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EVALUATION OF NASA-SPONSORED RESEARCH ON CAPITAL INVESTMENT DECISION MAKING IN THE CIVIL AVIATION INDUSTRY

March 1977

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PRELIMINARY REMARKS

The following report is a summary and evaluation of three studies that were performed for the Aircraft Energy Efficiency (ACEE) Office at NASA headquarters on capital investment decision making in the civil aviation industry. The studies were performed between July and November of 1976 by three nationally known research firms, Arthur D. Little, Inc., Battelle Columbus Laboratories, and Gellman Research Associates. The author of this report closely monitored the progress and evolution of these studies from the beginning. This report is intended to provide a concise explanation of the significant findings of the studies, both individually and as a total package. Furthermore, it is hoped that the observations and evaluation of the author will assist NASA personnel in their own evaluations and in determining how to disseminate and act upon the results of the studies.

The purpose of these studies was to provide ACEE with information regarding how aircraft manufacturers and commercial airlines make investment decisions regarding the acquisition of new and derivative technology. This information was requested to assist NASA in its efforts to promote the development of energy efficient technology and to be responsive to the needs and constraints of industry planners.

To put the findings of the three studies into proper perspective, it is necessary to consider the environment in which they were performed. First of all, the timing of the studies was significant. The studies were completed a) within a relatively short turnaround time (four to five months); b) during the summer months when the consultants themselves as well as their interview sources had scheduled vacations at various intervals; c) prior to a presidential election and in the face of widespread uncertainty regarding regulatory questions and other government policy issues; and, finally, d) during a period of economic instability in which the financial fortunes of the civil aviation industry were subject to heated debate and often conflicting analyses by recognized experts in the field. The latter two constraints presented both a problem and an opportunity. While widespread uncertainty regarding the future of the industry makes definitive conclusions impossible for the most part, it is also during such turbulent times that careful analysis is most important.

THE MARKET FOR AIRLINE AIRCRAFT

by

Arthur D. Little, Inc., and Simat, Hellieser & Eichner, Inc.

The ADL study is a careful look at the future reequipment needs of U.S. airlines and the forces that will affect demand for new aircraft over the next decade. The study relies heavily on a proprietary forecasting model of airline equipment requirements and capital availability. The model, which belongs to ADL's subcontractor, Simat, Hellieser and Eichner, Inc. (SH&E), provides forecasts for each of the U.S. Trunks and Pan American Airlines of earnings, equipment purchases, capital needs and sources, and breakdowns of total invested capital between internal and external financing out to 1984.

The purpose of the study is "to examine the anatomy of equipment forecasts" and the divergent assumptions used in making them. In this way ADL attempts to "flag" those variables to which forecasts are most sensitive and to describe the factors which may ultimately have the greatest impact on the future demand for aircraft.

The SH&E forecasting model projects total purchases of 744 passenger aircraft by 1984 at a cost of $18.5 billion. This results in total capital requirements of $29.6 billion, of which the airlines will be capable of financing internally only $18.3 billion. By comparison, other independent forecasts of airline capital requirements out to 1985 have predicted capital needs ranging between $21 billion and $47 billion.

Faced with this tremendous disparity in forecasting (a total of $26 billion, "over twice the total capital investment committed to launch the U.S. airline industry into the jet age"), the study points out that the majority of this difference can be explained by the sensitivity of the forecasts to assumptions regarding the service life of civil aircraft. Table 1 on the following page gives a comparison of four independent forecasts of airline capital requirements and the assumptions made in arriving at the final amount forecast.

According to the ADL study, the most significant difference among these forecasts is the estimated service life of the aircraft. The following sensitivity test illustrates the dramatic impact of the service life assumption, holding all other assumptions constant:

Service Life Assumption	16 yrs.	17 yrs.	18 yrs.	19 yrs.	20 yrs.
Aircraft Retired by 1984	1225	1138	793	712	341

The uncertainty surrounding the service life assumption is important and may easily contribute to the industry's risk perceptions regarding future investments. While the different assumptions tend to "wash out" as the forecasting horizon is extended outward, a difference of only a few years can be very unsettling to those responsible for short-run investment planning.

