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Aeronautical Decision Making - Cockpit Resource Management

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16. Abstract

Aviation accident data indicate that the majority of aircraft mishaps are due to judgment error. This training manual is part of a project to develop materials and techniques to help improve pilot decision making. Training programs using prototype versions of these materials have demonstrated substantial reductions in pilot error rates. The results of such tests were statistically significant and ranged from approximately 10% to 50% fewer mistakes.

This manual is designed to explain the risks associated with flying activities involving multi-crew aircraft, the underlying behavioral causes of typical accidents, and the effects of stress on pilot decision making. The objective of this material is to enhance interpersonal communication and to facilitate effective leadership and coordination between crewmembers. It provides a sophisticated approach to developing concerted action based on optimal decision making. Several Cockpit Resources Management (CRM) principles are presented in the manual; included are delegation of responsibilities, prioritization, vigilance and monitoring, joint discussion and planning, and receptive leadership techniques.

This manual is one of a series on Aeronautical Decision Making (ADM) prepared for the following pilot audiences:

(1) Student and Private
(2) Instructor
(3) Instrument
(4) Instrument
(5) Helicopter
(6) Multi-crew.

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FOREWORD

This aeronautical decision making training manual for cockpit resource management is the third of three reports in the Professional Pilot Series. The first in this series, Aeronautical Decision Making for Instrument Pilots" contains introductory and other judgment material focused on the instrument pilot. The second report in this series, Aeronautical Decision Making for Commercial Pilots, continues where the instrument manual and focus in particular, on the judgment problem of the commercial pilot. This third manual in this series focuses on aeronautical decision making for multi-person crews referred to as Cockpit Resource Management.

This three-part Professional Pilot Series is the second half of a six part series of manuals on aeronautical decision making which is the result of ten years of research, development, testing, and evaluation of the effectiveness of teaching pilot decision making. The first half, called the "Basic Pilot Series," consists of three training manuals developed for student, instructor, and helicopter pilots.

The material contained in this manual has not been reviewed and tested to the same extent as the previous five ADM manuals of this series. Consequently, it does not reflect the same level of maturity. However, it is an accurate reflection of the crew resource management efforts currently underway. This manual will serve as a useful introduction for some and a review for others. This work has been conducted in parallel with operational reviews by the FAA Office of Flight Standards. We expect that this work will be updated and expanded as new ideas and techniques are developed.

The teaching technique used is to expose the student to flight situations and ask for responses. Feedback about the responses is given to help the student learn to make better decisions. In all cases, situations are taken from real-world incidents or accidents. That is, all scenarios have actually happened to someone in the aviation community. We have used these sources because they are more likely to leave a lasting impression than created stories.

In other literature, the term "pilot error" is often used to describe an accident cause and is an oversimplification, implying that the flight crew intended to have an accident. Pilots intend to fly safely, but they sometimes make decisional errors. Their skill or luck is often sufficient to get them out of situations resulting from poor judgment. The objective of this manual is to teach multi-pilot crew techniques, including interpersonal communication, to avoid situations that require luck or skill greater than their capabilities. Good judgment means avoiding situations that require superior skill to overcome.

The were a number of people and organizations who contributed their material and ideas to this manual. The author wishes to thank Major E.H. Aufderheide, the author of the Air Force manual entitled, Aircrew Coordination Training: A Military Airlift Command Workshop on Human Resource Management in the Aircraft for significant parts used in this manual. The author wishes to express his appreciation to the United Airlines and Captain David Shroyer, formerly with United Airlines, for their generous support of this effort to establish a universal CRM evaluation methodology useful throughout the

industry. The author's participation in the SMI/United CRM Training Course, observation of United recurrency training, volumes of reports and data, and many useful philosophies and insights were approved and/or provided by Captain Shroyer.

The author would like to thank KLM and the Crew Management Course instructors, John Costley, Interaction Trainers, LTD, and Alvin Maan Voogd Bergwerf, MATCH, for the opportunity to participate in their most impressive course. John Costly obtained a great deal of additional information for this manual, including data on communication behavior, from both simulator and flight. The author would like to thank Continental Airlines and the Crew Coordination Concepts instructors, Frank Tullo and Chris Ballin, for the opportunity to participate in their most impressive shorter course. They too provided much additional insight above and beyond the course material itself. The author would like to thank Bob Mudge for spending time explaining his Cockpit Management Course as well as providing all of the latest material on the course. The author would also like to express my thanks to SimuFlite Training, Inc. for spending a day with me describing their training facility and training philosophy.

The author would like to thank the following additional people and organizations for providing material useful to this investigation:

Trans Australia Airlines	People Express
Qantas Airlines	USAir
Braniff Airlines	World Airways
The Evans Group	U.S. Air Force
Flight Safety International	U.S. Army

Finally, the author wishes to thank the following sources for scenarios, in part, because, until now, they have been responsible for most of our pilot judgment training:

"I Learned about Flying from that," Flying
"Aftermath," Flying
"Never Again," AOPA Pilot
"Callback," ASRS
"Pilot's Logbook," Private Pilot
Approach, U.S. Navy
"Grampaw Petibone," Naval Aviation News
Flying Safety, U.S. Air Force
"A Flight I'll Never Forget," Plane and Pilot
"Selection of Judgment Incidents," ASRS
Pilot Error, Editors of Flying
"Arm Chair Aviator"
Weather Flying, Robert Buck
Illusions, Richard Bach
"The Bush Pilot Syndrome, " Michael Mitchell
Various Accident Report Briefs, NTSB
OSU Pilot Judgment Survey

Richard S. Jensen

TABLE OF CONTENTS

Page

TABLE OF FIGURES

Chapter 1: BACKGROUND FOR CRM TRAINING

"In the past year and a half, an alarming number of safety investigation boards have concluded crew error was causal. Equally alarming is the realization that often the information missing from the critical, often final, decision was available to the crew. In some cases at least one crew member had the answer. While mishaps are always tragic, those in which the resources to prevent catastrophe were available and either unrecognized, unused, or simply not offered represent an especially intolerable category."

--- MAC Flyer ---

It has become a cliche in the aviation industry to state that the role and primary task of the flight crew is being changed by modern technology. Formerly, the primary task of the flight crew was navigation and manual manipulation of the controls. In modern airplanes, much of the actual navigation and control manipulation can and is being "down-loaded" to the on-board computer. The task of managing and supervising the flight deck and all of the resources available, that the crew always had, is becoming their primary task. This management task is being called, Cockpit Resource Management (CRM).

CRM means the effective use of all resources (hardware, software, and liveware) to achieve safe and efficient flight operations. Most flight crews operate this way today - the result is the safest aviation system in the history of flying. Experience, crew coordination training and Line Oriented Flight Training (LOFT) have been the major sources of CRM training to date. Specific training in cockpit management is a fairly new phenomenon. It has been brought to the forefront in the airline industry in recent years as a result of the large percentage of accidents resulting from the failure of the crew to properly manage the flight deck.

Technical competence, the cornerstone of effective crew performance, is assumed in CRM training. In addition to its obvious links to ability, training, and technical performance, technical competence may have indirect links to resource management. For example, a less technically competent crewmember may be highly defensive in order to preserve a competent self-image. This may result in the crewmember maintaining unrealistic and self-deceptive attitudes of personal competence, resistance to stress, and lack of need for support from other crewmembers. This person may project an air of all-knowing confidence and independence when, in fact, the opposite is true. Such behavior may have a highly adverse effect on CRM.

CRM is an extension of aeronautical decision making (ADM) concepts to the multi-person flight crew. Conceptually, CRM is the addition of the multi-person flight crew (with the additional focus on communication) to the decision training and evaluation being offered to the single-person cockpit elsewhere described as ADM. From a historical perspective, the development of CRM concepts as seen in the kickoff workshop held at the NASA Ames Research Center (Cooper, White, and Lauber, 1979) followed the initial report on pilot judgment (Jensen and Benel, 1977).

CRM development owes a great debt to the classic study by H.P. Ruffell-Smith (1979) in which a full mission simulation of a civil air transport scenario was conducted. This study was the first to show how crew coordination problems can result in poor decision making and performance. It was a strong motivator for CRM training and is often cited in the CRM literature.

Although personality is known to effect crew performance this is not a course to change personality. The course is designed to address behavior as a product of knowledge and thought process, personality, attitude, and background. We cannot change personality in a course such as this. However, we can teach ways to think clearly in decision making and we can have an impact on attitudes, interpersonal communications, leadership, and reactions to stress. These factors may result in more flexible behavioral strategies and more coordinated behavior in critical situations when maximum effectiveness is a Life or Death issue.

Finally, consider the term "pilot error" for a moment. This term, which has often been used to describe an accident cause, is an oversimplification, implying that the pilot somehow intended to have an accident. Pilots intend to fly safely, but they sometimes make decisional errors. Their skill or luck is often sufficient to get them out of situations resulting from poor judgment. One of the most important aspects of CRM training is to learn to recognize and persuade the other crewmembers to avoid situations that require luck or skill greater than one's capabilities.

CRM Training seeks to build upon the foundation of conventional flight training and experience to reduce the probability of pilot error. A structured approach is offered for your use when changes occur during a flight. This structured approach addresses all aspects of decision making in the cockpit and identifies the elements involved in good decision making. The objectives of this approach to training include:

1) Learning how to structure one's thoughts in making decisions.
2) Identifying personal attitudes that are hazardous to safe flight.
3) Learning how to recognize and cope with stress.
4) Developing risk assessment skills.
5) Learning to consider all resources available.
6) Learning to how evaluate your flight and decision making skills.

Recent CRM Related Accidents

Over the last few years, there has been an alarming number of airline accidents in which faulty CRM has been cited as a factor. Lauber (1979) identifies more than 60 such accidents between 1968 and 1976. Statistics have shown that over half of the accidents in the airline industry were the result of a faulty application of CRM. Beginning in 1972, nine accidents have been prime motivators for the development of CRM training programs. These accidents have also been the source of case study material in many of these programs. These 10 accidents were:

Eastern, L-1011, Miami, 1972
TWA, B-727, Washington Dulles, 1974

Pan American and KLM, both B-747s, at Tenerife, 1977
United, B-727, Salt Lake, 1977
United, DC-8, Portland, 1978
Saudi Arabian Airlines, B-747, Jedda, 1978
Western Airlines, DC-10, Mexico City, 1979
Danair, B-727, Tenerife, 1980
Air Florida, B-737, Washington National, 1982
National, B-727, Escambia Bay, 1978

In each of these accidents the captain failed to make effective decisions because he, or his crew, did not use effective CRM practices which are taught in this manual. Because we can learn so much from them, each of these accidents will be covered in detail elsewhere in this manual.

It has been well established that some form of CRM training is needed and airlines that have established such programs are to be applauded because they have taken action, beyond that required, to improve safety. However, there are many other major and minor airlines who have not yet begun such training in any formal way. Most corporate and air taxi operators do not have such training. It is further suggested that CRM should be offered, as a part of judgment training, from the beginning of a pilot's career.

Objectives of CRM Training

As indicated above, the ultimate objective of CRM training is accurate, effective aeronautical decision making. One of the most important keys to good cockpit management, as in any management position, is communication among crew members. Information must be requested, offered, and/or given freely in a timely way to permit the captain to make accurate, effective decisions. It also requires an understanding of communication styles used by other members of the crew for interpretation and to determine the proper emphasis for a response. Finally, it requires an understanding and acceptance of the unique role and leadership responsibility of each member of the crew. Therefore, the primary emphasis in CRM training is in interpersonal communications.

The basis for any training course is the achievement of desired behavioral objectives within the trainees. In CRM training there are five basic objectives that are common to all courses: Developing Effective Interpersonal Communication Styles, Developing Leadership/Followership, Developing Decision Making Skills, Developing a "Team" Concept, and Dealing with Stress.

Chapter 2: BASIC CRM CONCEPTS

Decision Making

Decision making (or judgment) is the term used to describe all of the mental processes that we use in determining the courses of action that we take. Many pilots believe that good judgment is a natural process that is attained through experience. At the same time, they are generally convinced that if you don't have enough of the former, you will not live long enough to gain the latter. This classic "chicken-or-the-egg" syndrome can be overcome with the realization that good decision making skills, like any other skill required in flying airplanes, can be learned through a systematic training program more quickly, and certainly, more safely than through the time-honored "trial-and-error" method.

It is the objective of this manual to show you how aeronautical decision making skills can be improved in multi-person aircraft flight crews. Thus, all aspects of the course are developed for the purpose of enhancing decision making. Human factors such as management attitudes, leadership skills, knowledge, stress, and outside forces are identified, modified, and/or used where appropriate to improve flight crew decision making.

Personality versus Attitude

There are many factors known to affect aeronautical decision making. Among these are personality and attitudes. The term "personality" refers to relatively enduring characteristics of the individual acquired during development. These characteristics are quite resistant to change and are modifiable only through the considerable efforts of psychotherapy. We can be quite sure that personality factors can influence a person's management capabilities. However, because of the nature of personality traits, it would be futile to attempt to change them in pilot training and no such suggestion is made in this CRM training manual. Furthermore, most aviation psychologists believe that personality traits are important only in the most extreme cases and can be handled through selection of pilots.

On the other hand, attitudes are less deeply internalized components of the individual and are subject to change fairly easily. Attitudes are constantly bombarded by forces in our society such as advertisers, salesmen, teachers, politicians, and preachers attempting to change them. In the cockpit, management attitudes as well as attitudes toward risk taking and performance of all other aspects of the flying task can be modified through training. Therefore, a major thrust of CRM training is to improve the attitudes of the pilot so as to bring about better decision making.

Relationship versus Task

Two aspects of attitudes that are very important to CRM are concerns for relationships with others and completing the task at hand. Virtually all CRM courses use as their basis some form of relationship versus task model. Three forms of this model used in other CRM courses are the Management Grid offered by United (Blake and Mouton, 1964), the Leadership Effectiveness and

Adaptability Description (LEAD) model offered by KLM (Hersey and Blanchard, 1977), and the Behavioral Dimensions offered by Continental.

The relationship versus task model is usually presented as a matrix with one side representing the "Relationship" orientation and the other side representing the "Task" orientation. According to this model, one's behavioral orientation, including communication style, can be described by these two independent dimensions. People who are high on relationship orientation tend to consider the feelings of others first believing that the task can be best accomplished when everyone gets along well with each other. On the other hand, those who are high on task orientation tend to consider the accomplishment of the task more important than relationships and would act to get the job done whatever the cost to relationships. The ideal orientation for flight crews in most flight situations is a strong combination of both. More about that later.

Communication

Because it is the means by which cockpit resources are managed, the central focus of CRM training is cockpit communication. All courses provide some means of determining individual communication style. Most also provide training concerning the identification of the communication style of others. Some advocate a communication style, others leave it up to the individual to determine the communication style that works best for him or her. Some courses also advocate and teach listening techniques.

There are five important aspects to communication to which pilots should be proficient to be good resource managers and decision makers: Inquiry, Advocacy, Listening, Conflict Resolution, and Critique. Each of these elements will be covered in detail later in this manual.

Leadership

An essential part of the content of the CRM training program is leadership training. Each member of the crew must recognize that he or she has a leadership responsibility that is important to effective decision making. An often overlooked aspect of leadership training is the recognition of importance of the "followers" in management and decision making. Followers not only have an important leadership role in making decisions but their "maturity" is an important factor in adapting one's communication style.

The "Team" Concept

The cockpit crew is a team and must work together helping each other to do the best job possible for the team rather than working separately as individuals. An effective method for demonstrating and teaching team performance is through small group attempts to achieve "synergy" in problem solving. Synergy in CRM training means that the team performance is better than the best individual performance within the group. It is demonstrated by first giving each individual a test on some problem. Then small groups are assembled and instructed to establish "group" answers to the problems. The correct solutions are then given to everyone. The superiority of group answers over the best individual within the group is a measure of synergism or team work. This method is particularly effective in convincing the skeptical pilot of the importance of teamwork and communication.

Team training, as opposed to individual training, is the key to any good CRM course. The content of team training material must include the essentials of working together to accomplish a team effort. This is somewhat difficult to accomplish in aviation because most evaluations (flight checks) are made on an individual basis. This strong emphasis on individual performance tends may, at times be detrimental to contributions to the team effort. When accidents occur the crew is evaluated as a team - they go down together, most likely with the same fate. Sadly, this is the only consistent team performance evaluation being used today.

Dealing with Stress

One of the most significant and universal results of stress is a reduction in verbal communication. Thus, learning to deal effectively with the stress is another important aspect of CRM training.

Stress is the term used to define the body's response to the demands placed upon it by physical, physiological, and/or psychological forces known as stressors. For example, stress could be imposed by an unexpected windshear encountered during an approach, recognizing low oil pressure during engine run up, losing your wallet, or cutting your finger. Stressors such as these that related to the flight itself are known as acute, or flight related, stressors.. Other stressors resulting from life events are known as chronic, or non-flight related stressors. Examples of chronic stressors are financial commitments, job pressures, or family troubles. Learning to recognize and cope with both types of stress in ourselves and our fellow crew members is important to making good decisions.

Chapter 3: CRM TRAINING METHOD

This chapter is offered for instructors of CRM courses and is not necessarily needed by the student. It is offered because, although CRM can be taught largely in a classroom, such training requires a highly interactive approach which is different than many conventional courses. It cannot be taught effectively either with a manual such as this alone or through the conventional lecture technique. The objective of this chapter is to give some ideas concerning the techniques that have proven effective in teaching CRM.

The recommendations for CRM training offered here were discovered through a matching of the objectives of various CRM courses with the approaches that seemed to best meet those objectives in the most economical way. Suggestions are made concerning the length of the course, teaching methodology, the follow-up to the course, and evaluations of CRM training effectiveness.

Course Length

The 15 courses examined in preparation for this manual offer a wide variety of approaches to CRM training. They vary in length from five full days (08:00-22:00) down to as little as two hours. It appears that the basic CRM course could be completed in about two and one-half days running from 08:00 to 22:00.

Teaching Methods

There are many different teaching methods used in CRM courses. It is suggested that certain of these methods are uniquely essential to the communication and team training aspects of CRM. Among these essential methods are interactive discussion or role playing with feedback and small group discussion to demonstrate synergism within the group, and case studies. A certain amount of preparatory studying prior to attending the CRM course is essential and materials should be written for that exercise.

Small group discussions are necessary to bring about a significant amount of contribution from all members of the class. Communication styles are practiced and feedback from group members or observers can be very instructive and motivating. This method is particularly useful if reports of conclusions are made to the class as a whole. The accident reports provided with this manual, Appendices A - E, are a good source of material to assign for small group discussion. For example, a group could be asked to search for the use of certain communication styles by the crews involved and to determine the effectiveness of those styles.

Preliminary Studying. To accomplish the CRM course objectives a considerable amount of preliminary study material should be provided participants prior to attending the course. A minimum of 10 hours of preliminary individual study is recommended. Furthermore, participants must be required to prepare themselves with this material as measured by written tests prior to attendance in the course.

The content of the study material should include accident information as motivators, the basic concepts of CRM, self-assessment tests, and material on what is expected of the individual in his or her participation in the course. Much of the material in this manual would be useful for preliminary study.

Preliminary study material should be written so as to motivate experienced flight crews to study them. Ideally, the results of that study should be used in the classroom later.

Role Playing. A very effective method of teaching the identification of communication style is through role playing. This method is used in most courses but it is most effective when the role playing exercises are video taped for play back to the small group as well as the class as a whole. For communication training the response is often the same as reported during video taped LOFT (Line-Oriented Flight Training) exercises, namely, "Do I sound like that?" Students who put forth the effort in such exercises report a great and lasting benefit.

Case Studies. Cases studies can be conducted effectively by individuals and small groups, provided both report their findings to the class as a whole. They can also be used effectively, by a good teacher as illustrations during a lecture. Most CRM courses use a certain amount of case studies. The accident reports provided in Appendices A - E are case studies that can be used in whole or in pa[illegible] teach most aspects of CRM.

Video Tape. The p[illegible]ntation of video tapes of CRM accident simulations is a very effective instructional strategy. Tapes are available of the Eastern L-1011 accident in the Everglades, the Saudi Arabian accident in Jedda, and other accident simulations. Students should be asked to respond either individually to the tapes with questionnaires concerning CRM concepts or in small groups to discuss failures of the crew and ways to improve the CRM performance.

Slide-Tape. A less expensive, though effective audio visual technique is to use audio tapes of cockpit voice recorded final conversations of the flight crew of the CRM accidents augmented with slides of the cockpit and other aspects of the flight crew's environment. One such presentation has been made of the United DC-8 accident near Salt Lake City. As suggested above, students should be asked to respond either interactively, through questionnaires, or in small group discussions based on the CRM principles being advanced.

Lecture. Because many CRM concepts are new to pilots, an effective, consistent introduction of the concepts is best achieved through the use of good lecturing with appropriate visual aid materials. Although some fairly effective current CRM courses avoid lectures, their students may lack consistent knowledge and behavioral change because they do not really know the basic concepts very well. Lecture/discussion delivered in an interesting way for the purpose of introducing the concepts is very important to CRM training.

Follow-up

Because of the nature of the material being taught, i.e., attitudes, mental processing, and communication, there is a tendency to forget and/or revert back to one's original style very quickly. Therefore, CRM must be refreshed frequently throughout the pilot's career. Furthermore, to assure a behavioral change it is recommended that the refreshment of the behavior be conducted in LOFT training during recurrency annually. Such training must include the consistent use of CRM concepts taught in the course during the discussion prior to the LOFT as well as during debriefing following the LOFT. Finally, because of its known impact on behavior, the LOFT session should be video taped and played back to the crew during the debriefing. The debriefing should be structured so as to bring out all important aspects of the CRM and the use of CRM in the LOFT session.

CRM Course Outline

The following outline is offered as an example for a two and one-half day course in CRM. The course runs from 0800 through 2200 on the first two days and 0800 through 1200 on the third. The course should be taught by two instructors working together. It is further suggested that one of the instructors should be a line captain from the organization.

Much of the background information for the lectures is presented in this manual. However, it is expected that the manual will be augmented with other information from the instructors. Other material needed include videos of the Portland and Everglades accident simulations as well as the Caribbean Survival Exercise and the Strength Deployment Inventory. It is expected that this course would be modified to fit the particular needs of the organization using it.

Day 1

0800 Arrangements

Put participants at tables in groups of five or six

0800 Introductions

Instructors
Students

0815 Lecture 1

CRM related accident data
CRM concepts and definitions
Behavioral Dimensions

0900 Introduce video of Portland Accident simulation

Show video tape of Portland accident simulation

0945 Small group discussion with Appendix A of this manual

Portland accident
Identify communication styles of each member of crew
How did communication styles contribute to accident?

1000 Report of small group discussion

1030 Break

1045 Lecture 2

Communication styles
Verbal behavioral categories
Listening

1115 Small group discussion

Communication styles exhibited by crew prior to Washington National/14th Street Bridge accident (Appendix B)

1200 Lunch break

1300 Lecture 3

Relationship versus Task
Personal Characteristics Inventory

1500 Coffee Break

1515 Lecture 4

Theory of the Situation
Video simulation of Everglades accident

1545 Small group Discussion of Everglades accident (Appendix C)

Topic: Theories of the situation of Everglades accident crewmembers

1630 Reports of small group discussion

1800 Dinner

1930 Lecture 5

Developing the team concept
Synergism

2000 Small group exercise: Caribbean Survival Exercise

Day 2

0800 Lecture 6

Decision Making
DECIDE model
Attitudes

Small group discussion of Salt Lake City accident (Appendix D)

DECIDE model

Small group report

1030 Coffee break

Lecture 7

The Pilot Attitude Inventory
Hazardous attitudes
Poor judgment chain

1200 Lunch

1300 Lecture 8

Leadership/followership

1330 Small group discussion

Delegation exercise

1500 Coffee break

1800 Dinner

1930 Lecture 9

Introduce role playing exercise
Have participants develop a scenario from the flight deck

2000 Small group role play on video

2030 Small group report - viewing of video and critique

Day 3

0800 Lecture 10

Strength Deployment Inventory
Stress

1000 Coffee Break

Lecture 11

Evaluation
Summary
Action

1200 CRM Seminar concluded

Chapter 4: DECISION MAKING

The bottom line of the CRM training effort is better crew decision making. One of the major problems identified in airline accidents involving CRM has been that the captain "goes solo" in making decisions during an unusual situation.

A model representing a continuum of management decision processes is offered by Tannenbaum and Schmidt (1975). As shown in Figure 1, this concept deals with the decision making process used by various types of managers on a continuum from authoritarian (on the left) to democratic (on the right) corresponding to task oriented and relationship oriented management, respectively. This figure shows how the relationship between manager and subordinate changes as the manager's style moves from authoritarian to democratic. In most cases in the cockpit, best crew performance results from the mid-range of this scale. However, one must recognize that there may be times when either extreme may be needed.

MANAGEMENT DECISION STYLE SCALE

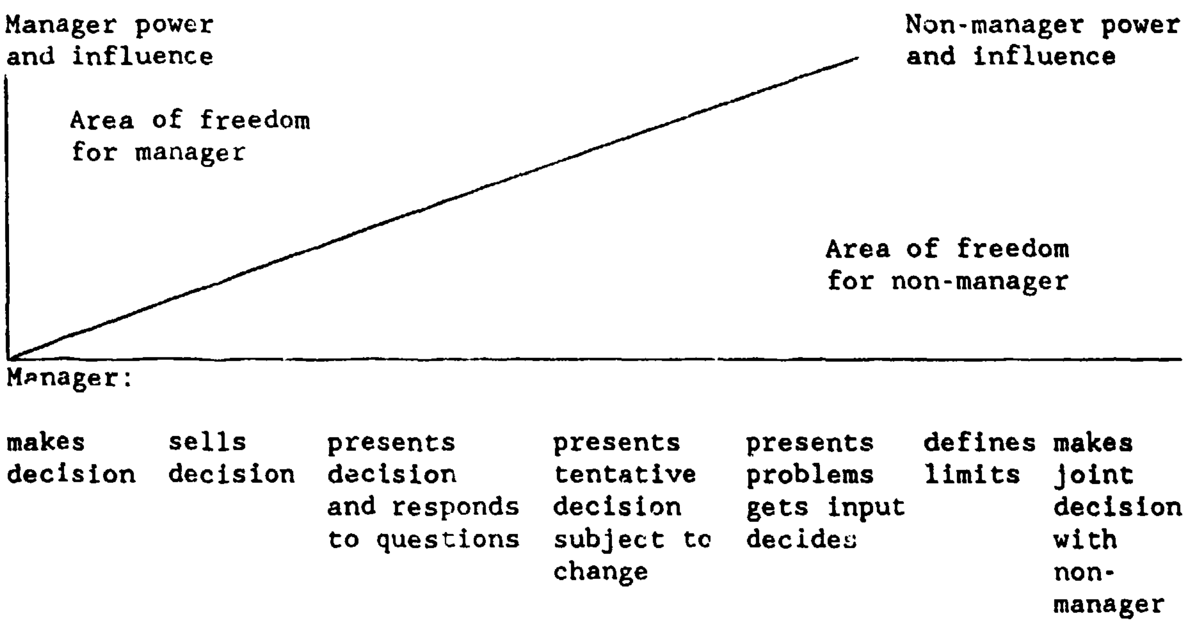

Figure 1. Range of Options for Managers and Non-Managers (Tannenbaum and Schmidt, 1975).

<u>ADM Definition</u>

Aeronautical decision making or pilot judgment is the mental process used by the pilot in the development of a decision in which the relevant information available and/or the expected outcome is probabilistic. There are two important parts to good ADM: discrimination, or <u>headwork</u>, and motivation, or <u>attitude</u>. Discrimination is the perceptual and intellectual ability of the pilot to detect, recognize, and diagnose problems, to determine available alternatives, and to determine the risk associated with each alternative. Motivation is an attitude or tendency within the pilot to resist non-safety related decision factors and to choose the best alternative consistent with the goals of society within the time frame permitted (Jensen and Benel, 1977).

Headwork

The first part of the definition, sometimes called "headwork" by pilots, refers to knowledge and intellectual abilities. It relies upon the pilot's capabilities to sense, store, retrieve, and integrate information. This part of the decision process is purely rational, and if used alone, would allow problem solving in much the same manner as a computer.

To reduce errors, headwork should be structured, orderly, and timely. This CRM program presents an approach to headwork that differs from many of the traditional pilot training programs. The traditional approach is to teach student pilots the capabilities and flight characteristics of an aircraft and its systems; knowledge of the national airspace system; general knowledge of meteorology; regulations; emergency procedures, and "stick and rudder" skills. The premise being that, if pilots have this kind of information, they will be able to exercise the good judgment required to assure safe flight.

This program teaches a structured approach called, DECIDE, to use in making decisions. In this approach the pilot is taught to do more than skillfully resolve emergencies as they occur. It is equally important to actively avoid those situations that might lead to emergencies by recognizing early signs of impending trouble and taking corrective action before a critical situation can develop. The following true story illustrates:

> A young pilot, who was recently hired by a large midwestern university, was flying in a light plane with his new boss to attend a meeting at the Air Force Academy. Their destination, Colorado Springs, was socked in at less than 1/4 mile obscured while their alternate, Denver, was clear. The boss wanted to go to Colorado Springs to "give it a try" even though only one other plane had attempted the approach that day and was not successful. The new hire, not wanting to be placed in a situation on approach where, at minimums, the boss says, "I think I can see something - let's go lower," and have to over rule him at that critical stage, instead over ruled him enroute and landed safely at the alternate.

In this example, the young hire sought to avoid a situation in which strong pressure would be brought upon him to decide to continue the approach. Furthermore, the additional pressure of time would make it even more difficult to make a rational decision. He choose to face the pressure at a time when all parties could be more rational even though it may have appeared to be a less than macho approach.

Outcome prediction is another key element in the headwork process. As a pilot considers an action, the consequences of taking, as well as not taking, that action must be carefully considered. The process of outcome prediction is learned through experience with as many outcomes as possible. The place to gain that experience is in the classroom, computer terminal, or flight simulator where the only risk is pride - not in the air where there is risk of physical injury.

DECIDE. The structured approach to headwork offered here is represented in a model called DECIDE (Benner, 1975). The DECIDE model is a six element decision making process that, when followed, can help to organize one's thoughts and prevent overlooking facts that may be important. When faced with any decision involving uncertainty, one should remember the acronym DECIDE as follows:

D - Detect: The decision maker detects the fact that a change has occurred that requires attention.

E - Estimate: The decision maker estimates the significance of the change to the flight.

C - Choose: The decision maker chooses a safe outcome for the flight.

I - Identify: The decision maker identifies plausible actions to control the change.

D - Do: The decision maker acts on the best options.

E - Evaluate: The decision maker evaluates the effect of the action on the change and on progress of the flight.

The DECIDE model is a "closed-loop" process, meaning that as soon as it is completed, thinking goes back to the beginning again. In practice, the last element of the process is where your thoughts should remain as a vigilant monitor of all factors that could produce change during the flight. When such a change occurs, that process is put into action. In using this model, begin with decisions that have some element of uncertainty (weather forecasts, fuel remaining, engine or navigation system reliability, etc.). As you repeatedly think through the model in these circumstances, it will become second nature to you and it will help you in all decisions.

The following case study, concerned with the Air Illinois Flight 710 accident that occurred near Carbondale Illinois in 1983, illustrates the use of the DECIDE model in ADM. A synopsis of the NTSB report is presented in Appendix E to this manual. The accident involved a HS-748-2A that had a generator failure at night in which improper procedures were followed causing the disconnection of the second generator from the d.c. bus. These procedural errors were followed by a chain of poor decisions leading to an attempt to make the destination on battery power. This attempt failed and the aircraft crashed several miles short of the destination when all d.c. electrical power was lost. The following chart illustrates the use of the DECIDE model in this example:

AIR ILLINOIS GENERATOR FAILURE IN NIGHT IFR CONDITIONS

CHANGE	D	E	C	I	D	ACTION	E
Left Gen Fails after TO	Y	Y	N	N	Y	CP misidentifies failed gen and disconnects good gen	Y
CP tells Dep Con "slight" electrical problem	Y	Y	Y	Y	Y	Dep Con offers return to Springfield Airport	Y
Crew gets Dep Con offer to return to Springfield	Y	Y	N	N	Y	Capt rejects offer and continues to Carbondale	Y
Right gen doesn't take electrical load	Y	Y	Y	Y	Y	CP tells Capt of loss of Right gen	Y
CP tells Capt of right gen failure	Y	Y	N	N	Y	Capt requests lower alt for VFR conditions	Y
CP tells Capt bat volt is dropping fast	Y	N	N	N	Y	Capt tells CP to put load shedding switch off	Y
CP reminds Capt of IFR weather at Carbondale	Y	N	N	N	N	No reaction	N
CP turns on radar to get position	Y	Y	N	N	Y	CP tells Capt about dropping voltage	Y
CP tells Capt Bat volt is dropping	Y	Y	Y	Y	Y	Capt turns off the radar	Y
CP warns Capt about low bat	Y	Y	Y	Y	Y	Capt starts descent to 2400	Y
Cockpit instruments start failing	Y	Y	Y	N	Y	Capt asks CP if he's got any instruments	Y

From this chart, one can observe the "Ys" indicating that the item was followed and "Ns" indicating that the item was not followed. The Ns would suggest thought processes that are clues to the reasons for the accident. A number of Ns are found in the "I" column indicating that there was a failure of the crew to identify the correct action to counter the change. However, the crucial Ns occurred when the co-pilot reminded the captain of IFR weather at Carbondale and got no response until it was too late. The co-pilot appeared to have the answer to avoiding the accident but did not offer it to the captain, nor did he voice his concerns about the action the captain was taking very assertively.

This model could be used to analyze the thought processes taking place in any accident in which sufficient communication and other behavioral data is available to answer the questions in the chart. Through such analysis the reasons behind many "pilot error" accidents might be found. Furthermore, the use of this technique through several accident scenarios as well as successful outcomes is an effective way to learn to structure your thought processes and make better decisions when faced with uncertain situations.

The above charting technique was developed by Russ Lawton of the AOPA Air Safety Foundation and tested in a LOFT type preliminary training evaluation at the Ohio State University. This study reported that pilots could be taught to make safer, more systematic decisions using this model (Jensen, Adrion, and Maresh, 1986). Work is continuing to improve and further validate this technique for teaching decision making (Lawton, 1986).

As an exercise, in this activity, read the NTSB synopsis of the United Airlines Flight 2860 into Salt Lake City given in Appendix D and chart the DECIDE model as shown above. Use the exercise to develop your own approach to structured decision making.

UNITED AIRLINES ACCIDENT AT SALT LAKE CITY

CHANGE	D	E	C	I	D	ACTION	E

Hazardous Attitudes

Motivation, the second part of the definition, is where the "human element" comes to play in the ADM process. It points toward the safety attitudes that have been developed within the pilot over his flying experience. It shows that pilot decision making is affected by non-safety factors such as job demands, convenience, monetary gain, self-esteem, commitment, etc. If properly developed, this part of pilot decision making would minimize information unrelated to the safety of the flight and direct the pilot's decision toward the use of more rational information and processes. Motivational decision making means recognizing that hazardous attitudes are present in every human decision and that these hazardous attitudes should give way to rational thought processes.

