Appendix Title	
Appendix 1 - Letter from Arthur Cox to daa RE: TUPE Arthur Cox	Confidential
Appendix 2A - Proposed Till Exit of Commercial Development Site at Dublin Airport daa	
Appendix 2B - Valuation Report of Dublin Airport Sites CBRE Advisors	Confidential
Appendix 3 - Report on Willingness to Pay for Improvements to Dublin Terminal 1 NERA Economic Consultants	
Appendix 4 - Analysis of Airport Capacity at Dublin Airport Ricondo & Associates Inc.	
Appendix 5 - Capex - Latest Expected 2014 daa	Confidential
Appendix 6 - Report on CAR’s Draft Determination: Cost of Capital NERA Economic Consultants	
Appendix 7 - Letter from Minister to daa RE: Dividend Requirement DTTAS	
Appendix 8 - Memo on CAR’s Passenger and Commercial Revenue Forecasts NERA Economic Consultants	
Appendix 9 - Letter from IAA to daa RE: Safety & Security IAA	
Appendix 10 - Report on Costing Errors in EY Capex Review daa	
Appendix 11 - Review of IT Investment Programme KPMG	
Appendix 12 - Proposed IT Innovation Investments daa	Confidential
Appendix 13 - Letter from Customer to daa RE: Future Plans for Dublin Airport Customer	Confidential
Appendix 14 - Report on T2 Outturn Expenditure ARUP	
Appendix 15 - Report on daa Risk Modelling NERA Economic Consultants	Confidential
Appendix 16 - Explanation of CAR’s Error RE: Capital Remuneration Application daa	
Appendix 17 - Project Costings for Customer daa	Confidential

Appendix 2A - Proposed Till Exit of Commercial Development Site at Dublin Airport

Source: daa

Proposed Till Exit of Commercial Development Sites at Dublin Airport – Note to CAR and Airport Users (02.07.2014)

Certain elements of this note and the associated appendices have been redacted to preserve commercial confidentiality. The unredacted versions are available to CAR and airport users who have signed and returned the relevant non-disclosure agreement (NDA). To obtain the NDA, please contact apcadmin@daa.ie.

Proposed till exit

Dublin Airport City (DAC) was a long-term commercial property development, first put forward by daa prior to the economic downturn in 2008. Latest, revised proposals would involve the development of circa 64 acres in the central and eastern areas of the Dublin Airport Campus. The area in question (see map below) is designated as a 'high technology' zone by Fingal County Council (FCC), subject to the completion of a Master Plan, which is currently being finalised by daa, and which will shortly be submitted to FCC. (The full area of the zoning is 70 acres, but not all of this area is within daa's control. Note other areas of the campus are not zoned 'high technology'. The general zoning status is 'DA Dublin Airport'.)

Note: See Appendix 1 for further detail

The development would consist of offices, hotel accommodation, associated car parking and ancillary retail. The quantum of the development would be up [redacted] subject to acceptance of the Master Plan and individual planning permissions. The timeline for full delivery would be dependent on the market demand and could extend for as long as 30 years or more. The order of magnitude of the investment requirement would be circa [redacted]

In the course of previous regulatory determination processes under the aegis of CAR, and in the more recent consultation process run by CAR with regard to exiting new commercial investments from the single till, DAC was agreed generally by the stakeholders (CAR, airlines, daa) to be an investment that would be expected to proceed outside the till, i.e. with neither the investment nor the ultimate associated income stream captured within the regulatory formula.[1]

In the course of our capex consultations with airlines earlier this year, daa presented (to parties who had signed the NDA) updated investment proposals. This presentation remains available to interested parties who complete the NDA. daa would summarise three main outcomes to this engagement as follows:

1. The airlines signalled that they would not support the investment being undertaken within the till.
2. The airlines signalled the importance of the regulated entity being insulated from risk associated with the development project.
3. It was agreed that daa would commission an independent valuation of the lands and assets that would need to be excluded from the till in order for the ex-till investment to take place.

With regard to 2 above, daa confirms that the project would proceed on a ring-fenced basis, with separate funding arrangements.[2]

With regard to 3 above, the independent valuation of the lands and assets in question has now been completed by CBRE. This report is available to parties who have signed the NDA. Summary details of the relevant valuation amounts are provided in tabular form later in this paper.

[1] We reference for example the following statement from CAR's paper CP1/2012 Future Investments and the Regulatory Till: *'Dublin Airport City provides an example . . . for which the Commission has previously indicated an intention to exclude its costs and revenues from the regulatory till (with the support of both the daa and airlines).'* (page 3)

[2] We note that CAR previously assessed its fulfilment of its responsibility to ensure the financial viability (including financeability) of the regulated entity on the basis of daa Group metrics, but that CAR proposes in the most recent draft determination to focus on regulated entity metrics. daa agrees that the latter approach is the appropriate one. Our proposal to ring-fence potential ex-till investment from the regulated entity is consistent with this approach.

Prior to presenting the valuation results, daa would make the following important contextual points. There is a shared general understanding that the lands and assets in question are currently 'owned' by the till. In recent years, daa has undertaken a number of investments in the areas in question which have not been funded by the till (i.e. the investment amounts have not been included in the Regulatory Asset Base (RAB)).[3] The key details of these ex-till investments by daa are the following:

- Purchase in 2009 of Aer Lingus leasehold interest in Head Office Building site (13.1 acres)
  - Purchase transactions plus small associated investment (circa €700k) amounted to €27m expenditure by daa
  - Purchase of various lease arrangements held since 1962 under a 99 year leasehold until 2061
  - Various buildings constructed by the tenant were acquired as part of the purchase (Head Office Building, Iolar, Imbus, Services Annex, ALSAA)
  - Rental income to daa under the pre-existing lease was a peppercorn rent of €11k per annum

- Purchase in 2013 of the leasehold interest in the Clarion Hotel site (5.16 acres) from the receiver of International Airport Hotel (IAHL) for €15m, plus €2.5m associated capital expenditure
  - The lease was to run until 2068
  - The hotel building and subsequent extensions were built by the tenant
  - The pre-existing concession income to daa was €200k per annum
  - Subsequent to this investment daa has entered into a 10-year concession agreement with Dalata (Maldron Group)

Since the above ex-till investments undertaken by daa have significantly increased the value of the area proposed for till exclusion, daa commissioned CBRE to value the lands and assets in question both **before** and **after** these investments. The results of these valuations are summarised in the table below. For ease of reference, the valuation splits the more central HOB/Clarion site of approximately 20 acres (also including the Garden Centre and ancillary land), named the 'Inner Zone', from

[3] We note CAR's view that development plans need not halt due to an externally imposed timeline for RAB adjustment to accommodate till exit. In CP1/2012, CAR states: *'[T]his [adjustment to RAB to be made at time of determination] does not mean that commercial investment plans could not be advanced between determinations.'* (pages 11-12)

the ‘Middle Zone’ and ‘Outer Zone’ of approximately 25 and 19 acres respectively. A detailed map and inventory of assets is included at Appendix 1.

An important point emerging from the table below is that the current valuation of the Inner Zone is less than the sum of the pre-existing value (€5m) and the quantum of investment undertaken by daa (€45m). Accordingly, the exclusion value of €5m proposed by daa for the land and assets is the more favourable (from the till’s perspective) of the two valuations shown below for the Inner Zone.

As a further explanatory note, the proposed exit value for the Middle and Outer Zones of €22m incorporates a reduction from the ‘gross’ valuation provided by CBRE on the basis of rental values (independently estimated in the CBRE report) to reflect de facto encumbrances relating to on-going daa occupancy/use of some of the lands/assets in question. As an example, daa occupies Cloghran House. If the asset were to exit the till at the gross value, then the till would be required to pay a rent for this occupancy to the ex-till business. Instead, daa proposes that the assets exit the till at a ‘net’ valuation which means no further transfer would be required between the till and the ex-till business. This is one example of a number of such instances. The details of these calculations are provided in Appendix 2 (which should be read in conjunction with the CBRE valuation report – both available subject to NDA).

Area	Valuation €m	Impact on Aeronautical Revenue Requirement €m	Comment
Inner Zone - HOB/Clarion/etc. **post** €45m investment by daa	43		CBRE valuation; Not proposed exit valuation
Inner Zone - HOB/Clarion/etc. **pre** €45m investment by daa	5	-0.3	CBRE valuation; Proposed exit valuation
Middle & Outer Zones	22	-1.3	CBRE valuation, amended by daa
Total impact of till exit	**27**	**-1.6**	

Note: As per comments above, the CBRE valuation for the Middle and Outer Zones has been amended by daa to produce a proposed exit valuation, as detailed in Appendix 2.

Note: The aeronautical revenue impact is based on (i) removal of the asset values in question from the RAB with an assumed asset life of 20 years and using the current allowed WACC of 7% as the discount rate, (ii) removal of the revenue flows currently associated with the assets in question.

In conclusion, daa proposes the exit from the till of the lands and assets in question – see Appendix 1 for full descriptions – at the values indicated in the table above. We calculate that this would have the impact of a €1.6m per annum reduction in the aeronautical revenue requirement, all other things equal.

PCB investment

As part of the same set of transactions in which daa purchased the Head Office Building site from Aer Lingus, the pre-existing PCB leasehold was also transferred from Aer Lingus to daa. This building was subsequently refurbished by daa at a net cost to daa of €4.1m and has been re-let, resulting in an IRR for the investment of 14.2% over the life the new lease. Note:

- For reasons of tenant confidentiality, details of rent, lease term etc. are not stated in this document, but are available to CAR on request.
- There was no capital allowance available to daa in the 2010-2014 determination period to cover this investment. A proposal for an allowance that would have covered expenditure of this type was disallowed by CAR in the 2009 final determination (CIP 2.015 – 9.55-9.56 of CAR CP3/2009).

In the capex reconciliations submitted to CAR in the run-up to the draft determination, daa presented the PCB investment as proposed for till exclusion. However, this asset was not included in the CBRE valuation as it is outside the Dublin Airport City zone (not included in the FCC 'high technology' zoning).

In the event of a decision that commercial properties outside the Dublin Airport City zone (such as Ryanair Head Office Building, TASC building etc.) would compete with Dublin Airport City and that these properties should therefore be excluded from the till, a further independent valuation of these particular properties would need to be undertaken. PCB would fall into this category. In the event that CAR does not require such an exclusion, the PCB investment should be included in the 2015 starting RAB. This would be daa's recommendation – as we believe the separate zoning corresponds to separate market segmentation. In the event of a contrary decision, i.e. to exclude PCB from the RAB, the revenue associated with this investment should also be excluded.

Appendix 1: Details of proposed till exclusion

Map reference	Building / Site Description	Site Area (Acres)
	INNER ZONE	
1	Head Office Building	13.10
2	Imbus House	
3	Iolar House	
4	ALSAA Pool	
5	Annex	
6	Mock-up Building	
7	Surplus car spaces	
8	Maldron	5.16
9	Garden Centre / Ancillary land	2.06
	TOTAL	**20.32**
	MIDDLE ZONE	
10	Cloghran House	0.55
11	St Josephs Credit Union	
12	Carpenters' Building	3.36
13	Maintenance Building	1.47
14	Purple Staff Carpark	8.05
15	Green Staff Carpark	3.37
16	White Staff Carpark	1.47
17	Taxi Rank	3.09
18	Kylemore Café	
19	The Radisson	3.26
20	Kealy's Carpark	0.63
	TOTAL	**25.25**
	OUTER ZONE	
21	Long Term Green Carpark	18.86
	TOTAL	**18.86**

Appendix 2: daa adjustments to CBRE valuation to reflect existing occupancy/use Confidential

Appendix 3 - Report on Willingness to Pay for Improvements to Dublin Terminal 1

Source: NERA Economic Consultants

NERA
ECONOMIC CONSULTING

Accent

Willingness to Pay for Improvements to Dublin Airport Terminal 1

Report for daa

30 July 2014

Project Team

<u>NERA</u>

Stuart Holder

Richard Druce

Peter Spittal

Thomas Ash

Alexander Malanyuk

<u>Accent</u>

Rob Sheldon

Rachel Risely

<u>Peer Reviewers</u>

Professor Kenneth Train (NERA and University of California, Berkeley)

Sarah Butler (NERA)

Professor Ken Willis (Newcastle University)

NERA Economic Consulting
15 Stratford Place
London W1C 1BE
United Kingdom
Tel: 44 20 7659 8500 Fax: 44 20 7659 8501
www.nera.com

CONFIDENTIALITY

We understand that the maintenance of confidentiality with respect to our clients' plans and data is critical to their interests. NERA Economic Consulting rigorously applies internal confidentiality practices to protect the confidentiality of all client information.

Similarly, our approaches and insights are proprietary and so we look to our clients to protect our interests in our proposals, presentations, methodologies and analytical techniques. Under no circumstances should this material be shared with any third party without the prior written consent of NERA Economic Consulting.

Contents

Executive Summary

This report, by NERA Economic Consulting and Accent for Dublin Airport Authority (daa), provides new evidence on the value to passengers that would be associated with a number of improvements to Terminal 1 (T1) at Dublin Airport. daa has drawn up a redevelopment proposal for T1 that aims to provide the capacity necessary to meet future traffic growth, to provide an improved experience for passengers, and to enhance retail opportunities. Some elements of this programme will provide benefits to existing or future airlines, and some elements will provide benefits to passengers. This report considers only those parts of the programme that will provide benefits mainly to passengers.

We focus on three specific parts of the T1 redevelopment programme:

- a range of improvements to the façade of T1, which will give the terminal a more modern outward appearance and make it more clearly identifiable as a separate terminal;
- a reconfiguration of the check-in and security screening areas of T1. The existing security screening facility will be moved to the mezzanine level – this will alleviate the pressures that both traffic growth and the introduction of new liquids, aerosols and gels regulations and other compliance requirements would place on the existing facility, allowing reduced queue times and also providing improved queuing areas before security screening and redress areas after screening. Improvements to the check-in area will provide a lighter and brighter ambience, and will allow the provision of self-service check-in kiosks and bag drop facilities plus an increase in toilet facilities;
- improvements to the arrivals area (after baggage reclaim), to provide a “modern Irish” welcome to arriving passengers, clearer wayfinding, and more space and better facilities for meeters and greeters.

The combined cost of these improvements is around €48 million, which daa has calculated would add around €0.20 per passenger to airport charges over a period of 25 years.

Stated Preference Methodology

We have used “stated preference” (SP) techniques to estimate how much extra (on top of their current fare) passengers are willing to pay for improvements to T1. This provides the most reliable methodology in cases where consumers’ preferences cannot be inferred directly from their responses in real market situations. We carried out a survey of 550 passengers, presenting them with a number of hypothetical choices between combinations of airport facilities and changes in their fare (either an increase or decrease). We then carried out an econometric analysis of their responses in order to generate robust estimates of passengers’ underlying willingness to pay for specific improvements at T1.

Our approach reflects the lessons from years of practical experience of using SP studies, often to value improvements to environmental standards or to specific aspects of transport service quality, and increasingly to assess the justification for capital expenditure in a range of regulated industries. Among other things, the questionnaire aims to present a realistic context, using a well-understood “payment vehicle” (i.e. airfares, which cover airport charges as well as a number of other costs) and clear factual descriptions of the options that respondents are asked to choose between.

Consistent with best practice, we used several different types of SP question to elicit information on passengers' willingness to pay for some or all of the proposed improvements. These included:

- "contingent valuation" questions, that test passengers' willingness to pay for the complete package of improvements. We used two different types of contingent valuation questions:
  - "dichotomous choice" contingent valuation questions, which give respondents a choice between either the status quo or the upgraded T1, with the upgraded option leading to a higher fare than the status quo,[1]
  - open-ended questions, where respondents are asked to state the maximum difference in fare for which they would still choose the upgraded option; and
- "choice experiment" questions, which are designed to test passengers' willingness to pay for the individual elements of the upgrade package. Respondents are asked to choose between two options, each of which features some elements of the improvement programme and a different change in fare.

Specific Changes Investigated

As this study is focused on the benefits to passengers that daa's investment programme will deliver, we divided the programme into five separate elements that will affect passengers in different ways:

- the improvements to the façade,
- the improved ambience and facilities in the check-in area,
- the improved layout and better queuing and redress areas for security screening,
- the expected reduction in security queue times (due to the increased capacity in the security screening area that the investment programme will deliver), and
- the improvements to the arrivals area.

For the improvements to the façade, check-in area, security screening area and arrivals area, the options included in the survey were simply either the status quo or the upgrade proposed by daa. Respondents were provided with a simple factual description of the specific improvements that each part of the programme will deliver, and a single illustration of each of the current and improved areas.

For security queue times, daa has calculated the expected difference in queue times, based on the maximum number of lanes available with or without the upgrade and projections of future traffic growth. We adopted conservative assumptions that, compared with the status quo, the proposed improvements will lead to queuing time reductions of 10 minutes in the peak hour and 2 minutes at other times of the day. But this could be an underestimate of the impact, as

[1] We used "double bounded" dichotomous choice questions, where the fare changes shown in the second or third questions reflected the respondent's answer to the previous question. For example, if a respondent chose the status quo, the next question would present the same two options but with a lower differential in fares.

the limited capacity in the current screening area plus the impact of traffic growth and new regulations could lead to much more significant increases in queuing times, perhaps at all times of the day, if the upgrade does not take place.

In addition to the specific improvements that the investment programme will deliver, survey respondents were asked to choose between options that included a hypothetical change in airfares. For options with none of the improvements, respondents were told that fares would decrease by €2.50 (selected as an easy-to-remember figure broadly consistent with the reduction in airport charges implied by CAR's Draft Determination). For options with some or all of the improvements:[2]

- in the dichotomous choice contingent valuation questions, respondents were told that the option with all of the improvements would be accompanied by fare increases of €2.50, €7.50 or €17.50,[3]
- in the choice experiment questions, respondents were told that options featuring some but not all of the improvements would be accompanied by changes in fares of -€1.50, zero, +€2.50 or +€7.50.

Figure 1 and Figure 2 show examples from the computer-based survey software of the SP questions that respondents were asked.[4]

---

2 These values were chosen for the pilot survey, based on evidence from similar studies and the project team's experience. The pilot survey worked well, and did not suggest a need either to increase or decrease these amounts.

3 These were the amounts shown on the first question (chosen at random from the three amounts). The amounts shown in subsequent questions then depended on the responses given.

4 As discussed further in the body of this report, respondents were also shown illustrations and descriptions of the proposed improvements to the airport facilities to enable them to make informed choices.

Figure 1
Example of Choice Experiment Question

Choice 1/8
Which option do you prefer A or B?

	Package A	Package B
TERMINAL 1 FACADE	As now	Improved
CHECK-IN AREA	As now	As now
SECURITY SCREENING AREA	As now	As now
SECURITY QUEUE TIMES	9 minutes	11 minutes
ARRIVALS AREA	Improved	As now
The **CHANGE IN YOUR FARE** above inflation to provide the service quality above is	Increase of **€7.50** Increase in total fare from €100.00 to €107.50	**No change in your fare** Total fare remains €100.00

Option A　　Option B

Figure 2
Example of Dichotomous Choice Contingent Valuation Question

Which option do you prefer A or B?

	Package A	Package B
TERMINAL 1 FACADE	As now	Improved
CHECK-IN AREA	As now	Improved
SECURITY SCREENING AREA	As now	Improved
SECURITY QUEUE TIMES	11 minutes	9 minutes
ARRIVALS AREA	As now	Improved
The **CHANGE IN YOUR FARE** above inflation to provide the service quality above is	Decrease of **€2.50**	Increase of **€2.50**

Option A　　Option B

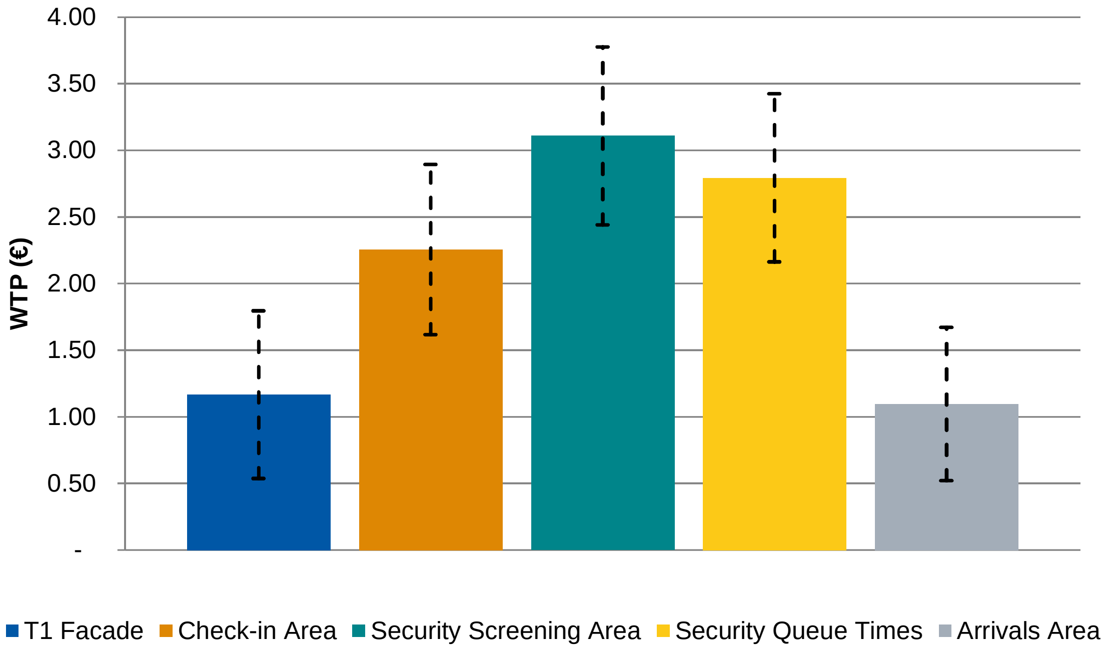
Findings

The main survey data consist of 550 completed responses. Respondents were recruited at T1 and invited to fill in an online questionnaire at a later date. We have analysed the composition of the sample to confirm it is representative of the wider population of passengers who use T1.

Our econometric analysis generated statistically significant estimates of passengers' willingness to pay for individual elements of the investment programme, and for the complete package of improvements. <u>We found these results to be robust</u> to the use of a number of different econometric models, and also the exclusion of some responses (e.g. possible protest responses) from the sample, which both resulted in only very small changes in estimated willingness to pay.

Figure 3 shows our central estimates of passengers' average willingness to pay for separate parts of the investment programme, together with the 95 per cent confidence intervals around these estimates. We estimate average willingness to pay of a little over €1 for each of the façade and arrivals area improvements, and between €2.26 and €3.11 for each of the check-in area, security screening area and security queue time improvements.

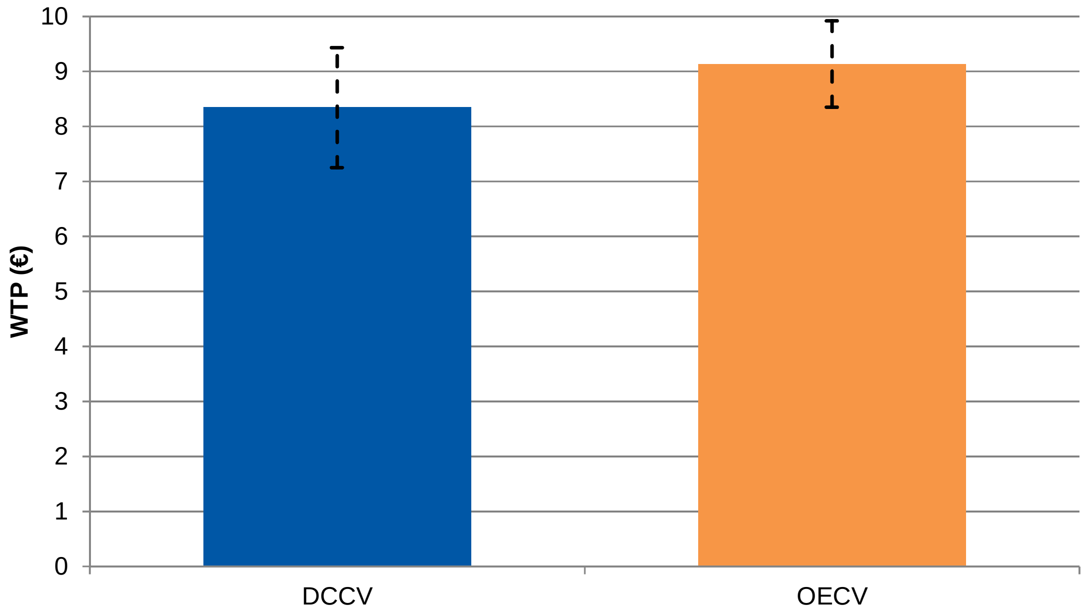
Figure 3
Willingness to Pay Estimates from Choice Experiment Questions



We found that including some details of passenger characteristics in our econometric models provided a better fit (and therefore more reliable estimates). In summary, passengers travelling with another adult, with children under 16, or who are UK residents had higher willingness to pay than the average of all T1 passengers, and there were some differences by airline. Passengers who checked in a bag had a higher than average willingness to pay for the improvements to the check-in area.

Figure 4 shows our central estimates of passengers' willingness to pay for the complete package of improvements (with, as before, 95 per cent confidence intervals also shown). We generated separate estimates from the dichotomous choice contingent valuation (DCCV) and open-ended contingent valuation (OECV) questions. We view the DCCV estimate, which shows passengers' average willingness to pay for all of the improvements covered by the survey of €8.34, as the most robust of the two estimates.

Figure 4
Willingness to Pay Estimates from Contingent Valuation Questions



For both sets of estimates, we found that business travellers and passengers checking-in bags had a higher than average willingness to pay. And the DCCV estimates also showed some differences across airlines. But in all cases (including non-business passengers, passengers who do not check-in bags, etc) the results were strongly positive, statistically significant, and suggest that the proposed improvements will generate benefits to passengers that significantly exceed their expected cost.

Overall, we believe our results provide strong evidence that daa's proposed improvements to T1 will generate benefits to passengers that are significantly higher than the expected cost of the improvements.

1. Introduction

This report, by NERA Economic Consulting and Accent for Dublin Airport Authority (daa), provides new evidence on the value to passengers that would be associated with a number of improvements to Terminal 1 (T1) at Dublin Airport. It draws on a stated preference survey of 550 passengers who travelled through T1 in June and July 2014, and detailed econometric analysis of their responses, to provide evidence on how passengers view the trade-off between airport charges (hence higher or lower fares) and the quality of facilities provided at T1.

daa has drawn up a redevelopment proposal for T1 that aims to provide the capacity necessary to meet future traffic growth, to provide an improved experience for passengers, and to enhance retail opportunities. Some elements of this programme will provide benefits to existing or future airlines. This report focuses on specific parts of the redevelopment programme that will mainly provide benefits to passengers (rather than benefits to airlines, or lower costs or higher commercial revenues for daa).

Future investment by daa is funded through airport charges, which are subject to a maximum price cap set by the Commission for Aviation Regulation (CAR). CAR's statutory objectives include references to meeting the requirements of, and protecting the interests of, "current and prospective users of Dublin Airport". When considering how much allowance for future investment to include in its price cap calculations, CAR has placed considerable weight on the views expressed by airlines and ground handlers. These parties have been involved in extensive consultations on daa's proposed investment programme. But passengers and other users of Dublin Airport have not so far been involved. In paragraph 6.32 of its Draft Determination, CAR states that "we have to this stage been limited to hearing the views of airlines and ground handlers".

In response to daa's argument that CAR's approach to regulation needs to place more emphasis on the views of passengers, in paragraph 2.8 of its Draft Determination CAR states that:

> "We are mindful that the definition of user for the purposes of making a Determination is broader than just airlines, and we are interested in receiving the views of the wider airport community on this Draft Determination. We expect the generality of users will a prefer lower price cap or more demanding service-quality standards to the status quo, but would be interested to hear from parties prepared to pay more for an even better service or, conversely, those who would sacrifice service quality in return for even lower airport charges. This Draft Determination is also an opportunity for all users, and not just airlines, to comment on DAA's investment plans at Dublin Airport."

This report provides significant new evidence on passengers' views, and in particular how they regard the trade-off between lower airport charges (hence lower fares) or improvements in facilities at Dublin Airport. It does so by applying best practice techniques that have been used for many years as an important input to government investment decisions, and have been increasingly seen by economic regulators as the best source of evidence on how customers value potential improvements in service standards.

Section 2 describes the specific investments covered by the survey, then Section 3 provides an overview of the use of stated preference techniques. Sections 4 to 7 give details of the questionnaire we used, the pilot survey, the performance of the survey and the econometric methodology we used to estimate passengers' willingness to pay (WTP) for the proposed improvements. Section 8 shows the main results that we generated from the survey, and Section 9 contains some concluding comments.

Appendix A to Appendix D provide further information about the study, including details of certain responses that we considered excluding from the analysis, further details of our econometric estimates, an overview of a range of sensitivity tests that we carried out, and a copy of the full questionnaire used for the survey.

As well as the highly experienced project team from NERA and Accent, we have benefitted from advice from two internal peer reviewers and one external peer reviewer. They are:

- Professor Kenneth Train, Adjunct Professor of Economics and Public Policy at the University of California, Berkeley and a Vice President in NERA's San Francisco office. He is a world expert in choice modelling, and has over 25 years' consulting experience in energy, telecommunications, environmental, transportation, and regulatory issues;
- Sarah Butler, Vice President NERA's San Francisco office and an expert in survey research, sampling, market research and statistical analysis. Prior to joining NERA, Sarah worked in market research, conducting survey research, focus groups, and in-depth interviews.
- Professor Ken Willis, Emeritus Professor of Economics of the Environment at the School of Architecture, Planning and Landscape at Newcastle University. He is Director of the Centre for Research in Environmental Appraisal & Management, and a renowned expert in the theory and practice of measuring willingness to pay. He has carried out applied studies in a wide range of industries, estimating willingness to pay for environmental policy and a wide range of applications in water, transport and other industries.

Professor Willis' review of the project is in Appendix E.

2. Summary of Proposed Improvements

T1 at Dublin Airport was opened in 1972 and, until the opening of Terminal 2 (T2) in 2010, was the only terminal operating at Dublin Airport. While T1 has been extended and had new piers added in the 42 years since its opening, there is now a clear difference between the dated appearance of T1 and the modern ambience of T2. As well as providing an inferior experience for passengers using T1, compared with those using T2, the current situation means that existing airlines have expressed reluctance to switch from T2 to T1, and new airlines might be reluctant to use T1 rather than T2. This will make it more difficult in future for daa to make the most effective use of the available capacity at Dublin Airport. And expected traffic growth and changes in security regulations mean that T1 may suffer from significant capacity constraints if some of the proposed investment does not take place.

To address this situation, daa has drawn up a redevelopment proposal for T1. As well as providing an improved experience for passengers, this investment programme aims to provide the capacity necessary to meet future traffic growth, and also to enhance retail opportunities. Some elements of this programme will provide benefits to existing or future airlines, for example because it will allow larger aircraft to use Dublin Airport in future.

This report focuses on three parts of the redevelopment programme that will mainly benefit passengers using T1:

- improvements to the façade of T1;
- a reconfiguration of the check-in and security screening areas of T1; and
- improvements to the arrivals area (after baggage reclaim).

As described below, three separate ways have been identified in which the reconfiguration of check-in and security screening areas would affect passengers, and we have included each of these as separate improvements in the survey. The survey therefore covers five separate aspects of the proposed improvements. For each of these, we have considered only two options: that the investment is undertaken in full, or that the improvement is not implemented at all.

The combined cost of these improvements would be around €48 million, which daa has calculated would add around €0.20 per passenger to airport charges over a period of 25 years.

We have excluded other parts of the investment programme from our analysis because they will generate benefits (e.g. improved service to airlines, improved operating efficiency) that do not directly affect passengers.

2.1. Improvements to the Terminal Façade

T1 is nearing the end of its design life, and requires a structural and environmental protection rehabilitation that will see its life extended for the next 20 years. The proposed investment will give the terminal a more modern outward appearance, and make it more clearly identifiable as a separate terminal.

These improvements are shown in Figure 2.1, which compares the current appearance of the T1 façade (in Panel A) with an artist's rendering of the façade following the improvements (in Panel B). These are essentially cosmetic changes, with an expected cost of less than €1 million.

Figure 2.1
T1 Façade Improvements

Panel A: As Now **Panel B: Proposed Improvement**

2.2. Reconfiguration of Check-In and Security Screening Areas

New regulations for the inspection of liquids, aerosols and gels (LAGs), due to come into effect from 2016, are likely to require larger security screening machines and lead to slower security processing times. Combined with the impact of expected future traffic growth, this means that there will be insufficient space at the current security screening area in T1 to meet anticipated future demand and longer queues will result.

To address this situation, daa proposes a reconfiguration of the check-in and security screening areas of T1. The existing security screening facility will be moved to the mezzanine level – as well as providing space for extra lanes and thus alleviating the pressures that both traffic growth and new LAGs regulations and other compliance requirements would place on the existing facility, the upgrade will also provide improved queuing areas before security screening and redress areas after screening. Improvements to the check-in area will then provide a lighter and brighter ambience, and will allow for the provision of self-service check-in kiosks and bag drop facilities plus an increase in toilet facilities.

For the stated preference survey, we separate the likely impacts of this reconfiguration into three discrete sets of improvements in passengers' experience – the improved ambience and facilities in the check-in area; the improved layout and better queuing and redress areas for security screening; and the expected reduction in security queue times.

2.2.1. Improved check-in area

daa's proposed investments in the check-in area are expected to generate improvements such as:

- clearer information, such as improved departure boards and wayfinding signage;
- a lighter and brighter ambience, in a naturally lit environment;
- provision of self-service check-in kiosks and bag drop facilities; and
- an increase in toilet facilities.

Figure 2.2 provides a visual comparison of the current and upgraded check-in areas.

Figure 2.2
Check-in Area Improvements

Panel A: As Now **Panel B: Proposed Improvement**

2.2.2. Improvements to the security screening area (excluding reduced queue times)

Aside from reductions in queue times, daa's investment in the security area is expected to deliver:

- improvements to ensure ease of movement and circulation through the area (such as more spacious areas for security queues and for repacking after the security check, and dedicated queue lanes for families and elderly passengers);
- shortest lane indicators to help improve queue management;
- a dedicated "redress" area after security; and
- improved information on wayfinding and flight details immediately after security.

We provide an illustration of the current and future layouts in Figure 2.3.

Figure 2.3
Security Screening Area Improvements

Panel A: As Now **Panel B: Proposed Improvement**

2.2.3. Reduced security queue times

daa's proposed investments in the security screening area will increase the amount of space available, and so will allow more capacity to be provided in peak times. If the investment does not go ahead, the implementation of future mandatory screening requirements will mean that queue times will increase compared with current levels.

daa has calculated the expected difference in queue times, based on the maximum number of lanes available with or without the upgrade and projections of future traffic growth. We adopted conservative assumptions that, compared with the status quo, the proposed improvements will lead to queuing time reductions of 10 minutes in the peak hour and 2 minutes at other times of the day. But this could be an underestimate of the impact, as the limited capacity in the current screening area, plus the impact of traffic growth and new regulations, could lead to much more significant increases in queuing times, perhaps at all times of the day, if the upgrade does not take place.

In the survey, respondents were asked to estimate how long they had queued at security screening. Starting from their estimate, the options presented to them included security queue times as summarised in Table 2.1.[5]

5 If respondents reported queue times of less than 6 minutes (peak passengers) or 2 minutes (off-peak passengers), rather than the adjustments shown in Table 2.1, they would be shown options with queue times of 1 or 11 minutes (peak passengers), or 1 or 3 minutes (off-peak passengers).

Table 2.1
Impact of Investment on Security Queue Times

	Peak queue times	Off-Peak
Improvement	5 minute reduction	1 minute reduction
No Improvement	5 minute increase	1 minute increase

Note: Peak times refer to all passengers departing between 06:30am and 07:30am.

2.3. Improvements to the Arrivals Area

There has been relatively little change to the arrivals area in T1 over the past 40 years. daa has proposed a rehabilitation programme to reset the area's basic fabric, in order to place it on a firm footing for the next period of its operational life.

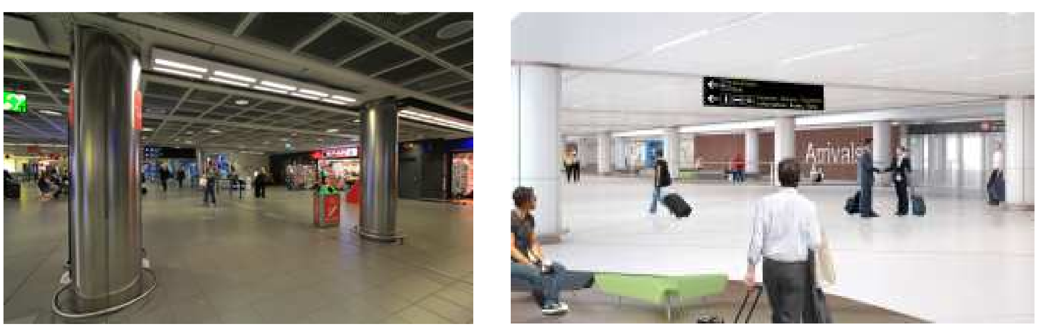
From the passenger's point of view, the benefits provided by the investment would include:

- an enlarged space for meeters and greeters, with better retail and food/beverage facilities along with an increase in the number of available seats (from 40 to 65) and a "modern Irish" welcome for arriving passengers; and
- a new "last chance" shop located after customs, and a new information "one stop shop" located adjacent to the exit doors.

Figure 2.4 illustrates the impact of these improvements.

Figure 2.4
Arrivals Area Improvements

Panel A: As Now **Panel B: Proposed Improvement**



3. Overview of Stated Preference Techniques

3.1. Theoretical Background

This study uses Stated Preference (SP) techniques to estimate passengers' willingness to pay for improvements to T1 at Dublin Airport. SP studies rely on data derived from individuals' descriptions of how they would act in given hypothetical situations. This is in contrast with Revealed Preference (RP) methods, which rely on data derived from individuals' actual responses to real market situations. Both SP and RP are used to estimate demand for goods and services where there exists no market for them.

In cases where relevant WTP information can be inferred from actual decisions, there is a case for preferring RP to SP as the estimates are based on individuals' actual choices, rather than choices they simply say they would make. However, there are a number of situations in which SP has advantages over RP. For example, a SP study can be used to:

- value hypothetical situations, whereas RP requires the attributes being valued (or attributes that are sufficiently similar) to be provided currently, and for individuals to actively make choices between them;
- tailor the estimates to the particular characteristics of the proposals being valued, and can be designed to elicit WTP for specific attributes or components of the programme;
- identify WTP for characteristics that constitute only a part of variation in price, as the questions can be designed so that changes in characteristics are linked directly to a specified change in price. By contrast, RP requires that price varies closely with changes in the attributes being valued. An implication of this is that, in these situations, robustly estimating WTP from RP data would require a far larger dataset than is required for SP; and
- provide a more precise estimate of total WTP than is available from RP studies. Observing how individuals behave in real market situations can only set broad limits on WTP: for example, if an individual chooses to buy a good, it reveals only that their WTP for its attributes is *at least* equal to the price they paid for it. Similarly, by choosing not to buy a good, the individual reveals only that their WTP is less than the price. SP surveys can be designed to generate a closer estimate of true WTP.

For a number of these reasons, SP is clearly more appropriate than RP for valuing daa's proposed investments in T1. By using SP, the study can be tailored to value the specific investments daa is considering, and so provide a close estimate of passengers' WTP for these improvements. And as both airfares and passengers' choice of airport reflect a large number of different factors in addition to airport quality, it would be difficult to obtain robust estimates of individuals' WTP for particular attributes from RP data.

In addition to SP and RP, both of which aim to derive WTP directly, some studies attempt to take information on WTP from one context and apply it to another. This is known as Benefits Transfer (BT). For example, in order to provide a WTP estimate for a benefit which has been valued in other contexts (such as avoiding noise or air pollution), researchers may apply (or adjust) these existing estimates instead of valuing the benefit directly.[6] However, BT suffers from many of the same problems as those listed above, particularly that it is impossible to generate WTP estimates tailored to a specific set of proposals using BT.[7] For this reason, and because BT is generally perceived to be unreliable (Bateman, et al 2002),[8] we focus on estimating WTP using SP in this report.

3.2. Use in Regulated Industries

SP methods are based on market research techniques developed in the US during the 1970s (Fowkes 1998),[9] and were first used to value non-market benefits in transport and environmental appraisal in the 1980s. The techniques have been applied widely in the period since, alongside a large academic literature which has developed a set of best practices. Recently, SP studies have been used in the UK to value the impacts of regulated company projects and programmes in a number of industries, including as an input to regulatory reviews.

SP studies have been commissioned by some airports to estimate passengers' willingness to pay for proposed improvements, including studies for Gatwick and Heathrow conducted by Accent. In its Final Proposals on the regulation of Heathrow from April 2014, the UK CAA noted that: [10]

> *the CAA acknowledges the value of research of this kind in gauging consumer preferences and relative priorities.*

The CAA has also commissioned a SP study directly, which it used alongside the SP study commissioned by Gatwick in deciding which capex schemes to include in its projections for Gatwick. It noted that the results of the two studies were similar, which gave it confidence in the robustness of the results:[11]

> *Where GAL and CAA research examined similar attributes, for example reducing security or check-in queues, the values identified were similar. This provided some confidence in the results.*

---

6 In some contexts, a study may apply a monetary estimate of WTP from another study directly. But it is also common for adjustments to be made to the WTP estimate in an attempt to make it more applicable to the characteristics of the proposal.

7 While there have been a limited number of studies aimed at valuing improvements to airport terminals, such as those discussed in Section 3.2, these studies have (1) not been conducted for Dublin T1 and (2) do not elicit values for daa's specific research proposal. Transferring these values to the present study would require very careful interpretation and a number of adjustments, and would be unlikely to provide robust or reliable estimates.

8 Bateman, et al. (2002), *Economic Valuation with Stated Preference Techniques, A Manual*

9 Fowkes (1998), "The development of stated preference techniques in transport planning", Working paper, Institute of Transport Studies.

10 CAA (2013), "Economic regulation at Heathrow from April 2014: Final Proposals", 3 October 2013, paragraph 11.9

11 CAA (2013), "Economic regulation at Gatwick from April 2014: Final Proposals", 3 October 2013, paragraph 4.38

In the English and Welsh water and sewerage industry, Ofwat strongly endorses the use of SP to value customers' investment priorities as an input to cost-benefit analyses.[12] As a result, almost every water and sewerage company with planned (non-statutory) investments conducts SP studies at each price review. For example, in Ofwat's PR14 guidance document, it states:[13]

> *We expect companies to have carried out appropriate benefits valuation assessments, such as 'willingness to pay' (WTP) or stated preference surveys, and collected other forms of evidence to back up their proposals, where appropriate.*

Ofwat has also played a central role in developing a common framework for the use of SP in the water and sewerage industry. This work led to the publication of UKWIR (2011),[14] which constitutes the industry guidebook on the use of SP in company business planning.

In addition, when government agencies seek to value the benefits of policy options related to environmental objectives in the water and sewerage industry, they often make use of SP evidence to assess option ability. For example, Defra commissioned a report in 2007 to value benefits associated with the EU's Water Framework Directive, which drew substantially on a SP study.[15]

SP studies have also been used in other UK regulated industries. In the energy industry, Ofgem has required transmission companies to provide evidence on consumers' WTP to reduce the visual impact of existing electricity transmission infrastructure in nationally designated landscapes as an input to the most recent price review (RIIO-T1). NGETL commissioned a stated preference study to support its submission. SP studies have also been commissioned by some of the electricity Distribution Network Operators (DNOs) as part of the ongoing RIIO-ED1 review. And in post the UK postal regulator (Postcomm, before regulatory responsibility was transferred to Ofcom), commissioned a SP study to estimate the social value of the post office network in order to support the UK government's application for state aid approval.[16]

3.3. SP Best Practices

We believe that SP provides the most robust basis for valuing the proposed improvements to T1.[17] However, we note that there are a number of potential pitfalls with this approach,

---

12 It has emphasised the importance of SP studies for two five-yearly regulatory reviews: PR09 and the current PR14.

13 Ofwat (2013), "Setting price controls for 2015-20 – final methodology and expectations for companies' business plans", July 2013, appendix A5.2.1

14 UKWIR (2011), "Carrying out willingness to pay surveys", 11/RG/07/22

15 NERA and Accent (2007), "Report on the benefits of water framework directive programmes of measures in England and Wales", 6 November 2007.

16 NERA and Accent (2009), "The Social Value of the Post Office Network", 5 August 2009.

17 And, as described in Section 3.2, regulators in aviation and other industries have relied on SP evidence in a similar context as an input to periodic reviews.

which it is important to consider when (1) designing the questionnaire[18] and (2) analysing the data generated by the survey to reliably draw inferences about consumers' preferences.

For example, questionnaire respondents may not give the options presented to them in a SP survey the same amount of attention that they would if they were acting in a real market (in which their choices would have an actual and direct financial implication). Or a respondent might purposely under- or over-state their true WTP if they realise that doing so is likely to lead to the outcome they prefer being implemented.

However, there is a substantial literature on estimating WTP robustly using SP techniques, which has developed a number of best practices designed to minimise the risks associated with SP. We outline a number of these best practices in this section.

3.3.1. Sample characteristics

It is important to ensure that the sample of survey respondents is representative of the target population (in the case of the present study, comprising users of Dublin T1).[19, 20] The estimates of average WTP will be biased if the sample is unrepresentative, and so it is important to choose a sampling method that ensures that the sample reflects the target population.

It is also important to verify the representativeness of the sample once it has been collected by comparing its characteristics with those of the target population. If this comparison reveals that the sample is unrepresentative in some way, and so the survey risks producing biased estimates of WTP, it may be possible to apply adjustments in subsequent analysis (for example, by applying higher weight to under-represented subgroups) to ensure that the estimates are representative of the population.[21]

It is also important to ensure that the sample is large enough to estimate WTP accurately, especially when estimating separate values for different subgroups of the population.[22] With a small sample, random variation in the data may make it difficult to identify statistically significant values.

---

18 Questionnaire "design" entails deciding on factors such as: the overall structure and order of the questions, the way the questions are worded and which information is presented, the specific combinations of attributes and payments included in valuation questions, and the inclusion of questions intended to validate responses. We describe our survey design in Section 4.

19 Note that, when we refer to "population", we are referring to all users of Dublin T1 and not, for example, the entire population of Ireland.

20 In addition, some people who do not use T1 might value improvements to it, for example if they feel national pride in having a modern airport terminal to welcome visitors to Ireland. Our method does not quantify these benefits, and so the total social benefit of improvements may be higher than our estimates suggest.

21 As discussed in Section 6.1, we note that our sample is representative of the population of T1 passengers, and so have not applied such an adjustment.

22 In some studies, a very large sample is required to robustly estimate separate estimates of WTP for different subsets of the population. However, this is not important in the case of the present study, where we are interested in estimating average WTP among all users of Dublin T1.

It is not straightforward to describe the impact of different sample sizes on the reliability of SP studies, as this also depends on factors such as the heterogeneity of views within the sample, and respondents' understanding of and approach to the questions asked. However, it is common to recommend sample sizes of around 500 for most valuation questions (Bateman et al 2002).[23] And it is also possible to collect more information from a sample of a given size by asking each respondent multiple valuation questions. Ultimately, however, the degree of precision in estimated valuations can be examined empirically using statistical techniques, as shown in Section 8.

3.3.2. Description of the proposed investment and payment vehicle

It is important that respondents fully understand the proposed programme of investments, so that they can make an informed trade-off between the improved quality of service they would receive and the additional charges they would face (compared to a situation in which the investments do not take place). The valuations recovered from a SP study may be sensitive to the information provided about the proposed changes, and also the way in which it is presented. In order to avoid systematic bias in the WTP estimates, it is important to:

- ensure that respondents are provided with enough information about the proposals, in a meaningful and understandable way, to allow them to make an informed decision about their WTP. It is also important to describe the "status quo" in a way that is comparable to the description of improvements; and
- avoid descriptions that are leading, or that are misleading regarding the extent of an improvement, as doing so would introduce systematic bias into the WTP estimates.

It is also important to ensure that respondents understand the method by which they would have to pay for the improvements, known as the "payment vehicle". If the respondents do not understand the way in which they would pay for the proposed improvements, or do not believe that the proposals would lead to an increased cost to them personally, they may overstate their WTP. And respondents should be given a realistic reference point (for example, their current airfare).

Finally, as far as possible, respondents should believe that their answers to survey questions will actually influence whether the proposals are implemented (and that they will be asked to pay the associated cost). If respondents do not believe that the proposals are credible, they may not answer questions sincerely (perhaps because they do not think that the questions are worth spending time considering). To provide credibility, respondents should be told:

- which organisation has commissioned the study, and the influence it has over whether the proposals are implemented;
- the context in which the study is being conducted (for example, that the proposals are currently under consideration and the commissioning organisation is deciding whether to go ahead with them); and

[23] Bateman, et al. (2002) states (on p110) that "it is common to recommend sample sizes of about 250-500 for open-ended CV questions, and about 500-1000 for closed-ended (referendum) CV questions."

- that the responses to the survey will be used directly in deciding whether to proceed with the proposals.

3.3.3. Form of choice question

In SP studies, respondents are asked a question (or series of questions) designed to elicit their WTP for a particular change. These questions often ask respondents to choose their most preferred package of improvements (and changes in price) from a small number of alternatives, or whether they would choose one particular option at a given price. Alternatively, respondents may be asked to simply state their maximum WTP for a proposed change. The form of choice question used to elicit WTP is an important consideration in designing the questionnaire, as these choices can have a substantial impact on the WTP estimates (and their validity). We discuss a number of key considerations in this section.

Researchers must decide whether to ask open-ended or closed (i.e. yes/no) questions about WTP. Responses from open-ended questions may be unreliable, as respondents often find it difficult to state their maximum WTP for a policy change that they may be unfamiliar with "out of the blue" (Bateman et al, 2002). It is therefore important to ensure that respondents are provided with sufficient context to provide a basis for their valuation when using open-ended questions. Such questions may also lead to a large number of protest responses (which are substantially higher or lower than true WTP).

By contrast, closed questions, in which the respondent is asked whether they would be willing to pay a certain amount in exchange for a programme of improvements (with the value asked randomised between respondents) can provide more robust evidence on true WTP than open-ended questions (Bateman et al. 2002). For example, closed form questions only require respondents to know whether or not they are willing to pay a given price in return for the proposal, which is more similar to the decisions they would be used to making in real markets (e.g. when shopping) than having to provide an estimate of their total WTP.

The form of choice question will also depend on whether the study aims to estimate the value of a complete package of improvements, or of individual components separately. "Contingent Valuation" (CV) questions are designed to estimate the value of an entire programme of improvements. Two widely used forms of CV question are "single-bounded" and "double-bounded" CV, which both ask a closed question about the respondent's valuation of an entire package of improvements.[24]

"Choice Experiments" (CE) are designed to estimate respondents' WTP for different components of a proposal separately from the others. In CE, respondents are asked to choose their preferred combination (or "package") of improvements from two or more alternatives. As these alternatives are made up of different combinations of improvements (rather than being "all or nothing"), they can be used to estimate WTP separately for each attribute.

---

[24] In single-bounded dichotomous choice questions, respondents are asked whether they would be willing to pay a certain amount in exchange for the proposed programme of improvements; in double-bounded dichotomous choice this question is followed up with a higher (or lower) amount in exchange for the improvements if the respondent answered yes (or no) to the first question.

Bateman et al. (2002) recommends using payment cards or dichotomous choice for contingent valuation questions, or using choice experiments to value individual attributes. As noted below, this study uses both of these valuation techniques to ensure that we cover the range of credible approaches.

Another important consideration in designing the choice questions is whether to estimate individuals' willingness to pay for the programme of improvements, or willingness to accept (WTA) compensation for the improvements to not go ahead. According to standard economic theory, whether the questions are framed as WTP or WTA should have no impact on the estimates, as respondents should consider the questions to be equivalent. However, this is unlikely to be the case in practice:

- a large literature in behavioural economics,[25] which examines the way in which individuals make choices in practice, suggests that WTA values are often larger (and sometimes considerably so) than WTP. Any differences between WTA and WTP for psychological reasons would be common to both SP and RP studies; and
- when stating a WTP value individuals are limited by their overall budget constraint, and so the values they state are unlikely to be unrealistically large. However, when asked how much they would be willing to accept in exchange for proposed improvements being cancelled, individuals may state any value.[26]

For these reasons, we believe it is more appropriate to elicit WTP than WTA. Furthermore, Bateman et al. (2002) recommends that, in principle, the value of policy scenarios should be measured in relation to a "reference" policy option (usually the "do nothing" scenario). If a policy option is an improvement relative to this reference option, the benefits should be measured by WTP; if the policy is less preferred than the reference option, its costs should be measured by WTA. Therefore, it is appropriate to measure the improvements to T1 using WTP.[27]

3.3.4. Assessing validity of responses

Following the choice questions, it is important to assess whether individuals have given valid responses, i.e. that the choices they have made reflect their true preferences, and so estimated WTP is equal to the actual value that the individual places on the proposals.

One important source of invalidity is protest responses, in which survey respondents make choices which purposely under- or overstate their actual WTP. Respondents may be motivated to provide such responses for various reasons including a rejection of the payment mechanism (e.g. being opposed in principle to an increase in airfares), a lack of belief that the

---

25 For example, Kahneman, Knetsch and Thaler (1990), "Experimental tests of the endowment effect and the Coase Theorem", *Journal of Political Economy*, *98*(6), pp1325 – 1348.

26 For example, when asked for their WTP for a product that reduces the risk of some catastrophic event by 20 per cent, an individual cannot feasibly pay more than their lifetime income. But the individual may not be willing to accept *any* compensation to have such a product taken away from them – i.e. their WTA would be infinitely greater than WTP (Bateman et al., 2002).

27 Bateman et al. (2002), p28.

proposed improvements would be introduced in practice, or opinions that daa is currently misspending its funds.

It is common practice to include questions that may identify protest responses (e.g. "what do you think about the plans to improve facilities at T1 in return for a small increase in fare paid by passengers", which may prompt respondents to state that they do not believe the improvements are credible, or that the cost should be absorbed by daa). As protest responses do not represent true WTP, it is good practice to investigate their influence on WTP estimates and consider excluding them from the analysis. We show the effect on estimated WTP of removing protest respondents as a sensitivity to our main analysis in Section 8.

Responses may also be invalid if respondents have not understood the survey questions, or have found responding to the survey to be particularly taxing. As with protest responses, it is common to include questions to establish whether respondents understood the choice questions, and felt able to answer them properly. It is also good practice to record the length of time that it took each individual to respond to the survey, as many respondents taking a long time (i.e. more than around 20 minutes) to complete the survey may indicate that it is confusing or too challenging.

4. Survey Design

4.1. Outline of Questionnaire

We include the final questionnaire used for the main survey in Appendix D. The survey is divided into two parts, which were administered at different times.

Part 1 is a recruitment questionnaire, which was administered in person to passengers waiting for departing flights at Dublin T1. The objective of this part of the survey was to ensure that our sample was representative of passengers at Dublin T1, according to type of destination airport.[28] We also collected some basic personal information, such as age, gender and country of residence.

Part 2 is the main survey. Passengers recruited at a departure gate who agreed to take part in the survey were emailed a link to the main survey a number of weeks after their initial interview, and completed it online. The main survey contains the following:

- an introductory section, which is intended to establish the credibility of the proposed investments, encourage the respondents to think that their responses could influence whether the proposed investments are carried out, and explain the mechanism by which they would face higher airfares as a result. It explains that:
  - the survey is being conducted on behalf of daa, and explains daa's role in operating Dublin Airport and setting charges;
  - the results of the research will be used to inform daa's decisions about whether to carry out the proposed improvements; and
  - daa would recover the costs of its investments through increased charges paid by airlines to use the airport, which would increase fares (whereas, absent any investment, fares are likely to fall slightly);
- a section collecting information about the respondent's recent experience of T1. We describe the information collected in this part of the questionnaire in Section 4.2 of this report. Aside from eliciting potentially useful information on the respondents' experiences of T1, which may help explain variations in WTP and allow us to estimate WTP more accurately, this section is intended to introduce the issues to be covered by the valuation questions and encourage the respondents to think about their recent experience of the terminal;
- the main valuation questions, including introductory material to explain the proposed improvements. We describe the contents of this part of the survey in Section 4.3 of this report. Our valuation section contains two exercises: (1) choice experiments, which we use to estimate passengers' WTP for each improvement separately from the others, and (2) contingent valuation questions, which we use to generate estimates of WTP for the entire package of improvements. In order to ensure that respondents' answers were not

[28] We used target quotas of sample recruits according to destination airport, to ensure that our sample matched the profile of passengers travelling through T1.

systematically influenced by the set of questions they saw first, we randomised the order of these two exercises between respondents;

- validation questions, designed to assess respondents' understanding of the valuation exercises and identify "protest responses". We describe these questions in more detail in Section 4.4 of this report; and
- questions about respondents' personal characteristics, covering the frequency with which the respondent has used Dublin Terminals 1 and 2 within the past year, the respondent's income and whether they consider themselves to have a disability that makes using an airport (or flying) difficult. Following established good practice, we have included these questions at the end of the questionnaire to minimise the information lost if respondents choose to exit the survey rather than answer the questions (which they may feel are overly personal or irrelevant).

We outline the content of these sections in more detail below.

4.2. Questions on Recent Experience of Terminal 1

The first set of questions on the main (online) survey relate to respondents' recent experience of using Dublin T1. These questions have two objectives: (1) to collect information on factors that may explain differences in WTP between respondents, which allows us to estimate WTP more accurately, and (2) to encourage respondents to recall their experience of using T1 in preparation for the valuations questions in the following section of the questionnaire.

We asked questions covering the following aspects of respondents' experience of T1:

- the cost of the respondent's ticket, and the time of their flight. We make use of both of these pieces of information when presenting the respondent with options in the valuation questions;[29]
- the check-in area, including how the respondent checked in for their flight (e.g. at an airline check-in desk, at a self-service machine in the airport, or online), whether they checked in any bags, whether they had to queue, and how they rate their experience of the T1 check-in area;[30]
- the security queue area, including the amount of time they had to queue, whether this was longer than expected, and how they would rate their experience of security queuing;
- arriving at T1 following an inbound flight, covering their experience of the arrivals hall; and

---

29 We presented changes in fare relative to the fare the respondent reported paying. We used the respondent's departure time to present changes in security queue times that would be likely to arise at the time they queued (i.e. between peak- and off-peak departure times) in each of the "improvement" and "as now" scenarios.

30 Respondents who both (1) checked in for their flight at an airline check-in desk or self-service kiosk at the airport and (2) checked in a bag were also told that, in addition to the other improvements to the check-in area, check-in times would reduce due to the provision of self-service check-in kiosks and self-bag drop.

- general questions covering the respondent's overall impression of those aspects of T1 that daa is proposing to improve, including ease of wayfinding, the ambiance and feel of the check-in and arrivals areas, the location of toilet facilities, and the location and range of retail facilities available in the arrivals area.

4.3. Stated Preference Questions

4.3.1. Introduction to SP questions

As explained in Section 3.3.2, it is crucial that respondents fully understand the implications of the proposed investments and payment vehicle, and believe that their responses may influence daa's decisions to invest. The choice card introductions have two objectives:

1. to explain the attributes to the respondents – this is important to ensure that respondents understand the attribute of service they are valuing; and
2. to explain the choice cards and the choices to be made, as respondents need to understand the information on the choice cards to make effective choices.

To meet objective 1, we have provided clear descriptions of the each of the five proposed improvements, along with pictures to illustrate the proposed impact on ambiance and layout where applicable. To ensure that respondents are able to compare the proposed improvement to the status quo, we also have provided a relevant illustration of T1 as it is currently for each improvement.

To meet objective 2, we have provided a clear set of instructions for both the choice experiment and contingent valuation questions that include (1) an example choice card, along with an explanation of its layout and (2) an explanation of the choice that we require respondents to make. Figure 4.1 shows the instructions provided to respondents before answering the choice experiment questions (and respondents were shown a similar explanation before answering the DCCV questions).

Figure 4.1
Explanation of Choice Experiment Questions

An example of a pair of options is shown below. Please take a moment to review these options.

	Package A	Package B
TERMINAL 1 FACADE	As now	Improved
CHECK-IN AREA	As now	Improved
SECURITY SCREENING AREA	As now	Improved
SECURITY QUEUE TIMES	5 minutes	10 minutes
ARRIVALS AREA	As now	Improved
The **CHANGE IN YOUR FARE** above inflation to provide the service quality above is	Increase of **€15.00** Increase in total fare from €100.00 to €115.00	Increase of **€5.00** Increase in total fare from €100.00 to €105.00

If you hover over the information icon you will see that some images have been included to help you visualise the difference between the choices.

Please select your preferred option, considering any changes to conditions and the facilities available at Terminal 1, as well as any changes to the cost of your ticket.

4.3.2. Payment vehicle

As discussed in Section 3.3.2, it is important to ensure that respondents understand the method by which they would have to pay for the improvements, known as the "payment vehicle". If the respondents do not understand the way in which they would pay for the proposed improvements, or do not believe that the proposals would lead to an increased cost to them personally, they may overstate their WTP.

In this study, <u>we have used airfares as the payment vehicle</u>. This has a number of advantages:

- it is <u>easy to understand</u>, especially as all respondents have recently taken a flight from T1. We have asked respondents to report the fare they paid for their recent flight from T1, and present variations in this fare in the SP exercises as both absolute changes (e.g. "Increase of €5") and in terms of the reported fare (e.g., for a respondent who reports a recent fare of €100, "Increase in total fare from €100 to €105") in order to provide context for the changes;
- it is <u>credible</u>, as daa is responsible for both undertaking the investments and setting charges to airlines. We have explained that fares are related to airport charges in the introduction to the survey.

4.3.3. Design of choice experiment questions

In our choice experiments, we presented respondents with a series of choice cards, each showing two packages of improvements. Each package describes a different combination of airport improvements and associated changes in fare, and we asked respondents to choose which of the two packages they prefer. We asked each respondent to consider eight choice cards. Each choice card contains:

- two randomly generated packages of improvements. As each of the five aspects of the improvement described in Section 2 is "all or nothing", there are only two potential options for each improvement (improved, or "as now");[31] and
- a randomly generated change in fare. We included the following changes in fare: a reduction of €1.50,[32] no change in fare, or an increase of €2.50 or €7.50. As described in Section 4.3.2, we have presented these changes in fare as both absolute changes, and also in the context of the fare the respondent paid.

We show an example choice card in Figure 4.2. We shaded the least good attribute in each package in order to help respondents identify their preferred package more easily. This is intended to reduce the difficulty experienced by respondents in answering the survey questions.

Figure 4.2
Example of Choice Experiment Question

Choice 1/8
Which option do you prefer A or B?

	Package A	Package B
TERMINAL 1 FACADE	As now	Improved
CHECK-IN AREA	As now	As now
SECURITY SCREENING AREA	As now	As now
SECURITY QUEUE TIMES	9 minutes	11 minutes
ARRIVALS AREA	Improved	As now
The CHANGE IN YOUR FARE above inflation to provide the service quality above is	Increase of €7.50 Increase in total fare from €100.00 to €107.50	No change in your fare Total fare remains €100.00

Option A Option B

There are 128 different combinations of each of the five improvements and different changes in fare, and so 128 unique packages.[33] We generated our choice cards, each of which contains two different packages for respondents to choose between, in the following way:

- first, we created a "long-list" of randomly generated pairs of packages; and

---

31 As each aspect has only two levels (it is improved, or it is not), there are $2^5 = 32$ different combinations of improvements.

32 Respondents were told that, in the absence of any improvements, fares would decrease by €2.50 (selected as an easy-to-remember figure broadly consistent with the reduction in airport charges implied by CAR's Draft Determination).

33 Calculated as the number of different fare levels multiplied by the number of different combinations of improvements, i.e. $4 \times 2^5 = 128$.

- we then filtered out any cards in which one package "dominates" the other, in the sense that at least some of its options are better and none are worse.

We generated a short-list of 9,000 choice cards in this way. We asked each respondent to consider eight of these, selected at random.[34]

4.3.4. Design of dichotomous choice contingent valuation questions

We used two "contingent valuation" techniques to estimate passengers' WTP for the entire package of improvements: "dichotomous choice" contingent valuation, as described in this section, followed directly by an "open-ended" contingent valuation question. We describe this open-ended question in Section 4.3.5.

In the dichotomous choice contingent valuation (DCCV) exercises, we presented respondents with a series of choice cards in which one package showed all attributes as "improved", and the other showed all attributes as "as now":

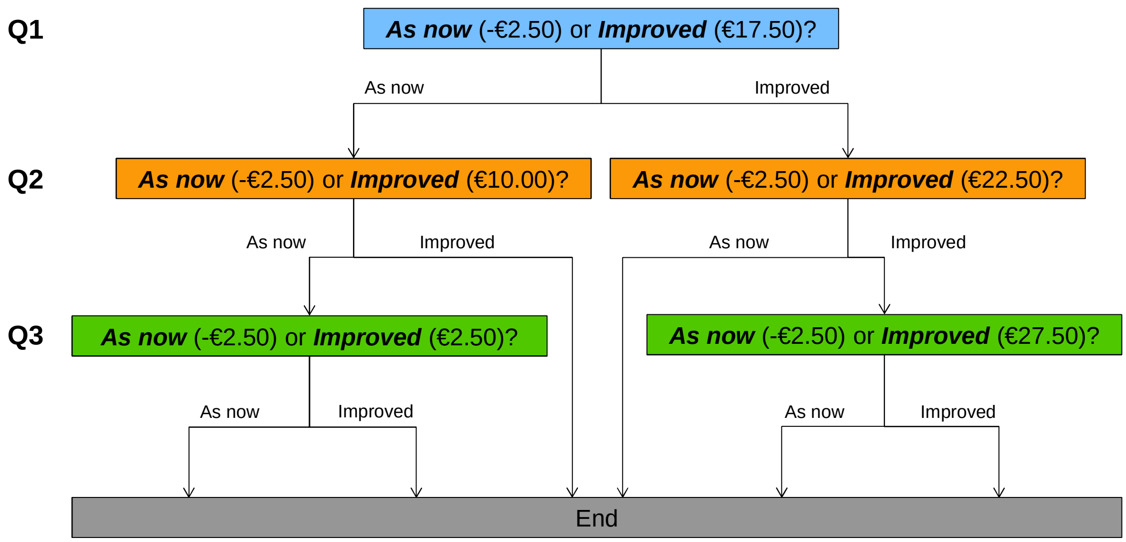
- the respondent was initially asked to choose between the two options, where the improvement option was associated with a higher fare, and the "as now" option was associated with a €2.50 fare reduction;
- respondents who chose the improvement option were then shown a similar choice card, but with a higher increase in fare associated with the improvements. Respondents who chose the "as now" option in the first question were shown a similar choice card with a lower increase in fare associated with the improvements; and
- depending on their answers to the first two questions, some respondents were shown a third question:
  - if the respondent chose the improvement option in both of the first questions, they were shown a third choice card in which the fare associated with the improvements was increased further. Similarly, respondents who chose the "as now" option in both of the first questions were shown a third card in which the fare associated with the improvements was reduced further; but
  - if the respondent's choice in the second question was different from the first (i.e. they chose the improvement option followed by "as now", or vice versa), they were not asked a third question.

The structure of these questions is illustrated in Figure 4.3 (where the change in fare associated with choosing "as now" is always a reduction of €2.50).

---

34 An alternative approach to generating our choice cards would have been to use a form of "efficient" (e.g. "D-optimal") design. Efficient designs ensure that the packages paired together on the choice cards elicit the maximum possible information from the survey, and so allow for estimates of WTP that are more precise and likely to be statistically significant. However, as discussed in Section 8, we have generated strongly statistically significant estimates of WTP with our simpler "random" choice card design.

Figure 4.3
Structure of Dichotomous Choice Contingent Valuation Questions



A potential criticism of dichotomous choice modelling is that responses may be systematically influenced by the fare presented in the first choice card. In order to eliminate any systematic anchoring, we randomly allocated each respondent one of three different fare increases (€2.50, €7.50 and €17.50) in the first question (and subsequent values).[35]

4.3.5. Design of open-ended contingent valuation questions

Directly following the DCCV questions, we asked respondents the following open-ended question about their WTP for the entire package of improvements.[36]

> *Recall that you paid €100.00 for your ticket, and if the improvements to Terminal 1 do not go ahead this would fall by €2.50 to €97.50. What is the maximum* **additional** *amount you would be prepared to pay, on top of the current fare of €100.00, to have Package B (which includes all of the improvements) rather than Package A?*

4.4. Validation Questions

As discussed in Section 3.3.4, it is important to assess whether individuals have given valid responses, i.e. that the choices they have made reflect their true preferences, and so estimated WTP is equal to the actual value that they place on the proposals. We have included questions designed to assess:

1. whether the respondent was a "protester", and motivated to purposely under- or over-state their true WTP; and

---

35 As discussed further in Section 8, we found some evidence that respondents' answers to the OECV question, which follow directly after the dichotomous choice questions, were influenced by the dichotomous choice starting value.

36 The example quoted is tailored to a respondent who reported that their recent fare was €100.

2. whether the respondent understood the valuation questions and, if not, the reasons for their misunderstanding.

We describe our approach to identifying protest responses in Section 6.2, and assessing respondents' understanding of the questions in Section 6.3.

4.5. Personal Characteristics

In the final section of the questionnaire, we asked respondents to provide personal information, covering:

- the number of flights the respondent has taken from Dublin Airport in the last 12 months, separated by (1) whether the flight departed from T1 or Terminal 2, and (2) whether the flight was for business or leisure;
- the respondent's best estimate of their total household income, before tax and other deductions;[37] and
- whether the respondent has a disability or impairment that makes using an airport or flying difficult.

As explained in Section 4.1, we have followed established good practice and asked these personal questions at the end of the survey. This minimises the information lost if respondents choose to exit the survey rather than answer the questions (which they may feel are overly personal or irrelevant).

[37] We asked respondents to indicate which of ten income categories they belong to, and also provided an option for respondents who preferred not to disclose the information.