The ADL study concludes that the major driving force behind actual aircraft retirements and replacement in the future will be government noise regulations. In the absence of truly major technological improvements in commercial aircraft, the other two determinants of economic service life, competition and productivity, will not bring about the retirement of significant numbers of older aircraft before environmental regulation has made them obsolete. Of the 1,758 aircraft owned by the Domestic Trunks and Pan Am as of December 31, 1975, over 1,200 did not meet FAR Part 36 requirements. The timetable that is ultimately chosen

TABLE 1

COMPARISON OF RECENT AIRCRAFT INVESTMENT FORECASTS

	ATA	DL&J	Boeing	SH&E
Group Forecast	U.S. Airlines	Trunk & PA	Trunk & PA	Trunk & PA
Years Forecast 1976 through	1985	1985	1985	1984
Aircraft Service Life[3] (Narrow Body)	18	18[1]	16	17[1]
Inflation Rate	6%	5%	6%	5.5%
Seating Density	CAB	CAB	CAB	CAB
Traffic Growth	5%	6%	6%	7.3%
Load Factor	60%	62%[2]	58%	60%
Add on for Spares and Ground Equipment	20%	20%	20%	25%
Capital Expenditures ($Bil.) Forecast	$26	$21	$47	$23

[1] Retirements based on individual airline analysis of needs and financing capability, whereas other forecasts are based on retirement at given elapsed year regardless of individual airline situation.

[2] 62% domestic, 57% international.

[3] Wide body aircraft will not be retired over forecast period except for occasional fleet simplification actions.

for compliance with FAR 36 regulations, therefore, will bear heavily on the timing of future demand for new aircraft.

In the two concluding chapters of the ADL study, the implications of possible changes in the structure of the airline and aerospace industries are discussed. Although no predictions are made, a brief summary of the most plausible outcomes of various possible changes is provided. After describing some of the major issues in the regulatory reform question, the ADL study concludes that future changes in the structure and performance of the airline and aerospace industries are "matters of speculation and conjecture" at this point in time.

The final section of the study is devoted to a discussion of the major issues that can significantly affect the future demand for U.S. commercial aircraft. These issues are 1) the emergence of multinational manufacturing consortia, 2) the structure of the U.S. aircraft/engine manufacturing industry, 3) airline deregulation, and 4) foreign competition.

The principal value of the ADL study is its description and analysis of the variables which are likely to have the greatest impact on the future demand for U.S. aircraft. The actual forecast of this demand over a specified time horizon is an impossible undertaking in view of the tremendous regulatory and economic uncertainties that currently confront the industry. There is thus widespread disagreement regarding the future structure and performance of the airlines and their equipment manufacturers. The ADL study explains the basis for this disagreement and points out some of the key forces that may ultimately determine the fate of the U.S. civil aviation industry. Foremost among these forces are government regulation and the financial performance of U.S. airlines.

FACTORS AFFECTING THE CORPORATE DECISION-MAKING
PROCESS OF AIR TRANSPORT MANUFACTURERS

by

Battelle, Columbus Laboratories

The Battelle study is a detailed analysis of the design and development process used by the jet engine and airframe manufacturers in bringing new aviation technology into commercial production. The raw data for the study were obtained in personal interviews with industry personnel, a literature survey, and by means of extensive analysis on the part of Battelle's in-house consultants. The study attempts to define both the key "decision influencers" and the principal barriers to innovation that affect the decision to progress from one stage to the next in the technological development process. It is a study of the timing of technological innovation and of the factors that influence the pace at which new technology can be integrated into commercial production.

Battelle's study methodology relies heavily on a matrix analysis of the "generic components" of the decision-making process in the commercial airframe and jet engine industry. The generic components in the decision-making process identified by Battelle are:

- design and development stages
- decision criteria
- decision influencers
- barriers to innovation.