Attitudes vs Personality Traits

Over the years of our development, each of us develops strategies to best accomplish our goals of dealing with life and the people around us. Some of these strategies become deeply ingrained and are known as personality traits. These traits are well established by the age of six and are difficult to change thereafter. Attitudes are strategies less deeply ingrained, which can be changed, especially under pressure from several sources at the same time. We are constantly bombarded with attempts to change our attitudes by teachers, theologians, advertising people, parents, peers and superiors. Because many of these attempts are successful in other fields, we know that they can be used in cockpit training as well. However, no attempt will be made to change one's personality.

The Pilot Attitude Inventory

The following questionnaire will assist you in evaluating your own attitudes as they may affect your pilot decision making. Answer the questions as honestly as possible. Your honest responses will greatly improve your performance in this training program. There are no right or wrong answers, and you need not reveal the results to anyone. The sole purpose of this questionnaire is to help determine your decisional attributes as an instrument pilot. Following the questionnaire, you will be shown how to score and interpret the results.

Instructions:

1. Read over each of the five situations and the five choices. Decide which one is the most likely reason why you might make the choice that is described. Place a numeral 1 in the space provided on the answer sheet.

2. Continue by placing a 2 by the next most probable reason, and so on, until you have filled in all five blanks with ratings of 1, 2, 3, 4 and 5.

3. Do all 10 situations and fill in each blank, even though you may disagree with all of the choices listed. Remember, there are no correct or "best" answers.

Example:

_5_ a. (your least likely response)
_3_ b.
_1_ c. (your most likely response)
_2_ d.
_4_ e.

Situation 1

Nearing the end of a long flight, your destination airport is reporting a ceiling of 800 feet and 1/2 mile visibility, fog and haze. You have just heard another aircraft miss the approach (ILS minimums are 200 and 1/2). You decide to attempt the ILS approach. Why did you make the attempt?

___a. Ceiling and visibility estimates are often not accurate.
___b. You are a better pilot than the one who just missed the approach.
___c. You might as well try, you can't change the weather.
___d. You are tired and just want to land now.
___e. You've always been able to complete approaches under these circumstances in the past.

Situation 2

You plan an important business flight under instrument conditions in an aircraft with no deicing equipment through an area in which "light to moderate rime or mixed icing in clouds, and precipitation above the freezing level, " has been forecast. You decide to make the trip, thinking:

___a. You believe that your altitudes enroute can be adjusted to avoid ice accumulation.
___b. You've been in this situation many times and nothing has happened.
___c. You must get to the business meeting in two hours and can't wait.
___d. You do not allow an icing forecast to stop you; weather briefers are usually overly cautious.
___e. There's nothing you can do about atmospheric conditions.

Situation 3

You arrive at the airport for a flight with a friend and plan to meet his other friend who is arriving on a commercial airplane at your destination. The airplane you scheduled has been grounded for avionics repairs. You are offered another airplane equipped with unfamiliar avionics. You depart on an instrument flight without a briefing on the unfamiliar equipment. Why?

___a. If the avionics are so difficult to operate, the FBO would not have "offered" the plane as a substitute.
___b. You are in a hurry to make the scheduled arrival.
___c. Avionics checkouts are not usually necessary.
___d. You do not want to admit that you are not familiar with the avionics.
___e. You probably won't need to use these radios anyway.

Situation 4

You arrive at your destination airport to pick up a passenger after the fuel pumps have closed. Your calculations before departing determined that there would be enough fuel to complete the trip with the required reserves. The winds on the trip were stronger than anticipated, and you are not certain of the exact fuel consumption. You decide to return home without refueling since:

___a. You can't remain overnight because you and your passenger have to be at the office in the morning.
___b. The required fuel reserves are overly conservative.
___c. The winds will probably diminish for the return trip.
___d. You don't want to admit to your lack of planning in front of anyone else.
___e. It's not your fault the airport services are not available; you will just have to try to make it home.

Situation 5

You have been cleared for the approach on an IFR practice flight with a friend acting as safety pilot. At the outer marker, ATC informs you of a low-level wind shear alert reported for your intended runway. Why do you continue to approach?

___a. You have to demonstrate to your friend that you can make this approach in spite of the wind.
___b. It has been a perfect approach so far; nothing is likely to go wrong.
___c. These alerts are for less experienced pilots.
___d. You need two more approaches to be current and want to get this one completed.
___e. The tower cleared you for the approach, so it must be safe.

Situation 6

You are about to fly some business associates in a multi-engine aircraft IFR to Miami, Florida. You notice a vibration during run-up of the left engine. Leaning the mixture does not reduce the vibration. You take-off without further diagnosis of the problem. Why?

___a. You need to be in Miami by five o'clock and are behind schedule, the aircraft can be checked in Miami.
___b. You have encountered the vibration before without any problem.
___c. You don't want your business associates to think you can't handle the aircraft.
___d. The requirement for two perfectly smooth running engines is overly conservative.
___e. The shop just checked this plane yesterday; the mechanics would not have released it if there were a problem.

Situation 7

You are in instrument meterological conditions and are receiving conflicting information from the two VOR receivers. You determine that the radios are out-of-tolerance and cannot determine your position. You believe ATC will soon suggest that you are off course and request a correction. You are thinking:

___a. Try to determine your position so ATC won't find out that you are lost.
___b. You will continue to navigate on the newer VOR receiver; it should work just fine.
___c. You will get out of this jam somehow, you always do.
___d. If ATC calls, you can be non-committal. If they knew all, they would only make things worse.
___e. Inform ATC immediately that you are lost and wait impatiently for a response.

Situation 8

During an instrument approach, ATC calls and asks how much fuel you have remaining. You have only two minutes before reaching the missed approach point, and wonder why they have inquired as to your fuel status. You are concerned about severe thunderstorm activity nearby and assume that you may be required to hold. You believe that:

___a. Your fuel status is fine, but you want to land as soon as possible before the thunderstorm arrives.
___b. You are in line with the runway and believe that you can land, even in any crosswind that might come up.
___c. You will have to complete this approach; the weather won't improve.
___d. You won't allow ATC to make you hold in potentially severe weather; it's not their neck.
___e The pilot who landed ahead of you completed the approach without any problems.

Situation 9

You are a new instrument pilot conducting an instrument flight of only twenty miles. The turn coordinator in your airplane is malfunctioning. The visibility is deteriorating, nearing approach minimums at your destination. You make this trip thinking:

___a. You've never had a need to use the turn coordinator.
___b. You recently passed the instrument flight test and believe you can handle this weather.
___c. Why worry about it; ATC will bet you out anyway.
___d. You had better get going now before you get stuck here.
___e. Back up systems are not needed for such a short trip.

Situation 10

You are on an instrument flight and encounter clear air turbulence. You are not wearing a shoulder harness and do not put it on. Why not?

___a. Putting on a shoulder harness might give the appearance that you are afraid; you don't want to alarm your passengers.
___b. Shoulder harness regulations are unnecessary for enroute operations.
___c. You haven't been hurt thus far by not wearing your shoulder harness.
___d. What's the use in putting on a shoulder harness; if it's your time, it's your time.
___e. You need to maintain aircraft control; there's no time for shoulder harnesses.

THE ATTITUDE INVENTORY

Scoring Key

Situation	Scale I	Scale II	Scale III	Scale IV	Scale V	Total
1	a.___	d.___	e.___	b.___	c.___	15
2	d.___	c.___	b.___	a.___	e.___	15
3	c.___	b.___	e.___	d.___	a.___	15
4	b.___	a.___	c.___	d.___	e.___	15
5	c.___	d.___	b.___	a.___	e.___	15
6	d.___	a.___	b.___	c.___	e.___	15
7	d.___	e.___	c.___	a.___	b.___	15
8	d.___	e.___	c.___	a.___	b.___	15
9	e.___	d.___	a.___	b.___	c.___	15
10	b.___	e.___	c.___	a.___	d.___	15
Total	___	___	___	___	___	150

The sum of your scores across should be 15 for each situation. If it is not, go back and make sure that you transferred the scores correctly and check your addition. The grand total should be 150.

Interpreting Your Attitude Inventory

The five hazardous attitudes that have been identified in this inventory are:

Scale I: Anti-Authority: This attitude is found in pilots who resent any external control over their actions. It is a tendency to disregard rules and procedures. "The [illegible]lations and SOPs are not for me."

Scale II: Impulsivity: This attitude is found in pilots who act quickly, usually in a manner that first comes to mind. "I must act now - there's no time."

Scale III: Invulnerability: This attitude is found in pilots who act as though nothing bad can happen to them. "It won't happen to me."

Scale IV: Macho: This attitude is found in pilots who continually try to prove themselves better than others. They tend to act with overconfidence and attempt difficult task for the admiration it gains them. "I'll show you - I can do it."

Scale V: Resignation: This attitude is found in pilots who feel that they have little or no control over their circumstances. They are resigned to let things be as they are. They may deny that the situation is as it appears. They are likely to fail to take charge of the situation. They may also let other people or commitments influence their decision making. "What's the use? It's not as bad as they say. They're counting on me."

Look at your scores on the scoring sheet. The higher scores indicate attitudes that are relatively stronger in you. They do <u>not</u> indicate how your attitudes compare with anyone else. Remember, these five hazardous attitudes are present in all pilots to different degrees. From your score on the inventory, you can see which are stronger in your own thought process. These may represent weaknesses that you should keep in mind as you attempt to make safe flying decisions under the pressure of people and circumstances.

Attempts to teach safe attitudes in decision making has been proven effective in numerous short-term studies both in the USA and in Canada (Berlin, Gruber, Holmes, Jensen, Lau, Mills, and O'Kane, 1982; Buch and Diehl, 1984; Diehl and Lester, 1987). Although further study is needed to prove its long-term effectiveness, it is mentioned here because of its proven value in improving decision making.

Countering Hazardous Attitudes

Even though the inventory does not show whether you have hazardous attitudes compared with other pilots, it does show the types of hazardous attitudes to which you would be most vulnerable. By going through the exercise of this inventory, you are now aware of the most dangerous attitudes that are present in pilots and may be able to recognize them both in yourself and in other pilots. This recognition is the first step toward countering these hazardous attitudes. It will help you understand your fellow crewmembers and adapt your communication style to better meet the needs of a particular situation.

In case you feel that one or more of these attitudes is strong in your own thinking, the following is a list of antidotes for you to think about when you encounter the hazardous attitudes:

THE FIVE ANTIDOTES

Hazardous Attitude	Antidote
Anti-Authority:	
"The regulations are for someone else."	"Follow the rules. They are usually right.
Impulsivity:	
"I must act now, there's no time."	"Not so fast. Think first."
Invulnerability:	
"It won't happen to me."	"It could happen to me."
Macho:	
"I'll show you. I can do it."	"Taking chances is foolish."
Resignation:	
"What's the use?"	"I'm not helpless. I can make a difference."

Chapter 5: RELATIONSHIP VERSUS TASK

The following questionnaire called the "Personal Characteristics Inventory" (PCI) is given at this point to focus the CRM training on the relationship versus task orientation which is important in multi-pilot crew decision making. Please answer the questions according to the instructions provided as honestly as you can. The scoring method and interpretation of the PCI will be provided later.

Personal Characteristics Inventory

The items below inquire about what kind of a person you think you are. Each item consists of a pair of characteristics, with the letters A-E in between. For example:

Not at all Artistic	A.....B.....C.....D.....C	Very Artistic

Each pair describes contradictory characteristics--that is, you cannot be both at the same time, such as very artistic and not at all artistic. The letters form a scale between the two extremes. You are to choose a letter which describes where you think you fall on the scale. For example, if you think you have no artistic ability, you would choose A. If you think you are pretty good, you should choose D. If you are only medium, you might choose C, and so forth. Circle the letter that best describes you. Be sure to answer every question.

1.	Not at all aggressive	A.....B.....C.....D.....E	Very aggressive
2.	Very whiny	A.....B.....C.....D.....E	Not at all whiny
3.	Not at all independent	A.....B.....C.....D.....E	Very independent
4.	Not at all arrogant	A.....B.....C.....D.....E	Very arrogant
5.	Not at all emotional	A.....B.....C.....D.....E	Very emotional
6.	Very submissive	A.....B.....C.....D.....E	Very dominant
7.	Very boastful	A.....B.....C.....D.....E	Not at all boastful
8.	Not at all excitable in a major crisis	A.....B.....C.....D.....E	Very excitable in major crises
9.	Very passive	A.....B.....C.....D.....E	Very active
10.	Not at all egotistical	A.....B.....C.....D.....E	Very egotistical

11.	Not at all able to devote self completely to others	A.....B.....C.....D.....E	Able to devote self completely to others
12.	Not at all spineless	A.....B.....C.....D.....E	Very spineless
13.	Very rough	A.....B.....C.....D.....E	Very gentle
14.	Not at all complaining	A.....B.....C.....D.....E	Very complaining
15.	Not at all helpful to others	A.....B.....C.....D.....E	Very helpful to others
16.	Not at all competitive	A.....B.....C.....D.....E	Very competitive
17.	Subordinates oneself to order	A.....B.....C.....D.....E	Never subordinates oneself to others
18.	Very home oriented	A.....B.....C.....D.....E	Very worldly
19.	Very greedy	A.....B.....C.....D.....E	Not at all greedy
20.	Not at all kind	A.....B.....C.....D.....E	Very kind
21.	Indifferent to other's approval	A.....B.....C.....D.....E	Highly needful of other's approval
22.	Very dictatorial	A.....B.....C.....D.....E	Not at all dictatorial
23.	Feelings not easily hurt	A.....B.....C.....D.....E	Feelings easily hurt
24.	Doesn't nag	A.....B.....C.....D.....E	Nags a lot
25.	Not at all aware of feelings of others	A.....B.....C.....D.....E	Very aware of feelings of others
26.	Can make decisions easily	A.....B.....C.....D.....E	Has difficulty making decisions
27.	Very fussy	A.....B.....C.....D.....E	Not at all fussy
28.	Give up very easily	A.....B.....C.....D.....E	Never gives up easily
29.	Very cynical	A.....B.....C.....D.....E	Not at all cynical
30.	Never cries	A.....B.....C.....D.....E	Cries very easily

31.	Not at all self-confident	A.....B.....C.....D.....E	Very self-confident
32.	Does not look out for self, principled	A.....B.....C.....D.....E	Looks out only for self, unprincipled
33.	Feels very inferior	A.....B.....C.....D.....E	Feels very superior
34.	Not at all hostile	A.....B.....C.....D.....E	Very hostile
35.	Not at all understanding of others	A.....B.....C.....D.....E	Very understanding of others
36.	Very cold in relations with others	A.....B.....C.....D.....E	Very warm in relations with others
37.	Very servile	A.....B.....C.....D.....E	Not at all servile
38.	Very little need for security	A.....B.....C.....D.....E	Very strong need for security
39.	Not at all gullible	A.....B.....C.....D.....E	Very gullible
40.	Goes to pieces under pressure	A.....B.....C.....D.....E	Stands up well under pressure

Scoring the PCI

To score your PCI, 14 questions are relevant. Seven are used to indicate "Instrumentality" or Task orientation and seven are used to indicate "Expressivity" or Relationship orientation. On the score sheet given below, write down your letter response to the question numbers indicated. The letter response should be converted to a number using the following formula: A-0, B-1, C-2, D-3, E-4. However, please note: On question 26, the reverse is used, i.e., E-0...A-4. Next to the letter response, write your number response. Total your scores for Task and Relationship at the bottom.

Task Questions			Relationship Questions		
Quest #	Letter	Number	Quest #	Letter	Number
3	____	____	5	____	____
9	____	____	11	____	____
16	____	____	13	____	____
26	____	____	15	____	____
28	____	____	20	____	____
31	____	____	25	____	____
33	____	____	35	____	____
40	____	____	36	____	____
Total		____			____

Interpreting the PCI

To determine where you stand on the Task versus Relationship matrix, place an X on the position of your scores on the PCI results graph shown in Figure 2. If your Task score is 21 or above, you would be considered high on task orientation. If your Relationship score is 23 or higher, you would be considered high on relationship orientation. Lower scores than these would be considered low on either scale.

Your score on this test should not be considered positive or negative as far as your capability as a pilot is concerned. However, if you are very low on either scale, you might consider looking carefully at the remainder of this course to improve your thought patterns in the cockpit. In tests of professional pilots, about 90 percent score high on task orientation and about 50 percent score high on relationship orientation.

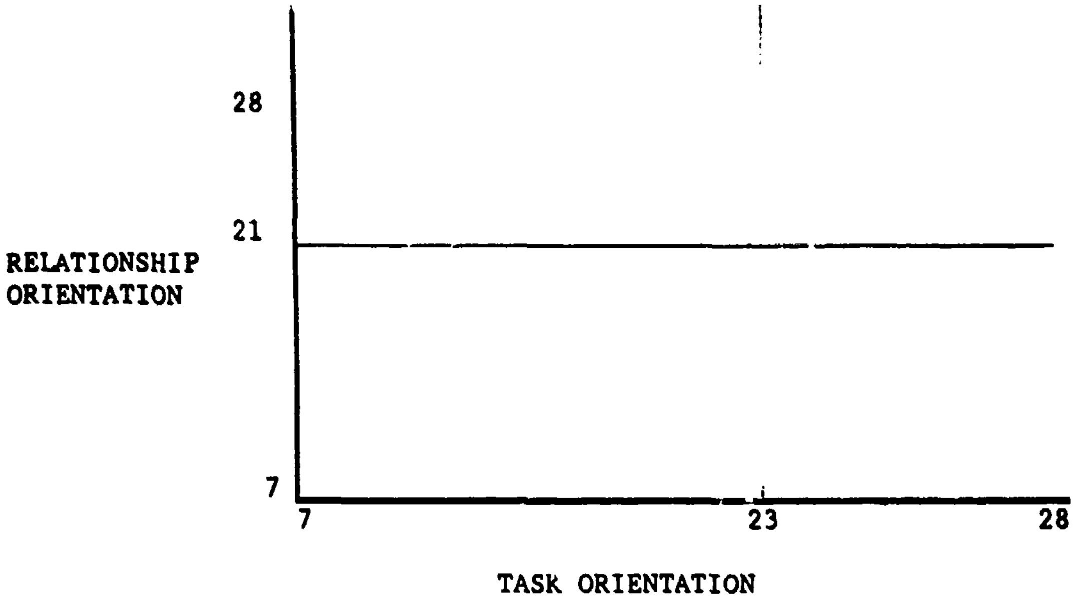

Figure 2. PCI result matrix for Relationship versus Task orientation.

Behavioral Dimensions

There are many theories concerning the leadership, management, or behavioral styles used in management courses. Three of these, together with their dimensions, that are used in CRM courses are:

THEORY	DIMENSIONS
McGregor's leadership model (1960)	Theory X (autocratic) and Theory Y (democratic)
Blake and Mouton (1964) "The Management Grid"	Concern for Relationship and Concern for People
Hersey and Blanchard (1977) "Situational Leadership"	Relationship and Task

Although each of these theories has a different approach to explaining personal orientation, all use a form of the relationship vs task matrix in their description of human behavior. The following relationship vs task model, offered by the Continental Airlines CRM Course (1985), is suggested here because it not only provides a representative form of the model but because it also provides a theoretical construct that is easily learned in a CRM short course and offers compelling arguments for its structure. As shown in Figure 3, there are four quadrants in this model:

Autonomous:	Low Relationship, Low Task
Nurturing:	High Relationship, Low Task
Aggressive:	Low Relationship, High Task
Assertive:	High Relationship, High Task

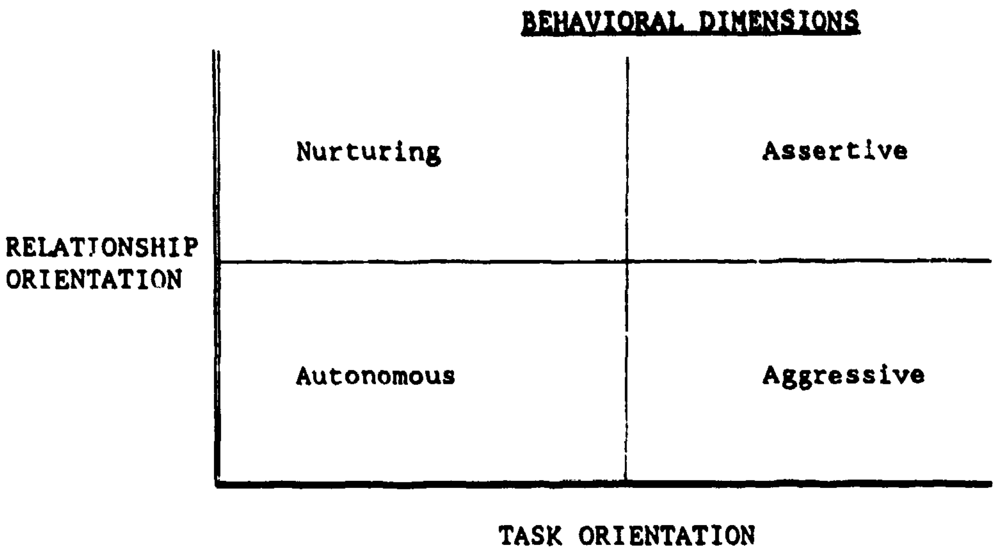

Figure 3. Basic behavioral dimensions (after Continental model).

In the application of this model to your cockpit, the assertive style of behavior is advocated because it produces best over all performance in decision making. Although each crew member comes to the cockpit with certain tendencies to be either nurturing, autonomous, and/or aggressive, you as a crew member, regardless of your position within the crew, should adapt these emphases to meet the demands of each situation. Extremes of each type are to be avoided because they discourage effective communication.

Some situations may require an aggressive/assertive style, e.g., an emergency in which there is little time to consider relationships or more information. Others may demand a nurturing/assertive style, e.g., helping a crew member through a mistake without destroying his ego. The objective should be to develop each of these styles so as to bring about an adaptable assertive overall style for cockpit communication. Finally, you as a member of the crew must be sure that the other crew member(s) know how you are acting (behaving) at all times, and it is equally important that you know how the other(s) are acting as well.

As one can see from an expanded version of the model shown in Figure 4, flexibility to move toward one or another of the three alternate quadrants is suggested depending on the situation, yet the basic assertive style is maintained. One can also see that the extreme in each of the non-assertive quadrants can lead to failures in communication and relationships. Those who go overboard in nurturing tend to violate their own rights. Those who are too aggressive violate the rights of others. Those who place too much emphasis on their own autonomy may fail to contribute anything useful.

BEHAVIORAL DIMENSIONS

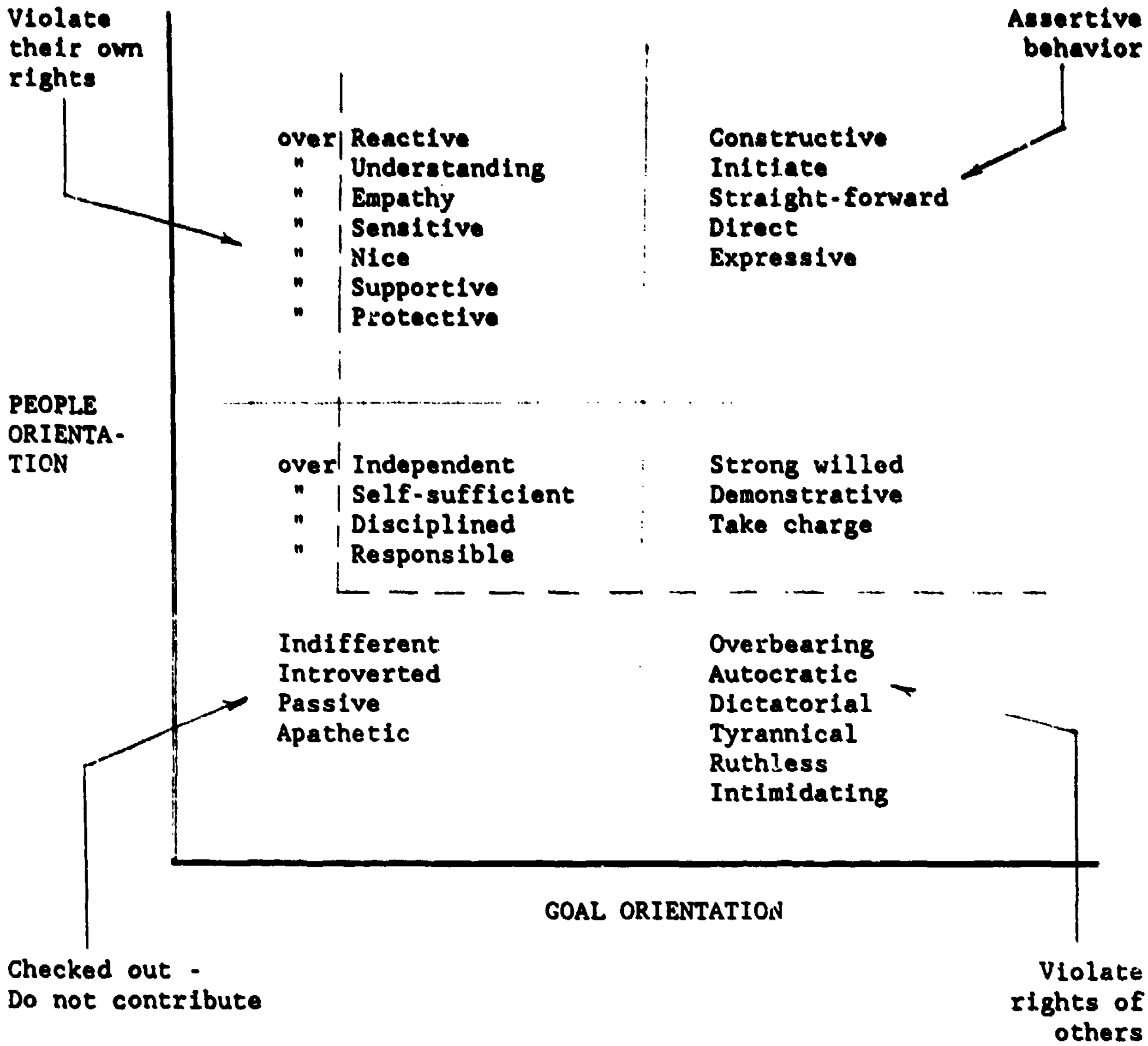

Figure 4. Behavior dimensions with descriptors showing how each dimension contributes to assertive behavior.

Theory of the Situation: Situational Awareness

Central to many CRM accidents one finds a discrepancy between what the crew perceives to be true about a given situation (and themselves and their actions) and what in fact is reality. Furthermore, as indicated above, the situation often determines the type of communication style one should use. To help you recognize the situation in which you may find yourself, the following concept called, "Theory of the Situation" is offered. This concept was developed by Dr. Lee Bolman of the Harvard University School of Education (1979).

One of the reasons for discrepancies between perceptions and reality is that a major function of the human perceptual system is to reduce and order the vast amount of information coming in through the senses so that we can understand and respond to it appropriately. Unfortunately, this information reduction and ordering process is not perfect and sometimes leads to mistakes or discrepancies from reality. The process is developed through many years of experience and is therefore different for every person. Perceptions of visual information is fairly consistent with all individuals. However, perceptions of situations based on cognitive material obtained through all the senses is not very consistent. The Theory of the Situation is an attempt to show how the various forces interact as we attempt to gain an awareness of the situation.

The following definitions are offered for the elements of this model:

THEORY OF THE SITUATION: What one assumes to be true based on his/her perception of the facts one has at any point in time.

REALITY: The situation as it is in reality - often fully known only by the "Monday Morning Quarterback."

THEORY IN USE: One's predictable behavior in a given situation that has been developed since birth.

ESPOUSED THEORY: An individual's account or explanation of his/her behavior. "How I say and believe I will behave."

THEORY IN PRACTICE: The set of skills, knowledge, and experience one calls upon according to his/her theory of the situation.

Figure 5 shows the relationships among the elements of the model. If the theory of the situation is in line with reality, the flight crew's assumptions are correct and safe flight decisions are likely. However, if the crew's assumptions are not correct a discrepancy exists between their theory of the situation and reality as indicated at the top of Figure 5. The greater this discrepancy, the greater the danger. It is these discrepancies that go unrecognized and magnify under stress that underlie most CRM accidents.

The remedy for the discrepancy between the theory of the situation and reality is through testing assumptions. This means actively checking your understanding of the situation with your other crew members, ATC and the instruments and/or computers on board the aircraft.

A second discrepancy can exist between our espoused theory and our theory in use which can also lead to decisional errors. If we say we will do something and have no intention of doing it, we create great misunderstandings within the crew and great conflicts within ourselves. The key to reducing this discrepancy is found in courses such as this which help to identify, through communication practice, the extent of this discrepancy and show you how to deal with it. A common response to LOFT exercises as well as the role

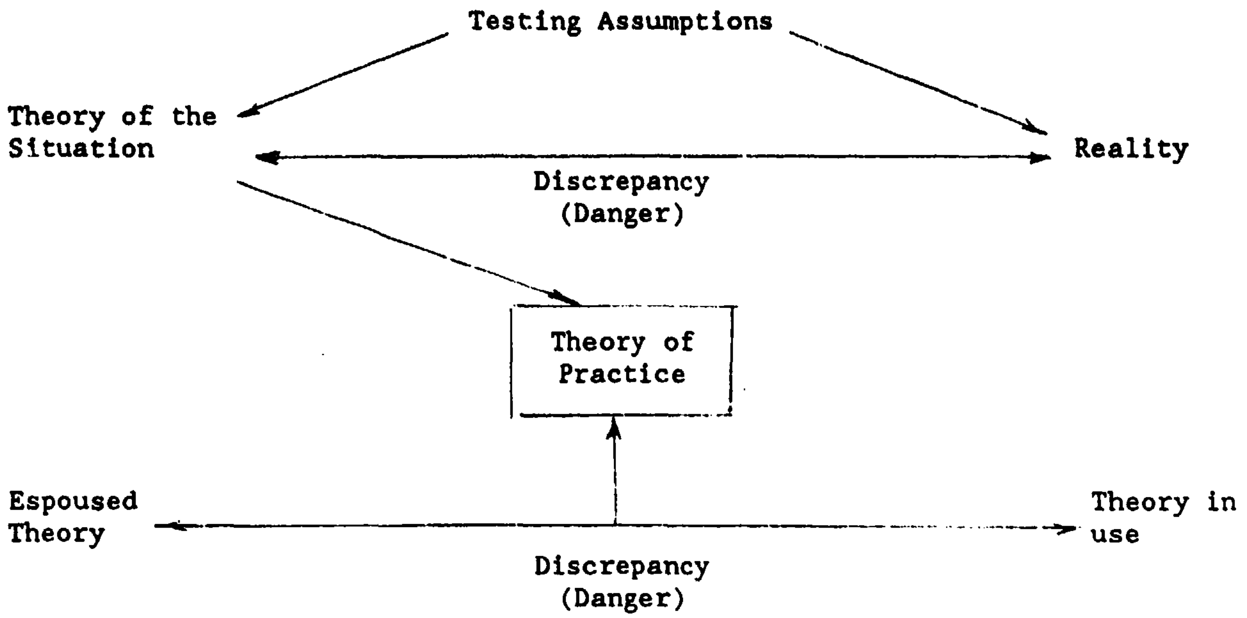

Figure 5. The Theory of the Situation (Continental Crew Coordination Concepts course).

Chapter 6: COMMUNICATION

The most important aspect of CRM training is interpersonal communication. It is through communication that management is conducted. It is the responsibility of all crew members to communicate effectively. Communication means more than speaking clearly with proper phraseology. It also means making the other person understand what you are saying as well as understanding what the other person is saying because it can mean the safety of the flight.

CRM courses list a wide variety of elements essential to good communication. We have selected five of these that are independent of each other and cover the important aspects of cockpit communication very well. None of these five elements deal with semantic clarity or proper grammar. All deal with the transfer of information important to understanding. These five aspects of effective communication are:

1. Inquiry
2. Advocacy
3. Listening
4. Conflict Resolution
5. Critique

Because of the importance of each of these aspects of communication, each will be considered in some detail with cockpit examples. Later, case studies will be presented to further your understanding of these ideas. It is important that you not only understand the concepts presented here, but also that you adapt them to your own communication practices.

Appendix A presents a synopsis of the NTSB report of one of the most cited CRM related accidents, the United Airlines accident in Portland in 1978. It should be studied for examples of failures in each of the forms of communication given.

Inquiry

Inquiry or information seeking is the first aspect of communication covered because it represents the beginning point to making effective decisions. Good decisions are based on good information. In the cockpit it consists of both a visual scan of the cockpit for the information and questioning other crew members or controllers for information. It also means asking for clarification when the information is not clearly understood.

In the cockpit, crewmembers with fragile egos are often reluctant to ask for clarification because it may reflect badly on either their intellect or their hearing, both of which are important, not only to maintaining flying status, but respect of peers as well. This feeling of an insecure ego, which is often fed by equally insecure peers and/or controllers who fire back a statement about how foolish you look to have to ask such a question, must be overcome if complete understanding and safe decisions are to be made consistently.

An example can be seen in the Air Florida accident (Appendix B) when at 1558:31 the co-pilot, who was flying, asked the captain, "Slushy runway, do you want me to (do) anything special for this or just go for it?" This was a clear inquiry about ideas for the takeoff as well as an expression of concern for the takeoff. He then repeated his concern in different, less direct, ways without a response from the captain three more times The captain's response was to first ridicule the question, "Unless you got anything special you'd like to do." He then ignored further expressions of inquiry and concern. Following the captain's response, the co-pilot became less clear in his further inquiries.

Advocacy

Advocacy refers to the need to state what you know or believe in a forthright manner. It means not only stating your position, but maintaining your position until completely convinced by the facts, not the authority of the other, that it is wrong. There are many examples of airline accidents in which other crewmembers had the correct answer, as indicated by the fact that he questioned the actions of the captain, but did not advocate his position strongly enough, or he capitulated far too soon to the authority of the captain. The United accident in Portland (Appendix A) in which the flight engineer expressed concern over the fuel state (1750:30) and the Air Florida accident in Washington (Appendix B) in which the co-pilot indicated concern for the difference in the engine temperatures (1548:59, 1559:54, 1559:58, 1600:02, 1600:05, 1600:10, 1600:23) are two examples. In both cases the captain's decision would have benefitted from a subordinate crewmember who was a greater advocate of his position.

Listening

As demonstrated in the Continental course, it is also important to include a strong element of active listening training as well. One of the greatest reasons for cockpit communication failures is the fact that no one was listening. Listening requires more than passive attention. It requires the listener to open up to the other person, actively inquire through questions and other forms of feedback, and respond appropriately (agreement, acknowledgment, disagreement) - but always accepting that what is said may be true to the other person. Listening is not passive - it is a part of communication for which all members of the crew are responsible. No one must be a sponge.

Non-listeners have the following traits:

Pre-Plan: Intent on what I want to say so I don't listen to what you are saying.