5. Pilot Testing

We conducted a pilot study to test an initial draft of our questionnaire. This is an important part of the survey development process, as it provides the opportunity to identify any potential problems before launching the main survey. We received 109 responses to the pilot survey.

First, we conducted a general review of the questionnaire, examining aspects such as its clarity and flow, the accuracy of all routings through the questionnaire, the ease of use of the show material, the design of the valuation questions and respondents' understanding of the exercises, and the amount of time it took respondents to complete the survey. We did not identify any problems with these aspects of the survey.

As a part of this general review, we also examined respondents' answers to verbatim questions, particularly where the respondent identified that they did not understand the valuation questions. This review identified that some respondents were confused by the form of the valuation questions, and in particular the way changes in fare were presented. In response to this, we made a number of changes to the explanations of valuation questions:

- we amended the drafting of the OECV question, to clarify to respondents that they are required to state the "maximum ***additional*** amount" that they would have been prepared to pay, "on top of the current fare" (rather than a total fare);
- we also made a number of smaller changes to drafting to improve clarity throughout the survey.

We then examined the representativeness of the pilot sample, in order to identify any problems with our sample recruitment process. We compared selected characteristics of the sample to the population figures provided by daa, and found that the sample was broadly representative of the population of passengers using T1. We concluded that there was no evidence of systematic sampling bias.

We also considered whether we could improve the design of our valuation questions. We increased the set of potential choice cards that the respondents could be shown in the CE exercises, from 100 in the pilot to 9,000 in the main survey. This increased the amount of variation in our data, and is likely to have increased the precision with which we have been able to estimate WTP.

We also examined whether respondents systematically chose the highest or lowest fare option in CE and DCCV exercises, in order to assess whether the fare levels presented on the choice cards were set at an appropriate level. For both the CE and DCCV, we noted that very few respondents systematically chose the highest or lowest fare for most or all of the questions. We also noted for the DCCV questions that:

- in the first question, nearly 30 per cent of respondents shown the lowest increase in fare for the improvement package (€2.50) rejected it, and chose the package without improvements. As some respondents were not willing to pay €2.50 for the improvements, we concluded that this fare level was not set too low; and

- over 20 per cent of respondents shown the highest increase in fare for the improvement package (€17.50) in the first DCCV question accepted it, and chose the package with improvements. As some respondents were willing to pay €17.50, we concluded that this fare level was not too high.

Therefore, we concluded that the fare increments in the first DCCV question were set at an appropriate level. However, we noted that a number of respondents whose first DCCV question showed a large fare increase chose the "as now" option in all three questions, and so their responses provided only limited information on their WTP. To address this, we increased the rate at which the fares increment for the "improvement" option declines throughout the subsequent DCCV questions, to reduce the likelihood that respondents would be shown a series of values that were all above their WTP.[38]

Finally, we conducted some initial econometric analysis of the data. If this analysis had produced counterintuitive results (such as negative estimates of WTP), it may have suggested a problem with the design of our survey (e.g. the way the proposed improvements were presented to respondents, or the level of the fare increments).

We found that all of our models produced intuitive and economically meaningful coefficient estimates on the improvements and change in fare, which were generally statistically significant. The models also produced WTP estimates that were generally statistically significant.[39]

Because of the limited time available to conduct the pilot analysis, and because it was only intended to provide a high-level check of survey performance (rather than generate robust results), we analysed the results of both the CE and DCCV models using conditional logit models. However, due to the interrelationship between the first, second and third questions in the DCCV, the WTP estimates derived using this technique are "inconsistent".[40] While we did not consider this to be a problem for the pilot analysis, for which robust results were not a priority, we used a more robust econometric approach to analyse the data from the main survey. This approach, as described in Section 7.2.2, makes more efficient use of the information provided by DCCV questions, and produces "consistent" estimates of WTP.

Overall, we concluded that the pilot survey performed well and produced coefficient estimates, and estimates of WTP, in line with expectations. However, due to the number of changes we made to the questionnaire between the pilot and the main survey, we have not included responses from the pilot in our main analysis.

---

38 We also considered a possible increase in the fare variation shown in the CE questions, as a reasonably high proportion of respondents were willing to select the highest fare option (suggesting that they may be willing to pay more). However, we decided to retain the existing fare levels to ensure that our WTP estimates are conservative.

39 The WTP estimates from our DCCV data were not statistically significant, but were nonetheless economically meaningful (as the coefficient estimates had the expected sign, and produced estimates of WTP that were similar in magnitude to our CE and OECV analyses). The statistical insignificance is likely to have been due to the relatively limited sample and the econometric methodology used to assess the pilot survey DCCV responses. As described in Section 8.2, our analysis of the DCCV data using the main sample finds a statistically significant average willingness to pay.

40 This means that, even in very large samples, the coefficient estimates derived from the model will not necessarily reflect the "true" parameters.

6. Survey Performance

6.1. Sample Representativeness

Our sample contains 550 respondents who recently took a flight from Dublin T1.[41] This is larger than the minimum sample sizes recommended for studies of this type, as discussed in Section 3.3.1. It is important to ensure that the sample used is representative of the population to avoid systematic sampling bias. daa has provided data on the average characteristics of T1 users in 2013,[42] including a breakdown of passengers by: gender, age, social class, purpose of trip, country of residence, party type (e.g. travelling alone, in a family group with children under 16, or with adults) and party size.

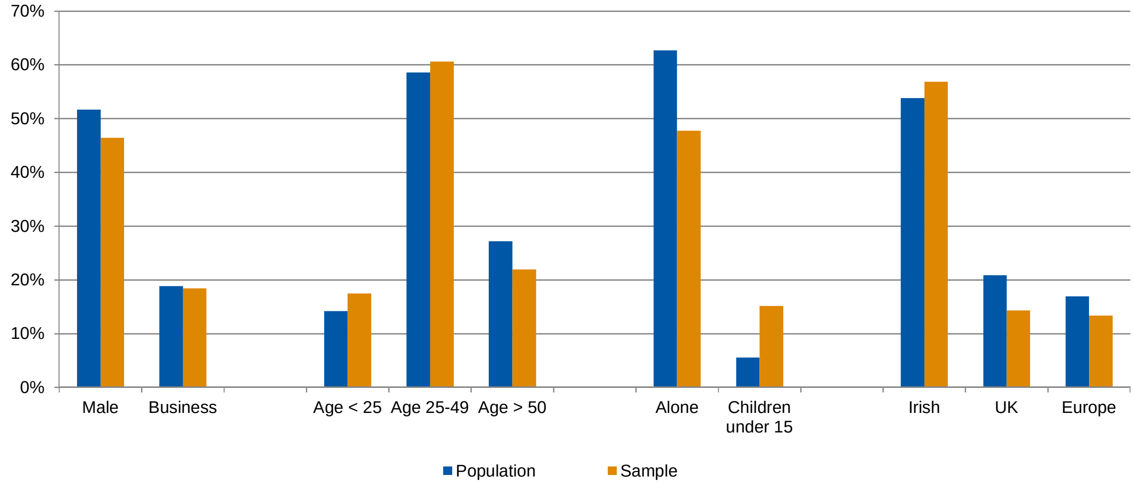
Figure 6.1 compares selected characteristics of the sample to the population figures provided by daa. Our sample appears to be broadly representative of the population. Male and business travellers are slightly over-represented, but the difference between our sample and the population characteristics is less than 5 per cent. Younger passengers also are slightly over-represented, but the difference is similarly small. The only characteristic for which there is a larger difference between the sample and the population is the respondents' party composition. People travelling with children under 15 are over-represented in our sample and passengers travelling alone are slightly over-represented.

However, taken together these differences are not large and we do not suspect any systematic sampling bias.

[41] Our dataset contains 542 respondents who completed the entire survey, and a further 65 who completed part of the survey. Of these 65, we have included eight respondents in our final dataset who completed all but the final three questions, none of which is directly relevant for our analysis. These questions asked whether the respondent would be happy to be contacted again for clarification or further research, and how they would like to receive their payment for completing the survey.

[42] These data are contained in "Demographic Profile 2013 and Q2 2013 -Request from Accent-Nera.xlsx", received by Accent on 22 May 2014.

Figure 6.1
Comparison of Sample with Population



6.2. Protest Responses

As described in Section 3.3.4, “protest responses” may provide an inaccurate view of a respondent’s true valuation. Respondents may be motivated to provide such responses for various reasons including a rejection of the payment mechanism, lack of belief in proposed improvements, or opinions that DAA is currently misspending its funds. As protest responses do not represent a true valuation, it is important to examine whether they significantly influence results.

We have investigated respondents’ verbal answers to the question "What do you think about the plans to improve the facilities at T1 in return for a small increase in the fare paid by passengers?". We have assessed the answers against three criteria, developed from first principles and experience of previous stated preference studies. The criteria are as follows:

1. Respondent believes that daa is responsible for paying for service improvements, and that improvements should not cause increases in fares;[43]
2. Respondent believes that current revenues are being misspent by daa; and
3. Respondent does not believe that proposed improvements will actually happen.

We have also examined responses to the 13 questions asking respondents to rate daa on a range of factors (e.g. “How would you rate your overall journey through the check-in area of Terminal 1?”). We have investigated all respondents who responded “Poor” or “Extremely Poor" to six or more of these questions, as this suggests general dissatisfaction with daa, and may indicate that the respondent will protest.

---

43 However, we have been careful to distinguish between (1) passengers with genuinely low (or zero) WTP and (2) protest respondents who are opposed to an increase in fare in principle.

Following this investigation, we have identified 29 (out of 550) protest responses. We provide a list of these responses, along with the reason for identifying them as protesters, in Appendix A.1. We have investigated the sensitivity of our results to excluding these responses from the sample and, as discussed in Section 8, found that our results are not sensitive to whether their responses are included.

6.3. Respondents' Understanding of Questions

As described in Section 3.3.4, it is important to establish whether any respondents had difficulty understanding the choice questions, as misunderstanding may invalidate results. We have identified cases where we suspect respondents may have misunderstood the questions, and examined the sensitivity of our WTP estimates to excluding these respondents.

We asked two questions designed to establish respondents' understanding of the SP questions: "Did you feel able to make comparisons between the choices presented to you?" and "In the choices, did you find each of the levels of service described realistic & easy to understand?". If respondents answered "no" to either of these questions, they were asked to provide reasons.

In all cases where respondents indicated that they did not understand the survey questions, we have investigated their written explanations for their lack of understanding. We have determined that the respondent misunderstood the questions if their explanation clearly indicated that they were confused by aspects of the survey.

Following this investigation, we have identified 39 (out of 550) such respondents. We provide a list of these responses, along with the reason for identifying them as protesters, in Appendix A.1. We have investigated the sensitivity of our results to excluding these responses from the sample and, as discussed in Section 8, found that our results are not sensitive to whether their responses are included.

7. Analytical Approach to Estimating WTP

7.1. Analytical Framework

Our analysis of WTP is founded on the theory of "utility", which is an economic concept that is intended to represent passengers' general wellbeing. We assume that each passenger's utility depends on (1) the quality the airport terminal provided by daa and (2) their fare – i.e., all else equal, passengers prefer higher quality and lower fares. Lower fares act as a proxy for the amount of money that passengers have left to spend on other things from which they also derive "utility".

Willingness to pay represents the increase in fare that would exactly offset any increase in a passenger's utility due to the upgraded airport facilities, so that the respondent's utility would be the same with either (1) the upgraded facilities (and a fare increase equal to their WTP) or (2) the status quo. Box 7.1 shows how WTP is derived from estimated utility functions.

Box 7.1
Willingness to Pay Calculations

The relationship between customers' utility, improvements to T1 and their airfare can be represented in an equation:

Utility (U) = a × Improvements (I) - b × Fare (F) + Residual, or random error (e)

The residual represents all the other factors that determine utility which are not represented in the equation (and is assumed takes a value of zero on average). Willingness to pay is the fare change that keeps a passenger's utility constant when the airport facilities are improved. We therefore need to examine *changes* in the utility function, which we represent using the "Δ" notation:

$\Delta U = a\Delta I - b\Delta F$

To find the fare change required to keep utility constant when the improvements are implemented, set $\Delta U = 0$ and rearrange the equation to obtain:

$WTP = \Delta F = (a / b) * \Delta I$

Hence, willingness to pay for improvements to the terminal is defined by the ratio a/b. These calculations underpin the estimation of willingness to pay in the remainder of this chapter.

7.2. Estimation Techniques

7.2.1. Choice Experiments

We used logit models to analyse the responses to the choice experiments, which model probabilities as a function of other variables. In this study, we modelled the probability that a respondent chooses a particular package of improvements as a function of its attributes (i.e.

the five improvements, and the associated increase in fare). We used the estimated coefficients from these regressions to estimate willingness to pay for each of the improvements.

We considered two specific forms of logit model for this analysis:

- a conditional logit model, which produces results that can be used to estimate willingness to pay for the average respondent in the sample, assuming that all respondents place the same value on service improvements (after adjusting for the characteristics controlled for in the econometric model); and
- a mixed logit model, which relaxes the assumption that all respondents value improvements by the same amount by allowing for random variation in preferences throughout the population, according to an assumed statistical distribution. It also imposes less restrictive assumptions on whether passengers consider the improvements to be substitutes or complements.

We have used the mixed logit model to generate our WTP estimates, as it allows us to recover more information on the distribution of passengers' WTP for different attributes,[44] and also places less restrictive assumptions on whether passengers consider the improvements to be substitutes or complements. In each of our models, we have also included a set of respondent characteristics that have a statistically significant (and economically meaningful) effect on WTP, as identified by our model selection procedure outlined in Section 7.3 below.

Using mixed logit requires an assumption on the statistical distribution that best describes the differences in passengers' preferences for the improvements.[45] We considered the two statistical distributions that are most commonly used in this form of analysis: the normal distribution, and the log-normal distribution (as illustrated in Figure 7.1).

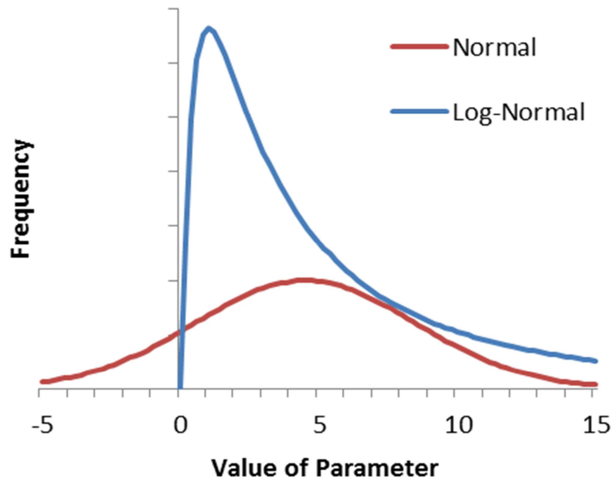
Imposing a normal distribution is likely to produce lower WTP estimates than using a log-normal distribution, as it allows for the possibility that respondents have unrealistically low (or even negative) valuations for the improvements. The log-normal model, by contrast, implies a relatively high probability that respondents value the improvements considerably more than the average, and so may overstate WTP. We have therefore assumed that random taste variation follows a normal distribution, which ensures that our estimates are conservative.

---

[44] The statistical tests we applied to the results of our mixed logit models suggest that random taste variation is present in the sample, and so the conditions imposed by the conditional logit model do not appear to hold in practice. Specifically, we find that the standard deviations of the estimated distribution of preferences in the mixed logit models are statistically significant.

[45] In order to avoid statistical difficulties in calculating WTP from our model, we have followed established theoretical literature and assumed that all passengers have the same preferences over changes in the fare (Daly et al. 2011).

Figure 7.1
Normal vs Log-Normal Distribution



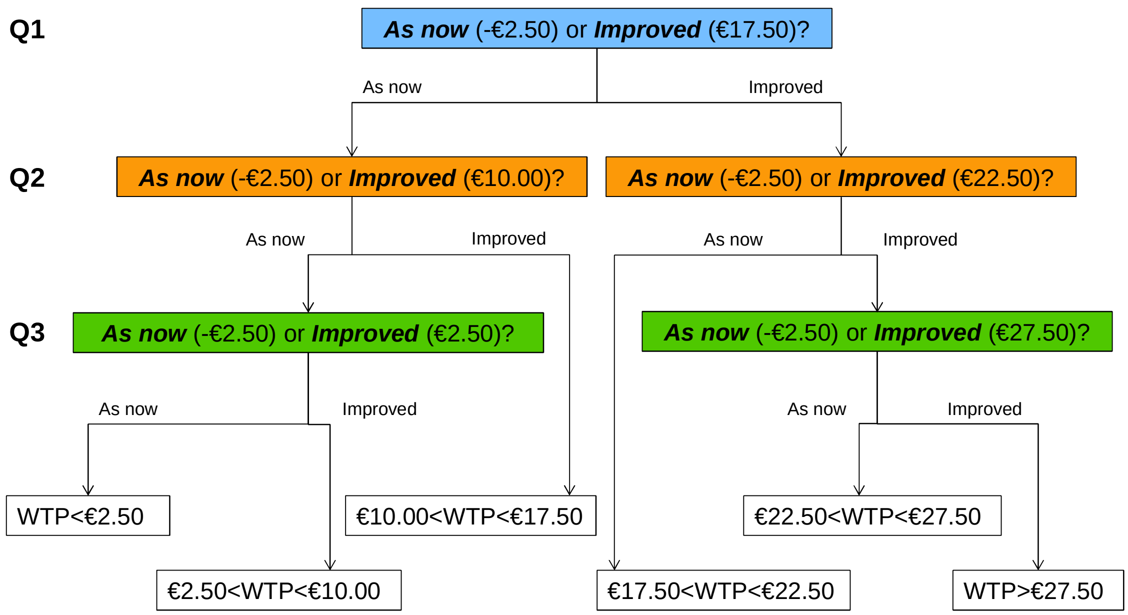
7.2.2. Dichotomous Choice Contingent Valuation

We estimated willingness to pay from the dichotomous choice contingent valuation (DCCV) questions using a probit model specifically designed to estimate WTP from these data.[46] This technique uses the repeated (iterative) dichotomous choice questions to put bounds on each respondent's WTP for the package of improvements. This is illustrated in Figure 7.2, which shows the series of values attached to the "improvement" option for our sequence of DCCV questions starting at €17.50 (where, as described in Section 4.3.3, the value attached to the "no improvement" option is -€2.50 at all stages). This is similar to Figure 4.3 above, but shows the implications of the respondent's decisions for the bounds we can place on their WTP.

---

[46] We have used the technique developed by L'opez-Feldman (2012), which is implemented by the "doubleb" Stata command. See L'opez-Feldman (2012), "Introduction to contingent valuation using Stata", available at http://mpra.ub.uni-muenchen.de/41018/

Figure 7.2
Using DCCV Questions to Put Bounds on WTP



Our econometric technique makes efficient use of this information to estimate respondents' average WTP for the entire package of improvements to T1, in contrast with other techniques (such as conditional and mixed logit, discussed in Section 7.2.1) that only use one of the bounds.[47] It applies the following two steps:

1. For each respondent, our procedure identifies the bounds that contain their WTP for the package of improvements; and
2. Using this information, it determines the parameters of the econometric model that best fit the data (using a numerical "maximum likelihood" procedure).

As with the choice experiment data, we have included a set of respondent characteristics in our models (as identified through our model selection procedure, outlined in Section 7.3).

7.2.3. Open Ended Contingent Valuation

At the end of the contingent valuation question, we asked respondents to state their maximum willingness to pay for the proposed improvements. We ran a linear regression of respondents'

[47] Standard econometric models would treat each respondent's answers as independent of each other. For example, if the respondent chose the "improvement" option for €17.50, and then "no improvement" for €22.50, these standard models would treat the answers as independent: the first revealing that WTP is between €17.50 and infinity, and the second revealing that WTP is between negative infinity and €22.50.

stated maximum WTP on (1) a constant term and (2) a set of respondent characteristics (as identified through our model selection procedure, set out in Section 7.3).[48]

The estimated coefficients from these regressions can be interpreted directly in terms of willingness to pay for the package of improvements:

- the coefficient on the constant term (in a model that does not control for respondent characteristics) is the average willingness to pay in the sample. In a model that does control for respondent characteristics, the constant represents average WTP among those respondents who do not belong to any of the groups controlled for in the model; and
- the coefficient on each characteristic shows how the average willingness to pay in each control category (e.g. business passengers) differs from the average of other passengers.

7.3. Model Selection

In order to recover accurate estimates of WTP, it is important to ensure that our econometric models are correctly specified, and include any factors that may influence passengers' WTP for improvements. As outlined in Section 4, we have collected data on a range of respondents' personal characteristics as a part of our survey. In order to determine the respondent characteristics that we should include in our econometric specification, we have followed the following model selection procedure:

1. Identify a "long-list" of respondent characteristics that we expect could influence WTP;
2. Through a process of statistical testing, identify those variables from the long-list that have a statistically significant impact on WTP, and therefore should be included in our final model; and
3. Perform a number of sensitivity tests on the final model, to ensure that it is statistically robust and has an economically meaningful interpretation.

We provide more information on each of these steps below.

7.3.1. Step 1: Identifying an initial set of explanatory factors

The first stage of our "testing down" procedure is to identify a set of respondent characteristics that we expect could influence WTP. We have included variables in our initial set to reflect the following characteristics:

- country of residence, in particular whether the respondent is from Ireland, the UK, other European countries, or elsewhere;
- whether the respondent is travelling for business;
- the respondent's personal characteristics, including age, gender and income; and

---

[48] We analysed the OECV responses using linear regression because we have a continuous variable (i.e. stated WTP) as the dependent variable. In the dichotomous choice contingent valuation and choice experiments, the dependent variable is a discrete choice and so we were required to use more advanced econometric techniques (i.e. logit or probit).

- variables intended to capture the amount of time the respondent spent in the check-in area, in particular whether they checked in a bag, and whether they checked in at the terminal (rather than, for example, online).

7.3.2. Step 2: Testing down

The second stage of our procedure is to identify which of the long-list of explanatory factors has a statistically significant impact on WTP. We estimated our model iteratively, initially including all of the characteristics identified in Step 1, and excluding explanatory factors that were not statistically significant. Throughout this process, we applied a relatively "loose" significance level,[49] and also excluded those variables that produce regression coefficients with implausible signs or magnitudes.

At each stage, we checked for either (1) reductions in the explanatory power of the model as a whole (i.e. the R^2) or (2) large changes in the estimated coefficients on other explanatory variables. This is necessary in case this model selection process misses important interactions between explanatory variables. For instance, it is possible that variables which are important for explaining variation in respondents' WTP for the improvements do not appear statistically significant, e.g. because of correlation between characteristics.

Through this process, we arrived at a final model in which all included respondent characteristics were statistically significant.

7.3.3. Step 3: Sensitivity testing of the final model

As a final step, we checked that our estimated model was statistically robust and economically meaningful. In particular, we:

- confirmed that our estimates had economically meaningful, intuitive coefficients (i.e. implied that, all else equal, respondents prefer to (1) have the improvements implemented and (2) avoid fare increases). This was the case for all of the models we arrived at in Step 2; and
- performed a statistical test of "joint significance" on all of the variables that we had excluded in Step 2. If these variables were jointly insignificant, then including them in the final model would not significantly improve its explanatory power.

[49] At this preliminary stage, we assess characteristics roughly against the 10% level of significance – if factors are almost significant at the 10% level, but not quite, we tend towards including them in the next iteration since measures of significance are subject to statistical error.

8. Results

8.1. Choice Experiment Data

8.1.1. Model selection

We followed the model selection procedure set out in Section 7.3 using a conditional logit modelling approach.[50] Through this procedure, we found that the following variables have a statistically significant impact on WTP in our CE data:

- whether the passenger is travelling with Ryanair. We find that Ryanair passengers are willing to pay less for all improvements than other passengers;
- the type of party that the respondent is travelling in, in particular whether they are travelling as a couple or in a family group with children under 16. Both couples and family groups are willing to pay more for all improvements than other passengers;
- the respondent's country of residence. In particular, passengers that have mostly lived in the UK for the last 12 months are willing to pay more for all improvements than other passengers; and
- whether the passenger checked in a bag. We find that passengers who checked in a bag are willing to pay more for the improvement to the check-in area than other customers, but found that whether a passenger checked in a bag did not have a statistically significant impact on WTP for all improvements.

The model that results from this selection procedure has good statistical properties: all estimated coefficients are statistically significant (at the 10 per cent significance level),[51] with economically meaningful coefficients.

8.1.2. WTP estimates

Figure 8.1 shows the average WTP estimates that we have estimated from our main model for each of the five improvements.[52] It also shows the 95 per cent confidence interval around each of these estimates, which reflect the degree of uncertainty caused by random variation in our sample.[53, 54]

---

[50] As noted in Section 7.2.1, our preferred econometric technique to analyse the CE data is mixed logit, as it has a number of theoretical advantages over conditional logit. However, estimating mixed logit models is more computationally demanding than conditional logit, and so it was not practical to use mixed logit in our iterative model selection procedure. We verified that our final model retained its desirable properties when estimated with mixed logit.

[51] The choice of significance level determines the threshold at which the estimated coefficients are classified as "significantly" different from zero (rather than reflecting only random variation in the data). Researchers commonly consider either the 5 per cent or 10 per cent level to provide sufficient confidence that the coefficient estimates reflect more than random sampling variation. However, it is important to acknowledge that the appropriateness of any particular significance level requires a somewhat subjective assessment.

[52] To calculate average WTP, we have estimated WTP at the sample average of each of the five respondent characteristics included in our model.

[53] There is a 5 per cent probability that the "true" WTP for these improvements in the population of passengers travelling through T1 is outside this range. Of this 5 per cent, 2.5 per cent represents the probability that WTP is below the range.

We estimate average willingness to pay of around €1 for each of the façade and arrivals area improvements, and between €2 and €3 for each of the check-in area, security screening area and security queue time improvements. Each of these estimates is strongly statistically significant, such that we can be very sure the "true" willingness to pay is positive.

Figure 8.1
Average WTP Estimates for Separate Improvements

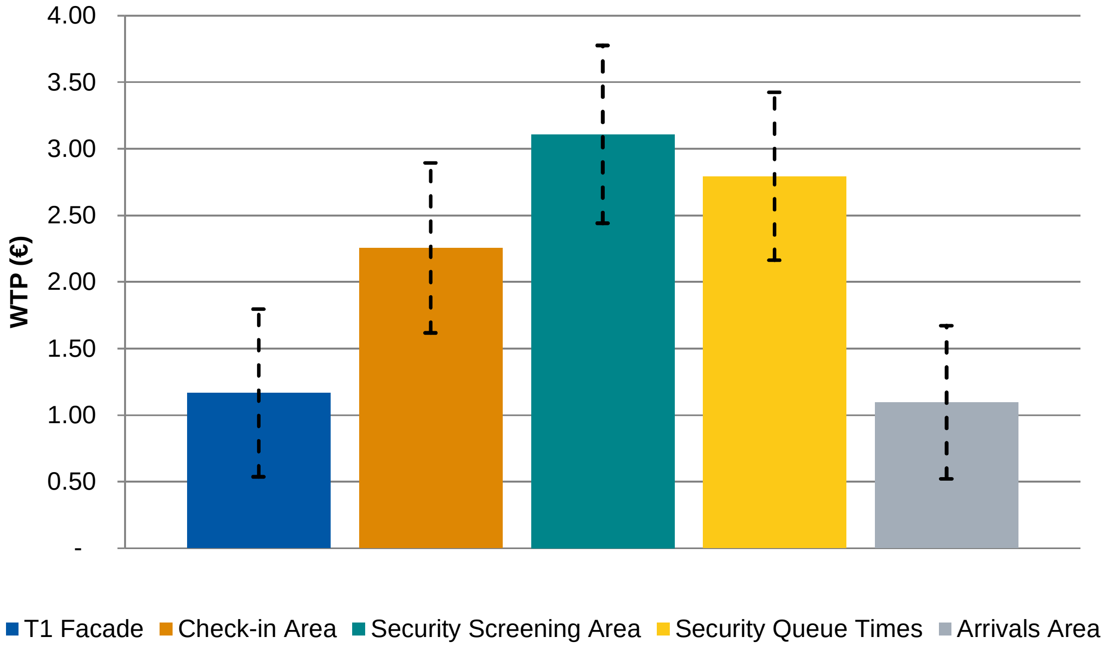


Table 8.1 presents our estimates of WTP from our main model, estimated using mixed logit. The table shows average WTP (as presented in Figure 8.1) in the first column, along with the confidence intervals around our estimates. In the other columns, we show how WTP varies with the characteristics of the respondent – we have varied one characteristic at a time, holding all others constant at the sample average. For example, in the second column, we show estimated WTP for a passenger who took a flight with Ryanair, but whose other characteristics are equal to the sample average.

Our analysis suggests that:

- Ryanair passengers' WTP for each of the improvements is lower on average than that of passengers using other airlines, but their WTP is still positive and statistically significant;

[54] We calculated these confidence intervals using the "delta" method, which is a widely-used approach used to identify the variance of functions of random variables, such as our WTP estimates. As a cross-check, we also calculated the confidence intervals using "bootstrapping", a numerical method for calculating the variance of a random variable with a complicated (or unknown) distribution. The confidence intervals we calculated from bootstrapping were all within €0.05 (9 per cent) of those calculated using the delta method, and so we concluded that the results are not sensitive to the choice of approach.

- conversely, passengers travelling with another adult, with children under 16, or that live in the UK had higher WTP than the average of all T1 passengers for each improvements; and
- passengers who checked in a bag are willing to pay more for the improvement to the check-in area (but not the other improvements) than the average of all T1 passengers.

Table 8.1
WTP Estimates for Separate Improvements

	Average		Ryanair Passengers		Travelling as a Couple		Family with Children under 16		Checked in a Bag		UK or Northern Ireland Resident	
	Central Estimate (€)	95% CI (€)	Central Estimate (€)	95% CI (€)	Central Estimate (€)	95% CI (€)	Central Estimate (€)	95% CI (€)	Central Estimate (€)	95% CI (€)	Central Estimate (€)	95% CI (€)
T1 Facade	1.17	0.54 1.80	1.04	0.47 1.60	1.45	0.63 2.26	1.76	0.67 2.85	1.17	0.54 1.80	1.55	0.64 2.47
Check-in Area	2.26	1.62 2.89	2.00	1.43 2.58	2.79	1.85 3.74	3.40	1.98 4.82	3.33	2.43 4.22	3.00	1.90 4.11
Security Screening Area	3.11	2.44 3.78	2.76	2.15 3.38	3.85	2.76 4.94	4.69	2.91 6.46	3.11	2.44 3.78	4.14	2.81 5.46
Security Queue Times	2.79	2.16 3.42	2.48	1.91 3.06	3.46	2.44 4.48	4.21	2.59 5.83	2.79	2.16 3.42	3.72	2.51 4.92
Arrivals Area	1.10	0.52 1.67	0.97	0.46 1.49	1.36	0.60 2.11	1.65	0.66 2.65	1.10	0.52 1.67	1.46	0.63 2.29

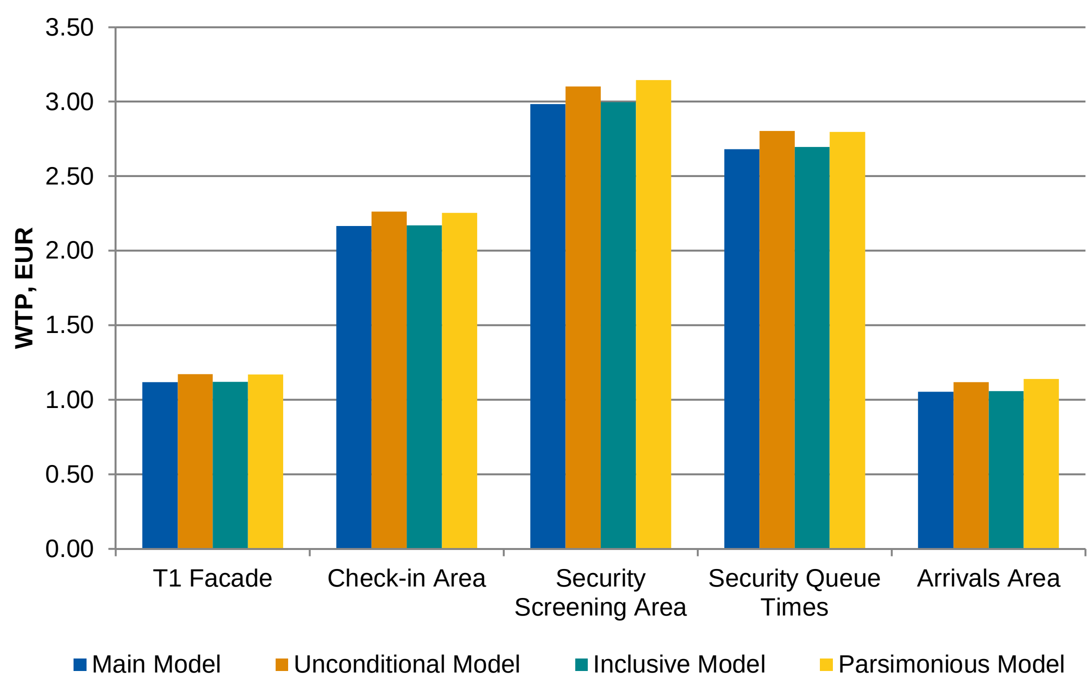
8.1.3. Robustness of estimates

We performed a range of sensitivities, and found that our estimates are very robust to changes in our approach and assumptions. Through our model selection procedure, described in Section 7.3, we identified a model with good statistical properties and economically intuitive coefficients. However, the results of this model selection procedure may fail to accurately identify the "true" model that explains respondents' choices. Therefore, we estimated three further model specifications in addition to the "main model" presented above, which are based on those emerging from our analysis using the DCCV and OECV datasets (below):

1. a model with no control variables (the "unconditional model");
2. a model including those control variables that we included in either of the DCCV or OECV models, as described in the following sections (the "inclusive model"); and
3. a model including only those control variables we included in all of the CE, DCCV and OECV models (the "parsimonious model").

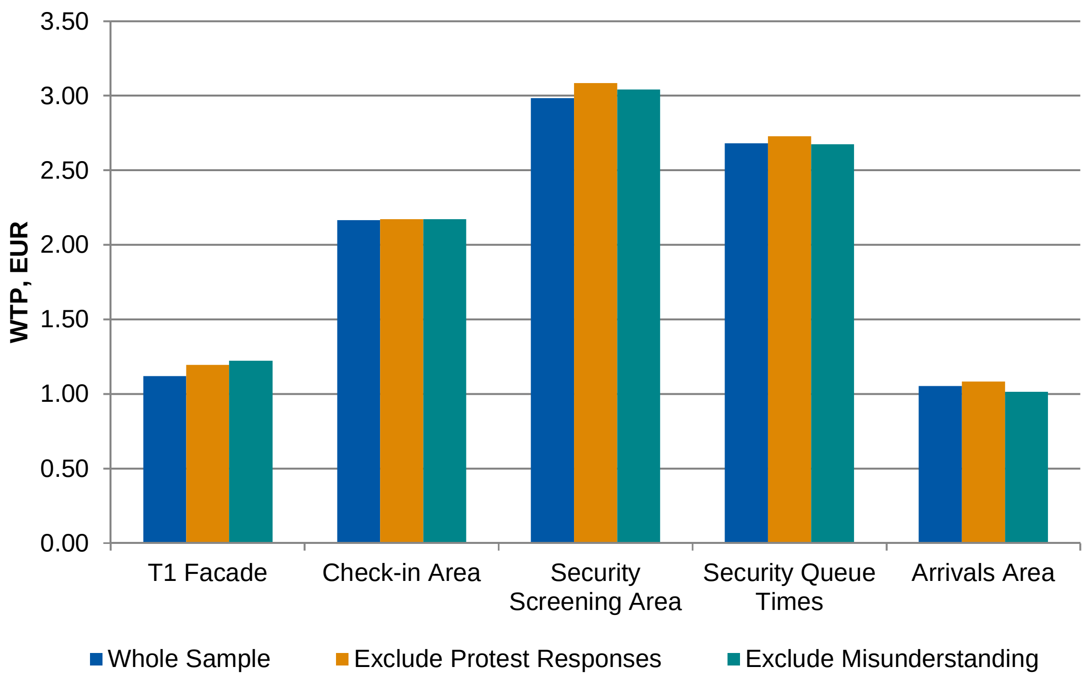
Figure 8.2 shows the average WTP estimates that we have calculated from each of these three models, alongside the estimates from our "main" model. The estimates are not sensitive to the choice of model, suggesting that our average WTP estimates in Figure 8.1 are robust.

Figure 8.2
Sensitivity of CE Estimates to Model Specification



We also estimated each model using samples that (1) exclude protest responses and (2) exclude those respondents who did not understand the questions (as described in Sections 6.2 and 6.3, above). Figure 8.3 shows the average WTP estimates that we have calculated from our "main" model using both of these samples, alongside the estimates from the whole sample. The results are very robust to excluding either of these types of respondent, which suggests that they are not unduly influencing the results.

Figure 8.3
Sensitivity of CE Estimates to Excluding Potentially Invalid Responses



Finally, we estimated our "main model", and each of the sensitivity models described above, using conditional logit as well as mixed logit to verify that our results are not sensitive to the choice of econometric technique. Figure 8.4 shows the WTP estimates from our main model, estimated with the whole sample using conditional logit and mixed logit.

The conditional logit model produces estimates of WTP that are marginally lower than the mixed logit estimates for each improvement: the mixed logit estimates are between 1 and 10 per cent higher than the corresponding conditional logit estimate (for security queue times and the T1 façade, respectively).[55] However, we note that:

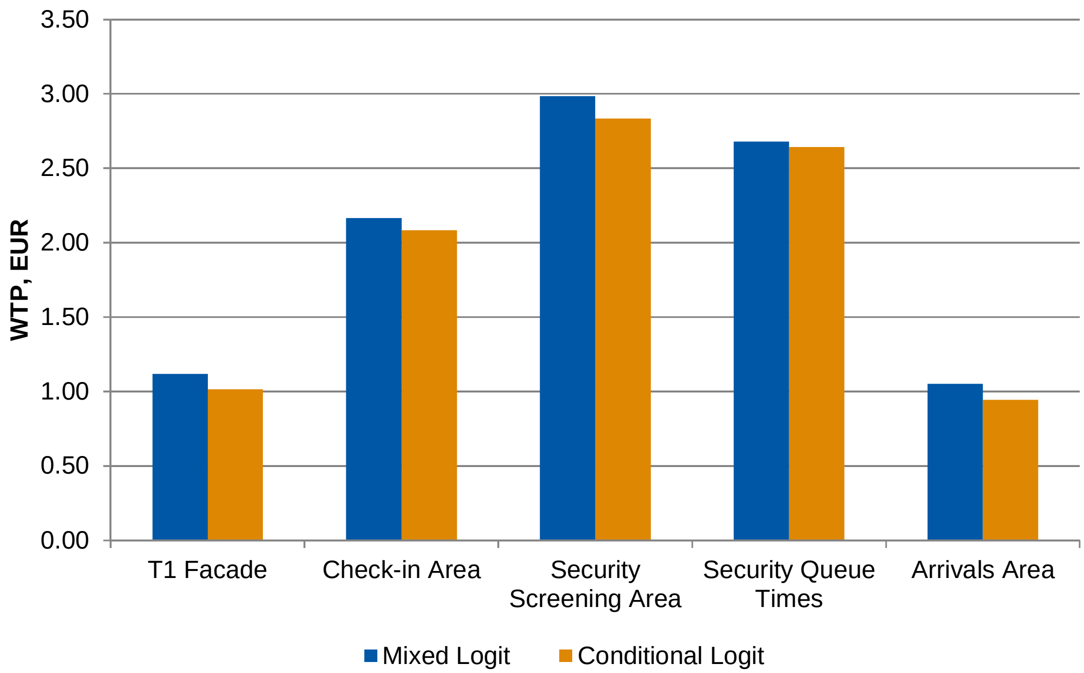
- for the reasons set out in Section 7.2.1, we believe that mixed logit has more desirable theoretical properties than the conditional logit model, and so we continue to prefer the mixed logit estimates; and
- while the conditional logit produces marginally lower WTP estimates for each improvement than the mixed logit model, the estimates are still strongly statistically

---

[55] The absolute differences in estimated WTP estimated from the two models are between €0.04 and €0.15 (corresponding to security queue times and the security screening area, respectively).

significant and substantially above their expected cost (which daa has calculated would be around €0.20 per passenger over a period of 25 years).

Figure 8.4
Sensitivity of CE Estimates to Econometric Technique



8.2. Dichotomous Choice Contingent Valuation

8.2.1. Model selection

We followed the same approach to model selection as with the CE data, using the probit model described in Section 7.2.2. Through this procedure, we identified that the following variables have a statistically significant impact on WTP in our DCCV data:

- whether the passenger is travelling for business. Business passengers are willing to pay more for the package of improvements than the average of all other passengers;[56]
- whether the passenger is travelling with Ryanair. We find that Ryanair passengers are willing to pay less for the package of improvements than other passengers; and
- whether the passenger checked in a bag. We find that passengers who checked in a bag are willing to pay more for the package of improvements than other customers.

---

56 We note that this effect could reflect either (or both) of (1) business passengers genuinely valuing the improvements more than non-business passengers, perhaps because they travel more frequently or value their time more than non-business passengers, or (2) business passengers appearing to have higher willingness to pay than non-business passengers because they might not bear the increased cost of their airfare personally. However, as shown in Figure 8.5, even non-business passengers have a statistically significant WTP for the improvements that is many times greater than the expected cost.

The model that results from this selection procedure has good statistical properties: all estimated coefficients are statistically significant (at the 10 per cent significance level), with economically meaningful coefficients.

8.2.2. WTP estimates

Figure 8.5 shows our estimate of passengers' average willingness to pay for the proposed improvements, along with the 95 per cent confidence intervals around the estimate.[57] On average, we estimate that passengers are willing to pay €8.34 for the entire package of improvements. It also shows how the estimates vary according to changes in respondents' characteristics. Our analysis suggests that:

- on average, business passengers are willing to pay more for the improvements than the average of non-business passengers using T1 (although we note that the confidence interval around this estimate is reasonably wide). Passengers who checked in a bag are also willing to pay more for the improvements than the average of other passengers using T1;
- Ryanair passengers are willing to pay less than other passengers on average, but their WTP is still positive and statistically significant.

We also present this information in Table 8.2.

57 As described in footnote 54, we calculated these confidence intervals using the "delta" method, and also using "bootstrapping" as a cross-check. The confidence intervals were not sensitive to the method of estimation.

Figure 8.5
WTP Estimates for All Improvements

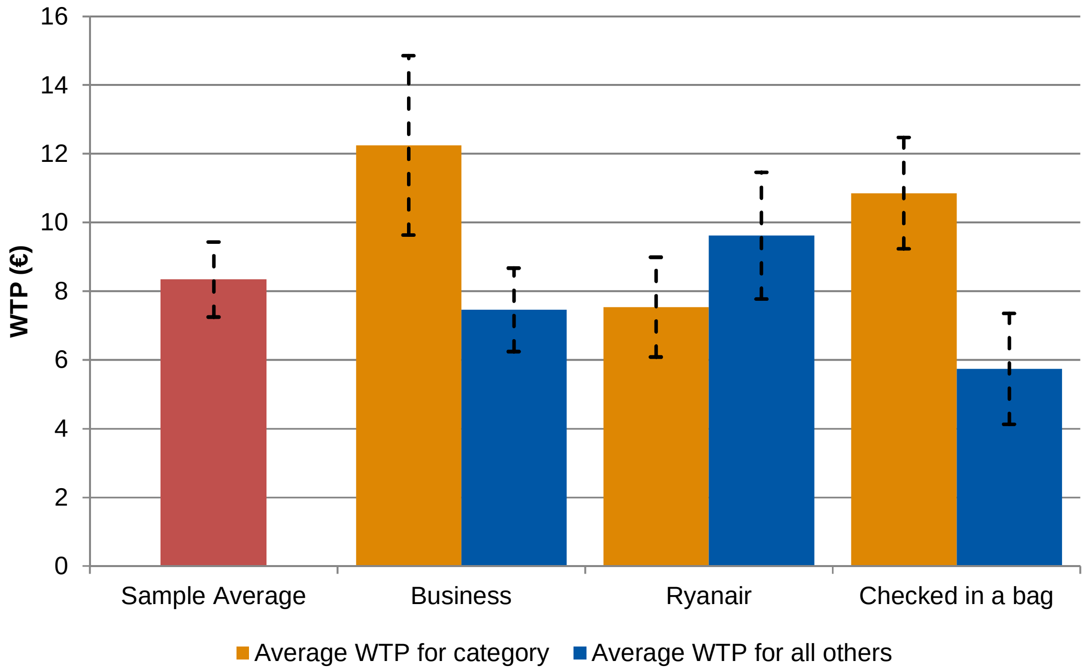


Table 8.2
DCCV Estimates of WTP for All Improvements

	Central Estimate (€)	95% Confidence Interval around Central Estimate (€)	
Average	***8.34***	***7.25***	***9.43***
Business	12.25	9.64	14.86
Non-business	7.46	6.25	8.67
Ryanair	7.54	6.09	8.99
Not Ryanair	9.62	7.77	11.46
Checked in a bag	10.85	9.23	12.47
Did not check in a bag	5.74	4.13	7.35

8.2.3. Robustness of estimates

We conducted a similar range of robustness checks on our DCCV results to those we conducted for our CE analysis, as described in Section 8.1.3. Our DCCV estimates are also very robust to these sensitivity checks.[58]

As in Section 8.1.3, we estimated three further model specifications in addition to our "main" model presented above: an "uncontrolled" model, a "parsimonious" model and an "inclusive" model. Figure 8.6 shows the average WTP estimates that we have calculated from each of these three models, alongside the estimates from our "main" model. The estimates are not sensitive to the choice of model.

We also estimated each model using samples that (1) exclude protest responses and (2) exclude those respondents who did not understand the questions (as described in Sections 6.2 and 6.3, above). Figure 8.7 shows the average WTP estimates that we have calculated from our "main" model using both of these samples, alongside the estimates from the whole sample. As with our CE analysis, the results are very robust to excluding either of these types of respondent, which suggests that they are not unduly influencing the results.

[58] One of our peer reviewers has identified that we might also investigate a non-parametric estimator for CV values (e.g. by using "Turnbull" estimation), which might provide additional understanding of the demand function for improvements at T1. This is a potentially interesting area of future research that we have not had time to investigate. Nonetheless, we feel that the analysis that we have conducted provides robust evidence on the average WTP for T1 users.

Figure 8.6
Sensitivity of DCCV Estimates to Model Specification

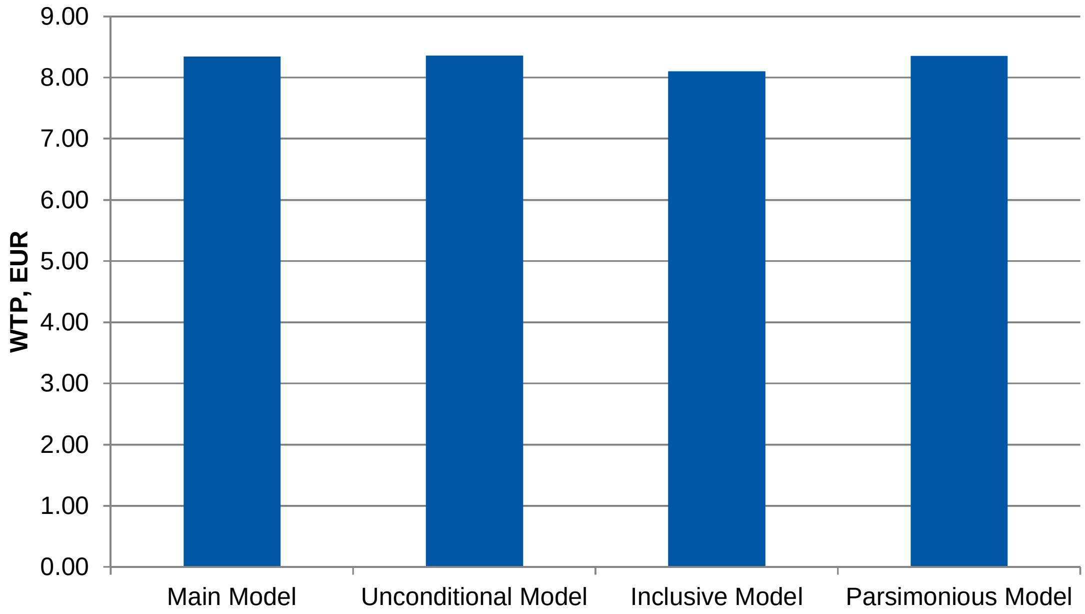
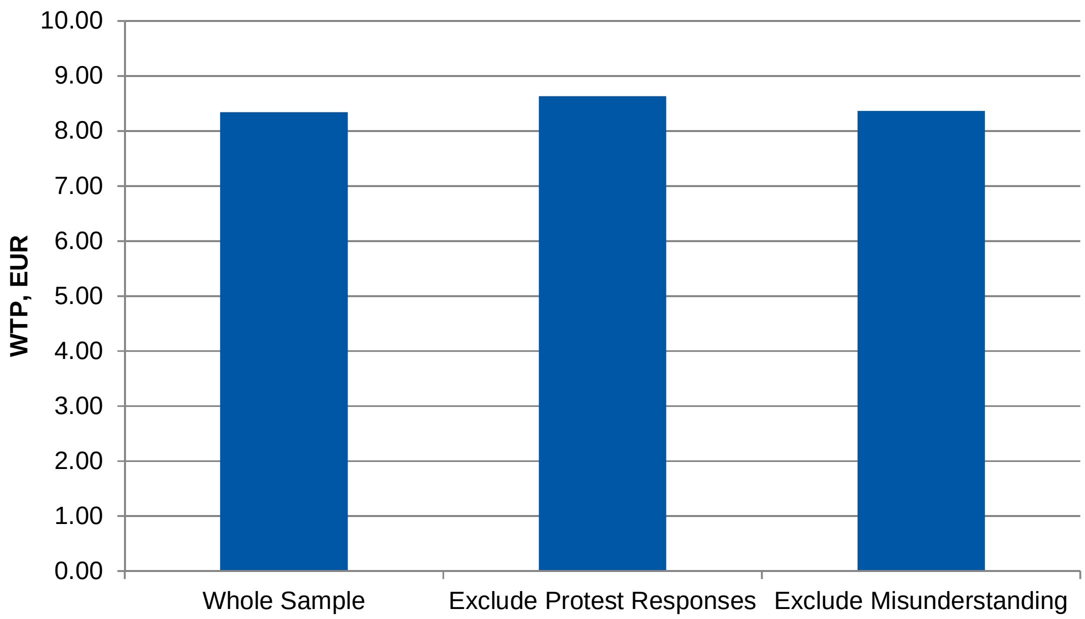


Figure 8.7
Sensitivity of DCCV Estimates to Excluding Potentially Invalid Responses



Finally, we tested statistically whether the WTP calculated from the DCCV questions was influenced by the fare increase respondents were shown in the first exercise. We re-estimated our “main model” with two additional dummy variables, the first of which is equal to one if the respondent was shown a fare increase of €7.50 in the first dichotomous choice exercise (and zero otherwise) and the second is equal to one if the initial value was €17.50. A statistically significant coefficient on either of these coefficients would indicate that respondents’ stated maximum WTP is anchored by the starting value.

Table 8.3 shows the coefficient estimates for the dummy variables included in this regression. The coefficient on neither dummy variable is statistically significant, suggesting that WTP estimated from the DCCV exercise was not influenced by the fare increase respondents were shown in the first question.

Table 8.3
Sensitivity of DCCV Exercises to Fare Shown in First Question

Variable	Coefficient Estimate
€7.50 Dummy	0.34
	(0.805)
€17.50 Dummy	1.83
	(0.179)
“Main” Model Controls	✓

Note: p-values in parentheses

8.3. Open Ended Contingent Valuation

8.3.1. Model selection

We followed the same approach to model selection as in our other two analyses, using the linear regression model described in Section 7.2.3. Through this procedure, we identified that the following variables have a statistically significant impact on WTP in our OECV data:

- whether the passenger is travelling for business. Business passengers are willing to pay more for the package of improvements than the average of all other passengers; [59]
- whether the passenger checked in a bag. We find that passengers who checked in a bag are willing to pay more on average for the package of improvements than other passengers; and
- whether the passenger is under the age of 18. Passengers aged under 18 are willing to pay more on average for the package of improvements than the average of other passengers.[60]

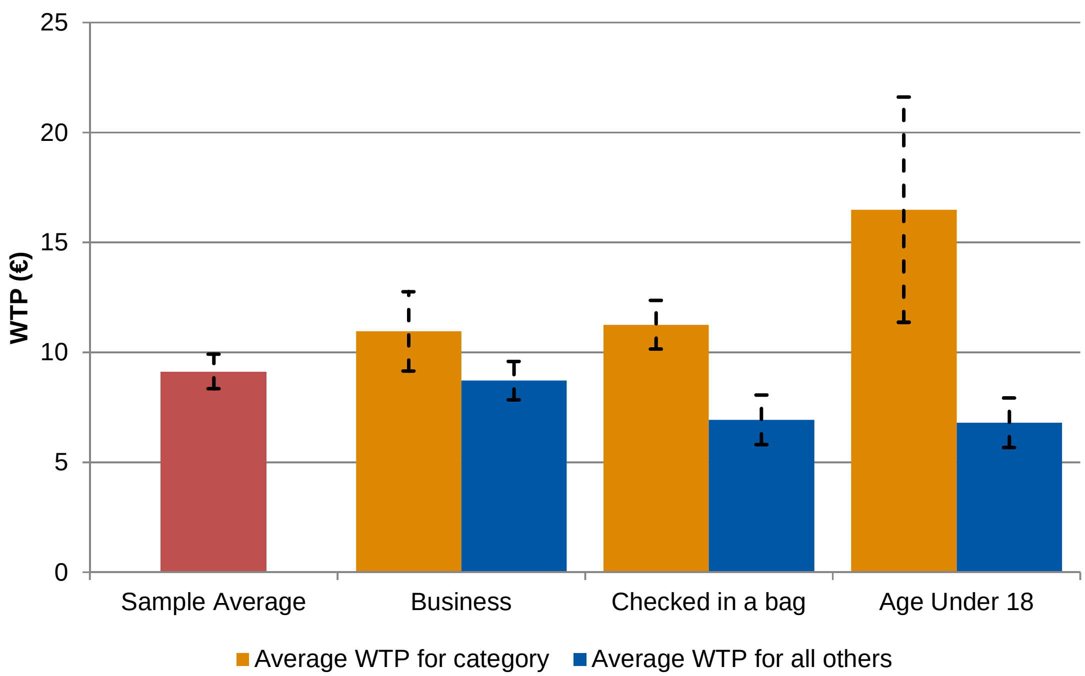
[59] As with the DCCV results discussed above, we note that this effect could reflect either (or both) of (1) business passengers genuinely valuing the improvements more than non-business passengers, perhaps because they travel more frequently or value their time more than non-business passengers, or (2) business passengers appearing to have higher willingness to pay than non-business passengers because they might not bear the increased cost of their airfare personally. However, as shown in Figure 8.8, even non-business passengers have a statistically significant WTP for the improvements that is many times greater than the expected cost.

The model that results from this selection procedure has good statistical properties: all estimated coefficients are statistically significant (at the 5 per cent significance level), with economically meaningful coefficients.

8.3.2. WTP estimates

Figure 8.8 shows our estimate of passengers' average willingness to pay for the proposed improvements, along with the 95 per cent confidence intervals around the estimate.[61, 62] On average, we estimate that passengers are willing to pay €9.13 for the entire package of improvements. Table 8.4 also shows how these estimates vary according to changes in respondents' characteristics. Our analysis suggests that, on average, business passengers, passengers who checked in a bag and passengers under the age of 18 are willing to pay more for the improvements than the average of all other passengers using T1.

Figure 8.8
WTP Estimates for All Improvements



---

[60] As with business customers, it may be the case that some passengers under the age of 18 would not pay for any increase in their airfare personally, and so may state WTP that is above their true valuation. However, we note that only 2.5 per cent of our sample are aged under 18, and so this finding does not substantially affect our WTP estimates.

[61] As described in footnote 54, we calculated these confidence intervals using the "delta" method, and also using "bootstrapping" as a cross-check. The confidence intervals were not sensitive to the method of estimation.

[62] One respondent in our sample reported a willingness to pay of €2395 above their reported fare of €356. We have excluded this outlying respondent from our analysis as (1) we do not think it is a true reflection of the respondent's WTP, but is likely to instead be the result of an error or a protest response, and (2) including it significantly inflates our estimates of average WTP. All other OECV responses were less than €60, and 90 per cent of responses were below €20.

Table 8.4
WTP Estimates for All Improvements

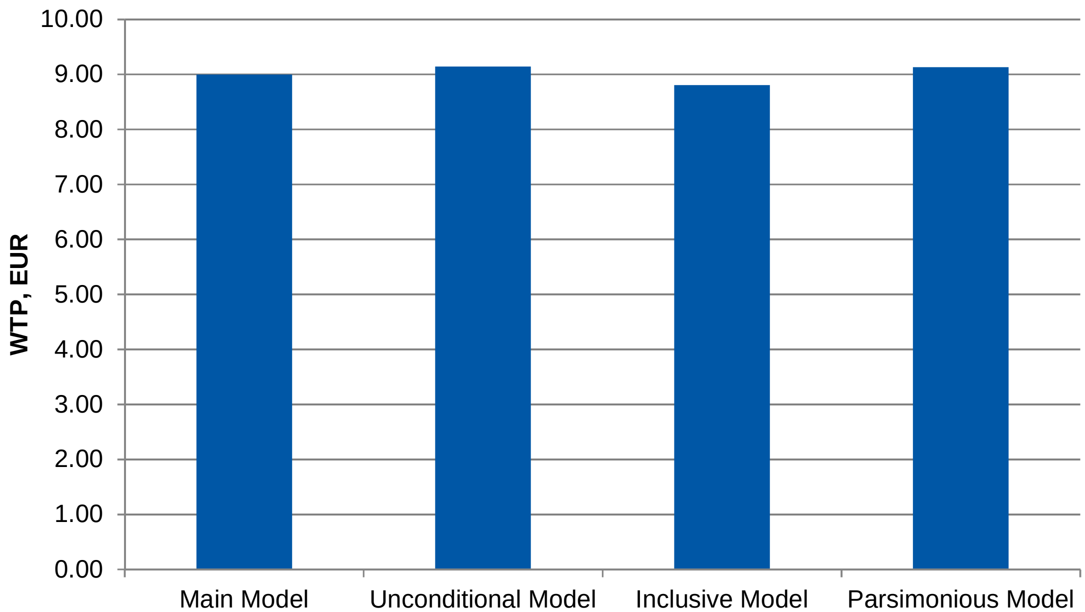
	Central Estimate (€)	95% Confidence Interval around Central Estimate (€)	
Average	***9.13***	***8.35***	***9.92***
Business	10.96	9.15	12.76
Non-business	8.72	7.85	9.59
Checked in a bag	11.25	10.15	12.36
Did not check in a bag	6.93	5.81	8.06
Age Under 18	16.48	11.36	21.60
Age Over 18	6.80	5.67	7.93

8.3.3. Robustness of estimates

We have conducted the same range of robustness checks on our OECV results that we conducted for our other analyses, as described above. Our OECV estimates are also very robust to these sensitivity checks.

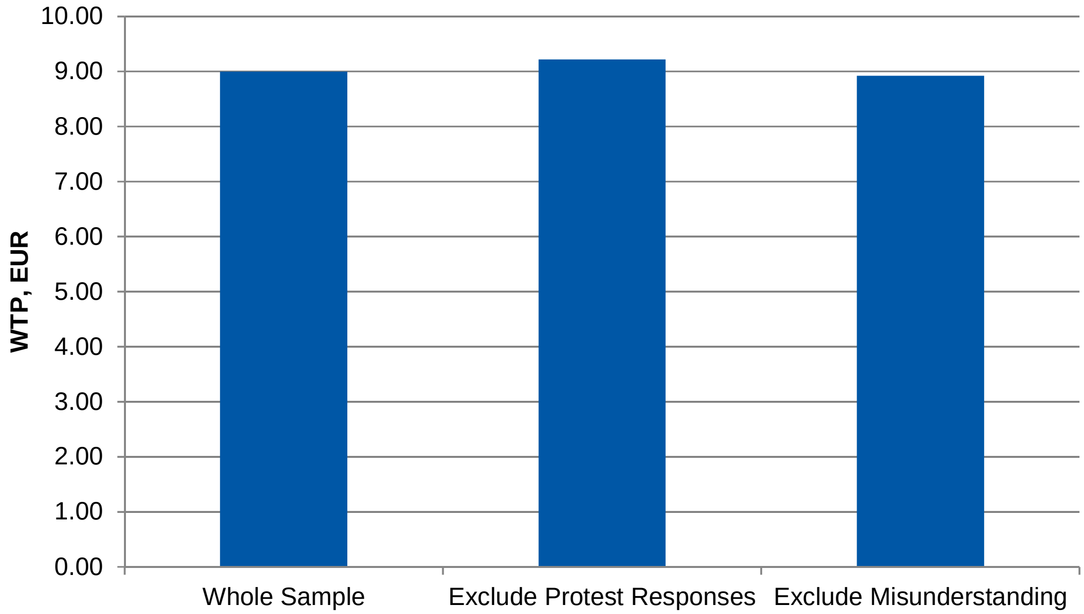
As described in Section 8.1.3, we estimated three further model specifications in addition to our "main" model presented above: an "uncontrolled" model, a "parsimonious" model and an "inclusive" model. Figure 8.9 shows the average WTP estimates that we have calculated from each of these three models, alongside the estimates from our "main" model. The estimates are not sensitive to the choice of model.

Figure 8.9
Sensitivity of OECV Estimates to Model Specification



We also estimated each model using samples that (1) exclude protest responses and (2) exclude those respondents who did not understand the questions (as described in Sections 6.2 and 6.3, above). Figure 8.10 shows the average WTP estimates that we have calculated from our "main" model using both of these samples, alongside the estimates from the whole sample. As with our other analyses, the results are very robust to excluding either of these types of respondent, which suggests that they are not unduly influencing the results.

Figure 8.10
Sensitivity of DCCV Estimates to Excluding Potentially Invalid Responses



Finally, we tested statistically whether respondents' stated WTP in the OECV question was influenced by the fare increase they were shown in the first DCCV exercise. As described above, in the dichotomous choice exercises respondents are initially asked either whether they would be willing to pay €2.50, €7.50 or €17.50 for the entire package of improvements. The OECV question directly follows these dichotomous choice questions.

We ran a linear regression of respondents' stated maximum WTP on those variables included in our "main model" and two dummy variables, the first of which is equal to one if the respondent was shown a fare increase of €7.50 in the first dichotomous choice exercise (and zero otherwise) and the second is equal to one if the initial value was €17.50. A statistically significant coefficient on either of these coefficients would indicate that respondents' stated maximum WTP is anchored by the starting value.

Table 8.5 shows the coefficient estimates for the dummy variables included in this regression. The coefficient estimates on both dummy variables are positive, and the coefficient estimate on the €17.50 dummy is statistically significant. These suggest that:

- respondents randomly shown €7.50 in the first DCCV question state a maximum WTP in the OECV question that is <u>not statistically significantly different</u> from those shown €2.50; and
- respondents randomly shown €17.50 in the first DCCV question state a maximum WTP in the OECV question that is, on average, €2.79 higher than the average stated by those shown €2.50.

Table 8.5
Sensitivity of OECV Stated WTP to DCCV Starting Value

Variable	Coefficient Estimate
€7.50 Dummy	1.60
	(0.112)
€17.50 Dummy	2.79
	(0.004)
"Main" Model Controls	✓

Note: p-values in parentheses

This provides some evidence that showing €17.50 in the first DCCV question may have anchored the value stated in the OECV question that directly followed it. However, we note that:

- increasing the DCCV fare by €15, from €2.50 to €17.50, only increased WTP stated in the OECV question by €2.79 on average, and so the fare increase shown in the first DCCV question has a proportionately small impact on OECV values;
- as we have randomised the fare increases shown in the first DCCV exercise between respondents, any anchoring effect that may exist will not have systematically biased our results; and
- even those respondents shown the lowest fare in the initial DCCV question still state a maximum WTP, on average, that is substantially above the cost of the proposed improvements.

Because of this finding, and also because of the more general reservations associated with open-ended questions (see Section 3.3.3), we view the DCCV estimate as the most robust of the two CV estimates.

9. Conclusions

This report fills an important gap in the current evidence base about the benefits of investment at Dublin Airport. While airlines and ground handlers have been consulted extensively about daa's proposed investment programme, to date there has been little or no reliable information about how other airport users – and passengers in particular – view the trade-off between lower airport charges (hence fares) and improvements in airport facilities.

We have used best practice techniques that have been refined over a number of years, and a methodology that is used to inform both government investment decisions and, increasingly, economic regulators' decisions on future capital allowances. Among other things, we have provided respondents with a realistic and plausible context for the survey, a factual description of the benefits that the investment programme will deliver for passengers, and a neutral presentation of the options on the choice cards that provide the main inputs for the econometric analysis.

In several respects, our approach has been conservative and our results may understate passengers' true underlying WTP for daa's proposed improvements. Some of our methodological decisions (for example our choice of econometric methodology) have been deliberately conservative. And the reduction in security queue times presented to respondents might well be an underestimate of the potential impact, as there is a risk that queue times could increase very significantly indeed if the proposed investment does not take place.

For both the individual components of the investment programme and the package as a whole, we have generated statistically significant estimates of passengers' WTP that are many times higher than the expected cost of the investments. The coefficients in our estimated models have the expected signs and plausible orders of magnitude. Moreover, our estimates of passengers' WTP are robust as we get similar findings from applying different econometric methodologies, and also if we exclude certain responses (possible protest responses or respondents who may not have understood the questions).

While the WTP estimates for individual improvements generated by the choice experiment questions should not be regarded as a reliable indication of the value of the complete package, we nevertheless draw some comfort from the fact that the estimates generated by the choice experiment, DCCV and OECV questions are of similar orders of magnitude.

A further indication of the reliability of our results is the consistent findings with respect to other explanatory factors (for example, Ryanair passengers consistently demonstrating lower WTP than other passengers using T1). In many cases, we did not have prior expectations about the impact of these external factors. But the differences we found are plausible and also consistent in cases where we might have reason to expect a specific difference (for example, passengers who check in bags attach a higher value to the proposed improvements to the check-in area).

Importantly, while we identified some factors that may lead to lower WTP in certain groups of passengers, even in these cases the value associated with daa's proposed improvements is still strongly positive, and many times greater than the expected cost.

In some respects, it is not surprising that this study generated strong and robust results. SP techniques have been used successfully to examine customers' WTP for a wide range of proposed improvements (for example, environmental protection measures, or improvements to the reliability or quality of water supplies), many of which are likely to be more complex or more difficult for survey respondents to consider than the relatively straightforward improvements addressed by the current study.

Overall, we believe our results provide strong evidence that daa's proposed improvements to T1 will generate benefits to passengers that are significantly higher than the expected cost of the improvements.

Appendix A. List of Invalid Responses

A.1. Protest Responses

Table A.1 shows those responses that we classified as “protest responses” and our reasons for doing so.

Table A.1
Protest Responses

	Verbatim answer to the question "What do you think about the plans to improve the facilities at T1 in return for a small increase in the fare paid by passengers?"	Reason for excluding
1	I feel that any improvements to terminal 1 should be completed within current costs ie passengers should not see an increase in fares. The most important part of my trip is the queue times at security and boarding for everything else it is functionality rather than appearance that is important.	**Does not understand payment vehicle. Believes it is not the passengers who should pay for the improvements.**
2	I don't think the fare should be paied by pasengers	**Believes it is not the passengers who should pay for the improvements.**
3	Never a good idea to pass on expense to customers.	**Believes it is not the passengers who should pay for the improvements.**
4	Joke. You already spent too much on T2 and should look for funds internally by cost saving	**Believes it is not the passengers who should pay for the improvements.**
5	Don't think it's acceptable as prices shouldn't change	**Does not agree with fare increases in principle.**
6	Could be done from other in comes. Ex. Advertisements	**Believes it is not the passengers who should pay for the improvements.**
7	All improvements should be funded by improved efficiencies in the operation of the terminals	**Believes it is not the passengers who should pay for the improvements.**
8	Passengers should not have to foot the bill for improvements	**Believes it is not the passengers who should pay for the improvements.**
9	Operational profits should be used to make improvements not additional charges for passengers	**Believes it is not the passengers who should pay for the improvements.**
10	I don't think passengers should be made to pay. Airlines/ DAA/ Government should fund this cost	**Believes it is not the passengers who should pay for the improvements.**
11	I don't think the DAA should penalise passengers with additional charges	**Believes it is not the passengers who should pay for the improvements.**

12	Cost of improving T1 should not be passed onto passengers. Dublin airport is well capable of these improvements by using other ways to generate funds	**Believes it is not the passengers who should pay for the improvements.**
13	I don't feel passengers should be made pay more.	**Believes it is not the passengers who should pay for the improvements.**
14	I think current prices are generally uncompetitive and feel airport improvements should not incur a further cost for travellers	**Believes it is not the passengers who should pay for the improvements.**
15	I do not think that your customers should be paying for improvements that you should be making anyway. You need to up your game for Terminal 1 and it should have been done long ago from monies taken from your profits and invested. It is not my responsibility to fund your business improvements.	**Believes it is not the passengers who should pay for the improvements.**
16	i truly think passengers shouldn't pay more for the improving of the airport.	**Believes it is not the passengers who should pay for the improvements.**
17	I think the improvements should be made without increase in fares!	**Does not agree with fare increases in principle.**
18	People feel get are paying enough as it is. The aurlibe tax has just gone without any noticeable decrease to fares - it's just more taxes for very little benefit . DAA should b able to budget for capital improvements without landing it back on customers.	**Believes it is not the passengers who should pay for the improvements.**
19	I pay a lot of money for flights every year and resent a pay increase at all	**Does not agree with fare increases in principle.**
20	I do not think passengers should pay for improvements	**Believes it is not the passengers who should pay for the improvements.**
21	Don't like that costs would be reflected in passenger fares.	**Believes it is not the passengers who should pay for the improvements.**
22	Dublin airport is the way by which we arrive in your country. A better service should be paid by the country, i.e. Ireland, since we arrive there to bring money to irish businesses and we would like to be welcomed in the best possible way. Bad experience with Dublin airport? Surely word of mouth won't be nice with you. No way the costs should be on us. Let me understand: we bring money to your country and we should pay to do that? Are you really saying that?	**Believes it is not the passengers who should pay for the improvements.**
23	Absorb the costs, don't pass onto passengers	**Believes it is not the passengers who should pay for the improvements.**
24	I will not pay extra for tickets	**Believes it is not the passengers who should pay for the improvements.**
25	I don't agree, some flights are way more expensive than they should be	**Does not agree with fare increases in principle.**

26	fare shouldn't be increased	**Does not agree with fare increases in principle.**
27	T1 when compared to T2 looks extremely shabby and security clearance can be very stressful especially if travelling with young children or older relatives - improvements in this area would certainly be welcome although I feel passengers are already paying a lot for flights so the costs should be passed on to the airlines.	**Believes it is not the passengers who should pay for the improvements.**
28	Cost was high enough so don't want to pay any more	**Does not agree with fare increases in principle.**
29	I think air passengers have been hit enough in recent years with the absolute ridiculous €10 departure tax plus the constant barrage of hidden costs and constant increases in surcharges from our two main airlines. It makes getting off this island ridiculously expensive. Lack of clear or forward thinking results in these constant refurbishments. Get it right first time!	**Does not agree with fare increases in principle.**

A.2. Respondents who Misunderstood Valuation Question

Table A.2 shows those respondents that we identified as potentially misunderstanding the valuation question and our reasons for doing so.