Each generic component was subdivided into its various elements so that the interaction of these components could be studied in detail. Although the elements were very similar for both jet engine and airframe manufacturers, a few of the elements were necessarily different due to differences in technical and organizational structure in the respective industry segments. Subsequent to interviews with members of the industry, the Battelle interviewers spent considerable time filling in detailed matrices, simplified versions of which are shown on the following page. In these matrices, Battelle attempted to match:

a) the design criteria considered in the development of a new technology with the design and development stages during which the criteria were found to be relevant;

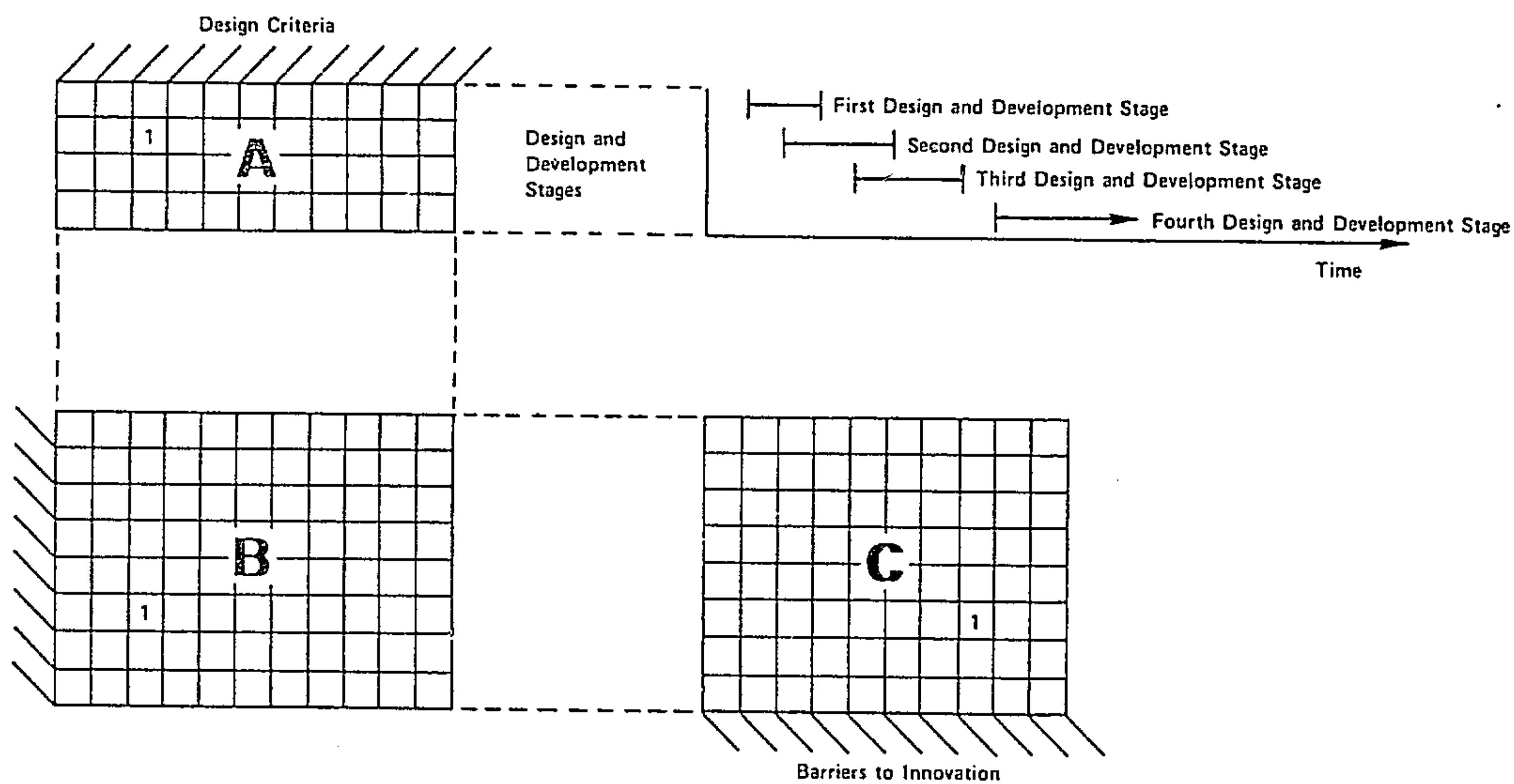
b) the decision influencers that have an impact on the decision process with the design criteria, and

c) the barriers to innovation with the decision influencers.

