COST BENEFIT ANALYSIS OF TERMINAL 2 AND RUNWAY 2 AT DUBLIN AIRPORT

REPORT FOR THE COMMISSION FOR AVIATION REGULATION

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DRAFT

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IMPORTANT NOTICE

1. INTRODUCTION

This report has been prepared by CEPA as part of ongoing support to the Commission for Aviation Regulation (CAR) in Ireland. The work presented here has benefited from discussion with CAR and its advisors but reflects the views of CEPA. This work is linked with the interim review of Dublin Airport Authority's (DAA's) revised Capital Investment Plan (CIP2006). However, the work also goes beyond CIP2006 since it considers the proposed second runway (R2) at the airport alongside terminal two (T2). Only the latter is included in CIP2006.

Any calculation like the one presented in this report is only as good as the assumptions and data underlying it. While every effort has been made to establish credible assumptions and robust data, the results of this work must be treated as indicative or first-cut views. What is important is to:

- establish a robust but pragmatic methodology;
- determine what key assumptions are needed; and
- set out initial views on these assumptions.

It should then be possible for interested parties to utilise the model (published alongside this report) and input alternative assumptions to determine what they view as credible estimates for the calculation.

1.1. Role of CBA for commercial projects

Cost-Benefit Analysis (CBA) is a standard planning tool used to assess public sector investment. It is a Department of Finance requirement that any public sector investment in excess of €30m undertake a CBA. Department of Transport provides detailed guidelines on the inputs to such assessments.

No CBA has as yet been prepared for the major increase in airport capacity entailed through the T2 and R2 projects. As a state-owned company working in a commercial environment it is not entirely clear what role a CBA would have for DAA. The interest of the airport operator is whether the investments are financially viable and this, to a great extent, depends on the regulatory decisions taken if and when the investments are given regulatory approval.

However, for CAR a CBA can play a key role in illuminating some of the core issues that it needs to consider when assessing the investments. These issues include:

- Whether the investment is justified through the broader social and economic impacts that it entails?
- Are there benefits accruing to the users of the airport that are difficult for the airport to recover or to agents that do not have a direct relationship with the airport and consequently make direct recovery difficult? And
- What lessons can be learned for the optimal timing of the projects?

With respect to the question of broader benefits, or ones where the airport faces difficulty in recovering the benefit, an issue that CAR would need to consider is how the airport is to be compensated for this shortfall. Two options exist:

- users that can be charged at the airport cross-subsidise other beneficiaries such as those that benefit from the improved broader economic environment; and/or
- other forms of payment are made to compensate – such as a subsidy payment from Government. Subsidies may be economically justifiable if the broader economy benefits in ways that do not generate a direct revenue flow (e.g. from environmental benefits or changes in land valuations). Alternatively, payments from specific industries may be justified if they share in the wider benefits.

As explained in the following section, the primary consideration of this report is linked to the optimal timing of the projects although the other issues can also be assessed through the model.

1.2. Structure of this report

In the sections that follow we set out:

- in Section 2, the approach to estimating the CBA;
- in Section 3, the initial findings in terms of optimal timing for the projects as well as traditional CBA values;
- in Section 4, a summary of the key findings of this report and the questions that require further consideration for refinement of the results; and
- in Annexes 1-9, the technical detail underlying the assumptions, the model and the various results.

2. MODEL AND KEY ASSUMPTIONS

This section sets out:

- the approach adopted to modelling the costs and benefits of the T2 and R2 projects; and
- the key assumptions that drive the result and any issues related to those assumptions.

2.1. Model

As part of the review of the justification for the significant planned expenditure on T2 and R2 over the next five to seven years a consideration of the costs and benefits has been addressed. Specifically:

- the negative benefits of not building, or at least delaying, the two major capex items has been considered, this involves a consideration of, among other things, congestion costs for airport users, and diversion costs for passengers constrained-out of the airport; and
- the costs of building the two key capex projects – including capital and operating costs.

A model that computes the costs and benefits, based on various assumptions outlined in this report, has been prepared. The model shows the annual costs and benefits of a perpetual project (described later in the section) and so allows an estimate of the appropriate date at which the projects should be operational to achieve economic efficiency. The model is built around a "do nothing" option derived from DAA work for Fingal Council on what would happen to passengers and air traffic movements (ATMs) if the airport was constrained. Some sensitivity analysis to identify the material assumptions has also been undertaken. We also report on other factors that could significantly affect the final estimate.[1]

The model is designed to provide a simple graphical representation of the scenario's impact against the appropriate base case. It has been built in such a way as to allow consideration of:

- the terminal and runway as a combined package (both coming on-stream at the same time); or
- the terminal and runway separately.

This allows some flexibility of analysis and base cases for each of the three investment options have been established to facilitate scenario and sensitivity analysis.

[1] Since the model identifies the point at which the costs and benefits are matched it is inevitable that the NPV of the investment decision will be positive, if measured at that point (of course, if different discount rates were used for costs and benefits then a different situation could arise). For completeness some standard NPV results are shown in annex 8.

An allocation of benefits and costs has to be made when the individual elements of the combined investment are considered. Where direct allocations of costs can be made, this have been done. Where the allocation is less clear, assumptions have been made. In one case the same level of impact is ascribed to two different project options since they only differ in respect of their start date. The allocation of benefits between T2 and R2 is an area that would benefit from further consideration.

2.2. Key Assumptions

The model incorporates a range of benefits and costs. These are, on the whole, similar to the standard approaches adopted either as per the "high-level" calculations of Jorge and Rus[2] or the more detailed/comprehensive approach adopted by the UK Government for the SERAS project.[3] A brief description of the benefits and costs of expanding the airport capacity are set out below – more detailed descriptions including the indicative calculations are provided in the annexes to this report.

2.2.1. Value of time

At the heart of many of the benefits is the fact that an expanded airport will reduce congestion and so reduce the time involved in travel. The key to valuing this improvement is the value of time of travellers.