Table A.2
Respondents who Misunderstood Valuation Question

	Verbatim answer to the question "Why weren't you able to make the comparisons in the choices?"	Verbatim answer to the question "Which levels did you feel were not realistic or easy to understand?"	Reason for excluding
1	I dunno, too much info, too many useless improvements	-1 Not applicable	**Was confused by the amount of information.**
2	too complicated, too many options	TMI	**Was confused by the number of options.**
3	Too complicated, can't recall the photos	All	**Felt that the survey was too complicated.**
4	I'm not sure I get all the facts correctly.	I'm not sure I get all the facts correctly.	**Was confused and thus was likely to misunderstand the questions.**
5	-1 Not applicable	too many questions with no clear directive	**Felt that the survey was too complicated.**
6	Too many options. Pictures not with options at time of choice	Too much inormtation and choices, stopped reading.	**Was confused by the number of options.**
7	There were to many choices. Difficult to remember the choices and options contained within.	Most of them	**Was confused by the number of options.**
8	Confusing	-1 Not applicable	**Felt confused and thus was likely to misunderstand the questions.**
9	didn't understand the question at all to be honest!	all of them	**Did not understand the questions.**
10	Understanding what you want is confusing	none	**Felt confused and thus was likely to misunderstand the questions.**
11	-1 Not applicable	It was confusing generally	**Felt confused and thus was likely to misunderstand the questions.**

12	Sorry, options were too confusing. The one area that I would be willing to pay an increase of up to 5 Euro is for improved times and layout of security. I'm happy enough with the façade, arrivals and check in and I don't think any improvements are worth the increase in fare.	pretty much all of them. I'm an educated professional but struggled to understand the options.	**Felt confused and thus was likely to misunderstand the questions.**
13	a liitlebitconfusion	-1 Not applicable	**Felt confused and thus was likely to misunderstand the questions.**
14	Kind of confusing about changes	-1 Not applicable	**Felt confused and thus was likely to misunderstand the questions.**
15	Only interested in reducing queueing time for t home e security check!	Too complicated!	**Felt confused and thus was likely to misunderstand the questions.**
16	found the structure of the questions confusing	THe cobination of optionality and pricing apperead arbitraty	**Felt confused and thus was likely to misunderstand the questions.**
17	Mobile device	A little confusing being presented with tables of info	**Found it difficult to respond to questions on a mobile device.**
18	Confused	Most	**Felt confused and thus was likely to misunderstand the questions.**
19	Too repetitive and confusing	The inclusion of minor adjustments in the fare	**Felt confused and thus was likely to misunderstand the questions.**
20	I found all the different options confusing. I think the facade and the security section of the terminal need to be changed. I don't see any great propblem with the arrivals, departures or check-in areas. I obviously don't want my ticket to increase as the ryanair flight, which I take often, is already quite expensive. I think an increase of around 2.50 euros is acceptable, but I would consider paying up to a max of 10 euro.	-1 Not applicable	**Felt confused and thus was likely to misunderstand the questions.**

21	It was too confusing	Too many options, they started to look the same	**Felt confused and thus was likely to misunderstand the questions. Also, felt there were too many options.**
22	Too many choices, confused....	I dont really know what could be realistic, but all improvements definitely looked less chaotic, more spacious, clean and airy...maybe that white painting made the impression for me...	**Felt confused and thus was likely to misunderstand the questions. Also, felt there were too many options.**
23	Because it was too complicated a question each time. The change in prices is pretty meaningless also	The combination of elements makes it too complex	**Felt that the survey was too complicated.**
24	terrible survey question far too confusing and similar yawn	all the comparision tables	**Felt confused and thus was likely to misunderstand the questions.**
25	Stupidly confusing surgery. - considering most people would complete it on their phone. Too many questions & too much txt to b interested in	Too much txt - mainly pictures with abut of colour added for comparison	**Felt confused and thus was likely to misunderstand the questions.**
26	No experience ion this area	Confusing	**Was confused and thus was likely to misunderstand the questions.**
27	The options were quite confusing	Most	**Was confused and thus was likely to misunderstand the questions.**
28	-1 Not applicable	Hard to understand options	**Was confused and thus was likely to misunderstand the questions.**
29	Confused	-1 Not applicable	**Was confused and thus was likely to misunderstand the questions.**
30	-1 Not applicable	to complicated	**Welt that the survey was too complicated.**
31	-1 Not applicable	it´s confusing with the different choices of improvments and as it is now	**Was confused and thus was likely to misunderstand the questions.**
32	Not clear, confusing	-1 Not applicable	**Was confused and thus was likely to misunderstand the questions.**

33	Too much information, not displayed clearly	-1 Not applicable	**Felt that there was too much information.**
34	Because i did not understand sorry	I spaek just a litle english	**Did not understand questions.**
35	i was confused	-1 Not applicable	**Was confused and thus was likely to misunderstand the questions.**
36	not enough information	layout difficult to follow	**Found it hard to evaluate the options with given information.**
37	No obvious differences in the 'as now' and 'improved' terminal facade pictures. Too many different combinations and factors in each choice. Somewhat confusing and the temptation was to simply go for the option with the least price increase	-1 Not applicable	**Was confused and thus was likely to misunderstand the questions.**
38	Way too many options, way too messy: im a marketer working for yahoo and I think this questionnaire is very poorly created.	Same as before	**Felt that there were too many options.**
39	Complicated system	-1 Not applicable	**Felt that the survey was too complicated.**

Appendix B. Coefficient Estimates from Main Models

B.1. Choice Experiments

Table B.1 shows the estimated coefficients for our "main" model that we used for choice experiments, estimated using (1) mixed logit and (2) conditional logit. We present p-values (in parentheses) under the coefficients, which indicate that all included variables are statistically significant (at 10% level). The table also shows the estimates standard deviations from the mixed logit model, which reflect the degree of heterogeneity in passengers' preferences for each of the improvements (as described in Section 7.2.1)

Table B.1
Coefficient Estimates for the Choice Experiments Models

VARIABLES	**Conditional Logit coefficients**	**Mixed Logit coefficients**	
	Mean Coefficients	**Mixed Logit Mean Coefficients**	**Mixed Logit Standard Deviation Coefficients**
T1 Facade	0.1636	0.2170	0.6506
	(0.001)	(0.000)	(0.000)
Check-in Area	0.1825	0.2127	0.6851
	(0.006)	(0.015)	(0.000)
Security Screening Area	0.4566	0.5785	0.7583
	(0.000)	(0.000)	(0.000)
Security Queue Times	0.4260	0.5196	0.6122
	(0.000)	(0.000)	(0.000)
Arrivals Area	0.1521	0.2041	0.3842
	(0.001)	(0.000)	(0.004)
Fare	-0.1526	-0.1820	Non-stochastic
	(0.000)	(0.000)	
Live in UK/Northern Ireland	0.0534	0.0540	Non-stochastic
(Interacted with Fare)	(0.027)	(0.008)	
Ryanair	-0.0483	-0.0604	Non-stochastic
(Interacted with Fare)	(0.020)	(0.000)	
Couple	0.0425	0.0500	Non-stochastic
(Interacted with Fare)	(0.065)	(0.009)	
Family under 15	0.0594	0.0738	Non-stochastic
(Interacted with Fare)	(0.040)	(0.001)	
Checked in bag	0.3009	0.4064	Non-stochastic
(Interacted with Check-in Area)	(0.002)	(0.001)	
Observations	8,800	8,800	
Loglikelihood	-2,750	-2,707	

Note: p-values in parentheses

B.2. Dichotomous Choice Contingent Valuation

Table B.2 shows the estimated coefficients for our "main" econometric) model that we used to analyse our DCCV data. All estimated coefficients are statistically significant (at 10% level).

Table B.2
Coefficient Estimates for the Dichotomous Choice Contingent Valuation Model

VARIABLES	DCCV coefficients
Business	4.7878
	(0.001)
Ryanair	-2.0812
	(0.095)
Checked in bag	5.1123
	(0.000)
Constant	6.1317
	(0.000)
Observations	550
Loglikelihood	-922

Note: p-values in parentheses

B.3. Open-ended Contingent Valuation

Table B.3 shows the estimated coefficients for our main econometric model that we used to analyse our OECV data. All coefficients are statistically significant (at 10% level).

One respondent in our sample reported a willingness to pay of €2395 above their reported fare of €356. We have excluded this outlying respondent from our analysis as (1) we do not think it is a true reflection of the respondent's WTP, but is likely to instead be the result of an error or a protest response, and (2) including it in our analysis significantly inflates our estimates of average WTP. Therefore the regressions presented in Table B.3 are estimated on a sample with one fewer respondents than Table B.2.

Table B.3
Coefficient Estimates for the Open-ended Contingent Valuation Model

VARIABLES	PCCV coefficients
Business	2.2381
	(0.030)
Checked in bag	4.3190
	(0.000)
Age under 18	5.3641
	(0.043)
Constant	6.3876
	(0.000)
Observations	549
Loglikelihood	-2,006

Note: p-values in parentheses

Appendix C. Sensitivity of Results

C.1. Sensitivity to Model Form

As described in Section 8, we examined the sensitivity of each of our analyses to changes in model specification, and found that our WTP estimates are not sensitive to these changes. In this Appendix, we present more detail on these robustness checks. All estimated parameters are very insensitive to model form.

C.1.1. Choice Experiments

Table C.1 shows coefficient estimates for the conditional logit model across the four specifications described in Section 8.1.3 above. The coefficients are very robust to changes in model specification.

Table C.1
Conditional Logit Coefficients for Sensitivity Analyses

VARIABLES	Tested Down Model	Unconditional Model	Inclusive Model	Parsimonious Model
T1 Facade	0.1636	0.1649	0.1634	0.1632
	(0.001)	(0.001)	(0.001)	(0.001)
Check-in Area	0.1825	0.3354	0.1837	0.1627
	(0.006)	(0.000)	(0.006)	(0.013)
Security Screening Area	0.4566	0.4494	0.4574	0.4544
	(0.000)	(0.000)	(0.000)	(0.000)
Security Queue Times	0.4260	0.4211	0.4266	0.4202
	(0.000)	(0.000)	(0.000)	(0.000)
Arrivals Area	0.1521	0.1530	0.1521	0.1551
	(0.001)	(0.001)	(0.001)	(0.001)
Fare	-0.1526	-0.1510	-0.1579	-0.1521
	(0.000)	(0.000)	(0.000)	(0.000)
Live in UK/Northern Ireland	0.0534		0.0526	
(Interacted with Fare)	(0.027)		(0.029)	
Business			0.0141	0.0080
(Interacted with Fare)			(0.585)	(0.752)
Ryanair	-0.0483		-0.0462	
(Interacted with Fare)	(0.020)		(0.027)	
Couple	0.0425		0.0452	
(Interacted with Fare)	(0.065)		(0.053)	
Family under 15	0.0594		0.0630	
(Interacted with Fare)	(0.040)		(0.035)	
Age under 18			0.0045	
(Interacted with Fare)			(0.926)	
Checked in bag	0.3009		0.3003	0.3333
(Interacted with Check-in Area)	(0.002)		(0.002)	(0.001)
Observations	8,800	8,800	8,800	8,800
Loglikelihood	-2,750	-2,773	-2,749	-2,766

Note: p-values in parentheses

Table C.2 shows coefficient estimates for the four specifications discussed in Section 8.1.3, estimated using mixed logit. The coefficient estimates are very robust to changes in model specification.

Table C.2
Mixed Logit Coefficients for Sensitivity Analyses

VARIABLES	Tested Down Model	Unconditional Model	Inclusive Model	Parsimonious Model
T1 Façade - Mean Coefficient	0.2170 (0.000)	0.2155 (0.000)	0.2166 (0.000)	0.2147 (0.000)
T1 Façade - Standard Deviation Coefficient	0.6506 (0.000)	0.6299 (0.000)	0.6495 (0.000)	0.6339 (0.000)
Check-in Area - Mean Coefficient	0.2127 (0.015)	0.4164 (0.000)	0.2126 (0.015)	0.1832 (0.035)
Check-in Area - Standard Deviation Coefficient	0.6851 (0.000)	0.7274 (0.000)	0.6874 (0.000)	0.6997 (0.000)
Security Screening Area - Mean Coefficient	0.5785 (0.000)	0.5707 (0.000)	0.5793 (0.000)	0.5768 (0.000)
Security Screening Area - Standard Deviation Coefficient	0.7583 (0.000)	0.7596 (0.000)	0.7611 (0.000)	0.7669 (0.000)
Security Queue Times - Mean Coefficient	0.5196 (0.000)	0.5159 (0.000)	0.5210 (0.000)	0.5131 (0.000)
Security Queue Times - Standard Deviation Coefficient	0.6122 (0.000)	0.5823 (0.000)	0.6117 (0.000)	0.5870 (0.000)
Arrivals Area - Mean Coefficient	0.2041 (0.000)	0.2061 (0.000)	0.2044 (0.000)	0.2089 (0.000)
Arrivals Area - Standard Deviation Coefficient	0.3842 (0.004)	0.3866 (0.003)	0.3862 (0.004)	0.4000 (0.002)
Fare - Mean Coefficient	-0.1820 (0.000)	-0.1840 (0.000)	-0.1860 (0.000)	-0.1846 (0.000)
Fare - Standard Deviation Coefficient	Non-stochastic			

Live in UK/Northern Ireland - Mean Coefficient	0.0540		0.0537	
(Interacted with Fare)	(0.008)		(0.008)	
Live in UK/Northern Ireland - Standard Deviation Coefficient	Non-stochastic			
Business - Mean Coefficient			0.0115	0.0062
(Interacted with Fare)			(0.606)	(0.765)
Business - Standard Deviation Coefficient	Non-stochastic			
Ryanair - Mean Coefficient	-0.0604		-0.0585	
(Interacted with Fare)	(0.000)		(0.001)	
Ryanair - Standard Deviation Coefficient	Non-stochastic			
Couple - Mean Coefficient	0.0500		0.0529	
(Interacted with Fare)	(0.009)		(0.007)	
Couple - Standard Deviation Coefficient	Non-stochastic			
Family under 15 - Mean Coefficient	0.0738		0.0763	
(Interacted with Fare)	(0.001)		(0.001)	
Family under 15 - Standard Deviation Coefficient	Non-stochastic			
Checked in bag - Mean Coefficient	0.4064		0.4060	0.4528
(Interacted with Check-in Area)	(0.001)		(0.001)	(0.000)
Checked in bag - Standard Deviation Coefficient	Non-stochastic			
Observations	8,800	8,800	8,800	8,800
Loglikelihood	-2,707	-2,730	-2,707	-2,723

Note: p-values in parentheses

C.1.2. Dichotomous Choice Contingent Valuation

Table C.3 shows coefficient estimates for our DCCV model estimated for each of the four model specifications discussed in Section 8.2.3. The coefficients are very insensitive to model specification. We note that the constant shows some variation between the models, which is because each model is estimated using a different set of controls (as the constant is an estimate of the mean WTP conditional on controls).

Table C.3
DCCV Coefficients for Sensitivity Analyses

VARIABLES	Tested Down Model	Unconditional Model	Inclusive Model	Parsimonious Model
Business	4.7878		4.5569	5.3132
	(0.001)		(0.003)	(0.000)
Live in UK/Northern Ireland			2.3757	
			(0.137)	
Age under 18			-2.6674	
			(0.452)	
Ryanair	-2.0812		-2.6004	
	(0.095)		(0.043)	
Couple			-0.9311	
			(0.477)	
Family under 15			1.7406	
			(0.325)	
Checked in bag	5.1123		4.9056	5.9018
	(0.000)		(0.000)	(0.000)
Constant	6.1317	8.3592	6.3566	4.3686
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	550	550	550	550
Loglikelihood	-922	-941	-920	-923

Note: p-values in parentheses

C.1.3. Open-ended Contingent Valuation

Table C.4 shows coefficient estimates for our OECV model for each of the four model specifications described in Section 8.3.3. The coefficient estimates are very robust to changes in model specification. We note that the constant shows some variation between the models, which is because each model is estimated using a different set of controls (as the constant is an estimate of the mean WTP conditional on controls).

Table C.4
OECV Coefficients for Sensitivity Analyses

VARIABLES	Tested Down Model	Unconditional Model	Inclusive Model	Parsimonious Model
Business	2.2381		1.8421	2.1639
	(0.030)		(0.092)	(0.036)
Live in UK/Northern Ireland			1.3672	
			(0.237)	
Age under 18	5.3641		5.4053	
	(0.043)		(0.042)	
Ryanair			-0.8879	
			(0.345)	
Couple			-0.3306	
			(0.729)	
Family under 15			-0.1774	
			(0.890)	
Checked in bag	4.3190		4.0418	4.4445
	(0.000)		(0.000)	(0.000)
Constant	6.3876	9.1376	7.0670	6.4650
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	549	549	549	549
Loglikelihood	-2,006	-2,024	-2,005	-2,008

Note: p-values in parentheses

C.2. Sensitivity to Invalid Responses

As discussed in Appendix A, we identified some respondents whose responses might not reflect their true WTP, as (1) the respondent may have purposely over- or under-stated their true WTP (and so were a "protest respondent", or (2) the respondent might have misunderstood the valuation questions. We have examined the sensitivity of our estimates to excluding these two categories of respondent from the dataset. We have therefore estimated our econometric models using three samples:

4. the whole sample;
5. a sample that excludes protest responses; and
6. a sample that excludes respondents who misunderstood the questions;

Our results are not sensitive to excluding either of these two groups, as tables below show.

C.2.1. Choice Experiments

Table C.5 shows the coefficients for our main conditional logit model, estimated using each of the three samples discussed above. The coefficient estimates are very robust to excluding the suspected invalid responses.

Table C.5
Conditional Logit Coefficients Excluding Suspected Invalid Responses

VARIABLES	Whole sample	Excluding Protest Responses	Excluding Respondents Who Misunderstood the Questions
T1 Facade	0.1636	0.1797	0.1865
	(0.001)	(0.001)	(0.000)
Check-in Area	0.1825	0.1658	0.1682
	(0.006)	(0.015)	(0.014)
Security Screening Area	0.4566	0.4548	0.4735
	(0.000)	(0.000)	(0.000)
Security Queue Times	0.4260	0.4188	0.4291
	(0.000)	(0.000)	(0.000)
Arrivals Area	0.1521	0.1516	0.1537
	(0.001)	(0.002)	(0.002)
Fare	-0.1526	-0.1512	-0.1540
	(0.000)	(0.000)	(0.000)
Live in UK/Northern Ireland	0.0534	0.0550	0.0580
(Interacted with Fare)	(0.027)	(0.022)	(0.017)
Ryanair	-0.0483	-0.0408	-0.0531
(Interacted with Fare)	(0.020)	(0.053)	(0.014)
Couple	0.0425	0.0379	0.0468
(Interacted with Fare)	(0.065)	(0.105)	(0.051)
Family under 15	0.0594	0.0585	0.0657
(Interacted with Fare)	(0.040)	(0.042)	(0.026)
Checked in bag	0.3009	0.3100	0.3270
(Interacted with Check-in Area)	(0.002)	(0.002)	(0.001)
Observations	8,800	8,352	8,272
Loglikelihood	-2,750	-2,624	-2,579

Note: p-values in parentheses

Table C.6 shows the coefficients for our main mixed logit model, estimated using each of the three samples discussed above. The coefficient estimates are very robust to excluding suspected invalid responses.

Table C.6
Mixed Logit Coefficients Excluding Suspected Invalid Responses

VARIABLES	Whole sample	Excluding Protest Responses	Excluding Respondents Who Misunderstood the Questions
T1 Façade - Mean Coefficient	0.2170 (0.000)	0.2310 (0.000)	0.2451 (0.000)
T1 Façade - Standard Deviation Coefficient	0.6506 (0.000)	0.6757 (0.000)	0.6922 (0.000)
Check-in Area - Mean Coefficient	0.2127 (0.015)	0.1944 (0.038)	0.2072 (0.026)
Check-in Area - Standard Deviation Coefficient	0.6851 (0.000)	0.7308 (0.000)	0.7129 (0.000)
Security Screening Area - Mean Coefficient	0.5785 (0.000)	0.5963 (0.000)	0.6103 (0.000)
Security Screening Area - Standard Deviation Coefficient	0.7583 (0.000)	0.8222 (0.000)	0.7876 (0.000)
Security Queue Times - Mean Coefficient	0.5196 (0.000)	0.5272 (0.000)	0.5366 (0.000)
Security Queue Times – Standard Deviation Coefficient	0.6122 (0.000)	0.6963 (0.000)	0.6711 (0.000)
Arrivals Area - Mean Coefficient	0.2041 (0.000)	0.2090 (0.000)	0.2034 (0.001)
Arrivals Area - Standard Deviation Coefficient	0.3842 (0.004)	0.4524 (0.000)	0.4412 (0.000)
Fare - Mean Coefficient	-0.1820 (0.000)	-0.1847 (0.000)	-0.1892 (0.000)
Fare - Standard Deviation Coefficient		Non-stochastic	

Live in UK/Northern Ireland - Mean Coefficient	0.0540	0.0559	0.0584
(Interacted with Fare)	(0.008)	(0.008)	(0.006)
Live in UK/Northern Ireland - Standard Deviation Coefficient		Non-stochastic	
Ryanair - Mean Coefficient	-0.0604	-0.0524	-0.0674
(Interacted with Fare)	(0.000)	(0.003)	(0.000)
Ryanair - Standard Deviation Coefficient		Non-stochastic	
Couple - Mean Coefficient	0.0500	0.0444	0.0594
(Interacted with Fare)	(0.009)	(0.025)	(0.003)
Couple - Standard Deviation Coefficient		Non-stochastic	
Family under 15 - Mean Coefficient	0.0738	0.0732	0.0860
(Interacted with Fare)	(0.001)	(0.002)	(0.000)
Family under 15 - Standard Deviation Coefficient		Non-stochastic	
Checked in bag - Mean Coefficient	0.4064	0.4426	0.4488
(Interacted with Check-in Area)	(0.001)	(0.001)	(0.000)
Checked in bag - Standard Deviation Coefficient		Non-stochastic	
Observations	8,800	8,352	8,272
Loglikelihood	-2,707	-2,577	-2,533

Note: p-values in parentheses

C.2.2. Dichotomous Choice Contingent Valuation

Table C.7 shows the coefficients for our DCCV model estimated using each of the three samples discussed above. The coefficients are very insensitive to excluding suspected invalid responses.

Table C.7
DCCV Coefficients Excluding Suspected Invalid Responses

VARIABLES	Whole sample	Excluding Protest Responses	Excluding Respondents Who Misunderstood the Questions
Business	4.7878	6.1906	4.5245
	(0.001)	(0.000)	(0.003)
Ryanair	-2.0812	-1.1938	-1.7548
	(0.095)	(0.350)	(0.179)
Checked in bag	5.1123	5.0819	5.5225
	(0.000)	(0.000)	(0.000)
Constant	6.1317	5.6349	5.7939
	(0.000)	(0.000)	(0.000)
Observations	550	522	517
Loglikelihood	-922	-877	-867

Note: p-values in parentheses

C.2.3. Open-ended Contingent Valuation

Table C.8 shows the coefficients for our OECV model estimated using each of the three samples discussed above. The coefficient estimates are very robust to excluding suspected invalid responses.

Table C.8
OECV Coefficients Excluding Suspected Invalid Responses

VARIABLES	Whole sample	Excluding Protest Responses	Excluding Respondents Who Misunderstood the Questions
Business	2.2381	2.9170	1.5586
	(0.030)	(0.007)	(0.138)
Age under 18	5.3641	6.0686	5.3323
	(0.043)	(0.029)	(0.042)
Checked in bag	4.3190	4.0575	4.4688
	(0.000)	(0.000)	(0.000)
Constant	6.3876	6.6153	6.3565
	(0.000)	(0.000)	(0.000)
Observations	549	521	516
Loglikelihood	-2,006	-1,908	-1,880

Note: p-values in parentheses

Appendix D. Final Questionnaire

2751: DAA T1 Service Improvements Mainstage Launched Version Online

Recruitment: CAPI

This research is being undertaken by Accent and RedC on behalf of DAA. This research is looking at how people make air travel choices and where they would like to see any improvements to their airport experience.

Please be assured that any answers you give will be treated in confidence in accordance with the Code of Conduct of the Market Research Society.

Q1. **INTERVIEWER RECORD RECRUITMENT DAY OF INTERVIEW**:

Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
Sunday

Q2. **INTERVIEWER RECORD RECRUITMENT DATE OF INTERVIEW (DD/MM/YYYY):**

Q3. Would you be willing to take part in an online survey for Dublin Airport? The questionnaire will take about 20 minutes and you will be provided with a €5 Amazon voucher to thank you for your time or we can make a donation of the same amount to a charity of your choice. An email containing a link to the online survey will be sent to you within a few days.

INTERVIEWER: EXPLAIN VOUCHER CAN BE SENT IN CURRENCY OF CHOICE AND WILL BE AWARDED ON COMPLETION OF ONLINE INTERVIEW

Yes
No – **THANK AND CLOSE**

Q4. Can I just ask you a few questions about your journey first? This should only take two or three minutes. Which airline are you flying with on the flight you are about to board?

Ryanair
Aer Arann **THANK AND CLOSE**
Air Canada
Air France
Air Transat
Blue Air
British Airways
City Jet
Flybe
Germanwings
Iberia
Logan Air **THANK AND CLOSE**
Lufthansa
Luxair
Norwegian

SAS
Swissair
Tarom
Turkish Airlines
Other **THAND AND CLOSE**

Q5. And which airport are you flying to?

DP: ONLY SHOW THE AIRPORTS SERVED BY THE AIRLINE SELECTED IN Q5

SHOW	IF Q5 EQUALS	ASSIGN TO THIS QUOTA
Alicante	Ryanair	ASQ (non hub)
Barcelona	Ryanair	Hubs (inc ASQ)
Basle	Ryanair	Continental Europe (non hub/ASQ)
Berlin	Ryanair	Hubs (inc ASQ)
Biarirtz	Ryanair	Continental Europe (non hub/ASQ)
Birmingham	Ryanair	UK (non hub/ASQ)
Bratislava	Ryanair	Continental Europe (non hub/ASQ)
Bremen	Ryanair	Continental Europe (non hub/ASQ)
Bristol	Ryanair	ASQ (non hub)
Brussels	Ryanair	ASQ (non hub)
Bucharest	Ryanair	ASQ (non hub)
Bucharest	Blue Air	ASQ (non hub)
Bucharest	Tarom	ASQ (non hub)
Budapest	Ryanair	ASQ (non hub)
Carcassone	Ryanair	Continental Europe (non hub/ASQ)
Cologne	Germanwings	Continental Europe (non hub/ASQ)
Copenhagen	SAS	ASQ (non hub)
Copenhagen	Norwegian	Hubs (inc ASQ)
Edinburgh	Ryanair	UK (non hub/ASQ)
Eindhoven	Ryanair	Continental Europe (non hub/ASQ)
Exeter	FlyBe	UK (non hub/ASQ)

Faro	Ryanair	ASQ (non hub)
Frankfurt	Lufthansa	Hubs (inc ASQ)
Frankfurt Hann	Ryanair	Continental Europe (non hub/ASQ)
Gdansk	Ryanair	Continental Europe (non hub/ASQ)
Girona	Ryanair	Continental Europe (non hub/ASQ)
Glasgow	Ryanair	ASQ (non hub)
Helsinki	Norwegian	ASQ (non hub)
Ibiza	Ryanair	ASQ (non hub)
Istanbul	Turkish Airlines	Continental Europe (non hub/ASQ)
Katowice	Ryanair	Continental Europe (non hub/ASQ)
Kaunas	Ryanair	Continental Europe (non hub/ASQ)
Krakow	Ryanair	Continental Europe (non hub/ASQ)
Lanzarote	Ryanair	ASQ (non hub)
Las Palmas	Ryanair	ASQ (non hub)
Leeds/Bradford	Ryanair	UK (non hub/ASQ)
Lisbon	Ryanair	ASQ (non hub)
Liverpool	Ryanair	UK (non hub/ASQ)
London City	Air France	UK (non hub/ASQ)
London City	City Jet	UK (non hub/ASQ)
London Gatwick	Ryanair	Hubs (inc ASQ)
London Heathrow	British Airways	Hubs (inc ASQ)
London Luton	Ryanair	ASQ (non hub)
Luxembourg	Luxair	Continental Europe (non hub/ASQ)
Madrid	Ryanair	Hubs (inc ASQ)
Madrid	Iberia	Hubs (inc ASQ)
Malaga	Ryanair	ASQ (non hub)
Malta	Ryanair	Continental Europe (non hub/ASQ)

Manchester	Ryanair	ASQ (non hub)
Memmingen	Ryanair	Continental Europe (non hub/ASQ)
Milan – Bergamo	Ryanair	Continental Europe (non hub/ASQ)
Munich	Lufthansa	Continental Europe (non hub/ASQ)
Nantes	Ryanair	Continental Europe (non hub/ASQ)
Newcastle	Ryanair	UK (non hub/ASQ)
Nice	Ryanair	ASQ (non hub)
Nottingham East Midlands	Ryanair	UK (non hub/ASQ)
Oslo	SAS	Hubs (inc ASQ)
Oslo	Norwegian	Hubs (inc ASQ)
Oslo – Rygge	Ryanair	Continental Europe (non hub/ASQ)
Palma	Ryanair	ASQ (non hub)
Paris – Charles de Gualle	Air France	Hubs (inc ASQ)
Paris – Beauvais	Ryanair	Continental Europe (non hub/ASQ)
Pisa	Ryanair	Continental Europe (non hub/ASQ)
Poznan	Ryanair	Continental Europe (non hub/ASQ)
Prague	Ryanair	ASQ (non hub)
Reus	Ryanair	Continental Europe (non hub/ASQ)
Riga	Ryanair	Continental Europe (non hub/ASQ)
Rome	Ryanair	Hubs (inc ASQ)
Southampton	Flybe	UK (non hub/ASQ)
Stansted	Ryanair	ASQ (non hub)
Stockholm	SAS	ASQ (non hub)
Stockholm – Stavsta	Ryanair	Continental Europe (non hub/ASQ)
Tenerife	Ryanair	ASQ (non hub)
Toronto	Air Canada	Nth America
Toronto	Air Transat	Nth America

Venice	Ryanair	ASQ (non hub)
Vilnius	Ryanair	Continental Europe (non hub/ASQ)
Warsaw	Ryanair	Continental Europe (non hub/ASQ)
Wroclaw	Ryanair	Continental Europe (non hub/ASQ)
Zurich	Swissair	ASQ (non hub)

Q6. **ALLOCATE TO QUOTA**:
ASQ (non hub)
Hubs (inc ASQ)
Continental Europe (non hub/ASQ)
UK (no hub/ASQ)
Nth America

Q7. What is the <u>main</u> reason for your trip today?
Business/Conference
Main/Annual Holiday
Additional Holiday
Visiting Friends & Relatives
Personal/Family
Other (please specify)

Q8. How many other people are travelling with you today?
None **EXCLUSIVE**
Adults aged 16 yrs and older (**PLEASE WRITE IN THE NUMBER**)
Children aged 6-15 (**PLEASE WRITE IN THE NUMBER**)
Children 2 to 5 (**PLEASE WRITE IN THE NUMBER**)
Infants up to 2 years of age (**PLEASE WRITE IN THE NUMBER**)

Q8A **ASK IF Q8.3 OR Q8.4 IS MORE THAN 5. OTHERS GO TO Q9**: Are you travelling as part of a school party?
Yes
No

Q9. Is this your outward, return or a single journey?
Outward
Return
Single **GO TO Q11**

Q10. **IF Q9=1 ASK:** How long will you be away?
IF Q9=2 ASK: How long have you been away?

Q11. In which country have you lived for most of the last 12 months?
DP – RESPONSE CODES IN NON BOLD. BOLD = HEADINGS

ALL IRELAND (ROI AND NI)
Eire (Republic of Ireland)
Northern Ireland

UK
UK (excluding Northern Ireland)
Channel Isles

EUROPE
Austria
Belgium
Bulgaria, Romania
Cyprus & Malta
Denmark (Excludes Greenland & Faroe Is)
Finland
France (inc. Corsica & Monaco)
Germany
Greece
Iceland
Italy (inc Sicily, Sardinia & Elba)
Luxembourg
Netherlands
Norway
Portugal (inc Maderia & Azores)
Spain (inc Balearics)
Sweden
Switzerland
Turkey
Eastern Europe (NON EU only)
Other Eastern Europe (Czech, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia)
Rest of Europe (Canaries, Gibraltar, Greenland, Faroe Is, Andorra, Liechtenstein)

NORTH AMERICA
Canada
US (inc. Bahamas, Hawaii, Puerto Rico, US Minor Is)
Central America/Caribbean

OTHER
North Africa (Algeria, Egypt, Libya, Morocco, Tunisia)
Central, East & West Africa
Republic of South Africa (inc Windhoek, Namibia)
Middle East (Afghanistan, Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Yemen, Oman, Qatar, Saudi Arabia, Syria, UAE)
India, Pakistan, Sri Lanka (inc. Maldives)
Japan
Rest of Asia
Australia & New Zealand
South America
Other (please specify)

Q12. **DO NOT ASK BUT RECORD GENDER**:
Male
Female

Q13. Which of the following age groups are you in?
Less than 18
18-24

25-34
35-49
50-59
60-64
65+
Would rather not say

Q14. We will email you a link for the online survey for you to complete once you have made your flight from Dublin today. Can I please take a note of your email address?

Name:
Email address:
Check field for email address **(IF NOT MATCHED – GO BACK TO "EMAIL ADDRESS")**

Please note that the survey link will be sent from Accent and not RedC or DAA. As mentioned earlier you will be provided with your €5 once the main survey has been completed.

Main questionnaire: Online

Many thanks for taking the time to participate in this research which is being undertaken by Accent on behalf of Dublin Airport Authority, or DAA, which operates Dublin Airport. DAA is responsible for the day-to-day operation of Dublin airport, as well as developing and maintaining the airport buildings and facilities. DAA recovers the costs of operating, maintaining and developing Dublin Airport through charges to the airlines that use the airport, which airlines typically seek to recover as one component of the fare that passengers pay.

This research looks at how people make air travel choices and where they would like to see any improvements to their airport experience. The results of this research will inform DAA's decisions about whether to invest in improvements to Terminal 1 of Dublin Airport. If DAA does not invest in improvements to Terminal 1, fares are expected to fall slightly. However, if DAA does invest in improvements, it would recover the costs through its charges to airlines, and therefore fares would be expected to fall by less or even increase.

Please be assured that any answers you give will be treated in confidence in accordance with the Code of Conduct of the Market Research Society. As mentioned at the time of recruitment this interview will take approximately 20 minutes to complete.

As mentioned at recruitment, we will send you a €5 Amazon voucher (or equivalent value in a currency of your choice) once the project is completed. Alternatively we will give you the opportunity to donate your "thank you" incentive to charity. You will be shown these two options at the end of the interview.

We would like to start by asking you some questions about the flight you took from Dublin Airport on Q1. As a reminder you took a flight from Dublin to Q5 with Q4. Your flight departed from Terminal 1. For the remainder of the interview we will refer to the airport/terminal as Terminal 1.

Q15. We will be asking you a number of questions relating to the cost of your ticket, based on your flight departing from Dublin. Which currency would be the most appropriate to use for recording your responses?

Euro
£ sterling
$ US
$ Canadian

Q16. How did you travel to Terminal 1 to catch your flight? **MULTICODE**

Air (connecting flight at Dublin) **THANK AND CLOSE**
Private car/Car Park Shuttle Bus
Rental car
Scheduled/Public Bus/Coach
Charter Coach/Bus
Hotel Shuttle
Taxi/minicab
Other (please type in)

Q17. How much did your ticket cost? If you don't know the exact cost please provide your best estimate and note this is the cost of your flight and should not include any additional items such as parking or travel to the airport.
Please round your answer to the nearest #currency from Q15#
ADD FOR THOSE TRAVELLING WITH OTHERS (Q8≠1): Please provide the cost just for your ticket (and not for those who were travelling with you).

DP – RESPONSE CODE TO USE CURRENCY SELECTED IN Q15
DP – ANSWER MUST BE GREATER THAN 2.50

Q18. Is this your actual ticket cost or your best estimate?

My actual ticket cost
My best estimate

Q18A What was the scheduled departure time of your flight?

24 hr clock
DP – DO NOT ALLOW TIMES BETWEEN 0100 AND 0500

Check-in and Security

Q19. Where did you get your boarding card issued for your flight from Terminal 1?

Airline check-in desk
Self service check-in at airport
Printed myself after I checked in online **GO TO Q22**
Other (please type in) **GO TO Q22**

Q20. Approximately how long did you queue to check in?

I didn't have to queue
Record time in minutes: **MAX OF 600**

Q21. Was the time you had to queue… **IF CODE 1 AT Q20 THEN DO NOT SHOW CODE 1 AT Q21**
Longer than expected?
About what you expected?
Quicker than expected?

Q22. Did you check in any bags?
Yes
No **GO TO Q25**

Q23. Approximately how long did you queue to check your bags in at Terminal 1?
I didn't have to queue
Record time in minutes: **MAX OF 600**

Q24. Was the time you had to queue…
Longer than expected? **IF CODE 1 AT Q23 DO NOT SHOW**
About what you expected?
Quicker than expected?

Q25. **ASK IF Q19=1, 2 OR 3. OTHERS GO TO Q26:** How would you rate your overall check-in experience at Terminal 1? **PLEASE ENSURE THE SCALE HAS EXCELLENT AT THE TOP**
Excellent (5)
Good (4)
Average (3)
Poor (2)
Extremely Poor (1)

GO TO Q27

Q26. How would you rate your overall journey through the check-in area of Terminal 1?
PLEASE ENSURE THE SCALE HAS EXCELLENT AT THE TOP
Excellent (5)
Good (4)
Average (3)
Poor (2)
Extremely Poor (1)

Q27. Approximately how long did you spend queuing at security screening at Terminal 1? Please note this is the time from when you joined a queue (if there was one) to when you passed through the x-ray machines.

Record time in minutes: **MAX OF 600**

Q28. Was the time you had to queue…
Longer than expected?
About what you expected?
Quicker than expected?

Q29. How would you rate your overall security screening experience at Terminal 1? **PLEASE ENSURE THE SCALE HAS EXCELLENT AT THE TOP**

Excellent (5)
Good (4)
Average (3)
Poor (2)
Extremely Poor (1)

9.1.1. Satisfaction with Departing from Dublin T1

Q30. Thinking about your experience departing from Terminal 1, please rate the airport in terms of …… **PLEASE ENSURE THAT THE SCALE STARTS WITH EXCELLENT.**

	Excellent	Good	Average	Poor	Extremely Poor	Don't know
Ease of finding your way around T1	5	4	3	2	1	0
Ambience/feel of check in area at T1	5	4	3	2	1	0
Cleanliness of T1 overall	5	4	3	2	1	0
Ambience/feel of security area at T1	5	4	3	2	1	0
Security queuing time at T1	5	4	3	2	1	0
Location of toilet facilities at T1	5	4	3	2	1	0
Cleanliness of toilet facilities at T1	5	4	3	2	1	0

Flying into Dublin T1. IF SINGLE TRIP AT Q9 (Q9=3) GO TO AIRPORT EXPERIENCE.

Q31. [EMPTY]

Q32. [EMPTY]

Q33. Thinking about your experience arriving at Terminal 1, please rate the airport in terms of ……
Please note that we are referring to the area you experience once you've passed through baggage reclaim
PLEASE ENSURE THAT THE SCALE STARTS WITH EXCELLENT

	Excellent	Good	Average	Poor	Extremely Poor	Don't know
Ease of finding your way around arrivals hall at T1	5	4	3	2	1	0
Ambience/feel of arrivals hall at T1	5	4	3	2	1	0
Location and range of retail facilities in arrivals hall at T1	5	4	3	2	1	0

DP – ROTATE [SP AND DIAGNOSTICS] WITH SI QUESTIONS [Q34 THRU Q41]

9.1.2. Airport Experience Exercise

We will now show you some choices involving combinations of improvements to different parts of Terminal 1 and changes in your fare.

ADD FOLLOWING IF SHOWING SP BEFORE TICKET CHOICES:

These choices cover:

- The terminal façade. You will be shown two different options:

Terminal 1 façade remains as it is now

Improvements to ensure those unfamiliar with Dublin airport Terminal 1 would have clear signage and be clearly identifiable as a separate terminal

- Check-in area. You will be shown two different options:

Check-in experience remains as it is now

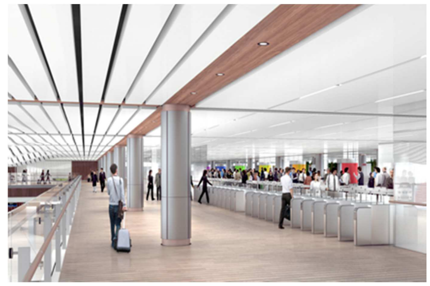
Improvements to the check-in areas provide a naturally lit environment.
Provision of self-service kiosks and bag drop facilities.
Clear information e.g. departure board, wayfinding signage, where to go next.
Improved toilet facilities in more convenient locations

ADD IF Q19=1 OR 2 AND Q22=1

Reduced check-in times due to the provision of self service check-in kiosks and self-bag drop

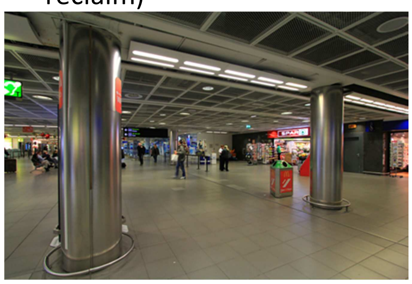
- Security screening area

Security screening area remains as it is now



Improvements to security area to enhance ease of movement and circulation through security.
Shortest lane indicators to assist passenger flow through security.
A dedicated post security redress area.
Clear information on wayfinding and flight details immediately post security

  - Security queue times – you will be shown the time it will take you to pass through security screening up until the point that you reach the x-ray machine
  - Arrivals area (the area you experience once you've passed through baggage reclaim)



Arrivals area remains as it is now

Improvements to arrivals area to include easy to locate arrivals information, modern and clean toilets and a coffee shop.
A 'modern Irish' welcome with uninterrupted views to ensure clear wayfinding

- The change in your fare above inflation

For each pair of options we present, please say which option you prefer. When making your choices please assume that all other aspects of your journey which are not mentioned are the same as for your journey to Q5 with Q4.

An example of a pair of options is shown below. Please take a moment to review these options.

INSERT EXAMPLE OF NERA CV SHOWCARD

If you hover over the information icon you will see that some images have been included to help you visualise the difference between the choices.

Please select your preferred option, considering any changes to conditions and the facilities available at Terminal 1, as well as any changes to the cost of your ticket.

INSERT SP HERE

SHORTENED TEXT VERSION FOR SP EXERCISES PLUS HOVER BUTTONS TO SHOW FULL TEXT AS ABOVE FOR EVERY ATTRIBUTE:

- T1 Façade:
  - As now
  - Improved
- Check-in area:
  - As now
  - Improved
- Security screening area:
  - As now
  - Improved
- Security queue times:
  - Shown in minutes
- Arrivals area:
  - As now
  - Improved

DP – INSTRUCTIONS FOR SECURITY QUEUE TIMES – BASED ON STATED SCHEDULED DEPARTURE TIME Q18A:

IF Q27 >5 FOR PEAK (I.E. Q18A=0630-0730 or earlier) or Q27 >3 FOR OFF-PEAK (I.E. Q18A=000-0629 and 0731-1159 or later) USE THE FOLLOWING TABLE:

	Peak = Q18A=0630-0730 or earlier	**Off-Peak = Q18A=000-0629 and 0731-1159 or later**
Improvement	Q27 -5 minutes	Q27 -1 minute
No Improvement	Q27 +5 minutes	Q27 +1 minute

IF Q27 ≤5 FOR PEAK (I.E. Q18A=0630-0730) or Q27 ≤3 FOR OFF-PEAK (I.E. Q18A=000-0629 and 0731-1159) USE THE FOLLOWING TABLE:

	Peak = Q18A=0630-0730 or earlier	**Off-Peak = Q18A=000-0629 and 0731-1159 or later**
Improvement	1 minute	1 minute
No Improvement	11 minutes	3 minutes

DIAGNOSTICS

We would now like to ask you a few questions about the series of choices you have just made.

D1 **ASK ALL:** Did you feel able to make comparisons between the choices presented to you?
Yes **GO TO D3**
No

D2 Why weren't you able to make the comparisons in the choices?
TYPE IN

D3 **ASK ALL:** In the choices, did you find each of the levels of service described realistic & easy to understand?
Yes **GO TO D5**
No

D4 Which levels did you feel were not realistic or easy to understand?
TYPE IN

D5 **ASK ALL**: Did you notice that some of the options in the exercises you've just completed were shaded?
Yes
No **GO TO TICKET CHOICES OR STATED PREFERENCE DEPENDING ON ROTATION ORDER**

D6 And did you use this shading to inform the choices you made in the exercises?
Yes
No

GO TO TICKET CHOICES OR STATED PREFERENCE DEPENDING ON ROTATION ORDER

DP – TICKET CHOICES INCREASES/DECREASES IN THREE SEQUENCS:
SEQUENCE 1: €2.50 AT Q34, €5 AT Q35, €7.50 AT Q36, €0 AT Q38 AND -€1.50 AT Q39
SEQUENCE 2: €7.50 AT Q34, €10 AT Q35, €12.50 AT Q36, €4 AT Q38 AND €0 AT Q39
SEQUENCE 3: €17.50 AT Q34, €22.50 AT Q35, €27.50 AT Q36, €10 AT Q38 AND €2.50 AT Q39

DP FARE INCREASES TO BE SHOWN IN CURRENCY OF CHOICE
€-1.50/£-1.20/US$-2.05/CANADIAN $-2.20
€2.50/£2/US$3.40/CANADIAN $3.65
€4/£3.20/US$5.45/CANADIAN $5.85
€5/£4/US$6.80/CANADIAN $7.30
€7.50/£6/US$10.20/CANADIAN $10.95
€10/£8/US$13.60/CANADIAN $14.60
€12.50/£10/US$17/CANADIAN $18.25
€17.50/£14/US$23.80/CANADIAN $25.50
€22.50/£18/US$30.60/CANADIAN $32.80
€27.50/£22/US$37.45/CANADIAN $40.05

ROTATE SEQUENCES BETWEEN INTERVIEWS

Ticket Choices

We will now show you some choices between two situations:

1. DAA does not carry out any improvements to Terminal and your fare reduces by €2.50 [DP show in preferred currency £2/US$3.40/Canadian $3.65]

2. DAA carries out a number of possible improvements to Terminal 1, and your fare either reduces by less or increases.

ADD FOLLOWING IF SHOWING TICKET CHOICES BEFORE SP:

These choices cover:

- The terminal façade. You will be shown two different options:

Terminal 1 façade remains as it is now

Improvements to ensure those unfamiliar with Dublin airport Terminal 1 would have clear signage and be clearly identifiable as a separate terminal

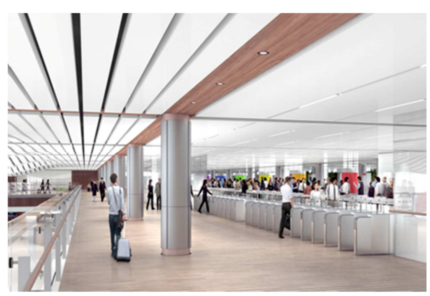
- Check-in area. You will be shown two different options:

Check-in experience remains as it is now

Improvements to the check-in areas provide a naturally lit environment.
Provision of self-service kiosks and bag drop facilities.
Clear information e.g. departure board, wayfinding signage, where to go next
Improved toilet facilities in more convenient locations
ADD IF Q19=1 OR 2 AND Q22=1
Reduced check-in times due to the provision of self service check-in kiosks and self-bag drop

- Security screening area

Security screening area remains as it is now



Improvements to security area to enhance ease of movement and circulation through security.
Shortest lane indicators to assist passenger flow through security.

A dedicated post security redress area
Clear information on wayfinding and flight details immediately post security

- Security queue times – you will be shown the time it will take you to pass through security screening up until the point that you reach the x-ray machine
- Arrivals area (the area you experience once you've passed through baggage reclaim)

Arrivals area remains as it is now

Improvements to arrivals area to include easy to locate arrivals information, modern and clean toilets and a coffee shop.
A 'modern Irish' welcome with uninterrupted views to ensure clear wayfinding

- The change in your fare above inflation

For each pair of options we present, please say which option you prefer. When making your choices please assume that all other aspects of your journey which are not mentioned are the same as for your journey to Q5 with Q4.

An example of a pair of options is shown below. Please note that, if part of an option is shaded, this part is different from the other option shown; where neither option is shaded, both options are the same for that part of the terminal. Please take a moment to review these options.

INSERT EXAMPLE OF NERA CV SHOWCARD

You will see that some images have been included to help you visualise the difference between the choices.

Please select your preferred option, considering any changes to conditions and the facilities available at Terminal 1, as well as any changes to the cost of your ticket.

Q34. Which option do you prefer A or B?
SHOW RELEVANT CURRENCY FROM Q15
Option A
Option B **GO TO Q38**

Q35. Which option do you prefer A or B?

Option A
Option B **GO TO Q37**

Q36. Which option do you prefer A or B?

Option A
Option B

Q37. Recall that you paid #Q17# for your ticket, and if the improvements to Terminal 1 do not go ahead this would fall by €2.50 [DP show in preferred currency £2/US$3.40/Canadian $3.65] to [#Q17# - €2.50]. What is the maximum ***additional*** amount you would be prepared to pay, on top of the current fare of #Q17#, to have Package B (which includes all of the improvements) rather than Package A?

€__________ on top of the current fare of #Q17#

EURO/CENT [OR RELEVANT CURRENCY FROM Q15]
DP PLEASE ALLOW FOR NEGATIVE VALUES BUT DO NOT MAKE OBVIOUS TO RESPONDENTS

GO TO Q42

Q38. Which option do you prefer A or B?

Option A **GO TO Q41**
Option B

Q39. Which option do you prefer A or B?

Option A
Option B

Q41. Recall that you paid #Q17# for your ticket, and if the improvements to Terminal 1 do not go ahead this would fall by €2.50 [DP show in preferred currency £2/US$3.40/Canadian $3.65] to [#Q17# - €2.50]. What is the maximum ***additional*** amount you would be prepared to pay, on top of the current fare of #Q17#, to have Package B (which includes all of the improvements) rather than Package A?

€__________ on top of the current fare of #Q17#

EURO/CENT [OR RELEVANT CURRENCY FROM Q15]
DP PLEASE ALLOW FOR NEGATIVE VALUES BUT DO NOT MAKE OBVIOUS TO RESPONDENTS

T1 Improvements

Q42. We have been asking your opinions about the potential improvements that could be made to T1. For each of these please tell us how important you believe it is that DAA carries out the improvements shown to you earlier in the questionnaire

	Very important	Important	Neither/ nor	Not very important	Not at all important	Don't know
Terminal façade:	5	4	3	2	1	0
Check-in area	5	4	3	2	1	0
Security screening area	5	4	3	2	1	0
Security queue times	5	4	3	2	1	0
Arrivals area	5	4	3	2	1	0

Q43. What do you think about the plans to improve the facilities at T1 in return for a small increase in the fare paid by passengers?

About Airline Tickets

Q44. What do you think is included in the cost of your airline ticket? (open ended)

Q45. How much of the airline ticket price of Q17 do you think goes to DAA? **PLEASE ENTER A VALUE TO THE NEAREST RELEVANT CURRENCY FROM Q15**

Q46. Do you think that airports charge a fixed rate or a percentage of airline ticket?
Fixed amount
Percentage of airline ticket

Q47. What proportion do you think each of the following contributes to the cost of your ticket?
NOTE – MUST ADD UP TO 100%
Airport charges (total for both airports used on journey)
Airline staff (pilots, cabin crew, etc)
Aircraft costs (including purchase costs and maintenance)
Fuel costs
Air traffic control charges
Other

About you

Finally, some questions about yourself. The personal information you provide during this survey will be kept confidential by Accent and will not be disclosed to third parties. It will be used for analysis purposes only.

Q49. How many flights have you taken to or from Dublin Airport in the last 12 months for the following purposes? All boxes need to be completed including where you have taken 0 flights. If you don't know, please give your best estimate.
PLEASE COUNT RETURN FLIGHTS AS TWO

	Business	Leisure
Terminal 1	#	#
Dublin T2	#	#

Q50. What is your total annual household income, before tax and other deductions? If you don't know, please give your best estimate.

DP – BANDS TO REFLECT PREFERRED CURRENCY

Q52. Do you have a disability or impairment that makes using an airport or flying difficult?
Yes
No
Prefer not to say

Q54. We really appreciate the time that you have given us today. Would you be willing to be contacted again for clarification purposes or be invited to take part in other research for us?
Yes, for both clarification and further research
Yes, for clarification only
Yes, for further research only
No

Q55. Accent, on behalf of DAA, would like to thank you for taking the time to complete this questionnaire. As mentioned, we will provide you with a €5 Amazon voucher in your chosen currency or make a donation to a charity on your behalf. Please tell us which you would prefer?

Amazon voucher
Charity donation – NB: IN HOVER BUTTON ADD - Cystic Fibrosis Ireland, Special Olympics Ireland and Jack & Jill Foundation

ADD IF CODE 2: Many thanks. We will make a donation on your behalf to DAA's chosen charities – Cystic Fibrosis Ireland, Special Olympics Ireland and Jack & Jill Foundation.
GO TO THANK AND CLOSE

Q56. **ADD IF CODE 1 AT Q55:** We will send your Amazon voucher to the email address collected as part of this research process. You should receive it within 4 weeks. Please select your preferred currency for the voucher:

Euro
£ sterling
$ US
$ Canadian

9.1.3. Thank you for your help in this research

This research was conducted under the terms of the MRS code of conduct and is completely confidential.

Appendix E. Peer Review

Willingness to Pay for Improvements to Dublin Airport Terminal 1:
Report to Dublin Airport Authority by NERA

A review
Ken Willis,
Newcastle University

30th July 2014

General

The "Willingness to Pay for Improvements to Dublin Airport Terminal 1" study, undertaken by NERA, is an excellent piece of research. The research provides detailed evidence on passengers' views on proposed improvements to Terminal 1 (T1), and passengers' trade-off between airport charges (via airline fares) in relation to the proposed improvements in facilities at T1.

The research methodology is thorough and detailed: it is "state of the art" in the application of stated preference methods.

Methodology

The report provides a coherent and eloquent overview of stated preference (SP) techniques, their advantages, and use to assess customer preferences in regulated industries.

The report rightly outlines the conditions in a SP study necessary to ensure results are accurate, reliable, and robust. These are that customers fully understand the new service standards which will be provided so that they can make an informed decision about the value of these improvements to themselves; and that the SP payment mechanism is incentive compatible i.e. customers believe their stated willingness-to-pay (WTP) amount will be collected. These conditions have been met. The survey instrument describes the change in service in T1 compared to what is currently available. The illustrations enable passengers to visualise the appearance of the improvements, and comprehend their impact. The payment mechanism is convincing since it is linked to the airline ticket price, and passengers now recognise that airlines are charged for airport facilities.

The study uses both contingent valuation (CV) and choice experiment (CE) methods to value willingness-to-pay (WTP) for the proposed improvements. This procedure of including both CE and CV questions in the same questionnaire is now often adopted in SP studies.

The study rightly recognises the need to address the issue of invalid responses to the SP questions, i.e. protest responses and those where the respondent did not understand the questions.

Survey design

The structure of the questionnaire follows standard practice in SP surveys in first explaining the proposed changes, then eliciting respondent's use and experience of airport services, followed by the

SP WTP questions, and questions to assess the validity of WTP responses, and concluding with information on demographic and socio-economic information about the respondent.

Although SP studies now often use both CE and CV questions in the same questionnaire, the CV and CE values are not necessarily independent, and may be correlated. Respondents' WTP for the CV questions may be conditioned on their previous responses to the CE questions, and vice versa. To ensure that respondents' answers were not systematically influenced by the set of questions they saw first, the order of these two exercises was randomised between respondents. This ensures that there is no systematic bias in one SP method relative to the other, but does not eliminate the possible WTP correlation problem. In addition, the open-ended (OE) or payment card (PC) CV WTP responses might be conditioned by the WTP amounts presented in the initial single-bounded (SB) CV question.

The CE and CV questions were clearly explained to respondents. Each choice alternative comprise six attributes, including the change in ticket price. Each CE card comprised only two alternative packages of attributes which made it easy for respondents to indicate which package they preferred. Each package comprised six attributes which is about the maximum number of attributes a respondent can trade-off against each other without resorting to some heuristic to simplify the choice e.g. by considering or giving greater weight to only a sub-set of attributes.

The experimental design is a random design, pairing the 128 different combinations of 'packages' (all possible permutations of attribute levels). Many CE studies use a "D-efficient" fractional factorial experimental design, to maximise the information from the data. However, the random design appears to have worked well since highly statistically significant WTP values for the attributes have been derived in the econometric models. NERA correctly removed choice set which had dominated packages.

Sample

The main survey sample of 550 randomly selected T1 passengers is sufficient to ensure that the sample is representative of Dublin Airport T1 customers, and that the results are statistically significant.

The sample is broadly representative of T1 passengers compared with known characteristics of T1 users. So Dublin Airport Authority (daa) can be confident that the results derived from the survey data are representative of T1 passengers.

Almost 20% of respondents were business passengers. A potential issue could arise in business passenger values for T1 improvement. Non-business passengers bear the cost of their ticket, and thus the cost of any T1 improvement. Unless the business passenger is self-employed, the business passenger's firm, rather than the respondent, bears the cost of the airline ticket. Thus business passengers can vote for an improvement without an increased cost to themselves personally. Hence business passengers have a potential incentive to select improvements irrespective of cost. This may lead to some business passengers overstating their true WTP.

Estimating WTP

Choice models

The choice models adopted in the analysis are appropriate: a conditional logit (CL) model, and a mixed logit (MXL) model which allows for heterogeneity in preferences between passengers.

Appendix B1 reports the MXL logit and CL model results. The MXL model relaxes the assumption that all respondents value improvements by the same amount by allowing for random variation in preferences across passengers, according to an assumed statistical distribution (here a normal distribution).

The results reported in Appendix B1 can be judged in terms of the statistical significance of the coefficients and the direction of the sign on the coefficients, and the goodness-of-fit of the models to the data as indicated by log likelihood function. Appendix B1 reveals the MXL model is a better fit to the data than the CL model [it has a higher log likelihood].

The CE cards vary one or more attribute level (i.e. T1 façade, check-in area, security screening area, security queue times, and arrivals area). Only occasionally will a respondent have to choose between the complete package of improvements against the current unimproved situation. This contrasts with the CV approach where the complete package of improvements is always set against the current unimproved situation with only the price of the airline ticket varying.

Contingent valuation

The CV WTP value for the entire package of T1 improvements are also derived from the double-bounded (DB) dichotomous choice contingent valuation (DCCV) questions, with a follow-up open-ended (OE) CV question in the form of a payment card CV (PCCV) question.

The WTP estimate is derived from a parametric analysis of the WTP response data including explanatory variables such as type of passenger (business or non-business), whether bag check-in was used, and age of passenger (age <18). Indeed, in Appendix B2 the DCCV analysis shows that business passengers are WTP more for the package of improvements to T1 compared to non-business passengers. But it is not possible to determine whether this is due to the improvements being more valuable to business passengers or some business passengers bidding more for improvements simply because they personally don't have to bear the cost of the increased ticket prices. However, as NERA note in footnotes 56 and 59, non-business passengers value the improvements, so it is reasonable to assume that a significant element of business passenger WTP value is 'true' WTP.

Appendix B3 results raise some concern since they reveal the statistical significance of the explanatory variable "age under 18". Passengers "aged under 18" are willing to pay more on average for the package of improvements than the average of other passengers. But how many passengers under the age of 18 purchased their own tickets, and were therefore decision-makers? Perhaps respondents under the age of 18 should not have been selected in the survey as respondents; and for non-business passengers eligibility restricted to those who personally paid for tickets. However, in mitigation, footnote 60 states that only 2.5% of the sample were under the age of 18, and this is unlikely to significantly affect the WTP estimates.

Parametric analysis of the CV data is often complemented by a non-parametric or a distribution free estimator for CV mean and median WTP amounts; and also perhaps a Turnbull estimator of the mean and median CV values, if it is deemed necessary to apply a monotonicity restriction on the distribution free estimator. These non-parametric estimators provide additional understanding to the demand function for improvements at T1: mapping out the demand curve for the improvement package as the proportion of passengers willing to pay specific prices for the improvements. This analysis might be included in future research.

Validity

The Report is commendable is assessing the robustness of the estimates, and testing the sensitivity of the WTP results for the exclusion of protest responses and cases where respondents did not fully understand the questions.

In many studies the CE value of the sum of the attribute improvements often exceeds that of a CV estimate for the package of improvements. Why this should occur has not been determined. It may result from the presentation of the two SP methods: CV presenting the package improvement on one side of the scales against money on the other, whereas in a CE money is just one attribute amongst many and so may be given less weight in the decision.

However, in this NERA study, the CE and CV estimates of WTP values for the whole package of improvements are remarkably similar. The CE value for the package of improvements is €10.43 [derived by summing the WTP estimates for individual attribute improvements in Table 8.1]. This compares to a DCCV WTP estimate of €8.34, and an OE CV value is €9.13. The convergence of these estimates engenders confidence in the results.

Conclusions

The stated preference study by NERA, for Dublin Airport Authority, is an excellent, commendable, and professional piece of research. The study is "state of the art" and conforms to best practice. The analysis is meticulous and detailed, and provides accurate and reliable information about passengers' preferences. daa can be assured that the passenger WTP values derived by NERA for the proposed improvements to T1 are accurate, reliable, and robust. The Report provides a wealth of information on passengers' WTP values, which daa can confidently use in a cost-benefit analysis of investment to improve Terminal 1 facilities for passengers.

Report qualifications/assumptions and limiting conditions

NERA
ECONOMIC CONSULTING

NERA Economic Consulting
15 Stratford Place
London W1C 1BE
United Kingdom
Tel: 44 20 7659 8500 Fax: 44 20 7659 8501
www.nera.com

NERA UK Limited, registered in England and Wales, No 3974527
Registered Office: 15 Stratford Place, London W1C 1BE

Appendix 4 - Analysis of Airport Capacity at Dublin Airport

Source: Ricondo & Associates Inc.

Dublin Airport

Airfield Capacity Analysis

Briefing Paper

PREPARED FOR:

daa

PREPARED BY:

RICONDO & ASSOCIATES, INC.

29 July 2014

FINAL

[FINAL]

INTRODUCTION

The growth and development of Dublin Airport has benefited over many decades from a continuous focus on the future through long-term planning, safeguarding of land, and timely implementation of capacity improvements. As part of this on-going process, daa engaged Ricondo & Associates (R&A), an internationally recognized aviation consulting firm, to assess the capacity of the existing airfield and identify capacity-enhancing improvements for the next ten years or until construction of Runway 10L-28R, the proposed northern parallel runway.

The following sections review the findings of the airfield capacity and development analysis, focusing on the following elements:

- Review of the simulation analyses that were conducted for the existing airfield and potential improvement projects in the vicinity of existing Runway 10-28,
- Review of the capacity triggers presented by daa in its Capital Investment Programme (CIP) 2015-2019 Proposals and by CAR in its May 2014 Draft Determination of Maximum Level of Airport Charges at Dublin Airport (Draft Determination), and
- Review of various implementation scenarios for the timing and configuration of additional capacity-enhancing airfield infrastructure.

The discussion outlined in the following sections is accompanied by a technical appendix that details the demand forecasts, simulation model outputs, and capacity implementation scenarios considered during the airfield capacity analysis.

AIRFIELD CAPACITY ANALYSIS

Establishing airfield capacity is a complex issue, governed by a range of factors, including geography, climate and weather, aircraft fleet mix, schedule, infrastructure, and air traffic control. Capacity deficits result in increasing delays to aircraft operations when flight schedules are not restricted by slot coordination. As delays increase during peak periods and across the year, traffic growth becomes increasingly constrained and, if additional capacity is not implemented, ultimately ceases as delays become economically unsustainable for airlines and passengers alike.

Measurement of delay to aircraft movements is further complicated by the slot coordination process, which shifts the impact of capacity deficits from increasing delays to increasing impacts on airlines, passengers, and the national economy due to deterioration in the availability, frequency, and timing of air transportation services relative to market demand. While these impacts are real and consequential, the slot coordination process alters how they are experienced and impedes direct measurement. Simulated delay resulting from an unrestricted schedule serves as a proxy for the unquantifiable upstream impacts associated with the slot coordination process.

R&A developed a dynamic airfield simulation model for Dublin Airport to assess the operational implications of traffic growth scenarios on the existing airfield infrastructure as well as to test the operational benefits of infrastructure development options. The simulation model (Simmod Plus!) utilises inputs such as the physical airfield layout (runways, taxiways, and stands), air traffic control procedures, ground movement procedures, and unconstrained design day flight schedules representing future traffic volumes. The model runs a full day of scheduled activity and outputs operational performance in terms of throughput rates and delay experienced per air traffic movement (ATM).

R&A facilitated several coordination sessions with daa airfield operations staff as well as the Irish Aviation Authority (IAA) to ensure that assumptions in the simulation model were consistent with existing and proposed operating conditions at the Airport. This included, among other items, discussion of aircraft separations as well as potential changes to operating rules that might result if additional airfield infrastructure was implemented.

Maximum throughput volumes and detailed delay metrics were compiled for airborne delay experienced by arriving movements and ground delay experienced by both arriving and departing movements after simulating a 2014 baseline schedule as well as 2019 and 2024 schedules for the three forecast scenarios used by daa for capital planning (Core, T1 High Growth, and T2 High Growth [Transfer]). Establishing airfield capacity by looking at a combination of hourly throughput as well as resulting delay provides both an absolute capacity over a discrete period of time (the throughput) and a metric approximating the level of service the airfield is providing to users (the delay).

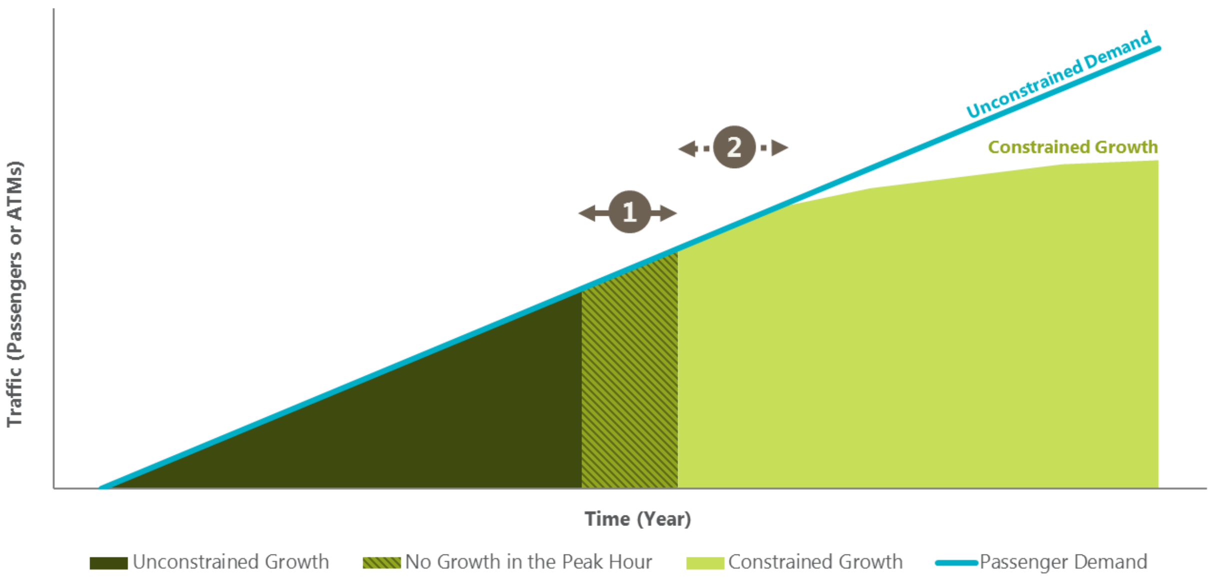
Exhibit 1 illustrates the following two key points in the demand-capacity relationship:

- **Point 1:** Achievable peak hour arrival and departure throughput. The point at which no further growth is possible in peak hour operations and overall traffic growth begins to be constrained. Point 1 is expressed as a range, to account for variations in forecast schedule and type of peak period (departures-only peak differs from overall ATMs peak). While the slot coordinator uses a level of service metric of a maximum of 10 minutes of average delay per ATM over a consecutive 30-minute period, R&A suggest that setting Point 1 using 10 minutes of average delay per ATM over a consecutive 2-hour period is more appropriate given that the flight schedules simulated represent unconstrained demand. The slot regulator's metric would flatten the schedule via the coordination process to remove peaks resulting in over 10 minutes of delay. The point at which average delay per ATM operating in the peak 2-hour period reaches 10 minutes is representative of the point at which the slot coordination process can no longer adjust schedules within the peak hour to add more flights and maintain average delay at or below 10 minutes.
- **Point 2:** The activity level at which the magnitude of delay is severe and overall traffic growth is curtailed. Point 2 cannot be precisely determined; airline and market response to peak period growth constraints are unique to individual airports. A number of different approaches are available to estimate when Point 2 might occur, including analysis of delay over a broad period of time. In the United States, for example, the regulator (the Federal Aviation Administration) sets four-to-six minutes of average annual delay per ATM as the range in which an airport is approaching its practical capacity and beyond which significant growth constraints would occur.

