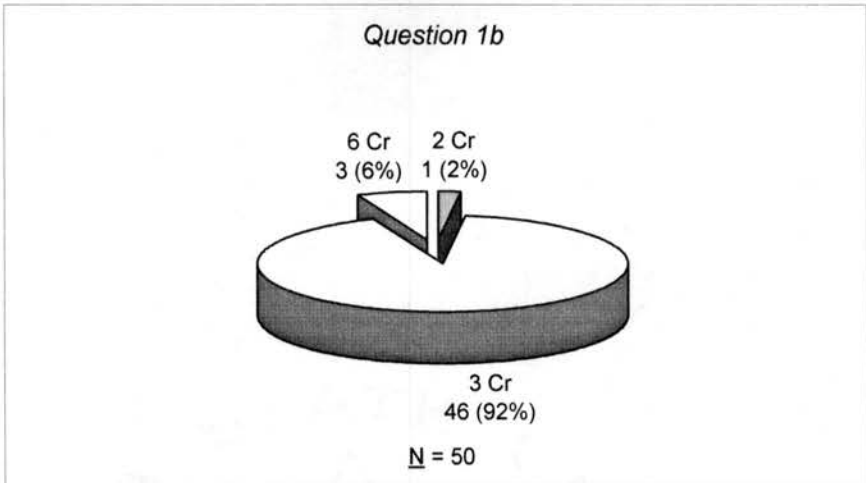


Figure 23. Semester Credit Hours Granted for an Aviation Safety Course

Questionnaire item 1c was used to obtain information about instructors who were currently teaching the Aviation Safety course. Many respondents reported more than one type of instructor. The result of the survey is given in Figure 24 which shows that the course were taught by 51 faculty members, 11 Certified Flight Instructors or Ground Instructors, 11 adjunct faculty members.

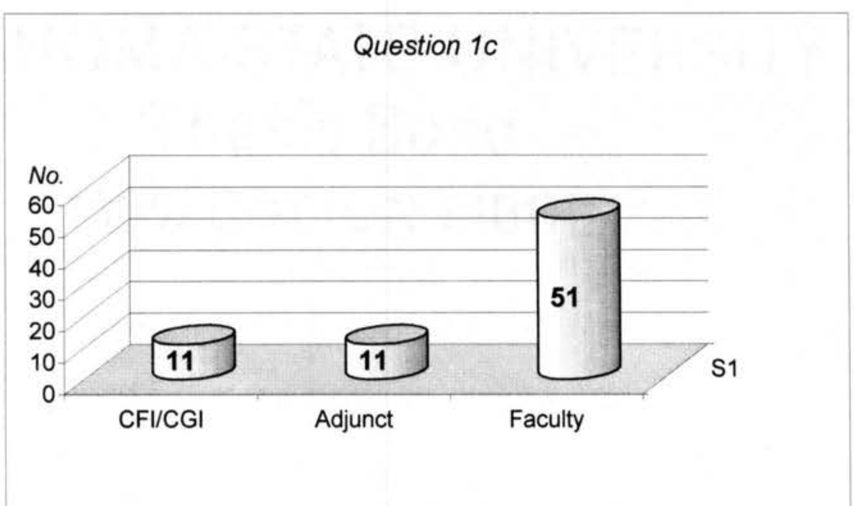


Figure 24. Type of Instructors Teaching an Aviation Safety Course

Questionnaire item 2 was designated to determine what type of aviation safety related courses were taught in UAA member schools. Nine courses were selected for this survey by the researcher: *Accident Investigation*, *Accident Prevention*, *Aircraft Safety*, *Aviation Psychology, Aviation Physiology*, *Crew Resource Management (CRM)*, *Aviation Safety Management*, *Flight Safety*, and *Human Factors*. The result showed that *Human Factors* and *CRM* courses were the first and second highest frequencies respectively among the several courses. In addition to the above addressed courses in the survey, *Aviation Law* is mentioned by three schools. *System Safety* and *Industrial Accident Prevention* were addressed by one institution respectively. The frequencies of the courses are shown in Figure 25.

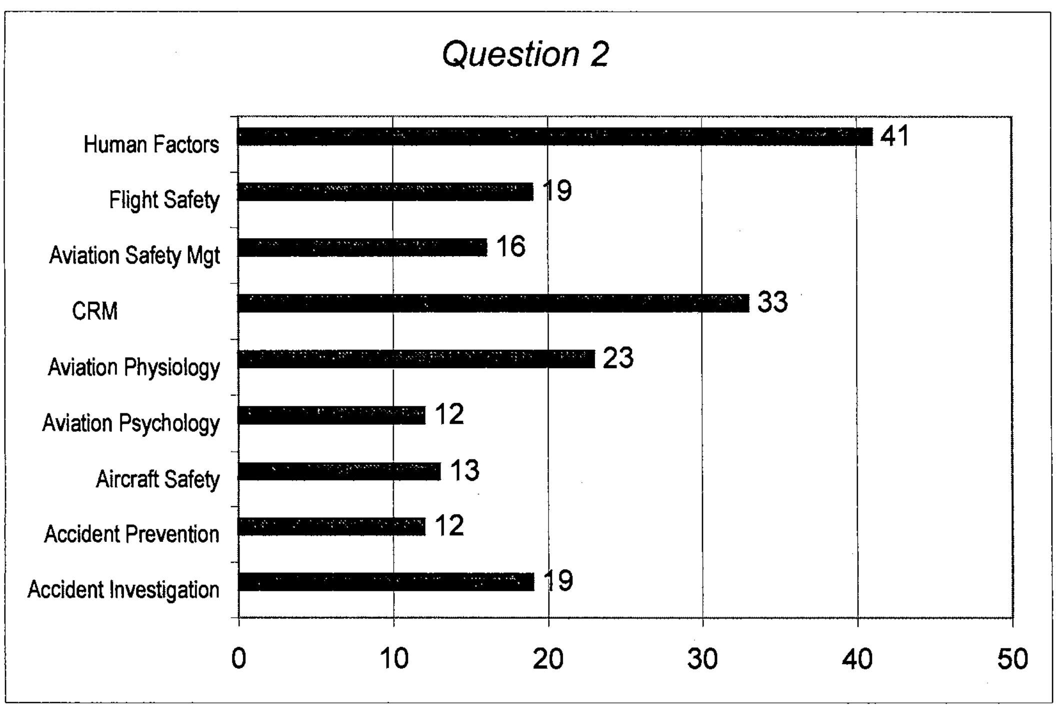


Figure 25. Aviation Safety Related Courses Offered by the Participating Schools

To determine the perceived importance of formal instruction in an Aviation Safety course, question number 3 asked the participants to respond to the necessity of the course from unnecessary to necessary on a Likert scale of 1 to 10, 10 being "absolutely necessary." The range of scores was 3 to 10. The mean was 9.13, the median was 9.11, and the mode was 10. The level of frequency is shown in Figure 26 (N =137).

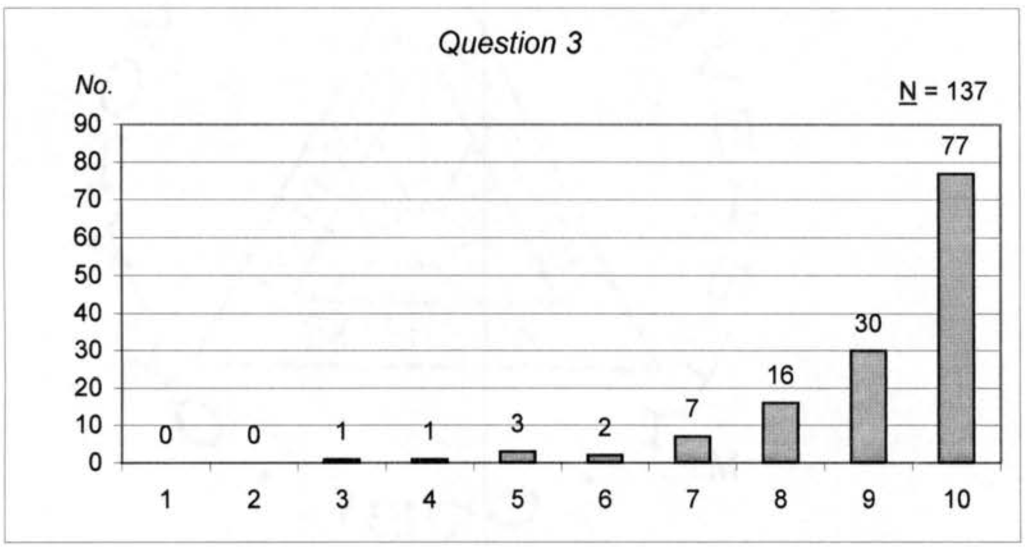


Figure 26. The Perceived Need for an Aviation Safety Course

Questionnaire item 4 was asked to determine the optimum level to offer an Aviation Safety course. As shown Figure 27, the institutions granting Associate degrees showed a high number of frequencies during the freshman and sophomore years. Although the responses from Baccalaureate program were spread out over all levels, junior and senior levels showed more frequencies than other levels among the respondents. Sixteen respondents stated that all undergraduate levels of instruction were necessary. Eleven respondents mentioned that graduate level instruction was necessary. The response of the postgraduate program was counted in the 4-year program. The total number of participants was 137.

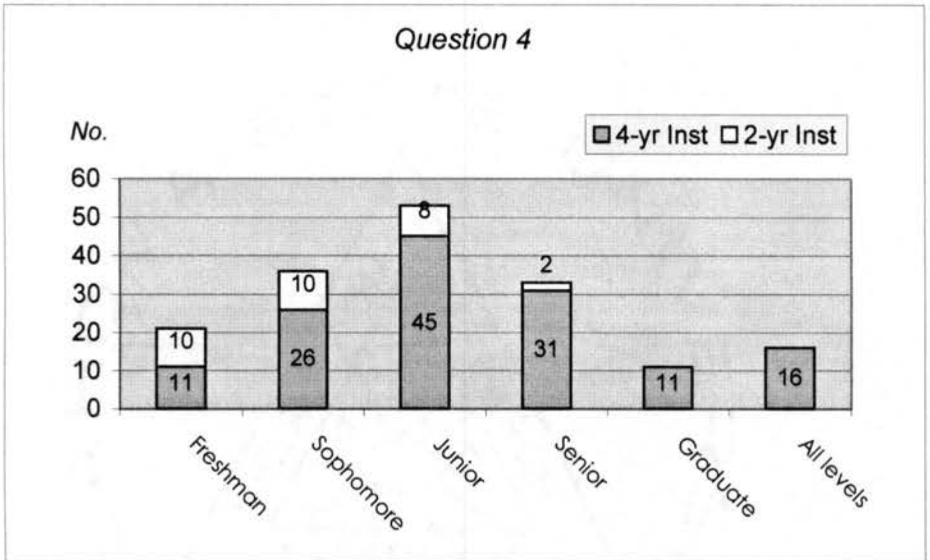


Figure 27. The Perceived Optimum Level of Instruction of an Aviation Safety Course

Questionnaire item 5 asked what would be the appropriate number of credit hours for an Aviation Safety course. The result of the survey revealed that 96 (70%) out of 137 preferred 3 credit semester hours. Opinions varied from 2 to 24 semester hours. The frequencies of each credit hour indicated in Figure 28 are broken down: two responds of 2 hours, ninety-six responds of 3 hours, two responds of 4 hours, two responds of 5 hours, twelve responds of 6 hours, three responds of 9 hours, ten responds of 10+ hours, two responds of 2 to 3 hours, five responds of 3 to 6 hours, one respond of 4 to 5 hours, and one respond of 3 to 9 hours.

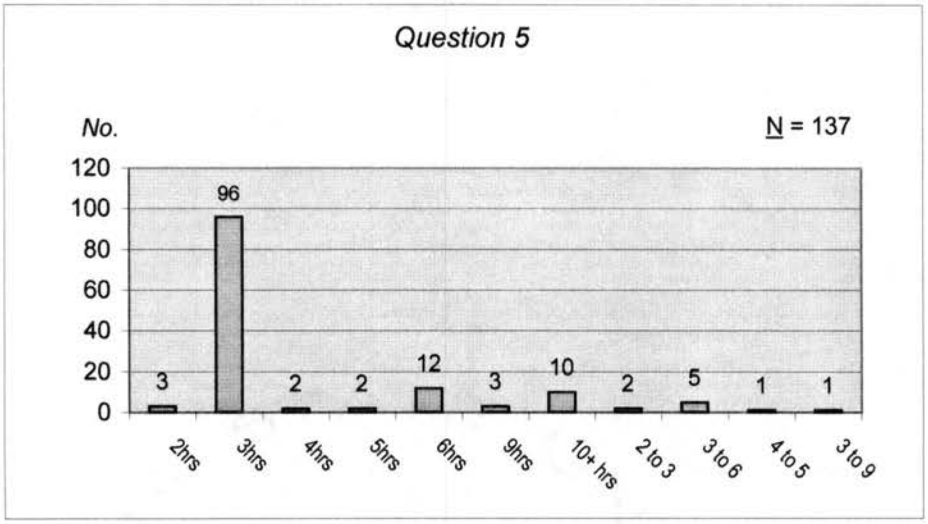


Figure 28. Appropriate Semester Credit for an Aviation Safety Course

Questionnaire item 6 was used to determine what type of instructor was appropriate to provide instruction in Aviation Safety. In total, 158 responses were addressed by 137 participants. It should be note that a participant could respond to more than one item. One hundred and eight responded they should be faculty members; 26 responded they could be adjunct faculty; and 24 responded they should be Certified Flight/Ground Instructors as shown in Figure 29.

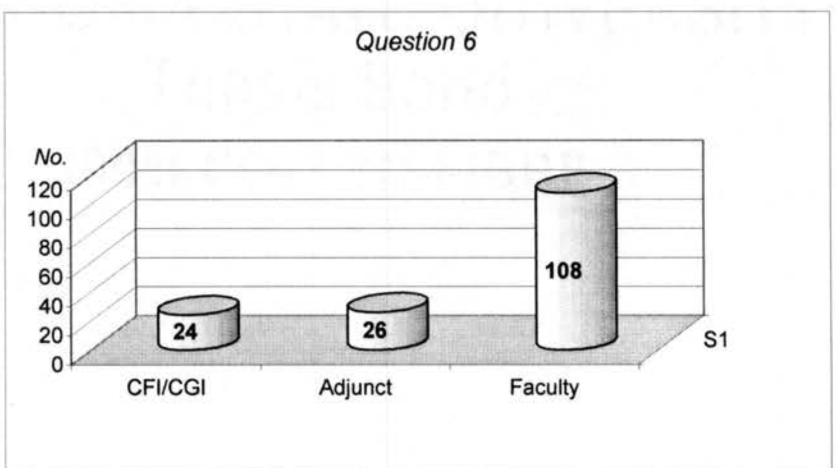


Figure 29. Perceived Type of Instructor by Respondents

Nineteen respondents made comments about what an aviation safety instructor should possess. In summary, they stated that aviation field experiences were more important than certain nominal ranks and titles in determining instructors for an Aviation Safety course. The comments by respondents were:

- Response 1: Experienced personnel
- Response 2: Specialist in aviation safety--guest lecturers
- Response 3: Individuals with recent and ongoing experience in the subjects as safety enfolds with new impetus
- Response 4: Safety related training and background in aviation etc.
- Response 5: Those appropriate for the subject being taught
- Response 6: Adjunct if experienced in aviation safety
- Response 7: Depending on background (Adjunct)
- Response 8: One who has an appropriate background
- Response 9: Experienced person in aviation safety program management
- Response 10: Specialist in industry, could be adjunct faculty
- Response 11: With work experience
- Response 12: Certified aviation person
- Response 13: Must have a safety background
- Response 14: Someone who specializes in safety
- Response 15: Experienced safety, security officials
- Response 16: Depends on the person
- Response 17: Depending on the subject
- Response 18: Safety background and training

- Response 19: Aviation program manager

Questionnaire item 7 asked respondents to recommend an appropriate textbook for an Aviation Safety course. Nine textbooks were selected by the researcher for this survey. Most of these books had been used previously for aviation safety related courses in some schools. The researcher interviewed three instructors who taught Aviation Safety courses in order to get information on current textbooks for an Aviation Safety course. In addition to this interview, availability of textbooks which addressed aviation safety was obtained from two major on-line book stores in the United States: one is "Barnes & Noble" available at http://www.barnesandnoble.com and the other is "Amazon" available at http://www.amazon.com. The textbooks proposed for this study were:

A. Ellis, G. (1984). Air crash Investigation of General Aviation Aircraft. Greybull, WY: Glenndale Book.
B. Wood, R. & Sweginnis, R. (1999). Aircraft Accident Investigation (10th printing). Casper, WY: Endeavor Books.
C. Krause, S. S. (1996). Aircraft Safety: Accident Investigations, Analyses, & Applications. New York: McGraw-Hill.
D. Taylor L. (1998). Air Travel: How safe is it? (2nd ed.). Cambridge, MA: Blackwell Science Publishing.
E. Wood, R. H. (1997). Aviation Safety Programs: A Management Handbook (2nd ed.). Englewood, CO: Jeppesen Sanderson Inc.
F. Wells, A. T. (1997). Commercial Aviation Safety (2nd ed.): New York: McGraw-Hill.
G. Wells, A. T. (1992). Flight Safety: A Primer for General Aviation Pilots. Blue Ridge Summit, PA: Tab Books.
H. Hawkins, F. H. (1997). Human Factors in Flight (2nd ed.). Brookfield, Vermont: Ashgate.
I. Wiener E. L. & Nagel, D. C. (Eds.). (1988). Human Factors in Aviation. San Diego, CA: Academic Press.

One respondent pointed out that some books were out of print and currently not available. According to an on-line book search, only one text is currently out of print: *Flight Safety: A Primer for General Aviation Pilots* by Wells (1992). However, the book was included in the list because the book was still preferred by some instructors. According to the results of this survey, Ellis's and Taylor's books were recommended by the participants. Taylor's first edition of "Air Travel: How safe is it?" published in 1988 was a pioneering textbook for an Aviation Safety course. The book was used for some aviation safety courses. Taylor published the second edition in 1998. The question item requested that respondents select only one book or specify another choice for a fair interpretation under equal amount of selection from each respondent. A total of 101 respondents offered their opinions including eighty-two single text selections, fourteen multiple text selections, and five others. Among the other selections, two institutions used their own texts compiled by the institutions or instructors, and three respondents addressed other selections not on the list. Other selections from the respondents were:

1. Frazier, D. A. (1998). The ABCs of Safe Flying. New York: McGraw-Hill.
2. Taylor, J. C. & Christensen T. D. (1998). Airline Maintenance Resource Management: Improving Communication. Society of Automotive Engineer.
3. Pilot Error series published by McGraw-Hill.

Input from fourteen respondents who chose more than one book were not counted in each book's sum so there would not be a misrepresentation of the overall data. The frequencies are given in Figure 30.

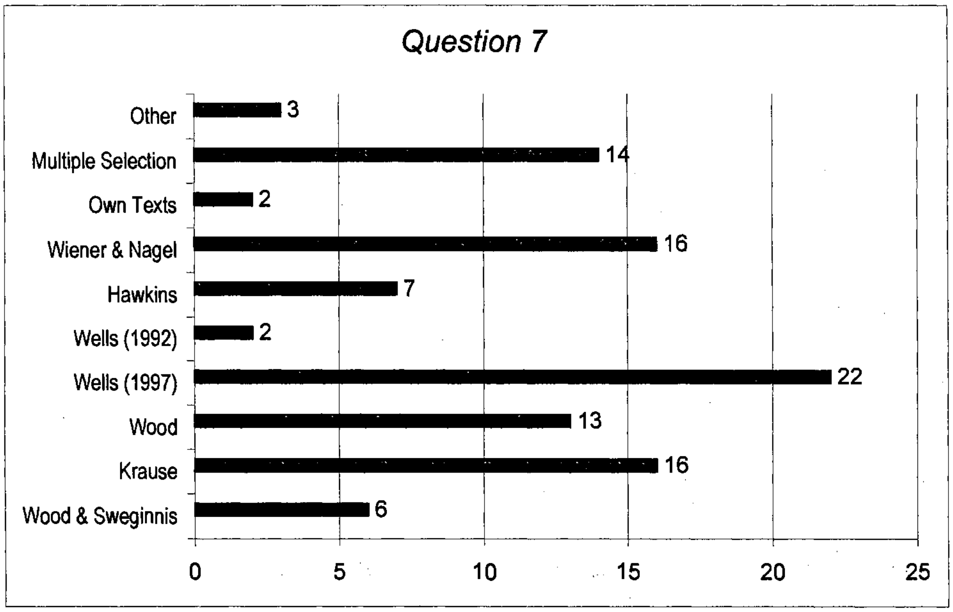


Figure 30. Preferred Textbooks for an Aviation Safety Course by the Respondents

Part II. Instruction

In the following section, the data obtained is presented in pie charts. In each pie graph, the frequency and percentage of each designation is located next to each pie section. Missing responses were not included in the pie graphs. The total responses (N) for each figure is located under each pie chart. Each question response was based upon the following six designations: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), Strongly Disagree (SD), and Not Applicable (NA). Questionnaire item 8, composed of 16 sub-questions, were asked to determine the characteristics and scope of an Aviation Safety course.