Whenever the interrelationship between two elements was considered important, a value of "1" was placed in the proper square; otherwise "0" was recorded. In this way the interviewers attempted to convey a composite picture of the attitudes of the three major airframe manufacturers on the one hand (Boeing, McDonnell Douglas and Lockheed), and the two jet engine manufacturers on the other (Pratt and Whitney Aircraft and General Electric).

After the initial three matrices were completed, the relative importance of the individual barriers and the decision influencers was determined (by means of simple matrix multiplication) for each stage in the design and development process and for the process overall. The resultantlists of decision elements, ranked according to their perceived importance, are described in detail in the Battelle report and are not duplicated here.

Interpretation of these rankings, however, should be done with great care not to overestimate the precision of the analysis. Due to the subjective nature of the investigation, the data have passed through a



FRAMEWORK FOR STRUCTURING THE INTERACTION OF BARRIERS TO INNOVATION, DECISION INFLUENCERS, AND DESIGN CRITERIA IN AIR TRANSPORT DESIGN series of "filters," each of which tends to magnify the subjective character of the study. The raw data were obtained principally through private interviews with industry personnel. The first "filter," then, is created by the personal impressions and interpretations of these people. Secondly, the Battelle staff needed to interpret the answers obtained to determine the degree of importance to be ascribed to each answer. For example, in analyzing any particular barrier to innovation, the interviewer had to determine the degree to which the barrier was considered important by the interviewee and the degree of certainty to be placed on this interpretation. In other words, the interview data were passed through a second filter, the <u>perceptions</u> of the interviewer.

Finally, the raw data had to be condensed and organized in a meaningful fashion. It was at this stage that the greatest amount of subjectivity occurred. The interviewers spent many hours filling in the complicated matrices described previously and deciding whether particular barriers were "important" relative to various decision influencers, at various stages in the development process, and according to a variety of decision criteria. To avoid greater complexity in the analysis, no attempt was made to weight these interpretations, but rather a simple binary scale was used whereby two elements were considered to be either "matched" or "not matched." For example, the barrier called "lack of trained maintenance personnel" was considered either to be important to, say, the board of directors, or it was not considered important. The <u>degree</u> of importance was ignored and there were no obvious guidelines for deciding at what point the barriers became significant. Obviously, at some point it can be argued that all barriers are important to all decision influencers, and that all decision influencers are important to the decision process.

It is very likely that different rankings would have been obtained had a weighted scale been employed. Even then, however, the subjectivity of the findings would be very great indeed.

The study employs an innovative research technique to analyze a very difficult and complicated process; its results reflect the best judgment of a competent group of consultants. The nature of the study methodology, however, makes these results highly sensitive to errors in perception and interpretation on the part of the interviewing staff.

As a result, the fact that one barrier or decision influencer is ranked ahead of another is not very significant; indeed, it may be very misleading. On the other hand, highly ranked barriers taken as a group are probably a good indication of some of the elements to which the decision to incorporate new technology is perceived to be highly sensitive.

In addition to the above analysis, the Battelle study also provides a brief history and analysis of recent developments in the engine and airframe manufacturing industry. Special recognition is given to the timing of the design and development process employed prior to the final commitment to commercial production. The selection of the design and development stages mentioned previously was directed by this analysis. An appendix is also provided in which special issues relevant to advanced composite structures are discussed along with recommendations concerning the timing and direction of composite design and development efforts. Specific suggestions include the education and retraining of technical personnel, improvements in design and testing techniques, and the pursuit of opportunities to reduce the overall cost of the design and development process.

The value of the Battelle study to NASA comes not in the apparent precision of the study, but in the exercise of identifying the barriers that exist to technological innovation. Their analysis serves to remind us of the risk perceptions of the industry decision makers. In almost every case, the most important barriers to innovation reflect the uncertainty surrounding the cost of new technology and/or the risk-averse nature of the industry decision makers.

ANALYSIS OF FLIGHT EQUIPMENT PURCHASING PRACTICES OF REPRESENTATIVE AIR CARRIERS

by

Gellman Research Associates

The Gellman study is an analysis of investment decision making in the commercial air transportation industry. It attempts to describe the detailed process used by air carriers to decide whether or not to purchase flight equipment. In view of the many technological and organizational changes that have occurred in the industry, documenting this decision process is clearly both an important and formidable task.