The R&A airfield simulation model achieved a maximum **Point 1** throughput of 37 departures and 44 total ATMs over an hour for the existing airfield, assuming implementation of the improvements associated with Phases 1 through 3 of the Runway 10-28 capacity optimisation programme identified by the Runway

Process Improvement Group.[1] **Table 1** quantifies the average delay per aircraft movement during the peak 30-minute period (the slot regulator's metric) and the peak 2-hour period (R&A's proxy metric to account for the use of unconstrained flight schedules in the simulation analysis) and illustrates the increasing magnitude of delay incurred as demand grows beyond Point 1.

Exhibit 1: Capacity Analysis – Points 1 and 2



SOURCE: Ricondo & Associates, Inc. July 2014
PREPARED BY: Ricondo & Associates, Inc. July 2014

Table 1: Average Delay per ATM for the Baseline Model (West Flow, Minutes)

		PEAK 30-MINUTE PERIOD		PEAK 2-HOUR PERIOD	
FORECAST SCENARIO	PASSENGERS (MPPA)	DEPARTURE DELAY	ARRIVAL DELAY	DEPARTURE DELAY	ARRIVAL DELAY
2014 Baseline	20.1	8.2	8.8	5.8	4.7
2019 Core	23.6	14.4	12.0	12.1	9.4
2024 Core	27.2	32.0	17.0	19.8	16.8

SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

[1] The Runway Process Improvement Group was formed in April 2013 with the aim of delivering the maximum capacity for Runway 10-28 at the Airport through the adoption of international best practices and standards for air traffic control. The group consists of key stakeholder representatives from airlines, IAA, and daa and works with the Dublin Airport Coordination Committee to ensure that capacity improvements are formally declared and available for future scheduling seasons. Phases 1 through 3 of the capacity optimisation programme reduce departure-departure airspace separations and reduce in-trail separations for aircraft entering UK airspace from Dublin Airport, allowing for an increase from 33 to 37 departures during the peak departure hour.

R&A also evaluated and simulated the delay-reduction benefit that additional entry points to Runway 10-28, as proposed by daa in its CIP 2015-2019 Proposals, would have as compared to the existing airfield. The modelling of this scenario assumed diverging departures during busy periods. R&A estimates that the range for Point 1 after the additional Runway 10-28 entry points are implemented is 24.7 to 25.9 mppa based on daa's Core Forecast. The corresponding delay metrics for this scenario are shown in **Table 2**.

Table 2: Average Delay per ATM for the Airfield with Multiple Entry Taxiways and Diverging Departures (West Flow, Minutes)

		PEAK 30-MINUTE PERIOD		PEAK 2-HOUR PERIOD	
FORECAST SCENARIO	PASSENGERS (MPPA)	DEPARTURE DELAY	ARRIVAL DELAY	DEPARTURE DELAY	ARRIVAL DELAY
2014 Baseline	20.1	8.2	8.8	5.8	4.7
2019 Core	23.6	10.8	9.8	7.3	8.1
2024 Core	27.2	19.6	15.7	15.4	15.3

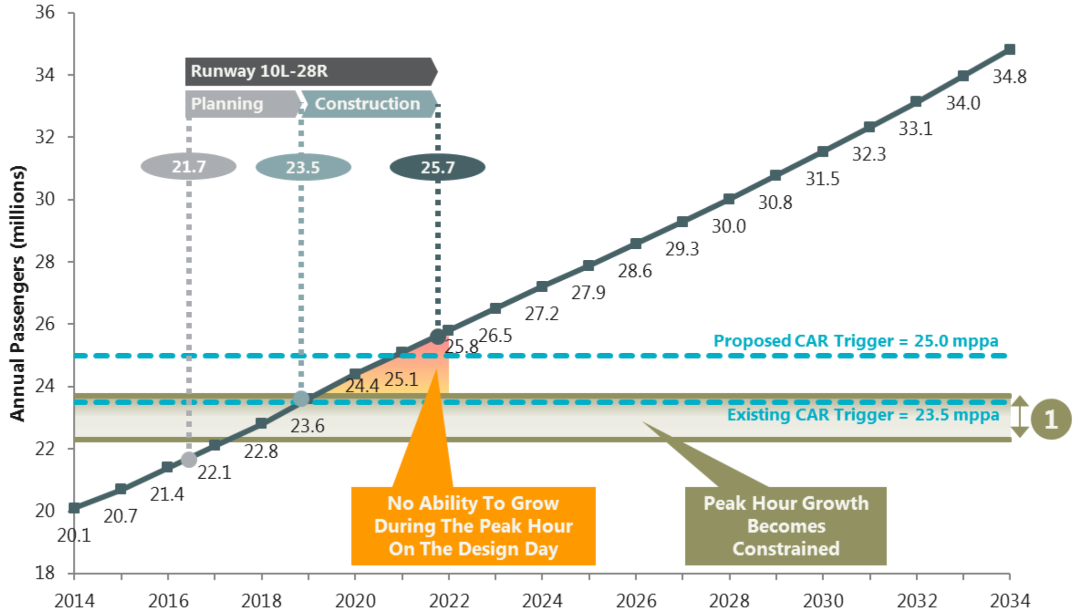
SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

The R&A simulation analysis indicates that peak period delays during the design day accelerate rapidly beyond Point 1, indicating that Point 2, or the practical capacity of the airfield, is quite close to Point 1. Given Dublin Airport's geography at the western edge of its primary market, location on an island with limited ground transport alternatives to the majority of destinations served from the airport, and the prevalence of based low-cost carriers requiring early morning departure slots, the range between Point 1 and Point 2 is likely to be narrow compared to other European airports. In aggregate, these factors suggest that Point 1 be established as the trigger for additional capacity development.

REGULATORY DETERMINATIONS AND CAPACITY TRIGGERS

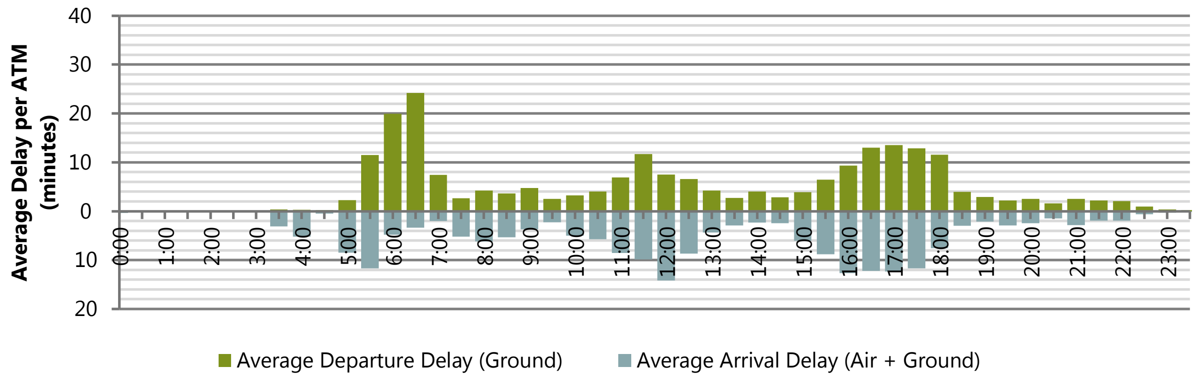
The Irish Commission for Aviation Regulation (CAR) established a trigger for future Runway 10L-28R of 23.5 mppa in the existing charges settlement that expires at the end of 2014. **Exhibit 2** depicts the timing of Core Forecast growth against the 22.3 – 23.7 mppa range for Point 1 based on the existing airfield and the key timings for planning, construction start, and implementation of Runway 10L-28R. The corresponding level of delay that would be experienced over the design day just prior to commissioning the additional capacity is shown in **Exhibit 3**. Congestion occurs in the morning and late afternoon peak periods, reaching a maximum of 24 minutes of delay per departure and 14 minutes of delay per arrival in the busiest 30-minute periods.

Exhibit 2: Runway 10L-28R Implementation at Existing CAR Trigger



SOURCE: Dublin Airport Airfield Capacity Analysis, July 2014
PREPARED BY: Ricondo & Associates, Inc., July 2014

Exhibit 3: Average Design Day Delay per ATM Corresponding to Development of Runway 10L-28R at Existing CAR Trigger (West Flow)



SOURCE: Dublin Airport Airfield Capacity Analysis, July 2014
PREPARED BY: Ricondo & Associates, Inc., July 2014

[FINAL]

Exhibit 4 depicts the timing of Core Forecast growth against both the existing and proposed range for Point 1 based on the Baseline Model and a model including multiple entry taxiways and diverging departures, respectively. This scenario implements capacity just in time to allow peak hour growth to continue unabated as required to accommodate the Core Forecast. The corresponding level of delay that would be experienced over the design day just prior to commissioning the additional capacity is shown in **Exhibit 5**. Some congestion occurs in the morning and late afternoon peak periods, reaching a maximum of 15 minutes of delay per departure and 13 minutes of delay per arrival in the busiest 30-minute periods.

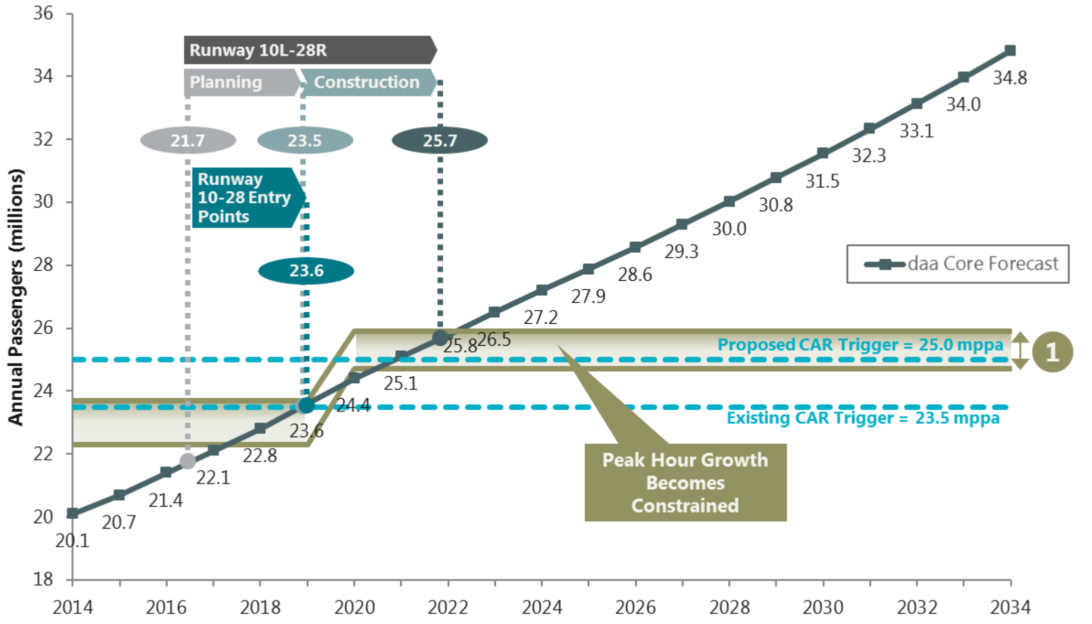
The CAR, in its Draft Determination, suggested that the trigger for the entire Runway 10L-28R project (including both the construction and planning phases) be triggered at 25.0 mppa without capacity-enhancing improvements to the existing airfield. The resulting timing of additional airfield capacity relative to Core Forecast growth and the range for Point 1 is shown in **Exhibit 6**. The corresponding level of delay that would be experienced over the design day just prior to commissioning Runway 10L-28R is shown in **Exhibit 7**. Severe congestion occurs in the morning and late afternoon peak periods, reaching a maximum of 32 minutes of delay per departure and 17 minutes of delay per arrival in the busiest 30-minute periods.

Similar to Exhibit 4, **Exhibit 8** depicts a two-step capacity-enhancing process, whereby the additional Runway 10-28 entry points would be available by the time Core Forecast growth reached 23.7 mppa and construction of Runway 10L-28R would begin at the 25.0 mppa trigger proposed by CAR in its Draft Determination. The corresponding level of delay that would be experienced over the design day just prior to commissioning Runway 10L-28R is shown in **Exhibit 9**. Some congestion occurs in the morning and late afternoon peak periods, reaching a maximum of 15 minutes of delay per departure and 18 minutes of delay per arrival in the busiest 30-minute periods.

In conclusion, the level of delay that would occur with a trigger higher than 23.5 mppa, the duration required to construct Runway 10L-28R, and the likelihood that constrained growth would occur absent additional airfield capacity, suggests that the trigger for Runway 10L-28R should be maintained at 23.5 mppa. Additionally, implementation of additional entry points and diverging departure at existing Runway 10-28 prior to reaching Point 1 will allow unconstrained growth to continue while uninterrupted while Runway 10L-28R is under construction.

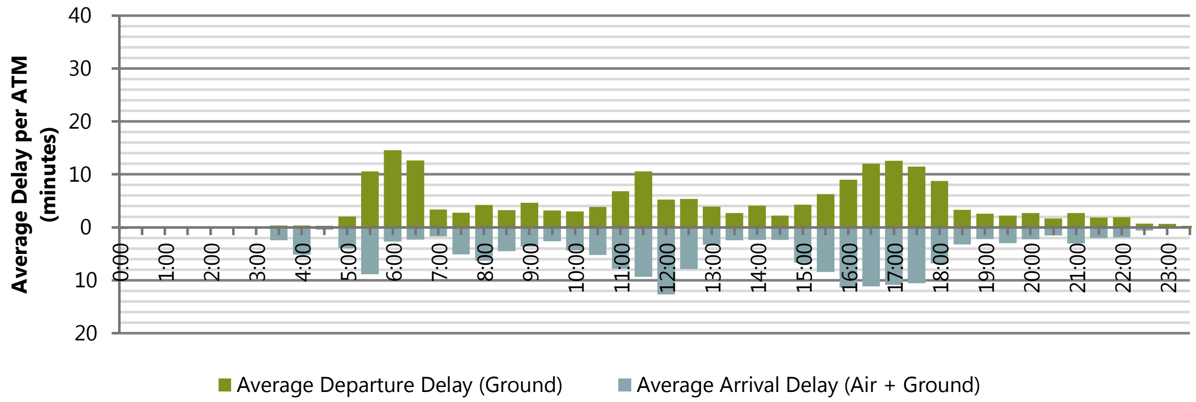
[FINAL]

Exhibit 4: Runway 10-28 Entry Points at Point 1 Followed by Runway 10L-28R at Existing CAR Trigger



SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

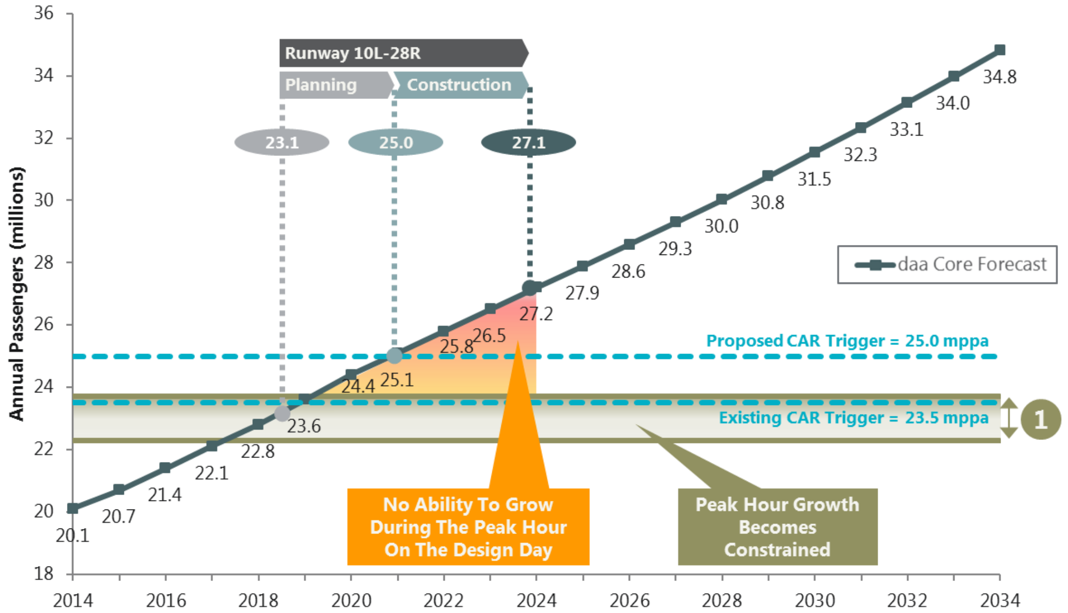
Exhibit 5: Average Design Day Delay per ATM Corresponding to Development of Runway 10L-28R at Existing CAR Trigger Coupled With Runway 10-28 Entry Points (West Flow)



SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 20

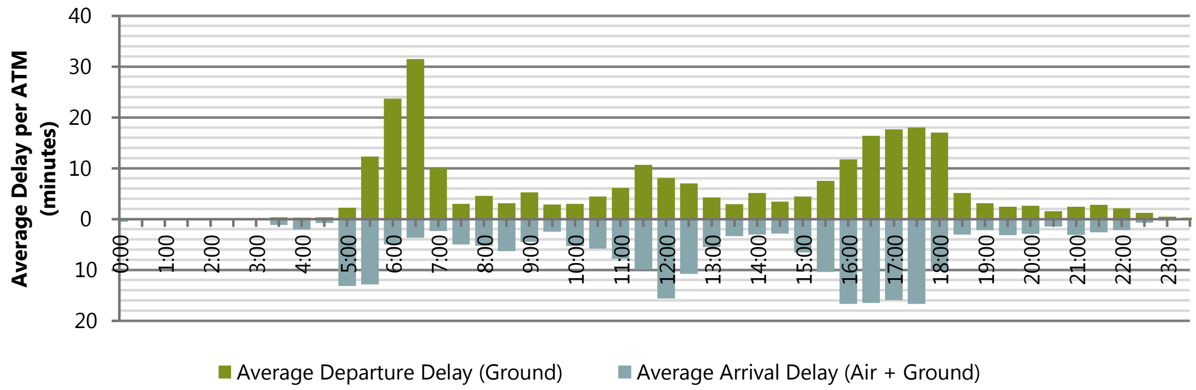
[FINAL]

Exhibit 6: Runway 10L-28R Implementation at Proposed CAR Trigger



SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

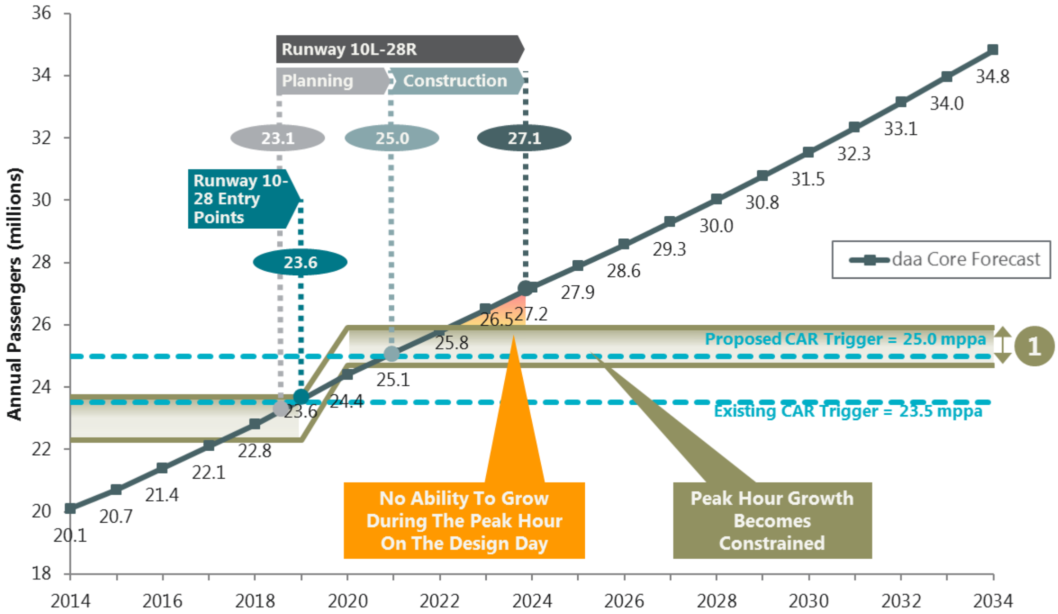
Exhibit 7: Average Design Day Delay per ATM Corresponding to Development of Runway 10L-28R at Proposed CAR Trigger (West Flow)



SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

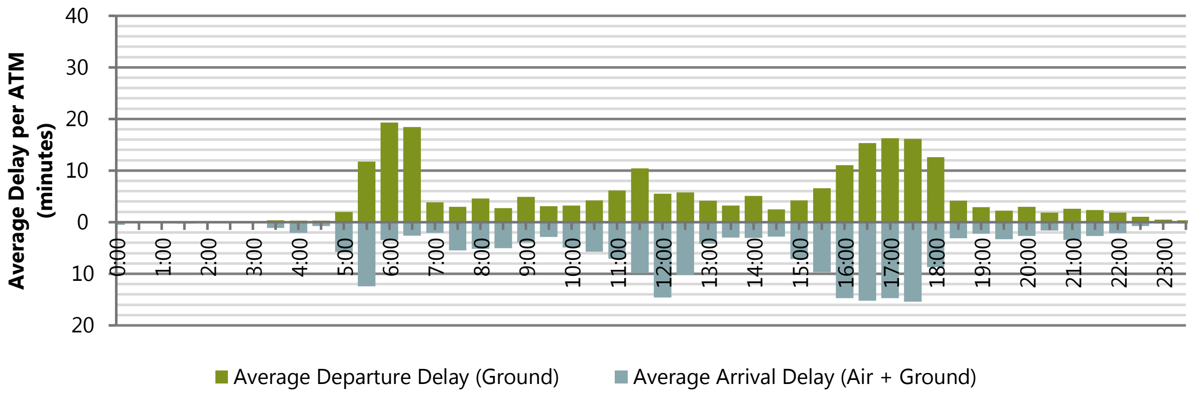
[FINAL]

Exhibit 8: Runway 10-28 Entry Points at Point 1 Followed by Runway 10L-28R at Proposed CAR Trigger



SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

Exhibit 9: Average Design Day Delay per ATM Corresponding to Development of Runway 10L-28R at Existing CAR Trigger Coupled With Runway 10-28 Entry Points (West Flow)



SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

Dublin Airport

Airfield Capacity Analysis

Briefing Paper

Technical Appendix

PREPARED FOR:

daa

PREPARED BY:

RICONDO & ASSOCIATES, INC.

29 July 2014

FINAL

Table of Contents

[FINAL]

List of Tables

[FINAL]

List of Exhibits

1. Introduction

This Technical Appendix is an accompaniment to the Airfield Capacity Analysis Briefing Paper summarising the results and conclusions of analyses conducted by Ricondo & Associates, Inc. (R&A) for Dublin Airport (the Airport). Dublin Airport Authority (daa) requested that R&A prepare this Technical Appendix to:

- Summarise the simulation analyses that were conducted for the existing airfield and potential improvement projects in the vicinity of existing Runway 10-28,
- Review of the capacity triggers presented by daa in its Capital Investment Programme (CIP) 2015-2019 Proposals and by CAR in its May 2014 Draft Determination of Maximum Level of Airport Charges at Dublin Airport (Draft Determination), and
- Review various implementation scenarios for the timing and configuration of additional capacity-enhancing airfield infrastructure.

This Technical Appendix is organised into three additional sections, as follows:

- **Section 2** provides a summary of the demand forecasts considered as part of the Capacity Analysis
- **Section 3** summarises the key findings from the R&A dynamic simulation analysis on overall maximum runway throughput, resulting levels of delay, and the timing at which activity growth could become constrained without investment in additional airfield infrastructure
- **Section 4** reviews the proposals and triggers from the CIP 2015-2019 Proposal and Draft Determination for airfield infrastructure, and identifies and evaluates the timing and configuration of various airfield capacity-enhancing scenarios

2. Demand Forecasts

Three aviation demand forecast scenarios, developed by daa, were provided to R&A for use in the Airfield Capacity Analysis. The forecast scenarios included an annual projection of passengers and air traffic movements (ATMs) for a 10-year planning horizon (through 2024). Additionally, future design day flight schedules were developed to the airfield capacity analysis for the 5-year (2019) and 10-year (2024) activity level for each forecast scenario. These forecast scenarios and design day flight schedules for 2019 were first prepared by daa in mid-2013 to support the T1 Redevelopment Plan and other studies. Flight schedules for 2024 were developed by daa based on the same assumptions and principles for the 2019 scenarios. Continued use of these schedules for the Airfield Capacity Analysis allows for consistent activity forecasts to be utilised across the Airport for comprehensive planning purposes.

The Core Forecast (also referred to as the Centreline Forecast) and related design day flight schedules for 2019 and 2024 provided the basis for defining the facilities required to accommodate future demand volumes and patterns at the Airport. To ensure the flexibility of the Airfield Capacity Analysis to account for potential uncertainties and fluctuations inherent in the aviation industry, two alternative forecasts were developed by daa and were analysed in the Airfield Capacity Analysis. These alternative scenarios – T1 High Growth (also referred to as the High Growth LCC Forecast) and T2 High Growth (Transfer) – would generally have a greater impact on the facilities as the demand is expected to be greater if new flights are added during or adjacent to existing peak periods.

Table 2-1 summarises annual forecast passenger activity and **Table 2-2** summarises annual forecast ATMs for the three forecast scenarios. Although multiple forecast scenarios were used in the Airfield Capacity Analysis, only the Core Forecast is discussed in detail in this Technical Appendix.

The Core Forecast projects that passenger traffic will increase at compounded annual growth rate (CAGR) of 3.07 percent between 2014 and 2024. In the first five years from 2014 to 2019, passenger traffic will grow at a slightly more aggressive CAGR of 3.26 percent compared with 2019 to 2024 growing at a CAGR of 2.88 percent. ATMs, meanwhile, are projected to increase at a CAGR of 2.25 percent between 2014 and 2024. In the 5-year period from 2014 to 2019, the CAGR will be 2.16 percent, compared with a CAGR of 2.33 percent between 2019 and 2024. The discrepancy in growth rates between passenger activity and ATMs suggest that airlines will be upgauging to larger aircraft, as per the fleet plans of both Aer Lingus and Ryanair.

Table 2-1: Passenger Forecasts

	ANNUAL PASSENGERS (MILLIONS)		
YEAR	CORE	T1 HIGH GROWTH	T2 HIGH GROWTH (TRANSFER)
2014	20.1	20.1	20.1
2015	20.7	20.9	20.7
2016	21.4	21.9	21.6
2017	22.1	22.9	22.5
2018	22.8	24.0	23.4
2019	23.6	25.0	24.2
2020	24.4	25.8	25.0
2021	25.1	26.6	25.7
2022	25.8	27.3	26.4
2023	26.5	28.0	27.1
2024	27.2	28.7	27.8

SOURCE: Dublin Airport Authority, March 2014.
PREPARED BY: Ricondo & Associates, Inc., March 2014.

Although Dublin Airport is a Level 3 slot coordinated airport, the forecasts and corresponding design day flights schedules are unconstrained, meaning that the times of flights are not subject to alteration by the coordination process. Unconstrained forecasts were utilised in order to measure the ability of the Airport and the air traffic control system to supply the capacity required to meet demands over the planning horizon. Use of slot coordinated schedules distorts the demand profile, shifting the consequences of insufficient capacity from measurable operational and delay performance indicators to harder to quantify implications for airlines, passengers, and long term traffic growth at the Airport. Unconstrained schedules allow the establishment of baseline delay and measurement of the delay performance of development alternatives, permitting a like-for-like comparison of options to improve the capacity and efficiency of the airfield.

Table 2-2: Air Traffic Movements Forecasts

	ANNUAL AIR TRAFFIC MOVEMENTS		
YEAR	CORE	T1 HIGH GROWTH	T2 HIGH GROWTH (TRANSFER)
2014	172,564	172,564	172,564
2015	175,855	177,330	175,855
2016	179,346	183,509	181,562
2017	183,336	190,241	186,656
2018	187,785	197,656	192,461
2019	192,042	204,023	196,856
2020	196,764	208,745	201,577
2021	201,845	213,826	206,659
2022	206,348	218,329	211,162
2023	210,896	222,877	215,710
2024	215,476	227,457	220,290

SOURCE: Dublin Airport Authority, March 2014.
PREPARED BY: Ricondo & Associates, Inc., March 2014.

While the Core Forecast scenario is based on both historical trends at the Airport and expected growth in aviation activity, the two high growth forecast scenarios were defined to reflect reasonable conditions that could develop at the Airport over a 10-year planning horizon for the Airfield Capacity Analysis. The likelihood of any specific scenario occurring, including the Core, is unknown; however, monitoring the magnitude and characteristics of activity as it occurs will allow daa to identify which forecast scenario best represents future activity.

Table 2-3 shows the clock-hour profiles of arrivals, departures, and total movements in the 2019 design day flight schedule. The peak clock-hour total movements occur between 10:00 and 10:59, with 46 total movements. The peak clock-hour departure total occurs between 5:00 and 5:59 with 35 movements, representing 11.1 percent of total departures, while the peak arrival clock-hour total occurs between 11:00 and 11:59 with 26 movements, approximately 8.3 percent of total arrivals. **Exhibit 2-1** plots the hourly activity described in the table.

Table 2-4 shows the clock-hour profiles of arrivals, departures, and total movements in the 2024 design day flight schedule. The peak clock-hour total movements occur between 11:00 and 11:59, with 47 total movements as the peak hour shifts slightly from 2019. The peak clock-hour departure total occurs between 5:00 and 5:59 with 41 movements, representing 12.2 percent of total departures, while the peak arrival clock-hour total occurs between 11:00 and 11:59 with 29 movements, approximately 8.4 percent of total arrivals. **Exhibit 2-2** plots the hourly activity.

Table 2-3: Design Day Air Traffic Movements Summary - 2019 Core Forecast

TIME OF DAY (HOURLY, UTC)	ARRIVALS	DEPARTURES	TOTAL MOVEMENTS
0:00 - 0:59	2	0	2
1:00 - 1:59	2	0	2
2:00 - 2:59	0	1	1
3:00 - 3:59	1	1	2
4:00 - 4:59	7	2	9
5:00 - 5:59	3	35	38
6:00 - 6:59	11	27	38
7:00 - 7:59	19	15	34
8:00 - 8:59	15	21	36
9:00 - 9:59	16	13	29
10:00 -10:59	21	25	46
11:00 - 11:59	26	18	44
12:00 - 12:59	14	17	31
13:00 - 13:59	13	14	27
14:00 - 14:59	18	18	36
15:00 - 15:59	18	23	41
16:00 - 16:59	19	22	41
17:00 - 17:59	17	23	40
18:00 - 18:59	13	14	27
19:00 - 19:59	13	12	25
20:00 - 20:59	18	6	24
21:00 - 21:59	21	5	26
22:00 - 22:59	21	2	23
23:00 - 23:59	7	1	8
	315	315	630
Peak Block Hour	26	35	46
Peak Percent	8.3%	11.1%	7.3%
Peak Rolling 60-minutes	26	41	51
Peak Rolling 60-minute Percent	8.3%	13.0%	8.1%
Time Period	11:00 - 11:59	5:20 - 6:19	15:10 - 16:09
	11:10 - 12:09	5:30 - 6:29	

NOTE: Peak rolling 60-minutes calculations utilised 10-minute segments of time.

SOURCE: Dublin Airport Authority, February 2014.
PREPARED BY: Ricondo & Associates, Inc., February 2014.

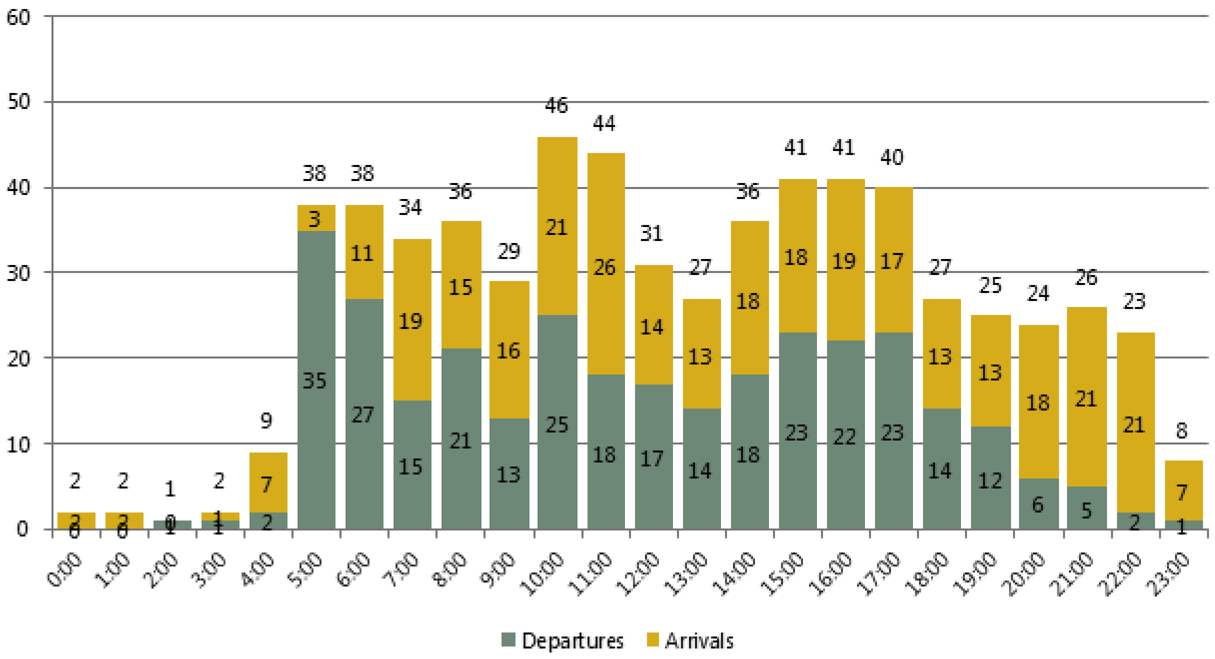
Table 2-4: Design Day Air Traffic Movements Summary - 2024 Core Forecast

TIME OF DAY (HOURLY, UTC)	ARRIVALS	DEPARTURES	TOTAL MOVEMENTS
0:00 - 0:59	2	0	2
1:00 - 1:59	2	0	2
2:00 - 2:59	0	1	1
3:00 - 3:59	1	1	2
4:00 - 4:59	8	2	10
5:00 - 5:59	3	41	44
6:00 - 6:59	14	30	44
7:00 - 7:59	20	16	36
8:00 - 8:59	16	22	38
9:00 - 9:59	16	14	30
10:00 -10:59	21	25	46
11:00 - 11:59	29	18	47
12:00 - 12:59	15	19	34
13:00 - 13:59	15	16	31
14:00 - 14:59	20	19	39
15:00 - 15:59	20	25	45
16:00 - 16:59	21	25	46
17:00 - 17:59	20	25	45
18:00 - 18:59	13	15	28
19:00 - 19:59	14	14	28
20:00 - 20:59	18	7	25
21:00 - 21:59	25	5	30
22:00 - 22:59	24	4	28
23:00 - 23:59	8	1	9
	345	345	690
Peak Block Hour	29	41	47
Peak Percent	8.4%	12.2%	6.8%
Peak Rolling 60-minutes	29	46	55
Peak Rolling 60-minute Percent	8.4%	13.3%	8.0%
Time Period	11:00 - 11:59	5:20 - 6:19	15:10 - 16:09
	11:10 - 12:09	5:30 - 6:29	

NOTE: Peak rolling 60-minutes calculations utilised 10-minute segments of time.

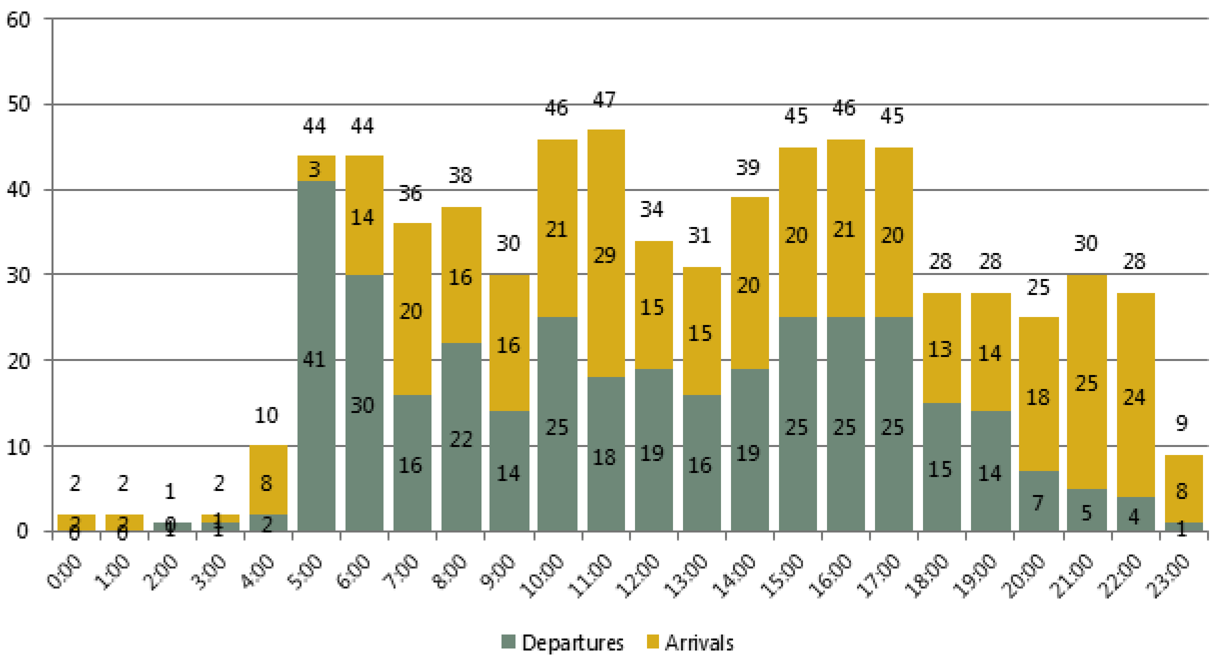
SOURCE: Dublin Airport Authority, February 2014.
PREPARED BY: Ricondo & Associates, Inc., March 2014.

Exhibit 2-1: Design Day Hourly Air Traffic Movements – 2019 Core Forecast



SOURCE: Dublin Airport Authority, February 2014.
PREPARED BY: Ricondo & Associates, Inc., February 2014.

Exhibit 2-2: Design Day Hourly Air Traffic Movements – 2024 Core Forecast



SOURCE: Dublin Airport Authority, February 2014.
PREPARED BY: Ricondo & Associates, Inc., February 2014.

3. Airfield Capacity and Delay Analysis

Establishing airfield capacity is a complex issue that is governed by a range of factors, including geography, climate and weather, aircraft fleet mix, flight schedules, infrastructure, and air traffic control. Capacity deficits result in increasing delays to aircraft operations when flight schedules are not restricted by slot coordination. As delays increase during peak periods and across the year, traffic growth becomes increasingly constrained and, if additional capacity is not implemented, ultimately ceases as delays become economically unsustainable for airlines and passengers alike.

Measurement of delay to aircraft movements is further complicated by the slot coordination process, which shifts the impact of capacity deficits from increasing delays to increasing impacts on airlines, passengers, and the national economy due to deterioration in the availability, frequency, and timing of air transportation services relative to market demand. While these impacts are real and consequential, the slot coordination process alters how they are experienced and impedes direct measurement.

The following section details the evaluation approach, stakeholder coordination, simulation model development and output, and key findings from R&A's Airfield Capacity Analysis.

3.1 Approach

R&A undertook a detailed airfield capacity analysis for the Airport using a dynamic airfield simulation model to assess the throughput and delay associated with the existing airfield as well as the improvements identified by daa and IAA as part of the CIP 2015-2019 Proposal (discussed in greater detail in Section 3.4.1). The simulation model was then used to calculate aircraft movement and delay statistics in order to identify the capacity of the existing airfield and evaluate further airfield and airspace capacity-enhancement and delay-reduction opportunities.

3.2 Stakeholder Coordination

R&A facilitated several coordination sessions with daa airfield operations staff as well as IAA to ensure that assumptions in the simulation model were consistent with existing and proposed operating conditions at the Airport. This included, among other items, discussion of aircraft separations and potential changes to operating rules that might result if additional airfield infrastructure was implemented. R&A also reviewed preliminary model outputs and conclusions with IAA.

3.3 Simulation Model Development and Delay Measurement

R&A used Simmod PLUS!, a dynamic fast-time simulation model developed by ATAC Corporation capable of simulating aircraft movements in the airspace and at airports, for the capacity and delay analysis. Simmod Plus! is a network-based model in which airspace and ground facilities are represented by nodes and links on which aircraft move. Activity is input via a flight schedule, and runway throughput, travel time, and delay data are compiled as flights travel through the model and interact with each other according to air traffic control procedures. Output from the model includes an animated playback of aircraft movements for review and to enable refinement of model performance as well as numerical tabular data that can be further processed and analysed.

3.3.1 SIMULATION MODEL INPUTS AND CALIBRATION

Assumptions that define the Airport's operating environment at the time of this study were reviewed and accepted by both daa and IAA. The following briefly summarises the baseline model assumptions.

3.3.1.1 Airfield Operating Configurations and Ground Movements

The focus of R&A's Airfield Capacity Analysis was on Runway 10-28 and related taxiway infrastructure. Consideration of dual-runway operating configurations involving Runway 16-34 were not studied in detail because they do not provide sufficient coverage to allow an increase in declared capacity for slot coordination purposes.

Runway 10-28 operates in two directions, East and West. West Flow, which occurs approximately 80 percent of all weather conditions, consists of departures from and arrivals to Runway 28. Departing aircraft generally flow south to Taxiways E1 to access the runway. Arriving aircraft taxi back on the B taxiways and to the terminal either via Taxiways M2 and H2 or on Taxiway B3 and B2 for aircraft accessing Pier 4.

East Flow, which occurs approximately 20 percent of all weather conditions, consists of departures from and arrivals to Runway 10. Departing aircraft from the terminal area generally flow to Taxiway M2 and down to the B taxiways to access Runway 10. Arriving aircraft taxi to the terminal area using either Taxiway H2 or B3/B2 and into the terminal area. Aircraft movements in the model are consistent with the restrictions published in Section 1.3 of the Airport's Aeronautical Information Publication (AIP). Taxiing speeds are assumed to be 15 knots for taxiways, 10 knots for apron stand taxilanes, and 5 knots when entering a stand.

3.3.1.2 Runway Exit Utilisation

Aircraft exits and runway occupancy time (ROT) were based on probability distributions assigned to aircraft/runway exit combinations. Runway exit utilisation and associated ROT for East Flow and West Flow were derived from daa-provided historical data for three months in the summer of 2013. As recommended by IAA, runway exit utilisation for Taxiway E3, the preferred exit taxiway for Runway 10, during East Flow was increased to represent ongoing runway capacity initiatives as part of the high intensity runway operations (HIRO) strategy.

3.3.1.3 Stand Allocation and Pushbacks

Stand assignments determined during the Airfield Capacity Analysis were carried forward to the simulation modelling. In the model, aircraft always attempt to use their assigned stand first. However, because aircraft may not arrive on time, due to punctuality or delay incurred in the model, aircraft are dynamically reallocated if their originally assigned stand was unavailable. An alternative stand is chosen based on airline and aircraft gauge restrictions.

Aircraft pushbacks are controlled by applying a pushback time period and blocking the flow of traffic around the stand. A duration period of 3 minutes is calculated by determining the time it would take to complete a pushback for a stand of average length at 4 knots and adding a 2-minute engine start period. During the entirety of the pushback, the area adjacent to the stand must remain sterile of other aircraft, thereby approximating occupancy of the apron stand taxilane. The required sterile area is adjusted based on pushback procedures associated for each individual stand. This is determined to closely represent actual pushback procedures that occur at the Airport.

3.3.1.4 Meteorological Conditions

Meteorological conditions (wind, ceiling, and visibility) affect air traffic control procedures in use at the airport. For this analysis, both airfield operating configurations (West Flow and East Flow) are simulated assuming VMC due to their prevalence at the Airport.

3.3.1.5 Impending Airfield Improvements

In order to effectively model the ability of the Airport to handle the forecast levels of traffic, and to accurately allocate the traffic volumes to different parts of the airfield, these improvements are included in the simulation models. Apron 5G is assumed to be operational for all 2019 and 2024 forecast scenarios. Apron 300R is assumed to be operational for all 2019 and 2024 forecast scenarios except the 2019 Core Forecast.

3.3.1.6 Punctuality

The model uses probabilities to produce unique output representing realistic variations in day-to-day traffic. The probability primarily responsible for driving variation in the model adjusts the arrival or departure time of each flight. Three months of daa-provided historical data from the summer of 2013 were analysed in order to identify trends in airline, aircraft, and origin/destination punctuality.

3.3.1.7 Airspace Movements

Aircraft that transition through the airspace in the vicinity of the Airport (overflights) were not considered in this analysis.

- **Routing:** Aircraft arriving at and departing from the Airport were assigned a Standard Terminal Arrival Route (STAR) or Standard Instrument Departure (SID) based on aircraft type and origin/destination. Information regarding origin/destination and STAR/SID pairing was provided by IAA. The physical make-up of each route, such as airspace fixes, was derived from aeronautical charts published by IAA on 12 December 2013, the most recent set of charts available at initiation of the development of the models.
- **En-route Separation Minima:** Separation minima define the smallest longitudinal (in front of or behind), lateral (side by side), or vertical (above or below) distances between aircraft. As each aircraft in the model is assigned to a STAR or SID and must follow the assigned route between

fixes, only longitudinal separation is considered in the model. It is important to note that these separations reflect the actual separation applied by controllers and may be greater than the minimum requirement. They are based on ICAO documentation and agreements with IAA staff.

- **Successive Runway Operation Minima:** In addition to separating aircraft moving throughout the airspace, procedures are in place at the Airport to safely separate successive aircraft operations on the same runway. Criteria based on ICAO documentation and agreements with IAA staff were used in the model.

Any airspace constraints associated with the interaction of Irish and United Kingdom airspace was not considered in this analysis. It is therefore assumed that IAA, working closely with NATS and other stakeholders, will be able to provide sufficient capacity for routes between each other's airspace boundaries as demand requires.

3.3.2 DELAY MEASUREMENT

A primary indicator of airport congestion resulting from airfield infrastructure is aircraft delay, which is the additional time, above and beyond normal unimpeded movement times, during which aircraft are prevented from moving through the airspace and around the airfield due to the presence of other aircraft. Measuring aircraft delay provides additional insight into the capacity of an airfield by allowing an assessment of level of service; that is, as delays increase level of service degrades.

Simmod Plus! reports delay times for different phases of flight, thereby providing the ability to identify factors that were the most constraining on the overall operation of the Airport. There are three primary delay metrics that are utilised in the Airfield Capacity Analysis, as follows:

- **Departure Ground Delay** is the total delay, in minutes, incurred by an aircraft from the time an aircraft attempts to pushback from the gate until it begins its departure takeoff roll. This includes, but is not limited to, airfield congestion and waiting time in the departure queue.
- **Arrival Air Delay** is the total delay, in minutes, incurred by an aircraft from the time it attempts to traverse the first link of a STAR until it crosses the runway threshold. This includes holds, path stretching, metering, and speed changes.
- **Arrival Ground Delay** is the total delay, in minutes, incurred by an aircraft from the end of its landing roll until it reaches the gate. This includes, but is not limited to, holding due to runway crossings and general taxiway congestion.

Simmod Plus! tracks delay accumulation using half-hour averages throughout the simulation day. Additionally, the model quantifies the number of ATMs that occurred on the runway over the same half-hour period. Delay incurred in any of the above metrics was allocated to the half-hour period (shown in UTC) when the runway operation, meaning when the arrival or departure, occurred. For example, if an arrival landed at 10:29 and incurred 3 minutes of delay while taxiing to a stand, all 3 minutes of delay were allocated to the half hour starting at 10:00.

Similarly, any air delay incurred by the aircraft is allocated to the half hour starting at 10:00. The total delay incurred in each category was then summed for all aircraft arriving or departing and divided by the corresponding number of operations in that half hour to derive the half-hour average. Simulated delay resulting from an unrestricted schedule serves as a proxy for the unquantifiable but real upstream impacts associated with the slot coordination process.

The delay metrics presented in the following sections refer to both average delay per ATM and total delay. Average delay per ATM is the total delay incurred over a period of time divided by the total number of ATMs over that same period of time. For example, average departure ground delay is the total departure delay incurred divided by the number of departing ATMs in a given period.

3.4 Simulation Modelling Results

Using the design day flight schedules for 2014, 2019, and 2024 prepared by daa, a series of simulations were run to model the performance of the existing airfield with a few planned airfield improvements in order to establish a baseline by which to assess delay reductions of potential airfield and airspace improvements. A second series of simulation models focused on quantifying the benefits that would be provided through the implementation of additional runway entry points at both ends of Runway 10-28 combined with implementation of diverging departure air traffic control procedures. Both configurations were modelled in both East and West Flows to ensure an overall understanding of airfield performance. The findings of the simulation modelling are described in the following sections.

3.4.1 BASELINE MODEL

The first set of simulation runs focus on a baseline model scenario (the Baseline Model) includes use of Runway 10-28 and supporting taxiway and apron infrastructure. It does not assume any capacity benefit from the ability to use Runway 16-34 given that its availability is limited to certain airfield operating configurations and meteorological conditions. It does, however, assume that IAA is able to reduce aircraft-to-aircraft separations in line with Phases 1 through 3 of the programme to enhance the declared capacity of Runway 10-28 identified by the Runway Process Improvement Group (RPIG).[1] The Baseline Model was run for a 2014 unconstrained schedule[2] as well as the future flight schedules for the 2019 and 2024. The Baseline Model establishes a starting point from which to assess delay reductions of potential airfield and airspace improvements.

3.4.1.1 Baseline Model Results

Overall average delay was calculated for the Baseline Model for each of the forecast scenarios. **Exhibit 3-1** illustrates the average amount of departure ground delay. As shown on the exhibit, the average delay increases from 3 to 4 minutes per departure to 9 to 10 minutes for the 2024 Core Forecast. Overall average delay is higher for the T1 High Growth and High Growth Transfer forecast scenarios.

---

[1] The Runway Process Improvement Group was formed in April 2013 with the aim of delivering the maximum capacity for Runway 10-28 at the Airport through the adoption of international best practices and standards for air traffic control. The group consists of key stakeholder representatives from airlines, IAA, and daa and works with the Dublin Airport Coordination Committee to ensure that capacity improvements are formally declared and available for future scheduling seasons. Phases 1 through 3 of the capacity optimization programme reduce departure-departure airspace separations and reduce in-trail separations for aircraft entering UK airspace from Dublin Airport, allowing for an increase from 33 to 37 departures during the peak departure hour.

[2] daa provided both an unconstrained and slot coordinated schedule for the 2014 design day. The unconstrained schedule is based on airline-requested schedule timings prior to the slot cleared times issued for the Summer 2014 scheduling season by the Dublin Airport Coordination Committee.

Exhibit 3-2 illustrates the average amount of arrival ground delay. As shown on the exhibit, the average delay increases from 1.3 to 2.3 minutes per arrival for West Flow. Generally this is caused by arriving aircraft not able to quickly access stands due to departing aircraft queued in the terminal area. Average arrival ground delay in East Flow decreases from 1.0 to 0.7 minutes for the 2024 Core Forecast. Much of the arrival delay for East Flow is attributed to congestion around Pier 1. Eventually, the introduction of Apron 5G and associated dual Code C taxilanes helps reduce arrival delay.

Exhibit 3-3 illustrates the average amount of arrival air delay. As shown on the exhibit, the average delay increases from 1.5 to 1.7 minutes per arrival up to 4.1 to 4.4 minutes for the 2024 Core Forecast. Overall average delay is higher for the High Growth forecast scenarios.

Bar graphs of the simulation metrics were created for each activity level and for West Flow and East Flow for comparative purposes and the identification of significant trends. The number of departures and arrivals processed in the model by hour for each forecast scenario is also provided. **Exhibit 3-4** shows the average delay for every half hour and the number of ATMs by hour for the 2014 unconstrained schedule. As shown, the average delay in any half-hour does not exceed 10 minutes for departures or arrivals. An average of ten minutes of delay per ATM over one half hour is general identified as an acceptable amount of delay by the slot coordinator, who declares available capacity based on this criterion.

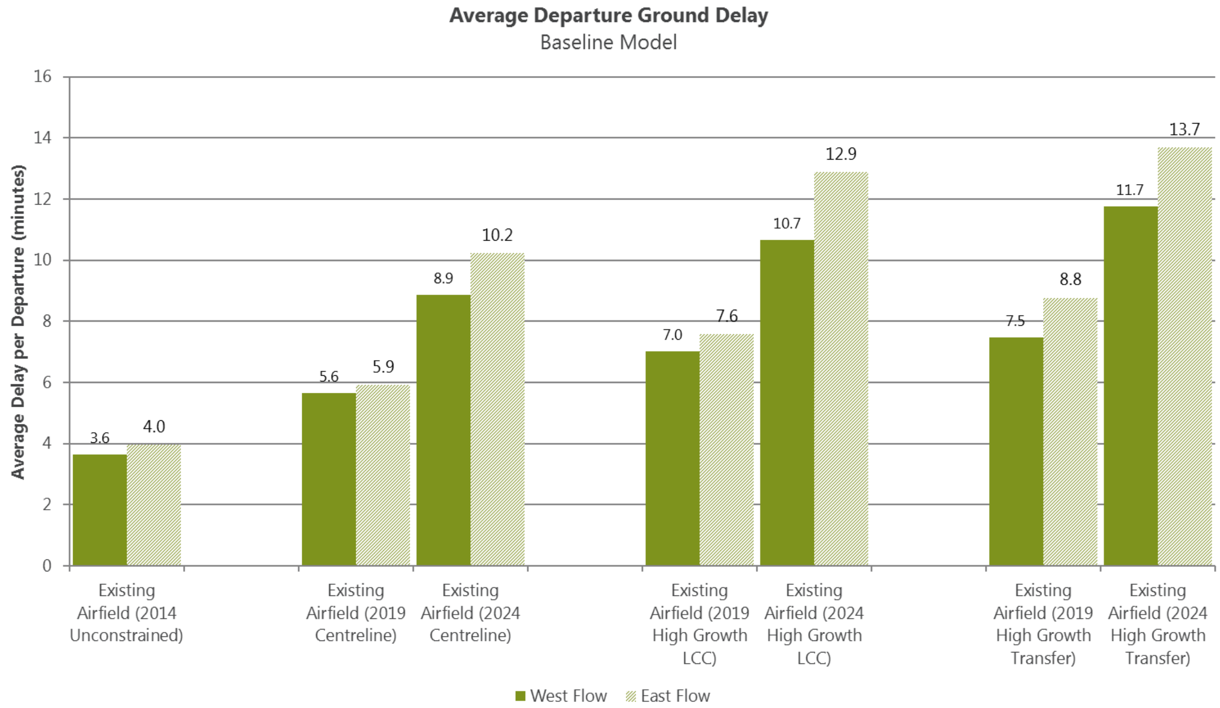
The maximum number of departures, 29, occurs in 05:00 hour (all times UTC) in West Flow while the maximum number of ATMs occurs in the 16:00 hour in East Flow. The maximum number of ATMs does not exceed the declared capacity established for Summer 2014, as shown on **Exhibit 3-5**. The simulation results that show declared capacity is not exceeded and delays are less than an average of 10 minutes for any half hour appear to coincide with the 10-minute delay criteria established by the slot coordinator.

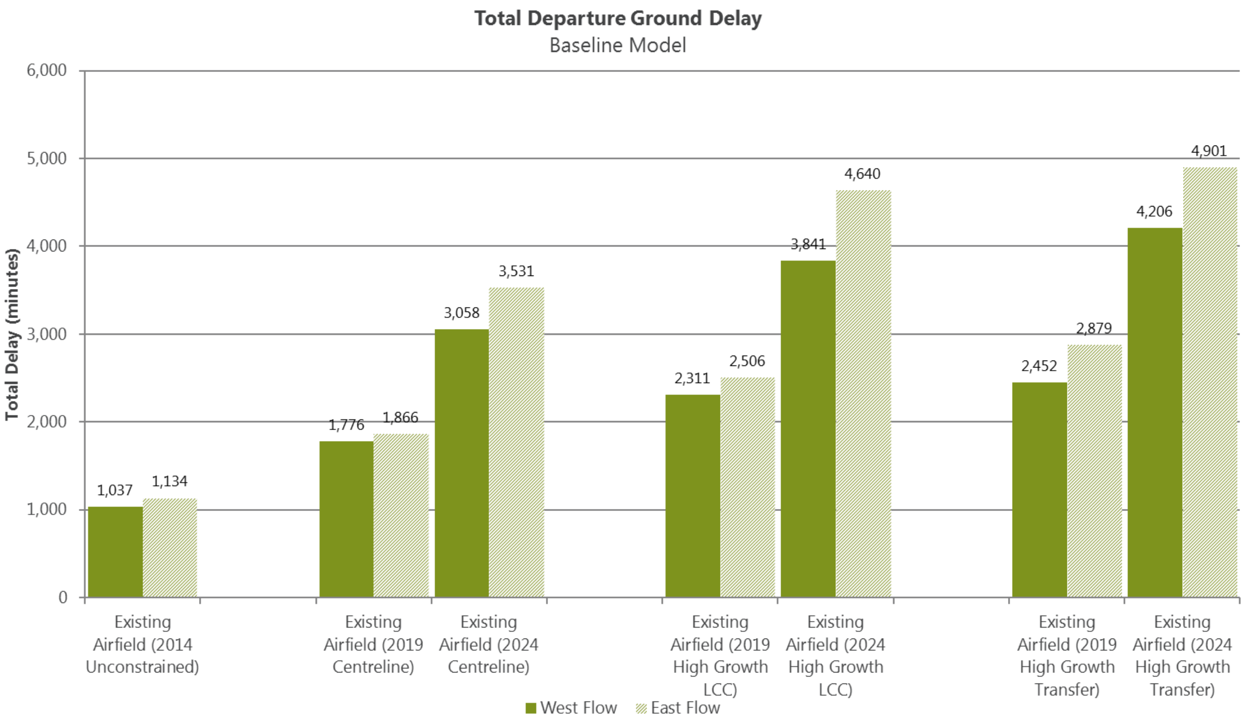
Exhibit 3-6 shows the average delay for every half hour and the number of ATMs by hour for the 2019 Core Forecast. Average departure delays in the morning peak begin to reach approximately 15 minutes. This is caused by an increase in scheduled demand in the 05:00 and 06:00 hours. Average arrival ground delays are generally low throughout the day while average air delays increase during the mid-day peak, are approximately 10 minutes or less.

It should be noted that arrival ground delays are shown in the model between 3:30 and 4:30 and are caused by two transatlantic flights arriving early in the model (based on the punctuality assumptions) that have a tendency to arrive early and have to wait for a gate to open up because there have not yet been any departures. Although delay appears to be significant during this time, only these two arriving aircraft experience significant delays.

[FINAL]

Exhibit 3-1: Baseline Model – Average and Total Departure Ground Delay

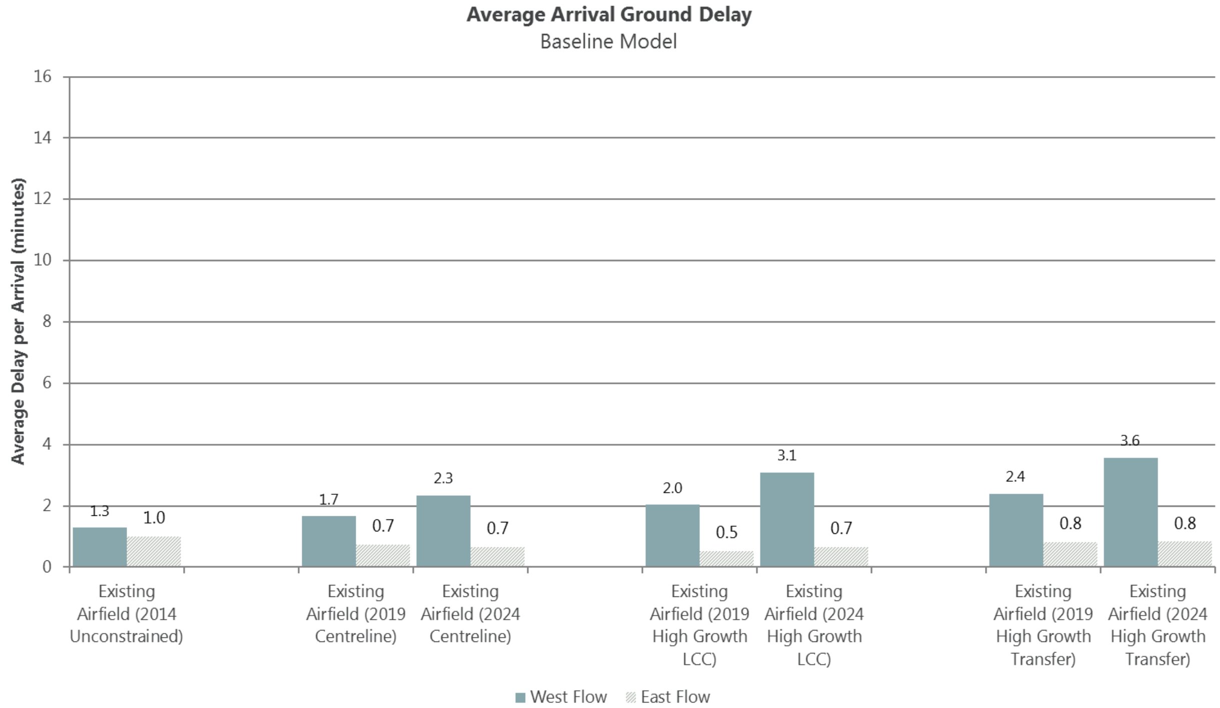


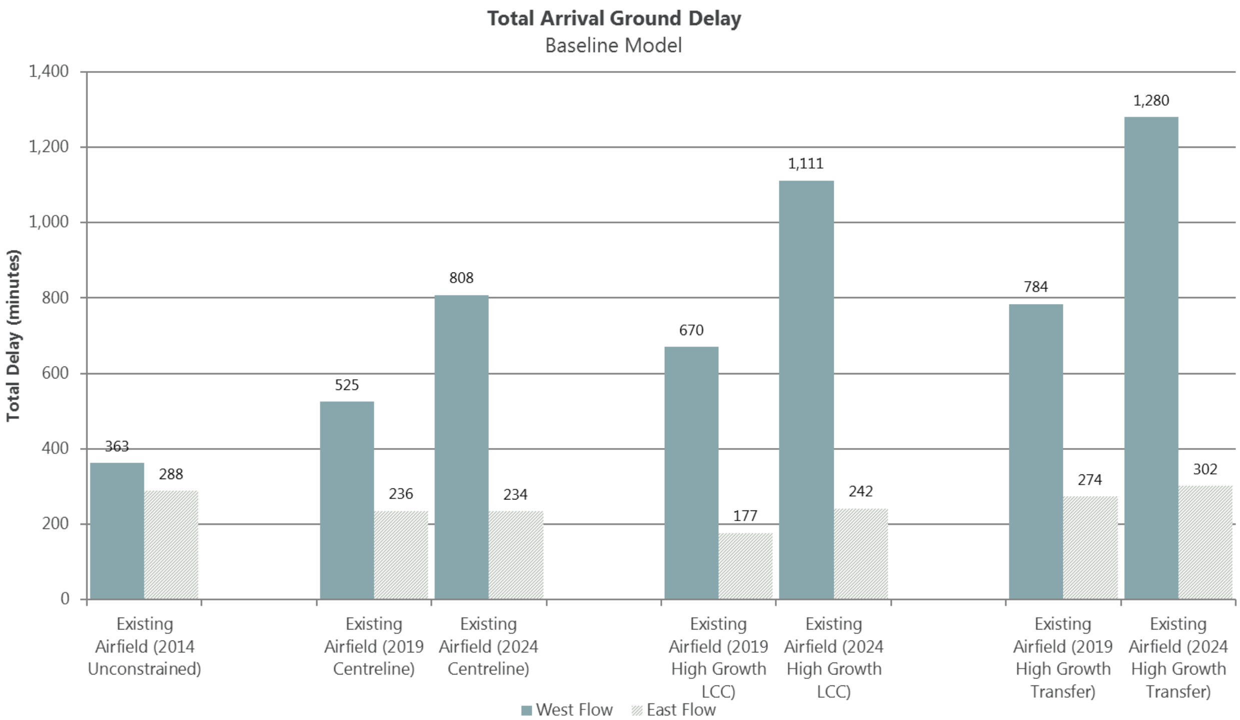


SOURCE: Ricondo & Associates, Inc., May 2014.
PREPARED BY: Ricondo & Associates, Inc., May 2014.

[FINAL]

Exhibit 3-2: Baseline Model – Average and Total Arrival Ground Delay

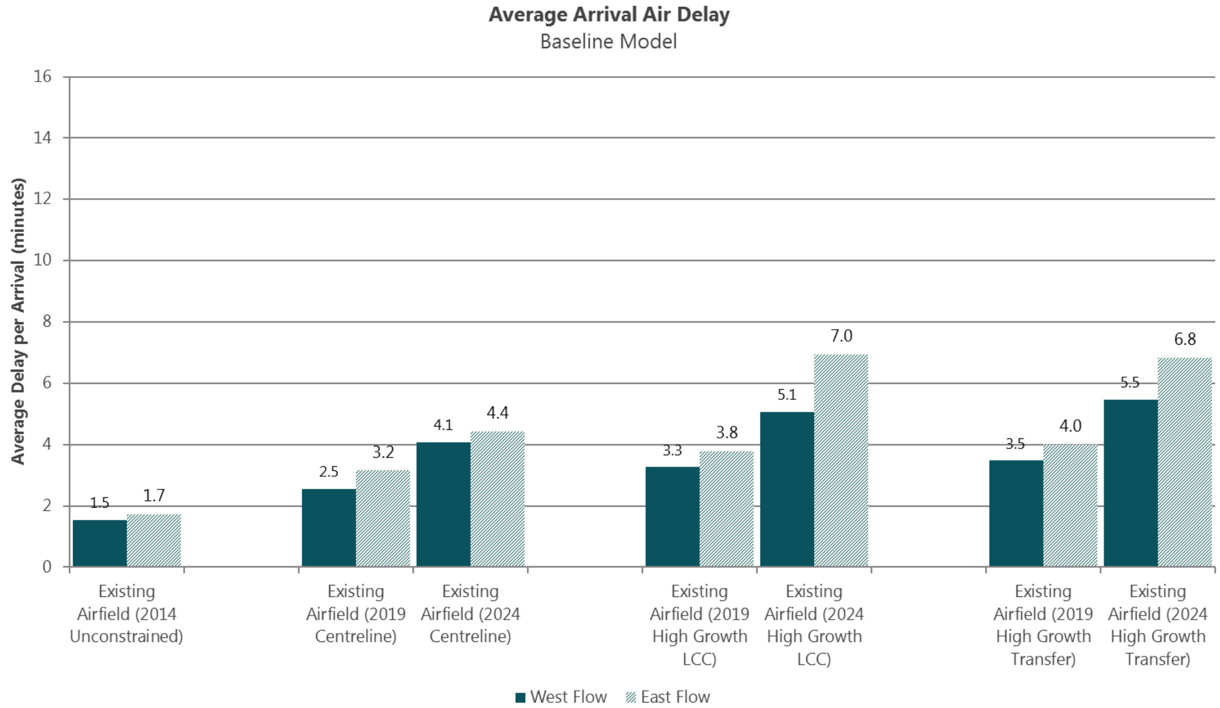


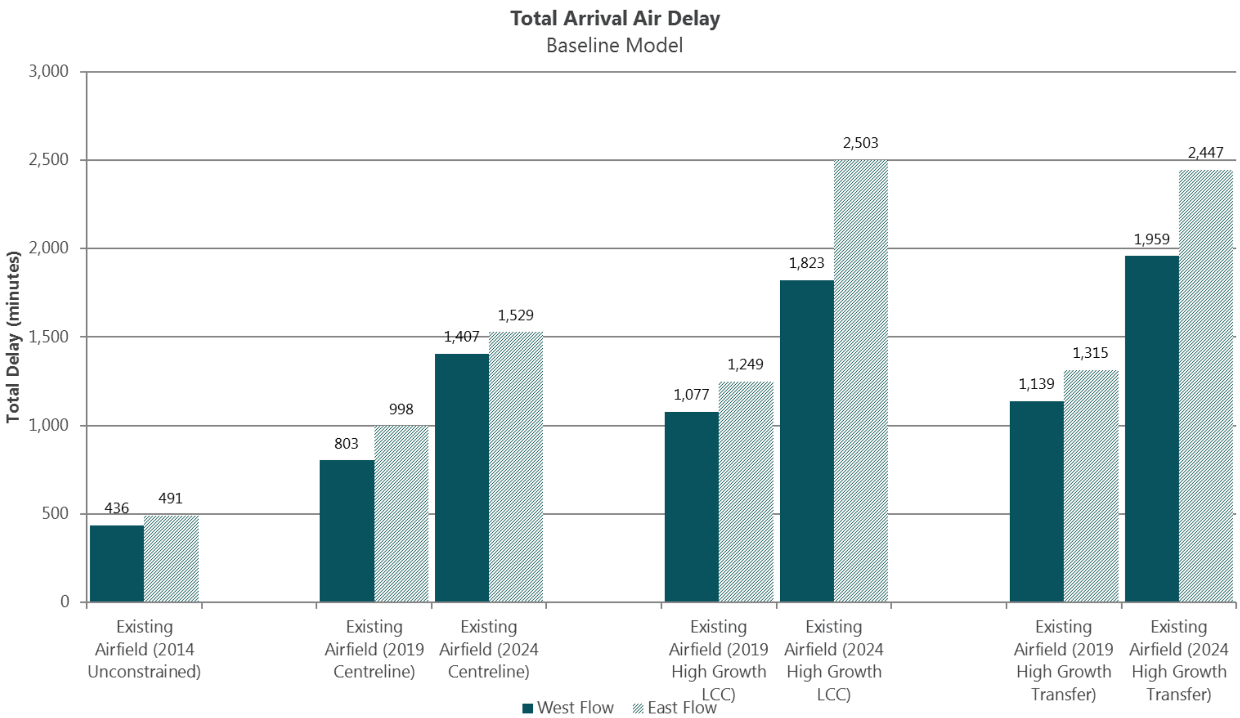


SOURCE: Ricondo & Associates, Inc., May 2014.
PREPARED BY: Ricondo & Associates, Inc., May 2014.