Question 8*a* asked if an Aviation Safety course should be a flexible course not relying on certain texts or topics. It seemed to be a challenging or controversial item for some participants. Seven respondents made comments such as "bad question," "dangerous idea" and "inappropriate question." However, the result shown in Figure 31 showed that two-fifths of the respondents (40%) collectively strongly agree (27%) and agree (13%) while 37% of the respondent collectively disagree (23%) and strongly disagree (14%) with this issue. The rest of respondents reported neutral (23%) and none reported not applicable (NA).

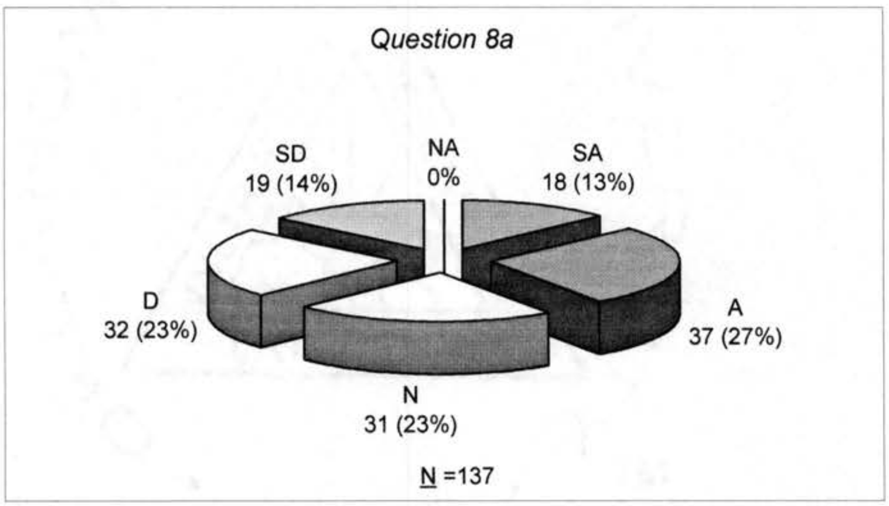


Figure 31. A Flexible Course Not Relying on Certain Texts or Topics

Questionnaire item 8*b* asked if a safety course should be an advanced course for junior or senior standing. Three respondents left notes that this item was not appropriate for 2-year Associate degree programs. The data in Figure 32 shows that three-fifths of respondents (60%) collectively strongly agree (28%) or agree (32%) while a relatively low percentage of respondents disagree (15%) and strongly disagree (8%). The neutral and not applicable responses were 16% and 18% respectively.

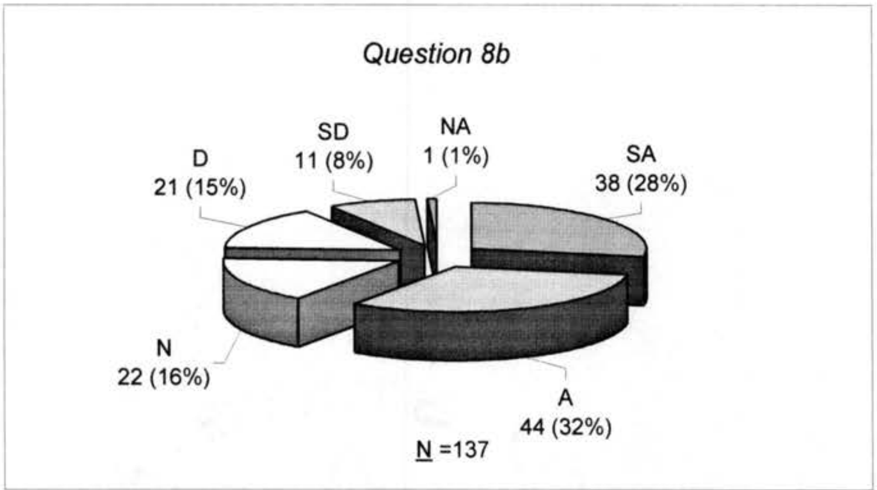


Figure 32. An Advanced Course for Junior or Senior Standing in the Course Works

The data in Figure 33 shows that a majority of respondents (80%) strongly agree (19%) and agree (61%) that a safety course should focus on case studies of aircraft accidents and safety.

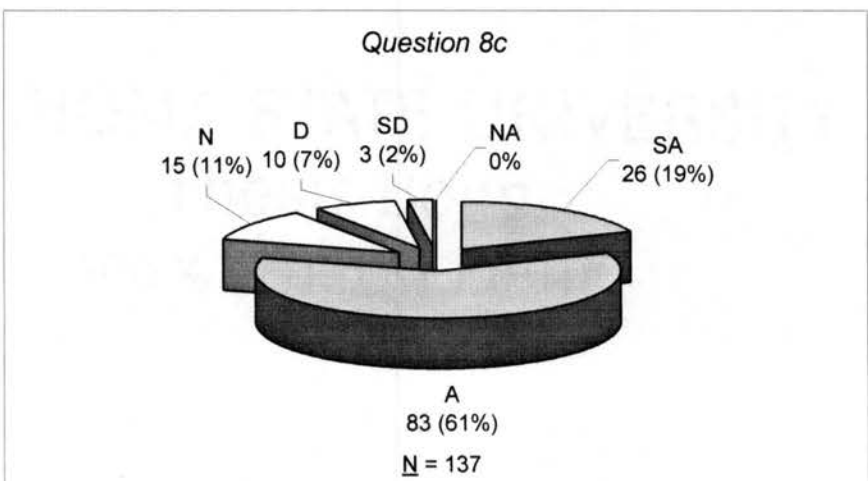


Figure 33. Case Studies of Aircraft Accidents and Safety

The data in Figure 34 reveals the respondents' opinions as to whether a safety course should focus on current trends and issues in aviation safety. Almost all members (92%) collectively agree (58%) and strongly agree (34%). Only one percent disagreed.

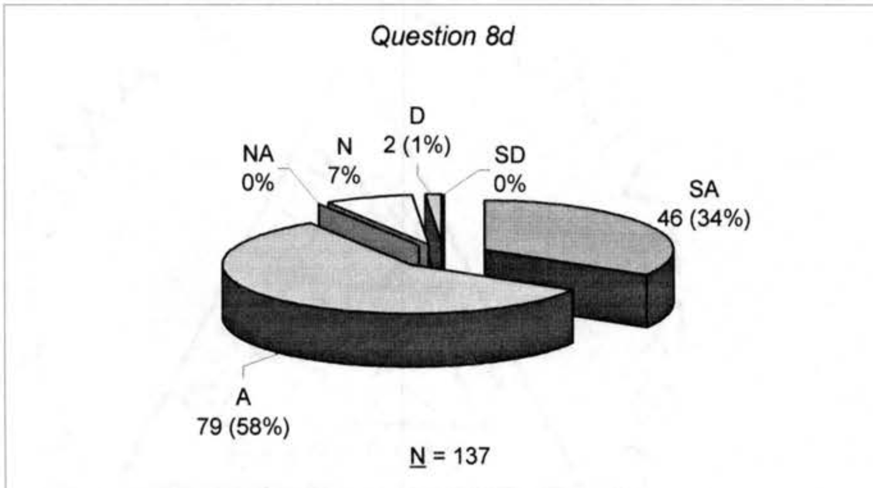


Figure 34. Current Trends and Issues of Aviation Safety

Questionnaire item 8*e* asked if a safety course should focus on developing a sample aviation safety program or accident prevention program for an organization. Data in Figure 35 reveals that fifty-three percent of respondents strongly agree (16%) and agree (37%) while thirteen percent disagree and three percent strongly disagree about this issue. Thirty percent were neutral.

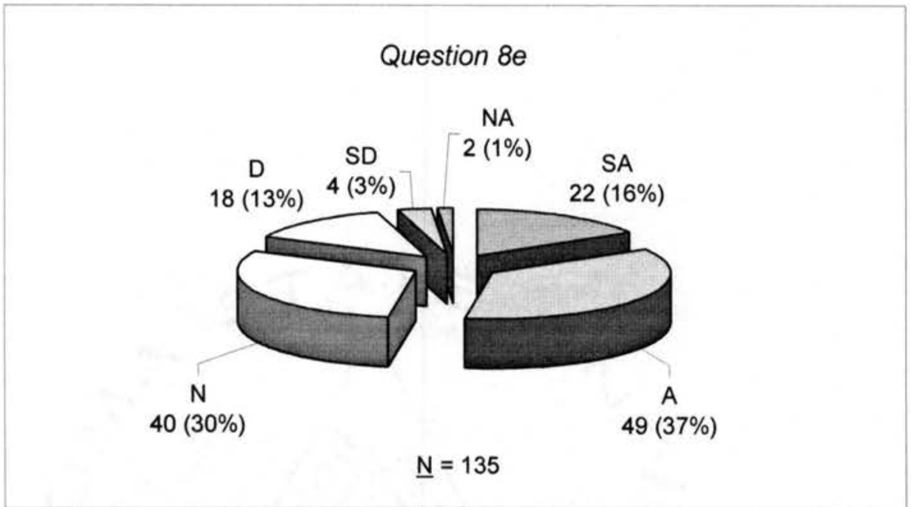


Figure 35. Developing a Sample Aviation Safety Program or Accident Prevention Program

Questionnaire item *8f* asked respondents to offer opinions as to whether a safety course should focus on enhancing flight skills or maneuvers and safety operations. A respondent keenly pointed out this item was not appropriate for the students in non-pilot programs. The information depicted in Figure 36 shows that fifty-one percent of respondents collectively disagree (35%) and strongly disagree (16%) while fourteen percent agree and 8 percent strongly agree about this matter. The rest of respondents were twenty-six percent neutral and one percent not applicable.

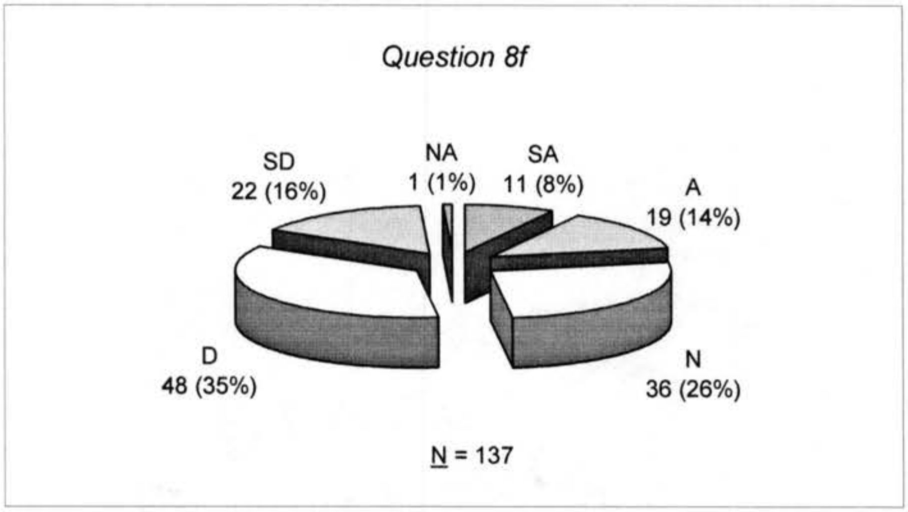


Figure 36. Enhancing Flight Skills or Maneuvers and Safety Operation

The information in Figure 37 indicates that a majority of respondents (88%) strongly agree or agree with focusing on frameworks of strengthening safety concepts. A low percentage of respondents' input breaks down: 1% strongly disagree, 1% disagree, 9% neutral, and 1% not applicable.

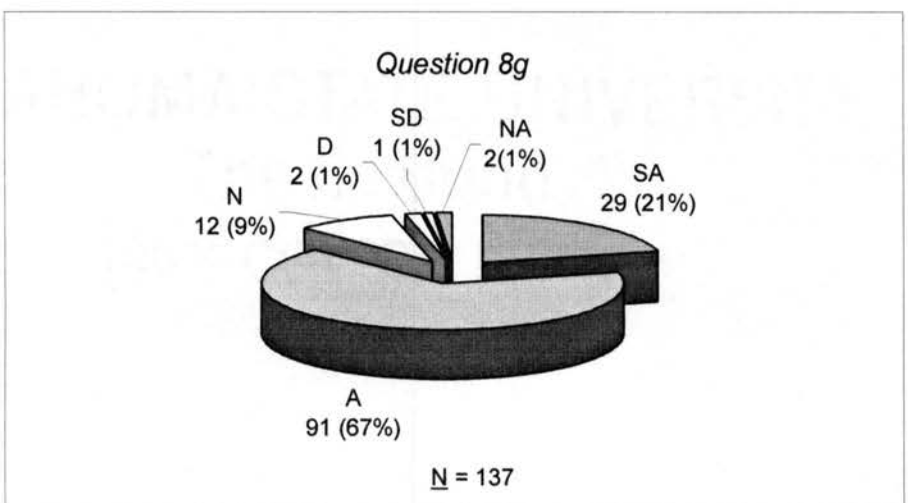


Figure 37. Focusing on Frameworks of Strengthening Safety Concepts

Questionnaire item 8*h* asked if a safety course should focus on human factors. The results shown in Figure 38 indicate the topic of human factors is an important element in safety education: 31 % strongly agree, 56% agree, 7% neutral, 5% disagree, none strongly disagree, and 1% not applicable.

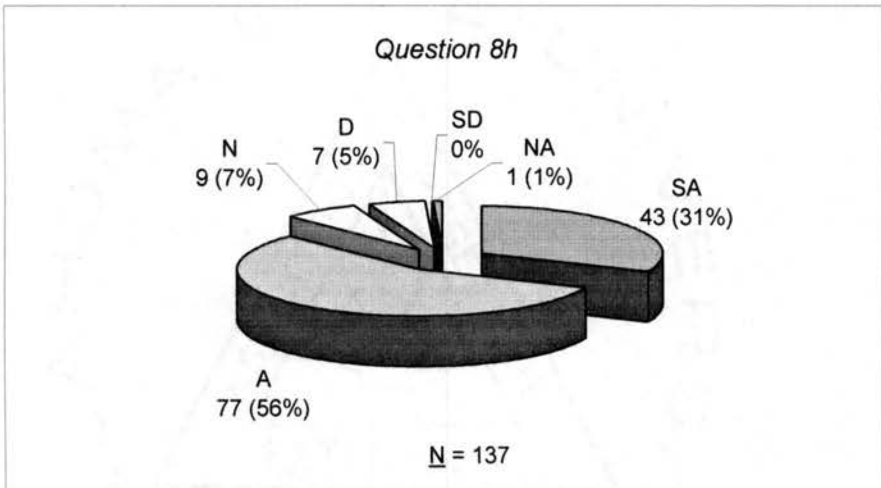


Figure 38. Focusing on Human Factors

Questionnaire item 8*i* asked the participants to state whether an Aviation Safety course should focus on narrowing the gap between real world of aviation and school work. The question seemed obscure or controversial for some participants. Seven members mentioned that they did not understand the meaning of the question and put question marks on it. This question was asked because criticism of some if not many, collegiate aviation safety education programs seldom reflected recent, real world professional experience in business, industry, or a government agency. The information depicted in Figure 39 shows that sixty-two percent of the participants strongly agree (18%) or agree (44%) with this matter. Other opinions comprise 22% neutral, 7% disagree, 2% strongly disagree, and 7% not applicable.

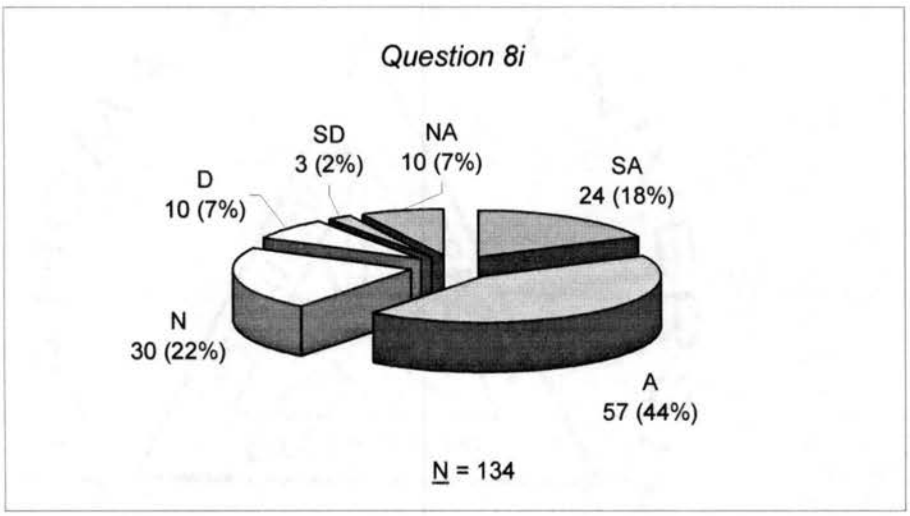


Figure 39. Narrowing Gaps between Real Aviation World and School Works

Questionnaire item 8*j* asked if a safety course should focus on a theoretical framework of safety. The data in Figure 40 shows that forty-seven percent of respondents strongly agree and agree while two percent strongly disagree and seventeen percent disagree.

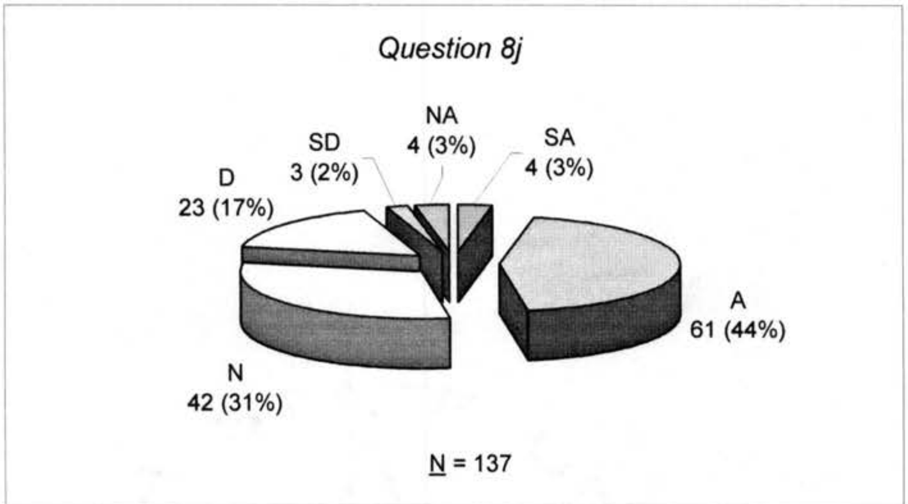


Figure 40. Need of a Theoretical Framework of Safety

The data in Figure 41 shows the respondents' concern for extra laboratory hours or field work in a safety course. Approximately, two-fifths of respondents (39%) disagree or strongly disagree with this issue. The percentage breakdowns are: 5% strongly agree, 21% agree, 28% neutral, 29% disagree, 10% strongly disagree, and 7% not applicable.

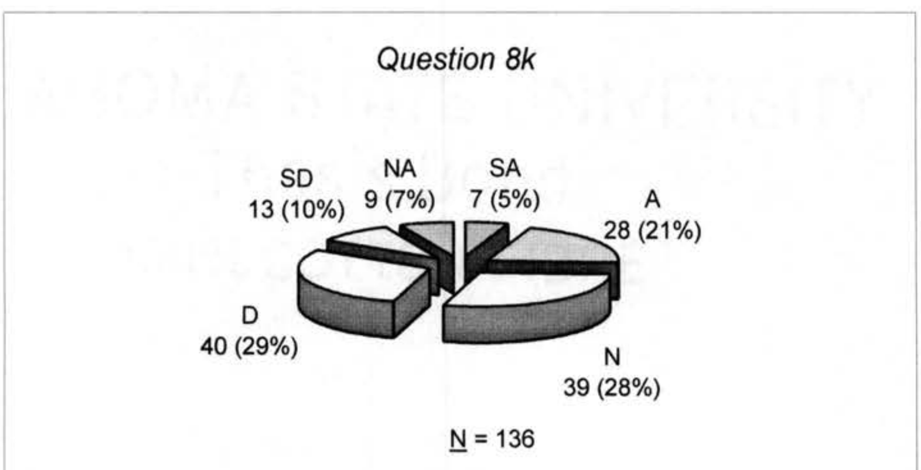


Figure 41. Necessity of Extra Lab Hours or Field Work

Questionnaire item 8*l* asked if a safety course should focus on experimental aircraft safety. The responses are recorded in Figure 42. Those with a neutral opinion had the highest percentage (38%). Forty-three percent of respondents collectively strongly disagreed (12%) and disagreed (31%).