Standard Irish Government CBA rates would suggest an all-in (market price which incorporates direct taxes) of around €21 per hour. This is towards the top end of Government quoted hourly wage rates (adjusted for tax). Consequently a range with €21 as the upper end and €13 as the lower end is employed. The lower value is derived from Government data.

Two additional points should be noted. First, this value relates to business travellers and it is standard practice to employ a scaler to determine what rate should be considered for leisure passengers. These scalers tend to vary between 0.3 and 0.7 – depending on on the mode of transport and other factors. A value of 0.4 has been employed when determining the indicative results in this report. Second, a valuation of business time at the gross earnings of a business traveller (representing the output loss to the economy from their not working while travelling) is based on a now potentially outmoded concept of travel time. It is not dead time – or at least not all of it is – since both business and leisure passengers travel with mobile phones and laptop computers. As such, the traditional way of valuing this travel time – particularly at the upper end of the scale - may be an overstatement of the cost.

2.2.2. Value of delay

Building on the value of time there is the question of the value of delay – or the benefit of removing that delay for travellers. Two types of delay can be considered:

2 *Cost-benefit analysis of investments in airport infrastructure: a practical approach*, Jorge and Rus, Air Transport Management, 2004.

3 Available from the Department for Transport, UK, website (accessed February 2007).

- the delay during passenger processing that arises due to congestion (this can vary between peak and off-peak); and
- the delay airside caused by congestion.

For the former an approach based around the additional amount of time that a passenger has to allow getting to the airport and being processed is a standard valuation technique.

The latter type of delay can be measured in two ways. First, a direct estimate of the additional time could be derived. A recent Oxford Economic Forecasting study[4] provided a per minute estimate of airline costs for delay - €34.16 covering staff costs, fuel etc. In addition, the cost to passengers can be estimated using the value of time using the method outlined above as per any other delay. A second approach, adopted by the University of Westminster when estimating this cost for Eurocontrol[5] is to focus only on significant delays (those in excess of 15 minutes) which lead to strategic costs for an airline. This report estimates the cost for the airline is on average €72 per minute.

For the base calculation the first, direct, estimation approach is adopted. The model incorporates the second approach as an alternative sensitivity check.

2.2.3. Benefits of not being displaced

A congested airport will reach a point at which some passengers are displaced (constrained-off). These passengers will either need to find an alternative travel mode (or different airport) or choose not to travel.

Again, two approaches can be used to assess the impact of being displaced from the airport:

1) a consumer surplus approach where the value to the displaced passengers is estimated through the price elasticity, quantity displaced and average ticket price; or
2) a valuation of the costs imposed by passengers needing to switch to alternative travel methods (air or other modes).

The first approach is that adopted by SERAS while Jorge and Rus adopt a simple version of the latter (focusing only on the additional travel time to an alternative airport).

Both approaches are available in the model but the default approach is that of consumer surplus. The key assumptions employed here are a price elasticity of -0.8, an average all-in ticket price of €50 and the quantity displaced as per DAA's constrained forecast (described below).

The alternative travel approach requires an estimate of how many displaced passengers would: (i) travel to Belfast (the main source of airport competition for Dublin); (ii) choose an alternative mode (such as ferry); or (iii) decide to not travel. While an interesting approach, this valuation method requires a greater number of assumptions

[4] *Economic Contribution of the aviation industry in the UK*, October 2006.
[5] *Evaluating the true cost of airlines of one minute of airborne or ground delay.*

than the consumer surplus approach unless the simple two hours additional travel time for every displaced passenger, is used (as per Jorge and Rus).

2.2.4. Value of improved quality

Congestion causes the experience of travelling through the airport to be less enjoyable than if the airport was unconstrained. Valuing improved airport quality is difficult, but is a major benefit of increasing capacity (at least in the short- to medium-term).

Two sets of information are available to consider for this:

- the premium that passengers are charged for using a full-service terminal rather than a low cost terminal at those airports where separate low cost terminals exist (and the right to charge differential prices exists); and
- limited survey evidence from DAA on the additional cost passengers would be willing to pay.

These values provide an indication of how passengers might value improved quality, but the ones currently available are only tentative first shot estimates.

As will be seen later in the report, these benefits can be a significant part of the overall benefit and, as such, deserve further consideration.

2.2.5. The impact of constraints on passenger numbers

The "do nothing" base line involves no addition of capacity at the airport. Establishing the overall impact that not building T2 and R2 would have on the number of passengers and ATMs that Dublin airport could handle is not straight-forward. Clearly it is possible to process more passengers with the existing capacity with a reduction in the quality of service being delivered – as has been the case in the last few years at the airport. There are, however, some binding constraints. The number of ATMs that can occur is constrained by the physical capacity of the airport as well as the air traffic control (ATC) requirements. However, even with a fixed number of ATMs, it is still possible to increase the number of passengers if larger planes are utilised.

There is also an expectation that if no new infrastructure was provided some operators would choose to expand overseas bases rather than Dublin. This will have an impact on peak demand, possible number/route for flights etc. Incorporating this into a constrained forecast is much more of an art rather than a science.

DAA, as part of the planning application for R2, provided Fingal County Council with a constrained forecast assuming neither R2 and T2 occur. The annual impact of constraining the airport has been taken from this report and grafted onto a more recent unconstrained traffic forecast.

2.2.6. The mix of passengers

Two issues need to be considered here:

- the proportion of peak and off-peak passengers (peak are taken to be 30% of the total); and
- the proportion of business and leisure passengers (taken to vary between peak and off-peak).

The chosen assumptions for these two variables have an important impact on the level of estimated benefits since the value of time is affected as well as the degree of delay..

2.2.7. The costs of constructing the projects

There are three relevant categories of costs for providing the additional capacity that need to be included. These are:

- capital costs;
- operating costs; and
- the discount rate.

