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**A COST ANALYSIS:
RE-ENGINEING A BOEING 727-200 (ADVANCED)
VERSUS BUYING A NEW BOEING 757-200**

Peter B. Coddington

The Boeing 727-200 and 757-200 are both narrowbody aircraft designed for short- to medium-range flights carrying 164 to 214 passengers. Until recently, when overtaken by the Boeing 737, the 727-200 program was the most successful aircraft program in history. The 727 airplane has carried 2.3 billion passengers, equivalent to half the world's population (Sterling, 1992).

More than half of all 727s sold were advanced 200s and as late as 1990 an incredible 50% of all U.S. passenger traffic had flown on 727-200s since the advanced model was launched in 1971. For several years it was this plane ... that provided Boeing with its positive cash flow and almost singlehandedly wiped out the company's debt. (Sterling, 1992, p. 343)

With this kind of achievement, the 727 program was hard to discontinue. (Actually, the 757 program was originally named the 727-300 program.)

The need for a successor to the 727-200 (advanced) was spurred by the oil crisis of 1973 and by increasing public demand for noise suppression. The 757 program used only two engines under each wing instead of the three engines used in the 727. These two engines were not only Stage 3 compliant but also much more fuel efficient. There are now 497 757-200s operating worldwide while there are still 910 727-200 (advanced) models operating. A gradual phase-out of the 727s and phase-in of the 757 could occur over time, but public outcry over noise at airports around the country has led the government to force airlines to move more quickly.

THE PROBLEM

The airline industry has been mandated by the Airport Noise and Capacity Act of November 5, 1990, to reduce the noise of their fleets. U.S. carriers are required to decrease their Stage 2 fleet to 45% by 1994, 35% by 1996, 25% by 1998, and by 1999 only quieter Stage 3 aircraft will be allowed to land at U.S. airports. Most European countries have already adopted similar restrictions, and other geographic regions are following suit. In addition, many local municipalities and airport authorities are pushing for noise reduction earlier than the 1999 deadline. Stage 3 aircraft are those that register 94.7 decibels or less at takeoff and 100.7 decibels or less when landing.

Noise reduction can be accomplished in one of three ways. The first is by replacing noisy Stage 2 aircraft with new, quieter Stage 3 aircraft. The second is by

retrofitting, or "hushkitting," the existing aircraft. The third way to reduce aircraft noise is by putting new engines on the existing airframes, or re-engining. This study will examine the benefits of re-engining aircraft versus purchasing new aircraft—specifically, buying a new Boeing 757-200 or re-engining a used Boeing 727-200 (advanced).

Buying new aircraft to replace the existing fleet is an expenditure the airline industry cannot easily afford at present. Due to destructive fare competition, oil price spikes during the Persian Gulf War, and a depressed travel market, the U.S. airline industry has lost \$10 billion since 1990 (Air Transport Association of America, 1993). To put this figure in perspective, if one added all the profitable years the U.S. airline industry has had since 1945, the cumulative total of profits made would be just under \$10 billion (M. Mistrik, personal

A Cost Analysis

communication, March 2, 1993). In effect, the past three years have negated all profits the U.S. airline industry has earned for almost the last 50 years.

Considering its dismal performance and the scarcity of capital in the wake of bank failures and global recession, the airline industry is unlikely to raise the huge amount of capital necessary to buy new aircraft, much less replace by 1999 the 43% of its fleet which is presently Stage 2 (Greene, 1993). Pratt & Whitney claims \$130 billion would be needed to replace all Stage 2 aircraft. The possibility of replacing older aircraft becomes more remote in light of the \$27 billion in aircraft orders that have been cancelled or deferred since December 1991 (M. Mistrik, personal communication, March 10, 1993). United, Northwest, Delta, USair, and American have cancelled and deferred enough orders to force Boeing Company to lay off 20% of its work force, approximately 28,000 workers, during the next year and to reduce its rate of production by 35% (Betts, 1993). The production rate for the 757 will be cut from eight to five per month, considerably hampering aircraft replacement ability.

