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A Study to Determine the Feasibility of Establishing a National Program for Training Skilled Aviation Personnel.

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To determine the feasibility of establishing a training program for skilled flight and nonflight personnel which are critical to the aviation industry, data were collected from carriers, manufacturers, associations, and agencies. Employment needs were ascertained and a 1980 projection of supply and demand for professional pilots was formulated. A mathematical model for computer prediction was also developed. Existing pilot and mechanic curriculums were analyzed and an improved curriculum was devised. Two sites in the Phoenix area were proposed, and their usefulness for a national training program was examined with respect to location, land, runways, buildings, and utilities. Related to this examination was an analysis of the employment impact on a nearby Indian reservation. Cost estimates were developed on the basis of 500, 1,000, 1,500, and 2,000 student enrollment modules and a general financing plan was developed. Short and long range program plans were developed which included land leases and site development, an industry-sponsored non-profit educational organiztion, and designs for proposed facilities. (EM)

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A STUDY TO DETERMINE THE FEASIBILITY OF ESTABLISHING A NATIONAL PROGRAM FOR TRAINING SKILLED AVIATION PERSONNEL

U.S. DEPARTMENT OF COMMERCE
ECONOMIC DEVELOPMENT ADMINISTRATION

A STUDY TO DETERMINE THE FEASIBILITY OF ESTABLISHING A NATIONAL PROGRAM FOR TRAINING SKILLED AVIATION PERSONNEL.

prepared by

Arizona State University

for the

Economic Development Administration

This technical assistance study was accomplished by professional personnel under contract with the Economic Development Administration. The statements, findings, conclusions, recommendations, and other data in this report are solely those of the contractor and do not necessarily reflect the views of the Economic Development Administration.

U.S. DEPARTMENT OF COMMERCE
Alexander B. Trowbridge, Secretary

Ross D. Davis, Assistant Secretary
for Economic Development

September 1967

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FOREWORD

Aviation's dynamic growth since early in this century has dramatically refashioned America's travel patterns and given new form to the economic and social structure of the Nation. The greatly increased mobility afforded by air travel has proven particularly attractive to businessmen and opened up new modes of industrial development and plant site location.

Aviation technology today is on the verge of significant advances in a number of areas. The resulting increases in both number and complexity of aircraft will generate a continuing need for an adequate supply of skilled flight and ground personnel.

This study, prepared by Arizona State University under contract to the Economic Development Administration, investigates the feasibility of meeting the expected need through establishment of a civil aviation education center.

Ross D. Davis
Assistant Secretary of Commerce
for Economic Development

A STUDY TO DETERMINE THE FEASIBILITY OF ESTABLISHING A NATIONAL PROGRAM FOR TRAINING SKILLED AVIATION PERSONNEL

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- Aircraft Electronics Association, Inc.
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- Air Transport Association of America
- American Airlines, Inc.
- American Association of Airport Executives
- Arizona Economic Development Council
- Aviation Development Council
- Beech Aircraft Corporation
- The Boeing Company
- Bonanza Air Lines, Inc.
- Cessna Aircraft Company
- Civil Aeronautics Board
- Civil Air Patrol
- Douglas Aircraft Company, Inc.
- Federal Aviation Administration
- General Electric Company
- General Learning Corporation
- International Civil Aviation Organization
- Lockheed Aircraft Corporation
- National Aviation Trades Association, Inc.
- National Business Aircraft Association, Inc.
- North American Aviation, Inc.
- Piper Aircraft Corporation
- Trans World Airlines, Inc.
- United Air Lines, Inc.
- U. S. Department of Defense
- U. S. Department of Labor
- West Coast Airlines, Inc.

Special recognition is due many individuals too numerous to mention within the airlines, aircraft manufacturing organizations, state and federal government, military agencies, trade associations, and local organizations who contributed their valuable time and provided background material and advice to the study.

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A STUDY TO DETERMINE THE FEASIBILITY OF ESTABLISHING A NATIONAL PROGRAM FOR TRAINING SKILLED AVIATION PERSONNEL

General Introduction

Powered flight, which did not exist sixty-four years ago, has grown until it is now, and has been since July 1962, the largest single non-agrarian employer of people in the America economy. The employment figure in the manufacturing phase of aerospace accounted for 1,400,000 people at the end of 1966. The manufacturing of airframes alone accounted for the employment of more than 600,000 persons.

The significance of aviation can be evaluated best in light of the overall spectrum of transportation. America has shifted emphasis from a production economy to a distribution economy to such a degree that consumer expenditures for transportation have grown at a rate twice as great as consumer expenditures for all other goods and services since World War II.

In 1965, the Gross National Product was $697 billion. This is forecast to increase to $967 billion by 1970. Expenditures for transportation in 1965 were $209 billion and are expected to grow to $290 billion a year by 1970. Air transportation was 7% of the total national transportation expenditure in 1965 or $14.6 billion. This is expected to grow to $40.6 billion by 1970, or approximately 14% of the total national transportation expenditures.

The changing patterns and modes of travel resulting from this dynamic growth have altered the economic and social structure of the nation. People have become accustomed to mobile ways of living and businesses have become accustomed to depending on modern means of travel for carrying on their activities.

The growth picture cited above is based partly on the fact that aviation technology is, today, on the threshold of significant advances in a number of areas. Specific developments which are presently underway include the development of the supersonic transport, short-haul transport, stretched jet, and very large passenger/cargo jet aircraft, such as the C-5 and Boeing 747. In general aviation, the numbers of aircraft are expected to increase from slightly under 100,000 units in 1965 to over 300,000 units in 1980; from slightly over 16 million annual flight hours in 1965 to over 60 million in 1980.

These developments will open new passenger and airfreight markets and will result in significant increases in personal flying, as well as in productivity in commercial service. The increase in numbers and complexity of aircraft will also generate requirements for greater numbers of more highly skilled personnel.

At a time when aviation is entering its greatest period of growth, a critical problem has developed with respect to availability of highly skilled personnel, particularly pilots and mechanics. This problem has been developing slowly since 1960. Its historical background is as follows:

1. Twice during the period 1945 to present, the labor market for pilots and mechanics was flooded with a large surplus of trained personnel released from the military services following World War II and the Korean War. It was extremely difficult for many pilots, even with extensive training and experience, to find flying jobs in the civil aviation field.

2. In 1958, the industry entered a new era through the introduction of jet aircraft. The new jets were capable of greater payloads and higher speeds, and one aircraft could do the work of many. For example, one 707 could replace as many as seven DC-7 aircraft in service at that time. The introduction of the jets reduced the requirements for pilots and some low seniority flight personnel were actually furloughed.

3. The interest of our nation's youth declined somewhat as they observed these developments. An atmosphere had been created that made aviation an unattractive choice for young people seeking stable, secure careers. The following comments were frequently submitted in response to questions raised by researchers studying flight skills and training: "Why select a career that was already over-crowded?" - "Aircraft mechanics are underpaid and many must find jobs in other industries, so why should I pay money I don't have to learn a trade for a job which is not available?" Consequently, enrollment in aviation courses dwindled and the number of schools offering aviation training slowly decreased.

4. The lack of interest and the reduction in training of new pilots has also occurred at a time when World War II pilots now flying in civil aviation were being lost in ever-increasing numbers due to retirement, for medical reasons, or due to promotion.

Early in 1964, the Administrator of the Federal Aviation Agency, Mr. Najeeb Halaby, established an Aviation Human Resources Study Board because of his growing concern with the number of indications that civil aviation might be facing potentially serious shortages of highly skilled workers requiring extensive training. The Board's study was given the working name of "Project Long Look". The Board was authorized to conduct necessary research and analysis to measure current manpower resources in military, commercial, and general aviation.

The Board determined that significant numbers of flight and maintenance personnel would be required to meet the growth needs of the industry and that annual attrition losses of personnel due to retirement, disability, or promotion will increase substantially between 1965 and 1980. It was further determined that fewer military pilots are available than in previous years and the percentage of military pilots continuing on in civilian aviation is dwindling. The report stated that adequate numbers of trained flight/mechanical personnel will not be available at present training and attrition rates.

On the basis of the future quantitative and qualitative needs, as indicated in the foregoing discussion, and because of its interests in and responsibility for the development of skills and knowledge in the field of aviation, Arizona State University embarked on a program to determine the feasibility for establishing an aviation training operation as a continued part of its functions.

Because of the economic development potential for such a training operation, the study was sponsored by the U. S. Department of Commerce, Economic Development Administration. Many contributions were also made to the study by local and national organizations with interests in the fields of aviation and education.

The immediate objective of this study was to determine the feasibility for the establishment of a program for training skilled flight and non-flight personnel which are critically needed by the nation's aviation industry. The training program visualized would provide for academic training of both ground support and flight personnel, including a four-year baccalaureate degree in Aeronautical Technology earned in an accredited university, with primary and advanced flight training conducted at an appropriate training base.

The Feasibility Study would include an accurate determination of the needs with respect to both types and numbers of personnel to be trained, the establishment of detailed curricula for the various training courses, the selection of the most suitable training base for the flight operations portion of the program, and the development of detailed costs and methods for financing such a program. The study was conducted in coordination with and extensive cooperation from the aviation industry.

The study was initiated in December 1966 and continued for a period of six months, culminating in this final report. The study included five major areas of investigation, the results of which are presented in this report under Sections I through V. Following is an abstracted summary of the work performed, along with major conclusions and recommendations from the five sections of the report.

Summary

Section I - Quantitative Requirements for Skilled Aviation Personnel: This part of the overall study was conducted in three divisions -- the civil air carrier requirements, the general aviation requirements, and a projection of the supply and demand for professional pilots. Requirements for non-commercial pilots or those who fly for personal reasons were not treated in this study due, primarily, to the lack of documentation in this area of aviation operations. (Total aircraft units and total flight hour estimates did, however, include personal flying.)

In the civil air carrier requirements part of the study, data was acquired from leading carriers, aircraft manufacturers, aircraft equipment manufacturers, Air Line Pilots Association, Air Transport Association of America, Civil Aeronautics Board, Federal Aviation Administration, International Civil Aviation Organization, and from numerous key individuals. The data were translated into revenue passenger and cargo ton-miles of operation and aircraft fleet size projections, with due recognition of the various potential growth limiting factors.

A mathematical model was also developed for use in computer prediction of future cockpit and mechanic work forces, based on historical relationships between all of the key growth factors and the growth data obtained from the sources cited. The pilot and mechanic work force projections were then treated to sensitivity analysis by varying some of the input data factors in the mathematical model for the purpose of determining those factors which have the greatest influence on the projections of future needs.

In the general aviation category, the total fleet size and annual hours of operation were forecasted, using two different growth rates. Using the fleet size and annual hours of operation projections, the future (1965-1980) requirements for commercial pilots and total mechanics were projected.

Finally, the commercial pilot requirements were analyzed in terms of supply from military releases and from non-military pilot training programs. A "critical projection level" method was established to aid in determining production levels of commercial pilots to supply the needs of the future. Further military release data is needed, however, to project the findings to 1980.

Section II - Curriculum Study: This part of the overall study concerned itself with analyses of existing mechanic and pilot curricula and a determination of the improvements that should be made to meet the current and future qualitative needs of the industry.

As a result of these analyses, current Arizona State University curricula were upgraded and are now considered qualitative improvements over existing curricula primarily in their assessment of and provisions for meeting the future needs of the industry.

The role of new educational technology and the part it can play in the improvement of aviation training was studied in considerable depth. A number of conclusions and recommendations for the future continued improvement of aviation curricula were developed as a result of these studies.

Section III - Site Selection Study: In this section of the overall study, consideration was given to the possibility of utilizing one of two sites as a location for the proposed training center. The two sites were the Litchfield Naval Air Station west of Phoenix (being closed by the Department of Defense) and the Goodyear Auxiliary Airfield located on the Gila River Indian Reservation.

Both sites were examined in detail with respect to availability and suitability of land, runways, buildings, utilities, etc. In addition, the proximity of the two sites to other air operations in the area was examined and analyzed in light of a proposed training operation. On the basis of the foregoing, it was determined that the Goodyear Auxiliary Airfield was the most suitable site for the proposed aviation training center.

The economic impact on the Indian Reservation site was then analyzed in detail from the standpoint of potential jobs and income for the community and for individuals residing on the Reservation.

Section IV - Cost and Financing: In this section of the study, costs for the facilities of the proposed training center were estimated after developing a number of cost factors related to enrollment, space allocations, and unit costs. Equipment costs were also estimated, including the educational equipment, aircraft, ground support equipment, and synthetic trainers required. These estimates, along with the annual operating costs for the proposed training center, were all developed on the basis of 500, 1000, 1500, and 2000 student modules.

Historical sources and the distribution of funds for educational institutions were examined, and a general plan for the financing of the proposed center was developed. In this general plan, the roles of the University, the aviation industry, and the federal government were outlined.

Section V - Implementation Plan: In this section of the study, both short- and long-range plans were developed. The short-range plans included the immediate actions required, such as negotiation with the Tribal Council for long-term land leases and site development; the establishment of an industry-sponsored, non-profit educational organization; and the design and development programs for both the academic and flight training facilities of the proposed center.

The long-range plans included an examination of the research and development activities necessary to integrate new educational technologies in the overall training center operations.

Conclusions

Some of the major conclusions derived from the studies summarized above are:

1. Revenue passenger miles for U.S. civil air carriers will increase from 76 billion passenger miles in 1965 to 315 billion passenger miles in 1980; cargo ton-miles from 3.1 to 38.1 billion ton-miles; and the aircraft fleet will grow from 2,125 to slightly over 3,000 aircraft.

2. The employment of civil air carrier aircraft cockpit crew members will increase from 22,972 in 1965 to 43,665 in 1980, with a total cumulative requirement of 35,906 new pilots for that period.

3. The civil air carrier mechanic work force will increase from 43,667 in 1965 to 80,224 in 1980, with a total cumulative requirement of 95,392 new mechanics for that period.

4. The general aviation fleet will increase from 104,000 to 315,000 units, with total flight hours increasing from 16.7 to 63 million flight hours per year by 1980.

5. Commercial pilot requirements in general aviation will increase from 48,760 in 1965 to 184,750 in 1980, with a total cumulative requirement for 182,075 pilots for that period.

6. The number of mechanics in general aviation will increase from 40,000 in 1965 to 120,000 in 1980, with a total cumulative requirement for 138,483 new mechanics during that period (approximately one-third would be certificated).

7. Relatively little research has been executed which relates to pilot and mechanic qualitative curriculum design and its operational effectiveness. This is also true for other aviation curricula.

8. A comprehensive, qualitative research program utilizing a variety of methodologies is greatly needed in a broad variety of important aspects of aviation education.

9. Instructional time in terms of clock hours, despite its limitations as a qualitative standard of proficiency, remains as the "core logic" of curriculum design in institutions involved in aviation education.

10. Better defined standards of competence and improved measurement techniques for achievement should be important objectives in upgrading and revising curricula.

11. The proposed pilot and maintenance technician curricula derived from this study represent qualitative improvement over existing curricula primarily in their assessment and provisions for meeting emerging needs.

12. The joint Arizona State University/General Learning Corporation research effort in vocational/technical curriculum development based on a computer-aided multimedia approach will provide great assistance and impetus to the application of technology to aviation education.

13. The location of an aviation training center on the Goodyear Auxiliary Airfield will result in significant benefits to the Indian population and will also provide job opportunities to the disadvantaged of the surrounding communities.

14. An inventory/analysis of job skills on the Indian Reservation should be made and a training program undertaken to teach the required skills to qualified personnel for the jobs created by the establishment of a training center and other developments which are occurring on the Reservation.

15. The total cost for all facilities and equipment for the proposed training center will be approximately $7,000 per student and the annual cost of operation will be approximately $2,000 per student, plus the costs for flight training.

16. Because of the national implications and direct benefits to the aviation industry, the proposed aviation training center should be established and operated as a cooperative effort between the University, the aviation industry, and the federal government.

17. A single organization to represent all of the aviation industry's needs will be required for the cooperative effort cited above. A non-profit, membership corporation should be considered for the purpose.

18. The functions of the aviation training center could be most effectively performed by the University assuming the responsibility for conducting the academic portions of the training program and the industry-established organization conducting the flight training portions of the total program, with research and development being performed separately and jointly as appropriate.

19. The development of the site and facilities, procurement of equipment, and establishment of faculty and staff should be completed by 1 September 1968 for the flight center and by 1 September 1969 for the academic center.

Recommendations

Following are some of the major recommendations contained in the report:

1. Because of the difficulties experienced in assembling the data necessary for analyzing future personnel requirements, particularly in the general aviation segment, a data center should be established with continuous inputs provided by every segment of the industry.

2. The mathematical model developed for predicting air carrier pilot and mechanic requirements be further developed and utilized in connection with recommendation "1" above. The model could also be expanded for use in general aviation and with other modes of transportation.

3. Full consideration be given to the establishment and operation of an aviation training center, as described and discussed in this report. Such a center would help meet some of the quantitative requirements for the aviation industry, as well as some of the qualitative requirements discussed in other sections of the report.

4. Consideration be given to the implementation of the proposed pilot and aviation maintenance technician curricula as the nucleus of a future and broader aviation occupational group of curricula, and that such implementation be considered in the concept of the aviation training center, as explored in this study.

5. Concentrated efforts be made to initiate an organized aviation education research program to attack vital problems, some of which are:

    A. Pilot Task Analysis (Terminal Behavior Analysis): A study, comparable in depth and duration, is needed to ascertain civilian pilot tasks in terms of what a pilot does and the sequence in which he does it; the relevance of tasks, one to another; the priority of learning sequence of tasks he performs; the frequency with which he performs tasks; and the degrees of manipulative skills required of specific tasks.

    B. A Comparative Cost Analysis of In-Depth Specialty Training for Pilots and Non-Pilots: Undoubtedly, individual carriers are conducting on-going cost analyses of their own training investments. A collective analysis concentrating on what is being taught; how it is being taught; measurement factors of productivity; temperament factors effect on training; aptitude identifications and correlations, if any; and other areas need to be determined. The products of such research could then be related to what can and should be done by pre-professional education and training institutions to reduce the on-the-job training investments of the carriers.

C. <u>Instructor Personnel Education and Training for Aviation Curricula</u>: Research and training activities are needed, especially in the use of currently available media, modules, and methods, but, more importantly, in the potential applications of new educational technology to aeronautical technology curricula.

6. An aviation industry/education research and development center be established within the context of the proposed aviation training center to initiate, conduct or coordinate these studies as appropriate. Further, it is recommended that careful attention be given to plans for national dissemination and implementation of the anticipated research findings, curricula, instructional materials and systems.

7. Within the context of the proposed aviation training center, consideration be given to the establishment of a (civil aviation industry) education/training documentation center, providing for automated retrieval and remote access provisions for the civil aviation industry.

8. That encouragement and assistance be provided the aviation industry in the establishment of a private, non-profit organization whose primary function will be to establish and operate the flight training portion of the proposed aviation center as a cooperative venture with the University.

9. A program be established, in cooperation with the Bureau of Indian Affairs, for the identification of skills, aptitudes, and attitudes of the total population on the Reservation, followed by a comprehensive pre-vocational, vocational/technical and social training program to prepare the Indians for the advantages to be derived from the training center and other area development programs.

10. An early conference be scheduled for representatives of the civil aviation industry, the federal government, and Arizona State University. The purpose of the conference will be to develop a plan for a joint cooperative effort to establish an aviation training center of national significance, as discussed throughout this report.

11. The division of responsibility for the establishment and operation of the aviation training center be for the industry-sponsored, non-profit education organization to establish and operate the flight training program, and the University establish and operate the academic program. The federal government should provide both organizations with financing and operations assistance.

Epilogue

It is obvious from the information presented in this report that a combination of powerful factors are at work in aviation today which, when assessed, dictate equally powerful and perhaps radically different approaches in aviation education. The primary factors referred to are, of course, the massive and accelerating growth in aviation and a corollary and equally dynamic technological progress. While there are a variety of lesser but important factors operating, the third major factor which gives rise to great national concern is the apparent absence of an accompanying dynamic response on the part of civil aviation education. Even a cursory examination reveals a "business as usual" and traditional education/training operation and little or no research and development in aviation curriculum structure or methods.

A similar and somewhat more intensive examination will reveal a small but growing area of research and development of great promise in the application of newer educational technology in academic disciplines other than aviation education. Importantly, there appears not to have been evolved or deliberately developed in America a mechanism, structure or center capable of the research, demonstration, implementation and wide dissemination which could activate dynamic educational response to meet emerging civil aviation needs.

The brief attempt at assessment given here is intended to be realistic as opposed to being simply negativistic. Certainly, it presupposes a great pride in America's monumental progress in aviation and commends those individual efforts in aviation education in attempting to service that progress to date.

It must be universally accepted that the great growth in civil aviation of the immediate past is the product of numerous factors but, importantly, it is a product of the accelerating technology, which sets up a dynamic interaction with growth to the end that the factors of growth and technology become mutually stimulating. It is equally apparent that even in this recent rapid growth period, the aviation industry is on the threshold of what might be termed a "quantum leap" in growth. Unfortunately, no comparable prospect of a "quantum leap" in aviation education can be anticipated from the existing aviation education structure and its present capability.

It was from this frame of reference that the concept of a civil air academy or civil aviation training center was conceived. The concept was developed as the prospective instrument of the aviation community, certainly not to be viewed as the "place" where all personnel trainee quantitative requirements would be met, but far more significantly as the "place" where innovative and creative aviation curricula and instructional materials systems are designed, tested and perfected for implementation nationally, in order to mobilize efficiently the existing and emerging aviation education agencies of the nation. In short, it is visualized as the vehicle required to generate an aviation education "quantum leap".

To paraphrase a noted philosopher, "Nothing is so powerful as an idea or concept whose time has arrived". Informal explorations of the aviation training center concept and its "timeliness" with a variety of leaders in the aviation industry resulted in encouragement to the end that this Feasibility Study was undertaken. Having now been completed, it is sincerely hoped that the study findings will serve the leadership of the aviation community as a useful tool in meeting the challenges faced.

SECTION I

QUANTITATIVE REQUIREMENTS
FOR
SKILLED AVIATION PERSONNEL

General

This section of the report presents the results of that portion of the feasibility study which was undertaken to determine present and future industry personnel requirements in certain skill categories. Because of time and resource limitations, the study specifically covered only the pilot and mechanic requirements. Other skill categories are discussed briefly in the report but were not studied in depth.

The quantitative personnel requirements study results are presented in three parts. The first part deals only with the personnel requirements for the air carrier segment of the civil industry, the second part deals with the general aviation requirements, and the third part covers an overall analysis of the supply and demand problem.

The part of the study dealing with civil air carrier requirements developed forecasts for new hire pilots and mechanics from 1965 through 1980. The civil air carrier segment of the industry consists of certificated route air carriers (trunk, local service, territorial and international, helicopter, Hawaiian, Alaskan, and all-cargo carriers), plus the commercial operators and supplemental carriers. This portion of the feasibility study served a dual purpose, in that it provided the data for the basic study and also for a doctoral dissertation for Professor D. Clay Whybark, one of the Arizona State University study team members.

The general aviation requirements portion of the overall study developed needs for pilots and mechanics during the period 1965 through 1980. Two approaches were taken in this part of the overall study. One approach taken by Dr. Leslie Thomason and his associates of the Cessna Aircraft Company covered a very detailed analysis of the requirements for the period 1966-1975. The second approach, by Arizona State University study team members, was not as detailed and covered the period 1965-1980. General aviation operations include all civil aircraft operations, except those classified as air carrier operations. This segment of the aviation industry embraces a multitude of diverse and increasing uses of aircraft, ranging from the transportation of personnel and cargo by business firms in corporate aircraft and by air taxi operators to aerial application (cropdusting), power and pipeline patrol, and flying for pleasure.

The third part of the quantitative requirements study is a projection of the supply of commercial pilots and a comparison to the demand. Two major sources of supply were investigated. The first of these was the military, since this has been the traditional source of commercial pilots in the United States. The second source investigated was the non-military production of pilots by the aviation industry.

The assumptions which established certain limitations in each of the studies and the methodology used in performing the studies is presented, as appropriate, within each of the three parts.

CIVIL AIR CARRIER
QUANTITATIVE REQUIREMENTS FOR
PILOTS AND MECHANICS

Introduction

This section of the feasibility study for an aviation training center at Arizona State University develops the forecasts of the required new hire pilots and mechanics from 1965 through 1980 for the civil air carrier segment of the aviation industry. This segment consists of the certificated route air carriers (trunk, local service, territorial and international, helicopter, Hawaiian, Alaskan, and all-cargo carriers), plus the commercial operators and supplemental carriers.

Within the civil air carrier industry, the certificated route air carriers have done the most extensive reporting of statistics. Thus, throughout this report, the statistical processing was done with this data, unless explicitly stated otherwise. The underlying assumption is that the statistical relationships of the certificated carriers can be applied to the commercial operators and supplemental carriers for forecasting purposes. Even if this assumption does not hold for certain conditions, it will not make a major difference in the total picture because of the relative size of the two groups. The supplemental carriers and commercial operators combined operated only 229 aircraft (10.2% of the total industry), mostly of the smaller size, and employed approximately 1,000 pilots (less than 5% of the total) at year-end 1965.

Throughout this report, any reference to pilots includes "pilots, copilots or other flight personnel", as reported by the Federal Aviation Administration and Civil Aeronautics Board. Included are captains, first and second officers, and flight engineers. Analogous terms would be flight deck personnel or cockpit force. For mechanics the definition also follows the reporting of the FAA and CAB. In this instance, the total is not restricted to licensed but includes all persons reported by the airlines as working at mechanics' jobs. It may seem as though the mechanics are not sufficiently covered in the report. This is not intended. The same basic process was used to forecast both pilot and mechanic requirements. When the methodology was applicable to both pilots and mechanics, it is most often presented in terms of pilots. In cases where results or conclusions were different for mechanics than for pilots, this difference is pointed out.

The method for developing the forecast involved several steps. The first step was the overall projection of pilot (mechanic) employment in any given year. In order to do this, the historical relationship between pilot employment and other variables (i.e., aircraft) was established, using statistics. Forecasts of these other variables were then developed and used to determine overall employment levels. Next, factors that might limit the forecasts were investigated to be certain that the results were feasible. Finally, the annual losses to the industry were determined to find the number of replacements needed each year. The sum of replacements and increases in employment levels defines the new hire requirements.

As in all forecasts, some basic assumptions as to the political and economic climate must be set forth. In this study, it was assumed that there would be neither a greatly improved nor aggravated world political situation and that the United States will be involved in "brush war" conflicts throughout the period of study. The economy will continue to grow at its present rate and that there will be neither major reduction nor increase in disposable personal income growth.

Assumptions regarding competition to air travel by other modes are discussed in detail in the section on possible limitations to growth. The following pages explain the basic procedure as outlined above. Then the findings and implications of the findings are presented.

Sources of Data

Data have been collected from several organizations by interview or from their publications. Some important contributors of data are listed below:

- Air Line Pilots Association, International
- Air Transport Association of America
- American Airlines, Inc.
- Bonanza Air Lines, Inc.
- The Boeing Company
- Civil Aeronautics Board
- Douglas Aircraft Company, Inc.
- Federal Aviation Administration
- General Electric Company
- International Civil Aviation Organization
- Lockheed Aircraft Corporation
- North American Aviation, Inc.
- Trans World Airlines, Inc.
- United Air Lines, Inc.
- West Coast Airlines, Inc.

The contributions of these organizations in time and material were invaluable in accomplishing this study. It must be stressed, however, that they are in no way responsible for the accuracy or conclusions of this report. In some cases, their data have been substantially modified to meet the requirements of this study.

A summary of the historical statistics used in this effort is reported in Figures I-1 and I-2 for the total certificated route air carrier portion of the industry. Essentially, three source documents supplied the data found in those figures: the CAB Handbook[1], the FAA Handbook[2], and ATA's Facts and Figures[3]. In some years, there are discrepancies between these documents, although the source document for each is the CAB's Form 41. Most often this is explained by differences in the carriers which are included in the reporting agency's definition of the industry or whether unscheduled service is included. Form 41 is a detailed statistical reporting form that is filed periodically by all carriers in the industry.[4] In some cases, this document was referred to for more detailed information or to clear up apparent differences in other reports.

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[1] Civil Aeronautics Board, Handbook of Airline Statistics, 1965 ed., Bureau of Accounts and Statistics, Washington, D. C., December 1965.

[2] Federal Aviation Agency, FAA Statistical Handbook of Aviation, 1965 ed.

[3] Air Transport Association of America, Air Transport Facts & Figures, 1966 (official publication of the Air Transport Association of America, Washington, D. C.)

[4] Civil Aeronautics Board, Uniform System of Accounts and Reports for Air Carriers, 1 January 1957.

TOTAL CERTIFICATED ROUTE AIR CARRIERS

UNSCHEDULED SEAT MILES, REVENUE PASSENGER MILES
REVENUE PASS. TON MILES ESTIMATED FOR YEARS 1949/50
AND UNSCHEDULED TON MILES ESTIMATED FOR YEARS 1945/46
ALL CARGO COCKPIT CREWS ESTIMATED FOR YEARS 1951/60

DOMESTIC AND INTERNATIONAL
SCHEDULED + UNSCHEDULED SERVICE

DATA FROM FAA/CAB HANDBOOKS
AND/OR COMPANY FILES
AS OF DECEMBER 31 EACH YEAR

COCKPIT FORCE ***	TOTAL AIRCRAFT FLEET	TOTAL PISTON AIRCRAFT	TOTAL TURBOPROP AIRCRAFT	TOTAL PURE JET AIRCRAFT	TOTAL HELI-COPTER	SEAT MILES (000,000)	TON MILES (000)	REVENUE TON-MILES (000)	REVENUE PASS.T-MS (000)	REVENUE PASS.MLS (000,000)	REVENUE CARG.T-MS (000)	DATE
6943	518	517	0	0	1	4399	781000	469981	363014	3810	106957	1945
8723	821	821	0	0	0	9110	1201693	791385	686785	7049	104600	1946
7970	964	961	0	0	3	12298	1662228	942612	776752	7950	165860	1947
8441	1053	1048	0	0	5	13720	1905511	1006833	778546	7969	228287	1948
8445	1151	1140	0	0	11	15526	2151299	1151891	875152	8952	276739	1949
8998	1203	1192	0	0	11	17192	2426043	1397670	1017285	10343	380365	1950
10940	1231	1222	0	0	9	20354	2838280	1743292	1311224	13445	432068	1951
11463	1342	1328	0	0	14	24472	3366662	2004815	1547622	15859	457193	1952
12485	1421	1404	0	0	17	29288	3954983	2288152	1801003	18482	487149	1953
12557	1446	1426	0	0	20	33815	4463194	2563795	2043324	20975	520471	1954
14396	1480	1453	8	0	19	39056	5288535	3087808	2404923	24632	682885	1955
15980	1723	1649	54	0	20	44830	6171390	3618636	2788944	28663	829692	1956
18263	1835	1750	59	0	26	52669	7230384	4082394	3151403	32793	930991	1957
17130	1895	1777	90	6	22	54699	7326393	4120228	3168650	32968	951578	1958
18546	1850	1530	213	84	23	60796	8336525	4734093	3629669	37782	1104424	1959
17346	1867	1413	227	202	25	66974	9383531	5024283	3850342	40050	1173941	1960
18098	1877	1282	257	319	19	74153	10578367	5394631	4021801	41792	1372830	1961
17971	1831	1164	251	396	20	85504	12325910	6238261	4457824	46270	1780437	1962
18310	1832	1136	250	426	20	98049	13930752	6860302	5104030	53216	1756272	1963
19551	1863	1026	259	558	20	110048	16302481	8015941	5957845	61799	2058096	1964
21972	1896	867	296	712	21	129391	19662196	9895082	7087859	73217	2807223	1965

*** COCKPIT FORCE = PILOTS + COPILOTS + OTHER FLIGHT PERSONNEL

Figure I - 1

TOTAL CERTIFICATED ROUTE AIR CARRIERS

UNSCHEDULED SEAT MILES, REVENUE PASSENGER MILES
REVENUE PASS. TON MILES ESTIMATED FOR YEARS 1949/50
AND UNSCHEDULED TON MILES ESTIMATED FOR YEARS 1945/46
ALL CARGO COCKPIT CREWS ESTIMATED FOR YEARS 1951/60

DOMESTIC AND INTERNATIONAL
SCHEDULED + UNSCHEDULED SERVICE

DATA FROM FAA/CAB HANDBOOKS
AND/OR COMPANY FILES
AS OF DECEMBER 31 EACH YEAR

MECHANIC FORCE	TOTAL AIRCRAFT FLEET	TOTAL PISTON AIRCRAFT	TOTAL TURBOPROP AIRCRAFT	TOTAL PURE JET AIRCRAFT	TOTAL HELI-COPTER	SEAT MILES (000,000)	TON MILES (000)	REVENUE TON-MILES (000)	REVENUE PASS.T-MS (000)	REVENUE PASS.MLS (000,000)	REVENUE CARG.T-MS (000)	DATE
21146	964	961	0	0	3	12294	1662228	942612	776752	7950	165860	1947
21828	1053	1048	0	0	5	13720	1905511	1006833	778546	7969	228287	1948
19839	1151	1140	0	0	11	15526	2151299	1151891	875152	8952	276739	1949
20162	1203	1192	0	0	11	17192	2426043	1397670	1017285	10343	380385	1950
24255	1231	1222	0	0	9	20354	2838280	1743292	1311224	13445	432068	1951
26933	1342	1328	0	0	14	24472	3366662	2004815	1547622	15859	457193	1952
26946	1421	1404	0	0	17	29288	3954983	2288152	1801003	18482	487149	1953
25568	1446	1426	0	0	20	33815	4463194	2563795	2043324	20975	520471	1954
29911	1480	1453	8	0	19	39056	5288535	3087808	2404923	24632	682885	1955
32016	1723	1649	54	0	20	44830	6171390	3618636	2788944	28663	829692	1956
32210	1835	1750	59	0	26	52669	7230884	4082394	3151403	32793	930991	1957
30331	1895	1777	90	6	22	54699	7326393	4120228	3168650	32968	951578	1958
32277	1850	1530	213	84	23	60796	8336525	4734093	3629669	37782	1104424	1959
34181	1867	1413	227	202	25	66974	9383531	5024283	3850342	40050	1173941	1960
34065	1877	1282	257	319	19	74153	10578367	5394631	4021801	41792	1372830	1961
34925	1831	1164	251	396	20	85504	12325910	6238261	4457824	46270	1780437	1962
34453	1832	1136	250	426	20	98049	13930752	6860302	5104030	53216	1756272	1963
39360	1863	1026	259	558	20	110048	16302481	8015941	5957845	61799	2058096	1964
41667	1896	867	296	712	21	129391	19662196	9895082	7087859	73217	2807223	1965

Figure I - 2

Data were gathered on a number of operating statistics, aircraft, and employment for the years 1945 through 1965. The year 1947 was chosen as the starting point for statistical processing because that was the year in which the wartime flying time maximum of 100 hours per month was reduced to 85 hours a month. For some statistics for the early years, it was necessary to refer to the reports of agencies preceding the Federal Aviation Administration and Civil Aeronautics Board. In cases where there was a conflict in the data, not easily explained, the CAB or FAA data were used.

The historical operating statistics are not complete for all years as reported in the source documents. Estimates were made of some values to provide a complete data set. For the years 1949 and 1950, estimates were made of the unscheduled service totals for seat-miles, revenue passenger miles, and revenue passenger ton-miles. This was done by applying the ratio of scheduled to unscheduled service determined in the years for which data were available. The result was then checked by the ratio of the total of both services for the estimated statistics to other statistics during the same year. In the same manner, the unscheduled ton-mile statistics for the years 1945 and 1946 were estimated.

To complete the past employment of pilots and mechanics for all years, estimates were made of the number employed by all-cargo carriers during the years 1951 to 1960. This was done by applying the ratio of pilots to various other statistics that were available for that period for the all-cargo carriers. This was checked against the result obtained by the ratio of all-cargo pilots to the total for preceding and succeeding years. For mechanics the estimate was made on the basis of the relationship between employed pilots and mechanics.

It was necessary for some of the forecasts to make some estimate of the employment of pilots and mechanics in the supplemental carriers and the commercial operators. This was done by estimating the average number of pilots per crew in these two categories and then the number of crews per aircraft. For the former, two pilots per crew were used and the latter was slightly greater than two crews per aircraft. These figures are averages for the wide extremes found in this group.[5] By applying these factors to the number of aircraft owned by these two groups, a total of 1,000 pilots was estimated for employment at year-end 1965. The mechanic estimate is based on the relationship between mechanics and pilots. That ratio has been very constant at approximately two mechanics per pilot for several years. Thus, the estimated number of mechanics employed by the commercial operators and supplemental carriers was 2,000.

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[5] Special survey questionnaire sent to commercial operators and supplemental carriers.

Historical Relationships

The initial phase of the research was directed toward determining whether or not there had been a consistent relationship between employment levels and other variables over a twenty-year period. The variables to be studied were chosen on the basis of their availability historically, their use within the industry, and whether or not there were forecasts for them, or if they could be derived from existing forecasts. To quantify the relationships of the variables and to give confidence to their use in forecasting levels of employment, statistical processing of the data was necessary. In particular, linear correlation and regression analysis were used. Prior to doing the statistical work, however, the data were plotted to give insights into relationships that might go undiscovered in processing. Also, the plots were made to test the assumptions that underlie the statistical processing. For example, the regression equations assume a linear relationship between the variables. The regression and correlation analysis not only gave the relationship between the variables but some indication as to the strength of the relationship as well.[6]

A plot of revenue passenger miles and aircraft against pilot employment is shown in Figure I-3.[7] The relationship between pilot employment and total aircraft is essentially linear, and the linear regression line is shown in the plot. The line for revenue passenger miles is definitely not linear. This is characteristic of the plots for the other operating statistics. All had essentially the same shape, whether it was a capacity measure such as seat-miles or ton-miles or a revenue measure like revenue ton-miles. The load factors[8] have been constant over the past, which explains why the relationship was the same for either measure. Since traffic has been growing at a compounded rate, a logarithmic transformation of these variables was tried to see if it would be essentially linear with pilots. A square root transformation was also tried. The results of these transformations are plotted in Figure I-4. Both of these transformations yield essentially linear relationships. The resultant linear regression equations are shown as well in the plot.

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[6] Several good references exist on correlation analysis. A popular one for business problems is: Ezekiel, M., and Fox, K. A., Methods of Correlation and Regression Analysis, Linear and Curvilinear (3rd ed., New York: John Wiley, 1959).

[7] Because the relationship between mechanics and pilots has been constant over the years, the same results are obtained for a comparison of mechanics and these variables.

[8] The ratio of persons to seats on a given flight. For the industry as a whole, this has been relatively constant, averaging about 50% for all flights.

PILOT EMPLOYMENT AS A FUNCTION OF AIRCRAFT AND REVENUE PASSENGER MILES CERTIFICATED ROUTE AIR CARRIERS

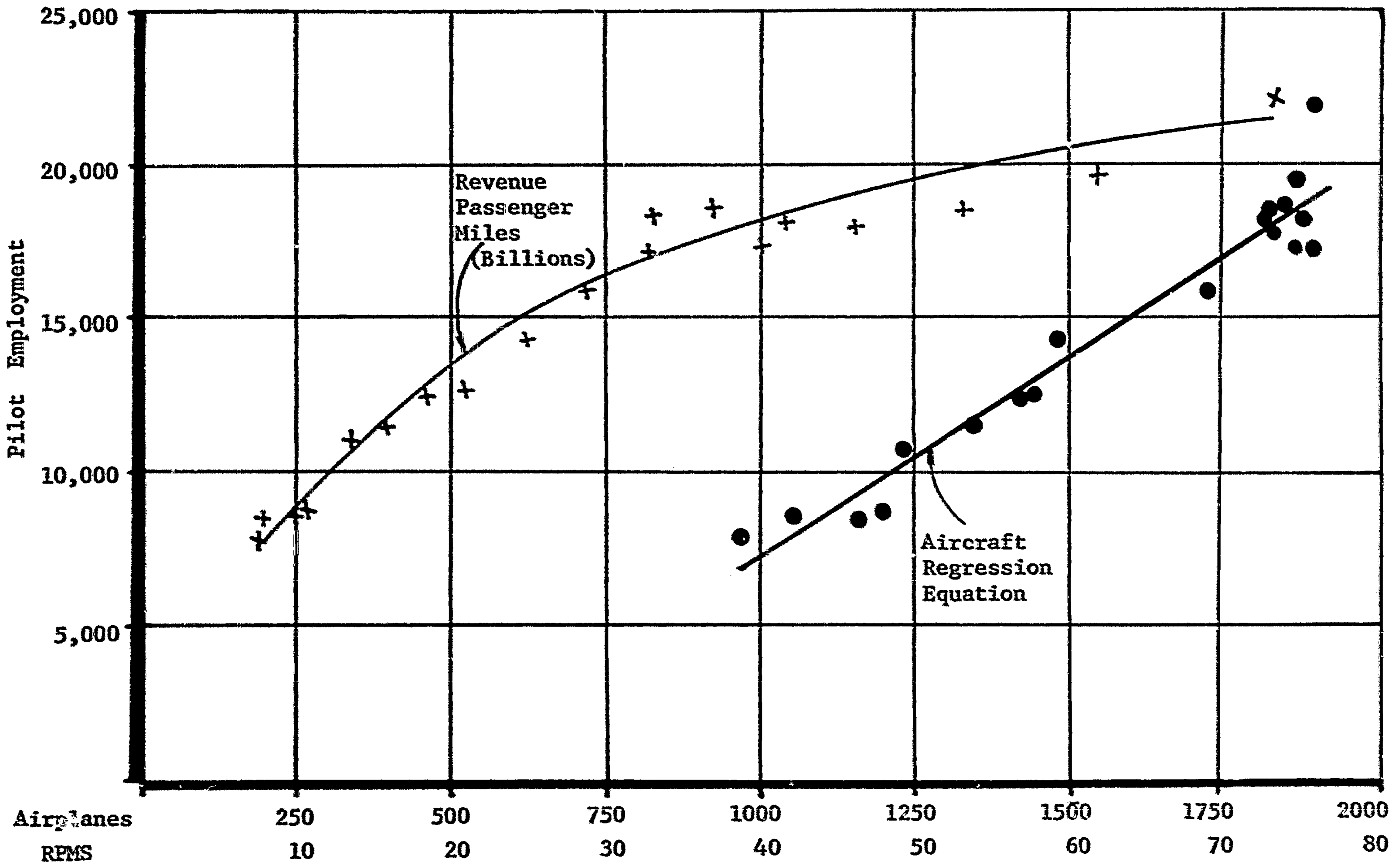

Figure I - 3

PILOT EMPLOYMENT AS A FUNCTION OF TRANSFORMED REVENUE PASSENGER MILES CERTIFICATED ROUTE AIR CARRIERS

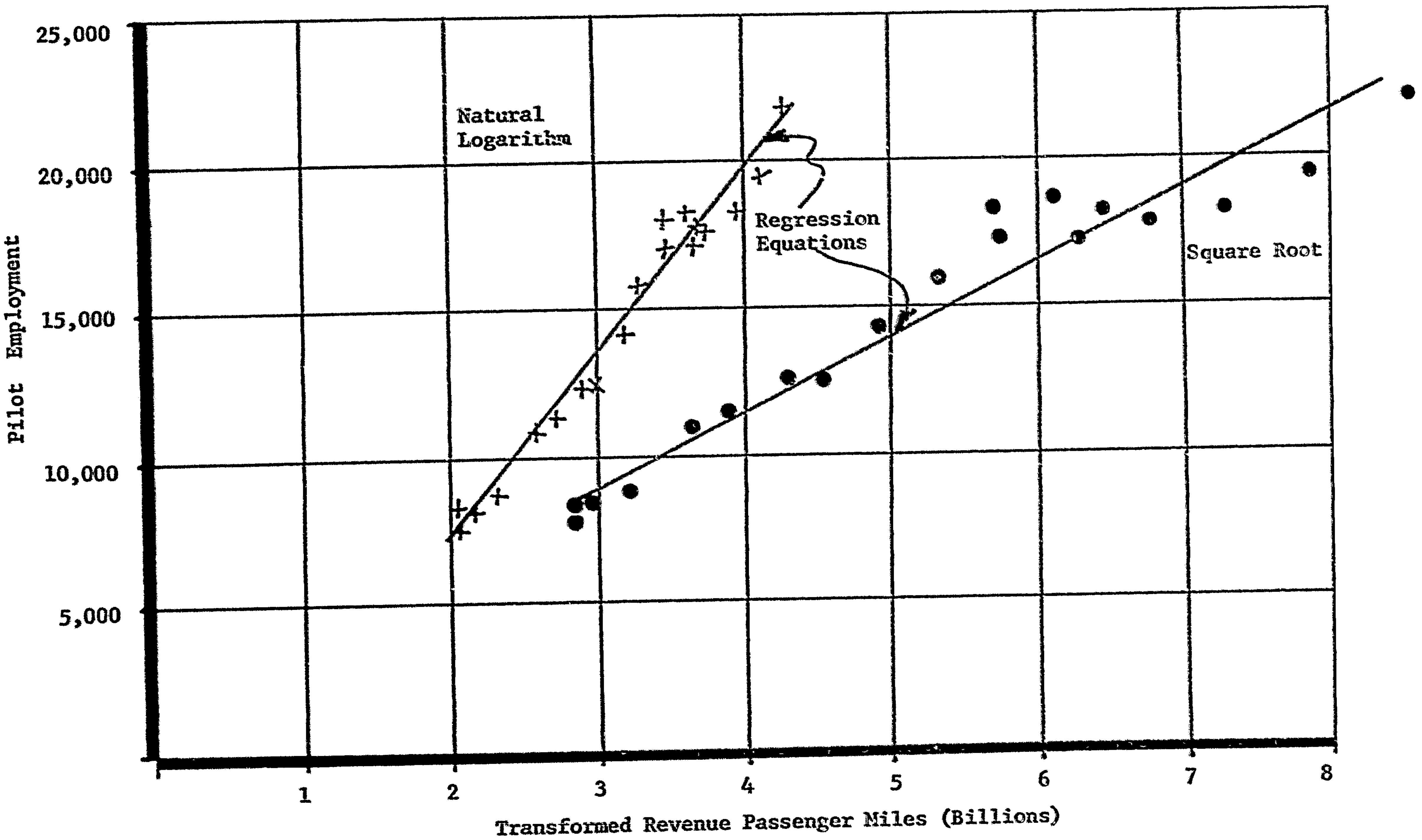

Figure I - 4

The first set of statistical relationships developed were those of the single linear correlation coefficients between various operating statistics, aircraft (also broken down by type), and the transformed variables versus pilots (mechanics). The intent of this effort was to determine if there was a sufficiently strong relationship between any single variable and pilots to provide a basis for forecasting pilot employment. A stepwise linear regression computer program was used for this data reduction.[9] The results of these runs are shown in Figures I-5 and I-6. Three sets of data are shown for the pilots. They represent the runs for years 1945-1965, 1947-1965, and 1951-1965. Since the correlation coefficients are uniformly higher for the run from 1947-1965, it is further evidence that those are the years upon which the forecasting equation should be based. The results for mechanics are shown only for 1947-1951 based on the same arguments.

The results of these runs show that the transformations did improve the statistical relationship between the operating statistics and employment. The logarithmic transformation is generally better than the square root transformation based on the higher correlation coefficients. The high level of correlation coefficients for these transformed statistics tends to support a percentage productivity change for pilots which has been suggested by some authors.[10]

The pilot requirements are more closely defined by the revenue operating statistics than the capacity operating statistics. This is evidenced by the higher correlation coefficients for the logarithmic transformation of revenue statistics than for those of capacity statistics. This is partly explained by the fact that newer and/or higher capacity aircraft are usually introduced on the high density, popular flights of an airline. The aircraft previously used on these flights are assigned the next dense route and so on throughout the system.[11] Thus, the system capacity tends to increase in steps. The revenue traffic, however, will tend to build up at a constant rate, requiring more of the same type of aircraft or introduction of a higher capacity aircraft. The requirement for additional pilots arises from the additional aircraft rather than replacement of aircraft. Also, there may be more pilot scheduling difficulties as frequencies increase to accommodate traffic growth, which could require more pilots as well.

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[9] The program was BMD 02R of the Biomedical Medical Department at UCLA. It is reported in: W. J. Dixon (ed.), BMD Biomedical Programs, Health Sciences Computing Facility, University of California, Los Angeles, January 1964.

[10] For example, see: Kahn, Mark L., Airline Flight Crews: Adjustment to Technological Change in a Regulated Growth Industry, Reprint Series No. 40, The Institute of Labor and Industrial Relations, The University of Michigan - Wayne State University.

[11] This does not work perfectly, of course, because of the need to match stage lengths with aircraft design and the use of old and new aircraft together on a run to support traffic increases.

SINGLE LINEAR CORRELATION COEFFICIENTS--PILOT EMPLOYMENT RELATED TO VARIOUS OPERATING STATISTICS OF THE CERTIFICATED ROUTE AIR CARRIERS

Variable	1945-1965	1947-1965	1951-1965
Aircraft			
Total	.946	.969	.939
Piston	.414	.195	-.260
Pure jet	.713	.714	.750
Turboprop	.851	.850	.865
Helicopter	.871	.855	.692
Ton-miles capacity (000)			
Untransformed	.908	.896	.887
Natural logarithm	.967	.976	.951
Square root	.958	.948	.925
Revenue ton-miles (000)			
Untransformed	.933	.924	.909
Natural logarithm	.972	.982	.963
Square root	.972	.966	.943
Revenue passenger-miles (billions)			
Untransformed	.945	.936	.921
Natural logarithm	.975	.984	.966
Square root	.978	.972	.950
Revenue cargo ton-miles (000)			
Untransformed	.897	.885	.876
Natural logarithm	.953	.966	.949
Square root	.951	.942	.919

Figure I - 5

SINGLE LINEAR CORRELATION COEFFICIENTS--MECHANIC EMPLOYMENT RELATED TO VARIOUS OPERATING STATISTICS OF THE CERTIFICATED ROUTE AIR CARRIERS

Variable	1947-1965
Aircraft	
Total	.908
Piston	.035
Pure jet	.803
Turboprop	.865
Helicopter	.766
Ton-miles capacity (000)	
Untransformed	.936
Natural logarithm	.972
Square root	.966
Revenue ton-miles (000)	
Untransformed	.954
Natural logarithm	.973
Square root	.976
Revenue passenger-miles (billions)	
Untransformed	.962
Natural logarithm	.974
Square root	.979
Revenue cargo ton-miles (000)	
Untransformed	.925
Natural logarithm	.959
Square root	.959

Figure I - 6

Some surprise may be occasioned by the generally high levels of correlation coefficients for almost all variables. For example, helicopters have a correlation coefficient of .855 with pilot employment. This is not unexpected, however, when both the pilot force and the number of helicopters have been increasing over time. Therefore, any of the statistics that are increasing over this time period show a generally high correlation coefficient with employment levels. The discrimination between the variables must be made on the basis of their usefulness in predicting, as well as differences in their correlation coefficients. As an illustration of this point, piston aircraft have a very low correlation coefficient with pilots. During this time period, the number of piston aircraft first increased and then decreased as jet aircraft were introduced into service. Pilot employment generally increased over the period.

There are some variables with high enough single correlation coefficients that they could be considered for use in projecting employment levels without additional processing. One in particular is the logarithmic transformation of revenue passenger miles with a correlation coefficient of .984 for pilot employment. Since this has been historically one of the important planning gauges in the industry, it is gratifying to see such high correlation coefficients.[12] Logically, one would expect the relationship between aircraft and pilots to be a strong one. This is the case, although the correlation coefficient is less than that for transformed revenue passenger miles. Many of the other relationships in Figure I-5 are simply not strong enough or there is not a good, logical basis for considering them for predicting employment levels.

A refinement of the statistical processing was based on logical considerations of those variables for which forecasts could be obtained and which had high single correlation coefficients. For example, it seemed that air freight would have an impact on employment apart from passenger traffic measures and should be combined with the passenger traffic to get total results. In addition, it appeared that there were differences in the effect of different types of aircraft on the total employment level and that these differences should be explored. In order to investigate these factors and to improve the relationships for forecasting purposes, multiple linear regression and correlation analysis were used. The results of the multiple correlation analysis are shown in Figures I-7 and I-8.

In general, the multiple correlation coefficients are higher than the single correlation coefficients. Adding the revenue cargo data to the revenue passenger data did, for example, improve the correlation with pilot employment over either alone, although only slightly (.984 compared to .985). As a

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[12] It is interesting to note that the CAB does not report this statistic for all services despite its widespread use within the industry. They publish instead revenue passenger ton-miles. This has the advantage of being directly comparable to the cargo values, which are also reported as ton-mile figures. For revenue passenger miles for all services, one must turn to the FAA Handbook.

MULTIPLE LINEAR CORRELATION COEFFICIENTS--PILOT EMPLOYMENT RELATED TO VARIOUS OPERATING STATISTICS OF THE CERTIFICATED ROUTE AIR CARRIERS

Variables	1947-1965
Aircraft, Case 1 Var. 1) Pure jet + turboprop Var. 2) Piston + helicopter	.982
Aircraft, Case 2 Var. 1) Pure jet Var. 2) Piston + helicopter + turboprop	.983
Revenue passenger miles and cargo ton-miles Case 1--natural logarithm transformation Var. 1) Revenue passenger-miles (billions) Var. 2) Revenue cargo ton-miles (000)	.985
Revenue passenger-miles and cargo ton-miles Case 2--square root transformation Var. 1) Revenue passenger-miles (billions) Var. 2) Revenue cargo ton-miles (000)	.979

Figure I - 7

MULTIPLE LINEAR CORRELATION COEFFICIENTS--MECHANIC EMPLOYMENT RELATED TO VARIOUS OPERATING STATISTICS OF THE CERTIFICATED ROUTE AIR CARRIERS

Variables	1947-1965
Aircraft, Case 1 Var. 1) Pure jet + turboprop Var. 2) Piston + helicopter	.958
Aircraft, Case 2 Var. 1) Pure jet Var. 2) Piston + turboprop + helicopter	.964
Revenue passenger-miles and cargo ton-miles Natural logarithm transformation Var. 1) Revenue passenger-miles (billions) Var. 2) Revenue cargo ton-miles (000)	.959*

*This is for the revenue passenger-miles variable alone. No improvement in correlation coefficient was gained by introducing the revenue cargo ton-miles variable.

Figure I - 8

further check on the usefulness of the square root transformation of the operating statistics, a multiple correlation analysis was run of this transformation of the revenue passenger and cargo data. In this instance, as well, the multiple relationship is stronger than that for revenue passenger miles alone. However, the overall result is lower for this transformation of the variables than for the logarithmic transformation. Based on this result, no further work was done with the square root transformations.

Substantial increases in the correlation coefficients are obtained by breaking the aircraft down into types (.969 compared to .983). This was expected because of the low single correlation coefficient of the piston aircraft discussed previously. Two combinations were tried: the combination of pure jet aircraft in one group and all other aircraft (propeller aircraft) in the second, and the combination of pure jet and turboprop (jet powered) in one group and piston and helicopter (piston) in the second. The results for each were similar, and both yielded improvements over unsegmented aircraft alone. A slightly higher correlation coefficient is shown for the run which had pure jets in one group and propeller aircraft in the other. The multiple correlation coefficient for the partition of the aircraft fleet is nearly the same as that for the revenue passenger and cargo result (.983 and .985, respectively).

Because of the closeness of the correlation coefficients and the logical appeal of the relationship between aircraft and pilot or mechanic employment, the multiple regression equations associated with the pure jet and propeller aircraft multiple correlation analysis were used as the predicting equations for this study. These equations and the regression equations for the other single and multiple regression runs are given in Figures I-9 and I-10. To further support the logic of using these equations for projecting overall employment, another test of these relationships was developed. A computer program was written to test projections of actual past employment. The test involved the computation of projected pilot (mechanic) employment for past years, using actual numbers of aircraft. This result was then compared to the actual employment level and printed out on a year-by-year basis. These runs (Figures I-11 and I-12) show the total number of pilots in error over the period and the average absolute value of the percentage error for the entire period. The results show an improvement in going from the single to multiple regression equations for both pilots and mechanics by the decrease in average percentage error. The average absolute error was slightly greater than 5% for mechanics and slightly less than 5% for pilots, using the multiple regression equations.

The problem of projecting overall employment levels has now been transformed into that of finding an acceptable forecast of aircraft by types over the period under study. Many such forecasts exist but all depend on projections of revenue passenger miles and cargo ton-miles. Different assumptions

PILOT EMPLOYMENT PROJECTION EQUATIONS--SINGLE AND MULTIPLE REGRESSION EQUATIONS ON STATISTICS OF THE CERTIFICATED ROUTE AIR CARRIERS

Aircraft

Total aircraft fleet (single regression)
Pilots = (total aircraft x 12.929) - 5585.03

Segmented aircraft fleet (multiple regression)
Pilots = (total pure jet x 15.289) + (total propeller x 11.269) - 3555.827
Pilots = ((piston + helicopter) x 10.940) - 3161.398 + ((pure jet + turboprop) x 13.760)

Revenue passenger-miles and cargo ton-miles

Revenue passenger-miles (single regression)
Pilots = (Ln(revenue passenger-miles) x 6136.875) - 4979.855

Revenue passenger-miles and cargo ton-miles (multiple regression)
Pilots = (Ln(revenue passenger-miles) x 7006.375) + 2923.557 - (Ln(revenue cargo ton-miles) x 790.837)

Figure I - 9

MECHANIC EMPLOYMENT PROJECTION EQUATIONS--SINGLE AND MULTIPLE REGRESSION EQUATIONS OF STATISTICS OF THE CERTIFICATED ROUTE AIR CARRIERS

Aircraft

Total aircraft fleet (single regression)
Mechanics = (total aircraft x 17.595) + 2020.51

Segmented aircraft fleet (multiple regression)
Mechanics = (total pure jet x 24.27) + 7759.71 + (total propeller x 12.90)
Mechanics = ((piston + helicopter) x 11.96) + 8880.62 + ((pure jet + turboprop) x 19.95)

Revenue passenger-miles and cargo ton-miles

Revenue passenger-miles (single regression)
Mechanics = (Ln(revenue passenger-miles) x 8815.91) + 1356.52

Figure I - 10

FORECAST ERROR DISTRIBUTION
ACTUAL VALUES USED IN FORMULA
ALL CERTIFICATED ROUTE AIR CARRIERS

YEAR	ACTUAL PILOTS	METHOD ONE	DIFFERENCE	PERCENT	METHOD TWO	DIFFERENCE	PERCENT
1947	7970	6880	-1089.52	-13.7	7307	-662.80	-8.3
1948	8441	8031	-409.55	-4.9	8310	-130.89	-1.6
1949	8445	9299	853.82	10.1	9414	969.45	11.5
1950	8798	9971	1173.30	13.3	10000	1202.42	13.7
1951	10940	10333	-606.59	-5.5	10316	-624.06	-5.7
1952	11463	11769	305.90	2.7	11567	103.77	0.9
1953	12485	12791	305.55	2.4	12457	-28.00	-0.2
1954	12557	13114	556.86	4.4	12739	181.71	1.4
1955	14396	13554	-842.44	-5.9	13122	-1274.15	-8.9
1956	15980	16696	716.11	4.5	15860	-119.86	-0.8
1957	18263	18145	-118.46	-0.6	17122	-1140.76	-6.2
1958	17130	18920	1790.48	10.5	17822	692.48	4.0
1959	18546	18339	-207.58	-1.1	17629	-917.05	-4.9
1960	17346	18558	1212.37	7.0	18295	948.88	5.5
1961	18098	18688	589.69	3.3	18878	779.91	4.3
1962	17971	18093	121.81	0.7	18669	698.09	3.9
1963	18310	18106	-204.26	-1.1	18801	490.96	2.7
1964	19551	18507	-1044.35	-5.3	19681	129.93	0.7
1965	21972	18869	-3103.25	-14.1	20672	-1300.12	-5.9

SUMMARY OF RESULTS

THE TOTAL ERROR IN PILOTS FORECAST WITH NO. 1 = 0
THE AVERAGE ABSOLUTE VALUE OF PERCENT DEVIATION = 5.85
THE FORMULA WAS PILOTS = (PLANES*12.9) - 5586

THE TOTAL ERROR IN PILOTS FORECAST WITH NO. 2 = 0
THE AVERAGE ABSOLUTE VALUE OF PERCENT DEVIATION = 4.79
THE FORMULA WAS PILOTS = (PROPELLER*11.27) +
(PUREJET*15.29) - 3556

Figure I - 11

```
                                  FORECAST ERROR DISTRIBUTION
                                 ACTUAL VALUES USED IN FORMULA
                               ALL CERTIFICATED ROUTE AIR CARRIERS

YEAR    ACTUAL MECHS.       METHOD ONE   DIFFERENCE   PERCENT      METHOD TWO   DIFFERENCE   PERCENT

1947        21140             18982       -2157.91     -10.2         20193        -946.62      -4.5
1948        21828             20548       -1279.96      -5.9         21341        -486.70      -2.2
1949        19839             22272        2433.35      12.3         22605        2766.31      13.9
1950        20102             23187        3085.29      15.3         23276        3174.00      15.8
1951        24255             23680        -575.05      -2.4         23637        -617.85      -2.5
1952        26933             25633       -1300.00      -4.8         25069       -1864.18      -6.9
1953        26946             27023          77.03       0.3         26088        -858.23      -3.2
1954        25568             27463        1894.88       7.4         26410         842.22       3.3
1955        29911             28061       -1849.89      -6.2         26849       -3062.25     -10.2
1956        32016             32337         320.69       1.0         29983       -2033.04      -6.4
1957        32210             34307        2097.33       6.5         31428        -782.46      -2.4
1958        30331             35363        5032.03      16.6         32270        1938.64       6.4
1959        32277             34571        2294.26       7.1         32576         299.09       0.9
1960        34181             34870         689.37       2.0         34137         -43.99      -0.1
1961        34065             35046         981.32       2.9         35596        1531.28       4.5
1962        34925             34237        -688.05      -2.0         35878         953.47       2.7
1963        34453             34255        -198.45      -0.6         36232        1779.46       5.2
1964        39360             34800       -4560.01     -11.6         38133       -1226.86      -3.1
1965        41667             35381       -6286.37     -15.1         40310       -1357.24      -3.3

                                      SUMMARY OF RESULTS

                  THE TOTAL ERROR IN MECHS. FORECAST WITH NO. 1    =   10
                  THE AVERAGE ABSOLUTE VALUE OF PERCENT DEVIATION = 6.85
                  THE FORMULA WAS MECHS. = (AIRCRAFT*17.595) + 2021

                  THE TOTAL ERROR IN MECHS. FORECAST WITH NO. 2    =    5
                  THE AVERAGE ABSOLUTE VALUE OF PERCENT DEVIATION = 5.14
                  THE FORMULA WAS MECHS. = (PROPELLER*12.898) +
                                           (PUREJET*24.268) + 7760
```

Figure I - 12

regarding new aircraft types and introduction dates cause differences in these forecasts. The next section discusses several forecasts of revenue passenger miles and cargo ton-miles and how they are translated into numbers of aircraft. The resultant fleet projection is then used, in combination with the regression equations to project overall employment levels of mechanics and pilots. The assumption that the commercial operators and supplemental carriers are sufficiently close in their operations to the rest of the industry so that the regression equations developed from data on the total certificated route air carriers will apply to the industry as a whole bears repeating. Separate provision is made later in the analysis to take into account any changes in the historical relationships which might occur in the future.

Forecasting RPMS, RCTMS and Aircraft

A basic planning statistic used throughout the industry is that of revenue passenger miles (RPMS). Because of this, a number of independent forecasts of RPMS exist and several alternative approaches to forecasting are found. A number of these forecasts were collected from airframe manufacturers, powerplant manufacturers, government agencies, and trade associations. The forecasts were made for differing purposes. Adjustments were, therefore, necessary to make them comparable. The problem was compounded by the need to include only the U.S. civil air carrier group, since many were developed for the entire Free World.

In order to accomplish these adjustments, some basic assumptions were required. In some cases, it has been assumed that forecasts of revenue passenger miles for the Free World would be equivalent to forecasts for the ICAO membership. Although the carriers included in these two groups are slightly different, the differences tend to be offsetting. In other instances, parts of one forecast are added to another to make them comparable. An example would be where one forecast covered domestic traffic only. The international traffic portion of another forecast would be added to it to arrive at an overall revenue passenger mile figure. In order to make the adjustment to U.S. civil air carrier, the historical relationship between Free World traffic and U.S. traffic was assumed to remain the same for the forecast period.

Since the growth in revenue passenger miles in the past has averaged approximately 13% a year, many of the forecasts consist of an estimate of the growth rate to be applied over the next several years. In cases where there was a discrepancy in the 1965 actual RPMS, it was assumed that the growth rate was accurate and the 1965 value was adjusted. In all cases, the forecasts were corrected to total Free World and total U.S. air carrier revenue passenger miles for comparability. A discussion of the individual forecasts follows.

The Boeing Company forecast[13] was divided into U.S. domestic, local service, and international traffic to arrive at the total U.S. civil air carrier traffic.[14] Two projections were made for each of these segments on the basis of different forecast growth rates. A "probable" forecast used growth rates that start at approximately 15% in 1966-67 and drop to about 6% in the late 1970's. A "possible" forecast was based upon growth rates that vary from approximately 17% in 1966 to a little over 8% by 1980. To get to total Free World traffic, Boeing added non-U.S. forecasts to these totals. The non-U.S. forecasts were based upon growth rates that vary from about 14% to 6% for the "probable" level and from 18% to 8% for the "possible" level. These two levels of forecast comprise the Boeing estimates. The "possible" level was found to be closest to the other forecasts examined.

Boeing checked the consistency of their forecasts with other economic indicators. Specifically, projections of the economic growth rates of the United States and those countries represented in the non-U.S. forecasts were evaluated to determine the ability to support the projected traffic growth. A further check on consistency was made by evaluating the compatibility of the air carrier forecasts with projections for the transportation sector of the overall economy. Although demand elasticities were not used directly in the forecasts, an underlying assumption of moderate fare decreases and continued use of promotional affairs was made. They felt that this would be necessary to support even the "possible" level of projected growth. The potential market population was checked against the passengers represented in the forecasts and the results were determined to be consistent with a continued increase in propensity to travel over the time period.

The Douglas Aircraft traffic forecast[15] parallels the Boeing forecast approach in the manner of validating their growth extrapolation. The Douglas Aircraft Company forecasted U.S. domestic air passenger traffic only, so it was adjusted by adding the Boeing forecast for international traffic. Douglas, in comparing the world to the U.S., reached the conclusion that "extensive analysis of the economics of countries other than the United States indicates that the rate of growth of factors contributing to air travel exceed those of the United States".[16] Upon this basis they developed their world forecast. They broke down the world forecast into segments in order to validate the projections for such major categories as North Atlantic traffic and intra-European traffic.

The net result of the Douglas forecast is a growth rate that is slightly less than that for Boeing over the period. Their validations of the forecast involved the same economic factors used by Boeing. In addition, they looked

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[13] Boeing Traffic Forecast (Renton, Washington: Report S-637, The Boeing Company, Commercial Airplane Division, 30 January 1967).

[14] Since this is one of the few forecasts that contains this information directly, it is used for comparison in the discussion of other forecasts.

[15] Measuring the 70's - An Air Travel Market Analysis (Long Beach, Calif.: Report C1-12/66-423, Douglas Aircraft Company, November 1966).

[16] Ibid., p. 10.

at U.S. intercity common carrier traffic. They compared their forecast for the air share of intercity travel with projections of total common carrier domestic intercity travel to check for consistency. They also looked at personal income and corporate profits as key factors in the support of continued growth of air travel.

The Federal Aviation Agency forecast[17] was developed in support of the supersonic transport (SST) investigations. They divided the total civil air carrier group into domestic passenger miles and international passenger miles and forecast each separately. Their composite forecast, however, was based upon the traffic forecast for the domestic segment adjusted by the historical relationship between domestic and international traffic. It is unique among the forecasts in that the growth rates which start at about 14% per year and decline to around 10% per year in 1970, then increase to 12% for the remaining years. The reason for this increasing growth rate toward the latter part of the period is the lower fares occasioned by the introduction of aircraft with lower operating costs during that period.

Other factors which have been included in the FAA forecasts are those related to continued real gross national product growth of between 2-3% per year and continued promotional or reduced fares on currently operating aircraft. The effect of reduced fares on stimulating passenger traffic is still an open question, although estimates of this effect are used explicitly in the FAA forecast. Some work has been done on trying to estimate the demand elasticity but, as yet, no precise conclusions have been reached.[18] The overall effect of this additional growth in the latter years is such that the FAA forecast is the highest of those discussed, except Boeing's "possible" forecast.

Yet another approach was used by the Civil Aeronautics Board in their forecast of passenger traffic.[19] Basically, their forecast involved the development of the statistical relationship between economic indicators and passenger traffic. The primary independent variables they used were consumer price index, disposable personal income, population, real disposable personal income, fares, and real fares. In this forecast, as in the FAA forecast, an estimate was made of fare elasticity which was included in the forecast equations.

Separate forecasts of the independent variables were developed or obtained from other sources and the dependent variable, revenue passenger miles, was then determined for each of the ten years of their forecast. Since this forecast was not on a growth projection basis, it is interesting to compare

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[17] Federal Aviation Agency, Aviation Forecasts Fiscal Years 1967-1977 (Washington: Office of Policy Development, Economics Division, January 1967).

[18] Gregory, William H., "Refined Air Elasticity Measure Sought", Aviation Week and Space Technology, 17 January 1965, pp. 40-43.

[19] Civil Aeronautics Board, Forecasts of Passenger Traffic of the Domestic Trunk Air Carriers, Domestic Operations, Scheduled Service, 1965-75, Staff Research Report No. 5, Research and Statistics Division, Bureau of Accounts and Statistics, September 1965.

the percentage growth rates as derived by this method with those used in the other forecasts. For the early years in this forecast, the growth rate was 9.3% and this declined to a closing growth rate of 7.6% per year. This is substantially less than the majority of the growth rates used in the other forecasts.

The CAB forecast was developed for the domestic trunk air carriers, domestic operations, scheduled service only. In order to equate this to total civil air carriers, it was necessary to inflate the result. Since the relationship between the total industry and the domestic trunk carriers has been reasonably stable over the past, the percentage relationship between those two groups during 1965 was applied to the forecast for the future. This corrected forecast is the lowest of the group for the total air carrier population, which is consistent with the overall lower growth rate which is derived from their forecasts.

The Air Transport Association forecast[20] consisted simply of three levels of projected growth rate. They were 10.8% for the low growth rate, 13.5% for the average growth rate, and 16.2% for the high growth rate. The average growth rate gives a forecast that is approximately equal to the Boeing "probable" forecast in the early years but considerably higher in the later years.

The Lockheed Aircraft Corporation developed a forecast of air passenger traffic in support of their bid for the SST contract.[21] Their forecast was also used as an input to a simulation model of an airline that they use for measuring markets for new aircraft.[22] Their approach to the forecasting problem was to separate and then forecast U.S. domestic and international traffic. For the U.S. domestic market forecast, they used three methods: (1) a market analysis technique, (2) a city-pair analysis, and (3) an economic index (GNP) method. The international traffic forecast was based upon an analysis of the relationship between the U.S. forecast and the trans-atlantic traffic, plus a trend extrapolation for major market areas of the world.

The basic underlying assumptions of all three approaches in forecasting the domestic traffic include continued growth in the GNP, continued downward pressure on airfares, increasing propensity to fly, and no major economic or political changes in the world situation. Lockheed's overall forecast is a composite of these three techniques. Although showing some differences for some time periods, they tended to support one another. The forecast for domestic scheduled traffic in the U.S. is adjusted in the same manner as for the CAB forecast and results in a total almost identical to the Douglas

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[20] Air Transport Facts & Figures, 1966, op. cit., p. 6.

[21] Air Traffic Demand 1967-1990 (Burbank, Calif.: Lockheed-California Company, OEA/SST/222, November 1966).

[22] Gunn, William A., "Airline System Simulation", Operations Research, XII (March 1964), pp. 206-229.

domestic forecast plus the Boeing international forecast. It is still somewhat lower than the Boeing "probable" forecast.

The General Electric forecast[23] is "about median of the range of opinion from several sources"[24] for the Free World. Their percentage growth rate varies from a little over 10% in 1965 to somewhat less than 9% in 1980. Since their U.S. forecast does not include international service, this is corrected by adding the Boeing international forecast to the basic General Electric forecast. This yields a result that is very close to the Boeing "probable" forecast. The validation of this forecast consisted of checking the reasonableness with forecasts from other sources.

The final forecast discussed is that of the North American Aviation Company. For their projection, they used a simple 10% per year annual growth rate.[25] This gave results which were nearly as low as the CAB forecast for the early years. By 1980 they project revenue passenger miles of about the same magnitude as Boeing or General Electric. The 10% rate was derived by comparing past forecasts of growth rates to actual past growth rates. North American considered that 10% would compensate for some of the past errors in projections.

It is surprising the extent of agreement that exists between these forecasts, considering the variety of reasons and techniques behind them. For purposes of this study, a composite of the various forecasts is used. It is less than the Boeing "probable" and General Electric forecasts. It is slightly less than the FAA and ATA projections but more than the corrected Douglas and Lockheed forecasts. It is considerably higher than the CAB forecast, which is the lowest of the group. It appears reasonable in light of the various validations of the other forecasts that have been made. These forecasts are presented in Figures I-13 and I-14.

Uniform opinion exists in the industry that the most rapidly growing sector of civil aviation is that of cargo. The traditional planning statistic in this area has been revenue cargo ton-miles. A number of forecasts of this statistic have been evaluated for use with the revenue passenger mile forecasts to develop aircraft requirements. The relatively new high growth rates of cargo have made forecasting in this area a very difficult task. Insufficient historical statistics and indifferent marketing efforts in the past have made it difficult to apply past trends or to use past relationships

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[23] General Electric Company, Commercial Market Profile and Identified Programs (Lynn, Mass.: Aircraft Engine Division, February 1967).

[24] Ibid., p. 18.

[25] Conversations with Clayton Clarke, of the North American Aviation, Inc. Commercial Marketing Group in Los Angeles, California.

REVENUE PASSENGER-MILE FORECASTS (BILLIONS)
VARIOUS SOURCES CORRECTED TO
U.S. CIVIL AIR CARRIER
ALL SERVICES

Year	ATA	Boeing Probable	CAB	Douglas	FAA	G.E.	Lockheed	North American	Composite
1965	76	76	76	76	76	76	76	76	76
1966		88			87				87
1967		103		99	98				99
1968		118			108				110
1969		133		121	119				123
1970	143	148	116		132	144	134	122	138
1971		165		145	148				152
1972		181			165				167
1973		198		170	184				184
1974		215							200
1975	269	232	169	200		224	204	195	218
1976		250							236
1977		269		230	286				255
1978		288							275
1979		307		262					295
1980	507	327				323	283	314	315
1985		428			450		400		

Figure I - 13

REVENUE PASSENGER MILE PROJECTIONS
U.S. CIVIL AIR CARRIERS

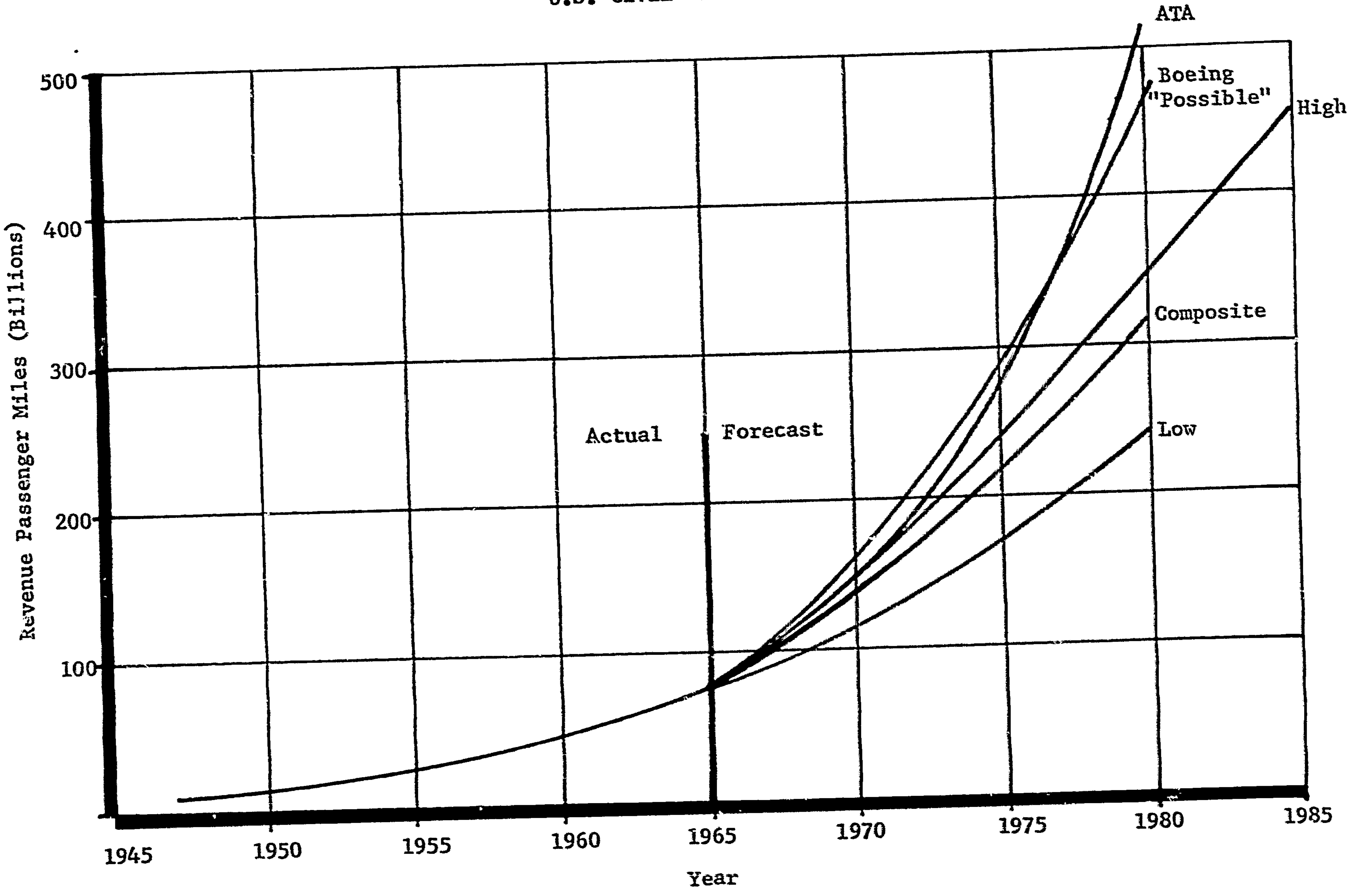

Figure I - 14

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to determine cargo volume in the future. Most forecasts in this area involve estimates as to what the cargo growth rates will be in the future.

