Papers —

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Changes In Growth Rates of Domestic Passenger Air Transportation

Several investigations have been made to determine the growth characteristics of domestic air transportation. Comick and Wallace[1] have compiled the results of several studies as shown in Fig. 1 reproduced from their publication. The wide range of forecasts from 20 to 90 billion passenger-miles in 1970 indicates that there is little agreement in the air transport field concerning its growth pattern. While the results of the study reported in this paper add still another trend curve, it is hoped that the method of analysis will be of some value to those interested in transportation research and that the trends indicated by the study will be useful to those in marketing and planning of air transportation.

Last year at this meeting, I presented a paper[2] in which I attempted to show that the growth of transportation in the various modes measured in ton-miles followed an "S" shaped growth pattern which could be approximated closely by the Gompertz growth curve. In general, the trend curves were derived by the method of Croxton and Cowden[3] in which the complete set of historical data for each mode was used to obtain an equation of the growth curve. It was demonstrated that although the extent and rate of growth was different for each mode, the sum of the ton-mileages of the modes for any given time equalled the trend value of total transportation which also followed the Gompertz curve. The correlation offered some credence to the use of the Gompertz curve in evaluating transportation trends.

Applying the same analysis to the statistics of domestic airline passenger miles[4] produces a trend curve as shown in Fig. 2 together with the plot of the historical data. It can be seen that there is poor correlation, and from this comparison it would appear that the Gompertz curve fails as a suitable model of the growth trend of air transportation. However, I offer a suggestion of the analysis of these same data which shows that the Gompertz curve does apply.

Referring to Fig. 3 in which the passenger-mile data are again plotted, it can be seen, as suggested in reference 1, that there are periodic flat spots, or periods of little or no growth, which are unrelated to trends in the economy. These flat spots occurred in the periods 1936-37, 1946-48, and 1957-58. By marking these periods off as shown in Fig. 3, it can be seen that they are each separated by nine years. These nine-year periods coincide with the predominant type aircraft in use. Prior to 1936, the Ford tri-motor air-

1T. F. Comick, W. M. Don Wallace, **Forecast of United States Domestic Airline Traffic 1961-1975**, The Boeing Company, August, 1961.

2Wm. F. Le Fevre, "Determining Transportation Trends by the Gompertz Growth Curve," American Transportation Research Forum, Second Annual Meeting, New York, Dec. 29, 1961.

3Croxton and Cowden, **Applied General Statistics**, Prentice-Hall, New York.

4**Handbook of Airline Statistics**, Civil Aeronautics Board, Washington, D.C.

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plane was in common use; in the second period 1937-46, the two-engine DC-3 type airplane was used; in the third period 1948-57, the four-engine propeller driven type airplane such as the DC-6 and 7 was predominant; now, in the fourth period, the turbo-jet type airplane has been introduced while propeller driven aircraft are still in use.

Considering the first period of growth 1927-37, a Gompertz curve can be derived which very closely fits the statistical data except between 1930 and 1936 when the Depression reduced the growth from its normal indicated trend. The equation of the growth curve for this period is

$$\frac{PM}{10^6} = 4797\ (.00136)^{.8325^{(Yr.-1926\frac{1}{2})}} \qquad (a)$$

PM=Passenger Miles

The curve of this equation and of equations for the second and third growth periods are plotted in Fig. 3.

In reference 2 the derivation of the inflection point is presented. The inflection point defines the point on the growth curve where there is a change from an increasing rate of growth to a decreasing rate of growth. For the first period growth in air transportation, the inflection point falls in 1932.

The second period of growth can be represented by a curve having the equation

$$\frac{PM}{10^6} = 19723\ (.02068)^{.8675^{(Yr.-1938)}} \qquad (b)$$

The indicated inflection point is at year 1945.

While the correlation between the data and the trend curve is not as good as in the first period, the setback in normal growth caused by World War II becomes evident.

Again, the third period growth can be defined by a curve having the equation

$$\frac{PM}{10^6} = 55439\ (.0907)^{.8844^{(Yr.-1948)}} \qquad (c)$$

for which the inflection point occurred in the year 1955. There is close correlation between the trend curve and historical data in the third period between 1949 and 1957.