The economic forecasts for the airline industry mirror the economy as a whole: When the economy picks up, the airline industry will pick up. *Aviation Week and Space Technology* is predicting that the airline industry will begin to regain earnings in 1998 (Ott, 1993). More significantly, the airline industry has some internal problems as a result of self-destructive fare wars. Airlines operating under Chapter 11 bankruptcy (3 of the 10 U.S. major carriers in 1992 were operating in bankruptcy) do not have to make payments to creditors. Without the requirement of making payments, these bankrupt carriers can lower their fares to unrealistic levels to attract travelers. To compete, the healthy carriers lower their fares, also. The result is an industry losing money.

The situation has reached the point where the U.S. government is debating the merits of re-regulation. In fact, President Clinton created a special committee, The National Commission To Ensure A Strong Competitive Airline Industry, to offer legislative suggestions which could save the airline industry. Other elected officials have recognized the difficulty air carriers will have complying with new Stage 3 rules. Senator Pressler from Washington has introduced Bill S.989 to amend the

Airport Noise and Capacity Act of 1990. This bill would offer government financing to replace Stage 2 aircraft, but it has just been introduced and must go through the legislative process. The fact remains that the airline industry must become Stage 3 compliant, but money for replacement aircraft is difficult to acquire.

If replacing Stage 2 aircraft with new Stage 3 aircraft is unfeasible, then the airlines have two options. First, they can hushkit their existing aircraft, which is initially the least expensive option, costing between \$2 and \$3 million. Second, they can re-engine existing aircraft at a cost of \$8-10 million. Hushkitting, while the least expensive option in upfront costs, actually ends up costing the airline more in operating costs and flight performance. Hushkits burn 5-10% more fuel than original engines and reduce thrust, which cuts range and lift capabilities (J. B. Hodson, personal communication, March 3, 1993).

This study assumes that re-engining is a better alternative than hushkitting and, in some cases, is preferable to buying a new aircraft. The study compares buying a new Boeing short/medium range narrowbody, the 757-200, to re-engining its predecessor, the Boeing 727-200 (advanced). The two aircraft are compared in three areas: purchasing costs, operating costs, and range/payload capabilities. This study is limited to an examination of 727s and 757s built for passenger travel. Although parts of the study could apply to 727s and 757s built for cargo, many of these aircraft were configured differently and would require a different methodology.

PURCHASING COST COMPARISON

Boeing Company does not have a published list of prices for their new aircraft, and new sales are kept confidential by Boeing Company and the purchaser. However, Avitas, an airline consultant, publishes an *Aircraft Blue Book* (1992) that quotes new 1992 Boeing 757-200 models as selling for \$50.1 million with a variance of 10%, depending on the deal reached by the purchaser and Boeing Company. Assuming the buyer gets the best deal possible, the purchase price would be \$45.1 million. The *International Aircraft Price Guide* (1992-1993) claims a price range of \$52-60 million for a new 757. Using a median figure of \$56 million from the *International Aircraft Price Guide* and averaging that with

the \$45.1 million from the *Aircraft Blue Book* yields an average price of \$50.6 million. Accordingly, for the purposes of this study, a new Boeing 757 is assumed to cost \$50.6 million. This model was first manufactured in 1982, and there are currently 270 flying and another 596 on order and option (Lambert, 1990).

The first Boeing 727-200 (advanced) was manufactured in 1972; the last was delivered in 1983 (cargo models were delivered as late as 1984). A total of 925 were manufactured for passenger travel, 15 of which have been destroyed. The majority, 589 models, were manufactured during or after 1978. These models are considered the most viable candidates for re-engining since they are between 10- and 15-years-old. Since a Boeing aircraft has a life expectancy of 25 years (Boeing, 1993), the 589 727s still have 10 to 15 years of service. The latter value of 15 years is used in this study.