Debate: No matter what is said some people want to take the other side "I'm going to play the devil's advocate."

Detour: Like pre-plan, but they wait for a key word to take the discussion to another area of interest to them.

Tune Out: Spouses and kids - whatever they have to say, it is not important enough for your attention.

On the other hand, active listeners:

Ask questions.
Paraphrase - did I hear you right?
Provide eye contact.
Use body language.

Active listening results in better communication, safety, efficiency, relationships, decision making, and harmony. To summarize active listening the following points are offered:

1. It is a basic human need to be heard and understood - active listening serves that need.

2. Active listening is a skill that must be learned.

3. In an emergency, active listening is a critical skill.

4. In normal situations, active listening enhances communication, eliminates barriers, and lays the groundwork for good communication during emergencies.

Conflict Resolution

If you and your other crewmembers are each advocating your position properly, conflict is inevitable. Therefore, an effective process is needed to resolve those conflicts. Conflicts are not necessarily bad as long as they arise over issues within the cockpit. They can become destructive when issues from outside the cockpit, such as taking sides on management policies, personality factors, personal weaknesses, social status, etc., are brought into the argument. It can also be destructive when the argument is over who is right rather than what is right. Such arguments can have a serious effect on the quality of the decisions made because thinking is focused on the wrong issues and when disagreement is not expressed.

Conflict can be constructive if it is handled right. The proper way to resolve conflicts is to:

1. Have a policy of crew coordination that is known and accepted by everyone.

2. When disagreement arises, keep the discussion on the issues needing resolution within the cockpit.

3. Bring out all issues of disagreement.

4. Acknowledge and express all feelings that are deep enough to cloud your thinking.

Properly handled conflict resolution is the key to the highest level of problem solving known. It leads to deeper thinking, creative new ideas, mutual respect, and higher self-esteem which strengthens team effectiveness. For these reasons, conflict should not be avoided when differences of opinion arise. Rather, it should be recognized as an opportunity to seek better solutions to problems that may not have been thought of previously.

Critique

Even more difficult than conflict resolution is the ability to provide an effective critique of fellow crewmembers. A critique is necessary because it teaches us how we can improve. We make mistakes on all flights. Someone said that straight-and-level flight can be defined as a series of error corrections. If we are only told of course and altitude errors (by our gages), we only improve our ability to track. To improve other cockpit skills such as problem solving, monitoring traffic, communication, etc., we need feedback in the form of a critique from our fellow crewmembers.

Who is responsible for giving the critique? Because of his position, the captain is first responsible for providing feedback to the other crewmembers. However, the captain also makes mistakes that need to be pointed out by his crew. In some CRM classes, captains have lamented the fact that they have never received any feedback concerning their performance except proficiency checks.

How should a critique be done? First, all members of the crew should know to expect a critique. CRM training such as this is useful in bringing about this awareness. Second, to reduce the pain and embarrassment, the critique should be invited by the crewmember getting the critique, especially if it is the captain. Third, the critique should consist of frank discussions among the crewmembers, beginning with flight planning, continuing through the flight, and ending with a debriefing at the end. If properly done, it can become a way of life in the cockpit that resolves conflict and misunderstandings before they arise by preventing issues and important feelings from being covered up.

The attitude and reactions of the person receiving the critique may be just as important as the initiative of the person giving the critique. The receiver's attitude should encourage the other to give feedback. On the other hand, the receiver should realize that feedback from any one person cannot be fully trusted because it comes from one perspective. Everyone who sees you perform, sees it from a different experiential background which influences his feedback to you. Therefore, it is necessary to get feedback from others to get an accurate picture of your performance.

Communication Evaluation

An important part of communication training is the evaluation of the style of communication being used both by self as well as others. There are four ways to evaluate one's own communication behavior: written tests, peer feedback, video tape, and expert observer feedback. In the case of flight crew communication evaluation all four methods are useful because each tends to confirm the accuracy of the others. The following techniques for evaluation of one's own communication style are recommended:

Written Test: The Person Characteristics Inventory (PCI) given above in Chapter 5 shows your communication style in terms of "expressivity."

Peer Feedback: As suggested above, the critique is a useful method consisting of fellow crewmembers providing feedback concerning communication styles that you are using. These should be stated in terms of the "behavioral dimensions" mentioned above.

Observer Feedback: This evaluation method consists of an expert observing and recording the communications being offered. This technique has been used successfully by the KLM CRM course both during small group discussion during the CRM course as well as in the cockpit. An example recording sheet with 13 different communication categories developed and used in the KLM course is shown in Figure 6. The recorded information is later shared with the student.

Video Tape: Another very effective communication evaluation technique is to have small groups of students make video tapes of their discussion in the resolution of a conflict. They, and other students, can observe the communication styles being offered. This technique has been used very successfully in Line Oriented Flight Training (LOFT) in the simulator as well as in the CRM classroom.

There is also a need to be able to recognize communication styles being used by others and situations that call for modifications to communication style. For example, some situations in which timing is critical require the use of an assertive style that moves toward aggressive. Recognition of other's style enables one to appropriately adjust one's own style as well.

COCKPIT COMMUNICATION
WORKLOAD

TYPE.................CREW........

ROUTE...................DATE.........

A/M	Pre-flight	Start-up	Taxi	Take-off	Climb-out	Cruise	Descent	Landing	Taxi	Shut-down

	CATEGORIES		CAPTAIN	CO-PILOT	FLIGHT ENG.	CABIN	ATC	GRD.	TOT.
REACTING	Supporting								
	Disagreeing								
	Defend/Attack								
	Blocking/Diff								
	Open								
COMMANDING	Directing	Immediate							
		Deferred							
INFORMATION PROCESSING	Giving Expl								
	Giving Op Info								
	Giving Info								
	Asides								
	Checking								
	Broadcast	ATC							
		PA							
QUESTIONING	Seeking Info								
	Testing Und								
	Testing Und-Sim								
ACTING	Physical Action								
	Totals								

interaction Trainers Ltd.

Figure 6. Communication coding sheet used in the KLM CRM course.

Chapter 7: EFFECTIVE LEADERSHIP

At the heart of cockpit resource management is effective leadership. Also necessary, is good followership. The following leadership and followership concepts, developed for the U.S. Air Force Aircrew Coordination Training course (Aufderheide, 1987), are most appropriate in the management of civilian cockpits as well.

Thirty Rules for Getting Things Done through Your People

1. Make the people on your crew want to do things.
2. Get to know your crew.
3. Be a good listener.
4. Criticize constructively.
5. Criticize in private.
6. Praise in public.
7. Be considerate.
8. Delegate responsibility for details in subordinates.
9. Give credit where it is due.
10. Avoid domination or forcefulness.
11. Show interest in and appreciation of the other fellow.
12. Make your wishes known by suggestions or requests, not orders.
13. When you make a suggestion, be sure to give the reasons for it.
14. Let your crew in on your plans in an early stage.
15. Never forget the leader sets the style for their people.
16. Play up the positive.
17. Be consistent.
18. Show you have confidence in your people and expect them to do their best.
19. Ask subordinates for their counsel and help.
20. When you make a mistake, admit it.
21. Give courteous hearing to ideas from subordinates.
22. If an idea is adopted, tell the originator why.
23. Remember, people carry out their own ideas best.
24. Be careful what you say and how you say it; it may be misunderstood.
25. Don't be upset by moderate grousing.
26. Build subordinates sense of the importance of their work.
27. Give your people goals.
28. Keep your people informed on matters affecting them.
29. Let subordinates take part in decisions affecting them.
30. Let your people know where they stand.

Traits of a Good Leader

Technical and professional competence. A cockpit leader is first and foremost a competent airman. Piloting skills must be exemplary and should inspire the confidence of subordinate crew members. Flight engineers and loadmasters must have a mastery of their job skills which reassure the commander and subordinates alike of their competence. Subordinates will give a leader a reasonable period to get their "feet-on-the-ground," but will not respect the individual who continually relies on others to make decisions or provide guidance.

Communicative skill. Leaders are highly presentable and have a wide-ranging vocabulary; they inspire individual and group confidence. They sense followers' moods and are respected by peers for verbalizing and presenting their views. As one statesman said, "Men lead with words."

Listening. A leader listens, but listening involves a great deal more than merely hearing. Leaders interpret and evaluate what they hear, and do not permit personal ideas, emotions, or prejudices to distort what a person says. Disciplined listening prevents them from tuning out subjects they consider too complex or uninteresting. Effective listening is difficult, but it is a key communication skill.

Decision making. An effective leader is skillful at problem analysis and decision-making. All available information should be sought out and utilized in arriving at a decision. It is easy to make decisions based upon narrow information but the results are generally less than optimum. Limited information which is readily available sometimes presents an incomplete or misleading picture of the situation. Making an extra effort to seek out additional information may place a new perspective upon the situation requiring a decision. There are a variety of resources available to MAC aircrews, depending upon the requirements for information, an none should be overlooked.

Courage. Leaders view courage as an essential binding influence for unity of action. Followers will usually excuse almost any stupidity, indiscretion, or ill-conceived action, but they will not accept excessive timidity. In holding strong to fundamental principles of leadership, effective leaders see themselves under a continuous challenge to prove by one means or another the quality and character of their person. Courage is indispensable if leaders expect to influence and give direction to the lives of other people.

Risk. A leader must be a risk taker. If they could perform without risk their jobs would be much easier, but risk taking is inherent in leadership. However, risks involving safety of flight must be balanced against the requirements of the mission. When time permits, decisions involving major risk should only be made after a full consideration of all the factors and facts available.

Perseverance. People who aspire to or have achieved leadership persevere in their work. They stick to tasks and see them through to completion, regardless of difficulties, and they are always optimistic and confident that they can find solutions to problems. They may even be a little bit stubborn when they are convinced of the correctness of a decision.

Sense of responsibility. Personal desires must be subordinated to the needs of MAC and the requirements of the mission. A leader recognizes responsibility and relishes it as an opportunity to display leadership skills.

Emotional stability. Leaders must exercise self-control if they expect to control others, and they must maintain control in the most trying situations. Furthermore, they should strive to keep their personal lives under control and should never allow personal problems to color decisions or reactions to adverse situations.

Enthusiasm. A leader must be genuinely enthusiastic in all the tasks which comprise the mission at hand. Followers will automatically give more of themselves and take more pride in their work when they know their leader is involved and committed. Some leaders are reluctant to delve into functional areas where they have little or no prior experience or qualifications, but it is important to seek new directions and to delve into unfamiliar areas.

Image. All leaders must have positive self-images formed through objective perception and interpretation of their environment. Self-images are controlling factors in their behavior because all people act as they perceive themselves. Leaders must develop their self-esteem and personal value.

Ethics. Ethics play a key role in the leadership function because they are the basis of all group interaction and decision-making. Professional ethics require leaders to maintain high standards of personal conduct and to adhere to those standards in all situations so that followers can rely on their actions. Leaders should not use their position for personal and special privileges.

Recognition. Leaders recognize the accomplishments of their people. William James, the philosopher, said, "The deepest principle in human nature is to be appreciated." The inability to satisfy needs for informal recognition is a common shortcoming of many commanders who are more problem and task oriented than people oriented. Good leaders are aware of the people surrounding them. They know the names of subordinates, their hometowns, family situations, etc. They keep their pulse on the feelings of their subordinates.

Sensitivity. A leader must be sensitive to their own psychological and physiological state and their impact on others. They should be particularly sensitive to departures from their norms occasioned by stress or fatigue. We must also be sensitive to the psychological and physiological states of other, and be prepared to adjust their style accordingly.

Flexibility. A leader must understand that no two people or two situations are ever exactly alike. Yesterday's approach may or may not be the correct approach for today or tomorrow. Effective leaders adapt their approaches to the particular persons or problems at hand. In dealing with problems and situations, leaders should always be ready to redefine and modify their approach in response to new developments.

Humor. Leaders should have a sense of humor because they set the tone for their aircraft. When the leader smiles it is easier for others to smile. Most people prefer to be part of a relaxed and pleasing crew rather than a crew laden with tension. Leaders should not take themselves too seriously. Humor can be a positive and welcome contribution to an efficient and effective cockpit.

Stamina. Leaders must have a high level of physical and mental stamina. Good leaders always seem at the ready and require only normal periods of rest.

They know how to pace themselves well and maintain themselves in good physical condition.

Traits of a Good Follower

Communication. With the possible exception of technical skills, there is nothing more important in supporting the commander than communication --two way communication. When they speak, a good follower listens carefully so that there will be no doubt as to what was said. If there is any question in your mind as to what was said or what is wanted, ask for a repeat. If you don't understand ask for clarification; a good leader knows there is no such thing as a dumb question. There is nothing worse for a commander than to think a subordinate has understood their words and is prepared to act accordingly, when in fact, they have not.

When you have something important for another crewmember, be sure he or she gets the message and understands it. Sometimes when a person is stressed by an emergency or abnormal situation it is difficult to get their attention--they are concentrating so hard it almost seems as though a barrier goes up excluding any outside input--but if you have information they should have, do whatever you must do to break through and be sure they understand what you have said.

Several years ago a large civilian airliner had an unsafe landing gear indication prior to landing at a city on the west coast. Preparations for a possible emergency landing were undertaken, and alternate gear indications were checked several times. All of this required time and fuel. Several times the flight engineer called out the decreasing fuel state to the captain (and copilot), but neither seemed to realize the gravity of the situation until the first engine flamed out from fuel exhaustion. Moments later the remaining engines flamed out. After listening to the cockpit voice recorder it was apparent that the engineer hadn't ever really gotten his message through. He had called out the fuel state in a calm voice, no urgency had been conveyed, and he had not broken through the barrier the captain had subconsciously erected against unsolicited communication. The flight engineer and several passengers died in the resulting crash.

Monitor. Be observant, know what is going on, be a part of the crew. Don't withdraw into your own shell and close the lid, or the shell could be your coffin. If you don't understand the action which is about to be taken or is underway, raise a question. It is a subordinate's duty to speak plainly to a superior if they perceive certain actions are hurting the mission. Every superior should consider the subordinate's viewpoint if it is rendered respectfully and is based on a genuine concern for the mission.

Listen to communications on the radio and the interphone. Be alert for missed calls or misunderstandings. If you think a mistake has been made, speak up and express your concerns. For example, if an Air Traffic clearance has been read back incorrectly the controller will usually pick it up, but not always. It's never out of line to ask for a clarification.

Contribute. A crew is not one man, but the entire complement assigned to the mission. Each man or woman has a definite contribution to make, particularly in their own area of expertise. The A/C doesn't have all the answers--no one person could--and they need your help to arrive at the best decisions. Avoid being a "yes" man. Give your honest opinion. Unless the A/C has all the facts they can't make an informed decision. If you have a suggestion to make which you think can contribute to the success of the mission, don't wait to be asked, but volunteer it to the A/C who should consider it if it is rendered respectfully. Once the decision is made to accept or reject your suggestion, be prepared to support the decision fully.

Technical and professional competence. Be the best you can be at your job. Take pride in what you do, set standards of yourself that equal or exceed those placed upon you by your superiors. Don't ever stop trying to be better. The A/C is unlikely to have the depth of knowledge you have in your specialty, consequently, he depends upon your help in guiding him to his decisions, especially when confronted with emergency or non-routine situations involving your area of expertise. But don't oversell yourself and scramble to catch up later. When you don't have an answer say you don't. Misleading the A/C isn't the way to accomplish the mission.

Sense of responsibility. Just as the captain is expected to subordinate his or her personal wishes and desires to the needs of MAC and the requirements of the mission, you must do the same. Just as the commander is expected to maintain a high standard of personal conduct, so should the subordinates. Don't let a seeming lack of responsibility by others influence you. You might be just the example the others need. Don't use your special knowledge or position for personal benefit.

Humor. A touch of appropriate humor in the aircraft can sometimes work wonders in establishing a relaxed atmosphere, an important characteristic of an effective work environment. Ideally, that touch will originate with the A/C, but don't let its absence preclude introduction. Some people, A/C's included, can appreciate humor, but just can't initiate it themselves. Your touch might be just what is needed to establish a relaxed and effective cockpit.

Developing a "Team" Concept

One of the most important functions of an effective leader is to develop a "team" concept within his/her group. By "team" concept we mean a feeling or motivation of to accomplish team goals over and above individual goals. The primary reason for using a team as opposed to an individual is to share the work so as to get the task done in a more timely and effective way. A second reason for using a team is to accomplish synergy or a higher level of performance than the best individual could perform alone.

In aviation we are trained to act as individuals rather than as members of a team. In virtually every flight test, we are judged on our individual performance. It is only very recently that some airline crews have been tested and passed (or failed) as a crew. For this reason, the team concept is somewhat difficult to teach to flight crews outside of the military.

An excellent exercise for learning the team concept is to attempt synergism in the performance of a task. Most CRM courses have exercises that can be used for this purpose. They consist of a problem, either from inside or outside of the aviation context, that each member is asked to perform individually. Then, the small group or "team" is brought together to attempt the solution of the problem as a team. If the team scores higher than the best individual within that team, it has achieved synergism. Synergism can best be achieved when all five of the communication concepts mentioned above in Chapter 6 (Inquiry, Advocacy, Listening, Conflict Resolution, and Critique) have been used by all individuals within the team. An excellent exercise for this purpose is:

The Caribbean Island Survival Exercise
Designs for Organizational Effectiveness
P.O. Box 1146
Fairfax, VA 22030
703-691-4056

Delegation

Another essential aspect of a good cockpit leader is an ability to delegate tasks to others, both for division of labor (task orientation) and to provide variety and experience to the other members of the crew (relationship orientation). In the cockpit, the captain is necessarily the leader primarily responsible for delegation. Although he or she gives up the specific task to other members of the crew, he or she still retains responsibility for its completion. Just as the delegator will obtain most of the benefits from the success of the mission, he or she must be willing to accept the risks involved.

Delegation begins with planning but continues as change takes place until the mission is completed. In planning with other crewmembers, the delegator should determine:

What has to be done?
Why?
How well?
When?
In what priority?
With what resources?
By whom?

Delegation should be made to each according to his interests, capabilities, and qualifications - not simply according to his position of authority in the cockpit. The delegator should obtain agreement among the crew for performance standards in terms of the quality and quantity expected, and the time of completion.

As the mission progresses and is completed, the following principles apply to the delegator:

1. Show interest in what is being done without overseeing so closely that the subordinate feels uncomfortable. Show satisfaction in a subordinate's performance front of others when it is justified.

2. Assess results in a non-threatening way.

3. Correct mistakes for the safe completion of the mission and to improve the performance of the subordinate - not to show why you have the position you do. Do not criticize the subordinate's failure.

4. Live with acceptable differences between the job that is done on your behalf and what you estimate you would have done yourself. People are different and quality, quantity, and method of work are bound to vary. Accept this principle as part of the price needed to complete the mission.

Other resources for leadership training and testing are:

The LEAD Test (Hersy and Blanchard)
Learning Resources Corporation
8517 Production Ave.
P.O. Box 26240
San Diego, CA 92126
714-578-5900
800-854-2143

Chapter 8: STRESS MANAGEMENT

You may be asking yourself, 'What does stress management have to do with decision making and CRM?' The answer is that stress is one of the most important forces affecting our ability to make logical decisions. While technical flying skill is somewhat immune, headwork is often adversely affected by stress. It causes us to have 'tunnel vision,' or a narrow point of view. We do not see all of the information that may be in front of us and we have difficulty making choices from among alternatives. In its most insidious form it is called panic during which we may even lose control of our motor coordination.

The second reason for this section is that decision making activities (and often the lack thereof), is one of the leading causes of stress. The simple commitment to make a flight, whether self-imposed or placed on us by others, can cause a great deal of mental stress that can lead to all of the problems mentioned above. Such pressure is one of the leading causes of workload in the cockpit and can cause us to fail to allocate the necessary attention to the task of flying the airplane.

The third reason is that one of the most significant and universal results of stress is a reduction in verbal communication. Thus, learning to deal effectively with the stress is another important aspect of CRM training.

The growing interest in stress in our society reflects the widespread awareness that stress is related to many physical and mental disorders, and to a large number of accidents in homes as well as aircraft. In this section, we examine stress as it affects our lives, in general, and our flying performance, in particular. Simply recognizing the involvement of stress does not necessarily solve the problem. It is necessary to understand how to cope with it as well. Suggestions are made to help you deal with stress more effectively.

Stress has a cumulative effect; some degree of stress can be of assistance in some situations, and stressors which persist over a long period can severely affect our performance and health. So stress would seem to have a positive effect on performance when it is low, performance will peak at an optimum level of stress, then decline as stress increases further. Furthermore, complex or unfamiliar tasks require a higher level of attention than simple or over-learned tasks. Complex and unfamiliar tasks also are adversely affected by increasing levels of stress other than those which are over-learned or simple.

Everyone operates most effectively at some moderate level of stress (Yerkes and Dodson, 1908). The relationship between stress and performance that has been verified in numerous experiments. The relationship between stress and performance that has been verified in numerous experiments is illustrated in Figure 7. At very low levels of stress, motivation and attention are minimal and, as a consequence, performance is poor. As the level of attention and motivation increase (and stress), so does performance. However, at very high levels of stress, panic ensues and performance deteriorates dramatically.

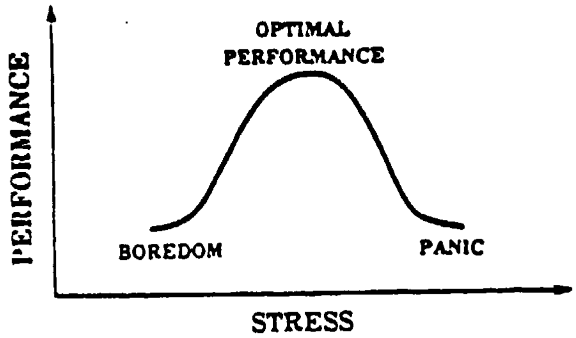

Figure 7. Relationship between stress and performance.

<u>What is Stress</u>?

Stress is the term used to describe the body's nonspecific response to demands placed upon it, whether these demands are pleasant or unpleasant. There are two broad categories of stress: chronic and acute. Chronic stress is the result of long-term demands placed on the body by life events both positive and negative. Acute stress results from demands placed on the body by the task at hand.

The demands for you could be an unexpected windshear encountered on landing, a higher than expected headwind forcing you to consider a different destination for your flight, losing your wallet, or cutting your finger. The human body responds to these and all other demands in three stages: First, there will be an alarm reaction; then resistance; and finally, exhaustion (if the demand continues). This three-stage response is part of our primitive biological coping mechanism which would have prepared our ancestors for 'fight or flight.'

In the alarm stage, the body recognizes the stressor and prepares for fight or flight by activating a part of the brain which stimulates the pituitary gland to release hormones. These hormones trigger the adrenal glands to pour out adrenaline. Adrenaline increases heartbeat and rate of breathing, raises blood sugar level, increases perspiration, dilates the pupils, and slows digestion. If the alarm results in <u>fear</u>, the body reacts with low blood pressure resulting in a pale face. The process results in a huge burst of energy, greater muscular strength, and better hearing and vision. You may recall experiencing such an alarm reaction during your early flying, for example, a sudden buffeting on late finals. You may recall the effects of your body's alarm reaction.

The body's reaction to anger in this stage, however, is quite different. Contrary to the alarm reaction to fear, the <u>anger</u> reaction results in the secretion of nor-adrenaline which results in a physiological reaction of high blood pressure as can be seen in the red face. In some ways the stress on the body produced by anger is much more dangerous than that produced by fear. In the short term solution to the immediate problem, the production of adrenaline causes a greater level of alertness (to a certain point) which permits a greater capability to find a solution. The long term results are not harmful unless they are very severe and lasting. On the other hand, the effects of anger, secretion of nor-adrenaline, cause high blood pressure which in the short term does not assist in the development of a solution to an immediate problem and in the long term can be very dangerous to one's health. These two types of stress should be kept in mind while studying this section. In particular, anger needs to be avoided in flying situations.

In the resistance stage, the body repairs any damage caused by the stress and may adapt to some stresses such as extreme cold, hard physical labor, or worries. Fortunately, most physical and emotional stressors are of brief duration and our bodies cope with the physiological demands of the stress. During our lifetime, we go through the first two stages many times. We need these response mechanisms to react to the many demands and threats of daily living.

However, if the stress continues (for example, if you were caught above clouds flying VFR or realize that you may not reach your destination because of a fuel shortage), the body will remain in a constant state of readiness for fight or retreat. It may be unable to keep up with the demands, leading to the final stage which is exhaustion. With exhaustion almost all control is lost as the mind is no longer able to keep a proper perspective. Sometimes pilots will resign themselves to their fate at this point.

In flying, accidents often occur when the task requirements exceed pilot capabilities, especially when stressors such as fatigue, illness, and emotions are involved. The difference between pilot capabilities and task requirements are shown in the "Margin of Safety" diagram shown in Figure 8. The margin of safety is minimal during the approach when task requirements are highest and pilot capabilities due to fatigue are reduced. If an abnormality or distraction occurs to make the task unexpectedly higher, or if the pilot's capabilities are further reduced due to strong emotions such as anger, lack of sleep, illness, alcohol, etc., an accident is risked.

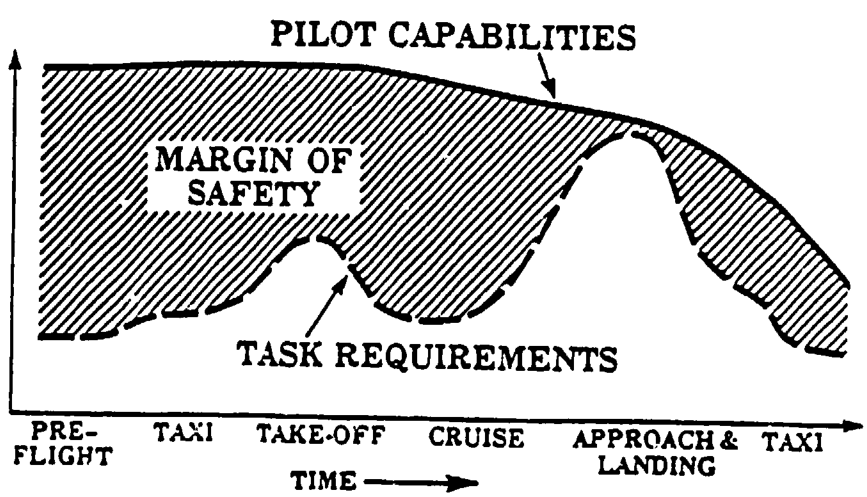

Figure 8. Conceptual diagram of margin of safety over the duration of a typical flight.

The Effects of Personality

There is no question that personality influences the way that we react to stress. Some people have personality styles that may contribute to stress related disorders. They may feel so fearful of making mistakes, of being criticized, of doing less than a perfect job that they withdraw from challenging situations or avoid confrontations, which result in feeling unfulfilled, frustrated, incompetent. As children, they may have learned that expressing feelings, such as anger, can get us into trouble. Thus, they express their anger indirectly or deny it altogether.

Cardiologists have described two personality types which have been linked with certain diseases. Type A behavior has been seen as a major cause of coronary heart disease and is characterized by a competitive, aggressive, achievement-oriented, time-dominated orientation to life. Type A people are usually unaware that their behavior creates problems for others or is detrimental to their health and well-being, since this behavior is condoned and applauded by our achievement-oriented society.

The behavior of a Type B person, in contrast, is everything Type A people reject. Type B individuals have found a comfortable, more relaxed pace. They look at scenery with enjoyment, allow time for frequent refreshment and rest stops, really enjoy being alone or with friends and family. Type Bs work more slowly and thoughtfully, which can permit greater creativity. They allow themselves the leisure to develop more fully as people, and have a number of outside interests, activities, and friendships. Many Type Bs have plenty of drive and achievements, but time is scheduled with a calendar, not a stopwatch. If you recognize the Type A pattern in yourself, you should consider modifying your life style. Not only will it make you a safer pilot but you will live longer as well.

How Much Stress is in Your Life?

If you hope to succeed at reducing stress associated with crisis management in the air, or with your job, it is essential to begin by making a personal assessment of stress in all areas of your life. You may face major stressors such as loss of income, serious illness, death of a family member, change in residence, or birth of a baby, plus a multitude of comparatively minor positive and negative stressors. These major and minor stressors have a cumulative effect which constitutes your total stress-adaptation score which can vary from year to year. To enhance your awareness about the level and sources of stress in your life, complete the following questionnaire. Circle the number to the left of each event listed that you have experienced in the last 12 months. Total your score at the end of the questionnaire.

Life Events Stress Profile

Life Change Units	Life Event
100	Death of spouse
73	Divorce
65	Marital separation
63	Jail term
63	Death of close family member
53	Personal injury
50	Marriage
47	Lost your job
45	Marital reconciliation
45	Retirement
44	Change in health of family member
40	Pregnancy
39	Sex difficulties
39	Gain of new family member
39	Business
38	Change in financial state
37	Death of close friend
36	Change to different line of work
35	Change in number of arguments with spouse or partner
31	Mortgage or loan over $10,000
30	Foreclosure of mortgage or loan
29	Change in responsibilities at work
29	Son or daughter leaving home
29	Trouble with in-laws or partner's family
28	Outstanding personal achievement
26	Spouse or partner begins or stops work
26	You begin or end work
25	Change in living conditions
24	Revision of personal habits
23	Trouble with boss or instructor
20	Change in work hours or conditions
20	Change in residence
20	Change in school or teaching institution
19	Change in recreational activities
19	Change in church activities
18	Change in social activities
17	Mortgage or loan less than $10,000
16	Change in sleeping habits
15	Change in number of family social events
15	Change in eating habits
13	Vacation
12	Christmas
11	Minor violations of tha law

Total Life Change Units __________ .

Interpreting the Life Stress Scale

The more change you have, the more likely you will suffer a decline in health. In a pilot study, it was found that of those persons who reported LCUs (life change units) that totaled between 150 and 199, 37 percent had associated health changes within a 2-year period of such life crises. Of those who had between 200 and 299 LCUs, 51 percent reported health changes, and for those with over 300 LCUs, 79 percent had associated injuries or illnesses to report. On the average, health changes followed life crises by one year.

If you have a high LCU score, it does not necessarily mean you will get sick or have an accident. Each of us has a personal stress adaptation limitation. When we exceed this level, stress overload may lead to poor health or illness. To avoid exceeding your personal limit, learn to recognize the warning signals from your body and mind those that tell you when your stress level is getting too high. When you observe warning signs, it is time to take preventative action. Some of the typical warning signs are given below.

Time and Stress

The urgency of time drives most of us. No where is this more evident than in piloting an aircraft. Multiple tasks must be performed simultaneously to get them done at all. Fuel remaining is directly related to time. Passenger requirements and economy of operation are often directly related to time. Demands often exceed the time available and overloading means that stress response is dangerously aroused. Irritability, impaired judgment, hypertension, headaches, and indigestion are frequent early signs of distress and potential illness. This is of crucial concern in the field of general aviation where one person must often make all of the decisions and perform all of the tasks alone.

Each person has a fairly well-defined sense of time urgency within which he or she works effectively and gains a sense of accomplishment. Beyond this comfort zone of reasonable time pressure, deadlines threaten, time seems to run out, there is not enough recovery time for a change of pace, and the person begins to feel over-stressed.

It is important that pilots learn to recognize their personal warning signs of racing against time so as to avoid that source of stress. The following could be your symptoms of chronic overload:

Do you?:

Rush your speech?
Hurry or complete other people's speech?
Hurry when you eat?
Hate to wait in line?
Never seem to catch up?
Schedule more activities than you have time available?
Detest 'wasting' time?
Drive too fast most of the time?

Often try to do several things at once?
Become impatient if others are too slow?
Have little time for relaxation, intimacy, or enjoying your environment.

Most of us go back and forth between such hurried behavior and a more relaxed schedule, but if you answered 'yes' to most of the above, you may be suffering from chronic overload. Greater distress is not inevitable. Some people can and do live faster lives, because their bodies and minds can handle a faster pace. Others learn to adjust to a faster pace. You can learn ways to remain healthy while living faster. But the chances of distress are greater, especially if you are not aware of the dangers or do little or nothing about them.

A frequent reaction to time pressure is juggling, attempting to cram several activities into insufficient time. The human brain seems to lack the capacity to perform many simultaneous conscious operations efficiently because one task may interfere with another. Too many pressures can lead to distress and into the poor judgment chain.

Accident data suggest that most mishaps result from a series of poor pilot decisions which may be called, 'The Poor Judgment (PJ) Chain.' One erroneous decision increases the probability of another and as the PJ chain grows, the chances for a safe conclusion to the flight decrease. Research has shown that errors lead to workload increases (Hart and Bortolussi, 1983) which compounded with the knowledge of the error greatly increases stress - and the probability of more errors. The best strategy for dealing with an error, whether decisional or flight control, is to break the PJ chain by 1) acknowledging the error and 2) taking action immediately to correct the error. Overloading either your mind or your aircraft can kill you.

<u>Lead-Time and After-Burn</u>

Associated with any activity are two necessary time periods - lead-time and after-burn. Consider, for example, an instructor facing an upgrading examination. Anticipatory stress is often useful in moderate amounts, because it prepares both your body and mind for what is about to happen. It increases sharpness and motivation, but it can also be an interference. A person pays more attention to what may happen rather than to what is happening. This reaction can cause pilots to 'get behind' their aircraft causing more time pressure and distress.

After-burn is the time needed after the test to think about results and to set the experience to rest. If there is not enough time to 'come down' - to relieve tensions built up during the anticipatory stage and the pressures of the review - then the energy that surged during the experience will not be released, and the body and mind will remain stressed. A fast pace, especially if it is led by someone who needs quite a bit of lead-in and after-burn time, can be a significant source of tension, stress, and disease. Have you experienced the sore back or stiff neck which sometimes result?

Coping with Stress

As stated previously, stress is the product of an entire life-style. It is not just the product of an occasional crisis. Consequently, each person must learn to monitor personal internal arousal levels and find ways to relieve stress. Health can be protected by using constructive coping responses to balance stress. For example, you can simply take a five minute break and relax. In flying, the appropriate time might be after reviewing the approach procedure and before contacting the approach controller.

One of the best ways to cope with stress over all is to use the 'Total Body Approach' or the 'Wellness Concept.' The objective of this concept is to attack the problem before it becomes serious. The total body approach takes account of all six aspects of well-being:

1. Physiological
2. Nutritional
3. Environmental
4. Emotional
5. Spiritual
6. Life-style values

What you do in one of these areas supports, enhances, and capitalizes on action in the other areas. For instance, poor eating habits may increase your stress level, leading to weight problems and lack of vitality. This lack of energy may slow down productivity and lead to increased pressure at home and at work to get things done. The pressure can lower your self-esteem or defensive behaviors, thus, throwing your entire life-style out of balance and increasing your stress to unhealthy levels.

Behaviors consistent with good health and low stress are:

1. Minimizing or stopping activities detrimental to your health, such as drinking to excess or smoking.

2. Increasing health-producing behaviors such as relaxing at regular intervals.

3. Using self-regulation and self-control information, such as appropriate time management and thought stopping (deliberately stopping yourself from thinking negatively).