There are not yet enough data points to establish the trend in the fourth period as for the first three periods. However, we can derive a trend curve which can be used for forecasting purposes. Again referring to Fig. 3, we can draw an envelope curve tangent to each of the three period growth curves at the inflection points. Taking points from this curve, it can be shown that it also is a Gompertz curve having the equation

(Yr.–1932)

$$\frac{PM}{10^6} = 243560\ (.000834)^{.9556} \qquad (d)$$

which is shown plotted in Fig. 3.

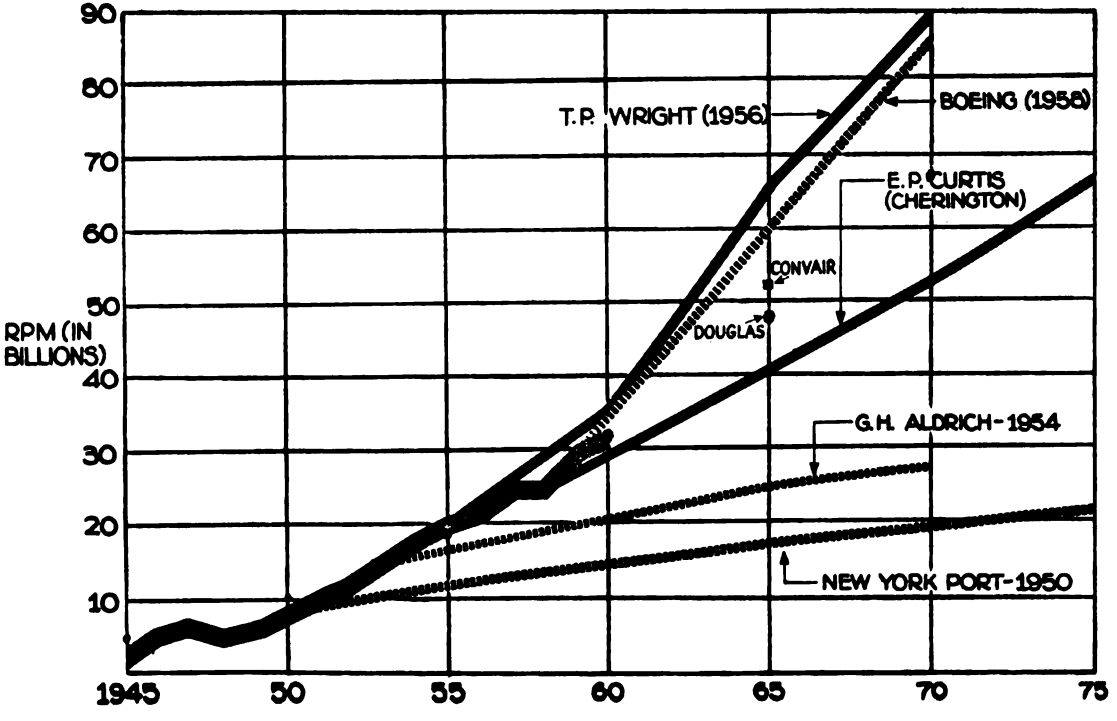
The envelope curve represents a maximum demand for air transportation which has been attained in each growth period only at the inflection points or where the trend curves reached a maximum rate of growth. While there is little similarity between the trend indicated by the envelope and the first period growth trend, each succeeding period trend curve approaches closer to the envelope curve as the air transport industry matures. Since 1955, and in the fourth period of growth since the advent of jet aircraft, the period growth is nearly coincident with the envelope curve. If the envelope curve represents the maximum potential demand for air transportation, then in recent years actual useage has become nearly equal to the indicated demand suggesting that the air passenger transportation industry has reached such maturity that its future growth can be defined by extrapolation of the envelope curve. On this basis, the demand for air passenger transportation will be in the order of 68 billion passenger miles in 1970 compared to 30.55 billion passenger miles in 1960.

Using the equation of the envelope curve, the inflection point will occur in 1975. Although growth will continue, should it follow the trend indicated by the envelope curve, the increase will be at a lower rate after 1975.

Economic indices such as the Gross National Product and Production Index are often used as indicators of trends in transportation. In reference 2 it was shown that there is little relationship between growth in modes of freight transportation and these common indicators. The same is true for air passenger transportation. There was a setback in air transportation coincident with the Depression of the Thirties. There was also a setback in air transportation during World War II, but this was a time of high values for the common indicators. Also, the economic indicators do not correlate with the flattened growth periods of air transport in 1937, 1946-47, 1956-57, as these were not considered periods of recession, while during actual recession years (1938, 1949, 1953 and so on) air traffic exhibited appreciable growth. Further, in the Fifties, air transportation does not show variable growth paralleling the economic cycles of the GNP. Instead, it has been shown that growth in air traffic has been largely influenced by the type of aircraft in use in each of three separate periods. Introduction of each aircraft type was followed by increased patronage with a decline to small growth at the end of each period during the transition period of change from one type airplane to another.