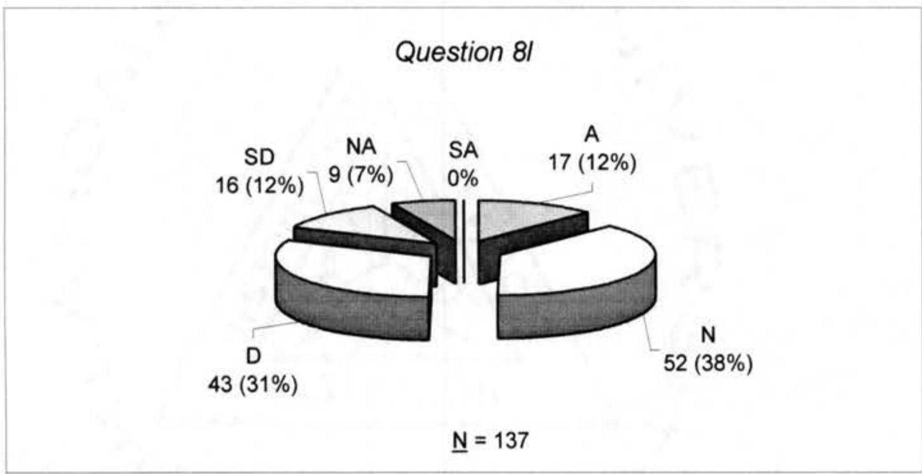


Figure 42. Necessity of Experimental Aircraft Safety

Questionnaire item 8*m* asked if a study of rotorcraft safety was necessary. Data in Figure 43 shows that slightly less than one-half of all the participants (47%) respond neutral. The other responses were: 1% strongly agree, 18% agree, 22% disagree, 8% strongly disagree, and 4% not applicable.

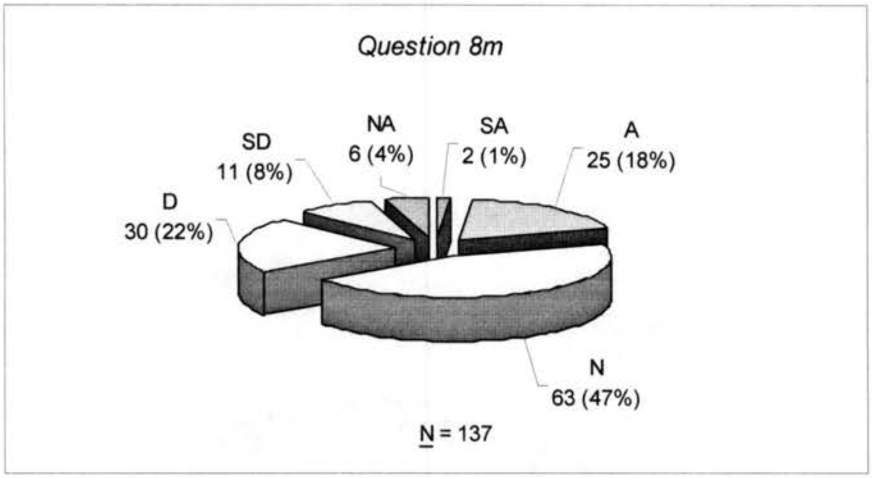


Figure 43. Necessity of Rotorcraft Safety

Questionnaire item 8*n* asked if a prerequisite course should be required for a safety course. Data in Figure 44 shows that slightly less than one-half of the participants (49%) strongly agree (13%) or agree (36%) with the necessity of a prerequisite course while twenty-five percent disagree and seven percent strongly disagree. The neutral responses were addressed from twenty participants (18%).

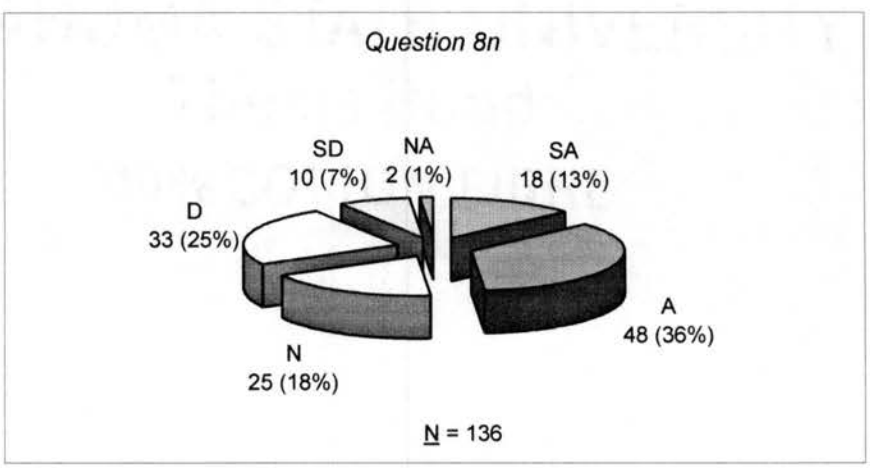


Figure 44. Necessity of Prerequisite Course

Questionnaire item 8*o* and 8p were designed to determine if an Aviation Safety course should take either a macroscopic or a microscopic approach. A macroscopic approach focuses on the whole system safety while a microscopic approach focuses on each individual safety element. The data in Figure 45 indicates that seventy-six percent of respondents strongly agree and agree while a low percentage of respondents disagree (4%) and strongly disagree (1%). The remaining opinions were 16% neutral and 3% not applicable.

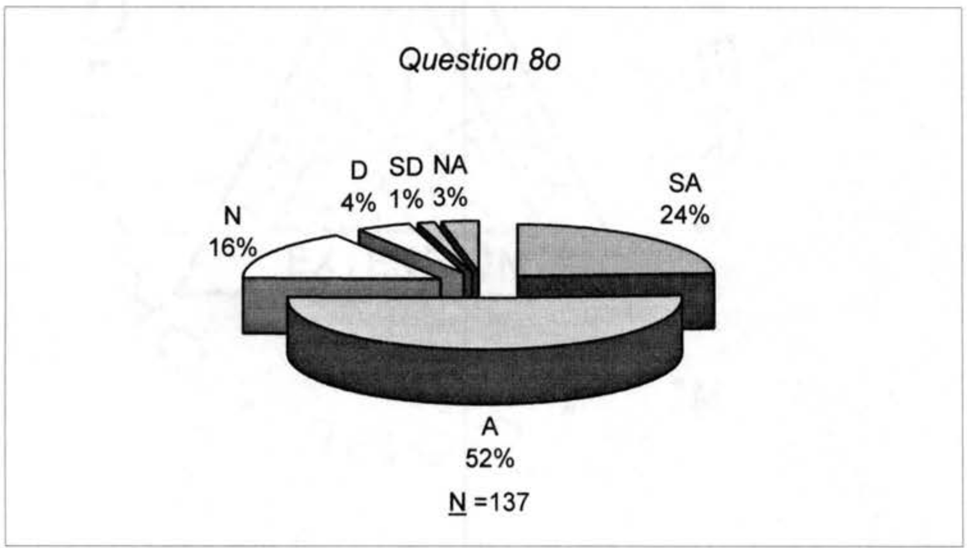


Figure 45. Macroscopic Approach in Safety

The information described in Figure 46 shows that thirty-one percent of respondents strongly agree (7%) and agree (24%) in response to taking a microscopic approach to safety. Respondents who disagreed and strongly disagreed accounted for thirty-four percent and seven percent respectively. The rest of the responses were twenty-three percent neutral and five percent not applicable.

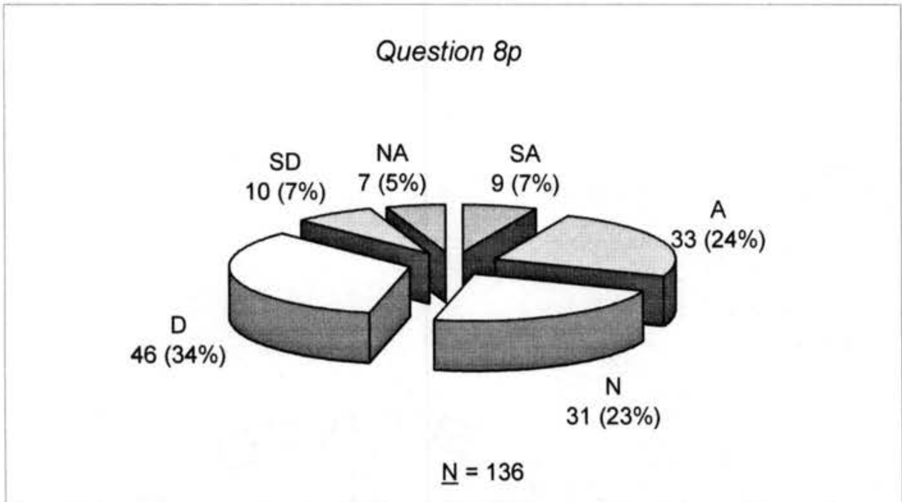


Figure 46. Microscopic Approach in Safety

Part III. Curricula

The objective of Part III was seeking participants' opinions concerning the topics and safety issues that should be discussed in a prospective Aviation Safety course. The data generated from the responds offered by participants were tabulated into pie charts. In each of the pie charts, the frequency and percentage of each designation was located next to each pie section. Missing responses or unanswered items were not included in the pie charts. The total responses (N) for each figure was located under each pie chart. Questionnaire item 9 was composed of 19 sub-questions.

Questionnaire item 9a asked if the accident investigation process and technology should be addressed in an Aviation Safety course. Data in Figure 47 shows that a majority of respondents (78%) either strongly agreed or agreed with this issue. Other responds were fifteen percent of neutral, five percent of disagree, one percent of strongly agree, and one percent of not applicable.

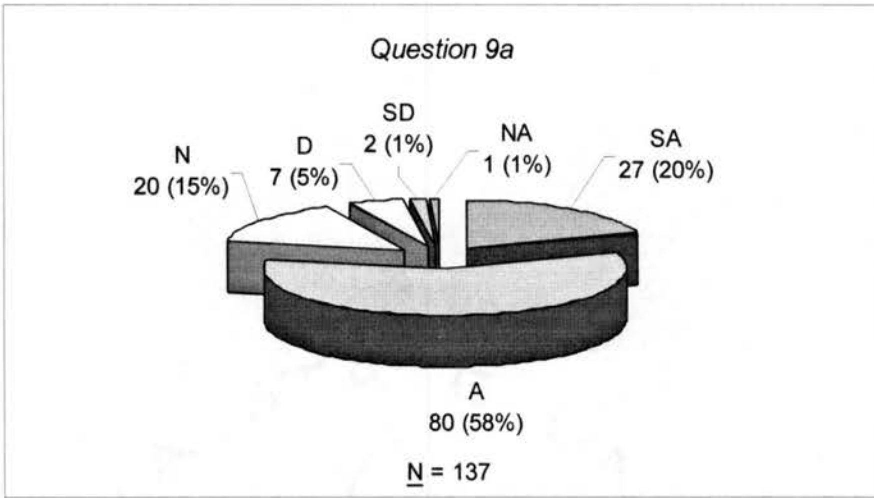


Figure 47. Need for Accident Investigation Process and Technology

Questionnaire item 9b asked if aircraft performance should be discussed in a safety course. The subject area included takeoff, climb, landing, crosswind components, and weight and balance. The data shown in Figure 48 indicates that 10% strongly agree, 33% agree, 23% neutral, 24% disagree, 9% strongly agree, and 1% not applicable.

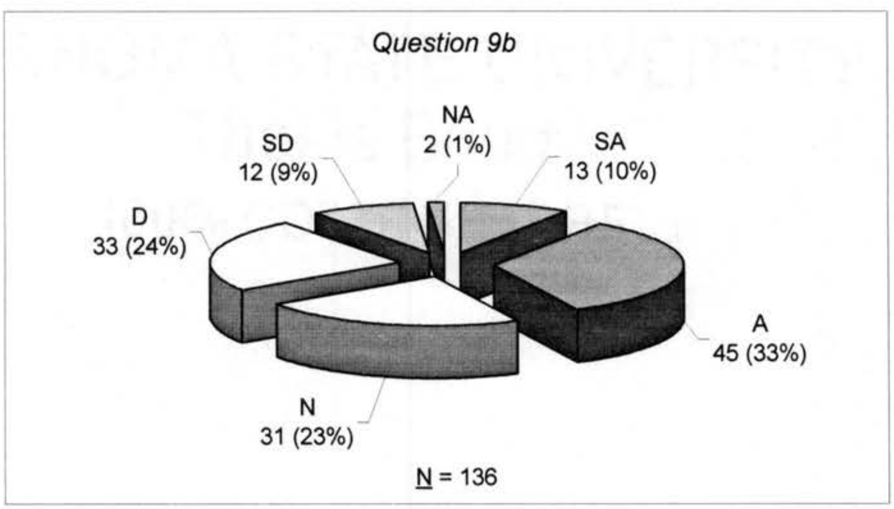


Figure 48. Need for Aircraft Performance

Questionnaire 9c asked if aviation history, from a safety perspective, should be included in an Aviation Safety course. The data in Figure 49 shows over one-half (56%) of the respondents strongly agree and agree. A low percentage of the respondents (3%) strongly disagree. Other responses were three percent disagree, twenty-seven percent neutral, and one percent not applicable.

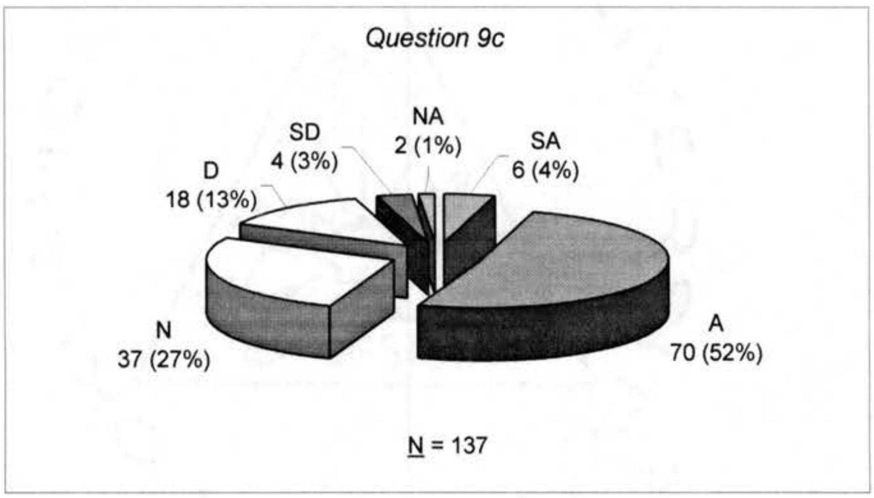


Figure 49. Need for Instruction in Aviation History with Safety Perspective

Questionnaire item 9d asked participants to state the necessity of instruction in Aviation Law, Federal Aviation Regulation (FAR), and Aeronautical Information Manual (AIM) in an Aviation Safety course. The data in Figure 50 shows that forty-five percent of respondents strongly agree and agree. Twenty-five percent of respondents strongly disagree and disagree while twenty-nine percent hold a neutral opinion, and one percent hold not applicable.

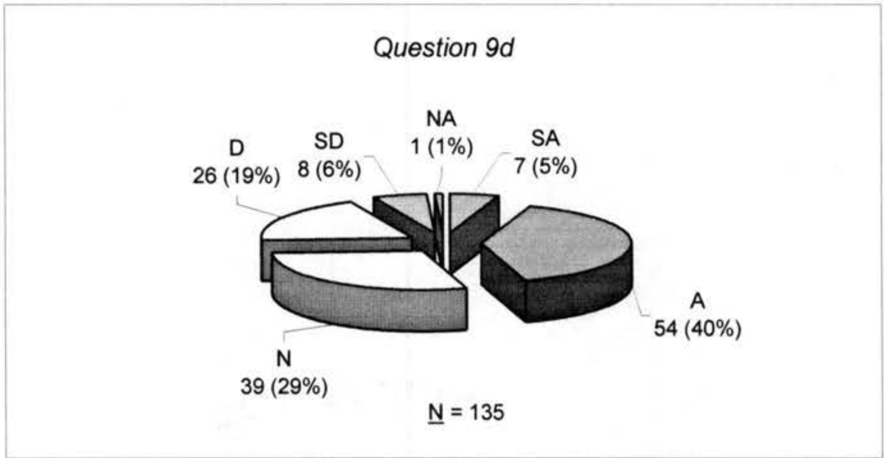


Figure 50. Need for Instruction in Aviation Law, FAR, and AIM

Questionnaire item 9e asked whether instruction in aviation security including bomb detection, baggage and passenger screening, and hijacking were necessary. The information in Figure 51 shows that 39% of all the participants strongly agree (9%) and agree (30%) with the statement. Twenty-seven percent of the respondents disagree and disagree while thirty-three percent have a neutral opinion, and one percent holds not applicable.

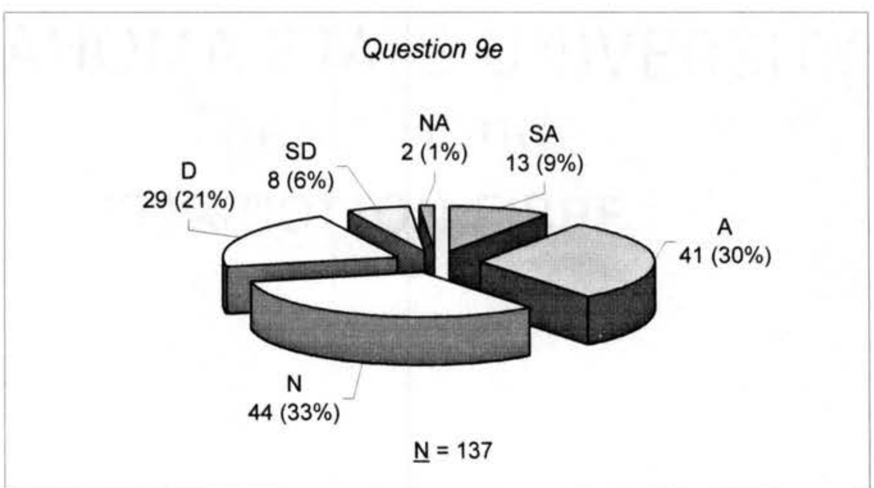


Figure 51. Need for Instruction in Aviation Security

Questionnaire item 9f asked if a theoretical framework in safety is necessary for an Aviation Safety course. The theoretical framework mentioned included behavioral theories, cognitive theories, SHELL model, and Reason's system approach. The information in Figure 52 shows that a majority of the participants agree (45%) or strongly agree (26%) with this statement. A low percentage of the respondents disagree (4%) while twenty-one percent hold neutral and four percent not applicable.

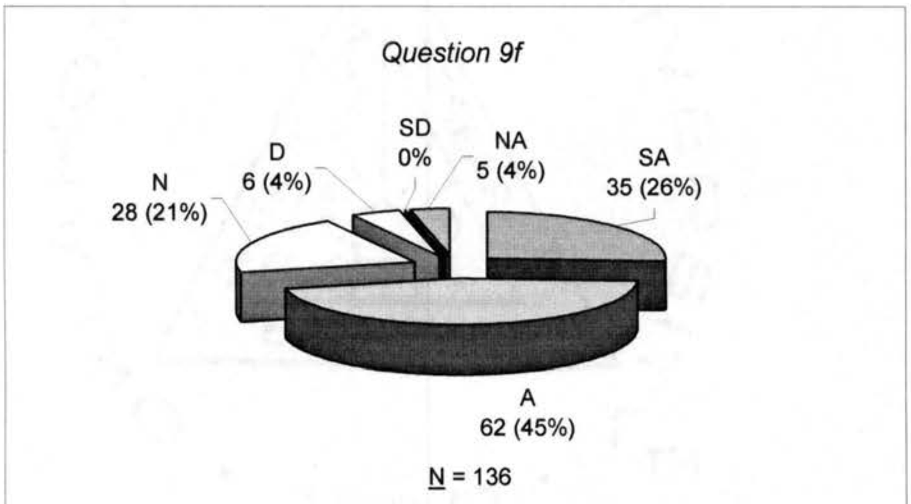


Figure 52. Need for Instruction of Theoretical Framework in Aviation Safety

Questionnaire item 9g asked if basic physics including aerodynamics in safety is necessary for an Aviation Safety course. In Figure 53, the data shows only twenty-eight percent strongly agree and agree. Respondents who disagree and strongly disagree account for twelve percent and thirty-two percent respectively. Other responses are twenty-seven percent neutral and one percent not applicable.