4. Being trained in health promotion strategies and technologies. these would include simple techniques as 'time out' (a five-minute shut down when you recognize that stress is increasing - you can do this quite effectively in your workplace), or taking the phone off the hook if you need to solve one problem at a time.

5. Accepting responsibility for your own health, by developing a stress reduction program.

Flexibility and a creative range of coping behaviors enable people to handle considerable stress. A limited coping repertoire may be harmful. For instance, if eating or drinking is the primary coping response to stress, obesity or alcoholism is like to present its own problems. It is a bad idea to use 'addictive' solutions to handle life stressors. Other potentially destructive responses include violence, procrastination, drug abuse, overwork, poor sleeping habits (sleep disorder), compulsive spending sprees, total withdrawal, and caustic remarks. They make a problem worse or initiate a new one rather than solve anything.

Living with distress is perhaps the least acceptable approach to dealing with stress. It may be necessary for short periods of time, but it does not promote long-term health. For instance, the intensity with which a concert pianist prepares for a Sydney Opera House performance is both invigorating and gruelling. The temporary sacrifice is made to reach a goal, but does little lasting harm. Unfortunately, some people are almost addicted to stress and go to great lengths to create distressful situations. These people not only live with distress, they wallow in it, playing out 'loser' and 'poor me' life scripts or showing how tough they are.

Withdrawing from the stressor is another coping response that enables one to get away from a distressful situation when other approaches have not reduced the distress. Leaving the scene for a while by recessing a meeting or taking a walk, a day off, a nap, or a vacation can be healthy responses to restore vitality and relieve overload. If you are in a commercial flying job in which you are constantly facing a superior who places all the responsibility on you for 'no-go' decisions, it may be time to withdraw.

However, like other coping responses, this approach can be constructive or destructive, depending upon when and how it is used. It can provide a change of pace and renewal or it may merely be a means of escape and, in fact, create more stress. This avoidance technique can create further problems unless it is used as a means of reducing the present level of stress, and not a way of withdrawing from the problem or its solution.

A more permanent move, such as changing your job, place of residence, or relationship, should be considered as a last resort in most cases. When the stressor cannot be changed (for instance, the crowding and noise of city life) and to remain in the same environment would mean living with perpetual distress, withdrawal may be the most viable coping response. But usually there are alternatives by means of which you can moderate the negative stressors in your life without leaving the stressful situation.

Changing how you relate to the specific stressors in your life means altering the relationship between yourself and the demands. The source of your tension may be an over-demanding chief pilot who assigns you a flight late in the day when you when you are already fatigued and then berates you for falling behind schedule. Being more assertive and candid with your boss about your work schedule and time demands, suggesting alternatives, and understanding his scheduling problems can defuse the daily tension. Other ways of changing the stress link are:

Developing new skills
Establishing a support network of close friends
Being more diplomatic

Being tolerant of others' imperfections and your own
Broadening your perspective

Although some situations are beyond our control (for example, the erratic movement of a low pressure system into your flight path and incomplete maintenance release), this is not true for all stressors. You can change many features in your environment that adversely affect your safety, health, and self-development. For instance, you can change others' actions toward you to the degree to which you alter your behavior. Distractions or discomfort associated with heat, light, or noise can often be simply controlled. Frequently changing jobs, cities, homes, or partners could overload your coping mechanism. The ideal is to change those things you can and accept those you cannot change by tolerating them and recognizing your own limitations.

There are several ways to lower the stress experienced when a situation cannot be changed. Some of these can be used even during a flight. Others would not be recommended in flight, but would require a more long-term solution. These suggestions are:

Moderation
Relaxation
Exercise
Communication with confidant
Professional counselling and therapy
Rest
Religious faith and practice

The selection of specific ways of managing stress is a matter of individual choice and circumstances. Consider:

1. In what ways will a particular choice or action promote your own good health and minimize distress?
2. In what ways will your efforts promote the health and development of others and reduce distress?

Stress is, thus, mobilized as a positive force.

Here is an exercise to try right now. Close your eyes and recall the last time you felt distressed. Try to recall how you reacted to that stress. Decide if it was primarily a physical and mental reaction. Many of us, when under intense stress, react both physically and mentally, but most of us favor one mode or the other. When you have a good idea of your usual mode of expression, open your eyes.

We will now review three modes of reacting to stress and describe some methods that work well for each mode. Think about the method which might best suit your needs. The first mode of reacting to stress is with our bodies. The following techniques are useful for those people who suffer physical symptoms such as headaches, backaches, stiff necks, tense or rigid bodies, ulcers, high blood pressure. These techniques take some time to learn. The effectiveness of each is dependent upon regular and considered use.

Deep muscle relaxation is a passive process that involves getting yourself into a relaxed position on a comfortable chair or lounge and then focusing your attention on various muscle groups throughout the body. First you tense, then release each group of muscles while saying to yourself 'Relax, relax, relax.' to build up an association between mental process and physical relaxation. Eventually it enables automatic relaxation when one thinks 'Relax'.

Progressive relaxation is a similar technique, except that you do not tense your muscles. Instead, you mentally suggest relaxation by thought like, 'My feet are completely relaxed, my feet are completely relaxed', while consciously relaxing foot muscles. Progressive relaxation is often accompanied by deep breathing or visualization techniques.

Deep breathing exercises can reduce tension by producing a deep state of calmness and relaxation. When you breathe softly and slowly, it is difficult for your emotions to become aroused out of a tranquil state. Several disciplines include breathing exercises as part of their relaxation strategies. In yoga, 'pranayama', or control of the life force, is an important study. Since we all have to breathe anyway, controlling your breathing is a quick and easy way to help relieve tension.

Other Coping Responses

We can improve our internal environment by training and shaping our minds. Loosening up inhibitions, overcoming our limitations, and working on developing a positive attitude toward life are all important aspects of a well-rounded, stress-controlled existence. Consider how you can use these strategies to help yourself deal with stressful concerns. These strategies will be helpful both in dealing with daily stress levels but also reduce the chance of high stress levels and panic in flight situations.

Develop a positive attitude towards life. Put stressors in a favorable context. Some stress is useful or necessary, remember? Recognize the beneficial aspects of stress, and use the power of positive thinking. Your attitude determines whether you perceive any experience as pleasant or unpleasant.

Many of us take things too seriously and need to learn to take one thing at a time. When we worry too much we need diversion, something to put in the place of worrying a pleasant thought. A though stoppage (Stop negative thought patterns by shouting words like 'stop' or 'no' in the middle of an anxious series of thoughts), or a change of scene (e.g. going to a movie, reading, visiting a friend, doing something to escape from your routine) are useful.

Inactivity is a serious health hazard. Exercise is one of the key elements to long life because it protects us by preventing or reversing physical illness, reduces physical tension and anxiety, and increases the quality of our lives. Aviation, for the most part, is a sedentary activity. We sit in an aircraft for long periods without any physical exertion. Health researchers strongly recommend that we build into our weekly activities at least three, 30-minute periods of some vigorous exercise. They add two important cautions:

1. Strenuous exertion by a middle-aged, overweight, sedentary person can be hazardous. For such persons, a medical evaluation is essential before beginning an exercise program.

2. Exercise alone will not reduce risk of coronary heart disease.

An important part of any stress management program is a nutritionally sound diet. The medical profession has provided a number of excellent suggestions for reducing stress through sound nutritional habits. Read and follow these dietary suggestions.

There is no panacea to help us manage stress. Our chances of success are increased if we take an overall approach to managing stress by giving attention to the three areas: physical, mental, and emotional.

Stress and Flying

In flying, we must consider three classes of stressors: physical, physiological, and psychological. Physical stressors include conditions associated with the environment such as temperature and humidity extremes, noise, vibration, and lack of oxygen: often encountered in flight. Physiological stressors include fatigue, lack of physical fitness, sleep loss, missed meals which have led to a low blood sugar level, discomfort associated with a full bladder or bowel, and disease. Psychological stressors are the social or emotional factors related to life stressors which we dealt with earlier, or they may be precipitated by mental workload such as analyzing an aircraft or navigational problem in flight. When you need to consider only one thing at a time to reach a decision, you generally will have no difficulty making a decision. In flight, however, you will frequently have to deal with many situations simultaneously. Sometimes decisions are based on incomplete information within a short time period.

For example, in a cross-country flight, you may realize that you are much lower on fuel then you expected. The clouds ahead appear to be building, and there is considerable static on the radio. You are off course and you can't seem to find a familiar ground reference point. On top of this, you failed to take a comfort stop before the flight and you now have a full bladder. The cabin heater is not functioning properly, and you are now starting to encounter turbulence. You now have many things on your mind. You begin to worry about arriving at your destination on time and missing an important appointment. You begin to worry about a forced landing and damaging the aircraft which a friend was not keen on lending you in the first place.

Your palms are now beginning to become sweaty and your heart is starting to pound. You feel a growing tension, and your thinking is becoming confused and unfocused. You may give too much attention to the 'what if' questions which should be ignored. You are reaching, or have already reached the overload state. It is probable that you will begin to make poor decisions. These might include pressing on into bad weather, or overflying good landing areas until you are almost out of fuel.

There can, thus, be plenty of stress with which to cope in the flying environment itself without adding to them the burden of your life stressors.

On the other hand, your life stressors may be sufficiently great already that one poor (initial) in-flight decision can lead to a dangerous compounding of stress-related conditions. Stress effects are cumulative. They will eventually build to a point where the burden is intolerable unless you know how to cope.

In flying, accidents often occur when the task requirements exceed pilot capabilities, especially when stressors such as fatigue and emotional complications are involved. The margin of safety is minimal during the approach when task requirements are highest and pilot capabilities due to fatigue are reduced. If an abnormality or distraction occurs here to make the task unexpectedly higher, or if the pilot's capabilities are further reduced due to strong emotions such as anger, lack of sleep, illness, alcohol, etc. an accident is risked.

There is no panacea to help us manage stress. Our chances of success are increased if we take an overall approach to managing stress by giving attention to the three areas: physical, mental, and emotional. Complete the following guide for stress reduction.

1. One way I can reduce unnecessary noise and irritations around me is to:

2. The amount of sleep I need each day in order to be maximally alert and able to cope with stress is:

3. I presently get that amount of sleep or rest.

   Yes_____ No_____

4. (For those who answered No to #3):

   A way I could rearrange my schedule in order to get enough sleep is:

5. Some changes or crises I foresee over the next year are:

6. Ways I can deal with these stresses are:

7. Identify kinds of stress you experience.

   When does it occur?
   How frequently?
   Under what conditions does it occur?
   Are any bad habits involved (Refer to the 5 hazardous attitudes)?

8. Prioritize which stresses concern you most. Choose one to work on first.

9. Review coping methods you've tried with what success, failure?

10. Consider possible solutions:

    Which can be implemented with most ease?
    Who can help with implementation?

11. Resources:

    Physical. What is your level of health, energy, sleep requirements?

    Emotional. Honestly appraise your emotional strengths and weaknesses.

    Social. How well do you relate to others? Do you have others you can turn to for support or help with problems?

    Intellectual. Give yourself credit for your abilities and interests.

    Spiritual. Your beliefs about what really matters.

And Remember: "A superior pilot uses his superior judgment to avoid stressful situations that require the use of his superior skills."

Anon

Most pilots give their aircraft a thorough preflight, yet many forget to preflight themselves. The following I'M SAFE checklist is a short summary of the material presented in this chapter and may be useful to you as a part of your flight preparation:

ARE YOU FIT TO FLY?
THE "I'M SAFE" CHECKLIST

I llness?	Do I have any symptoms?
M edication	Have I been taking prescription or over-the-counter drugs?
S tress?	Am I under psychological pressure from the job? Do I have money, health or family problems?
A lcohol?	Have I had anything to drink in the last 24 hours? Do I have a hang-over?
F atigue?	How much time since my last flight? Did I sleep well last night and am I adequately rested?
E ating?	Have I eaten enough of the proper foods to keep me adequately nourished during the entire flight?

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GLOSSARY

ACTIVE LISTENING: The skill of hearing and understanding another person and communicating it back. Placing yourself in the other person's place, responding with what you feel the sender said to check the accuracy or your understanding.

ADVOCACY: The act or process of stating, defending or maintaining a cause or proposal. Speaking when you believe the operation can be improved or when a possible error is sensed.

AGGRESSIVE BEHAVIOR: Forceful statements or actions, especially when intended to dominate or master. High in task orientation, low in relationship orientation. High concern for self-rights.

ASSERTIVE BEHAVIOR: Confident, positive statements or actions with openness toward other points of view. High in both task and relationship orientation. Concern for both self and other's rights.

AUTONOMOUS BEHAVIOR: Independent, self-reliant statements or actions with minimum outside input. Low in both task and relationship orientation.

CONFIRMATION: Acknowledging and accepting a message.

CONFLICT: An interpersonal event arising when individual or group needs and goals are incompatible or when parties perceive themselves in a win-or-lose situation.

CONSTRUCTIVE FEEDBACK: A descriptive, specific, well timed response focusing on modifiable behavior, promoting openness and trust.

CREATIVE LISTENING: The act of listening for what the other person intends, rather than listening to the spoken word.

CREW ORIENTATION: The initial crew interaction that promotes open and candid communications.

CRITICAL LISTENING: The act of discriminating between what is said and what is left unsaid.

CRITIQUE: The act of giving constructive feedback concerning the merits and demerits, based on knowledge.

DECISION-MAKING: The process of selecting a course of action from available options, based upon whatever information is available at the time.

DESIGNATED LEADER/FOLLOWER: The leader/follower established by social order or appointment.

DISCONFIRMATION: ignoring the sender and the message entirely.

DISCRETIONARY BEHAVIOR: That behavior for which specific procedures are not established in existing regulations, directives, and technical publications.

ESPOUSED THEORY: An individual's account or explanation of his/her behavior. "How I say and believe I will behave."

FEEDBACK: Response messages which clarify and ensure meaning is transferred.

FLIGHT TEAM LEADERSHIP: The distributed exercise of influence, in a particular situation, between the leader and the followers in order to reach specific goals.

FUNCTIONAL FOLLOWER: The person who defers to the person who has the most information and who has assumed the functional leadership.

FUNCTIONAL LEADER: The person in charge as defined by the moment and the situation. The person who, momentarily and temporarily, has the most information or knowledge about the current situation.

GROUP THINK: When a crew readily accepts and follows a functional leader's perception of the situation without critical analysis or examination; ie Non-Thinking, Non-Inquiring followership.

HUMAN FACTORS: Any combination of human attributes, characteristics, or limitations that in any way affect the crew-airplane-environment-mission-management relationship.

INFORMATION OVERLOAD: A condition where too much information is available.

INFORMATION UNDERLOAD: A condition where too little information is available.

INQUIRY: Actively seeking out relevant information.

NURTURING BEHAVIOR: Statements or actions of caring, support, or concern for the well-being of others. High relationship and low task orientation. High concern for the rights of others.

OPERATIONALLY RELEVANT COMMUNICATIONS: Those task-oriented interpersonal communications that are directly involved and related with command, control, and mission accomplishment.

OUTSIDER CREWMEMBER: The effect a new crewmember has on an existing crew. This changes the already established crew behavior pattern, and can result in intimidation and uncertainty in existing crewmembers.

REJECTION: Acknowledging the message, but not accepting it.

RELATIONSHIP ORIENTATION: Characterized by actions of concern for the maintenance of a relationship with other crewmembers. Actions based on the belief that "as long as the crew likes each other, the job will get done."

SELF-CONCEPT: The mental image you have of yourself; how people see themselves and their situation.

SELF-ESTEEM: A confidence and satisfaction with yourself.

SEMANTIC DISTORTION: A condition that occurs when either or both the speaker and listener assume they understand what is said.

SERIAL DISTORTION: A condition that occurs when the intended meaning of a message is changed as the message passes from person to person.

SITUATIONAL AWARENESS: A realization of what is going on at the moment in relation to what has gone in the past and what may go on in the immediate future.

STATUS DIFFERENTIAL: A perception that your rating or position is unequal to the rating or position of other persons in a social order, class, or profession.

SYNERGY: The total performance of the crew is greater than the performance of the best individual within the crew. It is achieved by working together, cooperating, seeking the most relevant information from each crewmember and placing the importance of the team above that of any individual on the team.

TASK ORIENTATION: Characterized by actions of controlling, directing, and organizing with a minimum of two-way communication.

TASK OVERLOAD: An occurrence when activity, which is at a maximum leads to frustration and anger.

TASK UNDERLOAD: An occurrence when activity, which is at a minimum, leads to complacency and boredom.

THEORY IN PRACTICE: The set of skills, knowledge, and experience one calls upon according to his/her theory of the situation.

THEORY OF THE SITUATION: What one assumes to be true based on the facts one has at any point in time.

THEORY IN USE: One's predictable behavior in a given situation that has been developed since birth.

APPENDIX A:

NATIONAL TRANSPORTATION SAFETY BOARD

AIRCRAFT ACCIDENT REPORT

UNITED AIRLINES, INC
PORTLAND, OREGON

December 28, 1978

NATIONAL TRANSPORTATION SAFETY BOARD

AIRCRAFT ACCIDENT REPORT

UNITED AIRLINES FLIGHT 173
PORTLAND, OREGON

December 28, 1978

SYNOPSIS

About 1815 Pacific standard time on December 28, 1978, United Airlines, Inc., Flight 173, a DC-8-61, crashed into a wooded, populated area of suburban Portland, Oregon, during an approach to the Portland International Airport. The aircraft had delayed southeast of the airport at a low altitude for about 1 hour while the flight crew coped with a landing gear malfunction and prepared the passengers for a possible emergency landing. The plane crashed about 6 nmi southeast of the airport. The aircraft was destroyed; there was no fire. Of the 181 passengers and 8 crewmembers aboard, 8 passengers, the flight engineer and a flight attendant were killed and 21 passengers and 2 crewmembers were injured seriously.

The National Transportation Safety Board determined that the probable cause of the accident was the failure of the captain to monitor properly the aircraft's fuel state and to properly respond to the low fuel state and the crewmember's advisories regarding fuel state. This resulted in fuel exhausted to all engines. His inattention resulted from preoccupation with a landing gear malfunction and preparation for a possible landing emergency.

Contributing to the accident was the failure of the other two flight crewmembers either to fully comprehend the criticality of the fuel state or to successfully communicate their concern to the captain.

ANALYSIS

The flight crew was properly certificated and each crewmember had received the training and the off-duty time prescribed by applicable regulations. There was no evidence of medical problems that might have affected their performance.

The aircraft was certificated and maintained according to applicable regulations. The gross weight and c.g. were within prescribed limits. Except for the failure of the piston rod on the right main landing gear retract cylinder assembly and the failure of the landing gear position indicating system, the aircraft's airframe, systems, structure and powerplants were not factors in this accident.

The investigation revealed that fuel was burned at a normal rate between Denver and Portland. The aircraft arrived in the Portland area with the pre-planned 13,800 lbs of fuel and began its delay at 5,000 ft with about 13,334 lbs.

The first problem which faced the captain of Flight 173 was the unsafe landing gear indication during the initial approach to Portland International Airport. This unsafe indication followed a loud thump, and abnormal vibration and an abnormal aircraft yaw as the landing gear was lowered. The Safety Board's investigation revealed that the landing gear problem was caused by severe corrosion in the mating threads where the right main landing gear retract cylinder assembly actuator piston rod was connected to the rod end. The corrosion allowed the two parts to pull apart and the right main landing gear to fall free when the flightcrew lowered the landing gear. This rapid fall disabled the microswitch for the right main landing gear which completes an electrical circuit to the gear-position indicators in the cockpit. The difference between the time it took for the right main landing gear to free fall and the time it took for the left main landing gear to extend normally, probably created a difference in aerodynamic drag for a short time. This difference in drag produced a transient yaw as the landing gear dropped.

Although the landing gear malfunction precipitated a series of events which culminated in the accident, the established company procedures for dealing with landing gear system failure(s) on the DC-8-61 are adequate to permit the safest possible operation and landing of the aircraft. Training procedures, including ground school, flight training, direct the flight crew to the Irregular Procedures section of the DC-8 Flight Manual, which must be in the possession of crew members while in flight. The Irregular Procedures section instructed the crew to determine the position of both the main nose and landing gear visual indicators. "If the visual indicators indicate the gear is down, then a landing can be made at the captain's discretion." The flight engineer's check of the visual indicators for both main landing gear showed that they down and locked. A visual check of the nose landing gear could not be made because the light which would have illuminated that down-and-locked visual indicator was not operating. However, unlike the main landing gear cockpit indicators, the cockpit indicator for the nose gear gave the proper "green geardown" indication.

Admittedly, the abnormal gear extension was cause for concern and a flight-crew should assess the situation before communicating with the dispatch or maintenance personnel. However, aside from the crew's discussing the problem and adhering to the DC-8 Flight Manual, the only remaining step was to contact company dispatch and line maintenance. From the time the captain informed Portland Approach of the gear problem until contact with company dispatch and line maintenance, about 28 min had elapsed. The irregular gear check procedures contained in their manual were brief, the weather was good, the area was void of heavy traffic and there were no additional problems experienced by the flight that would have delayed the captain's communicating with the company. The company maintenance staff verified that everything possible had been done to assure the integrity of the landing gear. Therefore, upon termination of communications with company dispatch and maintenance personnel, which was about 30 min before the crash, the captain could have made a landing attempt. The Safety Board believes that Flight 173 could have landed safely within 30 to 40 min after the landing gear malfunction.

Upon completing communications with company line maintenance and dispatch, the captain called the first flight attendant to the cockpit to instruct her to prepare the cabin for a possible abnormal landing. During the ensuing discussion, the captain did not assign the first flight attendant a specified time within which to prepare the cabin, as required by the flight manual. In the absence of such time constraint, the first flight attendant was probably left with the impression that time efficiency was not necessarily as important as the assurance of thorough preparation.

The Safety Board believes that any time a flight deviates from a flight plan, the flightcrew should evaluate the potential effect of such deviation on the aircraft fuel status. This flightcrew knew that the evaluation of the landing gear problem and preparation for an emergency landing would require extended holding before landing.

The flightcrew should have been aware that there were 46,700 lbs of fuel aboard the aircraft when it left Denver at 1433 and that there was about 45,650 lbs at takeoff at 1447. Regardless of whether they were aware of the actual fuel quantities, they certainly should have been aware that the initial fuel load was predicated on fuel consumption for the planned 2 hr 26 min en route flight, plus a reserve which includes sufficient fuel for 45 min at normal cruise and a contingency margin of about 20 min additional flight.

Therefore, the crew should have known and should have been concerned that fuel could become critical after holding. Proper crew management includes constant awareness of fuel remaining as it related to time. In fact, the Safety Board believes that proper planning would provide for enough fuel on landing for a go-around should it become necessary. Such planning should also consider possible fuel-quantity indication inaccuracies. This would necessitate establishing a deadline time for initiating the approach and constant monitoring of time, as well as the aircraft's position relative to the active runway. Such procedures should be routine for all flightcrews. However, based on available evidence, this flightcrew did not adhere to such procedures. On the contrary, the cockpit conversation indicates insufficient attention and a lack of awareness on the part of the captain about the aircraft's fuel state after entering and even after a prolonged period of holding. The other two flight crewmembers, although they made several comments regarding the aircraft's fuel state, did not express direct concern regarding the amount of time remaining to total fuel exhaustion. While there is evidence to indicate that the crew was aware of the amount of fuel remaining at various times, there is no evidence that the onboard quantity was monitored in relation to time remaining during the final 30 min of flight. The Safety Board believes that had the flight crew been aware of the fuel state, comments concerning time to fuel exhaustion would have been voiced. However, there was none until after the aircraft was already in a position from which recovery was not possible.

In analyzing the flightcrew's actions, the Safety Board considered that the crew could have been misled by inaccuracies within the fuel-quantity measuring system. However, those intracockpit comments and radio transmissions in which fuel quantity was mentioned indicate that the fuel-quantity indicating system was accurate.

Had the flightcrew related any of these fuel quantities to fuel flow, they should have been aware that fuel exhaustion would occur at or about 1815. Other evidence that the captain had failed to assess the effect of continued holding on fuel state was provided by his stated intentions to land about 1805 with 4,000 lbs of fuel on board. Just minutes earlier, at 1748:46, he was made aware that only 5,000 lbs remained. During the 16 min between the observation of 5,000 lbs and 1805, the aircraft would consume at least 3,000 lbs of fuel. Further evidence of the flightcrew's lack of concern or awareness was provided when just after his observations of 4,00 lbs remaining about 17 min before the crash, the second officer left the cockpit at the captain's request to check on cabin emergency evacuation preparations. Upon his return, about 4 min later, he gave the captain an estimate of another 2 or 3 min for the completion of the cabin preparation. At this time, the aircraft was in the general vicinity of the airport. In the initial interview with the captain, he stated that he felt the cabin preparation could be completed in from 10 to 15 min and that the "tail end of it" could be accomplished on the final approach to the airport. Certainly there was nothing more to do in the cockpit. All of the landing gear check procedures, as prescribed in the approved flight manual and recommended by company line maintenance, had been completed and dispatch has been notified and had alerted Portland company personnel of the problems.

Under these circumstances, there appears to have been no valid reason to discontinue their heading inbound toward the airport in order to make their previously estimated landing time. However, about 1801:12, the first officer accepted and the captain did not question a vector heading which would take them away from the airport and delay their landing time appreciable. Moreover, after the turn was completed, none of the flightcrew suggested turning toward the airport. Thus, it was at this time that the crew's continuing preoccupation with the landing gear problem and landing preparations became crucial and an accident became inevitable.

The Safety Board also considered the possibility that the captain was aware of the fuel quantity on board, but failed to relate the fuel state to time and distance from the airport and intentionally extended the flight to reduce the fuel load in order to reduce the potential of fire should the landing gear fail upon landing. The Safety Board could find no evidence, however, to support such a theory and believes that had he so intended, the captain would have advised the first officer and flight engineer. Therefore, the Safety Board can only conclude that the flightcrew failed to relate the fuel remaining and the rate of fuel flow to the time and distance from the airport, because their attention was directed almost entirely toward diagnosing the landing gear problem. Although on two occasions the captain confirmed with the company that he intended to land about 1905 and that he would be landing with about 4,000 lbs of fuel, this estimated time of arrival and landing fuel load were not adhered to, nor was the expected approach time given to Portland Approach. This failure to adhere to the estimated time of arrival and landing fuel loads strengthens the Board's belief that the landing gear problem had a seemingly disorganizing effect on the flightcrew's performance. Evidence indicates that their scan of the instruments probably narrowed as their thinking fixed on the gear. After the No. 4 engine had flamed out and with the fuel totalizer indicating 1,000 lbs, the captain was still involved in resetting circuit breakers to recheck landing gear light indications.

It was not until after it became apparent to the crew that total engine flame out was imminent that the captain was concerned and, in fact, may have been confused as to the amount of fuel which actually remained. About 6 min before all engines stopped, the captain stated that there was 1,000 lbs of fuel in the No. 1 main tank, and the flight engineer agreed with him. At this same time, the captain began to describe the gage indication as changing from 1,000 lbs to zero lbs. Since the No. 1 main tank gage does not change its indication from 1,000 to zero lbs directly, but decreases in increments of 100 lbs, the captain must have read the gage indication incorrectly. Actually, the action he described was that of a gage changing from 100 lbs to zero lbs.

The company had recently changed the fuel quantity gages on this aircraft from a direct reading digital-type to a three-figure indicator that had to be multiplied by a factor of 100 to get the actual individual tank values. In addition, the new totalizer gage, of the same three-figure presentation as the individual tank gages, had to be multiplied by a factor of 1,000 to get the actual total fuel. During the stress situation, the captain and the flight engineer may have mixed up these multipliers and used 1,000 when reading the individual tank gages instead of 100. However, there is no evidence from previous comments that such a mistake was made. By the time such confusion was indicated, the accident was inevitable.

The Safety Board believes that this accident exemplifies a recurring problem--a breakdown in cockpit management and teamwork during a situation involving malfunctions of aircraft system in flight. To combat this problem, responsibilities must be divided among members of the flightcrew while a malfunction is being resolved. In this case, apparently on one was specifically delegated the responsibility of monitoring fuel state.

Although the captain is in command and responsible for the performance of his crew, the actions of the other two flight crewmembers must be analyzed. Admittedly, the stature of a captain and his management style may exert subtle pressure on his crew to conform to his way of thinking. It may hinder interaction and adequate monitoring and force another crewmember to yield his right to express an opinion.

The first officer's main responsibility is to monitor the captain. In particular, he provides feedback for the captain. If the captain infers from the first officer's actions or inactions that his judgment is correct, the captain could receive reinforcement for an error or poor judgment. Although the first officer did, in fact, make several subtle comments questioning or discussing the aircraft's fuel state, it was not until after the No. 4 engine flamed out that he expressed a direct view, "Get this ... on the ground." Before that time, the comments were not given in a positive or direct tone. If the first officer recognized the criticality of the situation, he failed to convey these thoughts to the captain in a timely manner.

The flight engineer's responsibility, aside from management of the aircraft systems, is to monitor the captain's and first officer's action as they pertain to the performance of the aircraft, that is, takeoff, landing, holding speeds and range of the aircraft considering time and fuel flow. Although he informed the captain at 1750:30 that an additional "fifteen minutes is really gonna run us low on fuel here," there is no indication that he took affirmative action to insure that the captain was fully aware of the time to fuel exhaustion. Neither is there an indication that, upon returning to the cockpit at 1801:39, he relayed any concern about the aircraft's fuel state to the captain. Although he commented that 3,000 lbs of fuel remained, he failed to indicate time remaining or his views regarding the need to expedite the landing.

The first officer's and the flight engineer's inputs on the flight deck are important because they provide redundancy. The Safety Board believes that, in training of all airline cockpit and cabin crewmembers, assertiveness training should be a part of the standard curricula, including the need for individual initiative and effective expression of concern.

In order to determine whether the captain had received all available assistance during the emergency, the Safety Board evaluated the actions of the company dispatcher and his role relative to the accident sequence. According to the tape of the conversation between the captain, the company dispatcher and company line maintenance personnel, the captain had advised the dispatcher that he had 7,000 lbs of fuel aboard and that he intended to land in 15 or 20 min. The dispatcher then checked with the captain to ascertain a specific time for the landing and the captain agreed that 1805 was "a good ballpark." The dispatcher, according to his interview after the accident, then relayed this landing time and the aircraft's status to the company personnel in Portland. He also stated that his assessment of the situation was that of the fuel remaining upon landing would be low but the landing could be made successfully at 1805. The Safety Board believes that, with the information given to him by the captain, the dispatcher acted properly and in accordance with company procedures.

CONCLUSIONS

Findings

1. The flightcrew was properly certificated and qualified for the flight.

2. The aircraft was certificated, maintained and dispatched in accordance with Federal Aviation Regulations and approved company procedures.

3. Except for the failure of the piston rod on the right main landing gear retract cylinder assembly, with the resulting damage to the landing gear position indication system switch, there was no evidence of a failure or malfunction of the aircraft's structure, powerplants, flight controls, or systems.

4. The aircraft departed Denver with the required fuel aboard of 2 hrs 26 min for the en route flight and with the required FAR and company contingency fuel aboard of about 1 hr.

5. The aircraft began holding about 1712 at 5,000 ft with its gear down; this was about 2 hrs 24 min after it departed Denver.

6. The landing delay covered a period of about 1 hr 2 min.

7. All of the aircraft's engines flamed out because of fuel exhaustion about 1815--1 hr 3 min after it entered into hold and 3 hrs 27 min after it departed Denver.

8. Fuel exhaustion was predictable. The crew failed to equate the fuel remaining with time and distance from the airport.

9. No pertinent malfunctions were found during examinations of the fuel-quantity measuring system.

10. A new digital fuel-quantity indicating system was installed on this aircraft on May 12, 1978. This was in accordance with a DC-8 UAL fleetwide retrofit program.

11. Evidence indicates that the fuel quantity indicating system accurately indicated fuel quantity to the crew.

12. The fuel gages are readily visible to the captain and the second officer.

13. The captain failed to make decisive timely decisions.

14. The captain failed to relate time, distance from the airport and the aircraft's fuel state as his attention was directed completely toward the diagnosis of the gear problem and preparation of the passengers for an emergency landing. The gear problem had a disorganizing effect on the captain's performance.

15. Neither the first officer nor the flight engineer conveyed any concern about fuel exhaustion to the captain until the accident was inevitable.

Probable Cause

The National Transportation Safety Board determined that the probable cause of the accident was the failure of the captain to monitor properly the aircraft's fuel state and to properly respond to the low fuel state and the crewmember's advisories regarding fuel state. This resulted in fuel exhaustion to all engines. His inattention resulted from preoccupation with a landing gear malfunction and preparations for a possible landing emergency.

Contributing to the accident was the failure of the other two crewmembers either to fully comprehend the criticality of the fuel state or to successfully communicate their concern to the captain.

TRANSCRIPT OF A SUNDSTRAND V557 COCKPIT VOICE RECORDER
SERIAL NO. 1427 REMOVED FROM THE UNITED AIRLINES DC-8
WHICH WAS INVOLVED IN AN ACCIDENT AT
PORTLAND, OREGON ON DECEMBER 28, 1978

THE TIME IS IN PACIFIC STANDARD TIME

LEGEND

CAM	Cockpit area microphone voice or sound source
RDO	Radio transmission from accident aircraft
-1	Voice identified as Captain
-2	Voice identified as First Officer
-3	Voice identified as Flight Engineer
-4	Voice identified as off duty Captain
-5	Voice identified as Flight Attendant
-?	Voice unidentified
UNK	Unknown
*	Unintelligible word
#	Nonpertinent word
X	Nonpertinent text
%	Break in continuity
()	Questionable text
(())	Editorial insertion
---	Pause
PA	Portland Approach Control
CO	United Company
VHF	VHF Radio
XXX	Nonpertinent aircraft or facility call
PD	Portland Departure
TWR	Portland Tower

INTRA-COCKPIT — AIR-GROUND COMMUNICATIONS

TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-?	*		
CAM-1	How you doing (Dory)?		
CAM-5	We're ready for your announcement		
CAM-5	(Do) you have the signal for not evacuate also the signal for protective positions.		
1744:41 CAM-5	That's the only things I need from you right now		

CAM-1 Okay ah, what would you do? Have you got any suggestions about when to brace? Want to do it on the PA?

1744:50
CAM-5 I---I'll be honest with you, I've never had one of these before---My first, you know---*

CAM-1 All right, what we'll do is we'll have Frostie oh about a couple of minutes before touchdown signal for brace position

1745:00
PA United 173 heavy, turn left heading two two zero

1745:04
RDO-2 Left two twenty one seventy three heavy

CAM-5 Okay, he'll come on the PA

CAM-1 and then ah---

Cam-5 And if you don't want us to evacuate what's are you gonna say

1745:09
CAM-1 We'll either use the PA or we'll stand in the door and hollar

CAM-5 Okay, one or the other, ah we're reseating passengers right now and all the cabin lights are full up

CAM-1 Okay

CAM-5 Will go take it from there

CAM-1 All right

1745:23
CAM-3 I can see the red indicators from here, ya know but I can't tell ** if there's anything lined up. Cause I only got this to shine down there

CAM-3 ***all the way down

1746:21
CAM-3 Last guy to leave has gotta XXX
turn the battery external
power switch off

CAM-? You're right

CAM-? *

CAM-? *

1746:52
CAM-2 How much fuel we got
Frostie?