The dynamics of this industry are such that few commercial airlines have developed formal investment decision-making systems. Nonetheless, all of these companies maintain a variety of purchasing policies and practices, many of which can be schematically described and categorized.

By means of extensive personal interviews with airline executives and staff, the Gellman team first identified a "conceptual decision process" employed by all airlines. This process has two stages. The first stage is really an ongoing system whereby each carrier keeps abreast of significant developments in its environment and endeavors to plan accordingly. Specifically, the first stage involves three steps:

1. Identify the environment (competition, economic conditions, technology, etc.);

2. Determine the corporate direction (strategic planning and goal-setting); and

3. Identify policy options (acquire new aircraft, modify current aircraft, dispose of surplus aircraft).

The second stage, then, is the technical and financial evaluation of alternatives leading up to a final decision. This stage proceeds through four additional steps:

4. Evaluation of options (engineering, operations, marketing and finance);
5. Selection of best options;
6. Fine-tune best options; and
7. Approval.

Ten airlines were ultimately selected for the study, these being representative of different cross-sections of the industry. The decision-making process employed by them was analyzed and decision process flow charts for each were included in the Gellman report. The Gellman team determined that these decision processes could be grouped into three categories, and decision models unique to each group were constructed. The general characteristics that distinguished the three groups were as follows:

Group I

The two domestic trunk carriers in this group, although dissimilar in terms of size, have in common consistent profitability and each has a structured fleet planning process. These airlines are expected to sponsor new aircraft in the future and each has extensive engineering capability. Return on investment (ROI) is the determinant factor for their equipment purchases.

Group II

This category is comprised of three major trunk carriers and an international carrier. They are similar in that they have experienced financial difficulty recently and have no structured fleet planning process. Investment decisions by this group of airlines are financially constrained, and thus these airlines cannot be expected to sponsor a new aircraft during the near future. Like the Group I carriers, however, these companies also have extensive engineering capability and, with the exception of one airline, ROI is the determinant factor in equipment decisions.

Group III

The carriers in Group III include a scheduled all-cargo carrier and three supplemental carriers. They are similar in that they maintain a small fleet size and operate in a generally less sophisticated fashion than either of the other two categories of carriers. The managerial character of Group III carriers is "entrepreneurial" rather than systems-oriented. These carriers generally require unique equipment characteristics and trading aircraft is a major source of profit for them.

Having described the decision processes of the three groups of carriers, the Gellman study goes on to point out a number of barriers and catalysts to the commercial implementation of new technology, as perceived from the analysis of these groups. Among the more significant barriers mentioned is the financial weakness of the Group II carriers. The presumed implication of this barrier is that technological considerations may be subordinated to short-run financial demands, thus retarding the pace of the commercial integration of available new technology. On the other hand, while new equipment purchase decisions will require more extensive economic justification in the future, new cost-reducing technologies will be well received once confidence in the technology has been established.