For capital costs there are several elements that need to be considered:

- T2 as a terminal is only a part of the total T2 cost. A new pier, multi-story car-park, roads etc are all needed. These sum to €757m;[6]
- R2 has an estimated capital cost of €150m;
- a new ATC tower will be needed owing to the changed configuration, arising from both T2 and R2, at an estimated cost of €44m (described in CP10/2006 issued by CAR December 2006 and available from the website); and
- the opportunity cost of the land being utilised.

For the first three elements, values have been proposed during the draft price determinations but the value of land has not been addressed. Clearly land valuation can have a huge impact but measuring the opportunity use in the next alternative is difficult. Since the majority of the land is already owned by the airport or really has no alternative use but by the airport the opportunity cost could be low. However, even if the opportunity land use value were assumed to be small, it would still unambiguously increase the cost of providing the increased capacity.

Operating costs raise fewer fundamental problems. A percentage of the capital cost has been taken as the operating cost – in this case a range of between 7.5% and 10%. While this is an approximation, it is a simple benchmark rule that can be changed if better information is made available.

The allowed rate of return from the previous airport determination, 7.4%, has been taken as the discount rate although this is then compared with the Government's test discount rate of 5%. The box on the following page discusses some of the discount rate issues

[6] A further €170-180m of apron and stands could be included within this total. See *High-level analysis of DAA's investment plans: key issues*, Ian Rowson, February 2007. Available from the CAR website.

Box: Discount rates

The choice of an appropriate discount rate for these types of project, especially in the public sector is difficult.

Since the project will be funded through the company, the rate at which it can raise finance is clearly an important consideration – this is reflected in the company's WACC. Currently this is 7.4% real.

However, Government tends to use a social or time discount rate (TDR) that is significantly below this – currently 5% in Ireland. This reflects the broader ability of the Government to diversify risk over its larger portfolio as well as on an intergeneration basis over time.

Some academics and Governments have argued that differential rates should be used when considering "commercial" or risky activities. In the UK a higher rate was employed at one point for such projects although it has now returned to all projects facing the same rate.

If the lower TDR is utilised and the project is financially viable, but is not at the WACC, then an issue arises as to how that short-fall should be made-up. Arguably some form of subsidy could be appropriate.

Utilisation of a WACC for a commercial activity imposes a higher hurdle for the project and, as such, the use here could be viewed as being conservative. An alternative could be to use the TDR for those costs and benefits that arise in the broader social/environmental area and the WACC for the commercial aspects.

Since DAA is a commercial organisation the WACC has been employed here. However, some of the results in the annexes illustrate the impact of shifting over to the TDR and we would recommend further consideration of this issue.

One additional cost considered in the annual model is that of capital maintenance. The annual model, for simplicity, assumes that the capacity increase is a permanent one and is maintained at the same standard throughout time. As such, an annual capital maintenance charge has been allowed to ensure that the asset is maintained – this has been set at 2.5% of capital costs. This is driven by the normal life of a terminal asset which should be around 40 years.

3. Initial Results

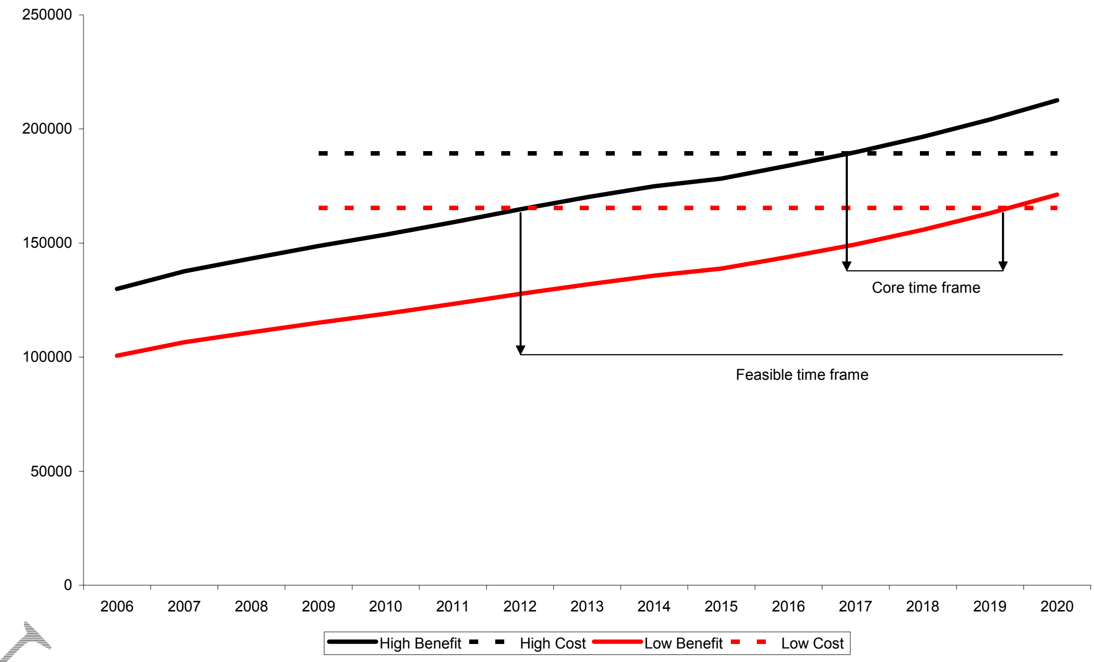
Utilising the base assumptions set out below in Table 3.1, we have estimated a combined model of costs and benefits for T2 accompanied by R2 has been estimated. Figure 3.1 provides a graphical illustration of the results relative to 'do-nothing'. Annex 2 sets out the overall impact of the elements and how they change over time.

Table 3.1 summarises the key assumptions in the base investment case and their justification.