The Boeing Company forecasted growth rates of 18.3% for 1965 through 1970, 25.5% for the succeeding five years, and 15% for the years between 1975 and 1980.[26] These rates were based upon the ability of air cargo to penetrate existing cargo movement, as well as expand markets for certain commodities. In order to accomplish this, they admit the need for favorable regulatory decisions and increased ability to handle shipments at major cargo hubs.

The Douglas forecasts[27] were divided into a basic forecast level which assumed no major effort to expand air cargo services and a high forecast level which was based upon an industry-wide air cargo marketing effort. The growth rates for their basic forecasts were 17% per year to 1970 and 23% per year through 1978, with declining growth rates from there on. The high level forecast was based upon a 25% per year growth rate initially which declined to 15% per year by 1980. These forecasts both were based upon extrapolations of past trends.

The Lockheed Aircraft Corporation, Georgia Division, has developed a more detailed approach for forecasting the cargo requirements.[28] They divided the cargo categories into the reported categories of scheduled freight, mail, express, and non-scheduled freight. They further segmented air freight carriage between cargo aircraft (including quick-change aircraft), bellyhold, and jumbo aircraft. They further divided their study into the major market areas of the world. With these breakdowns, they developed past trends between promotion and marketing effort and cargo carried, as well as developing rate elasticities for air cargo.

The result of these efforts was a forecast for various categories of cargo in different modes of carriage for different areas of the world. Their total forecast is very close to the Boeing forecast. Lockheed's average growth rate for freight is 16.7%, although it is somewhat higher in 1965 and tapers off toward the end of the period.

The General Electric Company also forecast revenue cargo ton-miles.[29] They forecast a growth rate of approximately 16% per year and validated this by comparing it with other industry forecasts. Their actual growth rate per year varied from about 25% in 1965 to about 14% in 1980. Therefore, their annual values were slightly different from the other forecasts.

The fact that it is difficult to get better forecasts on revenue cargo ton-miles is not too disappointing. It is the fastest growing segment of the industry at present. However, even these high growth rates, applied over the

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[26] Boeing Traffic Forecast, op. cit.

[27] Measuring the 70's, op. cit.

[28] Eckard, E. W., Free World Air Cargo Forecast (Marietta, Ga.: Commercial Marketing Research Department, Lockheed-Georgia Company, CMRS 59, August 1966).

[29] Commercial Market Profile, op. cit.

period from 1965 to 1980, do not make it a major element in the industry by 1980. The forecast figure for U.S. domestic air cargo in 1980 is still less than 1% of the forecast total common carrier intercity ton-miles.[30] This total, for revenue cargo ton-miles, represents less than 10% of the total forecast revenue ton-miles carried by air in 1980. The forecast revenue cargo ton-miles used in this study are shown in Figures I-15 and I-16.

One approach to determining overall aircraft requirements was used for most of the forecasts reviewed. It consisted of taking a revenue passenger mile forecast and revenue cargo ton-mile forecast and computing the number of airplanes required to carry that traffic. The process starts with estimates of load factors, productivity, ground time, speed, capacity, stage lengths, aircraft types, and schedules. These, in turn, are used to compute aircraft utilization and productivity, which then converts to numbers of aircraft required to support the forecasts. The disposition of the current fleet must be accounted for, so estimates were made of aircraft losses and replacement. Differences between forecasts could usually be attributed to differences in the assumptions made for these various parameters, rather than differences in the basic revenue passenger mile or cargo forecasts. This is supported by the general agreement between the RPM forecasts discussed in this study.

An approach that differs slightly from that outlined above was used by the FAA for their aircraft projection.[31] The method was applied to cargo aircraft and passenger aircraft separately. They used current aircraft purchase commitments and estimates of additional aircraft orders to compute the new aircraft additions to the fleet. Next, they developed replacement schedules for turboprop and piston aircraft to get net aircraft inventories. Essentially, they retired the piston aircraft completely by 1977. The few that still would be flying would be with the supplemental airlines and commercial operators. They used no retirement of current jet aircraft until after 1977.

To validate their forecast, the seat-mile and cargo capacity of the forecast fleet size was determined. This was adjusted by the load factor for comparison with their revenue passenger mile forecast. In this sense, the FAA worked the problem backwards from the procedure used by the other groups. Using this technique, they forecast a greater overall fleet size than any of the others. This was consistent with their high RPM forecast.

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[30] Eckard, op. cit., p. 1.

[31] Aviation Forecasts Fiscal Years 1967-1977, op. cit., p. 5.

REVENUE CARGO TON-MILE FORECAST (BILLIONS)
U.S. CIVIL AIR CARRIER--ALL SERVICES

Date	Revenue Cargo Ton-Miles
1965	3.1
1966	3.6
1967	4.2
1968	5.1
1969	6.0
1970	7.0
1971	8.8
1972	10.2
1973	12.3
1974	14.6
1975	16.9
1976	19.5
1977	22.7
1978	27.0
1979	32.0
1980	38.1

Figure I - 15

REVENUE CARGO TON-MILE PROJECTIONS
U.S. CIVIL AIR CARRIERS

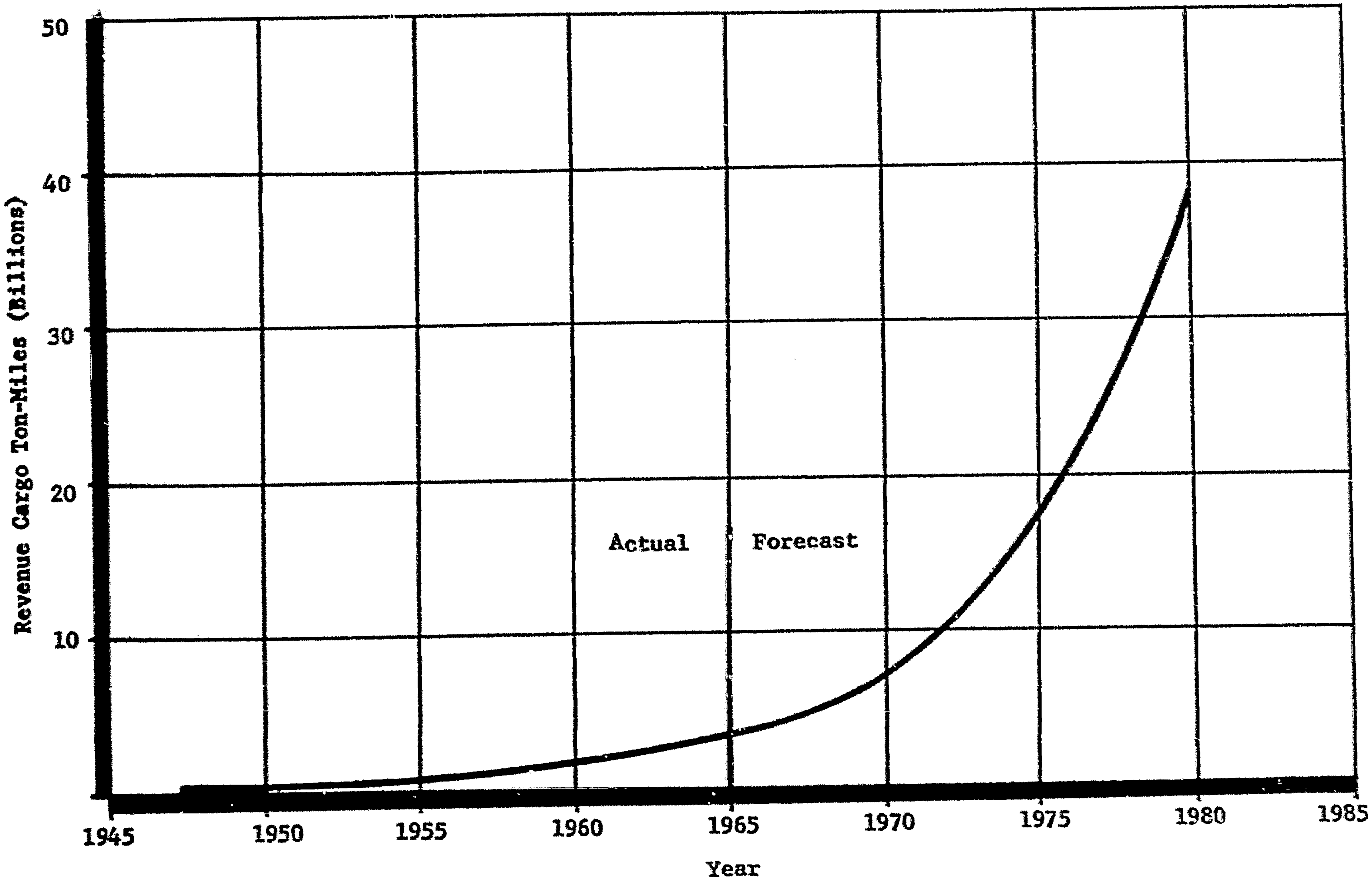

Figure I - 16

The General Electric forecast[32] methodology was the most detailed of those reviewed. They used their revenue passenger mile forecast and cargo ton-mile forecast to derive an aircraft forecast. They first divided the cargo and passenger forecasts into forecasts by stage lengths and then matched these stage length requirements with existing and future aircraft. In order to accomplish this, they developed a generalized computer program which determined the aircraft required for each of the stage-length forecasts. They forecast the Free World total, so an adjustment was made which reduced their forecast to that of the total U.S. civil air carrier group. This adjustment was made in two steps. First, the ratio of the revenue passenger miles carried by the Free World to the U.S. civil air carrier traffic was applied. The second step was to equate the number of aircraft in the U.S. civil air carrier fleet derived for 1965 to the actual fleet size in 1965.

The net result was a forecast of a declining number of aircraft until the early 1970's. Beyond that time the forecast was for increasing numbers of aircraft through 1980. A major portion of the early decline in the total fleet was occasioned by the rapid replacement of piston aircraft (which were forecast completely phased out by 1974) by short- and medium-range jet aircraft and smaller turboprop aircraft. General Electric also explicitly took into account existing jet retirement by using an estimate of economic obsolescence of the aircraft. Their retirements from the current fleet total 150 aircraft by 1975 and 700 aircraft by 1980. These retirement rates were used to adjust the other forecasts when retirement was not explicitly taken into account. The major part of these retirements were occasioned by the introduction of new aircraft types that General Electric believes will be introduced in the future. The General Electric forecast is the lowest of those reviewed.

The Boeing Company forecast[33] was comprised of separate forecasts for the world jet and propeller fleets, including those airplanes required for cargo. They showed a declining propeller fleet, although, since their figures included turboprop aircraft, they still showed 500 active propeller aircraft in 1980. Boeing used a straight fifteen-year life for jet aircraft to determine retirement and a 1% per year loss rate for all other reasons. The same adjustments were made to Boeing's world forecast as to General Electric's in order to get the U.S. portion.[34] The correction factor is somewhat greater than the ratio of the revenue passenger miles flown by the U.S. civil air carriers to those flown by the total Free World, as also found in the discussion of the General Electric forecast. This arises because, in general, the U.S. fleet is more modern and productive than that for the remainder of the Free World. Boeing's forecast fleet size was slightly less than that of the FAA.

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[32] Commercial Market Profile, op. cit., p. 25.

[33] Boeing Traffic Forecast, op. cit.

[34] It is interesting to note that General Electric forecasts a total of 225 Boeing 747's in 1975, with 100 for passengers and 125 for cargo. Boeing, on the other hand, forecasts 408, with 101 for cargo and 307 for passengers.

Douglas chose to forecast cumulative jet aircraft deliveries rather than aircraft fleet size.[35] In order to do this, they first developed the "seat-mile gap" that would exist between on-order aircraft capacity and that required by their RPM forecast. This was done for long-, medium-, and short-stage lengths. They then proceeded to fill this seat-mile gap with existing and contemplated aircraft types for each of the stage lengths. The on-order, plus their additions, were then turned into a cumulative aircraft delivery schedule for the Free World. To adjust this to the total civil air carrier fleet, the Boeing propeller fleet and existing jet fleet were added and the General Electric retirement figures were subtracted. The net result is a forecast that is slightly lower than that of Boeing.

The Lockheed Company forecasts were derived from their revenue passenger mile and cargo ton-mile forecasts for various stage lengths for the eleven trunk carriers and Pan American, only.[36] Their result was adjusted on the basis of the historical relationship between the fleet for that group of carriers and the total civil air carrier fleet size. The resultant forecast is somewhat less than Douglas' but greater than General Electric's. Lockheed assumed that a rapid replacement of currently operating equipment will take place in the 1970's; thus, they forecast a declining fleet size after that period.

All of the forecasts described included the Concorde, the U.S. supersonic transport, and the Boeing 747. In those forecasts where specific aircraft types were identified, the introduction of new aircraft types generally included another short-range jet type, stretched versions of the present short-range jets, and some form of airbus. The question of whether or not the supersonic transport will fly over land affects the forecasts to some extent because of its productivity but not greatly during the time period covered. The forecasts fall into two broad categories: (1) those with constantly increasing fleet size (Boeing, Douglas, and FAA), and (2) those which have a decreasing fleet size during some time period (General Electric and Lockheed). They are summarized in Figures I-17 and I-18. To determine what forecast to use for this study, a more detailed investigation of the requirements for the latter part of the 1960's was made.

The determination of the fleet size for the latter part of the 1960's was approached by taking the "on-order" aircraft delivery schedule as of year-end 1965 and adding to that the current fleet minus the retiring propeller aircraft. This placed a floor under the forecasts and gave a minimum expected fleet size for any given year. In the past, committed aircraft orders for future years have been less than the actual orders filled during that year.[37] This has been true even during years when deliveries of aircraft

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[35] Boeing Traffic Forecast, op. cit.

[36] Personal correspondence with J. A. Schwartz, Market Engineer, Lockheed-California Company, Burbank, California.

[37] The data for this analysis was taken from Aviation Forecasts Fiscal Years 1967-1977, op. cit. The extent to which the "minimum fleet levels", as computed, varies from actual is illustrated by the year 1966. At year end, there were 2,272 aircraft in the fleet compared to a forecast minimum of 2,172.

AIRCRAFT FORECASTS--U.S. CIVIL AIR CARRIER

Date	Boeing	Douglas	FAA	G.E.	Lockheed	Minimum Fleet Size	Prop.
1965	2125	2125	2125	2125	2125	2125	1400
1966	2265	2272	2337	2145	2150	2172	1293
1967	2390	2390	2366	2185	2210	2207	1000
1968	2505	2505	2400	2180	2290	2267	747
1969	2610	2610	2540	2095	2390	2276	683
1970	2695	2695	2700	1970	2480		675
1971	2780	2770	2875	1900	2565		681
1972	2850	2840	3000	1895	2650		634
1973	2940	2900		1935	2730		610
1974	3005	2960		2000	2785		600
1975	3090	3020		2085	2800		585
1976	3180	3070	3500	2155	2790		577
1977	3250	3115		2230	2770		560
1978	3330	3155		2315	2750		540
1979	3410	3195		2390	2730		520
1980	3485	3220		2470	2715		500

Figure I - 17

AIRCRAFT FLEET PROJECTIONS
U.S. CIVIL AIR CARRIERS

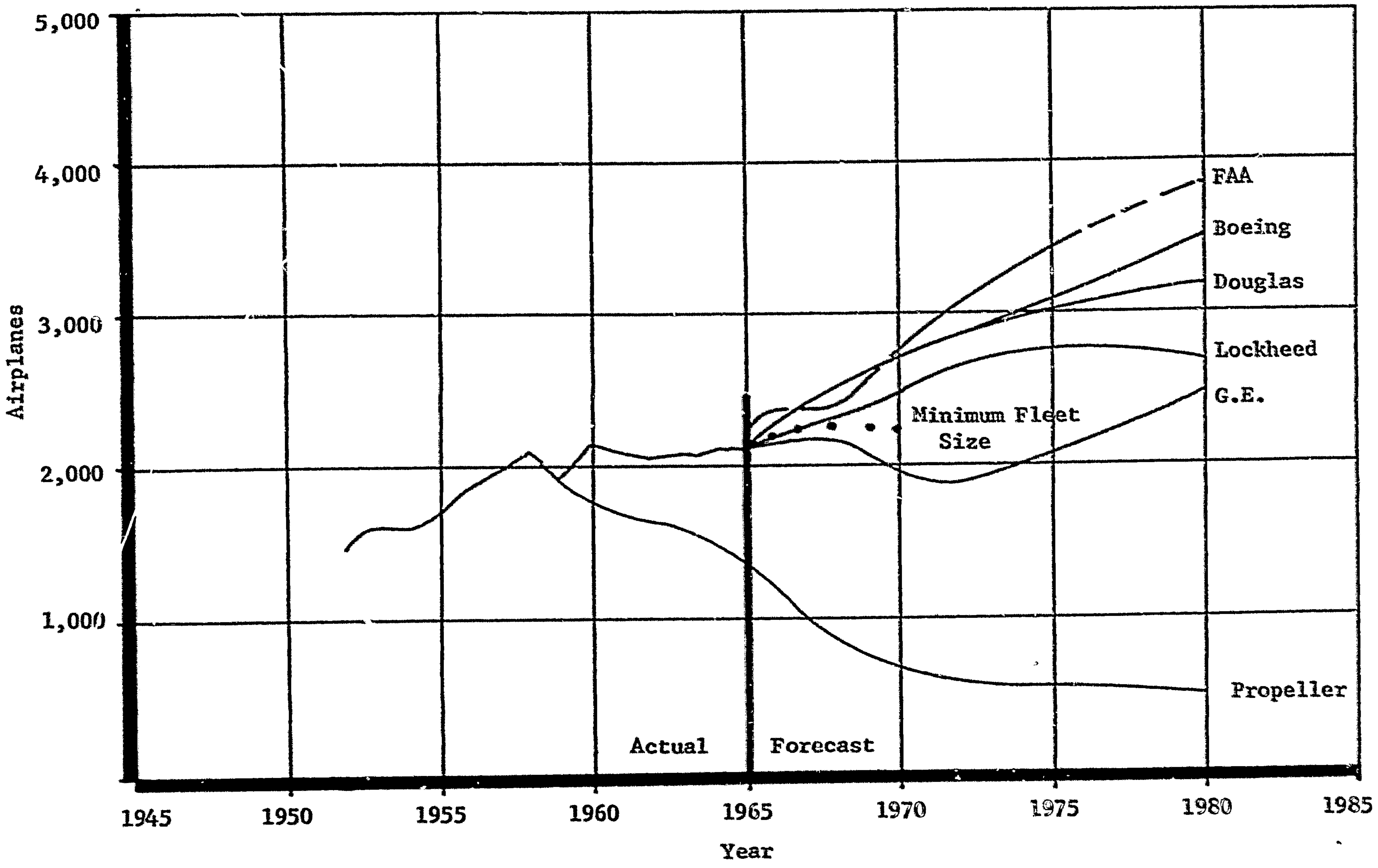

Figure I - 18

have been delayed. The minimum fleet size thus derived was greater than the General Electric forecast for all years and greater than the Lockheed aircraft forecast for the early years. Because of this, it was felt that one of the constantly increasing forecasts would be more likely during the latter part of the 1960's. Since the introduction of the Boeing 747 is planned for 1969 and the supersonic transport is expected in the mid-1970's, it is likely that the growth rate of the fleet would be declining during that period, as in the Douglas forecast. For these reasons, the Douglas forecast was selected as the basis for projecting new hire requirements.

This forecast shows a continually increasing number of aircraft in the fleet through 1980. This raises the question of whether or not it will be possible to continue to increase fleet size over this period. A corollary question is whether or not the increases in traffic growth are maintainable. Possible limitations to these forecasts do exist and were investigated. The results of these investigations follow.

Possible Limitations on Future Growth

One area of possible limitations on future growth in aircraft traffic is that of air traffic control. The air traffic controller's job is one requiring tremendous amounts of concentration, for he is expected to keep track of all aircraft that are flying in the airspace controlled from his center which are assigned to him at any point in time. The job becomes increasingly difficult as the numbers of aircraft in any area increase. This is especially true on the critical parts of a given flight, primarily when the aircraft is preparing for takeoff or landing. Thus, the areas of greatest congestion (i.e., New York, Los Angeles, and Chicago) are those with the greatest workload and density of traffic. There is serious debate about how adequately the current system handles the traffic under marginal conditions.[38] Much of this discussion centers on what changes are necessary to handle the traffic until new display equipment can be tested and installed.[39] The problem is one of maintaining a pace with the air traffic growth without overtaxing the system or the ability of the FAA to support new systems.

A factor which complicates this is that the loads are extremely uneven from area to area. It was pointed out above that the areas of highest traffic

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[38] Beck, Richard H., "1200 RVR--Cleared to Land", The Airline Pilot, August 1966, p. 9.

[39] Stein, Kenneth J., "ATC Staff Training with Alpha-Numerics", Aviation Week and Space Technology, 26 September 1966, p. 119.

concentration are the areas of greatest concern. The areas with lower traffic volumes have sufficiently lighter loads to cause great unevenness in the total network. One trend that is partially offsetting this is the increase in local service traffic and cities served.[40] In all likelihood, this trend will continue as new short-range aircraft, such as STOL (Short Takeoff and Landing) and VTOL (Verticle Takeoff and Landing), are perfected and introduced in commercial service. Even proposed systems like those which would locate traffic hub airports, for long stage-length departures, in relatively unpopulated areas require moving the passengers out of the metropolitan areas to these hubs. Thus, there would still be a high degree of congestion in the densely populated areas.

For the industry as a whole, it appears that the air traffic control system will maintain a pace with reasonable growth rates. Only for extremely high rates of growth (i.e., Boeing's "possible" rate) would there be any problem of saturation and limitations of traffic growth. If these levels were to materialize, then the total number of required pilots would be reduced. This possibility has been taken into account, in that potential limitations on the growth can be translated into new hire requirements reductions by reducing forecasts or changing the relationship between factors.

Another form of congestion that could place a limitation on traffic growth is that of ground handling. Ground handling, as used here, refers both to the handling of the aircraft on the ground, which affects turnaround times, and that connected with the passenger, his luggage and the freight to be moved by the aircraft. This is an area that needs much attention if it is not to choke off the time savings once the aircraft is airborne. By the time of the introduction of the Boeing 747, the systems must be capable of handling up to 500 people per flight. If major breakthroughs in techniques are not developed and implemented prior to this time, it will have severe impacts on the growth of air travel. It simply will not be a net saving of time to go by air if it takes hours to get in and out of the aircraft and to get luggage afterward. Some advances are being made in this regard concerning the handling of luggage.[41] Major advances have been made in handling freight by computerized sorting and storage systems and by containerization.[42]

The smaller airports are no longer immune to the implications of this potential bottleneck. In the past, it has been a relatively simple matter

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[40] The growth rate in revenue passenger miles for the trunk lines in 1963-65 were 14.4, 14.8, and 17.6%, while those of the local service carriers were 16.3, 20.1, and 16.8% for the same period. Source: CAB Handbook, op. cit.

[41] Coburn, R. F., "Air Transport Association of America Weighs Proposal to Back High-Speed Baggage System", Aviation Week and Space Technology, 23 January 1967, p. 40.

[42] "Pan Am Cargo Terminal Heavily Automated, Mechanized", Aviation Week and Space Technology, 22 May 1967, p. 37.

at the smaller fields because of the low frequency of service and the relatively small number of passengers. With the development of newer short-range aircraft and the growth of local service traffic, this very smallness tends to be a detriment to improvements in ground handling. In this area, major changes are necessary to support even the composite growth forecast. For the purposes of this study, the assumption has been made that the improvements will be made in time to support the projected passenger traffic levels. In the case of cargo, it has been in large part the development of these newer handling systems that led to the projections of such rapid growth.

A question related to that of passenger and freight congestion in the terminal is that of passenger congestion outside the terminal. This issue involves questions regarding the construction of new airports and expanding old ones. It also involves questions of parking and access. Considerable work is going on with regard to each prong of this problem. Efforts are being made to improve flows in existing facilities, and new facilities are being planned.[43] It looks as though improvements will come at a rate sufficient to support the forecast traffic levels.

The question of financing the new aircraft required to support the growth has occasionally been raised.[44] Should this prove a difficulty it could limit growth. However, if there is increasing traffic, then there would be a large cash flow and a sufficient internal generation of funds for capital investment. The lead time on commitment is long for new aircraft types, however, and the financing must be reasonably assured before the commitments can be given. Thus, it becomes important to forecast as accurately as possible. Douglas explored this question in their forecast of RPM and concluded that financing would not limit growth in the United States.[45] For this study, their conclusion is accepted.

Another possible limitation on air traffic growth arises due to the competitive potential of a high-speed ground transport system. Research has been conducted on possible systems for installation in the California and Northeast corridors. The possibility of a major shift of intercity passengers from the airlines to such a system is not in question. The installation of a high-speed rail transportation system between Tokyo and Osaka resulted in a 38% decline in traffic for Japan Airlines on that run.[46]

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[43] Air Transport Association of America, Air Transport Facts and Figures, 1967, official publication of the Air Transport Association of America, 31 January 1967.

[44] The Issues and Challenges of Air Transportation II: The Impact of New Technology, Proceedings of a symposium sponsored by Connecticut General Life Insurance Company, Hartford, Conn., 15-17 May 1963.

[45] Measuring the 70's, op. cit. They found problems in other parts of the world, however.

[46] Ross, Howard R., "High-Speed Intercity Ground Transport in 1980", Stanford Research Institute Journal, XII (November 1966), p. 10.

The carriers most likely to be hardest hit by this kind of competition would be the local service carriers who normally cover these shorter stage lengths. Some of the systems under contemplation, however, are for long enough stage lengths that some of the trunk carriers would also be affected. The possibilities of such systems limiting the growth of air traffic in the period to 1980 are slight. The conclusion of a Federal Aviation Agency supported study by Stanford Research Institute was "that it appeared unlikely that any HSGT (high-speed ground transportation) system would be operating in the California corridor by 1980".[47] Thus, this possibility is not considered limiting in this study.

In the realm of international travel, tourist facilities, international documentation and customs procedures pose possible limitations on traffic growth. Complaints have been registered from time to time that the increasing tide of tourism has indeed strained the hotel facilities in some parts of the world. This may become an even greater consideration as the negotiations for routes across the Pacific progress and an interest in the Southeast Asia area as a tourist attraction increases. It is very difficult to estimate what effects the increases in tourism will have on the construction of hotel facilities or vice versa. In order to exercise some degree of control over this possible limitation, a major trunk carrier in the United States has merged with a hotel chain to construct facilities along their route structure.[48] Work continues on liberalizing visa and customs requirements for tourists, in order to prevent any discouragement from that realm.[49] Due to these continuing efforts, no limitation from this source has been imposed on the forecasts for the future used in this study.

Since no limitations of traffic growth as forecast are envisioned, they have not been applied to the basic calculation of new hire requirements. Another possibility for changing overall employment projections arises with the consideration of pilot productivity. This possibility is considered in the next section.

The work rules under which a pilot flies almost completely define the conditions of his flying. They are usually developed in negotiations with the individual carriers by the representatives of the pilots. Of primary importance in determining the availability of a pilot for flying are the regulations concerning maximum flight hours. There are limitations on the number of hours a year, a month, and the number of hours of continuous flying that any pilot can do. During the period from 1947 to 1966, the legal

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[47] Ibid., p. 6.

[48] The merger of Hilton International Co. and TWA became effective 9 May 1967. Source: Aviation Week and Space Technology, 15 May 1967, p. 35.

[49] Cousins, Norman, "There Are No Aliens", Saturday Review, 11 March 1967, p. 28.

maximum number of hours per month was 85 hours.[50] Individual airline contracts need not correspond to this legal maximum, provided it is not exceeded. Many contracts currently require a maximum of only 75 hours per month.

Included in this maximum number of hours are certain non-flight credited hours. For example, flights at night or those which require a considerable amount of time away from home or lay-overs accumulate flight hours at a greater rate than clock time or gain credit for the long duty period. With these credits and the limitations placed in any given time period on the number of hours available, the scheduler's task is a very difficult one. He must try to schedule pilots to aircraft and flights which meet the legal restrictions and still minimize the non-flying flight credit hours. At the same time, he must satisfy the seniority bidding of pilots. His ability is also very much dependent upon his company's route structure. For certain route structures, it is possible to put together flight segments that add up to an eight-hour flying period and have the pilot back home at day's end. This is particularly true of some of the local service carriers. For other route structures, it is almost impossible to do this, since the one-way flight time to a given destination may be very close to the legal daily maximum number of hours that a pilot can fly. This, of course, would necessitate a "nonproductive" lay-over at that destination before he could either bring a flight back or take the succeeding flight on the next day to the next destination. These complications, coupled with the fact that scheduling is an extremely difficult problem in its own right, underscore the difficulty of the task of scheduling to maximize utilization of pilots.

The question of maximizing revenue production by pilots is complicated further by other factors. One of these revolves around the procedures concerning vacation time. Vacation assignment is subject to bidding procedures, based on seniority, such that the prime vacation times are bid for by the most senior pilots. The vacations must be provided for in the schedules and do detract from the availability of pilots for revenue productive flying. Vacations are somewhat easier to plan for than the training obligation of the airline which, in part, is dependent upon bidding. Eligible pilots bid on vacancies in aircraft for which they may not be checked out, necessitating training. This also decreases the available revenue production time for pilots. During the time when the more senior men are bidding for the most attractive vacation months, this becomes a real problem for scheduling. This particular study does not go into detail on the problems associated with this internal training-bidding-scheduling problem, but only treats the results of these obligations on the availability of pilots for revenue productive flying.

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[50] CAB Handbook, op. cit.

Further adding to the complications of the scheduler and losses due to vacations are a host of other factors associated with airline operations. Slippage is introduced into the plans because of weather, sick leave, deadheading, delays, accidents, and a multitude of other factors. The combined results of these factors mean that no pilot can be scheduled to fly the legal maximum of 85 hours a month or even the 75 hours a month specified in some of the contracts. The revenue production flight hours are called "stick hours" or "hard hours" in the industry. The actual number of stick hours varies considerably from airline to airline but generally lies in the range of 50-55 hours per month, with extremes of from 35 to 60 hours per month.[51] There are substantial arguments on what will happen in the future to this factor.

The airline point of view can be summarized as one of hoping to establish a floor on stick hours. They are willing to entertain different payment schemes if this floor can be maintained and/or they can gain some flexibility in scheduling the pilots to meet the peculiarities of a given schedule and route structure. This position on the part of the airlines is clear from the standpoint of the impact on their revenue. Reductions in stick hours have a compound effect, in that they feed back to the scheduling function and make it more difficult, thus increasing their impact.

The ALPA point of view hinges on the concept of a "duty period", which may or may not include flying. They are assessing a proposal to use a formula for computing pilot pay based on "work units" which are related to the time on duty, nature of the duty, and the time of start of duty.[52] Their feeling is that the pilots' workload is also related to the number of takeoffs and landings, and these will increase in a given duty period as the aircraft speeds become higher. The overall effect would be a decline in stick hours, as the average speed of aircraft increases, due to a faster rate of accumulating work units for the takeoffs and landings than at the straight clock rate.[53]

As a result of these considerations of the issue by both the airline management and ALPA, it was concluded that there will be a slight degradation in the number of stick hours flown per pilot per month in the future. It will probably be about the same rate as that already reflected in the historical relationships. For the determination of the

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[51] Based on interviews with several carriers.

[52] Langdon, Robert, "ALPA's Flight Time - Duty Time Study", The Air Line Pilot, November 1963, p. 4.

[53] There is need for some research on the question of finding an appropriate basis of pay for pilots. Should it be work load or responsibility, for instance?

number of new hires required, this has been assumed the case. Provision was made to study the effects of a greater rate of decline in stick hours than that which has been the case to date.

Another factor which affects the need for pilots is the crew complement per aircraft. It is anticipated that the Boeing 747 will have a crew complement of three. There is speculation that the SST, however, will have a complement of four, with a new officer's position being created called the "command officer". On the other hand, the smaller, short stage-length aircraft, such as the DC-9 and Boeing 737, are designed for crew complements of two.[54] The newer types of aircraft that are being contemplated for the even shorter stage lengths, such as the VTOL and the STOL aircraft, generally are planned for two-man crews. The present crew complements in the civil air carriers range from two to four. Thus, for this study, it was assumed that the mixture of crew complements would be the same as it has been in the past.

In summary, the projected growth rates seem attainable and the historical relationships are assumed to hold for the period through 1980. Overall employment levels, therefore, were determined directly from the aircraft forecast and statistical relationships. To get new hire requirements, it is necessary to add to the increases in employment, the replacement personnel required each year. To do this and to provide a means for testing some of the assumptions, a computer program was developed. A description of how it is used to determine overall requirements and the information which was processed by this program is given in the next section.

Statistical Description of Pilot and Mechanic Force

The factors which contribute to the demand for new pilots and are isolated for study are shown in Figure I-19. Thus far the discussion has centered on the factors of overall employment projection, limitations to these projections, and changes in pilot revenue-generating flying time. The other categories all represent aspects of the annual losses of pilots from the flying force. The projection and its components, plus the annual pilot loss rate and its components, form the basis of a computer model for determining the annual new hire requirements. The model was developed both for the calculation of these requirements and for testing the sensitivity of the results to changes in the assumptions or individual components.

Before using this model, it was necessary to develop a statistical description of the employed pilots and mechanics as of year-end 1965 as input data for the computer. It was also necessary to determine the values of certain

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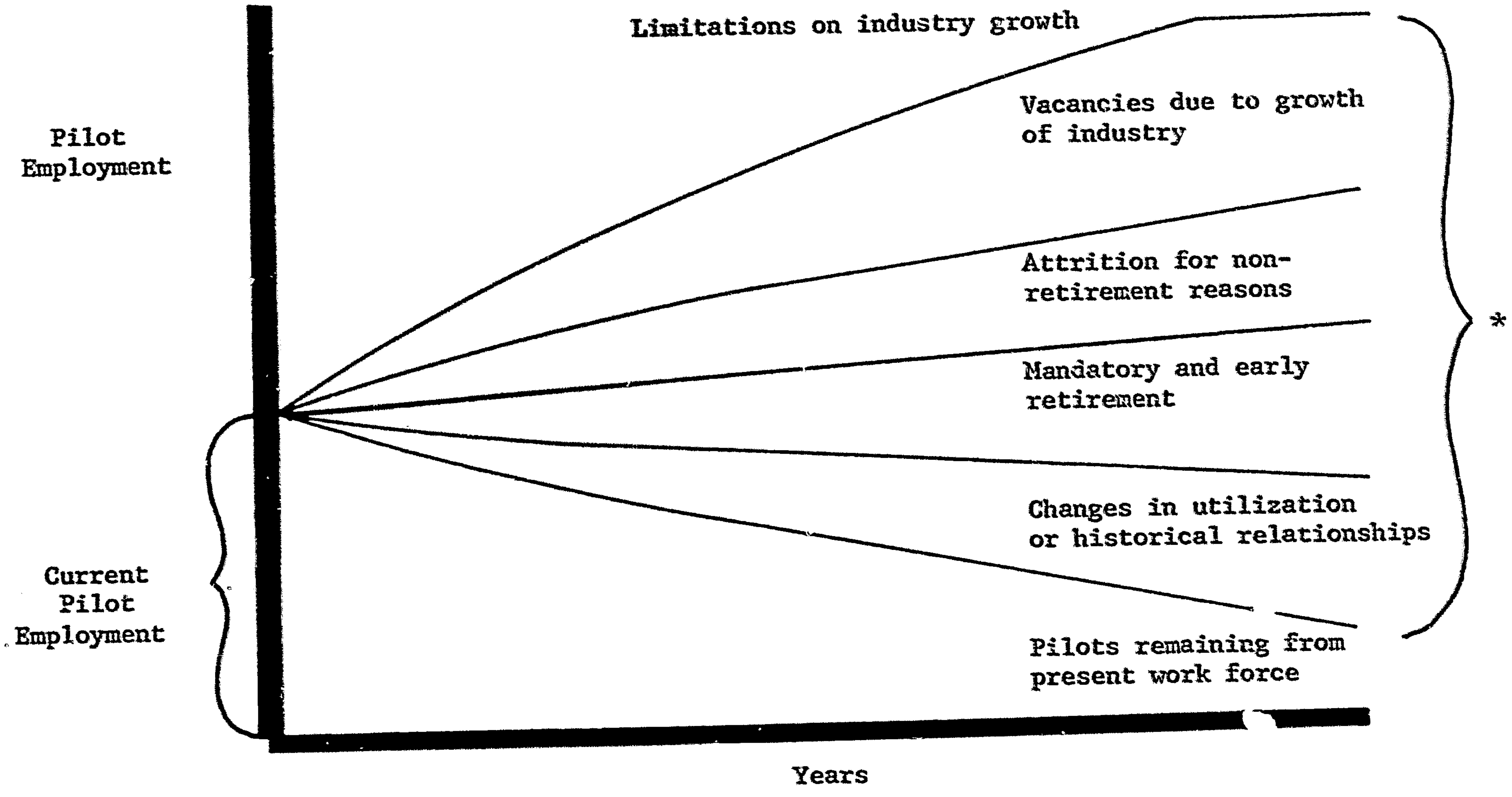
[54] United Air Lines and the Air Line Pilots Association are attempting to resolve the issue of whether the Boeing 737 will be flown with a two- or three-man crew. At this writing, the issue is still being discussed.

COMPONENTS OF NEW PILOT REQUIREMENTS



* Total new pilot requirements

Figure I - 19

parameters, i.e., those dealing with the annual losses for the duration of the forecast period. The remainder of this section will treat the determination of these values, as well as some of the assumptions incorporated in the model.[55] With those factors specified, the computer program calculates the new hire requirements on an annual basis and the cumulative requirements from year-end 1965.

The total number of pilots employed at year-end 1965 was 21,972, as shown in Figure I-1. Figure I-2 shows 41,667 mechanics employed at the same time. An estimate of 1,000 was made for the pilots employed by the commercial operators and supplemental carriers at year-end 1965.[56] For the mechanics, the comparable figure is 2,000. The discussion of how these estimates were made is found on previous pages of this report. That makes the total employment for the civil air carrier group 22,972 pilots and 43,667 mechanics at year-end 1965. These are the starting employment figures for the computer model.

The age distribution of the pilots employed in December of 1965 is derived from statistics on the age distribution of the certificated route air carrier pilots compiled by the FAA[57] and the ATA.[58] The FAA data were for 1964 and the ATA survey was for mid-1966. The ATA data includes the ages of the new hires employed during the first half of the year 1966 and, by adjusting the mid-1966 age distribution, a very close approximation of the age distribution of year-end 1965 was obtained. This was checked against the FAA distribution for 1964 and a United Air Lines age distribution for mid-1965 and mid-1966.[59] The agreement between all sources was quite close.

The age distribution of commercial operators and supplemental carrier pilots was checked for consistency with that of the total certificated route air carriers. Although the ages of these pilots tended to be somewhat more centrally distributed with a slightly higher average,[60] there was considerable agreement with the distribution of ages of total certificated route air carrier pilots. The small number of pilots involved and the small sample size in the commercial and supplemental age distribution survey led to a decision to use the certificated route air carrier statistics for the total civil air carrier group. This distribution, presented in Figure I-20, is a rounded composite of the source distributions.

Considerably less information is available on the age of mechanics. The FAA has an estimate for the year 1964[61] based on some trunk and local service

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[55] A detailed description of the model and program is on file in the Division of Industrial Design & Technology, Arizona State University, Tempe, Ariz.

[56] The FAA estimates that there were 1,264 pilots in this group in 1966. Source: Pilot Manpower Data, FAA Office of Policy Development, February 1967, p. 1.

[57] Federal Aviation Agency, Project Long Look, Report of the Aviation Human Resources Study Board on Manpower Requirements of the Civil Aviation Industry (Washington, D.C.: September 1964), p. 85.

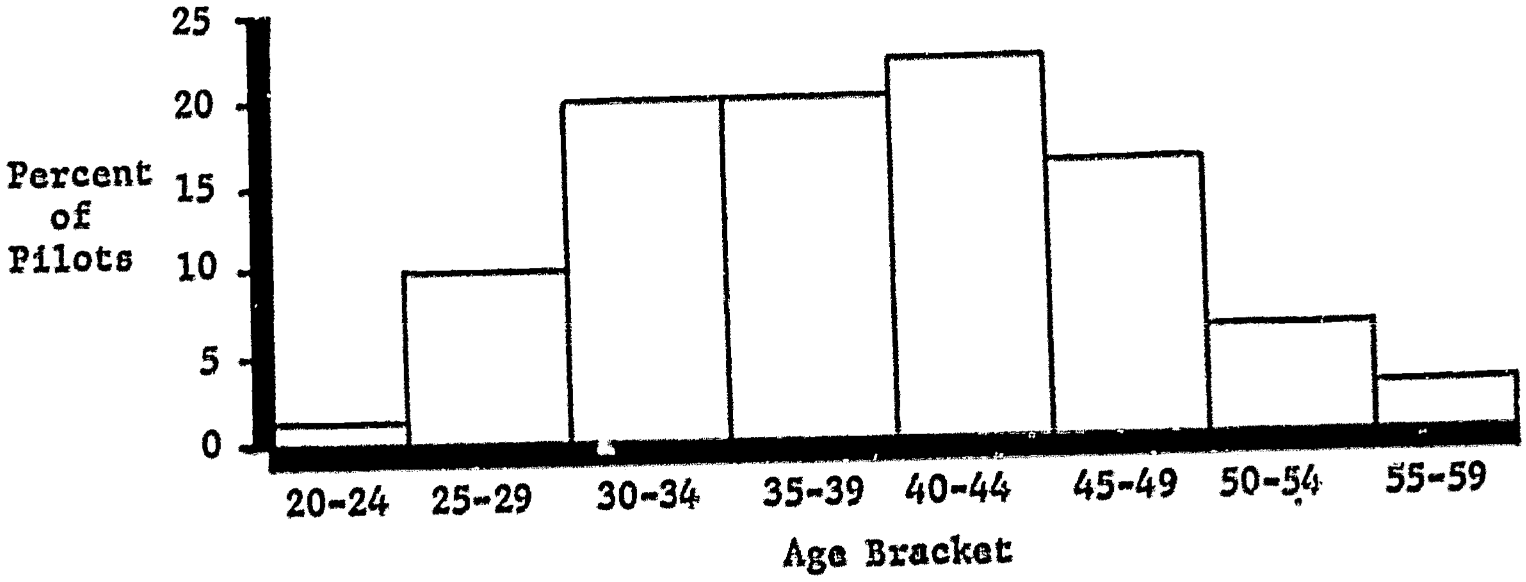
[58] Air Transport Association of America, unpublished survey, as of June 1966, dated January 1967.

[59] Personal interviews, United Air Lines, Chicago, Illinois.

[60] Special survey of supplemental carriers and commercial operators.

[61] FAA Project Long Look, op. cit., p. 100.

AGE DISTRIBUTION OF PILOTS
U.S. CIVIL AIR CARRIERS
DECEMBER 31, 1965



Age Bracket	Percent
20-24	1.5
25-29	10.0
30-34	20.0
35-39	20.0
40-44	21.5
45-49	17.0
50-54	7.0
55-59	3.0

Figure I - 20

carriers. The age distribution of the total group of persons with active mechanic certificates is considerably higher than the trunk and local carrier mechanics.[62] This is probably occasioned by the existence of a number of persons who have moved out of the mechanics job but still maintain their certificates. Since they are likely to be promoted later in their careers, this would account for the age distribution which includes them being higher than the sample of active mechanics. The distribution used and presented in Figure I-21 is that of the trunk and local service operators as reported in the FAA study. Since the distribution is in percentages, it is probably not significantly different from that of the total civil air carrier group.

The computer model redetermines the age distribution for the pilots and mechanics at the end of each year. The distribution changes somewhat as older men leave the force and younger ones are hired to replace them. Also, the growth over time, which is filled in large part with younger new hires, causes the age distribution to shift. This redetermination of the age distribution provides an opportunity for checking it during periods of introduction of newer aircraft. This could have important consequences regarding the experience levels of the men available for use on this equipment. Important in the evolution of this age shift is the new hire age distribution and that subject is treated next.

The maximum and minimum ages for pilot applicants were summarized for a majority of U.S. airlines in a survey by Air Transport World.[63] They show that some local service carriers will hire men at 19, although there is no evidence that any pilots have been hired that young. Some of the trunk carriers will hire men up to age 35.[64] The ATA did a survey of the new hires engaged by the certificated route air carriers during 1966, including their age distribution. Additional data are available in an ATA summary of the carriers 1965 hiring.[65] There is a slight difference between the age distribution reported for 1966 new hires as opposed to those for 1965. In 1965 the average age was 27 years and the range was 19-35 years. The average age was slightly higher in 1966, although the range was the same. Since the pilot age distribution was somewhat higher in the supplemental carriers and commercial operators than for the total certificated route air carrier pilots, it is probable that their hiring age distribution is also somewhat higher. Therefore, the ATA data for the 1966 new hires (summarized in Figure I-22) was used for the total civil air carrier group.

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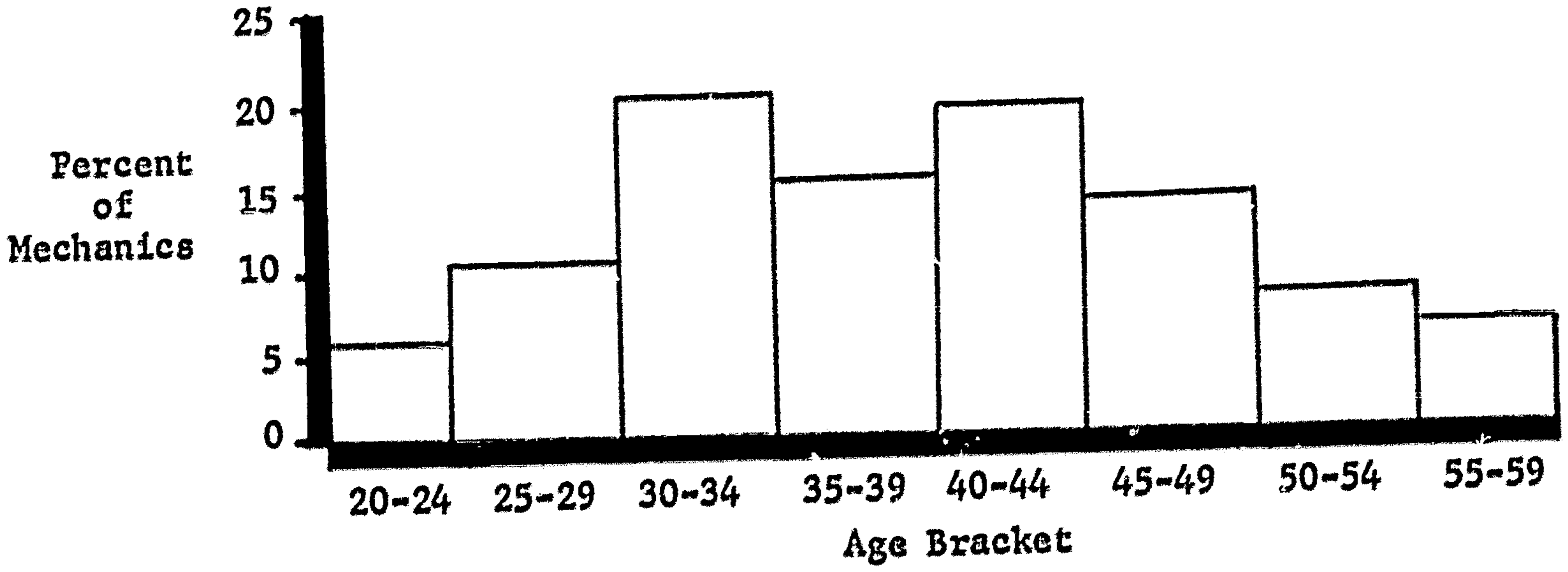
[62] Federal Aviation Agency, FAA Statistical Handbook of Aviation, 1966 ed., p. 84.

[63] "What the Airlines Need in New Flight Personnel", Air Transport World, January 1967, p. 21.

[64] It is interesting to note that even though the oldest stated applicant age is 35, 4.2% of the new hires in 1966 were between the ages of 35 and 39, and one new hire was in the 40-44 age group. This is probably due to the difficulty airlines were facing in getting the number of applicants to which they are accustomed.

[65] Summary of 1965 Airline Hires, Air Transport Association of America - Personnel Relations Conference (unpublished memoranda), April 1966, and industry questionnaires.

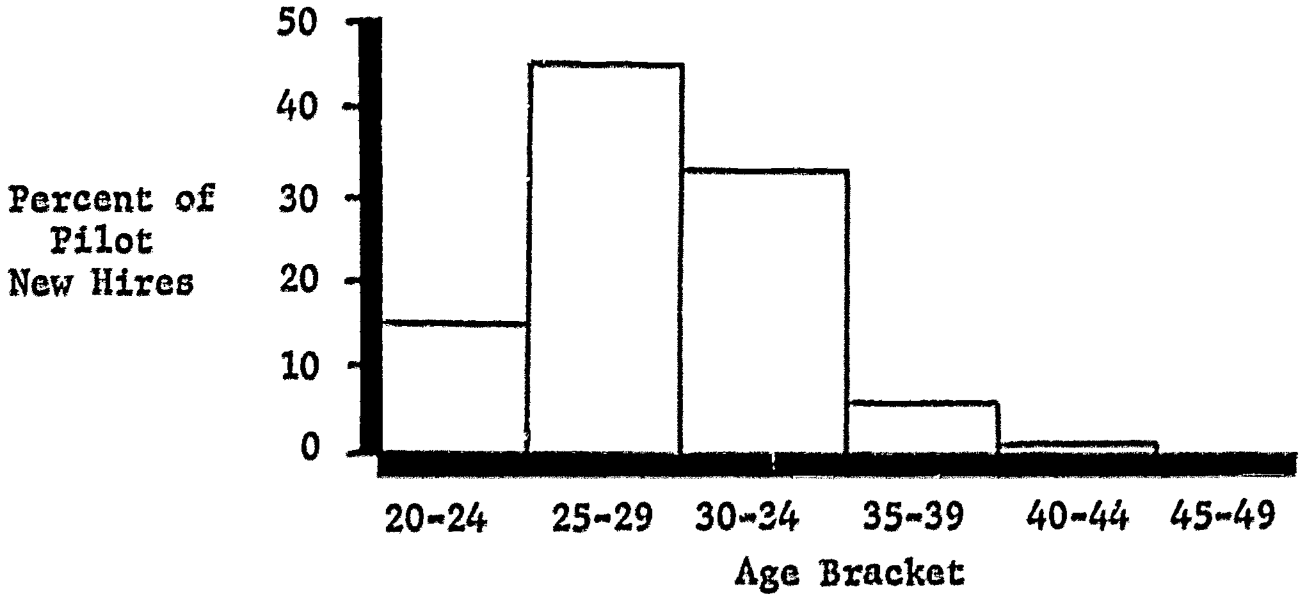
AGE DISTRIBUTION OF MECHANICS
U.S. CIVIL AIR CARRIERS
DECEMBER 31, 1965



Age Bracket	Percent
20-24	6.0
25-29	10.6
30-34	20.1
35-39	15.3
40-44	19.4
45-49	14.2
50-54	8.7
55-59	5.7

Figure I - 21

AGE DISTRIBUTION OF PILOT NEW HIRES
U.S. CIVIL AIR CARRIERS



Age Bracket	Percent
20-24	15.4
25-29	47.5
30-34	32.6
35-39	4.2
40-44	.3

Figure I - 22

The justification for using the distribution with the slightly higher average new hire age is the incorporation of the commercial operators and supplemental carriers in the group.

The new hire age distribution for mechanics used for the computer model is shown in Figure I-23. This is based on data compiled by the U. S. Department of Labor.[66] It generally agrees with the data which summarized the 1965 mechanic hiring as developed by the ATA.[67] Although some mechanics were hired below the age of 20, they were included in 20-24 age group for purposes of the computer model. This was necessary due to programming considerations but does not affect the resulting forecasts. Provision is made in the hiring policies of the airlines to hire mechanics up to age 60.[68] In practice, however, this is not generally done, and only 3% of the new hires are over age 45.

These two new hire age distributions represent the current hiring practices of the civil air carrier group. For purposes of projecting new hire requirements, they were left the same throughout the period. Nothing has been observed in the course of this study that would lead to a conclusion that the ages of the new hires of either the pilots or mechanics would change. There may be some year-to-year variation in the actual ages, but as an average the distributions developed will probably hold.

Annual Loss Rate of Pilots and Mechanics

For purposes of this study, the annual losses of pilots and mechanics to the industry include retirements, early retirements, and all other reasons. This latter category, called attrition in this report, would include quits, transfers to non-flying (non-mechanic) jobs, promotions out of these categories, death, proficiency failures, releases, and so on. A very important distinction must be made between the loss rate and a turnover rate (persons that have related employment levels). From an individual airline's standpoint, it is the turnover rate that is important. That is, the persons that leave must be replaced. For the industry as a whole, however, some of these persons may take jobs in other companies and thereby not require replacement from outside the industry.

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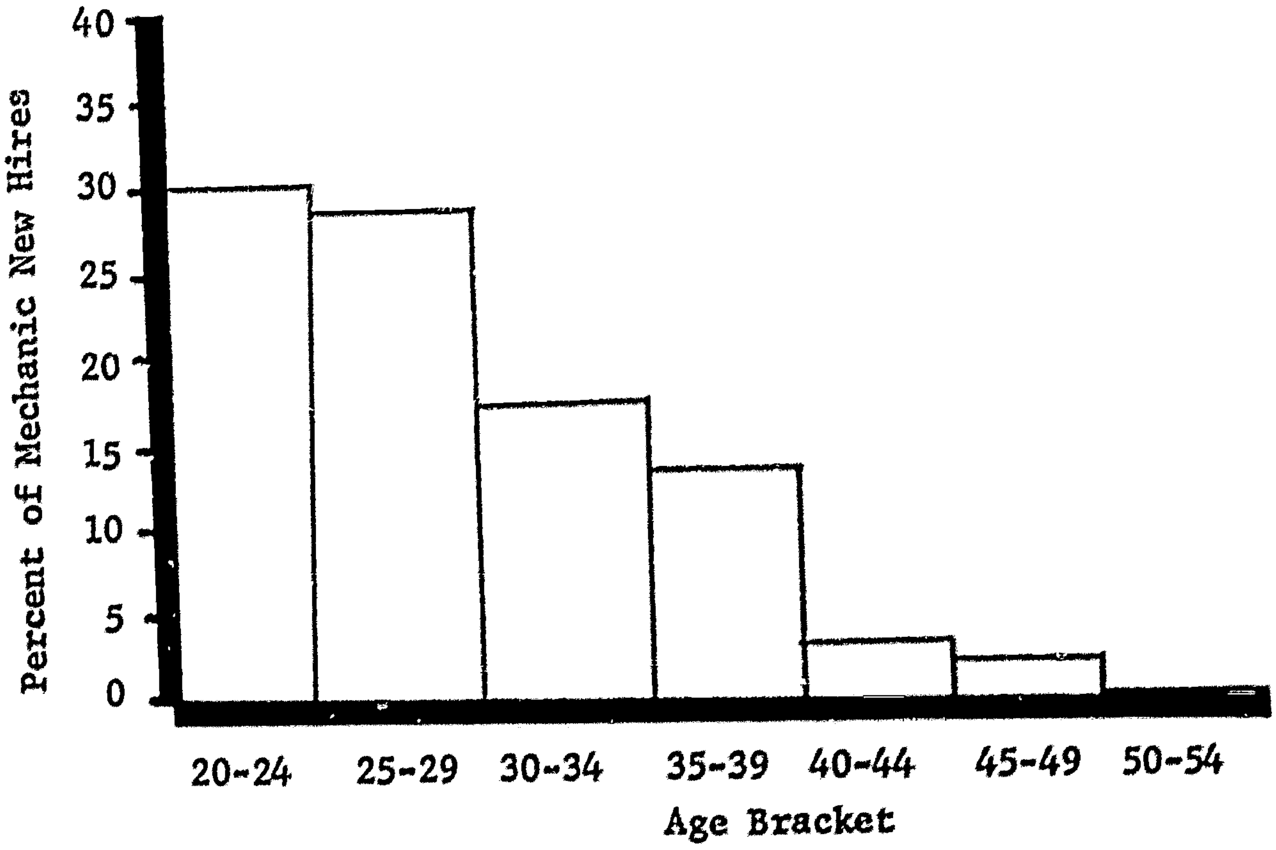
[66] Telephone conversations with the Bureau of Labor Statistics, U. S. Department of Labor, Washington, D. C.

[67] Summary of 1965 Airline Hires, op. cit.

[68] Ibid.

AGE DISTRIBUTION OF MECHANIC NEW HIRES
U.S. CIVIL AIR CARRIERS



Age Bracket	Percent
20-24	30.2
25-29	28.4
30-34	17.1
35-39	13.4
40-44	7.9
45-49	2.4
50-54	.6

Figure I - 23

Individual companies and the industry as a whole are justifiably proud of their records on pilot turnover. In the past, it has been less than .1% per month as compared to 4% per month for industry in general.[69] After corrections are made to the turnover rate to determine loss rate, the figure is lower still but not without importance. This is especially true in view of the cost involved in training and maintaining the proficiency of a pilot.

For two of the categories of loss (early retirement and attrition), the number of people involved each year is considered to be a probability function. That is, the per cent of the employed pilots who, for example, elect to retire early in a given year is considered variable. The number who actually do depends upon a variety of individual circumstances. To adequately describe this for purposes of the computer model, the probabilities of the various possible levels of early retirement were specified. The computer then determined the high, average, and low number of possible early retirements for each year. The same procedure was used for the yearly attrition. This led to a high, average, and low forecast and a summary of new hire requirements over the period, depending on the high, average, and low levels of early retirement and attrition. This was felt to be a more appropriate way of describing the phenomena associated with these two categories of loss. The question of the levels of attrition and their associated probabilities is discussed next.

The ATA surveyed the certificated route air carriers regarding industry pilot turnover experience for the year 1966.[70] They found a gross turnover of 1.77% for a sample of trunk, local service, and other carriers. This was divided into disability retirement,[71] death, promotion, and other. Only the latter category would be eligible for employment as pilots with other carriers and a portion of that category would likely not be employable. The "other" category represented over half (.96%) of the 1.77%. If 75% of the men of this group found employment in other companies in the industry, there was a net loss rate of 1.05% for the year 1966. This was compared to an implied loss rate of .7% for 1964 found in the FAA study.[72] In this study, they did not discuss the loss rate explicitly, but their projections indicate that .7% was the rate used.

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[69] Air Transport Association of America, 1966 ed., op. cit., p. 15.

[70] ATA Personnel Relations Conference unpublished memorandum, op. cit.

[71] The airlines distinguish a disability retirement in their retirement figures. For the purposes of this study, this category is treated under attrition rather than retirement.

[72] FAA Project Long Look, op. cit., p. 89.

To provide a better understanding of the attrition factor, detailed information was obtained from four carriers. These carriers account for nearly 50% of the pilot employment.[73] The results of this survey are shown in Figure I-24. This figure shows a turnover rate of 1.67% which agrees very closely with the ATA survey. The turnover in 1964 was 1.11%, showing about .4% difference between turnover and loss rate in the FAA study. For this study, the loss rate for the year1966 was set at 1.05%. This reflects the comments of the carriers to the effect that a number of pilots were changing jobs. Opportunities were opening up in different companies because of the difficulties in finding pilots. The 1.05% probably understates the requirements; consequently, the ability for testing the sensitivity of this factor was incorporated in the computer model. The range of possible attrition rates was set quite wide, reflecting the uncertainty in this factor. The range and the probabilities were based on conversations with the carriers and on the data from individual airlines. For 1966 the attrition rate range runs from .6% to 1.5%.

The individual carrier data, summarized in Figure I-24, indicates the possibility that the average attrition rate is increasing. Although the sample spans only the years from 1962 through 1966, the rate went up in each year except 1964. This suggests that the attrition rates for the years after 1966 possibly should be greater than 1.05%. There are other arguments for an increasing rate in the future and some that indicate the rate will be inhibited after a period. These will be discussed in the following paragraphs.

Several persons in the airlines discussed the present pilots' dedication to flying and the effect on the turnover rate.[74] As military-trained new hires have become fewer, there has been a trend to hire pilots with less experience than previously. At the same time, the airlines are trying to increase the educational prerequisites for their pilot applicants. These two factors combine to increase the probability of voluntary quits. In the first instance, a man with considerable experience has been exposed to the unique problems of being a pilot; he has come to grips with the extended time away from home, variable duty hours, and bidding procedures. The less experienced person will have to face these problems and decide whether it is really worthwhile for him. Higher educational requirements put two kinds of upward pressure on the attrition rate. In the first place, a greater number of employment possibilities are available to the persons with more formal education. In the second instance, the pilot may find it more difficult to find intellectual satisfaction with his job.

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[73] The airlines were American, Bonanza, Trans World, and United. They employed 9,852 of the 21,972 certificated route air carrier pilots employed in 1965.

[74] Personal interviews with individual carriers.

PILOT ATTRITION RATES
VARIOUS AIRLINES

	1962	1963	1964	1965	1966
American					
Pilots	2256	2225	2250	2776	3959
Attrition %	1.4	1.8	1.9	2.4	2.0
Bonanza					
Pilots	74	94	103	108	112
Attrition %	1.4	0	1.9	0	2.7
TWA					
Pilots	2163	2173	2623	3053	3583
Attrition %	2.0	1.6	0.8	0.8	1.5
United					
Pilots	3002	3059	3374	3895	4464
Attrition %	0.7	1.0	1.1	1.4	1.5
Total					
Pilots	7495	7551	8350	9852	12118
Attrition %	1.04	1.34	1.11	1.47	1.67

Figure I -24

In addition to these factors are the increasingly difficult training and checkout expected for the next generation of aircraft. The FAA has already initiated a program of updating the requirements for maintaining an Air Transport rating.[75] This program is based on flight proficiency; but as more is determined about pilots' physical requirements for flying, there is every likelihood of more stringent standards in this area as well.

Somewhat offsetting these factors is the research being conducted to provide better screening of applicants for flying jobs.[76] Much work is being done in this area, but major improvements have yet to be made. One of the difficulties in placing much emphasis on better screening is that it presupposes an adequate supply of applicants. The supply must be at such a level that, once the criteria have been applied, enough candidates remain to fill the available positions.

The net result of these considerations was that the attrition rate used in the model increases slightly until 1970. The average loss rate was increased from 1.05% in 1966 by .1% per year until 1970 and then held constant. The range of rates for each year remained constant throughout the fifteen-year period, with .1% being added to the upper and the lower limits annually. It was felt that by 1970, when the rate would be 1.45%, the cost of attrition would be great enough that some major management steps will have been taken to stabilize the rate. Also, it is likely that by then the screening criteria will have been improved sufficiently to assist in keeping the rate from climbing. The distributions for 1966 and 1970 are shown in Figure I-25.

The computer model assumes that this attrition is uniformly distributed between the ages of 20 and 60 for all pilots. There are two modifications that would perhaps improve the accuracy of this but which go beyond this study. The first of these would be to explicitly take into account the one-year probation period of new hire pilots. The losses during this first year are probably higher than in succeeding years because the pilots are not yet under the protection of a union contract.[77] A second consideration would be that of the interrelationship between the "promotion" of men (included in attrition) and retirement. It is likely that the pilots so promoted would be the more experienced and, hence, older pilots. Therefore, this would slightly increase the rate of attrition in the later years and also reduce the number of men who are still pilots when they retire. It was felt that these modifications would not materially change the overall

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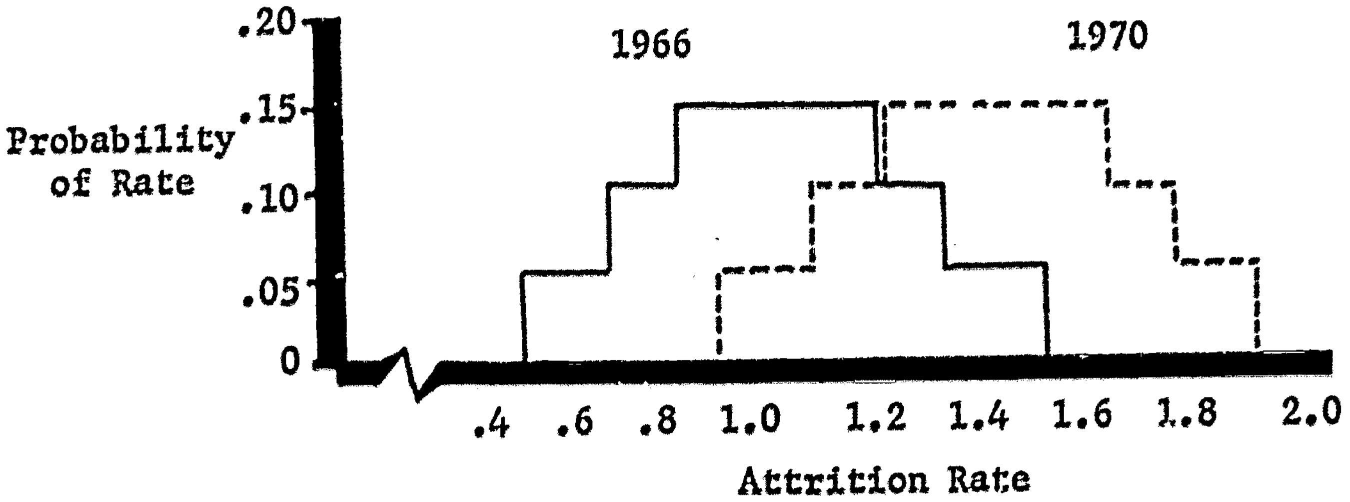
[75] Changes to parts 19, 61, and 121 of the Federal Air Regulations were published in the <u>Federal Register</u> (32 F.R. 260) on 11 January 1967.

[76] American Institute for Research, <u>Research on the Selection of Aircrew Personnel</u>, Research Note No. 13, April 1957.

[77] See, for example, the 1965-1966 Agreement between United Air Lines, Inc., and the Air Line Pilots Association, International, p. 45, or American Airlines, Inc., and Allied Pilots Association, 9 July 1965, p. 32.

PILOT ATTRITION RATE PROBABILITY DISTRIBUTION PROJECTIONS
CIVIL AIR CARRIERS



1966

Attrition Rate	Probability
0.6	.05
0.7	.05
0.8	.10
0.9	.15
1.0	.15
1.1	.15
1.2	.15
1.3	.10
1.4	.05
1.5	.05

Mean = 1.05

1970

Attrition Rate	Probability
1.0	.05
1.1	.05
1.2	.10
1.3	.15
1.4	.15
1.5	.15
1.6	.15
1.7	.10
1.8	.05
1.9	.05

Mean = 1.45

Figure I - 25

results of the forecast but would change slightly the levels of the individual components of the forecast.

The data on mechanic attrition were considerably less detailed than for pilots. An ATA survey on turnover included mechanics but gave only gross "separation" totals.[78] These must be adjusted for the mechanics who leave one company and go to another and for the other categories of attrition. The study indicated that the separation rate for mechanics was 6.6% for the year 1965 and 6.5% for the year 1964. Since data available on the details of these calculations only gave the separations from the company and did not include internal transfer out of the mechanic jobs, the 6.6% figure probably understates the actual loss of mechanics to an individual company. The separation classifications (quit, discharge, layoff, and miscellaneous) gave no indication of the employability of the mechanic in another company, although some certainly would be re-employable.

For purposes of this study, an industry mechanic attrition rate of 5.0% per year was used. This was determined as reasonable given the understatement of individual company loss and the fact that some of those who leave a company would be employed elsewhere in the industry. Since no trends are indicated in the data available, this rate was left constant for the forecast period. For the mechanic new hire forecast, only the average loss rate was used because of the lack of data upon which to determine a probability distribution of attrition.

Under the general category of attrition, a special area of consideration that affects pilots only is that of losses during the initial training by an airline. This factor is treated separately because it increases the initial hiring requirements rather than the overall pilot employment or replacements. A great deal of individual variability was found to exist in this factor. For some carriers, the attrition rate was effectively zero during training.[79] In other instances, the rate was as high as 10%.[80] These losses are dependent upon the training program and hiring philosophy, as well as the caliber of the incoming student pilots. For forecasting pilot new hire requirements, an average loss rate

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[78] Air Transport Association of America - Personnel Relations Conference, unpublished memorandum dated 25 February 1966.

[79] Some local service carriers have a very brief indoctrination training program and rely heavily on on-the-job training. Thus, their training losses really show up in the first-year attrition rates.

[80] The recently inaugurated "zero-time" training programs showed that the failure rate for low-time pilots was generally double that of the normal new hire. This has been substantiated in discussions with training directors of other airlines in their comments on low-time people.

of 5% for initial training in the certificated route air carrier segment was used.[81] The computer model used this factor to increase the required number of new hires necessary to meet the overall pilot projection for any given year. It was assumed that these pilots would not fly in revenue-production service but would simply leave the force during or after their initial training program.

For purposes of computing the forecast of new hire requirements for both pilots and mechanics in the civil air carrier industry, it was assumed that the commercial operators and supplemental carriers had the same attrition rates as the certificated route air carriers. Data were not available in sufficient detail to evaluate this assumption. Since the numbers involved in the commercial operators and supplemental carriers are small, it is felt that whatever error was introduced by this assumption was small relative to the total forecast. The same assumption was made for the remaining category of loss -- that of retirement. This was divided into mandatory and early retirement. A discussion of these categories follows.

The mandatory retirement age for pilots is 60 years. This regulation was established amidst considerable controversy.[82] As a result of this reduction from age 65, some of the carriers and the Air Line Pilots Association have been concerned about the possibility of future reductions in the mandatory age. Specifically, some planning has been done to assess the impact of a reduction in retirement age to 55.[83] The airlines do not want this reduction because it further reduces the productive life of the pilots, in whom they have a substantial investment. ALPA, likewise, maintains that the retirement age should not be lowered because of the reduction in earnings for their members. Thus, the probabilities of a retirement age reduction are slight. For these reasons, the retirement age was held constant at 60 throughout the period of the forecast.

It has been felt desirable for some time that retirement be based on condition rather than calendar age.[84] The objective would be to permit a man to fly as long as his physical condition and proficiency were such that he could accomplish the job with complete safety. Even though

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[81] Based on discussions with a number of training directors for both trunk and local service carriers.

[82] For a description of the arguments surrounding the decision to lower the retirement age to 60, see: Ruppenthal, Karl M., "Compulsory Retirement of Air Line Pilots", Industrial and Labor Relations Review, XIV, No. 4 (July 1961), p. 528.

[83] Personal conversations with various air carriers.

[84] Ruppenthal, op. cit., p. 528.

a pilot has two or three complete physicals a year and a like number of proficiency checks, no substantive agreement on a variable age retirement plan has come about. If this should be accomplished, very likely some men would be retired earlier than age 60 and others after that age, with the average age still approximately 60 years. Because of these possibilities, the model was written to accommodate various assumptions about retirement age, in order to measure their impact on new hire requirements.

The mandatory retirement age for mechanics is age 65.[85] For essentially the same reasons as mentioned for pilots, this was assumed to remain constant through 1980. For use in the computer model, however, the age distribution was changed slightly to allow an effective retirement age of 60 years for mechanics due to programming considerations. The results of the projections were not affected by this change.

One option available to pilots and not to mechanics is early retirement, a component of the annual losses of pilots. Most pilots in the civil air carrier industry have the right to retire prior to the mandatory age of 60 years on an actuarily reduced pension. In general, these plans permit retirement at age 50 after a specified number of years of service with the company.[86] Although the number of pilots who have elected to retire early is small, it is sufficiently large that this factor was isolated for study and is treated as a probability function analogous to the method used for attrition rates. In this manner, a high, average, and low figure are computed for each year and become part of the high, average, and low forecast.

A special survey of individual carriers,[87] summarized in Figure I-26, disclosed an early retirement rate of .09% for the year 1966. This compares closely to a rate of just under .1% found in an ATA study for the year 1966.[88] For this study, a 1966 average rate of .092% was used. The data for the years 1962 to 1966 indicate an upward trend with an increase each year except in 1965. This trend is evident despite the fact that these benefits had been gained for many of the pilots by ALPA only two years prior to 1962.[89]

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[85] FAA Project Long Look, op. cit., p. 96.

[86] A discussion of the evolution of these plans is found in: Baitsell, John, Airline Industrial Relations: Pilots and Flight Engineers (Boston, Mass.: Graduate School of Business, Harvard University, 1966), chap. 6.

[87] The airlines surveyed are listed in footnote 73.

[88] ATA unpublished survey dated January 1967, op. cit.

[89] Baitsell, op. cit., p. 166.

PILOT EARLY RETIREMENT RATES
VARIOUS AIRLINES

	1962	1963	1964	1965	1966
American					
Pilots	2256	2225	2250	2776	3959
Early Retirees %	.044	0	0	0	0
Bonanza					
Pilots	74	94	103	108	112
Early Retirees %	0	0	0	0	0
TWA					
Pilots	2163	2173	2623	3053	3583
Early Retirees %	0	0	.038	.164	.248
United					
Pilots	3002	3059	3374	3895	4464
Early Retirees %	0	.065	.118	0	.043
Total					
Pilots	7495	7551	8350	9852	12118
Early Retirees %	.013	.026	.060	.051	.091

Figure I - 26

The viewpoints of the airlines and ALPA agree substantially on the trends in early retirement. The airlines maintain that most pilots inherently like to fly and, thus, are not candidates for early retirement, unless there are extenuating circumstances. They point out that those who have retired early did so because of family pressures or illness or to run a business that they started earlier in their flying careers. The airlines maintain that the number of pilots with these reasons will continue to be small, although they might increase slightly. ALPA argues that the increase in early retirements from 1962 until the present is not a strong, permanent trend. They say that the men who have retired early were taking advantage of a relatively new contract provision and that the benefits will not improve greatly enough in the future to lure more pilots into early retirement. Even with the variable annuity funds that characterize most of the retirement plans, they point out that the financial incentives will be to continue flying. The marginal increase in retirement benefits during the years from age 50 to 60 is sufficiently high to keep most pilots active. ALPA concludes that the percentage electing this option will probably not increase substantially.

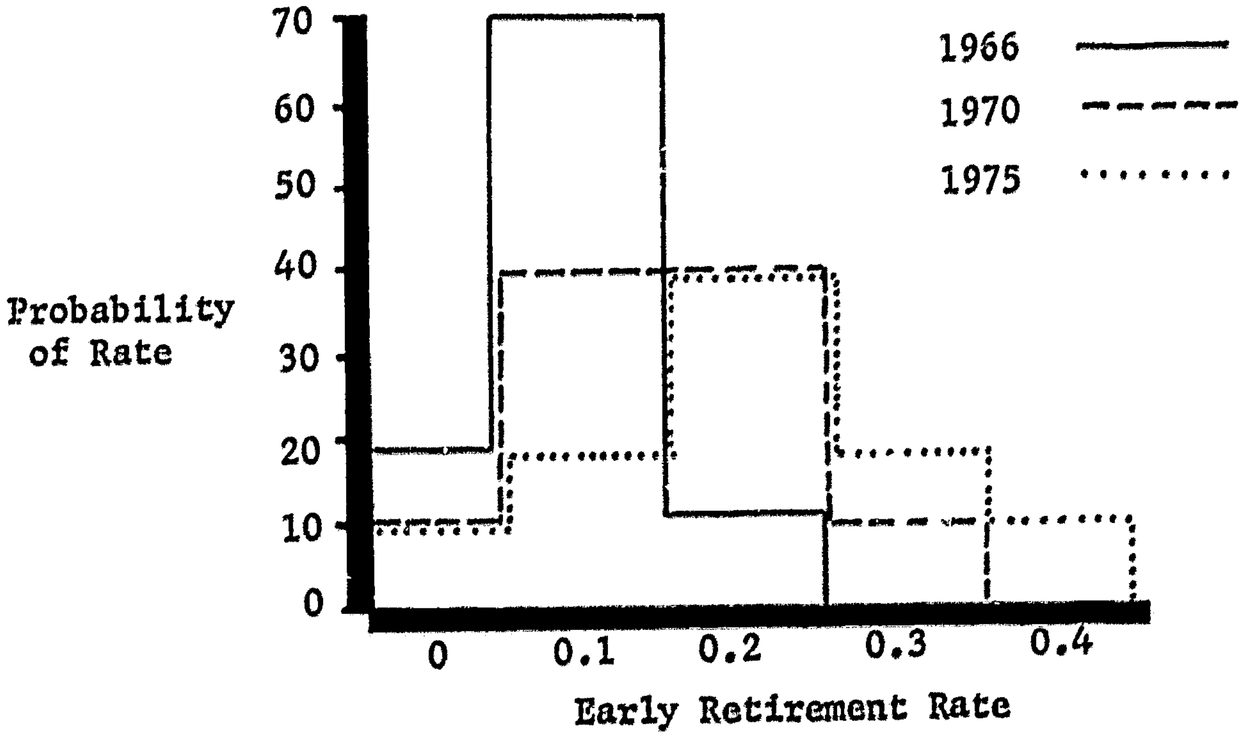
For the purposes of the projection of new hires, the early retirement rate was increased slightly over the period. The probability distributions used are summarized in Figure I-27. The average rate of .092% was used for 1966. In 1970 the average was increased to .15% and in 1975 it was increased to .20%. The method for increasing these averages was to change the probabilities and the range of possible rates. Thus, the uncertainty as to the levels of this factor were accounted for in the high and low forecasts. The early retirements were assumed to be uniformly distributed for all pilots between the ages of 50 and 58.