CAM-3 Five-thousand

CAM-2 Okay

1748:00
CAM-4 Gonna get us a spare
flashlight

CAM-5 Sir?

CAM-4 Gonna get us a spare
flashlight

1748:17
CAM-4 Less than three weeks,
three weeks to retire-
ment you better get me
outta here

1748:11
CAM-1 Thing to remember is
don't worry

CAM-? What?

CAM-1 Thing to remember is
don't worry

1748:21
CAM-4 Yeah

CAM-4 If I might make a suggest-
tion---
You should put your coat
on---

Both for your protection
and so you'll be noticed
so they'll know who you
are

1748:30
CAM-1 Oh that's okay

CAM-4 But if it gets, if it
gets hot it sure is nice
to not have bare arms

CAM-1 Yeah

1748:40
PA United one seventy three heavy, traffic eleven o'clock five miles north bound VFR Code Unknown

1748:40
CAM-1 But if anything goes
wrong you just charge
back there and get your
ass off, Okay

1748:45
RDO-2 Yeah we've got somebody out there

CAM-4 Yeah

PA 'Kay

CAM-4 I told, I told the gal,
put me where she wants me,
I think she wants me at
a wing exit

CAM-1 Okay fine, thank you

CAM-2 (We better turn around and
head west)

1748:54
CAM-2 Ah, what's the fuel show now,
Buddy?

1748:56
CAM-1 Five

CAM-2 Five

CAM-3 (The lights in the fuel pump---)

1749:00
CAM-1 That's about right, the feed
pumps are starting to blink

CAM-? That lights too big to shine
down there

CAM-? Yeah

CAM-? Maybe **

CAM-? You can always get a *

PA United one seventy three heavy turn left heading one six zero

RDO-2 Okay, left one six zero. You got one seven three heavy

1749:45
CAM-? Main gear back there

CAM-? Yeah both of them appear to be down and locked**

1749:50
RDO-2 That guy's out there about nine thirty, now is that right?

1749:53
PA Say again

1749:55
RDO-2 Ah, traffic's out there about nine thirty now?

CAM-? *I see him

1749-57
PA Ah no, he's about six o'clock now the one that I called earlier, now you got another about nine thirty, about five miles circling

1750:17
RDO-2 Yeah, I see somebody out there with a light on

1750:16
CAM-1 Okay

CAM-2 Hay, Frostie

CAM-3 Yes, sir

CAM-1 Give us a current card on weight figure about fifteen minutes

1750:30
CAM-3 Fifteen minutes?

CAM-1 Yeah, give us three for four thousand pounds on top of zero fuel weight

CAM-3 Not enough

1750:34
CAM-3 Fifteen minutes is gonna---
really run us low on fuel here

CAM-? Right

1750:35
PA United one seventy three heavy continue your left turn heading zero five zero

1750:39
RDO-2 Okay, left zero five zero

1750:47
CAM-3 *okay---take three
thousand pounds, ah two
hundred and four

1751:09
CAM-2 Maintenance have anything
to say

1751:16
CAM-3 He says I think you guys have
done everything you can and I
said we're reluctant to recycle
the gear for fear something is
bent or broken, we won't be able
to get it down

1751:22
CAM-? I agree

1751:29
CAM-2 Think we ought to warn these
people on the ground

CAM-1 Yeah, will do that right now

1751:35
CAM-1 Ah call the ramp, give em our
passenger count including laps
tell em we'll land with about four
thousand pounds of fuel and tell
them to give that to give that to
the fire department, I want United
mechanic to check the airplane
after we stop, before we taxi

1752:02
CAM-3 Yes, sir

1752:17
CAM-1 New numbers thirty four and
thirty nine

RDO-3 Seattle er Portland ramp United one seventy three Portland, go

RDO-3 United one seven three will be landing, ah in ah little bit and the information I'd like for you to pass on the fire department for us. We have souls on

PA United one seventy three heavy traffic at twelve 'clock five miles opposite direction two target

RDO-3 board one seven two one hundred and seventy two plus five ba; ah lap ah children

RDO-2 Okay, thank you

RDO-3 (cont') That would be five infants that's one seventy two plus five infants and pass it on to the fire department we'll be landing with about four thousand pounds fuel and ah requesting as soon as we stop United mechanics meet the airplane for an inspection prior to taxiing further, go ahead

CO One seventy three copied it all and I'll relay that on ah we're showing you at the field about zero five does that sound close?

RDO-3 Ah, fuel correct currently about five thousand pounds

CO Ah your ETA for the field about zero five

1753:30
CAM-3 He wants to know if we'll be landing about five after

1753:30
PA One seventy three heavy traffic, ten o'clock a mile unknown

CAM-1 Yes

1753:36
PA One seventy three heavy traffic ten to nine o'clock one half mile altitude unknown

1753:40
RDO-2 One seven three, thank you

1753:42
RDO-3 Affirmative about five after

CO Okay, Portland

CAM-? There's one down there?

CAM-? Yeah

1754:01
CAM-1 All done

CAM-3 Yes, sir

CAM-3 Ready for the * final descent check final approach, final descent check

1754:08
PA United one seventy three clear of the first traffic, now there's another one at eleven o'clock, moving twelve o'clock a mile south southwest bound

CAM-1 Okay

CAM-1 Do you want to run through the approach descent, yourself?

CAM-1 So you (don't forget something

1754:19
PA United one seventy three heavy traffic at twelve o'clock a half a mile

CAM-3 Yes, sir

1754:23
RDO-2 Yeah we got it down below

1754:27
CAM-2 He's going to have the company call out the equipment?

1754:31
CAM-1 We'll (call) dispatch in San Francisco and maintenance down there will handle it that way so we don't get it all over local radio. The ramp here is going to back it up by getting the crash equipment. How many people and all that?

CAM-1 When we get done back there then I'll tell them what we're going to do, so we don't end up with about a million rubber neckers out there

1755:04
CAM-3 Okay, approach descent check is complete

1755:1
CAM-1 Okay, check the new ATIS is delta

CAM-1 What I need is the wind, really

VHF Portland International Information delta Portland weather four thousand five hundred scattered visibility three zero temperature three zero, dew point one three winds three four zero degrees at eight altimeter three zero on six

1755:51
CAM-3 Wind is three forty at eight

1755:55
CAM-1 Okay

CAM-1 You want to be sure the flight bags and all that # are stowed * * * fastened, why don't you put all your books in your bag over there, Rod.

1756:53
CAM-2 How much fuel you got now?

CAM-3 *four, four --- thousand --- in each --- pounds

1757:02
PA One seventy three heavy turn left two eight five

CAM-2 Okay *

1757:06
RDO-2 Two eight five one seventy three heavy

1757:21
CAM-1 You might --- you might just take a walk back through the cabin and kinda see how things are going Okay?

1757:30
CAM-1 I don't want to, I don't want to hurry, em but I'd like to do it in another oh, ten minutes (or so)

CAM-3 Yeah, I'll see if its, --- get us ready

1758:18
CAM-2 If we do indeed --- have to
evacuate assuming that none
of us are incapacitated. Your
going to take care of shutdown,
right.

1758:28
CAM-2 Parking brakes, spoilers and
flaps, fuel shut off levels,
fire handles, battery switch
and all that **

1758:38
CAM-1 You just haul ass back there
and do whatever needs doing

CAM-1 I think that Jones is a pretty
level headed gal, and

1758:45
CAM-2 Pardon?

CAM-1 I think that "A" Stew is a
pretty level headed gal, and
sounds like she knows what she's
doing and been around for a while, I'm
sure Duke will help out

1800:15
CAM-2 We're not gonna have any antiskid
protection, either

1800:24
CAM-1 Well, I think the antiskid is
working, it's just the lights
that ain't working

1800:33
CAM-2 That light go off when you
push the circuit breaker in?

CAM-1 Yeah

CAM-2 Oh, it did

CAM-1 Yeah

CAM-2 Oh

1800:42
CAM-1 I won't use much breaking we'll
just let it roll out easy * *

1800:50
CAM-2 You plan to land as slow as you can with the power on?

CAM-1 Ah, I think about ref or there abouts try and hold the nose wheel off, I'm, I'm tempted to turn off the automatic spoilers to keep it from pitching down, but lets try and catch it

1801:12
PA United one seventy three heavy turn left heading on niner five

1801:15
RDO-2 Left one niner five one seven three heavy

1801:34
CAM-3 (You've got) another two or three minutes

CAM-1 Okay --- How are the people

1801:39
CAM-3 Well, they're pretty calm and cool ah --- some of em are obviously nervous, ah --- but for the most part they're taking it in stride --- they --- I ah stopped and reassured a couple of them, they seemed a little bit more --- more anxious than some of the others

1802:08
CAM-1 Okay, well about two minutes before landing that will be about four miles out, just pick up the mike --- the PA and say assume the brace position

CAM-3 Okay

1802:22
CAM-3 We got about three on the fuel (and that's it)

1802:28
CAM-1 Okay, on the touch down if the gear folds or something really jumps the track, get those boost pump off so that --- you might

even get the valves open	1802:44 PA United one seventy three heavy did you figure anything out yet about how much longer?
	1802:49 RDO-2 Yeah, we, ah, have indication our gear is abnormal it'll be our intention in about five minutes to land on two eight left, we would like the equipment standing by, our indication are the gear is down and locked, we've got our people prepared for an evacuation in the event that should become necessary
	1803:14 PA Seventy three heavy, okay advise when you'd like to begin your approach
	1803:17 RDO-1 Very well, they've about finished in the cabin --- I'd guess about another three, four, five minutes
	1803:23 PA United one seven three heavy, if you could, ahm give me souls on board and amount of fuel
1803:28 CAM-3 One seventy two plus, ah	
	1803:30 RDO-1 One seventy two an about four thousand well, make it three thousand pounds of fuel
CAM-3 Plus six laps	PA Thank you
	1803:38 RDO-1 Okay, and you can add to that one seventy two plus six laps, infants
CAM-2 I think he wants souls on board, he wants crew members and everything	
CAM-3 Ah, that right, he does, doesn't he?	
1803:58 CAM-3 Ah, five, three, eight, nine	
CAM-3 Eight, isn't it?	

CAM-1 Well, Okay

1804:04
CAM-2 One eighty five

CAM-1 There's one check that we missed

CAM-? What

CAM-1 Checking the gear warning horn

CAM-? * right

CAM-? right

CAM-1 right

CAM-? right

1804:44
CAM-1 How do we do that?

CAM-2 What we gotta do is get us
past flaps thirty five *

CAM-1 Thirty five what happen when
you close the throttles (any
idea)?

CAM-2 You can do that too, it'll
be one or three

1804:59
CAM-1 Yeah

1805:08
CAM-2 But we can't tell with that
breaker out I guess

CAM-3 Yeah

CAM-1 Push the breaker momentarily

CAM-1 Ready?

CAM-3 Yeah

1805:26
CAM-3 Okay, pull the breaker?

CAM-1 Yeah

1805:35

CAM-3 Okay, now we won't have the spoiler pump automatic spoilers

1805:39
CAM-1 Yes we will

CAM-3 The antiskid?

CAM-1 Well, wait a minute, I think the systems totally normal. Indications are what they are because the circuit breakers popped

CAM-3 Yeah

CAM-2 Right

CAM-3 Right

1805:54
CAM-1 Should have antiskid automatic spoilers and all that, we may not get ground shift because of mechanical ground shift problems

1806:04
CAM-2 Well, ah (let's have me) standby the spoilers, spoilers anyway if we don't get em, why I can ---

1806:10
CAM-1 I think if we get the antiskid fail light is off we'll get the automatic spoilers

1806:13
PA United one seven three heavy turn left heading zero five zero

CAM ((Sound of cabin door))

1806:19
CAM-1 How you doing?

CAM-5 Well, I think we're ready

1806:21
RDO-2 Left to zero five zero, United on seventy three heavy

1806:23
PA Roger

CAM-1 Okay

CAM-5 We've reseated, they've assigned

helpers and showed people how to
open exits, and ah,

CAM-1 Okay

CAM-5 We have they've told me they've
got able bodied men by the windows

CAM-5 The captain's in the very first
row of coach after the galley

CAM-? Any invalids (* * pull out windows *)

1806:34
CAM-5 He's going to take that
middle galley door its not
that far from the window

CAM-? Yeah * *

CAM-? *

CAM-? *

CAM-1 Okay we're going to go in now,
we should be landing in about
five minutes

CAM-(3/2) I think you just lost number four
buddy, you ---

CAM-5 Okay, I'll make the five minute
announcement, announcement, I'll
go I'm sitting down now

CAM-2 Better get some cross feeds open
there or something

CAM-3 Okay

CAM-5 All righty

1806:46
CAM-2 We're goin to lose an engine Buddy

CAM-1 Why

1806:52
CAM-2 Fuel

CAM-2 Open the crossfeeds, man

CAM-1 Open the crossfeeds there
or something ((simultaneous

with above))

1806:55
CAM-3 Showing fumes

CAM-2 Think, maybe we)

CAM-1 Showing a thousand or better

1807:00
CAM-2 I don't think its in there

CAM-3 Showing three thousand isn't it

CAM-1 Okay, it, its a

1807:06
CAM-2 Its flamed out

1807:12
RDO-1 United one seven three would like clearance for an approach into two eight left, now

1807:17
PA United one seventy three heavy, ok, roll out heading zero one zero ---be a vector to the visual runway two eight left and ah, you can report when you have the airport in sight suitable for a visual approach.

1807:25
RDO-1 Very well

1807:27
CAM-3 We're going to lose number three in a minute too

CAM-1 Well

1807:31
CAM-3 It's showing zero

CAM-1 You got a thousand pounds, you you got to

CAM-3 Five thousand in there, Buddy, but we lost it

CAM-1 All right

1807:38
CAM-3 Are you getting it back

1807:40
CAM-2 No, number four, you got that crossfeed open?

1807:40
CAM-3 No, I haven't got it open, which one

1807:42
CAM-1 Open em both, # get some fuel in there

CAM-1 Got some fuel pressure?

CAM-3 Yes, sir

1807:48
CAM-1 Rotation now she's coming

1807:52
CAM-1 Okay, watch one and two

CAM-1 We're showing down to zero or a thousand

CAM-3 Yeah

CAM-1 On number one

CAM-3 Right

1808:11
CAM-1 Well, open all four crossfeeds

CAM-3 All four?

CAM-1 Yeah

1808:14
CAM-2 All right now, its coming

1808:19
CAM-2 It's going to be # on approach though

CAM-? Yeah

1808:42
CAM-1 You gotta keep em running, Frostie

CAM-3 Yes, sir

1808:45
CAM-2 Get this # on the ground

CAM-3 Yeah

1808:50
RDO-1 United one seven three has got the field in sight not and we'd like as ASR to ten left er two eight left

CAM-3 It's showing not very much more fuel

1808:58
PA Okay, United one seventy three heavy, maintain five thousand

1809:03
RDO-1 Maintain five

1809:16
CAM-3 We're down to one on the totalizer

1809:17
CAM-3 Number two is empty

1809:21
RDO-1 United ah, one seven three is going to turn toward the airport and come on in

1809:27
PA Okay now you want to do it on a visual is that what you want?

CAM-2 Yeah

1809:32
RDO-1 Yeah

1809:33
PA Okay united one seventy three heavy ah turn left heading three six zero and verify you do have the airport in sight

1809:39
RDO-2 We do have the airport in sight, one six three heavy er, one seven three heavy

1809:42
PA One seven three heavy is cleared visual approach runway two eight left

1809:45
RDO-2 Cleared visual two eight left

CAM-1 Yeah
((Sound of spool down))

1809:51
CAM-2 You want the ILS on there
Buddy

CAM-1 Well

CAM-2 It's not going to do you
any good now

CAM-1 No, we'll get that # warning
thing if we do

1810:17
CAM-1 Ah, reset that circuit breaker
momentarily, see if we get gear
lights

1810:24
CAM-1 Yeah, the nose gears down

CAM-3 Off

CAM-1 Yeah

1810:33
CAM-1 About the time you give that
brace position

CAM-3 You say now

CAM-1 No, no but when you do push
that circuit breaker in

1810:43
CAM-3 Yes, sir

1810:47
RDO-1 How far you show us from the field?

1810:51
PA Ah, I'd call it eighteen flying
miles

1810:54
RDO-1 All right

1810:59
CAM-3 Boy, that fuel sure went to
hell all of a sudden, I told
you we had four

1811:14
CAM-1 There's ah, kind of an interstate high --- way type thing along that bank on the river in case we're short

1812:03
CAM-? Okay

1812:04
CAM-1 That's Troutdale over there about six of one half dozen of the other

1812:22
CAM-2 Let's take the shortest route to the airport

1812:42
RDO-1 What's our distance now?

1812:45
PA Twelve flying miles

1812:48
CAM-? Well, * *

1812:50
RDO-1 Okay

1812:52
CAM-1 About three miles

CAM-1 Four

CAM-? (Yeah)

1813:21
CAM-3 We've lost two engines guys

CAM-2 Sir?

1813:25
CAM-3 We just lost two engines, one and two

1813:28
CAM-2 You got all the pumps on and everything

1813:29
PA United one seventy three heavy contact Portland tower one one eight point seven, you're about eight or niner flying miles from the airport

CAM-3 Yep

1813:35

RDO-2 Okay, eighteen seven

PA Have a good one'

1813:38
CAM-1 They're all going

1813:41
CAM-1 We can't make Troutdale

1813:43
CAM-2 We can't make anything

1813:46
CAM-1 Okay, declare a mayday

1813:50
RDO-2 Portland tower United one seventy three heavy Mayday we're the engines are flaming out, we're going down, we're not able to make the airport

1813:58
TWR United one

1814:55 ((impact with transmission lines as derived from tower tape.))

1813:59
TWR ((end of tape))

APPENDIX B:

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

AIR FLORIDA, INC., BOEING 737-222, N62AF,
COLLISION WITH 14TH STREET BRIDGE
NEAR WASHINGTON NATIONAL AIRPORT
WASHINGTON, D.C.
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SYNOPSIS

On January 13, 1982, Air Florida Flight 90, a Boeing 737-222 (N62AF) was a scheduled flight to Fort Lauderdale, Florida, from Washington National Airport, Washington, D.C. There were 74 passengers, including 3 infants, and 5 crewmembers on board. The flight's scheduled departure time was delayed about 1 hour 45 minutes due to a moderate to heavy snowfall which necessitated the temporary closing of the airport.

Following takeoff from runway 36, which was made with snow and/or ice adhering to the aircraft, the aircraft crashed at 1601 e.s.t. into the barrier wall of the northbound span of the 14th Street Bridge, which connects the District of Columbia with Arlington County, Virginia, and plunged into the ice-covered Potomac River. It came to rest on the west side of the bridge 0.75 nm from the departure end of runway 36. Four passengers and one crewmember survived the crash.

When the aircraft hit the bridge, it struck seven occupied vehicles and then tore away a section of the bridge wall and bridge railing. Four persons in the vehicles were killed, four were injured.

The National Transportation Safety Board determines that the probable cause of this accident was the flightcrew's failure to use engine anti-ice during ground operation and takeoff, their decision to take off with snow/ice on the airfoil surfaces of the aircraft, and the captain's failure to reject the takeoff during the early stage when his attention was called to anomalous engine instrument readings. Contributing to the accident were the prolonged ground delay between deicing and the receipt of ATC takeoff clearance during which the airplane was exposed to continual precipitation, the known inherent pitchup characteristics of the B-737 aircraft when the leading edge is contaminated with even small amounts of snow or ice, and the limited experience of the flightcrew in jet transport winter operations.

FACTUAL INFORMATION

History of the Flight

On January 13, 1982, Air Florida, Inc., Flight 90, a Boeing 737-222 (N62AF), was a scheduled passenger flight from Washington National Airport, Washington, D.C., to the Fort Lauderdale International Airport, Fort Lauderdale, Florida, with an intermediate stop at the Tampa International

Airport, Tampa, Florida. Flight 90 was scheduled to depart Washington National Airport at 1415 e.s.t. The Boeing-737 had arrived at gate 12, Washington National Airport, as Flight 95 from Miami, Florida, at 1329. Snow was falling in Washington, D.C., in the morning and in various intensities when Flight 95 landed and continued to fall throughout the early afternoon.

Because of the snowfall, Washington National Airport was closed for snow removal from 1338 to 1453 and Flight 90's scheduled departure was delayed. At 1359:21, Flight 90 requested and received an instrument flight rules (IFR) clearance from clearance delivery.

Seventy-one passengers and 3 infants were boarded on the aircraft between 1400 and 1430; there were five crewmembers-captain, first officer, and three flight attendants. About 1420, American Airlines maintenance personnel began deicing the left side of the fuselage using a model D40D Trump vehicle (No. 5058) containing Union Carbide Aircraft Deicing Fluid II PM 5178. The deicing truck operator stated that the captain told him that he would like to start deicing just before the airport was scheduled to reopen at 1430 so that he could get in line for departure. American maintenance personnel stated that they observed about one-half inch of wet snow on the aircraft before the deicing fluid was applied. Fluid had been applied to an area of about 10 feet when the captain terminated the operation because the airport was not going to reopen at 1430. At that time, the flightcrew also informed the Air Florida maintenance representative that 11 other aircraft had departure priority and that there were 5 or 6 aircraft which had departure priority before Flight 90 could push back from the gate.

Between 1445 and 1450, the captain requested that the deicing operation be resumed. The left side of the aircraft was deiced first. According to the operation of the deicing vehicle, the wing, the fuselage, the tail section, the top part of the engine pylon, and the cowling were deiced with a heated solution consisting of 30 to 40 percent glycol and 60 to 70 percent water. No final overspray was applied. The operator based the proportions of the solution on guidance material from the American Airlines maintenance manual and his knowledge that the ambient temperature was 24 F, which he had obtained from current weather data received at the American Airlines line maintenance room. The operator also stated that he started spraying at the front section of the aircraft and progressed toward the tail using caution in the areas of the hinge points and control surfaces to assure that no ice or snow remained at these critical points. He also stated that it was snowing heavily as the deicing/anti-icing substance was applied to the left side of the aircraft.

Between 1445 and 1500, the operator of the deicing vehicle was relieved from his task, and he told his relief operator, a mechanic, that the left side of the aircraft had been deiced.

The relief operator proceeded to deice the right side of the aircraft with heated water followed by a finish anti-ice coat of 20 to 30 percent glycol and 70 to 80 percent water, also heated. He based these proportions on information that the ambient temperature was 28 F. (The actual temperature was 24 F.) The operator stated that he deiced/anti-iced the right side of the aircraft in the following sequence: the rudder, the stabilizer and elevator, the aft fuselage section, the upper forward fuselage, the wing section (leading to trailing edge), the top of the engine, the wingtip, and the nose.

Afterwards, he inspected both engine intakes and the landing gear for snow and/or ice accumulation; he stated that none was found. The deicing/anti-icing of Flight 90 was completed at 1510. At this time about 2 or 3 inches of wet snow was on the ground around the aircraft. Maintenance personnel involved in deicing/anti-icing the aircraft stated that they believed that the aircraft's trailing and leading edge devices were retracted. American Airlines personnel stated that no covers or plugs were installed over the engines or airframe opening during deicing operations.

At 1515, the aircraft was closed up and the jetway was retracted. Just before the jetway was retracted, the captain, who was sitting in the left cockpit seat, asked the Air Florida station manager, who was standing near the main cabin door, how much snow was on the aircraft. The station manager responded that there was a light dusting of snow on the left wing from the engine to the wingtip and that the area from the engine to the fuselage was clean. Snow continued to fall heavily.

A tug was standing by to push Flight 90 back from gate 12. The operator of the tug stated that a flight crewmember told him that the tower would call and advise them when pushback could start. At 1516:45, Flight 90 transmitted, "Ground Palm Ninety like to get in sequence, we're ready." Ground control replied, "Are you ready to push?" Flight 90 replied, "Affirmative," at 1516:37. At 1517:01, Ground control transmitted, "Okay, push approved for Palm Ninety-better still, just hold it right where you are Palm Ninety, I'll call you back." At 1523:37, Ground control transmitted, "Okay Palm Ninety, push approved."

At 1525, the tug attempted to push Flight 90 back. However, a combination of ice, snow, and glycol on the ramp and a slight incline prevented the tug, which was not equipped with chains, from moving the aircraft. When a flight crewmember suggested to the tug operator that the aircraft's engine reverse thrust be used to push the aircraft back, the operator advised the crewmember that this was contrary to policy of American Airlines. According to the tug operator, the aircraft's engines were started and both reversers were deployed. He then advised the flightcrew to use only "idle power".

Witnesses estimated that both engines were operated in reverse thrust for a period of 30 to 90 seconds. During this time, several Air Florida and American Airlines personnel observed snow and/or slush being blown toward the front of the aircraft. One witness stated that he saw water swirling at the base of the left (No. 1) engine inlet. Several Air Florida personnel stated that they saw an area of snow on the ground melted around the left engine for a radius ranging from 6 to 15 feet. No one observed a similar melted area under the right (No. 2) engine.

When the use of reverse thrust proved unsuccessful in moving the aircraft back, the engines were shut down with the reversers deployed. The same American Airlines mechanic that had inspected both engine intakes upon completion of the deicing/anti-icing operation performed another general examination of both engines. He stated that he saw no ice or snow at that time. Air Florida and American Airlines personnel standing near the aircraft after the aircraft's engines were shut down stated that they did not see any water, slush, snow, or ice on the wings.

At 1533, while the first tug was being disconnected from the towbar and a second tug was being brought into position, an assistant station manager for Air Florida who was inside the passenger terminal between gates 11 and 12 stated that he could see the upper fuselage and about 75 percent of the left wing inboard of the tip from his vantage point, which was about 25 feet from the aircraft. Although he observed snow on top of the fuselage, he said it did not appear to be heavy or thick. He saw snow on the nose and radome up to the bottom of the windshield and a light dusting of snow on the left wing.

At 1535, Flight 90 was pushed back without further difficulty. After the tug was disconnected both engines were restarted and the thrust reversers were stowed. The aircraft was ready to taxi away from the gate at 1538.

At 1538:16 while accomplishing after-start checklist items, the captain responded "off" to the first officer's callout of checklist item "anti-ice". At 1538:22 the ground controller said: "Okay and the American that's towing there...let's...six twenty four can you...get...around that...Palm on a pushback?" Flight 90 replied, "Ground Palm Ninety, we're ready to taxi out of his way." Ground control then transmitted, "Okay Palm Ninety, Roger, just pull up over behind that...TWA and hold right there. You'll be falling in line behind a...Apple...DC Nine." Flight 90 acknowledged this transmission at 1538:47. Flight 90 then fell in behind the New York DC-9. Nine air carrier aircraft and seven general aviation aircraft were awaiting departure when Flight 90 pushed back.

At 1540:15, the cockpit voice recorder (CVR) recorded a comment by the captain, "...go over to the hangar and get deiced," to which the first officer replied "yeah, definitely." The captain then made some additional comment which was not clear but contained the word "deiced," to which the first officer again replied "yeah...that's about it." At 1540:42, the first officer continued to say, "it's been a while since we've been deiced." At 1546:21, the captain said, "Tell you what, my windshield will be deiced, don't know about my wings." The first officer then commented, "well--all we need is the inside of the wings anyway, the wingtips are gonna speed up on eighty anyway, they'll shuck all that other stuff." At 1547:32, the captain commented, "(Gonna) get your wing now." Five seconds later, the first officer asked, "D'they get yours? Did they get your wingtip over 'er?" The captain replied, "I got a little on mine." The first officer then said, "A little, this one's got about a quarter to half an inch on it all the way."

At 1548:59, the first officer asked, "See this difference in that left engine and right one?" The captain replied, "Yeah." The first officer then commented, "I don't know why that's different - less it's hot air going into that right one, that must be it - from his exhaust - it was doing that at the chocks awhile ago...ah." At 1551:54, the captain said, "Don't do that - Apple, I need to get the other wing done."

At 1553:21, the first officer said, "Boy...this is a losing battle here on trying to deice those things, it (gives) you a false feeling of security that's all that does." Conversation between the captain and the first officer regarding the general topic of deicing continued until 1554:04.

At 1557:42, after the New York Air aircraft was cleared for takeoff, the captain and first officer proceeded to accomplish the pretakeoff checklist, including verification of the takeoff engine pressure ratio (EPR) setting of 2.4 and indicated airspeed bug settings of 138 kts (V); 140 kts (V) and 144 kts (V). Between 1558:26 and 1558:37, the first officer asked, "Slush (sic) runway, do you want me to do anything special for this or just go for it." (The first officer was the pilot flying the aircraft.) The captain responded, "unless you got anything special you'd like to do." The first officer replied, "Unless just take off the nosewheel early like a soft like a soft field takeoff or something; I'll take the nosewheel off and then we'll let it fly off."

At 1558:55, Flight 90 was cleared by local control to "taxi into position and hold" on runway 36 and to "be ready for an immediate (takeoff)." Before Flight 90 started to taxi, the flightcrew replied, "...position and hold," at 1558:58. As the aircraft was taxied, the tower transmitted the takeoff clearance and the pilot acknowledged, "Palm 90 cleared for takeoff." Also, at 1559:28, Flight 90 was told not to delay the departure since landing traffic was 2 1/2 miles out for runway 36; the last radio transmission from Flight 90 was the reply, "Okay" at 1559:46.

The CVR indicated that the pretakeoff checklist was completed at 1559:22. At 1559:45, as the aircraft was turning to the runway heading, the captain said, "Your throttle." At 1559:46, the sound of the engine spoolup was recorded, and the captain stated, "Holler if you need the wipers..." At 1559:56, the captain commented, "Real cold, real cold," and at 1559:58, the first officer remarked, "God, look at that thing, that don't seem right, does it?"

Between 1600:05 and 1600:10, the first officer stated, "...that;s not right...," to which the captain responded, "Yes it is, there's eighty." The first officer reiterated, "Naw, I don't think that's right." About 9 seconds later the first officer added, "...maybe it is," but then 2 seconds later, after the captain called, "hundred and twenty," the first officer said, "I don't know."

Eight seconds after the captain called "Vee one" and 2 seconds after he called "Vee two," the sound of the stickshaker recorded. At 1600:45, the captain said, "Forward, forward," and at 1600:48, "We only want five hundred." At 1600:50, the captain continued, "Come on, forward, forward, just barely climb." At 1601:00, the first officer said, "Larry, we're going down, Larry," to which the captain responded, "I know it."

About 1601, the aircraft struck the heavily congested northbound span of the 14th Street Bridge, which connects the District of Columbia with Arlington County, Virginia, and plunged into the ice-covered Potomac River. It came to rest on the west end of the bridge 0.75 nm from the departure end of runway 36. Heavy snow continued to fall and visibility at the airport was varying between 1/4 mile and 5/8 mile.

When the aircraft struck the bridge, it struck six occupied automobiles and a boom truck before tearing away a 41-foot section of the bridge wall and 97 feet of the bridge railings. As a result of the crash, 70 passengers, including 3 infants, and 4 crewmembers were killed. Four passengers and one crewmember were injured seriously. Four persons in vehicles on the bridge were killed; four were injured, one seriously.

At 1603, the duty officer at the airport fire station notified crash/fire/rescue (CFR) equipment based on his monitoring of a radio transmission between Washington National Tower and the operations officer that an aircraft was possibly off the end of runway 36.

Safety Board investigators interviewed more that 200 witnesses to establish the sequence of events form the start of takeoff until impact, and more than 100 written statements were obtained. Ground witnesses generally agreed that the aircraft was flying at an unusually low altitude with the wings level and attained a nose-high attitude of 30 to 40 before it hit the bridge. Four persons in a car on the bridge within several hundred feet from the point of impact claimed that large sheets of ice fell on their car.

A driver whose car was on the bridge at about the wingtip of the aircraft stated, "I heard screaming jet engines... The nose was up and the tail was down. It was like the pilot was still trying to climb but the plane was sinking fast. I was in the center left lane...about 5 or 6 cars lengths from where (the red car) was. I saw the tail of the plane tear across the top of the cars, smashing some tops and ripping off others...I saw it spin...(the red car)...around and then hit the guardrail. All the time it was going across the bridge it was sinking but the nose was pretty well up...I got the impression that the plane was swinging around a little and going in a straight direction into the river. The plane...seemed to go across the bridge at a slight angle and the dragging tail seemed to straighten out. It leveled out a little. Once the tail was across the bridge the plane seemed to continue sinking very fast but I don't recall the nose pointing down. If it was, it wasn't pointing down much. The plane seemed to hit the water intact in a combination sinking/plowing action. I saw the cockpit go under the ice. I got the impression it was skimming under the ice and water...I did not see the airplane break apart. It seemed to plow under the ice. I did not see any ice on the aircraft or any ice fall off the aircraft. I do not remember any wing dip as the plane came across the bridge. I saw nothing fall from the airplane as it crossed the bridge."

Between 1519 and 1524, a passenger on an arriving flight holding for gate space near Flight 90 saw some snow accumulated on the top and right side of the fuselage and photographed Flight 90. No witness saw the flightcrew leave the aircraft to inspect for snow/ice accumulations while at the gate. Departing and arriving flightcrews and others who saw Flight 90 before and during takeoff stated that the aircraft had an unusually heavy accumulation of snow or ice on it. An airline crew taxiing parallel to, but in the opposite direction of, Flight 90's takeoff, saw a portion of Flight 90's takeoff roll and discussed the extensive amount of snow on the fuselage. The captain's statement to the Board included the following: "I commented to my crew, 'look at the junk on that airplane',...Almost the entire length of the fuselage had a mottled area of snow and what appeared to be ice...along the top and upper side of the fuselage above the passenger cabin windows..." None of the witnesses at the airport could positively identify the rotation or liftoff point of Flight 90; however, they testified that it was beyond the intersection of runways 15 and 36, and that the aircraft's rate of climb was slow as it left the runway. Flightcrews awaiting departure were able to observe only about the first 2,000 feet of the aircraft's takeoff roll because of the heavy snowfall and restricted visibility.

At 1600:03, as Flight 90 was on the takeoff roll, the local controller had transmitted to an approaching Eastern 727, Flight 1451, "...the wind is zero one zero at one one, you're cleared to land runway three six; the runway visual range touchdown two thousand eight hundred rollout one thousand six hundred." At 1600:11 Eastern Flight 1451 acknowledged, "...cleared to land, over the lights." At 1600:56, the local controller transmitted, "Eastern fourteen fifty-one, turn left at the next taxiway, advise when you clear the runway, no delay clearing."

During witness interviews, one witness on the airport stated, "Immediately after I noticed the Air Florida 737, an Eastern 727 landed unbelievably close after (Air Florida) 737. I felt it was too close for normal conditions - let alone very hard snow.."