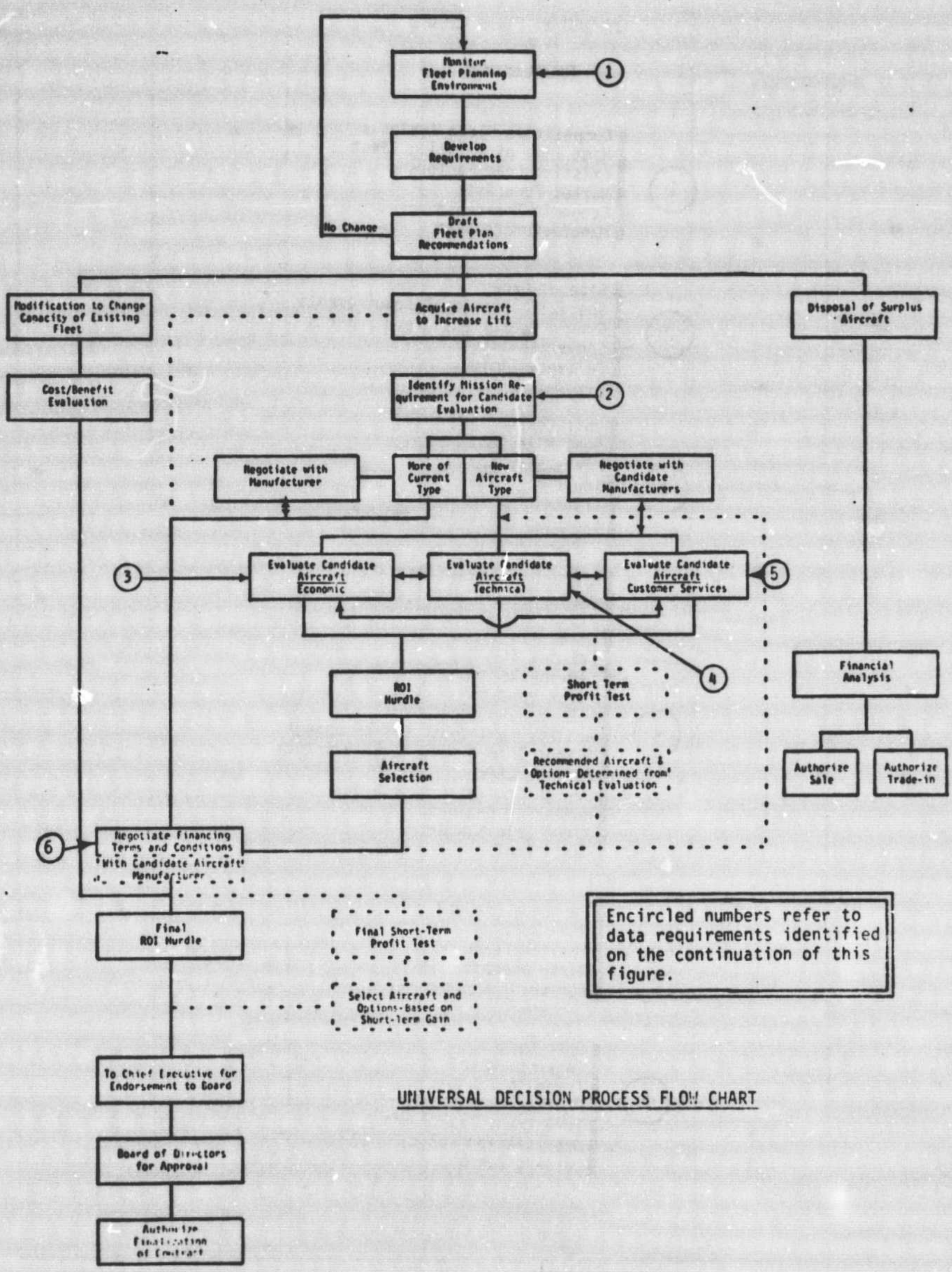
Another major barrier (or is it a catalyst?) is the position of the Group I carriers as the expected future sponsors of new aircraft. This implies a possible reduction in the number of alternative aircraft designs due to a greater emphasis on meeting the specific needs of these carriers, to the possible detriment of competing airlines.

By combining the decision process flow models for the three groups of carriers, the Gellman study finally derives the "universal" decision model. A reproduction of the flow chart depicting this universal decision-making process is shown on page 17.

The value of the Gellman study to NASA, in addition to identifying the foregoing decision-making calculus, is its analysis of the principal barriers to investments in new technology by the major air carriers. Paramount among these barriers is the financial condition of the air carrier industry. It is indicated that weaker carriers will be unable to make optimum and independent technology investments, since their investment policies will be dictated largely by financial considerations.

Another interesting conclusion of the study is that the "air carriers generally feel that aircraft producers do not understand sufficiently the process underlying the flight equipment investment decision." This results in misallocations of marketing resources, which may further delay the process of integrating new technology into commercial production.

The Gellman report lists a number of recommendations, most of which center around the need for good communications between industry and NASA. By learning more about the financial and engineering inputs to the airline investment decision-making process, as well as by integrating the industry decision makers into NASA's own R&T planning process, Gellman suggests that the speedy transfer of new technology can be facilitated.



Encircled numbers refer to data requirements identified on the continuation of this figure.