The *Aircraft Blue Book* (1992) quotes the current value of the 1978-1983 727 models as \$5.6-7.7 million. The *International Aircraft Price Guide* (1992-1993) quotes prices for the 1978-1983 models as falling between \$2.9 and \$9.5 million. Taking the average of the two sources, a 727-200 (advanced) manufactured between 1978-1983 costs \$6.4 million.

The cost of re-engining a 727-200 varies, depending on which company is used and how much extra refurbishment is completed on the airframe. Only one company, Valsan Partners, has successfully re-engined a 727-200 (advanced), so the data drawn from that effort is used to compare the refurbished 727 with the new 757. However, the Valsan program is not a complete re-engining because it replaces only the two outboard engines while rebuilding, or "hushing," the center engine. Other companies have announced plans to re-engine the 727. Rolls Royce has successfully re-engined 727-100 models, but has not re-engined any 727-200 models. The Rolls Royce program is a complete re-engining since all three engines are replaced with new engines. Rolls Royce uses the Tay 651 to re-engine 727-100s and has been extremely successful in cutting fuel costs by 18% for their launch customer, United Parcel Service (K. Shapiro, personal communication, March 1, 1993). But the Tay 651 does not supply enough thrust for the 727-200. Realizing the potential market for re-engining the

727-200, Rolls Royce conceptualized the Tay 670, which supplies 18,000 pounds of thrust, an ample amount to lift the 727-200. Rolls Royce had been looking for a launch customer for the Tay 670, but has recently stopped due to political considerations within the European community (J. Mathews, personal communication, February 17, 1993).

Two other companies have also announced preliminary plans to re-engine the 727: International Aero Engines (IAE) and Volpar Inc. Both have programs to transform the 727 from its present tri-engine configuration to a twin-engine aircraft. The engine in the tail would be removed, leaving the two outboard engines which would supply enough thrust to power the airplane and still cut present fuel burn by 26% (*International Aircraft Price Guide*, 1992-1993).

Though the Rolls Royce, IAE, and Volpar programs show the greatest promise because they replace all the old engines, the only 727-200 (advanced) models that have been refurbished are Valsan retrofits which replace only the two outboard engines and hushkit the tail engine. While the Valsan program is not a complete re-engining, it cuts fuel costs and increases payload and range. In addition, as stated above, the Valsan re-engined models offer the only reliable data for comparing a re-engined 727-200 with a new 757-200. Valsan has retrofitted 18 727-200 (advanced) models, has firm orders for another 52 aircraft, and holds options on 139 potential orders. Forecasts call for re-engining 450 727-200s of the 925 that are flying worldwide (Johnson, 1991).

A refurbished 727-200 (advanced) can have up to three modifications. In the example used in this study, all three modifications will be completed on the aircraft.

1. The Valsan re-engining program replaces the two sideboard engines and rebuilds the center engine at a cost of \$8.6 million.

2. The Valsan program puts winglets on the tips of each wing, thereby cutting fuel costs and increasing flight performance at a cost of \$500,000.

3. Dee Howard and Mytel plan to offer a cockpit conversion for the 727 for \$1 million, reducing the number of pilots needed from three to two.

The total cost of all three retrofits is \$10.1 million.

A Cost Analysis

Table 1
Average Operating Costs Per Block Hour, Second Quarter, 1992

	757-200	727-200	RE-727-200
FLYING OPERATIONS			
Crew Costs	\$556	\$598	\$556 (-42)
Fuel and Oil	\$610	\$756	\$627 (-129)
Rentals	\$475	\$86	\$488 (+402)
Insurance	\$14	\$3	\$3
Taxes	\$30	\$36	\$36
MAINTENANCE			
Airframes	\$101	\$239	\$239
Engines	\$87	\$140	\$80 (-60)
MAINTENANCE BURDEN	\$123	\$243	\$243
DEPRECIATION	\$210	\$109	\$109
OTHER	\$41	\$42	\$42
TOTAL BLOCK HOUR COST	\$2,248	\$2,252	\$2,424
TOTAL BLOCK HOURS	39,362	60,837	---
TOTAL AIRCRAFT IN FLEET	33.5	80.25	---

