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Analysing the Economic Trade-Offs in Aircraft Choice

David Smith
Bureau of Transport and Communications Economics

Tim Risbey
Bureau of Transport and Communications Economics

Tammy Braybrook
Bureau of Transport and Communications Economics

Abstract:

Aircraft acquisition and route network decisions require airline managers to heed many factors Simple ones such as economies of aircraft size, route distance, and aircraft loading are intuitive, but can often be confounded by more complex considerations such as passenger demand responses (to fare and frequency changes), and the S-curve effect (the relationship between flight frequency share and market share) In choosing the best aircraft type to operate a route, trade-offs are involved. To understand the financial implications of these trade-offs, data such as the direct cost of operating an aircraft on a route are required. Cost estimates can then be combined with other data, such as passenger (and revenue) forecasts, to help guide profit maximising decisions AEROCOST 2 is a model developed by the BTCE to estimate aircraft direct operating costs. The mathematics of AEROCOST 2 are briefly discussed in this paper, and the model used to illustrate the costs (and the trade-offs) in decisions which allocate an aircraft type to an air route.

Disclaimer The views expressed in this paper are those of the authors and do not necessarily represent those of the Bureau of Transport and Communications Economics.

Contact Author:

David Smith
Bureau of Transport and Communications Economics
22 Cooying Street
Canberra ACT 2601

telephone: (06) 274 7109   fax: (06) 274 6816
email: Dsmith@email dot gov.au

Introduction

We all make simple allocation decisions when choosing a vehicle in which to make a journey For example, do you drive the family minibus or the Mazda 121 to the local shop for a carton of milk The choice of course is clear and illustrates that particular vehicles are best suited for particular activities. The same applies to aviation, albeit at a more sophisticated level, and with somewhat greater penalties if poor choices are made.

Airline fleet and network planners face such allocation decisions. For example, an existing airline might wish to expand its network in response to changing patterns of demand (or the behaviour of its competitors) and needs to choose the best aircraft to do this A new entrant to a contested route might succeed or fail depending on its choice of aircraft. In choosing the best aircraft for a route many factors are taken into account: the volume and type of demand for the route (business/leisure); the presence and behaviour of competitors; route characteristics (length, other transport choices, and operating conditions); network synergies (eg., fleet mix); and of course, aircraft operating costs

Many of these factors can be quantified and thus analysed within a financial framework — a framework that allows the planner to trade-off relative costs and benefits associated with different aircraft choices and thus arrive at an optimal solution This paper shows how the BTCE's AEROCOST 2 model (*Aerocost*), which calculates aircraft direct operating costs, can be used to assist in analysing aircraft allocation choices.

The paper gives a brief overview of the structure and mathematics of *Aerocost*, highlights some of the key economics which influence aircraft choice, and illustrates via a set of simulations, how *Aerocost* can help planners make allocation decisions.

Overview of AEROCOST 2 — an aircraft direct operating cost model

In terms of an *input-process-output* modelling paradigm, *Aerocost* requires a user to choose an aircraft type and specify an air route for analysis The model then draws information from its databases, prompts the user for a number of parameter decisions, performs a series of cost calculations, and reports the results. This approach is schematically illustrated in figure 1, with each of the cost 'processes' described in more detail below.

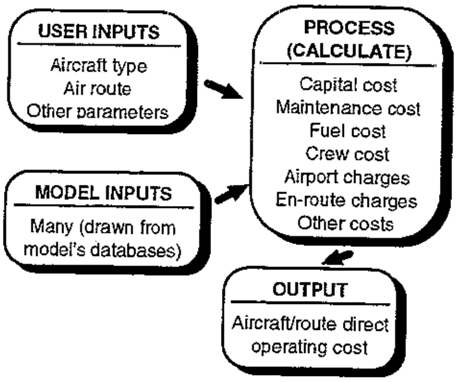

Figure 1 Schematic of the Aerocost 2 model

Capital costs

Aircraft capital costs include the cost of funds used to acquire the aircraft, the economic depreciation of the aircraft, and the cost of insurance Each of these is estimated for a single year of ownership, summed, and an appropriate proportion of this sum attributed to the operation of a route The proportion for attribution is based on how many block hours[1] the flight takes and the expected annual block hour utilisation of the aircraft.

