AIRCRAFT TECHNOLOGY
Kenneth R. Velten, McDonnell Douglas Corporation

There are four major points about future or current technology. All really concern themselves with fuel, which is the central problem. First, what should be done about the availability of fuel? Douglas has a model that takes an airline from the Official Airline Guide markets, splits it up and applies growth, and assigns airplanes, and the output of this model is illustrated by Figure 1 for a major U.S. carrier, which shows the number of aircraft required to handle its schedule from 1981 through 1995. This shows you the various kinds of transports that this particular major carrier will use. These are the first generation airplanes - large-capacity, long-range; medium-capacity, medium-range; stretched-capacity, long-range; and upper-medium-capacity, medium-range.

This is the fleet in 1995, and the amount of fuel that that fleet will take to fly the schedule, or the schedule as it has grown is shown in Figure 2. After some increases in 1981 and 1982, fuel requirements are just about level for this carrier, and this would apply for the whole U.S. system. That is, the current airplanes, plus new airplanes, will be able to provide the service and not use more fuel. The revenue passenger miles that that fleet could provide are shown in Figure 3. The growth rate is above 5 percent after 1985. We believe that future airplanes can give the increases in capacity that the system requires without substantially increasing the amount of fuel required.

The next question is the price of fuel - about 90 cents a gallon in 1980. Based on the Wharton model, which we use for econometric inputs, the world price will go up to about $90 a barrel in 1991. Jet fuel will go up to around $3 per gallon in current dollars, and in 1980 dollars up to about $1.50 per gallon. The Wharton assumption is that worldwide prices will go up 3 percent faster than U.S. inflation. Apparently it takes between two and five percent annual increase in jet fuel prices to bring world demand into balance with world supplies. It will not be a smooth growth curve but no one can say when the periodic shocks like the Iranian revolution will happen. This then is our forecast of the price of jet fuel.

What does that mean in terms of aircraft? In 1971 about 20 percent of direct operating cost (DOC) for a DC-10 was for fuel. By 1986 about 54 percent of the DOC will be for fuel. The new generation airplanes (one of which is labeled a DC-11) could lower that to about 45 percent of DOC (Figure 4). Technology can give you the kind of operating economics that will be needed to keep prices from rising too rapidly.

What about turboprops? Turboprops offer, at least theoretically, fuel savings over high-bypass engines of about 10 to 15 percent. They offer about 25 to 30 percent savings on fuel over the JT-3D's and the JT-8D's. They are very attractive, and much work is going into them. Douglas has had a NASA contract for wind tunnel tests of putting turboprops on a DC-9. The problem is that, to operate at Mach .8 the current generation turboprops are quite a bit down in efficiency (Figure 5). Operations at Mach .8 need very high horsepower - to operate a 100 passenger DC-9 at Mach .8 you need a 14,000 shaft horsepower engine. The U.S. has never built a turboprop engine of that shaft horsepower. The other problem is that even if we could build the gas generator, the turboprop engine is a jet engine driving a gear box which in turn drives the propeller. No one is completely sure whether we can build the kind of gear box to convert the speed at which this engine will operate to the speed at which the propellor will operate. It appears that to operate turboprops efficiently a way must be found to do so at Mach .6 . It is clear that turboprops make sense on short hauls, where they do not have to fly at Mach .8 . Such a speed would require a prop fan which is an 8 or 10 bladed propeller. No one knows how such a propeller would perform since no large ones have been tested. That is why we support the NASA program to operate a large demonstrator model. In our case this is a DC-9 fitted with two turboprops or propfans. The problem is that it will be 1988 before there is such an engine which is obviously too long in view of the rate with which the cost of fuel is going up (Figure 6). For another $90 million,

Figure 1. Market split report: aircraft inventory (a major U.S. carrier).