This completes the determination of the values of the data necessary for the computer model. The starting conditions, as described in the statistical description of the employed mechanics and pilots, and the annual loss rates over the period were inputs to the program. The program then converted these inputs into new hire requirements each year and summarized the cumulative requirements for all years. The results of the forecast for new hire mechanics and pilots and some of the implications of the sensitivity testing are described in the next section.

Forecast Results and Some Implications of Sensitivity Analysis

The results of a run of the computer model for projecting pilots, as shown in Figure I-28, gives the employment levels and new hires for the civil air carrier industry. This output is in three sections. The specification of the conditions of the run are included on the first page, the detailed

PILOT EARLY RETIREMENT RATE PROBABILITY DISTRIBUTION PROJECTIONS - CIVIL AIR CARRIERS



1966

Rate	Probability
0	.19
0.1	.70
0.2	.11
0.3	0
0.4	0

Mean = .092

1970

Rate	Probability
0	.10
0.1	.40
0.2	.40
0.3	.10
0.4	0

Mean = .150

1975

Rate	Probability
0	.10
0.1	.20
0.2	.40
0.3	.20
0.4	.10

Mean = .200

Figure I - 27

ARIZONA STATE UNIVERSITY

FEASIBILITY STUDY FOR

AVIATION TRAINING CENTER

PILOT FORECASTING

FROM 1966 TO 1980 SAMPLE SIZE = 100 AND INITIAL PILOT FORCE = 22,972

OTHER CONDITIONS

ASU JET AND PROP. BASED

THIS PROJECTION USES THE MULTIPLE LINEAR REGRESSION FOR JETS AND PROPELLER AIRCRAFT TO COMPUTE PILOTS. THE PROPELLER FORECAST IS FROM FAA. BASIC ASU RUN. THE GROUND RULES ARE SPELLED OUT IN THE BACKUP INFORMATION. MANDATORY RETIREMENT IS CONSTANT AT AGE 60 AND EARLY RETIREMENT IS UNIFORMLY DISTRIBUTED FROM AGE 50-58. ATTRITION IS UNIFORMLY DISTRIBUTED FROM AGE 20-59. NEW HIRES ARE 105 PERCENT OF REQUIREMENT. THE INITIAL PILOT FORCE INCLUDES AN ESTIMATE OF 1000 PILOTS FOR COMM. OPERATORS AND SUPPLEMENTAL CARRIERS.

Figure I-28

YEAR BY YEAR COMPUTATIONS

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                                                                                                         EARLY RETIREMENT
YEAR           AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE   PERCENT  0.   0.1  0.2  0.   0.   0.   0.   0.   0.   0.
1966          FORCE  1.5  10.0  20.0  20.0  21.5  17.0   7.0   3.0    60      PRBILTY 19.0 70.0 11.0 0.   0.   0.   0.   0.   0.   0.
              HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.
  ATTRITION PCNT/PROB  0.6/  5.0  0.7/  5.0  0.8/ 10.0  0.9/ 15.0  1.0/ 15.0  1.1/ 15.0  1.2/ 15.0  1.3/ 10.0  1.4/  5.0  1.5/  5.0

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES       ATTRITION        NEW HIRES
  25983           NONE          =1965         25983      138   138   138      0    23    46     138   241   345   3451  3584  3716


                                                                                                         EARLY RETIREMENT
YEAR           AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE   PERCENT  0.   0.1  0.2  0.   0.   0.   0.   0.   0.   0.
1967          FORCE  3.1  13.5  20.0  18.0  18.6  15.7   7.8   3.3    60      PRBILTY 19.0 70.0 11.0 0.   0.   0.   0.   0.   0.   0.
              HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.
  ATTRITION PCNT/PROB  0.7/  5.0  0.8/  5.0  0.9/ 10.0  1.0/ 15.0  1.1/ 15.0  1.2/ 15.0  1.3/ 15.0  1.4/ 10.0  1.5/  5.0  1.6/  5.0

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES       ATTRITION        NEW HIRES
  28965           NONE          =1965         28965      136   136   137      0    23    52     182   307   416   3465  3622  3766


                                                                                                         EARLY RETIREMENT
YEAR           AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE   PERCENT  0.   0.1  0.2  0.   0.   0.   0.   0.   0.   0.
1968          FORCE  4.0  15.5  20.4  17.2  16.4  14.6   8.5   3.5    60      PRBILTY 19.0 70.0 11.0 0.   0.   0.   0.   0.   0.   0.
              HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.
  ATTRITION PCNT/PROB  0.8/  5.0  0.9/  5.0  1.0/ 10.0  1.1/ 15.0  1.2/ 15.0  1.3/ 15.0  1.4/ 15.0  1.5/ 10.0  1.6/  5.0  1.7/  5.0

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES       ATTRITION        NEW HIRES
  31740           NONE          =1965         31740      129   131   136      0    25    58     232   355   492   3293  3450  3635


                                                                                                         EARLY RETIREMENT
YEAR           AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE   PERCENT  0.   0.1  0.2  0.   0.   0.   0.   0.   0.   0.
1969          FORCE  4.3  16.3  21.0  17.1  14.7  13.8   9.0   3.7    60      PRBILTY 19.0 70.0 11.0 0.   0.   0.   0.   0.   0.   0.
              HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.
  ATTRITION PCNT/PROB  0.9/  5.0  1.0/  5.0  1.1/ 10.0  1.2/ 15.0  1.3/ 15.0  1.4/ 15.0  1.5/ 15.0  1.6/ 10.0  1.7/  5.0  1.8/  5.0

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES       ATTRITION        NEW HIRES
  33603           NONE          =1965         33603      121   128   134      0    29    63     286   435   571   2382  2577  2763


                                                                                                         EARLY RETIREMENT
YEAR           AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE   PERCENT  0.   0.1  0.2  0.3  0.   0.   0.   0.   0.   0.
1970          FORCE  4.0  15.6  21.5  18.0  13.8  13.5   9.7   3.9    60      PRBILTY 10.0 40.0 40.0 10.0 0.   0.   0.   0.   0.   0.
              HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.
  ATTRITION PCNT/PROB  1.0/  5.0  1.1/  5.0  1.2/ 10.0  1.3/ 15.0  1.4/ 15.0  1.5/ 15.0  1.6/ 15.0  1.7/ 10.0  1.8/  5.0  1.9/  5.0

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES       ATTRITION        NEW HIRES
  34935           NONE          =1965         34935      109   122   132      0    50   101     336   478   638   1866  2081  2313
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Figure I-28 (cont'd.)

YEAR BY YEAR COMPUTATIONS

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YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                            EARLY RETIREMENT
1971        FORCE  3.4  14.2  22.0  19.3  13.2  13.4  10.4   4.1     60    PERCENT  0.   0.1  0.2  0.3  0.    0.    0.    0.    0.    0.
            HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.            PRBILTY 10.0 40.0 40.0 10.0  0.    0.    0.    0.    0.    0.
  ATTRITION PCNT/PROB  1.0/  5.0  1.1/  5.0  1.2/ 10.0  1.3/ 15.0  1.4/ 15.0  1.5/ 15.0  1.6/ 15.0  1.7/ 10.0  1.8/  5.0  1.9/  5.0

PROJECTION    LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES        ATTRITION         NEW HIRES
  36057          NONE          =1965       36057       274   291   313      0    51   105      349   507   664     1833  2071  2315


YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                            EARLY RETIREMENT
1972        FORCE  2.9  13.4  23.0  19.7  12.9  12.6  10.4   5.0     60    PERCENT  0.   0.1  0.2  0.3  0.    0.    0.    0.    0.    0.
            HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.            PRBILTY 10.0 40.0 40.0 10.0  0.    0.    0.    0.    0.    0.
  ATTRITION PCNT/PROB  1.0/  5.0  1.1/  5.0  1.2/ 10.0  1.3/ 15.0  1.4/ 15.0  1.5/ 15.0  1.6/ 15.0  1.7/ 10.0  1.8/  5.0  1.9/  5.0

PROJECTION    LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES        ATTRITION         NEW HIRES
  37316          NONE          =1965       37316       267   286   309      0    53   108      361   526   685     1981  2230  2480


YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                            EARLY RETIREMENT
1973        FORCE  2.6  12.9  23.3  20.0  13.0  11.9  10.4   5.9     60    PERCENT  0.   0.1  0.2  0.3  0.    0.    0.    0.    0.    0.
            HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.            PRBILTY 10.0 40.0 40.0 10.0  0.    0.    0.    0.    0.    0.
  ATTRITION PCNT/PROB  1.0/  5.0  1.1/  5.0  1.2/ 10.0  1.3/ 15.0  1.4/ 15.0  1.5/ 15.0  1.6/ 15.0  1.7/ 10.0  1.8/  5.0  1.9/  5.0

PROJECTION    LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES        ATTRITION         NEW HIRES
  38330          NONE          =1965       38330       238   266   304      0    60   112      373   531   709     1707  1964  2246


YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                            EARLY RETIREMENT
1974        FORCE  2.3  12.1  22.8  20.5  13.7  11.4  10.5   6.7     60    PERCENT  0.   0.1  0.2  0.3  0.    0.    0.    0.    0.    0.
            HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.            PRBILTY 10.0 40.0 40.0 10.0  0.    0.    0.    0.    0.    0.
  ATTRITION PCNT/PROB  1.0/  5.0  1.1/  5.0  1.2/ 10.0  1.3/ 15.0  1.4/ 15.0  1.5/ 15.0  1.6/ 15.0  1.7/ 10.0  1.8/  5.0  1.9/  5.0

PROJECTION    LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES        ATTRITION         NEW HIRES
  39288          NONE          =1965       39288       214   258   297      0    59   115      383   555   728     1633  1920  2203


YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                            EARLY RETIREMENT
1975        FORCE  2.2  11.4  21.7  21.0  14.8  11.0  10.5   7.4     60    PERCENT  0.   0.1  0.2  0.3  0.4   0.    0.    0.    0.    0.
            HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.            PRBILTY 10.0 20.0 40.0 20.0 10.0   0.    0.    0.    0.    0.
  ATTRITION PCNT/PROB  1.0/  5.0  1.1/  5.0  1.2/ 10.0  1.3/ 15.0  1.4/ 15.0  1.5/ 15.0  1.6/ 15.0  1.7/ 10.0  1.8/  5.0  1.9/  5.0

PROJECTION    LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES        ATTRITION         NEW HIRES
  40265          NONE          =1965       40265       172   229   289      0    72   157      393   572   746     1620  1943  2279
```

Figure I-28 (cont'd.)

YEAR BY YEAR COMPUTATIONS

```
YEAR                AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                   EARLY RETIREMENT
1976              FORCE  2.1  10.6  20.3  21.5  16.1  10.6  10.6   8.1     60     PERCENT  0.   0.1  0.2  0.3  0.4  0.    0.    0.    0.    0.
                  HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.               PRBILTY 10.0 20.0 40.0 20.0 10.0  0.    0.    0.    0.    0.
      ATTRITION PCNT/PROB  1.0/  5.0  1.1/  5.0  1.2/ 10.0  1.3/ 15.0  1.4/ 15.0  1.5/ 15.0  1.6/ 15.0  1.7/ 10.0  1.8/  5.0  1.9/  5.0

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS    REGULAR RETIRES        EARLY RETIRES          ATTRITION           NEW HIRES
   41062           NONE          =1965        41062       608   675   739        0    85   161       403   583   765     1898  2247  2585


YEAR                AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                   EARLY RETIREMENT
1977              FORCE  2.1  10.3  19.8  22.5  16.6  10.5  10.0   8.2     60     PERCENT  0.   0.1  0.2  0.3  0.4  0.    0.    0.    0.    0.
                  HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.               PRBILTY 10.0 20.0 40.0 20.0 10.0  0.    0.    0.    0.    0.
      ATTRITION PCNT/PROB  1.0/  5.0  1.1/  5.0  1.2/ 10.0  1.3/ 15.0  1.4/ 15.0  1.5/ 15.0  1.6/ 15.0  1.7/ 10.0  1.8/  5.0  1.9/  5.0

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS    REGULAR RETIRES        EARLY RETIRES          ATTRITION           NEW HIRES
   41818           NONE          =1965        41818       569   640   725        0    80   164       411   596   780     1823  2177  2547


YEAR                AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                   EARLY RETIREMENT
1978              FORCE  2.1  10.0  19.3  22.8  17.1  10.9   9.6   8.3     60     PERCENT  0.   0.1  0.2  0.3  0.4  0.    0.    0.    0.    0.
                  HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.               PRBILTY 10.0 20.0 40.0 20.0 10.0  0.    0.    0.    0.    0.
      ATTRITION PCNT/PROB  1.0/  5.0  1.1/  5.0  1.2/ 10.0  1.3/ 15.0  1.4/ 15.0  1.5/ 15.0  1.6/ 15.0  1.7/ 10.0  1.8/  5.0  1.9/  5.0

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS    REGULAR RETIRES        EARLY RETIRES          ATTRITION           NEW HIRES
   42510           NONE          =1965        42510       552   637   712        0    86   167       418   597   795     1745  2113  2484


YEAR                AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                   EARLY RETIREMENT
1979              FORCE  2.1   9.7  18.7  22.6  17.6  11.6   9.2   8.4     60     PERCENT  0.   0.1  0.2  0.3  0.4  0.    0.    0.    0.    0.
                  HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.               PRBILTY 10.0 20.0 40.0 20.0 10.0  0.    0.    0.    0.    0.
      ATTRITION PCNT/PROB  1.0/  5.0  1.1/  5.0  1.2/ 10.0  1.3/ 15.0  1.4/ 15.0  1.5/ 15.0  1.6/ 15.0  1.7/ 10.0  1.8/  5.0  1.9/  5.0

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS    REGULAR RETIRES        EARLY RETIRES          ATTRITION           NEW HIRES
   43202           NONE          =1965        43202       516   610   698        0    90   170       425   613   808     1715  2104  2487


YEAR                AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                   EARLY RETIREMENT
1980              FORCE  2.1   9.6  18.2  21.9  18.2  12.6   9.0   8.5     60     PERCENT  0.   0.1  0.2  0.3  0.4  0.    0.    0.    0.    0.
                  HIRES 15.4  47.5  32.6   4.2   0.3   0.    0.    0.               PRBILTY 10.0 20.0 40.0 20.0 10.0  0.    0.    0.    0.    0.
      ATTRITION PCNT/PROB  1.0/  5.0  1.1/  5.0  1.2/ 10.0  1.3/ 15.0  1.4/ 15.0  1.5/ 15.0  1.6/ 15.0  1.7/ 10.0  1.8/  5.0  1.9/  5.0

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS    REGULAR RETIRES        EARLY RETIRES          ATTRITION           NEW HIRES
   43665           NONE          =1965        43665       441   557   686        0    90   173       432   627   821     1402  1824  2249
```

Figure I-28 (cont'd.)

SUMMARY OF RESULTS

PILOTS BASED ON ASU JETS AND PROPS.

DATE	NEW HIRES LOW	NEW HIRES AVERAGE	NEW HIRES HIGH	CUMULATIVE LOW	CUMULATIVE AVERAGE	CUMULATIVE HIGH
1966	3451	3584	3716	3451	3584	3716
1967	3465	3622	3766	6916	7205	7482
1968	3293	3450	3635	10208	10656	11117
1969	2382	2577	2763	12591	13233	13880
1970	1866	2081	2313	14457	15314	16193
1971	1833	2071	2315	16290	17384	18508
1972	1981	2230	2480	18271	19614	20988
1973	1707	1964	2246	19978	21577	23233
1974	1633	1920	2203	21611	23498	25436
1975	1620	1943	2279	23231	25441	27715
1976	1898	2247	2585	25129	27688	30300
1977	1823	2177	2547	26952	29864	32847
1978	1745	2113	2484	28697	31977	35331
1979	1715	2104	2487	30412	34082	37817
1980	1402	1824	2249	31814	35906	40067

Figure I-28 (cont'd.)

year-by-year results including the values of the parameters for each year on the next three pages, and the last page includes a summary of the yearly requirements and cumulative requirements for each of the three levels of loss. The conditions of this run are those outlined in the previous sections. The projection of employment is based on the multiple regression equations for pilots which are based on pure jet and propeller aircraft. No limitations are placed on the projections for this run, and the stick hours are equal to those in 1965. The early retirement and attrition probability distributions are specified for each year and are equal to those developed in the preceding section. Retirement age is 60, and the training loss rate is 5%.

The projected level of employment at year-end 1980 is 43,665 pilots. That is nearly double the 22,972 employed at year-end 1965. To increase to this number and replace the pilots lost each year, 31,814 to 40,067 new hires will be required between year-end 1965 and year-end 1980. The average number of new hires that will be required is 35,906. The number of new hires required in each year varies due to the relationship of replacement and growth. For example, in 1972, 2,230 and again in 1976, 2,247 would be required, although the intervening years each would require fewer new pilots. An increase in the number of retirements in year 1976 accounts for this difference. The age distribution shifts over the fifteen-year period. While the portion of pilots in the lower two age groups remains relatively constant for the entire period, the per cent in the two older groups increases. The modal age group shifts downward to the 30-34 bracket initially and then shifts up to the 35-39 bracket by 1976.

The pilot employment levels are summarized in Figure I-29. The forecast levels developed here were compared to a projection based on an Air Transport Association of America survey.[90] The ATA asked their members to project their pilot hiring rates and employment levels until 1975. The majority of the carriers responding to this survey supplied data only through 1970. That group of carriers employed 75% of the pilots. Assuming that the employers of the remaining 25% would have the same trends in hiring rates, an adjustment was applied to the sample to equate it to the total civil air carrier industry. The number of respondents projecting to 1975 were considered too small to warrant correcting and comparing. The adjusted sample projected total pilot employment of 40,100 by year-end 1970. This is considerably higher than the forecast of 34,935 pilots employed in 1970 developed in this study, as seen in Figure I-29.

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[90] ATA unpublished survey dated January 1967, <u>op. cit.</u>

PROJECTED PILOT EMPLOYMENT
U.S. CIVIL AIR CARRIERS

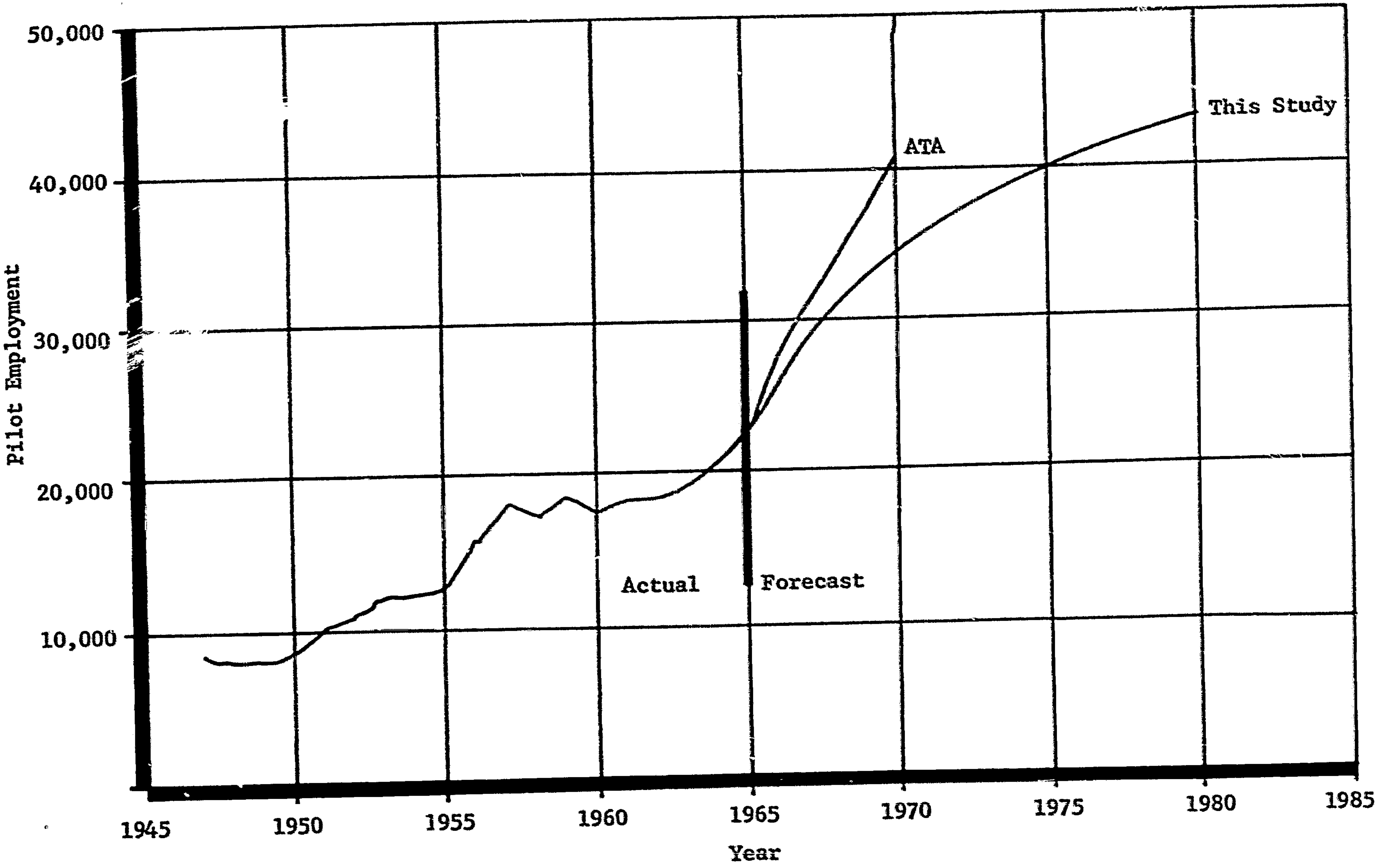

Figure I - 29

There are problems in simply asking the carriers for hiring rate projections to use as a basis for overall projections. One example will serve to illustrate this point. One airline projected a pilot new hire rate averaging 475 a year in mid-1966.[91] Toward the end of 1966, their projected rate was 800 a year.[92] In early 1967 their projected hiring rate for pilots was reported as being between 550 and 600 per year.[93] Any of a number of possible reasons would account for these differences. Different persons may have responded to the questionnaire. The same person, in responding at different times, might react to an immediate and temporary situation. Most important, perhaps, was the apparent lack of a framework or model for developing their projections. The model developed here, adapted to the individual airline's needs, could serve a useful purpose in this regard.

Cumulative new pilot requirements through 1980 were compared to the results of the FAA study of 1964.[94] Both are plotted in Figure I-30. The FAA study forecast a requirement of 14,878 new pilots between year-end 1965 and year-end 1980. This was based on 8,878 replacement pilots over the period and 400 new pilots per year for growth. Those figures are considerably less than even the low figure of 31,814 new pilots required, as forecast in this study. It is important to point out that the FAA study was based on a questionnaire submitted to the carriers and, therefore, was subject to the types of problems that were illustrated in the preceding paragraph. The derivation of pilot requirements from a model, such as that developed for this study, avoids these problems.

The computer output for the projection of mechanic employment levels and new hire requirements, presented in Figure I-31, is based on the factors developed in the preceding sections of this report. The format is identical to that of the pilot forecast. For the mechanic run, only the average requirements were developed due to a lack of data upon which to base probability distributions. The attrition rate is constant at 5%. Retirement age is 65 years (adjusted to 60 for computational purposes), with no early retirement option.

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[91] Ibid.

[92] "What the Airlines Need in New Flight Personnel", op. cit., p. 31.

[93] Brown, David A., "Military Pilot Shortage Part 1: Low Supply Forces Inefficient Employment", Aviation Week and Space Technology, 8 May 1967, p. 71.

[94] FAA Project Long Look, op. cit., pp. 9 and 89.

PROJECTED CUMULATIVE NEW PILOTS REQUIRED
U.S. CIVIL AIR CARRIERS

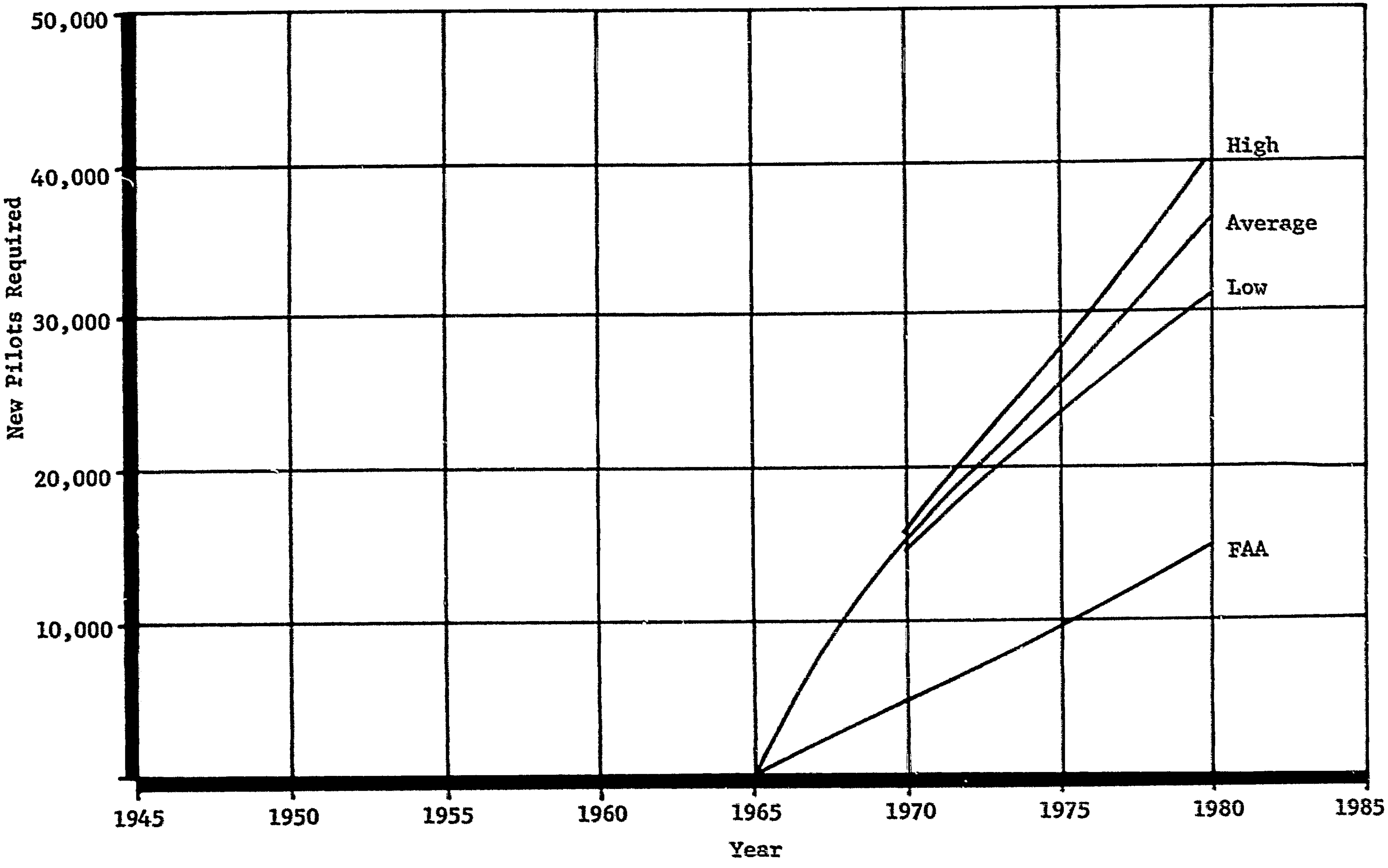

Figure I - 30

ARIZONA STATE UNIVERSITY
FEASIBILITY STUDY FOR
AVIATION TRAINING CENTER

MECHANIC FORECASTING
FROM 1966 TO 1980 SAMPLE SIZE = 1 AND INITIAL MECHANIC FORCE = 43,667
OTHER CONDITIONS
MECHANIC FORECAST
ASU JET AND PROP. BASED

THIS IS A MECHANIC FORECAST (IT IS 0 PERCENT HIGH). BASIC ASU RUN. THE GROUND RULES ARE SPELLED OUT IN THE BACKUP INFORMATION. RETIREMENT AGE IS 60 AND THERE IS NO EARLY RETIREMENT. ATTRITION IS 5.0 PERCENT (ADJUSTED FROM ATA REPORTS). THE INITIAL AGE DISTRIBUTION IS FROM LONG LOOK PG. 100. HIRING DISTR. IS BASED ON ATA DATA. INITIAL MECHANIC FORCE INCLUDES 2000 EST. FOR COMM. OPS. AND SUPPLS. BASED ON 2 TIMES THE PILOT ESTIMATE FOR THIS GROUP.

Figure I-31

YEAR BY YEAR COMPUTATIONS

```
YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                          EARLY RETIREMENT
1966         FORCE  6.0  10.6  20.1  15.3  19.4  14.2   8.7   5.7    60    PERCENT  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
             HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.          PRBILTY 50.0 50.0 0.   0.   0.   0.   0.   0.   0.   0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.

PROJECTION     LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES       ATTRITION          NEW HIRES
  48200           NONE          =1965        48200      498   498   498      0     0     0    2183  2183  2183    7214  7214  7214


YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                          EARLY RETIREMENT
1967         FORCE  8.6  12.5  18.1  16.0  17.1  13.5   8.6   5.4    60    PERCENT  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
  .          HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.          PRBILTY 50.0 50.0 0.   0.   0.   0.   0.   0.   0.   0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.

PROJECTION     LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES       ATTRITION          NEW HIRES
  54395           NONE          =1965        54395      473   473   473      0     0     0    2410  2410  2410    9078  9078  9078


YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                          EARLY RETIREMENT
1968         FORCE 10.6  14.6  17.0  16.6  15.3  12.7   8.2   5.1    60    PERCENT  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
             HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.          PRBILTY 50.0 50.0 0.   0.   0.   0.   0.   0.   0.   0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.

PROJECTION     LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES       ATTRITION          NEW HIRES
  60063           NONE          =1965        60063      447   447   447      0     0     0    2720  2720  2720    8834  8834  8834


YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                          EARLY RETIREMENT
1969         FORCE 11.1  16.3  16.5  17.1  14.0  12.3   8.0   4.8    60    PERCENT  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
             HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.          PRBILTY 50.0 50.0 0.   0.   0.   0.   0.   0.   0.   0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.

PROJECTION     LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES       ATTRITION          NEW HIRES
  63339           NONE          =1965        63339      419   419   419      0     0     0    3003  3003  3003    6698  6698  6698


YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                          EARLY RETIREMENT
1970         FORCE 10.2  17.3  16.4  17.7  13.4  12.4   8.0   4.7    60    PERCENT  0.   0.   0.   0.   0.   0.   0.   0.   0.   0.
             HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.          PRBILTY 50.0 50.0 0.   0.   0.   0.   0.   0.   0.   0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.

PROJECTION     LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES       ATTRITION          NEW HIRES
  65493           NONE          =1965        65493      390   390   390      0     0     0    3167  3167  3167    5711  5711  5711
```

Figure I-31 (cont'd.)

YEAR BY YEAR COMPUTATIONS

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                                                                                                EARLY RETIREMENT
YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE  PERCENT  0.   0.   0.   0.   0.   0.   0.   0.   0.
1971         FORCE  8.6  18.0  16.5  18.4  13.0  12.7   8.2   4.7   60      PRBILTY 50.0 50.0  0.   0.   0.   0.   0.   0.   0.
             HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.                      0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. / 0.  0. / 0.  0. / 0.  0.

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS   REGULAR RETIRES     EARLY RETIRES      ATTRITION        NEW HIRES
 67245            NONE          =1965       67245        623   623   623      0     0     0     3275 3275 3275   5649 5649 5649

                                                                                                EARLY RETIREMENT
YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE  PERCENT  0.   0.   0.   0.   0.   0.   0.   0.   0.
1972         FORCE  7.5  18.7  17.5  17.3  13.9  12.0   8.3   5.0   60      PRBILTY 50.0 50.0  0.   0.   0.   0.   0.   0.   0.
             HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.                      0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. / 0.  0. / 0.  0. / 0.  0.

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS   REGULAR RETIRES     EARLY RETIRES      ATTRITION        NEW HIRES
 69478            NONE          =1965       69478        588   588   588      0     0     0     3362 3362 3362   6183 6183 6183

                                                                                                EARLY RETIREMENT
YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE  PERCENT  0.   0.   0.   0.   0.   0.   0.   0.   0.
1973         FORCE  6.8  18.8  18.3  16.6  14.5  11.3   8.4   5.2   60      PRBILTY 50.0 50.0  0.   0.   0.   0.   0.   0.   0.
             HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.                      0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. / 0.  0. / 0.  0. / 0.  0.

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS   REGULAR RETIRES     EARLY RETIRES      ATTRITION        NEW HIRES
 71207            NONE          =1965       71207        550   550   550      0     0     0     3474 3474 3474   5753 5753 5753

                                                                                                EARLY RETIREMENT
YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE  PERCENT  0.   0.   0.   0.   0.   0.   0.   0.   0.
1974         FORCE  6.4  18.2  18.9  16.3  15.2  10.9   8.7   5.4   60      PRBILTY 50.0 50.0  0.   0.   0.   0.   0.   0.   0.
             HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.                      0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. / 0.  0. / 0.  0. / 0.  0.

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS   REGULAR RETIRES     EARLY RETIRES      ATTRITION        NEW HIRES
 72777            NONE          =1965       72777        507   507   507      0     0     0     3560 3560 3560   5638 5638 5638

                                                                                                EARLY RETIREMENT
YEAR          AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE  PERCENT  0.   0.   0.   0.   0.   0.   0.   0.   0.
1975         FORCE  6.2  17.1  19.5  16.2  15.8  10.6   9.0   5.6   60      PRBILTY 50.0 50.0  0.   0.   0.   0.   0.   0.   0.
             HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.                      0. / 0.  0. / 0.  0. / 0.  0. / 0.  0. / 0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. / 0.  0. / 0.  0. / 0.  0.

PROJECTION     LIMITATIONS    STICK-HOURS TOTAL PILOTS   REGULAR RETIRES     EARLY RETIRES      ATTRITION        NEW HIRES
 74404            NONE          =1965       74404        458   458   458      0     0     0     3639 3639 3639   5723 5723 5723
```

Figure I-31 (cont'd.)

YEAR BY YEAR COMPUTATIONS

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YEAR           AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                        EARLY RETIREMENT
1976           FORCE  6.1  15.6  20.0  16.4  16.4  10.4   9.4   5.8    60    PERCENT  0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
               HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.           PRBILTY 50.0 50.0  0.    0.    0.    0.    0.    0.    0.    0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.

PROJECTION     LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES          ATTRITION          NEW HIRES
  75708            NONE          =1965        75708     883   883   883      0      0      0    3720  3720  3720     5908  5908  5908


YEAR           AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                        EARLY RETIREMENT
1977           FORCE  6.0  14.8  20.5  17.2  15.5  11.2   8.8   5.9    60    PERCENT  0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
               HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.           PRBILTY 50.0 50.0  0.    0.    0.    0.    0.    0.    0.    0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.

PROJECTION     LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES          ATTRITION          NEW HIRES
  76994            NONE          =1965        76994     826   826   826      0      0      0    3785  3785  3785     5896  5896  5896


YEAR           AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                        EARLY RETIREMENT
1978           FORCE  6.0  14.2  20.6  17.9  15.0  11.9   8.4   6.1    60    PERCENT  0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
               HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.           PRBILTY 50.0 50.0  0.    0.    0.    0.    0.    0.    0.    0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.

PROJECTION     LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES          ATTRITION          NEW HIRES
  78192            NONE          =1965        78192     775   775   775      0      0      0    3850  3850  3850     5823  5823  5823


YEAR           AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                        EARLY RETIREMENT
1979           FORCE  5.9  13.8  20.1  18.5  14.8  12.5   8.2   6.3    60    PERCENT  0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
               HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.           PRBILTY 50.0 50.0  0.    0.    0.    0.    0.    0.    0.    0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.

PROJECTION     LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES          ATTRITION          NEW HIRES
  79390            NONE          =1965        79390     720   720   720      0      0      0    3910  3910  3910     5827  5827  5827


YEAR           AGE 20-24 25-29 30-34 35-39 40-44 45-49 50-54 55-59 RET. AGE                        EARLY RETIREMENT
1980           FORCE  5.8  13.7  19.2  18.9  14.8  13.0   8.0   6.6    60    PERCENT  0.    0.    0.    0.    0.    0.    0.    0.    0.    0.
               HIRES 30.2  28.4  17.1  13.4   7.9   2.4   0.6   0.           PRBILTY 50.0 50.0  0.    0.    0.    0.    0.    0.    0.    0.
  ATTRITION PCNT/PROB  5.0/ 50.0  5.0/ 50.0  0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.   0. /  0.