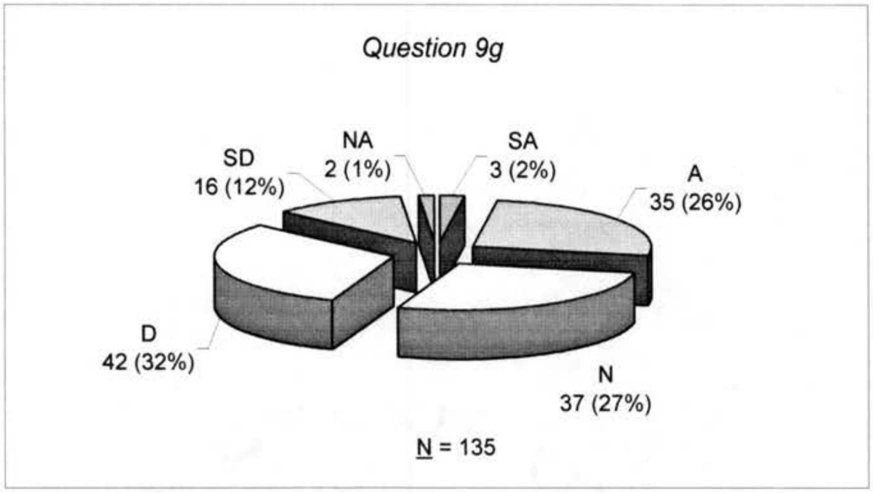


Figure 53. Need for Instruction in Basic Physics

Questionnaire item *9h* asked if the issue of ethics in safety including bogus parts should be included in an Aviation Safety course. The information in Figure 54 shows that a relatively high percentage of the respondents (62%) strongly agree and agree while a low percentage of the participants disagree (4%) and strongly disagree (3%). The rest of respondents are twenty-six percent neutral and one percent not applicable.

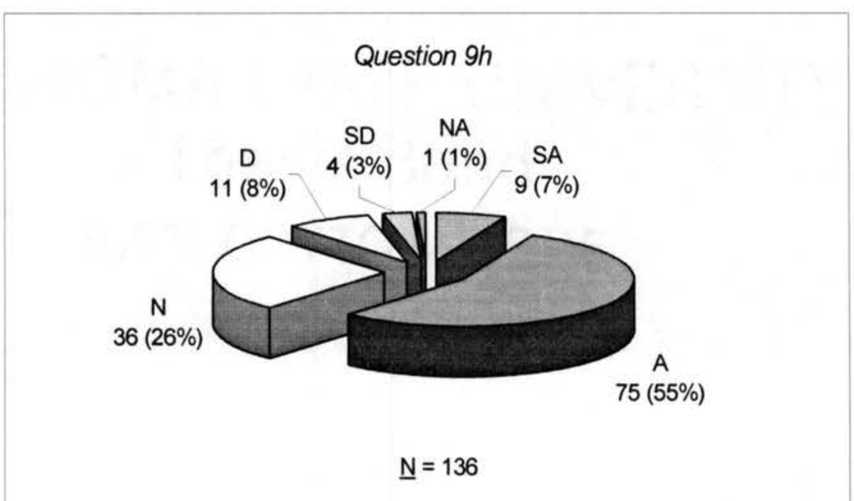


Figure 54. Need for Instruction of Ethics in Safety including Bogus Parts

Questionnaire item 9*i* asked if case studies of catastrophic aircraft accidents were necessary for an Aviation Safety course. The information in Figure 55 shows that a majority of participants strongly agree (29%) and agree (61%) with this statement. A low percentage of the respondents disagree (3%) and strongly disagree (1%) while five percent hold neutral and one percent not applicable.

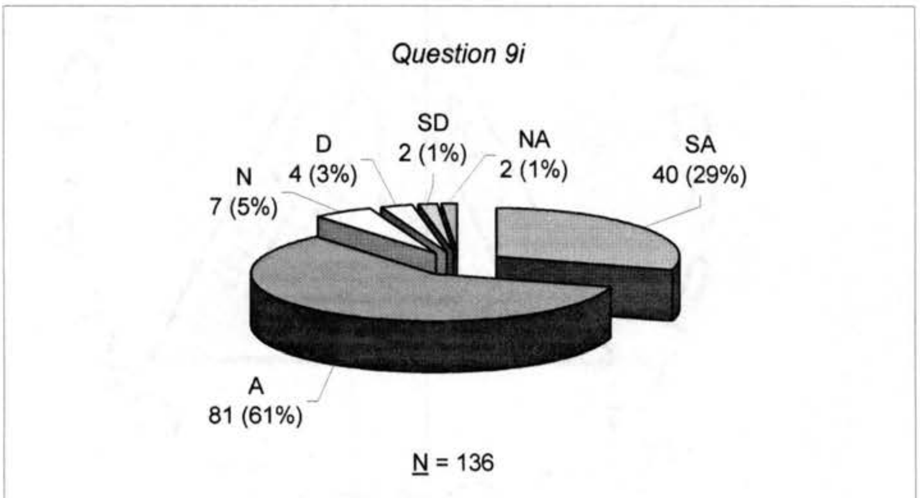


Figure 55. Need for Instruction in Case Studies of Catastrophic Aircraft Accidents

Questionnaire item 9*j* asked if computer skills including database, spreadsheet, and internet access were needed in an Aviation Safety course. The data in Figure 56 shows thirty-four percent strongly agree (6%) and agree (28%). Respondents who disagree and strongly disagree account for twenty-two percent and sixteen percent respectively. Other responses were twenty-seven percent neutral and one percent not applicable.

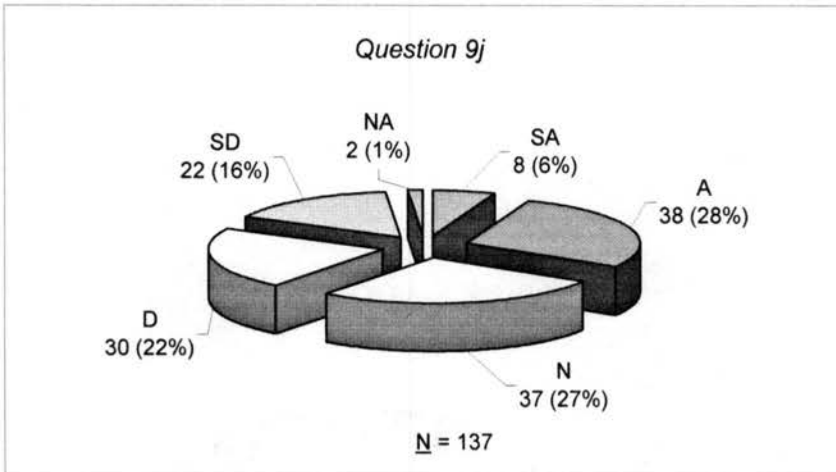


Figure 56. Need for Instruction in Computer Skills

Questionnaire item 9*k* tried to find a need for instruction in establishing an aviation safety program for an organization including accident prevention methodology and risk management. The information in Figure 57 shows that three-quarters of the respondents strongly agree (20%) and agree (55%). Respondents who disagree and strongly disagree account for six percent and three percent respectively. The remaining responses are eleven percent neutral and zero percent not applicable.

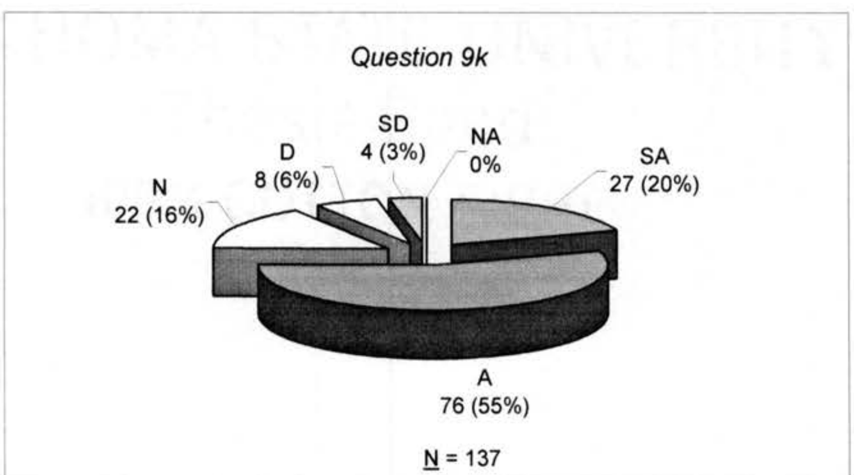


Figure 57. Need for Instruction in Establishing Aviation Safety Program

Questionnaire item 9*l* asked if familiarization of aircraft systems was necessary for an Aviation Safety course. The familiarization area included knowledge of airframe, powerplants, instruments, and avionics. The information in Figure 58 shows that a relatively low percentage of the respondents strongly agree (3%) and agree (24%) while forty-five percent of the participants disagree (35%) and strongly disagree (10%). The rest of respondents are twenty-seven percent neutral and one percent not applicable.

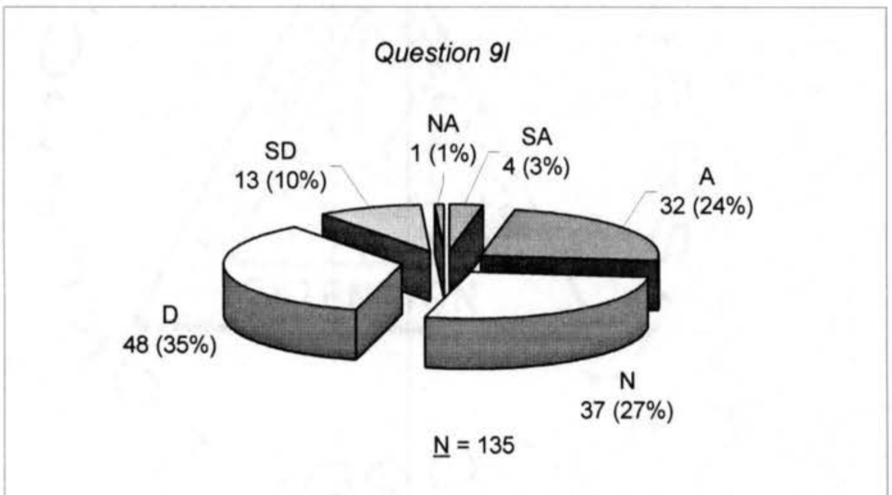


Figure 58. Need for Instruction in Familiarization of Aircraft System

Questionnaire item 9*m* asked if flight operations should be discussed in a safety course. The subject area included airport facilities, air traffic control, airspace, and communication procedures. The result of the survey as shown in Figure 59 indicates nine percent strongly agree, forty-eight percent agree, eighteen percent neutral, seventeen percent disagree, seven percent strongly agree, and one percent not applicable.

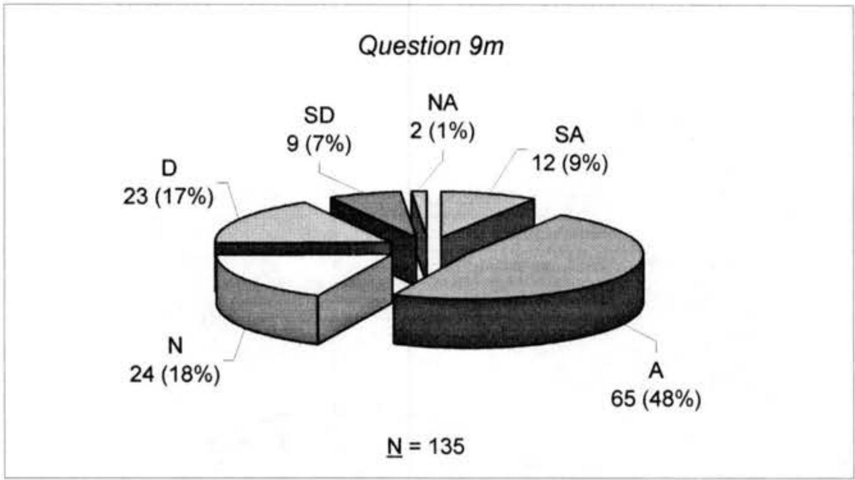


Figure 59. Need for Instruction in Flight Operations

Questionnaire item 9*n* asked if flight safety was necessary for an Aviation Safety course. The subject area included collision avoidance, controlled flight into terrain (CFIT), near miss, runway incursion and inflight fire. The information in Figure 60 shows that a majority of participants (88%) collectively agree with this statement: 19% strongly agree and 69% agree. A low percentage of the respondents disagree (3%) and strongly disagree (1%) while seven percent hold neutral and one percent not applicable.

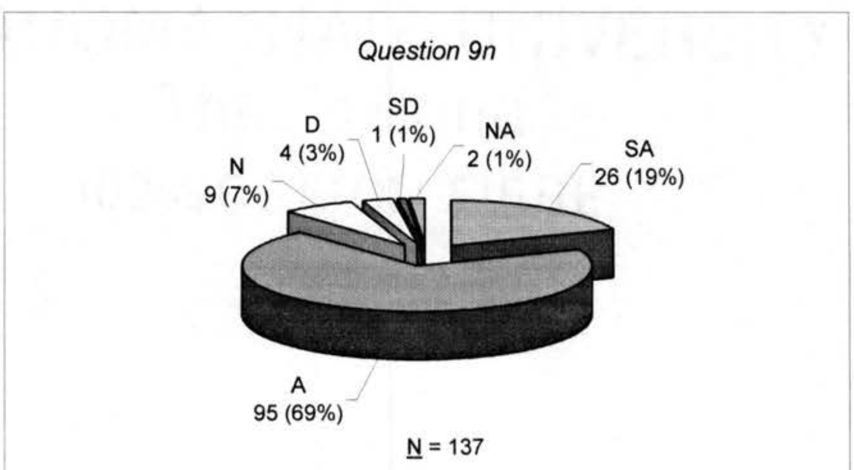


Figure 60. Need for Instruction in Flight Safety

Questionnaire item 9*o* asked participants' opinions with regard to the need for instruction in management of safety data. The subject area included data collection and selection, data analysis, and statistical analysis. The information in Figure 61 shows that sixty-six percent of participants strongly agree (20%) and agree (46%) with this topic. A low percentage of the respondents disagree (5%) and strongly disagree (3%) while thirty-four percent hold neutral and one percent not applicable.

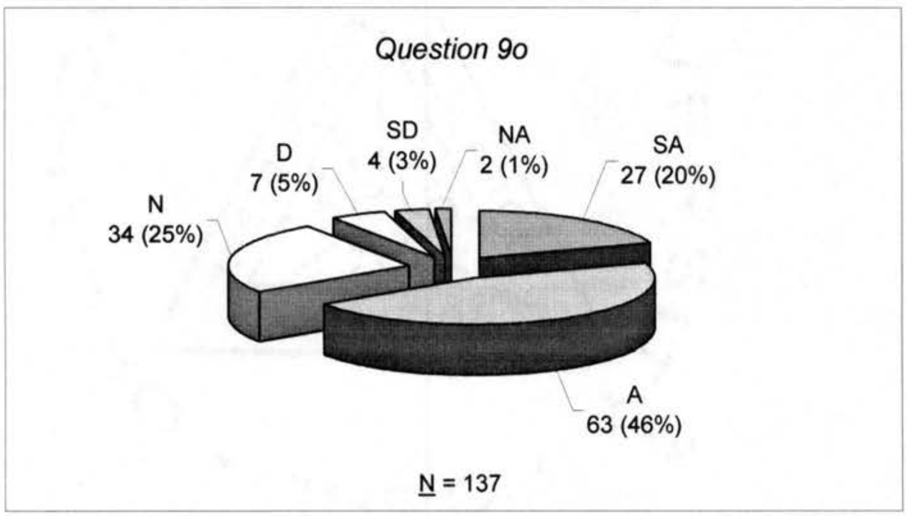


Figure 61. Need for Instruction in Management of Safety Data

Questionnaire item 9*p* asked if meteorology and atmospheric phenomena were necessary topics for a safety course. The subject area included thunderstorms, microbursts, lightening, windshears, and icing conditions. The result of the survey as shown in Figure 62 indicates nine percent strongly agree, forty-eight percent agree, eighteen percent neutral, seventeen percent disagree, seven percent strongly agree, and one percent not applicable.

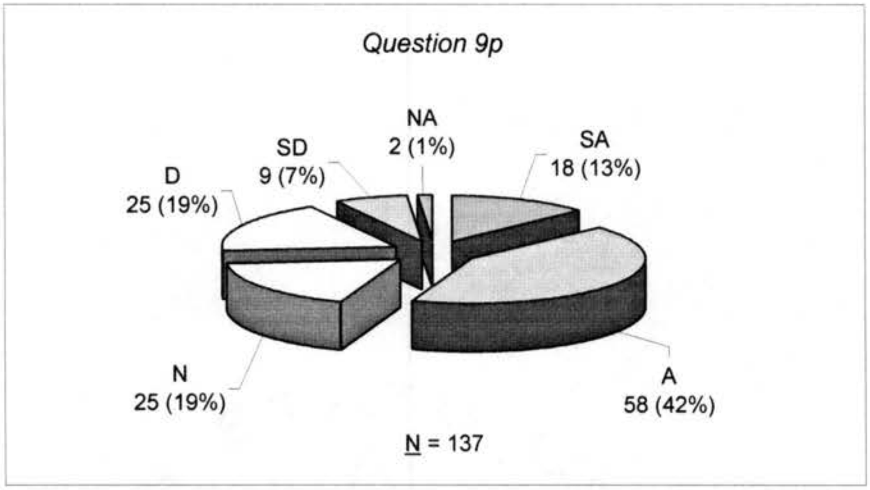


Figure 62. Need for Instruction in Meteorology and Atmospheric Phenomena

Questionnaire item *9q* asked if physiological human factors should be studied in an Aviation Safety course. The subject area includes hypoxia, hyperventilation, spatial disorientation, decompression sickness, motion sickness, vision in flight, and fatigue. The information in Figure 63 shows that a majority of participants (77%) strongly agree and agree. A low percentage of the respondents disagree (10%) and strongly disagree (2%) while ten percent hold neutral and one percent not applicable.

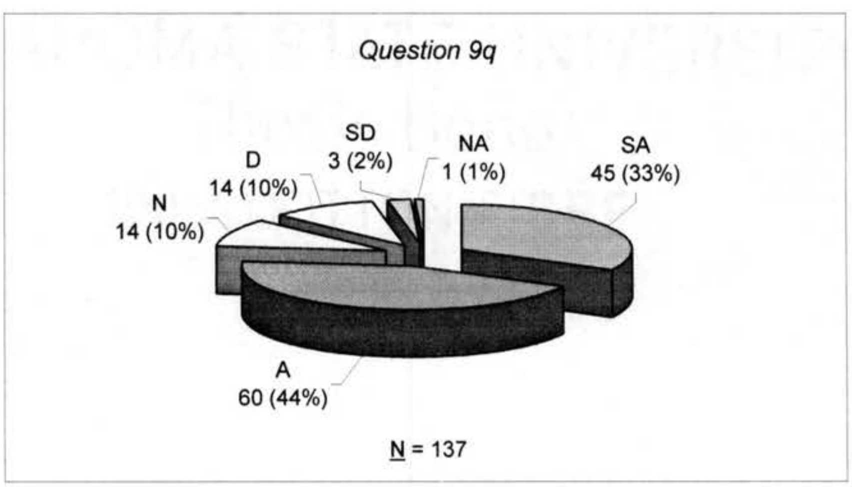


Figure 63. Need for Instruction in Physiological Human Factors

Questionnaire item 9*r* asked if psychological human factors need to be studied in an Aviation Safety course. The subject area included crew resource management (CRM), human errors, and stress alertness management. The information in Figure 64 shows that the majority of respondents (86%) strongly agree (19%) and agree (69%). A relatively low percentage of the respondents disagree (7%) while seven percent hold neutral and zero percent not applicable.

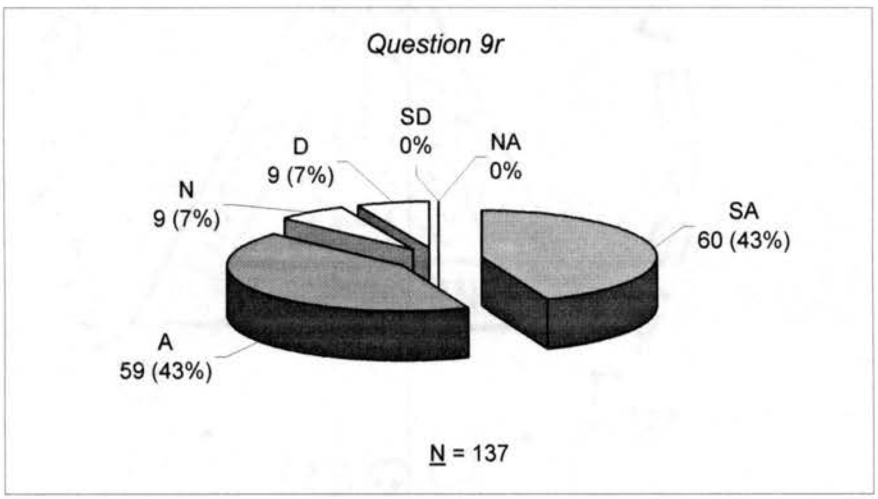


Figure 64. Need for Instruction in Psychological Human Factors

Questionnaire item 9s tried to determine the necessity of instruction concerning the aviation safety community including the Federal Aviation Administration (FAA), National Aeronautics and Space Administration (NASA), National Transportation Safety Board (NTSB), International Air Transport Association (IATA), and International Civil Aviation Organization (ICAO). The information in Figure 65 shows a skewed result. A majority of respondents (90%) strongly agree (34%) and agree (56%) with this statement. A low percentage of the respondents disagree (1%) and zero percent strongly disagree while eleven percent of respondents hold neutral and one percent not applicable.