Table 3.1: The Base Case

Element	Values	Justification
Diversion of passengers	Consumer surplus approach adopted	Most economically justified
Quality: Peak time	€4 per passenger	Based on the differential charged in Singapore between the low and standard quality terminals
Quality: Off-peak	€2 per passenger	Based on the DAA survey work undertaken in March 2006
Delay: Peak time	€4.55 - 7.35 per passenger	Cost assumptions explained in annex 2
Delay: Off-peak	€1.79 - 2.89 per passenger	Cost assumptions explained in annex 2
Delay: Airline	All minutes are valued	Cost assumptions explained in annex 2
Capex cost	€951m	Explained above
WACC (real)	7.4%	Based on the 2005 determination
Maintenance	2.5%	Based on an average asset life of 40 years
Opex	7.5-10% of capex cost	Assumption based on broad analysis of existing costs

Figure 3.1: The base scenario range for T2 and R2 combined (€'000)



As described in section 2, the model is designed to show the annual benefits and costs and it is where the date at which they cross the corresponding horizontal line is the optimal time indicated by the model for the assets to be operational.

Since the uncertainty about some of the key assumptions has meant that a range of values are utilised, there is a range of dates by which the assets should be operational. From the figure above it is possible to consider a 'core' period (2017 – 2019) and a broader 'feasible' period (2010 – 2020 plus). The derivation of these ranges is as follows:

(a) The core period is based on the dates derived from: (i) 2017 –high benefits (incorporating time valued at €21 per hour) and high costs (opex at 10% of capex); and (ii) 2019 – low benefits (incorporating time valued at €13 per hour) and low costs (opex at 7.5% of capex).

(b) The feasible period is based on the dates derived from: (i) 2012 – high benefits and low costs; and (ii) beyond 2020 – low benefits and high costs.

The estimates underlying Figure 3.1 above are set out in detail in Annexes 7 and 8.

Finally, there are some additional factors that are difficult, if not impossible, to quantify but which are likely to have an impact on the date. These are listed in the table below.

In taking this analysis further, we would recommend taking these points as the priorities for further sensitivity testing.

Table 3.2: Other possible factors

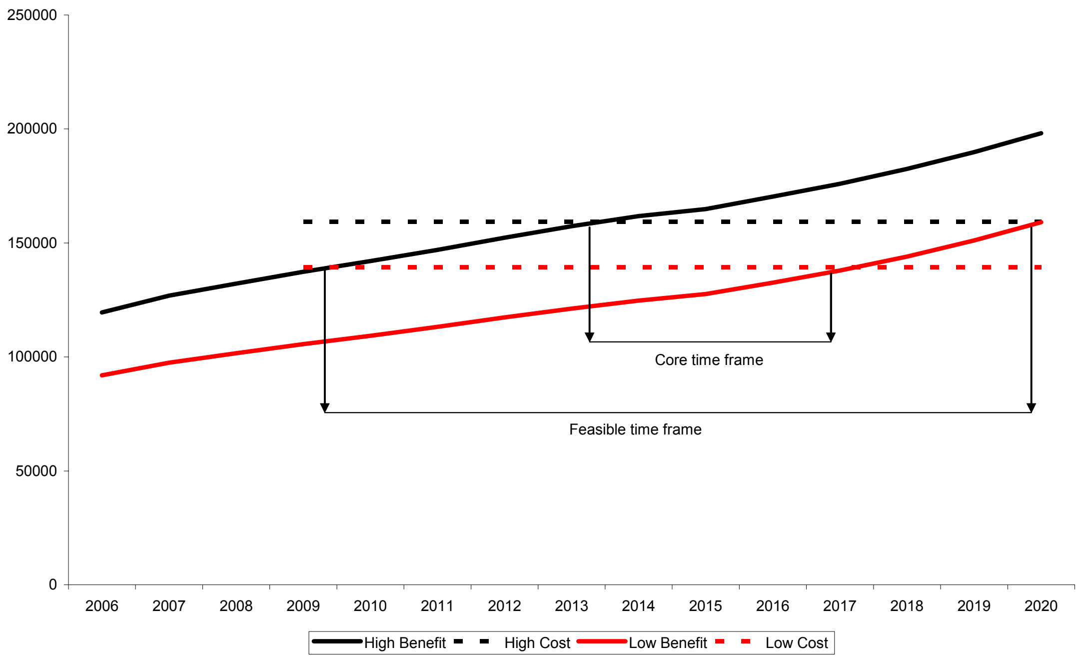
Factors likely to bring the "break-even" date forward	Factors likely to push the "break-even" date back
Real wages increase over time Commercial revenues defray some of the investment costs Employment impact of additional planes based in Dublin, terminal etc	Inclusion of the opportunity cost of land Constrained scenario is based on never building T2 and R2 and so may over-state impact on passenger numbers, ATMs etc Record of DAA delivering capex at above cost Changes in the real construction costs Environmental factors

3.1. T2 base case

Since the primary focus of interest is the proposed T2, the results of the base case for this stand-alone project are provided.

As can be seen from the figure, a very broad feasible period for the delivery of T2 can be proposed. It could range from as early as 2009 until as late as 2020 – although the core period of 2013 to 2017 is more precise.