PROJECTION     LIMITATIONS   STICK-HOURS TOTAL PILOTS   REGULAR RETIRES      EARLY RETIRES          ATTRITION          NEW HIRES
  80224            NONE          =1965        80224     652   652   652      0      0      0    3969  3969  3969     5456  5456  5456
```

Figure I-31 (cont'd.)

SUMMARY OF RESULTS

MECHANICS BASED ON ASU JETS AND PROPS.

DATE	LOW	NEW HIRES AVERAGE	HIGH	LOW	CUMULATIVE AVERAGE	HIGH
1966	7214	7214	7214	7214	7214	7214
1967	9078	9078	9078	16292	16292	16292
1968	8834	8834	8834	25126	25126	25126
1969	6698	6698	6698	31824	31824	31824
1970	5711	5711	5711	37536	37536	37536
1971	5649	5649	5649	43185	43185	43185
1972	6183	6183	6183	49368	49368	49368
1973	5753	5753	5753	55121	55121	55121
1974	5638	5638	5638	60759	60759	60759
1975	5723	5723	5723	66482	66482	66482
1976	5908	5908	5908	72390	72390	72390
1977	5896	5896	5896	78286	78286	78286
1978	5823	5823	5823	84109	84109	84109
1979	5827	5827	5827	89937	89937	89937
1980	5456	5456	5456	95392	95392	95392

Figure I-31 (cont'd.)

The projection shows a growth in mechanic employment from 43,667 at year-end in 1965 to 80,224 by year-end 1980. To meet this increase and replace the annual losses, a cumulative total of 95,392 new mechanics must be hired in the period. The annual employment and new hire requirements are summarized in Figures I-32 and I-33. The age distribution remains relatively constant throughout the period, although the modal age group shifts back and forth among all groups between age 25 and 44. The number of new hires goes up or down each year, as with the pilots, depending on the relationship between growth and replacements. The ratio of mechanics to pilots in 1965 was almost 2 to 1. By the year 1980, the projected ratio has changed only slightly (2.2 to 1). This change is consistent with the increasing complexity of the aircraft envisioned for this period.

The forecasting model was used as the basis for testing the sensitivity of the pilot projections to variations in some of the factors. Specifically, the results of changes in attrition, early retirement, stick hours, and aircraft projections were assessed. These results provide insights into areas where additional research would be of value in improving the accuracy of the model. The sensitivity of the projections varied greatly among the factors.

The effect of changes in propeller aircraft and early retirement was almost negligible. The projections were quite sensitive to changes in the number of jet aircraft, attrition and stick hours, however. The results of these tests, summarized in Figure I-34, and are discussed in more detail below.

For comparison purposes, a base run of the projection was made, fixing the attrition rate at 1.5% per year and the early retirement rate at .1% per year. This gave a cumulative new hire requirement of 36,175 pilots. Next, the early retirement rate was increased 500% to .5% per year. Everything else was held constant. This yielded a cumulative requirement of 37,267 pilots, approximately a 3% increase. Thus, a dramatic change in early retirement rate was nearly negligible, causing only a 3% increase in requirements.

Next, the forecast retirement rate of propeller aircraft was slowed 10% per year. That is, equivalently, the propeller fleet forecast was increased by 10% per year. This change, again from the base run, led to an increase of less than 1,000 cumulative new hire pilots required (the total was 36,943). The reason for this is the rapidity of replacement of propeller aircraft in the base forecast. Even a 10% change in this schedule does not materially affect the total number of aircraft in the fleet. Also, the fact that the regression equations show that more pilots are required to support a jet than a propeller aircraft works to reduce the effects of changes in the propeller forecast.

PROJECTED MECHANIC EMPLOYMENT
U.S. CIVIL AIR CARRIERS

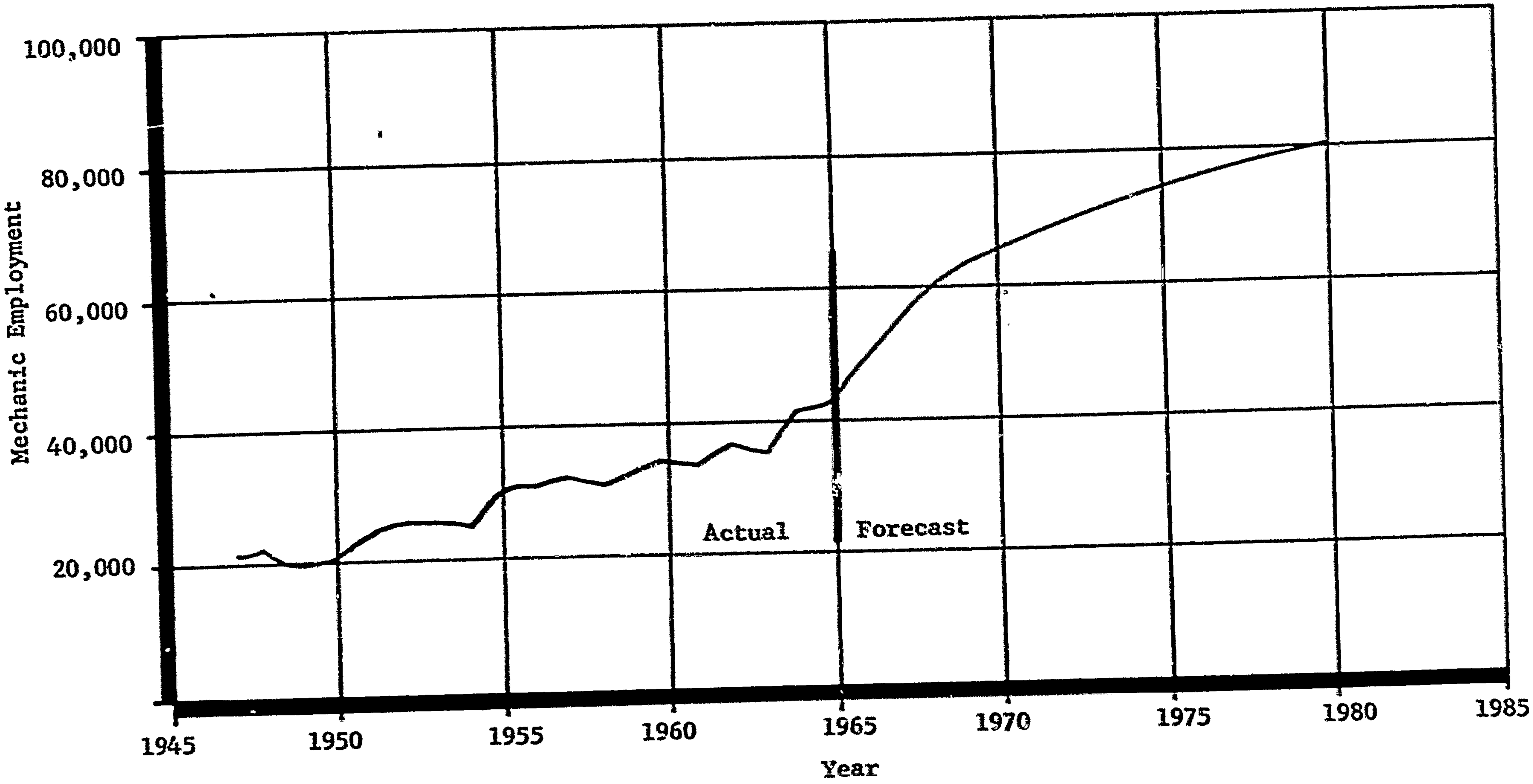

Figure I - 32

PROJECTED CUMULATIVE NEW MECHANICS REQUIRED
U.S. CIVIL AIR CARRIERS

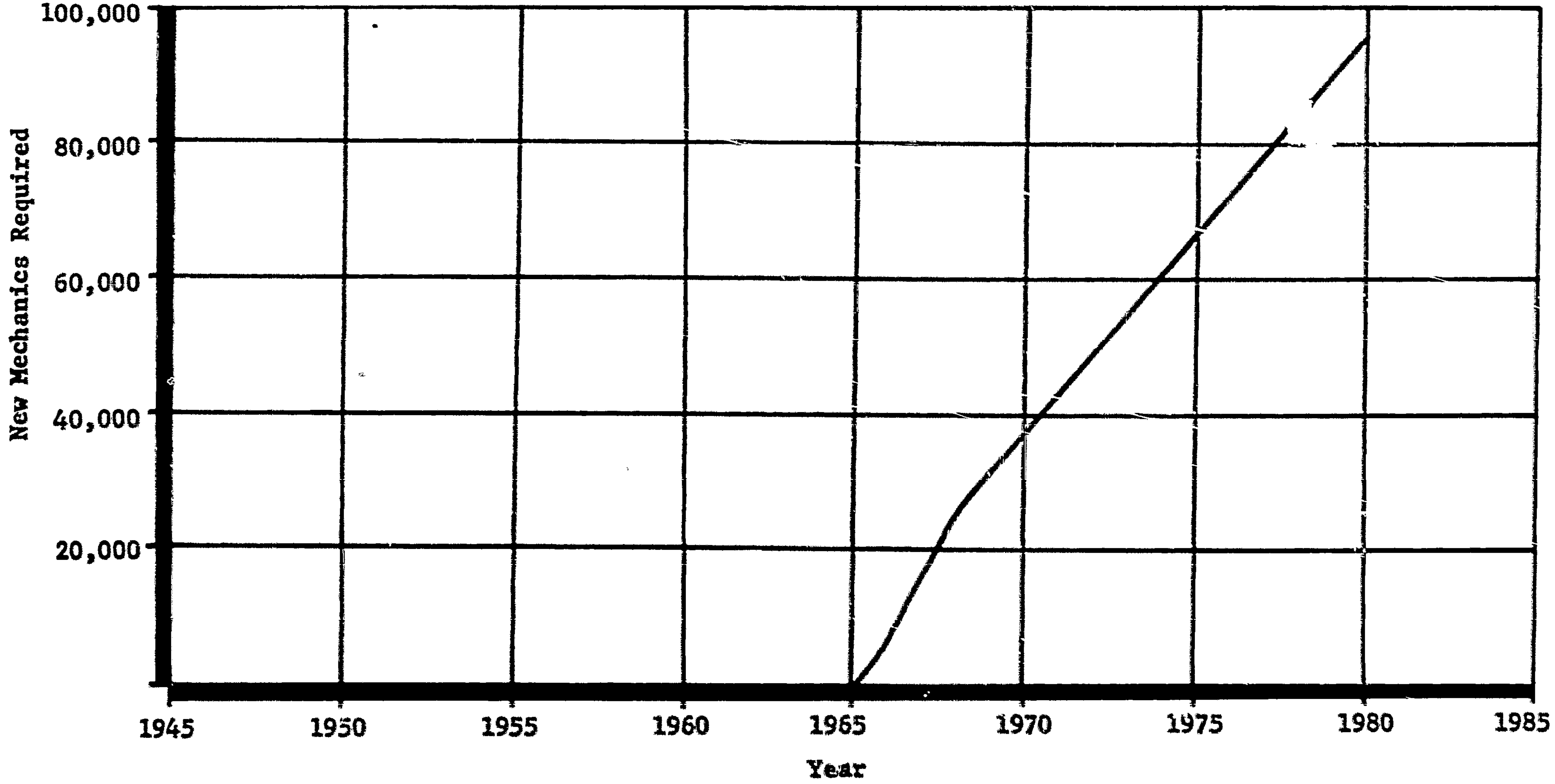

Figure I - 33

SENSITIVITY OF NEW PILOT REQUIREMENTS TO VARIOUS FACTORS IN THE PROJECTION MODEL

Conditions of Sensitivity Run (same as base run except as specified below)	Cumulative Pilot New Hires By 1980
1. Basic Run = Attrition Rate 1.5% and Early Retirement 0.1%	36,175
2. Change Early Retirement Rate to 0.5% Per Year	37,267
3. Reduce Rate of Propeller Aircraft Retirement By 10% Per Year	36,943
4. Increase Jet Aircraft Introduction Rate By 10% Per Year	41,283
5. Change Attrition Rate to 2.0% Per Year	39,265
6. Decrease Stick Hours By 1% Per Year	44,789

Figure I-34

Another run was made for jets on the same basis as that for propeller aircraft. The schedule of deliveries of jet aircraft was sped up by 10%. As could be expected, the effect was greater than that for propeller aircraft. The increase in required pilots was from 36,175 for the base run to 41,283 or over 5,000. The 10% increase in delivery schedule led to a 14% increase in pilot requirements. This indicates that any refinements in the jet forecast would increase the overall accuracy of the forecasts.

The sensitivity of the attrition rate was tested as well. In this case, the rate was changed from 1% to 1.5% to 2% per year. At 1%, the requirement was 33,086 pilots. At 1.5%, it was 36,175 pilots and, at 2%, it was 39,265 pilots. Doubling the rate gave a 17% increase in requirements. This is particularly important in terms of the model, since it appears that efforts to measure this rate more accurately would yield better forecasts. The importance of individual airlines maintaining close control of this factor is apparent, since it impinges so heavily on their requirements for new pilots.

A final run was made to test the sensitivity of the forecasts to changes in the stick hours of the pilots. In this instance, the forecast run shown in Figure I-28 was used as the basis of comparison. To this basic program was added a 1% per year reduction in stick hours. The result was to increase the average requirements for new hire pilots from 35,906 to 44,789. This represents a change of nearly 9,000 or 25%. With this magnitude of change in the projections, it is apparent that this factor needs to be measured and assessed carefully. The implications for the individual airlines are clear, since the cost of training the additional new pilots due to this small annual change in revenue-productive stick hours would be great indeed. Thus, it behooves management to control this factor as carefully as that of attrition.

GENERAL AVIATION
QUANTITATIVE REQUIREMENTS FOR PILOTS AND MECHANICS

Introduction

The purpose of this portion of Section I is to define the cumulative need for pilots with professional skills and for skilled aviation mechanics in the general aviation segment of civil aviation in the period 1965 to 1980.

General aviation operations include all civil aircraft operations, except those classified as air carrier operations. Thus, general aviation embraces a multitude of diverse and increasing uses of aircraft ranging from transportation of personnel and cargo by business firms in corporate aircraft and by air taxi operators to aerial application, power and pipeline patrol, and flying for pleasure. This part of the study does not include air carrier operations, as defined in the "air carrier" portion of the study, and military aviation is also excluded.

At year end 1965, there were 95,442 active aircraft in the general aviation fleet. This represents 98% of the total active civil aviation fleet in use at that time. In 1965, general aviation flew 16.7 million hours. This represents 78% of all civil flying done in 1965.[95] Approximately one-half of all civil aviation mechanics and more than half of all pilots with professional skills are engaged in general aviation activities.

These activities are grouped by Federal Aviation Administration classification into four main categories: (1) business flying, (2) personal flying, (3) instructional flying, and (4) commercial flying. Business flying is operation of business-owned or leased aircraft for business transportation use; that is, not for hire. Personal flying is use of an aircraft for personal purposes not associated with a business or profession and not for hire. Instructional flying is use of aircraft for formal instruction either with a flight instructor aboard or under the direction of a flight instructor. Commercial flying includes the following three types of general aviation activity:

1. Air taxi operation is for-hire use of non-air carrier aircraft for air transportation. Aircraft used are termed "small aircraft", which, by definition, means a maximum gross weight

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[95] FAA Statistical Handbook of Aviation, op. cit.

of 12,500 lbs. Air taxi operators' permits are required for all non-air carrier, for-hire, point-to-point transportation.

2. Aerial application use includes cropdusting and spraying for insect control and seeding for reforestation. Fire-fighting operations are excluded.

3. Industrial/special use includes pipeline patrol, advertising and photography.

The remaining uses of general aviation aircraft are grouped into a category termed "other" and include research and development flight testing, sales demonstrations, sport parachute jumping, and ferry flying.

During the overall Feasibility Study, Dr. Leslie Thomason and his associates at the Cessna Aircraft Company conducted a study of general aviation as it affects the feasibility of an aviation-oriented curriculum at Arizona State University.[96] The results of the Cessna study have been used to excellent advantage. Some of the methodology and discussion used for establishing factors from which employment can be predicted have been used in this report. The background material has been used for reference purposes.

Some of the quantitative measures and forecasts of the Cessna study are plotted along with the data developed by the Arizona State University study team. In most instances, the Cessna projections are approximately 20% higher than the Arizona State University figures. This is due to the fact that the Cessna projections were based on an average sales growth rate, in manufactured units, of 14.88% compounded annually.

The Arizona State University projections were based on a fleet growth rate of 8.19% compounded annually. When the fleet attrition is deducted from the Cessna sales growth rate, the Cessna fleet growth rate will average approximately 11%. The difference between this rate and the Arizona State University rate of 8.19% accounts for the differences in the two projections. When available, Federal Aviation Administration projections are also shown. These were 20% lower than the Arizona State University projections.

On the basis of the foregoing, and for the purposes of this study, the Cessna projections were considered as the possible upper limit and the Arizona State University projections as the lower limit of growth. On the basis of the dynamic growth experienced during the past three years, it is possible that even the Cessna projections might be exceeded.

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[96] Thomason, Leslie L., and associates, Study of General Aviation as It Affects the Feasibility of an Aviation Oriented Curriculum at Arizona State University, Cessna Aircraft Company, May 1967.

Assumptions

It is recognized that many variables affect the validity of long-range forecasting and, for that reason, certain limitations must be set. In this study, the following assumptions were made:

1. The forecasts are predicated on the Gross National Product continuing to grow between 3% and 5% per year.

2. A minimum of 20% of the national expenditures for all goods and services will be allocated to transportation of one type or another.

3. The percentage of the total national transportation budget dedicated to air transportation will remain between 7% and 14% of the total expenditure for transportation.

4. There will be a continuing affluency in an economy characterized as one in which approximately 50% of the disposable income is discretionary in nature.

5. There will be no major war beyond the Viet Nam situation during the forecast period (1965-1980).

Other assumptions affecting specific factors considered in the forecasting procedures, such as pilot retirement age, mechanic retirement age, etc., are dealt with as appropriate in the body of the report.

Data Sources

On 16-17 January 1967, a conference of over sixty key representatives of the aviation community was conducted on campus at Arizona State University to seek guidance, information, and assistance in the study effort being undertaken. The research plan for the Feasibility Study was outlined, reviewed, and discussed in workshop sessions. The degree of attendee interest and participation during this conference was extremely encouraging.

This meeting indicated, and subsequent investigation confirmed, that there is no detailed, factual statistical information available on employment in general aviation. Little or no data exists with which to make employment trend analyses. Limitations on the study effort, particularly calendar time available, precluded making an in-depth survey of general aviation aircraft owners and operators to seek the desired information.

A literature search revealed that substantial relevant information is available from the government, from industry, and from trade associations. Some of the most significant measures on which information is available are identified and defined below:

1. The Federal Aviation Administration records the total number of registered general aviation aircraft and this fleet size number is published annually.[97] Registration of all civil aircraft is required at the time of purchase. Registration is cancelled normally only upon the initiative of the owner and not infrequently owners neglect to cancel aircraft registration when the aircraft is retired or destroyed. There is no recurring annual validation of the continued existence of the aircraft. Thus, it is a poor measure of the number of active aircraft.

2. The FAA records the total number of registered general aviation aircraft with a current certificate of airworthiness.[98] To be eligible for flight, an aircraft must have a current certificate of airworthiness. The certificate of airworthiness is valid for twelve months and is renewable by satisfactory completion of a thorough inspection of the mechanical condition of the aircraft. Data submitted at the time of inspection on a FAA Form 2350 include information as to the primary use of the airplane and the total flight hours accrued during the twelve-month period preceding. This count is an accurate measure of the total number of active general aviation aircraft and was used as one of the fundamental parameters in developing employment forecasts.

3. As stated above, the Form 2350 also provides information on flight hours flown by each aircraft inspected during that year. Thus, total flight hours per year under this system cover all general aviation aircraft, except those joining the fleet as new aircraft during the year and those leaving the fleet during the year because of accidents, obsolescence, etc. The reported flight hours are adjusted slightly for these effects. The resultant estimated flight hours per year for all general aviation aircraft are reported in Table 5.1 of the <u>FAA Statistical Handbook of Aviation</u>. This measure was accepted as accurate for the purposes of this study.

4. FAA Form 2350 data supplemented by periodic in-depth surveys of a representative sample of general aviation aircraft owners and operators are used to verify the usage distribution of general aviation. The Form 2350 provides data on the primary

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[97] <u>FAA Statistical Handbook of Aviation</u>, <u>op. cit.</u>, Table 4.2.

[98] <u>Ibid.</u>, p. 61.

use of the aircraft; that is, business, personal, instructional, etc. The periodic survey supplements and verifies the above with information on flight hours flown in each of the several uses to which each airplane may be applied. The data thus developed is based on reports from 90% or more of the total general aviation fleet and is adjusted to represent usage distribution for the entire fleet. This information is contained in Table 5.2 of the FAA Statistical Handbook of Aviation and is used as one of the inputs to the employment forecast.

5. The Utility Airplane Council of the Aerospace Industries Association records information on utility aircraft production and new aircraft sales of U.S. manufacturers. This information was gathered and used as one of the inputs to the employment forecast.

6. Additionally, other information, including some predictions and forecasts for the future, were obtained from the Cessna Aircraft Company, Federal Aviation Administration, Beech Aircraft Corporation, U. S. Department of Labor, National Business Aircraft Association, Piper Aircraft Corporation, Civil Air Patrol, Aircraft Owners and Pilots Association, and a number of trade publications.

Active General Aviation Fleet

In order to provide a base for determining personnel needs, a quantitative evaluation must be made from which the size of the fleet can be determined. This is fundamental to later calculations which will be necessary to determine the requirements for personnel that will be necessary to operate and service the existing fleet in years to come, as well as the personnel required for the various supporting activities.

Historically, growth and personnel requirements forecasts have been too conservative, since most forecasting by industry and by the government has been straight line growth based on history. Particularly in the field of government forecasting, the cut-off date for the period of history used has often been based on the latest available published documents.

One of the first in-depth studies following World War II was conducted by the Curtis Commission with the participation of all segments of industry and government. The general aviation part of this work was the result of the endeavors of the General Aviation Facility Planning Group. In spite of cooperation of the entire aviation fraternity, these figures were conservative and, in some areas, such as in the field of personal flying, were quite incorrect.[99]

In 1963, President Kennedy requested the FAA to sponsor another in-depth study known as "Project Horizon". The report was published under the title, National Goals in Aviation. Here again, the forecast did not keep up with actual performance in growth.

A more recent example is found in the report of the FAA, published in July 1966, and generally distributed in October of that year.[100] Although this is a very thorough study, the cut-off date used for the period of history from which extrapolations were to be made was 31 December 1964. The study forecasts an active fleet of 160,000 units by 1975, which is considered even by the FAA as being extremely low, and that the projected rate of domestic sales for the industry (15,000 units a year) is likewise low. It is noted that, in 1966, the year in which the FAA report was issued, United States production, in fact, was 15,768 units. Assuming even 25% of these being for export purposes, it becomes evident that active performance should logically be far ahead of the projection by 1975.

At year end 1965, there were 95,442 general aviation aircraft in the United States. Of these, the distribution by usage and hours flown in each use during 1965 is shown in Figure I-35.

One of the considerations for the proposed aviation training center is to train pilots to at least a commercial license level. The primary focus of this study was, therefore, on those pilots who need professional skill levels of pilot capability in the routine performance of their duties. Considering the categories of aircraft usage shown in Figure I-35, with the exception of personal and business flying, this capability takes the form of the FAA commercial pilot's certificate, because the flying is normally for hire.

With respect to business aircraft, approximately one-third of all business aircraft in 1965 were in the executive transportation subcategory.[101] All aircraft in this subcategory are flown by professional pilots. The remaining two-thirds are aircraft used primarily for business transportation purposes.

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[99] The Curtis Commission forecast that personal use of aircraft in general aviation would decrease until it would become an insignificant part of general aviation. Reports show that, during the last few years, however, personal use of aircraft has grown at a faster rate than even business use of aircraft.

[100] Federal Aviation Agency, General Aviation, A Study and Forecast of the Fleet and Its Use in 1975 (Washington, D.C.: Office of Policy Development, Economics Division, July 1966).

[101] FAA Statistical Handbook of Aviation, op. cit., Table 5.3.

DISTRIBUTION OF AIRCRAFT & FLIGHT HOURS BY CATEGORY OF OPERATION (1965)

Use	1965 Year End		During 1965	
	Number of A/C	% of Total Fleet	Hrs. Flown (Millions)	% of Total Activity
Business	21,650	22.7	5.857	35.0
Personal	51,093	53.5	4.016	24.0
Aerial Application	5,041	5.3	1.143	6.8
Air Taxi	5,215	5.5	1.802	10.8
Industrial/Special	1,099	1.1	0.403	2.4
Instructional	8,034	8.4	3.346	20.0
Other	3,310	3.5	0.166	1.0
Total	95,442	100.0	16.7	100.0
Personal	51,093	53.5	4.0	24.0
Total Minus Personal	44,349 A/C	46.5%	12.7 million hours	76.0%

Source: FAA, Pilot Manpower Data, Office of Policy Development, Wash., D.C., Feb 67.

Figure I - 35

For this business use, the judgment assumption was made that the minimum desirable level of pilot capability is that of a commercial pilot. It was noted that a recent study revealed that 23% of all active commercial certificates were held by owners who fly their own planes.[102]

For the purposes of this study, it was assumed that all aircraft, except those involved in personal flying, would normally be flown by pilots with commercial pilot capabilities. As shown in Figure I-35, this type of flying involved 44,349 aircraft, which represents 46.5% of the total general aviation fleet. These aircraft flew 12.7 million hours, or 76% of the total hours flown in general aviation.

Projected Fleet Size

Three successive FAA fleet size forecasts were reviewed as part of this study. On page 51, Project Long Look states . . . "current trends in aircraft sales seem certain to outdistance the Federal Aviation Agency estimate of 102,000 aircraft in the active fleet by 1970 (Aviation Forecasts, Fiscal Years 1964-1969)". This was indeed the case. The 104,000 mark was actually passed in 1966. The July 1966 FAA forecast[103] predicts a fleet of 160,000 aircraft by 1975. The January 1967 (latest) FAA forecast[104] predicts a 1975 fleet of 173,500 aircraft. It is noted that each successive forecast is for greater growth.

In 1963, general aviation sales increased 13.1% over 1962. Since 1963, sales have increased each year over the preceding year by over 20%. Since 1962, general aviation sales have doubled. In recent years, air carrier industry activity measured in revenue passenger miles and revenue cargo ton-miles has increased rapidly. A substantial number of future air carrier activity forecasts were reviewed in connection with the air carrier portion of the overall study. Excellent correlation was noted between all forecasts reviewed. All predicted continued, rapid growth.

Many of the underlying causal factors responsible for the recent surging growth of air carrier business and general aviation growth are thought to be related. For example, the exchange of passengers at air hubs between air carriers and air taxi operators is beneficial to both. Air carrier growth stimulates air taxi growth.

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[102] Cessna Aircraft Company, Study of General Aviation, op. cit., p. 154.

[103] FAA General Aviation Forecast, op. cit.

[104] Aviation Forecasts Fiscal Years 1967-1977, op. cit.

The fleet growth rate predicted for this portion of the study was based on the assumption that general aviation fleet growth will continue to increase at a rate of slightly over 8% per year compounded to 1980, a somewhat more conservative rate than that used by Cessna. The predicted fleet growth rate is also less than industry-wide predictions for air carrier passenger mile and cargo ton-mile growth. It is, however, believed a reasonable lower limit when compared with the FAA and the Cessna projections.

On the basis of the foregoing, the total general aviation fleet is forecast to grow from slightly over 104,000 aircraft at year-end 1966 to 315,000 aircraft by year-end 1980. The calculations and curves are shown as Figures I-36 and I-37. The Cessna forecast to 1975 is approximately 20% higher and the FAA forecast is approximately 20% lower than the trend line forecast by the Arizona State University team.

Flight Hours Forecast

Civil aviation in 1965 accounted for 38 million aircraft operations reported at those airports having FAA air traffic control towers. Of all these operations, 70.2% involved general aviation aircraft; 20.6% involved air carriers; and 9.2% involved military aircraft. Had there been methods for determining the number of operations at airports without control towers, the number of general aviation activities and the per cent of the total operations for general aviation would have been much larger than the 70.2% figure reported.[105]

Of some 20 million aircraft hours flown by civil aviation during 1965, approximately 17 million were flown by general aviation. Preliminary figures for 1966 announced by the Education Subcommittee of the Utility Airplane Council (UAC) of the Aerospace Industries Association of America set this figure at more than 17 million hours. Since calendar year 1965 is the latest year for which reports are available, based on FAA Forms 2350, the 1965 figure is reported herein and shown in Figure I-38.

General aviation aircraft utilization measured in flight hours per aircraft per year has been increasing over the years. A comparison of FAA data for 1954 and 1964 reveals that utilization has increased 22%. This averages just over 2% per year compounded annually. It is believed that this increase is, at least in part, the result of improvements in both aircraft capabilities and capabilities of the federal airways navigational and traffic control systems.

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[105] The figures represent operations reported at 292 airports which have control towers. There are more than 9,000 other airports, all but approximately 300 of which are used exclusively by general aviation. Reference: "Total Aircraft Operations at Airports Having FAA Traffic Control Service, Calendar Years 1965-1966", as reported in Airports Mean Business, UAC, Airport Subcommittee.

GENERAL AVIATION ACTIVE AIRCRAFT - FLEET SIZE FORECAST

Numbers of Active Aircraft

Calendar Year End	Cessna Data	FAA Aviation Forecasts, FY-1966-1977, Jan. 1967, Table 6	Forecast of This Study - 8.19% Growth Per Year	
1965		95,442	95,442	actual
1966	104,882	104,000	104,737	actual
1967	114,585	112,000	113,000	
1968	125,732	120,000	123,000	
1969	138,537	128,000	133,000	
1970	153,248	136,000	143,000	
1971	170,148	144,000	155,000	
1972	189,562	152,000	168,000	
1973	211,865		182,000	
1974	237,486		197,000	
1975	266,920		213,000	
1976		180,000	230,000	
1977			249,000	
1978			269,000	
1979			291,000	
1980			315,000	

Figure I-36

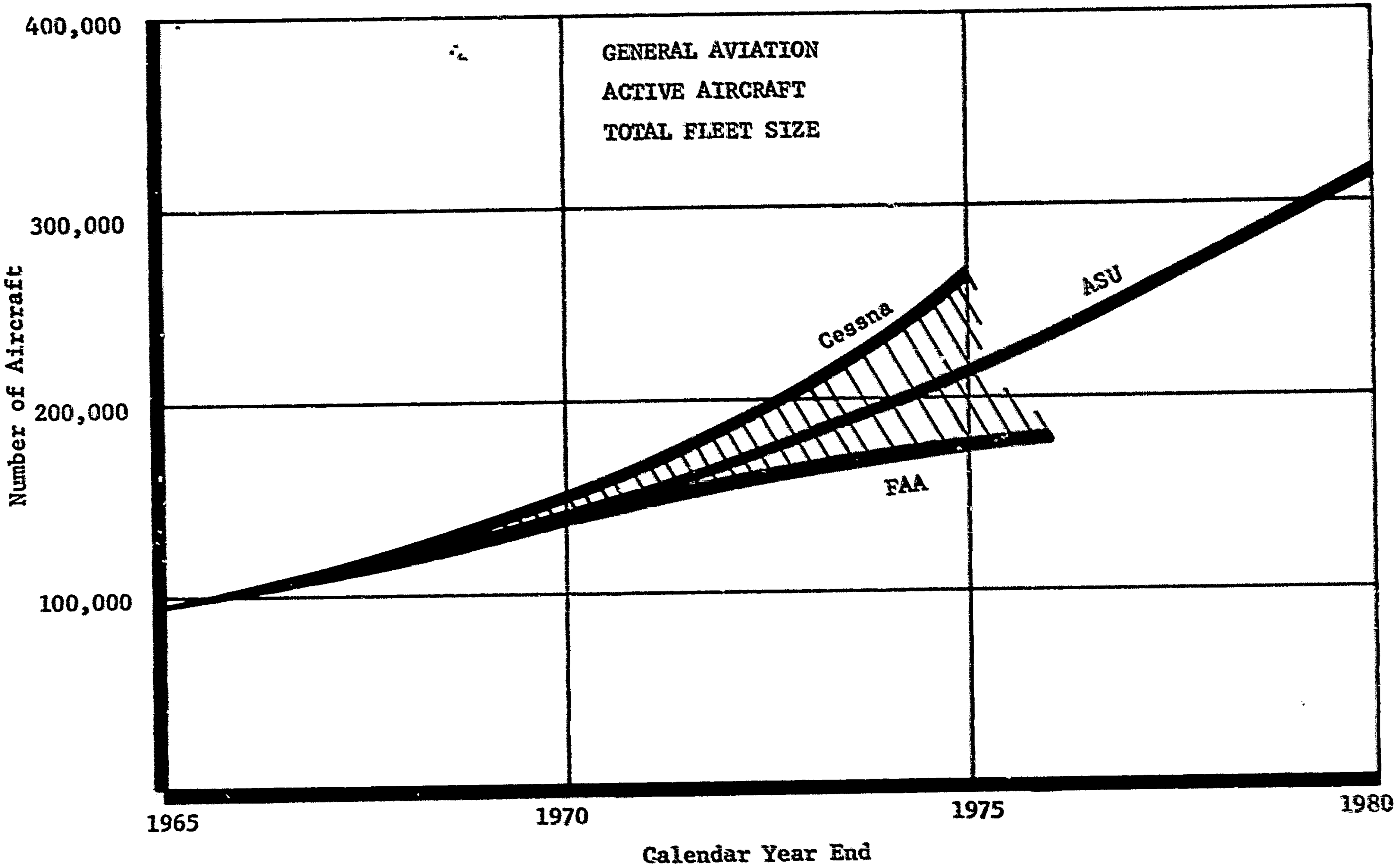
GENERAL AVIATION
ACTIVE AIRCRAFT
TOTAL FLEET SIZE
400,000
300,000
200,000
100,000
Number of Aircraft
Cessna
ASU
FAA
1965
1970
1975
1980
Calendar Year End

Figure I - 37

ESTIMATED HOURS FLOWN IN GENERAL AVIATION, BY TYPE OF FLYING: 1953-65

(Thousands of Hours)

Year	Total Hours	Business		Commercial		Instructional		Personal		Other	
		Hours	Per-Cent	Hours	Per-Cent	Hours	Per-Cent	Hours	Per-Cent	Hours	Per-Cent
1953 ...	8,527	3,626	42	1,649	19	1,248	15	1,846	22	158	1
1954 ...	8,963	3,875	43	1,829	20	1,292	15	1,920	22	47	[1]
1955[2] ..	9,500	4,300	45	1,950	21	1,275	13	1,975	21	---	---
1956[2] ..	10,200	4,600	45	2,000	20	1,500	15	2,100	20	---	---
1957 ...	10,938	4,864	45	2,013	18	1,864	17	2,109	19	88	1
1958[2] ..	12,579	5,699	45	2,365	19	2,150	17	2,365	19	---	---
1959[2] ..	12,903	5,699	44	2,365	18	2,043	16	2,796	22	---	---
1960[2] ..	13,121	5,699	44	2,365	18	1,828	14	3,172	24	57	[1]
1961[2] ..	13,602	5,699	42	2,634	19	1,796	13	3,398	25	75	1
1962[3] ..	14,500	5,431	38	3,051	21	2,385	16	3,489	24	144	1
1963[2] ..	15,106	5,740	38	3,172	21	2,417	16	3,626	24	151	1
1964[4] ..	15,738	5,823	37	3,305	21	2,675	17	3,777	24	158	1
1965[4] ..	16,733	5,857	35	3,348	20	3,346	20	4,016	24	166	1

[1] Less than 0.5 percent.

[2] No survey was conducted covering the noted years. Data for 1958-61 have been revised using a correction factor based on the 1962 survey of aircraft use in general aviation. Data for 1963 are based on hours and use reported on aircraft inspection reports adjusted by the same correction factor.

[3] The 1962 general aviation survey excluded gliders, blimps and balloon. These data have been adjusted to include them.

[4] Estimated from FAA Form 2350. Distribution of hours based on percentage use as reported in the General Aviation Aircraft Owners Survey of 1962.

Figure I - 38

This historic improvement for all of general aviation is forecast to continue at an average rate of approximately 1% per year throughout the forecast period. Flight hours flown per aircraft are thus forecast to increase at 1% per year through 1980. On this basis, the total flight hours flown annually in general aviation are forecast to increase from 16.7 million flight hours flown in 1965 to 63 million flight hours in 1980. Calculations and the forecast curve are shown as Figures I-39 and I-40. Of the 16.7 million hours flown in 1965, 12.7 million were flown in other than the personal flying category. That is, 12.7 million hours were flown in flights presumed to require at least commercial level pilot skills.

Flight hours flown in other categories than personal flying have been very close to 76% of total flight hours flown for some time. In 1960, this professional flying was 75.8% of the total and, in 1965, it was 76.0% of the total. It is forecast to remain at 76% of total to 1980.

As with the aircraft fleet forecast, the Cessna and FAA forecasts vary from the prediction of the Arizona State University study, one is higher and the other lower.

Commercial Pilot Requirements

The procedures used in developing the forecasts for future commercial pilot requirements are discussed below. The same procedures were also followed in developing the mechanic forecasts.

1. Establish present general aviation pilot and mechanic employment.

2. Knowing present general aviation fleet size, distribution according to use and flight hours flown, along with the predicted overall fleet size by 1980, the numbers of aircraft and flight hours representing non-personal use were developed.

3. Present pilot and mechanic employment was matched with present and forecast fleet size and flight hours and used to predict the number of pilots and mechanics needed by 1980. Suitable productivity changes were used as applicable. In this way, the numbers of new hire personnel needed to sustain the forecast growth were determined.

GENERAL AVIATION FLIGHT HOURS FLOWN - FORECAST

Millions of Hours

Calendar Year	Cessna Data	FAA Aviation Forecasts, FY-1967-77, Jan. 1967, Table 8 Adjusted to Calendar Years	Forecast of this Study 1.0819 X 1.01 = 1.0927 9.27% Annual Growth Rate	Forecast of This Study Other-Than-Personal Flying 76% of Total
1965		16.73 actual	16.73 actual	12.71 actual
1966		18.7	18.3	13.9
1967		20.2	20.0	15.2
1968		21.3	21.8	16.6
1969		22.9	23.9	18.1
1970	28.57	24.5	26.1	19.8
1971		26.3	28.5	21.6
1972		28.1	31.1	23.6
1973		29.9	34.0	25.8
1974			37.2	28.2
1975	50.85		40.6	30.9
1976		34.2	44.4	33.7
1977		35.7	48.4	36.8
1978			53.0	40.3
1979			57.9	44.0
1980			63.2	48.1

Figure I- 39

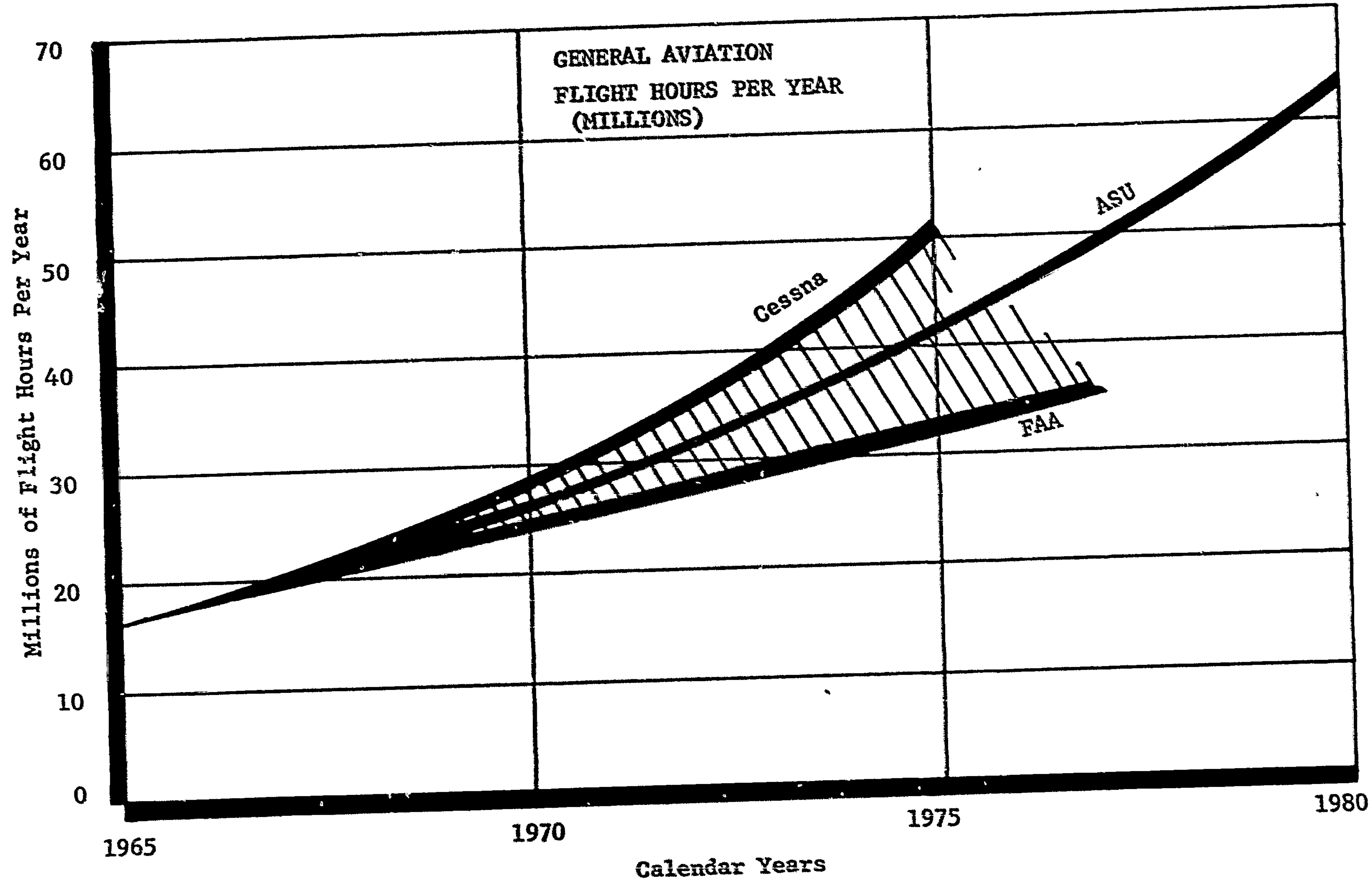
GENERAL AVIATION
FLIGHT HOURS PER YEAR
(MILLIONS)
Millions of Flight Hours Per Year
70
60
50
40
30
20
10
0
Cessna
ASU
FAA
1965
1970
1975
1980
Calendar Years

Figure I - 40

4. Suitable attrition factors were then determined. Attrition for this purpose included all permanent losses to general aviation pilot and mechanic employment. This included losses to the airlines, as well as to non-flying and non-aviation maintenance employment. Also included were medical disability, early retirement, and promotion as causal attrition factors. It was assumed that the number of pilots leaving the airlines to accept jobs in general aviation was negligible. Retirement was excluded as an attrition factor and is treated separately below. In this way, replacement, new hire personnel needed as a result of attrition were determined.

5. Aviation personnel age distribution data was applied to the present work force to determine the number of people at each age approaching retirement. Suitable retirement ages for each category of employees were applied and the number of retirees in each category computed for each year of the forecast period. This yielded the number of new hires and the replacement personnel required to offset the number of retirees. In this way, total personnel needed for growth and for replacement was determined.

Present Pilot Employment: It is estimated that general aviation employment of commercial pilots was approximately 48,760 at year-end 1965. The basis for this estimate is as follows:

1. National Business Aircraft Association Special Report 67-6 published in March 1967, page 16, states . . . "The best available estimates as to the current aircrew complement of the 7,000 multi-engine (business) aircraft place the total pilots and copilots employed at 14,000. This includes allowances for fleet operators who must maintain more than one crew per plane for high frequency, around-the-clock schedules. Adding the pilots for the 12,000 single-engine planes flown by professional pilots raises the total (business pilot employment) to 26,000." It is estimated that at year-end 1965, one year before this report was issued, that employment in this category was some 10% less; that is, approximately 23,650.

2. Employment in other categories is from FAA Pilot Manpower Data report.[106] Complete estimated employment by categories appears below:

Use	Year End 1965 Est. Pilot Employment
Business Transportation	23,650
Air Taxi Operations	6,200
Aerial Application	4,250
Industrial/Special	1,450
Flight Instruction	9,440
Other	3,770
Total Professional Pilots	48,760

Commercial Pilot Requirements Forecast: In projecting the commercial pilot requirements for general aviation during the period 1965-1980, it was assumed that the need for these professional pilots would increase at the same rate as the increase in flight hours, as projected in Figure I-40. In addition to those needed to increase the work force, pilots are also needed to replace those lost through attrition.

The pilot age distribution data from the Project Long Look report was plotted against age distribution data for all licensed commercial pilots taken from the FAA Statistical Handbook of Aviation.[107] The plots are shown in Figure I-41 and are seen to correlate well. The Project Long Look data is for early 1964 and the FAA data is for 1965. The Project Long Look data is considered accurate and was used as a basis for computing pilot retirement (a retirement age of 60 was used). The age distribution calculations are shown in Figure I-42.

Replacements are also required because of losses caused by diversion of commercial pilots from general aviation to air carriers and to employment outside aviation and for medical and disability retirement reasons. For trunk airline pilots during 1965, this non-retirement attrition factor was 1.7% of the total pilot work force. For general aviation, this attrition has been assumed at 2% of the work force through 1980.

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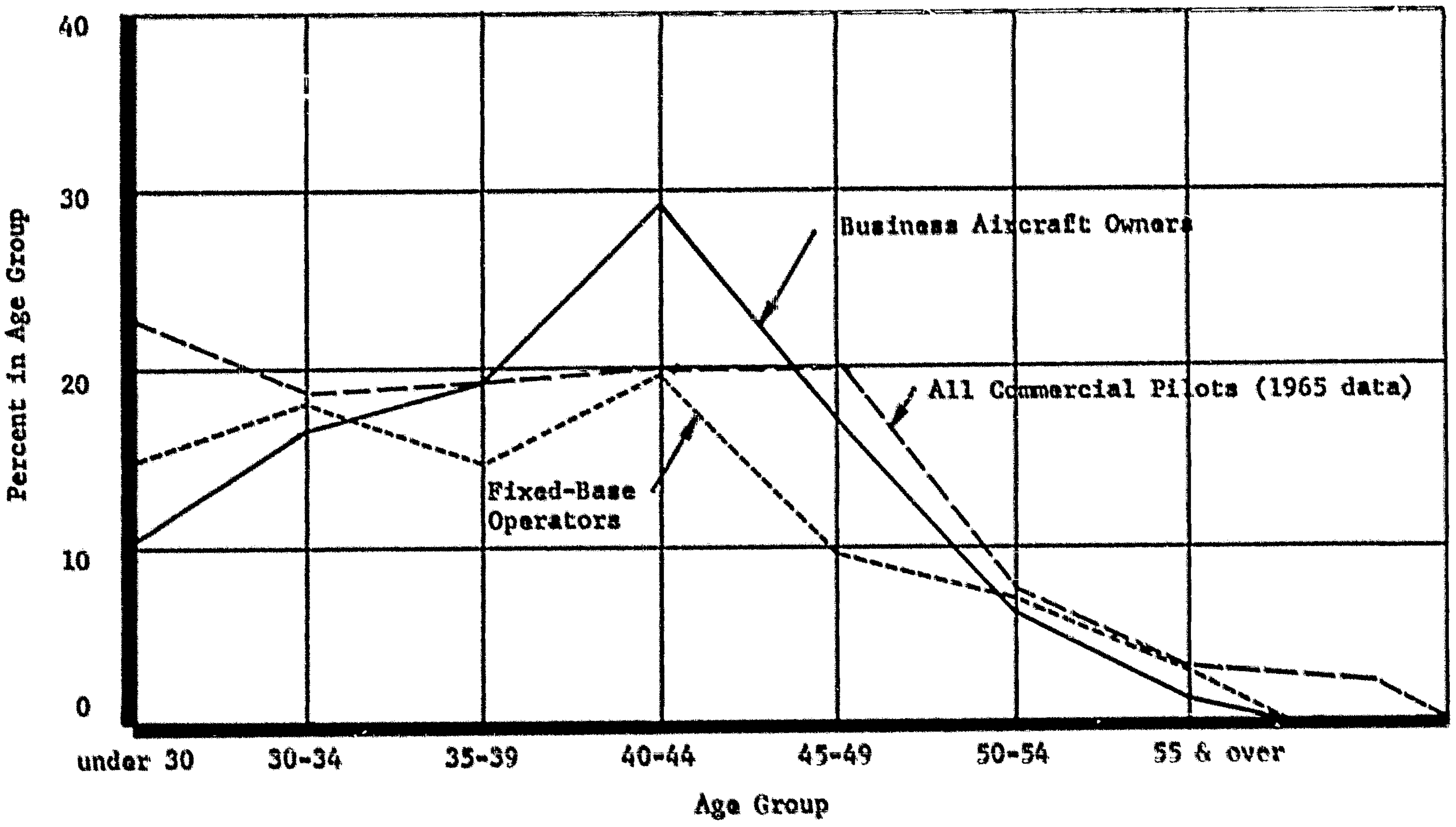
[106] Federal Aviation Agency, Pilot Manpower Data (Washington, D.C.: Office of Policy Development, February 1967), Table 2.

[107] FAA Statistical Handbook of Aviation, op. cit., Table 4.14.

PILOT AGE DISTRIBUTION
BY TYPE OF EMPLOYER



Source: All Commercial Pilots - Table 4.14, FAA Stat. Handbook
Other data - *Project Long Look*, p. 100 (early 1964 data)

Figure I-41

GENERAL AVIATION PILOTS - RETIREMENT

Business Pilots: % age 40 and over = Σ29.5 + 16.9 + 6.1 + 0.6 = 53.1%
FBO Pilots: % age 40 and over = Σ20.0 + 9.7 + 6.6 + 2.6 = 38.9%
Number of pilots with age distribution assumed like:

Business Pilots -			FBO Pilots -	
	Bus.	23,650	Flt Instruct.	9,440
	Indust.	1,450	Aerial Appl.	4,250
	Other	3,770	Air Taxi	5,200
	Total	28,870	Total	18,890

.531 X 28,870 = 15330

.389 X 18,890 = 7348

	1	2	3	4	5	
Age at Year End 1963	Business Aircraft, Ordinate Fig. 41	58.7 X 1 = No. Pilots at Age	Fixed-Base Op. Pilots Ordinate Fig. 41	37.8 X 3 = No. Pilots at Age	2 + 4 = Total at Age	Number Retiring at Year End
60	0	0	0	0	0	1963
59	0	0	0.6	23	23	1964
58	0.5	29	1.7	64	93	1965
57	1.0	59	2.6	98	157	1966
56	2.0	117	3.4	128	245	1967
55	3.0	176	4.2	159	335	1968
54	4.0	235	5.0	189	424	1969
53	5.1	300	5.9	223	523	1970
52	6.1	358	6.6	250	608	1971
51	8.2	482	7.3	276	758	1972
50	10.2	599	8.0	303	902	1973
49	12.5	734	8.5	322	1056	1974
48	14.7	863	9.1	344	1207	1975
47	18.8	1104	9.7	367	1471	1976
46	19.3	1134	13.9	526	1660	1977
45	21.9	1286	14.0	530	1816	1978
44	24.4	1433	16.0	605	2038	1979
43	26.9	1580	18.0	681	2261	1980
42	29.5	1733	20.0	757	2490	
41	27.5	1615	19.9	753	2368	
40	25.4	1492	19.8	749	2241	
	261.0 t	15329 t	194.2 t	7347 t	22676 t	

$\frac{15330}{261} = 58.7 \ \frac{\text{bus. pilots}}{\text{unit ordinate}}$

$\frac{7348}{194.2} = 37.8 \ \frac{\text{FBO pilots}}{\text{unit ordinate}}$

Figure I-42

On the basis of the information developed by Arizona State University, the cumulative commercial pilot requirements were calculated at approximately 182,000 over the period 1965-1980. The calculations are shown in Figure I-43. Two curves are plotted in Figure I-44 -- one showing the Arizona State University estimate for the period 1965-1980 and the other showing the Cessna estimate for the period 1966-1975. The Cessna information contained in the figure indicates that a total of 140,897 new commercial pilots will be required in general aviation during the nine-year period (1966-1975), including both augmentation and replacement of the existing pool of pilots. The Cessna projection is approximately 20% higher for the period covered. The two curves are assumed reasonable as the probable upper and lower limits for the commercial requirements.

General Aviation Mechanic Requirements

Present Mechanic Employment: On the basis of information derived from various sources, some of which are discussed below, it was estimated that 40,000 mechanics were employed in general aviation at year-end 1965.

In *Project Long Look*,[108] it is estimated that approximately 50,000 mechanic trained personnel were employed in general aviation in the 1963-1964 time period.

A U. S. Department of Labor Bureau of Statistics report[109] estimates mechanic employment in 1960 in each category of general aviation uses. This estimate totals approximately 33,000 mechanics.

Another approach to estimating the number of mechanics is through employment information from fixed-base operators. Fixed-base operators provide general aviation services at some 9,490 civil and joint civil-military airports of record in the United States. These services include aircraft sales, flight training, aircraft repair, servicing, hangar storage, airport operation, etc. While no accurate count of the total number of U.S. fixed-base operators has been made, the National Aviation Trades Association estimates that there are 3,500 with full-time activity.

The Cessna report states that . . . "a survey of 262 fixed-base operators . . . (indicates that) on an average, 6 (people) were employed as licensed ground personnel, either aircraft and powerplant mechanics or electronics repairmen, and 4.3 (people) were employed as unlicensed ground support personnel who actually worked on aircraft." The above group excludes servicing and unskilled personnel.

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[108] FAA *Project Long Look*, *op. cit.*, p. 51.

[109] U. S. Department of Labor, *Employment Requirements and Changing Occupational Structure in Civil Aviation*, Bureau of Statistics Report No. 1367, pp. 26-27.

GENERAL AVIATION PROFESSIONAL PILOT NEEDS

Calendar Year End	1 Population 9.27% Annual Growth Increase	2 Attrition at 2% of Avg. Pop. Cum. at Year End	3 Retirements Cum. at Year End from Fig. 42	4 Replacements Needed Cum. at Yr. End 4=2+3	5 Growth, Pilots Needed at Yr. End △ 1	6 Total Pilots Needed Each Yr. 6=4+5	7 Cumulative Total Pils. Needed 1965 to Year
1965	48,760						
1966	53,280	1020	157	1177	4520	5697	5697
1967	58,219	1115	245	1360	4939	6299	11996
1968	63,616	1218	335	1553	5397	6950	18946
1969	69,513	1331	424	1755	5897	7652	26598
1970	75,957	1455	523	1978	6444	8422	35020
1971	82,998	1590	608	2198	7041	9239	44259
1972	90,692	1737	758	2495	7694	10189	54448
1973	99,099	1898	902	2800	8407	11207	65655
1974	108,285	2074	1056	3130	9186	12316	77971
1975	118,323	2266	1207	3473	10038	13511	91482
1976	129,292	2476	1471	3947	10969	14916	106398
1977	141,277	2706	1660	4366	11985	16351	122749
1978	154,733	2963	1816	4779	13456	18234	140983
1979	169,077	3238	2038	5276	14344	19620	160603
1980	184,750	3538	2261	5799	15673	21472	182075
	△ 135,990	t 30625	15461	46086 t	135990 △	182076 t	

Figure I-43

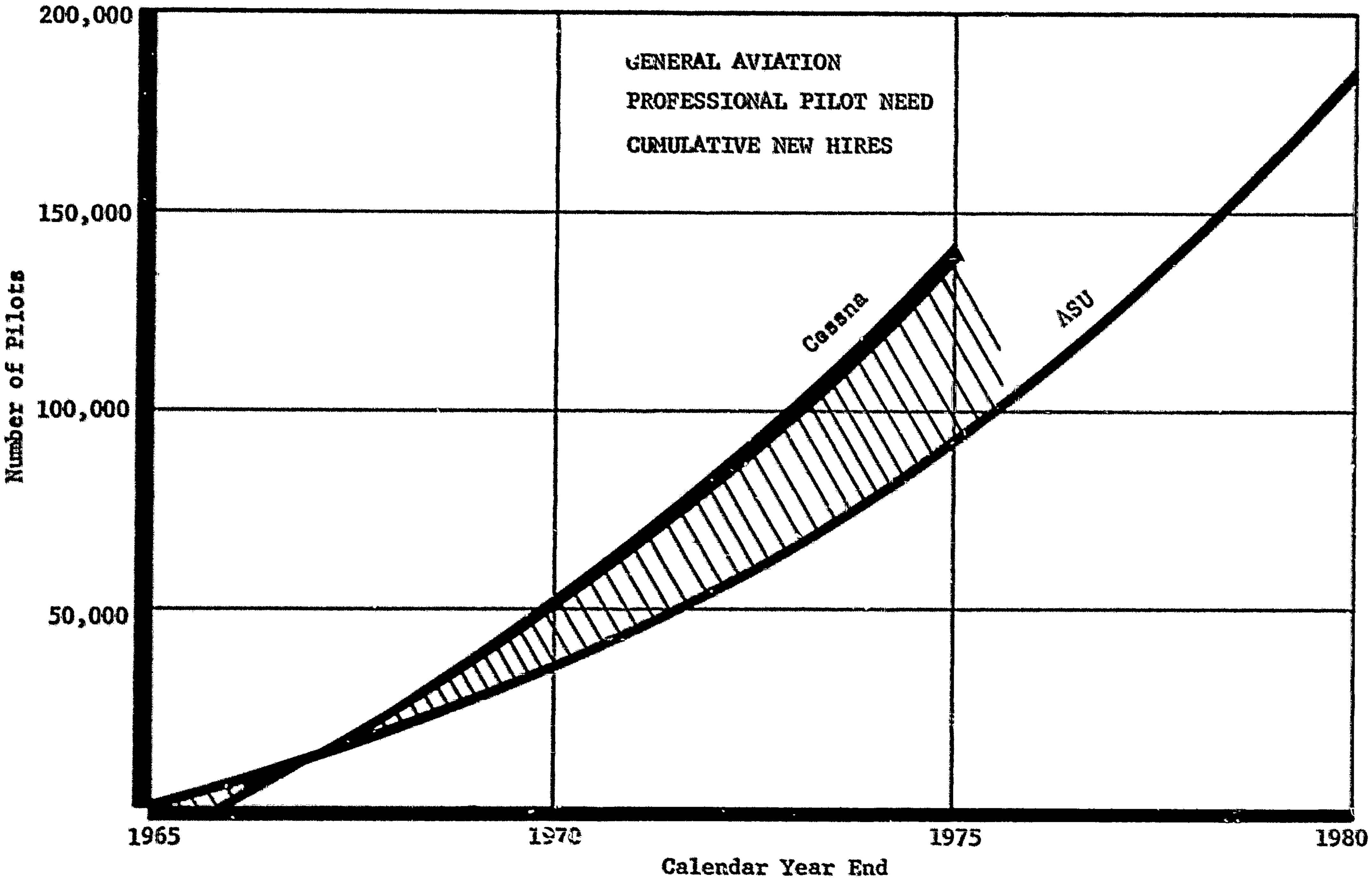
GENERAL AVIATION
PROFESSIONAL PILOT NEED
CUMULATIVE NEW HIRES
Number of Pilots
200,000
150,000
100,000
50,000
Cessna
ASU
1965
1970
1975
1980
Calendar Year End

Figure I - 44

In correspondence contributed to the study, personnel of the Aircraft Electronics Association, Sarasota, Florida, a national trade association dedicated to those serving general aviation electronics, estimated that, in 1965, general aviation utilized some 2,000-2,500 avionics technicians. Based on this and other inputs, it was deduced that the general aviation electronics repairman work force is small compared to mechanics. It was then assumed that, of the six licensed ground personnel employed by the average fixed-base operator above, five were aircraft and/or powerplant mechanics.

Assuming five licensed and four non-licensed mechanics per average fixed-base operator and 3,500 fixed-base operators, total mechanics in the employ of fixed-base operators are estimated at 31,000 to 32,000 personnel.

Mechanic requirements for business aviation and/or work done by independent certificated repair stations who are not also fixed-base operators are supplemental to the above. There are a number of engine and propeller facilities who fit the latter category who have large mechanic work forces. This combined need is estimated at 8,000 to 9,000 mechanics, for a total estimated work force at year-end 1965 of 40,000 mechanics.

Mechanic Requirements Forecast: Unlike the pilot force whose productivity is assumed constant, it is believed that the productivity of mechanics is increasing. It is also believed that improved reliability and maintainability of new aircraft, coupled with improved tools and techniques, will result in increased mechanic productivity at an average rate of 1.67% per year. This means that productivity will increase more than 25% by the end of 1980.

It is assumed that the mechanic work force needed varies with flight hours. Were mechanic productivity constant, the work force growth would be assumed equal to the Arizona State University forecast flight hours growth rate, 9.27% per year. Applying the productivity factor, the resultant growth rate is 9.27% minus 1.67% equals 7.6%. This factor was applied to the 1965 work force of 40,000 mechanics to arrive at a projected work force of 120,000 mechanics by 1980.

To determine the numbers of mechanics needed to replace those who leave the work force by 1980, mechanics age distribution data was taken from the Project Long Look report.[110] This was applied to the mechanics initial work force to determine the number of retirees each year through 1980. A retirement age of 65 was used. Age distribution data and calculations are shown in Figures I-45 and I-46.

For non-retirement attrition which includes factors such as diversion from general aviation employment to the airlines or airframe manufacturing, an attrition rate of 5% was used. Based on inputs from a number of sources, this rate is believed to be realistic.

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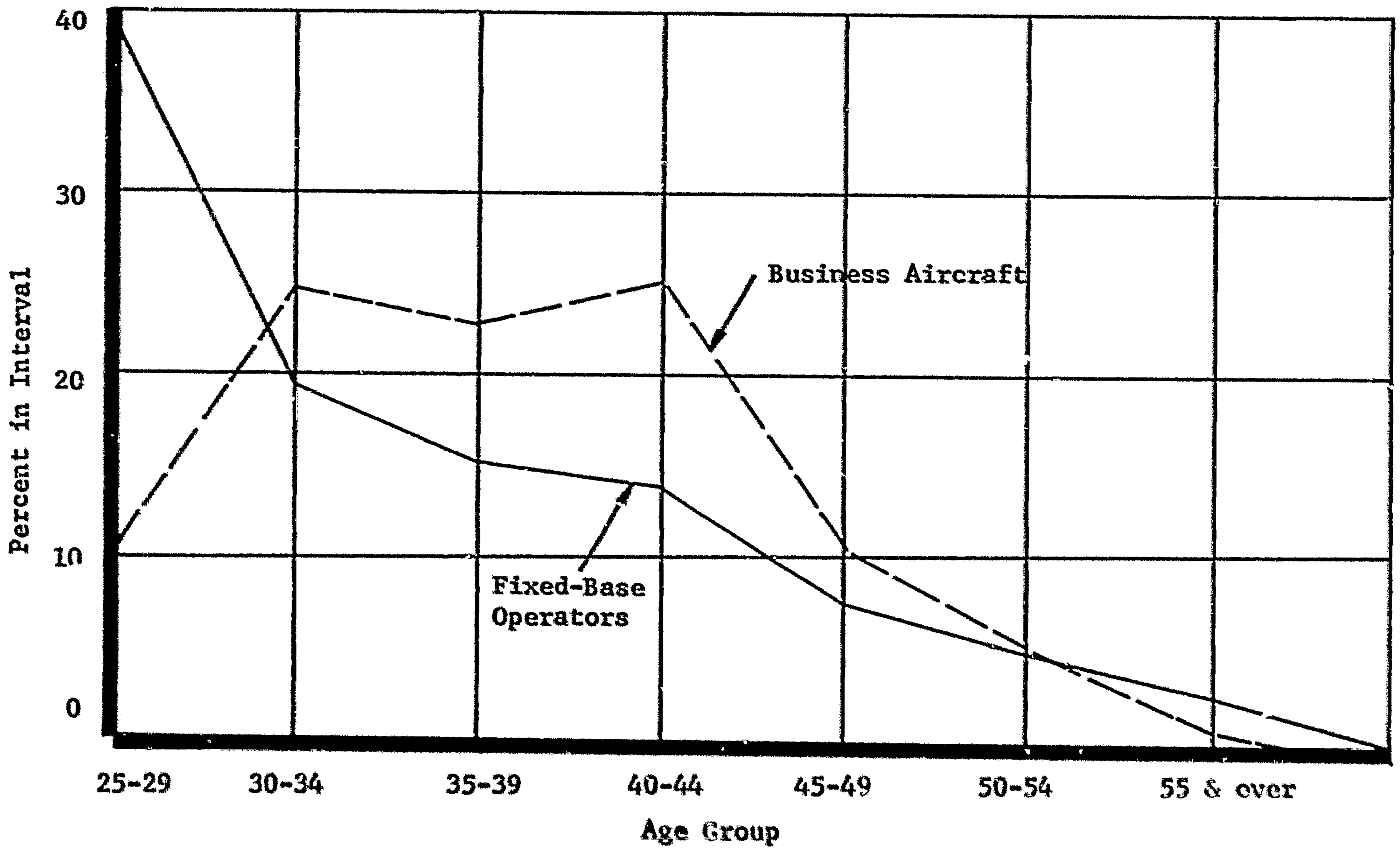
[110] FAA Project Long Look, op. cit., p. 100.

MECHANICS AGE DISTRIBUTION



Source: FAA Project Long Look, p. 100 (early 1964 data)

Figure I-45

GENERAL AVIATION MECHANICS - RETIREMENT

"Business" Mechanics - 9000 estimated

% age 45 and over = $\Sigma 10.8 + 5.1 + 1.0 = 16.9\%$

.169 X 9000 = 1521 "old" bus. mech.

$\frac{1521}{94.6}$ = 16.1 mech. per unit ordinate

FBO Mechanics - 31,000 estimated

% age 45 and over = $\Sigma 7.1 + 4.8 + 2.1 = 14.0\%$

.140 X 31000 = 4340 "old" FBO mech.

$\frac{4340}{73.6}$ = 59.0 mech. per unit ordinate

Age at Year End 1963	1 Business Mech. Ordinate from Fig.45	2 16.1 X 1 = No. Bus. Mech. at Age	3 FBO Mech. Ordinate from Fig.45	4 59.0 X 3 = No. FBO Mech. at Age	5 2 + 4 Total at Age	Number Retiring at Year End
65						1963
64						1964
63						1965
62						1966
61			0.3	18	18	1967
60			0.8	47	47	1968
59	0.2	3	1.2	71	74	1969
58	0.6	10	1.7	100	110	1970
57	1.1	18	2.1	124	142	1971
56	2.0	32	2.7	159	191	1972
55	2.8	45	3.1	183	228	1973
54	3.7	59	3.7	218	277	1974
53	4.4	71	4.2	248	319	1975
52	5.4	87	4.7	277	364	1976
51	6.6	106	5.2	307	413	1977
50	7.7	124	5.7	336	460	1978
49	8.8	141	6.1	360	501	1979
48	9.9	159	6.7	395	554	1980
47	10.9	175	7.1	419	594	
46	13.9	223	8.5	501	724	
45	16.6	267	9.8	578	845	
	94.6t	1520t	73.6t	4341t		

Figure I-46

The 1965-1980 estimates for the total number of mechanics required in general aviation, as developed by Arizona State University, are shown in Figure I-47. A trend curve of cumulative new hire mechanics for this period is shown in Figure I-48. The two figures indicate a cumulative need of 138,483 mechanics for the general aviation industry between 1965 and 1980.

The Cessna study covered general aviation mechanic requirements but analyzed only the requirement for certificated mechanics, while the Arizona State University study covered total mechanic requirements. The Cessna study also covered the period through 1975 only. Because of the wide variation in numbers, the Cessna data was not plotted in Figure I-48.

Discussion of Other Personnel Requirements

This part of the Feasibility Study was conducted to determine the quantitative requirements for skilled aviation personnel. Because of resources and time, the quantitative requirements study was limited to an in-depth analysis of the pilot and mechanic requirements only. During the study, however, other potential personnel shortage developments were noted and some of these are discussed below.

Electronics and Radio Personnel: Increased usage of airborne electronic equipment indicates a growing demand for qualified personnel to service such equipment. Radio ratings are given to FAA approved repair stations in three general classes -- Class I is Communications Equipment; Class II is Navigational Equipment; and Class III is Pulse or Radar Equipment.[111]

Of the 1,364 FAA repair stations, 467 include authority to conduct radio repair. Much of the legal basis for this area is covered by such acts as the Communications Act of 1934[112] and by various administrative acts and directives of the Federal Communications Commission.[113]

The increasing emphasis on airborne electronics is indicated by the fact that there are almost as many FAA approved radio repair stations as there are those approved for airframe repair and maintenance. There are over twice as many approved radio repair stations as there are approved powerplant repair stations.

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[111] This particular category of radio ratings does not include Class II, Electrical, or Class IV, Electronic Classifications, found under instrument ratings, or does it include Class II or Class III, Electrical and/or Electronic classes under accessory ratings.

[112] Public Law 416, 73rd Congress; 48 Stat. 1064; 47 U.S. Code 151, as amended.

[113] As an example, to perform maintenance work on a transmitter other than removal and replacement requires a FCC Class I license which is a rating of the FCC rather than of the FAA or the CAB.

GENERAL AVIATION MECHANICS

Year End	1 Population 40000 X (1.076)	2 Attrition at 5% of Av 2 = .04838 X 1 Cum. at Yr. End	3 Retirements Cum. at Yr. End	4 Replacements Needed, Cum. at Yr. End 4=2+3	5 Growth Needed at Yr. End Δ 1	6 Total Mechanics Needed at Yr. End 4+5=6	7 Total Mechanics Needed Cum. Σ 6
1965	40,000						
1966	43,040	2082		2082	3040	5122	5,122
1967	46,311	2241	18	2259	3271	5530	10,652
1968	49,831	2389	47	2436	3520	5956	16,608
1969	53,618	2594	74	2668	3787	6455	23,063
1970	57,693	2791	110	2901	4075	6976	30,039
1971	62,078	3003	142	3145	4385	7530	37,569
1972	66,796	3232	191	3423	4718	8141	45,710
1973	71,872	3477	228	3705	5076	8781	54,491
1974	77,334	3741	277	4018	5462	9480	63,971
1975	83,211	4026	319	4345	5877	10222	74,193
1976	89,535	4332	364	4696	6324	11020	85,213
1977	96,340	4661	413	5074	6805	11879	97,092
1978	103,661	5015	460	5475	7321	12796	109,888
1979	111,539	5396	501	5897	7878	13775	123,663
1980	120,000	5805	554	6359	8461	14820	138,483
		54785 t	3698 t	58483 t	80000 t		138,483 t

Figure I-47

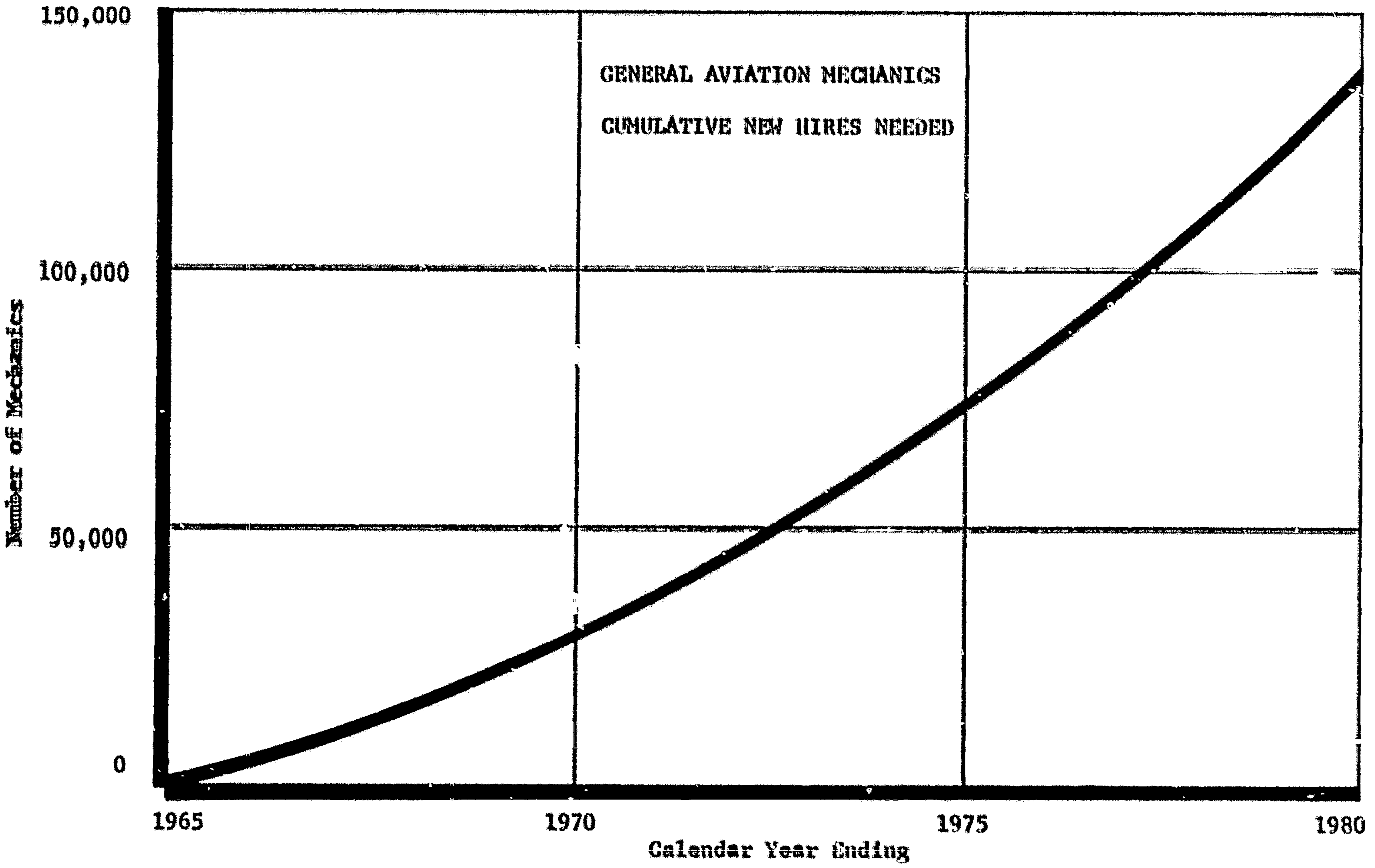
GENERAL AVIATION MECHANICS
CUMULATIVE NEW HIRES NEEDED
150,000
100,000
50,000
0
Number of Mechanics
1965
1970
1975
1980
Calendar Year Ending

Figure I-48

Flight Instructors. [illegible] flight instructor's [illegible] commercial [illegible] Even though [illegible] requirements [illegible] and based on the number of [illegible] provide the [illegible] for these flight instructors.

In 19[illegible], a [illegible] Aviation Agency [illegible] years. Following [illegible] change, the future of flight instruction.

In 19[illegible], [illegible] .00 new student [illegible] improvement [illegible] have changed [illegible] industry and government [illegible]. As a result, [illegible] 19[illegible].00 [illegible] 150,000 new [illegible] year by the end of 19[illegible]. Based on figures [illegible] Management Division of the Cessna Aircraft Company. [illegible] student [illegible].

Although there are over 15,000 [illegible] on the rolls of the FAA,[116] this number is not in any way related to the number of pilots who are actually employed as full-time flight instructors. Because of the [illegible] as well as certification requirements in process at the present time, [illegible] Proposed Rule Making No. [illegible],[117] it can be expected that the total number

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[114] Section [illegible], as added by Amendment No. [illegible], effective 15 September 1965, 30 F.R. [illegible].

[115] This is predicated on a historical pattern in which [illegible] of student pilots continue through the private rating and that 20% of the private pilots eventually buy aircraft of some type and 30% of these become purchasers of new equipment within two years after starting instruction.

[116] As of 31 December 1965, the FAA listed [illegible] active airmen with "flight instructor" certificates.

[117] Docket No. [illegible], "Certification of Pilots".

of active instructor certificates outstanding would be even less valid for a basis of calculation. Therefore, the ratio of unit sales to flight instruction appears to be the most logical approach. On this basis, there were the equivalent of 4,427 full-time flight instructors employed in 1966.

Using this in relationship to the unit sales made domestically (as projected by Cessna), we have a factor which, when applied against the unit sales expected in 1970, would mean that a requirement exists for 7,788 instructors on a full-time basis by the end of 1970. This would be 3,361 more than were in the pool at the end of 1966. In addition to the 3,361 needed to augment the pool, a replacement factor of 3.9 would indicate a need for 13,393 replacements during this same four-year period. Adding the augmentation number to the replacement number, the industry is facing a need for 16,754 flight instructors during this four-year period, 1967 through 1970, or a simple average increase of 4,188 per year. This is not unreasonable in view of the fact that almost 5,000 original issuances and additional ratings are being experienced at the present time for flight instructors. This is even more reasonable when it is recognized that a simple annual average does not reflect the true situation, since the greater requirements would be during the latter part of the four-year span.

On this same basis, a need for a total of 20,776 flight instructors can be expected by 1975. This is 12,988 above the 1970 requirements. Replacement requirements could run as high as 51,359 during this five-year span. The total of 12,988 augmentations and 51,359 replacements would mean 64,347 instructors during the five-year period, 1971 through 1975.

Marketing Personnel: Of 3,500 fixed-base operators in the United States, only 1,474 are franchised by major manufacturers of general aviation aircraft as retail dealers, selling the products of those manufacturers to retail customers. The non-franchised operators, therefore, do not normally deal in new aircraft. Many of them do sell used equipment; but since many of these are one-man operations, the proprietor is, in fact, the salesman for the company. As a result, the operation does not generally employ the services of a full-time marketing man. Also, as a result, these independent operators are excluded from these calculations and we are dealing with the 1,474 franchised retail outlets.

Applicants for a position as an aircraft salesman must have training and/or experience in the marketing of "high-ticket" items. In addition to a general knowledge of marketing in business, he must have special aviation training and orientation. A requirement is piloting ability through the level of demonstration techniques. Under existing laws, a salesman can operate as a demonstration pilot on a private pilot certificate if a sufficient number of hours are recorded in his "log book". Historically, however, the equivalent of a commercial rating is tantamount to the basic requirement relative to pilot skills and knowledge. In addition to being able to fly the aircraft at the demonstration skill level, a knowledge of components and systems is necessary, along with a general knowledge of operational and service problems.

There is an increasing demand for qualified salesmen. The last complete report on the intentions of fixed-base operators to expand this type of activity was a period ending at the close of 1965. The per cent of the fixed-base operators grossing more than a million dollars grew from 18.4% in 1962 to 27.8% in 1965. In 1965, the average income of fixed-base operators was $1,466,093. The median for that year was $396,750. Of the fixed-base operators, 36.7% listed aircraft sales as being the major source of the company's income. More significant was that, among the intended improvements and expansions listed, 25% indicated a definite plan to build a new sales showroom within the next eighteen months.[118]

With the projected increase in the number of units to be sold per year, an increase in the number of people necessary to market the products is obvious. It is impossible, however, to equate the number of salesmen required in relationship to the number of airplanes to be sold, since most salesmen operate on a draw plus commission, making the price of the aircraft important to his income. One salesman might sell one sophisticated twin-engine aircraft to a corporation and receive more income from that sale than a fleet of small trainers to a flight school. Therefore, a ratio of new salesmen required in relation to the number of units to be sold in future years would not be a true picture. Based on a factor developed by the Business Management Section of the Marketing Administration Department of the Cessna Aircraft Company in the fall of 1966, it appears that the most logical methodology is to study the dollar volume required from aircraft sales within a fixed-base operation to sustain one full-time salesman.

Based upon living costs throughout various sections of the country and the prevailing salaries of those areas, it has been determined that commissions and advances based on a retail sales volume of $332,000 a year will sustain one full-time salesman.

The dollar volume appears to be the only constant, since the mix of aircraft sold is quite variable. On an average, the typical salesman will sell 13 single-engine airplanes, including small trainers, plus 4 twins, plus a quantity of used aircraft which were "trade-ins". Some salesmen specialize in twin-engine aircraft only; some call only on corporate markets. Therefore, the estimated retail sales figure is used as a basis for this section. At the present time, it requires, on an average, a dollar volume of $332,000 a year to sustain or justify one full-

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[118] National Aviation Trades Association, <u>Survey of NATA Members</u>, 66-02, 29 April 1966.

time salesman. At the close of 1966, it is estimated that there were 1,675 individuals who were equivalent to full-time aircraft salesmen, selling new aircraft and/or used aircraft.

The estimated domestic retail value of new airplane sales is expected to grow until it is $968,631,000 a year by the close of 1970. On this basis, it would require a total of 2,917 full-time salesmen or their equivalence, which is an increase of 1,242 over the last reported figure at the close of 1966. This is an augmentation figure of 1,242, which is a simple annual average increase of slightly over 300 new salesmen a year.

By the same methodology, it is estimated that the retail value of new aircraft sales will reach $1,938,117,000 by the end of 1975. With $332,000 providing the basis for a full-time salesman, the total need by the end of 1975 will be for 5,837 salesmen, which is 2,920 more than expected in the selling force by the end of 1970. The augmentation figure of 1,242 for 1967 through 1970, plus 2,920 for 1971 through 1975, equals 4,162 new salesmen who must be added to the selling force of the franchised dealers between now and the end of 1975.

Since the marketing personnel normally move into selling from other aviation-related activities and their losses to those former activities have already been calculated in the manpower forecasts for commercial pilots, instructors, service personnel, et al., no replacement factor is calculated at this point for salesmen. To do so would duplicate these people in more than one category of employment needs.

Manufacturer and Business Aviation Requirements: The majority of the people employed by these two categories, in addition to the pilot and mechanic requirements discussed above, are engaged in production-type activities or clerical.

As an example, the aviation industry, as a whole, has great needs for draftsmen, tool and die personnel, machinists and lathe operators. Those people have the same skills as draftsmen, tool and die personnel, machinists and lathe operators in other industries, except that they are able to adapt their skills to the special needs of aviation. The same would apply to clerical or accounting personnel. Personnel with these skills must, therefore, be recruited in competition with other types of industries not related to aviation.

Port Authority and State Commission Requirements: The last published report of the FAA listed 9,566 airports of all types in the United States.[119] Of the 9,566, 3,570 are publicly owned, while the other 5,996 are private.

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[119] This is the figure that will be used for the purpose of this report, since it is a published listing and is readily available for reference.

Most private airports are operated by a fixed-base operator who serves as the owner of the airport itself, as well as the fixed-base operator; or he also directs the activities of the airport under some type of lease agreement with the owner in connection with his operation. It is the 3,570 public airports which this report is concerned with relative to the needs for professional personnel.

Of the publicly-owned airports, 4,106 are listed in the Airport Plan as characterizing "the national airport system and are thus considered the key to national air accessibility".[120] These are the airports which may participate in federal aid airport programs. There are 436 airports in the Plan which, in fact, are not at this time publicly owned but are considered as needed or will be replaced by public ownership within the five-year period of the Plan. Airports are classified as either airline airports or general aviation airports. The airline airports are further classified as large hub, medium hub, small hub, or nonhub, determined by the per cent of the total United States airline traffic accommodated.

The large hub is any airport complex accounting for 1% or more of the total United States passenger service; a medium hub accommodates between .25% to .99% of the total U.S. passenger traffic; a small hub accommodates between .05% to .24% of the total traffic; a nonhub accommodates .05% or less of the total United States traffic. The "hub" is defined as covering a geographic area which is the same as the metropolitan area or an independent city area and includes all airports of that area whether used by scheduled airlines or not. The last Federal Five-Year Airport Plan listed 515 communities served by airlines -- 21 of these were large hubs; 39 were medium hubs; 83 were small hubs; and 372 were nonhubs.[121]

These publicly-owned facilities serving the airlines as well as those publicly-owned facilities serving general aviation, almost without exception, have full-time airport managers and staffs. The licensing of "executive" airport managers is a function of the American Association of Airport Executives. This organization was founded in 1928 and has several classes of memberships, including executive members, associate members, affiliate members, and corporate members. Through a series of tests, a thesis and experience requirements, the Association accredits a manager as an "executive" airport manager. The last official directory published by the AAAE listed 252 executive managers.[122] Since date of publication, however, the number has grown to exceed 300.[123]

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[120] Federal Aviation Agency, 1965 National Airport Plan, Fiscal Year 1966-1970, Washington, D.C.

[121] National Airport Plan, Ibid., p. 10.

[122] American Association of Airport Executives, Airport Executives Directory, 1966.

[123] Based on a telephone conversation with Russell Hoyt, Executive Secretary, American Association of Airport Executives, Wilmington, Delaware, 9 March 1967.

Larger airports have several executive managers on their staffs. Based on reports of the AAAE, there are slightly over 500 airports which do have full-time managers. This means that well over half of the managers then would not be licensed or "executive" managers at the present time. Larger airports, such as large hubs and medium hubs, normally have an airport manager who has a staff consisting of several assistants, including those in charge of operations, finance, plans and development, and public relations or community services.

Small public airports with airline service usually have at least one or more assistant directors, while the larger airports go as high as 30 assistants who are professionally trained in their specialties. Information obtained directly from the Association of Airport Executives indicates that, shortly after the war, a strong flying background was the main prerequisite for personnel going into this type of work. Shortly thereafter, it shifted to an engineering emphasis. More recently, the emphasis has again shifted toward business administration with aviation orientation.[124]

At the present time, the monthly publication of the AAAE[125] lists from three to five openings each month for managers or assistant managers. If the 500 airports with full-time managers had an average of three assistants, this means that we today are employing approximately 2,000 full-time airport managers and assistant managers throughout the country. It is anticipated that, with the growth of air activity both in general aviation and in airline activities, the requirements for experienced and trained personnel would increase.

With respect to state commission requirements, according to the last count, 45 states out of 50 have an airport commission either operating as an independent commission or as a part of another agency, such as a planning and resources board. In only one state was it possible to find a one-man operation without assistant professional personnel. Some states, such as Montana, Nebraska, California, Wisconsin, and others, have complete staffs, including a director plus deputy directors in charge of special areas, such as airports, air age education, community services, operations and special activities.

A cursory examination of the source of employment indicates that, for the most part, employees of the commissions come from the region rather than being recruited on a national basis. This, however, is not always true.[126] It is calculated that approximately 200 persons having full-time employment as professional members of the staff for state commissions of aeronautics exist.

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[124] An example would be a county port authority operating as many as 10 or 15 airports under one authority, requiring that the airport manager himself, in fact, be a pilot in order to call on, inspect and supervise the activities of the various airports within the county.

[125] American Association of Airport Executives, The Airport Report, official publication of AAAE, Wilmington, Delaware.

[126] A good example would be the commissioner for the State of Nebraska who resigned to become the commissioner for the State of Michigan.

Summary of General Aviation Requirements

On the basis of the information presented in this portion of the report, it is indicated that the general aviation industry will require approximately 182,000 new commercial pilots and 138,000 new mechanics during the period 1965-1980. It is also indicated that personnel shortages are developing in skill areas other than pilots and mechanics.

As stated earlier in this section of the report, there is no detailed, factual statistical information available on employment in general aviation. Little or no data exists with which to make employment trend analyses. The projections made are considered realistic, however, considering the past growth history and projections made by others, such as Cessna Aircraft and the FAA.

The limitations on the projections made herein, along with the emerging needs for aviation-oriented skills other than pilots and mechanics, indicate a requirement for an "in-depth" study of general aviation requirements. Such a study would provide not only a better understanding of these needs but could also lead to the development of a suitable mathematical model for use in prediction of the various needs, such as the model developed for predicting air carrier requirements. The study should also cover each of the various categories of operation in the general aviation field.

A PROJECTION OF THE SUPPLY OF COMMERCIAL PILOTS AND A COMPARISON TO THE DEMAND

Introduction

In developing this projection of the supply of pilots available to meet civilian professional needs, two sources were considered. The first of these was the military, the traditional source of pilots for the major airlines of the United States, and the second was the non-military production of pilots by the general aviation sector of the industry.

During the course of the investigation, it became apparent that sufficiently detailed and reliable information upon which to base long-range projections was not available. In some instances, desirable military data are classified or would not be available in sufficient detail until completion of the installation of electronic data processing equipment. Likewise, the security surrounding military plans and the geographical dispersion of the general aviation training facilities prevented conducting personal interviews to overcome these data problems. Considerable reliance must be placed on appropriate evaluation of underlying factors, which required detailed data, to accurately forecast for long periods. Consequently, although the forecasts developed in this part of the report are developed through 1980, they should be considered as estimated trends and levels beyond 1970.

To make maximum use of the data that are available, as well as provide insights into the capacity required for producing trained pilots, the concept of a "critical production level" was developed. This level is the minimum number of issuances of commercial pilot ratings, supplementing military releases, required to avoid a pilot supply crisis. By utilizing this critical production level, it was not necessary to develop detailed forecasts of commercial certificate issuances. It was necessary only to determine whether or not the issuances would exceed the critical level in order to judge the national capacity to produce adequate numbers of new pilots.

Military Pilot Training and Releases

The determination of the number of future civilian pilot applicants with military training was divided into an examination of the past and anticipated pilot training levels and releases. The military, historically, has been an important source of pilots for the civil air carriers, as well as for general aviation. In 1964, 58.5% of the civil air carrier industry's pilots received their principal training in the military.[127] The corresponding figure for business aircraft operators was 47.8% and, for non-military state and federal government pilots, it was 64.9%.[128] The portion of new civil air carrier pilots with military training has been going down. It changed from 64.3% of the new hires in 1955 to 44.5% in 1963.[129] The situation in 1966 was somewhat different, in that 63.4% of the new hires were military trained, which raised the percentage of all military-trained pilots in the civil air carriers that year to 64.7%.[130] This reversal of the downward trend was, in part, attributed to increased military pilot releases due to the war in Viet Nam. The military has undertaken a number of steps to decrease the number of releases, in order to meet their commitments until sufficient replacements could be trained.[131]

Despite this apparent reversal of the trend, the airlines have complained that the supply of military pilots is declining in general, causing increased difficulty in satisfying their demand for pilots. Indeed, the inventory of pilots in the military has decreased. In the U. S. Air Force alone, the number of available pilots declined nearly 10,000 between June 1961 and March 1967.[132] This reduction in available personnel, coupled with an increasing resignation rate, was the cause of grave concern to the services. One result was that the needs of Viet Nam were being met at the expense of desirable manning levels in other locations around the globe.[133]

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[127] FAA Project Long Look, op. cit., p. 87.

[128] Ibid., p. 88.

[129] Ibid., p. 88.

[130] ATA unpublished memorandum dated 25 February 1966, op. cit.

[131] Brown, David A., "Military Pilot Shortage, Parts 1 & 2", Aviation Week and Space Technology, 8 May 1967, p. 66, and 15 May 1967, p. 94.

[132] Brown, op. cit., 15 May 1967, p. 97.

[133] "Pilot Shortage Serious; Will Get Worse", Journal of the Armed Forces, 6 May 1967, p. 1.

As a consequence of this situation, the services have taken action to increase their training rate substantially. The training rate has been slated to increase from slightly over 5,000 men per year to slightly more than 13,500 between fiscal 1966 and 1968.[134]

The past and projected training and release rates of military pilots are summarized in Figures I-49 and I-50.[135] The number of pilots released each year increased during the first half of 1960 and were somewhat higher than the number of pilots being trained, explaining the depletion in total inventory of available military pilots. The projections for pilot releases were based on the pilot retention rate, allowing four years for the training increases to materially affect the active inventory[136] and five years for the nominal duty obligation of a pilot.[137] The retention rate as a percentage of new pilots for all services was a little less than 10% of the pilots trained in 1966 and the programs initiated by the services were expected to stabilize, if not improve, the retention rate during the latter part of the 1960's.[138] Military pilot attrition from all other causes was assumed to remain constant at 5% for the forecast period.

The resultant forecast shows a relatively constant number of releases until 1970. This reflects the stabilized resignation rate and the lag between training commitment and effect in the field. By 1971, the number of releases is expected to increase as the first of the new pilots from the increased training levels reach the field. These new pilots will replace some of those on active duty who have been assigned extended tours and extremely long hours in order to meet the commitments of the services and, thus, would be inclined to leave rather than "re-up" for another tour. The rate was increased again the following year to reflect the end of the five-year obligation of some of the first pilots trained under the increased training rates. The release rate is expected to stabilize at about 8,600 per year after 1975, barring major changes in the world situation and/or training rates.

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[134] U. S. Department of Defense, Fiscal Years 1968-1972 Defense Program and 1968 Defense Budget (Washington, D.C.: 23 January 1967).

[135] From personnel records, Office of the Assistant Secretary of Defense - Manpower, Washington, D.C.

[136] Brown, *op. cit.*, Part 2. The U.S. Air Force plans on 18 months to activate bases and acquire aircraft, 12 months to train initial staff (or replace borrowed staff), and the remaining 18 months for training and deploying the first pilots.

[137] *Ibid.*, Part 1.

[138] *Ibid.*, Part 1.

MILITARY PILOT TRAINING AND RELEASES
ALL MILITARY SERVICES

Year	Pilots Trained		Pilots Released	
	Fiscal Year Actual	Calendar Year Estimate	Fiscal Year Actual	Calendar Year Estimate
1960	4,128	3,900	3,883	3,900
1961	3,887	3,650	4,016	3,900
1962	3,215	3,550	3,803	4,350
1963	3,926	4,200	4,943	5,150
1964	4,518	4,800	5,230	5,800
1965	5,103	5,200	6,389	6,300
1966	5,332	7,100	6,258	6,500
		Forecast - Calendar Year		
1967		11,100		6,400
1968		13,517		6,400
1969		13,517		6,500
1970		13,517		6,600
1971		13,517		7,600
1972		13,517		8,300
1973		13,517		8,400
1974		13,517		8,500
1975		13,517		8,500
1976		13,517		8,600
1977		13,517		8,600
1978		13,517		8,600
1979		13,517		8,600
1980		13,517		8,600

Figure I-49

PROJECTED MILITARY PILOT PRODUCTION
ALL MILITARY SERVICES

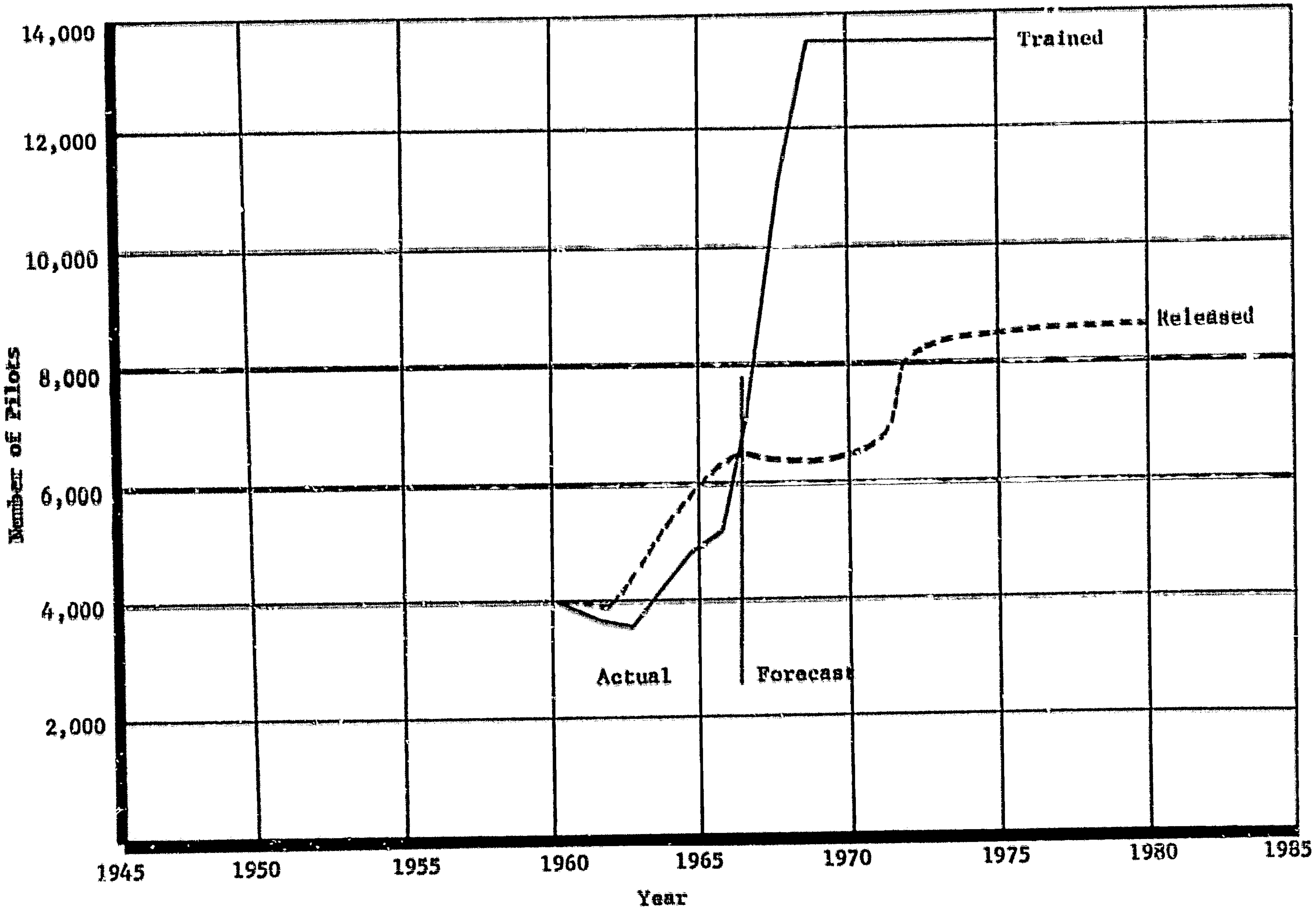

Figure I-50

A difficult problem, given the available data, is that of determining the number of these releasees who actually would qualify for civil or general aviation professional pilot jobs. For the civil air carriers, the maximum new hire pilot age is [illegible],[139] although it is higher in general aviation. For example, in [illegible] [illegible] of [illegible] of the federal government non-military new hires were [illegible] years old.[140] The applicant must also be physically fit and pass a series of screening examinations by the employer. An estimate that approximately 7% of the military releasees (excluding the disabled) were potential civil or general aviation pilots was made in a FAA study.[141] To validate this estimate, the ages of releasee pilots were reviewed.

It is doubtful that the ages of pilots with more than [illegible] years of service would qualify them for civilian pilot jobs. Of the U.S. Air Force releasees during [illegible], approximately [illegible] had less than [illegible] years of service. The corresponding figure for the U. S. Navy and Marine Corps was approximately [illegible].[142] These figures include the disabled, so they must be reduced somewhat to allow for those who would not be physically qualified. Since no reliable data were available on disabled releases and the FAA estimate of 7% is less than the per cent with fewer than [illegible] years of service, it was used in this study to represent the portion of total military releasees who would qualify as civilian pilot applicants.

A factor that is important in estimating non-military pilot production is the large portion of military-trained men who got their commercial pilot certificates before going on active duty. The percentage is difficult to estimate exactly because the FAA record of pilot certifications does not make this distinction. Another factor, accentuating [illegible] situation, is the portion of men who receive their training and certificates from non-military schools but are then drafted or volunteer for military service. They are not available to the civilian aviation industry until after their tour of duty. The men so affected are likely few in number because those who have an interest in flying and are of draft age have the choice of joining a service to get their flight training. For the purposes of this study, the latter category of persons is considered negligible. The portion of military-trained pilots who got commercial certificates before going on active duty is estimated to be 30%.

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[139] "What the Airlines Need in New Flight Personnel", op. cit., p. [illegible].

[140] FAA Forecast [illegible], op. cit., p. 65.

[141] Ibid., p. [illegible].

[142] From military personnel records, op. cit.

Non-Military Commercial Pilot Certification

To determine the non-military production of pilots, FAA issuances of commercial pilot certificates were studied. This represents the minimum certification for civilian aviation industry professional pilots.[143] Some pilots get their air transport rating before taking a job in the industry, but it is considerably more common that they get this rating after accumulating hours on the job. An instrument rating is required by most civil air carriers, but, if the applicant did not get this rating when he got his commercial certificate, this is often a part of the initial training by the carrier.

The certificated route air carriers generally require that a pilot applicant have a minimum of 500 to 2,000 hours of experience in addition to these ratings.[144] There are jobs available in general aviation to the pilot who has just received his commercial pilot certificate. In such cases, the pilot may fly for a period of time in general aviation to accumulate experience toward a job with one of the certificated carriers. The time lag, while the pilot is gaining experience in general aviation, is not a factor in this study, since the general aviation requirements are considered in the overall demand for pilots.

The summary of commercial certificate issues and the inventory of active commercial certificates are presented in Figures I-51 and I-52. It is noted that a substantial increase in commercial pilot certificate issuances has occurred since 1964. In order to determine whether or not this is the trend for the future, it is necessary to consider the number of flight schools and flight instructors that are available, as shown in Figures I-53 and I-54. The number of certificated flight schools has been growing since 1960, as has the number of flight instructors.[145] There was some indication that the facilities were near saturation in 1966 and

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[143] ATA unpublished survey dated January 1967, <u>op. cit.</u>

[144] <u>Ibid.</u>

[145] Of the 14,210 commercial certificates issued in 1966, correspondence with the FAA indicates that only 4,342 "graduated" from FAA certified schools. The reason is that there is no incentive for a certificated school to sponsor a student for his rating check. If he fails, the school gets a black mark and, if he passes, it is only as it should be. Therefore, the common practice is to let the student take the exam on his own after putting him in touch with a FAA examiner.

COMMERCIAL PILOT CERTIFICATES ISSUED AND ACTIVE

Year	Issued	Active
1959	5,956	93,815
1960	5,952	89,904
1961	5,517	92,976
1962	5,359	96,047
1963	6,279	96,341
1964	8,772	108,428
1965	11,043	116,665
1966	14,210	

Figure I-51

ISSUED AND ACTIVE COMMERCIAL PILOT CERTIFICATES

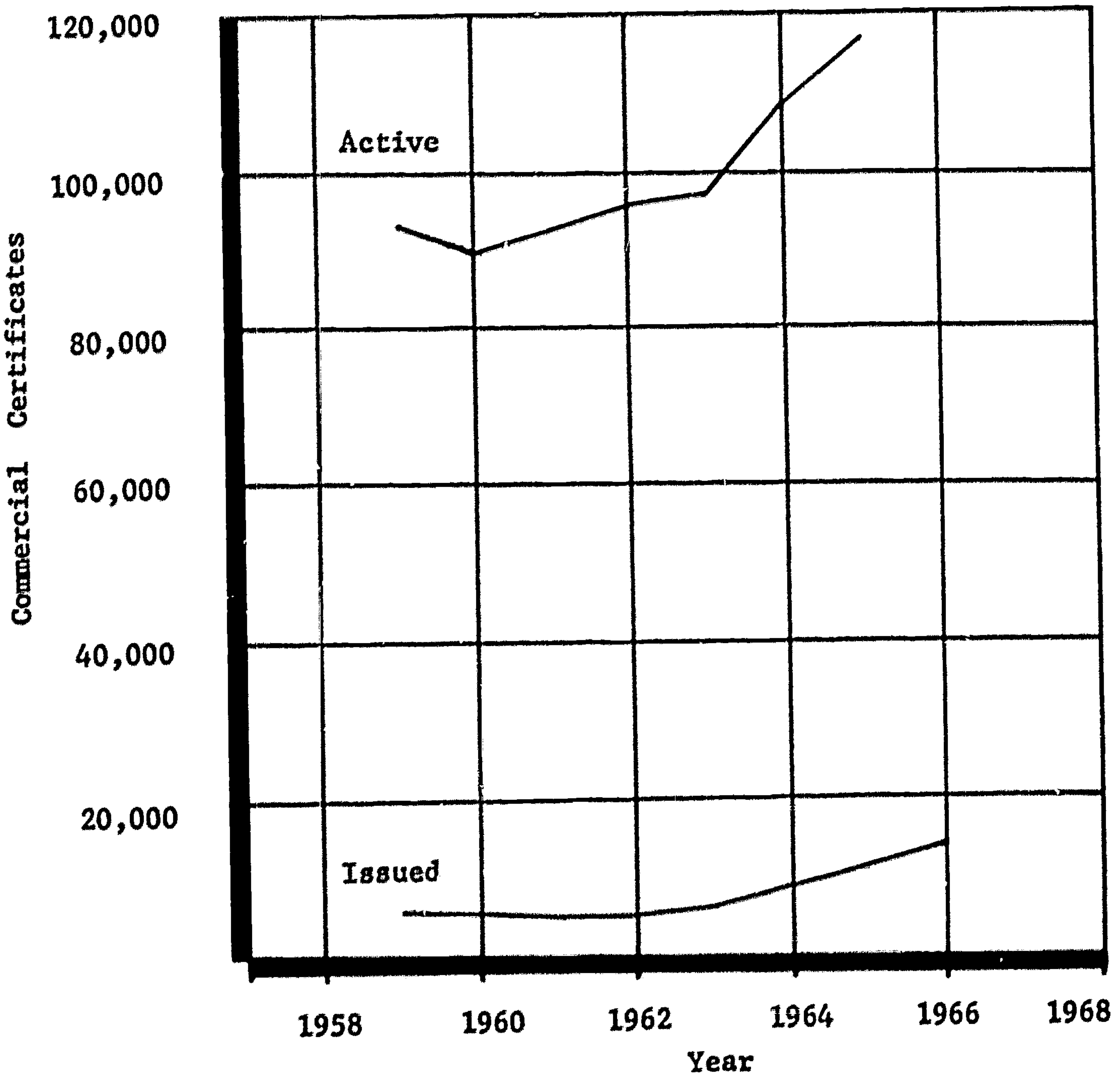

Figure I-52

FAA CERTIFICATED PILOT SCHOOLS, ACTIVE FLIGHT INSTRUCTOR CERTIFICATES, AND FLIGHT INSTRUCTOR CERTIFICATES ISSUED

Date	Certificated Pilot Schools	Active Flight Instructor Certificates	Issued Flight Instructor Certificates
1959	895	26,753	1,465
1960	895	31,459	2,099
1961	902	30,165	1,716
1962	984	28,873	4,047
1963	1,040	29,618	2,299
1964	1,108	32,158	2,412
1965	1,182	34,904	3,255
1966	1,365		4,047

Figure I-53

FAA CERTIFICATED PILOT SCHOOLS AND
ACTIVE AND ISSUED FLIGHT
INSTRUCTOR CERTIFICATES

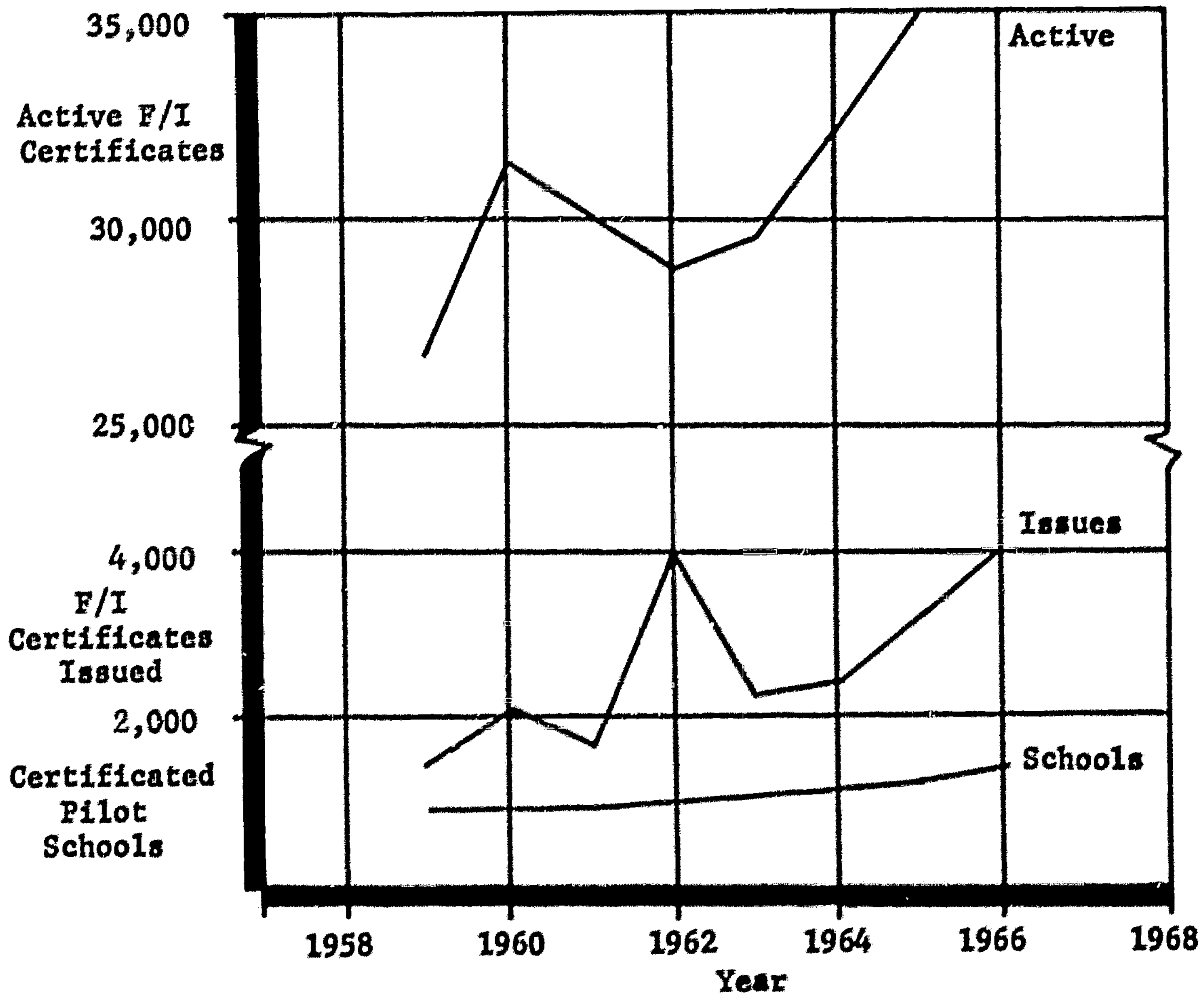

Figure I-54

any increases in the production of commercial certificates will likely require additional schools and instructors.[146] Some increases can be expected as additional students start their flight training. The significant question is how much production is necessary and will there be continued shortages. That question will be discussed after describing the commercial certificate holder in some detail.