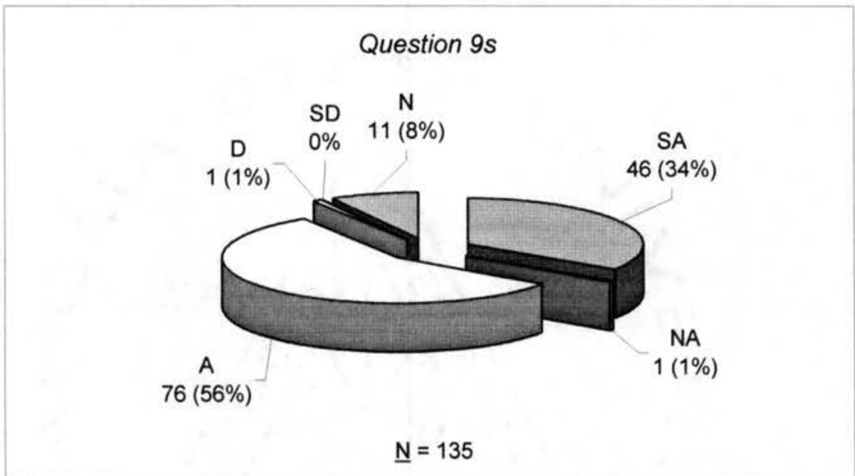


Figure 65. Need for Instruction in Aviation Safety Community

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to develop an Aviation Safety course suitable for collegiate level aviation degree programs. Prior to this study no analysis had been made showing what colleges and universities currently cover or perceive should be taught in an Aviation Safety course. A questionnaire was utilized to identify impending problems, current involvement of instruction for aviation safety education and to obtain perception or opinions about a prospective Aviation Safety course from University Aviation Association (UAA) members.

In Chapter II, the review of literature, six areas concerning both aviation education and aviation safety were reviewed in order to understand the nature of aviation safety. These areas included a historical review of aviation education, recent studies of aviation education and aviation safety, general aviation safety, commercial aviation safety, a theoretical framework of aviation education, and a theoretical framework of aviation safety.

The research method used was a non-experimental, descriptive survey as described by Wiggins & Stevens (1999) to investigate curriculum development issues in aviation safety. The measuring instrument was a survey questionnaire developed by the researcher with assistance from faculty members of the Department of Aviation Education at Oklahoma State University. The validation of the questionnaire was conducted for content and consistency by eight individuals, each an expert in his/her specialty in aviation safety.

The questionnaire was composed of three parts including Part I (Setting of Safety in the Curricula), Part II (Instruction) and Part III (Curricula). Part I (Setting of Safety in the Curricula) consisted of seven question items. Part II and III were composed of seventeen and twenty question items respectively. Part II related to the characteristics and scope of an aviation safety course. Part III dealt with topics and safety factors in an aviation safety course. For this study, a Likert scale was utilized for Parts II and III in the questionnaire. Six designations were used to get the respondents' perception and opinions with respect to aviation safety: Strongly Agree (SA), Agree (A), Neutral (N), Disagree(D), Strongly Disagree (SD), and Not Applicable (NA).

The subjects of the study were University Aviation Association (UAA) Institutional members and Professional members, based on the United States membership list dated November 1999. The population of the UAA members for the survey was identified as 111 Institutional members and 202 Professional members. A total of 313 questionnaires were sent by first class mail on February 7, 2000. Each questionnaire was accompanied by a cover letter of introduction outlining the purpose and importance of study. By March 10, 2000, 137 questionnaires were returned and were suitable for data interpretation from 72 institutions. The response rate of the questionnaires was 43.77%.

The data from the questionnaires were extrapolated and entered into a personal computer with database and spreadsheet programs for data compilation and the generation of graphs and charts. Finally, the database was utilized to yield frequency data for each questionnaire item. The frequency data is presented in either histograms or pie charts. The graphs included the total number of respondents, the frequency and percentage of each Likert type designation.

Findings

Setting of Safety in the Curricula

1. The percentage of schools that reported providing formal course work in Aviation Safety was 69.4%. Formal aviation safety instruction was conducted by eighty percent of the Bachelor's degree granting institutions and forty percent of the Associate degree granting institutions.

2. The current level at which an Aviation Safety course was taught revealed: four responses at 1st year, and six responses at 2nd year from 2-year program institutions; and six responses at the freshman level, 14 responses at the sophomore level, 24 responses at the junior level, and 20 responses at the senior level. There were five responses at the graduate level.

3. Three semester credit hours were granted for an Aviation Safety course by the majority of the institutions (92%) that offered a formal course work in Aviation Safety.

4. The type of instructor used to conduct an Aviation Safety course was most often a faculty member (51 responses).

5. Aviation safety related courses were offered by many UAA member institutions: Human Factors (41), Flight Safety (19), Aviation Safety Management (16),

CRM (33), Aviation Physiology (23), Aviation Psychology (12), Aircraft Safety (13), Accident Prevention (12), and Accident Investigation (19).

6. The perceived need for an Aviation Safety course was absolutely necessary. On a Likert scale of 1 to 10, with 10 representing "absolutely necessary," the mean score was 9.13.

7. The desired educational level to offer an Aviation Safety course revealed that freshman and sophomore levels were preferred by the 2-year program institutions while junior and senior levels were preferred by the Baccalaureate degree program institutions.

8. Seventy percent of the respondents preferred 3 credit hours for an Aviation Safety course.

9. The most appropriate type of instructor to provide instruction in aviation safety was a faculty member. One hundred and eight respondents out of 137 participants recommended a faculty member. However, nineteen respondents mentioned that field experience should be considered in determining an appropriate instructor for an Aviation Safety course.

10. "Commercial Aviation Safety" written by A. T. Wells (1997) was chosen by 22 respondents as the most preferred textbook for an Aviation Safety course. The next level of preferred textbooks were "Human Factors in Aviation" edited by E. L. Wiener and D. C. Nagel (1988) and "Aircraft Safety: Accident Investigations, Analyses, & Applications" written by S. S. Krause.

Instruction

1. Fifty-five respondents (40%) agreed/strongly agreed and that an Aviation Safety course should be a flexible course not relying on certain texts or topics while fifty-one respondents (37%) disagreed/strongly disagreed.

2. Eighty-two participants (60%) agreed/strongly agreed that an Aviation Safety course should be an advanced course for juniors or seniors.

3. A majority of participants (80%) agreed or strongly agreed that an Aviation Safety course should focus on case studies of aircraft accidents and safety.

4. One hundred and twenty-five respondents (92%) agreed or strongly agreed that an Aviation Safety course should focus on current trends and issues of aviation safety.

5. Seventy-one respondents (53%) agreed/strongly agreed that an Aviation Safety course should focus on developing an applicable aviation safety program or accident prevention program for an organization.

6. Seventy respondents (51%) disagreed/strongly disagreed that an Aviation Safety course should focus on enhancing flight skills or maneuvers and safety operation while twenty-two percent of respondents collectively agreed and strongly agreed.

7. A majority of respondents (88%) agreed/strongly agreed to the idea of focusing on frameworks of strengthening safety concepts in an Aviation Safety course.

8. One hundred and twenty participants (87%) agreed/strongly agreed that the safety course should focus on human factors.

9. Eighty-one respondents (62%) agreed/strongly agreed that the safety course should focus on narrowing the gap between real aviation field work and school work.

10. Sixty-five respondents (47%) recommended the need for theoretical frame works of safety in an Aviation Safety course.

11. Thirty-five respondents (26%) agreed or strongly agreed to the issue of necessity of extra laboratory hours for an Aviation Safety course while fifty-three (39%) respondents disagreed or strongly disagreed.

12. Fifty-nine respondents (43%) were collectively opposed to the necessity of experimental aircraft safety for an Aviation Safety course while only seventeen respondents (12%) were in favor.

13. Sixty-three participants (47%) showed neutral as the highest frequency in necessity for rotorcraft safety for an Aviation Safety course.

14. Sixty-six respondents (49%) were in favor of a necessity of prerequisite course for a safety course.

15. One hundred and three respondents (76%) recommended a macroscopic approach to safety.

16. Fifty-six respondents (41%) were opposed to a microscopic approach in safety while 42 respondents (31%) assented to this issue.

Curricula

1. One hundred and seven participants (78%) recommended that accident investigation process and technology should be addressed in an Aviation Safety course.

2. The need for aircraft performance was agreed/strongly agreed by fifty-eight participants (56%) and forty-five respondents were opposed.

3. Seventy-six respondents (56%) agreed/strongly agreed that aviation history, in a safety perspective should be included in an Aviation Safety course.

4. Sixty-one respondents (56%) were in favor of the need for instruction in aviation law, Federal Aviation Regulation, and the Aeronautical Information Manual.

5. Respondents were indifferent to the need for instruction in aviation security. Neutral designations were selected by forty-four respondents (33%).

6. The need for instruction of a theoretical framework in aviation safety was supported by ninety-seven respondents (71%)

7. Fifty-eight respondents (44%) were against the need for instruction in basic physics for a safety course.

8. Eighty-four respondents (62%) recommended a need for instruction in bogus parts and ethics in safety.

9. A majority of respondents (90%) took the affirmative in the need for instruction in case studies of catastrophic aircraft accidents.

10. The affirmative (34%) and negative (38%) opinions were almost evenly distributed on the matter of need for instruction in computer skills including database, spreadsheet, and internet access.

11. One hundred and three respondents (75 %) agreed/strongly agreed to the need for instruction in establishing an aviation safety program, including prevention technology and risk management.

12. The affirmative (34%) and negative (38%) opinions were almost evenly distributed on the matter of the need for instruction in familiarization of aircraft system including airframe, powerplants, instruments, and avionics.

13. Seventy-seven participants (57%) agreed/strongly agreed to the need for instruction in flight operations including airport facilities, air traffic control, airspace, and communication procedures.

14. One hundred and twenty one respondents (82%) took the affirmative in the need for instruction in flight safety including collision avoidance, controlled flight into terrain (CFIT), near misses, runway incursions, and inflight fires.

15. Ninety respondents (66%) agreed/strongly agree to the need for instruction in management of safety data including data collection, data selection, and statistical analysis.

16. Seventy-six participants (55%) agreed or strongly agreed to the need for instruction in meteorology and atmospheric phenomena including thunderstorms, microburst, lightening, windshears, and icing conditions.

17. One hundred and five respondents (77%) agreed or strongly agreed to the need for instruction in physiological human factors including hypoxia, hyperventilation, spatial disorientation, decompression sickness, motion sickness, vision in flight, and fatigue.

18. One hundred and nineteen respondents (86%) stated the affirmative with regard to the need for instruction in psychological human factors including crew resource management, human error, and stress alertness management.

19. Almost all respondents (90%) agreed or strongly agreed to the need for instruction about the aviation safety community including FAA, NASA, NTSB, and ICAO in an Aviation Safety course.

Conclusion

The study addressed various features of a prospective Aviation Safety course including assessment of the curriculum requirements, characteristics, scope, safety factors and safety elements. Responses to questionnaire revealed the UAA members' perceptions and opinions concerning an Aviation Safety course for collegiate aviation degree programs.

The findings of the study revealed that 69.4% of the UAA member institutions participated in the survey were providing formal course work in aviation safety. The respondents' perceived level for an Aviation Safety course was "absolutely necessary." Many comments about a safety course were obtained from the participants who conducted aviation courses. Comments from 29 respondents were selected for inclusion in Appendix C.

The respondents' comments are perceived by the researcher as three types: encouraging, informational, and skeptical. Among them, the skeptical comments came from several instructors who pointed out some impending problems of aviation safety education. The skeptical comments were:

- Two-year colleges with Associate degree programs do not have the flexibility to offer such a safety course due to a tight schedule (responses 4, 14, and 21).
- Aviation Safety should be integrated into every aviation course from the very beginning of the students' program of study (responses 7 and 22).
- The term "Aviation Safety course" is broad and ambiguous. One needs to specify the type of the course (response 10).
- Aviation safety cannot be covered in one course (response 11).

The message conveyed in the above comments may largely be true. However, if these views were absolutely true, we have only a little or no room for a formal safety course. Let us begin with a definition of safety. Collins Cobuild defines "safety is the state of being safe from harm or danger" (Sinclair J. et al., 1995). Freedom from harm or danger is a personal desire or an instinct to survive for living creatures. If safety is derived from basic instinct, we have far less margin of safety instruction. That is not the safety that we intend to explore in the aviation world. Three levels of safety have been addressed in the aviation field. The first level is to prevent the occurrence of an emergency called accident prevention. The second level is to minimize the effect of an emergency. This second level of safety can be approached by such things as fail-safe design, redundant device in the system, and pilot training in emergency procedures. The third level of safety is to minimize the injuries or fatalities in a crash (Fox, 1983).

The causes of accidents have been reduced owing to continuous endeavors based on a safety approach. These endeavors are comprised of improved aircraft design, redundancies, fail-safe system, backup system for malfunction, improved pilot and mechanic training, procedures, and regulations for safety. A prospective Aviation Safety course can be regarded as a safety approach to strengthen safety concepts. A prospective version of a safety course can be referred as a "small safety course" within the "big safety course" which indicates various aviation related courses in an aviation degree program. The objectives of the aviation related courses are different but are based on safety. However, the objective of a prospective Aviation Safety course is, in safety itself, "to develop knowledge of contributing factors affecting aviation safety and fostering control methods and techniques to reduce accidents related to the aircraft and aviation field"

(CMSU, 1999, p. 44). There are two ways to approach aviation safety: one is a microscopic approach focusing on individual safety elements and the other is a macroscopic approach focusing on whole system safety. If each course in aviation curricula can be called a microscopic course, an aviation program should have at least one macroscopic course. An Aviation Safety course can be a macroscopic course which projects the big picture of safety. Daniel Maurino pointed out a problem with the conventional attitude of safety. Conventional methods of aviation safety are called piecemeal (or microscopic by the researcher) approaches focusing on individual factors in aviation fields. Such attitudes made us neglect looking into the big picture of aviation safety, and conveying the notion that abnormal activities within aviation take place in isolation (Maurino, 1997).

We may not be able to address all of the issues and subject areas mentioned in questionnaire items 8 and 9 in a three credit semester course. The reason why so many topic areas were proposed was to get the respondents' perceived importance of each topic area. An Aviation Safety course should be an advanced course based on a macroscopic approach which can integrate or finalize the previous course work into the big picture of safety. The details of an Aviation Safety course based on the result of the study is given in the following recommendation section.

Current textbooks for an Aviation Safety course seldom discuss safety theories or models to provide a means of understanding complex or obscure phenomena of safety. An Aviation Safety course, on the graduate level, is needed to discuss safety models or theories to establish an effective safety program and select appropriate procedures or techniques. Various system safety models have been introduced to describe an incident or accident to a set of events and conditions that account for the outcome. Two major purposes of safety models are to understand past accidents and to learn how to prevent future accidents (Leveson, 1999). Several accident and human error models from system safety perspective were selected for inclusion in Appendix F.

A criticism of some if not many, collegiate aviation education programs seldom reflect recent, real world professional experience in business, industry, or a government agency. The vitality of aviation programs can be maintained by keeping up with current technology by updating systems, theories, and concepts. One of the ways to access the real world aspect of aviation safety is to get information from the professional aviation organizations such as Aerospace Medical Association (ASMA), Flight Safety Foundation (FSF), and the International Society of Air Safety Investigators (ISASI). FSF and the ISASI frequently upload aviation safety related articles, papers, and publications with html or pdf file format to their web sites. Their web sites are http://www.flightsafety.org and http://www.isasi.org respectively.

In conclusion, there may not be a perfect theory or magical word on how to prevent accidents in the human world. However, to enhance safety, we should not neglect critical lessons learned from previous accidents. We can improve accident prevention by reflecting better and corrected input at various levels in the system requiring appropriate feedback. The struggle for safety is an endless, tedious task against a relentless enemy inside and outside of the involved systems.

Recommendations

Based on the findings and conclusions of this study, the following recommendations are made:

1. The Aviation Safety course should be an advanced course based on a macroscopic approach for junior or senior in a Baccalaureate degree program. The course may not be suitable for a 2-year Associate degree program.

2. A graduate level Aviation Safety course should focus on specialized areas such as accident investigation and development of aviation safety program.

3. With respect to instruction, the safety course should focus on:

- Case studies of aircraft accident
- Current trends and issues of aviation safety
- Frameworks of strengthening safety concepts
- Human factors
- The "real world" aspect of aviation safety.

4. With regard to topics and elements, the safety course should include the following areas:

- Aircraft accident investigation process and technology
- Theoretical framework to support aviation safety
- Establishing an aviation safety program that include prevention methodology and risk management
- Ethics in safety including bogus parts
- Flight safety including collision avoidance, controlled flight into terrain, near misses, runway incursions and inflight fires
- Physiological human factors including hypoxia, hyperventilation, spatial disorientation, decompression sickness, motion sickness, vision in flight, and fatigue
- Psychological human factors including CRM, human error, and stress alertness management
- Aviation safety community including FAA, NASA, NTSB, and ICAO

Recommendations for Future Research

1. A comparative study is needed to identify the discrepancies in safety perception between Professional members and Corporate members in the University Aviation Association.

2. An analytical study, concerning the aviation safety programs of aviation industries including airlines and manufacturers, should be conducted for better understanding and updating the information of real world aspects of aviation safety.

3. A survey is needed to identify more normalized safety elements for collegiate aviation programs from three groups including (1) the instructors in academic institutions, (2) aviation safety managers or safety personnel of airlines, aircraft manufacturers, and fixed based operators, and (3) government safety personnel of NTSB and FAA.

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APPENDIXES

APPEXDIX A

COVER LETTER AND QUESTIONNAIRE

OSU OKLAHOMA STATE UNIVERSITY

Department of Aviation Education
300 Cordell North
Stillwater, OK 74078-8034
(405) 744-5856 or 744-7015
lhanyeo@okstate.edu
February 7, 2000

Dear Sir or Madam:

We respectfully request your participation in undertaking a dissertation study titled "*A Study of Aviation Safety Course for Collegiate Aviation Degree Programs*." Your response is extremely important for this study. We need your valuable opinions to determine the current structure of instruction for aviation safety as well as to develop an aviation safety course suitable to college and university aviation programs.

The subjects of the study are 111 Institutional members and more than 200 Professional members of University Aviation Association (UAA). The time to disburse the question and return them to the enclosed envelope should take no more than 15 minutes. It would be appreciated if you could complete the questionnaire by February 26, 2000. The data provided by you and other institutions that offer aviation-related courses will be analyzed. I would welcome any comments that you have concerning any aspect of aviation safety not covered in this instrument. I know that you are very busy, but I would appreciate your input and time. Your participation is voluntary and your response will remain confidential.

A self-addressed envelope is included to return your survey. If you have any questions or comments concerning the questionnaire, please do not hesitate to call or e-mail to me at lhanyeo@okstate.edu. Thank you in advance for your advice and assistance in this endeavor.

Sincerely,

Hanyeong Lee
Doctoral Student

Steven K. Marks, Ed.D.
Professor
Department of Aviation Education

Note:

You understand that participation is voluntary, that there is no penalty for refusal to participate, and that you are free to withdraw your participation in this survey. By completing and submitting this survey, you will be implying that you have read this letter, that you understand what is being asked of you, and that you are participating freely without coercion. If you have any questions concerning consent and participation, you may contact Dr. Steve Marks at phone number (405) 744-7015. You may also contact Sharon Bacher, Executive Secretary of the Institutional Review Board (IRB), 203 Whitehurst, Oklahoma State University, Stillwater, OK 74078: phone number (405) 744-5700.

Bringing Dreams to Life
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OKLAHOMA STATE UNIVERSITY

A STUDY OF AN AVIATION SAFETY COURSE FOR COLLEGIATE AVIATION DEGREE PROGRAMS: CURRICULUM DEVELOPMENT AND RECOMMENDATIONS

Please take a few moments to complete the following survey items.

PART I. SETTING OF SAFETY IN THE CURRICULA

1. Does your aviation program provide formal course work in Aviation Safety? Yes____ No____ (if no, go to #2)

   a. **If yes**, at what level? Freshman____ Sophomore____ Junior____ Senior____

   Other (please describe) ______________________________

   b. **If yes**, how many semester credit hours are awarded? _____ hours

   c. **If yes**, who teaches aviation safety course?

   Certified Flight/Ground Instructor____ Adjunct Faculty____ Faculty____

   Other (please specify)___________________________

2. If your school offers the following courses closely related to Aviation Safety, please check all that apply.

   ____A. Accident Investigation ____B. Accident Prevention ____C. Aircraft Safety

   ____D. Aviation Psychology ____E. Aviation Physiology ____F. CRM

   ____G. Aviation Safety Management ____H. Flight Safety ____I. Human Factors

   ____ J. Other similar Courses (please specify) ______________________________________

Please offer your opinion in setting an Aviation Safety Course for collegiate aviation programs.