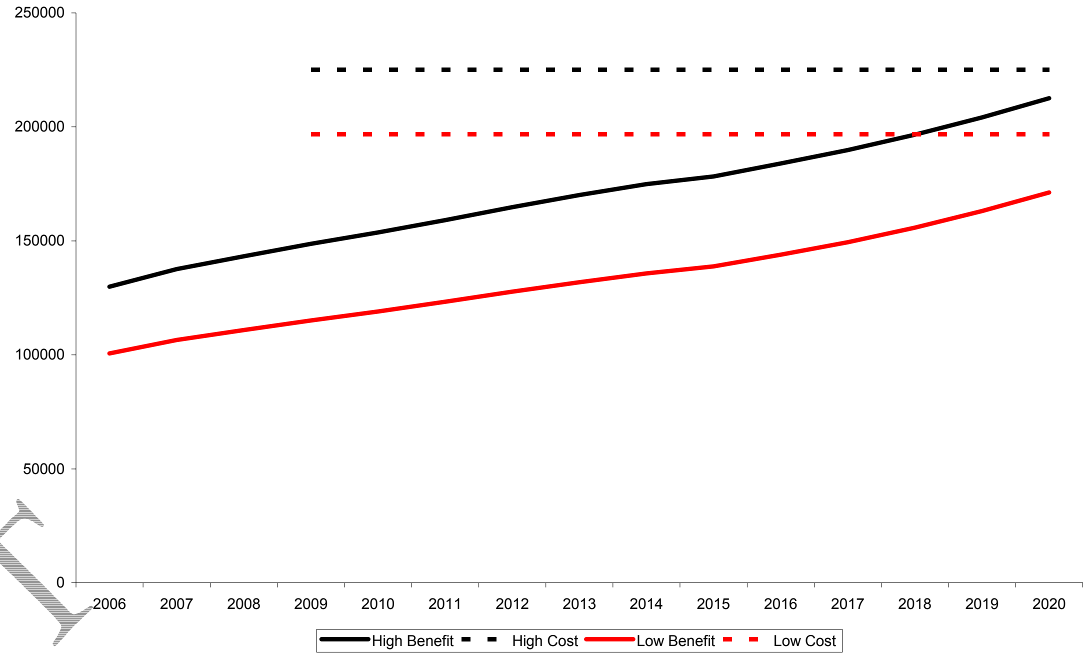
Figure 3.2: The T2 base case (€'000)



3.2. High capex scenario

As noted in Section 2, some of the apron works, stands etc arise because of the decision for T2. As such, a scenario has been modelled where an additional €180m of capex associated with this is included in the project costs. The following figure, Figure 3.3, illustrates the shift in the cost and benefit curves and shows that with these higher costs the optimal date shifts back significantly. Other scenarios incorporating similar types of change can be considered.

Figure 3.3: A high capex scenario for T2 and R2 (€'000)



4. SUMMARY

This report provides an overview of:

- a CBA methodology for assessing the optimal timing of investment in T2 and R2;
- the approach to valuing the key inputs; and
- an initial set of tentative results.

These results suggest that an investment programme which delivered the combined projects between 2012 and 2020 would seem to be appropriate, as compared to a 'do-nothing' option. The analysis so far undertaken suggests that the optimal date is likely to be in the period 2017 to 2019, although a much earlier date is justified if T2 alone is assessed. However, the exact position within this range is clearly dependent on some key assumptions concerning the valuation of costs and benefits as well as on the choice of discount rate.

Given the range of uncertainty about some of these values it is feasible that the true optimal point lies outside the period indicated. We suggest further sensitivity analysis be conducted to aid the decision-makers and reduce the uncertainties.

4.1. Issues for further refinement

Given the uncertainties we have discussed, the model provides a starting point and sets out a robust framework for the analysis. However, neither the model nor the results should be perceived as conclusive or complete. Rather, they high-light some of choices for the values of key assumptions and suggest where further refinement of those values is appropriate. These are refinements that other stakeholders are in a strong position to suggest or develop.

Particular areas requiring further refinement include:

- the value of time;
- the impact of constraining the capacity of the airport on passenger and ATM numbers;
- the appropriate price elasticity to use in the consumer surplus calculation;
- discount rates/WACC, construction costs/risks, length of life; and
- more formal risk analysis and mitigation methods

It would also be appropriate to consider further the allocation of benefits between T2 and R2.

ANNEX 1: VALUE OF TIME

The value of business and leisure time are key elements of the calculation of benefits. There are, however, multiple ways in which the values could be established.

Possible approaches include:

- consideration of the wage data available in Ireland;
- usage of the figure employed by the National Road Authority; and
- usage of the figures proposed by Goodbody Consultants in their 2004 work for the Department of Transport.

The following table provides a comparison of the figures proposed under these different approaches.

Approach	Data	Hourly rate (factor cost)	Hourly rate (market price – including taxes)
NRA	2002	17.6	21.0
Goodbody – all	2002	18.2	21.7
Goodbody – travellers	2002	22.2	26.5
Wage data	2005	10.8 – 19.9	12.9 – 23.7

The wage data, taken from the GoI statistics on salaries, provides evidence ranging from €10.76 to €19.86 per hour as average wages (assuming people work a 40 hour week).

Overall, a figure of €21 per hour has been used for the base model. This seems high (even though Goodbody has been arguing for higher values) and consequently should be treated with care.

The second issue to address is that of the value of leisure – this is normally expressed as a percentage of the business hourly rate. No agreement exists on the precise value of leisure time to use. Different values are used depending on the form of transport, type of leisure etc. A range of between 30% and 70% exists. The Irish Department for Transport uses a value of 40% and, as such, this value has been employed. Sensitivity analysis within this range is considered.

Finally, an issue that is starting to be discussed is whether this traditional approach to valuation is appropriate. For business travel, time spent travelling is not "dead" time but rather, with the advent of mobile phones, laptop computers and wireless internet, just another form of work time. As such, valuing it as though it is productive time wasted may not be as appropriate as 10 years or more ago. Further consideration of this issue is needed to determine how travel time should be valued in the future and whether this applies to leisure as well as business time.

ANNEX 2: VALUE OF DELAY

a) Time delays due to over-crowding

It is clear that as the airport becomes more crowded greater delays will occur. These delays impact on:

- airlines and passengers through greater delays at stand and as taxi-ing; and
- passengers through delays at the terminal, requirement for more time at the terminal to ensure catching the flight etc.

The former is discussed here while the latter is discussed in (b) below.