Not all the men who are certified as commercial pilots are employable as professional pilots in civilian aviation. The question of experience, which was raised earlier, may limit the choices of a potential pilot. Another factor which decreases the number available to the aviation industry is the number of pilots who fly for pleasure only or only occasionally for business reasons. They may obtain their commercial ratings with no intention of seeking employment as professional pilots. No reliable estimate of the number of such cases exists but, in general, they can be assumed to be some of the older men who receive their ratings. This older group very probably accounts for the majority of the men[147] who would not seek professional employment as pilots.

In 1963, 75% of the new issuances of commercial certificates went to men under 44 years of age.[148] This estimate, assuming the age distribution of those who get their commercial certificates remains constant, was used to define the portion of the new issuances who would be potential applicants in civil aviation. Even though the certificated route air carriers require that pilot applicants be 35 years old or younger, the older men would take jobs in general aviation. For that reason, in this study all individuals younger than 45 who get their commercial certificates are considered potential professional pilots. In actual hiring practice, the civil aviation industry attempts to hire military releases and young commercial certificate holders with flying experience. The low-experience or older pilots turn to general aviation. The employable pilot supply in any year was found by applying the 75% factor to the new commercial certificate issuances, subtracting those who were military trained, and adding the military releases for that year.

The Critical Production Level of Commercial Certificates

The minimum level of production of commercial certificates must be sufficient to just equal the demand for new hires in the civil aviation

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[146] Cessna Aircraft discontinued a national advertising campaign in late 1966 due to pressure from their distributors who were complaining of lack of instructors and time to meet the demand.

[147] Only about 1% of the commercial certificate holders are women.

[148] FAA Project Long Look, op. cit., p. 132.

industry each year when adjusted for unqualified professional pilots, military pilots and releases. This level is defined as the critical production level for this study. It does not allow for any buildup of pilot capacity for emergencies or unexpected surges in demand. To validate this concept, the actual past demand for new hire pilots was compared to the supply available. The estimates of past general aviation new hires were made by applying the ratio of new hires to fleet increases to past actual fleet size changes. Those for the civil air carriers were based on changes in actual employment plus replacement requirements for annual industry losses. The supply of employable pilots was developed using the factors presented in the preceding sections. These figures are summarized in Figure I-55 and are plotted, along with forecast demand for civilian pilots, in Figure I-56.

These indicate that, in the past, the supply of new pilots greatly exceeded the demand until 1965 when they were nearly equal. In 1966, the demand exceeded the supply. The years 1965 and 1966 posed serious problems for the industry regarding pilot recruiting. The "pilot shortage crisis" of this period was discussed at length in the first part of this section.[149] As further evidence of the problem, some of the comments by airline personnel who were directly involved in the hiring of pilots during that period are quoted below. The comments were in response to the question, "Was there a difficulty (in hiring) or shortage of qualified applicants (for pilot openings) in 1965?", on an Air Transport Association of America questionnaire.[150]

> "Yes. Greater expenditures for interviews and advertising. Up 30% over 1964."
>
> "Yes. Shortage experienced in all categories."
>
> "Yes. Compared with a decade ago."

The responses to this question, during personal interviews in 1966, indicated even greater difficulties were encountered in that year. This was to be expected from the unfavorable ratio of supply to demand for new pilots. It is apparent from the reaction to the situation in 1965-66 that at least the critical non-military production level of pilots must be maintained to prevent a similar crisis in the future.

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[149] See also: Wright, W., "Trunklines Press Pilot Recruiting Effort", <u>Aviation Week and Space Technology</u>, 31 January 1966, p. 35; or Ruppenthal, Karl M., "The Pilot Shortage", <u>The Nation</u>, 7 November 1966, p. 481.

[150] ATA special questionnaire, Personnel Relations Conference Division, 25 February 1966.

PAST ACTUAL DEMAND AND SUPPLY OF CIVILIAN PROFESSIONAL PILOTS

	Supply			Demand		
Year	Military	Non-Military	Total	Total	General Aviation	Civil Aviation
1960	2,730	2,120	4,850	953	1,890	-937
1961	2,730	1,950	4,680	3,182	2,030	1,152
1962	3,040	1,900	4,940	3,394	2,170	224
1963	3,600	2,190	5,790	2,796	2,100	696
1964	4,050	3,710	7,760	3,825	2,310	1,515
1965	4,410	5,180	9,590	8,539	5,630	2,909
1966	4,550	6,440	10,990	12,179	5,697	6,482

Figure I - 55

CIVILIAN PROFESSIONAL PILOT
DEMAND AND SUPPLY

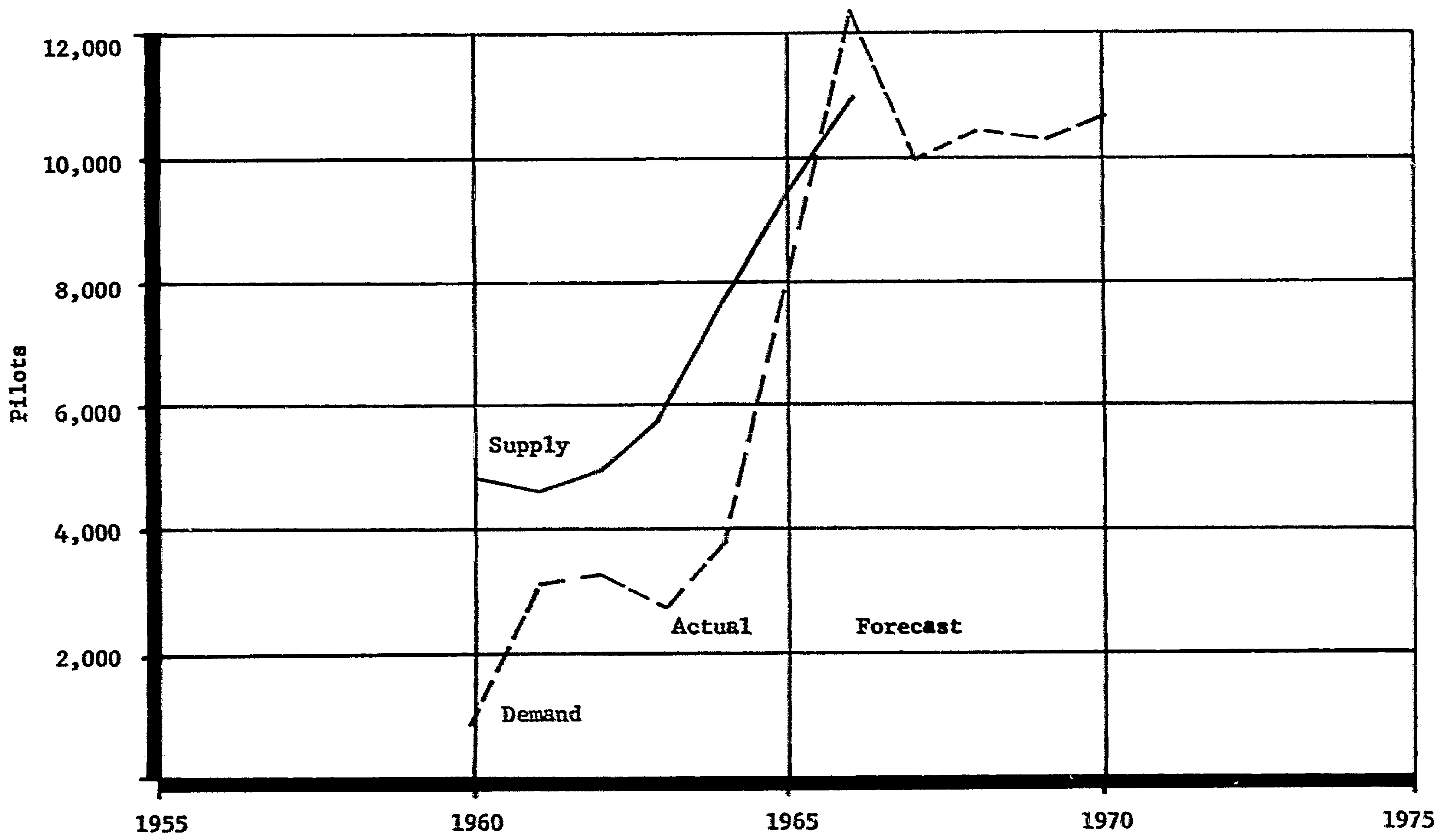

Figure I-56

Since the non-military production plus military releases of pilots did not cover the requirements for new hires in 1966, the question of how the industry satisfied their needs for that year merits investigation. Were commercial license holders available to be drawn into the work force that might not otherwise have been interested in flying professionally? In order to answer that question, the disposition of the total active commercial licenses in mid 1966 was estimated. The military holders were 60% of the pilot inventory. The civilian commercial license holders were estimated by equating the sum of the general and civil aviation holders plus all air transport rating holders to the total employment of civilian professional pilots. The remaining active commercial certificates number approximately 20,000, as shown in Figure I-57. Thus, there were additional persons available for employment as professional pilots, assuming they could qualify, but considerably fewer than would be expected in a normal period. A recent study indicates that approximately 23% of all active commercial certificates are generally held by individuals who fly their own aircraft or for pleasure rather than professionally.[151] Applying this ratio to the number of active commercial certificates in June 1966, indicated that some 28,000 persons would normally have been non-professional pilots as compared to the estimate of 20,000. It is likely that very few of the 20,000 could have qualified as professional pilots or would have been interested in doing so. Those few were probably hired during the remainder of 1966. Therefore, any demands for new pilots in excess of the projected supply probably cannot be filled from the reservoir of available pilots. To meet these demands, flight school graduates and military releases must be adequate. The question of what level this must be is discussed next.

Starting with the projected requirements for new pilots and assuming that the past relationship between production and eligible new hires will hold in the future, a projection of the critical level of commercial certificate production was developed. It is presented in Figures I-58 and I-59. Commercial certificate production must continue to increase through 1968 when it levels off due to decreased certificated route air carrier requirements and, in 1970, increased military releases. After 1971, the increasing general aviation requirements continue to reflect in increasing commercial certificate issuances. It should be stressed that this quantity just meets the required demand when added to the projected levels of military releases, without provision for increasing the national reservoir of trained pilots.

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[151] Cessna Aircraft Company, Study of General Aviation, op. cit., p. 154.

DISPOSITION OF ACTIVE COMMERCIAL CERTIFICATES
JUNE 1966

Active Certificates		
General Aviation		41,000
Civil Aviation		17,000
Military		44,000
Other*		20,000
	Total	122,000
Expected Other*		28,000

* Non-professional and non-military certificate holders.

Figure I-57

[illegible]

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
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[illegible]	[illegible]
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[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

[illegible]

PROJECTION OF THE CRITICAL LEVEL OF COMMERCIAL CERTIFICATE ISSUANCES

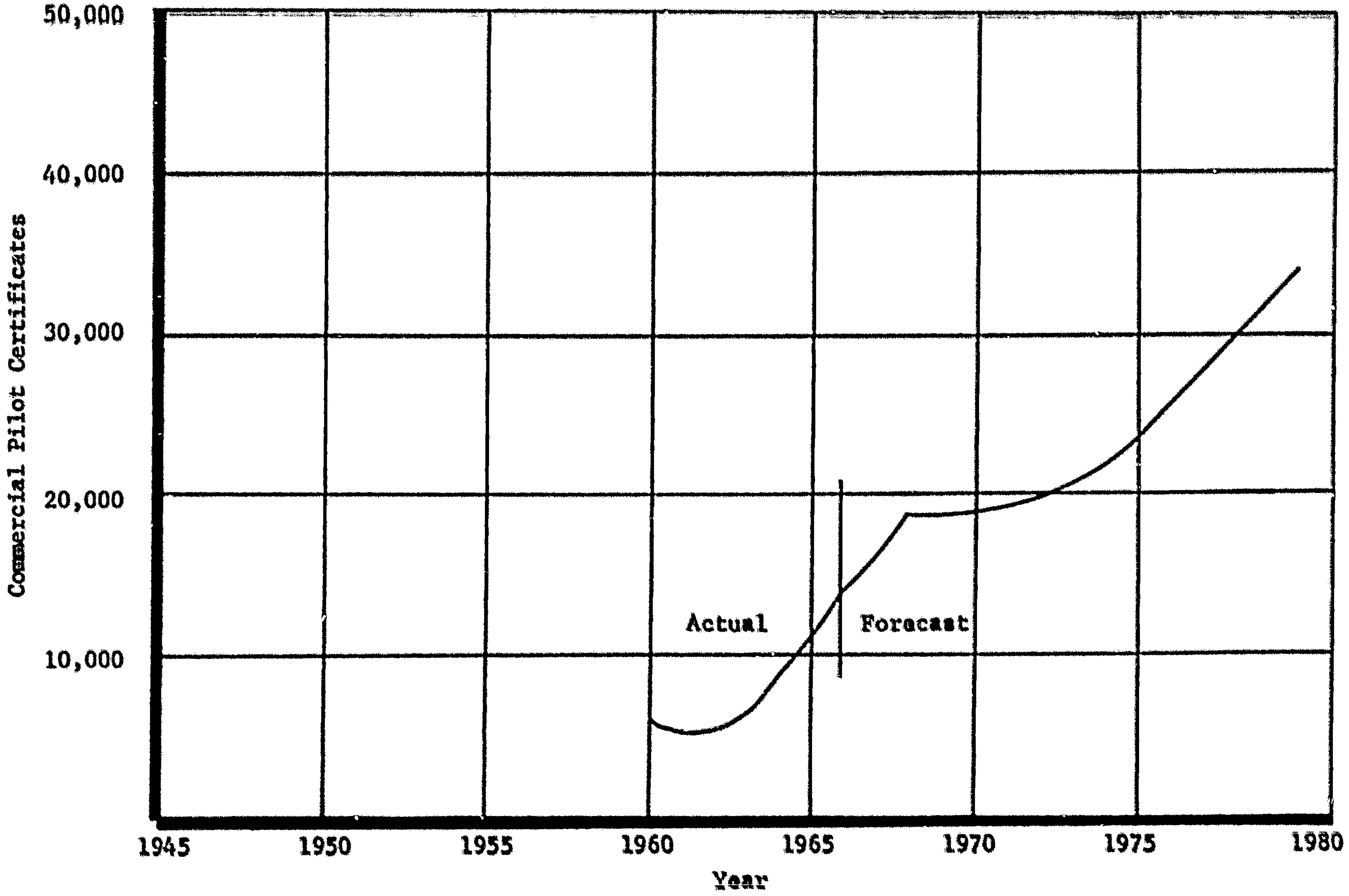

Figure I-59

Maintaining an Adequate Supply

It has been shown that the influence of the stepped-up military pilot production will not affect the supply of employable pilots until after 1970. The burden, therefore, of producing an adequate supply rests with the non-military flight schools of the nation. In comparing the required minimum issuances of commercial certificates with historical issuances, it is clear that the current number of schools and instructors are, at best, only marginally sufficient for meeting the need. In order to continue the growth and to maintain the levels of quality necessary, it is likely that more schools and instructors will be needed.

Since the demand in 1965 and 1966 probably eliminated the national reservoir of commercially certificated pilots, additional training capacity would be useful to produce quantities great enough to replenish this resource. A greater supply of new pilots would be valuable also in providing the industry with greater selectivity to meet their needs and in assuring the quality levels necessary to maintain the standard of safety required by the industry.

An argument for increasing the level of pilot production to something above the bare minimum is that of establishing and maintaining a reservoir for emergencies. Apparently, this reservoir was essential and nearly depleted in providing a sufficient number of pilots in the Viet Nam situation. The transportation sector of the United States has traditionally maintained adequate capacity to support a military or other national emergency. The ability of the aviation sector to maintain this capacity is dependent upon trained pilots. The increasing need for pilots throughout the period to 1980 indicates that there is little danger of over-production, even with the future increase in military pilot training.

Traditionally, the major trunk carriers have had several applicants for each pilot opening.[152] In 1965, there were approximately ten applicants for each opening at any single airline, but these applicants were likewise looking elsewhere.[153] In 1966, the airline officials say that ratio dropped considerably, in some cases to as low as 5 to 1.[154] The reason employers desire a high ratio of applicants to vacancies is to insure hiring the kind of pilots they desire. They must find applicants with the essential subjective qualities that would fit with their current pilots, as well as flying skill. The compatibility of the crew members is extremely important to the functioning of the crew and, hence, the safety of the flight. This is another argument for increasing pilot production to levels at least somewhat above the critical production level.

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[152] It has been estimated that after the Korean War there were as many as 100 employable pilots for each job opening. In that case, there were many that dropped out of the flying force. Ruppenthal, op. cit., p. 482.

[153] ATA special questionnaire, op. cit.

[154] Personal interviews.

Conclusions

On the basis of the data collected and analyzed, as presented in this section of the report, it is concluded that:

1. Revenue passenger mile operations for U.S. civil air carriers will increase from 76 billion passenger miles in 1965 to 315 billion passenger miles in 1980.
2. Revenue cargo ton-mile operations for U.S. civil air carriers will increase from 3.1 billion ton-miles in 1965 to 38.1 billion ton-miles in 1980.
3. The U.S. civil air carrier aircraft fleet will grow from 2,125 aircraft in 1965 to slightly over 3,000 aircraft in 1980.
4. Improvements in air traffic control and in passenger and cargo handling facilities will be made in time to support the projected growth rates, i.e., the growth rates will not be limited by these factors.
5. Financing of new equipment for U.S. air carriers will not be a limiting factor in growth during the period 1965-1980.
6. Competition from high-speed ground transportation systems will not be a limiting factor for the growth of civil air carrier operations during the period 1965-1980.
7. Tourist facilities, international documentation, and customs procedures will not be a limiting factor to the growth of the international operations of U.S. air carriers.
8. The projected growth rates are attainable and the historical relationships between aircraft and mixtures of crew complements will hold for the period 1965-1980.
9. The employment of civil air carrier aircraft cockpit crew members will increase from 22,972 in 1965 to 43,665 in 1980.
10. The cumulative requirement for civil air carrier new hire cockpit crew members will be 35,906 for the period 1965-1980.
11. The civil air carrier mechanic work force will increase from 43,667 in 1965 to 80,224 in 1980.
12. The cumulative requirements for civil air carrier mechanics will be 95,392 during the period 1965-1980.

13. The general aviation aircraft fleet will increase from slightly over 104,000 aircraft at year-end 1966 to 315,000 by 1980.

14. The number of flight hours flown annually by general aviation aircraft will increase from 16.7 million flight hours in 1965 to 63 million flight hours in 1980.

15. The number of commercial pilots in general aviation will increase from 48,760 in 1965 to a minimum of 184,750 in 1980.

16. The cumulative requirements for commercial pilots in general aviation for the period 1965-1980 will be 182,075.

17. The number of mechanics in general aviation will increase from 40,000 in 1965 to 120,000 in 1980.

18. The cumulative requirements for mechanics in general aviation during the period 1965-1980 will be 138,483.

19. The increase in production of pilots by the military services will not influence the current release rate markedly until 1970. (The release rate could be drastically reduced through a freeze by the Department of Defense.)

20. The demand for commercial pilots through 1980 indicates a market for trained military releases, but the degree of supplementation required from non-military sources cannot be determined more exactly until better projections of the military releases are available.

21. The demand for commercial pilots during the past few years has been met by reducing the national reservoir of available commercially certificated pilots.

22. The cumulative needs of the civil air carriers and general aviation for over 220,000 commercially certificated pilots between 1965 and 1980 is beyond the capability of current training outputs of both civil training production and military releases.

23. An increase in training activity to meet the cumulative needs for professionally trained pilots, as cited herein, for the period to 1980 will pose little danger to overproduction, even with the increase in military pilot training.

24. Substantial increases in training activity will be required to meet the cumulative mechanic needs of the total industry (233,875 between 1965-1980).

25. The mathematical model developed for use in predicting civil air carrier pilot and mechanic requirements is a very useful tool and can be used industry-wide or for single carrier predictions.

26. The analysis of growth and personnel requirements, as presented herein, is a valid assessment of the aviation industry's needs between 1965 and 1980.

27. There is an urgent requirement for an aviation data repository for use by all segments of aviation.

28. Shortages of other skills in aviation are developing and they should be studied in-depth, similar to the pilot and mechanic studies.

Recommendations

On the basis of the information developed and analyzed in this Section of the report and the conclusions set forth above, it is recommended that:

1. Because of the difficulties experienced in assembling the data necessary for analyzing future personnel requirements, particularly in the general aviation segment, a data center should be established with continuous inputs provided by every segment of the industry.

2. The mathematical model developed for predicting air carrier pilot and mechanic requirements be further developed and utilized in connection with recommendation "1" above. The model could also be expanded for use in general aviation and with other modes of transportation.

3. Methods be developed for improving the forecasting of military releases.

4. Studies be made of all new hire mechanics and pilots for the past ten or twenty years to develop a better understanding of the shifting of personnel between companies, military and civilian operations, general aviation and the air carriers, and different regions of the nation.

5. A detailed study be made of organizations training pilots and mechanics to determine both the quantitative and qualitative production of these skills for the future.

6. Studies be made of personal flying activities, along with other skill requirements in the aviation industry beyond those of pilots and mechanics. During this study, some of these skills were identified but not studied in any depth.

7. Full consideration be given to the establishment and operation of an aviation training center, as described and discussed in this report. Such a center would help meet some of the quantitative requirements for the aviation industry, as well as some of the qualitative requirements discussed in other sections of the report.

SECTION II

CURRICULUM STUDY

Introduction

This section of the Feasibility Study report presents the results of a curriculum requirements study which was undertaken as one task of the overall study.

The curriculum study was undertaken for the purpose of developing proposed pilot and aviation maintenance curricula which would satisfy the current and emerging skills and knowledge requirements of the aviation industry, i.e., curricula which would result in upgrading the professionalism of the aviation maintenance technician and pilot. The study was conducted in coordination with the airlines, aircraft manufacturers, pilot groups, maintenance experts, general aviation organizations, and regulatory agencies to assure that the curricula outlines included the real needs and requirements of the industry.

In January 1967, a conference was held at Arizona State University to appraise representatives of the objectives of the Feasibility Study and to request their assistance in providing certain input data. The conference was attended by approximately sixty-two representatives of the industry.[1] During the second day of the conference, a workshop was conducted on the subject of curricula development for skilled aviation personnel. The general results of the workshop are set forth below.

The broad objectives of the workshop were the establishment of the data requirements and the procedures for the acquisition of data which would permit the development of curricula outlines for the subjects required in a future aviation training program. The Allen study[2], which defines in detail the job specification of the aviation mechanic, was introduced and discussed. It was pointed out that the project study team

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[1] Proceedings - Arizona State University/Industry Conference on Aviation Training Feasibility Study, 16-17 January 1967, Arizona State University, Division of Industrial Design & Technology, Tempe, Arizona, January 1967.

[2] Allen, David, and associates, A National Study of the Aviation Mechanics Occupation, Division of Vocational Education, University of California at Los Angeles; Bureau of Industrial Education, California State Department of Education; U. S. Office of Education, 1966.

was considering use of the Allen study as a guide and reference in the curriculum study.

The initial discussion was to have been concerned with the mechanics occupation only; however, it is believed that some of the statements were intended to be applicable to both pilots and mechanics.

Comments from the participants were as follows:

1. The Allen study is excellent; the best work done on this subject in twenty-five years.
2. The full value of the Allen study will be realized only as FAA certification standards are revised and updated to match progress in definition and understanding of the job specifications.
3. Certification should be dependent upon achievement and demonstrated competence rather than upon hours spent in the classroom.
4. Better defined standards of competence and greatly improved measurement techniques should be important objectives in upgrading and revising curricula. Improved testing techniques are required to make sure that achievement is honestly and accurately measured.
5. More quality is needed in mechanic's curricula. Aviation trade schools are fulfilling industry's <u>quantity</u> requirements but not its <u>quality</u> requirements.
6. There is an increasing need for aviation personnel with broad educational backgrounds and the ability to make sound decisions based on knowledge.
7. In addition to providing an airframe and powerplant mechanics license, the mechanic's curricula should facilitate follow-on transition into courses of further academic study in allied career fields.
8. Additional emphasis is needed on curricula that will help the individual adapt to life.
9. In addition to review of the proposed mechanic's curricula by airline and general aviation management, it was recommended that the curricula be reviewed by line mechanics and by labor unions.

10. Aviation orientation and familiarization courses should be included in curricula offered by colleges of education to prospective secondary school educators.

11. Industry should provide scholarships for technical education and training in aviation.

On the basis of the foregoing, it appeared that it might be advantageous to replace the word "mechanic" with the word "technician" in the field of aviation and to upgrade the curricula for training technicians to the extent that academic credit could be allowed. Precedent for this exists in the field of medicine. The upgraded curricula, coupled with general education training, could achieve some of the goals indicated in the foregoing comments.

The current Arizona State University Aeronautical Technology program, which includes pilot training, is a four-year baccalaureate program. Tentative plans were discussed for revising this program to provide for other options, including aviation management courses and other non-flight skills. For curricula design, the project team proposed a procedure generally following the Allen study procedure to obtain core curricula material from a representative sample of the aviation community. Comments from the participants were as follows:

1. Air carrier pilot selection criteria should be carefully considered in curricula design. It should be recognized that factors, such as performance under stress and emotional stability, play a critical part in air carrier pilot selection.

2. The pilot's curriculum should be enriched substantially beyond job specification knowledge and skill requirements. Personality and attitudinal development curricula should receive suitable considerations.

3. It was noted that in a collegiate pilot curriculum, flight training, while significant, may be less important than the overall academic educational benefit.

4. The curriculum should offer courses in business management and principles of instruction and others in the socio, political, and economic spectrum.

5. There is a need for a study of the pilot's occupation patterned after the Allen study of the mechanic's occupation.

6. There is a need for an interpretation study of available data on psychological factors in pilot performance.

In summary, the conferees of the workshop expressed a desire for a broad <u>career</u> specification as opposed to a narrow <u>job</u> specification applicable to both the pilot and mechanic occupations. Efforts should be applied to broadening the curricula to include subjects which increase individual flexibility, versatility, and growth.

During the conference, the various industry representatives also agreed to participate with the study team to the maximum extent possible in providing input information and any other assistance of value to the study. The study details were then developed and the study was conducted as described in the discussions which follow.

Assumptions

In preparation for the conduct of the curriculum study, a number of assumptions were made, as follows:

1. That the personnel needs identified in Section I of this report are a valid assessment of the quantitative needs of the industry.
2. That the educational institutions of the nation currently engaged in training mechanics and pilots cannot produce the quantities of skilled manpower required in the next fifteen years.
3. That technological advances in the aviation industry will continue to create new qualitative demands of personnel that cannot be met by traditional education/training methods and curriculum designs.
4. That the application of educational technology to aviation education will be required to meet future quantitative and qualitative personnel requirements for selected aviation occupations.
5. That, while the quantitative requirements forecasted for pilots and mechanics were properly within the scope of this Feasibility Study, in-depth task analysis approaches to curriculum design for these two occupations were not encompassed in the scope as either one would constitute investigations of several times the magnitude of resources of the Feasibility Study.
6. That the recently completed task-oriented study of the mechanic's occupation by the Allen team is valid and that, with appropriate treatment of its findings with respect to the future, the results will provide a very excellent base for a curriculum proposal.

7. That, in the absence of a task analysis of the occupation of professional pilot and the preclusion of executing it in the scope of the present study, alternative and modified techniques could, nevertheless, be utilized to achieve a greatly improved curriculum design.

8. That an entirely separate, but parallel, in-depth joint research of Arizona State University and the General Learning Corporation[3] in the application of educational technology to electronics will contribute directly to the proposed aviation training center and its aviation curriculum development based upon task analysis.

Methodology

The methodology utilized in the conduct of the curriculum study derives from the assumptions stated above and included:

1. A survey of current research efforts in curriculum design and development for pilots and mechanics.
2. A polling of industry through visits and correspondence to determine emerging needs developing because of advancements in technology.
3. An examination of curricula offerings of selected FAA certificated training programs.
4. An in-depth examination of current and proposed Arizona State University curricula related to both the pilot and maintenance technician tasks.
5. A comparison of all data acquired under 1 through 4 above.
6. Preparation of outlines for proposed curricula.
7. A detailed analysis of new emerging educational technologies and the implications and potential for aviation training.

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[3] The General Learning Corporation is a relatively new corporation in the field of educational materials and systems development. The organization was established jointly by the General Electric Company and Time, Incorporated late in 1965.

Maintenance Technician Curriculum

The intent of the Feasibility Study may be briefly reviewed at this point to clarify the curriculum development procedures and the decisions made relative thereto. The objective of the Feasibility Study, as it relates to curriculum, was, after proper quantitative forecasting, to derive a qualitative curriculum proposal which would be suitable for the proposed aviation training center. Other related and important considerations beyond the Feasibility Study and beyond the derivation of a proposed curriculum also exist. Specifically, the method of implementation is of vital importance. It was the basic assumption of the project staff that the application of new educational technologies to maintenance technician training provides the greatest qualitative "quantum leap" for aviation education when developed, implemented, and validated in the proposed center and disseminated to other institutions engaged in training activities.

It should be fully realized that a task-oriented analysis, such as the Allen study, is a prerequisite for the very extensive development of instructional materials required for a multi-media, computer-assisted approach typical of educational technology. Thus, the existence of such a task-oriented aviation mechanic [illegible], together with the necessity for such an analysis, obviates additional [illegible] in deriving a proposed curriculum.

Because of the very extensive and refined research which the Allen study represents with its findings in the resultant core curriculum recommendation for aviation mechanics (technicians) and its obvious compatibility with future educational technology developments, it was used as a basis and guide in the development of both the maintenance technician and pilot curriculum outlines.

Allen Study: During the past two years, Dr. David Allen and his associates at the University of California at Los Angeles (UCLA) conducted a comprehensive study of the aviation mechanic occupation. A report on the subject was published in mid-1966.[4]

The national survey was undertaken to provide data for the accomplishment of three objectives:

1. To investigate the technical knowledge and manipulative skills of aviation mechanics as required by the aviation industry.
2. To identify a core curriculum for the training of aviation mechanics.
3. To identify the scope of training offered by industry.

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[4] *A National Study of the Aviation Mechanics Occupation*, *op. cit.*

Only aviation companies employing Federal Aviation Agency certified airframe and/or powerplant mechanics were included in the study. The assumptions for the study were:

1. That all manipulative skills require some technical knowledge but not all technical knowledge requires manipulative skills.

2. That all training in aviation mechanic schools will develop the mechanic's manipulative skills, so that he will be able to perform (in industry) work of return-to-flight quality.

Based on inputs secured directly from key aviation maintenance personnel representing airline line stations, airline overhaul stations, and large and small general aviation companies, the Allen team was able to identify the major work tasks and sub-tasks which are associated with the mechanic's daily on-the-job performance. The major work tasks identified were fifty-two (52) in number and are set forth in the block on the left side of Figure II-1 under the heading "Task Identification".

The survey was also designed to provide answers to five specific questions:

1. The number ("N") of men performing each task,

2. The frequency ("F") at which these men performed the task,

3. The level of technical knowledge ("T/K") required to do each task,

4. The conditions (time/skill/job planning) under which the return-to-flight manipulative skills ("M") had to be performed, and

5. The depth of training conducted by industry ("I").

Each of these five areas was structured internally to establish more precise measures of discrimination; thus:

Number (N) was expressed in percentages (using special character symbols usable in the processing of the study data) of the population sampled:

\+ = 10% or more   \- = 2-5%
$ = 5-10%   no symbol = less than 2%

MAINTENANCE TECHNICIAN CURRICULUM

COMPARISON OF EXISTING PROGRAMS & PROPOSED AVIATION TRAINING CENTER CURRICULUM

ALLEN STUDY CORE CURRICULUM		INDUSTRY INPUTS					RECOMMENDED TEACHING LEVELS		EMERGING INDUSTRY NEEDS SKILLS/KNOWLEDGE REQUIREMENTS - PERCENT			CONDENSED ANALYSIS FAA CERTIFICATED PROGRAMS CLASS HOURS (AVERAGE) TECH SCHOOLS			COLLEGES			UNIVERSITIES				ARIZONA STATE UNIVERSITY CURRICULUM (PROPOSED)		CLASS HOURS			
	TASK IDENTIFICATION	N	F	T	M	I	ADV. OCC.	FAA	INC.	NO. CHG.	DEC.	Lec	Lab	Wks	Lec	Lab	Wks	Lec	Lab	Wks	Tot	NUMBER	TITLE	Lec	Lab	Wks	Tot
1.	Woodworking	+	L	3	3	3	1	1+	0	5	95	-	-	-	-	-	-	13	21	4	38	TA-180	A/C & Aerospace Struc.	2	4	1.3	12
2.	Fabric Covering		L	3	2	3	2	2	5	0	95	9	17	-	-	-	-	11	21	3	32	TA-180	A/C & Aerospace Struc.	3	10	2.0	26
3.	Painting and Finishing	+	M	3	3	3	1	1+	65	5	30	-	-	-	-	-	-	11	20	3	31	TA-180-81	A/C & Aerospace Struc. Maint.	3	10	2.0	26
4.	Sheet Metal	+	M	3	3	3	3	3	90	5	5	-	-	-	16	-	3	16	33	4	49	TA-180	A/C & Aerospace Struc.	6	20	4.0	104
5.	Welding	+	M	3	3	3+	3	2	85	5	10	-	-	-	-	21	3	22	43	11	65	WT-166	Aeronautical Welding	1	3	18	108
6.	Assembly and Rigging	+	M	3	3	3	3	3	80	10	10	12	22	3	-	-	-	10	21	4	31	TA-181	A/C & Aerospace Maint.	3	8	1.3	163
7.	Landing Gear	+	M	3.5	3+	3.5	3	3	90	10	0	10	16	-	-	-	1	8	25	3	33	TA-181	A/C & Aerospace Maint.	2	4	1.3	12
8.	Hydraulic & Pneumatic Systems	+	M	3+	3+	3+	3	3	90	5	5	8	12	-	-	-	-	10	12	2	22	TA-181	A/C & Aerospace Maint.	6	16	3.3	77
9.	Fuel Systems	+	M	3	3	3	3	2	65	30	5	6	11	1	-	-	3	8	11	2	19	TA-181-287-88	A/C & Aerosp. Maint Powerplant	2	2	.3	2
10.	Air Conditioning & Pressurization	+	M	3	3	3	2	2+	60	35	5	8	12	-	-	-	-	5	7	2	12	TA-181-288	A/C & Aeros. Maint Powerplant Maint	3	6	1.3	13.3
11.	Electrical Power	+	M	4+	3	3+	3	3	85	15	0	-	-	4	9	-	-	21	43	7	64	TA-287-288	A/C & Aerosp Pwplt Pwplt Maint	2	4	2.0	12
12.	Flight Instruments	-	M	3+	2+	3+	2	2	80	5	15	7	9	1	-	-	3	7	11	3	18	TA-181-288	A/C & Aerosp Maint Pwplt Maint	2	4	1.0	8
13.	Auto Pilot and Approach Control	S	M	3.5	3	4	2	1	70	10	20	-	-	-	-	-	3	-	-	-	-	TA-181-288	A/C & Aerosp Maint Pwplt Maint	2	2	.3	2
14.	Aircraft Communications & Navigation Equip.	S	M	3	3	4	2	1	75	15	10	-	-	-	15	-	-	-	-	-	-	TA-181-288	A/C & Aerosp Maint Pwplt Maint	1	2	.3	1.3
15.	Engine Instruments (Electrical)	+	M	3	3	3	2	2	50	20	30	-	-	-	-	-	4	8	13	3	21	TA-181-287-88	A/C & Aerosp Maint Pwplt Maint	4	3	1.3	10.3
16.	Aircraft Fuel & Oil Measurement & Control	S	M	3	3	4	3	3	45	40	15	6	11	1	-	-	3	6	9	3	15	TA-288	A/C & Aerosp Powerplant Maint	2	-	.3	1
17.	Aircraft Landing Gear Electrical Units	+	M	3	3	3+	3	3	50	45	5	-	12	-	-	-	3	9	14	3	23	TA-181-287-88	A/C & Aerosp Maint Pwplt Maint	1	2	.3	1.3
18.	Fire Detection & Extinguishing Systems	+	M	3	3	3	2	2	50	40	10	7	10	2	-	-	1	7	6	2	13	TA-181-288	A/C & Aerosp Maint Pwplt Maint	2	4	1.0	6
19.	Ice and Rain Control	+	M	3	3	3	2	2	40	45	15	8	11	2	-	-	1	5	8	2	13	TA-180-288	A/C & Aerosp Struc Pwplt Maint	2	3	.3	2.3
20.	Warning Systems	+	M	3	3-	3	2	2	45	45	10	3	11	2	-	-	1	9	11	2	20	TA-180-287-88	A/C & Aeros Struc Pwplt Maint	2	2	.3	2
21.	Reciprocating Engines	+	M	4	4	4	3	3	5	70	25	18	28	4	9	-	-	13	26	4	39	TA-287	A/C & Aerospace Powerplant	2	4	17	102
22.	Turbine Engines	+	M	4	3	3+	3	3	100	0	0	19	29	4	-	-	-	13	22	4	35	TA-287-88	A/C & Aerosp Pwplt Pwplt Maint	2	4	1.0	8
23.	Lubricating Systems	+	M	3	3	3	2	2	60	35	5	12	17	3	13	-	4	10	24	3	34	TA-181-287-88	A/C & Aeros Maint Pwplt Maint	0	2	.3	2.3
24.	Ignition Systems	+	M	3	3	3	3	3	60	35	5	12	17	3	-	-	-	12	26	4	38	TA-287	A/C & Aerospace Powerplant	4	12	3.0	48
25.	Fuel Metering	+	M	3	3	3	4	3	50	50	0	15	25	3	-	-	-	11	21	3	32	TA-288	A/C & Aerospace Powerplant Maint	8	16	4.0	96
26.	Induction Systems	+	M	3	3	3	3	3	50	30	20	16	23	3	-	-	-	10	21	3	31	TA-287	A/C & Aerospace Powerplant	3	4	1.0	7
27.	Propellers (General)	+	M	3	3	3+	3	2	30	5	65	12	22	3	-	-	4	26	42	10	68	TA-180-288	A/C & Aerosp Struc Pwplt Maint	6	10	2.0	36
28.	Fixed Pitch Propellers (Wood)	-	L	3	3	3	3	2	0	0	100	COMBINED IN ITEM 27															
29.	Fixed Pitch Propellers (Metal)	-	M	3	3	3	3	2	10	0	90																
30.	Ground Adjustable Propellers	S	L	2	2	-	-	2	0	0	100																
31.	Two-Position Constant Speed Propellers	S	L	2	2	2	2	2	5	0	95																
32.	Constant Speed Feathering Propellers	+	M	3	3	3+	3	2	35	5	60																
33.	Reversible Propellers (Recip. Engines)	-	L	3+	3+	3+	3	2	15	10	75																
34.	Reversible Propellers (Turbine Engines)	S	M	3	3	4	3	2	40	25	35																
35.	Governors	S	M	3	3	3	3+	2	40	25	35																
36.	Drafting	+	M	3+	2	2	2	2	45	15	40	7	23	-	-	-	16	23	73	15	91	TD-111-12-380	Tech Dwg/Descr Geom/Aero Dwg-Des	1	17	18	324
37.	Weight and Balance	+	M	3+	3+	3	2	2	55	5	40	11	37	2	-	-	1	9	9	2	18	TA-181-288	A/C & Aerosp Maint Pwplt Maint	4	10	2.3	33
38.	Aircraft Materials and Processes	+	M	3	2	3	2+	2+	100	0	0	-	-	-	-	-	7	20	30	8	50	TA-180-81-287-88	A/C & Aeros Struc/Maint Pwplt	4	12	2.3	40
39.	Inspection Fundamentals	+	M	3	3	3	3+	3	100	0	0	11	27	3	-	-	3	10	21	3	31	TA-181-288	A/C & Aerosp Maint Pwplt Maint	3	10	2.3	37.3
40.	Aircraft and Engine Inspection	+	M	3	3	3	3	3	65	25	10	12	19	2	-	-	-	9	13	3	22	TA-181-288	A/C & Aerosp Maint Pwplt Maint	4	6	2.0	20
41.	Ground Support Equipment	+	M	2	3	3	2	2	55	20	25	13	25	4	-	-	-	-	-	4	-	TA-181-288	A/C & Aerosp Maint Pwplt Maint	2	2	.3	2
42.	Ground Handling	+	M	2	3	3	2	2	40	25	35	13	23	2	-	-	-	-	-	4	-	TA-180-287	A/C & Aerosp Strut Powerplant	1	2	.3	1.3
43.	Cleaning and Corrosion Control	+	M	3	3	3	2+	3	40	15	45	-	-	-	10	-	4	10	27	3	37	TA-180-287	A/C & Aerosp Strut Powerplant	4	8	2.0	24
44.	Aircraft Nomenclature	+	M	3	1	1	3	2+	75	10	15	-	10	-	10	-	4	-	-	-	-	TA-180-287	A/C & Aerosp Strut Powerplant	3	8	2.0	26
45.	Theory of Flight	+	M	3	1	1	3	2	55	20	25	8	13	2	-	-	-	13	18	3	31	TA-180-287	A/C & Aerosp Strut Powerplant	2	4	1.0	6
46.	Federal Aviation Regs. & Related Publ.	+	M	2	1	2	3	3	90	10	0	11	16	2	13	-	-	10	29	6	39	TA-180-81-287-88	A/C & Aeros Struc/Maint Pwplt	2	3	.3	2
47.	Shop Management Responsibilities	+	M	3	1	2	1	1	50	10	40	-	-	2	-	-	-	-	39	-	39	TA-287	A/C & Aerospace Powerplant	3	-	.3	1.3
48.	Ethics and Legal Responsibilities	+	M	3	-	3	3	3	65	30	5	-	-	-	-	-	-	-	-	-	-	CB-301	Business Law	3	-	18	54
49.	Mathematics	+	M	3	1	1	1	1	60	30	10	-	-	-	-	-	-	67	-	20	67	MA-117-18	College Algebra/Trigonometry	6	2	18	144
50.	English	+	M	3	1	1	4	3	90	10	0	-	-	-	-	-	-	99	-	27	99	EN-101-02	First Year English	6	-	18	108
51.	Physics	+	M	2	1	1	2+	2+	55	30	15	-	-	-	-	-	-	-	-	-	-	PH-111-12	General Physics	6	6	18	216
52.	Chemistry	+	M	2	1	1	1	-	30	35	35	-	-	-	-	-	-	-	-	-	-	CH-113-14	General Chemistry	6	6	18	216
																						TA-309	Technical Problems	2	-	18	36
																						EE-236	Numerical Methods	1	2	18	54
																						TA-300	Aircraft Design	2	-	18	36
																						TA-304	Applied Aerodynamics	2	-	18	36
																						TA-306	Aerosp Elect & Eltron Sys	2	-	18	36
																						TA-307	Aerospace Orientations	2	-	18	36
																						TA-308	Combustion Analysis	2	-	18	36
																						TA-340	Prin. Vert. Takeoff Aircraft	2	-	18	36
																						ME-380	Applied Thermodynamics	3	-	18	54
																						ME-330	Metallurgy	3	3	18	108
																						TM-261	Metal Processes	2	3	18	90
																						EE-200	Electricity & Electronics	3	3	18	108
																						TA-388	Propulsion	3	-	18	54
																						ME-230	Materials & Indust. Proc.	1	3	18	72
																						CB-204	Introduction to Business	3	-	18	54

AVERAGE CREDIT HOURS BASED ON SEMESTER HRS CREDIT = 72 HRS (UNIVERSITY ONLY)

* CREDIT HOURS BASED ON SEMESTER HRS = 90 SEMESTER HOURS

Figure II-1

Frequency (F) was expressed:

L = low - job performed semi-annually or less often
H = high - job performed daily, weekly, monthly

Technical Knowledge (T/K) was graduated in five levels:

1. Knowledge - ability to locate information and follow directions
2. Comprehension - ability to interpret information and drawings needed to do the job
3. Application - ability to transfer principles and to transfer learning to new situations
4. Analysis - ability to break a malfunction into its fundamental parts in order to troubleshoot
5. Synthesis - ability to combine knowledge of principles and procedures to complete repairs and to construct new or substitute parts

Manipulative Skill (M) was represented:

1. Not needed
2. Reasonable time limit, no job planning required
3. Reasonable time limit, job planning required
4. Time critical, no job planning required
5. Time critical, job planning required

Industry Training (I) was measured in degree offered:

1. None offered
2. Orientation or familiarization
3. Basic or general information
4. Training in-depth

The findings of the Allen study, as derived from the industry survey, have been summarized and presented in accordance with the above described code system in the columns headed "Industry Inputs" in the left-hand block of columnar information presented in Figure II-1.

One of the important phases of the Allen study was the formation of a National Advisory Committee (N.A.C.) to assist the Allen research team. It consisted of individuals representing private and public aviation mechanic training schools, small and large general aviation companies, airlines, U. S. Department of Labor, and Federal Aviation Agency. This distribution of background was selected to provide a broad spectrum of knowledge that would assist the Allen research team in achieving the objectives of their study.

After the data from the industry inputs was assembled and coded, as described above, the National Advisory Committee was able to review the entire data and make recommendations regarding teaching levels, including the depth of training, the instructional settings, and the testing levels for the major tasks. The Committee was guided by several established levels of instruction to which any sub-topic of the core curriculum could be taught. These levels of instruction are summarized as follows:

Level 1 = Knowledge

Student should be able to recall facts, theories, concepts and principles, locate information and follow directions. Instructional Setting: lectures, demonstrations, discussions.

Level 2 = Understand

Student should be able to interpret information in manuals, drawings and data sheets; make direct application of theories, principles and concepts; perform basic manipulative operations. Instructional Setting: lectures, demonstrations, discussions, introductory skills.

Level 3 = Apply

Student should be able to make direct, and transfer, application of knowledge and skill in the performance of work units; make independent airworthiness judgments based on his own knowledge and experience, and perform the required manipulative operations to a return-to-service standard. Instructional Setting: lectures, demonstrations, discussions, and manipulative skills.

The teaching levels recommended by the Committee for each of the major tasks of the core curriculum are shown in the column headed "Recommended Teaching Levels - Adv. Cmte." in the left-hand block of information, Figure II-1.

Revision to FAR-147: In February 1967, the Chief, Maintenance Division, Flight Standards Service, Federal Aviation Agency, Washington, D. C., contacted all Certificated Mechanic School Directors by letter, requesting their comments regarding a FAA proposal for revision and upgrading of various sections of FAA Regulation 147, Mechanic Schools.

The proposed revisions dealt with curriculum changes and teaching levels for the array of tasks which are those identified with the aviation mechanic. The changes proposed by the FAA appear to lean heavily on the concepts and findings of the Allen study.

The FAA recommended teaching levels have been incorporated in the block of information on the left side of Figure II-1 under the column headed "Recommended Teaching Levels - FAA" for comparison with the levels recommended by the Advisory Committee in the Allen study. FAA terminology was not always compatible with that of the Allen study and, since the Advisory Committee's recommendations were summarized, the comparison provides an admittedly limited frame of reference. In spite of this, however, there appears to be extraordinary concurrence between the Advisory Committee and FAA recommendations.

Emerging Industry Needs: The next step in the study was to obtain the opinions, comments, and judgments from key industry representatives in relating the Allen core curriculum tasks to the emerging and projected job skill requirements of the aviation industry.

A simple form was prepared which included a summary of the Allen study, as presented above. The information was sent to industry representatives of the January 1967 Arizona State University/Industry conference with a request that, based on their past experiences and their knowledge of current and developing technologies, would they identify whether:

1. The (Allen study) tasks will increase or decrease in significance in the next ten years;
2. Will shift in emphasis;
3. Will no longer be needed; or
4. Be supplanted by task skills which have not, as yet, been specifically identified.

It was also requested that the response to the above questions should include a reason for the respondents' choice for each task, recommendations for directing the study team's attention to specific subject matter and/or tasks, and any counsel or suggestions for further research. The professional positions and distribution of the respondents is shown in Figure II-2.

The data resulting from the survey are presented in the second block of information (from the left) in the columns headed "Emerging Industry Needs", Figure II-1. The responses received are given in percentages, so that the numerical value shown represents the percentage of respondents who indicated for each task its probability of increasing, decreasing, or not changing in importance. Visual inspection of the "No Change" column reveals very generally lower percentages of respondents who predict changes in emphasis for most topics. In the other two data columns, the percentages of respondents predicting changes in topical emphasis are very often large in magnitude and vary in the direction of increase or decrease from topic to topic.

The larger implication is that the dynamic technological change will require corresponding dynamism in shifting curriculum emphasis. The more specific implication for the purposes of the curriculum design phase of the present study lies in its counsel for the topical selection itself and centrally for the allocation of emphasis as expressed in time devoted and teaching testing levels.

Accordingly, the data were used to consider the initial inclusion of each topic and its appropriate emphasis within the proposed maintenance technician curriculum of Arizona State University. Through this action, it was felt that traditional curriculum lag could be reduced, at least in part, in meeting the entry level standards of performance for aviation technicians.

FAA Certificated Programs: Concurrent with the efforts described above, some additional activity was undertaken. While well aware of the inherent limitations of searches of "literature", it was felt that an exploratory approach to the literature of educational institutions certificated by the Federal Aviation Agency might provide useful insights with respect to their aviation mechanic curriculum structures and practices.

In this effort, six universities, two colleges, and four technical training schools were identified as offering FAA certificated aviation mechanic curricula. The Directors, Deans, or Department Heads were contacted by letter and telephone to appraise them of the Arizona State University project. In each case, requests were made for current catalogs

MAINTENANCE TECHNICIAN PROGRAM

RESPONDENT DISTRIBUTION

Professional Position	Government	University	Mfrs.	Comm. Airlines	Military	Other
FAA District Supervisor	1					
CAP Deputy Chief of Staff - Education & Training	1					
Assoc. Professor, Dept. of Aviation		1				
Maintenance Experts		2				
Supervisor - Education & Training			1			
Advisor/Pilot, Office of Vice President & Manager			1			
Director of Technology Training				1		
Director of Personnel				1		
Director of Maintenance Services				1		
Manager of Training				1		
Training Instructors				2		
Training Supervisor				1		
Manager of Personnel				1		
Supervisor - Vocational Training - High School						1
Maintenance Line Supervisors					4	
Manager - Marketing Research			1			
Commandant - Student Pilot Training					1	

Figure II-2

and bulletins; proposed changes, if any; other literature; and personal comments on the design, structure, and content of their aviation mechanic education programs.

Following this data collection, it was analyzed on the basis of institutional data, curriculum grouping, curriculum content as related to the Allen study tasks, in terms of class hours (lecture, laboratory) and units of credit where applicable.

Although certified by the FAA, some of the institutions were not academically accredited; however, they are producing "graduates" who successfully pass the FAA tests. The FAA certificated institutions selected for analysis were:

I. <u>Universities</u>

  A. Purdue University
  B. Oklahoma State University
  C. Southern Illinois University
  D. University of Illinois
  E. Western Michigan University
  F. Utah State University

II. <u>Colleges</u>

  A. San Jose State College
  B. Parks College of Aeronautical Technology (St. Louis)

III. <u>Training Schools</u>

  A. Embry-Riddle Aeronautical Institute
  B. Spartan School of Aeronautics
  C. Wentworth Institute
  D. Northrop Institute of Technology

Those familiar with aviation mechanic vocational/technical education will realize the repute and competence of these institutions. They were also selected for geographical dispersion to preclude the possible effects of provincialism.

In addition to analyzing each institution for its inclusion of the Allen tasks, a correlative analysis was made of each of the fifty-two tasks in the Allen core curriculum for inclusion in the variety of courses offered by the institutions. This latter effort is not to be considered a study in redundancy. The research staff was well aware that a precise identification of the duration (in class hours) and the depth of subject coverage could be obtained only by talking directly with the individual instructors of the chosen institutions. Since such an in-depth approach is of proportions as to constitute an entirely separate effort of considerable magnitude in time and cost, it was precluded for the purpose of the present study. Accordingly, the most reasonable, workable approach was adopted, which was to use the semantic terms of the Allen "tasks" and to relate their frequency of appearance in any and all courses offered within the specified curriculum, as published by the respective institution.

The data derived from this literature investigation is presented in the third block of information from the left (Figure II-1) under the heading "Consensus Analysis - FAA Certificated Programs".

Several explanations are required relative to the FAA certificated institution data derived through the literature search just described. The original purpose of this effort was that useful insights might be gained with respect to their respective and collective instructional content, emphasis and relationships to FAA minimum requirements. It was discovered, however, that the format of the literature was so generalized and, therefore, so imprecise that the data that could be achieved in this way was less than had been considered desirable.

As for the data presented in this category of Figure II-1, it will be observed that there is an absence of entry in many instances. Since all institutions whose literature was studied are FAA certificated, it must be assumed that minimum requirements are being met, even though no such entry appears. Because of the difficulty expressed, it was impossible to identify the respective topic treatment in those specific institutions and instances.

It must be pointed out that, while all institutions selected were comparable on the basis of gross FAA certification, the aviation mechanic's curriculum existing in the two categories of colleges and universities can be expected to include some general education course work not present in the remaining institutions. This work would be beyond the narrower considerations of the fifty-two Allen tasks studied and would occur chiefly in science, mathematics, and selected technical subject matter. Examples of the latter are in areas of applied thermodynamics and drafting. It was, therefore, determined that only the analysis/synthesis data of the six universities included would yield useful and valid comparisons with that of Arizona State University's existing courses.

The data with respect to all universities is presented in sub-columns, giving the allocations respectively to lecture or laboratory and their combined total in terms of weeks as related to the Allen topics. As indicated by legend in the figure, the entries for each sub-column represent the average time allocation to a given Allen topic. Expressed in other terms, each entry represents the average total student "exposure" to a given topic for either lecture, laboratory, or their combined total.

In attempting to derive the academic credit (semester hours) awarded by the universities for their aviation mechanic curricula, the credits allowed by each had necessarily to be translated from quarter and trimester hours into semester hour equivalencies. More basic to the problem of comparability is the fact that one or more Allen tasks are very often integrated or placed into context of other subject matter in a variety of ways, the sum total of which is awarded a fixed amount of credit. Most of the unique Allen tasks cannot be extracted from this context in order to ascertain the credit or fractional credit which is appropriate. As related to the present study, the precise credit values for each Allen topic, as practiced in the six universities, has obviously limited value. Moreover, when related to the resources available for this study, a judgment was made that in-depth, further investigation was neither feasible nor desirable. While approximations of the total average credit awarded for an Allen task is presented in Figure II-1, its approximate nature should be understood.

An alternative approach to approximate credit assessment was to total the credits earned (six universities) in all courses applicable to the aviation mechanic curricula and obtain their average. It was discerned that the range of credits was from a low of 65 semester hour equivalent in one institution to a high of 85 semester hours in another. The average credit hours awarded by the six universities was 72 semester hours.

Arizona State University Curriculum: Finally, the Allen topic content was investigated with respect to their inclusion in the existing array of courses of the Aeronautical Technology curriculum of Arizona State University. The extent of present emphasis of the respective topics was carefully analyzed, so that topic treatment and time allocation could be identified in the respective aviation courses. The data obtained was summarized in the right-hand block of information in Figure II-1 under the heading "Arizona State University Curriculum (Proposed)".

Specific courses being offered in the Aeronautical Technology program were examined for purposes of relating course content with the "topical" tasks of the Allen study. The numbers and titles of these courses which contain portions of all or part of the indicated requirements of the Allen tasks are listed in the Arizona State University column of Figure II-1. Sub-columns giving the allocations respectively to lecture or laboratory and their combined total in terms of weeks, as related to the Allen tasks, are also presented.

The approximate credit hour assessment for the various Allen tasks identified in the Arizona State University courses averaged 90 semester hours -- somewhat higher than the average for the other six universities studied. This appears to be due to the fact that a more precise identification of class hours and depth of coverage could be made because of the study team being located physically at Arizona State University.

Figure II-1, then, presents in order of horizontal progression from left to right: (1) the Allen tasks (52); (2) industry consensus; (3) National Advisory Committee teaching level consensus; (4) FAA recommended teaching level consensus; (5) industry survey data regarding projected emphasis; (6) certificated institutions topical analysis; and (7) the Arizona State University topical analysis and proposed curriculum.

Having completed the several investigative activities, the end task became that of the construction of an aviation maintenance technician curriculum which would be qualitatively acceptable and, therefore, feasible to be implemented in the context of the proposed aviation training center.

With the Allen study and its associated core curriculum determined to be the base of the new curriculum design, it was necessary only to extract and bring together those existing Aeronautical Technology courses identified in the right-hand block of Figure II-1, as treating significantly the Allen topics. In this way, the basic framework of technical courses were shown to be in existence in existing Arizona State University courses. To these were added the general education courses required to permit certification at the Associate in Applied Science degree level (two years).

After developing the collection of courses which constitute the curriculum proposal, the final step was that of sequencing the courses. The results are presented in the suggested sequential pattern, Figure II-3, which represents the derived Proposed Maintenance Technician Training Program.

The program is based on two calendar years of activity and, upon completion of the program, the student would earn the Associate in Applied Science degree. The credits earned under this program would be transferrable to one of the three options of the Bachelor of Science degree programs in Air Transportation discussed in the pilot curriculum study which follows.

ARIZONA STATE UNIVERSITY

AIRCRAFT MAINTENANCE TECHNICIAN TRAINING PROGRAM

1st YEAR

First Semester	Hrs.	Second Semester	Hrs.
EN 111 First Year English	[illegible]	EN 102 First Year English	3
MA 117 College Algebra	[illegible]	MA 118 Trigonometry	3
TA 1[illegible] A/C & Aerospace Struct.	[illegible]	TA 1[illegible] A/C & Aerospace Maint.	3
[illegible] Aeronautical Welding	[illegible]	[illegible] Descriptive Geometry	2
TM [illegible] Metal Processes	[illegible]	[illegible] General Chemistry	4
ED [illegible] Technical Drawing	[illegible]	TA 10[illegible] Technical Problems	2
	[illegible]		17

SUMMER SESSION

First Session		Second Session	
GB [illegible] Intro. to Business	[illegible]	[illegible] Aero Eng. & Design	2
[illegible] Numerical Methods	[illegible]	GB 30[illegible] Business Law	3
	[illegible]		5

2nd YEAR

First Semester		Second Semester	
TA 2[illegible] A/C & Aerospace [illegible]	[illegible]	TA 20[illegible] A/C & Aerosp Repair Maint	3
CH 11[illegible] General Chemistry	[illegible]	PH 11[illegible] General Physics	4
PH 111 General Physics	[illegible]	ME 30[illegible] Applied Thermodynamics	3
EE 200 Electricity & Electronics	[illegible]	TA 30[illegible] Aerospace Orientation	2
TA 3[illegible] Airport Planning	[illegible]	ME 3[illegible] Metallurgy	3
ME 230 Materials & Manuf. Proc.	[illegible]	TA 30[illegible] Aerosp Elect & Elect Sys	2
	18		17

SUMMER SESSION

First Session		Second Session	
TA 300 Aircraft Design	[illegible]	TA 30[illegible] Applied Aerodynamics	2
TA 308 Inspection Analysis	[illegible]	TA 30[illegible] Propulsion	3
TA [illegible] [illegible]	[illegible]		
	[illegible]		5

Figure II-[illegible]

Discussion: Although the basic framework of the proposed curriculum was now developed, other important factors required incorporation to finalize the work. It will be remembered that the teaching, testing levels of the Allen topics, as recommended by the National Advisory Committee and the Federal Aviation Agency, are to be relied upon heavily for the "internal" topic treatment and emphasis within courses. The predicted effects of technological change, as indicated by the industry survey, also have important implications for internal treatment of Allen topics. In this respect, the clear implications were that changes demanding a higher order of technical information were required. To accommodate some of these emerging requirements, additional subject matter not included in the courses indicated in Figure II-1 were incorporated in the proposed curriculum, Figure II-3.

While no reference has previously been made, it should also be noted that the Arizona State University Aeronautical Technology staff has been, for many months, assessing the internal topic structure teaching level and logic of the spectrum of Aeronautical courses in the four-year programs. These efforts, while not fully completed, have aided materially in selecting those additional aviation technical courses which can be expected to fulfill some of the objectives of meeting emerging technical requirements.

The maintenance technician training program, as suggested in Figure II-3, covers subjects offered in junior or community colleges and the Allen study, and also offer greater technical depth and subjects which meet the general education requirements for collegiate credit.

There is some question regarding the number of clock hours required by subject area to meet FAA certification requirements. It is hoped that, with continued improvements through curriculum development programs and the introduction of new educational technologies in the proposed training center, future certification emphasis will be on student achievement rather than on course hours of instruction.

A professional set of performance criteria tests should be developed which would be used to determine whether the student should be certificated for all or any part of the overall curriculum. If properly developed, the performance criteria tests could be used for "sub-certification", i.e., as a welder, sheet metal specialist, hydraulic specialist, electronic specialist, etc. Each of these specialty certificates would be added to and become a part of his overall A&P license.

The foregoing concept would permit a variety of flexible actions on the part of the student, the training institutions, and the certification/accreditation bodies, as follows:

1. The student who is not able to attend a two- or four-year program, but must, for economic reasons, become productive at the earliest possible time, can obtain his training in a specialty field, such as welding, and be certificated by the FAA. He can then become productive in the aviation maintenance industry.

2. If the performance criteria test were properly developed and the course material structured to produce a terminal behavior to meet the performance criteria, he would not only be certificated by the FAA but also be given collegiate credit which could be applied toward a degree, if he chose to further his education at a later date.

3. The performance criteria test approach would lead to a standardization of curricula for training maintenance technicians in all schools -- whether junior colleges, colleges, or universities. It would also establish a basis for awarding credits and, most importantly, a basis for the transferring of credits from one institution to another.

Another possible advantage that might be gained through such an approach is the development of a heretofore untouched manpower pool, which includes many of the disadvantaged people of our nation.

The massive manpower needs for the aviation industry were clearly identified and reported in Section I of this report. Traditional manpower sources of the American population appear to be inadequate to meet the magnitude of future needs, as indicated. Accordingly, and based upon both philosophical and economic considerations, it is highly desirable that sources of manpower which have been heretofore untouched or utilized should be explored and developed.

Reference is made to the disadvantaged segments of the society and, especially, to the Indians, Negroes, and Spanish-speaking Americans. It is believed that through the intelligent and skillful development of aviation vocational/technical curricula based upon the "sub-certification" philosophy and upon educational technology which will help the slow achiever or potential drop-out achieve success and, thus, provide a new block of manpower for the aviation community. This would, at the same time, alleviate the plight of certain disadvantaged people.

Pilot Curriculum

A literature search revealed that some limited efforts have been made to research the nature of pilots' tasks. Efforts have been made by the U. S. Air Force at the Aeromedical Research Laboratories, Wright-Patterson Air Force Base, and by the other military services. Some work has also been undertaken by the pilot training functions of the commercial carriers. Personal investigation and interrogation of directors of pilot training programs of various commercial carriers revealed that there is universal concern, some limited experimentation, and much interest in pilot training program renovation and innovation.

In the academic universe, Federal Aviation Regulations (Part 141) for pilot training set the parameters and guides for curriculum content and course duration, primarily with respect to flying hours. Conformity with the Regulations achieves government certification which is a prerequisite for pilot certification at all levels.

While an in-depth analysis of pilot tasks was found not to exist, even though it is vitally needed, the nature of that type of research effort was well beyond the stated scope of purpose and financial resources of this Feasibility Study. Accordingly, the decision was made to undertake an analysis of institutional literature related to the Federal Aviation Regulations for pilot certification.

Current Job Skills-Knowledge: In the absence of any precedential studies, such as the Allen study in the maintenance technician area, it became necessary to first develop a listing of job skills and knowledge requirements in a topical array for subsequent analysis. This was done by securing and analyzing FAA regulations for general and, where possible, specific subject matters related to pilot training. Institutional catalogs and bulletins were also analyzed for semantic/subject conformity with FAA requirements.

A listing was made of all subject courses offered, whatever the institution. The criterion was to avoid redundancy. The listing served several purposes, as follows:

1. It permitted identification of the extraordinary array of courses offered in the (nominal) pilot training programs in the various institutions.

2. It was an attempt to identify an intrinsic uniformity or cohesive pattern from which could be derived a core curriculum.

3. It aided the structuring of course offerings into a rational pattern from which to design an industry survey form to be used for obtaining expert counsel with regard to the significance of specific skills and knowledge for the next ten years and the development of the appropriate emphasis within future Arizona State University curricula.

The end product of the procedure described above resulted in a job skills/knowledge listing of fifty-three (53) items. It should be noted that all items were not "required" but were included, inasmuch as the fulfillment of general education degree requirements was involved as well as major fields of specialization. The listing is shown in the left-hand block of Figure II-4 under the heading "Current Job Skills - Knowledge".

Projected Industry Estimates: The item listing was then utilized as the basis for preparation of a survey form for submission to experts in the aviation industry. The specific purpose of the survey form was to elicit a response to each item with respect to its relationship to the pilot's tasks of the future, as influenced by emerging aviation technology. Thus, each respondent was asked to rate each item as to whether the emphasis should be increased or decreased in the structuring of a pilot curriculum.

The industry sample to whom the survey form was directed consisted of representatives who participated in the Arizona State University/Industry conference held in January 1967. A response was received from thirty-two individuals of thirty-five, which represents a 90% response. The respondents' distribution across the industry, as well as their professional title distribution, is presented in Figure II-5.

The response received from the industry representatives is presented in the second block from the left in Figure II-4. The numerical values shown are percentages of the respondents who indicated the probability for each skill increasing, decreasing, or not changing in importance. An examination of the three columns indicates that most of the respondents felt increased emphasis should be placed on the majority of the skills or knowledge areas listed.

PILOT CURRICULUM

COMPARISON OF EXISTING PROGRAMS & [illegible]

No.	CURRENT JOB SKILLS - KNOWLEDGE	PROJECTED INDUSTRY ESTIMATES - PERCENTAGE SKILL/KNOWLEDGE REQUIREMENTS: WILL INCREASE	NO CHANGE	WILL DECREASE
1.	English Composition	95	5	0
2.	Speech	[illegible]	[illegible]	0
3.	College Algebra	[illegible]	[illegible]	[illegible]
4.	Trigonometry	[illegible]	[illegible]	[illegible]
5.	Technical Drawing	[illegible]	[illegible]	[illegible]
6.	Economics	[illegible]	[illegible]	[illegible]
7.	Chemistry (Basic)	[illegible]	[illegible]	[illegible]
8.	Chemistry (Applied)	[illegible]	[illegible]	[illegible]
9.	Social Science	[illegible]	[illegible]	[illegible]
10	Literature (Humanities)	[illegible]	[illegible]	[illegible]
11.	Business Law	[illegible]	[illegible]	[illegible]
12.	Physics	[illegible]	[illegible]	[illegible]
13.	Biology	[illegible]	[illegible]	[illegible]
14.	Psychology	[illegible]	[illegible]	[illegible]
15.	Descriptive Geometry	[illegible]	[illegible]	[illegible]
16.	Analytic Geometry - Calculus	[illegible]	[illegible]	[illegible]
17.	Differential Equations - Fourier	[illegible]	[illegible]	[illegible]
18.	Numerical Methods	[illegible]	[illegible]	[illegible]
19.	Electricity & Electronics	[illegible]	[illegible]	[illegible]
20.	Direct Current Circuits	[illegible]	[illegible]	[illegible]
21.	Technical Writing	[illegible]	[illegible]	[illegible]
22	Aerospace Orientation	[illegible]	[illegible]	[illegible]
23.	Science & Technology - Statics	[illegible]	[illegible]	[illegible]
24	Aeronautics - Theory of Flight	[illegible]	[illegible]	[illegible]
25	Federal Aviation Regulations	[illegible]	[illegible]	[illegible]
26	Meteorology	[illegible]	[illegible]	[illegible]
27	Navigation	[illegible]	[illegible]	[illegible]
28	Flight Training - Private Pilot	95	5	0
	- Commercial Pilot	100	0	0
	- Instrument	100	0	0
	- Multi-Engine	100	0	0
29	Airway Procedures	95	5	0
30	Flight Operations	[illegible]	0	0
31	Combustion Analysis	[illegible]	[illegible]	[illegible]
32	Weight & Balance	[illegible]	[illegible]	[illegible]
33	Applied Thermodynamics	[illegible]	[illegible]	[illegible]
34	Aircraft Systems & Components	[illegible]	[illegible]	[illegible]
35	Aircraft Engines	[illegible]	[illegible]	[illegible]
36	Metal Processes	[illegible]	5	[illegible]
37.	Aircraft Electrical Systems	[illegible]	[illegible]	[illegible]
38	Principles of Vertical Takeoff Aircraft	85	15	0
39.	Aircraft Design	[illegible]	[illegible]	[illegible]
40.	Fluids	[illegible]	[illegible]	[illegible]
41	Aeronautical Welding	[illegible]	[illegible]	[illegible]
42	Air Carrier Regulations	[illegible]	[illegible]	5
43	Flight Planning & Management	85	[illegible]	5
44.	Principles of Management	95	5	0
45.	Systems Analysis	[illegible]	[illegible]	[illegible]
46.	Aviation Safety	95	5	0
47.	Air Traffic Control	95	5	0
48.	Accident Investigation	[illegible]	[illegible]	[illegible]
49.	Airline Administration	85	[illegible]	5
50.	Supervision & Labor	65	[illegible]	15
51.	Transportation Management	65	[illegible]	15
52.	Airport Operations	70	[illegible]	15
53.	Work Analysis & Design	65	[illegible]	15

NSI - not specifically indicated
* - general education
** - technical core

NUMBER	TITLE
EN 101-2	English
	Elective
MA 117	College Algebra
MA 118	Trigonometry
[illegible] 101	Technical Drawing
[illegible]	Introduction to Business
[illegible]	General Chemistry
	Elective
	Elective
[illegible]	Business Law
[illegible]	General Physics
	Elective
	Elective
[illegible]	Descriptive Geometry
[illegible]	Analytic Geometry & Calculus
[illegible]	Differential Equations & Fourier An[illegible]
[illegible]	[illegible]
[illegible]	Systems Analysis
CA 401	Business Systems Analysis
CA 461	Aviation Safety
CA 311	Air Traffic Control
CA 402	Accident Investigation
CA 470-471	Airline Administration
[illegible]	Supervision & Labor
[illegible] 341	Transportation
CA-301	Airport Operations
[illegible]	Work Analysis & Design
[illegible]	Human Engineering
[illegible]	Human Factors in Space Travel
CA-309	Radio Operation
CA-312	Instruments & Elect. Systems
MI-302	Manufacturing Design
CA-401	Aircraft & Aerospace Design
CA-321	Applied Aerodynamics
CA-384	Airport Planning
ED-380	Aerospace Dwg. & Design
MI-330	Metallurgy
CA-498	Pro-Seminar
CA-380	A/C & Aerospace Structures
CA-381	A/C & Aerospace Maintenance
MI-230	Materials & Mfg. Processes
CA-389	Aerospace Mfg. Analysis
CA-339	Technical Problems

Figure II-4

PILOT TRAINING PROGRAM

RESPONDENT DISTRIBUTION

Professional Position	Govt.	Univ.	Mfrs.	Comm. Airlines	Military
FAA District Supervisor	1				
CAP Deputy Chief of Staff - Education and Training	1				
Instructor Pilots		2			
Supervisor - Educ. & Training			1		
Advisor/Pilot, Office of Vice President & Manager			1		
Director of Flight				1	
Assistant Chief Pilot				1	
Director, Technology Training				1	
Director, Personnel				1	
Director, Maintenance Services				1	
District Transportation Mgr.				1	
Asst. Director - Flying Operations				1	
Manager of Training				1	
Training Instructor				1	
Training Supervisors				5	
Managers of Personnel				2	
Special Asst. to Director of Flight Operations Training				1	
Flight Training Manager				1	
Pilots					4
Commander, Student Pilot Squadron					1
Asst. Director, Flying Training and Airline Captain				1	
Commandant - Student Pilot Training					1
Manager, Marketing Research			1		

Figure II-5

FAA Certificated Programs: Following the establishment of the job skills/knowledge listing, an analysis was made of the institutional literature which identified curriculum courses, class-hour duration, flying hour duration, and academic credit, as published by nine FAA certificated pilot training institutions. A number of department heads responsible for pilot training programs were also contacted by telephone and mail to appraise them of the Arizona State University study and to request additional data. The nine institutions selected for study were as follows:

I. Universities
   A. Purdue University
   B. Southern Illinois University
   C. Western Michigan University
   D. Auburn University
   E. University of Illinois

II. Colleges
   A. Southeastern State College (Durant, Okla.)
   B. Parks College of Aeronautical Technology (St. Louis)

III. Flying Schools
   A. Embry-Riddle Aeronautical Institute
   B. Spartan School of Aeronautics

The rationale for their selection was based upon FAA certification, geographic dispersion, repute (qualitative passing of FAA tests by "graduates"), and continuity (a history of successful "product").

The results of the analysis of institutional data is presented in the third block from the left in Figure II-4 under the heading "Consensus Analysis - FAA Certified Programs". The results are presented for flying schools, colleges, and universities under columnar headings of lecture hours, lab hours, weeks duration, and total hours per week for the various skill/knowledge topics listed. The credit offered by an institution is shown, regardless of whether it is transferrable. Where zeros appear in the listing, it is an indication that course coverage of that particular topic is not offered in the pilot training curriculum.

Again, as in the maintenance technician curriculum study, the approach used here was to relate the semantic terms of the skill/knowledge "task" listing to the frequency of appearance in the courses offered within a specified curriculum, as published by the respective institution. The limitations of precise comparisons dictated by the approach used should be understood by the reader.

Arizona State University Curriculum: Following the analysis of institutional offerings, the topic listing was examined with respect to the inclusion of the individual items in courses being currently offered in the Aeronautical Technology curriculum of Arizona State University.

It was found that the fifty-three skill/knowledge requirements listed were identifiable in the existing Arizona State University courses shown by number and title in the right-hand block of information in Figure II-4 under the heading "Arizona State University Proposed Curriculum".

After analyzing the existing Arizona State University course offerings in terms of the topical skills-knowledge listing, the industry's projected estimates of the importance of these skills-knowledge requirements for the future and the FAA certificated programs offered by nine leading flying schools, colleges and universities, a proposed curriculum was developed for the aviation training center.

The proposed curriculum consists of three options, as follows:

Option I - Aeronautical Technology, which is the broad technical program

Option II - A Professional Pilot Training curriculum

Option III - An Air Transportation Management curriculum

Options I and II are now being offered and Option III will be offered in the 1967-68 academic year. The three options all lead to the Bachelor of Science degree. In general, they have a standard core, equivalent to the Freshman and Sophomore years. After completion of the standard core, the student may then select the option of his choice and proceed in a program which would be equivalent to the Junior and Senior years, emerging with a Bachelor of Science degree. The suggested patterns for each of the three options are set forth in Figures II-6, 7 and 8.

FIGURE II-6

OPTION I

AERONAUTICAL TECHNOLOGY PATTERN

FRESHMAN

First Semester	Hrs.	Second Semester	Hrs.
1-EN 101 First Year English	3	1-EN 102 First Year English	3
1-MA 117 College Algebra	3	1-MA 118 Trigonometry	2
TA 180 A/C & Aerospace Struct.	3	TA 181 A/C & Aerospace Maint.	3
TM 161 Metal Processes	3	WT 166 Aeronautical Welding	3
TD 111 Technical Drawing	2	TD 112 Descriptive Geometry	2
1-PE 101 Freshman Physical Education	0.5	ME 230 Materials & Indust. Proc.	2
1-AS 101 Basic Air Science	2.5	3-GB 101 Introduction to Business	3
	17.0	1-PE 102 Freshman Physical Ed.	0.5
		1-AS 102 Basic Air Science	0.5
			19.0

SOPHOMORE

TA 287 A/C & Aerospace Pwplt.	3	TA 288 A/C & Aerosp Pwplt Maint	3
IA 109 Technical Problems	2	1-PH 112 General Physics	4
1-PH 111 General Physics	4	1-CH 114 General Chemistry	4
1-CH 113 General Chemistry	4	TE 300 Direct Current Circuits	3
TE 200 Electricity & Electronics	3	ME 380 Applied Thermodynamics	3
TA 307 Aerospace Orientations	2	1-AS 202 Basic Air Science	2.5
1-AS 201 Basic Air Science	0.5		19.5
	18.5		

JUNIOR

TA 300 Aircraft Design	2	TA 301 Applied Aerodynamics	2
3-HU Upper Division	3	3-HU Upper Division	3
TA 306 Aerosp Elect. & Elect. Sys.	2	TA 384 Airport Planning	2
TA 308 Combustion Analysis	2	TA 388 Propulsion	3
TA 310 Prin. Vert. Takeoff A/C	2	TD 380 Aero Drawing & Design	2
EE 226 Numerical Methods	2	TA 389 Aerospace Mfg. Analysis	2
ME 330 Metallurgy	3	TA 486 Flight Operations Mgmt.	2
ME 381 Applied Thermodynamics	3	Approved Electives	3
	19.0		19.0

SENIOR

TA 390 Systems Analysis	2	TA 487 A/C & Aerospace Design	3
TA 488 Airline Management	2	TA 490 Aerospace Sys. Analysis	3
TD 400 Technical Writing	3	TA 498 Pro-Seminar	3
TA 498 Pro-Seminar	3	SS Electives - Upper Division	3
SS Electives - Upper Division	3	Approved Electives	7
Approved Electives	6		19.0
	19.0		

SUGGESTED ELECTIVES

TA 182 Air Navigation	3	3-MG 301 Principles of Management	3
TA 183 Glider Pilot Rating	2	3-GB 305 Business Law	3
TA 185 Private Pilot Certificate	1-3	IE 322 Work Analysis & Design	3
TA 382 Advanced Air Navigation	2	IE 439 Supervision & Labor	2
TA 383 Instrument Rating	2	IA 443 Safety	2
TA 385 Commercial Pilot Cert.	2-8	1-MA 120-121 Anal. Geom. & Calculus	4 ea.
TA 386 Flight Instructors Rating	2	1-MA 212 Analytical Geom. & Calculus	4
TA 387 Multi-Engine Rating	1	1-MA 220 Differential Equations	3
TD 340 Fluids	3	1-MA 360 Diff. Eq. & Fourier Analy.	3
ME 301-302 Sci. & Tech. in Hist.	3 ea.	EE 326 Numerical Methods	3
ME 332 Manufacturing Design	2		

FIGURE II-7

OPTION II

AIR TRANSPORTATION
PILOT TRAINING PROGRAM PATTERN

JUNIOR

First Semester	Hrs.	Second Semester	Hrs.
TA 182 Air Navigation	3	TA 309 Radio Operation	2
TA 300 Aircraft Design	2	TA 311 Air Traffic Control	2
TA 302 Meteorology	3	TA 312 Instruments & Instr Systems	2
TA 303 Federal Air Regulations	2	TA 382 Advanced Air Navigation	2
TA 305 Weight and Balance	1	TA 384 Airport Planning	2
TA 306 Aerosp Elect & Elect Systems	2	TA 388 Propulsion	3
TA 308 Combustion Analysis	2	3-HU Upper Division	3
3-HU Upper Division	2		
	17		16
TA 185 Primary Flight Training	3	TA 385 Advanced Flight Training	3
Total Clock Hours	40	Total Clock Hours	40

SUMMER SESSION

KE 320 Metallurgy	3
MG 301 Principles of Management	3
Electives and/or Deficiencies	6
	12
TA 385 Advanced Flight Training	3
Total Clock Hours	40

SENIOR

First Semester		Second Semester	
TA 389 Aerospace Mfg. Analysis	2	TA 486 Flight Operations Mgmt.	2
TA 390 Systems Analysis	2	TA 487 Aircraft Design	3
TA 391 Airport Operation	2	TA 492 Accident Investigation	3
TA 488 Airline Management	2	TA 493 Airline Administration	2
TA 491 Aviation Safety	2	TA 498 Pro-Seminar in Air Transp.	3
TD 400 Technical Writing	3	SS Electives - Upper Division	3
SS Electives - Upper Division	3		
	16		16
TA 385 Advanced Flight Training	2	TA 383 Advanced Flight & Instrument Rating	2
Total Clock Hours	40	Total Clock Hours	40

SUMMER SESSION

Electives and/or Deficiencies	12 Semester Hours
TA 386 & TA 387 Advanced Flight and Instrument Rating	10 to 40 Clock Hours

FIGURE II-8

OPTION III

AIR TRANSPORTATION
AVIATION MANAGEMENT TRAINING PATTERN