An opportunity cost approach is used to estimate the value of capital in the aircraft The current market price (economic value) of the aircraft is used in a weighted average cost of capital equation, which accounts for the cost of equity funds to shareholders and/or the cost of debt funds to airline management The capital asset pricing model is used to estimate the opportunity cost of equity capital. Alternatively, *Aerocost* allows for the estimation of lease costs. Economic depreciation is the amount by which the *economic* value of the aircraft declines over the period of use, and implicitly takes into account the market's expectations of future revenue and cost streams associated with ownership of the aircraft. Insurance cost includes hull, third party and passenger liability

Maintenance costs

In practice, there are so many different types of maintenance (and cost), that industry peak bodies such as the International Civil Aviation Organisation (ICAO) consider it adequate to group *all* maintenance and overhaul costs into a single item covering routine maintenance, maintenance checks, periodic overhauls and repairs (including within this all associated maintenance labour expenses). In keeping with this approach, *Aerocost* uses a single block hour maintenance cost for each aircraft. Maintenance cost estimates are thus allocated to the operation of a route on the basis of block hours flown.

Fuel costs

Fuel costs are calculated by estimating the *fuel burn* for a route and multiplying this by the current market price for fuel. Manufacturers specifications for fuel burn form the basis of a regression analysis which takes into account flight distance and variations on aircraft weight. The equation thus derived for each aircraft type allows for fuel burn estimates[2] for a wide variety of routes and weight (loadings). Aircraft loading estimates include explicit allowance for passengers, freight, and all fuel on board (including tankerage, statutory reserves, holding and flight fuel).

Crew Costs

Aerocost calculates crew costs on the basis of block hour rates. These express individual crew costs in terms of their total annual cost to an employer divided through by the

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[1] Block time is from when engines are switched on at departure to when they are switched off at arrival.

[2] Simplifying assumptions include: aircraft operate at long range cruise altitude and speed; climb and descent rates are standard; zero head and tail winds; and standard temperature and pressure conditions.

number of aircraft block hours they are expected to work annually. Total crew costs for a route are estimated by multiplying block hour crew rates[3] by the block hours flown.

A simple example illustrates the concept. Suppose a cabin crew member earns a base salary of $40000. Adding superannuation, insurance, allowances and loadings, meals and accommodation, training and administrative overheads, the annual cost to an airline might approach $55000. Accounting for recreation leave, public holidays, sick leave and time in training, relocating, signing-on, pre and post flight turnaround, et cetera, we might expect ≈ 1100 hours are worked annually during aircraft block time. Hence, we would estimate a cabin crew block hour rate of $50 per hour ($55000÷1100hr).

Aeronautical (airport and enroute) costs

Aerocost accounts for the costs incurred at airports and those payable for enroute services such as navigation aids and meteorological data. The range of *airport* charges levied throughout the world is quite extensive and variable. The charging formulae and rates are also prone to frequent change. *Aerocost* is fully calibrated for Australian airport charges, and to a lesser extent for many international airports where (unfortunately) the complexity of charging schemes does not lend itself to convenient modelling.

There are many different *en-route* charging formula used throughout the world, and within each of these formulae different countries have different charge rates. Where possible, *Aerocost* is calibrated with updated charge rates/categories from the IATA airport and en-route charges manual (IATA, 1987 and updates). The model also stores 'typical' routing information between airport pairs, which indicate airspace (charge distance) overflown. The reference for constructing route data is Jeppesen Airway Manual maps (Jeppesen).

Other costs

Within the residual category of *other* costs, *Aerocost* accounts for in-flight provisioning, ground handling and freight handling. In-flight provisioning includes the cost of providing passengers with consumables (food and drink), and to a lessor extent entertainment material such as magazines and movies. Provisioning is calculated on a passenger basis with differences in costs between seat classes averaged out. The model assumes a four-tiered provisioning cost based on route distance. Ground handling costs include baggage handling, aircraft cleaning, and refuelling. *Aerocost* assumes the aggregate ground handling charge for an aircraft bears a close relationship to its size and so calculates costs on the basis of aircraft seats. Freight costs which might be thought of as 'direct' operating costs are basically those associated with freight loading and unloading. *Aerocost* estimates freight handling costs as a per unit weight (tonnes) handling charge times the freight carried on a flight.

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[3] *Aerocost* allows for five crew categories: pilot; first officer; flight engineer; purser; and cabin crew.

Some important aircraft and airline economics [4]

Aerocost calculates *aircraft direct operating costs.* However, allocation decisions are not made on this basis alone. Other economic relationships come into consideration, some of which are intuitive and some of which are a bit more obscure. While in isolation many of these relationships give a clear indication of which direction to lean in making an aircraft allocation decision, in combination, they can be competitive. For example, economies of aircraft size suggest 'the bigger the aircraft the better' whereas the S-curve effect of flight frequency suggests using smaller aircraft to obtain market share advantage. This section of the paper discusses some of the key aircraft and airline economics and illustrates a number of the trade-offs that arise between them.