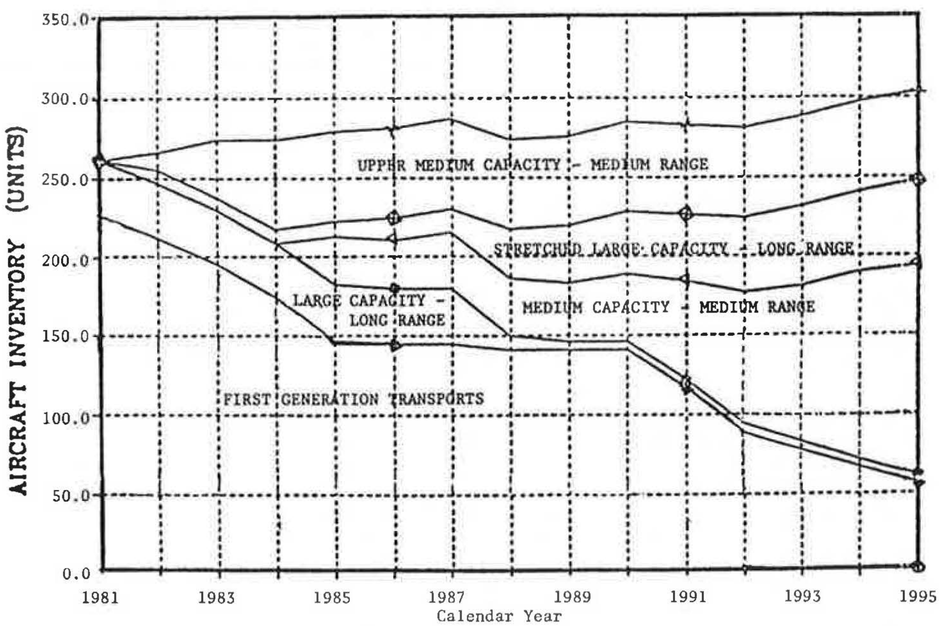


Figure 2. Market split report: annual fuel consumption (a major U.S. carrier).

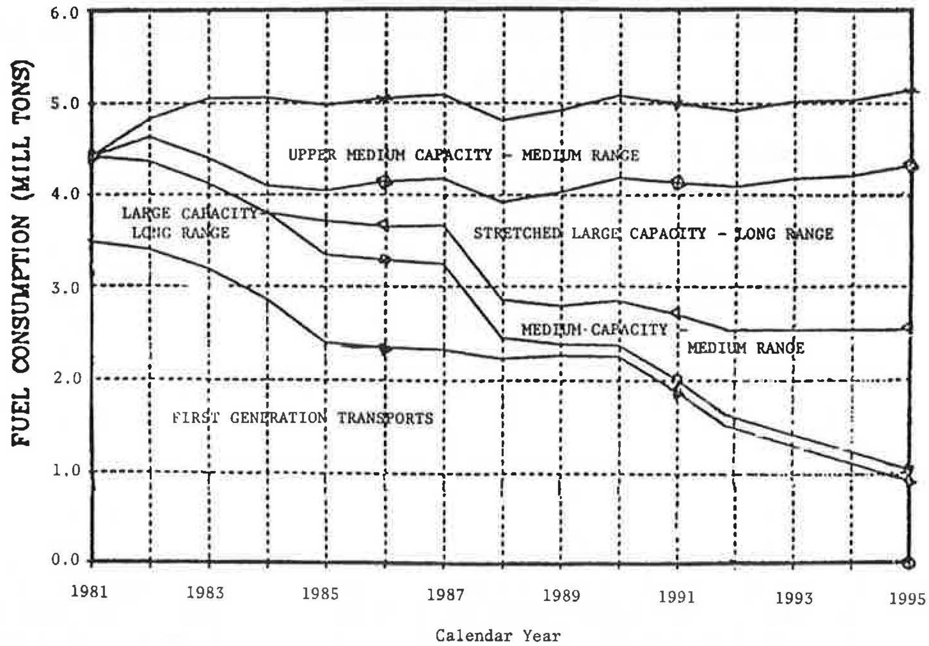
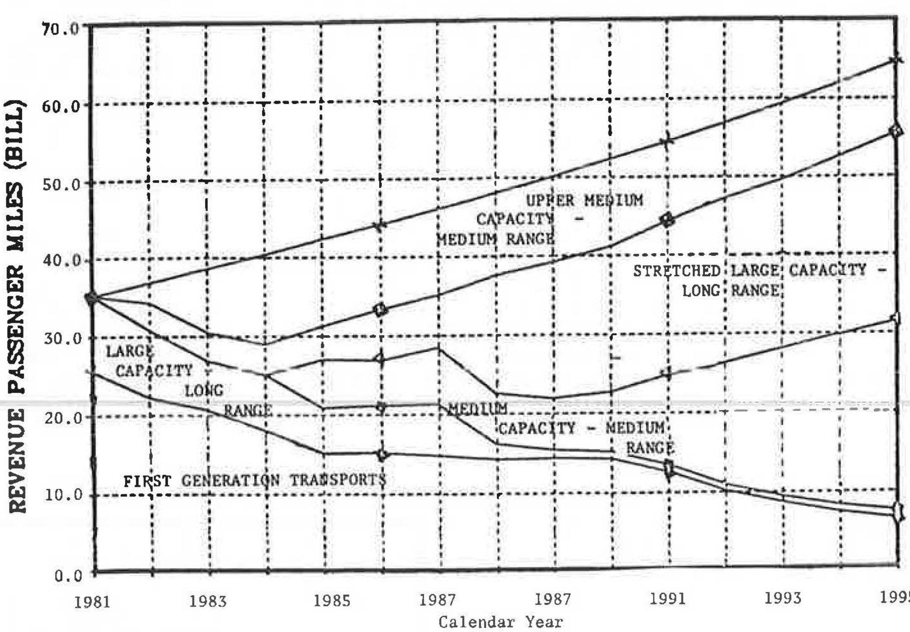