3. How do you personally feel about conducting formal instruction in an Aviation Safety course in higher education (undergraduate or graduate levels)? Please **circle** the appropriate numbered response.

   unnecessary necessary absolutely necessary

   1 2 3 4 5 6 7 8 9 10

4. What do you feel is the optimum collegiate level to educate aviation students in an Aviation Safety course?

   Freshman____ Sophomore____ Junior____ Senior____ Other_____________

5. Appropriate credit hours of an Aviation Safety course will be ____ hrs.

6. Whom do you feel would be the best person to provide instruction in Aviation Safety?

Certified Flight/Ground Instructor____ Adjunct Faculty____ Faculty____
Other (please specify)______________________

7. If You are familiar with any of these books, which one would you select for an Aviation Safety course? Please choose ***one book*** or specify ***other choice*** in the blank.

____ A. Air crash Investigation of General Aviation Aircraft (Glenn Ellis: Glenndale Books)
____ B. Aircraft Accident Investigation (Richard Wood & Robert Sweginnis: Wood)
____ C. Aircraft Safety: Accident Investigations, Analyses, & Applications (Shari Stamford Krause)
____ D. Air Travel: How safe is it? (Laurie Taylor: BSP Books)
____ E. Aviation Safety Programs: A Management Handbook (Richard H. Wood: Jeppesen)
____ F. Commercial Aviation Safety (Alexander Wells: Tab Books)
____ G. Flight Safety: A Primer for General Aviation Pilots (Alexander Wells: Tab Books)
____ H. Human Factors in Flight (Frank H Hawkins: Ashgate)
____ I. Human Factors in Aviation (edited by Earl L. Wiener & David C. Nagel: Academic Press)

____ J. Other: ____

PART II. INSTRUCTION

Directions: Please **circle** one of the corresponding numbers that follows each statement. It is very important that you answer every statement; if you cannot provide a response to a statement owing to insufficient information, you are unsure about what the statement means, or it is outside your area of expertise, please circle "**NA**" (Not Applicable).

The following response mechanism will be used in the questions.

1 = Strongly Agree (SA) **2 = Agree (A)** **3 = Neutral (N)**
4 = Disagree (D) **5 = Strongly Disagree (SD)** **6 = Not Applicable (NA)**

8. The characteristics and scope of an Aviation Safety course in an aviation degree program should:

	SA	A	N	D	SD	NA
a. be a flexible course not relying on certain texts or topics.	1	2	3	4	5	6
b. be an advanced course for junior or senior standing in the course works.	1	2	3	4	5	6
c. focus on case studies of aircraft accidents and safety.	1	2	3	4	5	6
d. focus on current trends and issues of aviation safety.	1	2	3	4	5	6
e. focus on developing a sample Aviation Safety program or accident prevention program.	1	2	3	4	5	6

	SA	A	N	D	SD	NA
f. focus on enhancing flight skills/maneuvers and safety operation.	1	2	3	4	5	6
g. focus on frameworks of strengthening safety concepts.	1	2	3	4	5	6
h. focus on Human factors.	1	2	3	4	5	6
i. focus on narrowing gaps between real aviation world and school works.	1	2	3	4	5	6
j. focus on theoretical frame works of safety.	1	2	3	4	5	6
k. have extra laboratory hours or field work.	1	2	3	4	5	6
l. include Experimental Aircraft Safety	1	2	3	4	5	6
m. include Rotorcraft Safety.	1	2	3	4	5	6
n. require prerequisite courses (e.g. Aviation Psychology, or Human Factors).	1	2	3	4	5	6
o. take a macroscopic approach focusing on whole system safety.	1	2	3	4	5	6
p. take a microscopic approach focusing on individual safety elements.	1	2	3	4	5	6

q. Other factors not mentioned in the list (please specify):

Part III. CURRICULA

9. The topics or safety factors that should be discussed in an Aviation Safety course:

	SA	A	N	D	SD	NA
a. Accident investigation process and technology	1	2	3	4	5	6
b. Aircraft performance including takeoff, landing, climb, crosswind components and weight & balance	1	2	3	4	5	6
c. Aviation history in safety perspective	1	2	3	4	5	6
d. Aviation law, FAR, and AIM	1	2	3	4	5	6
e. Aviation security including bomb detection, baggage & passenger screening, and hijacking	1	2	3	4	5	6
f. Aviation theoretical frame work in safety (e.g., SHELL/SHEL model, cognitive theories, behavioral theories, and Reason's system approach)	1	2	3	4	5	6
g. Basic Physics including Aerodynamics	1	2	3	4	5	6
h. Ethics in safety including bogus parts	1	2	3	4	5	6
i. Case studies of catastrophic aircraft accidents	1	2	3	4	5	6

	SA	A	N	D	SD	NA
j. Computer skills including Database, Spreadsheet, and Internet access	1	2	3	4	5	6
k. Establishing an aviation safety program including prevention methodology, and risk management	1	2	3	4	5	6
l. Familiarization of aircraft system including airframe, powerplants, instruments, and avionics.	1	2	3	4	5	6
m. Flight operations including airport facilities, air traffic control, airspace and communication procedures	1	2	3	4	5	6
n. Flight safety including collision avoidance, CFIT, near misses, runway incursions and inflight fires	1	2	3	4	5	6
o. Management of safety data (e.g., data collection & selection, data analysis and statistical analysis)	1	2	3	4	5	6
p. Meteorology and atmospheric phenomena including thunderstorms, microbursts, lightening, windshears, and icing conditions,	1	2	3	4	5	6
q. Physiological human factors including hypoxia, hyperventilation, spatial disorientation, decompression sickness, motion sickness, vision in flight, and fatigue.	1	2	3	4	5	6
r. Psychological human factors including CRM, human errors, and stress alertness management	1	2	3	4	5	6
s. The aviation safety community including FAA, NASA NTSB, IATA, and ICAO	1	2	3	4	5	6

t. Other factors not mentioned in the list (please specify):

10. If you have any comments concerning aviation safety education, especially not covered in the questionnaire, please describe in the space below (attach additional pages if necessary).

THANK YOU FOR YOUR TIME IN COMPLETING THIS QUESTIONNAIRE

APPENDIX B

INSTITUTIONAL REVIEW BOARD APPROVAL FORM

OKLAHOMA STATE UNIVERSITY
INSTITUTIONAL REVIEW BOARD

Date:	February 7, 2000	IRB #:	ED-00-202

Proposal Title: "A STUDY OF AVIATION SAFETY COURSE FOR COLLEGIATE AVIATION DEGREE PROGRAMS: CURRICULUM DEVELOPMENT AND RECOMMENDATIONS"

Principal Investigator(s): Steven Marks
Hanyeong Lee

Reviewed and Processed as: Exempt

Approval Status Recommended by Reviewer(s): Approved

Signature:

Carol Olson, Director of University Research Compliance

February 7, 2000
Date

Approvals are valid for one calendar year, after which time a request for continuation must be submitted. Any modification to the research project approved by the IRB must be submitted for approval with the advisor's signature. The IRB office MUST be notified in writing when a project is complete. Approved projects are subject to monitoring by the IRB. Expedited and exempt projects may be reviewed by the full Institutional Review Board.

APPENDIX C

RESPONDENTS COMMENTS TO QUESTIONNAIRE ITEM 10

Response 1

Regarding Part I.
Question 2: Our flight safety course contains elements of questionnaire item 8a though 8i including meteorology (severe weather, weather observations, etc.), organizations that promote aviation safety (i.e. AOPA, and FSF), security, search and rescue, pilot weather briefing services, and much more.
Question 4: Students should have some experience flying to have a better comprehension of, and appreciation for, the material. At the same time, it's never too soon to get them into safe habits. So, sophomore is about right.
Question 6: Most comprehensive experience is desired. A person with pilot rating or some kind of background in aviation world obviously bring more to the program.
Question 7: I'm familiar with several of the books listed, and chose C for the format and content. (If I was going to write a book on Flight Safety, it probably would have come out just like this one!).

Regarding Part II.
Question 8: Course should be flexible and practical, with a lot of handouts to include brief discussions or questions on the topics. Our course is heavy on audio/visual, "Touch-feely" and demonstration. Numerous guest speakers provide expert information and present the "real world" aspect of flight safety. While reliance on guest speakers is somewhat risky (last minutes cancellation, etc.), being flexible with the material lessens the risk. Speakers are invariably high motivated and add excitement to the course.

A couple of minutes spent before the lesson to review significant headline events from the media lends timeliness and further interest, generating discussion, and often reinforcing material already presented.

I gave low mark to the item 8f because I think practicing/enhancing flight skills is better suited to actual flight operations. However, enhancing safety operation is certainly tied in and important.
For 8j, theory is important and should be covered somewhat, but people are more interested in what really works in the real world. Tie theory in with successful programs like CRM and that should work very fine.

For 8n, prerequisite are pretty desirable. Particularly psychology (anything to do with human factors), meteorology, flight physiology, etc. This world allows getting more deeply into areas like CRM or ADM without belaboring the fundamentals of these areas.

Regarding Part III.
For questionnaire items in 9, all these factors are very important and interrelate. Basic aerodynamics should already be covered in fundamentals previously, but often come up in lectures on wind shear, etc. In which it's inevitable to review. Only a couple of

minutes may be necessary to support the lecture, and a little review is not at all bad. This assumes the class participants are flying students and not a non-flying general audience.

Another way we promote safety in out program at the grass roots flying level is to handout material on AOPA. We have incorporated AOPA's Weather Strategies and Weather Tactics material into our lesson on Pilot Weather Briefing. The lesson on organizations that promote flying safety foundation and other groups. We schedule an actual Wings Program presentation into one of our classes to introduce students to the FAA Accident Prevention Program, and to reduce their apprehensions regarding "the Feds". Our local FSDO specialist does a superb job, and the students get their first positive experience with actual credit toward their first Pin.

Response 2.
Most aviation curricula will include classes like aviation psychology, aviation physiology, weather, propulsions, etc. Aviation safety classes could incorporate some of the theories from these classes for macroscopic view but should remain focused on certain objectives in a microscopically viewed courses. "Micro" classes could include airport safety and security, human factors, and accident investigation. The students can choose what "micro" classes support his/her emphasis the most (i.e. airport, airline, private pilot, etc.).

Response 3.
Different students need different safety topics. The students in pilot training program need to emphasize in-flight safety. The students who major in business administration need to approach safety from a management perspective. Although all topics may be important some would be emphasized for some types of student and not others.

Response 4.
Please understand that community colleges in Associate degree programs have constraints on what courses they can offer. I feel somewhat reluctant to respond to your survey because while safety is an attitude that we emphasize throughout out training. We have no flexibility to offer this one subject area as a standing alone course. Baccalaureate programs may have this flexibility to offer subject.

Response 5.
We need a good textbook for a collegiate level safety course.

Response 6.
Items marked with in the questionnaire are offered in other courses in our Aeronautical Management Technology degree program. Further information is available, at http://eastair.east.asu.edu, including curriculum for both flight and management B.S. degrees and management and Human Factors M.S.T. degrees.

Note: Aviation Physiology (AMT 541) and CRM/LOFT (AMT 546) are both offered as graduate course.

Response 7.
"Aviation safety" is integrated into every aviation courses from the very beginning of the students' program of study. Aviation safety as a philosophy of operation, as well as an operational practice, should be part of the framework for every course in an aviation curriculum. Safety awareness must be centered to everything that an aviation professional does.

Response 8.
At the university level of pilot training for career pilots, I feel that safety is a major concern. Safety education could actually be broken down and advance throughout the training period. Freshman should be introduced to a class including airport safety, flight operations, weather, aircraft performance, etc. Senior or graduate students would get further in depth of safety education including accident investigations and possibly creating safety programs.

Response 9.
My comments may be skewed upward as my students are aerospace technicians, pilots, and air traffic controller. Most are relatively mature: middle management level between 25 to 35 years of age and 10-15 years experience.

Response 10.
Much too broad using the term "Aviation Safety Course" needs to know what kind of aviation safety course.

Response 11.
Aviation safety cannot be covered in one course. You can take one element and focus on it.

Response 12.
9t. What first steps to take if /when designated as the person responsible for an accident prevention program.
In working with Dick Woods and others, over a number of years, we found the paradox where the solo accident investigator/prevention program person is the all-in-one. With more experience, indeed the most experience, that person is now an Investigation In Charge (IIC); a manager! At the height of his or her career, he/she must manage, direct and coordinate a host of specialists ranging from metallurgy, aerodynamics, avionics, public relations, and even politics.

Response 13.
These should be an Aviation or Flight safety course for all aviation students. However, every course from ground schools to air traffic, to airport management to corroborate or airline management should include some aspects of safety. Safety is a whole system subject and needs to be addressed.

Response 14.
We are a two-year Associate degree program in aviation, so our overview course in Aviation Safety is quite basic and introductory. However, a 4-year institution could consider an introductory (but not freshman) course or an advanced course (senior level).

Response 15.
Such courses must be tailored to the "purpose" of the course. Is it theory-based? Is it based on application of theory? It depends on purpose of curriculum: is the program management? Flight? Maintenance?

Response 16.
Aircraft safety should be taught by professionals who have experience in both practical and academic background.

Response 17.
Question 9:
Workers' compensation, OSHA, National Safety Council, DoD safety centers, and NTSB, FAA Training at Oklahoma City.
Question 10:
Airlines are concerned about FOD.
ATA's FOQ1A Program and CSST Program
AIA PSM +I Cr. Study
NASA's AGATE & STAT programs
Some basic on toxicology should be covered too. Also non aviation safety affects the industry too: accident at home, and at play.

Response 18.
Human factors, affecting aviation maintenance, is needed in the maintenance field.

Response 19.
Safety courses should have different content depending on the student's program emphasis. I would approach safety differently for a flight student than an aviation management student or maintenance student.

Response 20.
You are apparently trying to typecast courses. Obviously, a generic catch all courses should include basic items but the exact course contend will vary according to the

expertise of the instructor, department resources and type of students, not to mention their program (e.g., maintenance, administration, flying).

Response 21.
We have only a 2-year community college Associate degree program. Consequently, we do not address these subjects directly. We consider them upper division courses.

Response 22.
Aviation safety should be part of every flight course. We are a 141 and 147 school. Most of our students are enrolled in Associate degree programs. So we believe the safety training-education should be part of every flight and ground school course.

Response 23.
Because so many components incorporate aviation safety, our program has more than one safety course. To fit all the above components in one 3 credit course would be too much!

Response 24.
An Aviation Safety course should be a senior course. The students can use all of the skills and knowledge received from other courses.

Response 25.
I really suggest two-prong approach. Aviation safety followed by aircraft accident investigation. A Strong background or foundation in statistics (especially interpolation), Human Factors, Psychology, and physiology. I also endorse at least a private pilot certificate for each person pursing this education.

Response 26.
Continue to a database relating to significant and life threatening safety issue so that trends may be identified and projected. Collegiate settings are perfect for the research required.

Response 27.
Background and hand-on experience is important.

Response 28.
Dispatch resource management has recently risen to prominence among safety factors being considered by interested parties, and most notably regulatory agencies.

Response 29.
My institution offers a Human Factors course for student at the sophomore level. I offer a safety management course at the Junior level that focuses on program development, cognitive issues in human factors, i.e. human error, judgement, decision-making etc.; aircraft accident analysis utilizes NTSB accident reports.

APPENDIX D

UAA INSTITUTIONAL MEMBERSHIP LIST

1.
Academy Education Center
3050 Metro Drive Ste 200
Minneapolis, MN 55425

2
Aims Community College
P.O. Box 69
Greeley, CO 80632-0069

3
Andrews University, Airpark
Aviation Department
Griggs Road
Berrien Springs, MI 49103

4
Arizona State University
Sim Building Room 205
7442 East Tillman Avenue
Mesa, AZ 85212

5
Auburn University
211 Aerospace Engineering
Auburn University, AL 36849

6
Averett College
420 W. Main Street
Danville, VA 24541

7
Baylor University
P.O. Box 97413
Waco, TX 76798-7413

8
Belleville Area College
2500 Carlyle Ave
Belleville, IL 62221

9
Backhawk Technical College
4618 S. Columbia Drive
Janesville, WI 53546-9120

10
Bowling Green State University
Technology Annex
Bowling Green, OH 43403-0307

11
Bridgewater State College
Dept of Aviation Science
Bridgewater, MA 02325-0002

12
Broward Community College
7200 Pines Boulevard Bld 99
Pembroke Pines, FL 33024

13
Central Missouri State Univ.
Dept. of Power & Transportation
TRG 210
Warrensburg, MO 64093

14
Central Texas College
P.O. Box 1800
Killeen, TX 76540-1800

15
Central Washington University
Flight Technology, 400 E. 8th Ave.
Ellensburg, WA 98926-7515

16
Clayton State College
P.O. Box 285
Morrow, GA 30260-0285

17
College of Aeronautics
La Guardia Airport
Flushing, NY 11371-1000

18
Colorado Northwestern Community College
500 Kennedy Drive
Rangely, CO 81648

19
Community College of Baltimore County
Catonsville, Aviation Program
800 S. Rolling Road
Baltimore, MD 21228

20
Community College of Beaver County
Aviation Science Center
125 Cessna Drive
Beaver Falls, PA 15010-1060

21
Daniel Webster College
20 University Drive
Nashua, NH 03063

22
Davis College
4747 Monroe Street
Toledo, OH 43623-4307

23
Delta State University
P.O. Box 3203
Cleveland, MS 38733

24
Dixie College
225 S. 700 E.
Saint George, UT 84770

25
Dowling College
School of Aviation & Transportation
Idle Hour Boulevard
Oakdale, NY 11769-1999

26
Eastern Kentucky University
Aviation Program
404 Burrier Building, 521 Lancaster Ave
Richmond, KY 40475-3102

27
Eastern Michigan University
122 Sill Hall
Ypsilanti, MI 48197

28
Embry-Riddle Aeronautical University
3200 North Willow Creek Road
Prescott, AZ 86301

29
Embry-Riddle Aeronautical University
600 South Clyde Morris Boulevard
Daytona Beach, FL 32114-3900

30
Fairmont State College
Robert C. Byrd National Aerospace Education Center
1050 E. Benedum Industrial Dr.
Bridgeport, WV 26330