Economies of aircraft size. A fundamental reflection of aircraft technology is that operating cost per *seat* generally declines with aircraft size. Some of the logic for this (apart from technological reasons) lies in the fact that input costs such as flight crew are distributed across an increasingly large passenger base as aircraft size increases. Such a relationship might suggest buying the biggest aircraft available. *But*, as aircraft size and the number of seats to be filled increases, is it reasonable to assume that passenger numbers increase accordingly, and if not what happens to unit costs? There are two parts to the answer: the economies of load factor; and the nature of demand for air transport.

Economies of load factor. As the aircraft load factor increases, the cost per *passenger* on board decreases. The reasons for this are fairly straightforward. A number of aircraft direct operating costs are fixed (such as flight crew) irrespective of the aircraft load factor, and more passengers on board allow these costs to be spread across a bigger base. Further, the fuel consumed on a flight is related to the total in-flight weight of the aircraft, of which a relatively small part is due to passengers. For example, a fully laden Boeing 747 might have 400 passengers on board (contributing around 40 tonnes of weight), but this is only a small part of the aircraft's 360 tonne take-off weight.

What then of the *ability* of an airline to load up its 'bigger' aircraft. To answer this we need to look at the nature of demand for air transport.

Seasonality and daily/weekly cycles in demand. Demand for air transport on most routes usually displays a number of patterns. Seasonality is often evident, reflecting factors such holiday periods, climate, and business cycles. Weekly demand exhibits working week and weekend leisure travel patterns, and on a daily basis (especially for business routes) demand for early-out-late-home same day flights is often present.

These patterns of demand suggest the reasons for which travellers are utilising air transport services, and also indicate (at any given point) the volume of demand in a market. However, the *actual* volume of demand in a market is only a part of the *potential* demand, and reflects the responses of travellers to a number of key demand

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[4] Tretheway and Oum (1992), Doganis (1991), Oum (1995), O'Connor (1995), and Shaw (1987) are a few of the contemporary authors addressing airline economics. This section draws on these sources.

inducing factors. These can be modelled by econometric techniques and their influence on underlying demand illustrated. Key factors include the response to price, flight frequency, and other factors beyond the influence of airlines (such as personal income).

Demand elasticity — air fare. Air travellers display a clear demand response to changes in air fares. It is an inverse relationship, with air fare reductions generating an increase in demand (and vice-versa). Business travellers are less sensitive to price variation than non-business travellers. A recent BTCE working paper (BTCE, 1995) estimated demand elasticities for Australia's international aviation markets. The study found that Australian leisure elasticities (to 12 different destinations) ranged from -0.5 to -1.2 [5]

Demand elasticity — flight frequency. Air travellers also display a demand response to changes in the number of flights available in a market, although not as strongly as to air fare changes. Empirical estimates of flight frequency elasticity are hard to come by, but in earlier BTCE work we assumed an average value for business travellers of 0.15, and for non-business of 0.05. This broadly accords with the findings of Morrison and Winston (1986) who derived a business frequency elasticity of 0.21 and a leisure elasticity of 0.05 for the United States domestic market.

Other demand elasticities. In addition to fare and frequency, travel demand responds to a variety of factors, such as marketing, special events, service quality, brand and safety, *but,* in terms of empirical significance, one of the strongest responses is to change in personal income. BTCE, 1995 estimates income elasticities for travel in many of Australia's key international markets and commonly finds values in the range of 1 to 3.

So, where are we in answering the question of 'can airlines generate the additional demand required to maintain load factors on larger aircraft'? The above discussion shows that in the short run most additional demand would need to be generated by *reducing* air fares. But what if this was not practical, and instead an airline chose to improve load factors by reducing the number of flights it offered? Unfortunately this might result in the loss of some passengers. If the airline was the sole operator, passengers would leave the market because of the less attractive number and timing of flights. If the airline was in a competitive market, it might lose further passengers as a result of a phenomenon called the S-curve of flight frequency response.

S–curve effect of flight frequency. Aviation economists dub the relationship in aviation markets between an airline's share of total flights and its share of total passengers as the S–curve effect of flight frequency. The relationship illustrates that as an airline adds flights in a given market it can disproportionately increase its passenger share (and vice versa). A number of factors underlie this relationship, a dominant one most likely being the underlying flight frequency response (elasticity) shown particularly by business travellers. The S-curve relationship is illustrated in figure 2.

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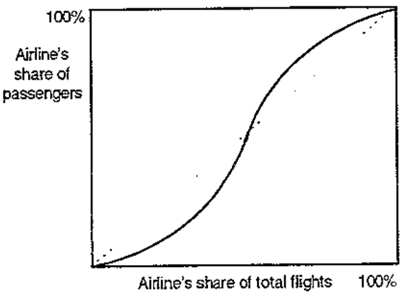
[5] An elasticity of -0.5 means that for every 1 per cent cut in airfares, there is a resultant 0.5 per cent increase in aggregate demand for them.