JUNIOR

First Semester	Hrs.
TA 300 Aircraft Design	2
TA 306 Aerosp Elect. & Elect. Systems	2
TA 308 Combustion Analysis	2
HU Upper Division	2
MG 301 Principles of Management	3
EE 226 Digital Computer Programming	2
IE 322 Work Analysis & Design	3
GB 341 Transportation	3
	19

Second Semester	Hrs.
TA 301 Applied Aerodynamics	2
TA 384 Airport Planning	2
TA 388 Propulsion	3
TA 390 Systems Analysis	2
KE 320 Metallurgy	3
KE 389 Program Control Methods	2
HU Upper Division	3
GB 305 Business Law	3
	20

SENIOR

First Semester	
TA 303 Civil Air Regulations	2
TA 391 Airport Operation	2
TA 488 Airline Management	2
TA 491 Aviation Safety	2
TA 498 Pro-Seminar in Air Transp.	3
TD 400 Technical Writing	3
SS Electives - Upper Division	3
GB 461 Air Transportation	3
	20

Second Semester	
TA 311 Air Traffic Control	2
TA 486 Flight Operations Mgmt.	2
TA 487 Aircraft Design	3
TA 492 Accident Investigation	3
TA 493 Airline Administration	2
TA 498 Pro-Seminar in Air Transp.	3
SS Electives - Upper Division	3
	18

Discussion: An examination of the subjects listed in the proposed curriculum in the right-hand block of Figure II-4 will show that more additions were proposed than the current Job Skills-Knowledge listings in the left-hand block. The legend identifies such additions, as well as indicating the core curriculum experiences which are common to each of the three Bachelor of Science aviation options listed in Figures II-6, 7 and 8.

The clock hours offered in the proposed curricula are considerably more than required for FAA ground school certification (item 28, Figure II-4). The flight hours are not listed but will consist of 250 flight hours, plus synthetic trainer time. This will provide for a commercial pilot's license with an instrument rating.

The relationships between the academic and flight portions of the baccalaureate, three-option program and the maintenance technician program for the proposed aviation training center are shown in Figure II-9.

The three options are shown under the major heading "Aeronautical Technology". Options I and III are non-flight and Option II includes approximately 250 hours of primary and advanced flight training. The technician program, as described previously in this section of the report, will be conducted under the heading "Support Personnel". The "Special Courses" area pertains to short-term, contract-type courses, such as flight training for ROTC students, aviation seminars, etc.

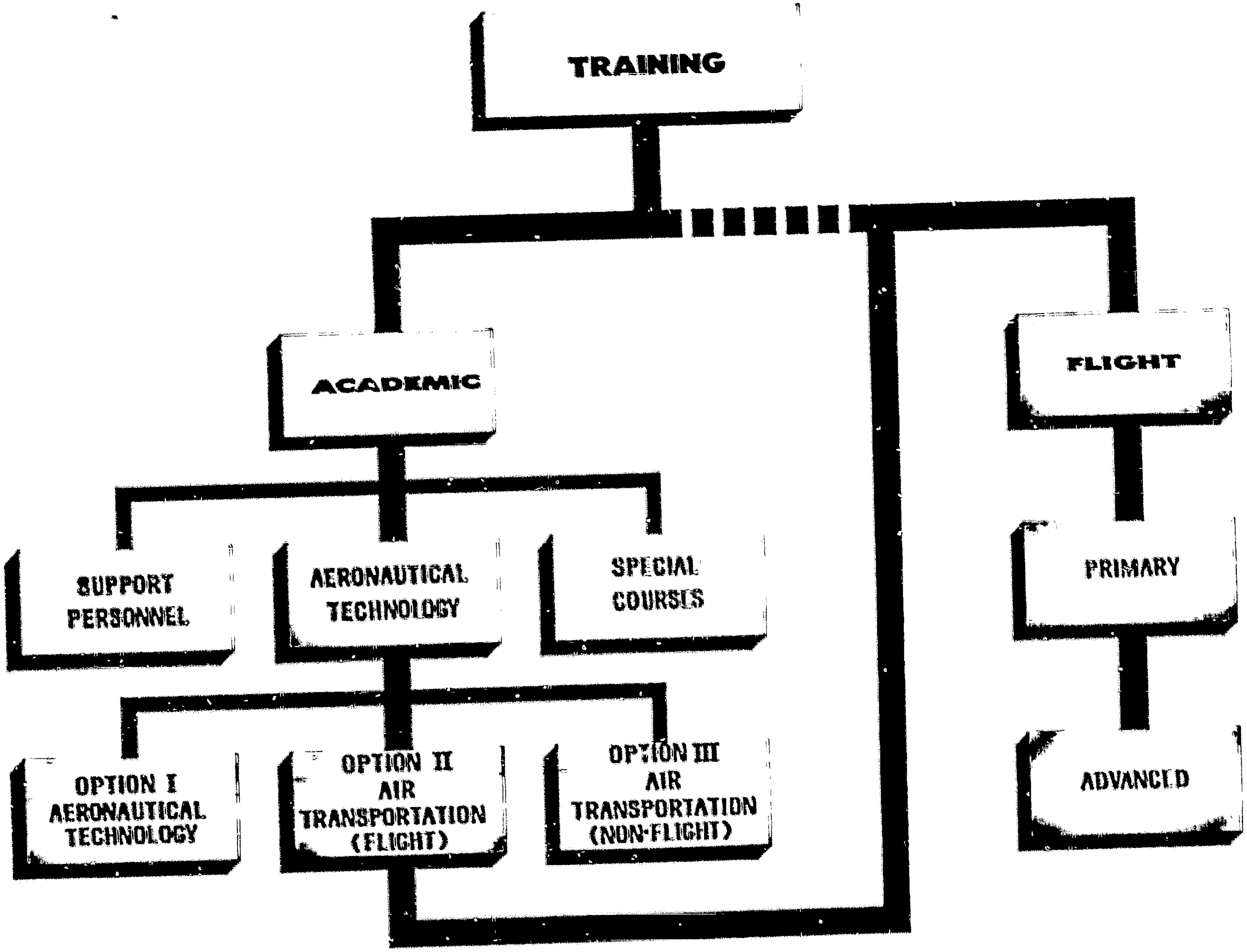
As in all flight training activities, a significant percentage of the students drop out because of aptitude and attitude deficiencies. In this program, they will be able to select one of the non-flight options regardless of when they drop out of the flight program (within reason, of course). This provides for a considerable amount of flexibility for the student.

This flexibility goes beyond the baccalaureate program, in that the student can drop back to the maintenance technician program and obtain a certificate in the Associate in Applied Science degree level or become a specialist in one of the technician areas. Conversely, the maintenance technician student can move upward into the Aeronautical Technology area for a Bachelor of Science degree, if he chooses to do so, with his earned credits applying toward the degree.

Taking into account the constraints on this part of the overall Feasibility Study, it is felt that the initial step for improving existing curricula has been achieved. It is anticipated that accelerated improvements will occur in the proposed aviation training center through curriculum and educational technology developments. As these improvements are disseminated and put into practice, aviation students of the future will be equipped with the qualitative skills and knowledge necessary to meet the emerging job requirements of the aviation industry.

FIGURE II-9

AIR TRANSPORTATION PROGRAM



New Education Technology

In the various definitions of the two verbs "to train" and "to educate", the underlying similarity is "to develop or form by systematic instruction". The term "instruction" seems to be a word which can refer to general operations with which both training and education are concerned. In this sense, this portion of the report is concerned with "instructional technology" and its role in aviation training.

Aviation is on the verge of significant advancements in many areas. The intercontinental supersonic aircraft, the very large super transports, the smaller economical local service transports -- all of these will open great passenger markets and increase the number of aircraft in commercial service. New general aviation aircraft production will also steadily increase. Each will expand industries already in critical need of highly skilled technicians, mechanics, and pilots. The quantitative requirements to meet these needs have been amply documented in Section I of this report.

Each will require even greater degrees of highly skilled training and technical knowledge. This training must start long before job openings occur. Young people must be motivated early in their school careers to follow courses which lead to employment in the aviation industry. One of the goals should be to upgrade the image of aviation as a profession which is prepared for in universities offering baccalaureate degrees and certified ratings in many aviation disciplines; in schools offering effective, up-to-date curricula (curricula employing the most effective and up-to-date instructional technologies available); and in institutions offering a broad education, as well as specific skill training. This is an image of educational institutions whose graduates are eagerly recruited for responsible jobs in the aviation industry, because they have been amply prepared for their careers by curricula that are specifically designed to develop the students' behavior in patterns which match realistic occupational requirements.

Many people, unfortunately, have become conditioned to think of educational technology as being synonymous with teaching machines. Educational technology is, in fact, the science of designing new curricula which makes maximum, effective use of modes, methods, media, materials, and machines, in order to permit students to achieve specific, pre-determined behavioral objectives which are based upon specific occupational requirements.

There are four basic tenets by which educational technologists are guided:

1. Students are individuals and learning materials and courses must be designed so as to adapt to the individual. Lockstep educational methods are no longer satisfactory.

2. Curriculum objectives must be defined in terms of specific, observable behavioral changes. These changes in a student's behavior are brought about by careful presentation of information, the student's own interaction in response, and the student's discovery of principles and concepts.

3. If the desired results are not achieved, then the learning materials are at fault. If the student does not pass the criterion test, it is not the fault of the student but rather the inadequacy of learning materials and they must be re-designed.

4. In the process of designing learning materials, the media selected for a particular step or lesson is principally determined by the subject matter. For example, audio is required in learning music appreciation and visuals are a must in learning art appreciation. Most subject matter areas lie somewhere between these two extremes and require the use of what has become known as multi-media.

One of the most difficult challenges in systems design is the complete definition of objectives. It is easy to say, for example, that we want a new aircraft that can fly higher, faster and farther. Similarly, it is easy to say that what we want is an education system that prepares more individuals better, for more complex roles in our society and at a lower cost. These statements are inadequate definitions of objectives.

To desigr the aircraft, we must define the top speed, the maximum runway length, the minimum acceptable range and payload, etc. Similarly, for the learning process we must define our educational objectives specifically in terms of the competence the student must demonstrate upon completion of the educational experience. This competence must be specified by the end user; in this case, the aviation industry itself.

The resultant desired behavioral change is then broken down into many small steps which students can accomplish one at a time. These steps are carefully designed to achieve specific, small objectives. Information, materials, and media are then prepared for this minute step. As each step and lesson or series of lessons are designed, they are tested with students in a realistic learning situation. If the desired behavioral objectives are not achieved, then the program and learning materials are re-designed until these desired results are obtained. An illustration of these principles is presented in Figure II-10.

SYSTEM DESIGN FOR EDUCATIONAL TECHNOLOGY
(COMPUTER-BASED/MULTI-MEDIA)

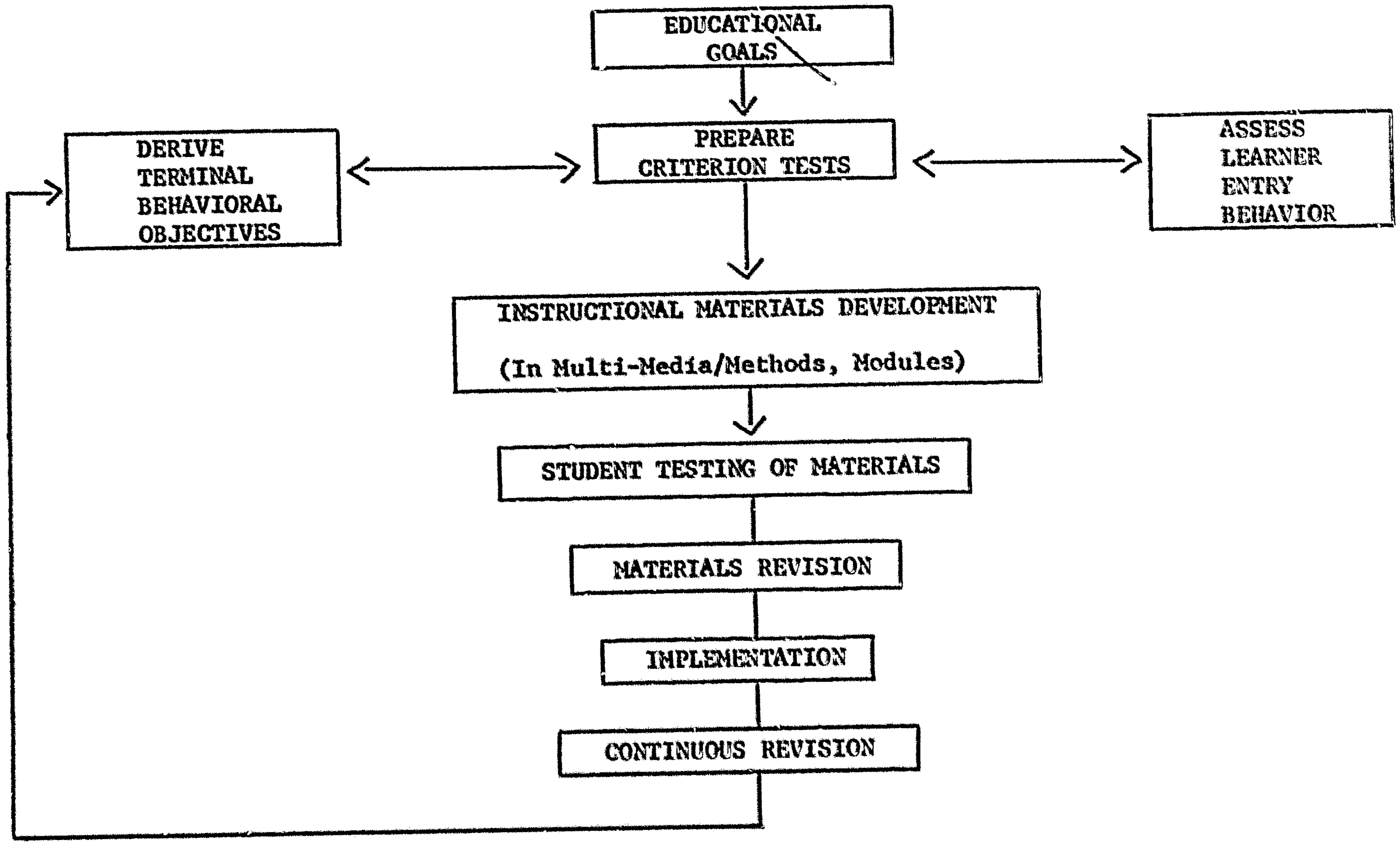


Figure II-10

A new curriculum for aviation training must include not only the equipment but the program material (text, films, slides, workbooks, computer programs, and the entire software lineup) which goes with it. It must also include the proper facilities for its use, the means to keep the system working, and the methods by which it will interact with both instructors and students.

Many in the aviation educational community are currently emphasizing curriculum development projects which seek to tap the total capacity of the individual, including the intellectual, the manipulative, the creative, and the social. These efforts are aimed at exposing students to an understanding of the real world through a series of experiences which capitalize on the universal desire of youth to investigate for himself. The common theme of these activities is to bring the "real life" world of aviation requirements into the schools, so that graduating students may be immediately useful and productive in the aviation industry without the need for a long, tedious and expensive on-the-job training. The key to all of this is, of course, the development of realistic job requirements data which will serve to identify the specific educational objectives of the new individualized curricula being developed.

Along with curriculum development efforts, great emphasis is also being placed on compatible educational equipment developments. One of the equipment areas receiving great attention is the use of computers in learning. The past fifteen years have seen computers grow from the status of unusual tools for specialized research to the status of systems which support, sometimes in an indispensable way, a significant proportion of our society's activities. Through this evolutionary period, there have occurred a number of major advances in which the vision and perseverance of pioneering workers have achieved successful application of computers to new areas. Most often, the appearance of computer capability in a new activity has had a marked impact on patterns of work in that activity.

Office procedures have changed, along with training requirements, employment opportunities, facility requirements, and so on. Most importantly, with computer application and use, quality and productivity have improved.

Viewed in this perspective, the concept of use of computers in learning is an exciting, but natural, development. The concept is based on the simple assumption that there are, in a learning environment, some functions analogous to those in other activities to which computers have been successfully applied. If there are such functions and they constitute a significant supporting element in learning, the learning environment will be made more productive through the use of computers.

Computer-aided learning (CAL) is learning in an environment where the material presented to the learner is selected and sequenced to be responsive to the learner's needs, with the aid of a computer.

In the definition just given, the key words are "selected . . . to be responsive". A familiar use of responsive selection is represented by the medical prescription. In this case, the prescription results when a physician's diagnosis is used as "input data" to a procedure containing, simply, rules for prescribing. Clearly, if rules for prescribing were complete, unambiguous, and constant over reasonable periods of time, the procedure could be mechanized.

The concept of a prescription is used also in computer-aided learning. Here, the prescription consists of a sequence of presentation of learning material. The selection of this sequence is made following a procedure which uses as its "input data" specific information about the learner. Just as in the medical case, mechanization of the procedure depends on rules for selection which are complete, unambiguous, and reasonably static.

Of course, medical prescriptions are not mechanized partly because the rules are not sufficiently well defined, partly because it is probably cheaper for a doctor to do it. Is there any reason to believe that the rules for preparing a "learning prescription" are better defined or that such prescriptions are cheaper to produce?

It is at this point that the analogy breaks down in a vitally important way. Fortunately, most of us need medical prescriptions infrequently. But a student, a learner, needs a learning prescription on a minute-by-minute, hour-by-hour basis. In today's educational environment, the prescription he gets is inadequate because educational economics do not permit individualized prescription when traditional methods are used. Possibly the greatest promise in computers for learning is the expectation that they will make individualized prescription economically feasible.

Programmed instruction, for example, is a specific form of the prescription concept. If the use of the computer is not required and if the pattern of prescriptions is not too complex, it is practical to present programmed instruction in book form. This is currently being done in many subject areas, although use of such material is not widespread.

In programmed instruction, units of material are covered by learners in relatively short time periods, minutes in most cases, sometimes even less. To cover a substantial amount of subject matter, the learner passes through a large number of units. Also, if a branched structure is used, the number of possible individual paths becomes very large.

If computer capability is added to this picture, the problems become much easier to solve. It is an easy task for a computer to compare student responses with stored tables of correct and incorrect responses, to follow a given procedure for selection of succeeding units, to accumulate a history of responses for individual students, and even to provide electrical impulses to control devices which contain the unit sequences in various forms. Using a computer in this way gives us a basic pattern for computer-aided learning.

The operation of an advanced education technology system is presented in Figure II-11. The figure illustrates the principles described above and shows how the computer can be used in selecting the individualized prescription for a student on the basis of pre-entry information and learner behavior measurement data.

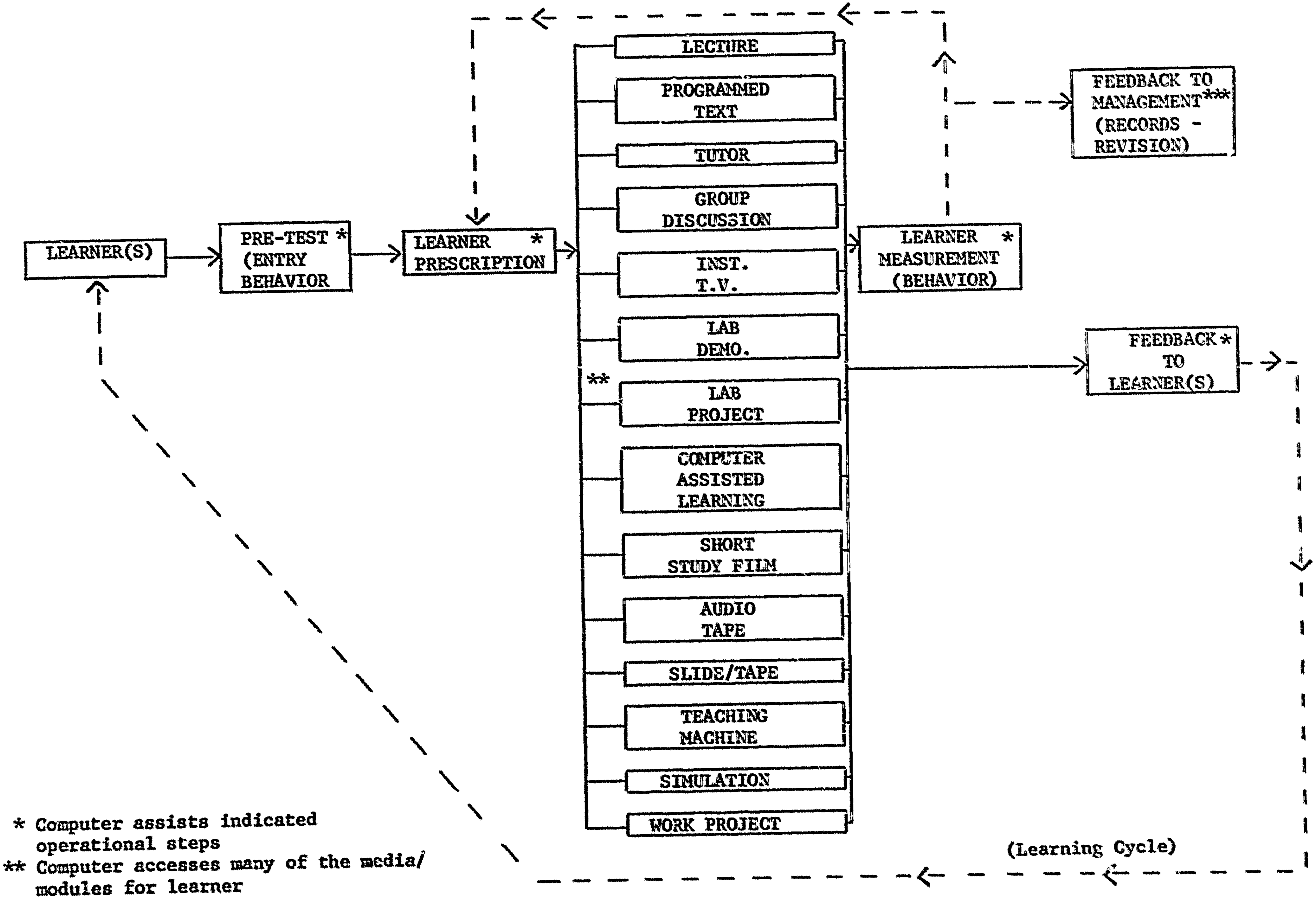
An optimistic view has been taken here in describing the potential benefits of CAL. It is easy to find obstacles which will impede progress in CAL, but we are at the point where each obstacle seems to be matched by a feasible advance. To accomplish the necessary advances, however, will certainly require experiment, and experiments in learning pose distinct problems. Experimental and developmental testing on a fairly large scale are needed. The widening range of social and economic needs calls for major steps toward education, as an individual learning experience, for vast numbers of people. Even considering the difficulties, the use of CAL promises a way to plan these steps with the strength of a new, powerful tool.

It is anticipated that the products of the cooperative operation and research activities suggested for the proposed aviation training center will be beneficial to the aviation industry and a credit to the educational community. It is also believed that they will be a major contribution to the skilled manpower reservoir of the country at large and, therefore, an enhancement of the vital human resources which are in the long run the most important single resource that an industry or a country possesses.

Section I of this report documented the need for significant numbers of skilled aviation personnel, particularly pilots and mechanics. The task of developing the tremendous numbers of required skilled manpower is a formidable one which no single university and no single company can hope to accomplish by themselves.

The industry/university working relationship recommended for the proposed aviation training center could form the basis for meeting the future skilled manpower needs of the nation. By dedicating their respective talents

OPERATION OF EDUCATIONAL TECHNOLOGY SYSTEM
(COMPUTER-BASED/MULTI-MEDIA)



* Computer assists indicated operational steps

** Computer accesses many of the media/ modules for learner

*** Computer provides data processing for educational management

Figure II-11

and efforts to the task of creating new aviation curricula and education technology, they may be able to set the pace that others may follow. These joint activities, coupled with immediate and widespread dissemination of findings, could result in the solution of both the quantitative and qualitative requirements of the industry on a national basis.

What is needed is not just more of the contemporary air colleges and fixed-base flight training operations but rather a comprehensive, efficient, total academic/vocational/technical curriculum development program combined with an equally comprehensive developmental program for new educational technologies. These efforts should be designed from the start to be responsive to the requirements of the aviation industry.

Conclusions

The major conclusions derived from an analysis of current aviation training activities and the potential for new education technology and its role in these activities were as follows:

1. Relatively little research has been executed which relates to pilot and mechanic qualitative curriculum design and its operational effectiveness. This is also true for other aviation curricula.

2. The one exception is the Allen study of the aviation mechanic's occupation. This is an excellent study; the best work done in twenty-five years.

3. A comprehensive, qualitative research program utilizing a variety of methodologies is greatly needed in a broad variety of important aspects of aviation education.

4. An extraordinary array of courses (subjects) are offered within the pilot and mechanic training programs of the selected FAA certificated institutions.

5. Although the literature of the selected FAA certificated institutions did not overtly identify the tasks covered within a subject, there was a rather consistent thread of continuity within all curricula.

6. In response to the findings and recommendations for the revision of core curriculum and the teaching levels of the aviation mechanic curriculum, as presented in the Allen study, the Federal Aviation Administration has proposed a quantitative revision upwards for the total hours of instruction required.

7. Instructional time in terms of clock hours, despite its limitations as a qualitative standard of proficiency, remains as the "core logic" of curriculum design in institutions involved in aviation education.

8. Certification should be dependent upon achievement and demonstrated competence rather than hours spent in a classroom.

9. Better defined standards of competence and improved measurement techniques for achievement should be important objectives in upgrading and revising curricula.

10. In addition to providing FAA certification, the aviation maintenance technician's curricula should facilitate follow-on transition into courses of further academic study in allied career fields.

11. The pilot's curriculum should be enriched substantially beyond job specification knowledge and skill requirements. Personality and attitudinal development courses should be given consideration.

12. There is a requirement for a study of the pilot's occupation patterned after the Allen study of the mechanic's occupation.

13. The proposed pilot and maintenance technician curricula derived from this study represent qualitative improvement over existing curricula primarily in their assessment and provisions for meeting emerging needs.

14. While representing substantial improvement, the maximazation of efficiency in aviation curricula design can occur only when the required further research identified in the recommendations is performed and when such curricula are operationally implemented with newer educational technology.

15. Task-oriented curricula, despite a great deal of discussion of "terminal behavior", is a relatively new concept at the college and university level. In trying to "fit" university subjects and courses to precise tasks, the accommodation factor necessarily had an intrinsic resiliency.

16. The implementation of curricula via educational technology is currently feasible from a technical viewpoint.

17. The joint Arizona State University/General Learning Corporation research effort in vocational/technical curriculum development based on a computer-aided multi-media approach will provide great assistance and impetus to the application of technology to aviation education.

Recommendations

On the basis of the information contained in this Section of the report and the conclusions presented above, it is recommended that:

1. Full consideration be given to the implementation of the proposed pilot and aviation maintenance technician curricula as the nucleus of a future and broader aviation occupational group of curricula, and that such implementation be considered in the concept of the aviation training center, as explored in this study.

2. Concentrated efforts be made to initiate an organized aviation education research program to attack vital problems, some of which are:

   A. Pilot Task Analysis (Terminal Behavior Analysis): A study, comparable in depth and duration, is needed to ascertain civilian pilot tasks in terms of what a pilot does and the sequence in which he does it; the relevance of tasks, one to another; the priority of learning sequence of tasks he performs; the frequency with which he performs tasks; and the degrees of manipulative skills required of specific tasks.

   B. Relevance of FAA Certification Requirements (Especially in the Area of Aviation Mechanics to the Daily Job Performance in the Current and Emerging Aeronautical Industry): More attention should be given to the possibility of FAA "specialist certification; enabling the vocational training of qualified manpower who can work under the direction and supervision of FAA certified supervisors, thus helping to meet some of the projected industry manpower needs. A study should also be made of the relevance of quantitative measures of training to qualitative measures of performance.

   C. The Relevance of Current and Proposed Aeronautical Technology Curricula to Professional Terminal Behavior: Quantitative research is needed to identify precisely what various aviation industry jobs require behavioristically and how a particular behavior might be optimally derived (acquired to the highest level of acceptable performance in the shortest period of time). This research effort could, at the same time, study the relevance of position guides, organizational structure as it affects actual daily operational behavior and the human acts involved in conducting the job. Subsequently, the curriculum design would stipulate objectives for producing that behavior.

D. The Operational Proficiency of Certificated Aviation Mechanic and Pilot Training Institutions: Research is needed to ascertain qualitative measures of curriculum content, structure, and design; instructional capability and teacher training; uses of educational methodologies; on-the-job proficiency and productivity of graduates; climate for innovation within the institution; the "feedback" efforts adopted to measure their own performance; industry acceptance of graduates; and industry utility or use of graduates.

E. A Comparative Cost Analysis of In-Depth Specialty Training for Pilots and Non-Pilots: Undoubtedly, individual carriers are conducting on-going cost analyses of their own training investments. A collective analysis concentrating on what is being taught; how it is being taught; measurement factors of productivity; temperament factors effect on training; aptitude identifications and correlations, if any; and other areas need to be determined. The products of such research could then be related to what can and should be done by pre-professional education and training institutions to reduce the on-the-job training investments of the carriers.

F. The Relations of Task Performance Levels to Psychic Motivations, Especially Among Pilots: Are there intellectual and attitudinal factors which can be identified and used as predictive elements for success in pilot training? Such research can be related to career and personal development choices, aptitudes, and motivations.

G. The Role of Advanced Education Technology: Extensive research and experimentation is required to determine the role of newly emerging educational technologies in aviation training operations.

H. Instructor Personnel Education and Training for Aviation Curricula: Research and training activities are needed, especially in the use of currently available media, modules and methods, but, more importantly, in the potential applications of new educational technology to aeronautical technology curricula.

I. Motivation Programs: Research efforts are needed for the analysis and design of educational programs whose objectives will be to motivate high school students, teenagers and other segments of our population to pursue professional careers in the aviation industry.

3. An aviation industry/education research and development center be established within the context of the proposed aviation training center to initiate, conduct or coordinate these studies as appropriate. Further, it is recommended that careful attention be given to plans for national dissemination and implementation of the anticipated research findings, curricula, instructional materials and systems.

4. Within the context of the proposed aviation training center, fullest consideration be given to the establishment of a (civil aviation industry) education/training documentation center, providing for automated retrieval and remote access provisions for the civil aviation industry.

SECTION III

SITE SELECTION STUDY

Introduction

This section of the report deals with the selection of a site suitable for accommodating the type aviation training center visualized. During the site selection study, consideration was given to the existence and suitability of land, runways, buildings, and utilities; location with respect to other air traffic, such as commercial airways and military operations and to practice areas; the current status of each site; and the potential economic impact of an aviation training center on surrounding communities.

The original submission of the feasibility study proposal to the Economic Development Administration was based on the premise that, if such a center were established, the economic benefits to the local community would be significant and that a project for the establishment of such a center would, therefore, qualify as an economic development program. The two locations considered in the site selection study were the Litchfield Naval Air Station located west of the City of Phoenix and the Goodyear Auxiliary Airfield located on the Gila River Indian Reservation southwest of Phoenix. Both of the sites are within a twenty-mile radius of Phoenix and both were faced with or are experiencing serious economic problems. Only the Gila River Indian Reservation site, however, is located in an Economic Development Administration Redevelopment Area. Figure III-1 shows the location of the two sites in relation to Phoenix, Tempe, and other communities.

Methodology

The research and evaluation procedures followed during the site selection study included:

1. Visits to both sites to examine facilities, records, and equipment.
2. Conferences with appropriate representatives of both locations.

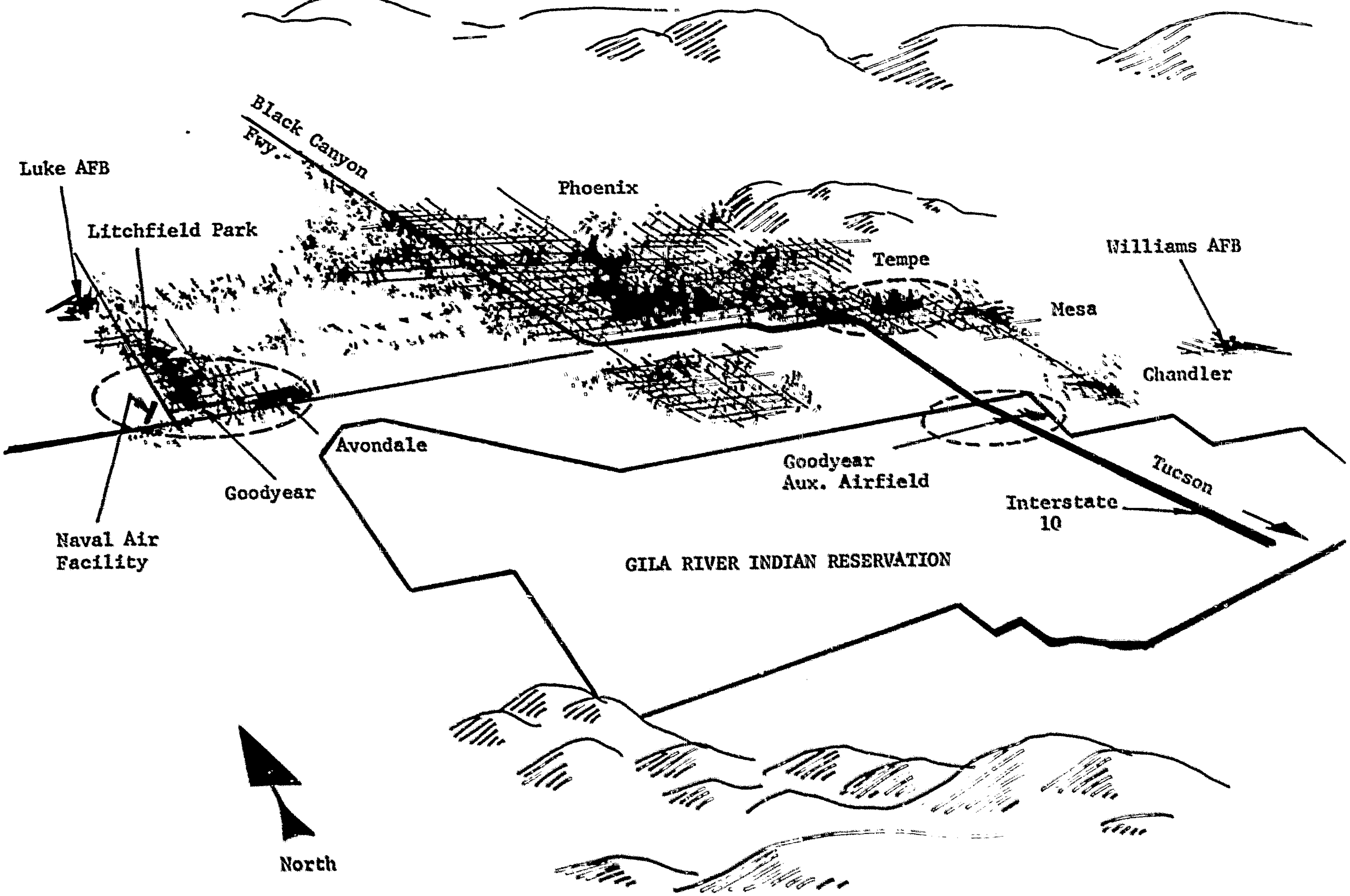


Figure III-1 - Geographic Relationships of Proposed Sites

3. Detailed studies of civil airways operations in the vicinity of both sites and of the military operations of Luke and Williams Air Force Bases, which are in close proximity to the Litchfield and Goodyear Auxiliary sites, respectively.

4. The past, present, and future economic outlook for areas surrounding each site were analyzed.

5. A detailed analysis of the economic impact of the proposed training center on surrounding areas was made. Types and potential number of jobs which might be created and the potential individual and area income were estimated.

Description of Sites

Litchfield Naval Air Station: The U. S. Naval Air Facility located at Litchfield Park, Arizona, approximately twenty miles west of Phoenix, was a storage, reclamation, and disposal complex designed for utilization by the U. S. armed forces in their aviation programs. The facility was established during World War II as an auxiliary acceptance unit for Navy patrol bombers. Through progressive utilization and growth, the facility expanded to its present size of 805 acres, containing 200 buildings and structures.

The complex, valued at over $15 million, had a work force of 1,085 people at peak employment, of which 700 were civilians. The annual payroll of over $4.5 million contributed substantially to the economic stability of the communities of Avondale, Goodyear, and Litchfield Park, which supplied most of the work force. The combined population of these communities is approximately 9,000.

A decision to deactivate this facility was made by the U. S. Department of Defense in 1964. This deactivation program, designed to improve operating efficiency and achieve certain monetary savings for the federal government, is underway and will be completed by 1 July 1967.

The shutdown program was expected to cause a loss of about 60% of the economic stability of the three small communities mentioned above. This loss has not developed, however, because new work has been obtained in these communities at a rate approximately equal to the rate of loss caused by the phased shutdown of the Naval Air Station. Of the 700 civilians employed at the Naval Air Station, 50 resigned from Civil Service, 75 retired, 315 transferred to other government and local jobs, and 260 transferred to other locations which absorbed the facility's functions, such as Tucson, Arizona, or some of the Naval facilities in California.[1] The new work acquired in the three communities more than offset the payroll losses caused by the dispersal of the personnel.

During the shutdown program, all equipment was removed, leaving only the vacant buildings available for future occupants. Following is a detailed description of the total facility:

> Land: Slightly over 805 acres of land are available within the complex shown in Figure III-2. Of this total acreage, approximately 12 acres are considered improved and the balance are considered semi- or unimproved acreage. A total of 9.3 miles of roads are located on the base. Of this total, 5.5 miles are paved of bituminous asphalt and 3.8 miles are unpaved. A chain link security fence encloses the base. This fence is 6 feet in height, with three or five strands of barbed wire. The total length of the fence enclosing the base is 36,760 linear feet.
>
> Acquisition information indicates that approximately 655 acres of land were transferred to the U. S. Navy by the Reconstruction Finance Corporation through a quit claim deed in December 1948 The additional land was acquired later from private owners through condemnation proceedings. Several out-grants and easements exist with the El Paso Natural Gas Company, Southern Pacific Railroad, and the Goodyear Aerospace Corporation with respect to gas mains, railroad crossings, and joint usage of the runway. These agreements are expected to be maintained by any future occupant of the base.
>
> Runways: The airfield includes a single runway, 8,500' long X 150' wide. The runway is of asphaltic concrete and has an excellent base and runway lights. The runway is designed to accommodate heavy, four-engine aircraft. A total of 202,900

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[1] From personal interview with Naval Air Station Personnel Department.

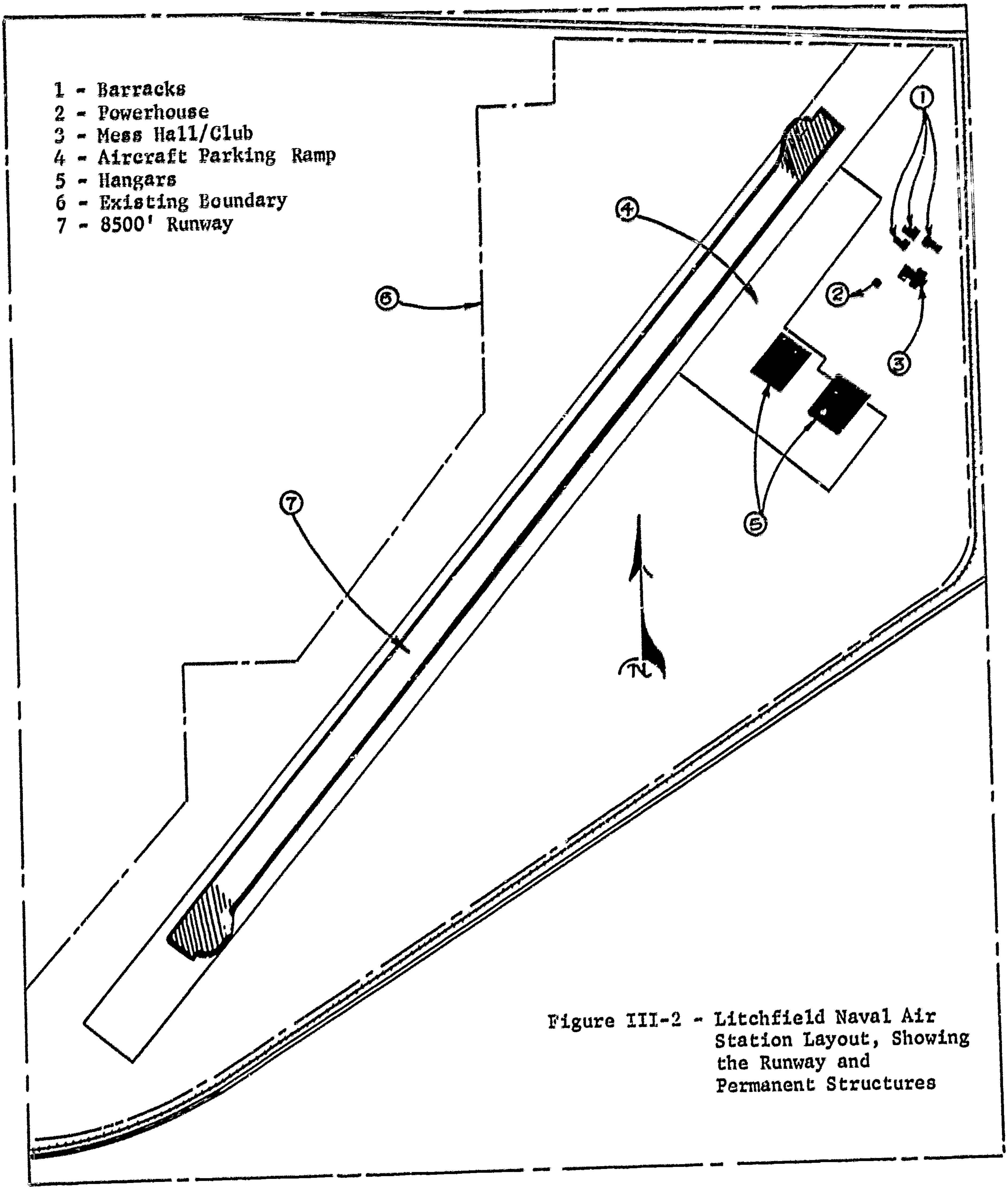

Figure III-2 - Litchfield Naval Air Station Layout, Showing the Runway and Permanent Structures sq. yds. of aircraft parking aprons (PC) are located adjacent to the service hangars, extending to the NE alongside the runway. The long dimension parallel to the runway is 2,100 feet in length and 300 feet wide, with a single wheel load capacity of 120,000 lbs. The short leg of the "L" shaped apron measures approximately 1,400 feet in length and 700 feet wide.

Buildings, Structures, and Miscellaneous Facilities: A total of 112 buildings did exist on the facility, of which 30 were considered permanent, 61 semi-permanent, and 21 temporary. Some of these buildings were removed during the shutdown procedure.

The facilities on the base include certain key buildings, particularly two hangars numbered 18 and 52. Hangar No. 18 is 400' long X 300' wide X 60' high. Two doors are contained in the structure on each side, providing for door openings 320 feet in width. The door heights are 39' 10". Shops and office space in the amount of 29,000 sq. ft. are included in this building. The building contains a total of 120,246 sq. ft. The hangar is constructed of reinforced concrete foundation and floor, wood frame with cement asbestos shingled walls, and bituminous roof coating on a wooden roof. The building was constructed in 1945 and is considered a permanent building.

Hangar No. 52 is 450' long X 300' wide X 60' in height, with two doors per side, providing for a 320' door opening on each side. The door heights are 39' 5". The hangar contains shops and office space, along with supply warehousing in the amount of 43,700 sq. ft. A total of 145,000 sq. ft. of floor space is contained within this hangar building. The hangar is constructed on a reinforced concrete foundation and floor. It has metal siding and a metal bituminous roof coating on a metal roof. The hangar was constructed in 1953 and is considered a permanent structure.

Three permanent, two-story, brick barracks buildings are located on the base for personnel support. These barracks each contain 14,300 sq. ft. of floor space. Each barracks is rated at 116-man capacity. Another permanent, one-story, brick building contains the galley, mess hall, theater, and office space. This building contains 18,600 sq. ft. of floor space. The mess hall is rated at 320-man capacity and the theater is rated at 400-man capacity.

In addition to the structures described above, the base contains approximately 88 additional structures, including a seven-story, concrete control tower. The dimensions of the control tower are 21' X 21' X 78'. A 60-ton capacity truck scale is also located on the base.

Utilities

1. Electricity: Electricity is purchased from the Arizona Public Service Company. Distribution lines are basically overhead lines. Emergency generating capabilities which exist on the base include an auxiliary generator, with a 93.8 kva capability; a 25 kva stand-by generator for runway lighting; a 27.5 kva emergency generator for radio receivers; a 93.8 kva system for control tower operations; and a 25 kva power check facility.

2. Natural Gas: Natural gas is purchased from the Arizona Public Service Company and the El Paso Natural Gas Company. Main gas lines feed all of the key buildings.

3. Boiler/Steam Plants: One boiler house supplies steam to hangars Nos. 18 and 52. It contains three boilers, one of which is rated at 300 h.p. and two at 250 h.p. This boiler house was constructed during the year 1945. Another boiler house supplies steam to the three permanent barracks and the mess hall. This boiler house is equipped with two boilers rated at 200 h.p. each.

4. Water: Two wells are located on the base. One well supplies station needs at 600 gallons per minute capacity and the other provides water for fire use at a rate of 800 gallons per minute. There are two major and three minor water reservoirs located on the facility, with a total storage capacity for 1,028,500 gallons.

5. Sanitary Sewer: Four sewage pumping plants are located on the Naval Air Station. One is a lift station, one is a sewage/sludge pumphouse, one is a wash rack pump station, and the fourth is a sewage pump station.

6. Compressed Air: Two major compressed air plants are located on the station, serving the various buildings and facilities which require compressed air for their operation.

7. Fuel Storage: The base contains a total of 12 storage tanks located at convenient locations for aircraft fueling and for the support of other base activities. Total storage capacity is 137,000 gallons.

Goodyear Auxiliary Airfield: The Goodyear Auxiliary Airfield is located in the northeast corner of the Gila River Indian Reservation in central Arizona. The northern boundary of the Reservation is approximately 15 miles from Phoenix, the State Capitol, and the southern boundary is approximately 65 miles from Tucson, Arizona's second largest city. Interstate Highway 10, connecting the cities of Phoenix and Tucson, passes through the Reservation directly adjacent to the Goodyear Auxiliary Airfield. This freeway will be completed early in 1968. The Airfield itself is approximately 10 miles due south of Tempe, Arizona (Arizona State University), and 5 miles west of Chandler. On the freeway, it will be just 15 minutes from downtown Phoenix.

An extensive area development program has been undertaken in the northeast corner of the Reservation due west of Chandler. The Goodyear Auxiliary Airfield lies within this development area. This program includes development of industrial, residential, and recreational sites on Reservation land.

The study indicated that, if this site were selected for the proposed training center, it would be advantageous to develop the flight portion of the center on the Goodyear Auxiliary Airfield and a separate aviation academic center in the residential development area approximately 3 miles from the Airfield. This would place the academic center a sufficient distance from the flight training activity to prevent any distractions associated with the flight activity. The academic center could ultimately serve as the initial facility of a future Arizona State University branch campus, if the demand for such a campus develops. The locations for the various sites discussed above are shown in Figure III-3.

Following is a more detailed description of the Airfield and development area being considered for the location of the proposed aviation training center:

> Land: The Airfield land parcel includes 1,349 acres, laid out so that all future buildings necessary for flight operations and maintenance of aircraft could be designed to optimize all airfield activities. Representatives of the Tribal Council have also indicated a willingness to negotiate a long-term lease agreement with Arizona State University for the consideration of one (1) dollar for tribal land in the residential development area for the academic center.[2] This land, in addition to the Airfield site, would provide enough space to satisfy all the needs of the proposed aviation training center in the foreseeable future.
>
> Runways: Two runways are available on the Airfield. The main runway, laid out in a northwest-southeast direction, is 8,000 feet in length and 150 feet wide. The runway was originally 9,240 feet in length and 300 feet wide. In 1963, the U. S. Air Force resurfaced the runway 150 feet in width, for a distance of 8,000 feet. This runway is in good condition and is designed to accommodate any of the aircraft being considered for use in the proposed training program.
>
> A second runway runs northeast-southwest, is 5,500 feet long and 300 feet wide. It is in poor condition and would require resurfacing for continuous utilization. Two taxiways are available. The northwest-southeast is in good condition, while the east-west taxiway is poor and needs resurfacing. An aircraft parking apron 2,675' X 1,000' is also available but in poor condition. There is no lighting on any of the runways.

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[2] Discussions with Loyde A. Allison, Governor, Gila River Indian Community, Sacaton, Arizona.

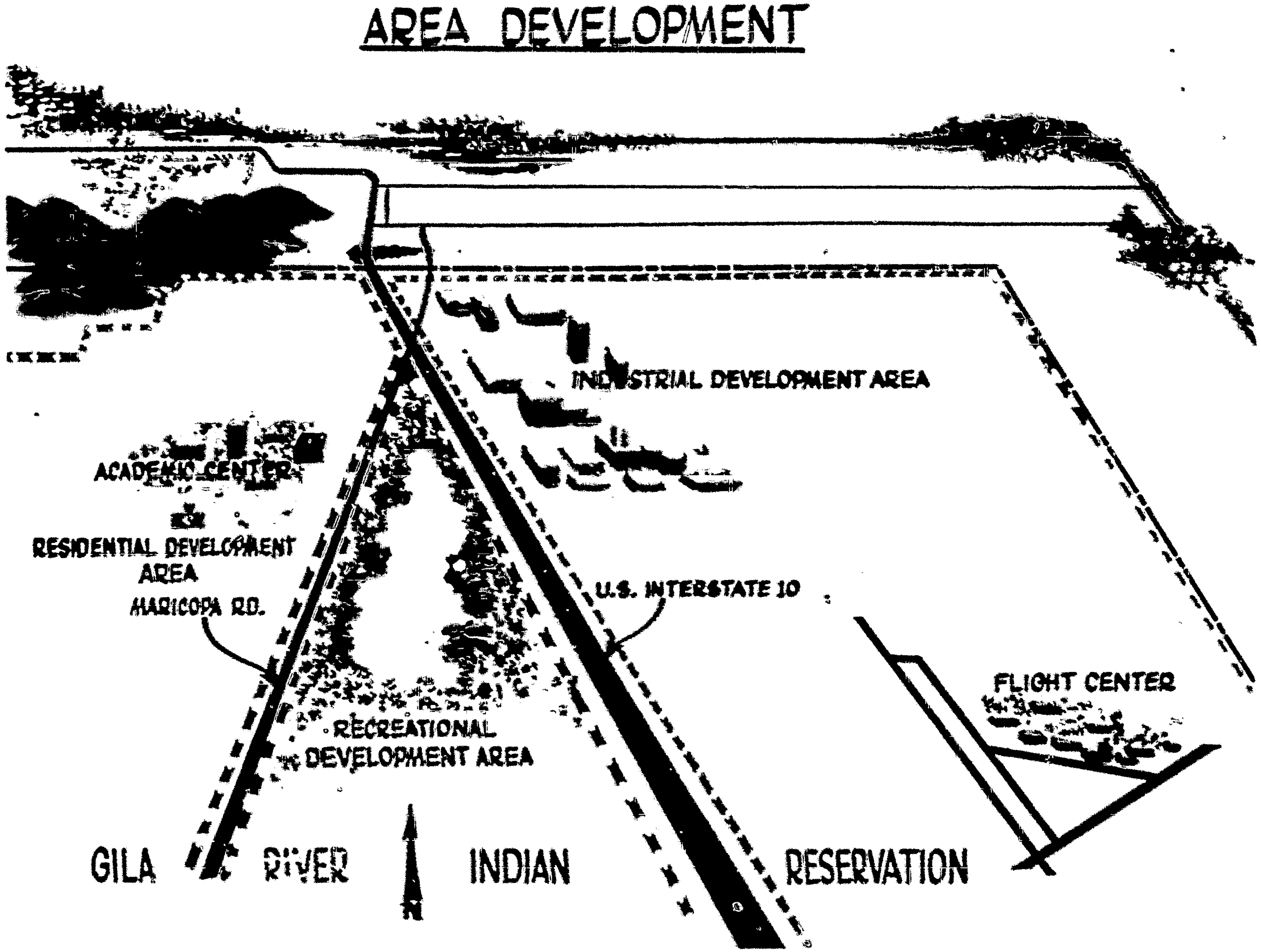


Figure III-3 - Development Areas & Proposed Training Center Locations

Buildings, Structures, Etc.: There are no buildings or other structures available on the Airfield. New facilities would be required to accommodate the proposed aviation training program. Utility services at this location will become available in conjunction with the development of the Kyrene Industrial Park, which is underway in the area just north of the Goodyear Auxiliary Airfield site.

Utilities

1. Electricity: Electricity for the portion of the Reservation being considered for the proposed training center is provided by the Salt River Project system. The electricity requirements of the proposed training center can be developed and expanded as the need arises.

2. Gas: The El Paso Natural Gas Company has several pipelines crossing the Reservation, one of which passes through a portion of the Airfield. Obtaining gas services poses no problems at the Airfield site.

3. Water: Water for industrial purposes can be readily developed on the Reservation. The use of agricultural wells has established the underground water pattern in the area for future development. Water for all purposes should be adequate for the foreseeable future.

4. Sewer: A joint venture sewer project between the City of Chandler and the Gila River Indian Community is presently underway. This sewer project will service the Kyrene Industrial Park and all of the adjacent development areas, including the proposed aviation training center.

Suitability of Proposed Sites

Both of the bases considered in the site selection study were carefully analyzed for their suitability from the standpoint of adequacy of land, runways, facilities, and utilities; proximity to other aviation operations, civil or military; accessibility from Arizona State University; economic impact on surrounding communities; and factors related to their acquisition. Following are the results of the analysis:

Litchfield Naval Air Station

Land: The land acreage of the Litchfield Naval Air Station is adequate for the purposes of the proposed aviation training center. Sufficient acreage exists to permit expansion to the maximum size foreseeable.

Runways: Even though only one runway exists on the facility, it is adequate to handle any size aircraft that might be utilized in the program. Since only one runway is available, operations may be curtailed at times, but this is not expected to occur very often because of the direction of prevailing winds.

Buildings: Only the two hangar buildings and the four permanent buildings described above would be suitable for use in the proposed aviation training program and then only after extensive modification. At this date, these buildings have been requested by other governmental agencies for their use. New buildings would, therefore, be required to accommodate the training center.

Utilities: With exception of the sewer system which would probably require expansion, all other utilities appear to be adequate to support the training program. Short runs would be required to connect new buildings into the existing utility systems.

Proximity to Other Air Operations: Litchfield's proximity to Luke Air Force Base and its location on airway V-16 are problems in its consideration as an aviation training site. The Luke Air Force Base flying activities have recently been increased to an average of approximately 250 jet missions per training day. This amounts to approximately 650 runway actions per training day, and additional training requirements are anticipated in the near future.

In view of the above facts, it seemed appropriate to review some of the flight traffic highlights involved in Luke Air Force Base training operations and point out several particularly significant airspace areas and procedures which will be important to the safety of any aviation activities conducted in areas west of Phoenix and, particularly, with respect to any operations conducted from the Litchfield Naval Air Station.

Airway V-16 from Blythe, to Buckeye, to Phoenix lies due south of Luke Air Force Base and almost directly above the Litchfield Naval Air Station. Since 75% of all Luke sorties (about 187 per weekday) proceed south to the Luke Air Force Base Gunnery Range Complex and the airspace training area southeast of Gila Bend, the Federal Aviation Administration deemed it necessary to separate this military jet traffic from other airspace users passing through the area by way of a flight path along airway V-16. The so-called "Luke V-16 corridor" resulted. Provisions for its use by military jet aircraft and avoidance by other aircraft are defined in Federal Aviation Regulations. A summary of the details of this provision are shown in Figure III-4. Total Luke jet crossings or entries into the V-16 corridor average over 400 per training day and almost 50 per hour, if averaged over a nine-hour day.

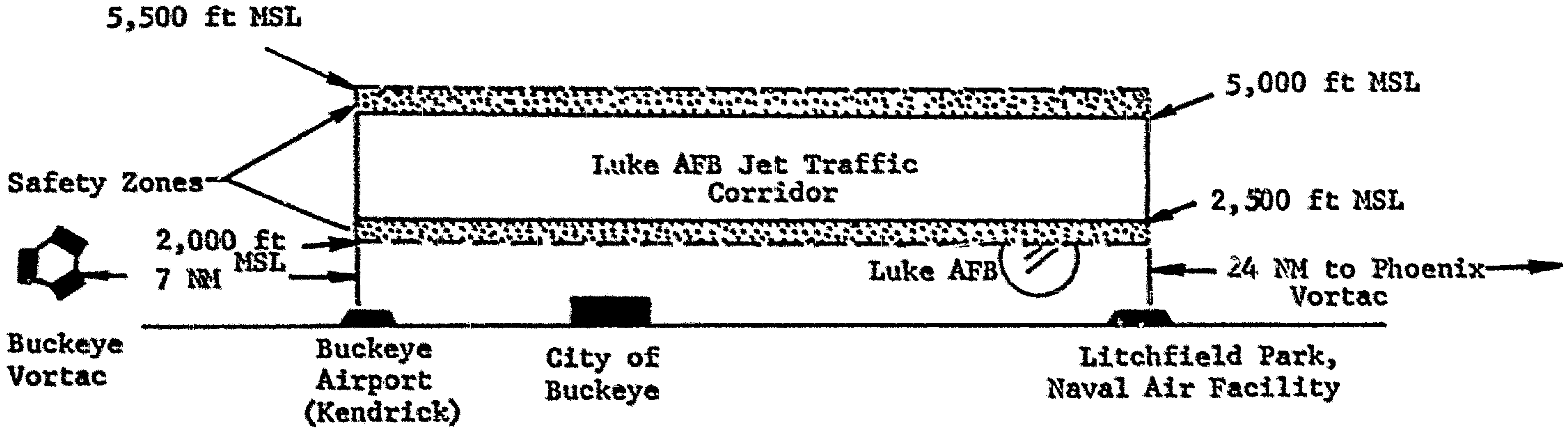
Several other areas heavily traveled by Luke jet traffic are depicted in Figure III-5. Training is normally conducted each weekday between 6:00 a.m. and 6:00 p.m. Mountain Time and, occasionally, on Saturday. Night training sessions are usually held an average of three times per week.

All Luke traffic that proceeds to the south passes through the area labeled "2" in Figure III-5, as well as the Luke jet traffic corridor across airway V-16. It is significant that ATC does not clear IFR traffic on airways V-66, V-94, and V-461 at those altitudes used by Luke traffic while daytime training is in progress. Although these altitudes are not prohibited to other than Luke VFR air traffic, they are areas that should be avoided due to the high density of Luke jet traffic during the periods of the day cited above.

Another high density area is the Phoenix-Wickenburg highway area north of Luke Air Force Base, from Wickenburg to Peoria. The busiest portion of this area is between Sun City and Luke AFB Auxiliary No. 1. Every jet aircraft operating out of Luke Air Force Base must cross this part of the highway at least twice between 2,500 and 5,000 feet MSL.

Additional details related to Luke Air Force Base operations are contained in Figures III-6 through III-8. Figure III-6

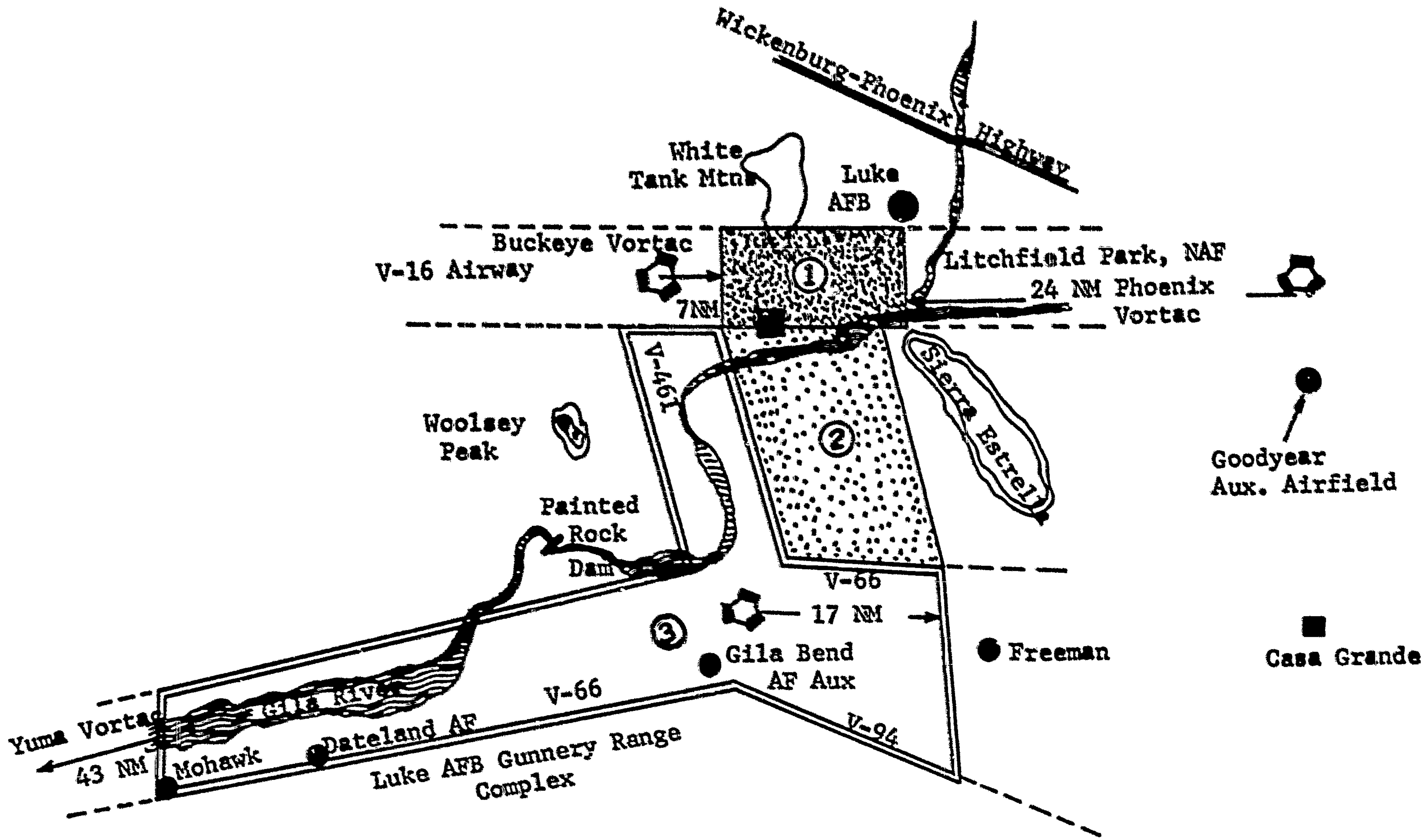
PROFILE OF V-16 AIRWAY CROSSING



1. Luke jet traffic uses the Luke corridor airspace exclusively, from 6:00 a.m. to 6:00 p.m. MST daily, Monday thru Saturday, for VFR training.
2. The airspace between 5,000 ft MSL and 5,500 ft MSL and that between 2,000 ft MSL and 2,500 ft MSL is not used during the times specified in 1, above.
3. All other air traffic is restricted to the airspace, at or below 2,000 ft MSL or at or above 5,500 ft MSL during the times specified in 1, above.

Source: Air Traffic, Hq., 4510th Combat Crew Training Wing (TAC), Luke AFB, Arizona, 16 May 1966.

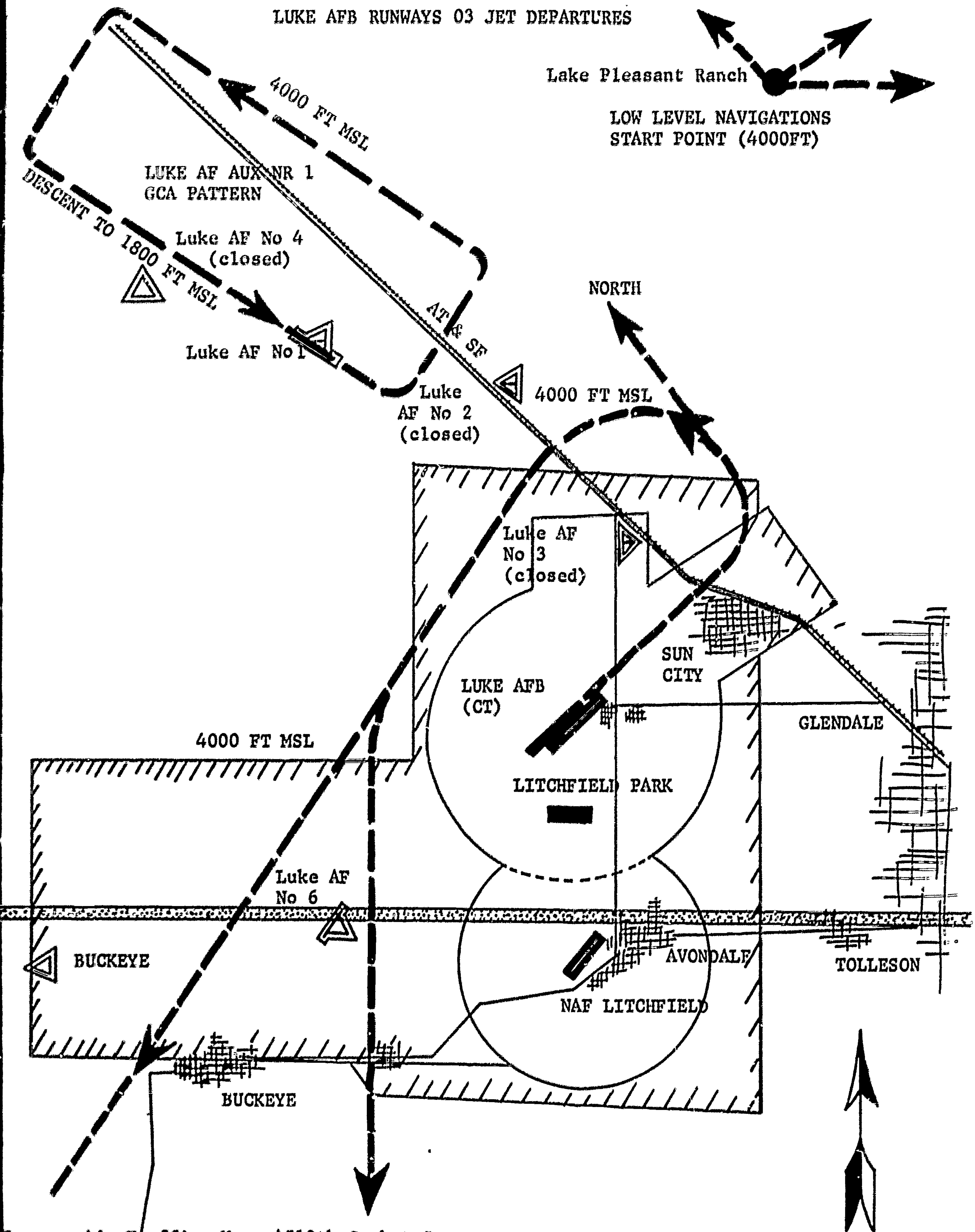
Figure III-4



1. The Luke AFB jet traffic corridor, detailed Fig III-4.
2. Luke jets use the area labeled as 2 for high performance climbs and descents between 2,500 and 16,000 ft MSL.
3. Luke jets cross the portions of airways V-66, V-94, and V-461, that are enclosed by double lines, between 4,000 and 6,000 ft MSL and at 15,000 and 16,000 ft MSL.

Source: Air Traffic, Hq., 4510th Combat Crew Training Wing (TAC), Luke AFB, Arizona, 16 May 1966.

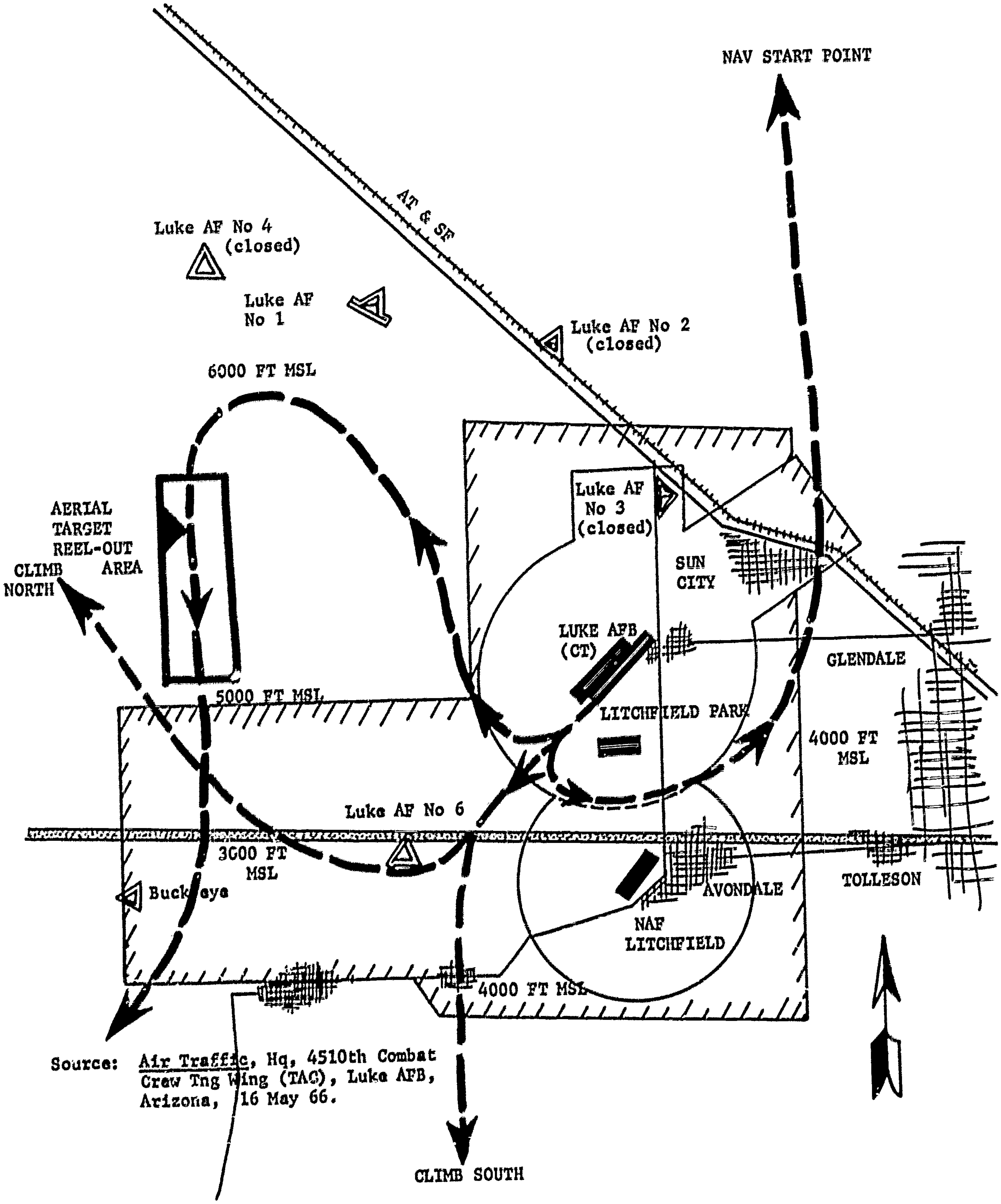
Figure III-5


LUKE AFB RUNWAYS 03 JET DEPARTURES

Source: Air Traffic, Hq., 4510th Combat Crew
Tng Wing (TAC), Luke AFB, Arizona,
16 May 66

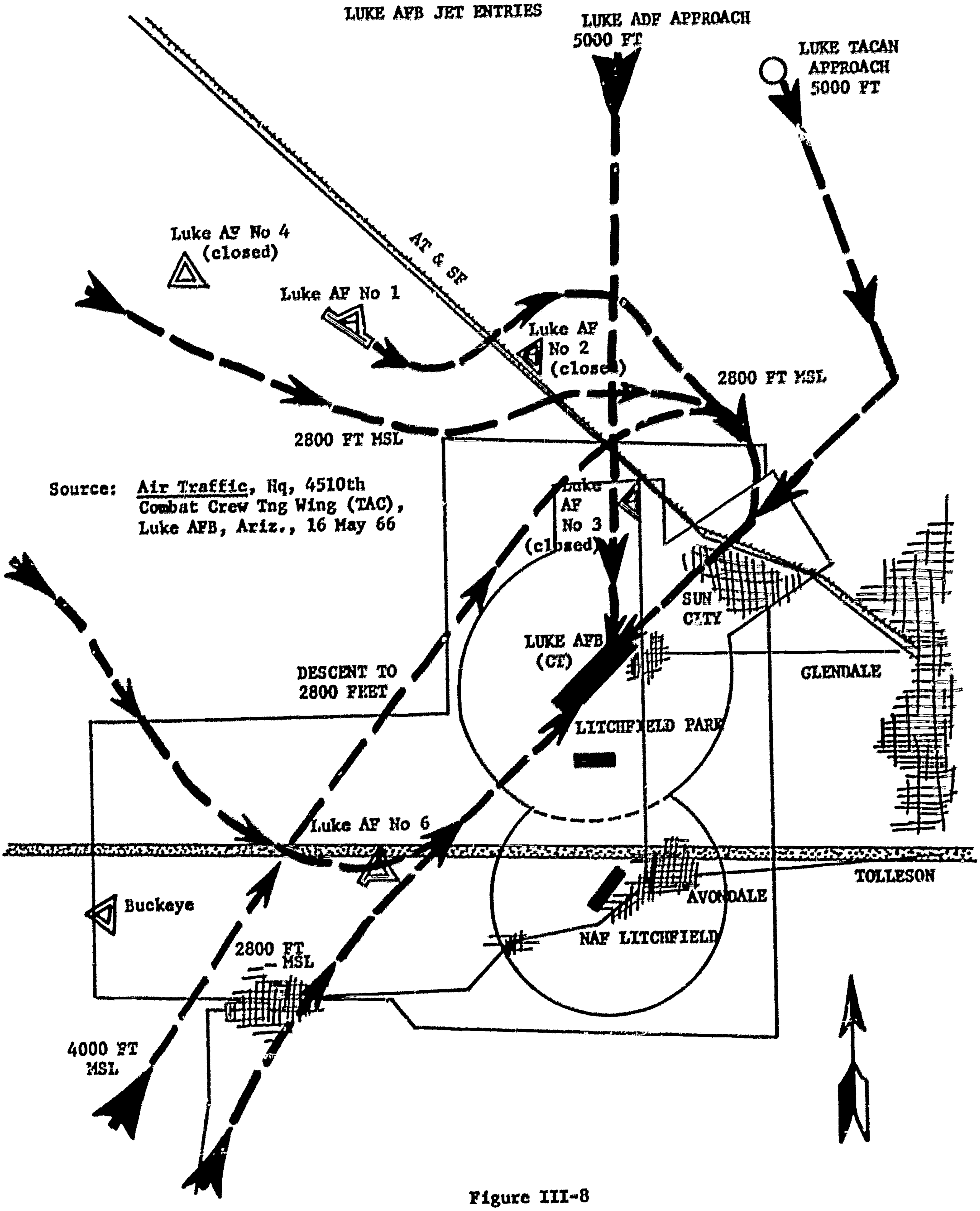
Figure III-6

LUKE AFB RUNWAYS 21 JET DEPARTURES



Source: Air Traffic, Hq, 4510th Combat Crew Tng Wing (TAC), Luke AFB, Arizona, 16 May 66.

Figure III-7



Source: Air Traffic, Hq, 4510th Combat Crew Tng Wing (TAC), Luke AFB, Ariz., 16 May 66

Figure III-8

shows the Luke AFB 03 jet departures. Figure III-7 shows Luke AFB runway 21 jet departures, and Figure III-8 shows the Luke AFB jet entries. Special attention is invited to the overlap of the Luke AFB operating patterns with those of the Litchfield Naval Air Station patterns in Figures III-6 through III-8. Figure III-9 shows additional operations in the Phoenix area, including both military operations and civil airways.

Because of the proximity of the Litchfield facility to the high density operations at Luke Air Force Base, the U. S. Air Force submitted a formal objection to the use of the Litchfield facility as a training base in such close proximity to their high performance jet training activity. The Department of Defense, in turn, released the Litchfield facility to the General Services Administration for disposition, with the provision that it be disposed of as a non-flight facility.[3]

The City of Phoenix is attempting to obtain the base as an auxiliary airport at this time[4], and Arizona State University is supporting the city's position.[5] If the Litchfield facility could be retained by the City of Phoenix as an auxiliary general aviation field, it might be possible to conduct some of the proposed aviation training center's advanced flight training at that site in the future.

In summary, it appears that, because of the proximity of the Litchfield site to Luke Air Force Base and the objections of the U. S. Air Force to novice training in an area of high density jet training activities leading to the current Department of Defense/General Services Administration position, it will probably not be possible for Arizona State University to acquire and operate the Litchfield Naval Air Station as an aviation training center.

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[3] Letter from GSA Regional Administrator (G. E. McNamara) to Mayor, City of Phoenix (Milton Graham), dated 23 March 1967.

[4] Letter from Mayor Milton Graham to Joseph Tippets, Federal Aviation Administration, Western Region, Los Angeles, Calif., dated 17 March 1967.

[5] Letter from Dr. Walter Burdette, Div. of Industrial Design & Technology, Arizona State University, to Elmer M. Parks, Federal Aviation Administration, Los Angeles, Calif., dated 2 May 1967.

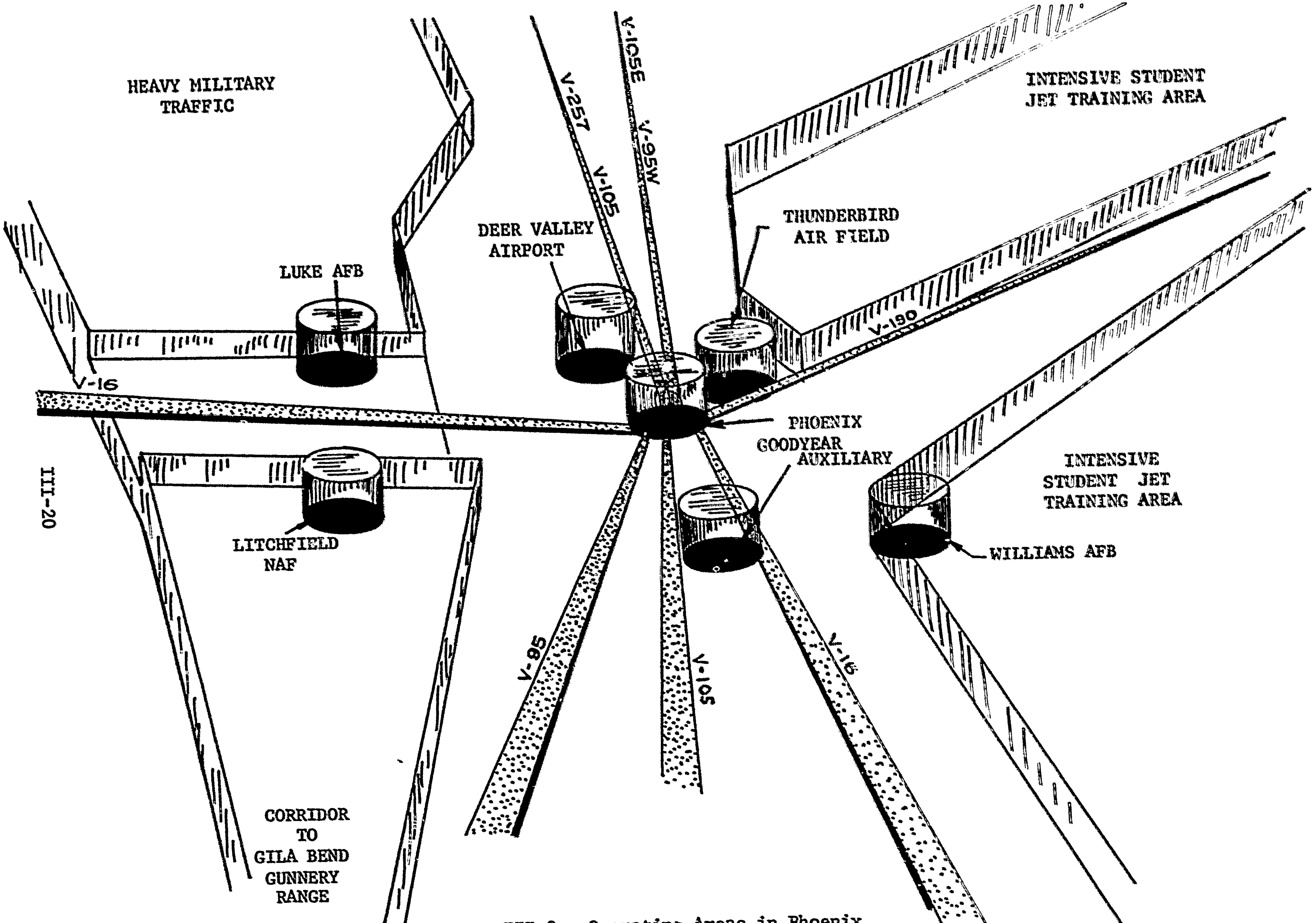

Figure III-9 - Operating Areas in Phoenix Vicinity

Goodyear Auxiliary Airfield

Land: The Airfield proper includes approximately 1,349 acres, a small percentage of which is tribal land and the balance is allotted acreage. The land at the Airfield site is adequate for the flight activities at the proposed training center. As stated earlier, representatives of the Tribal Council have also agreed to negotiate a long-term lease agreement for additional land inthe residential development area for academic facilities of the proposed training center. The acreage at both sites is adequate for the proposed center and will accommodate expansion programs for the foreseeable future.

Runways: The long runway (8,000' X 150') is in good condition and capable of handling all aircraft that have been considered for utilization in the training program in the foreseeable future. The shorter runway (5,500' X 300') is in poor condition and would require resurfacing if used in the program. Both runways would also require lighting systems. One of the taxiways and the (2,675' X 1,000') parking ramp would also require resurfacing.

Buildings and Utilities: As stated earlier, there are no buildings on the Goodyear Auxiliary Airfield site. Utility services, including electricity, gas and water, are available at the site and sewage disposal facilities will become available in conjunction with the development of the Kyrene Industrial Park and the residential area, both of which are just to the north of the Airfield. Short runs will be required to connect into existing systems and those under development.

Proximity to Other Air Operations: The Goodyear Auxiliary Airfield is located near several areas of relatively light air traffic. The Airfield lies directly beneath the intersection of three federal airways, designated V-95, V-105, and V-16 (see Figure III-9). These airways extend upward from an altitude of either 4,000 feet or 5,000 feet above sea level to an altitude of 18,000 feet, and each airway is 8 nautical miles wide. Two of the airways, V-95 and V-16, begin at 5,000 feet above sea level, while the other, V-105, begins at 4,000 feet. Airway V-105 passes almost directly over the Goodyear Auxiliary Airfield; V-95 lies to the west; and airway V-16 lies to the east of the airport location. The airspace beneath these airways is not restricted. Thus, the airfield traffic area, which extends upward from the surface to 3,000 feet above the ground, would not interfere with airway airspace.

Just to the west of the Goodyear Auxiliary Airfield, beginning at a distance of approximately 7.5 nautical miles from the center of the Airfield, lies a trapezoidal shaped area which, although surrounded by airways, is not restricted use airspace. This irregularly shaped area includes approximately 750 square miles and is an area of light air traffic which is suitable for use as a flight training area. The center of this area is approximately 25 nautical miles, or about 15 minutes of flight by light airplane, away from the Airfield.

The training area just described lies within an area of controlled airspace beginning at 1,200 feet above ground level. Within this airspace, the Federal Aviation Administration maintains facilities for the control of traffic operating under instrument flight rules. These facilities include the normal airways navigation aids and also air traffic control radar. The availability of these facilities is both beneficial and necessary, in that they are essential to the completion of instrument training for pilots.

Most of the immediate airspace south of the Airfield is occupied by federal airways which, as mentioned above, extend from 5,000 feet above sea level upward. The ground elevation in this area, however, is generally lower than 2,000 feet. This leaves 3,000 feet or more of lightly used airspace, including approximately 1,000 square miles which is suitable for flight training operations within 40 nautical miles of the Goodyear Auxiliary Airfield.

The two areas described above include a total of approximately 1,750 square miles of usable airspace. If the amount of airspace allocated to each training aircraft is 40 square miles, then 43 aircraft could reasonably be operated in this space. Present forecasts indicate that the proposed training facility will eventually utilize a total of approximately 40 aircraft. It appears, therefore, that the airspace necessary to conduct training operations is available and will continue to be available.

This estimate of airspace needs for the proposed training center is conservative. Most operators in closely-controlled training programs using light, single-engine aircraft determine airspace requirements on the basis of 20 square miles per aircraft. Although this would seem to indicate crowded airspace, it should be kept in mind that in a controlled program, such as that under consideration, altitude separation can be used to ease airspace congestion. (It is interesting to note that, if the proposed training center were located at the Litchfield Naval Air Station site, it would be necessary to conduct training flights in the same two areas described above.)

The Goodyear Auxiliary Airfield is presently being used by Williams Air Force Base, 16 miles to the east, for jet transition training under a lease arrangement with the Tribal Council on the Gila River Indian Reservation. The reason for its use by the U. S. Air Force is to relieve congestion on the already over-crowded Williams AFB runways.

Williams Air Force Base operates an undergraduate pilot training program and has between 400 and 600 students in training at one time. Primary flight training (phase 1) consists of 6 weeks and 30 flight hours in Cessna T-41 (Cessna 172 equivalent) aircraft. The students are billeted at Williams Air Force Base and transported by bus to the Casa Grande Airport, 25 miles south of Williams AFB, for this phase 1 primary flight training. Koenig Aviation at Casa Grande operates and maintains twenty-one USAF T-41 aircraft for this purpose.

Primary flight training (phase 2) consists of 20 weeks training and 90 flight hours in T-37 (small, twin-engine, low-performance jet) type aircraft.[6] Students fly out of Williams Air Force Base with these aircraft and use the Coolidge-Florence Airport for takeoff and landing practice. The Coolidge-Florence Airport is located 30 air miles southeast of Williams Air Force Base.

Basic flight training completes the undergraduate pilot course and consists of 26 weeks and 120 flight hours in Northrop T-38 aircraft. This program is conducted at Williams Air Force Base and the Goodyear Auxiliary Airfield is used for practice instrument approaches and landings.[7] All T-38 traffic is presently radar controlled by Phoenix FAA to assure positive aircraft separation. Phoenix FAA reports that T-38 use of the Goodyear Auxiliary Airfield averages approximately 50 operations per day.

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[6] T-37 Wing Manual 55-37, 3525th Pilot Training Wing, Williams Air Force Base, Arizona, January 1967.

[7] T-38 Wing Manual 55-38, 3525th Pilot Training Wing, Williams Air Force Base, Arizona, January 1967.

Williams Air Force Base also has intensive jet training areas east and northeast of Phoenix, extending from 10,000 to 20,000 feet MSL. This airspace is not legally unusable by civil aviation but is the airspace within which Williams high speed traffic is concentrated.

The use of the Goodyear Auxiliary Airfield by Williams is a temporary measure to relieve congestion at the Williams Air Force Base. If reductions in training activity by Williams (not visualized at this time) developed or if the congestion at the Williams AFB could be relieved with other measures, such as a third runway at that location, the Goodyear Auxiliary Airfield could be used as the flight area of the proposed training center. It is planned to undertake negotiations with the U. S. Air Force during the second phase of the study to determine the steps necessary to establish the Goodyear Auxiliary Airfield for use as a civil aviation training center.

Economic Factors

The economic decline which had been expected in the communities near the Litchfield Naval Air Station did not materialize, as stated earlier, because new income-producing activities were developed and the labor force did not experience any unemployment or loss of income due to the shutdown of the Litchfield facility. The selection of the Litchfield site and the establishment of the proposed training center thereon could not, therefore, be considered an economic program factor, inasmuch as the area is not economically depressed. This factor, coupled with the Department of Defense and General Services Administration positions regarding disposition of the base as a non-flight facility and the air traffic problems that would be created by the establishment of a training center at that location, essentially eliminated the Litchfield site from further consideration as a flight training center.

On the basis of the foregoing, further discussion of the economic impact of the proposed training center on surrounding communities will pertain to the Goodyear Auxiliary Airfield site only. In order to convey a more accurate understanding of the economic impact created by locating the proposed training center on the Goodyear Auxiliary Airfield site, it is first necessary to describe the economic conditions that exist on the Reservation. Following is a detailed description of the area and the conditions which presently exist on the Gila River Indian Reservation.

Geographic Description: The Gila River Indian Reservation is located in central Arizona, southeast of Phoenix. The area lies in the heart of the Central Arizona Basin, a broad, gently sloping alluvial plain, approximately 100 miles long and having an average width of about 50 miles, bordered by northwest-tending mountain ranges. Detached mountain ranges, rocky and barren, rise abruptly from the valley floor to form imperfect topographical divisions or interruptions in the general plain.

The Reservation is a typical southwestern desert area that cannot be cultivated without irrigation. However, even if sufficient water were available, about 82% of the land is unsuitable for cultivation. The area totals some 372,022 acres. The elevation of the bottom land ranges from 935 feet at the western boundary to 4,450 feet at the eastern line. It is 1,274 feet at Sacaton, headquarters of the Gila River Indian Reservation. The average elevation of the irrigated land in the western part of the Reservation is about 1,000 to 1,500 feet.

The climate in this area is typical of the arid regions of the Southwest. The winters are mild with occasional light frosts and moderate but irregular rains from December through March. The summers are warm and dry with occasional thunderstorms during July, August, and September. The maximum temperature ranges from 115°F. to 126°F.; the minimum from 8°F. to 18°F., with an average annual temperature of approximately 70°F. The average growing season is approximately 250 days, with the first frost occurring about November 15th and the last about March 15th. Relative humidity is generally low and the loss of water by evaporation is very high.

Transportation Facilities: The extreme eastern end of the Gila River Indian Reservation is serviced by the Southern Pacific Railroad. Although no passenger service stops are made within the Reservation, convenient stops are made at Chandler and Coolidge -- locations which are just a few miles from the Reservation proper. There are railroad facilities at Dock, Arizona, approximately 4 miles north of Sacaton, but these facilities are used primarily for handling and shipping livestock. Rail facilities are being provided for servicing the Kyrene Industrial Park development area just north of the Goodyear Auxiliary Airfield. The Pacific Greyhound Bus Lines give the eastern end of the Gila River Indian Reservation excellent service each day. Sacaton, headquarters for the Pima Agency, has ten daily bus stops that carry passengers directly into Phoenix to the north and Tucson to the south. The communities of Gila Crossing, Progressive Colony, and Maricopa Colony on the western end of the Reservation have access to transportation services furnished by the Metropolitan Bus Lines of Phoenix.

Air transportation facilities are available in Phoenix, approximately 40 miles from Sacaton and much nearer from the central or western area of the Reservation. American, Apache, Bonanza, Continental, Frontier, Trans World, and Western Airlines are conveniently located in Phoenix, approximately fifteen minutes from the Goodyear Auxiliary Airfield on the new Interstate Highway 10.

Roads: A network of all-weather roads, 180 miles in all, and 221 miles of secondary roads, connect the Gila River communities with Sacaton, Phoenix, Chandler, Tempe, Coolidge, Casa Grande, and the other urban centers in the vicinity of the Gila River Indian Reservation.[8] This road system on the Reservation is comprised of the following:

a.	State paved roads	52.5 miles
b.	County paved roads	17.5 miles
c.	Reservation paved roads . . .	43.8 miles
d.	Primary (graveled)	66.1 miles
e.	Secondary	221.7 miles
	Total	401.6 miles

The new Interstate Highway 10 which traverses the area will become a major factor in opening the area to industrial, commercial, and recreational development. Other new roads will be developed as a part of the development efforts.

Present Use of Land Area: Irrigable land is probably the most important single natural resource on the Reservation at the present time. There are approximately 67,000 acres of irrigable lands, of which some 33,000 are farmed annually. The range lands are considered poor; however, rainy periods permit the growing of enough forage so that local Indians raise cattle and horses on a very limited scale. The use pattern for total Reservation area is as follows:[9]

	Tribal Lands	Allotted Lands
Used by Indians	4%	6%
Used by non-Indians	1%	19%
Idle	95%	75%

(Approximately 27% of the total land is allotted to individuals and families and the remaining 73% is community owned by the tribe.)

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[8] Records of Bureau of Indian Affairs - Pima Agency.

[9] Ibid.

Factors Contributing to the Economic Decline: One of the factors which has contributed to the economic decline of the Reservation is the periodical shortage of water to carry on an extensive agricultural program. The use of groundwater has been resorted to with a certain degree of success. However, further study is needed to determine the greatest potential of this resource. The economy of the Gila River people is closely associated with irrigable lands and water rights appurtenant thereto, and the future development of the agriculture portion of the Reservation's economy depends upon a participation in a well-organized planning and development program to furnish the area a water supply of suitable quantity and quality.

A high percentage of small, uneconomical farm units and heirship problems further contribute to the economic decline. Small, individual allotments with multiple heirs are scattered throughout the area and are a deterrent to a feasible agricultural program. Small, original allotments and their further diminution in size due to heirship divisions, coupled with a limited and uncertain water supply, are the main contributors to the fact that less than 50% of the allotted, irrigable area is currently being used.

Extensive technological changes and mechanization in the agricultural industry in this and surrounding areas has also created large-scale unemployment; and since the area presently depends primarily on an agriculture-based economy, this problem will continue to grow. These technological changes will, in no small degree, call for training the unskilled and retraining of those with obsolete vocational skills due to these technical changes and because of the large-scale industrial development programs underway.

Population and Labor Force: A study recently completed under the auspices of the Bureau of Ethnic Research of the University of Arizona[10] places the population of the Gila River Redevelopment Area at 7,113 persons. Of this number, 4,628 people live within the boundaries of the Gila River Indian Reservation. The remaining 2,485 live either adjacent to the Reservation or represent those persons who live in Arizona part time off the Reservation, dependent on existing job opportunities. The total of 7,113 represents an increase of 894 over the latest estimate of population in the Redevelopment Area. There has been an out-migration of approximately 1.5% for employment, vocational training, and retraining. This has been offset by a birth rate of approximately 3.5%. The average number of persons living on the Reservation is 6,000.

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[10] University of Arizona, William H. Kelly, Indians of the Southwest (Annual Report), Bureau of Ethnic Research, Department of Anthropology, Tucson, Arizona, 1966.

The number of persons which make up the labor force in the Gila River Redevelopment Area is 1,815. The following tabulation shows the present employment status of this labor force:

a.	Employed	1,165
b.	Permanent	470
c.	Temporary	695
d.	Unemployed	650
	Total Labor Force	1,815

Since persons listed as "temporarily employed" usually work in the seasonal agricultural field, they are unemployed the greater part of the year. A survey completed in May 1966 showed an unemployment figure of 1,050 as of that date.[11]

The principal characteristics of the labor force are a lack of skilled and semi-skilled individuals. The income of the individuals within the Gila River Redevelopment Area is provided primarily through seasonal agriculture employment, common labor, domestic service, and some semi-skilled factory work. The income level of the average family is estimated to be $2,000 annually.[12]

Manpower Needs to Reduce Unemployment: On the basis of the foregoing employment situation, an analysis was made of the manpower needs of the future to reduce the unemployment to an acceptable 4% level. Following are the results of the analysis:

A. The number of jobs required to reduce the above unemployment to a 4% level is 977, arrived at as follows:

1.	The 1966 average rate unemployed (58%) applied to 1,815	1,050
2.	4% of 1966 average work force of 1,815	73
3.	Difference, indicating number of jobs required	977

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[11] Gila River Indian Community, VH-THAW-HUP-EA-JU, It Must Happen, May 1966, p. 52.

[12] It Must Happen, Ibid., p. 17.

B. The number of jobs to meet normal growth 1966-1971 is 276, developed as follows:

	Male	Female
1. Growth in population, 14 years and over, 1966-1971	260	300
2. Area labor force participation rates, 1966	69.1%	32.1%
3. Jobs required to meet normal growth in labor force, 1966-1971, based on area participation rates	180	96

C. The number of jobs required to raise area labor force participation rates to national average by 1971 is 27, developed as follows:

	Male	Female
1. National labor force participation rates, 1966	76.6%	34.5%
2. Area labor force participation rates, 1966	69.1%	32.1%
3. Difference in rates	7.5%	2.4%
4. Jobs required to raise area rates to national rates (difference in rates, 3, applied to growth in area labor force, 1966-1971)	20	7

In summary, 977 new jobs will be required to reduce the current unemployment rate to 4%. An additional 276 jobs will be required to meet the normal growth in labor force by 1971, plus 27 jobs to raise the area labor force participation rates to the national average by 1971. Thus, a requirement exists for at least 1,280 new jobs for the Reservation personnel by 1971, if the unemployment rate is to be reduced to an acceptable rate of 4%.

Current Economic Development Programs: Economic development of the Gila River Indian Reservation is essential if the serious unemployment rate of the Reservation is to be significantly reduced and the median income raised above the poverty level. This development will also bring income to the Gila River Indian Community which will enable it to carry out many of the programs for social and community improvement.

The Reservation is quite favorably situated for economic development, being bisected by the new Interstate Highway 10 and other major highways. It lies just south of the large and expanding Phoenix-Tempe-Mesa-Chandler urban complex and has the towns of Coolidge and Casa Grande on the east and south. Adequate water, gas and power are available, as well as rail facilities for Reservation use.

In early 1966, the Gila River Indian Community established a comprehensive long-range program to develop the resources on the Reservation. The program involves far-reaching economic, community and social development programs designed to reduce unemployment and create personal and tribal income. This long-range program is called "VH-THAW-HUP-EA-JU" or It Must Happen.[13] Many of the individual projects are underway, particularly with respect to economic development, and the objectives of the overall program are being successfully achieved.

The core of economic development program is the establishment of three industrial parks.[14] The three parks will be managed by non-profit corporations which will lease Gila River Indian Community lands. One of the parks will be an agricultural-industrial park established for cattle feeding and allied industries. This will alleviate the present problem of cattle feeders who are forced to move their operations out of Phoenix. The other parks will be utilized for light and heavy industrial development. To date, six industrial corporations have negotiated for and are breaking ground in the park sites.

It is felt by the tribe that the cooperative approach to the development of the industrial parks which encompass non-Indian business entities will bring advantages to both groups. Joint development of the Chandler sewage line is a prime example of the result of mutual cooperation. The City of Chandler will be provided a means of adequate sewage disposal, and sewage facilities will be available at the site of one of the proposed industrial parks.

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[13] It Must Happen, op. cit.

[14] It Must Happen, Ibid., pp. 13-28.

It is anticipated that the development of the three industrial parks will satisfy 20% of the job needs within the next twelve months and 43% within five years.[15] Grants for basic facilities development and loans to prospective lessees from the government and private sources will be essential to and are being obtained for the industrial park development program.

Leasing of lands for special uses has also proved a significant source of income to the community in past years. This can continue for such uses as a major testing site for a large construction equipment company and for a planned residential community. Mineral leasing offers another possible source of tribal income. Rising copper prices and new methods of processing copper ores have stimulated renewed interest by private capital in Reservation lands.

Nature has provided the Reservation with very attractive scenery and a variety of outdoor recreational resources. Establishment of parks and game-bird management are equally important potentials for development. Also, the Reservation is geographically located near other large and colorful Indian reservations in Southwestern United States. Appreciating these facts, opportunities for developing accommodations and attractions for the vacationer and traveler appear to be abundant. The tribe realizes that they must expand development of a wide variety of recreational opportunities in the immediate future, otherwise the fringe benefits of jobs, technical training and income will go to areas outside the Reservation.

It is anticipated that new legislation now being enacted will remove many of the hindrances to development that have handicapped tribes in the past. In this regard, the Gila River Indian Community has proposed legislation that it believes will be beneficial to Indian tribes. It has also requested specific legislation, such as the authority for ninety-nine year leases which is essential for full economic development of the Reservation.[16]

It is felt that the fifty-one projects comprising the <u>It Must Happen</u> program will meet most of the Reservation needs and are highly realistic. Within two years, if these projects are completed, total Reservation income could increase by $2,606,200 and 545 additional jobs will be available, excluding income and jobs created by the proposed aviation training center. By the fifth year from the initiation of this plan, Reservation income will have increased by $6,543,800 and 1,200 total additional jobs will be available. Mean family income will have risen from $2,000 in 1966 to about $3,000 (the poverty line) by 1968 and to $5,400 by 1971.[17]

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[15] It Must Happen, Ibid., p. 14.

[16] Gila River Indian Community, Progress Report, It Must Happen, 15 February 1967.

[17] It Must Happen, op. cit., p. 51.

Economic Impact of Proposed Training Center

Potential Job Opportunities: The additional jobs created by establishment of the proposed aviation training center on the Reservation and the income derived therefrom would be in addition to that cited above. To determine the economic impact of the training center, both the short- and long-range job opportunities were examined.

Within the time and resource parameters of the study, a preliminary estimate of the number of jobs created by the establishment of the proposed center was made. The identification of the potential jobs was made under four major categories:

1. Site Development
2. Facilities Development
3. Operation of Training Center
4. Services

Under each of the four categories, a feasible listing of job opportunities which would derive from the establishment of the center was developed; however, in some of the categories, such as site development, it was not possible to estimate the number of potential jobs at this time. The numbers would depend on such factors as design of the facilities, timetable for development, etc. In these cases, only the readily identifiable types of jobs were listed.

In the training center operations category, it was possible to identify both types of jobs and the numbers of jobs created. The numbers were based upon an analysis of personnel requirements for various student modules or blocks. Four student modules were considered, i.e., 500, 1000, 1500, and 2000. It was also assumed that one-half of the students would be enrolled in the flight training program and the balance would be enrolled in non-flight options or in the technician training programs. A listing of the potential job opportunities under the four categories is set forth below:

Site Development: The jobs created under this category would be short term or temporary -- for the duration of the development program. Since the number of personnel required to fill these jobs would depend upon the scope and timetable of the development program, only the job titles have been listed:

- Surveyor teams
- Heavy equipment operators
- Truck drivers
- Underground systems installers
- Supply stores personnel
- Accounting personnel
- Supervisors

Facilities Development: This category involves primarily the construction of the various buildings required for the operation of the training center, such as classroom buildings, hangars, dormitories, administrative buildings, garages, recreation, etc. Again, the jobs created will be of a short term or temporary nature.

- Surveyors
- Truck drivers
- Carpenters
- Bricklayers
- Welders
- Electricians
- Plumbers
- Roofers
- Glaziers
- Heating/air conditioning installers
- Painters
- Communications personnel
- Apprentices (to all trades)
- Supply stores personnel
- Accounting personnel
- Supervisors

(Note: Some of the personnel trained for both the site and facilities development jobs would be retained after these developments are completed to maintain and service the facilities they helped develop.)

Operation of Training Center: As stated above, the estimates for personnel under this category were based upon four modules of student enrollment, i.e., 500, 1000, 1500, and 2000. Following is a listing of types of jobs that would be created, along with the numbers of jobs under each module. These would all be long-range or permanent positions.

Job Categories	Per 500 Students	Per 1000 Students	Per 1500 Students	Per 2000 Students
1. Professional				
- Non-Flight	23	45	68	90
- Flight	17	34	50	67
2. Aircraft Maintenance Support	5	9	13	18
3. Staff and Administration	40	79	118	157
4. Food and Dormitory Services	50	110	166	230
Totals	135	277	415	562

The basis for items 1 and 2 above is detailed in the next section of this report. Item 3 includes maintenance and service personnel who are on the training center payroll. The numbers shown are based upon a 1 to 1 ratio of both the flight and non-flight personnel.[18] The numbers shown in item 4 are based upon current Arizona State University experience and may or may not be on the training center payroll, as these services are often obtained under contract. The numbers here may also be conservative, inasmuch as a higher ratio of students than past experience would indicate may be living on the aviation training center campus due to the unique nature of the proposed training system, i.e., utilization of new educational technologies.

Services: These are considered peripheral services which will develop naturally as the proposed center and other developments come into existence. These would be long-range or permanent jobs and the organizations established to offer the services could all be owned by the tribe or tribal members. Again, it is not possible to estimate numbers.

I. Recreation

A. Swimming

1. Lifeguards
2. Locker room attendants
3. Maintenance
4. Food and drink concession

B. Boating/Fishing

1. Gas/oil services
2. Boat and tackle concession
3. Maintenance
4. Food and drink concession

C. Golf

1. Grounds keepers
2. Cart rental/maintenance
3. Pro shop (supplies and sales)
4. Instruction

D. Tennis

1. Services
2. Maintenance

E. Horseback Riding

1. Instruction
2. Custodial care

F. Hobby/Art Centers

1. Instruction
2. Sales

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[18] Additional part-time student employees are also used to supplement permanent payroll personnel; however, these are not considered here, inasmuch as they have little effect on overall costs.

II. Business Operations

A. Supermarket
   1. Checkout clerks
   2. Supply and stock personnel
   3. Meat counter (butchers)
   4. Supervisors

B. Restaurant
   1. Cooks
   2. Waitresses
   3. Cashiers

C. Motel
   1. Clerks
   2. Maids
   3. Food/drink service personnel
   4. Vending machine operations
   5. Souvenir sales

D. Automotive
   1. Service station (gas/oil) personnel
   2. Parking lot attendants
   3. Bus service personnel

E. Laundry
   1. Clerks
   2. Plant personnel
   3. Distributors

F. Banking
   1. Cashiers
   2. Clerks
   3. Supervisors

G. Security
   1. Policemen
   2. Administration