In the past, there has been a significant change in design and use of aircraft especially in the first three periods of growth. Now with both propeller driven and jet aircraft in use and with airplanes designed for specific application in short, medium, and long block distances, the airplane type may not have the marked influence on air traffic growth characteristics previously experienced. Instead the growth may follow more closely the demand curve developed in this study. The statistics of air traffic volume since 1955 seem to support this opinion.

FIGURE 1
FORECASTS OF U.S. DOMESTIC AIR TRAVEL



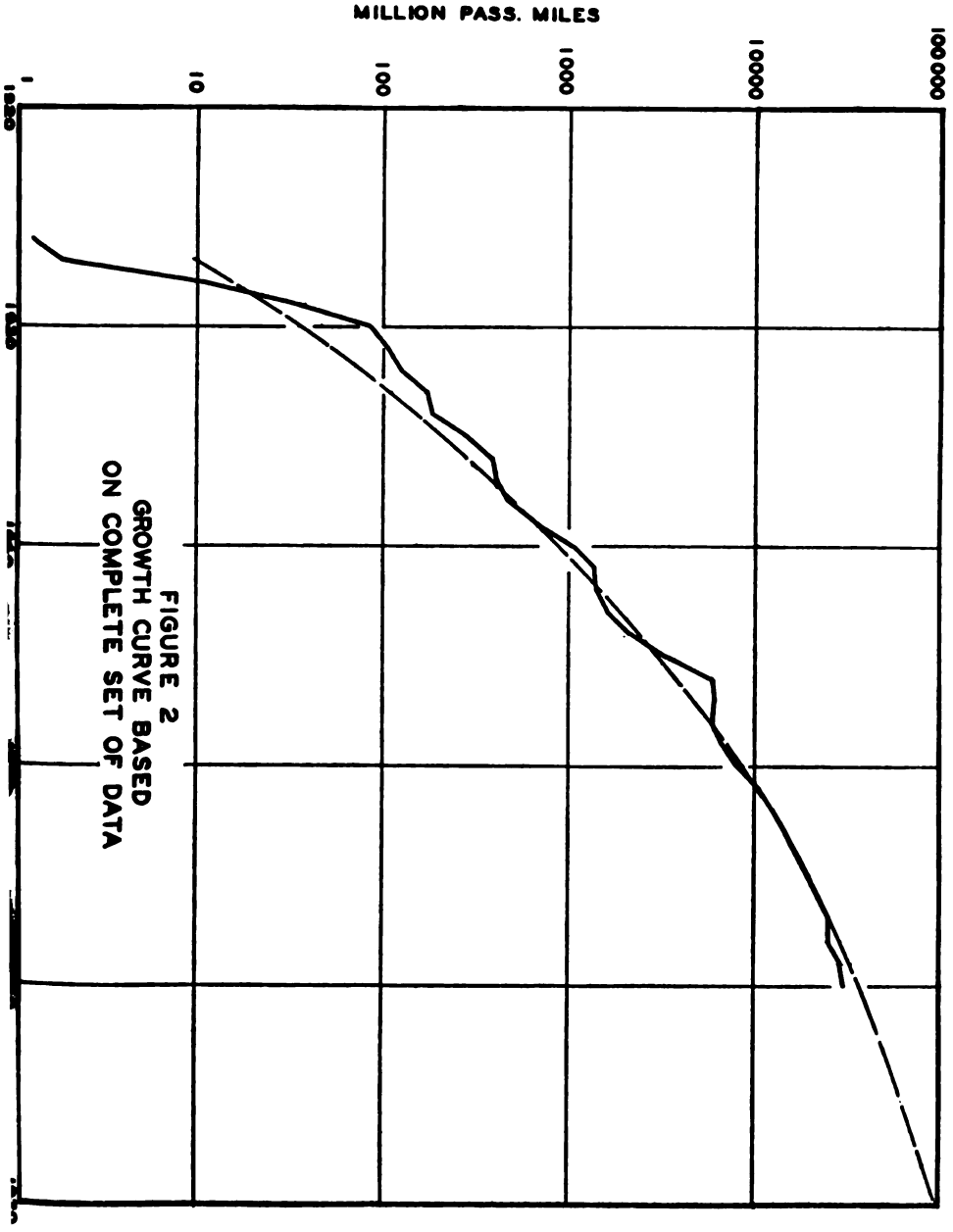


FIGURE 2
GROWTH CURVE BASED
ON COMPLETE SET OF DATA

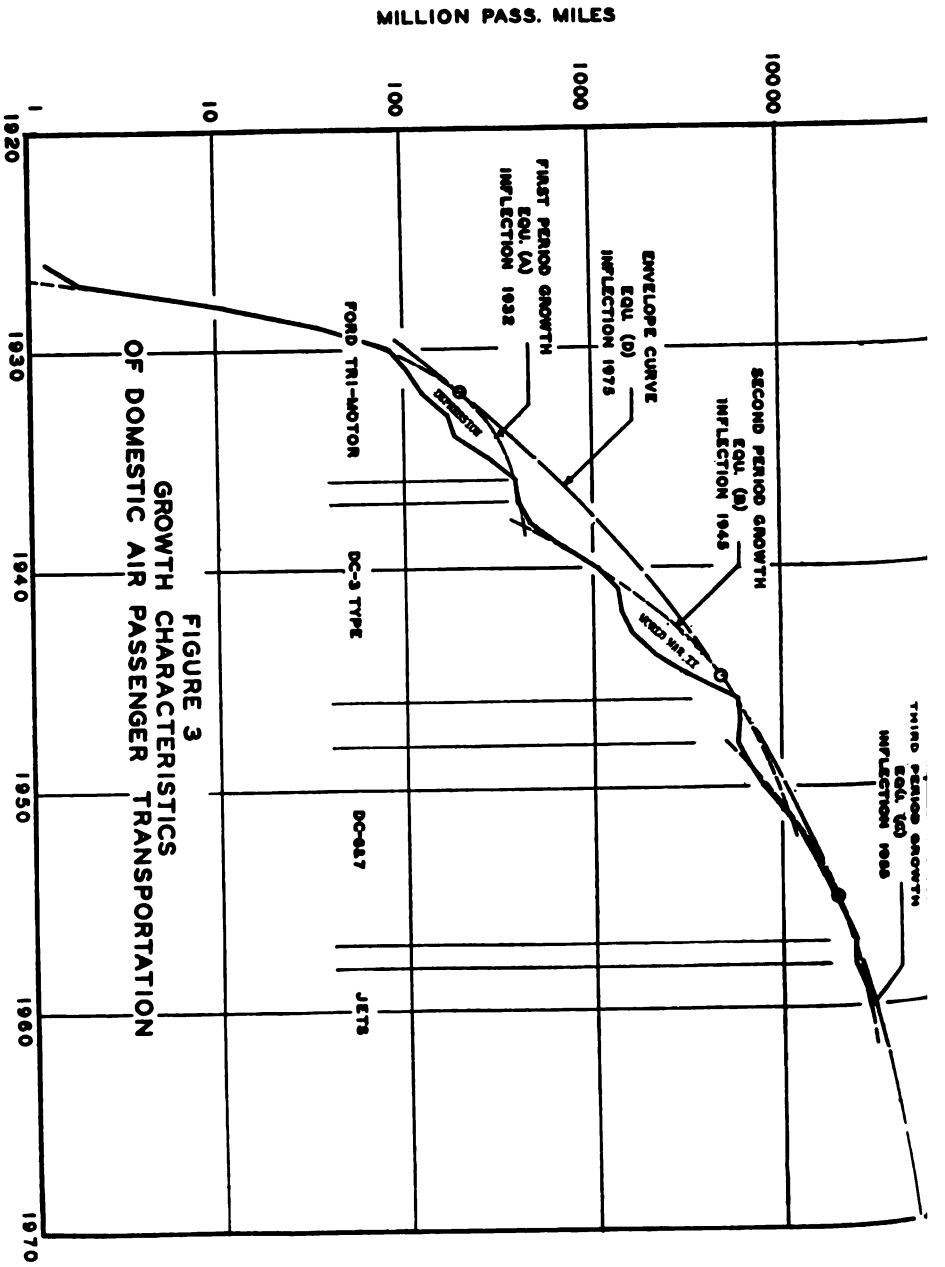


FIGURE 3
GROWTH CHARACTERISTICS
OF DOMESTIC AIR PASSENGER TRANSPORTATION