Source: Tretheway and Oum, 1992

Figure 2 S-curve effect of flight frequency

The S-curve effect is just one of a number of factors that describe how travellers choose *between* competing airlines. Other factors include service quality, brand loyalty and preference for large networks.

Service quality response. Most travellers, not surprisingly, are affected by, and react to, aspects of airline service quality. Service quality includes many things such as: flight frequency; on-time performance; safety; in-flight service; cabin configuration; ratio of cabin crew to passengers; flight duration (aircraft speed); and aircraft age. The effects on passenger demand of changes in many of these are intuitive, but the last two (speed and age) bear further illumination.

Aircraft speed affects flight duration, and flight duration has a cost to the traveller, related to a personal valuation of travel time. This might mean a traveller with a high value of time chooses a faster but more expensive flight in order to reduce time in the air. An example could be the CEO, who values his time at $500 per hour, choosing the more expensive Concord flight from the UK to the US, over a slower but cheaper Boeing 747 flight. At a domestic level, this factor could be important when considering whether to allocate, for example, a turboprop or a faster jet aircraft to a regional route.

We consider aircraft age worth discussing because we include *capital* as a direct operating cost in *Aerocost*. Older aircraft are usually cheaper to acquire (in some cases substantially so) thus resulting in lower capital costs per block hour flown. However, there are trade-offs. Not only is there the potential of a service quality related loss of patronage (perceptions of aircraft safety), there are trade-offs with other operating costs. The newer an aircraft, the more likely it is to have more efficient engines and a better aerodynamic design, both of which translate into better fuel efficiency (and thus lower operating costs). Further, maintenance costs are usually lower on newer aircraft.

Brand loyalty. Brand loyalty *is* a feature of airline markets, and particularly important to airlines in Australia's domestic market, where air fares offered by the major players are virtually identical. Brand loyalty is strengthened through the use of strategies such as attractive lounge facilities and frequent flyer programs.

Preference for large networks. Most travellers display a preference (all other factors being equal) for airlines that have large networks. A number of reasons probably underlie this, but perhaps the most obvious is the seamlessness of connections offered by large network airlines compared to the inconvenience of having to handle luggage, coordinate connections, and make numerous bookings when splicing together a journey which makes use of several different airlines. This factor is well recognised by airlines, and has contributed towards the proliferation of code-share agreements which (at least in the traveller's eyes) artificially inflate the extent of an airlines network.

And what of networks — are there economies within the size of a network, the density of a network, or related to the route distances flown within a network?

Economies of firm size Tretheway and Oum (1992) find that the airline industry has "roughly constant" economies of firm size In other words, adding or dropping cities from an airline's network does not raise or lower the airline's unit costs.

Economies of traffic density However, there is evidence of economies of traffic density in airline operations, that is, cost per passenger declines as the number of passengers per point served in a network (airport) increases. Tretheway and Oum (1992, p10) find that at some point declines in cost per passenger *may* actually taper off, and the curve flatten This point is referred to as the minimum efficient traffic density level

Flight distance A relatively simple relationship exists between flight distance and cost per kilometre, that sees a reduction in cost *per kilometre* as flight distance increases. Essentially, this results from the fact that significant quantities of fuel are expended lifting the aircraft and its cargo to cruising altitude, and can be further understood if we include a number of the single occurrence costs such as flight preparation and ground/freight handling A further contributing factor is the nature of some maintenance actions that are linked to cycles (take-off-landing) rather than flying hours

The preceding discussion has highlighted a number of the key economic relationships that occur in the aviation industry and help explain supply and demand behaviour Clearly, with such a multitude of often competing factors, the more that can be quantified the better for planning the allocation of aircraft types to routes The following section illustrates, via a series of hypothetical scenarios, how *Aerocost*, in quantifying airline direct operating costs, helps untangle the web of trade-offs.[6]

Scenario — modelling new entry into a competitive market

A new operator contemplating entry to Australia's domestic aviation market might consider the core trunk routes of Sydney (SYD) to Melbourne (MEL) and SYD to Brisbane (BNE) — together these routes account for close to 35 per cent of domestic air travel demand.[7] In this scenario we explore the question of: what might be the most appropriate aircraft with which to enter these routes as a small, competitive operator?