Potential Income to Community: As stated earlier, analysis of the economic impact to surrounding communities resulting from the establishment of an aviation training center is based upon student modules of 500 to 2,000. It is also based on the assumption that one-half of the students will be enrolled in the flight option and the balance in non-flight options.

On the basis of the numbers of students presently enrolled in the Arizona State University Aeronautical Technology Program (325 during academic year 1966-67) and the estimated growth of this enrollment (750-1,000 in two years), the aviation training center should be designed for a minimum of 1,000 students initially, with provisions for expansion to accommodate 2,000 students by 1972.

On the basis of the foregoing, a number of cost/income factors have been developed which would contribute to the surrounding communities. These factors are discussed below:

1. Construction Costs: On the basis of information contained in the "cost" section of this report, it is estimated that the proposed aviation training center will cost on the order of $8,000 per student, including equipment. Of this amount, 80% is estimated for labor and materials and 20% for equipment. The labor and materials allocation is further broken down to 60% labor and 40% materials, with the 75% of the labor amount allocated to skilled and 25% to unskilled labor.

By using the foregoing allocations, construction of the training center would contribute $2,880 per student to skilled labor and $920 per student to the unskilled labor pool. By applying these figures to the initial design for a 1,000-student body institution, construction would contribute $3,800,000 to labor in the surrounding communities.

If the Gila River Indian Reservation labor pool could be adequately trained to occupy all of the non-skilled jobs and one-half of the skilled jobs, the construction of the first phase of the training center (1,000-student design) would contribute approximately $2,460,000 to the Indian economy. A like, or higher, amount would be contributed to the economy as a result of the expansion to a 2,000-student body center by 1972.

2. Training Costs (Non-Flight): On the basis of current experience at Arizona State University and in other educational institutions, it is estimated that training costs in the proposed aviation training center will be on the order of approximately $2,000 per student per year.[19] Approximately one-half, or $1,000, of the total amount is estimated for salaries and wages and the balance is for operations, travel and capital.[20]

On the basis of the above, establishment of the training center would initially contribute $1,000,000 per year to the local economy in the way of salaries and wages, building to $2,000,000 per year by 1972. If the Indians could be adequately trained to assume 25% of the positions on the faculty and staff, the annual income to that population could be $250,000 initially, building up to $500,000 per year by 1972.

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[19] Arizona State University total expenditures for 1966-67 were $27,570,564. Fall semester enrollment was 16,766 full-time equivalent students (head count 20,750) for a per FTE student cost of $1,644.

[20] Total wages and salaries for Arizona State University during 1966-67 were $11,838,607. This represents approximately 43% of total expenditures.

3. Training Costs (Flight): In addition to the training costs cited above for the non-flight training activites, an additional cost, estimated at $25 per flight hour, will result. If one-half of the students enroll in the flight option, each of them will fly 250 hours over a four-year period, or approximately 60 hours per year.

At a rate of $25 per hour, the flight training program would cost an estimated $750,000 per year. Of this amount, approximately 40%, or $300,000, would be allocated to salaries, the balance to fuel, oil, spares, etc. This would build up to approximately $600,000 by 1972. If the Indians could also be adequately trained to assume 25% of these positions, the annual income to that population from this source could be $85,000 initially, building up to $170,000 by 1972.

4. Other Costs: In addition to the training costs, special studies conducted by the University of Arizona indicate that student and student related expenditures in a community will average approximately $3,000 per student per year.[21] These expenditures include such items as food and soft drinks off campus, rooms off campus, automobile expenses, medicines and personal care, and wearing apparel; student union operations and bookstores; expenditures by sororities and fraternities; expenditures by student visitors; and purchases of automobiles, appliances, luxury items, travel, insurance, etc.

These expenditures would contribute an additional $3,000,000 to the local economy initially, building up to $6,000,000 by 1972. If it may be assumed that one-third of this income contributed to salaries and that 25% of the salary positions were occupied by Indians, the initial annual income from this source would be $250,000, increasing to $500,000 by 1972.

Summary: The following table summarizes the potential income to the Indian community, resulting from the establishment of the proposed aviation training center. These figures are related to direct income (salaries and wages) and do not include profits derived from the leasing of property or the establishment of business operations which would transact business with the training center.

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[21] University of Arizona, Arizona Daily Wildcat 1966-67, Tucson, Arizona.

POTENTIAL LABOR INCOME
FOR INDIANS
BASED ON STUDENT BODY OF 1000
(Double by 1972)

Cost Categories	Total Cost	Total Salaries	Est. Indian Salaries
1. Construction (non-recurring)	$8,000,000	$3,800,000	$2,460,000
2. Training, Non-Flight (recurring annually)	1,500,000	500,000	250,000
3. Training, Flight (recurring annually)	900,000	360,000	85,000
4. Student & Student Related Expenditures (recurring annually)	3,000,000	1,000,000	250,000

Discussion: Many of the job opportunities described herein are associated with both the developmental and operational activities which could occur with the establishment of the proposed aviation training center. An examination of the variety of jobs listed reveals that many more jobs or sub-tasks could have been listed. There also appears to be some duplication in the listing. Because of the preliminary nature and the limitations of the Feasibility Study, it was decided to list only the most obvious jobs related to the development and operations of the proposed aviation training center. With regard to the apparent duplications, workers usually fill only one job in one assignment, i.e., a maintenance technician in the flight training program would not also be a maintenance technician in a motor pool, or a cook in the student cafeteria will not at the same time function as a cook in a motel.

One of the purposes of the Feasibility Study was to determine the economic impact of the proposed aviation training center on the surrounding communities, particularly the Indian Reservation, in terms of jobs and income. Based upon the foregoing analyses, it is indicated that quite a number and variety of jobs will become available if the training center is developed. A problem which exists, however, is the unknown factor of Indian population and skills.

Although some studies have been made to categorize the supervisory, managerial and professional skills of the Indian, no probing, in-depth inventory has yet been made which clearly specifies their levels of talents, skills, aptitudes, and attitudes. Without these definitive, detailed, substantive analyses of the aptitudes and attitudes of the Indian population, it is difficult to estimate how many of these people would be capable of or interested in participating in remedial or vocational training programs which would prepare them for gainful employment in many of the jobs discussed herein.

Coincidental with the development of the air training facility, a significant industrial effort is already being undertaken in the immediate geographical vicinity of the proposed site for the training facility. The marriage of these two efforts produces a vast array of job opportunities which is outside the scope of this study, but the concurrent developments can only enhance the economic enrichment of the people who can supply the physical labor force for these undertakings. In addition, the generic natures of many of the jobs required in developing the proposed training facility lend themselves to speedy transfer to other job opportunities which will develop from the economic investments being made by the Indians themselves or by related private industry in that geographic area.

On the basis of the foregoing, it appears that short-range pre-vocational and vocational training programs should be undertaken, immediately following an in-depth analysis of the current levels of skills, aptitudes, and attitudes of the Indian population. It would appear that some non-skilled jobs require no measurement of skill, but certain menial labors might not be attitudinally acceptable to specific Indians. This is one of the key reasons why a survey, or inventory, should be undertaken. More importantly, aptitudes and attitudes toward semi-skilled work (truck driving, welding, cooking, clerical work) should be identified to ascertain the resources of the manpower pool. It is entirely possible that there will be more jobs than available manpower and that it may be necessary to identify non-Reservation talents among the disadvantaged of nearby areas, such as Chandler, Guadalupe, and South Phoenix.

For the personal development of the Indians and the economic "upgrading" of the entire area and in keeping with the air training program goals and objectives, both short- and long-range vocational-technical training programs should be undertaken to prepare the Indian population for the professional roles and careers which are being structured within the Arizona State University proposed aviation training program, i.e., highly-skilled technicians in electronics, avionics, powerplant maintenance, private and commercial pilot positions, aviation business management. Given the proper educational assistance and motivation before entry into such a program, it is entirely probable that the Indian will achieve a high degree of success. Historically, he has been identified as possessing above average level manipulatory skills so necessary to much of the technical work in the aviation field. It is believed that this potential can be brought to productive reality by a carefully structured vocational-technical training program.

Conclusions

After a detailed analysis of the proposed training sites, including military and civil flight operations in the vicinity of both sites and the past, present and future economic outlook for the areas surrounding each site, it is concluded that:

1. Of the two proposed training sites evaluated during the study, the Goodyear Auxiliary Airfield located on the Gila River Indian Reservation offers the greatest potential as a site for the proposed aviation training center.
2. The use of the Goodyear Auxiliary Airfield as a training site would create no significant problems with other air traffic in the area and would provide for an adequate practice area over the Reservation.
3. The location of an aviation training center on the Goodyear Auxiliary Airfield will result in significant benefits to the Indian population and will also provide job opportunities to the disadvantaged of the surrounding communities. The center would result in the establishment of approximately 600 new jobs by 1972, of which over 25% could be occupied by the Indians.
4. The ideal operating arrangement for a training center on the Reservation would be to locate the flight training operations on the Goodyear Auxiliary Airfield and the academic training in the residential area planned for development approximately three miles from the Airfield.
5. The land acreage available at the Goodyear Auxiliary Airfield and that offered by the tribal representatives in the proposed residential development area is sufficient for any foreseeable future expansion programs.
6. A short-range inventory/analysis of job skills on the Indian Reservation should be made and a training program undertaken to teach the required skills to qualified personnel for the jobs created by the establishment of a training center and other developments which are occurring on the Reservation.
7. A long-range program should be initiated to identify skills, aptitudes, and attitudes of the total Indian population on the Reservation and a comprehensive pre-vocational/vocational/social program of training be undertaken to prepare the population for the advantages to be derived from the training center and other area development efforts.

Recommendations

On the basis of the foregoing conclusions and the information and data contained in this Section of the report, it is recommended that:

1. Immediate conferences be scheduled with representatives of the Gila River Indian Reservation for the purpose of negotiating long-term lease arrangements for the proposed aviation training center sites selected and discussed in this report.

2. Negotiations be conducted with the U. S. Air Force and other interested organizations for the use of the Goodyear Auxiliary Airfield as the site for the flight operations of the proposed aviation training center.

3. Encouragement and assistance be provided the aviation industry in the establishment of a private, non-profit organization whose primary function will be to establish and operate the flight training portion of the proposed aviation center as a cooperative venture with the University.

4. A short-range inventory/analysis of job skills on the Indian Reservation be made and a training program established to teach required skills to qualified personnel for the jobs created during the training center site and facilities development programs.

5. A long-range program be established, in cooperation with the Bureau of Indian Affairs, for the identification of skills, aptitudes, and attitudes of the total population on the Reservation, followed by a comprehensive pre-vocational, vocational/technical and social training program to prepare the Indians for the advantages to be derived from the training center and other area development programs.

SECTION IV

COST AND FINANCING

Introduction

This section of the Feasibility Study report presents preliminary cost estimates for the establishment and operation of the proposed aviation training center, along with suggested methods for financing these costs.

Some of the factors considered in developing the preliminary cost estimates were the classroom and laboratory requirements; administrative space requirements; housing and cafeteria requirements for students, faculty, and staff; the requirements for single- and twin-engine aircraft, with spares; hangar and ramp space requirements; ground support equipment for operations and maintenance; and faculty and staff requirements.

This portion of the overall study analyzed financing procedures and patterns of the past, along with sources of funds for site and facilities development, the procurement of equipment, and potential income for underwriting the costs of operation. On the basis of the cost estimates developed and an analysis of financing procedures and sources of funds, a proposed plan for financing the establishment and operation of the proposed center was developed.

In developing the cost and financing information related to the physical aspects of the proposed center, it was necessary to examine the characteristics desired and the specific requirements that must be met by the center. It was found that there was no universal pattern by which facilities and real estate are combined to form the desired arrangement. The possible patterns are as many as the schools themselves.

There is one element which schools have in common, however, and that is they are all in transition and must look deeply into the future. The new technological developments in both the fields of education and aviation raise new questions regarding education and training, the answers to which will influence the design of the facilities and the center itself. The planning of the proposed center must be far reaching and take into account everything important that is happening or is about to happen to education in America and not just the establishment of a center for the sake of meeting some of aviation's quantitative requirements.

In developing cost estimates for the facilities required to meet the future requirements of the proposed center, it was assumed that space of all kinds - instructional, laboratory, residential - would be designed for maximum convertibility. For example, dormitories would be designed for learning, as well as for the living necessities. More attention would be given to the social and psychological needs of the student and to more rewarding interaction between student and teacher.

The instructional space would be designed for the greatest possible flexibility to meet needs ranging from large lecture to individual study, and it should be readily convertible. Moveable walls for year-to-year operations and operable walls for immediate operation should be the rule, rather than the exception, in the design of the instructional facilities.

To achieve comparable flexibility in laboratories is more difficult, but it can and has been done in a number of recently designed institutions. The explosion of scientific knowledge makes yesterday's laboratories obsolete today. Some of the new institutions have shown that laboratories can be flexible and convertible, with designs that arrange utilities and equipment so as not to freeze the pattern of walls and spaces.

Closely related to the need for flexibility in the design of the facilities for the proposed center is the need for the full utilization of space, time, people, and things. Flexible facilities mean that space can be readily adapted to use by large groups or small, depending on instructional needs. The facilities of the center should be designed for double or triple duty of the space, and the space and equipment should be designed into the facilities in a manner to permit maximum individual study.

Independent study will assume central importance in the proposed center. It is expected that this development will exploit a new maturity in the student and an increased recognition by educators of the power of self-teaching. Independent study is, in part, a form of utilization whereby the center can use the minimum faculty with the maximum student body to greatest advantage.

Because teaching talent is in short supply in the general academic community, the faculty should not be wasted on mere exposition of "facts". They will be expected to devote more time to values, concepts, and meaning in very large or small groups. Students will get many of their "facts" from inanimate devices, such as books, films, tapes, television, teaching machines, and computers, rather than from live teachers. The buildings of the center should be designed to accommodate these new educational technologies as they prove themselves effective.

The design of the center should also permit better use of time. The utilization of physical facilities in many schools today is poor, whether measured by day, week, or semester. It is planned that the facilities of the proposed center will use more hours of the day and more weeks of the year than is currently being done in most schools. It is expected that the days will start earlier and end later, and that weekends will be used as well. The academic year will stretch to match the calendar.

In summary, the design of the center should provide for an environment that favors learning and understanding and intellectual interchange. The architecture and design of the center should help to reconcile the conflict between mass education and the individual and to strike a balance between the economics of education and the needs and values of the student.

The foregoing are, at any rate, the factors that were considered in the preliminary planning and which formed the basis for the estimates which are presented in the following parts of this section.

Assumptions

In developing the cost and financing information for this section of the overall Feasibility Study, the following assumptions were made:

1. It was assumed that one-half of the student body would be enrolled in the flight option of the total program and that the balance of the students would select the non-flight collegiate and technician training options.

2. That the flight training program would include 250 hours of flight training and that the flight time would be accumulated during a period of time equivalent to a standard four-year baccalaureate degree program.

3. That the flight training would be conducted at the Goodyear Auxiliary Airfield and all academic activities would be conducted at a site to be selected in the residential development area described in Section III of this report.

4. That the academic activities would be conducted under the direct auspices of Arizona State University and that the flight training would be conducted by a corporation, possibly a non-profit, membership corporation sponsored by the aviation industry.

5. That existing, upgraded curricula will be used initially and that these will be continually improved and designed for use with new educational technologies as they are developed and proven. New techniques and educational materials presently in use by military, industry, and educational institutions will be screened and, wherever possible, put into immediate use.

Methodology

The following methodology was used in developing the cost and financing information presented in this section:

1. A determination was made of the possible enrollment or size of the student body.
2. Cost factors were based upon student modules of 500, 1000, 1500, and 2000 students. These were further broken down to costs per student.
3. Surveys were made of the facilities of other educational institutions from both a design and cost point of view.
4. Preliminary cost estimates were developed for facilities, equipment, and operations for both the academic and the flight programs.
5. A proposed financing plan was developed in which the University, the aviation industry, and the government each played a role.

Development of Cost Factors

To arrive at cost estimates for a center of the type envisioned is basically a problem of simple multiplication. The number of square feet of space required by the center multiplied by the unit cost (in dollars per square foot) provides the estimate. While this approach is oversimplified, it nonetheless makes the subject intelligible -- a subject which is often made so complex that it becomes incomprehensible.

Space Requirements: The space requirements of an educational institution are based primarily on the student enrollment and the educational program. While the planners and architects may save some space by use of designs which may reduce the area in corridors, service centers, etc., the basic decisions which determine space requirements are program decisions and student enrollment.

In developing the space requirements for the proposed center, it was first necessary to determine an initial and future enrollment level. These levels were established on the basis of the current enrollment in Aeronautical Technology at Arizona State University and on local and national enrollment projections.

Current Enrollment in Aeronautical Technology (Arizona State University): The Aeronautical Technology program conducted by the Division of Industrial Design and Technology at Arizona State University currently (1966-67) has 325 full-time Aeronautical majors enrolled.[1] Fifty percent (50%) of these are out-of-state students.

This program offers two collegiate options with a Bachelor of Science degree and, for the first time during the 1966-67 school year, flight training through a commercial license and an instrument rating was offered under the auspices of the University. The actual flight training is conducted under a contract between the University and a fixed-base operator.

Because some of the courses presently (1966-67) offered have never been listed in the Arizona State University catalog, it is anticipated that enrollment in the Aeronautical Technology program will increase significantly when the new catalog (1967-68) is published.

On the basis of the foregoing, it is estimated that the enrollment in this program will expand to at least 750 full-time students by September 1968, the beginning of the 1968-69 school year. This is also the target date for activating the portion of the proposed training center in the residential development area on the Gila River Indian Reservation described in Section III of this report.

Projected Arizona State University Enrollment: During a long-range planning study conducted by Arizona State University in late 1965,[2] the future student enrollment was estimated. Figure IV-1 shows the projected on-campus head count, on-campus full-time equivalent (FTE), and the extension and residence center enrollments.

An analysis of the estimates presented in Figure IV-1 indicates a growth of 68-69% total increase in enrollment during the period 1966 to fall semester of 1974, with an increase of 78% between fall semester 1968 and fall semester 1974.

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[1] Enrollment records of Division of Industrial Design & Technology, College of Engineering Sciences, Arizona State University, Tempe, Arizona.

[2] A Report to the Board of Regents on Long Range Planning for the Ten-Year Period Ending June 30, 1975, Arizona State University, Tempe, Arizona, December 20, 1965.

PROJECTED ARIZONA STATE UNIVERSITY
ENROLLMENT (1966-1975)

Year	On Campus Head Count*	On Campus FTE Enrollment*	Extension and Residence Centers
1966	[illegible],700	16,76[illegible]	3,600
1967	22,250	18,245	3,900
1968	23,650	19,393	4,200
1969	24,900	20,418	4,500
1970	26,000	21,320	4,800
1971	27,000	22,140	5,100
1972	28,000	22,960	5,400
1973	29,000	23,780	5,700
1974	30,000	24,600	6,000

* Does not include Extension enrollment in off-campus residence centers, shown separately in last column.

Source: A Report to the Board of Regents on Long Range Planning, Arizona State University, 20 Dec 65.

Figure IV-1

If the 69% growth rate is applied to the student population in the Aeronautical Technology program enrolled at present (1966-67), the total enrollment in 1974 would be 549. If the 78% growth rate is applied to the student population estimated for the fall of 1968 (750), the 1974 enrollment would be 1,335.

Growth in National Enrollment: Another approach taken to project the possible enrollment of the proposed training center was to examine the potential growth of college enrollment nationally. Figure IV-2 shows the estimated growth in enrollment for the period 1965-1975 in numbers and in percentage increments for three different projection rates.[3]

If the average percentage increases are applied to the 1966-67 Aeronautical Technology enrollment (325) for the period to 1970 and again to 1975, the enrollment by 1975 would be 1,058. If the 84% average increase between 1970 and 1975 is applied to the enrollment estimate of 750 (fall 1968), the enrollment in 1975 would be 1,380. The latter estimate is considered most reasonable and is probably overconservative when compared with the growth in requirements for skilled aviation personnel, as developed in Section I of this report.

Enrollment Summary: On the basis of the foregoing projections, the enrollment in the proposed aviation training center could range from slightly over 500 to approximately 1,400. It is quite possible, based on the dynamic growth of the aviation industry and the operating concept advocated for the proposed center, that the enrollment will be on the order of 2,000 by 1972.

A center with its own faculty and organization, serving at least 500 students, is probably the minimum essential for efficiency and economy. Similarly, a college with 2,000 students probably represents the upper limits, if the needs of individuality, breadth of training, and scope and initiative are fully provided.

In this section, the planning and estimating was based on student modules of 500, 1000, 1500, and 2000. Emphasis, however, is placed on the concept of a center designed to accommodate a 1000-student enrollment, initially, with provisions for expansion to 2000 by 1972. If continued dynamic growth of the industry and its requirements for skilled personnel justified further expansion beyond the 2000-student level, such expansion could be accomplished on a modular basis.

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[3] The Economics of Higher Education, U. S. Office of Education, Washington, D. C., 1962.

GROWTH IN COLLEGE ENROLLMENT

Projections	1965	1970	% Increase	1975	% Increase
I - Assumes Rate of College Attendance will be Unchanged	4,337,000	5,205,000	83%	5,941,000	88%
II - Assumes Rate Will Increase but only Because of Tendency of Offspring of College-Trained Fathers to Go to College	4,664,000	5,960,000	78%	7,090,000	84%
III - Assumes Rate of Increase will Continue	5,220,000	6,959,000	75%	8,616,000	80%
Average Percentage Increase			77%		84%

Source: <u>The Economics of Higher Education</u>,
U.S. Office of Education, 1962.

Figure IV-2

Classroom/Laboratory Space Requirements Per Student: Following a determination of current and projected enrollment levels, it was then necessary to develop estimates of space requirements for individual students for both educational and residential facilities. These were developed by surveying a number of institutions, including universities and secondary schools.

One survey was conducted by Arizona State University in 1965 to determine the net space available per FTE student in nine Western and Midwestern universities and colleges.[4] The results of this survey are shown in Figure IV-3.

The net assignable space per student shown in Figure IV-3 includes both classrooms and laboratories. An analysis of the information reveals that the average net assignable space in the nine institutions surveyed is approximately 144.5 square feet. "But it has been suggested that with more efficient utilization, 125 square feet should be adequate."[5] Mr. Walter A. Netch, Jr., of the Skidmore, Owings and Merrill architectural firm, has had an opportunity to confront the problem of campus planning in a number of places and he calls for the allocation of 150 square feet per undergraduate student and 200 square feet per graduate student.

By way of comparison, the present (1966-67) net assignable square feet of space per FTE student at Arizona State University is 78.3. The past, current, and projected space available per student is shown in Figure IV-4. Construction programs have been recommended, in order to achieve a minimum standard of 120 net assignable square feet per FTE student by 1 July 1975.

The Educational Facilities Laboratories, Inc., of New York, surveyed 100 secondary schools which were built during the period 1956 to 1958.[6] The area per student, as well as the unit costs, were computed. The schools were also sorted into geographic regions. Seventy-two of the schools had data available in sufficiently comparable form for inclusion in Figure IV-5.

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[4] A Report to Board of Regents, op. cit.

[5] Bricks and Mortarboards, A Report on College Planning and Building, Educational Facilities Laboratories, Inc., New York, N.Y., 1966, p. 145.

[6] The Cost of a Schoolhouse, Educational Facilities Laboratories, Inc., New York, N.Y., 1960.

NET ASSIGNABLE BUILDING SPACE PER STUDENT ENROLLED*

Institution	Applicable Year	Net Sq. Ft. Per Student
Univ. of Calif. (Berkeley)	1955	153.0
Univ. of Ill. (Urbana-Champaign)	1962	148.2
Oklahoma State University	1960	139.5
University of Oklahoma	1960	130.5
Western Illinois Univ. (Macomb)	1962	116.6
Calif. St. Polytechnic (San Luis Obispo)	1955	180.0
Humboldt State College	1955	181.0
Fresno State College	1955	130.0
Chico State College	1955	122.0

* Non-residential net assignable sq. ft. of building space per full-time equivalent student enrolled.

Source: A Report to the Board of Regents on Long Range Planning, Arizona State University, 20 Dec 65.

Figure IV-3

NON-HOUSING SPACE PER FTE STUDENT AND NORMAL CAPACITY OF FACILITIES ACTUAL AND PROJECTED

1964-65 THROUGH 1974-75

First Semester Of	On-Campus Enrollment		Net Square Ft. of Building Space*	Net Assignable Sq. Ft. Per FTE Student		Normal FTE Capacity
	Total	FTE		Actual	Recommended	
1964-65	16,921	13,671	974,280	71.3	120	8,119
1965-66	19,198	15,924	1,092,835	68.6	120	9,107
1966-67	20,750	16,766	1,312,660	78.3	120	10,939
1967-68	22,250	18,245	1,545,070	84.7	120	12,876
1968-69	23,650	19,393	1,681,698	86.7	120	14,014
1969-70	24,900	20,418	1,735,032	85.0	120	14,459
1970-71	26,000	21,320	1,938,553	90.9	120	16,155
1971-72	27,000	22,140	2,173,888	98.2	120	18,116
1972-73	28,000	22,960	2,371,027	103.3	120	19,759
1973-74	29,000	23,780	2,661,695	111.9	120	22,181
1974-75	30,000	24,600	2,952,030	120.0	120	24,600

* Excluding elementary training school, Sun Devil stadium, swimming pool, student residence halls, and facilities not located on main campus.

Source: A Report to the Board of Regents on Long Range Planning, Arizona State University, 20 Dec 65.

Figure IV-4

MEDIAN SPACE REQUIREMENTS FOR SECONDARY
SCHOOLS IN SQ. FT./STUDENT BY REGIONS

Region	Classrooms	Auxiliary Areas (1)	Service	Total
Northeast	34	39	18	116(2)
Southeast	27	24	15	75
North Central	38	37	45	117
South Central	26	31	38	78
Western	35	32	24	95

(1) The auxiliary areas include libraries, music rooms, administration, cafeteria, gymnasium and auditorium.

(2) The totals shown here are the medial totals and are not the sum of the medians of each category. For this reason, the columns will not add across.

Source: The Cost of a Schoolhouse, Educational Facilities Labs, 1960.

Figure IV-5

4-13

It is interesting to note that most of the secondary schools had an average overall space allocation of more than 95 square feet per student, 80% of the minimum considered for universities and colleges. The Northeast and North Central regions were very close to this minimum with 116 and 117 square feet per student, respectively. This may be a reflection of the differences in climate, however, where outside space is often used as corridor space and in part the additional auxiliary areas which require more service and structure areas. The climate factor may also be significant in the apparently low space/student allocation at Arizona State University in comparison with comparable schools.

Student Residence Space Requirements: During a study of college housing in theearly 1960's, an analysis was made of space and cost data for a number of student residence structures built during the late 1950's.[7] The space allocation per student data is presented in Figure IV-6.

A review of the information contained in Figure IV-6 indicates an average allocation of space per student to be slightly over 275 square feet. By way of comparison, recently constructed dormitories at Arizona State University had an average of 205 square feet allocated to each student. These average figures include the cafeteria space. The space indicated is for undergraduate single students. Architects have recommended 250 square feet for graduate students and, of course, much more than this for married students.

Summary of Space Requirements: On the basis of the enrollment and space allocation data collected and analyzed, as set forth above, it is concluded that the proposed aviation training center should be designed to accommodate 1,000 students, initially, with provisions to expand to a 2,000-student level within four years after start-up. The design of the center should also permit further growth on a modular basis, as future increases in enrollment justify.

It is also concluded that a minimum of 120 square feet of assignable space per student should be used for educational facilities (classrooms/laboratories) and 275 square feet per student for residence facilities in all future planning for the proposed training center. On this basis, the initial educational space requirements, excluding student residence halls, swimming pools, airplane hangars, etc.,[8] would be on the order of 120,000 square feet, with plans to grow to 240,000 square feet by 1972, or four years after target start-up date.

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[7] College Students Live Here, A Study of College Housing, Educational Facilities Laboratories, Inc., New York, N.Y., 1961.

[8] Space requirements for hangars or maintenance shops and other "special" facilities will be shown when those items are discussed.

SURVEY OF DORMITORY SPACE ALLOCATION

School	Dorm.	No. Floors	Area/Student
University of Chicago	Stanley R. Pierce Hall	10	309.7 sq. ft.
Colorado State Univ.	Green Hall	3	245.0
	Newsom Hall	3	251.0
	Aylesworth Hall	3	208.0
	Ellis Hall	3	208.0
	Allison Hall	3	224.0
University of Oregon	Walton Hall	3&4	231.0
University of Penna.	Women's Residence Hall	5	256.0
Stephens College, Mo.	West Hall	4	260.6
Syracuse University	Sadler Hall	8	273.4
Univ. of Washington	Terry Hall	11	345.0
	Lander Hall	8	253.0
Wesleyan University	Foss Hill I	2&3	513.0

Source: College Students Live Here, Educational Facilities Labs, 1961.

Figure IV-6

Unit Cost Factors: As stated earlier, the two elements which determine the cost of an institution are the space required (square feet in this instance) and the unit cost (dollars per square foot). The space requirements for the proposed training center have been developed above and the next step is to develop the unit cost or dollars per square foot of required space.

It is recognized that the cost per square foot basis for costing has its limitations because it does not say anything about the quality of materials and construction, which add up to the cost per square foot, and, also, because it does not relate to the usefulness of the space provided. In order to develop an acceptable cost factor to use for planning purposes, however, it was assumed that the quality of material and construction, along with space usefulness, were comparable for the various institutions surveyed.

Classroom/Laboratory Costs: One survey of costs involved eight universities and colleges which used innovative and unique designs to accommodate new educational technologies, such as educational television, computer-assisted teaching systems, study carrels, etc., and provided for maximum flexibility and convertibility. The results of this survey are presented in Figure IV-7.

The average cost per square foot for the institutions surveyed was $23.50. This is somewhat higher than costs experienced in the construction of more conventional buildings. For example, the Arizona State University construction costs have been averaging $16-$18 per square foot in recent years.

In the Educational Facilities Laboratories survey of the 100 secondary schools built in the 1956-1958 time period, it was found that the average costs ranged from a low of $13.70 per square foot in the South to $17.84 in the Northeast.[9] The results of the Educational Facilities Laboratories survey are shown in Figure IV-8.

It is interesting to note the influence of the mechanical costs (wiring, heating, plumbing and ventilating) on the total cost of the buildings. These vary from 21% of the total cost in the South to 32% in the Northeast. This is, in part, due to the climate which affects not only the size of a building but also the unit cost.

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[9] The Cost of a Schoolhouse, op. cit.

A SURVEY OF EDUCATIONAL FACILITIES COSTS PER SQUARE FOOT*

Institution	Cost/Sq. Ft.
Stephens College, Mo.	$ 22.00
Chicago Teachers College, North	19.00
Columbia University Law School	26.00/27.00
Southern Illinois University	23.00/24.00
University College, Miami	15.26
Retina Foundation, Boston	37.25
Colorado College	19.66
Rice University, Texas	22.00

* Includes classrooms and laboratories and equipment.

Source: Bricks and Mortarboards, Educational Facilities Labs, 1966.

Figure IV-7

MEDIAN COST PER SQUARE FOOT BY REGION

Region	Total Bldg. Cost	Mechanical Cost	Bldg. Cost W/O Mechanical
Northeast	$ 17.84	$ 5.69	$ 12.15
South	13.70	2.89	10.81
Middlewest	14.91	4.34	10.57
West	14.64	4.60	10.04

Source: The Cost of a Schoolhouse, Educational Facilities Labs, 1960.

Figure IV-8

On the basis of the data obtained during the Educational Facilities Laboratories survey, it was possible to develop not only the median cost per square foot ($15.99) but also a distribution of that cost to all of the elements involved in the construction of a building. The distribution of the per square foot cost to the elements which make up this cost are shown in Figure IV-9.

An examination of the cost information contained in Figure IV-9 reveals why it is difficult to keep construction costs down. There is, obviously, no room for dramatic reductions in the cost figures for the individual cost elements. The only means for achieving economy is by careful attention to every single detail of each of the elements which make up the per square foot cost.

Student Residence Costs: In a recent study of college housing, data was acquired which permitted the development of costs per square foot and also costs per student for both the buildings and furnishings.[10] The costs for thirteen (13) buildings built by eight (8) institutions are shown in Figure IV-10.

An examination of the information presented in Figure IV-10 shows the costs ranging from a low of $3,252 to a high of $10,791, for an average of $4,813 per student. These are building costs without furnishings. The furnishings costs range from a low of $210 to a high of $602, for an average of $371 per student. The average total cost is $5,184 per student.

The costs per square foot of structure ranged from a low of $12.45 to a high of $23.13, for an average of $17.10 per square foot. This is somewhat lower than the cost for the educational facilities surveyed, primarily because of the innovative approaches that were used in the educational facilities surveyed. By way of comparison, the recent dormitory construction costs at Arizona State University were approximately $20 per square foot, including furnishings. It is interesting to note, however, that the furnishings costs averaged only $175 per student as compared to $371 in the institutions surveyed. The reason for this apparent difference is that many of the furnishings in the Arizona State University dormitories are built-in and are considered as part of the construction costs, resulting in increased construction costs and reduced furnishings costs.

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[10] College Students Live Here, op. cit.

MEDIAN COST PER SQUARE FOOT*

Cost Item	Cost/Sq. Ft. Gross Area	% Total Cost
Excavation	$ 0.34	2
Footings & Foundation	1.00	6
Structural Frame	1.57	10
Structural Floors	1.25	8
Roof Deck	0.50	3
Roofing & Insulation	0.45	3
Exterior Walls	2.00	12
Interior Partitions	2.45	15
Finished Floors	0.40	3
Ceilings	0.28	2
Plumbing	1.15	7
Heating & Ventilating	1.90	12
Electrical & Lighting Fixtures	1.45	9
Misc. Equipment (Built-In)	0.75	5
Contractor Job Overhead	0.50	3
Total	$15.99	100%

* Based on a survey of 72 secondary schools with all costs adjusted to the 1959 "Engineering News Record Index" to account for inflationary and regional differences due to year built and location.

Source: The Cost of a Schoolhouse, Educational Facilities Labs, 1960.

Figure IV-9

SURVEY OF STUDENT RESIDENCE COSTS

School	Dorm.	No. Floors	Costs*		Furnishings Cost/Student
			Per Student	Per Sq Ft	
Univ. of Chicago	Pierce Hall	10	$6740	$21.76	$602
Colo. State Univ.	Green Hall	3	3737	15.23	256
	Newsom Hall	3	3431	13.67	237
	Aylesworth Hall	3	3350	16.09	210
	Ellis Hall	3	3252	15.61	210
	Allison Hall	3	3378	15.05	211
Univ. of Oregon	Walton Hall	3&4	3548	15.34	471
Univ. of Penna.	Women's Residence	5	5497	21.47	527
Stephens Coll., Mo.	West Hall	4	4650	17.80	443
Syracuse Univ.	Sadler Hall	8	6327	23.13	358
Univ. of Wash.	Terry Hall	11	4298	12.45	439
	Lander Hall	8	3468	13.69	509
Wesleyan Univ.	Foss Hill I	2&3	10791	21.02	-

* Excluding land and furnishings.

Source: College Students Live Here, Educational Facilities Labs, 1961.

Figure IV-10

Summary of Cost Factors: On the basis of the cost data collected and analyzed for this section of the report, it is concluded that the costs for the proposed aviation training center will range from $20 to $25 per square foot for the educational facilities and from $17 to $18 per square foot for the student residence facilities.

These facilities unit costs are somewhat higher than have been experienced in the past; however, these added costs will provide greatly improved flexibility and convertibility and are expected to result in more efficient and effective teaching. The flexibility and convertibility costs more than conventional construction but, in the long run, it will more than pay for itself because of the fact that the facilities will be more productive.

Facility Cost Estimates for Proposed Center

After developing average space requirements per student and unit costs for construction of educational and housing facilities, it was then possible to develop preliminary cost estimates for the facilities required in the proposed training center.

As determined in Section III of this report, two operational sites on the Gila River Indian Reservation are being considered for the proposed center -- an academic center in the residential development area and a flight center on the Goodyear Auxiliary Airfield. All students will use the academic center on a full-time basis and one-half of the students will use the flight center. The student residence facilities will be located in the residential area as a part of the academic center.

In developing the cost estimates for the proposed center, due consideration was given to the special purpose of the center and the manner in which it would operate, as these factors might contribute to construction costs, economy, and efficiency of its operation. Many of the expensive specialized facilities, such as necessary on the Arizona State University main campus in Tempe, will either not be necessary, be reduced to a minimum, or will be uniquely provided. Every opportunity to make use of the central facilities at the Tempe campus will be made wherever feasible and wherever conducive to the purpose of the center.

For example, the program envisioned for the center does not include or require a large central union building, large central business operations, large auditora, stadia, or other athletic plants to accommodate thousands of spectators. Some central physical facilities will be necessary, such as cooling, heating, and other utilities; but on the whole, the life of the center will revolve around its own unique environs, its own imaginative buildings, combining many traditional features, a multi-purpose dining hall, a compact library and/or an aviation information center, activities center, and playing fields, combined in a new, fresh "[illegible]" style.

The key concept envisioned for the center is effective, attractive, multi-purpose, functional structures. The educational and residential facilities and adjacent outdoor area will be designed and landscaped to function harmoniously. Separate residential quarters, for both male and female students, will be provided (because of the nature of the center, the female enrollment will be very limited), connected and served by common facilities, including the dining hall. The dining hall could also be designed to serve as a cultural center, suitable for dances, films, dramatic performances, and as a possible center for forum discussions of a contemporary nature.

By skillful design and location, additional gymnasium/recreational facilities can be envisioned to serve the larger needs of the center and without extensive additional space being devoted to locker rooms, dressing rooms, and overduplication of showers and washroom facilities, if access is easy and convenient from the men and women's residential quarters.

The cost estimates for the educational, residential, and flight center facilities were developed separately below, based on the space and cost factors developed in preceding paragraphs and with due consideration for the design and operational concepts discussed above.

<u>Educational Facilities Cost Estimates:</u> The preliminary cost estimates for the educational facilities developed below include both classroom and laboratory space and general equipment. The space factor used in developing the estimates is based on 120 square feet of space for each full-time equivalent student, as developed earlier in this section of the report.

The unit cost factors for construction of educational facilities, as developed earlier, were estimated to range from $20 to $25 per square foot. This would be applicable to facilities which incorporated new, innovative approaches to education and with provisions in the design for maximum flexibility and convertibility. In developing the preliminary cost estimates for planning purposes, the figure of $22.50 per square foot unit cost is used for the construction of the educational facilities.

The space requirements and costs for construction of educational facilities for the proposed training center, based on the above discussion, are shown in Figure IV-11 for the four modules of students. On the basis of the enrollment analysis made earlier, it was concluded that the center should be designed for a minimum of 1,000 students, initially, with provisions for expansion to 2,000 by 1972. The costs shown in Figure IV-11 indicate that the educational facilities would be $2,700,000 for the 1,000-student center.

EDUCATIONAL FACILITIES COST ESTIMATES

Student Module	Space Reqmts. in Sq. Ft.	Costs at $22.50/Sq. Ft.
500	60,000	$ 1,350,000
1000	120,000	2,700,000
1500	180,000	4,050,000
2000	240,000	5,400,000

Figure IV-11

The cost for a 2,000-student center is estimated at $5,400,000 -- double the 1,000-student module. It is, of course, recognized that doubling the enrollment, as presently envisioned between 1968 and 1972, will not necessarily result in doubling the cost of the initial design for a student body of 1,000. For planning purposes, however, the basic space and unit costs are applied.

Student Residence Facilities Cost Estimates: The cost estimates developed for the construction of student residence facilities are based on the philosophy that living in any dormitory will teach a student something, and that during the detailed design of these facilities it must be decided what the institution wants the student to learn there and plan the buildings accordingly.

In the designing of the residential facilities for the proposed aviation training center, consideration will be given to the utilization of these facilities for supplementing or reinforcing the academic program, making them the partner to the classrooms and laboratories, as in the new housing at Michigan State; making the dormitory itself theclassroom, as in Stephens College's West Hall; or making the dormitory the focus of a variety of learning aids - from tutors to television to computer-based, multi-media student carrels for study. Such design approaches are expected to be not only feasible but also economical, in spite of the costs. With the availability of such innovative facilities, it is anticipated that a high percentage of the students will live in these residential facilities, particularly the out-of-state students.

An examination of the student enrollment in the current Arizona State University Aeronautical Technology program revealed that over 50% of the students were from out-of-state. The average for the University as a whole is 15% out-of-state enrollment. This seems to indicate a general shortage of aviation-oriented courses in colleges and universities, resulting in higher out-of-state enrollment percentages in those schools which provide aviation-oriented programs.

It is anticipated that the percentage of out-of-state enrollments in the proposed training center will be even higher because of the "national" character of the center and, also, because of the new, innovative approaches to education that are being planned in the design of not only the educational facilities but also in the student residential facilities.

Because of the anticipated higher (estimated 75%) out-of-state enrollment and attraction of the innovative educational character of the student residence facilities in the proposed training center, it is believed at least 75% of the total student enrollment will live in the residential facilities at the academic center. This is the figure that is used in estimating the costs for these facilities and is in keeping with the increases in the percentage of enrollment population living in student housing facilities being anticipated and planned for in many of the new educational institutions. For example, Pennsylvania State is planning to house 75% of its undergraduates in student housing.

The preliminary cost estimates for the student residence facilities at the proposed aviation training center were developed on the basis that 75% of the student body would be living in these facilities, that the facilities would be designed to provide 250 square feet of space per student, and at a cost of $17.50 per square foot construction cost. The preliminary cost estimates are shown in Figure IV-12.

On the basis of the information developed as shown in Figure IV-12, it appears that the initial student residence facility cost will range from $3,281,250 for the 1,000 student module to $6,562,500 for the 2,000 student module. These construction costs will be experienced during the period 1968-1972.

It must be noted that no provisions have been made in the estimates for married student or apartment-type or faculty housing. These items will be analyzed in detail during the preliminary design phase and, if required, will be priced during that phase of the program.

Flight Center Facilities Costs: The facilities required at the flight center include an operations building, hangars, and ramp space for maintenance and parking of the aircraft.

The operations building must be designed to provide office space for administrative personnel and flight instructors, a minimum conference room, and space for synthetic flight trainers. No provisions are provided in the estimates for future expansion of the staff for R&D purposes or for special R&D facilities which are expected to be developed. These will be considered separately, if or when they are developed.

Operations Building Cost Estimates: Under the operations costs portion of this section, it has been determined that a total of 22, 43, 63, and 85 personnel, respectively, would be required to operate the flight center for the four student modules considered throughout the study. The

STUDENT RESIDENCE FACILITIES
COST ESTIMATES

Student Module	No. in Residence at 75%	Space Rqmts.	Cost at $17.50/Sq. Ft.
500	375	93,750	$ 1,640,625
1000	750	187,500	3,281,250
1500	1125	281,250	4,921,875
2000	1500	375,000	6,562,500

Figure IV-12

operations building would be required to provide space for 17, 34, 50, and 67 people, respectively, for the four modules, with the balance of the total numbers of personnel (maintenance) being housed in the hangars. By using the 120 square feet space allocation per individual and a $17.50 per square foot unit cost, it was possible to calculate the costs for that part of the operations building occupied by personnel.

In addition, space will be required to house a battery of synthetic trainers. It is planned that one trainer will be provided for each 50 flight students, resulting in a need for 5, 10, 15, and 20 trainers, respectively, for the four student modules. Using the new Link General Aviation Trainer (GAT-1) as a basis, each trainer would require an area of 250 square feet of floor space.

On the basis of the foregoing, the total space and costs were calculated for the operations building as shown in Figure IV-13. The space requirements are 6,580 square feet for the initial 1,000 student module and 13,040 square feet for the 2,000 student module to be provided by 1972. Preliminary cost estimates for the 1,000 student module are $115,150 and $228,200 for the 2,000 student module.

Hangar Cost Estimates: The hangar cost estimates are based on an average construction cost of $10 per square foot. The number of square feet of space required to perform the necessary maintenance inside the hangars is a function of the total number of aircraft in the training pool.

For the purpose of this study, it was assumed that one-third of the total number of aircraft in the pool would be the maximum number inside the maintenance hangar at any one time, and that 1,600 square feet of floor space would be provided for each aircraft. This space would provide for all the floor space required in the maintenance operation -- for both single- and twin-engine aircraft.

On the basis of the foregoing factors, it was possible to calculate the space and cost estimates, as shown in Figure IV-14. The space requirements for the 1,000 student module which would have a maximum of 7 of its 20 allocated aircraft in the hangar at any one time are 11,200 square feet, costing an estimated $112,000. For the 2,000 student module, 13 of its 38 aircraft hangared at any one time would require 20,800 square feet of space at an estimated cost of $208,000. These cost estimates include ramp space for parking.

OPERATIONS BUILDING COST ESTIMATES

Student Module	Space Requirements			Cost at
	Pers	Trnrs	Total	$17.50/Sq. Ft.
500	2,040	1,250	3,290	$ 57,575
1000	4,080	2,500	6,580	115,150
1500	6,000	3,750	9,750	170,625
2000	8,040	5,000	13,040	228,200

Figure IV-13

HANGAR SPACE AND COST ESTIMATES

Student Module	No. A/C Hangared	Space Required at 1600 Sq Ft/Aircraft	Cost at $10/Sq Ft
500	4	6,400	$ 64,000
1000	7	11,200	112,000
1500	9	14,400	144,000
2000	13	20,800	208,000

Figure IV-14

Total Facilities Cost Summary: After the development of cost estimates for each of the various types of facilities required for the proposed training center, it is then possible to summarize the total estimated facilities costs, as shown in Figure IV-15. An analysis of the cost estimates presented in Figure IV-15 shows that the cost per student for facilities runs $6,224, $6,208, $6,191, and $6,199, respectively, for the four student modules considered.

Equipment Cost Estimates

Two types of equipment are required for operation of the proposed aviation training center -- the standard equipment normally required in classrooms, laboratories, and administrative offices of an educational institution for the academic portion of the center and that equipment required for flight training operations.

The equipment required in the academic portion of the center has been accounted for in the cost factors used in developing the facilities cost estimates. The per square foot cost experience for educational facilities in recent years, for example, has been $16-$18, including the cost of equipment. The figure used in this study has been $22.50 per square foot for educational facilities, which should be adequate to provide for the flexibility and expandability requirements and, also, for some of the new educational technologies which are now available. The far-reaching. higher-cost equipment related to computer-based systems will be priced and financed separately as they become available.

The equipment required for flight training operations, along with cost estimates for such equipment, has been developed and are presented below. These requirements include the number of and type aircraft, the number of synthetic trainers, and the operations and maintenance support equipment.

Aircraft: An estimate of the number of aircraft required to conduct the flight training program for each of the four student modules was predicated on the following:

1. Each student will complete a total of 250 hours of flight during a four-year equivalent program.
2. The flight training will be conducted in light, two-place, single-engine and light, twin-engine aircraft.
3. Each student will receive 180 hours of basic flight training in single-engine aircraft and 70 hours of advanced flight training in twin-engine aircraft.
4. Aircraft will be utilized eight (8) flight hours per day.

TOTAL FACILITIES COST ESTIMATES

Facilities Required	Student Modules			
	500	1000	1500	2000
Educational	$1,350,000	$2,700,000	$4,050,000	$ 5,400,000
Student Residence	1,640,625	3,281,250	4,921,875	6,562,500
Operations Bldg.	57,575	115,150	170,625	228,200
Hangar	64,000	112,000	144,000	208,000
Total Costs	$3,112,200	$6,208,400	$9,286,500	$12,398,700

Figure IV-15

5. The number of spare aircraft will be 15% of the number required for the training program.

6. Flight training operations will be conducted five (5) days per week, 50 weeks per year, for a total of 250 days per year.

On the basis of the foregoing, the following equations were developed for determining the number of aircraft required in the training program:

1. Single-Engine Aircraft

$$\frac{\text{No. Students (250, 500, 750, or 1000) X 180 hrs/Student}}{\text{4 Yrs X 2000 hrs/yr/aircraft}} \text{ X } 1.15$$

2. Twin-Engine Aircraft

$$\frac{\text{No. Students (250, 500, 750, or 1000) X 70 hrs/Student}}{\text{4 Yrs X 2000 hrs/yr/aircraft}} \text{ X } 1.15$$

During the study, an analysis was also made of the types of aircraft available for use in the training program. The analysis revealed that aircraft suitable for the purpose and adequately equipped with flight and navigational instruments could be procured for an estimated cost of $15,000 and $50,000, respectively, for single- and twin-engine aircraft.

Having determined the number of aircraft required and costs per aircraft, the total costs for aircraft for the four modules were then developed, as shown in Figure IV-16. The results indicate a requirement for 20 aircraft, 14 single-engine (S.E.) and 6 multi-engine (M.E.), for the 1,000 student module, at a total cost estimate of $510,000. A total of 38 aircraft (27 S.E. and 11 M.E.) are required for the 2,000 student module, at a total cost estimate of $955,000.

Ground Support Equipment: The ground support equipment required in the proposed training program will be of a less complex nature than generally found on larger airports due to the light aircraft planned for use in the program. No special equipment is required other than general shop equipment, such as sheet metal tools, battery service tools, spark plug cleaner and tester, etc. Equipment required for repair and test of electronics is the high-dollar equipment needed for the operation.

AIRCRAFT COST ESTIMATES

Student Module	No. S.E. A/C	No. M.E. A/C	Cost S.E. A/C	Cost M.E. A/C	Total Cost
500	7	4	$105,000	$200,000	$305,000
1000	14	6	210,000	300,000	510,000
1500	20	8	300,000	400,000	700,000
2000	27	11	405,000	550,000	955,000

Figure IV-16

For planning purposes, it is estimated that the ground support equipment costs will be 10% of the acquisition costs of the aircraft. The costs, based on this estimate, are shown in Figure IV-17.

Synthetic Trainers: It is planned to acquire a number of synthetic trainers which are capable of realistically simulating the flight characteristics of the type aircraft being flown by the students. The trainers will be used to teach flight skills to the basic pilots, to upgrade the student with instruction in instrument and navigational procedures, to safely conduct emergency procedures, and to stimulate interest in advanced training.

The trainers should be capable of providing full motion, including rough air simulation; realistic engine and airframe sounds to put the student into the most realistic training situation; and typical instrument panel arrangements of modular design, so that they may be readily changed to represent different aircraft types. Both single- and twin-engine trainers are planned.

It is planned to provide one trainer for each block of 50 flight students, at a ratio of one twin-engine to four single-engine trainers. The number of trainers and costs for each module are shown in Figure IV-18. Costs are based on estimates of $10,000 and $18,000 for the single- and twin-engine trainers, respectively.

The training provided with the trainers will be in addition to the flight time in aircraft to upgrade the quality of the overall training activity. Consideration will be given to the substitution of trainer time for flight time, if controlled research programs can provide the appropriate data necessary to justify the substitution with the particular trainers in use.

Summary of Equipment Cost Estimates: Using the information developed in the preceding paragraphs, the total equipment cost estimates were tabulated and are shown in Figure IV-19.

An examination of the total costs for equipment required in support of flight training program shows costs of $1,574, $1,354, $1,259, and $1,282 per student for the four student modules, respectively.[11]

When the above figures are added to the total facilities cost estimates presented in Figure IV-15, the total investment for the proposed training center per student becomes $7,798, $7,562, $7,430, and $7,481 for the four modules, respectively.

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[11] These per student costs pertain only to the flight students, which represent one-half of the student modules.

GROUND SUPPORT EQUIPMENT COST ESTIMATES

Student Module	Costs
500	$ 30,500
1000	51,000
1500	70,000
2000	95,500

Figure IV-17

SYNTHETIC TRAINER COST ESTIMATES

Student Module	No. S.E. Trainers	No. M.E. Trainers	Costs
500	4	1	$ 58,000
1000	8	2	116,000
1500	12	3	174,000
2000	16	4	232,000

Figure IV-18

SUMMARY OF EQUIPMENT COST ESTIMATES

Equipment	Student Modules 500	1000	1500	2000
Aircraft	$ 305,000	$ 510,000	$ 700,000	$ 955,000
Ground Support Equipment	30,500	51,000	70,000	95,500
Synthetic Trainers	58,000	116,000	174,000	232,000
Total	$ 393,500	$ 677,000	$ 944,000	$1,282,500

Figure IV-19

Operations Cost Estimates

In keeping with the concept of the proposed aviation training center, as envisioned throughout this report, two centers of operation will be considered in developing operating cost estimates -- the academic center and the flight center. These are both treated separately and are based on the following general guidelines which have been developed on the basis of current Arizona State University experience:

1. Faculty and staff personnel are provided at a ratio of 1 to 4 or 5 students.
2. Staff and administrative personnel are provided at a ratio of 1 to 1 professional or faculty member.
3. Food and dormitory services personnel are provided at a ratio of 1 to 9 or 10 students.

More specific rules for developing cost estimates are presented with each specific cost element as it is developed. The cost estimates allow for annual increases in per capita student cost from 9 to 10% in anticipation of a continuing increase in the price of supplies and equipment, as well as normal salary adjustments.

Academic Center Operating Cost Estimates: The costs for operation of the academic center are divided between personnel and other costs (operations, travel, etc.). On the basis of the guidelines set forth above, the total personnel requirements were estimated and these are set forth in Figure IV-20, ranging from a total of 96 for the 500 student module to 410 for the 2,000 student module.

As greater use is made of new educational technologies, the faculty to student ratio will be reduced because of greater emphasis on individual study. Such reductions, however, will be offset by a requirement for technicians, educational psychologists, media specialists, etc., who will be required to develop and maintain instructional material and equipment.

After developing the personnel requirements, as set forth in Figure IV-20, costs were then developed for the four modules on the basis of average annual salaries of $10,000 for faculty members, $4,800 for staff and administrative personnel, and $3,600 for food and dormitory services personnel. Each of these averages includes part-time student employees, with higher percentages of low-income, part-time personnel in the latter categories. The cost estimates for personnel are set forth in Figure IV-21.

PERSONNEL REQUIREMENTS FOR
OPERATION OF ACADEMIC CENTER

Student Module	Faculty	Staff & Admin.	Food & Dorm. Serv.	Total
500	23	23	50	96
1000	45	45	110	200
1500	68	68	166	302
2000	90	90	230	410

Figure IV-20

PERSONNEL COST ESTIMATES (ANNUAL)
FOR ACADEMIC CENTER

Student Module	Faculty	Staff & Admin.	Food & Dorm. Serv.	Total
500	$ 230,000	$ 110,400	$ 180,000	$ 520,400
1000	450,000	216,000	396,000	1,062,000
1500	680,000	326,400	597,000	1,603,400
2000	900,000	432,000	828,000	2,160,000

Figure IV-21

Personnel costs or salary and wage expenses have represented slightly more than one-half of the total expenditures at Arizona State University for the past several years.[12] The "other" expenditures covered operations, travel, capital, and services. Using this general guideline as a basis and a per student wage and salary estimate of approximately $1,000 derived from Figure IV-21, an "other costs" figure of $1,000 per student was used for developing the overall operating costs for the academic center. By adding this cost element to the personnel cost estimates developed in Figure IV-21, the total annual cost of operation for the academic center was estimated, as shown in Figure IV-22.

An examination of the information in Figure IV-22 indicates a total annual cost of approximately $2,000 per student for the proposed academic center. The current total cost per FTE student at Arizona State University is approximately $1,700.[13] This is considered a reasonable cost when viewed in the light of the new educational technologies to be employed. It is also in line with the 1974-75 estimates for FTE students (24,600) and the projected operating budget ($57,000,000), resulting in an estimated annual cost of $2,320 per FTE student at that time.[14]

Flight Center Operating Cost Estimates: The annual costs of operation for the flight center are divided between personnel, aircraft operating costs (fuel and oil), spare parts, insurance and depreciation. In developing the annual operating cost estimates, no consideration was given to food and dormitory service personnel, inasmuch as all these costs were covered under the academic center cost estimates. Also, the student modules will only be one-half of the number used in the other estimate, since only one-half of the students are assumed to be enrolled in the flight training portion of the program.

Personnel Requirements: Three types of personnel are required for the operation of the flight center -- flight instructors, maintenance technicians, and staff/administrative personnel. With respect to the flight instructors, they will perform dual flight instruction and also the simulator training. The number required is based on a limitation of four hours of flight instruction per day, per instructor; and since there are 235 working man-days per year;[15] a flight instructor man-year would equal 940 hours. The number of flight instructors required, then, would be equal

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[12] Arizona State University, Financial Report for the Year Ended June 30, 1966, Tempe, Arizona.

[13] Total expenditure in 1966 $27,570,564 ÷ 15,924 FTE students = $1,720.

[14] A Report to Board of Regents, op. cit., Table 28.

[15] The actual number of man-hours available per man per year are 1,880, based on an eight-hour day, five-day week, with allowances for sick leave, vacation and holidays. 1880 ÷ 8 = 235 man-days.

ESTIMATED ANNUAL OPERATING COST OF ACADEMIC CENTER

Student Module	Est. Personnel Costs	Other Costs*	Total
500	$ 520.400	$ 500,000	$ 1,020,400
1000	1,062,000	1,000,000	2,062,000
1500	1,603,400	1,500,000	3,103,400
2000	2,160,000	2,000,000	4,160,000

* Includes operations, travel, services, and capital.

Figure IV-22

to the total number of flight hours of operation per year divided by 940. The total number of flight hours flown per year is equal to the number of hours flown per student multiplied by the number of students. Thus, the number of flight instructors required for each module becomes:

1. For the 500 student module

$$\frac{250 \times 62.5}{940} = \frac{15,625}{940} = 17 \text{ Instructors}$$

2. For the 1,000 student module

$$\frac{500 \times 62.5}{940} = \frac{31,250}{940} = 34 \text{ Instructors}$$

3. For the 1,500 student module

$$\frac{750 \times 62.5}{940} = \frac{46,875}{940} = 50 \text{ Instructors}$$

4. For the 2,000 student module

$$\frac{1000 \times 62.5}{940} = \frac{62,500}{940} = 67 \text{ Instructors}$$

Maintenance personnel requirements have been developed on the basis of one maintenance man-hour for every five flight hours with single-engine aircraft and one maintenance man-hour for each flighthour with twin-engine aircraft. In addition, one engine mechanic will be required for every twelve engines operating. On the basis of the foregoing, the following maintenance personnel requirements were developed:

1. 500 student module

Single-engine flight time = 11,250 hrs/yr
Twin-engine flight time = 4,375 hrs/yr
<u>Total</u> = 15,625 hrs/yr

$$\text{Personnel for S.E. A/C} = \frac{11250}{5 \times 1880} = 1.2$$

$$\text{Personnel for T.E. A/C} = \frac{4375}{1880} = 2.3$$

$$\text{Personnel req'd for engine O.H.} = \frac{15}{12} = 1.2$$

Total Personnel Req'd 4.7 or 5

2. 1,000 student module

Single-engine flight time = 22,500 hrs/yr
Twin-engine flight time = 8,750 hrs/yr
Total = 31,250 hrs/yr

Personnel for S.E. A/C = $\frac{22500}{5 \times 1880}$ = 2.4

Personnel for T.E. A/C = $\frac{8750}{1880}$ = 4.9

Personnel req'd for engine O.H. = $\frac{26}{12}$ = 2.1

Total Personnel Req'd 9.4 or 9

3. 1,500 student module

Single-engine flight time = 33,750 hrs/yr
Twin-engine flight time = 13,125 hrs/yr
Total = 46,875 hrs/yr

Personnel for S.E. A/C = $\frac{33750}{5 \times 1880}$ = 3.6

Personnel for T.E. A/C = $\frac{13125}{1880}$ = 6.7

Personnel req'd for engine O.H. = $\frac{36}{12}$ = 3.0

Total Personnel Req'd 13.3 or 13

4. 2,000 student module

Single-engine flight time = 45,000 hrs/yr
Twin-engine flight time = 17,500 hrs/yr
Total = 62,500 hrs/yr

Personnel for S.E. A/C = $\frac{45000}{5 \times 1880}$ = 4.8

Personnel for T.E. A/C = $\frac{17500}{1880}$ = 9.3

Personnel req'd for engine O.H. = $\frac{49}{12}$ = 4.0

Total Personnel Req'd 18.1 or 18

With regard to staff and administrative personnel requirements, a ratio of 1 to 1 flight instructor was used in developing the estimates, the same ratio used in the development of staff and administrative personnel requirements for the academic center. A summary of total personnel requirements for the flight center is set forth in Figure IV-23.

Annual Personnel Cost Estimates: After developing the personnel requirements, as set forth in Figure IV-23, costs were developed for the four modules on the basis of average annual salaries of $12,000 for flight instructors, $6,000 for maintenance technicians, and $4,800 for staff and administrative personnel. The average cost estimates used here are somewhat higher in the first two personnel categories than used in the academic center because of a much lower utilization of part-time student personnel in the flight operations. On the basis of the foregoing, the annual personnel costs were developed and are set forth in Figure IV-24.

Annual Operating Cost Estimates/Hour/Aircraft: For developing direct operating cost figures for the flight operations, a cost per hour figure was established for both the single-engine and the twin-engine operations. The cost per hour figures were established as follows:[16]

	Single Engine	Twin Engine
Fuel and oil costs/hour	$ 2.50	$ 6.00
Depreciation	.62	3.00
Spare parts	.50	2.75
Insurance	.65	1.00
Engine overhaul, less labor	.75	1.50
Total Cost/Hour	$ 5.02	$14.25

Using the cost per hour figures developed above, the annual operating costs for the four student modules were calculated and are presented in Figure IV-25, showing an annual operating cost of $118,819 for the smallest module and $475,276 for the largest student module.

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[16] Figures obtained by correspondence from general aviation aircraft manufacturer.

ESTIMATED PERSONNEL REQUIREMENTS
FOR FLIGHT CENTER

Student Module	Flight Instr.	Maint. Tech.	Staff & Admin.	Total
250	17	5	17	39
500	34	9	34	77
750	50	13	50	113
1000	67	18	67	152

Figure IV-23

ESTIMATED PERSONNEL COSTS FOR FLIGHT CENTER

Student Module	Flight Instr.	Maint. Tech.	Staff & Admin.	Total
250	$ 204,000	$ 30,000	$ 81,600	$ 315,600
500	408,000	54,000	163,200	625,200
750	600,000	78,000	240,000	918,000
1000	804,000	108,000	321,600	1,233,600

Figure IV-24

ANNUAL AIRCRAFT OPERATIONS
COST ESTIMATES

Student Module	S.E. Hrs.	S.E. Costs	M.E. Hrs.	M.E. Costs	Total Costs
250	11,250	$ 56,475	4,375	$ 62,344	$ 118,819
500	22,500	112,950	8,750	124,688	237,638
750	33,750	169,425	13,125	187,032	356,457
1000	45,000	225,900	17,500	249,376	475,276

Figure IV-25

Annual Rental Cost Estimates: It is assumed that the facilities at the flight center will be built by the Indian tribe and leased to the organization conducting the flight training program. The estimated rental price for the operations building is based on a $4.00 per square foot per year rate, including all costs except communications. The estimated rental price for the hangar space is based on a $1.50 per square foot per year rate.

In addition to the facilities rental costs, further costs will be incurred for the utilization of airfield property other than the facilities. For estimating purposes, the figures of $1,750, $3,500, $5,250, and $7,000 per year have been used in developing the overall leasing cost estimates. This would be roughly the equivalent of 50, 100, 150, or 200 acres of land.

On the basis of the foregoing, the estimates for annual leasing costs were developed and are presented in Figure IV-26. The leasing costs range from an annual cost of $24,510 for the smallest module to $90,360 for the largest student module.

Estimated Annual Operating Cost of Flight Center: After developing the cost estimates for personnel, aircraft operations and leasing costs, the total annual costs for operation of the flight center were developed, as shown in Figure IV-27. The costs range from $458,929 per year for the 250 flight student module to a high of $1,799,236 for the 1,000 student module.

An analysis of the cost figures presented in Figure IV-27 reveals that the average cost per flight hour ranges from $28.80 to $29.20 for the various modules. This appears to be somewhat high when viewed in light of the fact that 170 of the 250 hours of flight training will be conducted in single-engine and 80 hours in twin-engine aircraft. The cost estimates are based, however, on 100 hours of dual instruction in the single-engine aircraft, 70 hours of solo in single-engine aircraft, and 80 hours of advanced instrument flight in the twin-engine aircraft. When the fixed-base operator rates are applied to this flight program, the cost is not unreasonable. In addition, a considerable amount of synthetic trainer time is also included in this estimate.

On the basis of the planned flight program supplemented with synthetic trainer time, it is believed that a very high quality commercial/instrument pilot will result. If some of the trainer time can be substituted for the flight time and if the aircraft utilization rates are increased, the cost per flight hour would be significantly reduced.

ANNUAL LEASING COST ESTIMATES

Student Module	Opn Bldg Space	Opn Bldg Costs	Hangar Space	Hangar Costs	Land Lease Costs	Total Costs
250	3,290	$ 13,160	6,400	$ 9,600	$ 1,750	$ 24,510
500	6,580	26,320	11,200	16,800	3,500	46,620
750	9,750	39,000	14,400	21,600	5,250	65,850
1000	13,040	52,160	20,800	31,200	7,000	90,360

Figure IV-26

ESTIMATED ANNUAL OPERATING COSTS OF FLIGHT CENTER

Cost Categories	Student Modules			
	250	500	750	1000
Personnel	$ 315,600	$ 625,200	$ 918,000	$ 1,233,600
A/C Operations	118,819	237,638	356,457	475,276
Leasing	24,510	46,620	65,850	90,360
Totals	$ 458,929	$ 909,458	$1,340,307	$ 1,799,236

Figure IV-27

Financing

As developed in this report, the annual cost for training one student in the proposed training center will be approximately $2,000. Added to this is an additional $1,800 for each student enrolled in the flight training option of the program and from $1,000 to $1,200 per year for food and housing costs.

The training costs cited are somewhat higher than normally experienced -- this being due primarily to the planned utilization of new educational technologies in the proposed center, with a resultant increase in quality education. If these can be used successfully, it may be possible for the student to obtain his entire education at a total cost less than he is currently paying, even though the annual costs are expected to be higher. This is because he will have the opportunity to complete a four-year course in three years, or less, if he has the capability. This will be possible due to the self-pacing concept planned as a part of the teaching/learning system.

In spite of the higher costs cited above, these can be expected to increase even further, because the center will be subject to the same inflationary pressures that affect the rest of the economy. The higher education budget in 1970, for example, is expected to be more than triple the $3.6 billion spent in 1957-58. By 1975, it will have multiplied more than five times.

The financial experts hold that the nation can afford these increased costs, particularly if we can improve education quantitatively and qualitatively. The estimated budget for 1975, they point out, amounts to only 1.9% of the projected gross national product for that year. The real question is how the added costs will be shared between students and parents; federal, state, and local governments; and private philanthropy.

Sources and Distribution of Education Funds: The major sources of funds for operating institutions of higher learning have been obtained from four major sources, generally as follows:[17]

Tuition	25%
Government	48%
Endowments	16%
Other, etc.	11%

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[17] Keezer, Dexter M., Editor, Financing Higher Education, 1960-70 (New York: McGraw-Hill, 1959).