Flight 90 crashed during daylight hours at 1601:01 at 38 51'N longitude and 77 02' W latitude. Elevation was 37 feet mean sea level.

Injuries to Persons

Injuries	Crew	Passenger	Other*	Total
Fatal	4	70**	4	78
Serious	1	4	1	6
Minor	0	0	3	3
None	0	0	0	0
Total	5	74	8	87

* Persons in vehicles on the bridge
** Including three infants

Personnel Information

Both pilots were trained and certified in accordance with current regulations. Neither pilot had any record of FAA violations.

The captain was described by pilots who knew him or flew with him as a quiet person. According to available information, he did not have any sleep or eating pattern changes recently; the 24 to 72 hours before January 13 also were unremarkable. Pilots indicated that the captain had good operational skills and knowledge and had operated well in high workload flying situations. His leadership style was described as not different from other captains. On May 8, 1980, during a line check in B-737 the captain was found to be unsatisfactory in the following areas, adherence to regulations, checklist usage, flight procedures such as departures and cruise control, approaches and landings. As a result of this line check, the captain's initial line check qualification as a B-737 captain was suspended. On August 27, 1980, he received a satisfactory grade on a line check and was granted the authority to act as pilot-in-command. On April 24, 1981, the captain received an unsatisfactory grade on a recurrent proficiency check when he showed deficiencies in memory items, knowledge of aircraft systems, and aircraft limitations. Three days later, the captain took a proficiency recheck and received a satisfactory grade. On October 21, 1981, the captain satisfactorily completed a B-737 simulator course in lieu of a proficiency check. His last line check was satisfactorily completed on April 29, 1981.

The first officer was described by personal friends and pilots as a witty, bright, outgoing individual. According to available information, he had no recent sleep or eating pattern changes. The 24 to 72 hours before January 13 were spent with his family and were unremarkable. On the morning of January 13, the first officer was described as well rested and in a good mood. Acquaintances indicated that he had an excellent command of the physical and mental skill in aircraft piloting. Those who had flown with him during stressful flight operations said that during those times he remained the same witty, sharp individual "who knew his limitations." Several persons said that he was the type of pilot who would not hesitate to speak up if he knew something specific was wrong with flight operations. He had completed all required checks satisfactorily.

The Safety Board reviewed the winter operations conducted by the captain and first officer and found that the captain, after upgrading to captain B-737 aircraft, had flown eight takeoffs or landings in which precipitation and freezing or near-freezing conditions occurred, and that the first officer had flown two takeoffs or landings in such conditions during his employment with Air Florida, Inc. The captain and first officer had flown together as a crew only 17 1/2 hours.

TRANSCRIPT OF A SUNDSTRAND V-577 COCKPIT VOICE RECORDER S/N 2282
REMOVED FROM AN AIR FLORIDA B-737 WHICH WAS INVOLVED IN AN ACCIDENT
AT WASHINGTON, D.C., ON JANUARY 13, 1982

LEGEND

CAM	Cockpit area microphone voice or sound source
RDO	Radio transmission from accident aircraft
-1	Voice identified as Captain
-2	Voice identified as First Officer
-3	Voice identified as Head Stewardess
-4	Voice identified as Stewardess
-?	Voice unidentified
TUG	Tractor
INC	Intercom
AOPS	American Operations
LC	Tower (Local Control)
PA	Public address system
GND	Ground Control
E133	Eastern one three three
625	One six tow five
NYA 58	New York Air fifty-eight
556	TWA five fifty-six
00J	Eight thousand juliet
451	Eastern fourteen fifty-one
41M	Four one mike
68G	Six eight gulf
*	Unintelligible word
#	Nonpertinent word
%	Break in continuity
( )	Questionable text
(( ))	Editorial insertion
---	Pause

Note: All times are expressed in local time based on the 24-hour clock.

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
CAM-2	*figure it out	5:30:48 TUG	You have your brakes on right?
CAM-2	We're too heavy for the ice	INC-1	Yeah, brakes are on
CAM-2	They got a tractor with chains on it? They got one right over here		
	((PA announcement relative to pushback))		

15:31:33
AOPS Palm ninety from American Operations

15:31:36
RDO-2 Palm ninety, go ahead

15:31:38
AOPS Okay, your agent just called to tell me to tell you to amend your release showing nineteen twenty-five zulu per initial RH

15:31:51
RDO-2 Okay, nineteen twenty-five romeo hotel, thanks

CAM-1 That's not so # great

AOPS Roger, how's it look for you, gonna be departing soon, I hope

15:32:03
RDO-2 Well, we're working on it, what time does he say to do it, it's twenty thirty-five right now

1532:07
AOPS That's the interesting thing, he said nineteen twenty-five, let me give him a buzz back cause we think that maybe he meant twenty twenty-five, hang on

CAM-1 Ah we'll take that

1532:18
RDO-2 Okay

1532:22
CAM-2 I hadn't called ground to tell 'em make it, do you want me to tell 'em?

CAM-? **call 'em and tell 'em**

CAM-2 I'm surprised we couldn't power it out of here

CAM-1 Well we could of if he wanted me to pull some reverse

CAM-? *

1532:59
CAM-1 I've done it in Minneapolis and I had to come up to one point four, one point five

1533:05
CAM-1 It had chains on it

1533:15
CAM-2 ((Chuckle)) did you hear that guy, think he'll get a gate in a second, I don't see anybody pushing

CAM-2 Want me to tell Ground that we're temporarily indisposed?

1533:25
CAM-2 He'll call us surely

CAM-2 Where are you guys?

CAM-? **

CAM-? Huh

CAM-2 **

1533:40
CAM-2 It's twenty-five, it's not too cold really

CAM-1 It's not really that cold

CAM-2 It's not that cold, cold, like ten with the wind blowing, you know

1534:09
CAM-2 People's going to deplane in the snow here

CAM-2 Piedmont's going to park it on the ramp

1534:24
CAM-1 Here comes the chain tractor

1535:06
TUG Ready to roll

INC-1 Ready to roll

TUG Brakes off

INC-1 Brakes are off, "A"pumps are off, interconnects closed

1535:14

CAM-2 Well that's a difference, do you want twenty-five (or start up)

TUG Bet those vacuum cleaners would do wonders as a snow melter

CAM-2 Yeah

INC-1 Sure do

1534:40
CAM-2 I guess (I) never even thought about it being a little plane like this, figured they'ed push it out of there, you know but we're pretty heavy, we're a hundred and two thousand sitting there

1536:19
TUG You can start engines if you want, I don't know whether you got'em running or not

1536:23
INC-1 I'll tell you what, I,m gonna wait till you disconnect before I start them up so I can get the buckets closed

1536:31
GND Okay, parking brakes

1536:34
INC-1 Okay, brakes are set

TUG Stand by for salute and we'll see ya later

1536:43 Right'o, thanks a lot

1536:50
CAM-1 Checklist again, right

CAM-2 We did it and we're down to before start, that's all

CAM-2 Shoulder harness

CAM-1 On

CAM-2 Air conditioning pack

CAM-1 Off

CAM-2 Start pressure

CAM-1 Up

CAM-2 Anti-collision

CAM-1 On

CAM-2 Starts complete

1537:01
CAM-2 LaGuardia's not accepting anybody
right now

CAM-3/4Is it raining in Tampa?

CAM-2 Rainy and foggy

CAM-3/4How is the temperature?

CAM-? Fifty

CAM-2 Sixty

M-1 ((Sound of laughter)) can they land here?

1537:31
CAM-2 Drop

CAM-2 Oil pressure

1537:41
CAM ((Strange sound apparently associated with engine start))

1537:46
CAM-2 (Eighty-seven) (bet it feels like
a gas stove)

CAM-1 Temperature

1537:49
CAM-2 (Isn't that an artist though)

CAM-1 Huh--oil pressure

1538:06
CAM ((Second strange sound apparently
associated with engine start))

CAM ((Sound of igniters))

CAM-1 Stowed

CAM-2 Cut out

1538:16
CAM-1 After start

CAM-2	Electrical		
CAM-1	Generators		
CAM-2	Pitot heat		
CAM-1	on		
CAM-2	Anti-ice		
CAM-1	(off)		
CAM-2	Air conditioning pressurization		
CAM-1	Packs on flight		
CAM-2	APU		
CAM-1	Running		
CAM-2	Start levers		
CAM-1	Idle		
CAM-2	Door warning lights		
CAM-1	out		
CAM-2	You want me to hold the flaps till we get up closer?		
		1538:22 GRD	Can you get around that Palm on the pushback?
CAM-1	He said something about Palm		
CAM-2	Yeah		
CAM-2	((chuckle))	1538:34 RDO-2	Ground Palm ninety, we're ready to taxi out of his way
		1538:39 GRD	Okay Palm ninety, roger, just pull up over, behind that, ah, TWA and hold right there, you'll be falling in line behind a, oh Apple DC nine
		1538:47 RDO-2	Palm one ninety
CAM	((sound of takeoff warning))		

1538:58

CAM-2 Behind that Apple, I guess

CAM-1 Behind what TWA?

1539:04
CAM-2 Over by the TWA to follow that
Apple, apparently

CAM-2 ((whistling))

1539:29
CAM-2 Boy, this is shitty, it's probably
the shittiest snow I've seen

CAM ((sound of takeoff warning horn))

CAM ((beginning of flight attendant P/A))

1540:15
CAM-1 **go over to the hangar and get
deiced

CAM-2 Yeah

CAM-2 Definitely

CAM-1 ** deiced **((laughter))

CAM-2 Yeah, that's about it

1540:42
CAM-2 It's been a while since
we've been deiced

CAM-1 Thank I'll go home and (play)**

1541:24
CAM-2 That Citation over there,
that guy's about ankle deep in it

CAM ((sound of laughter))

1541:47
CAM-2 Hello Donna

CAM-3 I love it out here

CAM-2 It fun

CAM-3 I love it

CAM-3 The neat way the tire tracks

1541:52

CAM-2 See that Citation over there, looks like he's up to his knees

CAM-4 Look at all the tire tracks in the snow

CAM-3 Huh

CAM-4 The tire tracks in the snow

CAM-3/4 * * *

1542:13
CAM-2 No that's a DC nine Apple New York Air

CAM-4 Is that the way ours are, that low to the ground, too

1542:21
CAM-2 I don't know, those are dash tens there, aren't they, DC nine dash tens, don't know what we had, thirties? Is that a thirty?

CAM-4 It is *

1542:29
CAM-1 Doesn't look like it, I can't see, I can't tell

CAM-1 I need to see something other that what we're looking at

1542:59
CAM-2 ((sound of whistling))

CAM-1 **snow**snow

1543:22
CAM-2 Pretty poky

CAM-4 What does the "N" stand for on all the aircraft, before the number?

CAM-1 U.S. registered

CAM-2 U.S. United States see everyone of them have an "N" on it see, then yo see somebody else like, ah

CAM-4 (like Bahamas)

1543:37
CAM-1 "C" is Canada, yeah I think, or is it "Y"

CAM-2 I think, I think it is "C"

CAM-2 There's, ah, you know Venezuela

CAM-2 Next time you have a weird one, you can look up

RDO ((radio call pertaining to Palm))

CAM ***

CAM-2 Stand by a second

1544:59
CAM-2 I never got back to Operations on the twenty twenty-five, we can put twenty-five, romeo hotel, just, just go for it

CAM-2 That's what time it is, awhile ago instead of nineteen twenty-five, I think the guy just ** he added four instead of five

CAM-1 That's why I said, that's why I gave the agent twenty-five so I wouldn't have to be concerned with that #

CAM-2 What's our release good for, one hour? one hour release

CAM-2 Ha, Ha, god eh said LaGuardia is not taking anybody, # it's early yet ((sound of laughter)) we may end up in Kennedy or somewhere, you never know ((sound of laughter))

1545:43
CAM-1 Bradley, Albany

CAM-2 Yeah

1545:51
CAM-2 There's PSA's Eastern jet coming in ((sound of laughter))

CAM-2 And they used to laugh at us for flying those green tails, you know

CAM-2 Whatever it was

1546:21
CAM-1 Tell you what,my windshield will be deiced, don't know about my wing

1546:27
CAM-2 Well all we really need is the inside of the wings anyway, the wing tips are gonna speed up by eighty anyway, they'll shuck all that other stuff ((sound of laughter))

1546:34
CAM-2 There's Palm thirty-five coming in

1546:51
CAM ((sound of laughter))

1547:01
CAM-2 Yeah, Palm thirty-five's in the holding pattern right now

1547:32
CAM-1 (Gonna) get you wing now

1547:37
CAM-2 D'they get yours? can you see you wing tip over 'er

CAM-1 I got a little on mine

CAM-2 A little

1547:46
CAM-2 This one's got about a quarter to half an inch on it all the way

1547:53
CAM-2 Look how the ice is just hanging on his, ah, back, back there, see that?

CAM-2 Side there

1548:06
CAM-2 W'its impressive that big old planes get in here with the weather this bad you know,

it's impressive

1548:13
CAM-2 It never ceases to amaze me when we break out of the clouds, there's the runway, d'care how many times we do it. God, we did good! ((sound of laughter))

1548:24
CAM-2 See all those icicles on the back there and everything

CAM-1 Yeah

1548:31
CAM-2 He's getting excited there, he got his flaps down, he thinks he's getting close ((sound of laughter))

1548:59
CAM-2 See this difference in that left engine and right one

CAM-1 Yeah

CAM-2 Don't know why that's different

1549:05
CAM-2 Less it's his hot air going into that right one, that must be it

CAM-2 From his exhaust

CAM-2 It was doing that in the chocks awhile ago but, ah

1549:42
GND Okay, Palm ninety, cross runway three and if there's space and then monitor the tower on nineteen one, don't call him, he'll call you

1549:49
RDO-2 Palm ninety

CAM-? ((sound of whistling))

1550:08
CAM-2 I'm certainly glad there's people taxiing on the same place I want to go cause I can't see the runway, taxiway without these flags ((sound of

take off warning))

1550:29
CAM-? ((sound of whistling))

1550:38
CAM-1 Where would I be if I were a holding line?

CAM-2 I would think that would be about right here, agreed?

1550:45
CAM-2 May be a little further up there, I don't know

CAM-1 Ah, # he's barely off of it

CAM-2 I know it

1551:05
CAM-2 This thing's settled down a little bit, might'a been his hot air going over it

1551:13
CAM ((sound of laughter))

1551:23
CAM-4 We still fourth

CAM-2 Yeah

CAM-4 Fourth now

1551:49
CAM-1 Don't do that Apple, I need to get the other wing done ((sound of laughter))

1552:04
LC Now for Palm ninety, if you're with me you'll be going out after, ah, the red DC nine Apple type

1552:09
RDO-2 Palm ninety

CAM ((sound of laughter))

1552:30
RDO ((Tower gives direction to Eastern concerning CAT two line))

CAM-2 That guy shooting CAT two ILS's there says how come there was a

small Lear on the runway when we
((sound of laughter))

CAM-1 When we landed on the taxiway

1552:42
CAM-1 You ought to talk to Rich Lussow
he landed on a --- landed on a
closed runway in, ah, Chicago

1552:49
CAM-2 Accidently

1552:53
CAM-1 In about sixteen inches, a seven two
seven, that /stopped just like that

CAM-2 I'll bet it did smooth deceleration, eh,
((sound of laughter))

1553:21
CAM-2 Boy, this is a, this a losing battle
here on trying to deice those things,
it(gives) you a false feeling of
security that's all that does

CAM-1 That, ah, satisfies the Feds

CAM-2 Yeah

CAM-2 As good and crisp as the air is and
no heavier than we are I'd

CAM-1 Right there is where the icing truck,
they ought to have two of them, you
pull right

CAM-2 Right out

1553:42
CAM-1 Like cattle, like cows right

CAM-1 Right in between these things and then

CAM-2 Get you position back

CAM-1 Now you're cleared for takeoff

CAM-2 Yeah and you taxi through kinda like
a car wash or something

CAM-1 Yeah

1553:51

CAM-1 Hit that thing with about eight billion gallons of glycol

1554:04
CAM-1 In Minneapolis, the truck they were deicing us with the heater didn't work on it, the# glycol was freezing the moment it hit

CAM-2 Especially that cold metal like that

CAM-1 Yeah

CAM-2 Well I haven't seen anybody go around yet, they're doing good

CAM-2 Boy I'll bet all the school kids are just # in their pants here. It's fun for them, no school tomorrow, ya hoo ((sound of laughter))

1555:00
CAM-1 What do think we should use for a takeoff alternate

CAM-2 Well, it must be within an hour, is that Stewart up there within an hour?

1555:09
CAM-2 About thirty-five minutes up there isn't it, on one

CAM-2 Dulles got a big old runway over there probably about the same, probably about the same stuff as here, you know

1555:36
CAM-1 Been into Stewart?

CAM-2 No, I've overflown it several times, over by the water over there, kinda long, it looks like an Air Force base, use ta be something

CAM-1 Yeah

CAM-2 Looks pretty good

1555:44
CAM-1 Yeah, it's a nice airport

CAM-2 Is it?

CAM-2 You been there, haven't you	
CAM-2 Did you have to from White Plains	
1555:49 CAM-2 Yeah	
CAM-2 I heard, ah	
CAM-1 In the service too	
CAM-2 Yeah, we were in, we were into White Plains one time, we were in earlier in the day and then saw some guys at the bar late that night come straggling in there really bitching, where in the # you all been, we been to Stewart man, we drove a van over here	
CAM-2 Nice touchdown	
	1556:11 LC Eastern one three three taxi into position and hold
CAM-1 Right on it	
CAM-2 Uh uh	1556:15 E133 Eastern's one three three, position and hold
1556:19 CAM ((sounds of laughter))	
1556:20 CAM-2 Cut his wing tip	
	1556:24 LC Grumman one six two five, turn left taxi clear and hold, ground point seven as you clear
	1556:28 625 One six two five
1556:39 CAM-1 Sure glad I'm not taking on in for	1556:39 LC Eastern one thirty three cleared that piece of # takeoff
	1556:42 E133 Cleared to go, Eastern's one thirty-three on the roll
CAM-2 Yeah that thing right there, that gets your attention	
	1556:44 LC Roger

INTRA-COCKPIT		AIR-GROUND COMMUNICATIONS	
1556:47 CAM-2	Hopefully, that's, ah, is that turbo charged or fuel injected?	1556:47 LC	Apple fifty-eight taxi into position and hold, be ready for an immediate
		1556:50 NYA 58	Position and hold, Apple fifty eight
1556:51 CAM-2	Hate to blast outta here with carburetor ice all over me		
		1556:53 556	TWA fifty-six is inside OXONN
1556:54 CAM-2	Specially with the monument staring you in the face		
1556:56 CAM-1	They call it the, ah, four twenty-Golden Eagle		
		1556:56 LC	Trans World five fifty-six roger, one, runway three six
1556:59 CAM-2	Yeah		
1557:02 CAM-1	It's, ah, pretty fancy		
1557:05 CAM	((sound similar to parking brake release))		
CAM	((sound of takeoff warning horn simultaneous with above))		
		1557:07 LC	Trans World five fifty-six, the wind is zero one zero at one zero, you're cleared to land runway three six visual range is three thousand touchdown is at ah, rollout is one thousand eight hundred
1557:30 CAM-2	Where do you want to go?		
		1557:31 LC	Apple fifty-eight cleared for takeoff traffic's three south for the runway
1557:32 CAM-1	I just don't want to blast him		

1557:34	CAM-1	CAT two line's right here			
			1557:34	NYA 58	Apple fifty-eight take off
1557:35	CAM-1	I'm on it			
1557:38	CAM-2	Yeah			
1557:42	CAM-2	Do you want to run everything but the flaps?			
1557:44	CAM-1	Yeah	1557:44	LC	Eastern one thirty-three contact departure control
1557:45	CAM-2	Start switches			
1557:46	CAM-1	They're on			
1557:46	CAM-1	Recall			
1557:47	CAM-1	Checked	1557:47	E133	Okay sir, good day
1557:47	CAM-1	Checked			
1557:48	CAM-2	Flight controls	1557:48	LC	Good day
	CAM-1	Bottoms			
1557:49	CAM-2	Tops good			
1557:50	CAM-2	Let's check these tops again since we been setting here awhile			
1557:55	CAM-2	I think we get to go here in a minute			
			1557:56	OOJ	National tower eight thousand juliet approaching Pisca
1557:58	CAM-2	Ought to work			

1558:00
CAM-2 Flaps we don't have yet

1558:01
CAM-2 Stab trim set at five point three

1558:02
CAM-1 Set

1558:03
CAM-2 Zero fuel weight, we corrected that up

1558:04
LC Eight thousand juliet Washington tower report Oxonn

1558:05
CAM-2 Ought to be, ah, seventy-nine one now

1558:07
OOJ Eight thousand juliet

CAM-1 Seventy-seven

1558:08
CAM-2 Seventy-seven one

1558:09
CAM-1 Set

CAM-2 Okay

1558:10
CAM-2 EPR all the way two oh four

1558:12
CAM-2 Indicated airspeed bugs are a thirty-eight, forty, forty four

1558:16
556 TWA five fifty-six cleared to land?

1558:18
LC Five fifty-six is cleared to land the wind is zero one zero at one zero

1558:20
CAM-1 Set

1558:21
CAM-2 Cockpit door

1558:22

1558:22

CAM-1 Locked

556 Cleared to land TWA five fifty-six

1558:23
CAM-2 Takeoff briefing

1558:24
451 Eastern fourteen fifty-one by the marker

1558:25
CAM-2 Air Florida standard

1558:26
CAM-2 Slushy runway, do you want me to anything special for this or just go for it

1558:26
LC Eastern fourteen fifty-one runway three six

1558:31
CAM-1 Unless you got anything special you'd like to do

1558:31
LC Apple fifty-eight contact departure control

1558:33
CAM-2 Unless just takeoff the nose wheel early like a soft field takeoff or something

1558:33
NYA NYA 58Fifty-eight so long

1558:37
CAM-2 I'll take the nose wheel off and then we'll let it fly off

1558:39
CAM-2 Be out the three two six, climb to five, I'll pull it back to about one point five five supposed to be about one six depending on how scared we are

1558:45
CAM ((sound of laughter))

1558:47
CAM-2 Up to five, squawk set, departure is eighteen one, down to flaps ((sound of laughter))

1558:55
LC Palm ninety taxi into position and hold, be ready for an immediate

1558:56
CAM-2 Oh, he pranged it on there

1558:58
RDO-2 Palm ninety position and hold

1558:59
CAM ((sound similar to parking brake being let off))

1559:00
CAM ((sound of takeoff warning))

CAM ((sound similar to flap lever activation))

1559:03
CAM ((sound of takeoff warning ceases))

1559:03
451 Eastern fourteen fifty-one, keep it at reduced speed, traffic's going to depart, Trans World five fifty-six left turn off if you can turn at the next taxiway, it would be appreciated nothing's been plowed

1559:06
PA Ladies and gentlemen, we have just been cleared on the runway for takeoff flight attendants please be seated

1559:15
CAM-2 Flight attendant alert

1559:16
CAM-1 given

1559:16
CAM-2 Bleeds

1559:17
CAM-1 They're off

1559:18
CAM-2 Strobes, external lights

1559:18
LC Okay contact ground point seven right there, thank you for your cooperation

CAM-1 On

1559:19
CAM-2 Anti skid

CAM-1 On

1559:21
CAM-2 Transponder

CAM-1 On

1559:22
CAM-2 Takeoff's complete

1559:24
LC Palm ninety cleared for takeoff

1559:26
RDO-2 Palm ninety cleared for takeoff

1559:28
LC No delay on departure if you will, traffic's two and a half out for the runway

1559:32
CAM-1 Okay

1559:32
RDO-2 Okay

1559:45
CAM-1 Your throttles

1559:46
CAM-2 Okay

1559:48
CAM ((sound of engine spoolup))

1559:49
CAM-1 Holler if you need the wipers

1559:51
CAM-1 It's spooled

1559:53
CAM-? Ho

CAM-? Whoo

1559:54
CAM-2 Really cold here

1559:55
CAM-2 Got 'em?

1559:56
CAM-1 Real cold

1559:56
41M Ground four one mike, we behind the Piedmont?

1559:57

CAM-1 Real cold

1559:58
CAM-2 God, look at that thing

1559:59
LC Four one mike, you're behind the Piedmont

1600:02
CAM-2 That don't seem right does it?

1600:03
LC Eastern fourteen fifty-one, the wind is zero one zero at one one you're cleared to land runway three six, the visual range touchdown two thousand eight hundred rollout one thousand six hundred

1600:05
CAM-2 Ah, that's not right

1600:09
CAM-2 (Well)---

1600:10
CAM-2 Naw, I don't think that's right

1600:11
E451 Fourteen fifty-one cleared to land over the lights

1600:19
CAM-2 Ah, maybe it is

1600:21
CAM-1 Hundred and twenty

1600:23
CAM-2 I don't know

1600:24
OOJ Oxonn for eight thousand juliet

1600:26
LC Eight thousand juliet runway three six, you're cleared to land the wind is zero one zero at one two

1600:28
OOJ Eight thousand juliet cleared to land

1600:31
CAM-1 Vee two

1600:38
68G Position and hold six eight gulf

1600:39
CAM ((sound of stickshaker starts and continues to impact))

1600:41
LC Palm ninety, contact departure control

1600:45
CAM-1 Forward, forward

1600:47
CAM-? Easy

1600:48
CAM-1 We only want five hundred

1600:50
CAM-1 Come on, forward

1600:52
172 Tower Us Air one seven two with you ten out

1600:53
CAM-1 Forward

1600:54
LC US Air one seven two, roger

1600:55
CAM-1 Just barely climb

1600:56
LC Eastern fourteen fifty-one, turn left at the next taxiway, advise when you clear the runway, no delay clearing

1600:59
CAM (stalling) we're (falling)

1601:00
CAM-2 Larry, we're going down, Larry

1601:01
CAM-1 I know it

1601:01 ((sound of impact))

APPENDIX C:

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C.
Aircraft Accident Report

EASTERN AIR LINES, INC.
L-1011, N310EA
MIAMI, FLORIDA
December, 1987

APPENDIX C:

NATIONAL TRANSPORTATION SAFETY BOARD
Washington, D.C.
Aircraft Accident Report

EASTERN AIR LINES, INC.
L-1011, N310EA
MIAMI, FLORIDA
DECEMBER 29, 1987

SYNOPSIS

An Eastern Air Lines Lockheed L-1011 crashed at 2343 eastern standard time, December 29, 1972, approximately 18 miles west-northwest of Miami International Airport, Miami, Florida. The aircraft was destroyed. There were 163 passengers and a crew of 13 aboard the aircraft; 94 passengers and 5 crewmembers received fatal injuries. All other occupants received injuries which ranged in severity from minor to critical.

The flight diverted from its approach to Miami International Airport because the nose landing gear position indicating system of the aircraft did not indicate that the nose gear was locked in the down position. The aircraft climbed to 2,000 feet man sea level and followed a clearance to proceed west from the airport at that altitude. During this time, the crew attempted to correct the malfunction and to determine whether or not the nose landing gear was extended.

The aircraft crashed into the Everglades shortly after being cleared by Miami Approach Control for a left turn back to Miami International Airport. Surviving passengers and crewmembers stated that the flight was routine and operated normally before impact with the ground.

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the flight crew to monitor the flight instruments during the final 4 minutes of flight, and to detect an unexpected descent soon enough to prevent impact with the ground. Preoccupation with a malfunction of the nose gear position indicating system distracted the crew's attention from the instruments and allowed the descent to go unnoticed.

1.1 History of the Flight

Eastern Air Lines, Inc., Lockheed L-1011, N310EA, operating as Flight 401 (EAL 401), was a scheduled passenger flight from the John F. Kennedy International Airport (JFK), Jamaica, New York, to the Miami International Airport (MIA), Miami, Florida.

On December 29, 1972, the flight departed from JFK at 2120 1/ with 163 passengers and 13 crewmembers on board and was cleared to MIA in accordance with an instrument flight rules flight plan.

The flight was uneventful until the approach to MIA. The landing gear handle was placed in the "down" position during the preparation for landing, and the green light, which would have indicated to the flightcrew that the nose landing gear was fully extended and locked, failed to illuminate. The captain recycled the landing gear, but the green light still failed to illuminate.

At 2334:05, EAL 401 called the MIA tower and stated, "Ah, tower, this is Eastern, ah, four zero one, it looks like we're gonna have to circle, we don't have a light on our nose gear yet."

At 2334:14, the tower advised, "Eastern four oh one heavy, roger, pull up, climb straight ahead to two thousand, go back to approach control, one twenty eight six."

At 2334:21, the flight acknowledged, "Okay, going up to two thousand, one twenty eight six."

At 2335:09, EAL 401 contacted MIA approach control and reported, "All right, ah, approach control, Eastern four zero one, we're right over the airport here and climbing to two thousand feet, in fact, we've just reached two thousand feet and we've got to get a green light on our nose gear."

At 2335:20, approach control acknowledged the flight's transmission and instructed EAL 401 to maintain 2,000 feet mean sea level and turn to a heading of 360 degrees magnetic. The new heading was acknowledged by EAL 401 at 2335:28.

At 2336:04, the captain instructed the first officer, who was flying the aircraft, to engage the autopilot. The first officer acknowledged the instruction.

At 2336:27, MIA approach control requested, "Eastern four oh one, turn left heading three zero zero.." EAL 401 acknowledged the request and complied.

The first officer successfully removed the nose gear light lens assembly, but it jammed when he attempted to replace it.

At 2337:08, the captain instructed the second officer to enter the forward electronics bay, below the flight deck, to check visually the alignment of the nose gear indices.

At 2337:24, a downward vertical acceleration transient of 0.04 g caused the aircraft to descend 100 feet; the loss in altitude was arrested by a pitchup input.

At 2337:48, approach control requested the flight to turn left to a heading of 270 degrees magnetic. EAL 401 acknowledged the request and turned to the new heading.

Meanwhile, the flightcrew continued their attempts to free the nose gear position light lens form its retainer, without success. At 2338:34, the captain again directed the second officer to descend into the forward electronics bay and check the alignment of the nose gear indices.

At 2338:46, EAL 401 called MIA approach control and said "Eastern four oh one'll go ah, out west just a little further if we can here and, ah, see if we can get this light to come on here." MIA approach control granted the request.

From 2338:56 until 2341:05, the captain and the first officer discussed the faulty nose gear position light lens assembly and how it might have been reinserted incorrectly.

At 2340:38, a half-second C-chord, which indicated a deviation of +/- 250 feet from the selected altitude, sounded in the cockpit. No crewmember commented on the C-chord. No pitch change to correct for the loss of altitude was recorded.

Shortly after 2341, the second officer raised his head into the cockpit and stated, "I can't see it, it's pitch dark and I throw the little light, I get, ah, nothing."

The flightcrew and an Eastern Air Lines maintenance specialist who was occupying the forward observer seat them discussed the operation of the nose wheelwell light. Afterward, the specialist went into the electronics bay to assist the second officer.

At 2341:40, MIA approach control asked, "Eastern, ah, four oh one how are things comin' along out there?"

This query was made a few seconds after the MIA controller noted an altitude reading of 900 feet in the EAL 401 alphanumeric data block on his radar display. The controller testified that he contacted EAL 401 because the flight was nearing the airspace boundary within his jurisdiction. He further stated that he had no doubt at that moment about the safety of the aircraft. Momentary deviations in altitude information on the radar display, he said, are not uncommon; and more than one scan on the display would be required to verify a deviation requiring controller action.

At 2341:44, EAL 401 replied to the controller's query with, "Okay, we'd like to turn around an come, come back in," and at 2341:47, approach control granted the request with, "Eastern four oh one turn left heading one eight zero." EAL 401 acknowledged and started the turn.

At 2342:05, the first officer said, "We did something to the altitude." The captain's reply was, "What?"
At 2342:07, the first officer asked, "We're still at two thousand, right?" and the captain immediately exclaimed, "Hey, what's happening here?"

At 2342:10, the first of six radio altimeter warning "beep" sounds began; the ceased immediately before the sound of the initial ground impact.

At 2342:12, while the aircraft was in a left bank of 28 degrees, it crashed into the Everglades at a point 18.7 statute miles west-northwest of

MIA (latitude 25 degrees 52' N., longitude 80 degrees 36'W.). The aircraft was destroyed by the impact.

Local weather at the time of the accident was clear, with unrestricted visibility. The accident occurred in darkness, and there was no Moon.

Two ground witnesses had observed the aircraft shortly before impact to be at an altitude that appeared low.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Other
Fatal	5	94	0
Nonfatal	10*	67	0
None	0	0	

*Includes two nonrevenue passengers, one occupying an observers seat in the cockpit and the other seated in the first-class section of the cabin.

The accident survivors sustained various injuries; the most prevalent were fractures of the ribs, spine, pelvis, and lower extremities. Fourteen persons had various degrees of burns. Seventeen persons received only minor injuries and did not require hospitalization.

Post-mortem examination of the captain revealed a tumor which emanated from the right side of the tentorium in the cranial cavity. The tumor displaced and thinned the adjacent right occipital lobe of the brain. The lesser portion of this meningioma extended downward into the superior portion of the right cerebellar hemisphere. The tumor measured 4.3 centimeters laterally, 5.7 centimeters vertically, and 4.0 centimeters in an anterior-posterior direction.

1.3 Damage to Aircraft

The aircraft was destroyed.

1.4 Other Damage

None.

It is obvious that this accident, as well as others, was not the final consequence of a single error, but was the cumulative result of several minor deviations from normal operating procedures which triggered a sequence of events with disastrous results.

2.2 Conclusions

(a) Findings

1. The crew was trained, qualified, and certificated for the operation.

2. The aircraft was certificated, equipped, and maintained in accordance with applicable regulations.

3. There was no failure or malfunction of the structure, powerplants, systems, or components of the aircraft before impact, except that both bulbs in the nose landing gear position indicating system were burned out.

4. The aircraft struck the ground in a 28 degree left bank with a high rate of sink.

5. There was no fire until the integrity of the left wing fuel tank was destroyed after impact.

6. The tumor in the cranial cavity of the captain did not contribute to the accident.

7. The autopilot was utilized in basic CWS.

8. The flightcrew was unaware of the low force gradient input required to effect a change in aircraft attitude while in CWS.

9. The company training program met the requirements of the Federal Aviation Administration.

10. Three flight crewmembers were preoccupied in an attempt to ascertain the position of the nose landing gear.

11. The second officer, followed later by the jump seat occupant, went into the forward electronics bay to check the nose gear down position indices.

12. The second officer was unable visually to determine the position of the nose gear.

13. The flightcrew did not hear the aural altitude alert which sounded as the aircraft descended through 1,750 feet m.s.l.

14. There were several manual thrust reductions during the final descent.

15. The speed control system did not affect the reduction in thrust.

16. The flightcrew did not monitor the flight instruments during the final descent until seconds before impact.

17. The captain failed to assure that a pilot was monitoring the progress of the aircraft at all times.

(b) Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the failure of the flightcrew to monitor the flight instruments during the final 4 minutes of flight, and to detect an unexpected descent soon enough to prevent impact with the ground. Preoccupation with a malfunction of the nose landing gear position indicating system distracted the crew's attention from the instruments and allowed the descent to go unnoticed.