31
Florida Institute of Technology
School of Aeronautics
150 W. University Blvd.
Melbourne, FL 32901-6975

32
Florida Memorial College
15800 NW 42nd Street
Miami, FL 33054

33
Fox Valley Technical College
1825 N. Bluemound Drive
Appleton, WI 54913-2277

34
Gateway Technical College
4940 88 Avenue
Kenosha, WI 53144-9610

35
Georgia State University
Dept of Public Adm & Urban Studies, University Plaza
Atlanta, GA 30303-3088

36
Guilford Technical Community College
GTCC Aviation Center
260 N. Regional Road
Greensboro, NC 27409

37
Hampton University
Department of Aviation
Hampton, VA 23668

38
Henderson State University
HSU Box 7611
Arkadelphia, AR 71999-0001

39
Indian Hills Community College
525 Grandview Avenue
Ottumwa, IA 52501

40
Indiana State University
Aerospace Technology, TC216
Terre Haute, IN 47809

41
Inver Hills Community College
2500 80th Street East
Inver Grove Heights, MN 55076

42
Iowa Lakes Community College
300 18th Street
Estherville, IA 51334-2721

43
Jacksonville University
2800 University Boulevard N
Jacksonville, FL 32211

44
Kansas State University - Salina
2310 Centennial Road
Salina, KS 67401

45
Kent State University
212 A Van Deusen Hall
Kent, OH 44242

46
LeTourneau University
P O Box 7001
Longview, TX 75607-7001

47
Lehigh Carbon Community College
Airport Site, 600 Hayden Circle
Allentown, PA 18103-9323

48
Lenoir Community College
P.O. Box 188
Kinston, NC 28502-0188

49
Lewis University
Route 53
Romeoville, IL 60446

50
Louisiana Tech University
P.O. Box 3181, Tech Station
Ruston, LA 71272-9989

51
Lynn University
3960 Airport Rd
Boca Raton, FL 33431-5598

52
Mercer County Community College
1200 Old Trenton Road
Trenton, NJ 08690

53
Metropolitan State College of Denver
Campus Box 30 P O Box 173362
Denver, CO 80217-3362

54
Metropolitan State University
700 E. 7th St.
Saint Paul, MN 55106-5000

55
Miami-Dade Community College
Aviation Department
500 College Terrace
Homestead, FL 33030

56
Middle Tennessee State University
Box 67 Aerospace Dept
Murfreesboro, TN 37132-0001

57
Minneapolis College - Aviation Center
10100 Flying Cloud Drive
Eden Prairie, MN 55347-4016

58
Minnesota State University-Mankato
P. O. Box 8400, MSU Box 52
Mankato, MN 56001-8400

59
Mountain View College
4849 W. Illinois Avenue
Dallas, TX 75211-6599

60
Naugatuck Valley Community Technical College
750 Chase Parkway
Waterbury, CT 06708

61
Navarro College
3200 West 7th Avenue
Corsicana, TX 75110

62
North Shore Community College
One Ferncroft Road
Danvers, MA 01923

63
Northeast Louisiana University
Aviation Department
700 University Avenue, CNSB 310
Monroe, LA 71209-0590

64
Northern Michigan University
401 Presque Isle Avenue
Marquette, MI 49855-5396

65
Northland Community & Technical College
747 Airport Drive
Thief River Falls, MN 56701

66
Northwestern Michigan College
1701 E. Front St
Traverse City, MI 49686

67
OHIO UNIVERSITY
Aviation Department
O. U. Airport
Athens, OH 45701-2979

68
Oklahoma State University
318 Willard Hall
Stillwater, OK 74074-4045

69
Palo Alto College
1400 W. Villaret Blvd.
San Antonio, TX 78224-2499

70
Parks College of Engineering & Aviation
Saint Louis University
3450 Lindell Boulevard
Saint Louis, MO 63156-0907

71
Pennsylvania College of Technology
One College Avenue
Williamsport, PA 17701

72
Purdue University
Aviation Technology Department
1 Purdue Airport
West Lafayette, IN 47906-3398

73
Rocky Mountain College
1511 Poly Drive
Billings, MT 59102-1996

74
Salt Lake Community College
551 North 2200 West
Salt Lake City, UT 84116

75
San Jacinto College
8060 Spencer Hwy.
Pasadena, TX 77501-2007

76
San Jose State University
Department of Aviation
One Washington Square
San Jose, CA 95192-0081

77
San Juan College
4601 College Blvd
Farmington, NM 87402

78
Schenectady County Community College
78 Washington Avenue
Schenectady, NY 12305

79
Sinclair Community College
444 W. 3rd Street
Dayton, OH 45402-1460

80
South Dakota State University
College of Edu & Counseling, SDSU
Box 507, Wenona Hall
Brookings, SD 57007

81
Southeastern Oklahoma State University
Box 4136, Aerospace
Durant, OK 74701

82
Southern Illinois University - Carbondale
College of Applied Sciences
Carbondale, IL 62901-6623

83
Southern University At Shreveport-Boissier City
3050 Martin L. King, Jr. Drive
Shreveport, LA 71107

84
Spartan School of Aeronautics
8820 East Pine Street
Tulsa, OK 74115

85
St. Cloud State University
HH 216 - SCSU, 720 4th Avenue S.
St. Cloud, MN 56301-4498

86
St. Francis College
180 Remsen Street
Brooklyn Heights, NY 11201

87
State University of New York
2350 Broad Hollow Rd
Farmingdale, NY 11735-1021

88
Tennessee Technology Center, Nashville
7204 Cockrill Bend Road
Nashville, TN 37209

89
Texas State Technical College - Waco
3801 Campus Drive
Waco, TX 76705

90
The Ohio State University
OSU Airport Hangar 5
2160 West Case Road
Columbus, OH 43235-2526

91
Tulsa Community College Tulsa Technology Center
801 East 91st Street
Tulsa, OK 74132

92
University of Alaska - Anchorage
2811 Merrill Field Drive
Anchorage, AK 99501

93
University of Cincinnati - Clermont College
4200 Clermont College Drive
Batavia, OH 45103-9747

94
University of Dubuque
2000 University Avenue
Dubuque, IA 52001

95
University of Illinois - Institute of Aviation
Willard Airport, 1 Airport Road
Savoy, IL 61847

96
University of Maryland Eastern Shore
Engineering and Aviation Sciences
30806 University Blvd., South
Princess Anne, MD 21853-1299

97
University of Nebraska - Kearney
905 West 25th Street
Kearney, NE 68849-4430

98
University of Nebraska - Omaha
6001 Dodge Street
422 Allwine Hall
Omaha, NE 68182-0508

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University of New Haven
300 Orange Avenue
West Haven, CT 06516

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University of North Dakota
Box 9007 University Station
University Avenue & Tulane Drive
Grand Forks, ND 58202-9007

101
University of Oklahoma
Department of Aviation
1700 Lexington
Norman, OK 73069

102
University of Southern California
Continuing Education, School of Eng.
Los Angeles, CA 90089-0021

103
University of the District of Columbia
H-2, Washington National Airport
Washington, DC 20001

104
Utah State University
ITE Department
Logan, UT 84321-6000

105
Utah Valley State College
MS #114
800 W. 1200 South
Orem, UT 84058-5999

106
Western Michigan University
College of Aviation
237 N. Helmer Road
Battle Creek, MI 49015-1682

107
Western Nebraska Community College
371 College Drive
Sidney, NE 69162-9799

108
Western Oklahoma State College
2801 N. Main Street
Altus, OK 73521-1310

109
Wichita State University
NIAR
1845 N. Fairmount
Wichita, KS 67260-0093

110
Wilmington College
320 N DuPont Highway
New Castle, DE 19720-6491

111
Winona State University
P.O. Box 5838
Winona, MN 55987

Note: The population of the study was the University Aviation Association 111 Institutional members and 202 Professional members in the United States. However, Professional membership and the names of Institutional representatives was not posted in the membership list because some members preferred confidentiality. The Institutional membership list was base on November, 1999.

APPENDIX E

FAA AVIATION SYSTEM INDICATORS AND LONG-RANGE AEROSPACE FORECASTS IN THE UNITED STATES

AVIATION SYSTEM INDICATORS

LARGE AIR CARRIER ACCIDENT DATA

Calendar Year	No. of Accidents	No. of Flight Hours	Accident Rate per 100,000 flight hours	No. of Departures	Accident Rate per 100,000 departures
1992	18	12,359,715	0.15	7,880,707	0.23
1993	23	12,706,206	0.18	8,073,173	0.28
1994	23	13,124,315	0.18	8,238,306	0.28
1995	36	13,505,257	0.27	8,457,465	0.43
1996	38	13,746,112	0.28	8,228,810	0.46
1997	49	15,829,408	0.31	10,300,040	0.48
1998	48	16,508,000	0.29	10,318,000	0.47

Data sources: NTSB - Accident data; DOT, FAA - Flight hour and departure data
Note: Many operations formerly conducted under commuter air carrier rules (scheduled Part 135) are conducted under large air carrier rules (Part 121) as of April 1997

COMMUTER AIR CARRIER ACCIDENT DATA

Calendar Year	No. of Accidents	No. of Flight Hours	Accident Rate per 100,000 flight hours	No. of Departures	Accident Rate per 100,000 departures
1992	23	2,335,349	0.98	3,114,932	0.74
1993	16	2,638,347	0.61	3,601,902	0.44
1994	10	2,784,129	0.36	3,581,189	0.28
1995	12	2,627,866	0.46	3,220,262	0.37
1996	11	2,756,755	0.40	3,515,040	0.31
1997	17	982,764	1.73	1,394,528	1.22
1998	8	513,000	1.56	791,206	1.01

Data sources: NTSB - Accident data; DOT, FAA - Flight hour and departure data
Note: Many operations formerly conducted under commuter air carrier rules (scheduled Part 135) are conducted under large air carrier rules (Part 121) as of April

AiR TAXI ACCIDENT DATA

Calendar Year	No. of Accidents	No. of Flight Hours	Accident Rate per 100,000 flight hours
1992	76	1,967,000	3.86
1993	69	1,659,000	4.16
1994	85	1,854,000	4.58
1995	75	1,707,000	4.39
1996	90	2,029,000	4.44
1997	82	2,250,000	3.64
1998	79	2,537,500	3.11

Data sources: NTSB - Accident data; FAA - Flight hour estimates

GENERAL AVIATION ACCIDENT DATA

Calendar Year	No. of Accidents	No. of Flight Hours	Accident Rate per 100,000 flight hours
1992	2,073	24,780,000	8.37
1993	2,039	22,796,000	8.94
1994	1,995	22,235,000	8.97
1995	2,053	24,906,000	8.24
1996	1,907	24,881,000	7.66
1997	1,858	25,473,000	7.29
1998	1,907	26,796,000	7.12

Data sources: NTSB - Accident data; FAA - Flight hour estimates

ROTORCRAFT ACCIDENT DATA

Calendar Year	No. of Accidents	No. of Flight Hours	Accident Rate per 100,000 flight hours
1992	194	2,126,184	9.12
1993	177	1,917,856	9.23
1994	207	1,936,636	10.69
1995	162	2,064,811	7.85
1996	178	2,152,289	8.27
1997	168	2,239,007	7.50
1998	205	2,398,708	8.55

Data sources: NTSB - Accident data; FAA - Flight hour estimates

MIDAIR COLLISION ACCIDENT DATA

Calendar Year	No. of Accidents	Total System Flight Hours	Accident Rate per 100,000 flight hours
1992	13	41,442,064	0.031
1993	13	39,799,553	0.033
1994	12	39,997,444	0.030
1995	15	42,746,123	0.035
1996	19	43,412,867	0.044
1997	15	44,535,172	0.034
1998	15	46,354,500	0.032

Data sources: NTSB - Accident data; DOT, FAA - Flight hour estimates

LARGE AIR CARRIER AIRCRAFT INCIDENT DATA

Calendar Year	No. of Incidents	No. of Flight Hours	Incident Rate per 100,000 flt hours	No. of Departures	Incident Rate per 100,000 departures
1992	503	12,359,715	4.07	7,880,707	6.38
1993	417	12,706,206	3.28	8,073,173	5.17
1994	362	13,124,315	2.76	8,238,306	4.39
1995	352	13,505,257	2.61	8,457,465	4.16
1996	398	13,746,112	2.90	8,228,810	4.84
1997	434	15,829,408	2.74	10,300,040	4.21
1998	Not complete	16,508,000		10,318,000	

Note: Many operations formerly conducted under commuter air carrier rules (scheduled Part 135) are conducted under large air carrier rules (Part 121) as of April

COMMUTER AIR CARRIER AIRCRAFT INCIDENT DATA

Calendar Year	No. of Incidents	No. of Flight Hours	Incident Rate per 100,000 flight hours	No. of Departures	Incident Rate per 100,000 departures
1992	214	2,335,349	9.16	3,114,932	6.87
1993	177	2,638,347	6.71	3,601,902	4.91
1994	127	2,784,129	4.56	3,581,189	3.55
1995	107	2,627,866	4.07	3,220,262	3.32
1996	92	2,756,755	3.34	3,515,040	2.62
1997	21	982,764	2.14	1,394,528	1.51
1998	Not complete	513,000		791,206	

Note: Many operations formerly conducted under commuter air carrier rules (scheduled Part 135) are conducted under large air carrier rules (Part 121) as of April

AIR TAXI AIRCRAFT INCIDENT DATA

Calendar Year	No. of Accident	No. of Flight Hours	Incident Rate per 100,000 flight hrs
1992	148	1,967,000	7.52
1993	150	1,659,000	9.04
1994	184	1,854,000	9.92
1995	201	1,707,000	11.78
1996	164	2,029,000	8.08
1997	151	2,250,000	6.71
1998	Not complete	2,537,500	

Data source: FAA

ROTORCRAFT AIRCRAFT INCIDENT DATA

Calendar Year	No. of Incidents	No. of Flight Hours	Incident Rate per 100,000 flight hrs
1992	86	2,126,184	4.04
1993	99	1,917,856	5.16
1994	80	1,936,636	4.13
1995	124	2,064,811	6.01
1996	73	2,152,289	3.39
1997	73	2,239,007	3.26
1998	Not complete	2,398,708	

Data source: FAA

GENERAL AVIATION AIRCRAFT INCIDENT DATA

Calendar Year	No. of Incidents	No. of Flight Hours	Incident Rate per 100,000 flight hrs
1992	2,308	24,780,000	9.31
1993	2,025	22,796,000	8.88
1994	1,863	22,235,000	8.38
1995	1,824	24,906,000	7.32
1996	1,673	24,881,000	6.72
1997	1,565	25,473,000	6.14
1998	Not complete	26,796,000	

Data source: FAA

NEAR MIDAIR COLLISION (NMAC) DATA

Calendar Year	No. of NMACs
1992	311
1993	254
1994	275
1995	238
1996	194
1997	236
1998	207

Data source: FAA

AIR CARRIER NEAR MIDAIR COLLISION (NMAC) DATA

Calendar Year	No. of NMACs	No. of Flight Hours	NMAC Rate per 100,000 flight hours
1992	127	16,662,064	0.76
1993	109	17,003,553	0.64
1994	142	17,762,444	0.80
1995	112	17,840,123	0.63
1996	88	18,531,867	0.47
1997	127	19,062,172	0.67
1998	99	19,558,500	0.51

Data sources: FAA - NMAC data; DOT, FAA - Flight hour data

PILOT DEVIATION DATA

Calendar Year	No. of Pilot Deviations	Total System Flight Hours	Pilot Deviation Rate per 100,000 flight hours
1992	1,673	41,442,064	4.04
1993	1,451	39,799,553	3.65
1994	1,252	39,997,444	3.13
1995	1,175	42,746,123	2.75
1996	1,275	43,412,867	2.94
1997	1,496	44,535,172	3.36
1998	1,597	46,354,500	3.45

Data sources: FAA - NMAC data; DOT, FAA - Flight hour data

OPERATIONAL ERROR DATA

Calendar Year	No. of Operational Errors	No. of Facility Activities	Operational Error Rate (per 100,000 facility activities)
1992	737	144,167,634	0.51
1993	760	144,427,234	0.53
1994	767	147,019,869	0.52
1995	767	147,497,917	0.52
1996	791	147,916,934	0.53
1997	790	152,800,008	0.52
1998	898	160,570,789	0.56

Data source: FAA

DELAY RATE DATA

Calendar Year	No. of Delays	No. of Facility Activities	Delay Rate per 100,000 facility activities
1992	280,821	144,167,634	194.8
1993	275,759	144,427,234	190.9
1994	247,719	147,019,869	168.5
1995	236,794	147,497,917	160.5
1996	271,509	147,916,934	183.6
1997	245,453	152,800,008	160.6
1998	314,471	160,570,789	195.8

Data source: FAA

DELAYS DUE TO VOLUME DATA

Calendar Year	No. of Delays	No. of Facility Activities	Delay Rate per 100,000 facility activities
1992	76,298	144,167,634	52.9
1993	59,591	144,427,234	41.3
1994	47,744	147,019,869	32.5
1995	43,717	147,497,917	29.6
1996	50,110	147,916,934	33.9
1997	54,419	152,800,008	35.6
1998	44,932	160,570,789	28.0

Data source: FAA

CERTIFICATED AIRMEN DATA

Type of Certificate	Number of Airmen by Calendar Year						
	1992	1993	1994	1995	1996	1997	1998
Private (1)	288,078	283,700	284,236	261,399	254,002	247,602	247,226
Commercial (1)	146,385	143,014	138,728	133,980	129,187	125,300	122,053
Student	114,597	103,583	96,254	101,279	94,947	96,101	97,736
Airline Transport (1)	115,855	117,070	117,434	123,877	127,486	130,858	134,612
Rotorcraft (only)	9,652	9,168	8,719	7,183	6,961	6,801	6,964
Glider (only)	8,205	8,328	8,476	11,234	9,413	9,394	9,402
Lighter-than-Air (2)	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Recreational	187	206	241	232	265	284	305
Pilot Total	**682,959**	**665,069**	**654,088**	**639,184**	**622,261**	**616,340**	**618,298**
Mechanic (3,4)	384,669	401,060	411,071	405,294	329,239	332,254	336,670
Ground Instructor (3)	73,276	76,050	77,789	96,165	68,573	69,366	70,334
Flight Engineer	61,022	60,277	59,467	60,267	61,459	62,544	63,700
Parachute Rigger (3)	8,163	8,417	8,631	11,824	10,269	10,336	10,459
Dispatcher (3)	12,264	12,883	13,410	15,642	13,272	13,967	14,804
Flight Navigator	1,154	1,039	990	916	847	782	712
Repairman (3,4)	N/A	N/A	N/A	61,223	50,768	51,643	52,909
Nonpilot Total (5,6)	**540,548**	**559,726**	**571,358**	**651,331**	**534,427**	**540,892**	**549,588**

Data source: FAA

REGISTERED AIRCRAFT DATA

Calendar Year	Fixed Wing Piston	Fixed Wing Turbojet	Fixed Wing Turboprop	Rotorcraft Piston	Rotorcraft Turbine	Balloon	Glider	Blimp	Total Number of Aircraft
1991	236,028	9,947	7,806	5,976	4,858	6,292	4,542	33	275,482
1992	236,508	10,318	7,999	6,052	4,900	6,553	4,622	33	276,985
1993	237,556	10,695	8,161	6,174	4,970	6,794	4,669	37	279,056
1994	238,506	11,156	8,328	6,224	5,235	6,993	4,808	38	281,288
1995									
1996									
1997	243,036	12,886	8,921	6,643	6,164	7,592	4,951	49	290,242

Data source: FAA
Description: This indicator shows the number of FAA-registered aircraft. ***(Note: These data were not collected by the FAA for 1995 or 1996.)***

LONG-RANGE FORECASTS AVIATION DEMAND AND ACTIVITY

Domestic Passengers ACTUAL — MARCH 1999 FORECAST — LONG-RANGE FORECAST

	1998	2000	2005	2010	2015	2020	2025
Enplanements (In Millions)							
Air Carrier	554.6	581.0	688.6	828.0	978.7	1,129.0	1,271.2
Regional/Commuter	66.1	74.9	97.6	123.8	151.3	180.6	210.4
Aircraft Fleets (In Thousands)							
Air Carrier*	5.2	5.6	6.9	8.4	10.0	11.7	13.4
Regional/Commuter	2.0	2.2	2.6	2.9	3.2	3.5	3.8
General Aviation	194.8	199.3	210.0	220.8	230.9	240.3	248.8
Civil Helicopter**	6.8	6.9	7.2	7.4	7.7	7.9	8.1
Hours Flown (In Millions)							
Air Carrier	13.1	13.6	16.3	19.8	23.7	27.7	31.7
Regional/Commuter	3.7	4.1	5.3	6.6	7.9	9.4	10.8
General Aviation	28.2	29.2	31.7	34.1	36.6	38.8	40.8
Active Pilots (In Thousands)							
Total	618.3	640.4	697.9	735.1	772.6	812.0	849.2
Instrument Rated	300.2	311.4	337.3	354.5	372.6	391.6	409.5
Estimated Civil U.S. Operation (In Millions)							
Commercial	28.6	29.8	33.1	36.6	40.2	43.9	47.6
General Aviation	87.4	88.3	90.5	92.8	95.0	97.2	99.2

* Includes regional jets.

** Included in General Aviation.

Source: FAA Long-Range Aerospace Forecasts Fiscal Years 2015, 2020, AND 2035, June 1999 p. 13.

