would go a long way toward meeting the requirement for planning data. Where significant activities covered by the reporting requirements are performed through a service contract, either the service expense or the staff PME of the contractor should be reported.

Data on facility requirements (square feet of space by class or use) could be collected directly from airport authorities.

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AN ENGINE MANUFACTURER'S VIEW OF CAB FORM 41 DATA

George W. Kleinert, General Electric Company

Summary

The aerospace manufacturing industry makes extensive use of data from Civil Aeronautics Board reports in projecting world traffic growth and potential demand for new aircraft and engines, in analysis of airplane usage and evaluation of new and derivative engine designs and in studies to optimize overall engine maintenance costs. Use of this data and concerted effort by the manufacturers and the airlines have resulted in commercial aircraft with lower operating costs and have given the United States leadership in commercial aviation.

CAB Form 41 data would be much more useful to engine and aircraft manufacturers if additional data such as flight length, derate, average engine age and accounting practices could be factored into the final value. In order to achieve this type of standardization, the industry would have to agree on a common format and a mutually acceptable method to normalize engine maintenance cost data.

New and Existing Airplane Evaluation

CAB data provides the basis for many new and derivative airplane and engine evaluations which compare calculated direct operating costs of new systems with those in service. Elements of CAB data are used to develop empirical relationships between direct operating costs and design or operating factors that influence these costs. Design decisions based on these analyses contribute to progressive reductions in direct operating costs as new airplanes and engines are introduced.

The use of this data as references and concerted effort by the manufacturers and the airlines have resulted in commercial aircraft with lower operating costs and has given the U.S. leadership in commercial aviation.

Aircraft Market Forecast and Market Analysis

The manufacturer has developed a number of computer programs which use CAB data and related economic factors to forecast future travel demand. The U.S. and foreign segments can be combined to yield total world forecasts. Detailed CAB statistics such as load factor, seats, stage length, etc., can be analyzed to permit a better understanding of the total system as well as individual airline operation. In this way the individual airline and industry's future needs in new aircraft and engines can be more clearly defined. This permits an assessment of future market needs by aircraft size, range, and operating characteristics. Because of the long lead time in developing new aircraft systems - particularly the propulsion system - the manufacturers must anticipate airline requirements by three to five years in order to be able to offer, at the proper time, the type aircraft which meets airline requirements.

The total market for new aircraft is generated by the need to accommodate growth as well as replacement of aircraft being retired. Aircraft retirement plans are frequently influenced by the airline financial status. Studies of financial trends of the industry and debt structure permit projection of capital requirements and resources. This provides a guide of the industry's ability to purchase new equipment. These studies forecast the measure of the financing assistance which may be required by the airline industry.

In analyzing the travel demand and the type of equipment being utilized to meet this demand, the manufacturers are able to identify new product opportunities, and hence new market opportunities. New airplanes allow the airlines to serve their routes more efficiently.

Engine Maintenance Cost Elements

Engine maintenance costs consist primarily of three elements:

1. Material cost
2. Labor costs
3. Outside services.

The combination of these three elements establishes the total direct maintenance cost for the engine. From an engine manufacturer's viewpoint and also the airlines' viewpoint, this data provides the basis for judging the cost performance of competing equipment.

In the past several years, fuel costs (Figure 1) have risen at a much faster rate than material and labor costs (Figure 2). For this reason engine and aircraft manufacturers are conducting trade-off studies comparing engine maintenance costs versus fuel burn.

Preliminary results of studies conducted on future twin engine, wide-body aircraft indicate, for example, that the fuel burn savings by climbing at maximum available power (zero derate) will offset the increased engine maintenance cost by a factor of two and one half to one. As fuel prices continue to rise in comparison to engine maintenance costs, airline operators will probably modify their engine maintenance practices to optimize overall direct operating costs. For example, it may become economically feasible to remove an engine prematurely to restore specific fuel consumption performance.

Figure 1. Jet fuel price escalation trends.

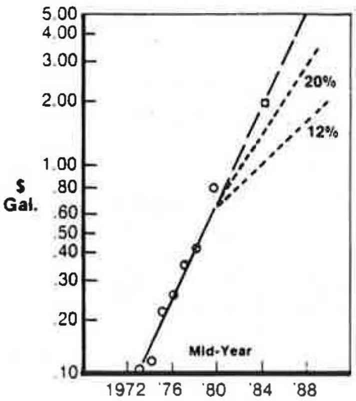


Figure 2. Labor cost.