UNIVERSAL DECISION PROCESS FLOW CHART

DECISION FLOW CHART

(continued)

(1)
- Competitive Fleet Analysis
- High Time of Existing Fleet
- Existing Load Factors
- Market Forecasts
- Economic Forecasts
- Manufacturers Data

(2)
- Size of Order
- Special Operational Requirements
- Ground Operational Requirements
- Convertability
- Delivery Timing

(3)
- Unit Costs
- Seat Mile Costs
- Plane Mile Costs
- Ton Mile Costs
- Trade-in
- Expected Break-even Load Factor
- Used vs New

(4)
- Airport Compatability
- Performance Specifications
- Plane Mile Costs
- Seat Mile Costs
- Commonality
- Service Record
- First Operator
- U.S. Manufacture
- Ability to Request Design Changes
- Flight Operations Characteristics
- Service Life
- Design Concept
- Number of Engines
- After Sale Support
- Parts Pool

(5)
- Passenger Appeal
- Wide Body
- Service Features
- First Operator
- Number of Engines

(6)
- Unit Cost
- Interest Rate
- Trade-in
- Profit
- Investment Tax Credit
- Depreciation Policy
- Leasing Terms

The decision diagrams developed in the Gellman study are interesting and warrant further analysis. Additional elaboration of the engineering components of the process could be enlightening, especially since the engineering input proved to be of greater importance to the overall investment decision-making process than was initially expected by the Gellman team.

GENERAL IMPLICATIONS OF THE STUDIES

The results of the three studies include a number of specific observations and detailed commentaries, but the underlying theme in each of them can be summarized in a single word: uncertainty.

The ADL study demonstrated the extreme difficulty in forecasting the future demand for aircraft in light of the uncertain economic and regulatory environment facing the airline industry today.

The Battelle study highlighted the barriers to technological innovation and the sensitivity of the industry decision makers to specific elements of technological and economic uncertainty.

Finally, the Gellman study revealed the airlines' reluctance to commit themselves to expensive capital investments in new technology in the face of uncertain economic benefits and limited capital availability.

While all of this comes as little surprise to anyone familiar with the industry's recent history, sometimes the full significance of obvious conditions is easily overlooked. Recognition of the specific uncertainties brought out in the studies may lead not only to greater understanding, but potentially to actions designed to alleviate uncertainty and thereby hasten the pace of technological advance.

Timing is of critical importance to the ACEE technology program. It is clear that no new aircraft will be built <u>as a result of</u> the availability of energy efficient technology alone; rather energy efficient technology will be incorporated into commercial production only when forces that lie beyond NASA's influence have created a need for new equipment. The critical question thus becomes whether or not the ACEE technologies will be ready for commercial introduction at that time. The three studies recently concluded have pointed out some of the most important criteria by which the "readiness" of this technology will be judged by investors when that decision is made. The one common property of these criteria is the investor's perception of economic risk.

Economic Risk

According to Mr. Irwin Kabus, senior operations research officer at the Morgan Guaranty Trust Company of New York, economic risk can be defined as follows:

> "Essentially, risk is a consequence of the fact that investment alternatives are governed by environmental factors beyond our control—that is, they are surrounded by uncertainty. As a result of this uncertainty, no one particular return can be associated with an investment alternative; rather, what is associated is a range of possible returns along with their corresponding chances of occurrence. If the range of possible returns, corresponding to a particular investment alternative, is wide, with the returns at the extremes having significant chances of occurring, then that investment alternative is called risky. Conversely, the narrower the range of possible outcomes, the less risky is the alternative."[1]

Risk, therefore, is the perceived variability of the potential economic return from investment alternatives. The greater the uncertainty regarding the outcome of a given investment, the wider the perceived variability of return and the greater the investor's perception of risk will be. It naturally follows from this statement that risk perceptions can be reduced to the extent that investor uncertainty is eliminated.

Unfortunately, there are no precise instruments with which risk can be measured. It is entirely a function of the perceptions of a given investor regarding some set of future events, and even the investor himself is hard pressed to quantify his own risk perceptions in any meaningful fashion.