Two approaches exist to estimating the cost for airlines and passengers of airside delay:

- direct estimation on a per minute basis; and
- estimation of costs of significant delay – those in excess of 15 minutes.

i) Direct per minute estimation

For every minute that a plane is delayed the following costs can be incurred:

- fuel costs if engines are running;
- staff costs – both on-board (which can be significant given the limitations on the time that on-board staff are allowed to work before alternative staff have to be found) and on the ground; and
- passenger costs through the time spent waiting.

A recent Oxford Economic Forecasting study on air transport reported a per minute cost of £23.40 (€34.16) as reported by British Airways.

This would suggest a total per minute cost of delay of €66.78, comprising:

- Airline costs - €34.16; and
- Passenger costs - €32.62 (assuming 170 passengers on a plane of whom 25% are business) – the basis for this calculation is provided in annex 1.

The average delay is not a straightforward number to estimate. One option is to consider the additional two minutes per flight, required to increase runway capacity, as an acceptable conservative estimate of the average delay imposed by congestion. This is also in-line with the estimates provided by airlines that are members of the Association of European Airlines (taking the average length of delay for those flights that are delayed).

ii) Estimation of significant delays

Using the Eurocontrol data we have an average estimate of €72 per minute for delays in excess of 15 minutes, capturing costs to the airlines etc.

If: 18 hours of operation per day

365 days of operation per annum

46 slots per hour (based on IAA data)

Total: 302,220 slots per annum

Each additional 1% of aircraft delayed for an average of 17 minutes (this is the existing average delay for delayed aircraft in the UK/Irish segment) equates to: ***€3.7m***[7]

b) Delay costs for passengers – waiting time at the terminal

If the peak hour expands and services become more crowded, how much additional time will passengers need to leave themselves for checking-in etc?

If: Average *additional* time required at the airport is 30 minutes during peak hour and 15 minutes in off-peak

Use a range of €13 - €21 per hour as the real wage for business passengers and 40% of this (€5.2 - €8.4 per hour) for leisure (described in annex 1)

Assume 50% of the busy hour customers are business and 25% of off-peak

For each passenger, the additional cost is ***€4.55 - €7.35*** during the busy-hour and ***€1.79 - €2.89*** during off-peak time.

[7] Numbers in bold and italic are used in specific cells in the model.

ANNEX 3: VALUE FOR DISPLACED PASSENGERS

If Dublin does not expand, some customers are likely to be displaced to other airports that have excess capacity while other passengers will choose to travel by a different mode of transport or not travel at all. Two approaches exist for estimating the cost of constraining passengers off the airport:

- estimation derived from standard consumer surplus methods; and
- direct estimation based on consideration of the alternative costs of travel.

i) Consumer surplus based calculation

The standard economics method of assessing the "cost" to consumers of being displaced from travel through Dublin Airport is to measure the deadweight consumer and producer loss associated with them being displaced.

This is estimated by considering the price increase that would be necessary to make the displaced (constrained-off) customers choose to be displaced. This requires data on:

- an average price of a ticket (including regulated charges);
- the estimated number of customers displaced; and
- an estimated price-elasticity of demand.

The first two elements are relatively straight-forward. The estimate of the number of customers that will be constrained off is provided by the DAA constrained forecast (discussed elsewhere in this note). The average ticket price is a little more difficult but, with information from low cost airlines on average ticket prices and the passenger charges, an average one-way all-in ticket price of about €50 would be appropriate.

Customers most likely to be displaced are those travelling short-haul. As such, the price elasticity should be based on short-haul options. Recent work by the CAA has provided information on estimates of price elasticity – these have been used by DAA in its traffic forecasting.

Estimates of short-haul elasticities range from -0.768 to -0.870. In our estimation we have adopted a value of -0.8. This is likely to prove to be very conservative – there is debate about what actual level of elasticity exists with some commentators arguing for figures closer to 1 (or even higher). However, our conservative estimate provides a high value for the benefits implied by not constraining passengers and the impact of higher price elasticities can be checked through their use in scenarios.

The consumer loss is measured as:

$$Loss = 0.5\left[\left(p^c - p\right)\left(q - q^c\right)\right]$$

Where: p is the all-in price of the ticket;

q is the quantity of passengers travelling; and

^{c} refers to the constrained value.

So the loss is half the difference in price multiplied by half the difference in quantity (note, the formula is written for ease to provide a positive value).

ii) Direct estimation of costs of alternative travel[8]

Two forms of alternative travel are considered:

Air travel from Belfast

If: Average travel time to Belfast from Dublin is 2.5 hours by coach (waiting time as well as travel time) and 2 hours by train

Use 2 hours of additional travel time as a conservative estimate

Use a real value of €21 per hour for business passengers and 40% of this (€8.4 per hour) for leisure

Assume cost of the coach journey is €7 per trip

For each passenger displaced (assumed to be a leisure passenger) from Dublin to Belfast, the cost is: ***€23.8*** (***€17.4*** if leisure time is worth €5.2 per hour)

Passenger ferry from Dublin

Some passengers, especially leisure ones, may choose to return to the previous form of popular travel (prior to the low frill airlines) – the ferry.

If: Average additional time required is 4 hours (fast ferry service is 1 hour 40 minutes, train from Holyhead to London is 4 hours 30 minutes, but save time getting to airport, going through long check-in process etc)

Use a real value of €21 per hour (conservative) for business passengers and 40% of this (€8.4 per hour) for leisure

Assume that only leisure passengers will use this service

Assume net price differential is €20 per trip – taking into account ferry cost €50, UK rail travel €30 (based on a cheap ticket booked two weeks in advance), airline cost €40 and savings on rail travel from UK airport to London €20

For every leisure passenger who chooses to switch to travel by ferry, the cost is: **€53.6** (**€40.8** if the value of leisure time is **€5.2** per hour).

[8] This is our less preferred approach but is included for completeness and to provide something of a comparator.

ANNEX 4: VALUE OF IMPROVED QUALITY EXPERIENCE

It is clear that congestion at an airport reduces the value of the experience of flying – the crowds, lack of seating etc. While it is difficult to value such a diminution of experience there are some possible measures that can be used.