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[6] For a PC based tool Aerocost is quite sophisticated However, there are some things it is not It is not a flight planning tool (fuel burns are for 'generalised' flights conditions — ISA/ cruise altitude/no winds). Nor is it likely to be as accurate as more sophisticated (complex and expensive) models employed by major airlines (although, we have been informed that it comes quite close) Further, Aerocost estimates are input data dependant. For example, we might suggest an average market value for a Boeing 737-300 of $33 million, but a user might want to model a specific aircraft valued at $40 million However, such a parameter change can, and should, be made to obtain *accurate* cost outputs

[7] Avstats, DOTARD data for calendar year 1996

We consider four aircraft types, being guided by those currently operated by incumbent airlines, Qantas and Ansett. These are the: Boeing 737-300; Airbus 320-200; Boeing 767-200; and Airbus 300-B4-600. We look at the trade-offs between aircraft size and air fares, and illustrate the relative cost advantages of each aircraft type.

General parameters and assumptions

Flight schedule To keep the analysis simple, we model a single aircraft operation. We base the aircraft in Sydney, and assume an average 1 hour turn-around at each airport (passenger and baggage loading/unloading, refuelling, re-provisioning, and cleaning). We also assume the new entrant's schedule does not need to be tied to the daily business travel cycle (see explanation below) and thus hypothesise a daily flight schedule as shown in table 1. For simplicity we assume this daily schedule is the same each day of the week. We also assume adequate access is available to domestic terminals at SYD, MEL and BNE.

Table 1 Daily flight schedule

Arrive	Airport	*Depart*
	SYD	— 07:00
08:20 —	MEL	— 09:20
10:35 —	SYD	— 11:35
12:55 —	BNE	— 13:55
15:20 —	SYD	— 16:20
17:40 —	MEL	— 18:40
19:55 —	SYD	

Passenger type Where are the new entrant's passengers going to come from? A conservative assessment of the MEL–SYD–BNE travel market would suggest that:

- the new entrant will attract *no* full fare business travellers (such travellers respond to features that start-up airline usually cannot offer in competition with incumbents, such as a wide choice of departure times and service quality such as airport lounges, extensive networks, and benefits under frequent flyer programs);
- the new entrant can attract *some* of the existing full economy fare passengers by offering an unrestricted full fare at, say 80 per cent, of the incumbents' fare[8] Assuming this pricing policy, we might propose, on average, 20 such passengers are attracted across to *each* of the new entrant's flights; and
- the rest of the new entrant's passengers will have to come from price based stimulation of the discount travel market

Passenger loading. Regarding the stimulation of the discount travel market, we make the following assumptions and use the following data:

- irrespective of aircraft size, the new entrant wishes to achieve a 70 per cent load factor on each flight, which (accounting for the 20 full fare passengers per flight) allows us to determine how many discount travellers are required to be generated;
- the discount traveller has an air fare elasticity of -1.5;
- (incumbent) return discount fares = \$215 (SYD–MEL) and \$214 (SYD–BNE);
- annual discount return travel ≈ 1,100,081 (SYD–MEL) and 712,306 (SYD–BNE), which on a daily basis ≈ 3014 (SYD–MEL) and 1952 (SYD–BNE);[9] and

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[8] Based on March 1997 full economy return these would be: \$442 (SYD–MEL) and \$475 (SYD–BNE).

[9] Source: loosely based on Avstats, DOTARD data for calendar year 1996

- because of competition from the incumbents, *twice* as many passengers as needed by the new entrant will have to be generated (that is, discount price matching, albeit with more restrictive conditions, will mean some newly generated discount travellers in the market will go to incumbent airlines)

Modelling the Boeing 737-300

Looking first at the cost side, *Aerocost* is used to estimate the direct operating costs of flying a Boeing 737-300 to the schedule shown in table 1 Table 2 below illustrates the results Key assumptions underlying these cost estimates are reported in appendix A

Table 2 *Aerocost* estimates of direct operating costs for the Boeing 737-300

Cost	SYD-MEL	MEL-SYD	SYD-BNE	BNE-SYD	SYD-MEL	MEL-SYD	Daily cost
Capital	2 277	2 135	2 277	2 420	2 277	2 135	$13 521
Fuel	1 493	1 493	1 561	1 561	1 493	1 493	$9 094
Maintenance	1 133	1 063	1 133	1 204	1 133	1 063	$6 729
Crew	762	714	762	810	762	714	$4 524
Airport	784	1 155	746	1 155	784	1 155	$5 779
Enroute	255	255	274	274	255	255	$1 568
Other	2 160	2 160	2 160	2 160	2 160	2 160	$12 960
Total	8 864	8 975	8 913	9 584	8 864	8 975	$54 175
Av. cost / seat	$ 81	$ 82	$ 81	$ 87	$ 81	$ 82	**$ 164**

Note: The average *daily* cost per seat (bottom right number of $164) is for a *return* seat – this is to allow comparison with revenue estimates derived in the next section.