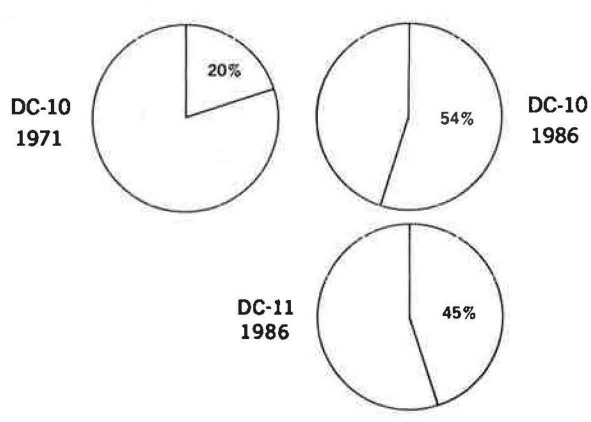
Figure 3. Market split report: revenue passenger miles (a major U.S. carrier).



that development could be achieved by about 1985. We have also recommended to NASA and Congress some research into gear boxes and full-scale propfans. All that will be necessary to develop practical turboprops. These are for small capacity planes, 100 passengers or less, and short haul, 500 miles or less.

Figure 7 covers the fourth point, the supersonic transport (SST). We have been working on SST technology for ten years. NASA has been sponsoring a great deal of such work. Improvement has been made so that at $1.20/gal. fuel cost, we can design an AST as we call it, which would carry 350 passengers across the North Atlantic, New York to London, for about $103 for fuel per passenger, compared to $243 for the current Concorde aircraft (Figure 7). The technology has been developed for an SST, with fuel costs not too much above those of a DC-10, which is at $76 a passenger. If the SST could

Figure 4. Fuel as a percentage of DOC.



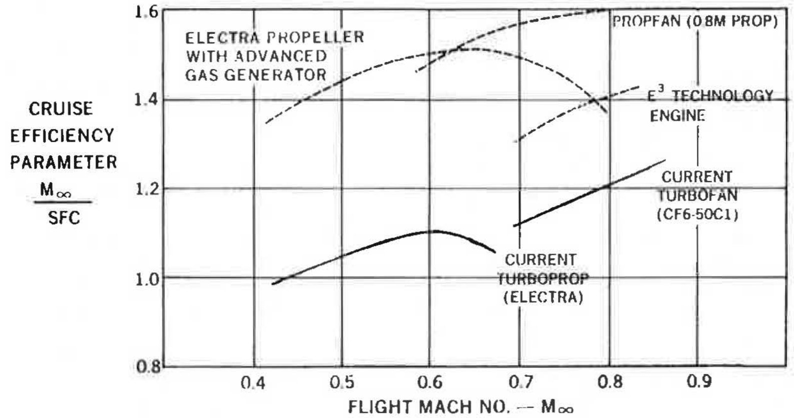


Figure 5. Propulsion cruise-efficiency comparison.