The expenditure or distribution of the education dollars in institutions of higher education has been essentially as indicated below:[18]

Student Education	66.7%
Research	22.2%
Public Service, etc.	11.1%

It is argued that, because the student benefits monetarily from his college education, he ought to pay a larger share of the cost. Harvard economist, Seymour E. Harris, for example, suggested that the following shifts in the financial burden might occur:[19]

	1957-58	1969-70
Tuition	25%	40%
Government	48%	38%
Endowment Income & Gifts	16%	12%
Other (scholarship funds from various sources, etc.)	11%	11%

Others also argue that colleges should raise tuition fees, even to charging all students the full cost of their education, and what the student or his parents cannot pay from current earnings and past savings they should borrow.

On the other hand, there are many who hold that our society benefits from the higher education of talented youth and that society ought to continue to pay its share of the cost and, perhaps, even increase its proportionate contribution. Because of the unique national implications of the proposed aviation training center, it is felt that industry and the federal government should assume a higher percentage of the total cost. Following is a further discussion of the various sources of income considered for financing the costs of the proposed aviation training center:

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[18] The Economics of Higher Education, op. cit.

[19] Harris, Seymour, Higher Education: Resources and Finance (New York: McGraw-Hill, 1962), p. 28.

1. Student Tuition: The easiest course for obtaining the necessary operating revenue is to charge or raise the student tuition. During the past fifteen years, the tuition charged at first-rate, private institutions has tripled -- an average rate of increase of about 7-8% per year. There is little evidence that these increases have been excessive; however, they have certainly increased the urgency of fully developed student financial aid programs. They have also increased the attractiveness of public institutions but have not destroyed the strong appeal of good private colleges. The tuition increases have also resulted in increases - long overdue - in the salary scale of the academic profession. The question which is now raised is whether tuition can continue to rise at recent rates without handicapping both students and parents. Because of the anticipated increase in the cost of training in the proposed training center over that presently experienced at Arizona State University, it is planned to find both public and private sources of funds which can be used to underwrite a portion of the costs of training for the students to supplement possible increases in tuition costs.

2. Taxes: The increased flow of tax money into higher education has been one of the great social achievements since World War II. Federal funds, the largest single new force in higher education, will probably continue to grow. Increases in both federal and state tax money will be sought to defray some of the costs of construction and operation of the proposed training center. Federal funds will be solicited in the areas of facilities and equipment, curriculum development, teacher training, establishment of a library/information center, etc. State funds will be used to defray some of the wage and salary costs of the staff and faculty.

3. Gifts: Gifts to educational institutions are good and there should be more of them. It should also be pointed out that most of the cost of such generosity is borne by the government through the tax deductions it permits. Gifts to educational institutions have multiplied 3½ times during the last fifteen years; however, key leaders of the nation feel that they should be 5 times what they are. Because of the national implications of the proposed aviation training center and the individual benefits that may be derived from such a center, there is a special obligation and opportunity open to those individuals and organizations who have profited from aviation in this nation. Plans for the establishment of the center will include provisions for such gifts.

4. Endowment Funds: In the establishment of the proposed training center, efforts will include the solicitation of funds for the establishment of an endowment fund. The fund should be invested in a manner to provide the maximum return commensurate with the investment risk.

Further Need for Responsibility Sharing: In addition to the problem of sharing the financial burden of the proposed training center, there is also the burden of responsibility for upgrading and controlling the quality of aviation training. Contacts with industry representatives, during the Feasibility Study, indicated that the industry was keenly interested in and hopeful for significant advancements in the development of educational materials, along with teaching methods and techniques in aviation training programs. The emphasis was always less on the quantitative and more on the qualitative results desired, i.e., more effort should be devoted to advancing the "state-of-the-art" in education and to upgrading the professionalism of skilled aviation personnel.

Another strong impression gained during the study was that there is a general lack of communication or dialogue between the aviation industry and the academic community. It is believed that this lack of communication is, to a great extent, responsible for the fact that aviation or aviation-oriented curricula have not kept pace with the technological advancements in the field of aviation (the exception is engineering). It is felt that this problem could be overcome with programs which would provide for more interaction between industry representatives and educators, resulting in greater understanding and involvement on the part of all concerned.

On the basis of the foregoing, it is believed that a central aviation training center in which the industry, the federal government, and the academic community each played a role on a cooperative basis could solve both the financial and the quality control problems related to the aviation training needs of the nation.

Such a center would not only train a significant number of skilled aviation personnel to the desired qualitative levels but, more importantly, it could conduct the research in education necessary for the advancement of aviation curricula and the development of improved teaching methods and techniques. The results of such activity would be extremely beneficial to the industry, the government, and all educational institutions engaged in aviation training.

A working relationship, as described above, could be developed if the aviation industry would establish a non-profit aviation education corporation or foundation to work with a university on a joint cooperative basis. Such a foundation could actually conduct the flight training portion of the total program under contract with the university and, also, perform some of the research in education, as appropriate. If the foundation were a membership organization, including aviation and related industries along with educational institutions engaged in aviation training, it would provide the basis for the industry and the academic community to communicate and interact on problems of mutual interest and concern in the area of aviation education.

The board of directors or board of governors of such a foundation could be comprised of leading aviation and education personnel. This would provide the industry and other academic institutions with a voice in the policy and quality control in matters related to aviation training and research in education.

A joint cooperative working relationship, as described above, would achieve the following benefits:

1. Coordinated Efforts: The present practice is for individual elements of both the industry and the academic community to undertake unilateral actions related to problems concerned with aviation education. A working relationship, as described above, would eliminate much of the unilateral action, as presently experienced; the duplication of effort and resultant expenditure of unnecessary manpower and dollars; and would provide for a coordinated approach to the major problems faced by the nation in aviation education.

2. Policy and Quality Control: Under present practices, the aviation industry has little voice with respect to the policy and quality control in training programs for personnel who will ultimately be absorbed by that industry. The establishment of a foundation, as suggested, would provide a bridge or a voice for the industry to communicate with the educational institutions and enable it to become directly involved in problems related to the industry.

3. Combining of Forces: A working relationship, as suggested, would provide a means for combining the forces of industry and the academic community. Industry and government personnel and educators from various academic institutions could be assigned to the organization for given periods of time to attack problems of mutual interest. This organization could also be used as a vehicle for personnel exchange programs in which educators could be delegated to serve time in the industry and industry representatives delegated to teach in the training center. Such programs would keep the academic community abreast of the "real" world in aviation and would also familiarize the industry representatives with the problems of education. Such "teacher training" programs would be beneficial to all concerned.

4. Cooperative Research: Under present practices, resources in terms of personnel and money are being expended on fragmented efforts which are of such scope as to require the combined efforts of several organizations. An example is the development of acceptable pilot selection and screening techniques. Another area is in the development of educational materials suitable for use with the new emerging educational technologies. The establishment of a foundation, as suggested, would provide a basis for cooperative and coordinated research efforts, such as those described above.

5. Aviation Information Center: Under present practices, many organizations have independent libraries containing aviation information. Although these libraries will continue to be a necessary part of an individual organization's operation, they are too costly and too slow to meet many of the day-to-day urgent information requirements in both the fields of education and industry. There is a need for a central, automated information center for aviation which can serve not only the educational system but the total industry as well. Such an automated information center could be designed to be accessed with remote terminals. The medical profession is presently establishing such an information center for use by that profession. The remote accessed aviation information center could be one of the services offered to the membership of the foundation as a part of the membership fee.

6. Data/Forecasting Center: One of the difficult problems encountered in the conduct of the Feasibility Study was the acquisition of data. Because there is no central source of information, it was necessary to visit with many people and organizations to acquire the data needed in support of the study. Also, the forecasting of future needs and requirements in the aviation industry has been extremely poor in the past. This is also believed to be due, in part, to thelack of a central data center. With an aviation information center, as described above, along with the new forecasting techniques developed recently, the information center could also become a forecasting center for many of the overall needs and requirements of the aviation industry and also the educational institutions involved in aviation training.

7. Status Quo Vs. Professionalism: Under present practices involving unilateral and independent activities on the part of the various institutions engaged in aviation training, considerable time will be required before real advancements in educational materials and new innovative methods and techniques are actually developed within the various academic institutions. A center, such as suggested, would eliminate the status quo which has existed for too long and permit the early development of new aviation educational materials and teaching systems that will produce the degree of professionalism desired and meet the technological needs of the future.

8. Interaction: There is, today, very little interaction between the industry and the various educational institutions engaged in aviation training. A center, such as described, could serve as a catalyst, providing the means for bringing all interested parties together in a continuing working relationship and for the dissemination of the results of its research efforts through the industry and the academic institutions engaged in aviation training on a timely and continuing basis.

9. Cost Sharing: A joint working arrangement, as described above, would also provide a basis for the cost sharing of a program which has national implications of concern to the aviation industry and the government, as well as the academic community.

10. Tax Advantage: A foundation established as suggested above would provide for tax write-offs for membership and other contributions. Such contributions would provide a portion of the funds needed to relieve the financial burden related to the operation of the training center. The government would then also be sharing in the costs of operation through the tax deductions it permitted.

11. "Civil" Training Center: The establishment of a foundation, as described above, would result in a true "civil" aviation center, as opposed to a government established center as provided for in Senate Bill S-1602 introduced by Senator Metcalf of Montana in April 1967 and House Bill H.R. 13442 introduced by Congressman Wolff of New York in March 1966. The cooperative working arrangement, as discussed above, would provide the same benefits enumerated in the above mentioned bills and would also be in keeping with the recommendations of the Aviation Human Resources Study Board which conducted a study on the manpower requirements of the civil aviation industry in 1964. In one of the recommendations, it was stated . . . "The requirement in the United States is not for a federally supported civil air academy or for a military civil aviation training mission . . . In the Board's view, the air carriers could most easily assure their pilot and mechanic requirements are met by developing cooperative programs with one or more of the existing, qualified public or private schools offering aviation training. Such cooperation can assure the maintenance of advanced technology and use of modern equipment in the educational establishments."[20]

Financing Plan: An examination of the costs estimated for the establishment and operation of the proposed aviation training center leads to the obvious conclusion that Arizona State University cannot, by itself, finance the program. Because of the national character of the proposed center, it would cause an unfair financial burden to be placed on the local or state taxpayer to provide the necessary finances for the proposed center. On the basis of the foregoing discussion, it is suggested that the cost of financing the proposed center be shared in accordance with the following general plan:

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[20] Federal Aviation Agency, Project Long Look, Report of the Aviation Human Resources Study Board on Manpower Requirements of the Civil Aviation Industry (Washington, D.C.: September 1964), p. 22.

Role of Arizona State University: The role of Arizona State University in sharing the burden of financing the proposed center should be to continue its responsibilities for bringing the academic program to the students, i.e., operation of the academic facilities of the proposed center. It is presently offering an Aeronautical Technology program to over 300 students and would expand its faculty and staff to handle the 1,000/2,000 student modules in the proposed facilities on the Gila River Indian Reservation.

The faculty, staff, and other operating costs would be underwritten with tuition collected from the students, from local and state taxes, and from gifts. The tuition rates will be as established by the Board of Regents.

The University should also conduct and participate in aviation education research leading to the development and use of improved curricula, equipment, methods and techniques. Funds for such research will be solicited on a project-by-project basis from government, foundation, and private sources.

The University should be responsible for the operation of the student residence facilities, whether directly or by contract. The costs for the operation of these facilities are assumed to be self-liquidating, by charging the student residents the actual cost of operation.

The following statement, made by Dr. G. Homer Durham, President, Arizona State University, in 1963 and again in 1965, illustrates Arizona State University's interest in participating in the development of human resources in aviation:[21]

> "The American economy is undergoing a quiet revolution. Higher education is the foundation of the change. Arizona's ability and genius in financing higher education will largely determine the future of the state. At one time, mineral exploration and development were primary. Next followed the ranches, agriculture, the cultivation of good soils and husbanding of water resources. Then came the need for better public schools and highways. Now, the crucial investment in our changing national economic and industrial life lies in cultivating the extraordinary human resources and skills that can anticipate and shape the scientific, social, and humane aspects of the aerospace age. Some states are well ahead of us in the venture. But Arizona is far from the rear, is moving rapidly, and can move further towards the forefront."

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[21] A Report to the Board of Regents, op. cit., p. 17.

Role of the Aviation Industry: The role of the aviation industry in the establishment and operation of the proposed aviation training center should be to establish a private, non-profit organization which would represent all segments of the aviation industry, the federal government, and educational institutions on matters related to aviation education.

A membership-type corporation or foundation is suggested as a possible means for maximum involvement and representation for the various segments of our society concerned with the problems of aviation education. Membership funds would be used to operate the organization and to underwrite a share of the cost of operating the proposed training center. As a non-profit organization, its members would be permitted to deduct membership fees and other gifts and contributions from income taxes.

The corporation or foundation established by the industry should assume the responsibility for the construction of facilities, procurement of the equipment, and for the operation of the flight program at the proposed aviation training center. The development of the facilities could be done in cooperation with the Indians, who could obtain the financing for site and facilities development and then provide the facilities to the organization on a long-term lease basis. The costs for conducting the operation would be partly defrayed by charging the students some acceptable fee and partly with membership fees, gifts and contributions.

The foundation should also conduct research in aviation training, as appropriate, and participate with the University and other agencies in aviation education research activities of mutual interest. These activities would be financed with funds provided for specific research proposals from government, industry, other foundations, and from private philanthropic sources.

The activities of the non-profit organization, as described above, would result in a national civil aviation center directed by representatives of all segments of our society who are concerned with aviation education. It would provide industry with a direct voice in establishing policy and controlling quality in the training of skilled aviation personnel. It would also serve as a direct link between the industry and the academic community, with the industry's needs and requirements flowing into the center, and information, knowledge, and skills flowing back to the industry from the center and other educational institutions associated therewith. The University, the local community, and the state's representatives would provide every assistance in the establishment of the organization.

Role of the Government: Because of the national implications of the skilled aviation manpower requirements problem and also because of the economic development potential for the Gila River Indian Reservation, the federal government should play an active role in the establishment and operation of the proposed center.

The government should assist in the site and facilities development program by providing maximum possible grants, contracts, and long-term, low interest loans to the Indians, the University, and the non-profit corporation to be established by the aviation industry. Funds for this purpose are available within the U. S. Department of Commerce under Titles I and II of the Economic Development Act of 1965.

Other governmental agencies, in addition to the U. S. Department of Commerce, have direct interests in the proposed program and its related activities. For example, the U. S. Department of the Interior, Bureau of Indian Affairs, has a vital interest in the pre-vocational, vocational, and social training of the Indians to prepare them for jobs created by the proposed center and other developments taking place on the Reservation; the U. S. Department of Labor has a direct interest in the training of skilled personnel for the nation's manpower pool and training for the disadvantaged; the U. S. Department of Health, Education, and Welfare, U. S. Office of Education, has a wide spectrum of interests and responsibilities in construction of educational facilities, the improvement of programs, instruction and administration in school systems, in teacher training and student assistance, and for research in education -- all of which are involved in the proposed program; and the U. S. Department of Transportation, Federal Aviation Administration and Civil Aeronautics Board, who have direct interests and responsibilities in fostering, encouraging, and assisting the development of civil aviation in this nation.

Because of the direct interests and responsibilities of the agencies cited in matters closely related to the proposed training center and the potential benefits to the nation resulting from the existence of such a center, consideration should be given to a pooling of resources of these agencies with the U. S. Department of Commerce for the support of a coordinated program which would bring the proposed center into existence. Such a program would also serve the interests and responsibilities of the agencies cited. Every effort will be made to bring these agencies together in a cooperative venture basis. If this cannot be achieved, each agency will be solicited individually with separate proposals for assistance in the establishment and operation of the proposed center.

Conclusions

After the development of potential enrollment in the proposed training center, facilities sizing and cost factors and an analysis of financing possibilities, it is concluded that:

1. The enrollment in the center will be approximately 1,000 students, initially, increasing to approximately 2,000 by 1972.
2. The development of the academic facilities of the training center should be based upon a minimum of 120 square feet of space for each student, with 275 square feet allocated per student for housing space.
3. Because of innovative and unique design approaches to accommodate new educational technologies, the construction costs for the academic facilities will be on the order of $23.50 per square foot. The student residence facilities will cost on the order of $16-$18 per square foot.
4. The total cost of the educational facilities, including general equipment, will be approximately $2,700,000 for the 1,000 student module and $5,400,000 for the 2,000 student module.
5. The total cost for student residence facilities, for 75% of the enrolled student population, will be approximately $3,281,250 for the 1,000 student module and $6,562,500 for the 2,000 student module.
6. The costs for the flight center facilities, including an operations building and hangar facilities, will be approximately $227,150 for the 1,000 student enrollment and $436,200 for the 2,000 student module.
7. The cost for flight training equipment, including aircraft, ground support equipment, and synthetic trainers will be approximately $677,000 for the 1,000 student body and $1,282,500 for the 2,000 student body.

8. The annual operating costs for the academic center will be approximately $2,062,000 for the 1,000 student module and $4,160,000 for the 2,000 student module.

9. The annual operating costs for the flight center will be approximately $909,458 for the 1,000 student module and $1,799,236 for the 2,000 student module.

10. Because of the national implications and direct benefits to the aviation industry, the proposed aviation training center should be established and operated as a cooperative effort between the University, the aviation industry, and the federal government.

11. A single organization to represent all of the aviation industry's needs will be required for the cooperative effort cited in "10" above. A non-profit, membership corporation should be considered for the purpose.

12. The functions of the aviation training center could be most effectively performed by the University assuming the responsibility for conducting the academic portions of the training program and the industry-established organization conducting the flight training portions of the total program, research and development being performed separately and jointly as appropriate.

13. The establishment of a working relationship, as indicated above, would provide for a more equitable sharing of costs for the operation of the training center and would result in the maximum dissemination of research findings to institutions engaged in aviation training.

14. Arizona State University should continue its responsibility for the development of the academic portion of the training center and the acquisition of the equipment required for its operation. The non-profit corporation established by the industry should assume the responsibility for the development of the flight training center and the acquisition of the equipment required. Various agencies of the federal government should assist in the development of the facilities and the acquisition of the equipment.

15. The distribution of the operating costs for the proposed center should be approximately 40% tuition, 38% state and federal governments, and 23% industry and other sources.

Recommendations

On the basis of the institutional cost and financing investigation discussed in detail in this Section of the report, it is recommended that:

1. An early conference be scheduled for representatives of the civil aviation industry, the federal government, and Arizona State University. The purpose of the conference will be to develop a plan for a joint cooperative effort to establish an aviation training center of national significance, as discussed throughout this report.

2. The civil air industry establish a non-profit education organization which will represent all segments of aviation and which will work directly with the government and University in the establishment and operation of the aviation training center.

3. The division of responsibility for the establishment and operation of the aviation training center be for the industry-sponsored, non-profit education organization to establish and operate the flight training program, and the University establish and operate the academic program. The federal government should provide both organizations with financing and operations assistance.

4. Efforts be made to organize representation from all governmental agencies who have interests in the total Reservation program, so that all resources can be brought to bear on the developmental efforts in a single master program.

SECTION V

IMPLEMENTATION PLAN

Introduction

This section of the Feasibility Study report presents the results of an analysis of the actions necessary to bring the aviation training center and program into existence within a reasonable period of time. A schedule for these actions is also presented.

Both short- and long-range plans were examined and are described. The short-range plans involve actions necessary for the site and facilities development on the Indian Reservation and the transfer of the existing Aeronautical Technology program from the Arizona State University campus (Tempe) to the proposed academic site on the Reservation. The short-range plans also involve cooperative actions necessary for the establishment of an industry-sponsored, non-profit organization, along with those actions which are necessary for initiation of flight training operations on the Goodyear Auxiliary Airfield.

The long-range plans involve the continuous development of new educational technology, both software and hardware, and its introduction into the aviation training center operations. Recently developed technology which is now available, such as educational television, programmed instruction texts, student responders, etc., will be used to the maximum extent possible in the initial or short-range phase of the development. The design of the facilities, as discussed in other sections of this report, will include provisions for acceptance of, and compatibility with, some of the new technologies being developed, such as computer-assisted learning systems. Such systems are expected to become available in a significant manner in the long-range phase.

Assumptions

In developing the details for this section of the Feasibility Study, the following assumptions were made:

1. That the study results would be accepted by the aviation industry and the appropriate governmental agencies as a

valid assessment of the requirements for skilled aviation personnel and the proposed approach to the problem.

2. That the aviation industry will establish a non-profit organization to interface with Arizona State University and the government on a cooperative basis.

3. That Arizona State University will assume the responsibility for the development of the academic facilities at the proposed center and would present all academic instruction.

4. That the non-profit organization will assume the responsibility for the development of the flight training facilities at the proposed center and would conduct all flight training.

5. That suitable agreements can be negotiated with the Gila River Indian Reservation Tribal Council regarding leases for land and the development and leasing of facilities.

6. That an agreement can be reached with the U. S. Air Force regarding the use of the Goodyear Auxiliary Airfield as the site for the flight training portion of the proposed center.

7. That adequate financing can be arranged for the development and operation of the proposed aviation training center.

Short-Range Plans

The short-range phase of the program includes the general period 1967-1972. During this phase, all of the activities for the establishment and operation of the training center will be undertaken. It is planned that actual flight training will be initiated on the Goodyear Auxiliary Airfield by September 1968, and that the existing Aeronautical Technology program being conducted on the Arizona State University campus will be modified and transferred to the new facilities on the Reservation by September 1969. It is also planned to provide a capability for accommodating 2,000 aviation students by 1972. Some of the key efforts required to achieve these goals are discussed below.

<u>Negotiation with Tribal Council</u>: Many meetings and conferences have been held with the Gila River Indian Reservation Tribal Council and representatives thereof, along with local and national representatives of the Bureau of Indian Affairs, regarding the proposed program and its implications for the people of the Reservation.

Although enthusiastic support has been provided in every instance, it will now be necessary to negotiate formal agreements with respect to land, site development, facilities development, and leasing. Actions will be initiated in July 1967 to schedule meetings and conferences with appropriate representatives of the governing body and the people of the Reservation for the purpose of negotiating formal agreements on the following subjects:

Land: Two sites are involved on the Reservation -- the Goodyear Auxiliary Airfield, which is planned for use as the flight training site, and a location, yet to be determined, in the proposed residential development area, which is planned for use as the academic training site.

Negotiations will be undertaken to obtain the use of the required acreage at both locations, with formal agreements anticipated by 1 January 1968.

The Airfield site is presently under lease to the United States Government for use as a temporary base for flight out of Williams Air Force Base, east of Chandler, Arizona. It is planned to schedule a series of conferences at the earliest possible date, involving representatives of the Tribal Council, City of Chandler, U. S. Department of the Interior (Bureau of Indian Affairs), U. S. Department of Commerce, Williams Air Force Base, U. S. Air Force, Arizona Congressional delegation, and Arizona State University. The conferences will be held for the purpose of negotiating agreements which will permit the use of the Goodyear Auxiliary Airfield as a civil flight training center and, at the same time, not in any way hinder the military training operations at Williams Air Force Base.

Site Development: It is anticipated that the Tribal Council, or its representatives, will undertake the site development programs at both proposed locations. If, during the negotiations, it is developed that a joint venture might be more appropriate or desirable, suitable agreements will be drawn up for this purpose. During these negotiations, the exact amount and location of the necessary acreage will be defined and preliminary plans for development drawn up.

Facilities Development: During the conferences, the tentative details for facilities development will be discussed in depth with respect to the kinds of facilities, locations, utility requirements, future growth and operations. The role the people on the Reservation expect to play in connection with the establishment and operation of the proposed center will be defined.

Establishment of a Non-Profit Organization: As discussed in other sections of this report, it is proposed that the aviation industry establish a non-profit corporation or foundation to interface with the University for the establishment of a civil aviation training center.

Actions will be undertaken at the earliest possible time to meet with key industry leaders to encourage and assist them in the establishment of an organization which represents all segments of our society concerned with and interested in developing improvements in aviation education.

The tentative plan is to have the organization established by 1 January 1968, so that the organization can enter into agreements with the Tribal Council for site and facilities development. In addition, it will acquire equipment and personnel for initiation of flight training operations by 1 September 1968. Preliminary discussions with a number of leading representatives of the aviation industry have indicated a keen interest on their part for the establishment of the type organization suggested herein.

Preliminary Design Study: As stated in Section III of this report, an extensive area development program has been undertaken in the northeast corner of the Reservation due west of the City of Chandler. The Goodyear Auxiliary Airfield lies within this development area. The program includes the development of industrial, residential, and recreational sites on Reservation land. These areas are shown in Figure III-3 of Section III. In addition to the aviation training center proposed herein, a number of industrial corporations are already being established in the Kyrene Industrial Development Area and the residential and recreational developments will be initiated in the near future. These developments, in which the Reservation manpower will play a vital role, will benefit the population both materially and spiritually.

Each of these developments is presently being considered essentially as individual efforts -- none of which integrate the requirements of the proposed aviation training center sites. There is, therefore, a requirement for a preliminary planning study which will provide the basis for integration of the training center facilities requirements with other developments underway and, also, the preparation of criteria or specifications needed for the actual development or construction phase of the proposed program.

The objective of the preliminary study will be to plan an aviation training institution which is compatible with other development programs which are or will be undertaken in that area and which will meet the short-and long-range educational requirements of the institution. The study will provide the basis for orderly expansion to meet ultimate, anticipated growth with an acceptable growth pattern. The preliminary design study will combine the many seemingly unrelated elements into a unified whole.

The keyword during the preliminary planning study will be "flexibility". The facilities of the institution will be designed to allow for acceptance of and compatibility with the new educational technologies and also permit maximum interchange of functions throughout the years, even though the structure in itself is immobile. The preliminary plans will be developed in fairly specific detail for the next ten to fifteen-year period; however, beyond that time the plans will be sketched out in a broad, rather than specific sense.

The preliminary design study is expected to be initiated in July 1967 and continue for a period of six months. The schedule for the study and its relationship to other follow-on activities is shown in Figure V-1. Following is a discussion of the work that will be performed during the preliminary design study:

1. Development of Educational Objectives: Prior to the development of preliminary design details, a statement of the educational objectives of the institution will be developed. These objectives will include detailed information on the following items:

a. Overall objectives of the institution

b. Student group sizes and backgrounds

c. When and how students will operate as groups and as individuals

d. Types of curricula taught and whether and when new educational technologies, such as computer-aided learning, programmed instruction, television, etc., will be utilized and to what degree

e. If computer-aided learning is utilized, the number of terminals required and their locations

f. The number and location of student study carrels; also, how many would be wet and dry

IMPLEMENTATION SCHEDULE

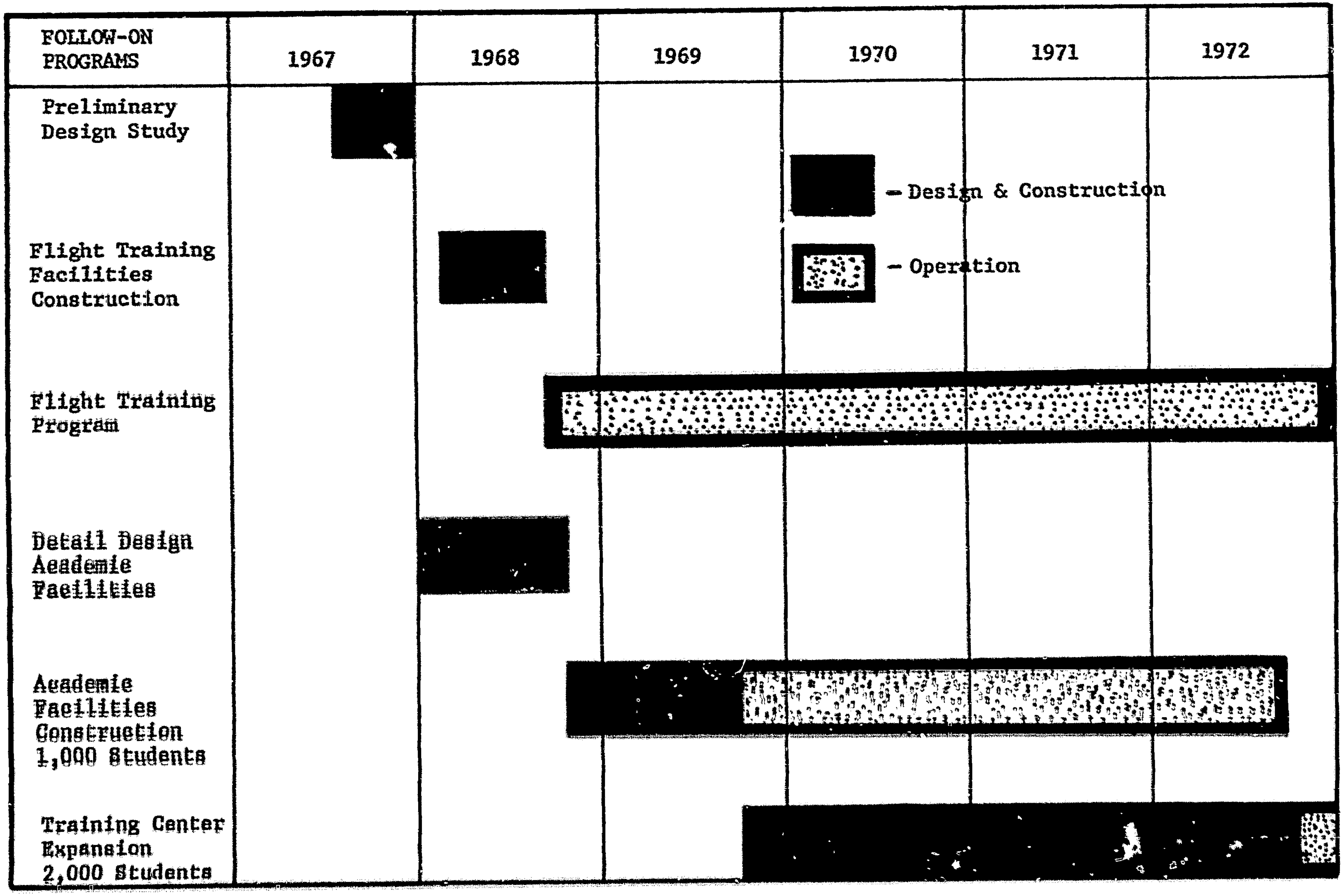


Figure V-1

g. The use of motion pictures, whether used by groups or individuals

h. The extent of use of closed-circuit television, both live and canned

i. The extent of use of educational television which is piped in from other sources and distributed through the institution

j. A description of the computer or data processing center with special cooling and humidity control requirements

k. Real time computer access requirements for student carrel operation, information retrieval, monitoring, etc.

l. Library or information center and its automated requirements

m. Intercommunication system for the institution -- whether voice only and/or television

n. Extent of use and locations of student/teacher response systems, both in classrooms and remote

o. Description, number and location of synthetic flight trainers

p. Description of all training equipment used in the program and its location

q. Esthetic requirements for the necessary psychological influences

2. Program Expansion Requirements: Under this item, a detailed plan for orderly expansion of the institution will be developed. The needs to support an initial enrollment will be defined; also, the ultimate size of the institution in terms of enrollment will be established. Target dates will be determined to permit an orderly growth until maximum enrollment is reached.

3. Facilities Requirements: The facilities required to meet the objectives of the institution, as described in preceding paragraphs, will be determined. Preliminary design details will be developed for the facilities, grouped under five major headings -- academic, administrative, recreational, residential, and ancillary. Following is a listing of the facilities anticipated at this time. This list of facilities will be tabulated and the specific requirements for the number of classrooms, laboratories, and other facilities will be determined; also, the size of the varying structures will be computed and listed. These requirements will be predicated on the planned growth of the institution.

a. Academic Facilities

Classrooms
Laboratories
Seminar Rooms
Faculty Work Areas
Audio-Visual Preparation Areas
Computer Center
Library/Information Center
Bookstore
Lecture Halls
Reception Areas
Counseling Rooms
Student Work Centers (Carrels)

b. Administrative Facilities

Administrative Offices
Staff Headquarters
Registration Area

c. Recreational Facilities

Student Union
Gymnasium
Swimming Pool
Auditorium
Athletic Fields
Tennis Courts
Intramural Athletics

d. Residential Facilities

Dormitories
Faculty Residences
Cafeterias

e. Ancillary Facilities

Mechanical Equipment Center
Physical Plant
Fire Station
Campus Security
Campus Laundry
Warehousing
Post Office
Infirmary
Chapel

4. Space Allocation: The first requirement under this item will be an analysis of space requirements. Once the facilities have been tabulated and listed, an area will be determined for the proper function of each of the individual structures. This particular project poses many problems not normally encountered for a typical campus. The nature of the technical background of the courses to be offered and the effects of and requirements for the utilization of new educational technologies will be studied carefully.

The design of the dormitories will pose different problems than normally encountered. The space allocation for the individual rooms will be determined by the proposed study and learning habits as dictated by the new proposed educational technologies. The student quarters may also incorporate study areas and both functions will probably be in use simultaneously most of the time. The planning module will adjust to this new concept of teaching and learning.

Space allocation will be based on an individual study of each building with the above basics in mind for all buildings. The special requirements for the technical needs of specific buildings will be over and above the following list:

a. Function of building as a whole

b. Breakdown of rooms within the building

c. Traffic patterns for corridor layouts

d. Feasibility of single level vs. multiple level layout

e. Vertical circulation

f. Location of electronic equipment

g. Space allocation for auxiliary facilities other than basic function of structure

h. Plumbing, mechanical, electrical, and telephone

5. Size of Training Center: Two sites, described in Section III of this report, have been tentatively selected as locations for the training center. The size of the center will be determined by the following factors:

a. The number of students

b. Proximity to existing outside communities

c. Availability of public transportation

d. Suburban area

e. Availability of land

f. Parking of automobiles and other vehicles

g. Cost of land

h. Type of curriculum offered

i. Proximity to the airfield

j. Low density plan

The results of the initial survey indicate a center of several hundred acres would be desirable, with adjacent tracts available to provide for the future. Preliminary negotiations with tribal leaders indicate that a portion of the acreage for the center can be obtained for the purpose on a long-term (dollar per year) type agreement.

6. Site Selection: A thorough analysis will be made of the sites tentatively selected. Some of the factors that will be considered, leading to the ultimate selection of the sites are:

a. Residential area development program

b. An area that would allow for a flight pattern which would not create a nuisance to the surrounding communities and a minimum of interference with commercial and military flight patterns

c. Land price

d. Existing means of transportation and proximity to known planned future freeways

e. Availability of utilities

f. Close proximity to already established communities

g. Cooperation of surrounding communities

h. Economic and vehicular impact on surrounding areas

i. Enough undeveloped land area surrounding the sites to accommodate the satellite businesses which will develop as a result of the aviation training center

7. <u>Aerial Survey and Topography</u>: A survey will be made of the entire development area, showing all of its natural contours and any vegetation that might be a hindrance or an asset to the finally selected locations for the training center facilities. The aerial survey will also indicate the natural flow of surface water. This will then be studied regarding the possibilities of disruption to the surrounding area and flooding on adjacent properties. Details will be developed on the following:

a. Topography

b. Boundaries

c. Natural vegetation that should be retained

d. Natural flow of surface water

e. Redistribution plans for surface water so as not to affect surrounding area

f. Scenic view

g. Building locations as related to hills, valleys and views

8. <u>Soils Analysis</u>: A soils analysis study will be made to allow for proper planning of the buildings and roads as related to surface and sub-surface soil conditions. This information will provide the basis for costs of trenching, foundations, and grading problems.

Specific soil borings will be performed for the sites. These tests will be located at selected key locations to determine the following general soil characteristics:

a. Sub-surface water condition

b. Bearing capacity

c. Expansion characteristics when wet

d. Stability of soil for trenching excavation

e. Water absorption characteristics

f. Alkalinity of soil as related to plant life

Ultimately, during the construction phase, additional borings will be necessary at each building site to more specifically determine soil conditions at each exact location. This is necessary for the final design of each structure.

9. Training Center Activity Zoning: The academic, administrative, residential, student activity zones, etc. will be grouped in a logical manner, relating them to each other, to the center, and to the community as a whole. It is most critical that the training center zoning be established to benefit not only the project but the surrounding area.

a. The zones will be located so that traffic from the main entrance can be channeled to any location without interruption of the use of other areas

b. The zones will locate the functions most used by outside services closer to the main highway

c. Zones most commonly interrelated will be adjacent to each other

d. Quiet zones will be located on the perimeter of active zones

e. The final result will be an organized pattern of selected activities working as a whole

10. Traffic Control: A study will be made of the flow for automotive, pedestrian, and bicycle traffic. Each will be studied on its own and then in the proper combination to each other. The following patterns will be established:

a. Traffic to the center from arterial and subsidiary streets

b. Movement of students, faculty, visitors, and delivery vehicles

c. Street patterns within the center

d. Location of parking areas in relation to their activities

e. Bicycle paths

f. Major pedestrian walks

g. Traffic between the academic and the air training facilities

h. The proper vehicular and pedestrian traffic between zones

11. Building Locations: Building locations within the various zones will again be related to each other in their own zone, as well as to the functions in other zones. The areas will have been pre-determined in another phase of the study and now the actual approximate physical dimensions of the various structures will be determined and the buildings located on the sites, as follows:

a. Academic Zone

(1) Organize the classroom or lecture buildings in relation to each other. This will be established by studying the prepared curriculum and reducing travel time between classes

(2) Locate the laboratory buildings with their related lecture facilities; again in association for minimum commuting time

(3) Plan the various phases of expansion from the original nucleus to the ultimate projected pattern

b. Administrative Zones

(1) The buildings in this category will be located to accommodate the constant daily flow of pedestrian and vehicular traffic from the academic, public and faculty areas

(2) The various functions within the area may finally dictate a single structure but that will only be determined by additional study

c. Student Activity Zone

(1) The structures that are used during class hours will be located adjacent to the academic area

(2) The structures used in conjunction with the public will be located adjacent to main arterial roads

(3) The athletic facilities will be located to allow for ease of access for both the public and student body

d. Residential Zone

(1) The dormitories will be located in close proximity to the academic area, because they also serve as instructional centers, with study carrels built in

(2) Quiet and restful open spaces will be adjacent to these structures to allow for relaxation from the rigors of today's university life

e. Ancillary Facilities

(1) These particular buildings, although listed in a separate category, will not necessarily be grouped together but will be interspersed throughout the campus and in their proper relationship to function

12. Landscaping: This involves not only the location of plant material but also the strategic location of open spaces, quiet zones, placement of parking areas, etc. It must introduce a harmonious relationship between the interior and exterior spaces. Details on the following will be developed:

a. Determination of types of plant material as a direct result of the soil analysis

b. Open areas between structures

c. Use of plant material for sound buffers

d. The placement of intimate and subdued exterior study areas

e. The location of secondary walkways, bicycle and equestrian paths

f. Most importantly, establish a campus atmosphere of proper balance between student, architecture and landscaping

13. Off-Site Utilities: The off-site utilities will be studied as they relate to this project. Conferences will be held with the City of Chandler and Bureau of Indian Affairs regarding their proposed facilities. Through such cooperation, details will be developed regarding the following items:

a. Determine the size of the existing or proposed power, sewer, water, and gas lines in relation to the project

b. Advise the proper authorities to provide the utilities to the site at the best location for the campus

c. Inform the authorities of the projected needs in each planned phase of construction, so that they may plan their own future requirements

14. On-Site Utilities: A very important factor of the planning of this project is to locate the utility and electronic distribution systems properly for all phases of development. Its component parts are:

- a. Individual building requirements for utilities and special electronic and television systems
  - (1) Analyze each building for its requirements for all utilities plus the additional special electronic and television requirements
  - (2) Determine the necessary sizes of all service lines to the building
  - (3) Connections to the distribution system
- b. Connections between buildings and off-site utilities
  - (1) Determine the flow pattern of sewer lines
  - (2) Locate the utility tunnels in the most economical manner
  - (3) Size tunnels to allow for expansion needs and ease of access for maintenance, repair and replacement
  - (4) Coordinate with off-site utility locations
  - (5) Determine location and size of intercommunication lines for electronic systems

15. Presentation of Preliminary Studies: The culmination of the efforts expended in the preliminary design study will be presented in written reports and in brochure form, containing plans and illustrations. The total study will be broken down as follows:

- a. Written reports of these items will include
  - (1) The educational objectives
  - (2) The entire program for construction and the planned phases of development

(3) The actual area required for each structure

(4) A copy of the aerial survey

(5) A copy of the soil analysis

(6) Engineers' reports on various phases of the project

b. Illustrations and plans will augment the written reports, including but not limited to the following:

(1) Area location map, showing surrounding communities and facilities

(2) Preliminary master plan of the academic and air training centers

(3) Plans showing the various phases of expansion

(4) Vehicular and pedestrian traffic patterns

(5) Location of all planned buildings and areas for future buildings, if needed

(6) Off-site utility locations and sizes

(7) Landscaping arrangements

(8) On-site utility tunnels and electronic raceways

(9) Aerial view of the training center as a completed project

(10) Athletic facilities

(11) Exterior recreational facilities

Flight Training Facilities Construction: As indicated in the Implementation Schedule (Figure V-1), this part of the short-range plan is scheduled to begin approximately February or March of 1968 and be completed by September 1968.

This schedule is, of course, based on the assumption that the industry-sponsored, non-profit organization will have been established and be in a position to undertake the project by that date, and that the necessary agreements have been negotiated with the Tribal Council and the U. S. Air Force regarding the use of the Goodyear Auxiliary Airfield.

The results of the preliminary design study are expected to contain sufficient information and data to permit the development of development documents, working drawings, and specifications for the award of contracts and the construction of the facilities.

Flight Training Program: During the period 1 January 1968 (target date for the establishment of the non-profit organization) and September 1968, the organization will develop equipment and personnel requirements and initiate the actions to procure the equipment and establish a training staff. The target date for initiation of flight training is September 1968, as shown in Figure V-1.

It is estimated that the initial student population will be less than 200, building up to an estimated 1,000 students by 1972. Equipment and facilities will be added, as required, to accommodate the increased enrollments.

Detailed Design - Academic Facilities: Innovative architectural design techniques are expected to be utilized in the design of the academic facilities because of the introduction of new educational technologies. Plans are presently being developed to support a request for a special grant from a private foundation for a detailed design study for the academic facilities of the training center.

It is expected that this grant will be awarded approximately 1 January 1968 and will continue for a period of an estimated ten months, as shown in the Implementation Schedule (Figure V-1). An architectural firm with a national reputation for innovative approaches to educational facilities design will be used in the detailed design study.

Academic Facilities Construction: At the conclusion of the detailed design study, design documents, working drawings, and specifications will be developed and contracts awarded for the construction of the academic facilities in the residential area of the Reservation.

It is assumed, of course, that the detailed design in the previous phase would be acceptable and that the necessary financing program for the facilities will have been arranged.

The construction of the facilities will take place during the period October 1968 to September 1969. Equipment lists will also be developed during this period and equipment procured for installation in the new facilities. During the latter phases, the current Aeronautical Technology program will be transferred from the Arizona State University campus (Tempe) to the new site and utilization of the new facilities will begin in September 1969.

During the period September 1969 through September 1972, the facilities will be expanded from a 1,000 student body center to a 2,000 student center.

Long-Range Plans

The long-range plans for the proposed training center will be to continue to develop and expand, as necessary, to accommodate the growth in student enrollment which will develop naturally with growth of the population and the aviation industry. More important, however, will be the continued improvement in instructional materials, equipment, and techniques through cooperative research and development programs conducted at the proposed training center.

The training center is expected to perform two major functions -- aviation academic and flight training and research and development in areas related to aviation education. Education, flight, maintenance, and safety research and experimentation will be conducted, much of it within the context of the training program.

The most important research and development visualized for the training center will be that related to the development of curriculum materials and teaching/learning systems for aviation education and the subsequent teacher training and dissemination programs. An experimental program which will lay the foundation for training center's R&D activity in curriculum and educational technology development is currently underway in a joint cooperative program being conducted by the General Learning Corporation, Arizona State University, and local and regional schools.

The program referred to is entitled "A Computer-Aided Learning Experiment in Vocational-Technical Education". Although the immediate objectives are concerned with an age group of a lower level (high school) than will be enrolled in the training center, the procedures and techniques will be directly applicable to the activities visualized for the training center. The follow-on or long-range objectives of the current program will include curriculum development of aviation education materials for all levels. The aviation training center's R&D program for curriculum and educational systems development is expected to grow out of this current program. It is described in some detail here because of its direct application to the future activities of the training center.

A Computer-Aided Learning (CAL) Experiment: The objectives of this program are to identify and assess the potential benefits of a multi-method/media approach to vocational-technical education involving computer-aided learning (CAL); to develop and operationally evaluate a pilot curriculum for disadvantaged youths, which can be further developed to have relevance for all secondary and collegiate students; to generate and document hypotheses, recommendations, and conclusions based on the results; to generate the necessary climate and conditions for successful further development of curricula which seek to induce learning along individually prescribed paths toward stated, observable, behavioral objectives which combine technical, academic, and personal/social goals and skills.

Detailed information will be obtained about the target population and about a cluster of entry level jobs in electronics. Job data will be used to derive behavioral objectives for critical academic, technical, and personal/social skills. A multi-method/media approach involving CAL will be used in instructional design. This approach provides for using, for example, taped or live lecture, laboratory, CAL, peer group discussion, programmed text, fixed image displays, and motion pictures, as judged most effective in strategies for inducing the desired learning. Instructional strategies will be developed based on analyses of student data, subject matter content, conditions of learning, and behavioral objectives. Representative students will be used in development (subsystem) testing and course (system) testing.

The results of this experimental project will contribute toward the body of knowledge pertaining to the practical application of the methods and techniques of educational technology, especially CAL, to the problems of vocational/technical education. The contributions include the development of a pilot course for inclusion in high school curricula, plus the organizational framework and community support required for further curriculum development efforts leading eventually to a complete new curriculum for secondary and collegiate level electronics technology.

The initial program will be conducted in six phases. The phases, which overlap, involve major groupings of activities with a common general goal. The six phases are as follows:

- Definition Phase
- Strategy Phase
- Development Phase
- Instruction Phase
- Evaluation Phase
- Report Phase

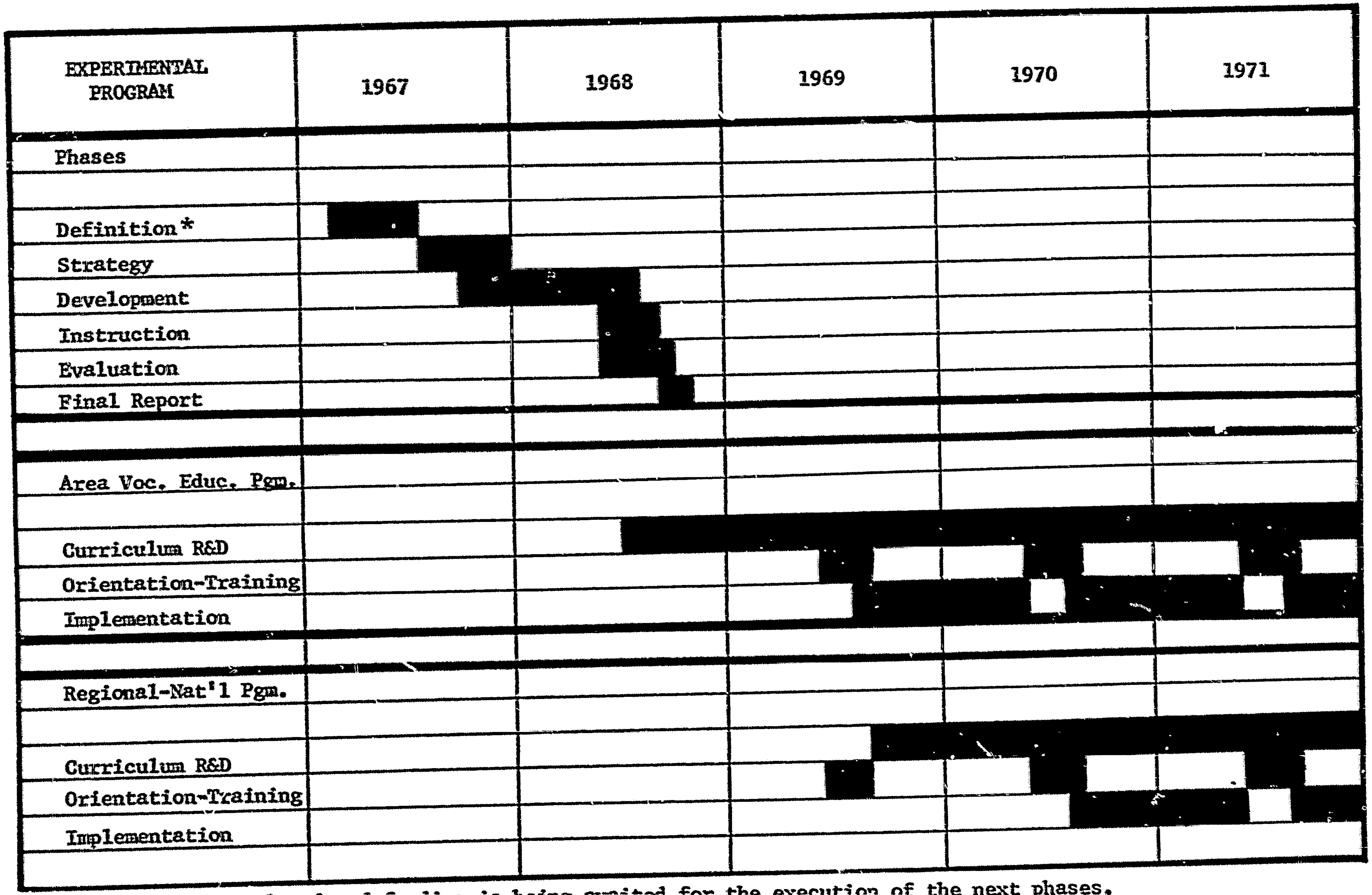
The time schedule for the six phases is shown in the upper block of the Program Schedule presented in Figure V-2. A discussion of each phase of the current program and the future follow-up programs is presented below:

Definition Phase: The primary purpose of the Definition Phase is to establish instructional goals, define quantitatively and qualitatively the target population, define (behaviorally) terminal objectives, and develop a course specification for use in subsequent phases.

Definition of target population will be developed, including available data about youths who meet such definitions by geographical areas. This information will be used to identify a population of male students in the local school system. This population of students meeting the definition is expected to total several hundred students.

A COMPUTER-AIDED LEARNING EXPERIMENT IN VOCATIONAL-TECHNICAL EDUCATION

PROGRAM SCHEDULE



* This phase is completed and funding is being awaited for the execution of the next phases.

Figure V-2

Data will be received from a variety of sources about the jobs skills required for entry-level jobs and job hierarchies in electronics. This data will be of three general classes: academic, person-social, and "electronics" skills. These data will be analyzed to develop a group of candidate terminal cognitive and manipulative skills for the pilot course.

Skills which are common to most jobs and job hierarchies will be identified and translated into terminal objectives. Terminal objectives will be specified in the Mager-fashion, e.g., they will be measurable, feasible, and understandable. A general objective's matrix (or matrix of learning modules) will be developed which reflects relationships between and among skills (e.g., reflecting skill hierarchies, skills of comparable levels). Each module will represent a logical "block of content". Estimates will be made of the amount of time the slow, medium, and fast students might require to master the material in such a block. Such time estimates will be necessary for the initial "sizing" of the course and for the development of the enabling behavioral objectives within the modules.

General functional specifications will be defined for use in investigating computer hardware-software systems available for use in the project. This investigation will identify and document information about available candidate systems, including how well each system meets the specifications, the conditions under which it is available, the costs involved, and other pertinent factors.

The Definition Phase will be documented in the form of a "course specification". This specification will, in effect, outline the requirements of a pilot learning system, i.e., system inputs, outputs, resources and guidelines will be indicated.

Strategy Phase: The Strategy Phase will be primarily concerned with the analysis, planning, and decision-making required to develop a learning system to meet the "course specifications".

Behavioral objectives previously set forth for each learning module will be analyzed. The purpose of this analysis is to specify the required enabling objectives within each module and to arrange them in instructional sequences. Redundant enabling objectives (considering all modules) will be eliminated and overlapping enabling objectives will be rewritten to eliminate the overlapping. This task will produce a greatly refined and possibly redesigned general matrix of learning modules and, within each module, the detailed sequences of enabling objectives.

Criterion tests will be developed based on the criterion of acceptable performance specified in the statements of behavior objectives. An absolute grade, score, or level of performance on a criterion test will be established as minimum passing or minimum qualifying.

Investigations will be made to determine the source and availability of electronic learning materials which may be utilized in the project. This task will be primarily concerned with making or completing the arrangements for obtaining desired learning materials. Utilization of materials already developed which can be used in the program will reduce materials development costs.

A computer hardware-software system will be selected from among those previously identified as available candidate systems. Media specified for use in the course will also be selected from among those available. Equipment selection will be based on: (1) the degree to which the functional requirements will be met, (2) technical features, and (3) relative cost.

The Arizona State University will make available two temporary campus buildings for the duration of the program. It is planned to use one of the buildings for office space for the project staff and the other for housing the student terminals and a classroom. Other required classrooms and laboratories will be provided through the use of certain areas in other campus buildings. Specifications will be prepared for the remodeling of the buildings and preparation of laboratories to accommodate the student terminals and other equipment and activities.

The results of the above efforts and the rationale for the decisions reached will be documented and reflected in a detailed plan for carrying out the activities in the Development Phase. The documentation will describe any present or anticipated problems.

Development Phase: The Development Phase will be primarily concerned with the development and preparation of learning materials. A major effort will focus on developing creative and effective ways to program content for each medium, so that students may truly enjoy learning and, in fact, learn. Methods and media will be related in such a way as to personally involve students with the content, where the interaction of student and content does not appear contrived but a natural consequence of motivating activities.

The essential subject matter will be delineated for each stated behavioral objective and will be cataloged in association with it for subsequent ease of reference. This subject matter will then, on a module-by-module basis, be programmed. Depending upon the strategy, some programmed steps will be linear and some will involve branching and possibly parallel paths, and some will utilize one media and some another as previously judged most effective in achieving the desired behavioral objectives. The tutorial and problem-solving/simulation modes of CAL may readily employ a mixture of linear, sensitive branching, and parallel paths, where large variability in step sizes may be imaginatively employed.

A major objective will be to provide academic learning that is concurrent with laboratory experience, so that learning is goal-oriented; thus, laboratory exercises will be simulated in CAL sessions and materials will be prepared to accomplish this. Also, problem-solving exercises will be developed for CAL sessions which will be available concurrent with the academic learning of the related concepts.

In the development of materials, emphasis will be placed on creating innovative problem-solving exercises in such areas as electronics troubleshooting, planning career strategies, and the effects of various on-the-job behaviors. The student will not only be presented with constructed problems but, where possible, will be led and encouraged to construct and solve his own problems.

It is hoped that, eventually, techniques can be developed which will permit students to construct, for example, circuits; assign "known" values; solve for "unknown" values (using the computer); and have his solution checked and/or corrected by the computer. Full realization of this goal may not be achievable within the limited scope of this first course, but it is one of the major objectives of the overall vocational education curriculum development program (of which this project is the first key step).

Development testing will be conducted to validate the programming for the modules using representative students. It will consist of one or more cycles of: (1) presenting the programmed module to students, (2) administering the criterion test and analyzing the results, and (3) making necessary changes in the programming. The programming of the materials will be evaluated on the basis of performance on criterion tests and other bases, which will include: (1) number of steps completed versus amount of time, (2) error rates and possible undesirable error patterns, and (3) error frequency per step.

Development testing will be carried out with a relatively small number of subjects. It is planned to use about ten students. These students will test the programmed modules in the order in which the modules might be presented to students in the Instruction Phase. Since the subject matter content of one module may be predicated on that in a previous one, it may be necessary to retain the same test students for all modules.

"Effectiveness" of the experimental course will be evaluated in terms of student achievement, motivation engendered, time-to-learn, acceptability to students and teachers, preparation time and cost, presentation time and cost, and technical design factors.

Instruction Phase: The most important part of this phase is the presentation of the course. The course will be presented twice, once each to two groups of twenty students. During the instructional presentations, student performance and controls will be carefully monitored. An objective will be to identify and obtain data about any unanticipated problems encountered. At the same time, the data required for evaluation purposes, as specified in the Evaluation Plan, will be obtained on a continuous basis and reviewed for proper quantity and quality.

Evaluation Phase: The Evaluation Phase will parallel the Instruction Phase from the beginning and extend beyond it. The Evaluation Phase will be conducted in accordance with an Evaluation Plan prepared earlier in the project.

At the conclusion of the courses, the students and the instructors will be interviewed to obtain their views (likes, dislikes, preferences, etc.), and these will be documented. The results of the final examinations, the interview information, and data regarding motivation will be included in the analyses being conducted. The objective of these analyses may be listed as follows:

1. To assess the significance of student population, course material, strategies employed, mode coverage and sequence, media applications, resources (e.g., computer system, staff, support services, monies available), and constraints (e.g., program preparation time, limitations of equipment and software, population sample size).

2. To identify, describe, and evaluate the major benefits and their implications for future efforts.

3. To identify, describe, and evaluate the major problems encountered and their implications for future efforts.

4. To generate hypotheses, recommendations, and conclusions.

The physical product of the Evaluation Phase will be a technical compendium representing the materials and documentation produced in this Phase and those that preceded it. This compendium will be properly cataloged and filed. This detailed, technical history of how the project was developed and implemented, including the key decisions that were made and their outcomes, should serve as very valuable reference material for use in guiding subsequent related efforts at the Arizona State University and particularly those curriculum development efforts planned for the aviation training center.

Results Expected and Use of Findings: The Arizona State University and the General Learning Corporation are confident that the objectives of the experimental program will be successfully achieved. In addition to meeting the proposal's stated objectives, at least two additional major results are expected, as follows:

1. It is fully expected that an operationally tested vocational-technical learning system will be produced that is unique in its creation, methods/media and content. Nearly all, if not all, of the individual components of this system can be found in past or present programs. However, the systematic design, development, and integration of these components in application to vocational education has not been done before. Of major importance, for example, is the fact that the terminal objectives will have been verified in the field. Also, there will be three stages of testing to insure adequate information about the success of the learning system. There will be a subsystem test series in the Development Phase and two complete systems tests in the Instruction and Evaluation Phases. This information will be of great value in making system and course improvements and for developing future courses for the aviation training center.

2. There is a great need in the education community for a documented history of the development of a learning system based on educational technology. The project will produce and maintain such documentation as will enable such a history to be written.

The findings of the experiment-demonstration will be evaluated, as described earlier in this program. A final report will be published and distributed widely. It is also planned to explore fully the possibilities of dissemination through seminars or symposia to be conducted at the project site. Such seminars might involve the various state and local supervisors of trade and industrial and technical education, as well as the leadership of the research coordinating units of the several states. Moreover, specific distribution and discussion of the findings of this experiment-demonstration is planned for the participating school districts and other organizations in newly emerging programs for the organic curriculum.

Area Vocational Education Development Program: The area program is planned for: (1) implementation of the "pilot" course in area schools; (2) summer institutes and in-service training of area teachers and administrators; (3) broadening of the "pilot" curriculum, both vertically and horizontally; and (4) design and initiation of procedures to coordinate area curriculum development activities under this program. The schedule of activity for this effort is shown in the center block of Figure V-2.

The area program would be a continuing one. Of major concern would be the vertical and horizontal expansion of the pilot curriculum on the part of Arizona State University and the aviation training center. Through the provision for summer institutes and in-service training, the project staff will support and coordinate area curriculum development activities in other disciplines.

As alluded to above, a major function of the area program is the coordination of area curriculum development activities. The Arizona State University will seek to serve as a curriculum coordination center that would serve the area in several ways, as follows:

1. By instituting procedures for getting and utilizing feedback on the success of the new curricula

2. By developing learning materials to improve existing courses or for new courses

3. By disseminating learning materials and course information

4. By providing consultation services and training and orientation programs

Regional-National Program: The tentative regional-national program would, on the regional level, involve four institutions for higher learning presently working cooperatively in the context of the Southwest Regional Laboratory for Educational Research and Development (SWRL).

Teams of selected personnel from each of the four collegiate institutions would, after proper orientation, participate with the experienced "core research staff" in planning developmental and instructional phases. Each of the four collegiate teams would approach new course material, so that additional new courses would accrue.

This regional plan is specifically designed to provide the additional benefit of preparing an experienced "core" team for each of the collegiate institutions which, upon return to their respective institutions, can be instrumental in the establishment of pre-service and in-service training programs in the geographical areas they represent.

On the national level, it is planned to involve teams from approximately ten institutions of higher learning representing different regions of the United States. Each institutional team would be assisted in the development of new areas or courses of instruction. The schedule for the area and regional programs is shown in the lower block of Figure V-2.

The experienced "core" teams of each of the four universities who participated in the previous regional program would necessarily be relied upon in this national program. Similarly, the original Arizona State University/General Learning Corporation research team and the experienced teams trained under the area program would be involved.

Upon the culmination of this national program effort, the ten university "core" teams would return to their respective institutions to establish pre-service and in-service programs for the geographical areas which they represent.

In summary, the findings of the experiment-demonstration conducted during the experimental CAL program will be used for the development of new curricula and for the in-service and pre-service teacher training programs at area, regional, and national levels. Teachers already in the field will be prepared for constructive participation in both curriculum development and in the pilot trials of the curricula being developed. The courses of instruction developed will be available to all institutions engaged in vocational-technical education.

Implications for Proposed Training Center. The implications of the above described program on the future curriculum and educational systems development activities of the proposed training center are obvious.

Some of the personnel presently engaged in the above described experimental CAL program will be directly involved in the establishment and operation of the proposed training center. They will establish programs similar to, or in cooperation with, the one described above for the continued investigation and development of aviation curricula and systems, utilizing to the maximum extent the results of the above program.

With a cooperative working relationship between the industry, the government, and the academic community, as discussed in other sections of this report, representatives of all segments of our aviation society could be brought together in a manner similar to that described in the Regional and National part of the program above. Thus, all segments would be providing direct inputs and receiving immediate benefits through actual experience, seminars, teacher training programs, developed curriculum materials, etc., which are carried back to their respective organizations or systems for implementation.

The same systems analysis and cooperative approach will be applied to other R&D areas, such as flight research, aviation medicine, maintenance research, and safety research as they apply to and influence the broad function of aviation education.

Conclusions

In order to develop the facilities for the proposed training center and to begin flight operations by September 1968, followed by the transfer of the current Arizona State University Aeronautical Technology program to the site by September 1969, it is concluded that the following actions will be necessary:

1. Negotiations with the Tribal Council for land use on the Reservation completed by 1 January 1968.
2. Negotiations with the U. S. Air Force regarding the use of the Goodyear Auxiliary Airfield completed by 1 January 1968.
3. Establishment of a non-profit organization by the aviation industry by 1 January 1968.
4. Completion of the preliminary facilities design study by 22 January 1968.
5. Development of the site and facilities, procurement of equipment and establishment of faculty and staff for the flight center completed by 1 September 1968.
6. Detailed design of the academic facilities completed by October 1968.
7. Development of site and facilities, procurement of equipment, and the establishment of faculty and staff for the academic facilities completed by 1 September 1969.

Recommendations

It is recommended that the dates set forth under Conclusions above be accepted as target dates for the completion of the activities cited, and that every effort be made to meet the schedule. This will assure early establishment and operation of an aviation training center of national significance and, more importantly, it will provide for the early economic uplift for the disadvantaged Indian population and people in the surrounding communities.

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