Source BTCE estimates

Now for the revenue side. Our analysis considers a *110 seat* configured 737-300 aircraft, which to achieve an average 70 per cent load factor would require about 77 passengers on board The schedule offers two return flights per day (SYD–MEL) which generates a daily requirement of 154 return travellers. Assuming 40 of these are economy transfers, the remaining 114 will be discount travellers. The SYD–MEL return discount airfare is $215, and the existing number of discount passengers in the market is ≈ 3014 per day To generate 228 travellers (twice the 114 needed) with a price elasticity of -1.5, the discount fare must be reduced by 5.0 per cent (228÷3,014÷1.5) and thus ≈ $204.

The flight schedule also offers one return flight per day between SYD–BNE (a daily return passenger requirement of 77, being 20 economy transfers and 57 new 'discounts'). Applying the same argument as above, we find the SYD–BNE fare must be reduced by 3.9 per cent to ≈ $206. These calculations are summarised in table 3.

Table 3 Estimates of operating revenues for the Boeing 737-300

Route	Discount pax	Discount fare	Economy pax	Economy fare	Revenue	Revenue/seat
SYD–MEL (return)	57	204	20	442	$20 468	$ 186
SYD–BNE (return)	57	206	20	475	$21 242	$ 193
Total (per day)	171		60		$62 178	**$ 188**

Source BTCE estimates

There are a number of ways of looking at these outputs, but for the purposes of simple comparison between aircraft types, we can see that the B737-300 service allows for a per (return) seat operating surplus of $24 ($188 revenue - $164 cost), or a daily operating surplus of $8,003, from which to cover indirect operating costs and overheads

Modelling the Airbus 320-200

Our Airbus 320-200 is a 140 seat aircraft. We use the same methodology as above to calculate operating costs, discount air fares and revenues. Only the final outputs are reported, costs in table 4, revenues in table 5, and key aircraft parameters in appendix A.

Table 4 *Aerocost* estimates of direct operating costs for the Airbus 320-200

Cost	SYD-MEL	MEL-SYD	SYD-BNE	BNE-SYD	SYD-MEL	MEL-SYD	Daily cost
Capital	2 764	2 591	2 764	2 936	2 764	2 591	$16 410
Fuel	1 636	1 636	1 713	1 713	1 636	1 636	$9 970
Maintenance	760	713	760	808	760	713	$4 514
Crew	946	887	946	1 005	946	887	$5 617
Airport	1 020	1 445	971	1 445	1 020	1 445	$7 346
Enroute	291	291	313	313	291	291	$1 790
Other	3 075	3 075	3 075	3 075	3 075	3 075	$18 450
Total	10 492	10 638	10 542	11 295	10 492	10 638	$64 097
Av. cost / seat	$ 75	$ 76	$ 75	$ 81	$ 75	$ 76	**$ 153**

Source BTCE estimates

Table 5 Estimates of operating revenues for the Airbus 320-200

Route	Discount pax	Discount fare	Economy pax	Economy fare	Revenue	Revenue/seat
SYD–MEL (return)	78	200	20	442	$24 440	$ 175
SYD–BNE (return)	78	203	20	475	$25 334	$ 181
Total (per day)	234		60		$74 214	**$ 177**

Source BTCE estimates

We can see that the Airbus 320-200 service allows for a per (return) seat operating surplus of $24 ($177 revenue - $153 cost), or a daily operating surplus of $10,117, from which to pay for indirect operating costs and overheads.

Modelling the Boeing 767–200

Our Boeing 767-200 is a 216 seat aircraft. Again, we use the same methodology as above to calculate operating costs, discount air fares and revenues for the Boeing 767-200. Final outputs are reported below — costs in table 6, revenues in table 7, and key aircraft parameter assumptions in appendix A

Table 6 ***Aerocost*** **estimates of direct operating costs for the Boeing 767-200**

Cost	SYD-MEL	MEL-SYD	SYD-BNE	BNE-SYD	SYD-MEL	MEL-SYD	Daily cost
Capital	1 755	1 646	1 755	1 865	1 755	1 646	$10 422
Fuel	2 450	2 450	2 601	2 601	2 450	2 450	$15 002
Maintenance	1 733	1 625	1 733	1 842	1 733	1 625	$10 291
Crew	1 122	1 052	1 122	1 192	1 122	1 052	$6 662
Airport	1 983	2 630	1 887	2 630	1 983	2 630	$13 743
Enroute	405	405	436	436	405	405	$2 492
Other	4 135	4 135	4 135	4 135	4 135	4 135	$24 810
Total	13 583	13 943	13 669	14 701	13 583	13 943	$83 422
Av. cost / seat	$ 63	$ 65	$ 63	$ 68	$ 63	$ 65	**$ 129**

Source BTCE estimates

Table 7 Estimates of operating revenues for the Boeing 767-200

Route	Discount pax	Discount fare	Economy pax	Economy fare	Revenue	Revenue/seat
SYD–MEL (return)	131	190	20	442	$33 730	$ 156
SYD–BNE (return)	131	195	20	475	$35 045	$ 162
Total (per day)	393		60		$102 505	**$ 158**