3. RECOMMENDATIONS

The Board further recommends that the Federal Aviation Administration:

Review the ARTS III program for the possible development of procedures to aid flightcrews when marked deviations in altitude are noticed by an Air Traffic Controller. (Recommendation A-73-46.)

The Board is aware of the present rulemaking proceedings initiated by the Flight Standards Service on April 18 concerning the required installation of Ground Proximity Warning Devices. However, in view of this accident and of previous recommendations on this subject made by this Board, we urge that the Federal Aviation Administration expedite its rulemaking proceedings.

APPENDIX D:

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

AIRCRAFT ACCIDENT REPORT

UNITED AIRLINES, INC.
DC-8F-54, N8047U
NEAR KAYSVILLE, UTAH
DECEMBER 18, 1977

APPENDIX D:

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

AIRCRAFT ACCIDENT REPORT

UNITED AIRLINES, INC.
DC-8F-54, N8047U
NEAR KAYSVILLE, UTAH
DECEMBER 18, 1977

SYNOPSIS

About 0138:28 m.s.t. on December 18, 1977, a United Airlines, Inc., DC-8F-54 cargo aircraft, operating as Flight 2860, crashed into a mountain in the Wasatch Range near Kaysville, Utah. The three flightcrew members, the only persons aboard the aircraft, were killed, and the aircraft was destroyed.

Flight 2860 encountered electrical system problems during its descent and approach to the Salt Lake City Airport. The flight requested a holding clearance which was given by the approach controller and accepted by the flightcrew. The flight then requested and received clearance to leave the approach control frequency for a "little minute" to communicate with company maintenance.

Flight 2860 was absent from the approach control frequency for about 7 1/2 minutes. During that time, the flight entered an area near hazardous terrain. The approach controller recognized Flight 2860's predicament but was unable to contact the flight. When Flight 2860 returned to approach control frequency, the controller told the flight that it was too close to terrain on its right and to make a left turn. After the controller repeated the instructions, the flight began a left turn and about 15 seconds later the controller told the flight to climb immediately to 8,000 feet. Eleven seconds later, the flight reported that it was climbing from 6,000 feet to 8,000 feet. The flight crashed into a 7,665-foot mountain near the 7,200-foot level.

The National Transportation Safety Board determines that the probable cause of this accident was the approach controller's issuance and the flightcrew's acceptance of an incomplete and ambiguous holding clearance in combination with the flightcrew's failure to adhere to prescribed impairment-of-communications procedures and prescribed holding procedures. The controller's and flightcrew's actions are attributed to probable habits of imprecise communication and of imprecise adherence to procedures developed through years of exposure to operations in a radar environment.

Contributing to the accident was the failure of the aircraft's No. 1 electrical system for unknown reasons.

FACTUAL INFORMATION

History of the Flight

On December 17, 1977, United Airlines, Inc., Flight 2860, a DC-8F-54 (N8047U), was a scheduled cargo flight from San Francisco, California, to Chicago, Illinois. About 2 1/2 hrs. before Flight 2860's scheduled departure from San Francisco, an intermediate stop a Salt Lake City, Utah, was scheduled.

According to the flight dispatcher, the flightcrew reported for duty a 2300. The captain and dispatcher discussed the weather situation at Salt Lake City, and the dispatcher informed the captain that the flight would be dispatched with the aircraft's No. 1 a.c. electrical generator inoperative. This conforms to company minimum-equipment-list procedures, and the dispatcher later stated that the lack of the generator seemed to present no problems to the captain. However, before the flightcrew left the dispatch office, the dispatcher received information that the generator had been repaired, and he passed this information to the captain.

On December 18, 1977, at 0017, Flight 2860 departed San Francisco on an instrument flight rules (IFR) flight plan for Salt Lake City. The flight's estimated time en route was 1 hr 12 min, and its planned cruise altitude was flight level (FL) 370.

Flight 2860's departure and en route portions of the flight were flown without reported difficulty, except the Salt Lake air route traffic control center (Salt Lake Center) sector 43 controller was unable to establish radio communications with the flight between 0105 and 0109 on frequency 133.45 MHz. At 0111:41, Flight 2860 established radio communication with the Salt Lake Center sector 41 controller on frequency 132.55 MHz and requested descent clearance for the approach to Salt Lake City Airport.

At 0111:52, the Salt Lake Center controller cleared the flight to descend to 15,000 ft and gave the altimeter setting as 29.58 in. At 0115:42, Flight 2860 requested landing and weather information for Salt Lake City Airport. The controller replied that the flight would soon be transferred to Salt Lake City approach control and the latter would provide the information requested. Flight 2860 s[illegible]d "Okay, cause we're working with radio problems too it looks like."

At 0116:43 the controller cleared Flight 2860 to contact Salt Lake City approach control frequency 126.8 MHz, and at 0116:58, Flight 2860 established radio communications with that facility. The Salt Lake City approach controller gave Flight 2860 radar vectors for a VOR approach to runway 16R at Salt Lake City Airport and cleared the flight to descend to 8,000 ft. The controller also gave the weather information as: "...measured 1,700 overcast, visibility 15, light rain, temperature 41, altimeter 29.58.

The a[illegible] con[illegible]ler continued to vector Flight 2860 for alignment with the VOR approach [illegible] runway 16R, and at 0120:38, he cleared the flight to descend to 6,000 ft. The flight acknowledged the descent clearance and asked the controller, "What's the ceiling...?" The controller responded, "Measured 1,700 broken, the wind is 160 at 10."

At 0122:32, Flight 2860 advised, "Okay, we got...a few little problems here, we're trying to check our gear and stuff right now." The controller replied, "Okay, if ...you need any help, I'll give you a vector back around to final, but you're 6 miles form the VOR." Flight 2860 said, "Okay..."

At 0124:18, the controller cleared Flight 2860 to land and gave the surface wind as 160 degrees at 13 kns. Flight 2860 replied "Roger, we got to check our gear first." At 0124:36, Flight 2860 indicated it would not land and the approach controller replied, "...fly runway heading, maintain 6,000, will vector you back around for an approach." Flight 2860 said, "Okay..."

The approach controller gave Flight 2860 instructions to turn right to a 330 degree heading and to maintain 6,000 ft. the flight acknowledged, and said, "Okay, we'd just as soon not get back in it if we can help it." The controller replied, "Okay, minimum vectoring altitude is 6,000, that's the best I can do for you to vector you back for the approach." Flight 2860 said, "Okay, we'll try that."

At 0127:31, Flight 2860 asked, "Take us out about 20 miles, can you do that?" The controller replied, "Affirmative", and Flight 2860 responded, "Okay, 'cause we're gonna have to get the gear down and try to find out what the heck is going on." At 0128:08, the controller said, "United...2860 turn right heading 345", and Flight 2860 replied, "345, twenty eighty sixty."

At 0129:01, Flight 2860 transmitted, "Ah tower, we're gonna have to, ah nuts, just a second." Fourteen seconds later, Flight 2860 asked, "You put us in a holding pattern at 6,000 here on the VOR for awhile?" The controller replied, "...roger, turn right, proceed direct to the Salt Lake VOR, hold on the, at the VOR, maintain 6,000." Flight 2860 said, "Okay, we'll hold north of the VOR, 6,000... right turns, Okay?" The controller said, "That's correct, northwest of the VOR at 6,000, right turns." Flight 2860 replied, "Okay".

At 0129:51 Flight 2860 asked, "Okay, now can we...leave you for a little minute, we wanna call San Francisco a minute?" The controller replied, "United 2860, frequency change approved," and at 0129:59 Flight 2860 said, "Thank you sir, we'll be back."

After the above transmission, Flight 2860 contacted United Airlines' system line maintenance control center in San Francisco. This contact was made through Aeronautical Radio, Inc. (ARINC) on frequency 130.6 MHz. Flight 2860 began this communication link at 0130:21 and terminated the link at 0137:11.

According to ARINC communications recordings, Flight 2860 established communications with the DC-8 maintenance controller at 0132:37. Flight 2860 informed the maintenance controller that the No. 1 electrical bus was inoperative, and the No. 3 generator would not parallel; also, the landing gear indicator lights did not present a "down" indication when the landing gear extended. The maintenance controller inquired whether the flightcrew had attempted to reset the No.1 bus, and the crew replied that they had. The controller inquired whether the No. 1 generator was providing normal volts and frequency, and the crew replied that it was providing "nothing, it's dead".

At 0133:37, the maintenance controller told the flightcrew to standby while he checked the electrical power source for the landing gear indicating system, and at 0135:08, the controller informed the flightcrew "...the landing gear position indicating system comes off the No. 1 bus..." He then inquired whether the flightcrew could get another generator to power the No. 1 bus, and the crew responded, "The No. 1 bus is dead and that's it." At 0135:30, the maintenance controller said, "Okay, you can't get any other generator to pick up the dead bus, and that's why your landing gear warning system does not work--because you got to have power to the 28-volt d.c. bus, No. 1." Flight 2860 replied, "Okay, I've gonna kind of figure who the 28-volt d.c. No. 1 -- I can't find that landing gear warning circuit breaker on the darn thing. Ah, also, I assume the hydraulic quantity pressure gage is on the same circuit breaker, same generator." The controller said that he would "check on it if you like," but Flight 2860 said, "Oh, before you go...one thing, if that's the only way they can get gear indicators, we're gonna go ahead and land then." The controller confirmed that the No. 1 28-volt d.c. bus powered the landing gear warning system.

At 0136:28 Flight 2860 terminated communication with the maintenance controller. In response to a query from ARINC on whether to keep the line to maintenance control open, Flight 2860 replied, "Well no, I guess we're...only got one radio, so we're back to the tower, we're going to land, we're going to call out the equipment." Flight 2860 terminated radio communications with ARINC at 0137:11.

While Flight 2860 was on the ARINC frequency, the Salt Lake City tower ground controller, at 0136:28, called the Salt Lake City flight service station (FSS) and told the specialist on duty there to transmit a message to United Flight 2860 on the Salt Lake City VOR frequency. The message to Flight 2860 was for the flight to contact Salt Lake City approach control on frequency 124.3 MHz. Between 0137:07 and 0137:22, the Salt Lake City approach controller attempted three times to establish radio communications with Flight 2860. At 0317:22, the ground controller asked the FSS specialist whether he had made the transmissions; the specialist replied that he had.

At 0137:26 Flight 2860 said, "...hello Salt Lake, United 2860 we're back." At 0137:31, the approach controller said, "United 2860, you're too close to terrain on the right side for a turn back to the VOR, make a left turn back to the VOR." Flight 2860 replied, "Say again," and at 0137:39, the controller said, "You're too close to terrain on the right side for the turn, make a left turn back to the VOR." At 0137:44, Flight 2860 said, "Okay".

At 0137:54 the approach controller asked, "United 2860, do you have light contact with the ground?" Flight 2860 replied, "Negative." At 0138:00 the controller said, "Okay, climb immediately to maintain 8,000." At 0138:07, the controller again transmitted, "United 2860, climb immediately, maintain 8,000," and 4 seconds later, Flight 2860 asked, United 2860 is out of six for eight." At 0138:36, the controller asked, "United 2860, how do you hear?" Flight 2860 did not respond to that transmission or to succeeding transmissions from the approach controller.

Shortly after 0135, at least seven witnesses in Kaysville, Utah, and the nearby community of Fruit Heights heard what they described as a jet aircraft flying low overhead. One of the witnesses saw a red light on the airplane as it flew in an easterly direction over her location in Kaysville. She could see nothing more of the airplane because it was obscured by clouds, rain, and darkness. The airplane continued eastward and a short time later, she saw a bright orange glow appear to the east. The glow lasted 3 to 4 secs and disappeared. Four other witnesses saw the orange glow shortly after hearing the airplane pass overhead. All of the witnesses said that it was raining at the time--several described the rain as heavy.

The accident occurred at night (0138:28) at an elevation of about 7,200 ft., and at altitude 41 degrees 02'41"N and longitude 111 degree 52'30"W.

Injuries to Persons

Injuries	Crew	Passengers	Other
Fatal	3	0	0
Serious	0	0	0
Minor/non	0	0	0

According to video maps in the Salt Lake City control tower radar displays, the minimum vectoring altitudes (MVA) varied considerably within the facility's control area. The MVA for the area about 3 mi east of V-21 (331 degree radial) to 5 mi west of V-21 between the Salt Lake City and Ogden VOR's was 6,000 ft. The MVA's on both side of this area were higher. On the east side, the MVA's extended to 9,000 ft and 10,500 ft.

ANALYSIS AND CONCLUSION

Analysis

The flightcrew was certificated properly, and all members were qualified for the flight. They had received the off-duty time required by regulation, and there was no evidence of medical factors that might have affected their performance.

There was evidence of ethyl alcohol in the second officer's body which according to the weight of medical opinion most likely occurred from his ingestion of alcohol within the 8-hr period preceding the flight. Since investigation of the second officer's activities before he departed San Francisco disclosed no evidence either alcohol consumption or of the noticeable effects of consumption, the Safety Board is unable to determine the extent, if any, to which the second officer's physiological and mental faculties might have been impaired by alcohol nor could the Board determine whether the blood alcohol level of the second officer contributed to the accident. However, the consumption of alcohol by members of a flightcrew within 8 hrs of flight is prohibited by regulation for good reason and should not be tolerated by anyone responsible for the operation of aircraft.

The aircraft was certificated, equipped, and maintained in accordance with regulations and approved procedures. Except for the electrical malfunction associated with the No. 1 electrical bus and the reported unparalleled state of the No. 3 generator, there was no evidence of a failure or malfunction of the aircraft's structure, powerplants, flight controls, or systems, including flight instrument and navigational systems. The post-accident condition of the engine components indicate that all four engines were running at high thrust selections when the aircraft crashed.

Based on the flightcrew's recorded conversation with United's system line maintenance controller, following the flight's descent for landing at Salt Lake City, the No. 1 electrical bus was not powered and all electrical components powered by the No. 1 bus were inoperative. The Safety Board was not able to determine why the No. 1 electrical bus could not be powered because many of the electrical components could not be recovered and because those recovered were too badly damaged to provide clues. However, we believe that the No. 1 generator probably was malfunctioning for the same reasons that it malfunctioned the day before. Also, although the generator control panel had been changed, the cause of the earlier malfunction apparently was intermittent and was not in the control panel as established by tests on the panel that was removed. Consequently, had the No. 1 generator drive been disconnected, as it had been the day before, the No. 1 bus-tie probably could have been closed and the No. 1 bus could have been powered by the Nos. 2 and 4 generators. The unparalleled state of the No. 3 generator appears to have been an unrelated malfunction which had no bearing on the problems associated with the No. 1 generator.

Notwithstanding Flight 2860's electrical systems problems, the Safety Board concludes that the failures associated with the No. 1 electrical system alone were not responsible for the accident. Although these failures precipitated a series of events which culminated in the accident, the aircraft's alternate electrical systems and the established procedures for dealing with electrical system failures were, for the most part, adequate to permit safe operation of the aircraft with the No. 1 electrical system inoperative. Further, although disconnection of the No.1 generator drive might have permitted the flightcrew to restore power to the No. 1 electrical bus, the flightcrew should have been able to safely fly, navigate, and land the aircraft with the bus inoperative.

An analysis of the series of events which followed Flight 2860's electrical system problems discloses numerous acts of omission and commission, the slight alteration of which probably could have prevented the accident. The first of these events was the holding clearance that was issued by the Salt Lake City approach controller. The clearance clearly did not conform to established holding clearance requirements because the holding radial was omitted.

The controller was not able to explain why he omitted the radial from the clearance. Under the circumstances, with 2 to 2 1/2 hrs. sleep in the 19 1/2-hr period preceding the accident, the controller might have been affected by fatigue. However, fatigue is a subjective physiological reaction since it affects each individual differently. Since the controller denied feeling fatigue, generalizations to the contrary would be speculative at best. It is believed more likely that since the controller intended that the flight hold northwest on the 331 degree radial and since the 331 degree radial was the only radial useful to the flightcrew in conducting a VOR approach to runway 16R, he probably thought that the holding radial was obvious and that, therefore, the direction of holding was sufficient. The flightcrew's response ("Okay") to the controller's correction of the holding direction from north to northwest would have tended to reassure him in this respect, as would the flight's subsequent return to the VOR via the 331 degree radial. Additionally, since the flight was apparently in visual flight conditions and under radar control and since there was no other traffic in the area, the controller probably did not consider the specific radial particularly important. As a practical matter, the omission of the holding radial would have been detected and corrected had communications with the flight not been interrupted.

Because of the lack of CVR information, the Safety Board is unable to determine why the captain and first officer might have failed to realize the omission of a specific holding radial from the holding clearance. Possibly, fatigue affected the flightcrew when the clearance was issued and throughout the remainder of the flight; but, there was no evidence that they did not make full use of the 13-hr rest period in San Francisco or of the rest periods afforded them before they reported for duty in Chicago on December 16. If the flightcrew made appropriate use of these rest periods, as the evidence indicates they did, fatigue should not have been a factor. Therefore, we believe it more likely that they probably failed to realize the omission, or the importance of the omission, because of distractions associated with the electrical system problems and because they were in visual flight conditions where the aircraft was just below the clouds and the visibility was good.

Flightcrew voice identification of ATC and ARINC tapes indicates that the captain originally was flying the aircraft and that the first officer was managing the radio communications. Shortly after the flight established communications with Salt Lake City approach control, the captain began making the radio transmissions, which indicates that the first officer probably was flying the aircraft when the holding clearance was requested, because the non-flying pilot usually manages the radio communications. Later transmissions on ARINC frequency show that the captain was active in discussing the electrical system problems with United's maintenance controller. Therefore, before the flight left the approach control frequency, the captain probably was significantly involved in the diagnoses of the electrical problems and, consequently, his attention probably was divided between those problems and flying activities.

Since the pattern of ground lights in the Salt Lake City-Ogden corridor are oriented in a true north-south direction and since, when the holding clearance was requested, the aircraft was about 7 to 8 mi west of those lights, the captain could have thought that holding north was more appropriate. His statement, "Okay, we'll hold north of the VOR...," tends to support such a train of thought. Whether the flightcrew discussed the matter is not known. However, the evidence indicates that the first officer accepted the 360 degree radial as the holding radial because the course selection in his horizontal situation indicator was found at 000. Additionally, the probable ground track shows that after the aircraft passed the VOR it flew the outbound leg of the holding pattern on about a 358 degree track. The captain's course selection apparently was left at or near 151, the designated course to the Salt Lake City VOR for the published VOR approach to runway 16R.

The second critical event in the series of events leading to the accident was the transfer of radio communications from approach control frequency to ARINC frequency. Under the circumstances, the controller was not aware that

Flight 2860 had radio communication problems and would need special handling because he was not told as required by regulations that the flight had lost a communications radio, the degree to which the loss impaired the flight's capability to operate IFR in the ATC system, or the nature and extent of assistance desired from ATC. Had the flightcrew given t s information to the controller, the controller might have been able to arr. ige for an alternate means of maintaining communications, such as establishing a voice receiving capability for the flight through the Salt Lake City VOR. It appears that the captain arranged both the holding clearance and the transfer of communications somewhat casually. Some of the casualness probably can be attributed to his divided attention. However, while holding at night at an altitude well below the elevation of surrounding mountains, a professional pilot would be careful about limiting his source of aircraft position information, particularly with unresolved electrical problems that could have the potential of affecting his navigational equipment.

On the other hand, the controller should have realized that the flight's request to leave the approach control frequency probably would result in a loss of ATC communications, and, therefore, would in effect terminate radar control for the duration of the loss. He should have further realized that while he was providing radar vectors and radar navigational guidance to an aircraft operating at MVA, he was also required to provide advisories in the event the aircraft deviated from its protected airspace. If the controller was unable to communicate with the flightcrew, he could not provide the deviation advisories to them. Therefore, in the absence of a request for emergency handling, he should have taken one of the following actions: (1) Directed the flight to a protected area which would not have required the controller's provision of radar navigational guidance, or (2) denied the request to leave the frequency.

Notwithstanding the controller's alternatives, he undoubtedly was misled by the captain's suggestion that the flight would only be off frequency "for a little minute." Given the aircraft's position, altitude, and groundspeed at that time (0129:51) and the flight's clearance to "turn right and proceed direct to the Salt Lake VOR...", the controller knew that the flight was safe from obstructing terrain for well over a minute. As the flight progressed, the aircraft passed over the VOR about 0132, or more than 2 minutes after the captain implied that the flight would be off the frequency for a short time.

In fact, the flight was absent from the controller's frequency for about 7 1/2 min. The ARINC transcripts show that 2 min 16 sec of the 7 1/2 min period were consumed in establishing communications with the maintenance controller. Consequently, the Board cannot explain why the captain thought the flight's absence from the frequency would be only "a little minute." However, the flightcrew probably was not concerned with the passage of time because they believed themselves in a safe area, and they were intent on solving the landing gear problem and a difficult electrical system problem. In any event, the whole pattern of imprecise communications with approach control suggests a somewhat casual and complacent attitude toward management of the flight.

During the 7 1/2 min period, (about 0136), it became obvious to the controllers that the flight would cross the 331 degree radial on a northerly track instead of turning right to intercept the radial and flying inbound on the 331 degree radial to the VOR. Consequently, the controllers attempted to contact the flight through the Salt Lake City and Ogden VOR's but were not successful because the flight was not monitoring the VOR's for voice transmissions even though both VOR receivers were tuned to the Salt Lake City VOR Frequency. This is verified because, according to the message transmitted, the flight was requested to contact approach control on frequency 124.3 MHz, but the aircraft's No. 2 transceiver--the only communications radio operative with the No. 1 electrical bus inoperative--was found at 126.8 MHz, the originally assigned frequency. Additionally, the flight terminated communications with ARINC at 0137:11, only 15 secs before they reported back on approach control frequency.

The third critical event was the manner in which the holding pattern was flown. According to Flight 2860's probable ground track, the standard time of 1 min on the outbound leg of the holding pattern was exceeded by about 1 min 30 sec. Additionally, according to FDR information, the flight's indicated airspeed on the outbound leg averaged about 240 kns as opposed to the authorized 200 kns. It is apparent from the probable ground track map that, had the flight adhered to the 1 min limitation and had it intercepted the 360 degree radial back to the VOR, it would have remained well clear of obstructing terrain. Also, calculations show that if the maximum authorized airspeed of 200 kns had been flown, the flight's right turn toward the 360 degree radial might have begun about 2.6 mi earlier, which would have kept the flight much farther from obstructing terrain. Finally, if both the 200-KIAS and 1-min limitations had been observed, the flight's outbound leg would have been about 4 mi long and the flight would have remained well clear of the hazardous terrain.

However, it is not certain what aid, if any, the flightcrew used to determine the length of the outbound leg. The inbound turn began about 10 nmi from the VOR which indicates that the first officer might have used 10 nmi on his DME as the measure of leg length even though the use of DME was not specified in the holding clearance. Since the controller had told the flight earlier that he could take it out 20 mi (north-northwest), the use of 10 nmi on the DME as the measure of leg length probably would have seemed reasonable to the first officer. On the other hand, the inbound turn was begun shortly after the discussion with United's maintenance controller ended, during the last portion of which the captain expressed his intention to "go ahead and land then." Consequently, it is possible that the first officer was monitoring the discussion and that he began the inbound turn shortly after the captain expressed his decision to land. Also, if the first officer's attention was partially directed toward the diagnoses of the electrical system problems, he might have lost track of the timing on the outbound leg. In any event, the holding pattern was not flown in conformity with prescribed procedures and, as a result, the aircraft was flown into an unsafe area when the air traffic controllers could not provide any assistance.

The final critical event which, if managed differently, might have prevented the accident was the exchange of communications between the controller and the flightcrew after the flight had returned to the approach control frequency. About 1 min elapsed between the time the flight reported back on the frequency and the time the aircraft struck the mountain. Considering the aircraft's speed and performance capability as demonstrated by the FDR traces, in about 30 secs or less the aircraft could have been flown safely above the mountains. Additionally, it is apparent from the probable ground track that had Flight 2860 continued its right turn, without climbing, and had it intercepted the 360 degree radial inbound, without overshoot, it would not have struck the mountains. On the other hand, had Flight 2860 begun the left turn immediately or had it begun the climb immediately after receipt of the controller's first instructions to turn and climb, is likely that the aircraft would not have crashed.

Considering the alternatives which were possibly available to the controller, instructions for an immediate turn and climb with stress on the immediacy of the action would have been most appropriate. However, the controller's radar display did not, and cannot, portray sufficient details of the terrain or the aircraft's flight track to permit the controller to make fine distinctions about the aircraft's proximity to obstructing terrain. Additionally, the radar display that the controller was using in the tower cab did not portray these features with as high fidelity as the plan position indicator displays in the radar room. Consequently, under the circumstances, the controller's instructions to the flight must be considered a judgmental matter on his part. However, since the MSAW alert was flashing and since the aircraft was headed toward areas where the MVA's were 9,000 ft and higher, the controller should have placed more emphasis on the urgency of the action he told Flight 2860 to take, and he should have given the flight instructions to immediately turn and immediately climb.

The conditions in the cockpit of Flight 2860 after the flight reported back on approach control frequency are not known because of the lack of CVR information. However, based on weather reports and witness reports, the flight apparently entered instrument flight conditions during the inbound turn, if not before, and the flightcrew was not aware that a dangerous situation was developing. Consequently, the controller's instructions probably surprised them sufficiently to cause delays in their responses. Additionally, simulation tests indicate that the GPWS would not have provided a warning until 7.7 to 10.2 secs before impact, which because of the rapidly rising terrain was too late.

Clearly, it was a preventable accident because so many independent events had to combine sequentially to produce the accident, and slight alterations in any of these events could have prevented it. However, we conclude that the most critical of the events was the manner in which understanding was reached on the holding clearance, because of the holding clearance had been properly given and properly understood the events that followed either would not have affected the safety of the aircraft or would not have occurred. We believe the major problem with the holding clearance was the lack of precision in the communications between the parties involved.

The captain knew that he had only one radio and that he would have to terminate ATC communications, and radar control, in order to communicate with United's maintenance controller. Further, from information available to him on the instrument approach chart and from his previous experience in Salt Lake City area, he should have known that 6,000 ft was well below the elevations of surrounding mountains. Therefore, he should have insisted on absolute certainty about where the flight was to hold. When the approach controller issued the holding instructions, he was not aware that communications had been troken and, therefore, the holding instructions were imprecise and contained an ambiguity which the flightcrew failed to detect.

The Board has noted this lack of precision in communications in other accidents, and we believe that some of it is attributable to complacency while operating in the radar environment. When under radar control, flightcrew communications and adherence to prescribed procedures may tend toward imprecision because they know that the controller has the means to detect and correct mistakes. On the other hand, the controller may be less precise in his communications and adherence to prescribed procedures because he has the means to correct any mistakes or misunderstandings that might occur. Consequently, after lengthy exposure to the pure radar environment, both flightcrews and air traffic controllers develop habits of imprecision in their communications with each other and in their adherence to prescribed procedures. Further, the exposure can lead to a loss of knowledge of procedures which, generally, were developed for use in the non-radar environment or for use in the event of lost communications and which may be used rarely with precision in the pure radar environment.

Flightcrews and controllers alike should consciously strive for precision in their communications with each other and in their adherence to prescribed procedures, not only to avoid events similar to those which led to this accident, but also because the loss of communications between the flightcrew and controller always terminates radar control and prevents both parties from correcting mistakes or clarifying ambiguities.

Another problem inherent in situations involving malfunctions of aircraft systems in flight is the division of responsibilities among members of the flightcrew while the malfunction is being resolved. The Safety Board has addressed these responsibilities in a number of accident reports. In this instance, because of the lack of CVR information, the manner in which the captain coordinated and managed the activities of the first officer and the second officer is not explicitly known. However, it is known from the ATC and ARINC communications recordings that the captain was actively involved in resolution of the electrical problem and in obtaining a holding clearance. Consequently, the captain probably was distracted by the electrical problem from supervision of the flying activities, including obtaining the holding clearance and the manner in which the first officer flew the holding pattern. Similarly, it is possible that the first officer was monitoring the resolution of the electrical problem and, therefore, was paying less than full attention to ATC communications and to flying the aircraft.

Since this type of situation is dynamic because the aircraft must be flown while the malfunction is resolved, it follows that the captain must manage the flightcrew in a manner which will insure absolute safe operation of the aircraft during the interim. Therefore, although each situation will vary depending on the type of aircraft involved, the complexity and criticality of the malfunction, the composition of the flightcrew, and many other factors, it remains that the captain's first and foremost responsibility is to insure safe operation of the aircraft. To achieve this objective, he must relegate other activities accordingly.

CONCLUSIONS

Findings

1. The flightcrew were properly certificated and were qualified for the flight.

2. There was toxicological evidence of alcohol in the second officer's body which according to the weight of medical opinion most likely resulted from his ingestion of alcohol during the 8-hr period preceding the flight; however, since there was no corroborative evidence of alcohol consumption or the effects thereof, the degree of impairment, if any, of the second officer's physiological and mental faculties could not be determined.

3. When initially dispatched, the aircraft's No. 1 a.c. electrical generator was inoperative, but repairs were completed and the dispatch release was revised accordingly before the flight departed San Francisco.

4. The aircraft's No. 1 electrical system malfunctioned during the flight's descent for the approach to Salt Lake City airport; the No. 1 electrical bus was inoperative and all of its associated electrical components were inoperative.

5. Other than components that were powered through the No. 1 electrical bus, there was no evidence of malfunction or failure of the aircraft's other systems, including flight instrument and navigational systems, or its structure, powerplants, or flight controls.

6. Contrary to United's DC-8 Flight Handbook, the No. 1 communications radio was powered through the No. 1 electrical bus; the radio was inoperative after the loss of the No. 1 bus.

7. The flightcrew was unable to verify landing gear extension because the landing gear indicator system was powered through the No. 1 electrical bus.

8. Shortly after the flight established communications with Salt Lake City approach control, the first officer began flying the aircraft and the captain managed the radio communications.

9. Contrary to regulations, the flightcrew did not inform ATC of the loss of a communications radio, the extent to which the loss impaired the flight's capability to operate IFR in the ATC system, or the assistance desired from ATC.

10. Because the captain wanted to communicate with United's system line maintenance control in San Francisco, he requested a holding clearance from the Salt Lake City approach controller.

11. The holding clearance issued by the approach controller was incomplete and attempts to clarify the clearance resulted in an ambiguity.

12. The approach controller intended that Flight 2860 hold northwest on the 331 degree radial of the Salt Lake City VOR, but he did not specify the radial.

13. The captain apparently intended to hold north of the Salt Lake City VOR but did not request a complete holding clearance, including a holding radial.

14. Because the approach controller did not issue a holding radial, and because the captain did not request a holding radial, the first officer assumed the 360 degree radial to be holding radial.

15. The approach controller was misled by the captain's request to leave the frequency for a "little minute"; the flight was absent from the frequency about 7 1/2 min.

16. During the flight's absence from the approach control frequency, the controllers recognized that the aircraft was entering a hazardous area but they were unable to communicate with the flight.

17. Flight 2860 was not monitoring the Salt Lake City VOR for voice transmissions even though both VOR receivers were tuned to the Salt Lake City VOR frequency.

18. The first officer did not fly the holding pattern in accordance with established procedures; as a result, the aircraft was unknowingly flown into an area near hazardous terrain.

19. When the flight returned to approach control frequency, the approach controller had determined that a left turn was required to prevent a collision with hazardous terrain.

20. The approach controller told Flight 2860 to turn left to avoid hazardous terrain on its right, but he did not stress the need for immediate action.

21. Because ATC radar displays cannot portray terrain features or an aircraft's track in fine detail, and because the display used by the controller had less fidelity than the usual approach control radar displays, the controller's instructions to Flight 2860 to turn and climb were judgmental.

22. When Flight 2860 received turn and climb instructions from the approach controller, it was in instrument flight conditions and the flightcrew was not able to make an independent assessment of their predicament.

23. The aircraft's GPWS probably functioned from 7.7 to 10.2 sec before impact but not in time for the flightcrew to prevent the aircraft's

collision with terrain which rose at a 32 degree angle from the horizontal.

24. The accident was not survivable because severe impact forces destroyed the aircraft and subjected the flightcrew to extreme traumatic injury.

Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the approach controller's issuance and the flightcrew's acceptance of an incomplete and ambiguous holding clearance in combination with the flightcrew's failure to adhere to prescribed impairment-of communications procedures and prescribed holding procedures. The controller's and flightcrew's actions are attributed to probable habits of imprecise communication and of imprecise adherence to procedures developed through years of exposure to operations in a radar environment.

Contributing to the accident was the failure if the aircraft's No. 1 electrical system for unknown reasons.