LONG-RANGE FORECASTS FAA WORKLOAD MEASURES

(In Millions)

	ACTUAL	MARCH 1999 FORECAST			LONG-RANGE FORECAST		
	1998	2000	2005	2010	2015	2020	2025
Tower Operations*							
Total	65.3	67.7	74.4	81.2	88.5	95.7	102.8
Itinerant	47.9	49.7	55.2	60.9	67.0	73.0	78.9
Air Carrier	14.3	15.0	17.3	20.0	22.7	25.4	28.0
Commuter/Air Taxi	10.2	10.6	11.8	13.3	14.9	16.5	18.1
General Aviation	22.1	22.9	24.7	26.3	28.0	29.7	31.4
Military	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Local	17.4	18.0	19.2	20.3	21.5	22.7	23.9
General Aviation	16.0	16.5	17.8	18.9	20.1	21.3	22.5
Military	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Instrument Operations*							
Total	49.9	51.9	57.7	63.9	70.3	76.6	82.9
Air carrier	15.4	16.1	18.7	21.5	24.3	27.1	29.9
Commuter/Air Taxi	11.2	11.6	13.0	14.6	16.4	18.1	19.9
General Aviation	19.9	20.7	22.6	24.4	26.2	28.0	29.7
Military	3.4	3.4	3.4	3.4	3.4	3.4	3.4
ARTCC Aircraft Handled							
Total	43.2	45.2	50.6	56.7	63.1	69.8	76.5
Air Carrier	23.2	24.6	28.2	32.4	36.8	41.4	46.1
Commuter/Air Taxi	7.1	7.5	8.3	9.3	10.4	11.6	12.7
General Aviation	8.6	9.0	9.9	10.8	11.7	12.6	13.5
Military	4.2	4.2	4.2	4.2	4.2	4.2	4.2
FSS Services							
Total	33.9	33.8	33.5	33.2	32.9	32.6	32.1
Pilot Briefs	8.7	8.6	8.4	8.2	8.1	8.0	7.9
Flight Plans Filed	6.5	6.6	6.8	7.0	7.1	7.2	7.2
Aircraft Contacted	3.4	3.3	3.1	2.8	2.5	2.2	1.9
DUATs	12.9	14.2	17.1	20.1	23.0	25.7	28.4

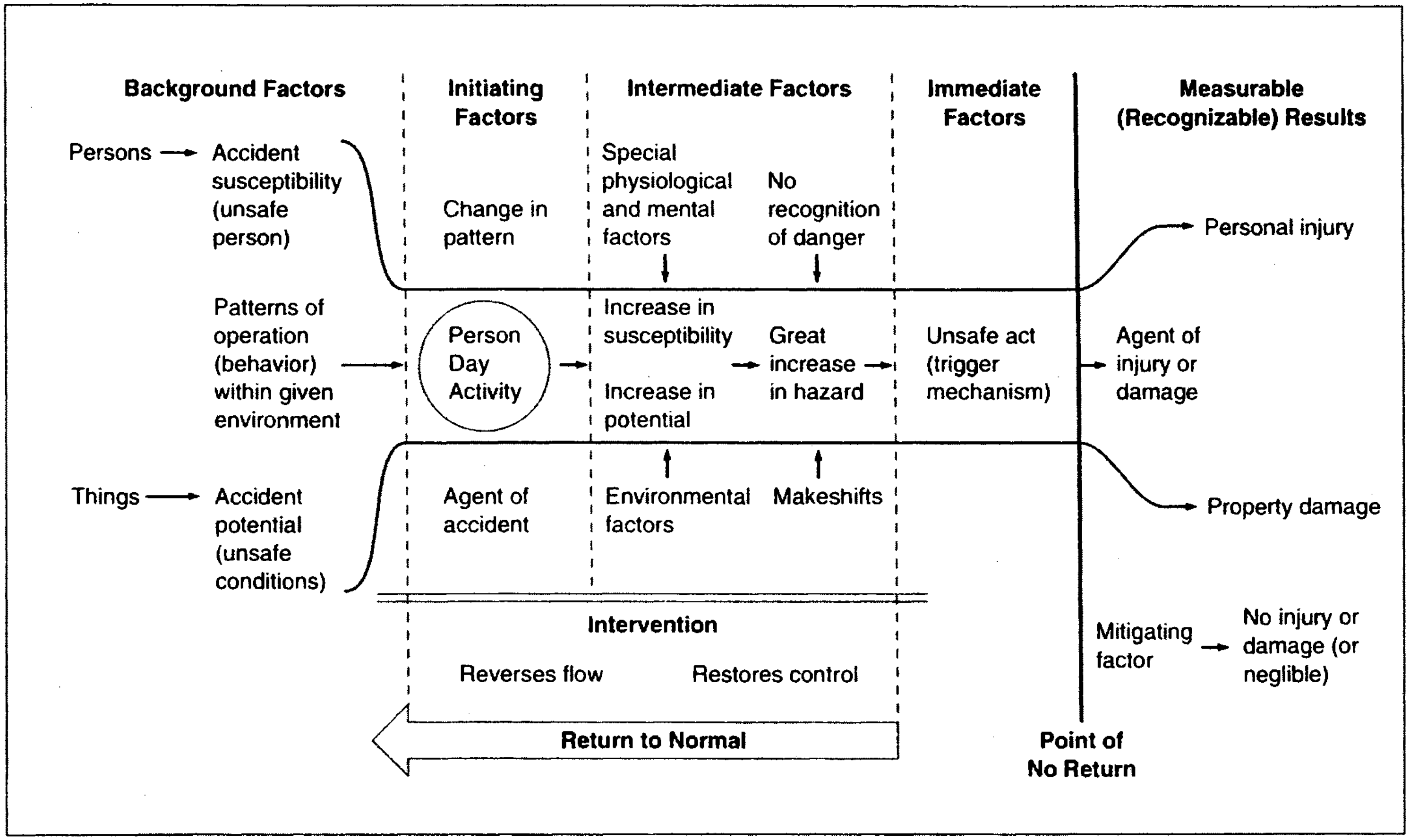
* Includes combined activity at FAA and contract towers.

Note: Totals may not add due to independent rounding.

Source: FAA Long-Range Aerospace Forecasts Fiscal Years 2015, 2020, AND 2035, June 1999 p. 18.

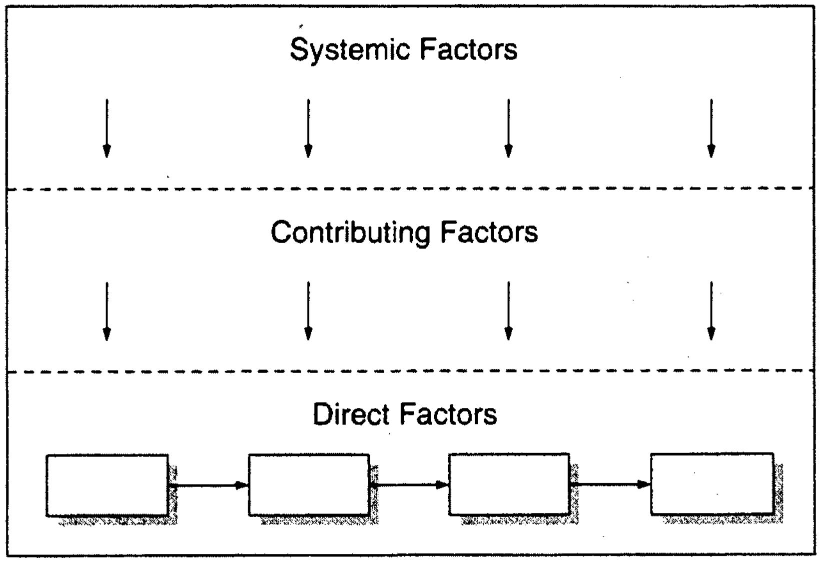
APPENDIX F

ACCIDENT AND HUMAN ERROR MODELS



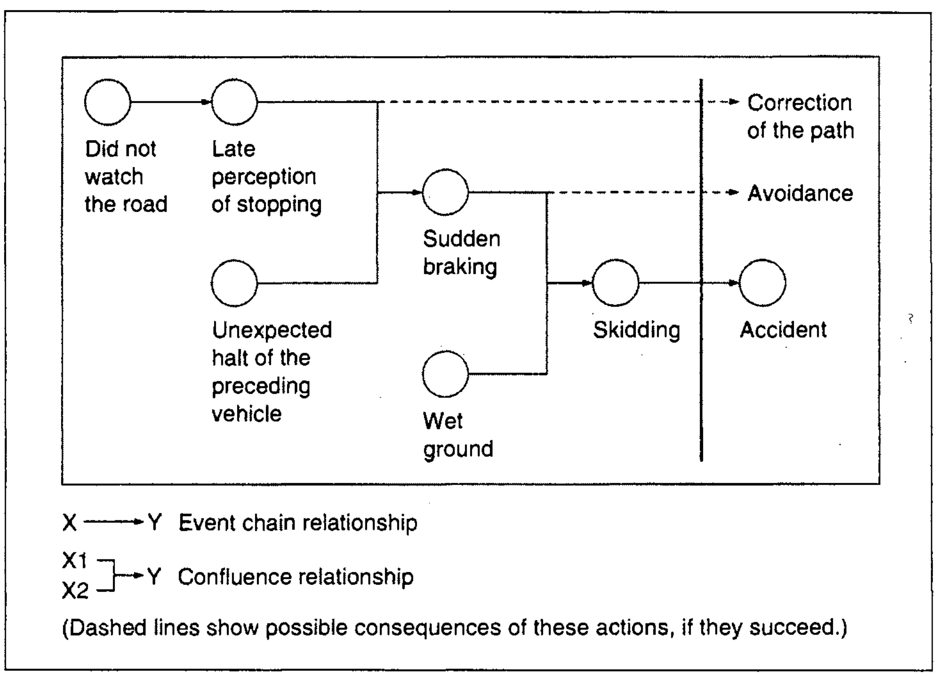
National Safety Council Model of Home Accidents

Source: Adapted from Nancy Leveson, Safeware: System Safety and Computers, p. 191.



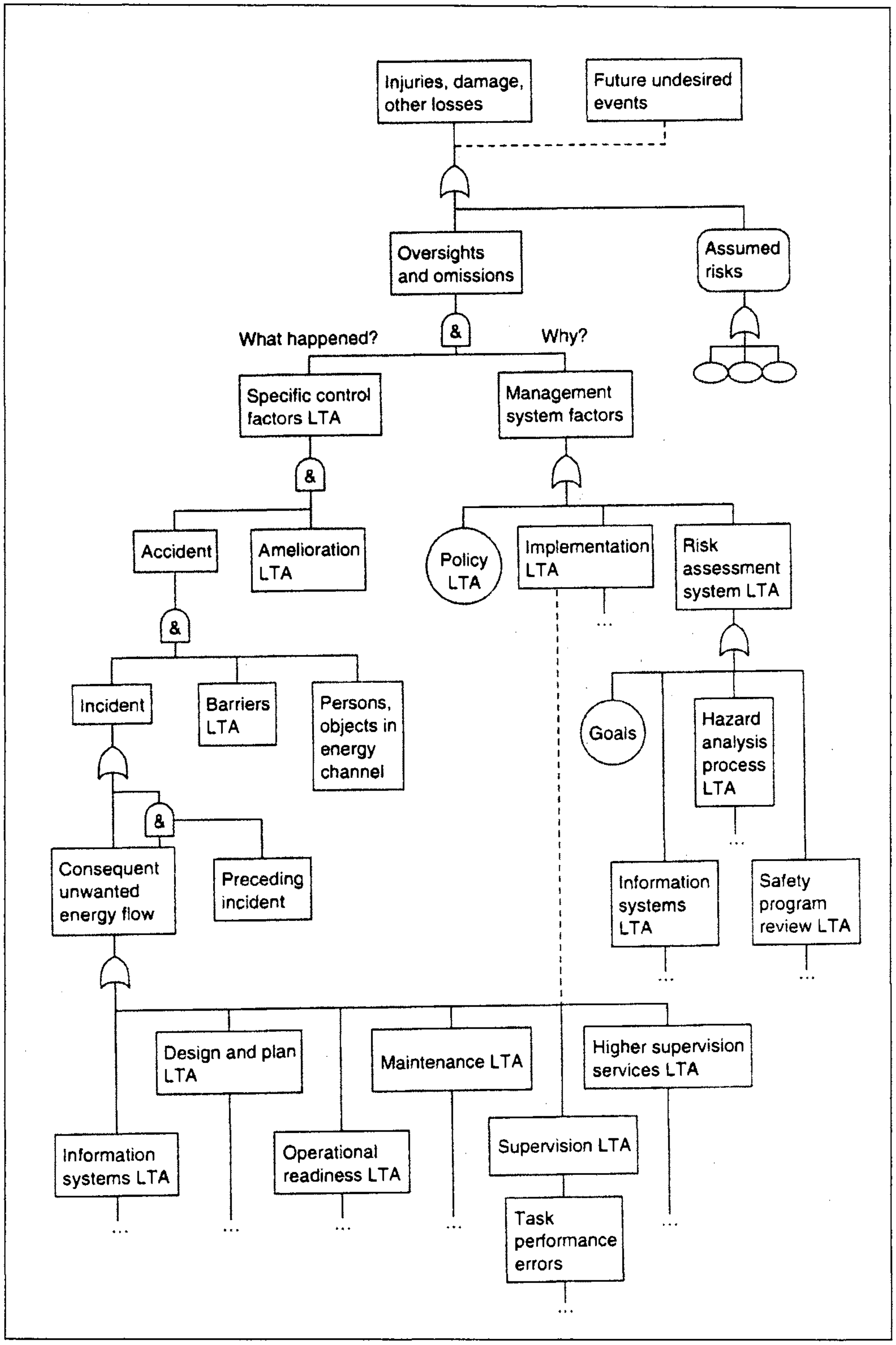
The National Transportation Safety Board Model of Accidents

Source: Adapted from Nancy Leveson, Safeware: System Safety and Computers, p. 199.



An INRS Diagram of an Accident

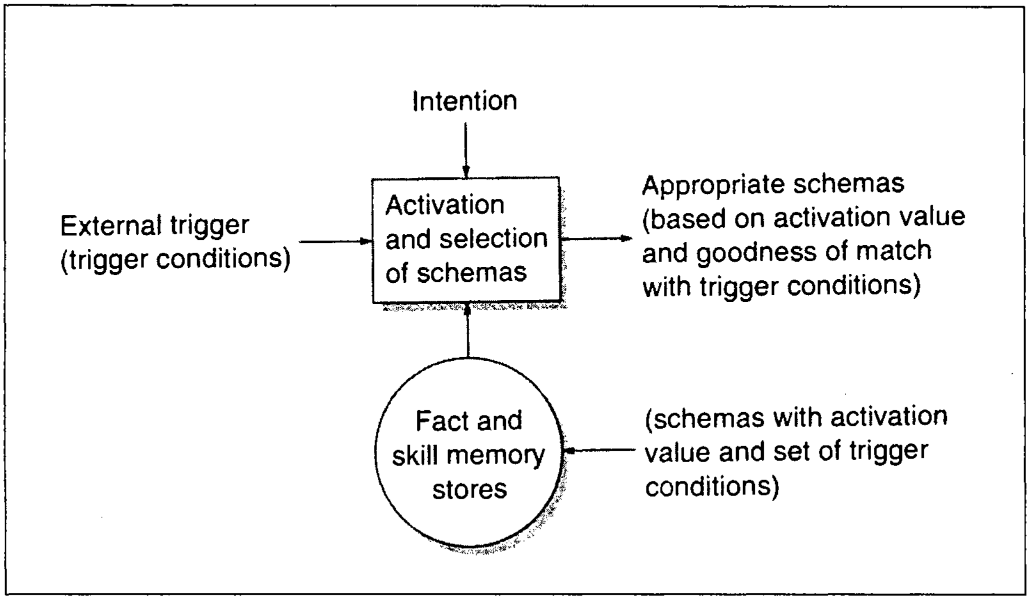
Source: Adapted from Nancy Leveson, Safeware: System Safety and Computers, p. 198.



Management Oversight and Risk Tree (MORT) Model

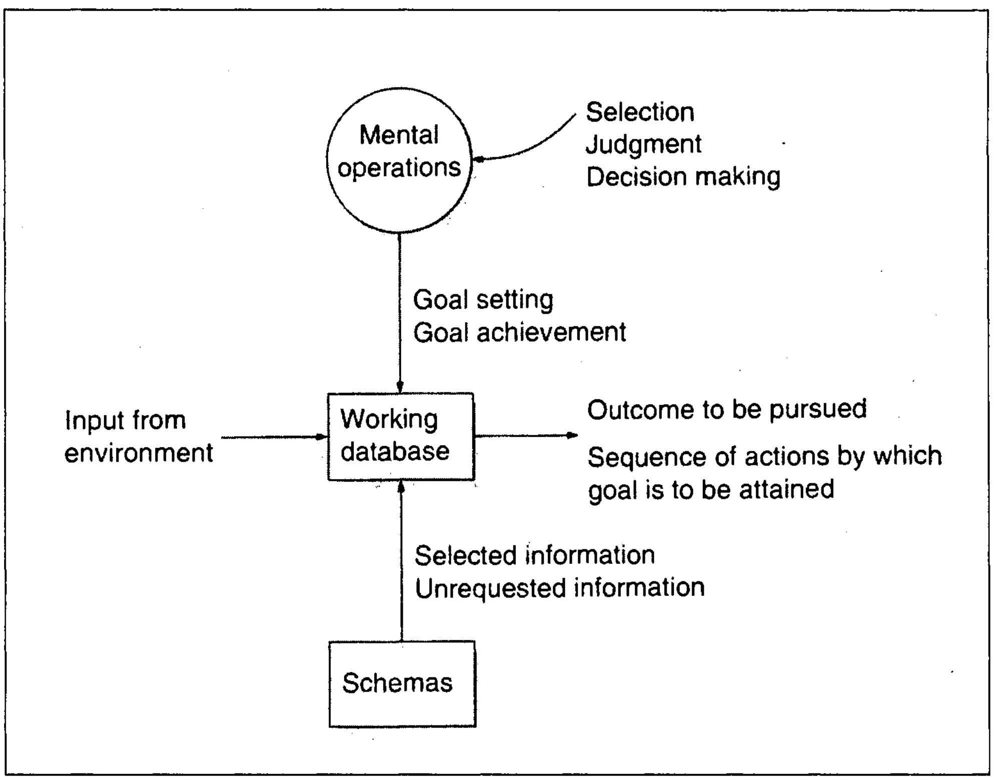
Source: Adapted from Nancy Leveson, Safeware: System Safety and Computers, p. 200.

Note: LTA stands for "less than adequate".



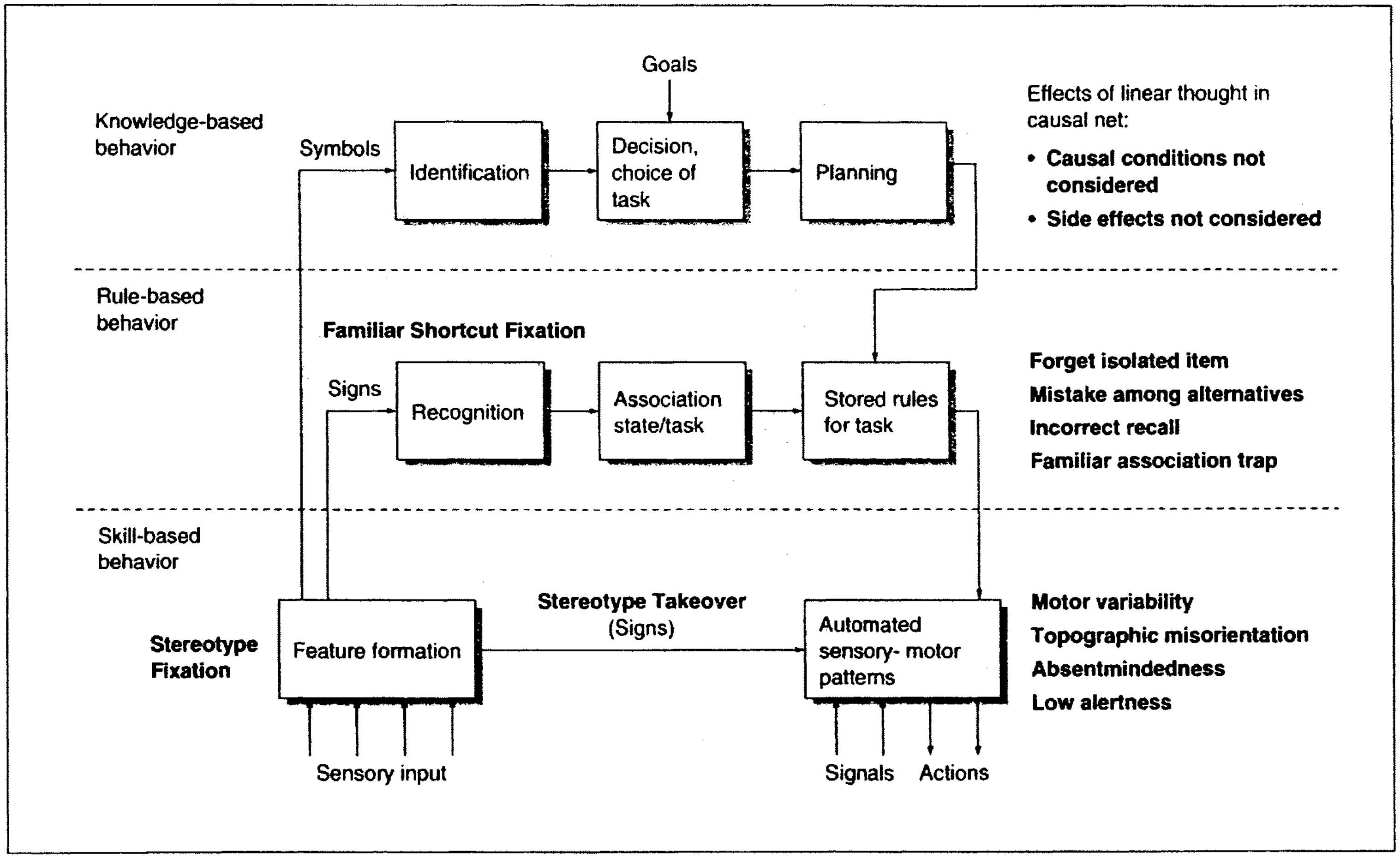
Norman's Activation Trigger Schema Model

Source: Adapted from Nancy Leveson, Safeware: System Safety and Computers, p. 210.



Reason's Basic Model of the Psychological Processes Involved Planning

Source: Adapted from Nancy Leveson, Safeware: System Safety and Computers, p. 214.



Skill-Rule-Knowledge Model and Associated Errors

Source: Adapted from Nancy Leveson, Safeware: System Safety and Computers, p. 220.

VITA

Hanyeong Lee

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Doctor of Education

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