Replacing all three engines or turning a 727 into a twin with new engines is a better example of re-engineing, but such projects have not yet been completed. Therefore, operating data of this kind can only be estimated. The Valsan program, part re-engine and part hushkitting, does supply real operating costs for a completed refurbishment. Winglets have not yet been FAA certified; however, a 727-200 so equipped has logged 130 hours during a test period. These 130 hours indicate a 5% decrease in fuel consumption (R. Wagenfeld, personal communication, March 1, 1993). Two companies plan on converting three-man cockpits into two-man: Dee Howard Co. and Mytel North Western Jet Air Craft in conjunction with Israel Aircraft. The cockpit conversion, while it has not yet been completed on any aircraft, is in the process of FAA

certification. The conversion eliminates some flight engineers, so the deduction of these salaries, a simple calculation, will be applied to the study's comparison. Crew costs, next to fuel costs, are the most expensive; standardizing all cockpits to a two-man configuration will provide significant savings throughout a fleet.

OPERATING COST COMPARISON

The operating costs of the two models can be compared by Department of Transportation (DOT) Form 41 data collected by the government. Each U.S. commercial air carrier that operates aircraft with 60 seats or more must, by law, submit the operating expenses of its fleet by model type. Based upon DOT Form 41 data from the second quarter of 1992, eight major U.S. carriers reported their operating costs for the 727-200, and six major carriers reported their operating costs for

the 757-200. For the purposes of this study, the average of all reporting carriers rather than each individual carrier will be used, although the choice to re-engine or buy new is best suited to an individual operator's route requirements. These average operating costs per block hour are adjusted and used as a basis for comparing the re-engined 727 and the new 757 (see Table 1). However, the new operating costs for the re-engined 727-200 must be calculated first.

DOT FORM 41 ADJUSTMENTS FOR A RE-ENGINED 727

A refurbished 727-200 will change the following DOT Form 41 line items: crew costs, fuel and oil, rentals, and maintenance.

The crew costs of a refurbished 727-200 are based on the \$1 million cockpit renovation that eliminates the flight engineer as the third crew member in the cockpit.

A flight engineer can cost an airline an average of \$65,000 a year to employ, depending on salary scale, allowances, and training costs. Depending on the route systems and duty restrictions, an airline can expect to employ between four and five flight engineers per aircraft. This translates to an annual cost of between \$260,000 and \$325,000 a year per aircraft. (Williams, 1992)

Assuming a median annual cost of \$292,500, it would take 3.4 years to pay off the \$1 million investment to retrofit the cockpit. Considering that a re-engined 727 has 15 years of service after refurbishment, the investment is worthwhile. The conversion makes the 727 cockpit identical to the two-man 757 configuration. Since the refurbished cockpit will also use two pilots instead of three, the crew costs are assumed to be the same as for the 757 (see Table 1).

Fuel and oil costs are reduced on the refurbished 727-200 for two reasons: the two new outboard engines burn less fuel, and the winglets save another 5% on fuel. The two new outboard engines are Pratt & Whitney JT8D-217C engines, replacing the old JT8D-15s on the 727s. The Valsan program does not re-engine the tail engine; Valsan only hushkits it by removing the thrust reverser and replacing it with an acoustical tailpipe. The Valsan re-engining on the 727-200 (advanced) has cut fuel costs by 12% (Valsan, 1992). Combining this 12% with the 5%

fuel savings from the winglets, there is a 17% reduction in fuel costs, or a \$128.52 reduction for the fuel and oil line item on the DOT Form 41 operating expense chart (see Table 1). However, a twin-engine aircraft, the 757-200, will be more fuel efficient than a tri-engine aircraft (727-200).