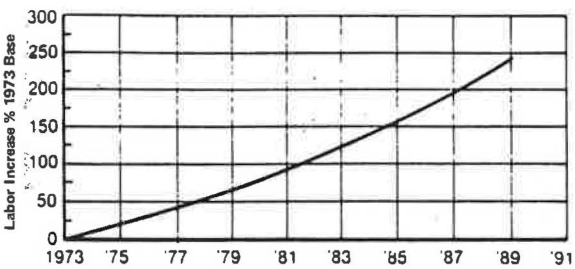


Figure 3. Computer input for severity model.

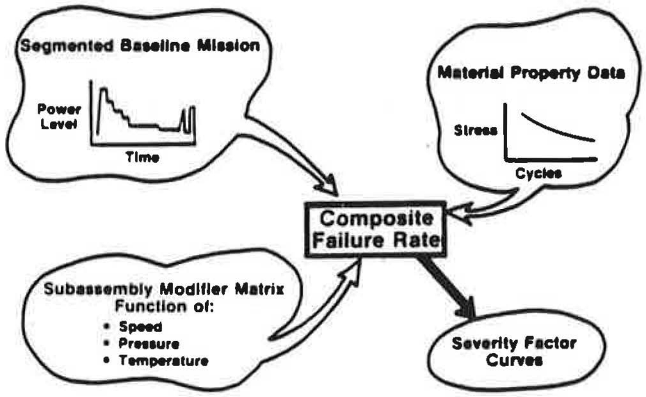
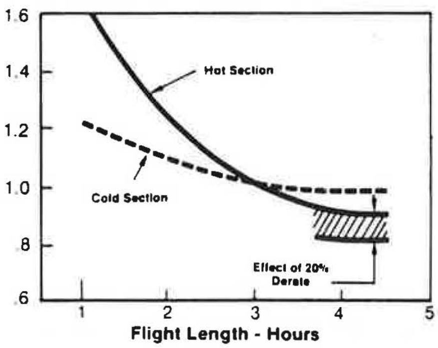


Figure 4. Sensitivity of engine components to flight length derate.



In order to monitor the results of the various tradeoff's that may be considered, it is imperative that fleet wide data similar to CAB Form 41 data is available for analysis.

Factors Affecting Engine Maintenance Costs

There are many factors affecting the maintenance cost of contemporary high by-pass ratio commercial transport engines. The following is a list of the most significant items with respect to cost:

- Derate
- Flight length
- Ambient temperature
- Environment
- Dilution/engine age
- Maintenance practices
- Airline accounting practices
- Warranty

Unfortunately there are no common standards in the commercial aviation industry to normalize these factors when making comparative evaluation. Therefore, each manufacturer generally develop his own method of normalization in order to understand competitive performance.

This presentation will briefly describe the methods employed by the General Electric Company's Aircraft Engine Group to determine the engine maintenance cost for the CF6-50 turbofan engine in operation throughout the world.

Aircraft mission severity has a very significant impact on the direct operating costs (DOC) of any powerplant, especially the high bypass ratio engines, currently powering the widebody aircraft in revenue service.

Figure 3 pictorially describes a mission severity computer program designed to provide a series of severity factors for various flight lengths and power settings. The program assumes a baseline mission cycle, then assesses the failure rate of each major subassembly, within the engine, as a function of engine speed, pressure and temperature. Also, the program contains information related to the material property data of each subassembly and the relative stress placed on each component as the physical characteristics change. The computer output is a set of severity factors for each condition of flight length and power setting.

Figure 4 shows the sensitivity of engine components (grouped into hot section and cold section) as a function of flight length. As a reference, a three hour flight length with zero derate has been selected as unity. As indicated by Figure 4, reducing the flight length or derate has a significant effect on the engine severity ratio.

Figure 5 shows the effect of derating for various flight lengths. Notice that the rate of severity increases much more rapidly as the flight length becomes less than two hours, especially at zero derate.

Definition of Effective Derate

Studies conducted by General Electric indicate that the effect on engine severity varies during takeoff, climb and cruise with a constant derate (see Figure 6). For this reason, GE uses the term "Effective Derate," which is the arithmatic sum of the partial derate values for takeoff, climb and cruise. For example, (see Figure 6) with a two hour flight leg and a 10 percent operational derate (derate pilot would observe) the effective derate in the sum of the partial derates (TO= 5.0 percent, CLB=2.5 percent, CRU=2.2 percent, or 9.7 percent). Once the

Figure 5. Effects of derate.

Figure 6. Effects on engine severity during takeoff, climb and cruse.