[FINAL]

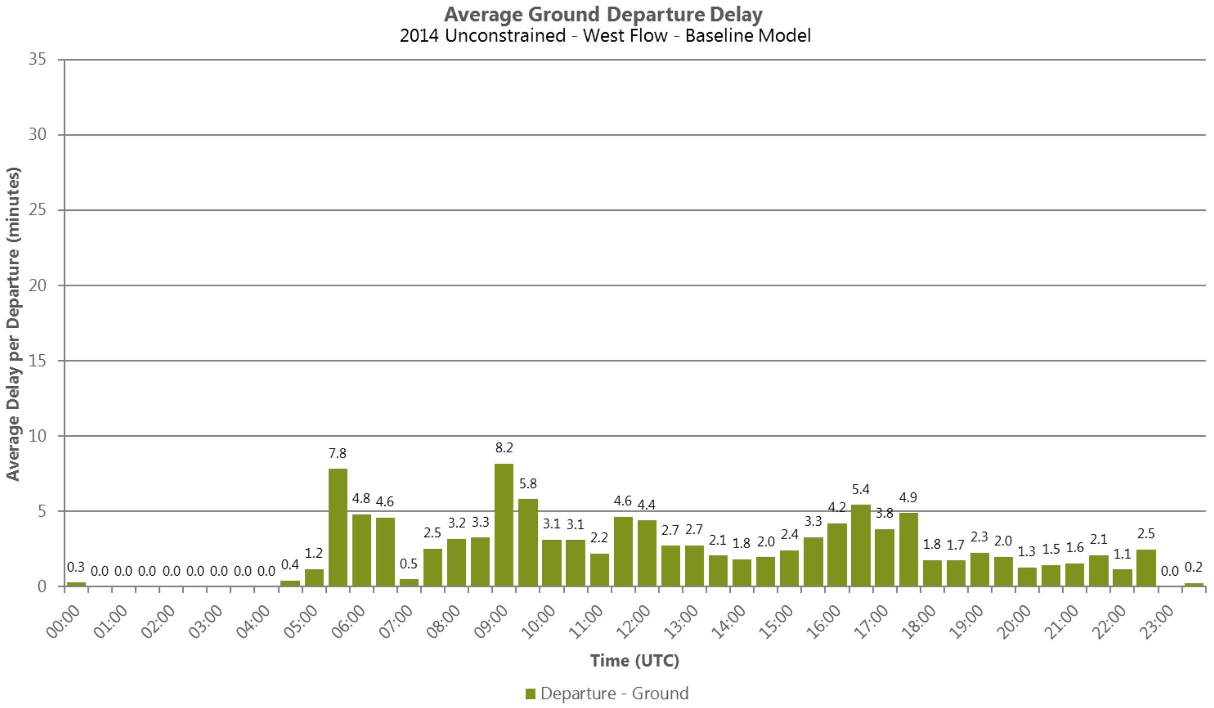
Exhibit 3-3: Baseline Model – Average and Total Arrival Air Delay

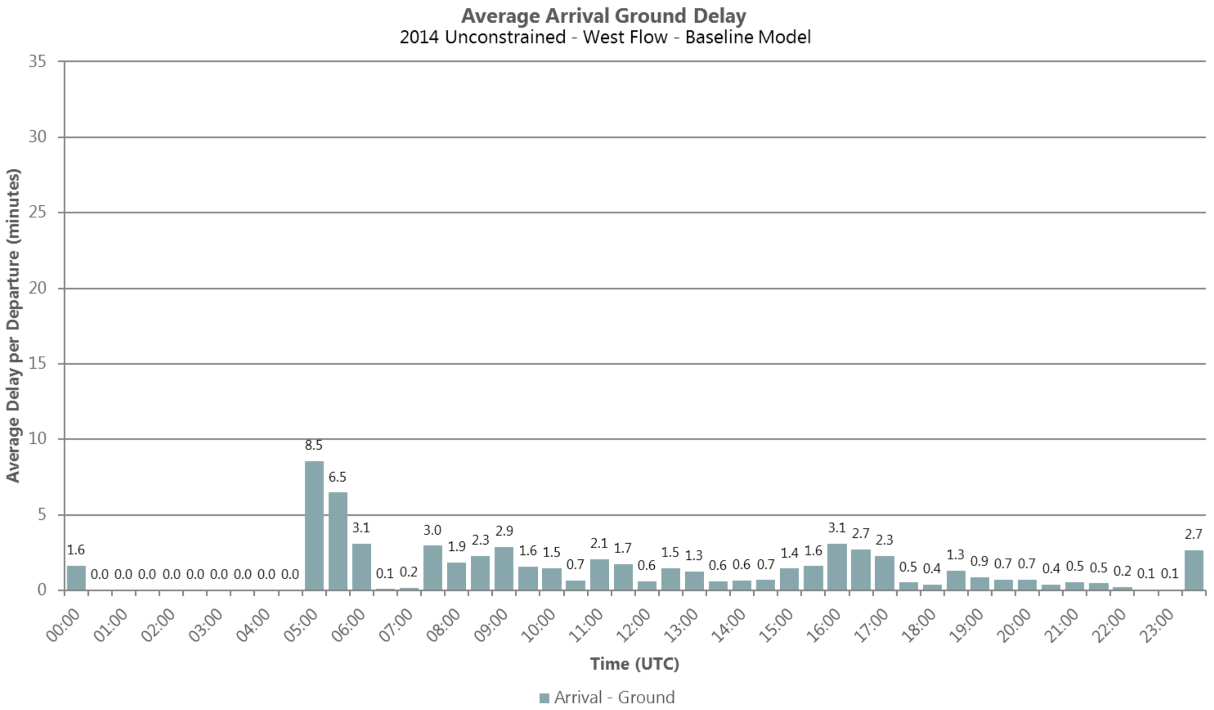




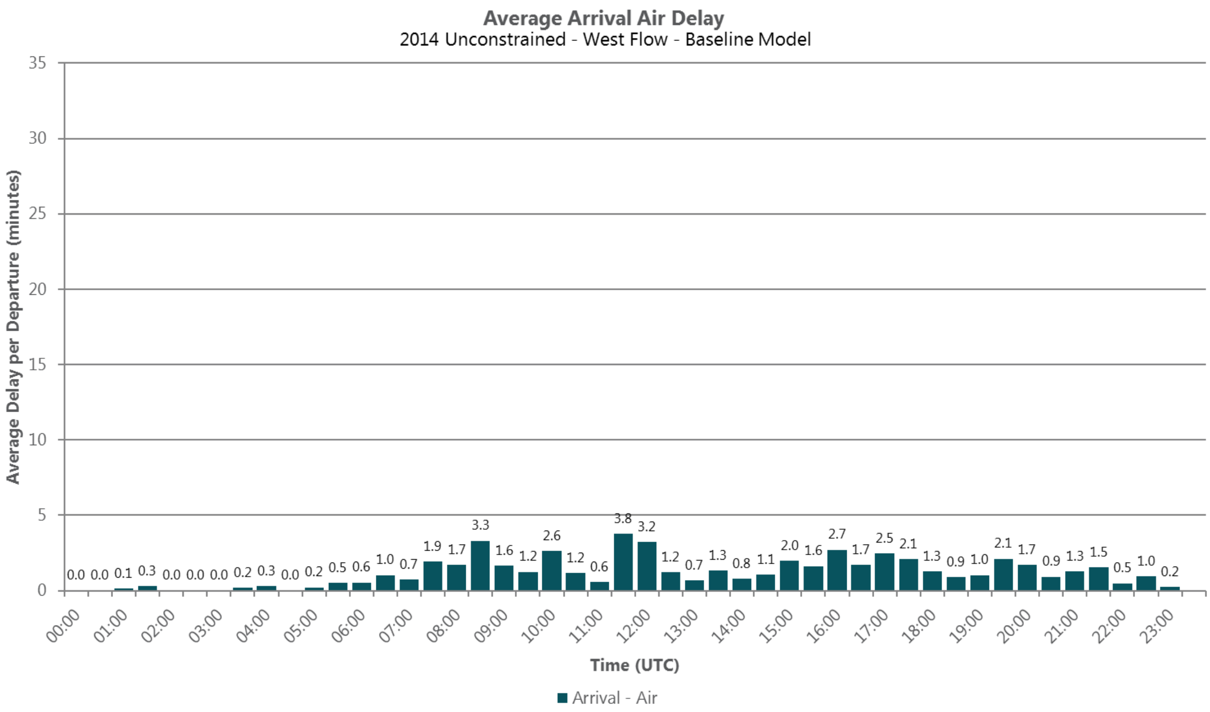
SOURCE: Ricondo & Associates, Inc., May 2014.
PREPARED BY: Ricondo & Associates, Inc., May 2014.

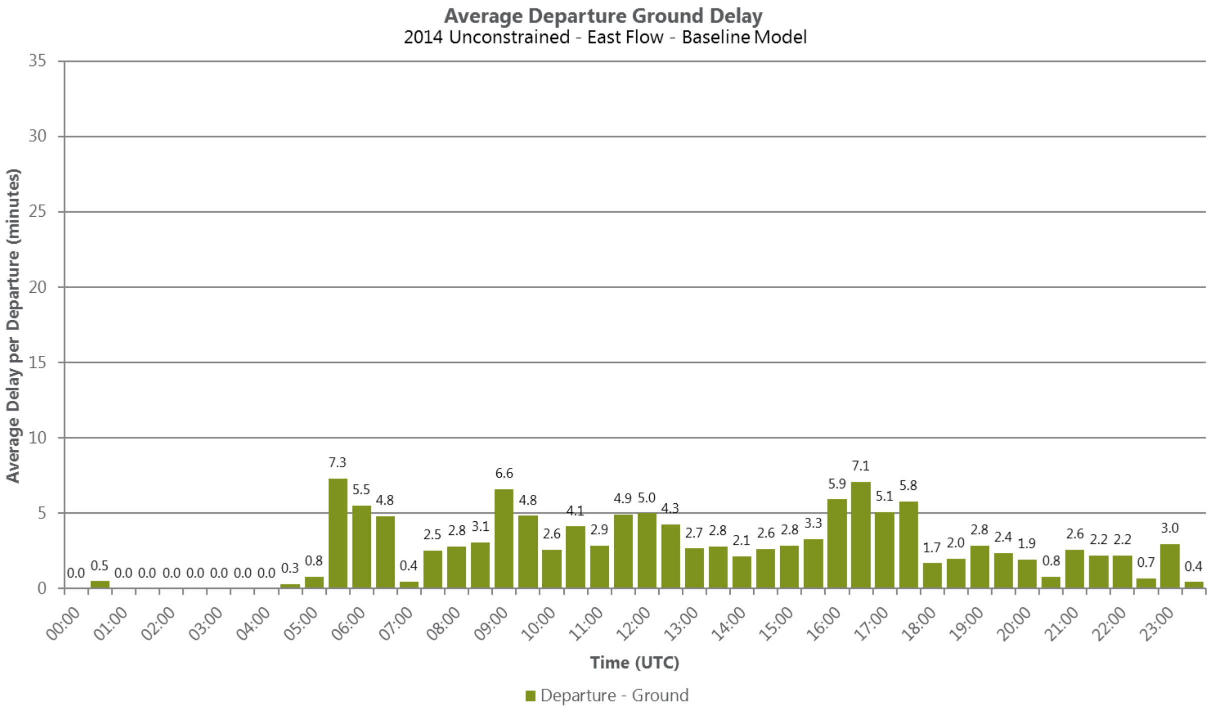
Exhibit 3-4: Baseline Model – 2014 Unconstrained, Delay and Air Traffic Movements



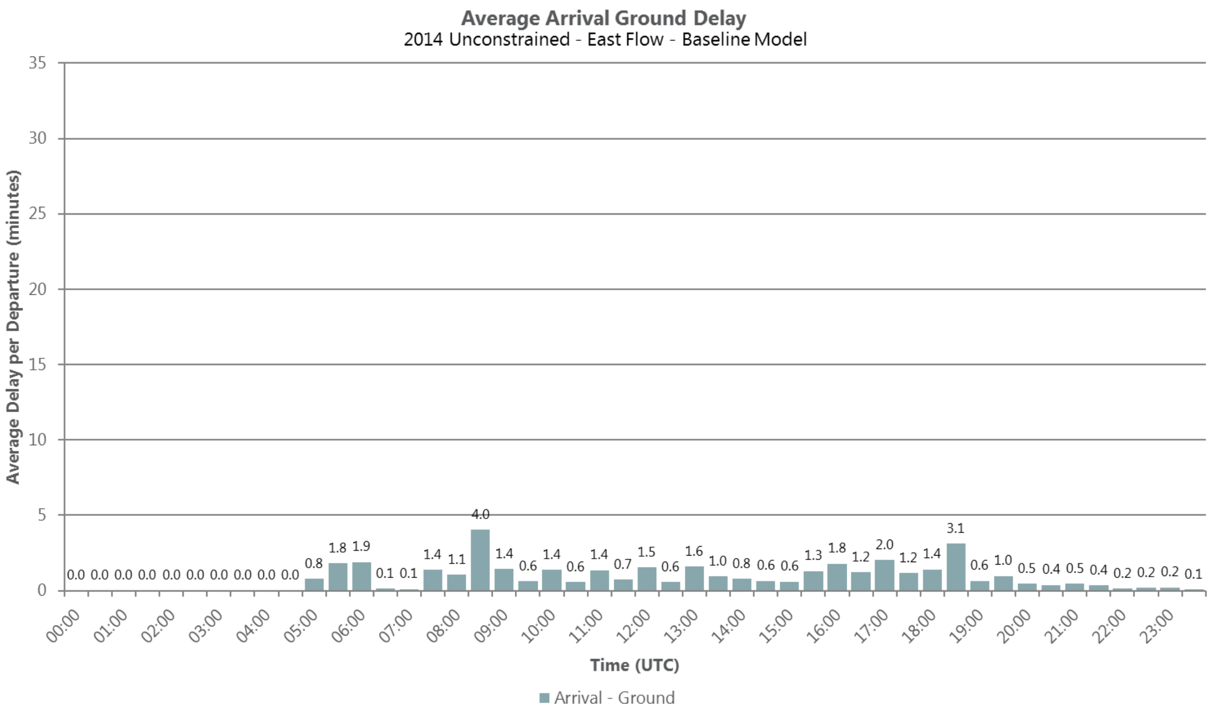


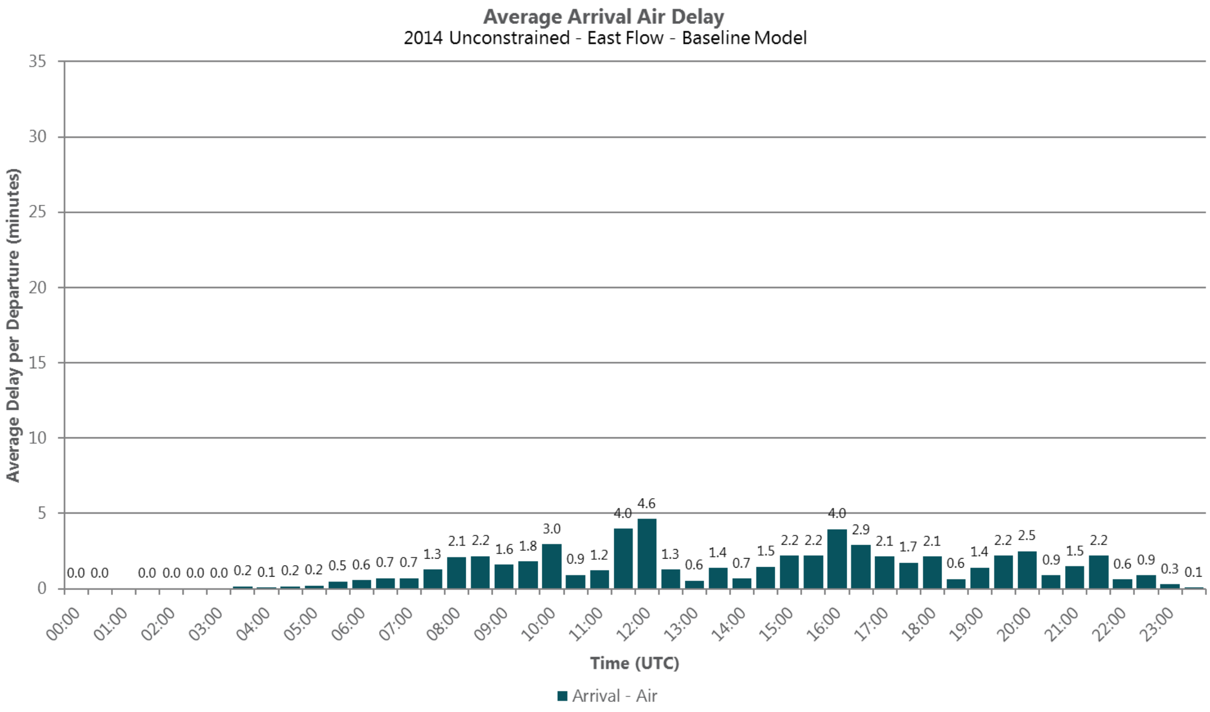
[FINAL]


Average Arrival Air Delay
2014 Unconstrained - West Flow - Baseline Model
Average Delay per Departure (minutes)
0 5 10 15 20 25 30 35
0.0 0.0 0.1 0.3 0.0 0.0 0.0 0.2 0.3 0.0 0.2 0.5 0.6 1.0 0.7 1.9 1.7 3.3 1.6 1.2 2.6 1.2 0.6 3.8 3.2 1.2 0.7 1.3 0.8 1.1 2.0 1.6 2.7 1.7 2.5 2.1 1.3 0.9 1.0 2.1 1.7 0.9 1.3 1.5 0.5 1.0 0.2
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Time (UTC)
Arrival - Air

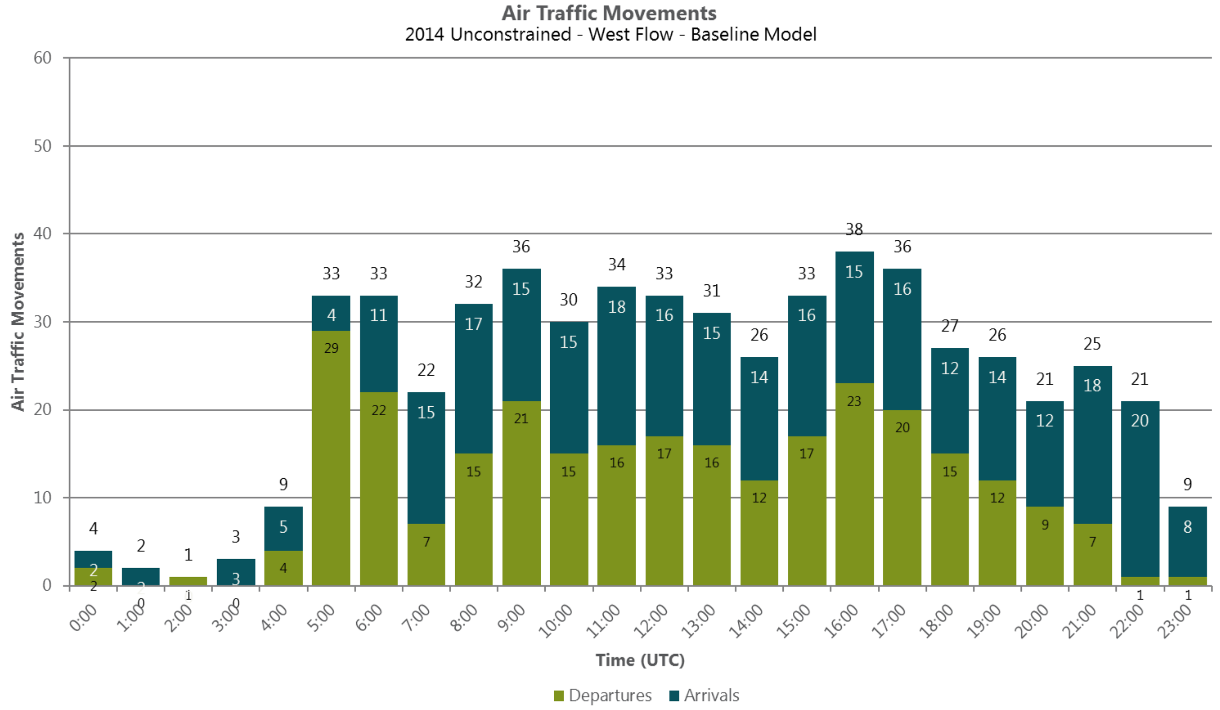

Average Departure Ground Delay
2014 Unconstrained - East Flow - Baseline Model
Average Delay per Departure (minutes)
0 5 10 15 20 25 30 35
0.0 0.5 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.3 0.8 7.3 5.5 4.8 0.4 2.5 2.8 3.1 6.6 4.8 2.6 4.1 2.9 4.9 5.0 4.3 2.7 2.8 2.1 2.6 2.8 3.3 5.9 7.1 5.1 5.8 1.7 2.0 2.8 2.4 1.9 0.8 2.6 2.2 2.2 0.7 3.0 0.4
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Time (UTC)
Departure - Ground

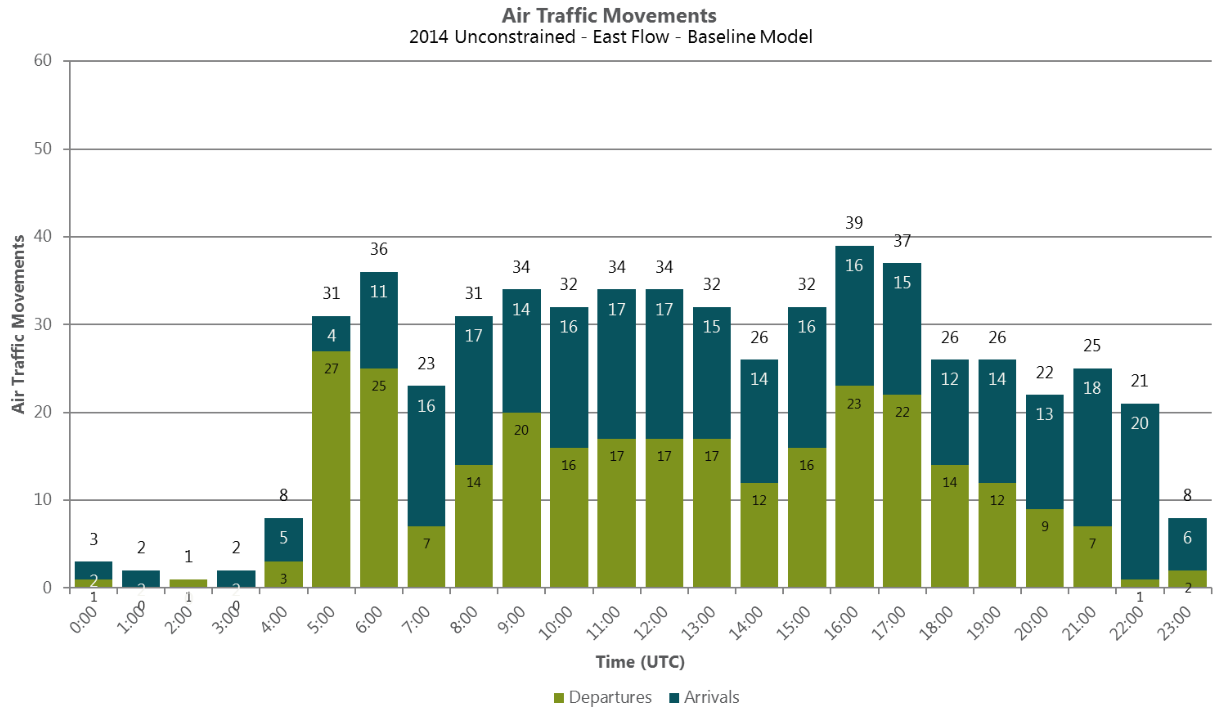
[FINAL]


Average Arrival Ground Delay
2014 Unconstrained - East Flow - Baseline Model
Average Delay per Departure (minutes)
Time (UTC)
Arrival - Ground


Average Arrival Air Delay
2014 Unconstrained - East Flow - Baseline Model
Average Delay per Departure (minutes)
Time (UTC)
Arrival - Air

[FINAL]

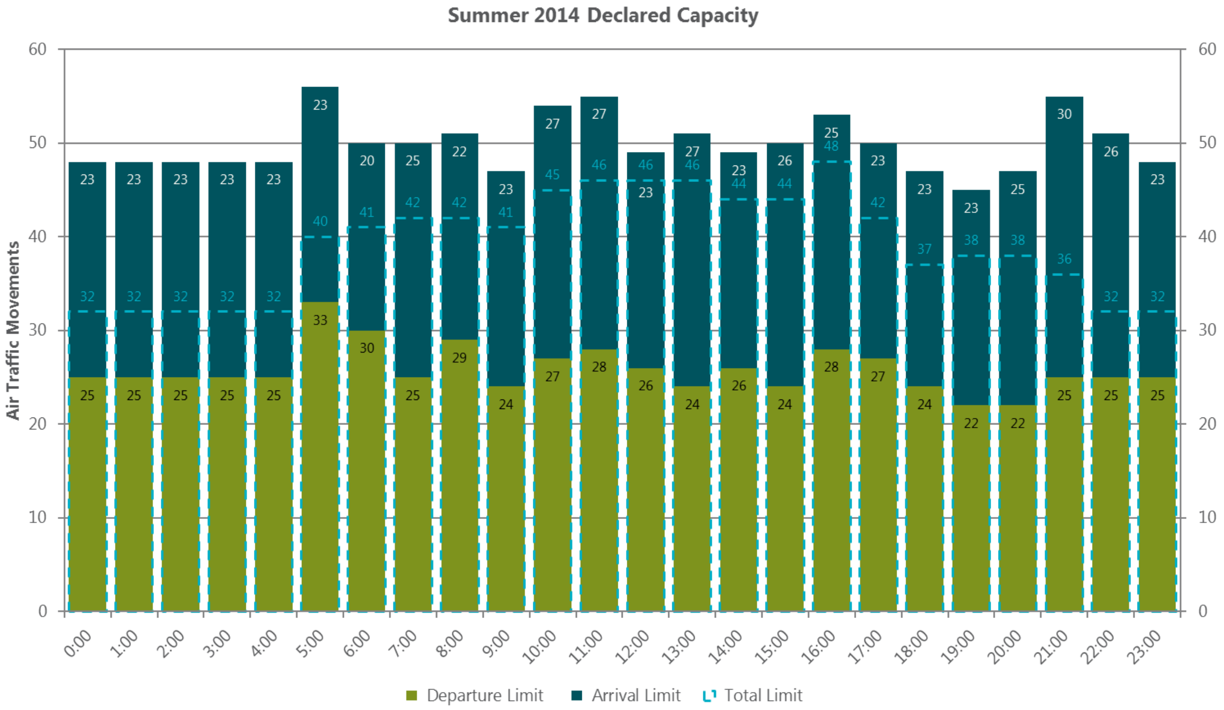




SOURCE: Ricondo & Associates, Inc., May 2014.
PREPARED BY: Ricondo & Associates, Inc., May 2014.

[FINAL]

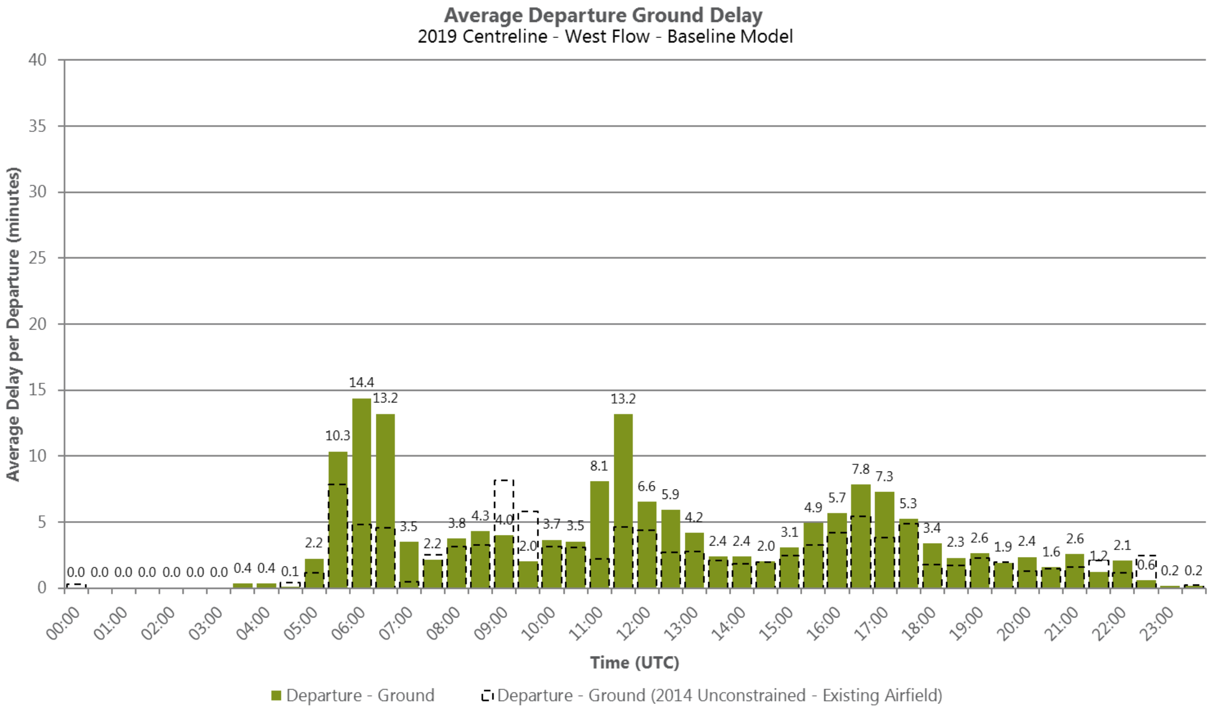
Exhibit 3-5: Declared Capacity, Summer 2014

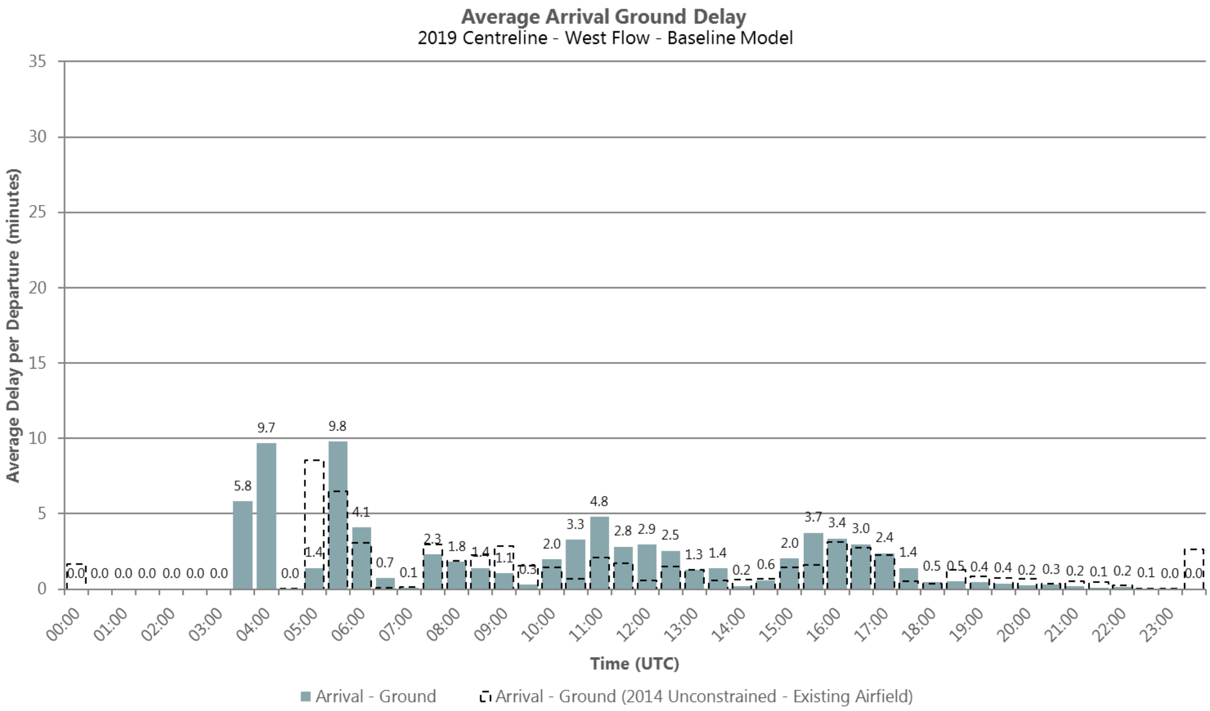


SOURCE: ACL International, *Dublin Capacity Declaration – Summer 2014*, no date.
PREPARED BY: Ricondo & Associates, Inc., June 2014.

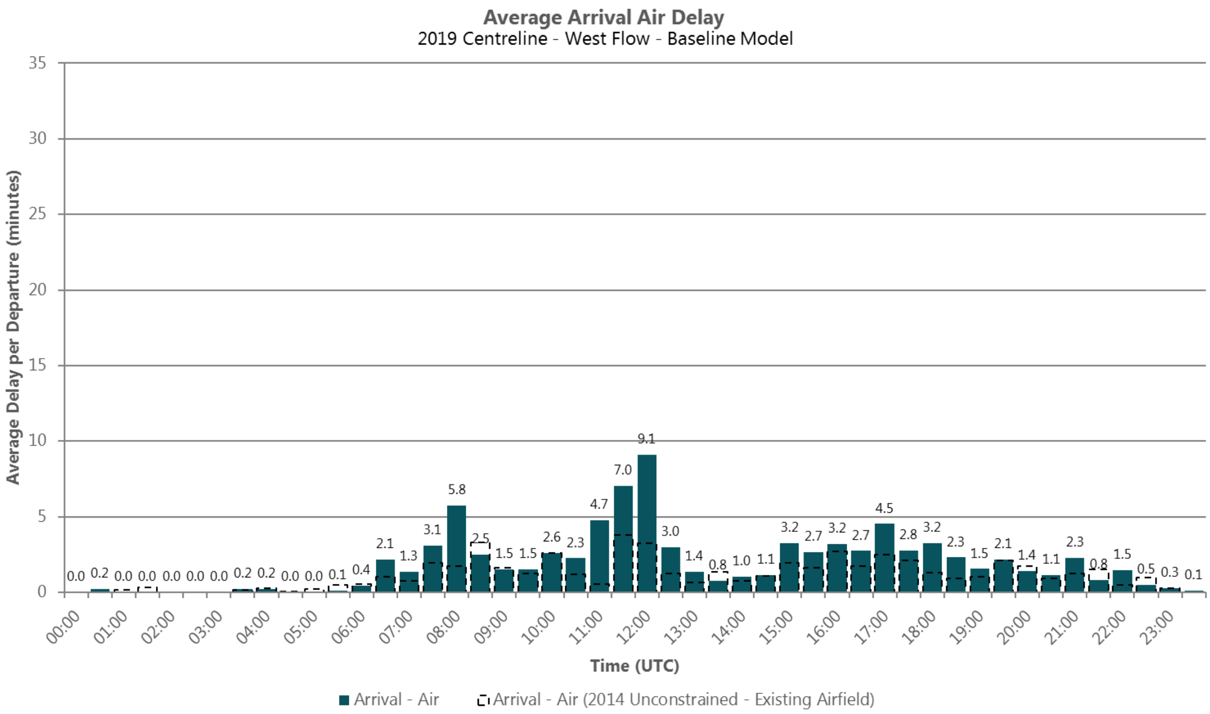
[FINAL]

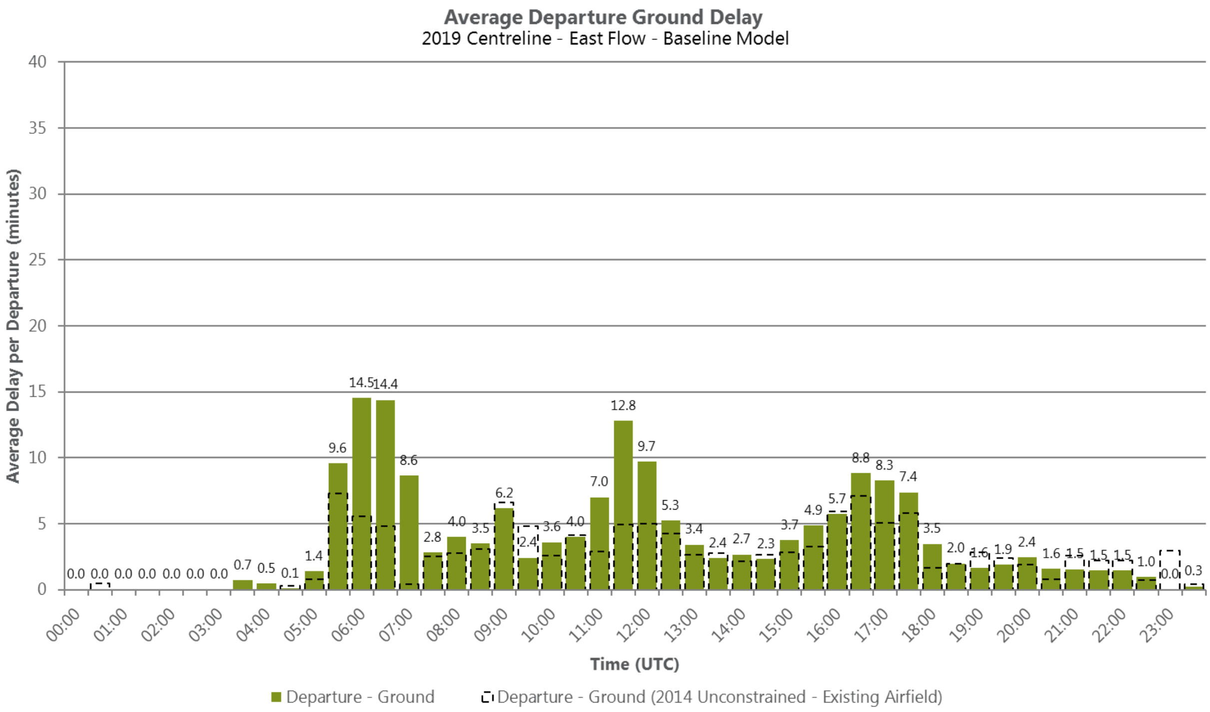
Exhibit 3-6: Baseline Model – 2019 Core Forecast, Delay, and Air Traffic Movements



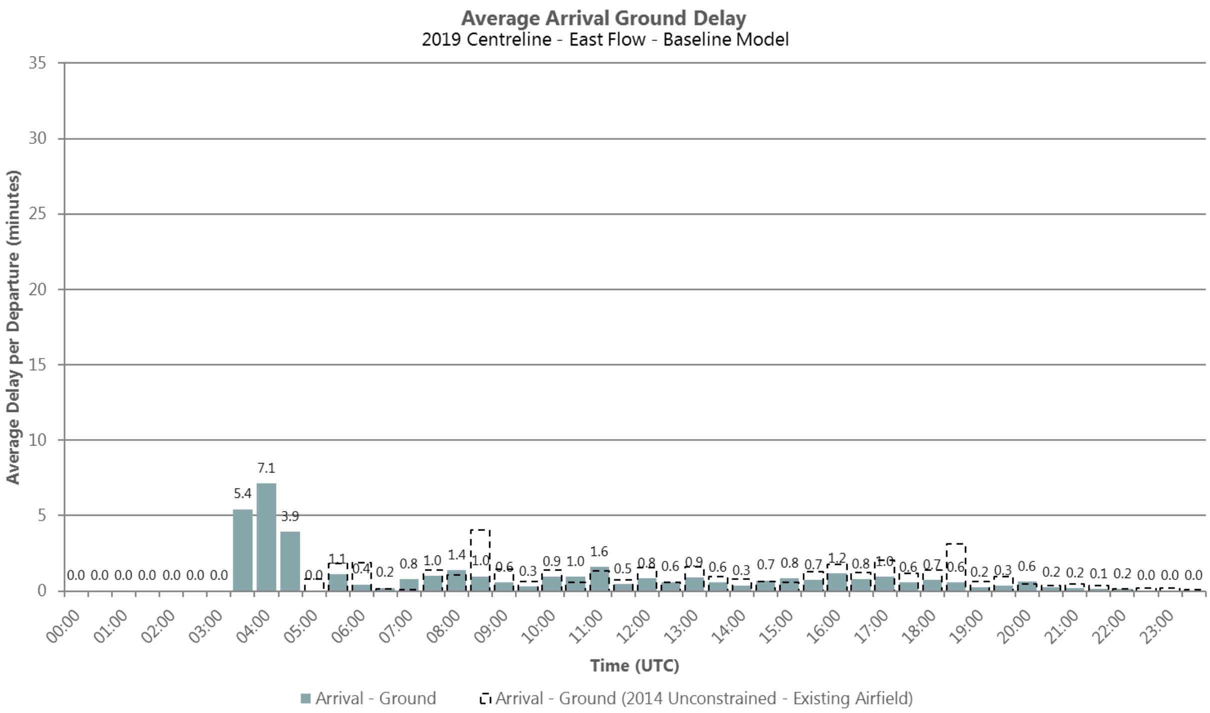


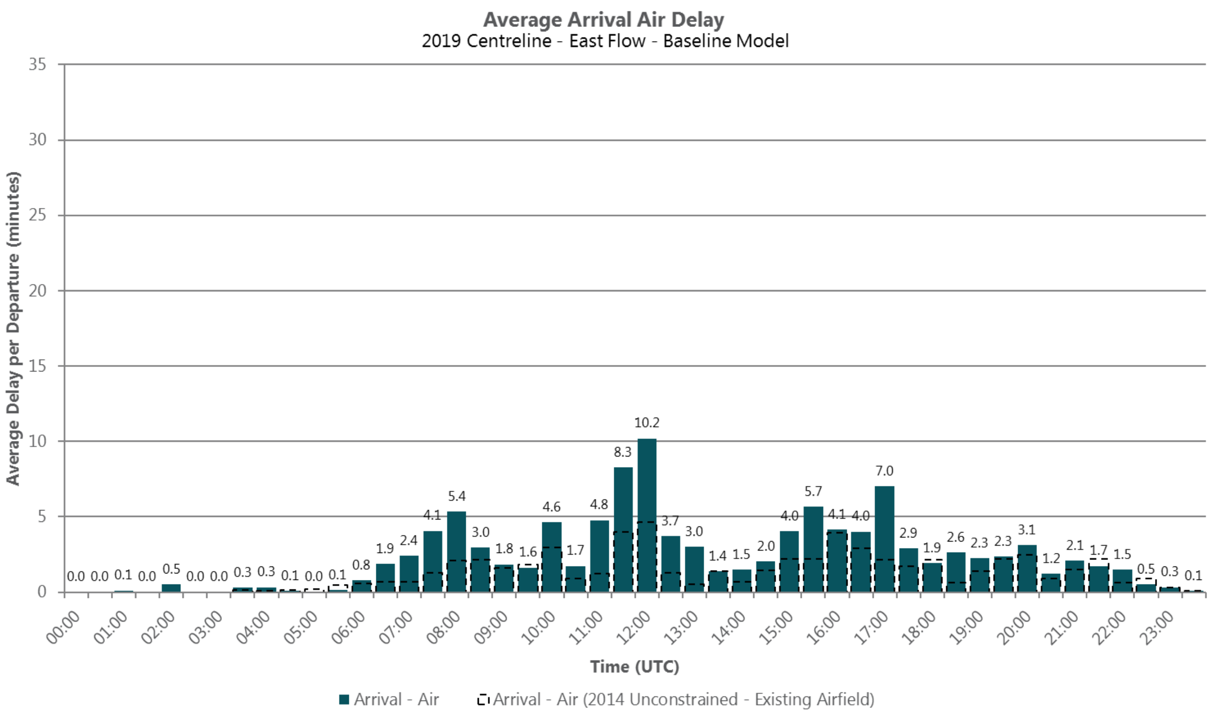
[FINAL]


Average Arrival Air Delay
2019 Centreline - West Flow - Baseline Model
Average Delay per Departure (minutes)
0.0 0.2 0.0 0.0 0.0 0.0 0.0 0.2 0.2 0.0 0.0 0.1 0.4 2.1 1.3 3.1 5.8 2.5 1.5 1.5 2.6 2.3 4.7 7.0 9.1 3.0 1.4 0.8 1.0 1.1 3.2 2.7 3.2 2.7 4.5 2.8 3.2 2.3 1.5 2.1 1.4 1.1 2.3 0.8 1.5 0.5 0.3 0.1
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Time (UTC)
Arrival - Air
Arrival - Air (2014 Unconstrained - Existing Airfield)

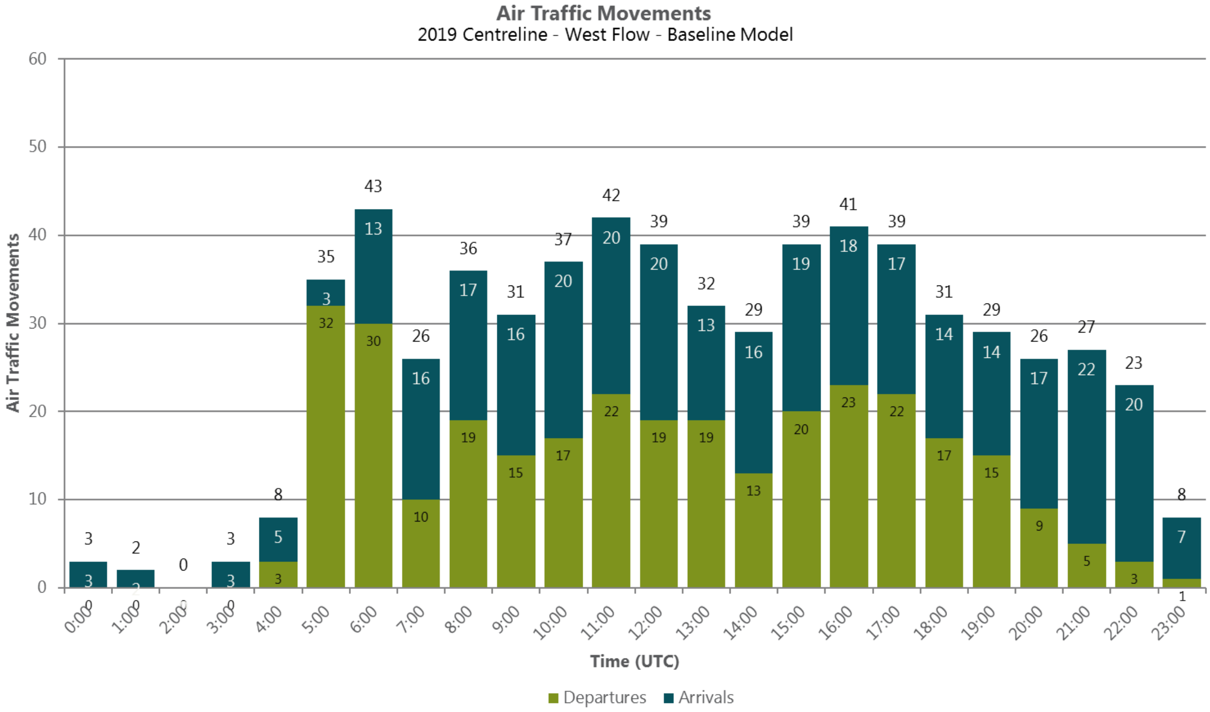

Average Departure Ground Delay
2019 Centreline - East Flow - Baseline Model
Average Delay per Departure (minutes)
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.7 0.5 0.1 1.4 9.6 14.5 14.4 8.6 2.8 4.0 3.5 6.2 2.4 3.6 4.0 7.0 12.8 9.7 5.3 3.4 2.4 2.7 2.3 3.7 4.9 5.7 8.8 8.3 7.4 3.5 2.0 1.6 1.9 2.4 1.6 1.5 1.5 1.5 1.0 0.0 0.3
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Time (UTC)
Departure - Ground
Departure - Ground (2014 Unconstrained - Existing Airfield)

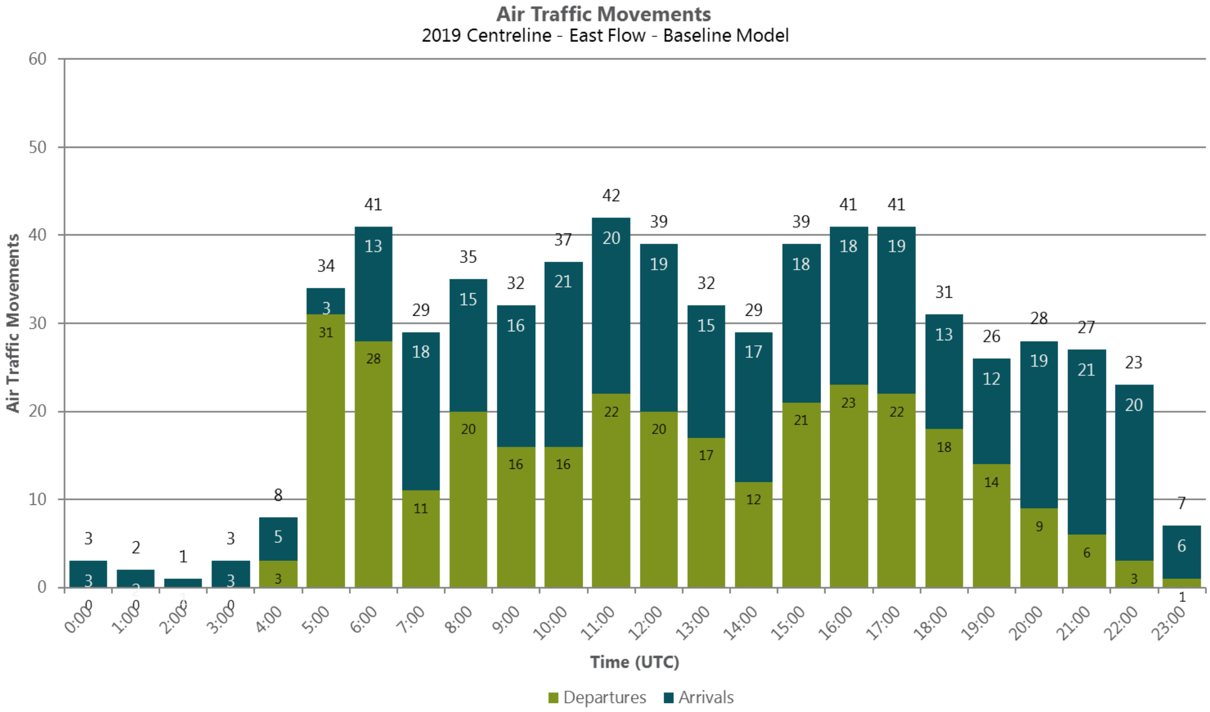
[FINAL]


Average Arrival Ground Delay
2019 Centreline - East Flow - Baseline Model
Average Delay per Departure (minutes)
35
30
25
20
15
10
5
0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 5.4 7.1 3.9 0.0 1.1 0.4 0.2 0.8 1.0 1.4 1.0 0.6 0.3 0.9 1.0 1.6 0.5 0.8 0.6 0.9 0.6 0.3 0.7 0.8 0.7 1.2 0.8 1.0 0.6 0.7 0.6 0.2 0.3 0.6 0.2 0.2 0.1 0.2 0.0 0.0 0.0
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Time (UTC)
Arrival - Ground
Arrival - Ground (2014 Unconstrained - Existing Airfield)


Average Arrival Air Delay
2019 Centreline - East Flow - Baseline Model
Average Delay per Departure (minutes)
35
30
25
20
15
10
5
0
0.0 0.0 0.1 0.0 0.5 0.0 0.0 0.3 0.3 0.1 0.0 0.1 0.8 1.9 2.4 4.1 5.4 3.0 1.8 1.6 4.6 1.7 4.8 8.3 10.2 3.7 3.0 1.4 1.5 2.0 4.0 5.7 4.1 4.0 7.0 2.9 1.9 2.6 2.3 2.3 3.1 1.2 2.1 1.7 1.5 0.5 0.3 0.1
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Time (UTC)
Arrival - Air
Arrival - Air (2014 Unconstrained - Existing Airfield)

[FINAL]



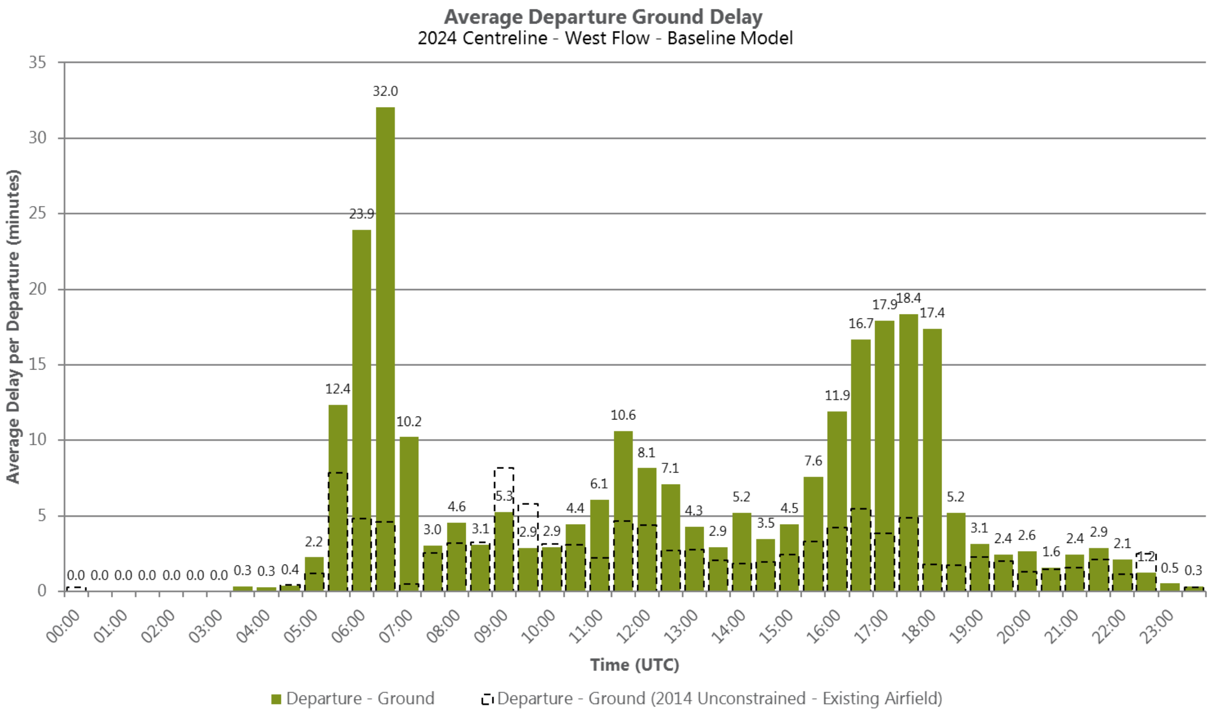


SOURCE: Ricondo & Associates, Inc., June 2014.
PREPARED BY: Ricondo & Associates, Inc., June 2014.

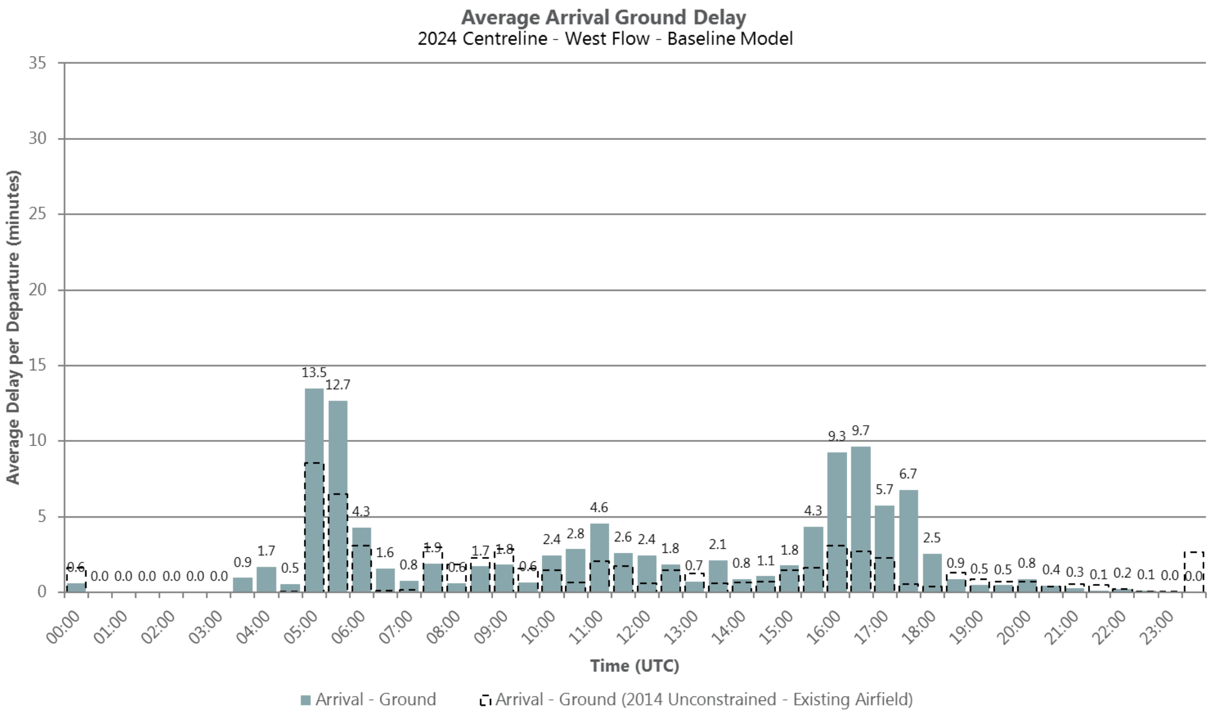
Exhibit 3-7 shows the average delay for every half hour and the number of ATMs by hour for the 2024 Core Forecast. Average departure delays in the morning peak exceed 10 minutes in the 05:30 and 06:00 half hours and exceed 30 minutes in the 06:30 half hour. Average departure delays in the late afternoon results in delays that exceed 10 minutes and reach up to 18 minutes in the 3 hours between 16:00 and 19:00. This is caused by an increase in both departure and arrivals demand (see Exhibit 2-2) during this peak. Average arrival ground delays exceed 10 minutes for 1 hour in the morning peak and again approach 10 minutes in the late afternoon peak during West Flow only, while average arrival ground delays are minimal during East Flow. Average air delays increase during the mid-day and late afternoon peaks and begin to exceed 10 minutes. This magnitude of delay indicates that the existing airfield is not able to accommodate the forecasted schedule of activity during peak periods.

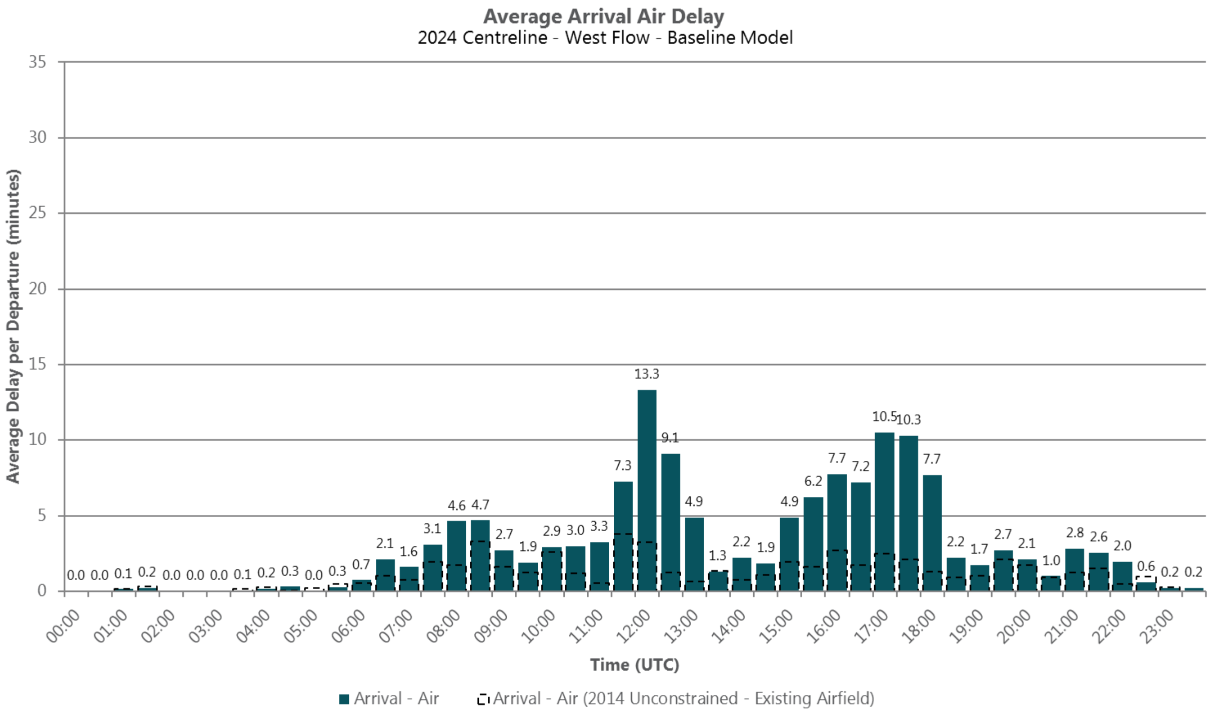
Although not shown in this Technical Appendix, delays throughout the day for both High Growth forecast scenarios exceed those in the Core Forecast due to an increased number of departures and arrivals. However, departure delays in the peak morning period are approximately equal to the 2024 Core Forecast while the delays in the late afternoon peak exceed those in the 2024 Core Forecast. Average arrival ground delays continue to be low in East Flow but reach or exceed 10 minutes in the peak periods. Average arrival air delays increase throughout the day and during peak periods in the High Growth forecast models.