The cost of maintaining a refurbished 727 should be less than that required to maintain the original because the two outboard engines are new and the tail engine is rebuilt. First-year maintenance is \$60 less per flight hour on the refurbished Valsan 727-200s (Williams, 1992).

The rental line item on the DOT Form 41 data covers any lease or mortgage payments the operator makes on the aircraft. This line item can vary considerably depending on whether the operator is leasing the aircraft, owns it, or is paying on a loan. Regardless of how the operator pays for the capital expense of the aircraft, this line item will increase because of the extra \$10.1 million needed to refurbish the aircraft. The following loan agreement is assumed for this study: The loan will be made at a 10% rate of interest, the operator will make a down payment of 10%, and the loan term will be for the expected life of the refurbished 727, 15 years. For the purpose of calculating the rental price per block hour, it is assumed that the 727 has an average utilization of eight block hours per day, or 2,920 block hours per year. Considering these assumptions, the yearly payment for the refurbished 727 would be \$1,173,468. Based on an annual utilization of 2,920 block hours, the rental for a newly refurbished 727 would be \$402 per block hour (see Table 1).

Before re-engining, the 727 is only \$4 more expensive to operate per block hour than the 757. After refurbishment, the 727 is \$176 more expensive to operate per block hour than the 757, which represents an 8% cost increase.

TOTAL FINANCIAL (OPERATING AND PURCHASING) COSTS COMPARED

Although the 727 is more expensive to operate, its purchasing cost is so low that it is less expensive to buy and operate than a new 757 for the first year and for the next 15 years. Still, the refurbished 727 will incur an additional cost during its 15-year life. The FAA's initiative on aging aircraft has created the Supplemental

A Cost Analysis

Table 2
757/727 Purchasing and Operating Cost Comparison

FOR 1 YEAR (In Millions of Dollars)		
	757	727
Purchasing Costs	\$50.6	\$6.4
Refurbishment Costs	----	\$10.1
Operating Costs	\$6.6	\$7.1
TOTAL COSTS	\$57.2	\$23.6*
* If 727 is already owned, the total is \$17.2		
FOR 15 YEARS (In Millions of Dollars)		
	757	727
Purchasing Costs	\$50.6	\$6.4
Refurbishment Costs	----	\$10.1
Operating Costs	\$99.0	\$106.5
SSID Compliance Costs	----	\$0.8
TOTAL COSTS	\$149.6	\$123.3*
*If 727 is already owned, the total is \$116.9		

Structural Inspection Directive (SSID), which requires a major overhaul of all aircraft with more than 60,000 cycles (one takeoff and one landing). All 727s 20 years or older will reach 60,000 cycles, resulting in an SSID cost of \$800,000 (P. Viola, personal communication, February 24, 1993).

Using the same annual utilization rate of 2,920 block hours, Table 2 shows how much it will cost to fly the two models the first year, and how much it will cost to fly the two models over a 15-year period.

In both cases, the refurbished 727 is a less expensive option. However, a new 757 is likely to have a longer lifespan than 15 years, while a refurbished 727 is not likely to last more than 15 years. Considering the present economic condition of the airline industry, the first-year saving is especially attractive. If an airline already owns a 727, the total cost to operate and modify the existing

aircraft is only \$17.2 million. If, on the other hand, an airline operator scrapped its existing 727 for a new 757, the cost for the first year would be \$57.2 million—a difference of \$40 million. Even over a 15-year period, an operator who already owns a 727 and refurbishes it is going to save \$32.7 million over buying a new 757. Considering that the 10 major U.S. airlines have a combined 463 727-200s in service ("Aircraft Inventories Worldwide," 1993), and their current economic condition is not strong, re-engining could be the only economically feasible option.