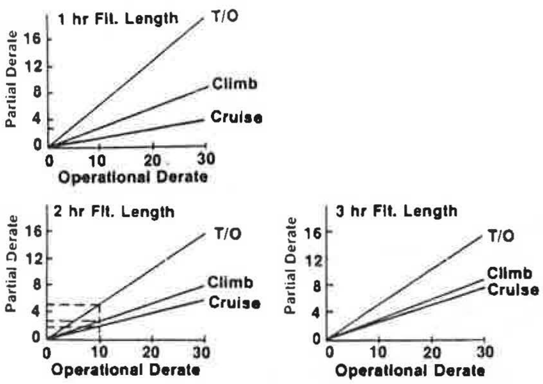
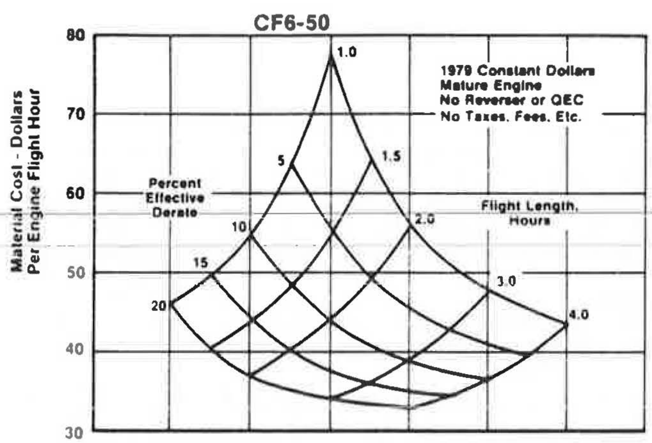


Figure 7. Estimated net maintenance material cost.



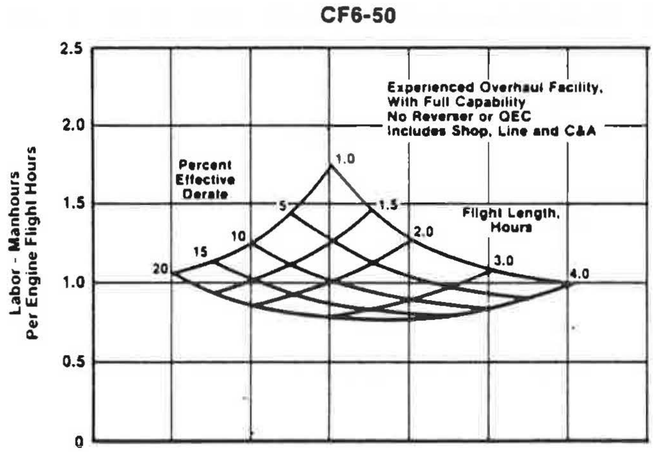
effective derate is determined then the severity factor can be determined for various flight lengths.

Figure 7 and 8 result from cross plotting the various flight lengths and derate and then multiplying the cost resulting severity factors times a baseline material cost (Figure 7) or maintenance labor index (Figure 8).

Engine Aging Characteristics - Dilution

The introduction of new equipment into the fleet has a diluting effect on the real mature maintenance cost of a given engine. In order to normalize fleet data that is made up of equipment with varying ages, the GE computer program has an aging factor (Figure 9) built into the program. The program utilizes the aircraft age and assumes an equivalent spare engine level (engines and modules) of 25 percent.

Figure 8. Estimated maintenance labor.



Difficulty In Using CAB Form 41 Data

CAB Form 41 engine maintenance cost data is raw data with no adjustments made for aircraft mission severity, fleet dilution, or user accounting practices. Therefore, from an engine manufacturer's viewpoint, the data must be normalized before meaningful comparisons can be made. This presentation has primarily emphasized the effects of mission severity and fleet dilution. However, user accounting practices can also impact apparent engine maintenance cost. For example, some airlines capitalize engine material costs during an upgrade program whereas others may expense these same costs. The result is a distorted comparison of reported material costs for users of like equipment on similar route structures.

Another example of misleading data, due to accounting practices, is encountered when an airline has engine maintenance work done by another airline. CAB Form 41 data will report material and labor expended by the second airline as an outside service when in reality it is material and labor. Also, generally included in the engine maintenance cost of an airline doing work for another airline is a fee which further distorts the real engine cost as compared to an airline doing their own engine maintenance.

How Can CAB Form 41 Data Be Improved?