Exhibit 3-7: Baseline Model – 2024 Core Forecast, Delay and Air Traffic Movements



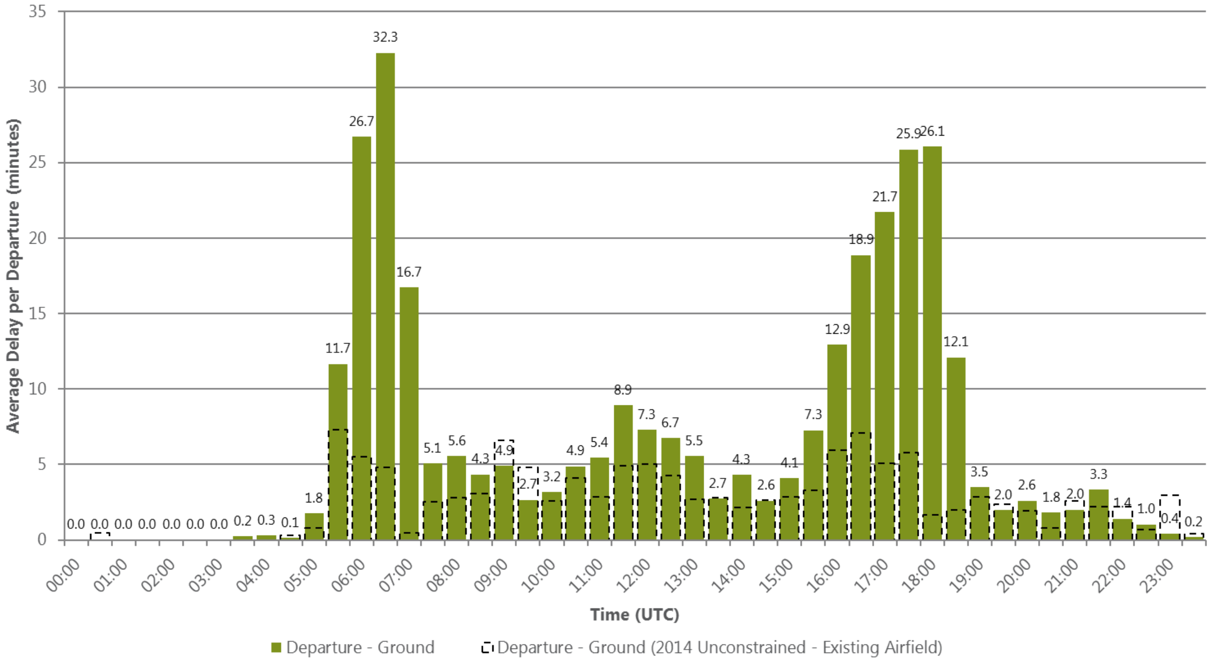
[FINAL]


Average Arrival Ground Delay
2024 Centreline - West Flow - Baseline Model
Average Delay per Departure (minutes)
Time (UTC)
Arrival - Ground
Arrival - Ground (2014 Unconstrained - Existing Airfield)

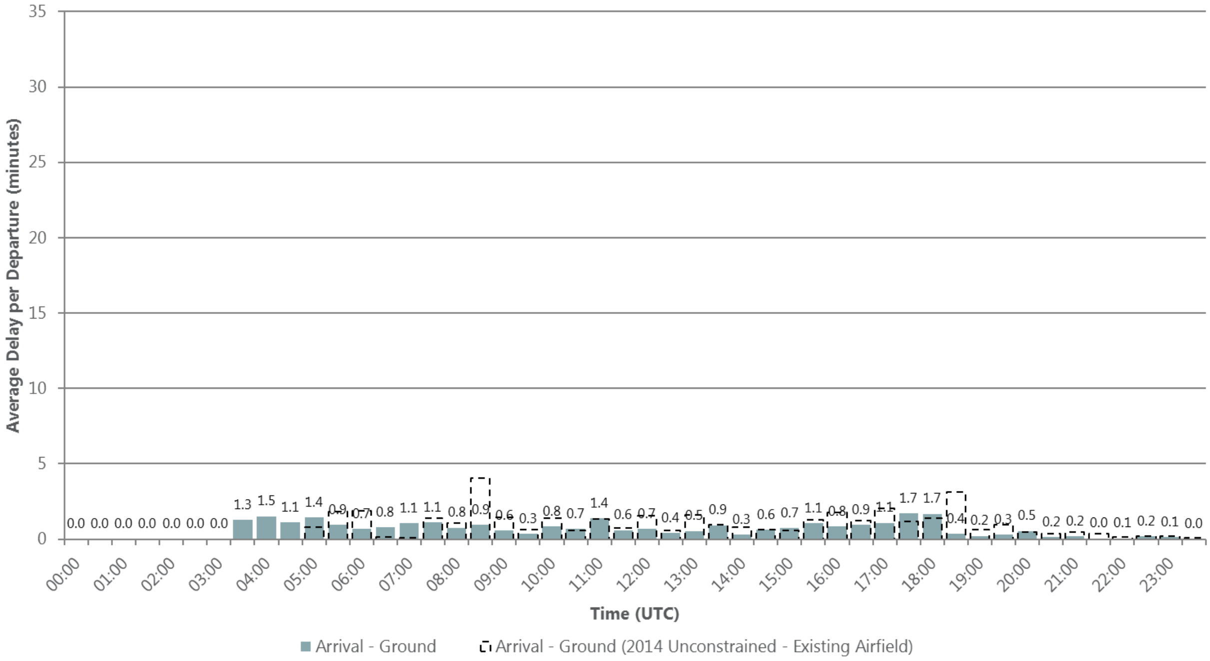

Average Arrival Air Delay
2024 Centreline - West Flow - Baseline Model
Average Delay per Departure (minutes)
Time (UTC)
Arrival - Air
Arrival - Air (2014 Unconstrained - Existing Airfield)

[FINAL]

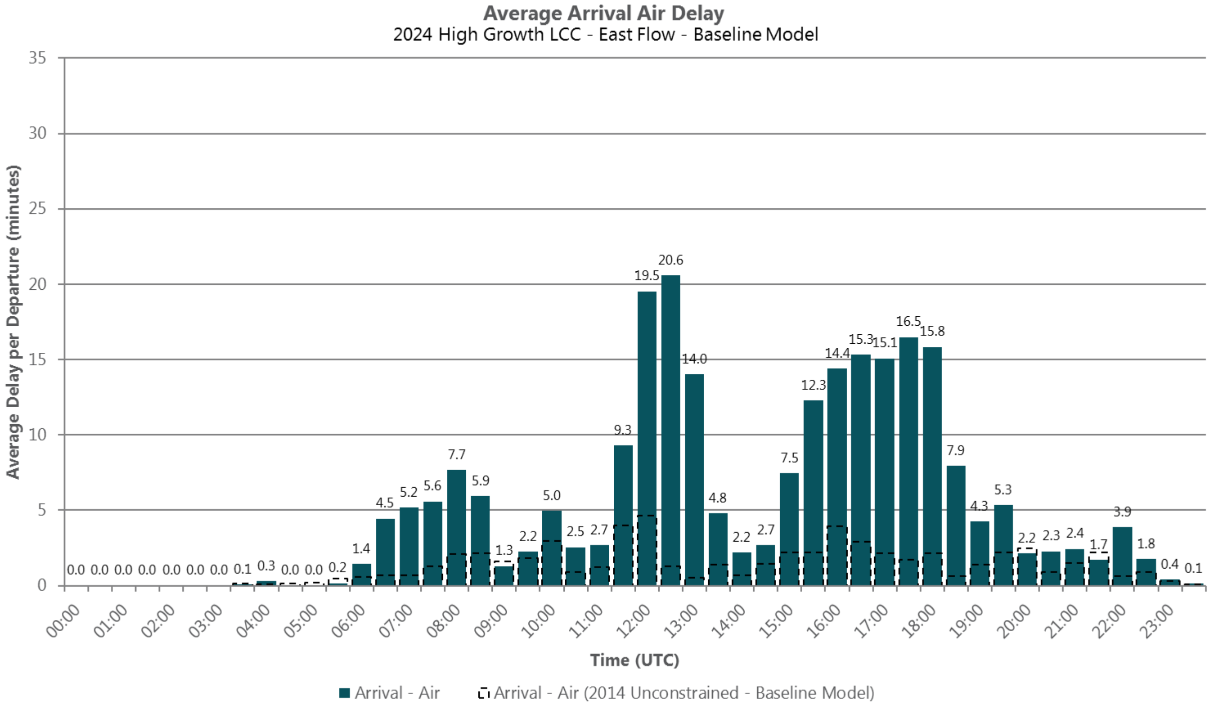
Average Departure Ground Delay
2024 Centreline - East Flow - Baseline Model

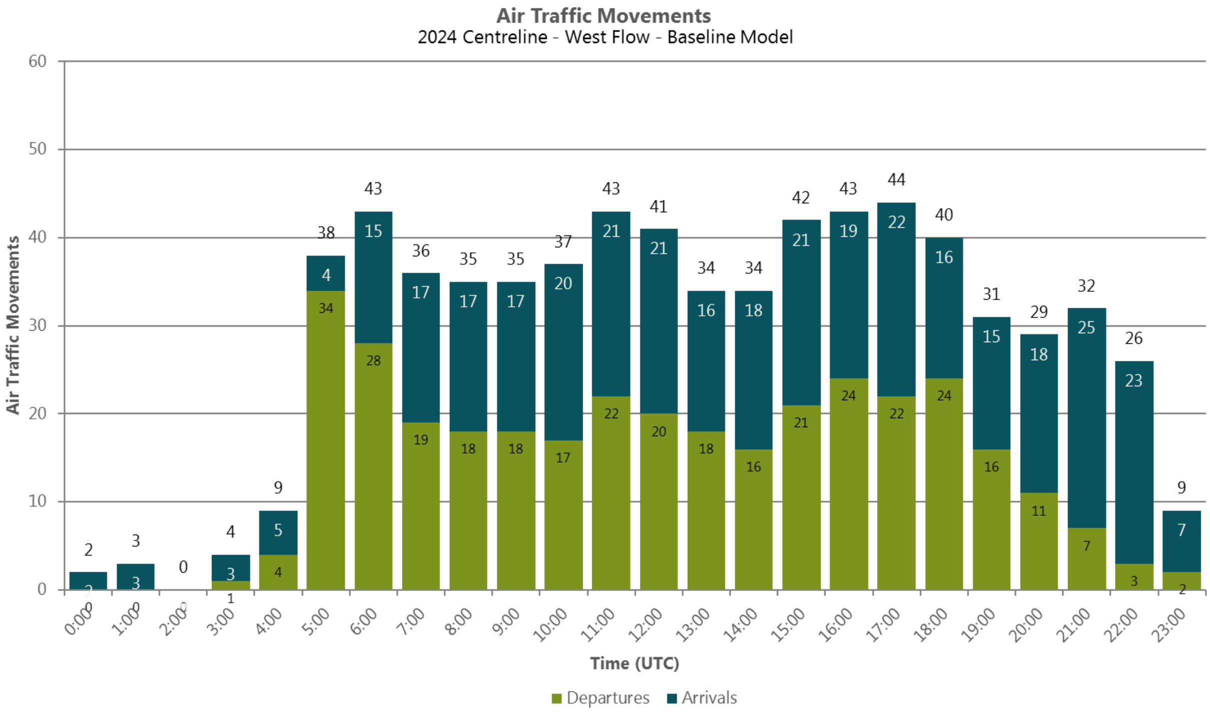


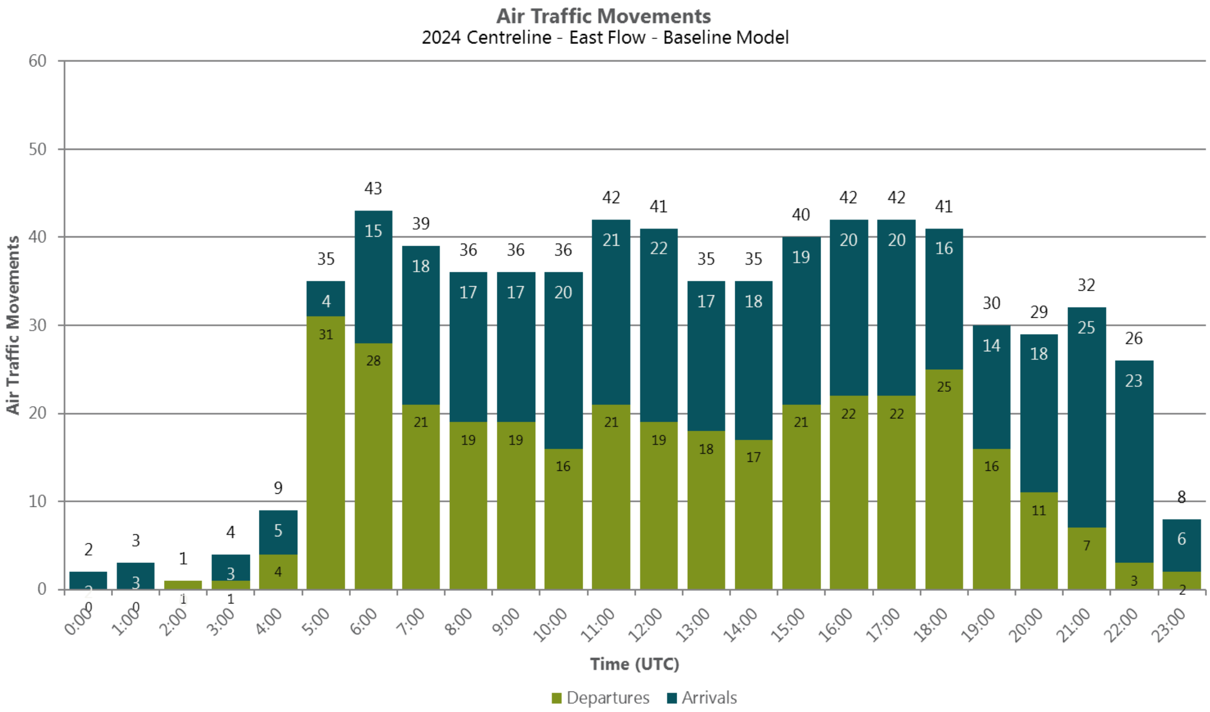
Average Arrival Ground Delay
2024 Centreline - East Flow - Baseline Model



[FINAL]


Average Arrival Air Delay
2024 High Growth LCC - East Flow - Baseline Model
Average Delay per Departure (minutes)
Time (UTC)
Arrival - Air
Arrival - Air (2014 Unconstrained - Baseline Model)


Air Traffic Movements
2024 Centreline - West Flow - Baseline Model
Air Traffic Movements
Time (UTC)
Departures
Arrivals



SOURCE: Ricondo & Associates, Inc., June 2014.
PREPARED BY: Ricondo & Associates, Inc., June 2014.

In all of the Baseline Models for the different forecast scenarios, the maximum number of hourly ATMs achieved is 44. The maximum number of departures in an hour is 37 and is achieved in one of the 2024 High Growth models during the 05:00 hour in morning peak. Although demand in this peak hour is 48, the airfield and runway are only able to accommodate up to 40 ATMs during this hour. With a fully loaded system, meaning aircraft are queued for departure or arrival, the existing airfield appears to be able to accommodate up to a maximum of 44 total ATMs (arrivals and departures) per hour.

3.4.1.2 Baseline Model Conclusions

Based on delay statistics and review of video playback of each simulation conducted for the Baseline Model, several areas of airfield constraints and opportunities for increasing capacity and decreasing delay can be identified. The delay observed in the simulations was comprised primarily of arrival air delay and departure ground delay that was attributable to demand for the runway exceeding capacity. A disproportionate amount of the delay occurs during the early morning departure peak and then again in the late afternoon when there are elevated levels of both arrivals and departures in the future design day flight schedules. Therefore, reducing the amount of time required between successive ATMs on the runway is the principal way to decrease aircraft delay.

There are a number of criteria, as well as separations, that are used in order to safely separate successive ATMs. However, per ICAO documentation, several of these can be reduced if an airport meets certain conditions. Notably, the time between successive departures can be reduced to approximately 60 seconds if the headings of the two aircraft diverge by 45 degrees or more. This operation, known as diverging departures, provides the greatest capacity when multiple runway entrances are established and allow air traffic controllers to optimise the sequence of the departure queue.

[FINAL]

3.4.2 PROPOSED AIRFIELD IMPROVEMENTS

The improvements proposed by daa (in conjunction with IAA) in its CIP 2015-2019 Proposal include the construction of aircraft line-up points (multiple runway entry taxiways) at both ends of Runway 10-28. These improvements will allow an increase in declared capacity on the runway to 39 departures in the peak departures hour (assuming unimpeded aircraft flow from the ramp to the runway) according to IAA.

Runways with activity levels similar to Runway 10-28 would typically have multiple runway entry taxiways at the ends of the runway in order to provide air traffic control with the ability to sequence aircraft for departure and to permit aircraft to bypass other aircraft during irregular operations. In West Flow, multiple entry taxiways also provide additional queuing area, thereby reducing the amount of queuing on taxilanes surrounding the terminal aprons.

R&A modelled the impact that the multiple entry taxiways, combined with diverging departures during busy periods, would have on capacity enhancement and delay reduction. Based on R&A's discussions with IAA, for East and West Flow the airspace structure was altered so that all aircraft departing to fixes south of the airport utilised the route structure in place for CAT A/B aircraft. Aircraft using any other fix continued to utilise the same routing from the baseline models. Use of the southbound CAT A/B routing produced CAT C/D routings that diverged by at least 45 degrees. Additionally, maintaining the airspace structure north of the airport would allow IAA to continue operating dual departures when weather conditions allow. Aircraft were segregated to different taxiways in order to property sequence departures and optimise the mix of departure headings. This allows for alternating use of headings and a decreased time interval between successive departures.

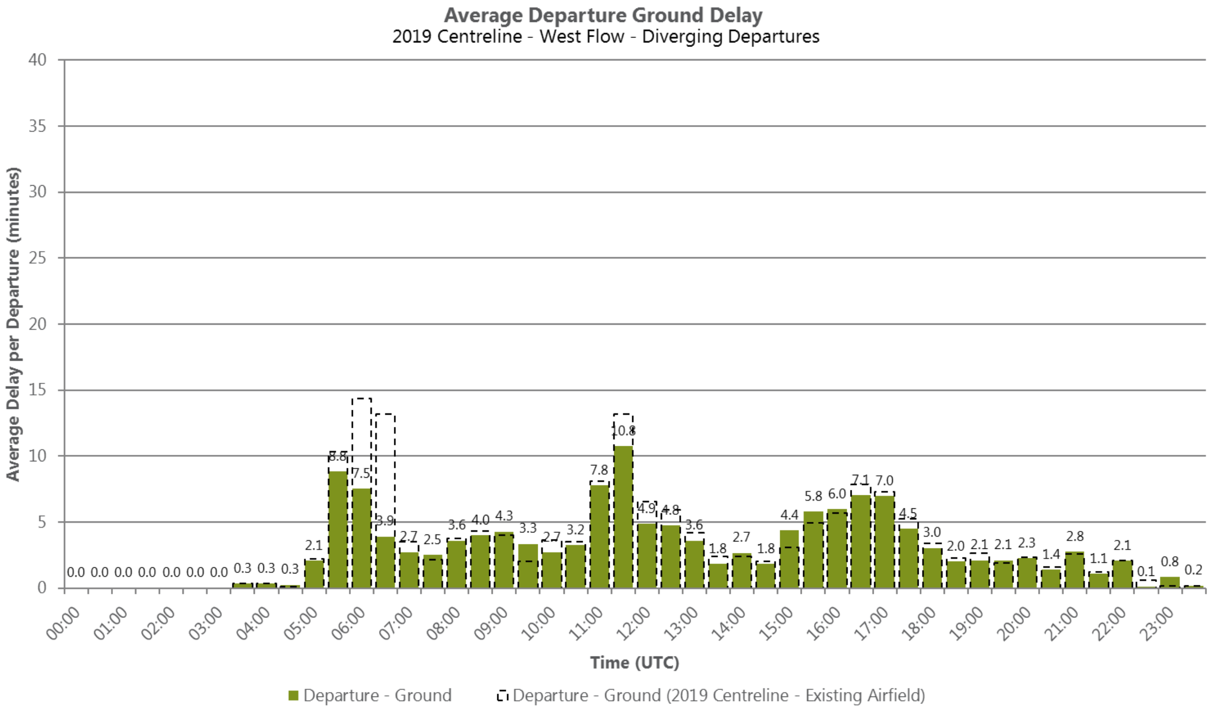
3.4.2.1 Proposed Airfield Improvements Model Results

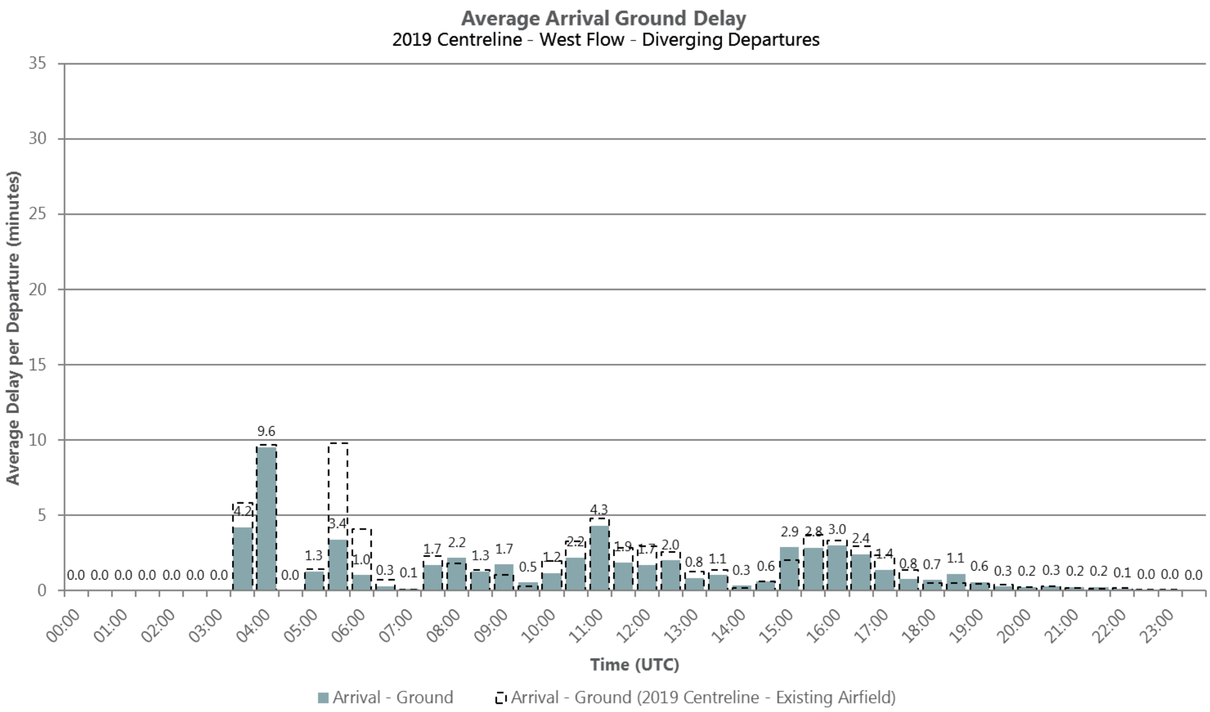
Exhibit 3-8 contains graphs that show the average delay by half hour and the number of ATMs processed in the model by hour for both the East and West Flow simulations for the 2019 Core Forecast. As shown in the graphs, the improvements reduce average delays below 10 minutes for the departure peak hour in the morning. Furthermore, the improvements reduce delay slightly for other parts of the day for both departing and arriving aircraft.

Exhibit 3-9 contains graphs that show the average delay by half hour and the number of ATMs by hour for both the East and West Flow simulations for the 2024 Core Forecast. Use of diverging departures reduces the average departure ground delay per operation for East and West Flow by approximately 15 percent. The majority of the delay savings, however, occurred during the morning departure rush, when there is an extended period of departure only operations. For the baseline models, aircraft departing between 6:30 and 7:00 incurred an average delay of over 30 minutes. With the implementation of diverging departures, the average delay during this period dropped to less than 20 minutes. Additionally, there were incremental benefits seen in in arrival ground delay and arrival air delay that resulted from being able to depart a higher number of aircraft.

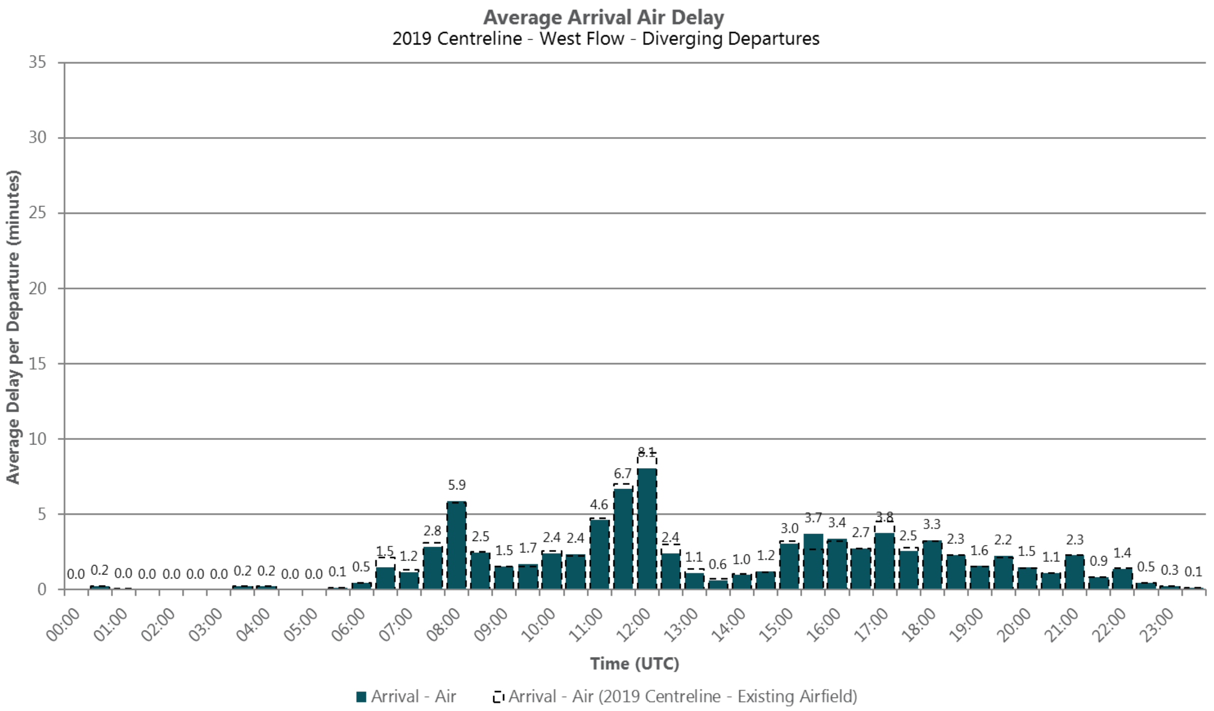
[FINAL]

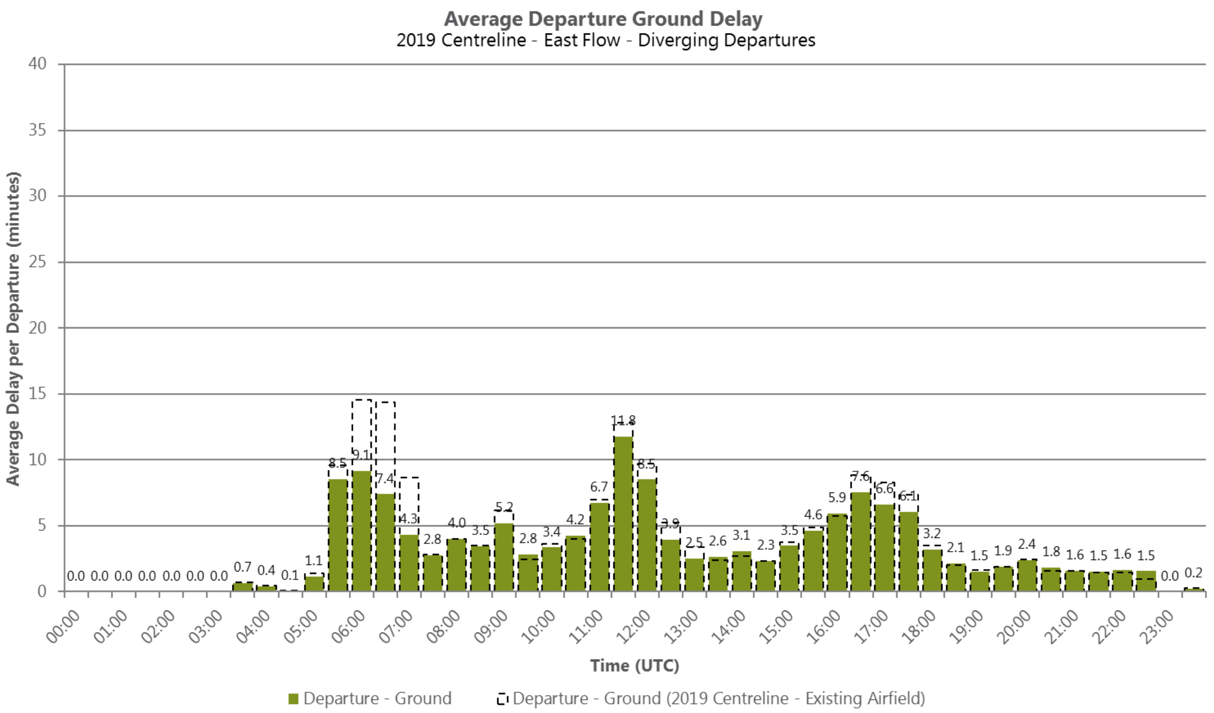
Exhibit 3-8: Multiple Entry Taxiways and Diverging Departures, 2019 Core Forecast, Delay and Air Traffic Movements



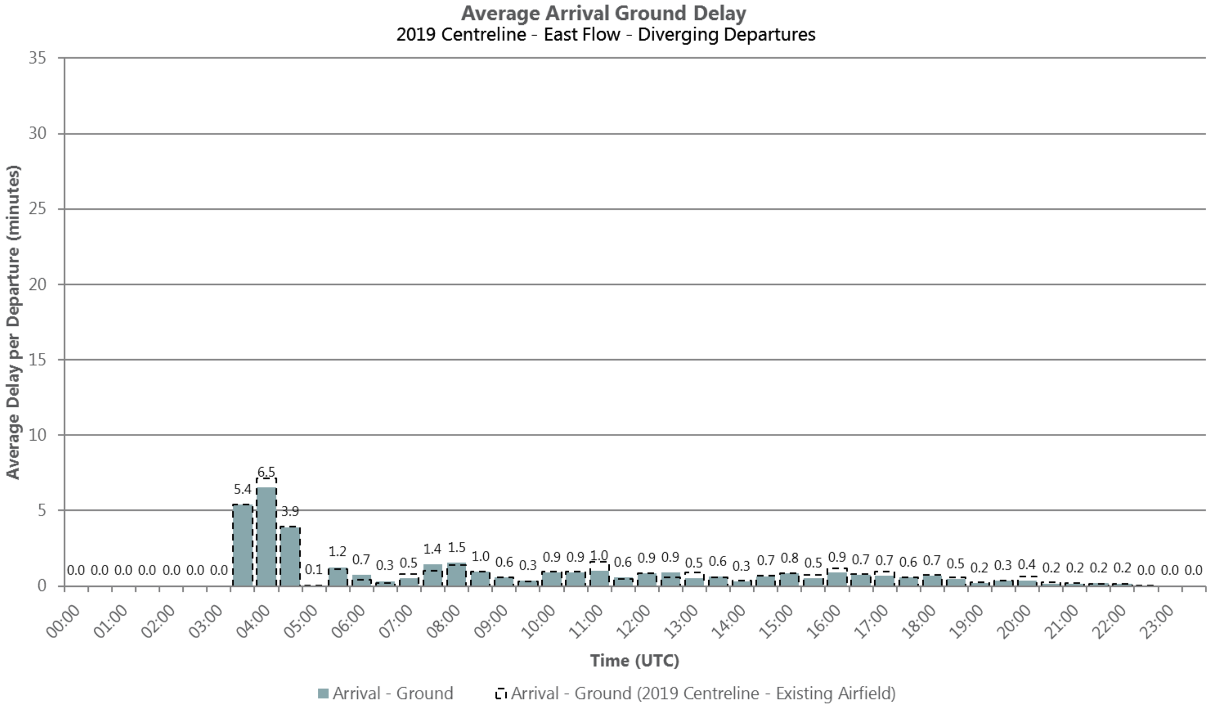


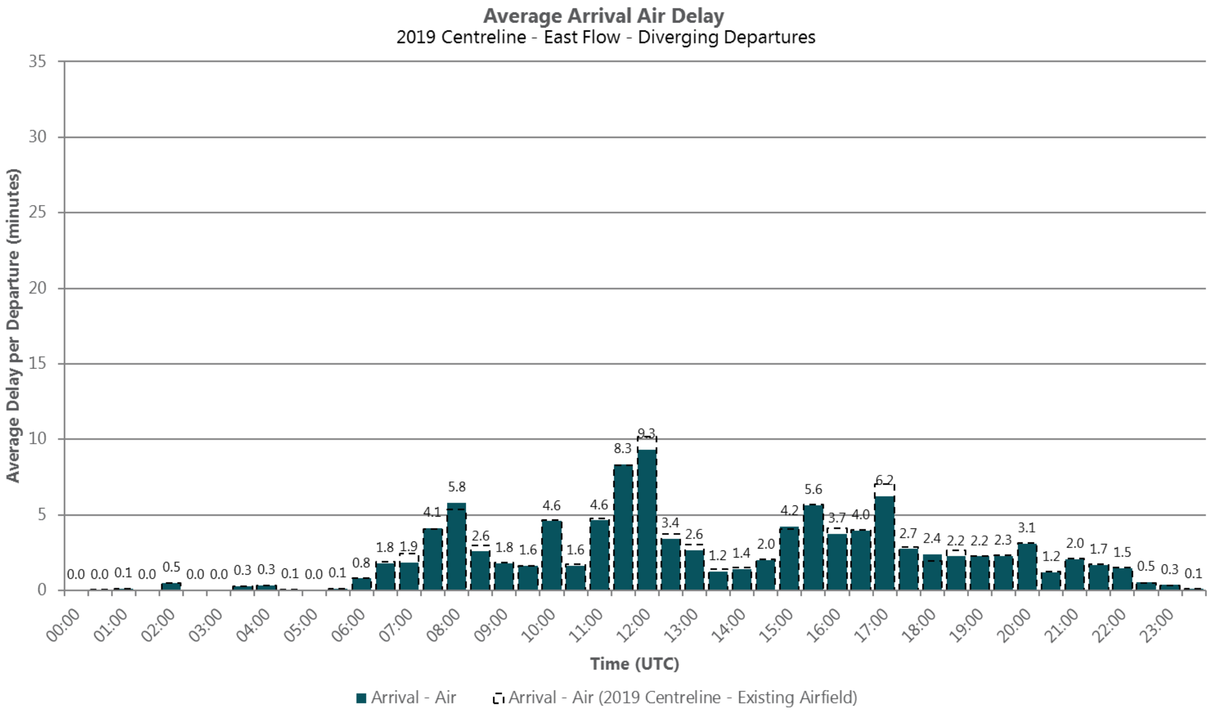
[FINAL]


Average Arrival Air Delay
2019 Centreline - West Flow - Diverging Departures
Average Delay per Departure (minutes)
Time (UTC)
Arrival - Air
Arrival - Air (2019 Centreline - Existing Airfield)

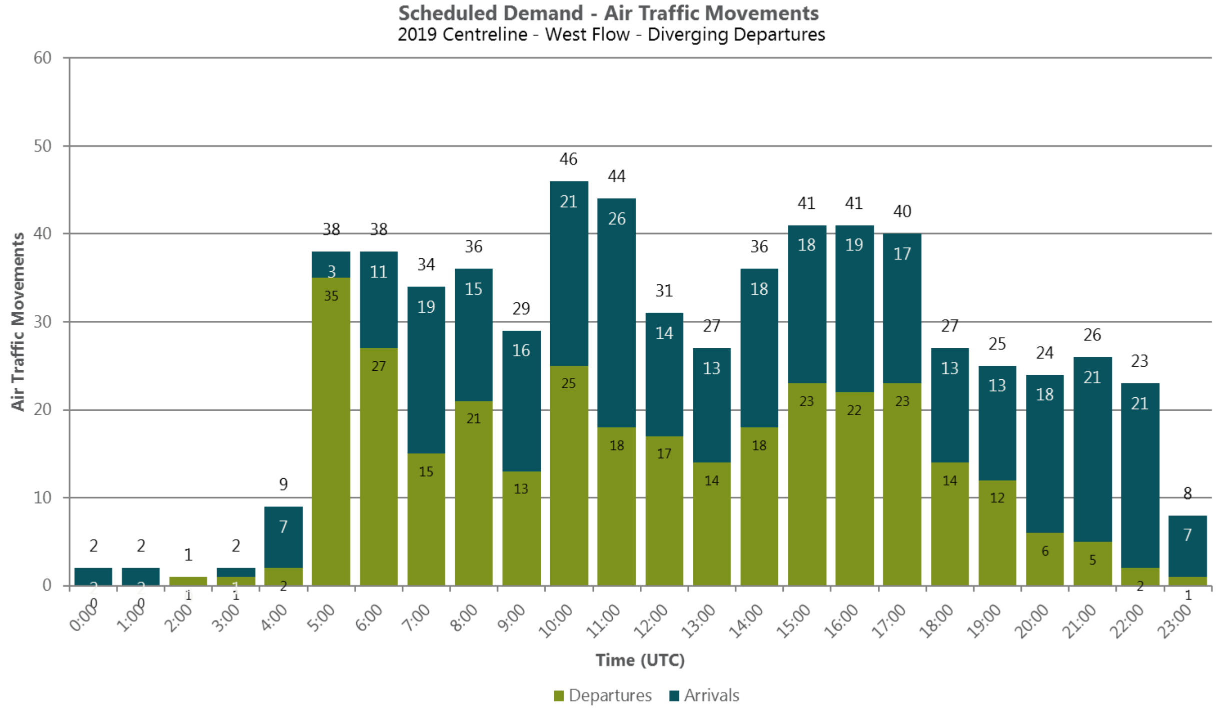

Average Departure Ground Delay
2019 Centreline - East Flow - Diverging Departures
Average Delay per Departure (minutes)
Time (UTC)
Departure - Ground
Departure - Ground (2019 Centreline - Existing Airfield)

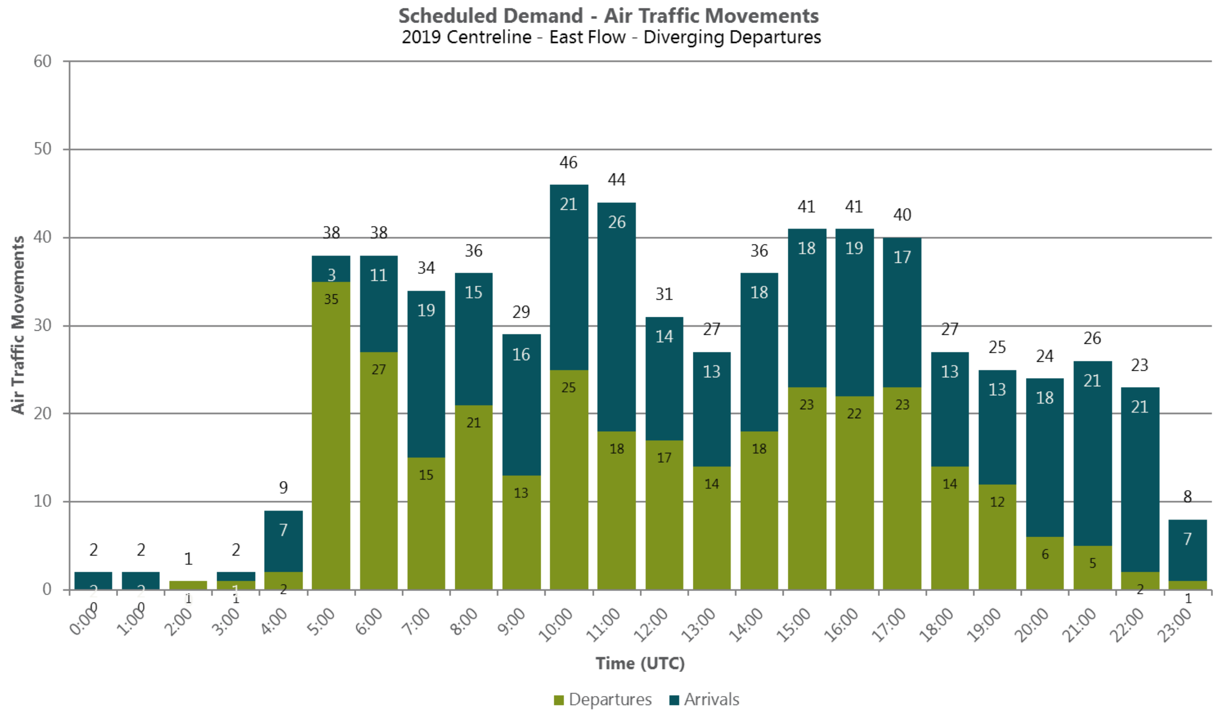
[FINAL]


Average Arrival Ground Delay
2019 Centreline - East Flow - Diverging Departures
Average Delay per Departure (minutes)
Time (UTC)
Arrival - Ground
Arrival - Ground (2019 Centreline - Existing Airfield)


Average Arrival Air Delay
2019 Centreline - East Flow - Diverging Departures
Average Delay per Departure (minutes)
Time (UTC)
Arrival - Air
Arrival - Air (2019 Centreline - Existing Airfield)

[FINAL]

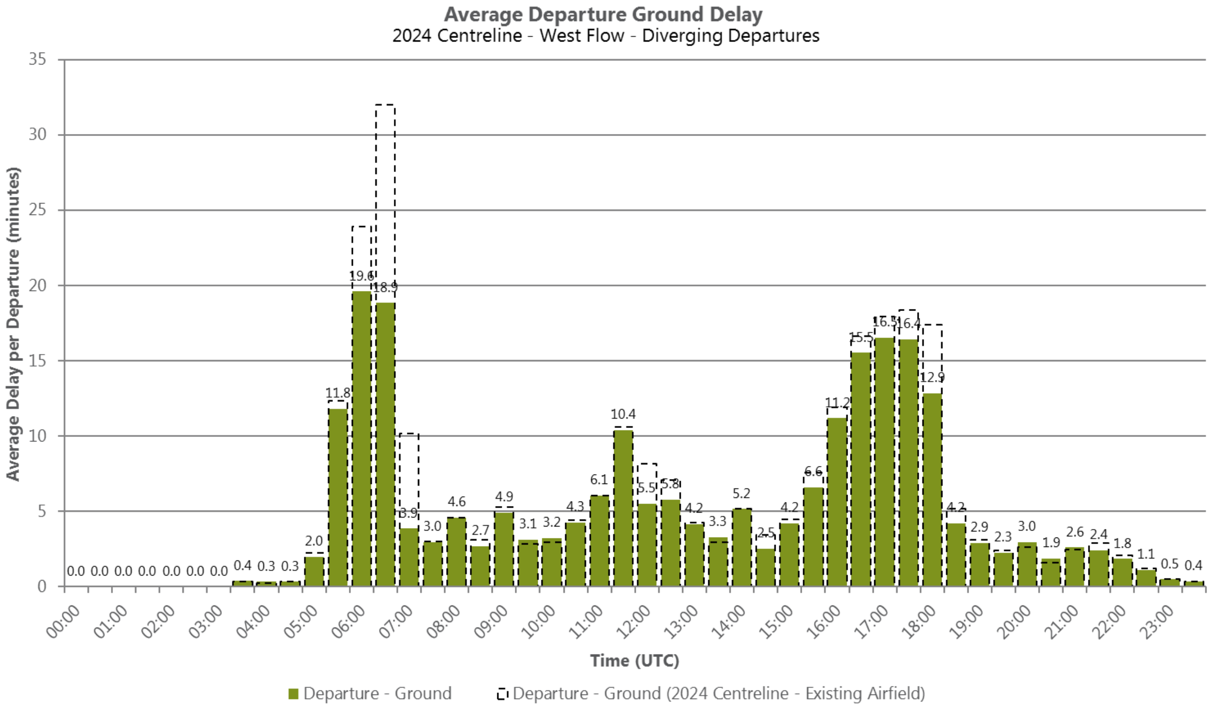


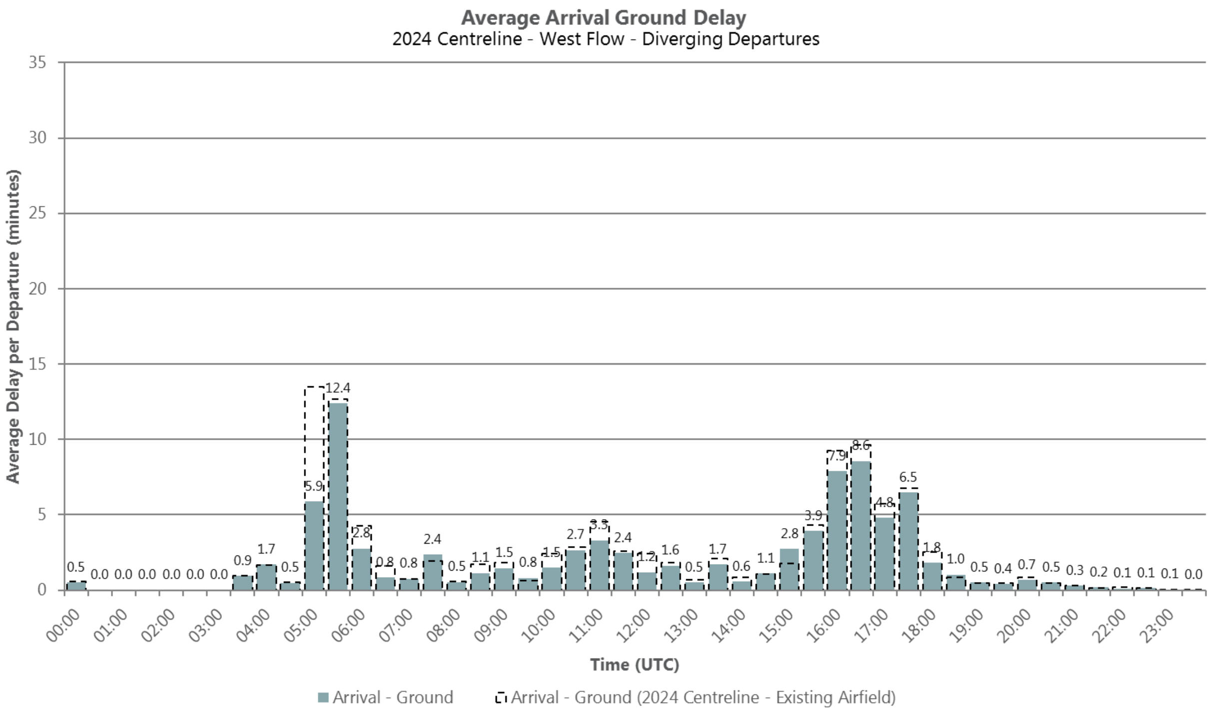


SOURCE: Ricondo & Associates, Inc., June 2014.
PREPARED BY: Ricondo & Associates, Inc., June 2014

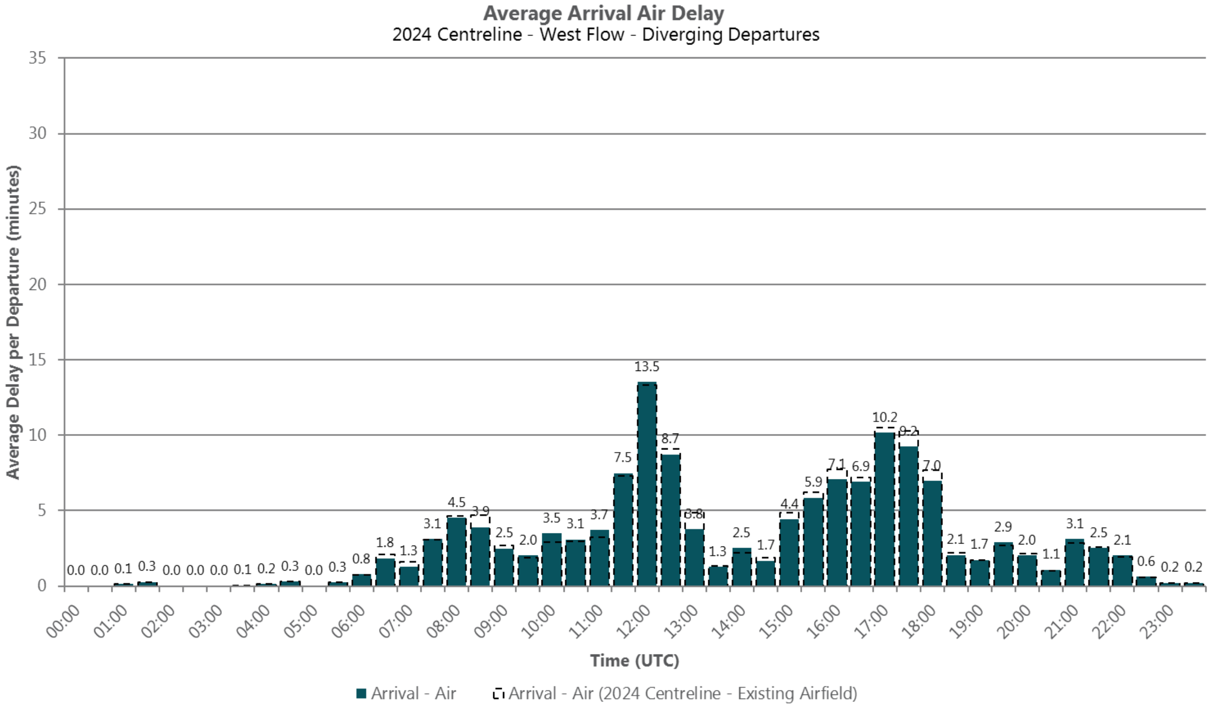
[FINAL]

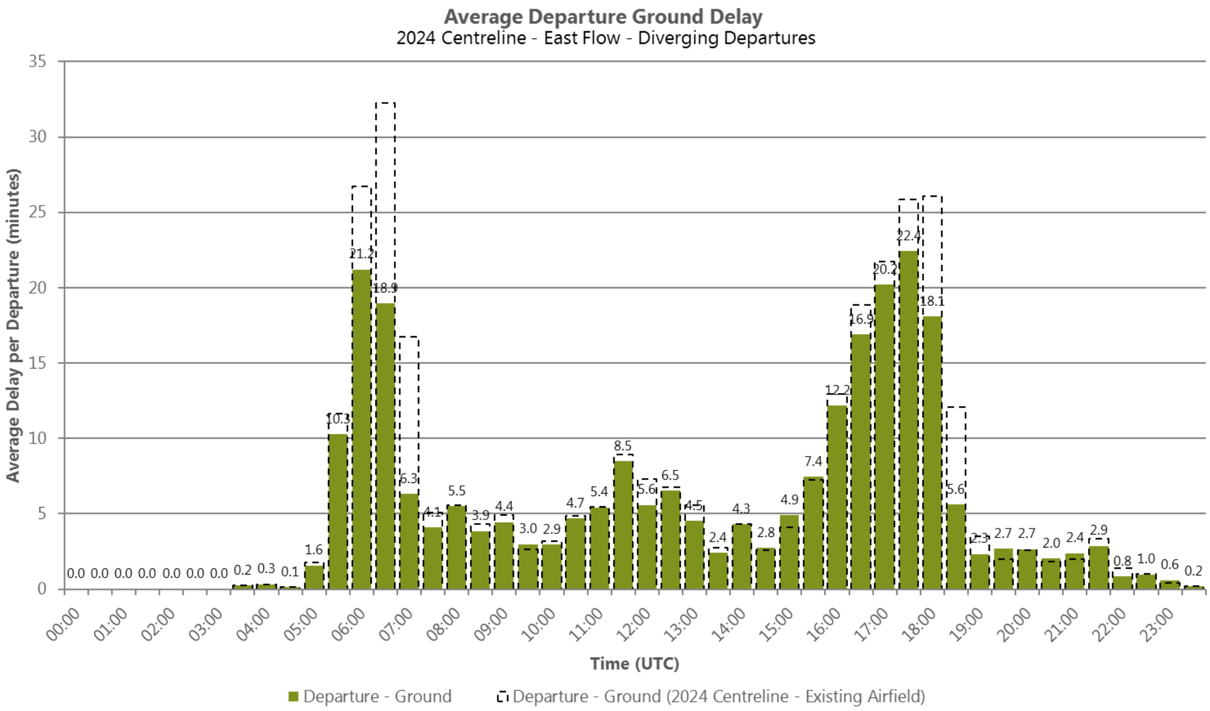
Exhibit 3-9: Multiple Entry Taxiways and Diverging Departures, 2024 Core Forecast, Delay and Air Traffic Movements



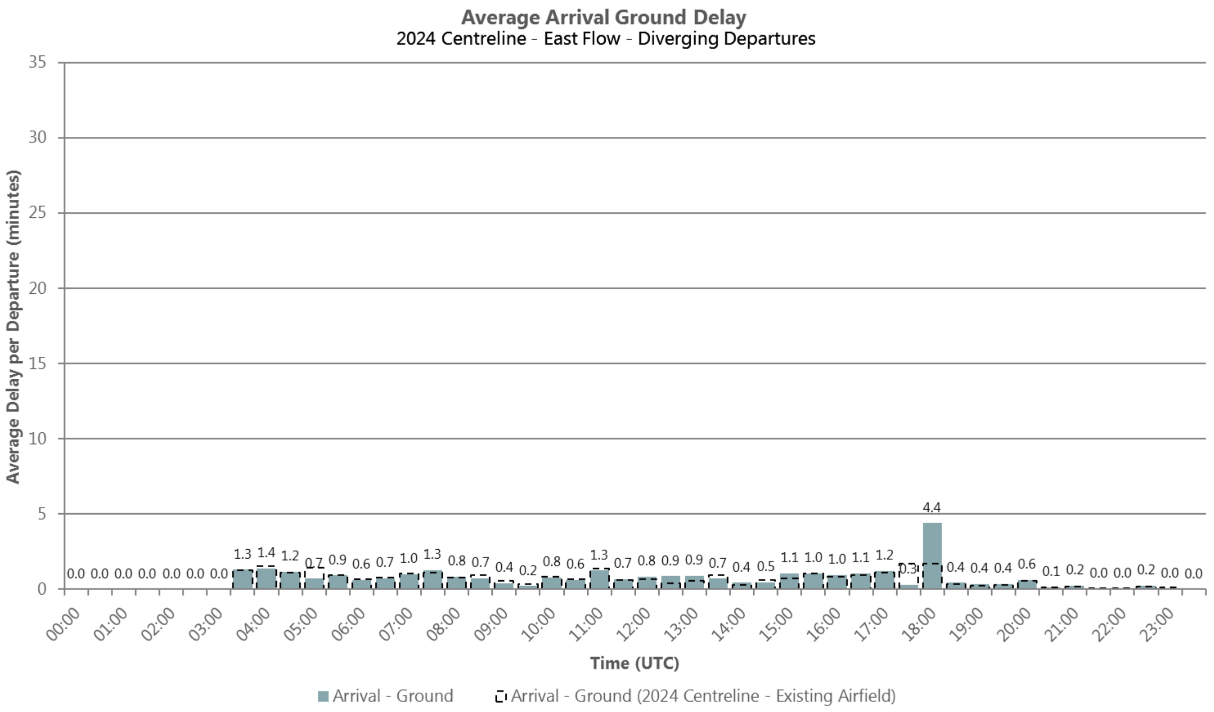


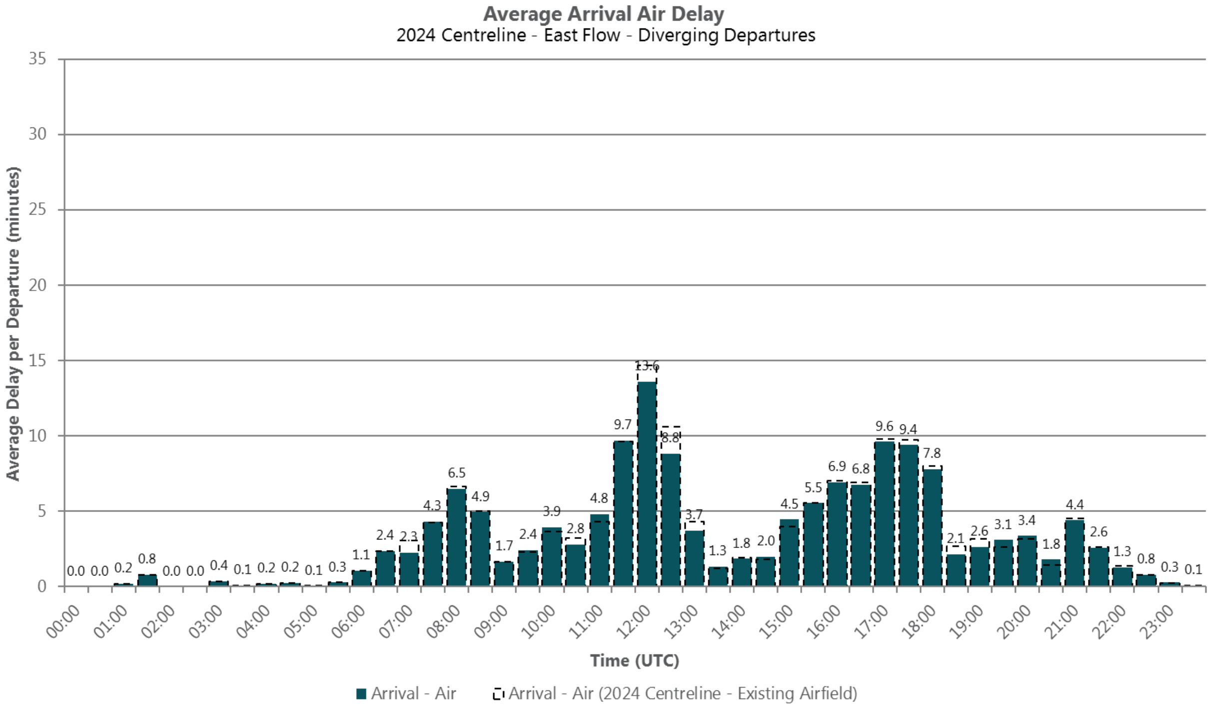
[FINAL]


Average Arrival Air Delay
2024 Centreline - West Flow - Diverging Departures
Average Delay per Departure (minutes)
35 30 25 20 15 10 5 0
0.0 0.0 0.1 0.3 0.0 0.0 0.0 0.1 0.2 0.3 0.0 0.3 0.8 1.8 1.3 3.1 4.5 3.9 2.5 2.0 3.5 3.1 3.7 7.5 13.5 8.7 3.8 1.3 2.5 1.7 4.4 5.9 7.1 6.9 10.2 9.2 7.0 2.1 1.7 2.9 2.0 1.1 3.1 2.5 2.1 0.6 0.2 0.2
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Time (UTC)
Arrival - Air
Arrival - Air (2024 Centreline - Existing Airfield)

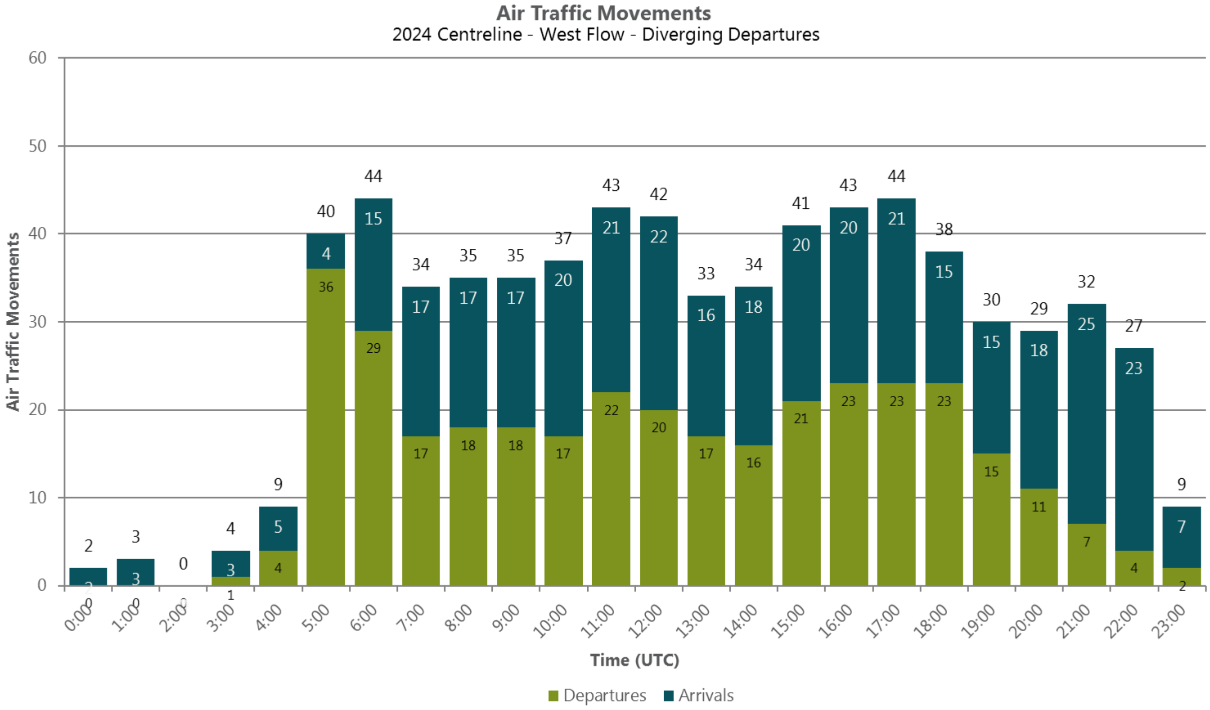

Average Departure Ground Delay
2024 Centreline - East Flow - Diverging Departures
Average Delay per Departure (minutes)
35 30 25 20 15 10 5 0
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.2 0.3 0.1 1.6 10.3 21.2 18.9 6.3 4.1 5.5 3.9 4.4 3.0 2.9 4.7 5.4 8.5 5.6 6.5 4.5 2.4 4.3 2.8 4.9 7.4 12.2 16.9 20.2 22.4 18.1 5.6 2.3 2.7 2.7 2.0 2.4 2.9 0.8 1.0 0.6 0.2
00:00 01:00 02:00 03:00 04:00 05:00 06:00 07:00 08:00 09:00 10:00 11:00 12:00 13:00 14:00 15:00 16:00 17:00 18:00 19:00 20:00 21:00 22:00 23:00
Time (UTC)
Departure - Ground
Departure - Ground (2024 Centreline - Existing Airfield)

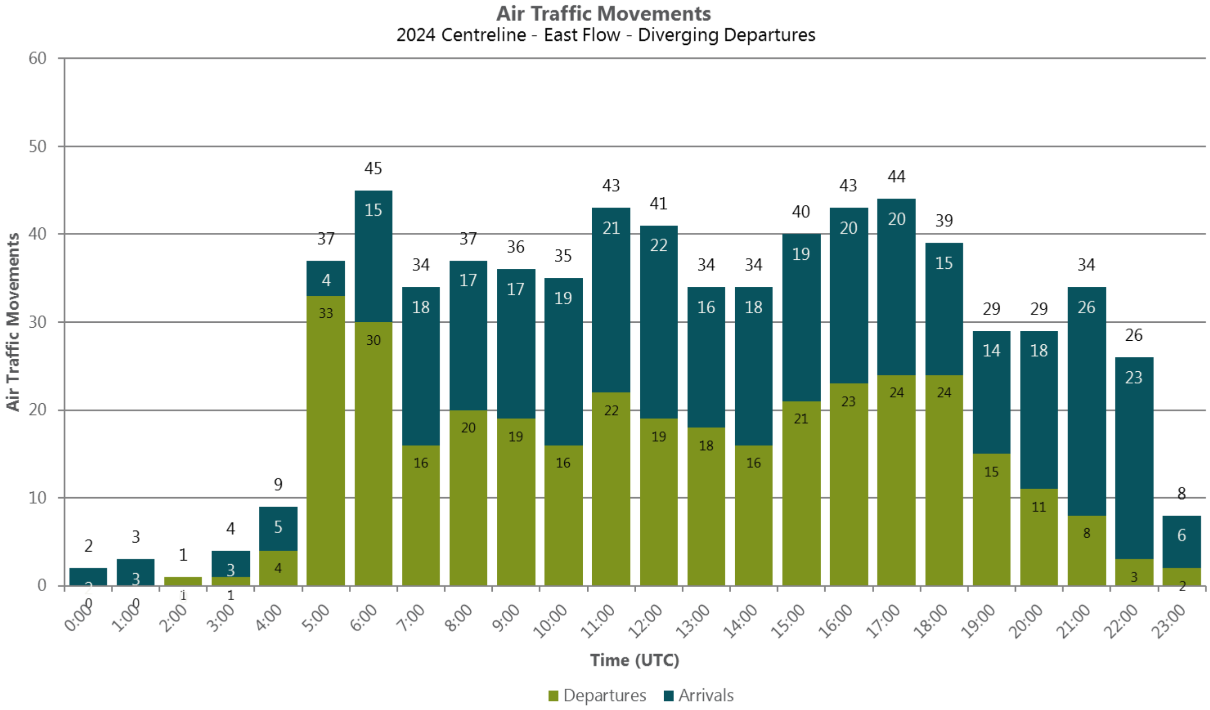
[FINAL]


Average Arrival Ground Delay
2024 Centreline - East Flow - Diverging Departures
Average Delay per Departure (minutes)
Time (UTC)
Arrival - Ground
Arrival - Ground (2024 Centreline - Existing Airfield)


Average Arrival Air Delay
2024 Centreline - East Flow - Diverging Departures
Average Delay per Departure (minutes)
Time (UTC)
Arrival - Air
Arrival - Air (2024 Centreline - Existing Airfield)

[FINAL]





SOURCE: Ricondo & Associates, Inc., June 2014.

PREPARED BY: Ricondo & Associates, Inc., June 2014.

3.4.2.2 Multiple Entry Taxiways and Diverging Departures Model Conclusions

The delay savings associated with the multiple entry taxiways and diverging departures indicate that the improvements would provide sufficient capacity to allow peak periods to grow to accommodate the 2019 Core Forecast schedule. Sometime between the activity projections in the 2019 and 2024 Core Forecast schedules, demand will exceed capacity in the peak periods and result in average delays that exceed 10 minutes.

3.5 Capacity and Delay Conclusions

The following sections describe key capacity triggers that can be quantified using the results of the simulation analysis and quantification of airfield throughput and aircraft delay.

3.5.1 AIRFIELD CAPACITY TRIGGERS

Prudent airport infrastructure planning delivers additional capacity at or slightly before it is required in order to accommodate growth in demand and to avoid costly and inefficient delays to aircraft operators, passengers, and other users. However, many airports around the world face various degrees of airfield infrastructure constraints that limit their ability to accommodate all of the demand that would use the airport absent infrastructure capacity constraints. Traffic growth, while impeded, does not stop abruptly when the first constraint is reached. However, it does begin to slow at an increasing rate the more severe the airfield constraint becomes. When growth does become constrained, the impacts to airports users become severe: prices increase while efficiency and operational resiliency decrease.

There are two key points in the demand-capacity relationship, as shown in **Exhibit 3-10**. The results of the R&A simulation analysis were analysed to help establish the traffic volume at which these points would be reached to help define the capacity of the airfield at the Airport.

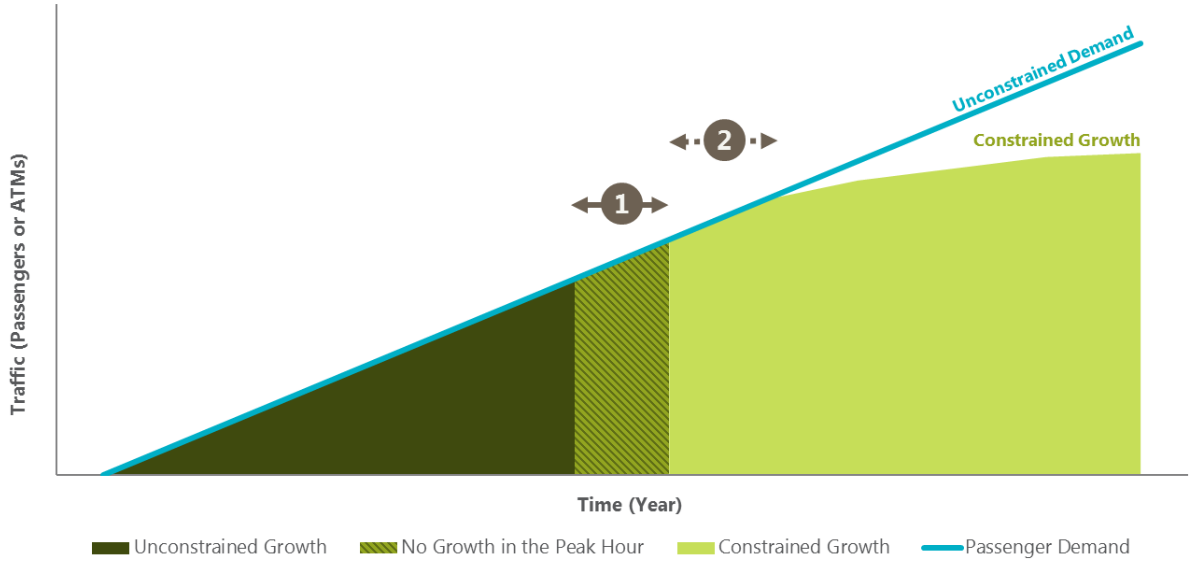
3.5.1.1 Point 1

Point 1 is based on the achievable peak hour arrival and departure throughput observed in the simulation models and represents the point at which no further growth is possible in peak hour operations and overall traffic growth begins to be constrained. Point 1 is expressed as a range to account for variations in forecast schedule and type of peak period (departures-only peak differs from overall ATMs peak). While the slot coordinator uses a level of service metric of a maximum of 10 minutes of average delay per ATM over a consecutive 30-minute period, R&A suggest that setting Point 1 using 10 minutes of average delay per ATM over a consecutive 2-hour period is more appropriate given that the flight schedules simulated represent unconstrained demand. The slot regulator's metric would flatten the schedule via the coordination process to remove peaks resulting in over 10 minutes of delay. The point at which average delay per ATM operating in the peak 2-hour period reaches 10 minutes is representative of the point at which the slot coordination process can no longer adjust schedules within the peak hour to add more flights and maintain average delay at or below 10 minutes.

3.5.1.2 Point 2

The activity level at which the magnitude of delay is severe and overall traffic growth is curtailed. Point 2 cannot be precisely determined; airline and market response to peak period growth constraints are unique to individual airports. A number of different approaches are available to estimate when Point 2 might occur, including analysis of delay over a broad period of time. In the United States, for example, the regulator (the Federal Aviation Administration) sets four-to-six minutes of average annual delay per ATM as the range in which an airport is approaching its practical capacity and beyond which significant growth constraints would occur.

Exhibit 3-10: Capacity Analysis – Points 1 and 2



SOURCE: Ricondo & Associates, Inc. July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

3.5.2 BASELINE MODEL CAPACITY TRIGGER

The R&A Baseline Model simulation achieved a maximum Point 1 throughput of 37 departures and 44 total ATMs over an hour for the existing airfield, assuming implementation of the airspace improvements associated with Phases 1 through 3 of the Runway 10-28 capacity optimisation programme identified by the RPIG. **Table 3-1** quantifies the average delay per aircraft movement during the peak 30-minute period (the slot regulator's metric) and the peak 2-hour period (R&A's proxy metric to account for the use of unconstrained flight schedules in the simulation analysis) and illustrates the increasing magnitude of delay incurred as demand grows beyond Point 1.

Table 3-1: Average Delay per ATM for the Baseline Model (West Flow, Minutes)

		PEAK 30-MINUTE PERIOD		PEAK 2-HOUR PERIOD	
FORECAST SCENARIO	PASSENGERS (MPPA)	DEPARTURE DELAY	ARRIVAL DELAY	DEPARTURE DELAY	ARRIVAL DELAY
2014 Baseline	20.1	8.2	8.8	5.8	4.7
2019 Core	23.6	14.4	12.0	12.1	9.4
2024 Core	27.2	32.0	17.0	19.8	16.8

SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

The annual passenger volume associated with Point 1 can be estimated using the relationship between traffic volumes in the future flight schedule and the overall annual forecast to which it is associated. R&A estimate that the range for Point 1 is 22.3 to 23.7 million passenger per annum (mppa) for the existing airfield based on daa Core Forecast. The higher figure, 23.7 mppa, represents annual traffic at which unconstrained growth during the peak hour on the design day can no longer accommodate additional growth on the Core Forecast.

3.5.3 MULTIPLE ENTRY TAXIWAYS AND DIVERGING DEPARTURES CAPACITY TRIGGER

If the multiple entry points for Runway 10-28, coupled with a migration to diverging departure air traffic control procedures, were implemented, R&A estimates that the range for Point 1 would increase to 24.7 to 25.9 mppa. The corresponding delay metrics for this scenario are shown in **Table 3-2**.

Table 3-2: Average Delay per ATM for the Airfield with Multiple Entry Taxiways and Diverging Departures (West Flow, Minutes)

		PEAK 30-MINUTE PERIOD		PEAK 2-HOUR PERIOD	
FORECAST SCENARIO	PASSENGERS (MPPA)	DEPARTURE DELAY	ARRIVAL DELAY	DEPARTURE DELAY	ARRIVAL DELAY
2014 Baseline	20.1	8.2	8.8	5.8	4.7
2019 Core	23.6	10.8	9.8	7.3	8.1
2024 Core	27.2	19.6	15.7	15.4	15.3

SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

The R&A simulation analysis indicates that peak period delays during the design day accelerate rapidly beyond Point 1, indicating that Point 2, or the practical capacity of the airfield, is quite close to Point 1. Given Dublin Airport's geography at the western edge of its primary market, location on an island with limited ground transport alternatives to the majority of destinations served from the airport, and the prevalence of based low-cost carriers requiring early morning departure slots, the range between Point 1 and Point 2 is likely to be narrow compared to other European airports. In aggregate, these factors suggest that Point 1 be established as the trigger for additional capacity development.

4. Capacity Implementation Scenarios

Daa identified two key ways to enhance airfield capacity in its CIP 2015-2019 Proposal. The first was to construct Runway 10L-28R, a parallel runway to existing Runway 10-28 on the north side of the Airport (the northern parallel runway). The second was to implement additional runway entry points to Runway 10-28.

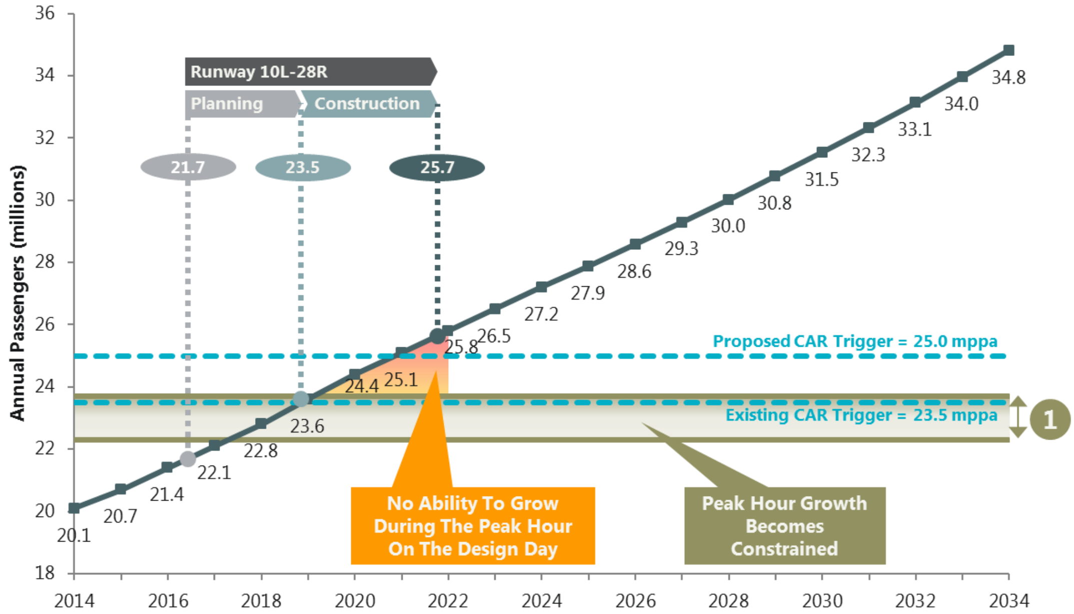
The CAR established a trigger for Runway 10L-28R of 23.5 mppa in the existing charges settlement that expires at the end of 2014. In the Draft Determination, CAR proposed setting the trigger for constructing Runway 10L-28R at 25.0 mppa but did not include the capital expenditure associated with the additional entry points suggested by daa in its proposed business plan.