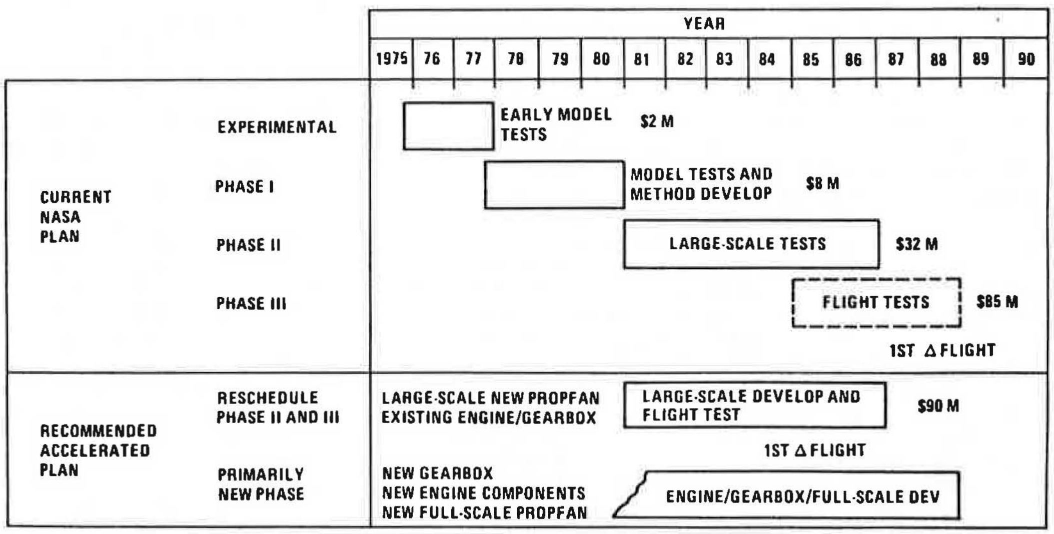
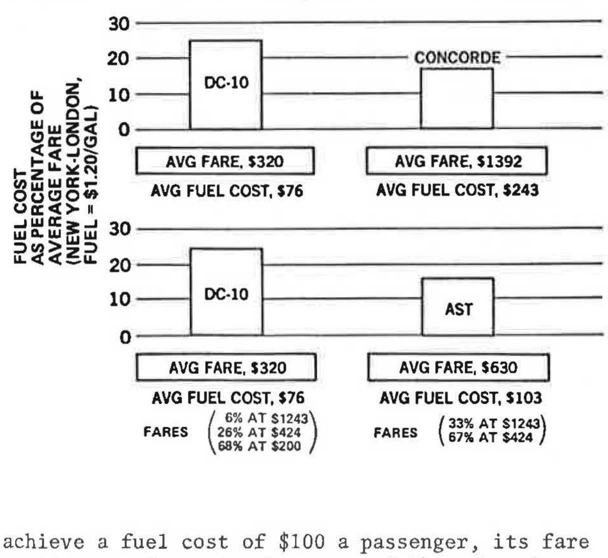


Figure 6. Propfan program schedule.

Figure 7. Fuel-cost comparison: New York-London.



achieve a fuel cost of $100 a passenger, its fare would come closer to the range of the subsonic fares. The Concorde now has to use the first class fare plus a premium in order to make any economic sense. Of course, the probem is that the SST development cost would be enormous, more than any U.S. company could stand on its own. But the technology is available. If an SST is really wanted we can give you one some time after 1995.

To summarize our four points: aircraft technology plus the change in engine technology will probably need about the same amount of fuel in the future. Technology will reduce the proportion that fuel cost contributes to DOC. Turboprops and propfans are needed for smaller aircraft to operate at short range and we ought to work with NASA to accelerate the propfan program. And if an SST is required and funds are made available, McDonnell Douglas will build one.

Discussion

Charles E. Curran, III, Republic Airlines

What about the plane that several carriers have been asking for - a 400 mile stage length, 150 passenger design. You said 500 miles and under should be turboprop, but for 100 seats and under.

Kenneth Velten

At this point it is not a turboprop. It would have to be a turbofan of some sort. But it would not be a turboprop. There is no engine of that size available that could be used. That is why we need the NASA program to make a good turboprop or propfan engine.