Source BTCE estimates

We can see that the Boeing 767-200 service allows for a per (return) seat operating surplus of $29 ($158 revenue - $129 cost), or a daily operating surplus of $19,083

Modelling the Airbus 300-B4-600

Our Airbus 300-B4-600 is a 230 seat aircraft Methodology and calculations are as above. Costs are in table 8, revenues in table 9, and aircraft parameter in appendix A

Table 8 ***Aerocost*** **estimates of direct operating costs for the Airbus 300-B4-600**

Cost	SYD-MEL	MEL-SYD	SYD-BNE	BNE-SYD	SYD-MEL	MEL-SYD	Daily cost
Capital	2 602	2 439	2 602	2 764	2 602	2 439	$15 448
Fuel	3 242	3 242	3 388	3 388	3 242	3 242	$19 744
Maintenance	1 733	1 625	1 733	1 771	1 842	1 625	$10 329
Crew	1 362	1 276	1 362	1 447	1 362	1 276	$8 085
Airport	2 290	3 119	2 180	3 119	2 290	3 119	$16 117
Enroute	436	436	468	468	436	436	$2 680
Other	5 475	5 475	5 475	5 475	5 475	5 475	$32 850
Total	17 140	17 612	17 208	18 432	17 249	17 612	$105 253
Av. cost / seat	$ 75	$ 77	$ 75	$ 80	$ 75	$ 77	**$ 153**

Source BTCE estimates

Table 9 Estimates of operating revenues for the Airbus 300-B4-600

Route	Discount pax	Discount fare	Economy pax	Economy fare	Revenue	Revenue/seat
SYD–MEL (return)	141	188	20	442	$35 348	$ 154
SYD–BNE (return)	141	193	20	475	$36 713	$ 160
Total (per day)	423		60		$107 409	**$ 156**

Source BTCE estimates

We can see that the Airbus 300-B4-600 allows only for a per (return) seat operating surplus of $3 ($156 revenue - $153 cost), or a daily operating surplus of $2,156.

Findings/aircraft selection

What does all this tell us? Bearing in mind the many assumptions made along the way (which are nonetheless based on actual market data and empirical observations) it appears that the economics of the MEL–SYD–BNE network best supports the choice (from the selection offered) of a Boeing 767-200. This aircraft offers the greatest daily operating surplus from which to cover indirect costs and overheads and earn a profit. The findings are not meant to be conclusive, rather they indicate the type of assumptions that can be modelled by planners to help in their aircraft allocation decisions.

Scenario — expansion of an existing (regional) network

In this scenario we use *Aerocost* to analyse the type of aircraft allocation decisions which might be made by management of a regional airline in deciding how best to expand their network. The decision is often a complex one, with trade-offs between aircraft type, load factor, fares and quality of service (such as flight time and comfort).

The scenario involves an airline based at airport B which is profitably serving origin–destination market A–B and wishes to expand to also serve market A–C. In addition, a small but uneconomic market exists for B–C flights. The airline does not have a competitor, and currently serves A–B with a Fokker F27-500 (F27) aircraft. Origin–destination demand and flight distances are as shown in figure 3. The choice under the scenario is which aircraft to buy to serve the A–C market.

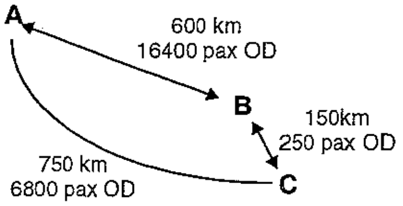

Figure 3 Route distance and air transport demand

If we assume (for simplicity) that its uneconomic to add B–C to the network by increasing the utilisation of the F27, then the decision becomes what aircraft type to buy to provide A–C direct flights. An aircraft seating about 20 could operate A–C at a reasonable load factor. Note that B is and will remain the home-base of the airline, thus the new aircraft will operate uneconomic 'early morning/late evening' flights between B–C. Note also that A–C direct services will *reduce demand* on A–B (we currently assume that 20 per cent of the 6800 A–C OD travellers *drive* between C and airport B in order to catch an A–B flight).