The following describes a series of capacity enhancement scenarios that examine the relationship between Core Forecast demand, project implementation timelines, and the existing and proposed CAR capacity triggers.

4.1 Existing CAR Trigger for Runway 10L-28R

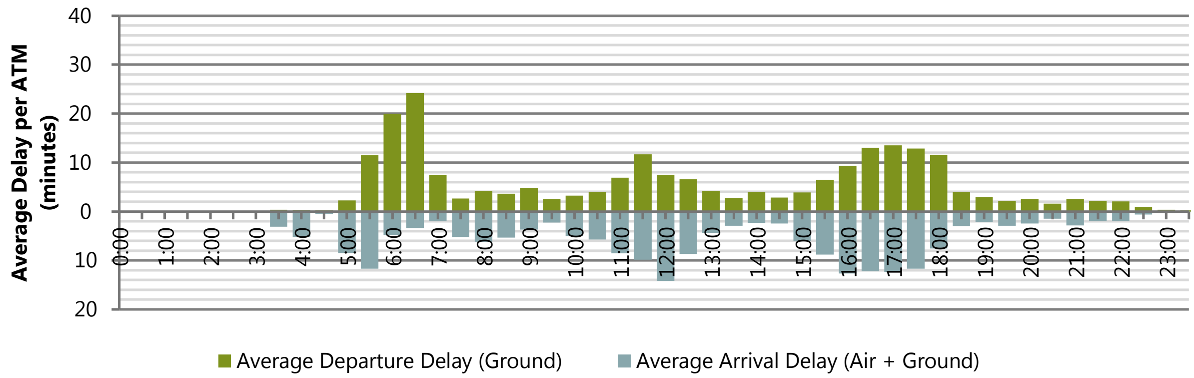
Assuming continuation of the Runway 10L-28R trigger as proposed by CAR in the prior regulatory settlement, **Exhibit 4-1** depicts the timing of Core Forecast growth against the 22.3 – 23.7 mppa range for Point 1 based on the existing airfield and the key timings for planning, construction start, and implementation of Runway 10L-28R. The corresponding level of delay that would be experienced over the design day just prior to commissioning the additional capacity is shown in **Exhibit 4-2**. Congestion occurs in the morning and late afternoon peak periods, reaching a maximum of 24 minutes of delay per departure and 14 minutes of delay per arrival in the busiest 30-minute periods.

Exhibit 4-1: Runway 10L-28R Implementation at Existing CAR Trigger



SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

Exhibit 4-2: Average Design Day Delay per ATM Corresponding to Development of Runway 10L-28R at Existing CAR Trigger (West Flow)

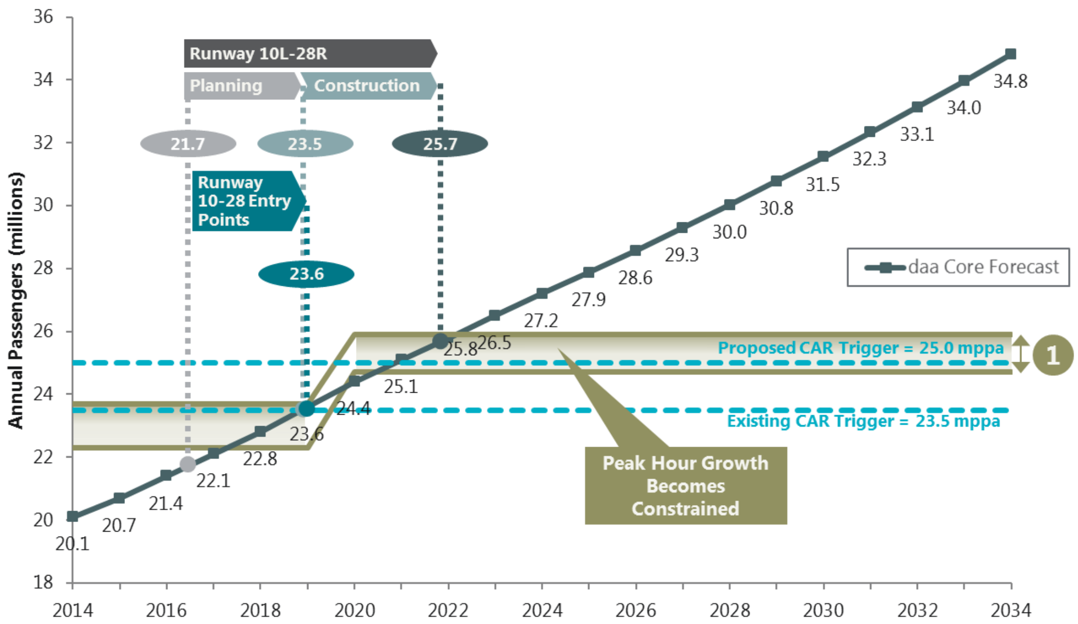


SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

4.2 Runway 10-28 Improvements and Existing CAR Trigger for Runway 10L-28R

Exhibit 4-3 depicts the timing of Core Forecast growth against both the existing and proposed range for Point 1 based on the Baseline Model and a model including multiple entry taxiways and diverging departures, respectively. This scenario implements capacity just in time to allow peak hour growth to continue unabated as required to accommodate the Core Forecast. The corresponding level of delay that would be experienced over the design day just prior to commissioning the additional capacity is shown in **Exhibit 4-4**. Some congestion occurs in the morning and late afternoon peak periods, reaching a maximum of 15 minutes of delay per departure and 13 minutes of delay per arrival in the busiest 30-minute periods.

Exhibit 4-3: Runway 10-28 Entry Points at Point 1 Followed by Runway 10L-28R at Existing CAR Trigger

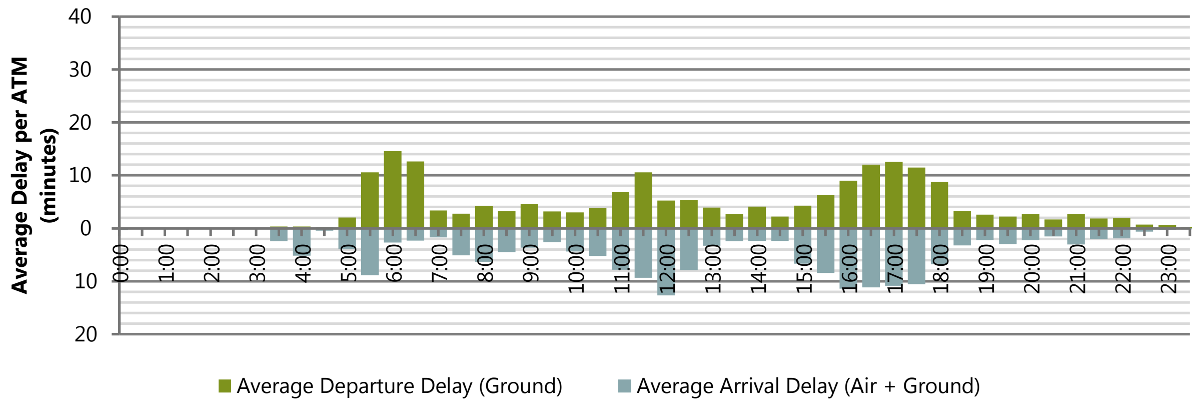


SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

4.3 Proposed CAR Trigger for Runway 10R-28L

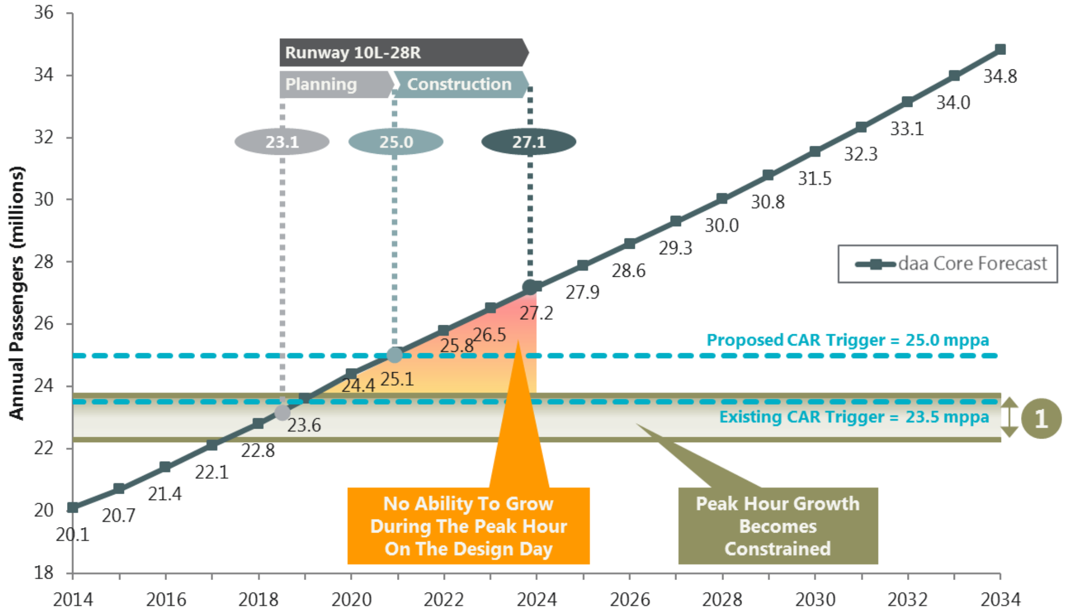
The CAR, in its Draft Determination, suggested that the trigger for the entire Runway 10L-28R project (including both the construction and planning phases) be triggered at 25.0 mppa without capacity-enhancing improvements to the existing airfield. The resulting timing of additional airfield capacity relative to Core Forecast growth and the range for Point 1 is shown in **Exhibit 4-5**. The corresponding level of delay that would be experienced over the design day just prior to commissioning Runway 10L-28R is shown in **Exhibit 4-6**. Severe congestion occurs in the morning and late afternoon peak periods, reaching a maximum of 32 minutes of delay per departure and 17 minutes of delay per arrival in the busiest 30-minute periods.

Exhibit 4-4: Average Design Day Delay per ATM Corresponding to Development of Runway 10L-28R at Existing CAR Trigger Coupled With Runway 10-28 Entry Points (West Flow)



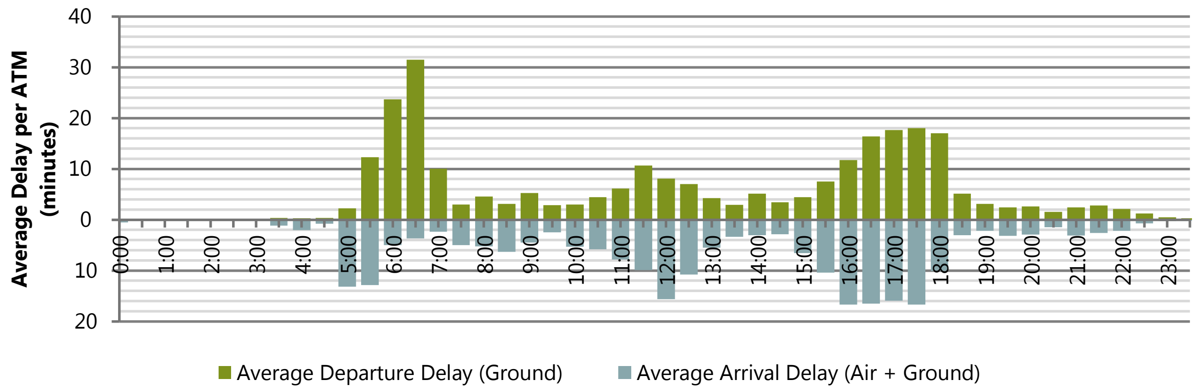
SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

Exhibit 4-5: Runway 10L-28R Implementation at Proposed CAR Trigger



SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

Exhibit 4-6: Average Design Day Delay per ATM Corresponding to Development of Runway 10L-28R at Proposed CAR Trigger (West Flow)



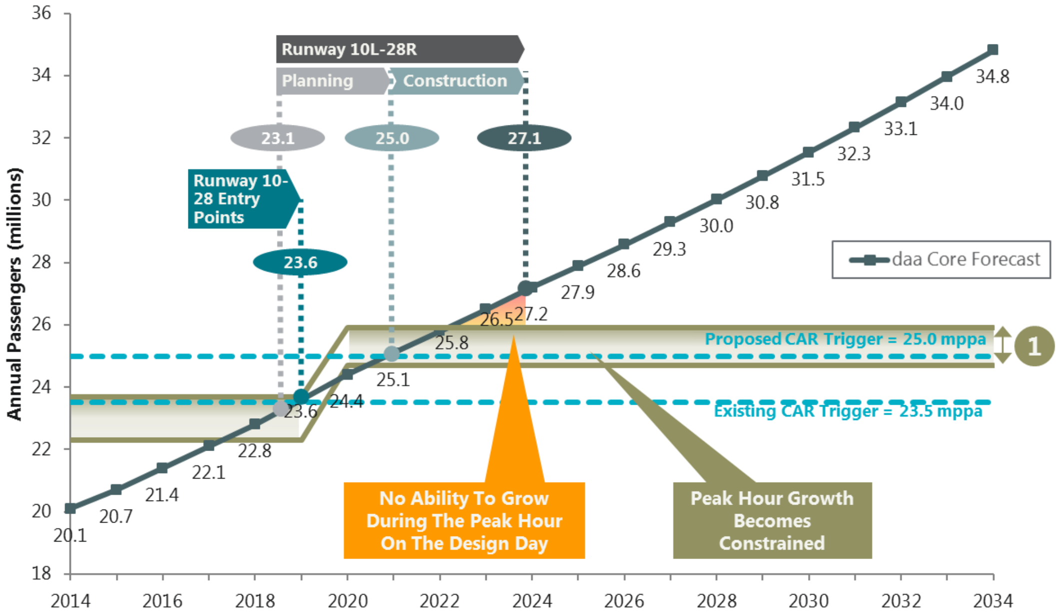
SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

4.4 Runway 10-28 Improvements and Proposed CAR Trigger for Runway 10L-28R

Similar to Exhibit 4-3, **Exhibit 4-7** depicts a two-step capacity-enhancing process, whereby the additional Runway 10-28 entry points would be available by the time Core Forecast growth reached 23.7 mppa and construction of Runway 10L-28R would begin at the 25.0 mppa trigger proposed by CAR in its Draft Determination. The corresponding level of delay that would be experienced over the design day just prior to commissioning Runway 10L-28R is shown in **Exhibit 4-8**. Some congestion occurs in the morning and late afternoon peak periods, reaching a maximum of 15 minutes of delay per departure and 18 minutes of delay per arrival in the busiest 30-minute periods.

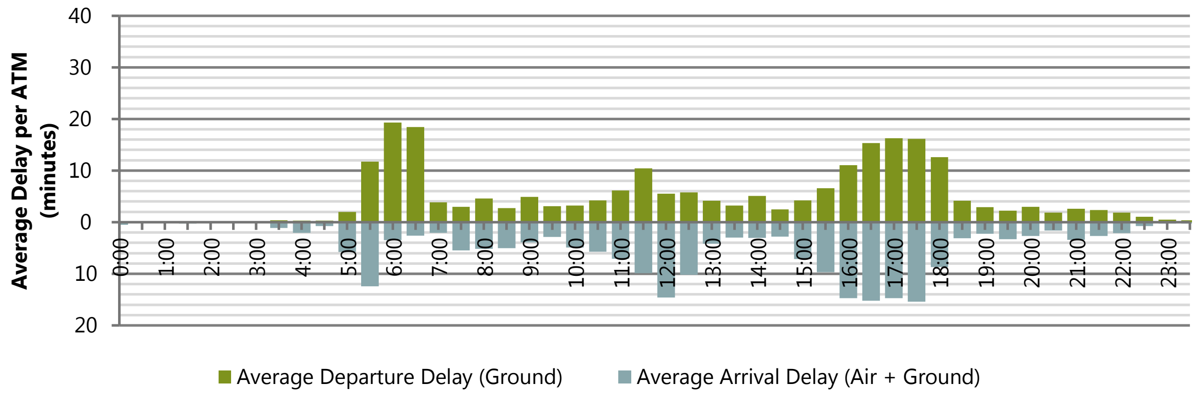
[FINAL]

Exhibit 4-7: Runway 10-28 Entry Points at Point 1 Followed by Runway 10L-28R at Proposed CAR Trigger



SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

Exhibit 4-8: Average Design Day Delay per ATM Corresponding to Development of Runway 10L-28R at Existing CAR Trigger Coupled With Runway 10-28 Entry Points (West Flow)



SOURCE: Ricondo & Associates, Inc., July 2014.
PREPARED BY: Ricondo & Associates, Inc., July 2014.

Appendix 6 - Report on CAR's Draft Determination: Cost of Capital

Source: NERA Economic Consultants

NERA
ECONOMIC CONSULTING

A Response to CAR’s Draft Determination on the Cost of Capital

A Report for Dublin Airport Authority

29 July 2014

Project Team

Dr. Richard Hern
Dominik Hübler
Arjun Dasgupta

NERA Economic Consulting
15 Stratford Place
London W1C 1BE
United Kingdom
Tel: 44 20 7659 8500 Fax: 44 20 7659 8501
www.nera.com

CONFIDENTIALITY

We understand that the maintenance of confidentiality with respect to our clients' plans and data is critical to their interests. NERA Economic Consulting rigorously applies internal confidentiality practices to protect the confidentiality of all client information.

Similarly, our approaches and insights are proprietary and so we look to our clients to protect our interests in our proposals, presentations, methodologies and analytical techniques. Under no circumstances should this material be shared with any third party without the prior written consent of NERA Economic Consulting.

Contents

Executive Summary

Dublin Airport Authority (daa) has requested NERA to provide a response to the Commission for Aviation Regulation's (CAR) draft determination on the cost of capital for the upcoming regulatory period.[1]

In its draft determination, CAR has estimated a range on the cost of capital (real, pre-tax) of 3.8%-5.9%. CAR selects a point of estimate of 5.8%, which is towards the top end of its range, but is nevertheless 1.2% below the level set at the 2009 determination.

Table 1.1
CAR Draft Determination vs 2009 Final Determination

	2009 Final Determination	2014 Draft Determination Range	2014 Draft Determination Point Estimate
Tax Rate	12.5%	12.5%	12.5%
Gearing	50%	50%-60%	50%
Risk-free Rate	2.5%	0%-1.5%	1.5%
Equity Risk Premium	5.0%	4.5%-5.0%	5.0%
Asset Beta	0.61	0.5-0.6	0.6
Equity Beta	1.22	1.0-1.5	1.2
Cost of Equity (Pre-tax)	**9.9%**	**5.1%-10.3%**	**8.6%**
Cost of Debt	**4.1%**	**2.5%-3.0%**	**3.0%**
WACC (Real, Pre-tax)	**7.0%**	**3.8%-5.9%**	**5.8%**

Source: CAR (31 July 2013) "Maximum Level of Airport Charges at Dublin Airport – Issues Paper", p56; CAR (29 May 2014): "Maximum Level of Airport Charges at Dublin Airport 2014 Draft Determination – Commission Paper 1/2014", p56.

Table 1.1 shows that the biggest drivers of the fall in the WACC between the 2009 final determination and the point estimate for the current draft determination are in the risk-free rate and the cost of debt:

- **Risk-free Rate**: CAR's point estimate of 1.5% results in a decline in the WACC of 60 basis points.
- **Cost of Debt**: CAR's point estimate of 3.0% results in a decline in the WACC of 60 basis points.

We believe CAR has made serious errors in setting its risk-free rate, as a result of which it has underestimated the overall cost of capital. In combination with failing to include a specific country risk premium (CRP) in the cost of capital, CAR's estimate results in an

[1] CAR (29 May 2014): "Maximum Level of Airport Charges at Dublin Airport 2014 Draft Determination – Commission Paper 1/2014".

underestimate of the "risk-free rate" for Irish investments. We describe the errors in CAR's methodology for estimating the risk-free rate and the country risk premium below.

Risk-free Rate

CAR estimates a point estimate of 1.5% for the upcoming regulatory period, compared to an estimate of 2.5% at the 2009 determination. CAR estimates the risk-free rate using a combination of current data on government bond yields and recent regulatory precedent.

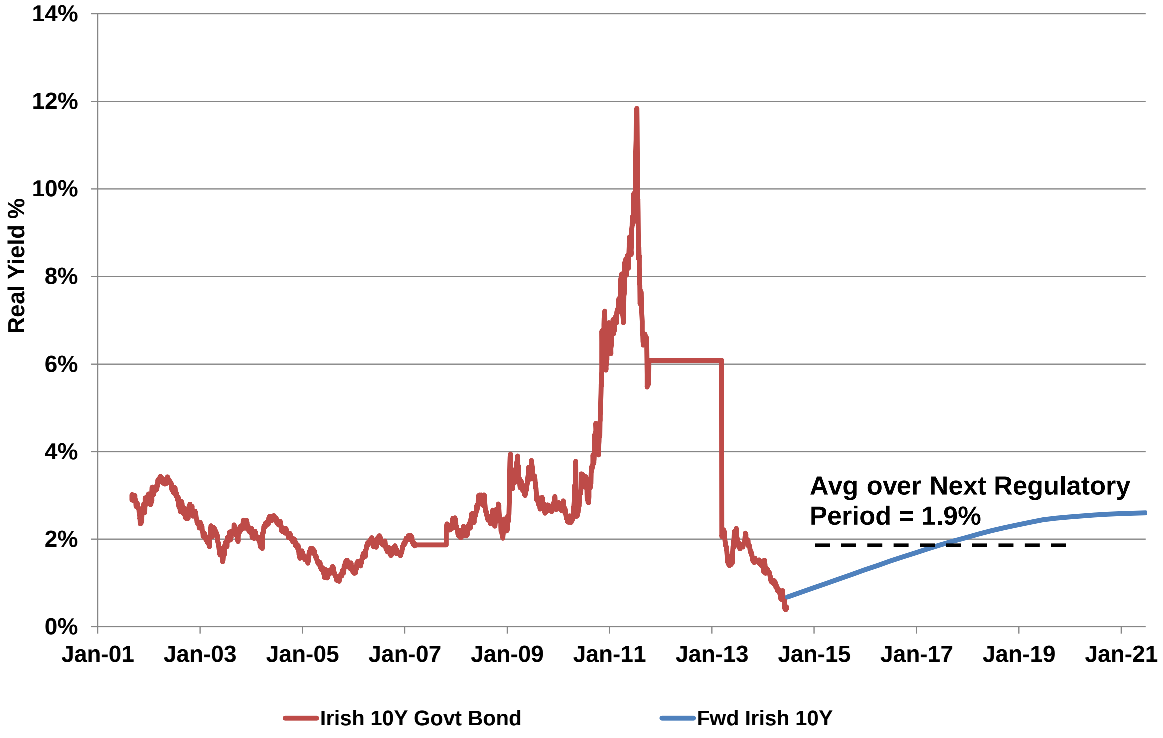
- CAR first look at historic real yield evidence on German and Finnish government bonds and argues that real yields are around zero.
- CAR then argues that the spread between Irish and German government bonds has narrowed and later argues that no spread (country risk premium) is required at all because
    i) CAR sees *"little empirical evidence to support a real risk-free rate plus country-risk premium above 1.5%"*
    ii) recent decisions by the Commission for Energy Regulation and ComReg do not include uplifts for a country-risk premium; and
    iii) CAR considers the theoretical basis for adding a country-risk premium to the CAPM calculations used to estimate the cost of equity to be weak; *"nor does the UK Competition and Markets Authority in its recent determination for Northern Ireland Electricity."*
- On that basis CAR derives a range from 0 to 1.5% based on its view that *"current market conditions could be cited to support values around zero; our past regulatory decisions and those of other regulators would offer more support for adopting values at the top of this range."*

We discuss the errors and inconsistencies in each of CAR's arguments in turn:

Key empirical evidence supports a risk-free estimate of c. 2.0%

- CAR reviews current and historic market conditions for German and Irish government bonds and concludes that there is *"little empirical evidence to support a real risk-free rate plus country-risk premium above 1.5%"*. However, CAR is setting the risk-free rate for the future regulatory period, which runs from 2015 to 2019. By corollary the risk-free rate must take into the forward-looking expectations of what the risk-free rate will be over this period, not just current market yields.
- Figure 1.1 shows that real yields on Irish government are projected to increase strongly over the period returning to levels more in line with the CAR's 2009 risk-free rate determination of 2.5% and that the average expected risk-free rate for Ireland over the regulatory period is 1.9%, well in excess of even the top end of CAR's estimate.

Figure 1.1
Forward Curves for Ireland



Source: Bloomberg data up to 20 June 2014; Note: We use a long-run CPI inflation estimate of 2.0%, based on the long-run forecast by Consensus Economics, source: Consensus Forecasts Global Outlook: 2013-2023 (October 2013)

- CAR is incorrect in arguing that its risk-free rate estimate is above the rate implied by market evidence, since current market evidence (based on forward curves) supports a rate much higher than what CAR has estimated. We note that the evidence from forward curves can be volatile and hence that in order to provide true "headroom" above the empirical evidence (CAR's stated aim in selecting its point estimate), it will need to select a real risk-free rate in excess of the 1.9% based on market evidence.

All recent Irish regulatory precedent contains implicit "country risk premium"

- CAR quotes recent decisions by the CER (Jan 14) and ComReg (Apr 14) as evidence in support of not including a country risk premium over and above the risk-free rate estimates taken by UK regulators.
- CAR's interpretation of recent Irish regulatory precedent (including CER, ComReg and IAA) is highly selective and fails to account for the fact that risk-free rates used in other regulated decisions in 2014 have been in the range of 2.0%-2.6%, a full 50-110bps above CAR's point estimate of 1.5%.
- Moreover, all these regulators have taken account of the expected "normalisation" of risk-free rates from their current low levels and the history of Irish yields being higher than the true risk-free rate, e.g.

- the CER estimates a risk-free rate of 2.0% for its recent determination on the cost of capital for electricity transmission and distribution.[2] The CER notes the CC's provisional determination on the risk-free rate range for NIE (1.0%-1.5%) and considers the Irish risk-free rate is likely to return to more 'normal' levels. On this basis, it sets a risk-free rate higher than the level set by the CC.
- ComReg argues that *"given expected normalisation in the Irish economy, though not to as strong a position as before the financial crisis, these higher figures [based on **Irish** precedent] are more likely to be appropriate than the low yields currently observed."*[3]
- the IAA estimated a risk-free rate of 2.6% with reference to yields on **Irish** government bonds prior to 2008. This implies that the IAA believes current market yields are distorted and are not appropriate for setting a forward-looking risk-free rate while it also believes local government bonds should be used.

CAR's characterisation of the theoretical case and regulatory precedent against a Country Risk Premium is highly selective and misleading

- CAR argues that the theoretical basis for adding a CRP is weak and recent regulatory precedent does not support its inclusion. This argument contains the following errors and inconsistencies:
- There is an extensive theoretical literature that supports the inclusion of a CRP. E.g. Damodaran (2011) and Bali and Cakici (2006) both argue that country risk should be remunerated in the CAPM framework,[4,5] otherwise investors are not compensated for the additional risk they face when investing in a particular country.
- As shown above all Irish regulators have included an implicit "country risk premium" by referencing Irish government bond yields and / or precedent. Similarly, regulators in all other countries significantly affected by the sovereign debt crisis continue to include country risk premiums, as we show in our January 2014 report.[6]
- CAR's reference to the CC's rejection of a Northern Ireland premium in the NIE case misses two important distinctions between the two cases.
  - Driver of the premium: NIE is located Northern Ireland (part of the UK, which is rated significantly higher than Ireland) and the argument about the risk premium is based on higher observed corporate debt yields as opposed to sovereign debt yields. The CC's rejection of the NI premium is based on the argument that it is possible that NIE's higher corporate debt yields are based on a different allocation of risk between

---

2 CER (31 January 2014): "Mid-term Review of WACC applying ti the Electricity TSO and TAO and ESB Networks Ltd for 2014 to 2015", p23.

3 ComReg (Apr 2014): ComReg 14/28, Costs of Capital (Mobile, Fixed Line, Broadcasting), para 4.10.

4 Damodaran, A. (2011): "Equity Risk Premiums (ERP): Determination, Estimation and Implications", Stern School of Business.

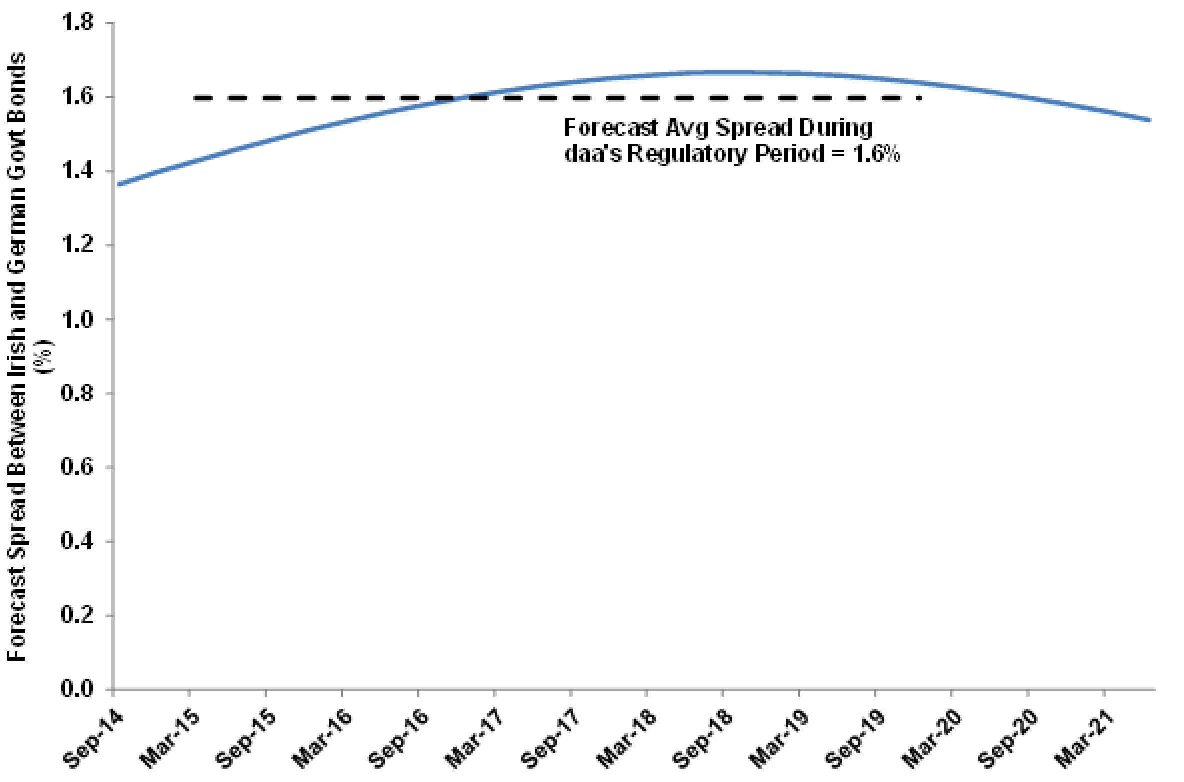
5 Bali, T ,Cakici, N, (2010): "World market risk, country-specific risk and expected returns in international stock markets", Journal of banking & finance, Vol 34 (6), p1152-1165.

6 NERA (Jan 2014): A Study into the Cost of Capital for daa

NIE's debt and equity holders.[7] The same argument cannot plausibly be made for daa where the debt premium is driven by the sovereign debt, which cannot plausibly be argued to be driven by a difference in risk allocation between daa and the Irish government bond holders.

- Continued existence of the premium: Moreover, the CC argues that the NIE corporate debt premium has recently fallen away and thus does not provide any reason to assume the continued existence of the premium.[8] The same is not true in the case of daa where our analysis of forward rates shows that the spread between German and Irish government bond yields is expected to remain positive and significant (even increase on average) over the next regulatory period, at an average of 1.6%.

Figure 1.2
Forward Spread Over Next Regulatory Period



Source: Bloomberg data as of 20 June 2014

Conclusion: CAR's determination of the risk-free rate range from 0 to 1.5% contains three substantial errors and inconsistencies

- In concluding that there is no empirical evidence to support a number in excess of 1.5% CAR fails to account for projections of the risk-free as implied by forward curves for

7 CC (2014): Northern Ireland Electricity Limited price determination; A reference under Article 15 of the Electricity (Northern Ireland) Order 1992 - Final determination, pp.13-17 to 13-20.

8 CC (2014): ibid, p.13-20.

Irish government bond debt that show a central estimate for the risk-free rate over the relevant regulatory period of 1.9%;

- In concluding that other Irish regulators have not included a country risk premium CAR fails to account for the fact that i) all three decisions for regulated companies in Ireland that were taken in the last six months have made reference to Irish government bond yields or precedent (i.e. included an implicit country risk premium) and ii) the range for the risk-free rate included in these decisions is between 2.0% and 2.6%, a full 50-110bps higher than CAR's decision.
- In concluding that there is no theoretical case for the country risk premium, CAR fails to acknowledge the significant body of academic literature in favour of a country risk premium, the fact that a country risk premium is also applied in all other countries affected by the sovereign debt crisis. Finally, we note that there were two important differences (source of premium and outlook for premium) between the NIE case (quoted by CAR), where the CC rejected the case for a premium and the situation of daa that render the CC decision irrelevant for the current case. Instead empirical evidence on the forward-looking CRP confirms that there is no reason to believe that the rationale for a CRP is going to drop away over the next regulatory period.

In light of the above errors, the minimum plausible estimate for the risk-free rate (including a country risk premium) is 2.0% while a more plausible central estimate would be more in line with other regulatory precedent for Ireland.

Cost of Debt

CAR estimates a range of 2.5%-3.0%, and selects the top end of its range as its point estimate.

CAR sets the cost of debt with reference to new debt only, and does not consider embedded debt. For the cost of new debt, CAR considers evidence from an ESB bond and a benchmark index.

CAR has adopted an inferior methodology in estimating the cost of debt using new debt costs only. The methodologically robust approach is to use a weighted average cost of embedded debt and new debt, in line with UK regulatory precedent. We believe this methodology has the following advantages:

- Our approach recognises that daa has raised finance efficiently at different points in the interest rate cycle and that it raises finance over periods longer than the price control period. We note that this approach relies on actual embedded debt costs, which allows daa to recover its efficiently incurred financing costs.
- This approach also takes into account daa's expected debt issuance and likely debt costs. Given benchmark indices do not allow daa to adequately recovers its debt costs, using forward curves is an improved methodology for setting the cost of new debt (because it represents the market's best expectation of the interest cost in future).

Our approach is widely used by UK regulators, including Ofwat, the CAA and the CC in its recent determination for NIE. CAR notes that it is willing to consider an embedded debt approach for future determinations, but would like to consult further before adopting such a methodology.

We estimate a weighted average cost of debt of 3.09%, based on daa's embedded debt and a forecast of cost of new debt. This estimate is based on our January 2014 report, and the latest data may support a different estimate.

Overall, we disagree with CAR's general approach, but the final estimate of 3.0% is only slightly below our view on the cost of debt. This is because the current cost of new debt is very similar to daa's cost of embedded debt, implying that adding embedded debt to the overall cost of debt does not change the estimate. In light of the limited empirical impact at the current review, now may be a good time to change to the more robust approach in order to de-risk daa's debt profile.

CAR's Estimate of Other CAPM Parameters

Equity risk premium (ERP): CAR estimates a range of 4.5%-5.0%, and selects the top end of its range as the point estimate. The estimate is based on long-run evidence and recent regulatory precedent. On a stand-alone basis we consider CAR's ERP point estimate of 5% to be appropriate for the forthcoming regulatory period. However, we note that the use of a long-run ERP needs to be combined with a consistent estimate of the risk-free rate rather than CAR's short-run focussed estimate of the risk-free rate.

Asset Beta: CAR estimates a range of 0.5-0.6, and selects the top end of its range. CAR reviews daa's risk profile, particularly volatility in passenger numbers and regulatory treatment of cost overruns, and looks at empirical estimates for comparators in the same way that NERA does. CAR settles on 0.6 as its point estimate because it considers daa faces more systematic risk than comparators. We note that any reduction in asset beta relative to the previous estimate of 0.61 is out of line with the CAA, which has increased rather than decreased its estimates of the beta for Heathrow (0.47 to 0.50) and Gatwick (0.52 to 0.56). In particular we note that there are a number of significant differences compared to other regulated utilities including volume risk, risk associated with the pension deficit and risks around the cost of debt that suggest that there should be a significant difference in risk between daa and regulated utilities. We therefore do not see any scope for reducing the asset beta below the previous estimate of 0.61, let alone to 0.5.

Gearing: CAR estimates a notional gearing range of 50%-60% and selects 50% as its point estimate. The only supporting evidence that CAR provides is that its final estimate is similar to the CAA's final estimates for Heathrow and Gatwick. We note that a gearing of 50% may risk daa's financeability, although the gearing assumption has a minimal impact on the overall cost of capital estimate itself.

NERA Assessment of the Cost of Capital

Our review of CAR's methodology for estimating the risk-free rate (including country-specific effects) shows that CAR has made three substantial errors and inconsistencies:

- Failure to take account of projected increases in government bond yields to c.2.5% real by the end of the period (1.9% on average);
- Incomplete and misleading interpretation of recent Irish regulatory precedent, where all regulators include at least an implicit country risk premium by way of reference to either Irish government bond yields and / or precedent; and

- Incomplete and erratic review of the theoretical literature and regulatory precedent on the country risk premium for the cost of equity that is not borne out by the empirical evidence on the forward spread between German and Irish government bond yields.

Our own analysis of forward curve evidence and a comprehensive review of Irish and international regulatory precedent as well as the theoretical literature support a risk-free rate estimate of at least 2.0%, significantly above CAR's estimate of 1.5% suggesting CAR has underestimated the pre-tax cost of equity by more than 50bps.

Further we note that daa bears significant additional risk compared to traditional utilities, e.g. with respect to changes in demand, deficits on its pension scheme and differences between the cost of new and embedded debt. CAR has not presented any evidence that any of these risks have reduced since 2009. In light of this and the fact that the CAA has increased rather than decreased its estimates of the beta for Heathrow (0.47 to 0.50) and Gatwick (0.52 to 0.56) while other regulators have allowed asset betas for mobile telephony (a lower risk activity than air travel) towards the upper end of CAR's range, there is no reason for CAR to use a lower beta than previously.

We also note that CAR has adopted an inferior methodology on the cost of debt compared to the standard UK approach. By only considering the cost of new debt, CAR exposes daa to significant risk around costs daa can no longer influence. The embedded debt costs represent the efficient debt costs that daa incurs on its current debt, and which the allowed rate of return must remunerate. At the current time there is limited difference between the two cost categories, which suggests now may be a good time to introduce such a change without significantly affecting the cost allowance.

1. Introduction

On 29 May 2014, the Commission for Aviation Regulation (CAR) published its draft determination on the maximum level of airport charges that Dublin Airport Authority (daa) may levy at Dublin Airport between 1 January 2015 and 31 December 2019. As part of its draft determination, CAR estimates the return on capital that Dublin Airport may earn over the period.

daa has commissioned NERA to provide an expert response to CAR's draft determination on the cost of capital for the upcoming regulatory period.[9] This study reviews the aspects of the draft determination in which we believe CAR has made errors or inconsistencies. Where we refer to "daa" we are referring to "daa's regulated assets".

In reviewing CAR's methodology for estimating the cost of capital we apply standard economic and financial models. In arriving at a final conclusion on CAR's range and point estimate, we consider a broad range of evidence including short-term and long-term historical market data, forward curve information and recent regulatory precedent. We also take account regulatory precedent from other countries that have been affected by the European sovereign debt crisis in a way that local bond rates can no longer be considered "risk-free".

The remainder of this report is structured as follows:

- Section 2 reviews CAR's estimate of the risk-free rate (and country risk premium);
- Section 3 considers CAR's methodology for estimating the cost of debt;
- Section 4 evaluates other aspects of CAR's cost of capital estimate;
- Section 5 concludes on CAR's estimate of the capital, and considers what we consider is the appropriate cost of capital after correcting CAR's errors and inconsistencies;
- The appendices provide supporting information on the calculation of the cost of debt.

9 CAR (29 May 2014): "Maximum Level of Airport Charges at Dublin Airport 2014 Draft Determination – Commission Paper 1/2014".

2. Risk-free Rate (and Country Risk Premium)

The real risk-free rate is the price that investors demand to exchange certain current consumption for certain future consumption. In practice there is no true risk-free rate that can be observed, especially in countries where the government bond yield is not risk-free, such as Ireland.

2.1. CAR's Estimate of the Risk-free Rate

In its draft determination, CAR estimates a risk-free range of 0%-1.5% and selects a point estimate of 1.5% at the top end of its range.[10] This compares to its final determination of 2.5% at the 2009 review.

Table 2.1
Risk-free Rate: CAR 2009 Determination vs 2014 Draft Determination

2009 Final Determination	2014 Draft Determination Range	2014 Draft Determination Point Estimate
2.5%	0%-1.5%	1.5%

Source: CAR (31 July 2013) "Maximum Level of Airport Charges at Dublin Airport – Issues Paper", p56; CAR (29 May 2014): "Maximum Level of Airport Charges at Dublin Airport 2014 Draft Determination – Commission Paper 1/2014", p56.

CAR estimates the risk-free rate using a combination of current data on government bond yields and recent regulatory precedent. CAR first looks at historic real yield evidence on German and Finnish government bonds and argues that real yields are around zero

CAR then argues that the spread between Irish and German government bonds has narrowed and later argues that no inclusion of the spread (country risk premium) is required at all because

i) CAR sees *"little empirical evidence to support a real risk-free rate plus country-risk premium above 1.5%"*

ii) recent decisions by the Commission for Energy Regulation and ComReg do not include uplifts for a country-risk premium; and

iii) CAR considers the theoretical basis for adding a country-risk premium to the CAPM calculations used to estimate the cost of equity to be weak; *"nor does the UK Competition and Markets Authority in its recent determination for Northern Ireland Electricity."*

On that basis CAR derives a range from 0 to 1.5% based on its view that *"current market conditions could be cited to support values around zero; our past regulatory decisions and those of other regulators would offer more support for adopting values at the top of this range."*

[10] CAR (29 May 2014): "Maximum Level of Airport Charges at Dublin Airport 2014 Draft Determination – Commission Paper 1/2014", p56.

- For its lower bound, CAR considers current market data on German government bond yields. CAR finds that spot German government bond yields are below zero (in real terms) and the average since 2009 is 0.44%.[11]
- For its upper bound, CAR considers recent Irish regulatory precedent on the risk-free rate. CAR finds that regulators have set the risk-free rate above current market evidence and concludes on an upper bound of 1.5%, which is equal to the Competition Commission's (CC) recent determination on the risk-free rate for Northern Ireland Electricity's (NIE) price control.[12]

CAR selects 1.5% as its final estimate, which lies at the top end of its range. Implicitly, CAR suggests that it has allowed some headroom over current market evidence based on the approach taken in recent decisions by other regulators.

However, our review of CAR's methodology shows that CAR has made three substantial errors and inconsistencies:

- Failure to take account of projected increases in government bond yields;
- Incomplete and misleading interpretation of recent Irish regulatory precedent; and
- Incomplete and erratic review of the theoretical literature and regulatory precedent on the country risk premium for the cost of equity.

We discuss these three points in turn below.

2.2. CAR's Failure to take account of projected increases in government bond yields

CAR reviews current and historic market conditions for German and Irish government bonds and concludes that there is *"little empirical evidence to support a real risk-free rate plus country-risk premium above 1.5%"*. However, CAR is setting the risk-free rate for the future regulatory period, which runs from 2015 to 2019. By corollary the risk-free rate must take into the forward-looking expectations of what the risk-free rate will be over this period, not just current market yields. CAR fails to do this.

The best available evidence for assessing the expected risk-free rate for the upcoming regulatory period is from forward curves. Forward curves show the market's expectation of the gilt yield at different points in the future, backed out from the yield curve for bonds of different maturities.[13]

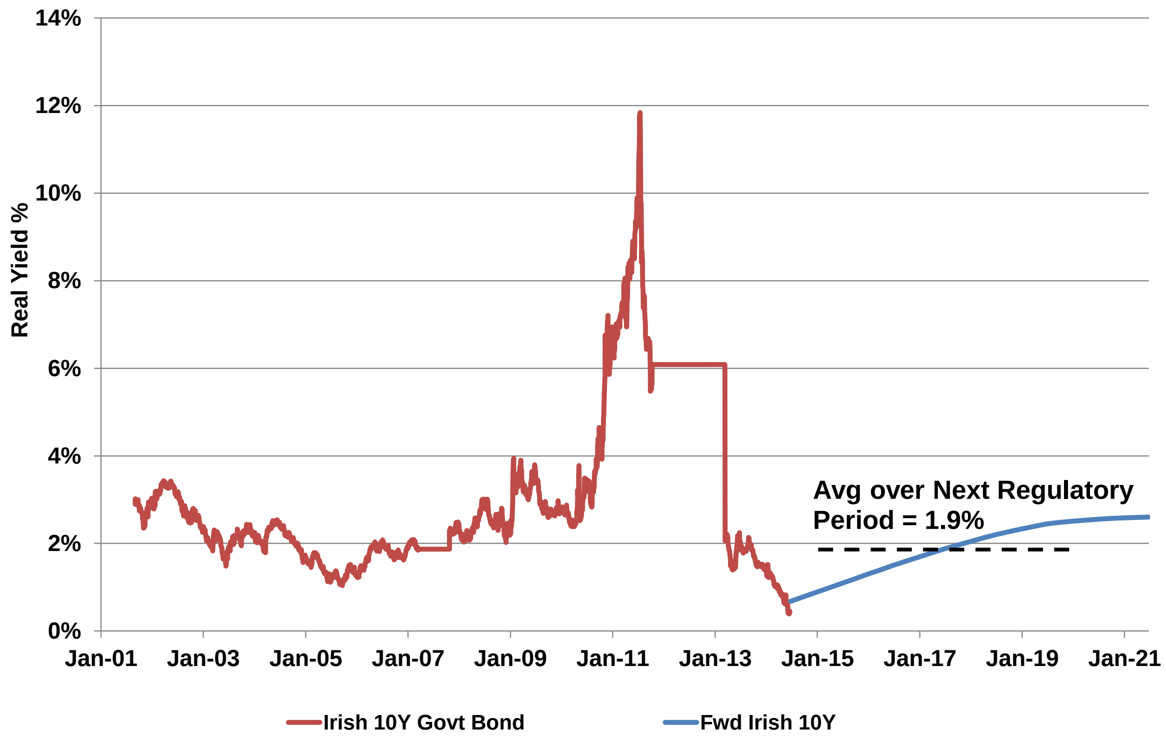
---

[11] CAR (29 May 2014): "Maximum Level of Airport Charges at Dublin Airport 2014 Draft Determination – Commission Paper 1/2014", paragraph 6.59.

[12] Competition Commission (26 March 2014): "Northern Ireland Electricity Limited price determination – Final determination", paragraph 13.129.

[13] E.g. the implied yield on a 10Y maturity bond 2 years from now is calculated by solving for the yield that explains the current difference in yield between a 2-year and a 12-year maturity bond. See e.g. Bank of England: "Notes on the Bank of England UK Yield Curves" for a full explanation of the rationale behind forward curves.

Figure 2.1
Government Bond Rates and Forward Curves for Ireland (2001-2021)



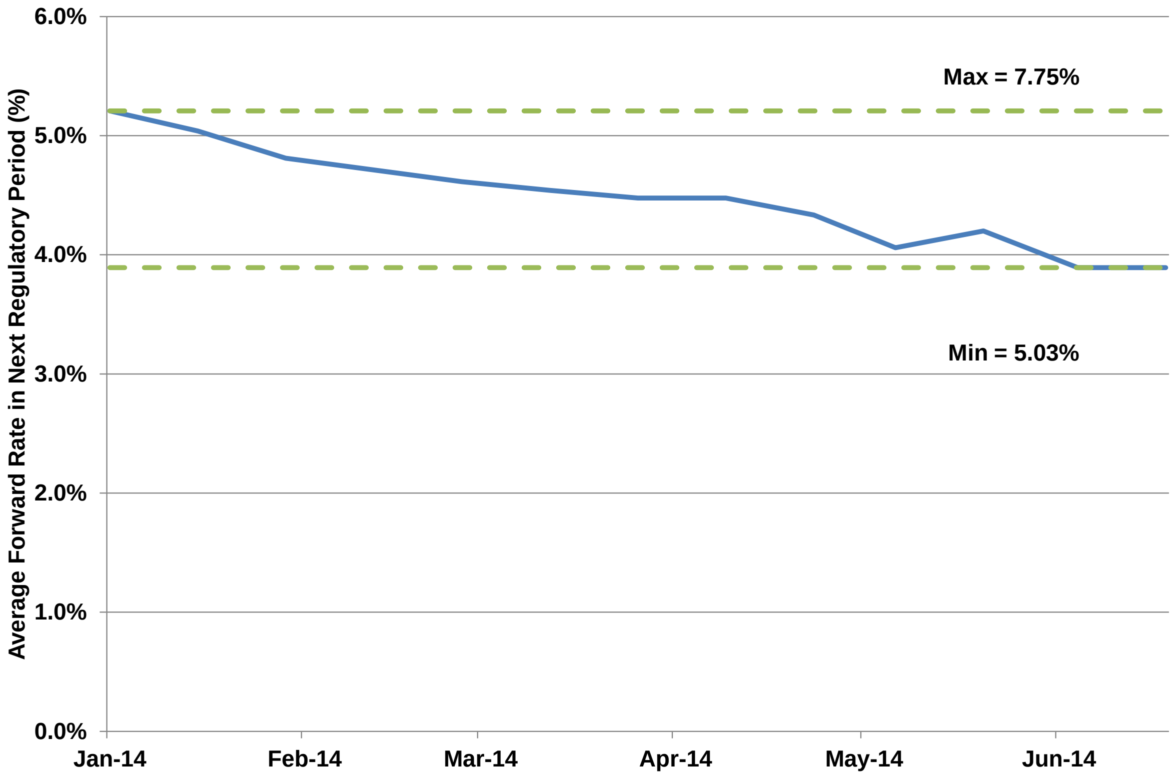
Source: Bloomberg data up to 20 June 2014. Note: (1) The forward curve is calculated by Bloomberg. (2) Bloomberg does not report government bond index data for certain time periods, and this is reflected in the flat and vertical sections in the chart (3) Note: We use a long-run CPI inflation estimate of 2.0%, based on the long-run forecast by Consensus Economics, source: Consensus Forecasts Global Outlook: 2013-2023 (October 2013)

Figure 2.1 provides clear evidence that spot government bond yields are significantly below the expected level over the upcoming regulatory period. CAR incorrectly focuses on short-term yields, as they are not a suitable proxy for the risk-free rate in the next regulatory period. Instead risk-free rates are projected to increase strongly over the period returning to levels more in line with the CAR's 2009 risk-free rate determination of 2.5% and that the average expected risk-free rate for Ireland over the regulatory period is 1.9%, well in excess of even the top end of CAR's current estimate.

In light of the above CAR is incorrect in arguing that its risk-free rate estimate is above the rate implied by market evidence, since current market evidence (based on forward curves) supports a rate much higher than what CAR has estimated.

We note that forward curves can be volatile as they are derived from spot yield curves, which have been volatile over the recent past. Figure 2.2 shows the implied average 10Y Irish government bond yield over the forthcoming regulatory period for forward curves taken at bi-weekly intervals over the last six months (a period during which Ireland's credit rating was twice upgraded by rating agency Moody's).

Figure 2.2
Volatility of Irish Forward Curve



Source: Bloomberg; Note: The average forward rate in the next regulatory period is calculated at bi-weekly intervals over the past year and the results are displayed above.

We note that the observed volatility reflects significant uncertainty in the market about the future path of gilt yields and the likely schedule for unwinding ultra-loose monetary policy. It is likely that the market has priced in some expectation of i) the eventual end to current exceptional monetary policy conditions and ii) the expectation of possible upgrades to Ireland's credit rating while the decline of the Irish government bond rate now appears to have reached a plateau.

Given the significant short-run volatility in the forward curve, CAR will need to select a real risk-free rate in excess of the 1.9% based on market evidence in order to provide true "headroom" above the empirical evidence (CAR's stated aim in selecting its point estimate).[14]

We note that this risk-free rate estimate is lower than the rate implied by long-run market data, as used in our January 2014 report. This reflects the significant increase in Ireland's credit rating that has reduced expected interest rates (as implied by forward curves) by more than 200bps over the last six months.

---

14 CAR states that „ *Having identified a suitable range, we have generally opted to choose a point estimate at the top of each range. We see merit in regulatory predictability, particularly for aspects such as the cost of capital where a gradual approach to changes in the value may better enable DAA to operate in a sustainable and financially viable manner."*

2.3. Incomplete and misleading interpretation of recent regulatory precedent

2.3.1. Failure to recognise the implicit CRP in recent Irish regulatory decisions

CAR estimates an upper bound for the risk-free rate of 1.5% based on its own review of recent regulatory precedent where 1.5% reflects the recent determination by the UK Competition Commission for Northern Ireland. CAR also selects this upper bound as its final point estimate. CAR quotes recent decisions by the CER (Jan 14) and ComReg (Apr 14) as evidence in support of not including a country risk premium over and above the risk-free rate estimates taken by UK regulators.

CAR's interpretation of recent Irish regulatory precedent (including CER, ComReg and IAA) is highly selective and fails to account for the fact that risk-free rates used in other regulated decisions in 2014 have been in the range of 2.0%-2.6%, a full 50-110bps above CAR's point estimate of 1.5%. Table 2.2 shows the actual values chosen for various regulated activities in Ireland including three decisions from the last six months.

Table 2.2
Irish Regulators' Risk-free Rates Since 2011

Regulator	Date	Regulated Entity	Real Risk-free Rate
Comreg	Apr 2014	Broadcasting, mobile and fixed-line telephony	2.3%
IAA	Mar 2014	IAA	2.6%
CER	Jan 2014	ESB Networks	2.0%
CER	Nov 2012	Bord Gáis Networks	3.5%-5.5%
CAR	Oct 2011	IAA	1.5%
		Average	**2.6%**

Source: CAR (29 May 2014): "Maximum Level of Airport Charges at Dublin Airport 2014 Draft Determination – Commission Paper 1/2014", Table 6.19.

CAR does not explicitly discuss why it concludes on a point estimate for a general parameter that is substantially below the values very recently set by other Irish regulators. In addition CAR's interpretation that these regulators have not included a CRP is not correct: All these regulators have taken account of the expected "normalisation" of risk-free rates from their current low levels and the history of Irish yields being higher than the true risk-free rate, e.g.

- the CER estimates a risk-free rate of 2.0% for its recent determination on the cost of capital for electricity transmission and distribution.[15] The CER notes the CC's provisional determination on the risk-free rate range for NIE (1.0%-1.5%) and considers

[15] CER (31 January 2014): "Mid-term Review of WACC applying ti the Electricity TSO and TAO and ESB Networks Ltd for 2014 to 2015", p23.

the Irish risk-free rate is likely to return to more 'normal' levels. On this basis, it sets a risk-free rate higher than the level set by the CC.

- ComReg argues that *"given expected normalisation in the Irish economy, though not to as strong a position as before the financial crisis, these higher figures [based on **Irish** precedent] are more likely to be appropriate than the low yields currently observed."*[16]
- the IAA estimated a risk-free rate of 2.6% with reference to yields on **Irish** government bonds prior to 2008. This implies that the IAA believes current market yields are distorted and are not appropriate for setting a forward-looking risk-free rate while it also believes local government bonds should be used.

In light of the above precedent, CAR's view that other Irish regulators (especially the CER and ComReg) have not included a CRP is incorrect and leads to an underestimate of the Irish "risk-free rate" of 50-110bps.

2.3.2. Erroneous use of the CC's estimate for NIE

CAR selects an upper bound of 1.5%, which it notes is the same as the CC's point estimate in its final determination for NIE's price control period. In light of the above points on the use of a CRP for Ireland the CC's decision for a UK-based company has limited read across in any case.

In addition we note that CAR has implicitly assumed that NIE's price control period is the same as daa's upcoming regulatory period, which is not the case. The NIE price control period runs from January 2013 to September 2017, whereas the price control period for daa runs from January 2015 to December 2019, finishing more than two years after the end of the NIE price control period.

Given the difference in regulatory period, the CC's estimate for NIE is not appropriate for setting the risk-free rate for daa's upcoming price control period even after accounting for differences in country risk. More specifically, forward curve evidence shows that Irish government bond yields are expected to increase by approximately 90 bps between the mid-point of the NIE price control period and the mid-point of daa's price control period (cf. Figure 2.1 above).

Based on the evidence from forward curves, we do not believe that the risk-free rate for the NIE decision is a suitable precedent for CAR to follow. Market evidence does not support the argument that the risk-free rate will remain constant between NIE's and daa's regulatory periods, and therefore CAR has incorrectly used the CC's point estimate of 1.5% for its upper bound.

2.4. CAR's Rejection of the CRP concept for equity is unfounded

CAR further argues that there is limited theoretical support for a country risk premium for equity and that the CC has just rejected such a concept for NIE, which CAR takes as evidence that no CRP should be included in any case. Below we show that:

---

[16] ComReg (Apr 2014): ComReg 14/28, Costs of Capital (Mobile, Fixed Line, Broadcasting), para 4.10.

- CAR fails to consider a significant body of the academic literature that argues for the inclusion of a CRP;
- CAR picks one unrepresentative regulatory decision that rejects the CRP under very different circumstances while ignoring broader evidence on the use of a CRP adjustment in the regulatory context in countries affected by the sovereign debt crisis; and
- CAR fails to consider forward-looking evidence on the continued existence of the empirical CRP for Ireland.

2.4.1. CAR fails to consider a significant body of the academic literature

CAR argues that there is little theoretical support for including a CRP in the cost of equity despite the fact that the importance of reflecting the impact of sovereign debt risk on the cost of capital has been widely recognised in finance literature[17], which shows that there are non-diversifiable downside risks associated with investing in a country with increased sovereign debt risks dating back to French & Poterba (1991).[18] Specifically, there are perceived to be increased risks of the government imposing adverse changes to an investor's prospect of cost recovery in order to raise finance for paying for government debt such as tax increases, alterations to the rate of return formula or cost disallowances.

The academic literature supports the inclusion of a CRP for riskier countries. Although there is no established methodology for how the risk premium should be incorporated into the cost of capital, the academic literature has offered a number of valid approaches to remunerate country-specific risk.

Damodaran (2011) discusses whether equity risk premia should vary across countries.[19] He notes that country-specific is only immaterial if it is idiosyncratic, i.e. that it will not spill over to other countries, or if all investors invest in global portfolios. However, both of these assumptions are difficult to sustain in reality. The first is unlikely to hold since correlation between countries is high with possibility of contagion. Moreover, the second is also refuted by evidence that investors tend to have a home bias in portfolios. Thus, Damodaran (2011) concludes *"equity risk premiums do vary across countries, with higher equity risk premiums applying to riskier countries"*.

Damodaran (2011) provides three alternatives methods by which the equity risk premium may be estimated:

---

17 See e.g. Damodaran (2003): Measuring Company Exposure to Country Risk: Theory and Practice, pp. 17-19 who discusses different ways of including a CRP in the WACC estimate including an adjustment of the ERP, risk-free rate and different ways of dealing with the "beta" of country risk.
See also Bali and Cakici (2006): "World Market Risk, Country-Specific Risk and Expected Returns in International Stock Markets", Working Paper who find that *"country-specific total and idiosyncratic risks are significantly priced in an ICAPM framework with partial integration."*

18 See e.g. French & Poterba (1991): "Investor diversification and international equity markets", American Economic Review.
Also see a report prepared by the CER's advisers Oxera (2012): What is the cost of capital of Bord Gais Networks on the different ways the sovereign debt crisis affects the cost of debt and equity.

19 Damodaran, A. (2011): "Equity Risk Premiums (ERP): Determination, Estimation and Implications", Stern School of Business.

- Country default spreads: These may be calculated as the difference between government bond yields across countries, default spreads based on credit ratings or credit-default swap spreads;
- Relative equity market volatility: The equity risk premium for a benchmark country, for example Germany, may be increased by the relative volatility of the country in question. This approach may be of less merit because equity market volatility are also affected by market illiquidity; and
- Scaled default spread: Under this approach, the above two methods are combined. The country default spread is scaled by the relative volatility of the equity index of the country in question to the volatility of the government bond. Again, this approach may be weakened by market illiquidity.

Bali and Cakici (2006) also support the inclusion of a CRP in the CAPM framework:[20]

> *"we investigate the significance of a cross-sectional relation between risk and return on countries' stock market indices, and find that the world market risk is not, but country-specific total and idiosyncratic risks are significantly priced in an ICAPM framework with partial integration. The results also indicate that the prices of total and idiosyncratic risks are not the same across countries."*

Again, this supports the view that the cost of capital must make an allowance for the difference in risks faced by an investor across countries. The academic literature has also previously produced empirical estimates of the equity risk premia in different countries and therefore the CRP. Fernandez et al (2011) produced a survey of 56 countries, combining evidence from academics, analysts and companies.[21] They estimated the average market risk premium as 6.0% in Ireland in 2011 and 5.4% in Germany, implying a CRP of 60bps.

The academic evidence shows that the CRP must be included in the CAPM framework. Although there is no established methodology for incorporating the risk premium, there is a firm consensus that the cost of equity must include this factor.

Therefore, CAR's view that there is no theoretical evidence to support the inclusion of a CRP in the cost of equity is simply untrue. There is a substantial literature on the importance of remunerating country-specific risk in the cost of equity, and therefore CAR has drawn an incorrect conclusion from its (seemingly incomplete) review of the theoretical literature.

2.4.2. CAR's Review of the regulatory literature on the CRP is incomplete and misleading

In addition to rejecting the theoretical notion of a CRP CAR also appears to be of the view that regulatory precedent for the inclusion of a CRP is limited.

[20] Bali, T ,Cakici, N, (2010): "World market risk, country-specific risk and expected returns in international stock markets", Journal of banking & finance, Vol 34 (6), p1152-1165.

[21] Fernandez, P, Aguirreamalloa, J, Corres, L (May 2011): "Market risk premium used in 56 countries in 2011: A survey with 6,014 answers", Working Paper WP-920, p3.

We have discussed in section 2.3.1 that CAR appears to overlook the implied CRP included in all recent Irish decisions (IAA, CER, ComReg) that reference either Irish bond yields and / or Irish regulatory precedent in concluding on risk-free rates significantly above UK benchmarks.

In addition, CAR appears to overlook that the use of a CRP is standard practice in all other EU countries that have been significantly affected by the sovereign debt crisis. We refer to the discussion in our Jan-14 report that sets out in more detail how regulators in Portugal, Italy and Spain all estimate the "risk-free rate" with reference to the local government bond rate.[22]

CAR chooses not to give any weight to this wealth of evidence for the inclusion of a CRP, instead signposting the CC's recent rejection of a CRP for NIE. However, CAR's reference to the CC's rejection of a Northern Ireland premium in the NIE case misses two important distinctions between the two cases.

- Driver of the premium: NIE is located Northern Ireland (part of the UK, which is rated significantly higher than Ireland) and the argument about the risk premium is based on higher observed corporate debt yields as opposed to sovereign debt yields. The CC's rejection of the NI premium is based on the argument that it is possible that NIE's higher corporate debt yields are based on a different allocation of risk between NIE's debt and equity holders.[23] The same argument cannot plausibly be made for daa where the debt premium is driven by the sovereign debt, which cannot plausibly be argued to be driven by a difference in risk allocation between daa and the Irish government bond holders.
- Continued existence of the premium: Moreover, the CC argues that the NIE corporate debt premium has recently fallen away and thus does not provide any reason to assume the continued existence of the premium.[24] The same is not true in the case of daa as we show in the next section.

Moreover, CAR appears to overlook that the CC did include a CRP on the beta rather than the risk-free rate. The CC argues that the Northern Irish regulatory regime is less well understood by investors than the GB regime, and therefore a CRP must be included to remunerate this risk.

2.4.3. Market Information shows that CRP is likely to remain in place going forward

One of the CC's main arguments for rejecting a CRP for Northern Ireland in the NIE case was the CC's finding that at current levels there was no longer any evidence of a yield differential between NIE's bonds and comparable bonds suggesting that any risk premium had fallen away. Below we show the same cannot be concluded for Ireland relative to AAA rated countries.

---

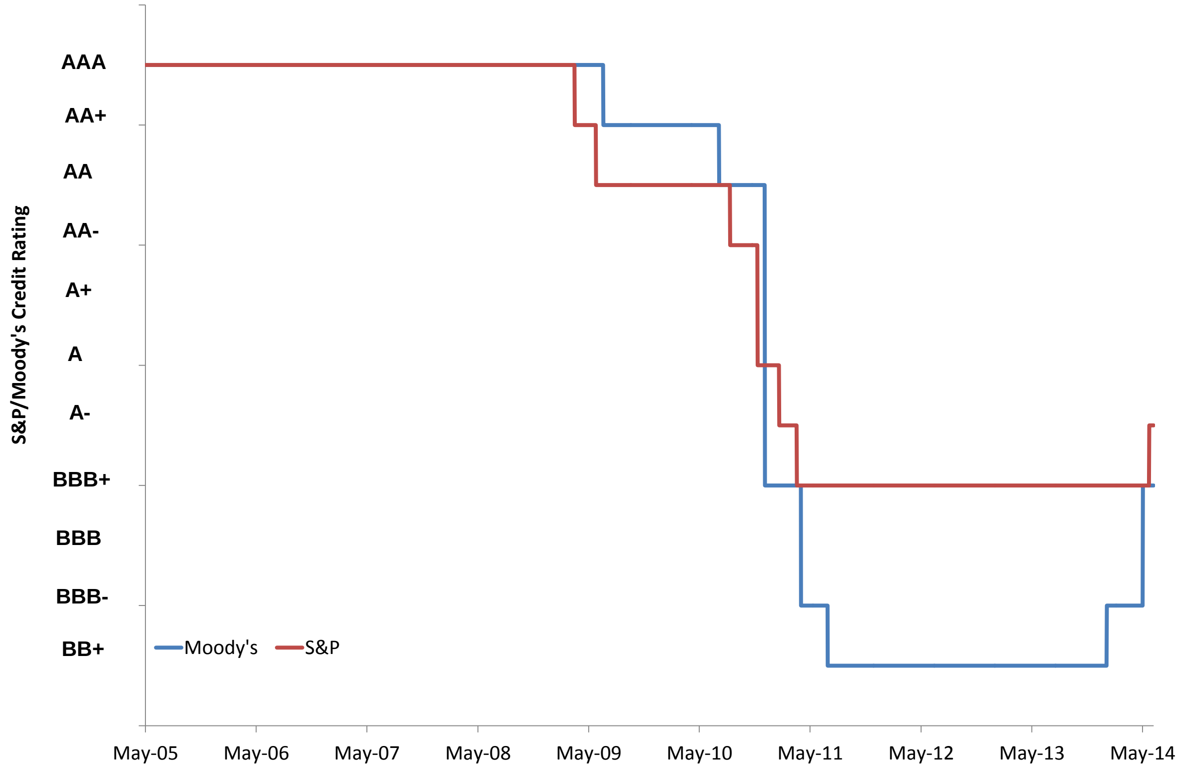
22 NERA (Jan 2014): A Study into the Cost of Capital for daa, pp.30-31.

23 CC (2014): Northern Ireland Electricity Limited price determination; A reference under Article 15 of the Electricity (Northern Ireland) Order 1992 - Final determination, pp.13-17 to 13-20.

24 CC (2014): ibid, p.13-20.

As shown in Figure 2.3 the Irish credit rating has improved significantly over the last six months but remains significantly below the credit rating of the countries CAR uses for estimating the risk-free rate.

Figure 2.3
Ireland Government Credit Rating



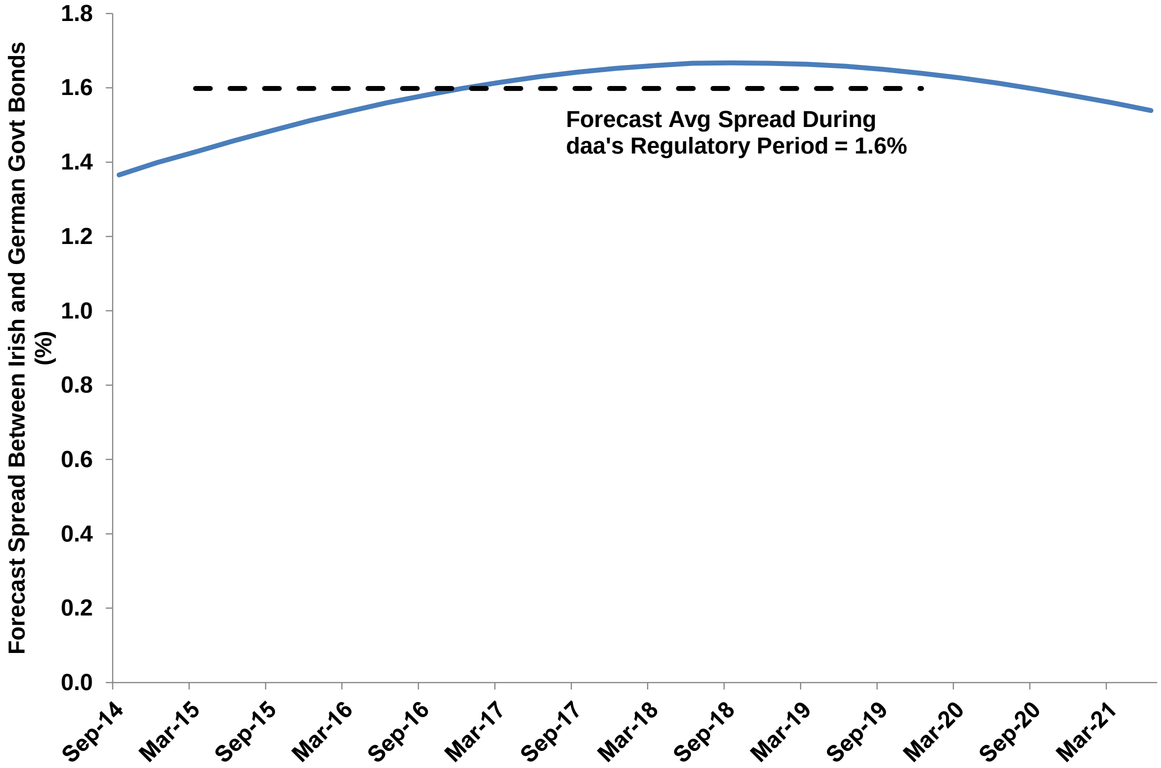
Source: Bloomberg sovereign credit ratings

Following the most recent upgrade to the credit rating in May 2014 Moody's changed the outlook from positive to stable suggesting further uplifts were unlikely in the short term.[25] This expectation of a continued differential is also reflected in forward-looking evidence derived from forward curves for German and Irish government bond yields.