First, in some countries where dedicated low cost terminals have been established alongside full service terminals there is a price differential applied to reflect the fact that the low cost terminal provides a lower quality of service (for example, concrete floors as opposed to carpeting). Some of this evidence is presented in a separate paper prepared by CEPA on congestion charging for the Commission. This provides a range of values from €2 to €4 per pax.

Second, during a 2005 customer survey DAA collected some information on customer willingness to pay. This suggested that customers would be willing to pay an additional €1 to €3 for service – although this was not directly linked to "improved" service. This survey considered both departing and arriving passengers.

Given this information, the following assumptions have been made:

- departing peak passengers value greater quality at €4 per pax; and
- departing off-peak and all arriving passengers value improved quality at €2 per pax – reflecting the fact that they travel through the airport at less crowded times.

We suggest that the estimates above be refined in further work e.g using contingent valuation techniques.

ANNEX 5: BASIC ASSUMPTIONS

There are some other basic assumptions that have been made:

- the split of arriving and departing passengers is assumed to be 50:50; and
- peak/busy-hour passengers are assumed to account for 30% of the total passenger throughput (based on the 3,850 busy hour passengers reported by DAA multiplied by 4 hours per day and 365 days in the year – giving a little over 6m busy-hour passengers at the moment out of about 20m total passengers).

Annex 6: Costs of T2 and R2

The assumptions for the costs have been based in part on the published CIP and in part on educated guesses.

Element	Value
T2	€757m
R2	€150m
ATC Tower	€44m
Opex (as a %age of capex)	7.5-10

Linked to these capex costs are the costs of remunerating the investment and maintaining the assets at the desired level of capacity.

Two possible remuneration rates can be considered:

- the weighted average cost of capital (WACC) – reflecting the company's cost of borrowing money (7.4%); and
- the social discount rate (SDR, also referred to as the Test Discount Rate) – reflecting the Government's view of the opportunity cost of investment (5%).

It is standard in cost-benefit analysis to use the SDR. However, there is debate as to whether some risk adjustment for market (or systematic) risk should be incorporated into the SDR, reflecting the fact that there are underlying risk differences between projects. This would push the value closer to the WACC.

However, in our base case we continue to use the WACC since it does reflect the cost of borrowing for the company. Given what this rate is being used for – estimating the financing cost of the investment – usage of a SDR would imply that a financing cost for the company would arise which would have to be met through a grant from the Government. If such a grant or an explanation as to how any financing gap would be covered were available then the SDR, or a risk adjusted value, could be used.

Since the capacity increase that is needed is a permanent one – the traffic forecasts suggest that passenger numbers will keep increasing – and consequently this increase in both runway and terminal capacity will always be required (a perpetuity assumption). As such, a charge representing the consumption of the services of the terminal and runway is needed – effectively a capital maintenance charge. It is assumed that this is reinvested so that the capacity of the project, and the quality of the service provided, is always held at the new level.

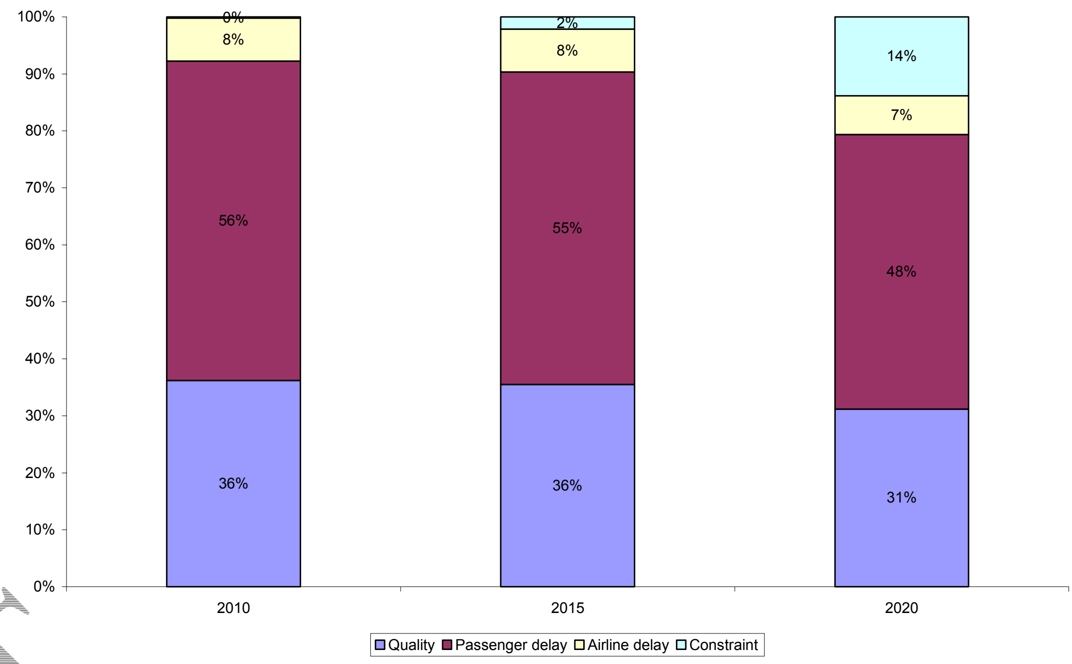
There is no consideration of possible cost over-runs in these capital costs. Some contingency is incorporated in the T2 figures. Overall any contingency is well below the 40% cost over-run consideration recommended by the UK Treasury for this type of assessment. A significant cost over-run could be a scenario. This as well as other risk mitigation issues are covered in the Green Book.