1. Irwin Kabus, "You Can Bank on Uncertainty," Harvard Business Review May/June, 1976, p. 95.

Obviously risk cannot be analyzed in a vacuum: it is only meaningful when compared to some level of anticipated economic return. As everyone knows, investors can usually be persuaded to assume relatively higher levels of perceived risk (variability of return) provided the expected return is sufficiently attractive. Furthermore, investors can be categorized according to the degree to which they are risk-averse. That is, highly risk-averse investors will require higher expected returns than less risk-averse investors facing comparable levels of perceived economic uncertainty.

The ADL and Gellman reports indicate that the U.S. airlines can be expected to show a higher aversion to economic risk over the foreseeable future than has been typical in recent years. By implication, therefore, their required return for incurring additional perceived risk will increase, i.e., they will demand the promise of greater benefits from an increment of risk-bearing technology than ever before. Since there are obvious limits to the potential near-term benefits of new technology, the goal of lowering investor perceptions of risk becomes critical to the incorporation of new technology on commercial aircraft.

Reducing Economic Risk

A variety of possible approaches to reducing investor uncertainty (both manufacturer and airline) are suggested either explicitly or implicitly in the three studies. Many of these fall into areas that NASA is already actively pursuing, while others imply possible adjustments in orientation or expansion of existing efforts. There exist at least three categories of action that could result in reduced perceptions of uncertainty about the benefits and costs of new technology.

The first category is information dissemination and exchange among government regulatory bodies, industry and NASA. One of the major concerns of the manufacturers is the time and cost of certifying new technology with the FAA. It is suggested by the Battelle study that the risk of certification delays is reduced by the frequent communications that take place between the regulatory bodies, industry and NASA concerning the status of developing technologies. The Gellman study points toward possible benefits from increased communications with the airline industry. Other specific recommendations might be offered as well, but the central point is clear: to the extent that all available information regarding the progress of new technology development is disseminated thoroughly among the relevant "decision influencers," perceptions of uncertainty and economic risk can be reduced.

A second category is NASA's financial and technical collaboration with industry in the early phases of new technology development. This, of course, is the principal activity of the ACEE technology program. The impact of this kind of activity is to limit much of the economic risk of long-range development and to broaden the information and experience base necessary to bring the technology into commercial production. Additional efforts in the design of new tools and techniques for use in such areas as nondestructive testing and materials fabrication are suggested by Battelle as possible amplifications of current activities.

The third general category of activity that can result in decreased perceptions of risk is the continued reevaluation on the part of NASA's technical managers of the needs and economic constraints of private industry.

As the economic and regulatory haze lifts over the industry during the near future, the structure and fortunes of the industry will become clearer, perhaps signalling the need for new kinds of technology and shifts in development activities. The ADL study points out some of the major variables that can create dramatic changes in civil aviation over the next decade and the need to closely monitor these forces. Forecasting new opportunities for technological integration is highly dependent upon an awareness and sensitivity toward these changes.

In summary, the findings of the three studies recently completed remind us of the risk-averse nature of the airlines and aircraft manufacturers and of the uncertainties to which they are most highly sensitive at the current time. By helping to reduce these uncertainties, NASA will be able to speed up the pace of technological innovation and the incorporation of energy efficient technologies in commercial aircraft.

General Reference

The following publications provide very helpful background information about the civil aviation industry.

Capron, W. M., Editor. Technological Change in Regulated Industries. Brookings Institution, Washington, D. C., 1974.

Douglas, G. W. and J. C. Miller III. Economic Regulation of Domestic Air Transport: Theory and Policy. Brookings Institution, Washington, D. C., 1974.

Ellison, A. P. and E. M. Stafford. The Dynamics of the Civil Aviation Industry. Saxon House, D. C. Heath Ltd., Westmead, England, 1974.

Freehan, W. E. The Fight For Competitive Advantage: A Study of the United States Domestic Trunk Air Carriers. Harvard University, 1972.

Graef, J. D. "Development of Requirements for, and Evaluation of, Manufacturer Advanced Design Aircraft", Society of Automotive Engineers, NAEM meeting, Los Angeles, California, October, 16-18, 1973.

Phillips, A. Technology and Market Structure: A Study of the Aircraft Industry. Lexington Books, D. C. Heath and Company, Lexington, Massachusetts, 1971.

Taneja, N. K. The Commercial Airline Industry. Lexington Books, D. C. Heath and Company, Lexington, Massachusetts, 1976.