RANGE AND PASSENGER CAPABILITY COMPARISONS

Cost is not the only important factor to an airline. The aircraft must be able to perform a set of tasks according to an operator's route requirements. Each operator would have to make its own comparisons based on the range and payload requirements within its particular route structure. This study is limited to a comparison of the range of

the refurbished 727 to the range of the 757 as measured in nautical miles. Payload, measured in terms of seats, can be altered to improve range in the sense that seats can be sacrificed for fuel storage. Also, range can vary depending on how many of the seats are full, affecting the weight of the aircraft. For purposes of comparison, each aircraft is assumed to have a fuel supply of 59,000 pounds of fuel. Under these conditions, the refurbished 727 can travel 2,300 nautical miles (nm) with 165 passengers (W. Johnson, personal communication, March 10, 1993). Under the same conditions, a 757 can travel 3,800 nm with 177 passengers. Therefore, the 757 can travel 1,500 nm farther with 12 more passengers.

CONCLUDING REMARKS

Table 3 provides a final comparison of the two models in costs and range/passenger load.

In conclusion, for the next 15-year period, a

Table 3
757/727 Cost versus Range/Passengers

YEAR 1 (In Millions of Dollars)			
	Cost	Range	Passengers
757	\$57.2	3,800 nm	165
727	\$23.6	2,300 nm	177
Difference	\$33.6	1,500 nm	12
YEAR 15 (In Millions of Dollars)			
757	\$149.6	3,800 nm	165
727	\$123.3	2,300 nm	177
Difference	\$26.3	1,500 nm	12

refurbished 727 will be less expensive to purchase and operate than a new 757, but the 757 will have more range and payload capabilities. Considering the current economic condition of the U.S. airline industry (3 of the 10 U.S. major airlines are operating under bankruptcy protection), a refurbished 727 is an attractive option. This option is even more attractive when an airline considers the immediacy of the Stage 3 compliancy, its current financial condition, and the comparisons in costs between refurbishment and buying new for the first year (a difference of \$40 million).

However, this savings must be weighed against an individual air carrier's need for range and payload in its route structure. The 757 does have more range and slightly more seats. Also, while outside the assumptions of this study, a new 757 will last longer than 15 years, while a refurbished 727 is unlikely to last any longer than 15 additional years. In a perfect world, a new 757 would be the best option for an airline that needs to remove Stage 2 727s. However, considering both the immediacy of compliance to Stage 3 laws (six months

until the first phase in 1994) and the current dismal economic situation in the airline industry, the refurbished 727 may be the next best, and only practical, option to a brand-new aircraft.

Politicians representing angry citizens have forced the government to enact the Airport Noise and Capacity Act. Airlines are being forced by federal law to quiet their fleets from a Stage 2 to a Stage 3 level. The airlines are in the worst economic condition in the history of the industry. How can they comply when they cannot afford replacement aircraft? How can the airlines afford to convert their aircraft in the next six months to six years when the majority of their fleets are Stage 2? The airlines must look to less expensive options such as re-engining for alleviating the noise problem such as re-engining.

Perhaps not all 463 727-200 (advanced) models in service will be refurbished to Stage 3 compliancy. Some may be replaced by new 757s, but the industry cannot by any means replace all 463 727-200s with new 757-200s in six years. The Boeing Company has conceded the fact that not all 727-200s will be replaced and has cut production back to five new 757-200s per month. That means, excluding delays and cancelled orders, Boeing will manufacture only 360 new 757-200s over the next six years. That is 103 aircraft short of replacing the existing 727-200 fleet without factoring in the need for additional aircraft to supply growing markets in the Far East and Latin America. Excluding inflation, the total cost of replacing the existing 727 fleet would be \$231.5 billion. Considering that the industry has lost \$10 billion in the last three years, raising \$231.5 billion in capital in the next six years seems very unlikely. In conclusion, taking into account the present economic landscape and the immediacy of the mandated noise suppression of the 727s, refurbishing a 727-200 (advanced) is the only feasible option to buying a new 757-200.□

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