RECOMMENDATIONS

On April 3, 1978, the Safety Board issued Safety Recommendations A-78-21 and A-78-22 to the Federal Aviation Administration as follows:

> "Review the adequacy of current cockpit voice recorder preflight testing procedures to assure satisfactory system operation. (A-78-21)"

> "Review the reliability of cockpit voice recorder units to assure that the mean time between failure is not excessive. (A-78-22)"

THE LAST TWENTY MINUTES:
(Voice communications between UAL 2860 and various people on the ground)

UAL2860:	Salt Lake City Center United twenty sixty how do you hear us?
SLC Center:	We hear you loud and clear now you've been calling us
UAL2860:	Yeah we sure have
SLC Center:	On one thirty two fifty five
UAL2860:	No we was on our other frequency but you never told us to change how about coming down
SLC Center:	You can come down to one five thousand Salt Lake altimeter two niner five eight
UAL2860:	Okay
UAL2860:	Center United uh twenty eight sixty give us the information at Salt Lake please
SLC Center:	Standby
UAL2860:	On the ATIS they're only giving uh they say it's raining and get some information later
SLC Center:	Roger you'll be talking to Approach and uh they'll uh have the more current information there
UAL2860:	Okay cause uh we're working with radio problems too it looks like
SLC Center:	United Twenty eight sixty contact Salt Lake Approach one two six point eight they'll give you the information
UAL2860:	Thank you
UAL2860:	Salt Lake approach United twenty eight sixty leaving eighteen for fifteen
SL Apprch:	United twenty eight sixty Salt Lake approach control ident descend and maintain an eight thousand turn left heading zero one zero vector runway one six right VOR approach current Salt Lake weather measured one thousand seven hundred broken two thousand overcast visibility one five light rain temperature four one altimeter two nine five eight
UAL2860:	Twenty nine fifty eight
0818:23	
SL Apprch:	United twenty eight sixty turn left heading zero seven zero maintain eight thousand if approach clearance is not received

prior to crossing the Salt Lake three three one radial turn right and execute the VOR approach

UAL2860: Ah how about a right turn zero seven zero

SL Apprch: That's correct a right turn to zero seven zero

UAL2860: Okie doke, will maintain eight and if we don't talk to ya by the three three one degree radial

SL Apprch: That's correct

UAL2860: Rog

0819:48

SL Apprch: United twenty eight sixty turn right heading zero niner zero

UAL2860: Zero nine Zero

0820:38

SL Apprch: United twenty eight sixty descend and maintain six thousand

UAL2860: Down to six

0821:21

SL Apprch: United twenty eight sixty turn right heading one four zero you're one zero miles from the VOR cleared for VOR runway one six right approach

SL Apprch: Cleared for the VOR one six approach

0822:23

UAL2860: What's the ceiling tower

SL Apprch: Measured one thousand seven hundred broken the wind is one six zero at one zero

UAL2860: Okay we got some we got a few little problems here we're trying to check our gear and stuff right now

SL Apprch: Okay if I can if you ah need any help I'll give you ah vector back around to final but you're six miles from the VOR

UAL2860: Okay thank you

0824:08

SL Apprch: United twenty eight sixty cleared to land runway one six right wind one six zero at one three

UAL2860: Roger we got to check our gear first

0824:29

UAL2860: That for the right runway or the left

SL Apprch: That's the right one you're lined up for right the right ah runway

UAL2860: Ah we may have to pass across (unintelligible)

SL Apprc United twenty eight sixty ah (unintelligible) fly runway heading maintain ah six thousand will vector you back around for an approach

UAL2860: Okay will

0825:24

SL Apprch: United twenty eight sixty turn ah observe you climbing turn right heading three three zero vector back around for an approach

UAL2860: Right three three zero United ah twenty eight sixty

UAL2860: You want us to go right now

SL Apprch: Ya you can make the turn now

UAL2860: Okay and what altitude

SL Apprch: Six thousand

UAL2860: Okay we'd just soon not get back in it if we can help it

SL Apprch: Okay minimum vectoring altitude is ah six thousand ah that's the best I can do for you to vector you back for the approach

UAL2860: Okay we'll try that

0826:18

SL Apprch: United twenty eight sixty you got your ah gear problem straightened out

UAL2860: No

SL Apprch: Okay

0827:31

UAL2860: Take us out about twenty miles can you do that

SL Apprch: Affirmative

UAL2860: Okay 'cause we're gonna have to get the gear down and try to find out what the heck going on

SL Apprch: Alrighty

0828:08

SL Apprch: United twenty eight ah twenty eight sixty turn right heading three four five

UAL2860: Three four five twenty eight sixty

0929:01

UAL2860: Ah tower we're gonna have to go ah ah nuts just a second

UAL2860: You put us in a holding pattern at six thousand here on the VOR for a while?

SL Apprch: United twenty eight sixty roger turn right proceed direct to the Salt Lake VOR hold on the at the VOR maintain six thousand

UAL2860: Okay we'll hold ah north of the VOR six thousand ah (unintelligible) right turns ah okay

SL Apprch: That's correct northwest of the VOR at six thousand right turns

UAL2860: Okay

0830:51

UAL2860: Okay now can we go ah leave you for a little minute we wanna call San Francisco a minute

SL Apprch: United twenty eight sixty frequency change approved

UAL2860: Thank you sir we'‾_ back

0831:11

UAL2860: San Francisco United uh twenty six eighty

UAL2860: Twenty eight sixty I'm sorry ARINC twenty eight sixty Uh

0831:28

UAL2860: ARINC United twenty eight sixty

SFO: United two eight six zero San Francisco

UAL2860: Yeh can you get us uh can you patch us in direct to Line Maintenance or do we have to go through dispatch

SFO: Well that depends on which maintenance you want to talk to

UAL2860: I want to talk to DC eight maintenance

SFO: Okay you want to talk to DC-8 line maintenance what station

UAL2860: San Francisco

SFO: Okay that makes it a lot easier standby

UAL2860: Okay

0832:16

SFO: Two eight six zero San Francisco the maintenance base at San Francisco line tied up right now you want to hold on

UAL2860: You better give them a land line then we got an emergency almost

SFO: You have an emergency we'll break it in standby

0832:37

SLMCC: United uh twenty eight sixty this is system line maintenance control center

UAL2860: Okay uh we've got a problem we've lost our number one buss uh we can't parallel our number three generator we put the gear down and we can't get any lights and we pressed the button and everything else and we have a problem

SLMCC: Okay uh on your number one buss uh I presume you uh tried resetting it and uh no no help is that correct

UAL2860: Yes we've uh we've done that

SLMCC: The generator has normal volts and frequency

UAL2860: Nothing its dead

SLMCC: Okay and you say you number three generator is working but it won't parallel

UAL2860: Affirmative (pause) - why can't we get gear lights

SLMCC: Uh standby by a minute let me check the source of the ah gear light indication just a minute

UAL2860: Okay uh we can't stay around here too long we're gonna have to get on the ground

0834:37

UAL2860: Uh San Francisco twenty eight sixty

0834:47

SFO: Two eight six zero this is ARINC San Francisco your maintenance man is checking he said he'd be right back on can I help you

UAL2860: No probably not

0835:04

SLMCC: Uh United uh twenty eight sixty uh are you still on

UAL2860: Yes

SLMCC: Okay uh the landing gear warning system comes off of the or rather landing gear position indicating system comes off the number one buss is dead uh in other words you can't get another generator to pick it up

UAL2860: The number one buss is dead and that's it

SLMCC: Okay you can't get any other generator to pick up the dead buss - and that's why your landing gear warning system does not work because you got to have power to the twenty eight volt DC buss number one

0835:48

UAL2860: Okay I'm gonna kind of figure who the twenty eight volt DC. Number one I can't find that landing gear warning circuit breaker on the darn thing. Uh also I assume the hydraulic quantity pressure gage is on the same circuit breaker same generator

SLMCC: Uh I don't know about that I can check on it if you like

UAL2860: Oh, before you go, we've got one other thing. If that's the only way they can get gear indicators were gonna go ahead and land then

SLMCC: Okay uh the number one

SLMCC: Okay the number one DC uh twenty eight volt DC buss does power the landing gear warning system

UAL2860: Okay thank you

SLMCC: Maintenance control center clear

0836:49

SFO: United two eight six zero San Francisco would you like me to leave this line open for you

UAL2860: Say again

SFO: This is San Francisco would you like me to leave this line open for you

UAL2860: Well no I guess not we're uh we're only got one radio so we're back to the tower we're going to land we're going to call out the equipment

SFO: Okay San Francisco roger

0837:11 During the last exchange with San Francisco, Approach Control attempted to contact United twenty eight sixty, three times and also requested the flight service station to transmit to United twenty eight sixty on the Salt Lake VOR

0837:26

UAL2860: Oh ah hello ah Salt Lake United twenty eight sixty we're back

SL Apprch: United twenty eight sixty you're too close to terrain on the right side for a turn back to the VOR make a left turn back to the VOR

UAL2860: Say again

SL Apprch: You're too close to terrain on the right side for the turn make a left turn back to the VOR

UAL2860: Okay

SL Apprch United twenty eight sixty do you have ah light contact with the ground

UAL2860: Negative

SL Apprch: Okay climb immediately to maintain eight thousand

0838:07

SL Apprch: United twenty eight sixty climb immediately maintain eight thousand

UAL2860: United twenty eight sixty is out of six for eight

0838:18

SL Apprch: Hill Tower Salt Lake

Hill AFB:	Hill
SL Apprch:	Ah United there's a United DC8 right over top of ya just southeast of ya he's make a left turn and climbing

....

0838:29 Impact

....

Hill AFB:	Okay RA
SL Apprch:	HE
SL Apprch:	United twenty eight sixty how do you hear
SL Apprch:	United twenty eight sixty heavy how do you hear approach control
SL Apprch:	United twenty eight sixty if you hear Salt Lake approach control make an immediate left turn immediate turn to the west
SL Apprch:	Hill Tower Salt Lake
Hill AFB:	Hill
SL Apprch:	Do you see anything up there to the southeast of ya
Hill AFB:	We can't see a thing
SL Apprch:	Okay
SL Apprch:	United twenty eight sixty how do you hear approach control

APPENDIX E:

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, DC 20594

AIRCRAFT ACCIDENT REPORT

AIR ILLINOIS HAWKER SIDDLEY
HS 748-2A, N748LL
NEAR PINCKNEYVILLE, ILLINOIS
OCTOBER 11, 1983

APPENDIX E:

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, DC 20594

AIRCRAFT ACCIDENT REPORT

AIR ILLINOIS HAWKER SIDDLEY
HS 748-2A, N748LL
NEAR PINCKNEYVILLE, ILLINOIS
OCTOBER 11, 1983

SYNOPSIS

On October 11, 1983, Air Illinois Flight 710 was being operated as a regularly scheduled passenger flight between Capital Airport, Springfield, Illinois and Southern Illinois Airport, Carbondale, Illinois. About 2020 central daylight time, Flight 710 departed Springfield with seven passengers and three crewmembers on board. About 1.5 minutes later, Flight 710 called Springfield departure control and reported that it had experienced a slight electrical problem but that it was continuing to its destination about 40 minutes away.

The cockpit voice recorder (CVR) transcript showed that shortly after takeoff Flight 710's left generator suffered a complete mechanical failure and that in responding to the failure of the left generator, the first officer mistakenly isolated the right generator and the right generator bus bar from the airplane's d.c. electrical distribution system and, thereafter, the right generator disconnected from the right generator bus bar. All subsequent attempts to restore the right generator to the airplane's d.c. electrical distribution system were unsuccessful, and the airplane proceeded toward Carbondale relying solely on its batteries for d.c. electrical power.

The flight toward Carbondale was conducted in instrument meteorological conditions. The cloud bases in the area of the accident were at 2,000 feet MSL with tops at 10,000 feet. Visibility below the cloud bases was 1 mile in rain, and there were scattered thunderstorms in the area.

About 2053, while the airplane was descending from its instrument flight rules (IFR) assigned altitude of 3,000 feet, battery power was depleted. Flight 710 continued to descend, turned about 180 degrees, and crashed in a rural area near Pinckneyville, Illinois, about 22 nmi northwest of the Southern Illinois Airport. The airplane was destroyed by impact forces, and all 10 persons on board the airplane were killed. There was no postcrash fire.

The National Transportation Safety Board determines that the probable cause of the accident was the captain's decision to continue the flight toward the more distant destination airport after the loss of d.c. electrical power from both airplane generators instead of returning to the nearby departure airport. The captain's decision was adversely affected by self-imposed psychological factors which led him to assess inadequately the airplane's battery endurance after the loss of generator power and the magnitude of the risks involved in continuing to the destination airport. Contributing to the accident was the airline management's failure to provide and the FAA's failure to assure an adequate company recurrent flightcrew training program which contributed to the captain's inability to assess properly the battery endurance of the airplane before making a decision to continue, and led to the inability of the captain and the first officer to cope promptly and correctly with the airplane's electrical malfunction.

FACTUAL INFORMATION

History of Flight

On October 11, 1983, Air Illinois Flight 710, a Hawker Siddley 748-2A was being operated as a regularly scheduled passenger flight between Chicago, Illinois, and the Southern Illinois Airport, Carbondale, Illinois, with an enroute stop at Springfield, Illinois. The flight was about 45 minutes behind schedule when it arrived at Capitol Airport, Springfield, Illinois, about 2005. The flightcrew remained on board while the airplane was loaded with 300 gallons of jet-A fuel. The flightcrew did not report any mechanical malfunctions to either the Air Illinois controlling dispatcher in Carbondale or to the ramp personnel at Springfield. Air Illinois station personnel gave the flightcrew documents containing the latest Carbondale weather and the airplane load information which had been prepared by the company dispatcher in Carbondale.

At 2011, at the request of Flight 710, the flight service specialist at the Decatur, Illinois Flight Service Station provided the flightcrew with the latest Carbondale weather and the St. Louis, Missouri, winds aloft. The flight service specialist said the reported ceiling and visibility at Carbondale were 2,000 feet overcast and 2 miles, three, six and nine thousand feet and asked the crew if it wanted the St. Louis weather. The crew replied, "Negative," and the Flight Service Station had no further contact with Flight 710.

The 127-nmi flight to Carbondale was to be flown in accordance with an Instrument Flight Rules (IFR) flight plan stored in Kansas City, Missouri, Air Route Traffic Control Center (ARTCC) computer. The routing was direct at an altitude of 9,000 feet and the estimated time en route was 45 minutes. However, at 2011:44, when Flight 710 requested its IFR clearance, it also requested 5,000 feet for its en route altitude. The request was approved.

Flight 710 had been scheduled to depart from Springfield at 1935; however, it was not cleared to taxi from the gate until 2015:14. There were 7 passengers and 3 crewmembers on board Flight 710 when it left the gate. At 2016:00, Flight 710 was cleared to taxi to runway 18 for takeoff. At 2019:40, Springfield tower cleared Flight 710 for takeoff, which occurred about 2020:00, and then, at 2020:43, the tower told the flight to contact Springfield departure control.

At 2012:14, Flight 710 contacted departure control and informed the controller that it was climbing through 1,500 feet. The departure controller advised the flight that he had it in radar contact, cleared it to climb to and maintain 5,000 feet, and cleared it to proceed direct to Carbondale after it received the Carbondale VOR (very high frequency omni directional radio) signal on its navigational radio. Flight 710 acknowledged receipt of the clearance.

At 2021:34, Flight 710 informed the departure controller that it had experienced a "slight electrical problem..." and that it would keep the controller "advised". The controller asked the flight if it was going to return to Springfield, and the flight reported that it did not intend to do so.

At 2022:10, the flight told departure control that "We'd like to stay as low as we can," and then it requested and was cleared to maintain 3,000 feet. The controller asked the flight if he could provide any assistance, and the flight responded, "...we're doing okay, thanks".

At 2023:54, the first officer told the captain that "the left (generator) is totally dead, the right (generator) is putting out voltage but I can't get a load on it." At 2024:26, the first officer reported, "zero voltage and amps (amperes) on the left side, the right (generator) is putting out twenty-seven and a half (volts) but I can't get it to come on the line." At 2025:42, he told the captain that the battery power was going down "pretty fast."

At 2026:03, Flight 710 reported to the Kansas City ARTCC and told the center controller that they were at 3,000 feet. Shortly thereafter, the first officer reported that the battery voltage was 22 volts.

At 2027:24, the captain called Kansas City center and stated that he had an "unusual request". He asked clearance to descent to 2,000 feet "even if we have to go VFR [visual flight rules]". He also asked the controller "to keep your eye on us if you can". The controller told the flight that he could not clear it to descend because 2,000 feet was below his "lowest usable altitude". He also told the flight that if it requested VFR and then descended to 2,000 feet he did not believe he would be able to remain on radar contact. The captain thanked the controller and continued to maintain 3,000 feet. During this conversation, the first officer reported that the battery voltage was 22.5 volts.

At 2028:45, the captain said, "Beacons off...", and at 2028:46, he said, "Nav (navigation) lights are off." At 2031:04, the first officer reminded the captain that Carbondale had a 2,000-foot ceiling and that the visibility was 2 miles with light rain and fog.

At 2033:07, the flight attendant came forward and the captain asked her if she could work with what she "had back there." The flight attendant reported that the only lights operating in the cabin were the reading lights, the lights by the lavatory, the baggage light, and the entrance lights. The captain instructed her to brief the passengers that he had turned off the excess lights because the airplane had experienced "a bit of an electrical problem..." but that they were going to continue to Carbondale. The flight attendant requested the Carbondale estimated time of arrival (ETA) ant the first officer said they would arrive "about on the hour".

At 2038:41, the first officer told the captain, "Well, when we...started losing the left one I reached up and hit the right [isolate button] trying to isolate the right side [be] cause I assumed the problem was the right side but they [the generators] both still went off."

At 2044:59, in response to the captain's request the first officer reported that the battery voltage was 20 volts. At 2049:23, Kansas City center requested Flight 710 to change radio frequencies. The flight acknowledged the request, which was the last radio communication from Flight 710.

At 2051:37, the first officer told the captain, "I don't know if we have enough juice to get out of this." At 2052:12, the captain asked the first officer to "Watch my altitude, I'm going to go down to twenty-four hundred (feet)." He then asked the first officer if he had a flashlight and to have it ready. At 2053:18, the first officer reported, "We're losing everything,...down to about thirteen volts," and, at 2053:28, he told the captain the airplane was at 2,400 feet. At 2054:00, the captain asked the first officer if he had any instruments. The first officer asked him to repeat, and at 2054:16, the captain asked, "Do you have any instruments, do you have a horizon [attitude director indicator]?"

About 2051, Kansas City center lost radar contact with Flight 710. The last confirmed radar return from Flight 710 occurred near the Centralia, Illinois VORTAC located about 40 nmi north of the Southern Illinois Airport. The accident occurred during the hours of darkness. The wreckage of the airplane was found in the rural area about 6 nmi northeast of Pinckneyville, Illinois, at 38 degrees 9' north latitude, and 89 degrees 19' west longitude. Three crewmembers and seven passengers were killed in the crash.

**** Voice Recording Not Available ****

APPENDIX F:

WESTERN AIRLINES DC-10 ACCIDENT
MEXICO CITY INTERNATIONAL AIRPORT
OCTOBER 31, 1979

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WESTERN AIRLINES DC-10 ACCIDENT
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November 903 Whiskey Alpha, a Douglas DC-10 Series 10, crashed while landing on runway 23 at the Mexico City International Airport. The runway was closed for repairs as per NOTAM 2841. The crew consisted of 3 flight crew members and 8 flight attendants assigned to the passenger cabin of the aircraft. Nine crewmembers, 63 passengers and 1 person on the ground were fatally injured; 14 passengers and 2 flight attendants survived.

The aircraft was destroyed by impact forces and fire. The Director-General of Civil Aviation, United States of Mexico, found that the probable cause of the accident was:

1. Failure of the Crew to adhere to the minimum altitude for the approach procedure for which they were cleared.

2. Failure of the crew to follow approved procedures during an instrument approach, and

3. Landing on a runway closed to traffic.

FLIGHT PERSONNEL

Captain Gilbert, 53, had a total flying time of 31,500 hours, 2,248 of which were on DC-10 aircraft. He had been qualified into Mexico City as Pilot-in-Command for about 15 years and estimated to have made 350 landings there. He had make 4 landings in Mexico City during the month of October, prior to the accident; the last occurring on October 4, where Flight 2605 was cleared to land on Runway 23 left, and did so. This landing occurred while the regular First Officer was on sick leave.

First Officer Reichel, 44, received his flight training in the United States under an agreement with the West German Air Force. His total flying time was 8,666 hours, of which 357 hours were in DC-10 aircraft. He had performed 15 landings at the Mexico City airport as a DC-10 First Officer; 4 occurring in October, the last 2 occurring on October 19 and 24, after the NOTAMed closure of Runway 23 left. One of these landings was made on Runway 23 left. It is interesting to note that Captain Gilbert had called in sick for these two flights and that one of the replacement captains testified at the hearing that First Officer Reichel failed to make altitude call-outs on his flight.

Second Officer Walsh, 39, had a total flying time of 6,469 hours, of which 1,351 were on the DC-10. He had recently made 16 flights into Mexico City as a DC-10 Second Officer; 5 occurring in October. The last 2 landings prior to the accident were made on the 19th and 24th. One of those landings was made on 23 left after the runway was notamed closed. On October 31, Runway 23, left was closed.

As you can see, all the flight crew members were well qualified, not only in the equipment they were operating, but also into the Mexico City

Airport. It is interesting to note that the last time the Captain had landed at Mexico City, he had landed in Runway 23 left, prior to the runway being notamed closed, while the other two flight crew members had each landed on Runway 23 left after it was closed as per notam, and once on Runway 23 right. Since the accident occurred in the early hours of the morning, as the sun was coming up, fatigue factor must be considered. Indications from the cockpit voice recorder bear this out, since sleep and naps were mentioned on a number of occasions.

The following is an account of the flight crew members' activities on the day they reported to work.

The Captain rose a 0900, flew a T-6 aircraft to a nearby airport, gave one hour of instruction in a Stearman aircraft and flew home. He had dinner at 1900 hours, and went to bed at 2030, rising at 2230. He reported for duty at 2340, having been advised previously that the flight was delayed one hour.

The First Officer lived near Seattle, WA, but was based in Los Angeles. It was his custom to commute to Los Angeles early and sleep during the day prior to the trip. On this day, he flew to Los Angeles as a passenger on a Western flight arriving at 2117. He had not been informed of the delay due to the commute involved. Whether he slept during the day is not known, but what is known is that the Los Angeles Chief Pilot called him up at 0800 regarding a discrepancy reported by Captain Gilbert concerning failure to adhere to dress codes and standards. It was not determined whether this call awakened him or if he was already awake.

The Second Officer was reported to have had a full night's sleep the previous night and a 3-hour nap in the afternoon.

As mentioned previously from the information obtained from the voice recorder, on three separate occasions, the crew discussed naps and sleep. The only logical reason, it would seem, is that the subject was foremost on their minds because of the physical discomfort sleep deprivation causes.

The Tower Controller was a person with some 17 years experience in Control Tower operations. His shift began at 1200 on the evening of th 30th and would have been over at 0700. It was customary, between midnight and 0600, to have only one controller on duty. This controller was the sole occupant in the Tower Cab during flight 2605's approach and accident at Mexico City airport.

PRELIMINARY INFORMATION

The runway, taxiway and approach lights were controlled from a substation located near the terminal area at the southwest corner of the airport. A technician was stationed at a position remote from the actual control room. Communications from the Tower Controller to the technician were via telephone and walkie-talkie radio. When the technician received a request for a lighting change, he had to leave his position and proceed to the adjacent room some 120 feet away to make the requested change.

Investigators visiting this area 24 hours after the accident found a large number of runway edge lighting fixtures stored in one of the warehouse rooms. They were advised that equipment was previously installed on Runway 23 left and 5 right and had been removed some 7 to 10 days prior to the accident. Main electrical wires to the approach lighting system and VASI for 23 left were observed to be disconnected. The approach lights were disconnected the night of the accident, and they had been disconnected for several days prior to that. There was a considerable number or 5-, 20-, and 40-gallon containers in the vicinity that were apparently used to illuminate and mark the construction area. During the hours of darkness, it was observed that these containers were lighted and burning, showing a considerable flame. In addition, a number of trucks and construction equipment were along the runway with their lights on.

Runway 23 left is equipped with a CAT I ILS approach. The outer compass locator and marker beacon coded identification MIKE ECHO is located 4.5 nautical miles from the threshold. The Tepexpan NDB coded TANGO PAPA XRAY is located approximately 11.3 nautical miles north-northeast of the runway; the decision height for the ILS is 200 feet.

The voice recorder was recovered from the wreckage; however, the unit had been pierced. This penetration came in contact with the erasure circuit sending a momentary electrical impulse to the bulk eraser, causing a wedge-shaped segment of the tape to be erased.

At 0540, the ARTC log entry indicates that the Tower Controller called and advised ARTC that the "the fog bank had covered the runways, and I'm unable to see the runways," and that "Western probably has to go around". This information was never passed on to Flight 2605.

The Tepexpan transition as shown requires a 90-degree intercept at the ILS. The normal tendency of pilots not too familiar with this transition is to fly through the ILS localizer course and have to re-intercept from the South. Methods commonly used to counter-act this problem were to slow the aircraft done well in advance and lead the turn at Tepexpan. When using the Tepexpan transition, time and distance constraints compress the workload into a very limited envelope even under normal conditions. Now, throw in cockpit malfunction (inability to engage the ILS), plus an inordinate number or radio transmissions at inopportune times, and it is not difficult to see how the crew got behind the power curve.

The review of the cockpit activity during the turn, approximately 1.5 minutes, showed that the Second Officer read the challenge portion of the instrument approach checklist with the Captain and First Officer responding. The Second Officer called out four checklist items and made one request. Fifteen responses from the Captain and First Officer were recorded. The First Officer made one communication change, possibly two navigation frequency changes and three radio calls. The flight also received two radio calls. There is also a possibility that the ILS signal could have been unstable due to heavy construction in progress, which may have induced the Captain to vary the flight path in reaction to the unstable localizer course.

From the outer-marker inbound, the aircraft was hand-flown. The landing checklist was started and cockpit activity accelerated. In the next 1 minute, 42 seconds, the Second Officer made 9 checklist call-outs, including repeats, plus a prelanding P. A. announcement. The Captain made 20 checklist responses, commands and comments. The First Officer responded to 3 items and made 5 radio calls. The Tower called the flight 6 times. The landing checklist was completed one mile from the runway threshold, 430 feet above touchdown elevation. While the First Officer responded to the Captain's commands, his checklist items and the radio calls, he failed to make any altitude call-outs, nor did he announce reaching DH, as required by procedures. The possibility exists that the callouts were made but erased in that portion of the CVR tape; however, it is highly unlikely that this was accomplished--rather, complete surprise was registered when the aircraft contacted the ground.

The Tower advised the flight at 0530 and 57 seconds that they were to the left of track and that was acknowledged: "Just a little bit." At 0540 and 6 seconds, the Tower asked: "Advise runway in sight. There's a layer of fog over the field." At 0540 and 35 seconds, the Tower asks: "Do you have the approach lights on the left in sight?" At this point, the aircraft is 400 feet above touchdown zone elevation, approaching ILS minimums. In spite of the fact that the flight had been advised, apparently the Tower's announcement (27 seconds before touchdown) that Runway 23 left was closed to traffic came as a complete surprise to the crew, especially the Captain.

TRANSCRIPT OF COMMUNICATIONS DURING THE LAST 20 MINUTES OF FLIGHT

Approach Communications:

05:23'10"	WA 2605	CENTRO MEXICO WESTERN TWO SIX ZERO--FIVE
23'12"	WA 2605	CENTRO MEXICO WESTERN TWO SIX ZERO--FIVE
24'08"	WA 2605	CENTRO MEXICO DO YOU READ WESTERN TWO SIX ZERO FIVE?
	CCA	GO AHEAD WESTERN
24'18"	WA 2605	OKAY WESTERN TWO SIX ZERO FIVE REQUESTING LOWER ALTITUDE
24'23"	CCA	TWO ZERO FIVE BEAM QUERETARO RADAR CONTACT DESCENT TO ONE THREE THOUSAND--PROCEED DIRECT TO TEPEXPAN THREE ZERO - TWO ZERO THE ALTIMETER EXPECT TWO - - THREE RIGHT APPROACH
24'33"	WA 2605	OKAY WILL DESCEND TO ONE THREE THOUSAND
24'59"	WA 2605	WESTERN TWO SIX ZERO LEAVING -- FIVE LEAVING THREE SEVEN ZERO PLEASE - ACKNOWLEDGE
05:26'10"	CCA	TWO SIX ZERO FIVE ROGER
25'12"	WA 2605	THANK YOU
28'10"		(TRAFFIC BN920 COYUCA FOUR/THREE-FIVE ZERO GDL FIVE TWO)

	WA 2605	MEXICO CITY WESTERN FLIGHT TWO SIX --ZERO FIVE OVER
	FIS	TWO SIX ZERO FIVE MEXICO
	WA 2605	UH..ROGER WILL BE ON THE BLOCKS AT - FIVE SIX PAST THE HOUR AND WILL HAVE TWO SIX THOUSAND IN TANKS AND CAN YOU GIVE ME MY GATE AND ALSO I COPIED ALL THE WEATHER EXCEPT THE WIND. (PARTIAL OBSCURATION 3 MILES HAZE, SMOKE, FOG, TEMP 09, DUE POINT 07, WIND 0607 KTS, ALTIMETER 3020)
	FIS	OKAY THE WIND ZERO SIX ZERO DEGREES - AT SEVEN KNOTS AND YOU GATE IS ELEVEN, ONE ONE
	WA 2605	ROGER COPIED GATE ONE ONE WESTERN SIX ZERO ONE UH...CORRECTION WESTERN TWO SIX ZERO FIVE OVER
	FIS	ROGER
05:29'00"	WA 2605	...AND MEXICO CITY WESTERN TWO SIX ZERO FIVE WHAT RUNWAY ARE THEY USING?
	FIS	<u>TWENTY THREE</u>
	WA 2605	UNDERSTAND RUNWAY TWO THREE
	FIS	ROGER
29'16"	CCA	WESTERN TWO SIX ZERO FIVE CHANGE TO ONE NINETEEN SEVEN
29'22"	WA 2605	SAY AGAIN TWO SIX O FIVE
	CCA	ONE NINE POINT SEVEN
	WA2605	ONE NINE POINT SEVEN "SO LONG"
29'37"	WA 2605	BUENAS NOCHES MEXICO WESTERN TWO ZERO FIVE DESCENDING TO ONE THREE THOUSAND WE ARE OUT OF TWO POINT FIVE
	TML	TWO SIX ZERO FIVE ROGER RADAR CONTACT
05:34'03"	TML	WESTERN TWO SIX ZERO FIVE DESCEND TO ONE ONE THOUSAND, CLEARED FOR TEPEXPAN <u>TWO THREE RIGHT</u>
34'10"	WA 2605	OKAY WE'LL DESCEND TO ONE ONE THOUSAND WESTERN TWENTY SIX O FIVE
	TLM	ROGER

34'19:	WA 2605	AND THAT WAS THE TEPEXPAN ARRIVAL FOR - UH.....TWENTY SIX O FIVE?
	TLM	THAT IS CORRECT
36'31"	TML	WESTERN TWENTY SIX ZERO FIVE TOWER -- ADVISES GROUND FOG ON THE RUNWAY AND TWO MILES VISIBILITY ON THE FINAL APPROACH
36'39"	WA 2605	ROGER TWENTY SIX ZERO FIVE
39'01"	TLM	WESTERN TWENTY SIX ZERO FIVE CHANGE TO TOWER ONE EIGHTEEN ONE RADAR SERVICE TERMINATED
39'04"	WA 2605	GOOD NIGHT ONE EIGHTEEN ONE TWENTY SIX ZERO FIVE
	TLM	ROGER

Communication with Mexico Tower

05:39'39"	WA 2605	GOOD MORNING UN...MEXICO TOWER WESTERN TWENTY SIX ZERO FIVE IS INBOUND FOR TWO THREE
05:39'45"	TWR	WESTERN TWO SIX ZERO FIVE, TWO THREE RIGHT REPORT OVER MIKE ECHO (OUTER MKR) WIND CALM
39'51"	WA 2605	ROGER
40'44"	WA 2605	AND WESTERN TWO SIX O FIVE IS INSIDE MIKE ECHO
40'58"	TWR	WESTERN TWO SIX O FIVE UH...ADVISE RUNWAY IN SIGHT
41'05"	TWR	DO YOU HAVE YOUR LIGHTS ON?
41'13"	TWR	WESTERN SIX O FIVE YOU ARE TO THE LEFT OF THE TRACK
41'14"	WA 2605	JUST A LITTLE BIT
41'40"	TWR	ADVISE RUNWAY IN SIGHT, THERE IS A ...LAYER OF A...FOG OVER THE FIELD
41'46"	WA 2605	TWO SIX O FIVE ROGER
41'51"	TWR	TWO SIX O FIVE DO YOU HAVE APPROACH LIGHT ON LEFT IN SIGHT?
41'52"	WA 2605	NEGATIVE
41'54"	TWR	OKAY SIR UH...APPROACH LIGHTS ARE ON RUNWAY TWO THREE LEFT BUT THAT RUN WAY IS CLOSED TO TRAFFIC
42'42"	WA 2605	OKAY TWO SIX O FIVE

	WA 2605	OH...(P/T)
	WA 2605	CLICK (P/T)
43'08"	TWR	TOWER SUBSTATION WESTERN JUST CRASHED
43'12"	SUB-EST	WE SAW IT WE ARE IN ROOM 6
43'16"	TWR	PLEASE ADVISE THE FIRE DEPARTMENT AND THE COMMAND
43'19"	SUB-EST	OKAY

NOTE: 0600 INFORMATION ALPHA CEILING INDEFINITE ZERO OBSCURED, VISIBILITY ZERO - FOG, SMOKE - TEMPERATURE 9 - ALTIMETER 3022. AIRPORT CLOSED UNTIL FURTHER NOTICE. AVION ACCIDENTADO 1152 ZULU.

The Flight Recorder indicated that the aircraft sustained a 2.026 G force, not that unusually heavy on touchdown. Tire marks show that the aircraft touched down with the left main landing gear in the dirt, left of the left shoulder of Runway 23 left, above 500 feet beyond the threshold. The right main landing gear tire marks began on the paved shoulder about 33 feet beyond where the left gear touched down, about 18 inches inboard of the pavement edge. Pitch attitude at touchdown was 2.46 degrees nose up, and had decreased about 2.5 degrees during the last 15 seconds.

It should be brought out at this point, that the normal altitude of the DC-10 during the approach is approximately 4 to 5 degrees nose up, and during the flare will increase to about 8 degrees nose up.

Engine power indications were virtually unchanged until about 9 seconds after initial touch down, when all engines were increased to a little over 100 percent. According to the research done by Dr. Zeller and McNorton, at the Norton Air Force Base, this time period typifies the normal reaction time of an average person who is tired.

After the aircraft initially touched down, it continued along the ground for about 400 feet on the main landing gear. The nose gear did not contact the ground at any time. At that point, the right main gear lifted off the ground and simultaneously struck a dump truck loaded with gravel. The aircraft speed decreased from 136 knots to 128 knots. The driver of the truck was fatally injured. The right main gear was severed and, as it swung aft, it and the destroyed truck wreckage impacted the right inboard flap and aileron which was carried away. This wreckage continued aft, tearing away all but 18 inches of the right horizontal stabilizer, along with the right inboard and outboard elevators.

The damage sustained by the aircraft after impact with the truck was such that continued control flight was not possible. The aircraft continued flying just clear of the ground near taxiway Alpha, and Runway 10, whereupon it struck a telephone junction box causing a flash-fire there. Wing tip contact continued along the ground as the bank angle increased to 34 degrees. Engine power on Number 3 engine increased to 95 percent, N1, as the wing flap struck a mobile lounge garage, ground support vehicles, trucks and cars parked there. Fire erupted almost immediately.

The aircraft finally impacted a 2-story concrete steel-reinforced building. The impact and fire destroyed the aircraft, several buildings and an undetermined amount of ground vehicles.

RECAP OF EVENTS

1. NOTAMs - the fact that the NOTAMs had previously been issued regarding the closure of 23 left, but two of the crew members had landed on the closed runway after it had been notamed.

2. Fatigue - lack of sleep obviously had an affect on the crew and their ability to respond.

3. ATC Clearance - 23 left was the clearance the crew expected to receive

4. Compressed workload saturated the crew in a short time-frame.

5. Equipment malfunction added another dimension during the critical phase of flight.

6. Untimely transmissions interrupted the crew at the precise times when altitude call-outs should have been made.

7. Approach light - Tower transmissions asking whether the approach lights on the left were in sight, when in reality they were disconnected, could have resulted in both pilots going heads-up.

8. ILS equipment substandard by ICAO standards, with no back-up complicated by construction equipment on the runway could have caused scalloping of the signal.

9. Approach Plate - no pictorial display of the side-step maneuver published. A note on the plate, all that was legally required, advised the pilots of the procedure.

10. Weather - deteriorating weather versus reported conditions, no RVR installed.

11. Improper Procedures - failure to make altitude call-outs when the aircraft reached decision height and descent below minimums for the published approach.