We analyse the relative operating costs of two likely aircraft, a British Aerospace Jetstream 31 (BAe31)and a Fairchild Metro III (Metro III). Key assumptions for the analysis are summarised in below in table 12

Table 12 Key schedule, supply and demand data

Option	Aircraft	Flight	Demand	Seats	Weekday returns	Weekend returns	Annual seats (one-way)	Load factor	Annual block hrs
Base	F27	A–B	17760[1]	52	2	1	32448	54.7	1872
Opt 1	F27	A–B	16400	52	2	1	32448	50.5	1872
	BAe31	A–C	6800	19	2	1	11856	57.4	2846
	BAe31	B–C	250[2]	19	1	1	6916	3.6	
Opt 2	F27	A–B	16400	52	2	1	32448	50.5	1872
	Metro III	A–C	6800	19	2	1	11856	57.4	2263
	Metro III	B–C	250	19	1	1	6916	3.6	

Notes: 1. 16400 plus 20% of A–C demand of 6800 (1360).
2 The first B–C and last C–B flights result from being based at B and are thus virtually empty.

The operating cost analysis

Table 13 below reports the results of an *Aerocost* analysis of the costs incurred in pursuing options 1 and 2. Costs are shown for a *one-way* operation of each flight sector.

Table 13 Aircraft direct operating costs under options 1 and 2

	Base	Option 1			Option 2		
	F27 A–B	F27 A–B	BAe31 A–C	BAe31 B–C	F27 A–B	Metro III A–C	Metro III B–C
Capital	437	437	408	217	437	313	79
Fuel	689	687	353	100	687	355	115
Maintenance	1274	1274	402	113	1274	327	83
Crew Costs	288	288	217	61	288	175	45
Enroute	127	127	61	8	127	64	9
Airport	327	327	128	76	327	131	80
Other	940	910	355	195	910	355	195
Total	$4082	$4050	$1924	$770	$4050	$1720	$ 606

Note: Key aircraft parameters are shown in appendix A
Source: BTCE estimates

Operating revenues

Each of the three options has passenger and revenue implications (kept fairly simple in order to expedite the analysis). Passenger and revenue data are summarised in table 14.

Table 14 Passengers carried and revenues earned under each option

	Return passengers carried			
Flight	Base	Option 1	Option 2	Return air fare
A–B	17760	16400	16400	$400
B–C	0	250	250	$200
C–A	0	6800	6800	$440

Source: BTCE estimates

The question raised in this scenario was which of the two aircraft was likely to be the most economical choice. We'll answer this by looking at annually aggregated operating costs and revenues, as summarised below in table 15

Table 15 Annual aggregates of operating costs and revenues under each option

	Base	Option 1	Option 2
Annual operating cost	$5,094 336	$8,016 112	$7,642 128
Annual revenue	$7.104.000	$9,602.000	$9.602,000
Annual operating surplus	$2,009,664	$1,585,888	$1,959,872

Source: BTCE estimates

Findings/aircraft selection

Bearing in mind the many assumptions made along the way, it seems the economics of the Metro III (over these routes) are slightly superior to the BAe31. However, we really should extrapolate beyond the simple operating surplus figure. If we were to take into account that option 2 is likely to involve additional overheads associated with establishing an airport presence at location C, we might question whether it was worthwhile expanding the airline network at this particular point in time. Clearly further analyses would be required as to the exact nature of the A–C air travel market.

Conclusions

The purpose of this paper is twofold. First, to illustrate some of the issues involved in making aircraft/route allocation decisions — issues brought about by the complex and often interdependent economic relationships that explain supply and demand behaviour in aviation markets. Second, to demonstrate how *Aerocost*, in providing a consistent and robust quantitative framework for estimating aircraft operating costs, can help the airline planner/analyst to make these allocation decisions. We've only been able to briefly touch on the full suite of complex modelling decisions that airline planners might make in simulating options for aircraft/route allocations. But in doing so, we hope we've been able to highlight some of the issues and some of the interrelationships between supply and demand decisions, and to illustrate how the *Aerocost* model can help with these.[10]

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Appendix A. *Aerocost* aircraft parameter assumptions

The parameter assumptions reported below can be varied depending on the requirements of a particular analysis. The values we chose in our scenarios are 'industry averages'.

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[10] *Aerocost* 2 is available from the BTCE. For further information contact David Smith (06) 274 7109

Table A1. Key aircraft data assumptions for the first (SYD–MEL–BNE) scenario

	B737-300	A320-200	B767-200	A300-B4
Seats	110	140	216	230
Value (A$million)	33	42	40	45
Provisioning ($/pax)	15	15	15	15
Fuel ($/l)	0.48	0.48	0.48	0 48
Maintenance ($/hr)	850	570	1300	1300

Source: BTCE estimates derived from a wide variety of sources

Table A2. Key aircraft data assumptions for the second (regional) scenario

	F27	BAe31	Metro III
Seats	52	19	19
Cruise speed (km/hr)	480	426	506
Value (A$ million)	2.3	2.9	1.9
Fuel ($/l)	0.59	0.59	0.59
Maintenance ($/hr)	849	205	207

Source: BTCE estimates derived from a wide variety of sources

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