ANNEX 7: IMPACT OF THE VARIOUS ELEMENTS

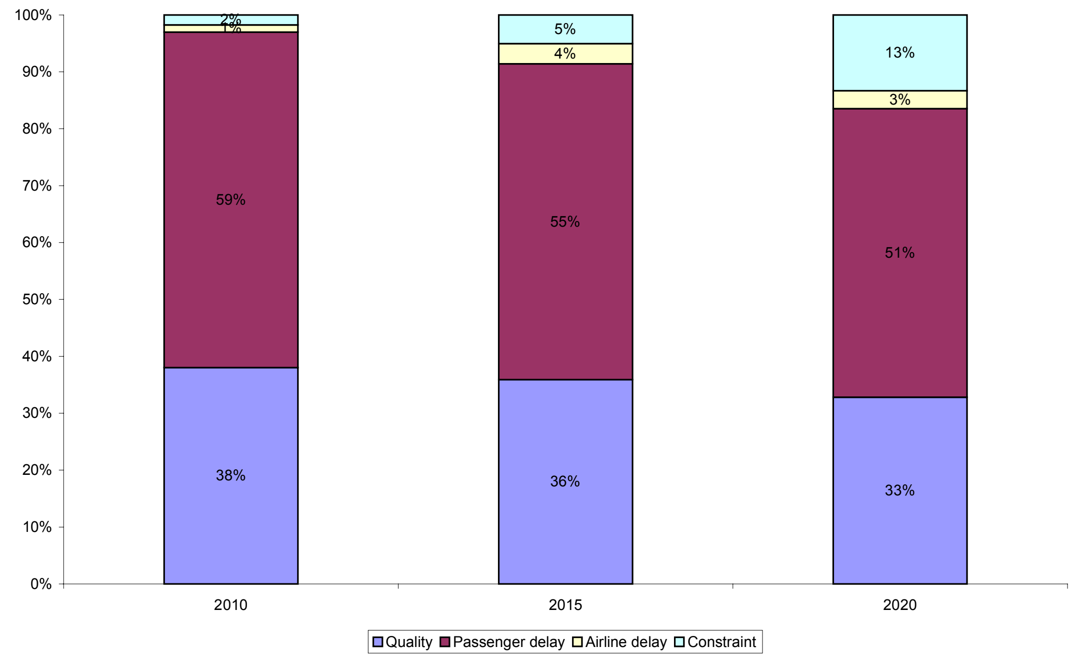
Element	**Value**	**Impact in 2010 (€m)**	**% of total benefits**
Quality		**55.6**	36-38
Peak	€4 per pax	14.5	
Off-peak[1]	€2 per pax	41.1	
Delay		**86.1**	56-59
Peak		26.7	
Off-peak		59.4	
Airline Delay[2]			1-8
All minutes delay		**1.9**	
Above 15 minutes		**11.6**	
Constrained-off[2]			0-2
Direct		**2.5**	
Consumer surplus		**0.3**	
Total		146.1-153.6	
Element	Value	**Impact in 2015 (€m)**	% of total benefits
Quality		**63.3**	36
Peak	€4 per pax	16.5	
Off-peak[1]	€2 per pax	46.8	
Delay		**97.8**	55
Peak		30.3	
Off-peak		67.5	
Airline Delay[2]			4-8
All minutes delay		**6.3**	
Above 15 minutes		**13.4**	
Constrained-off[2]			2-5
Direct		**8.9**	
Consumer surplus		**3.8**	
Total		176.3-178.3	
Element	Value	**Impact in 2020 (€m)**	% of total benefits
Quality		**66.3**	31-33
Peak	€4 per pax	17.3	
Off-peak[1]	€2 per pax	49.0	
Delay		**102.5**	48-51
Peak		31.8	
Off-peak		70.7	
Airline Delay[2]			3-7
All minutes delay		**6.3**	
Above 15 minutes		**14.5**	
Constrained-off[2]			13-14
Direct		**26.9**	
Consumer surplus		**29.4**	
Total		202.0-212.7	

Note: 1 note all arriving pax treated as off-peak
2 either but not both approaches within each category should be used to calculate impact

Consumer surplus estimation



Direct estimation



ANNEX 8: TRADITIONAL CBA RESULTS

As well as providing the annualised benefits and costs a more traditional NPV calculation has been undertaken – although to provide a greater signal re timing of the projects the NPV has been calculated assuming opening dates for the project ranging from 2009 to 2015 with the preferred date being the one with the highest NPV. Table A8.1 provides the results of the standard NPV calculation.

Table A8.1: Lumpsum capex NPV

Project	Base	TDR	7.5% opex	€13 time value	Combined
T2	-€167.7m	-€149.6m	-€63.9m	n/a	-€255.3m
	2012	2009	2009	2015+	2012
R2	n/a	n/a	n/a	n/a	n/a
	2015+	2015+	2015+	2015+	2015+
T2 and R2	n/a	-€297.7m	-€180.6m	n/a	n/a
	2015+	2012	2011	2015+	2015+

As can be seen, for the base case T2's optimal date is 2012 and R2's is after 2015. The combined project also has an optimal start date after 2015.

A series of scenarios, based on changing one or more of the assumptions is also reported in the table. From this it is clear that the impact of the several of the assumptions is important, such as the value of time. Shifting from €21 an hour to €13 an hour creates a situation where the NPV peaks much later in the period. Consequently coming to a final view on the appropriate value of time as well as the other assumptions is important to ensuring a robust result from the CBA.

To verify the annualised approach that has been adopted the NPV of the annualised flows has also been considered. These are set out in table A8.2. This confirms that the dates noted in the main part of the document are appropriate.

Table A8.2: Annualised capex NPV

Project	Base	TDR	7.5% opex	€13 time value	Combined
T2	n/a	€137.5m	€92.8m	n/a	€45.8m
	2015+	2011	2011	2015+	2014
R2	n/a	n/a	n/a	n/a	n/a
	2015+	2015+	2015+	2015+	2015+
T2 and R2	n/a	€63.3m	€34.2m	n/a	€3.8m
	2015+	2013	2014	2015+	2015

ANNEX 9: INDIVIDUAL PROJECT ANNUAL CBAS