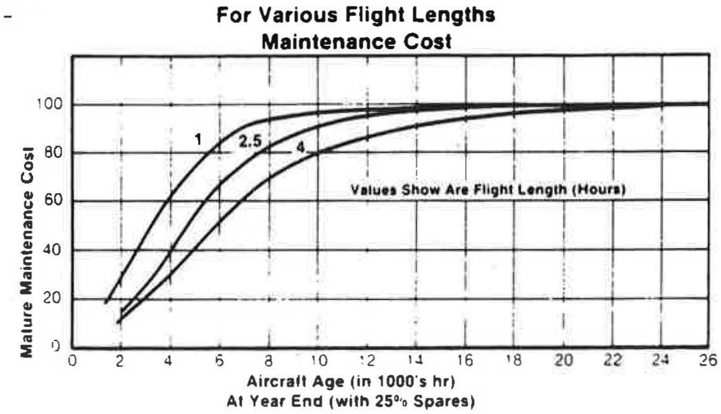
CAB Form 41 data would be much more useful to engine and aircraft manufacturers if additional data such as flight length, derate, average engine age and accounting practices could be factored into the final value. In order to achieve this type of standardization, the industry would have to agree on a common format and a mutually acceptable method of normalizing engine maintenance cost data.

Impact of Not Having CAB Data

The extensive base of detailed traffic and economics data (best in the free world) will be interrupted. Market demand forecasts as the basis for long range business planning will still be required but will contain less detail and will become less accurate.

The manufacturers will not be able to anticipate airplane requirements in terms of quantities or specific characteristics because the operational statistics relating to aircraft utilization, seating capacity, load factor, segment length, etc., will be lacking.

Figure 9. CF6-50 aging characteristics - dilution consideration.



Alternatives If There Is No Public Source For CAB Data

Alternative sources will have to be developed for key airline statistics such as fleet composition, travel demand, load factor, etc., from member airlines through IATA/ICAO, to permit basic industry trend forecasting.

Operational and economic data considered to be of general interest and of significant value may be collected and provided by selected government agencies (FAA/DOT) or industry associations (ATA/AIA).

Maintenance cost statistics and related cost elements could be obtained directly from individual airlines for the products involved by consulting with each airline.

Statistics of general interest to many groups (government, manufacturers, financial, academic) may be collected and organized by data vendors to provide continuity with earlier CAB data if discontinued.

USE OF SELECTIVE CAB DATA IN AIRPORT TRAFFIC FORECASTING

Johannes G. Augustinus, Port Authority of New York and New Jersey

Summary

As an airport operator, the Port Authority of New York and New Jersey has regularly used many segments of the Civil Aeronautics Board data base for forecasting and planning airport requirements in the New York area and in regulatory proceedings. The CAB data series became increasingly more important to the forecasting process as the aviation industry matured and there has been a growing need to supplement local with national data. Continuation of a minimum level of data collection in areas indicated appears vital to intelligently analyze, interpret and forecast regional traffic developments.

As an airport operator, the Port Authority of New York and New Jersey in the past has mainly used many segments of the large body of CAB data for forecasting purposes and, in the past, for presentations in regulatory proceedings. With the use in regulatory areas likely to diminish, the discussion will focus mainly on the use of these data in forecasting and related areas.

Airport operators, by definition, are primarily interested in passenger and/or cargo volumes rather than passenger miles (cargo ton miles), although some aspects of their operations such as fueling and average weight of aircraft are also a function of length of haul.

In order, however, to have a frame of reference for trends in the industry at large, the Port Authority also maintains some national models based on passenger mile (cargo ton mile) measurements, as done in many other sectors of the industry.

Although theoretical shortcomings can be recognized in such aggregate models (e.g., no market segmentation, either by volume or price levels) such models have proven to be useful tools in analyzing past trends and evaluating future prospects. Figure 1 shows the results of one such model, based on historical data from 1950 through 1973, and projecting domestic passenger miles for the period 1974 through 1979, assuming that the growth of the U.S. economy (GNP) and the airline yield levels had been accurately known in advance in 1973. The comparison with traffic growth as it did actually occur during that period, is, at its least, encouraging.

As pointed out by other panelists, it may be extremely difficult today to forecast accurately, or even approximately, some of the input variables in such a model, specifically a future yield variable. Nevertheless, comparisons as indicated here, at least serve the purpose of pinpointing the real problem areas in these kinds of forecasting activities, in this case forecasting the independent variables, rather than major shortcomings in the structure of the forecasting model itself.

In the fifties and part of the sixties, with most emphasis in planning work being on long term growth rather than short term fluctuations, and data series for econometric projections being in "short" supply (limited time periods), the Port Authority relied heavily on survey methods focusing on the demographic aspects of long term market growth. With the advancing maturity of the air travel market and its increasing sensitivity to business cycle fluctuations and pricing policies, econometric modeling techniques focusing on these aspects of market growth have become increasingly important, thus making many of the CAB data series much more vital to the forecasting process.