Figure 2.4 shows that the spread between German and Irish government bond yields is expected to remain positive and significant (even increase on average) over the next regulatory period, at an average of 1.6%.

25 Moody's (16 May 2014): Rating Action: Moody's upgrades Ireland to Baa1 from Baa3; outlook stable

Figure 2.4
Forecast Spread During Upcoming Regulatory Period



Source: Bloomberg data as of 20 June 2014

This forecast difference is broadly in line with the 1Y and 10Y averages for the difference between German and Irish government bond yields shown in Table 2.3.

Table 2.3
Ireland CRP Derived From 10Y Govt Bonds

	Ireland (%)	Germany (%)	Ireland Spread over Germany (%)
6M	3.0	1.6	**1.4**
1Y	3.4	1.7	**1.7**
2Y	3.5	1.6	**1.9**
5Y	5.7	2.2	**3.5**
10Y	4.8	3.0	**1.8**

Source: Bloomberg data up to 20 June 2014

In light of the above there does not appear to be any reason for concluding that the case for the inclusion of a CRP is no longer valid. Instead combining the forecast spread of 160bps with a forecast of German government bond yields, which are expected to increase from their current near-zero levels further supports the notion that CAR has significantly underestimated the Irish risk-free rate going forward.

2.5. Conclusion on CAR's Estimate of the Risk-free Rate and Country Risk Premium

CAR's determination of the risk-free rate range from 0 to 1.5% contains three substantial errors and inconsistencies:

- In concluding that there is no empirical evidence to support a number in excess of 1.5% CAR fails to account for projections of the risk-free as implied by forward curves for Irish government bond debt that show a central estimate for the risk-free rate over the relevant regulatory period of 1.9%;
- In concluding that other Irish regulators have not included a country risk premium CAR fails to account for the fact that i) all three decisions for regulated companies in Ireland that were taken in the last six months have made reference to Irish government bond yields or precedent (i.e. included an implicit country risk premium) and ii) the range for the risk-free rate included in these decisions is between 2.0% and 2.6%, a full 50-110bps higher than CAR's decision.
- In concluding that there is no theoretical case for the country risk premium, CAR fails to acknowledge the significant body of academic literature in favour of a country risk premium, the fact that a country risk premium is also applied in all other countries affected by the sovereign debt crisis. Finally, we note that there were two important differences (source of premium and outlook for premium) between the NIE case (quoted by CAR), where the CC rejected the case for a premium, and the situation of daa that render the CC decision irrelevant for the current case. Instead empirical evidence on the forward-looking CRP confirms that there is no reason to believe that the rationale for a CRP is going to drop away over the next regulatory period.

In light of the above errors, the minimum plausible estimate for the risk-free rate (including a country risk premium) is 2.0% while a more plausible central estimate would be more in line with other regulatory precedent for Ireland.

We note that this number remains well below the estimate in our January 2014 report (4.7%). This reflects the significant improvement in Ireland's credit rating since January (Moody's has upgraded Ireland's rating from Ba1 to Baa1 in two steps), which has been reflected in a drop of the forward risk-free rate by c. 270bps.

3. Cost of Debt

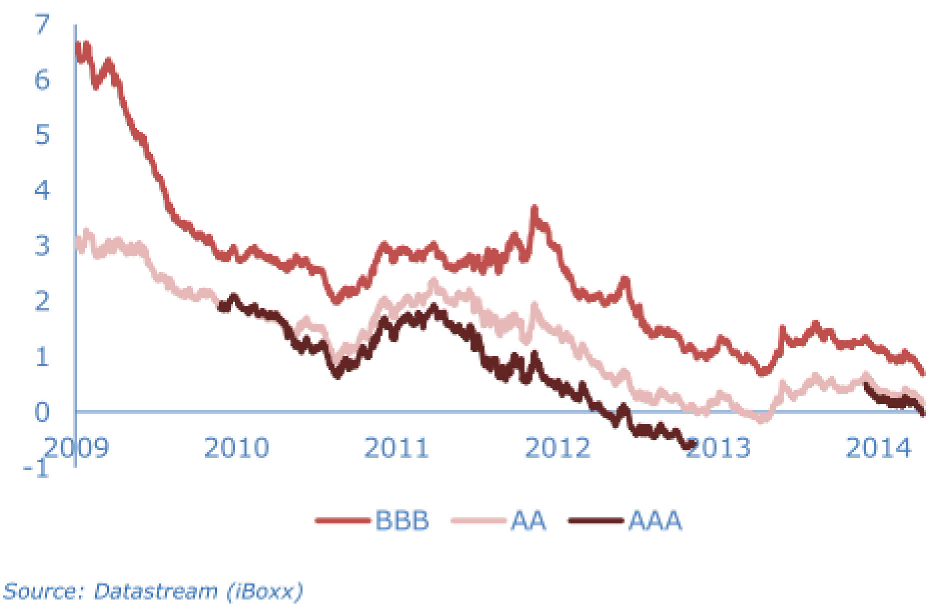
CAR estimates a range of 2.5%-3.0%, and selects the top end of its range as its point estimate.

3.1. CAR's Determination on the Cost of Debt

CAR sets the cost of debt with reference to new debt only, and does not consider embedded debt. For the cost of new debt, CAR considers evidence from an ESB bond and a benchmark index:

- ESB Bond: CAR finds that the nominal yield on one ESB bond are in line with benchmark corporate indices for the same credit rating, and concludes that no Irish debt premium is required on the cost of debt;
- Benchmark Index: CAR estimates the average yield since 2009 on the iBoxx Corporate Non-financials Index (7-10Y maturity) with BBB rating as 2.78%. CAR concludes on a range of 2.5%-3.0% assuming a BBB target rating for Dublin Airport.

Figure 3.1
CAR Evidence on Cost of Debt



Source: CAR (29 May 2014): "Maximum Level of Airport Charges at Dublin Airport 2014 Draft Determination – Commission Paper 1/2014", p59

3.2. NERA Assessment of CAR's Methodology

CAR does not consider the cost of embedded debt, and only sets the cost of debt with reference to new debt.

A superior method would be to use the weighted average of historic and future debt, in line with regulatory precedent by the majority of UK regulators (including Ofwat, CAA and the

CC) and our recommendations at the 2009 review.[26] In concluding on the cost of debt we propose that Dublin Airport should be allowed a cost of debt which is the weighted average of the following two components:

- The embedded cost of debt applied to that proportion of debt which will not be re-financed over the next review period; and
- The cost of new debt for the proportion of debt that will be new or re-financed over the upcoming control period.

We believe this methodology has the following advantages:

- Our approach recognises that daa has raised finance efficiently at different points in the interest rate cycle and that it raises finance over periods longer than the price control period. We note that this approach relies on actual embedded debt costs, which allows daa to recover its efficiently incurred financing costs.
- This approach also takes into account daa's expected debt issuance and likely debt costs. Given benchmark indices do not allow daa to adequately recovers its debt costs, using forward curves is an improved methodology for setting the cost of new debt (because it represents the market's best expectation of the interest cost in future).

Our approach is widely used by UK regulators, including Ofwat, the CAA and the CC in its recent determination for NIE. CAR notes that it is willing to consider an embedded debt approach for future determinations, but would like to consult further before adopting such a methodology.

We estimate a weighted average cost of debt of 3.09%, based on daa's embedded debt and a forecast of cost of new debt (see Appendix A). This estimate is based on our January 2014 report, and the latest data may support a different estimate.

Overall, we see significant benefits to a change in CAR's approach. However, we note that CAR's final estimate of 3.0% is only slightly below our view on the cost of debt. This is because the current cost of new debt is very similar to daa's cost of embedded debt, implying that adding embedded debt to the overall cost of debt does not change the estimate.

In light of the limited empirical impact at the current review, now may be a good time to change to the more robust approach in order to de-risk daa's debt profile.

[26] NERA (March 2009): "The Cost of Capital for Dublin Airport – A Report for Dublin Airport Authority", p43.

4. CAR's Draft Determination on Other CAPM Parameters

We also consider CAR's determination on estimates of the other CAPM parameters and the cost of debt. In particular, we consider CAR's estimate of the equity risk premium, asset beta and gearing.

4.1. Equity Risk Premium

CAR estimates an equity risk premium (ERP) in the range 4.5%-5.0%, and selected the top end of its range as the point estimate.

CAR prefers to use long-run evidence for estimating the ERP and also ensures consistency of its estimate with recent regulatory precedent. CAR selects a point estimate of 5.0%, in line with recent decisions by the CC, Comreg and the CER. On a stand-alone basis we consider CAR's ERP point estimate of 5% to be appropriate for the forthcoming regulatory period. However, we note that the use of a long-run ERP needs to be combined with a consistent estimate of the risk-free rate rather than CAR's short-run focussed estimate of the risk-free rate.

In section 2 we have discussed at length the problems associated with CAR's approach to estimating the risk-free rate.

4.2. Beta

CAR estimates a range of 0.5-0.6 for Dublin Airport's asset beta, and selects the top end of its range.

Table 4.1
Asset Beta: CAR 2009 Determination vs 2014 Draft Determination

2009 Final Determination	2014 Draft Determination Range	2014 Draft Determination Point Estimate
0.61	0.5-0.6	0.6

Source: CAR (31 July 2013) "Maximum Level of Airport Charges at Dublin Airport – Issues Paper", p56; CAR (29 May 2014): "Maximum Level of Airport Charges at Dublin Airport 2014 Draft Determination – Commission Paper 1/2014", p63.

CAR combines two pieces of evidence for estimating the beta: (1) change in systematic risk since the last review in 2009; (2) systematic risk relative to comparator airports.

On the first approach, CAR considers the following variables in assessing whether the systematic risks faced by daa have changed substantially since the 2009 review:

- Volatility in passenger volumes: CAR finds that daa faces volume risk from volatility in passenger volumes, but that this was also true in 2009;
- Cost risk: CAR views the regulatory treatment of cost overruns has remained the same since 2009 and that the overall regulatory regime has remained the same.

Based on the above evidence, CAR concludes that there is no compelling reason to change daa's asset beta substantially from its 2009 estimate.

On the second approach to estimating the asset beta, CAR analyses empirical estimates of the beta for comparator airports and recent regulatory decisions from other countries. CAR notes that short-term empirical estimates support the lower end of its range of 0.5-0.6, but that results based on short-term estimates may be unreliable. The recent regulatory precedent by the New Zealand Commerce Commission and CAA also supports CAR's range of 0.5-0.6.

CAR settles on 0.6 as its point estimate because it considers daa faces more systematic risk than its comparators although it indicates that it is open to reviewing this assumption with a view to a potential larger reduction:

> *"There is little evidence that might be cited to support adopting a higher value. We think there is an arguable case that for a lower beta, perhaps as low as 0.5. To go lower than this would require arguing that Dublin airport is less exposed to market risk than some utilities.*[27]

We note that any reduction in asset beta relative to the previous estimate of 0.61 is out of line with the CAA, which has increased rather than decreased its estimates of the beta for Heathrow (0.47 to 0.50) and Gatwick (0.52 to 0.56).

We further note that there are strong reasons to believe that there is a substantial risk differential between Dublin Airport and other regulated utilities that will need to be borne in mind when assessing the plausibility of potentially reducing daa's asset beta allowance. Key areas where daa is exposed to higher market risk than other utilities are:

- Volume risk, which is substantially higher in the aviation sector compared to other regulated sectors and not mitigated by a revenue cap;
- Risks associated with the pension deficit, which is highly correlated with the stock market and which – unlike other utilities - daa has to bear in full; and
- Risks around the cost of debt where daa – unlike other utilities – is not guaranteed to recover its cost of embedded debt.

All of the above suggest that there should be a significant difference in risk between daa and regulated utilities. In placing the asset beta of daa into context it appears more sensible to consider regulatory precedent for regulated telecommunications activities rather than traditional revenue cap regulated utilities supplying essential goods such as water and energy.

Beta estimates for mobile operators are more likely to represent a plausible minimum lower bound as they also face risk around the cost of debt as well as volume risk; albeit at a lower level given the lower income elasticity of demand for telephony services relative to air travel.[28]

---

27 CAR: Draft Determination, p. 63.

28 In the UK BT also faces pension deficit risk suggesting that but for the lower volume risk, it represents a relatively close comparator for daa's risk exposure.

Ofcom has recently (Jun-14) proposed an asset beta estimate of 0.54[29] while ComReg used a point estimate of 0.6 in its Apr-14 paper.[30]

In light of the above and the significantly lower risk borne by mobile operators relative to daa there does not appear to be any scope for reducing the asset beta below the previous estimate of 0.61, let alone down to 0.5. In fact in comparison to other regulatory precedent a more appropriate direction of change for daa’s would appear to be an increase rather than a decrease.

4.3. Gearing

CAR estimates a notional gearing range of 50%-60% and selects 50% as its point estimate. The only supporting evidence that CAR provides is that its final estimate is similar to the CAA’s final estimates for Heathrow and Gatwick.

CAR performs its own financeability assessment to determine whether daa is still able to finance its activities at reasonable terms. CAR finds that the associated FFO:debt ratios do not risk a downgrade.

A more robust way of estimating daa’s notional gearing would be to use its actual gearing based on its Annual Accounts. We display the actual gearing for 2010-13 in Table 4.2.

Table 4.2
daa Actual Gearing

	Gearing (%)
2010	43.1
2011	41.3
2012	41.5

Source: daa Annual Report 2012, p45.

daa’s actual gearing was 41.5% in 2012, and this corresponded to a credit rating of BBB. However, targeting a BBB credit rating may risk daa’s ability to remain financeable. Accordingly, we consider a gearing assumption lower than daa’s actual gearing would be appropriate to ensure financeability. daa has uncertain capex needs, and is also due to refinance around 50% of its existing debt facilities during the upcoming regulatory period, and therefore, it is critical that the gearing assumption enables daa to raise debt on fair and reasonable terms. In order to achieve this, we consider a gearing of 40% would be a more appropriate estimate.

29 Ofcom (Jun-14): Mobile call termination market review 2015-18, Annexes 11 - 17

30 ComReg (Apr-14): Review of Cost of Capital, p. 47.

We note that the choice of gearing does not have a significant impact on the overall cost of capital, because a lower gearing assumption decreases the equity beta, but this effect is offset by giving less weight to the lower cost of debt.

5. Conclusion on CAR Draft Determination on Cost of Capital

Our review of CAR’s methodology for estimating the risk-free rate (including country-specific effects) shows that CAR has made three substantial errors and inconsistencies:

- Failure to take account of projected increases in government bond yields to c.2.5% real by the end of the period (1.9% on average);
- Incomplete and misleading interpretation of recent Irish regulatory precedent, where all regulators include at least an implicit country risk premium by way of reference to either Irish government bond yields and / or precedent; and
- Incomplete and erratic review of the theoretical literature and regulatory precedent on the country risk premium for the cost of equity that is not borne out by the empirical evidence on the forward spread between German and Irish government bond yields.

Our own analysis of forward curve evidence and a comprehensive review of Irish and international regulatory precedent as well as the theoretical literature support a risk-free rate estimate of at least 2.0%, significantly above CAR’s estimate of 1.5% suggesting CAR has underestimated the pre-tax cost of equity by more than 50bps.

Further we note that daa bears significant additional risk compared to traditional utilities, e.g. with respect to changes in demand, deficits on its pension scheme and differences between the cost of new and embedded debt. CAR has not presented any evidence that any of these risks have reduced since 2009. In light of this and the fact that the CAA has increased rather than decreased its estimates of the beta for Heathrow (0.47 to 0.50) and Gatwick (0.52 to 0.56) while other regulators have allowed asset betas for mobile telephony (a lower risk activity than air travel) towards the upper end of CAR’s range, there is no reason for CAR to use a lower beta than previously.

We also note that CAR has adopted an inferior methodology on the cost of debt compared to the standard UK approach. By only considering the cost of new debt, CAR exposes daa to significant risk around costs daa can no longer influence. The embedded debt costs represent the efficient debt costs that daa incurs on its current debt, and which the allowed rate of return must remunerate. At the current time there is limited difference between the two cost categories, which suggests now may be a good time to introduce such a change without significantly affecting the cost allowance.

Based on the above errors and inconsistencies, CAR has underestimated the cost of capital. If CAR sets a robust risk-free rate estimate above 2.0% and adopts a weighted average cost of debt of 3.1%, its cost of capital estimate increases significantly above its current point estimate of 5.8%.

Appendix A. NERA Estimate of Weighted Average Cost of Debt

In this appendix, we estimate a weighted average cost of embedded and new debt. This is our preferred methodology because it remunerates daa for all its current debt and expected debt costs.

A.1. The Cost of Embedded Debt

We estimate the cost of embedded debt using daa's existing debt portfolio. Our estimate of the cost of embedded debt is for daa plc only. Based on our discussions with daa's finance department, we have no reason to believe that daa's credit rating, and therefore cost of debt, would be different between daa plc and daa's regulated business. We have therefore used daa plc's embedded cost of debt as a proxy for daa's embedded cost of debt for its regulated business. daa's current debt and borrowings are described in Table A.1.

Table A.1
daa's Current Borrowings at May 2013

Instrument	Original Loan Amount €m	May 2013 Interest Rate (%)	Bank Margin (%)	Total Current Cost of Funds (%)	Fixed /Floating	Loan Maturity
EIB	30	3.556	0.05	3.606	Fixed	2022
EIB	20	3.651	0.05	3.701	Fixed	2023
EIB	65	4.114	0.05	4.164	Fixed	2024
EIB	200	4.270	0.35	4.620	Fixed	2029
Bond	550*	5.0872	1.50	6.5872	Fixed	2018
EIB	125	5.070	0.05	5.120	Fixed	2020
EIB	260	0.353	0.351	0.7040	Floating	2031
Revolving Credit Facility	150	N/A	1.75	N/A	Fixed	2016
Overdraft	15	N/A	Prime + 0.5	N/A	Floating	Annual Review

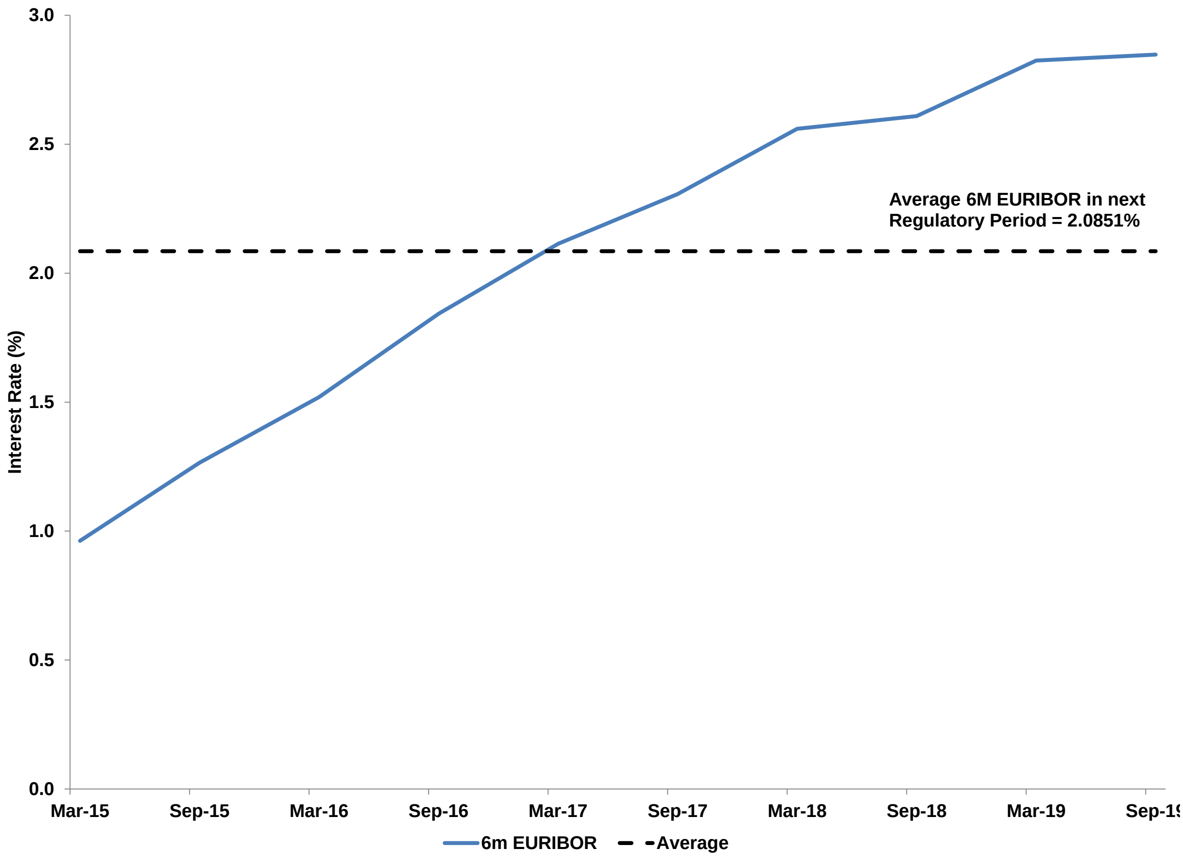
Source: *Provided by daa May 2013; Note: The original bond amount was €600m, but daa engaged in a buyback in 2011, and thus the revised bond amount is €550m.*

We estimate the cost of embedded debt as the total expected interest paid in the forthcoming regulatory period on existing debt divided by the total current borrowings. The total expected interest paid for fixed debt instruments can be easily derived from the May 2013 Treasury

Report, because the interest paid would not change between May 2013 and the next regulatory period.

However, the expected interest paid on daa's floating EIB loan must be estimated into the next regulatory period. We use 6m EURIBOR forward curves to derive the average interest rate paid between January 2015 and December 2019, and estimate the interest rate to be 2.44% (including the 0.351% bank margin). The 6m EURIBOR forward curve is shown in Figure A.1 and we note that estimates of this forward curve may change leading up to the beginning of the next regulatory period. CAR must use the most recent available information whilst setting the cost of debt allowance and this may differ from our estimate as new market information is reflect in the forward curve.

Figure A.1
6M EURIBOR Forward Curve



Source: Provided by daa September 2013

We exclude the revolving credit facility and bank overdraft from the cost of embedded debt since daa has not drawn on these facilities previously. These existing undrawn committed facilities exist to provide liquidity and provide financial flexibility, both of which are especially important during the on-going period of market turbulence. For these reasons we exclude the cost of these facilities (outside of transaction costs) from our estimate of daa's cost of embedded debt.

We combine the interest paid on floating and fixed debt instruments to estimate the cost of embedded debt as 5.04% in nominal terms.

A.2. The Cost of New Debt

The overall cost of debt allowance should also reflect the cost of new debt faced by daa on new issuances in the next regulatory period. In this sub-section, we therefore consider the likely coupon that daa would have to pay in order to issue a new bond in today's market.

We note that of daa's current borrowings, only its fixed rate bond and revolving credit facility are due to mature in the next regulatory period. We exclude the revolving credit facility from the cost of new debt since daa has not drawn on these facilities previously. These committed facilities exist to provide liquidity and provide financial flexibility, both of and therefore are not part of daa's ordinary financing activities. Therefore, we exclude these facilities (outside of transaction costs) from our estimate of daa's cost of new debt.

daa's existing bond is due to mature in July 2018. We assume that daa will issue a new bond one year prior to its existing bond maturing, which would be a prudent approach to ensure daa is in best position to take advantage of low rates in the period up to its bond maturing. Moreover, daa indicate the new bond issuance is likely to be of size €500m and will have a maturity of 10 years or more.

We note that it is important for daa to issue long-term debt to match its assets and liabilities, and to mitigate refinancing risk by spreading its debt maturities. This would enable daa to achieve a credit rating that ensures financeability over the entire regulatory period. Therefore, we would not recommend assuming a tenor lower than 10 years on the new issuances. Accordingly, we believe that the cost of a new 10 year bond is the most appropriate estimate for the new cost of debt. Using this information and Rothschild's indicative € pricing for daa, we derive the cost of new debt in Table A.2.

Table A.2
daa Cost of New Debt

Item	Issue Date	Maturity	Amount (€m)	Interest Rate (%)
Euroswaps forward rate	-	-	-	2.99
Spread to mid-swaps	-	-	-	2.14
Cost of new bond issuance	**09/07/2013**	**10 years**	**500**	**5.13**

Source: Data provided by daa September 2013;

Our estimate of the spread to mid-swaps is based on the spread identified by Rothschild in its indicative € pricing for daa Finance's new issuances. The current 2018 5-year maturity benchmark is trading at 149bps to mid-swaps. We add 25bps for the new issue premium and 40bps for the extension of the tenor.[31]

We estimate the nominal cost of new debt as 5.13%.

We note that this is made entirely of the re-issuance of daa's existing bond and assumes daa does not issue any other new instruments during the next regulatory period. If daa changes its capex plans and decides to issue additional debt, this would have to be reflected in our estimate of the cost of new debt.

A.3. Transaction and Pre-funding Costs

It is important to emphasise that the costs of debt finance considered above exclude transaction costs such as bank, legal, trustee and agent fees. These constitute an inevitable part of raising finance in the debt markets and hence need to be compensated for through an additional allowance. This allowance consists of remuneration for i) transaction costs and ii) pre-funding costs.

Transaction costs

The CAA recently demonstrated why such transactions costs should be included in their initial proposals for regulating Heathrow.[32] It noted that new issue premia, bond issue book runner fees, ancillary fees and expenses have to be taken into account for the estimate of cost of debt.

We therefore make an allowance for transaction costs based on past transaction costs incurred on daa's current borrowings. These include the following upfront and on-going costs:[33]

- Bank fees;
- Financial advisory fees;
- Legal fees;
- Ratings agency fees;
- EIB arrangement fees; and
- Commitment fees.

daa provide us with the transaction costs incurred on each of their current borrowings and for all upfront fees, we amortise the amount over the lifetime of the debt instrument to estimate the yearly. We estimate the total transaction cost allowance for embedded debt to be 9bps.

We also estimate the transaction costs associated with new debt issuances. This includes the transaction costs associated with the re-issuance of daa's existing bond and revolving credit

---

[31] Data provided by daa September 2013.

[32] CAA (April 2013): "Economic regulation at Heathrow from April 2013: initial proposals", p149.

[33] Data provided by daa July 2013

facility. We assume these to be the same as those incurred for the existing instruments and index them to the appropriate nominal value to reflect the inflation up to the re-issuance date.

We estimate the transaction cost allowance for new debt to be 33bps.

Pre-funding costs

daa notes that it has a considerable cost of carry on cash holdings, but this has been generated from non-regulated businesses. Since we are estimating the cost of debt for the regulated business, we do not include any pre-funding costs in our estimate of the cost of debt.

A.4. Conclusion

Our analysis has presented evidence on the suitability of a company-specific approach to the cost of debt given benchmark indices do not sufficiently capture Irish debt costs. We have therefore estimated a company-specific cost of embedded debt and cost of new debt. We combine these estimates to estimate the overall cost of debt, including transaction costs.

We weight the cost of embedded debt and cost of new debt to derive the overall cost of debt. The embedded debt weighting is equal to the proportion of total embedded and new debt that is embedded.[34] The remaining proportion is equal to the new debt weighting.

Our final estimates of the cost of debt are presented in Table A.3.

34 daa is expecting to issue a €500m new bond approximately at the beginning of the third year of the upcoming five-year price control period. In effect, the average new debt over the next regulatory period is €300m (3/5 x €500m). Therefore, compared to daa's current debt of around €1.16bn, this would suggest daa's embedded debt is approximately 80% of the total of embedded debt and new debt. We use this as our weighting for the cost of embedded debt.

Table A.3
NERA Estimate of Cost of Debt

Item	Weighting	Cost (%)
Embedded Debt Cost		5.04
Embedded Debt Transaction Costs		0.09
Total Cost of Embedded Debt	**80%**	**5.13**
New Debt Cost		5.13
New Debt Transaction Costs		0.33
Total Cost of New Debt	**20%**	**5.46**
Nominal Cost of Debt		**5.20**
Inflation		2.00
Real Cost of Debt		**3.09**

Source: NERA Analysis, Inflation from Eurostat forecasts

We estimate a nominal cost of debt of 5.20% and apply an inflation of 2%, based on Eurostat forecasts over the next regulatory period. **Thus, we estimate a real cost of debt of 3.09% for the next regulatory period.**

Report qualifications/assumptions and limiting conditions

This report is for the exclusive use of the NERA Economic Consulting client named herein. This report is not intended for general circulation or publication, nor is it to be reproduced, quoted or distributed for any purpose without the prior written permission of NERA Economic Consulting. There are no third party beneficiaries with respect to this report, and NERA Economic Consulting does not accept any liability to any third party.

Information furnished by others, upon which all or portions of this report are based, is believed to be reliable but has not been independently verified, unless otherwise expressly indicated. Public information and industry and statistical data are from sources we deem to be reliable; however, we make no representation as to the accuracy or completeness of such information. The findings contained in this report may contain predictions based on current data and historical trends. Any such predictions are subject to inherent risks and uncertainties. NERA Economic Consulting accepts no responsibility for actual results or future events.

The opinions expressed in this report are valid only for the purpose stated herein and as of the date of this report. No obligation is assumed to revise this report to reflect changes, events or conditions, which occur subsequent to the date hereof.

All decisions in connection with the implementation or use of advice or recommendations contained in this report are the sole responsibility of the client. This report does not represent investment advice nor does it provide an opinion regarding the fairness of any transaction to any and all parties.

NERA
ECONOMIC CONSULTING

NERA Economic Consulting
15 Stratford Place
London W1C 1BE
United Kingdom
Tel: 44 20 7659 8500 Fax: 44 20 7659 8501
www.nera.com

Appendix 7 - Letter from Minister to daa RE: Dividend Requirement

Source: Department of Transport, Tourism & Sport

Oifig an Aire
44 Sráid Chill Dara, Baile Átha Cliath 2, Éire.

Office of the Minister
44 Kildare Street, Dublin 2, Ireland.

An Roinn Iompair, Turasóireachta agus Spóirt
Department of Transport, Tourism and Sport

Tel: +353 1 670 7444 **Locall:** 1890 443311 **Fax:** +353 1 604 1183 **Web:** www.dttas.ie **Email:** minister@dttas.ie

E2299

1ST October 2013

Mr Pádraig O Riordan
Chairman
DAA
Dublin Airport
Co Dublin

Dear Chairman

I refer to correspondence earlier in the year between our respective officials regarding the payment of dividends by DAA.

The last time a dividend was paid by DAA was in 2009 when a dividend of €19.4 m was paid to the Exchequer in respect of the financial year 2008. I note that the company's business plan assumes a resumption of dividend payments on a return to airport profitability, assumed to be 2014.

As part of the Standard and Poor's (S&P) review of DAA's credit rating, officials of both the Departmetn of Public Expenditure and Review (DPER) and my Department met with representatives of S&P in March last. Both Departments indicated to S&P that it was not intended that DAA would be asked to pay dividends to the shareholder in the medium term while the company is addressing its debt burden. This was an important issue for S&P, as it is for DAA, especially as a *dividend in specie* of €105.5m, representing the book value of the net assets transferred to Shannon Airport Authority, was made in 2012.

Accordingly, there is no question of seeking a dividend from DAA this year. However, in light of the continuing seriousness of the public finances, I do not consider this position to be sustainable and I am now putting the DAA on notice of my intention to seek a dividend from 2014 onwards. Officials of my Department will be in contact with your senior executives to explore how this objective is to be met.

Yours sincerely

Leo Varadkar T.D.
Minister for Transport, Tourism and Sport

Appendix 8 - Memo on CAR's Passenger and Commercial Revenue Forecasts

Source: NERA Economic Consultants

NERA
ECONOMIC CONSULTING

NERA Economic Consulting
15 Stratford Place
London W1C 1BE
United Kingdom
Tel: +44 20 7659 8500 Fax: +44 20 7659 8501
www.nera.com

MEMO

TO: daa
DATE: 30 July 2014
FROM: NERA
SUBJECT: Passenger and Commercial Revenue Forecasts

This memo considers several aspects of the methodology that CAR has used to forecast passenger traffic and commercial revenues for its Draft Determination. In particular, it includes:

- a summary of the approaches used by UK aviation regulators to forecast commercial revenues;
- a review of the econometric analysis that CAR carried out to estimate elasticities for its forecasts, including whether it has calculated coefficients accurately, whether its methodology leads to reliable estimates of the underlying coefficients, and some specific comments on the estimated elasticities for individual categories of commercial revenue; and
- our assessment of whether CAR has applied its estimated elasticities correctly.

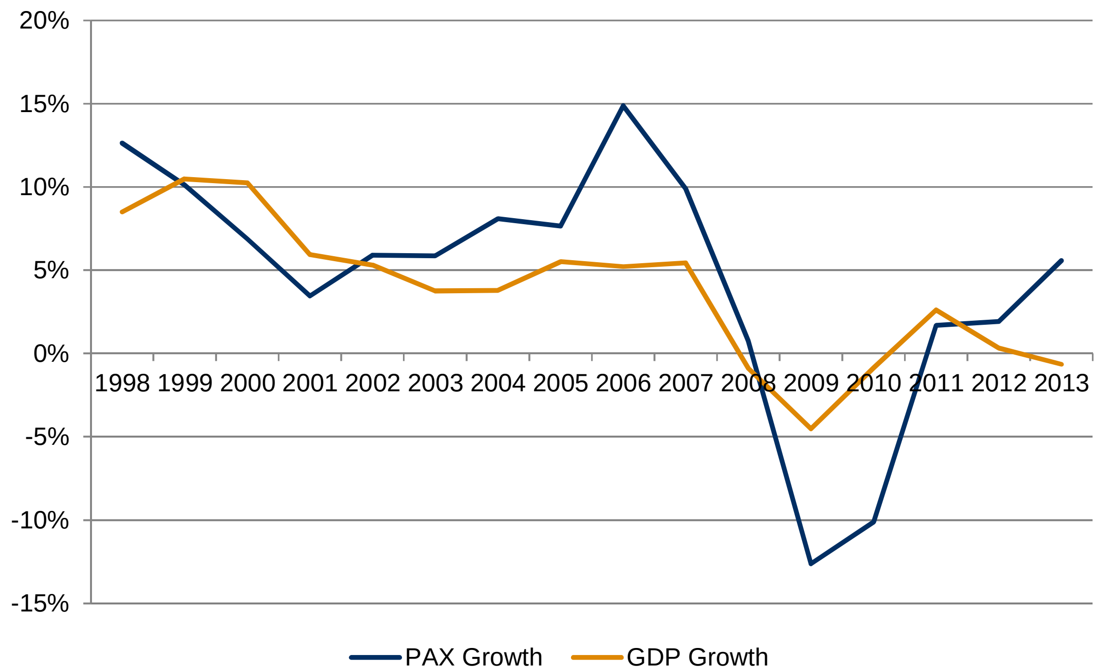
In general, CAR has adopted a very simplistic approach. Among other things:

- it has included only a very small number of explanatory variables in its analysis – only GDP, monthly dummy variables and further dummies for 2006-7 for its passenger traffic model, and only passenger numbers, monthly dummies and a time trend for its commercial revenue models;
- in addition, CAR has restricted itself to the simplest model possible, using only current levels of each variables, rather than models that include differences or lagged variables.

As a result, CAR's forecasts fail to reflect the impact of many other factors that daa has taken into account for its own forecasts, and which other regulators might normally be expected to consider as well. In the case of passenger traffic, this includes important information about airlines' planned schedules in the short to medium term, macroeconomic growth in countries other than Ireland, and other trends affecting the aviation industry. And for commercial revenues, these include a large number of specific factors that have affected particular categories of revenue in recent years, or are likely to affect future growth rates.

It is not clear, moreover, why CAR has used dummy variables for 2006-7 in its passenger model, but not for other years when there was a substantial difference between real GDP growth and passenger growth. More generally, however, the use of dummy variables may simply serve to neutralise the impact of years that do not support CAR's assumed relationship. As shown in Figure 1, over the last 10 years there has sometimes been a very substantial difference between passenger traffic growth and real GDP growth, raising serious questions about whether CAR's simplistic approach is appropriate for forecasting future growth.

Figure 1
Comparison of Real GDP and Passenger Growth



Commercial Revenues - Approach Adopted by UK Regulators

In general, the UK Civil Aviation Authority (CAA) and Competition Commission (CC) have not used elasticities similar to CAR's estimates to generate forecasts of future commercial revenues. Instead, for the last two reviews, the CAA has engaged consultants to carry out a detailed review of potential future commercial revenues:

- these reviews have considered a larger number of separate categories of revenue, rather than the very high level categories used by CAR;
- for many categories of revenue, the consultants have carried out a detailed review of recent trends in revenues per passenger, the specific factors that have affected these past trends, and considered a range of different possible reasons why revenues (per passenger) in the forthcoming control period may be higher or lower than those suggested by recent trends;
- the consultants have generally taken each airport's own forecasts as their starting point, and identified specific reasons for adopting more (or less) challenging assumptions;
- the consultants have also had detailed discussions with a range of stakeholders, including both the airport operator and those involved in commercial activities; and

- the regulators have explained the reasons for adopting particular assumptions in relation to specific revenue categories, and both airports and airlines have been able to comment on these.

As a result, the CAA and CC have been able to take full account of a wide range of different factors affecting commercial revenues, and adopt pragmatic assumptions that reflect the underlying business conditions relevant to each separate revenue stream. These reflect both demand side (e.g. macroeconomic conditions, changes in passenger mix) and supply side (e.g. redevelopment programmes, or the impact of security processing on the average time each passenger spends in retail areas) changes that may affect commercial revenues.

Other observations on the experience of recent UK reviews of airport charges are that:

- during the most recent review, the CAA's consultants (Steer Davies Gleave) reported that Heathrow has developed an econometric model that it uses to generate its own forecasts. However, unlike CAR's, this is a very detailed model which projects revenues for a large number of separate categories. Steer Davies Gleave reported that, on average, there are around 40 drivers for each category of revenue;
- under the CAA's "constructive engagement", the projections have already been subject to extensive consultation with airlines before they are reviewed by the CAA's consultants.

Review of CAR's Econometric Analysis

Using the dataset supplied by DAA and information about the specific equations estimated by CAR,[1] we have replicated the econometric results shown in Table 3.2 and Appendix 3 of the draft determination. In most cases, we found the same elasticities as reported by CAR, though with a few other discrepancies.[2] Nevertheless, as described below, we have significant reservations about both the reliability of these estimates, given the very simple econometric models estimated by CAR, and the way that CAR has used these elasticities to generate forecasts (see next section).

For retail revenues, moreover, we believe that CAR has made a serious error in its analysis. It has estimated an elasticity of 0.91 for retail revenues, which include both direct retail and concession revenues. It has defined these revenues as:

total retail sales + total concessions revenues – cost of goods sold

However, it has not taken account of the fact that the cost of goods sold already appears as a negative entry in the dataset supplied by daa. Therefore, CAR has actually *added rather than*

1 passenger_data_clean.csv, pax_regression, CR_monthly_data_cleaned.csv and CR Regressions, sent to NERA by email on 10 June 2014.

2 Specifically, in the passenger traffic model we estimated a constant of -12.78 rather than -10.12 as shown in Table 3.2. In Table A3.5 (Other Revenue), we believe the constant in model (1) should be 2.27 rather than 2.22, and the coefficient on ln(pax) in model (2) should be 2.06 rather than 2.05.

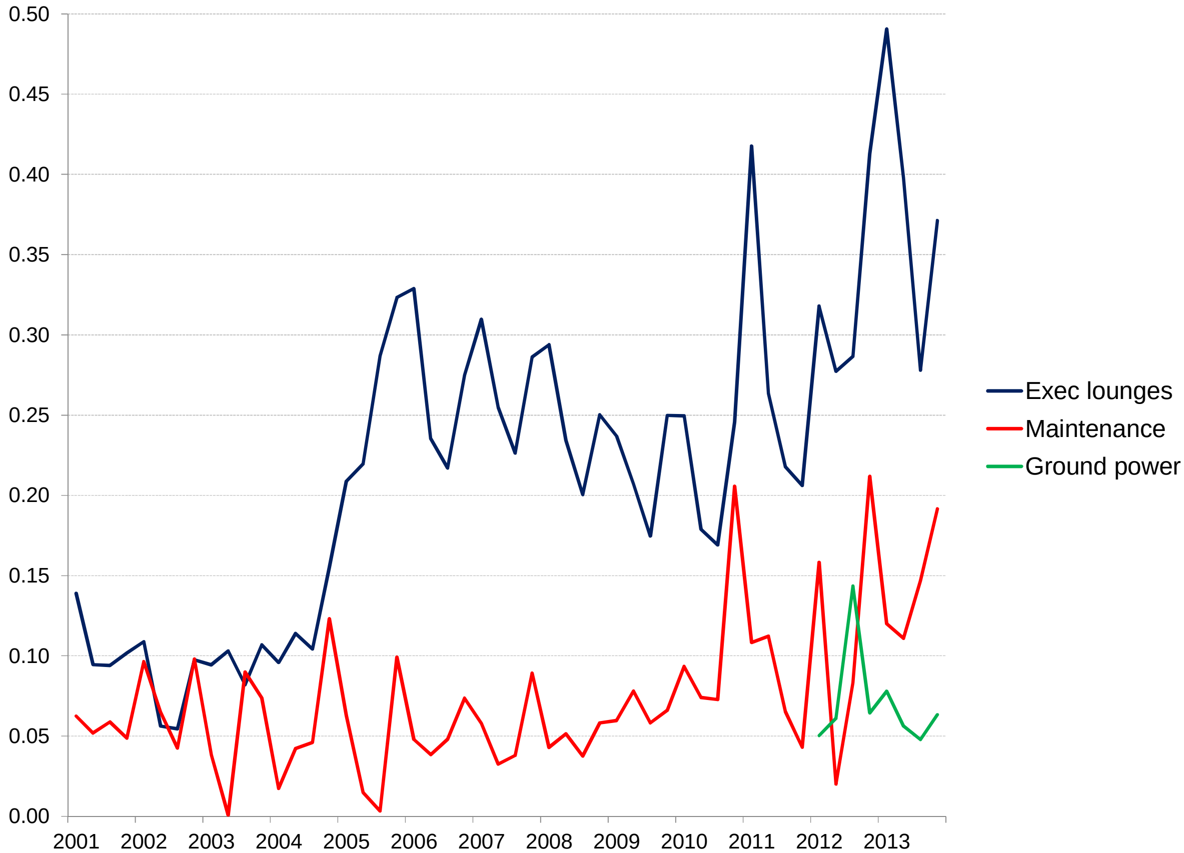
subtracted the cost of goods sold when calculating net retail revenues. If CAR had carried out this adjustment correctly, it would have estimated an elasticity for retail revenues of 0.74 rather than 0.91.[3]

Two further observations on CAR's analysis are that:

- its retail revenues elasticity is estimated over a shorter time period than the other commercial revenue elasticities (2005-13, rather than 2001-13), as the dataset does not include any cost of sales data for the period 2001-04. The estimated elasticity may therefore be less reliable than if it had been estimated from a larger dataset;
- CAR has estimated an elasticity of 1.3 for "other" activities (excluding customs and border protection). This is implausibly high. It is very unlikely indeed to reflect an underlying relationship between commercial revenues and passenger numbers. This category includes a number of different revenue streams, which exhibit quite different behaviour (and some of which are only present for part of the relevant period) – three of the categories mentioned by CAR are shown in Figure 2 below. The estimated elasticity for this unconnected group of revenues does not provide a suitable basis for forecasting future growth.

3 This is CAR's model (3). The estimated elasticity for the other two models would have been 0.84.

Figure 2
Real Revenues Per Passenger (€, quarterly, Dec 2011 prices)



Even though we have generated the same elasticities as CAR, we have strong reservations about the reliability of these estimates. CAR does not seem to have considered the potential problems associated with "non-stationary" variables in time series analysis.[4] Regression analyses including non-stationary series can lead to spurious conclusions, and may often indicate that a relationship exists between variables when it does not.

Notwithstanding the impact of the financial crisis, which might make non-stationarity more difficult to detect, we have found some evidence of non-stationarity in the case of GDP. This creates a risk that CAR's simple econometric estimates will find a spuriously strong elasticity. For commercial revenues, the relatively short time period covered by CAR's analysis, and the

---

4 Non-stationary variables are sometimes described as a "random walk", because their values in one period are equal to the value in the previous period plus a random shock.

disruption caused during this period by the global financial crisis, means that we have not been able to find statistical evidence of non-stationarity. However, visual inspection of the data suggests that several of the variables could be non-stationary, which would lead to a risk that CAR's regressions would identify spurious correlations.

We also found evidence of autocorrelation,[5] which suggests that the estimation is "inefficient" (i.e. the estimated standard errors are larger than they could be with a properly specified model). This could also indicate that the simple models estimated by CAR are missing some potentially important dynamic effect, which would mean that the models are mis-specified and the estimated coefficients would be biased. If, for example, there is a lag between the change in GDP and the resulting impact on passenger volumes, this could explain the mis-specification of CAR's passenger model. As far as we are aware, CAR has neither considered nor tested for dynamic effects.

The Annex to this memo contains actual vs fitted charts for passenger traffic and for each category of revenue (except property rentals and CBP revenues, for which CAR did not apply an elasticity). While they also raise questions about whether some data are outliers, the charts suggest that CAR's estimated relationships are a rather poor predictor of future growth. This is not surprising, as CAR's analysis considers only a single explanatory variable, and therefore does not reflect the many other factors likely to influence each dependent variable. The problem of omitted variables can lead to biased estimates of coefficients for those variables that are included in the analysis.

CAR's Use its Econometric Estimates

To forecast future passenger traffic and commercial revenues, CAR has applied its estimated elasticities to its forecasts of respectively real GDP and future increases in passenger numbers. In the case of commercial revenues, in particular, there are two inconsistencies in its methodology:

- it has applied elasticities that it estimated from equations including a time trend. But it has not taken account of these time trends when generating its forecasts of future revenues; and
- it has made additional allowances for "incremental commercial revenues" generated by future investments proposed by daa. But it has not attempted to isolate the impact of similar past investments that will have boosted commercial revenues in the period covered by its econometric analysis.

Even if CAR had adopted a consistent approach, however, we note that its estimated elasticities still suffer from the problems discussed in the previous section.

[5] This is based on "Breusch-Godfrey" tests, which are flexible tests for autocorrelation in regression residuals. In the passenger model, for example, we found evidence of autocorrelation in models including 1, 2 and 3 lags – i.e. the residual in quarter t is correlated with the residual at t-1, t-2 and t-3.

For retail, car parking and property concessions revenues, the time trend associated with the elasticity estimate used by CAR was negative. Table 1 shows the annual trend estimated by CAR,[6] and also the change in 2019 revenues that would result from including the trend in CAR’s forecasts.

Table 1
CAR's Estimated Time Trends

	Trend (% per year)	Impact on 2019 revenue (€m)
Retail	-2.4%	-8.3
Car parking	-6.0%	-9.1
Property concessions	-1.2%	-1.3
Other revenue	+4.8%	+2.3

In most cases, CAR does not explain or justify its apparent decision not to apply the time trends alongside the corresponding elasticities. However, for car park revenues, CAR does suggest some specific reasons why the previous negative time trend might not continue (see paragraph 5.39).

In addition, while CAR has forecast an increase of 18.3 per cent in commercial revenues between 2013 and 2019, this includes an increase of 5.6 per cent (nearly a third of the total increase) that is generated by incremental investment projects rather than traffic growth. Since CAR’s econometric analysis does not make any allowance for the incremental revenues generated by past investments, the estimated elasticities will attribute all such revenues to the impact of passenger growth (or time trends).

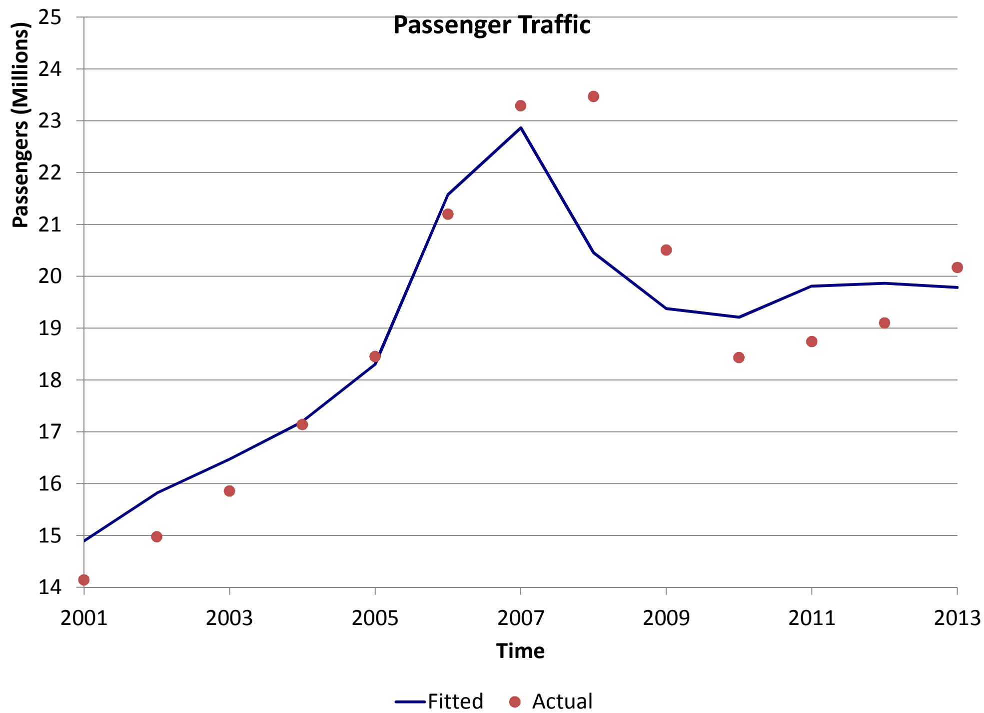
A further important risk with CAR’s approach is that, if the starting point (CAR’s estimate of the likely 2014 outturn for passenger traffic, and 2013 outturns for commercial revenues) is unusually high or low, this over or underperformance will be locked into the forecasts for the entire period. For passenger traffic in particular, the actual vs fitted chart in the Annex to this memo suggests that passenger volumes in 2013 were already above those that CAR’s equation would have predicted, and we understand that there has been further strong growth during the first part of 2014. To the

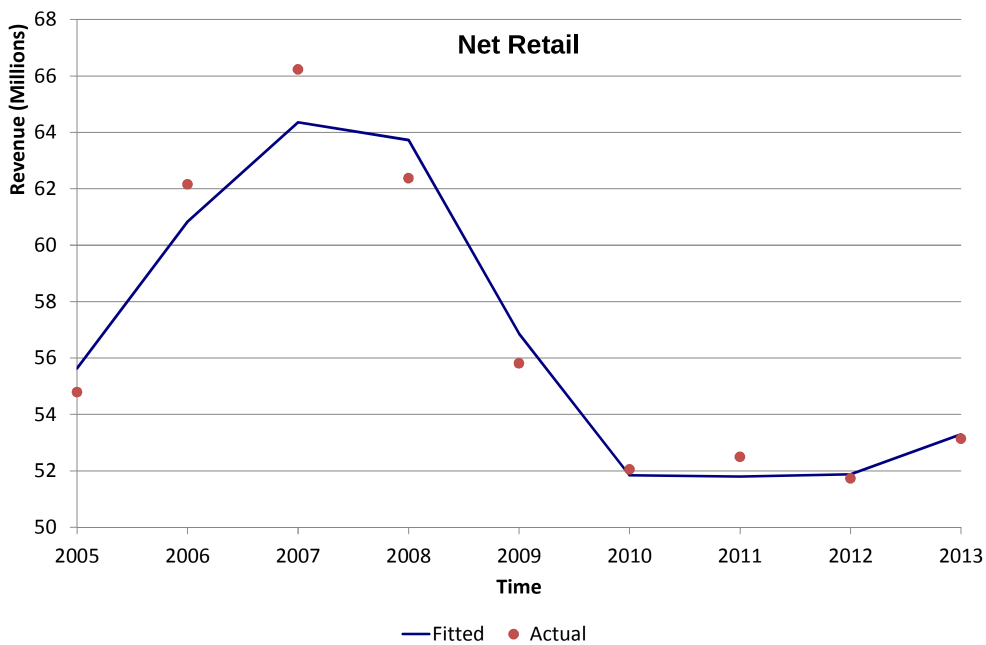
6 The trend coefficients shown in Appendix 3 of the draft determination are generated from monthly data, and therefore need to be multiplied by 12 to show the annual time trend. The time trends shown in Table 1 are based on the coefficients reported (to one significant figure only) in Appendix 3, rather than our own replication of CAR’s econometric analysis as used in the daa corrections of CAR's revenue forecast. This also means that the estimated time trend for retail revenues is based on CAR’s model with cost of goods sold erroneously added rather than subtracted.

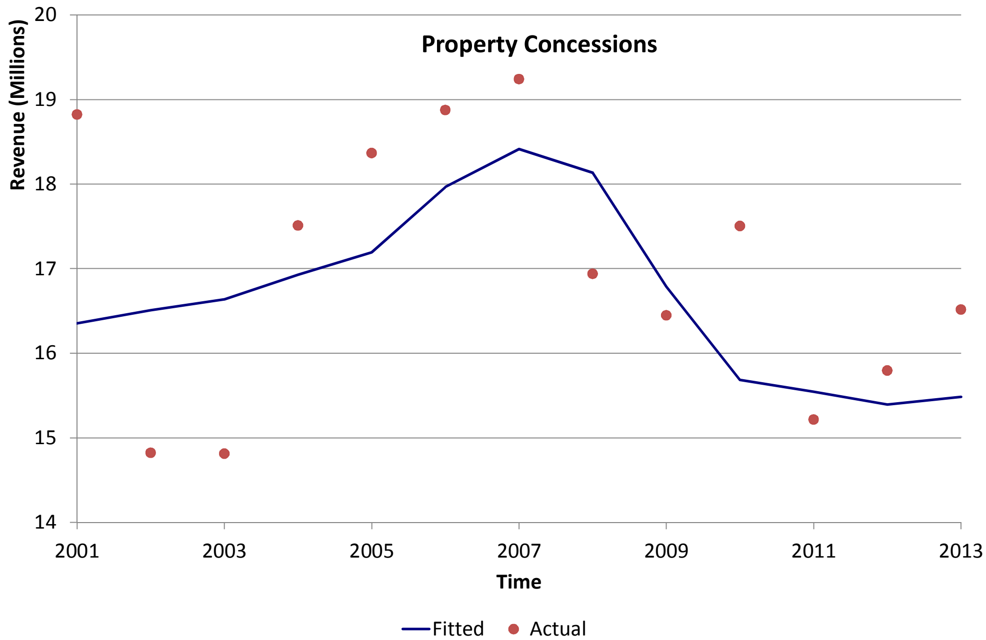
extent that current outturns are "above trend", then this provides an artificially high starting point from which to apply CAR's forecasts of future growth rates.[7]

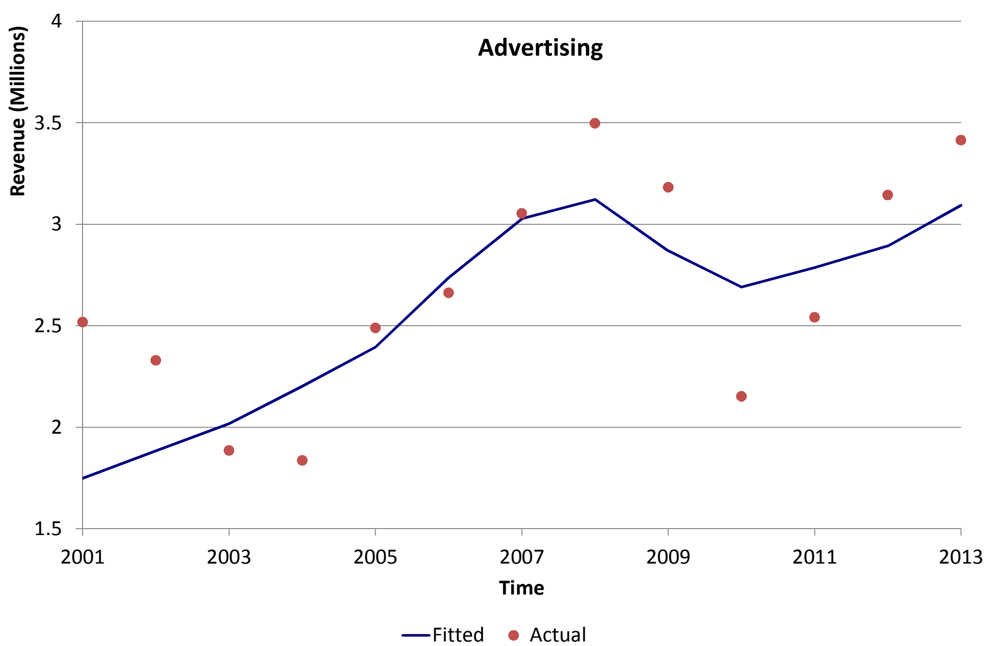
[7] The overstatement could be exacerbated by CAR's proposed approach to forecasting 2014 outturn passenger traffic, which features a mechanistic assumption that the year-on-year growth rates experienced during the first part of the year will continue throughout the rest of 2014.

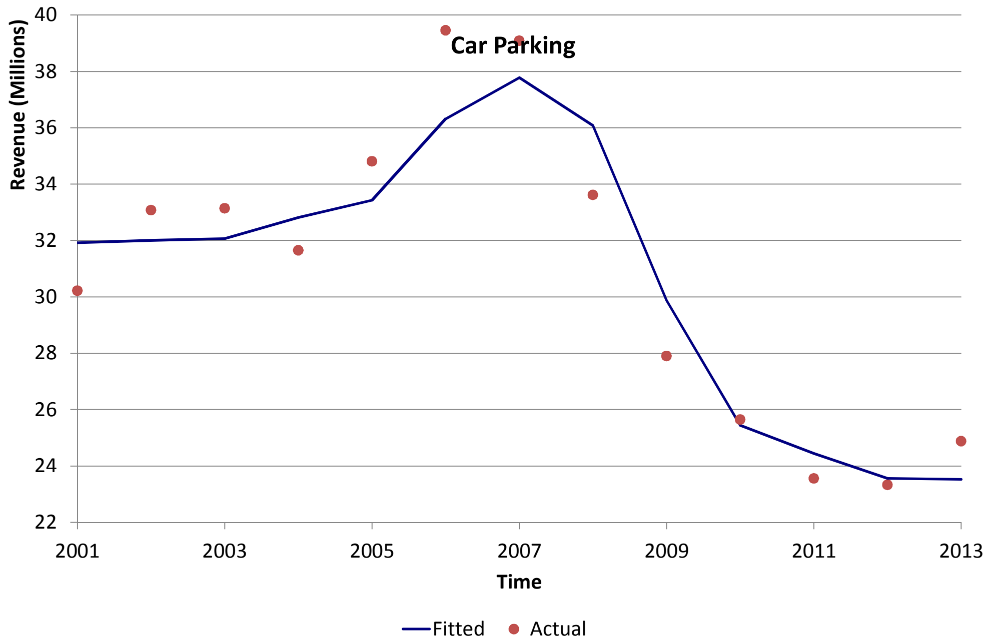
Annex: Actual vs Fitted Charts

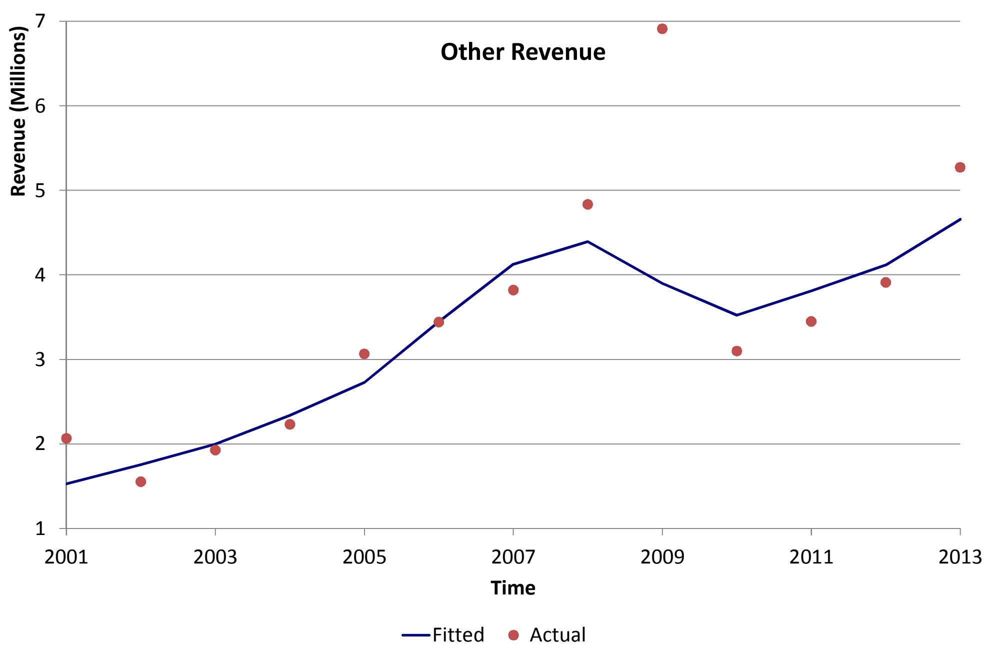





Property Concessions
Revenue (Millions)
20
19
18
17
16
15
14
2001
2003
2005
2007
2009
2011
2013
Time
Fitted
Actual


Advertising
Revenue (Millions)
4
3.5
3
2.5
2
1.5
2001
2003
2005
2007
2009
2011
2013
Time
Fitted
Actual


Car Parking
Revenue (Millions)
40
38
36
34
32
30
28
26
24
22
2001
2003
2005
2007
2009
2011
2013
Time
Fitted
Actual


Other Revenue
Revenue (Millions)
7
6
5
4
3
2
1
2001
2003
2005
2007
2009
2011
2013
Time
Fitted
Actual

Appendix 9 - Letter from IAA to daa RE: Safety & Security

Source: Irish Aviation Authority

Irish Aviation Authority
The Times Building
11–12 D'Olier Street
Dublin 2, Ireland

Údarás Eitlíochta na hÉireann
Foirgneamh na hAmanna
11–12 Sráid D'Olier
Baile Átha Cliath 2, Éire

T: +353 1 671 8655
F: +353 1 679 2934
www.iaa.ie

Safety Regulation Division

Rannán na Rialachán Sábháilteachta

15th July 2014

Mr. Michael Feehan,
Security Manager,
Dublin Airport,
Co. Dublin.

RE: CAR Draft Determination

Dear Mr. Feehan,

I refer to the draft CAR determination for Dublin Airport and in particular to the aviation security aspects.

The IAA is the Appropriate Authority in the State responsible for co-ordination and monitoring implementation of the National Civil Aviation Security Programme for Ireland.

Our role is that of regulator ensuring that applicable aviation security regulations are implemented at Dublin Airport. In this regard I would like to confirm that the following regulations pertaining to aviation security at airports will be required to be implemented;

By 1st September 2015 at the latest, a defined percentage of passengers must be screened using Explosive Trace Detection, Explosive Trace Detection Dogs or Security scanners.

By 1st July 2020 all Explosive Trace Detection Equipment must comply with EU standards.

The European Commission is committed to lifting the current ban on liquids, aerosols and gels (LAGs) applied to passengers intending to travel on aircraft from an EU airport. Phase I in lifting the ban was implemented with effect from 31st January 2014. This required screening of medicines and other defined liquids using Liquid Explosive Detection systems (LEDS). Phase II will require screening of LAGs and is likely to apply to clear liquids in clear bottles. Phase III will then be the total lifting of the ban and the requirement that all LAGs be screened using LEDS equipment. Implementation dates are being finalised at present at EU level. In addition all Liquid Explosive Detection systems must meet Standard 2 by 31st January 2016.

All new Explosive Detection Systems installed after 1st September 2014 must meet Standard 3. Existing standard 2 Explosive Detection Systems installed at Dublin Airport must be replaced with systems meeting Standard 3 by 1st September 2020.

The International Civil Aviation Organisation (ICAO) in their Aviation Security Manual note that airport security can be best achieved through a holistic approach that optimises the

(a) design of airport facilities
(b) design of security systems
(c) design of operational processes
(d) deployment of security personnel and
(e) accountability of all personnel.

With regard to layout of passenger screening areas, ICAO states "movement through a passenger screening checkpoint should be quick and efficient, at the same time affording the opportunity to detect weapons and other dangerous devices, articles and substances. As passenger queues at passenger screening checkpoints adjacent to public areas could be targeted for attack, passenger throughput levels should be as high as possible."

ICAO also notes that it is often not possible to accelerate the screening process, and suggests options to improve the passenger experience such as assigning more screeners at each screening point and optimising the space utilisation.

It is a matter for Dublin airport to design and implement a holistic security system, incorporating people, equipment and procedures, in order to ensure compliance with security regulations and to achieve the overall aviation security objective of preventing acts of unlawful interference against civil aviation.

Yours sincerely

Sinéad Quirke

Sinéad Quirke
Assistant Director Regulatory Performance and Personnel Licensing

Appendix 10 - Report on Costing Errors in EY Capex Review

Source: daa

1. Costing Errors in EY Capex Review (which can subsumed within the envelope approach to capex).

1. CIP 15.6.001 – Runway 16-34 pavement Rehabilitation (€ 24.3m v €21.6m allowed)
daa have included an allowance for operational restrictions & night-time working. EY have reduced this allowance on the basis that that '*rehabilitation can be done by day*'. This is however not the case.

Runway 16-34 is currently required for dual operations in the early morning in order to reduce delay on the apron and improve efficiency. In addition, allowance for handback has to be provided for in the contract in the event of an unplanned closure of Runway 10-28 when the works are ongoing. On that basis we have anticipated that a significant amount of these works will be carried out outside normal working hours for which there is a premium. The costs included by daa include for this assumption and need to be re-evaluated by EY on that basis.

2. CIP 15.6.055 – Taxiway Rehabilitation (€ 16m v €12.5m allowed)
The main difference is due to the rate applied, € 140/m2 (EY). The rate used by EY is too low and justification is somewhat inaccurate, based on inaccurate assumptions. The EY rate used is based on asphalt inlay and not full pavement reconstruction.

With the limited information available at this stage it is difficult to be certain of the exact rehabilitation details in every case although we are sure that reconstruction will be necessary in a number of areas based on a number of considerations including;

- Where foundations have failed or realignment of the taxiway is needed (e.g. D3. G, B7, P1) then full reconstruction is the only option.
- An inlay will not be an option where the failed pavement is currently PQ Concrete only with no existing overlay.
- An overlay will not be an option where the pavement surface levels are restricted by adjacent/adjoining pavements.

Full reconstruction will definitely be necessary in approximately 50% of the situations either in full or part.
Other rates referenced in the CIP are as follows;

- CIP 6.001 RW16-34 Rehabilitation € 110/m2 (inlay)
- CIP 6.001 RW16-34 Rehabilitation € 450/m2 (reconstruction)
- CIP 6.017 RW10-28 Overlay € 130/m2 (overlay)
- CIP 6.002 Apron Rehabilitation € 180/m2 (reconstruction)
- CIP 6.006 Apron Road Rehabilitation € 170/m2 (reconstruction)
- CIP 6.055 Taxiway Rehabilitation € 140/m2 (reconstruction)

The EY rate used is based on asphalt inlay / overlay and not full pavement reconstruction. As can be seen from above the range of full pavement reconstruction is € 450 to €170.

daa rate is for combination of full reconstruction and pavement overlay/inlay, and is more accurate at € 170/m2.

3. CIP 15.2.009 Consolidated Car Rental centre (€10.0m v €7.9m allowed)

The EY Rate is based on high level estimate provided in the CIP and information submitted as part of EY queries as is summarised as follows

- Building – 1,700m2 €2,140,000
- Preparation Area – 1,500m2 €2,610,000
- Parking – 1000 spaces - €1,530,000
- Fees and Contingency - €1,665,000
- Total allowed €7,945,000

Additional information is now available and a more detailed (although still conceptual estimate) has been developed by a specialist consultant Arwe Service GMBH. A copy of a revised capital estimate for this project is included below. This estimate highlights the following items which are not catered for in the E&Y €7.945m as set out above.

- Fuelling station and equipment €500,000
- Washing & Valeting Equipment and Drainage Requirements €2,060,000
- Capital Contributions €355,000

These items should be added to the E&Y estimate to increase the allowance to €10,215,000

Dublin Airport Authority — Project data Sheet
CAPITAL INVESTMENT PLAN — CIP 15.2.009

Workstream	***Revenue Projects***			
Project	Consolidated Car Rental Centre			
Project Financial KPI	Quantity	Unit	Description	Cost	Cost per unit
Functional Units	NA	Spaces		10,215,200	Na

LEVEL 1 COST ANALYSIS	Represents	Total
Design Costs	6%	600,000
Construction Costs	83%	8,460,000
Others	3%	355,200
Contingency Costs	8%	800,000
Total	100%	10,215,200

KEY ASSUMPTIONS

Based on a consolidated centre providing a single point for car rental pick-up.
- Single storey construction
- Fuel station
- Washing facilities & Specail Drainage requirements
- New Fencing / CCTV / Security Provisions
- New Buildings 1,700m2 Reception /& 1,500m2 Maintenance & Prep area

The costs allow for working above a live carpark envrionment

LEVEL 2 COST ANALYSIS

PROPOSED DESIGN FEE ALLOCATION ACROSS GATES

Design & Management Costs	Value	% fee	Total fee		Total
Design & management Costs	8,460,000	8.0%	600,000		600,000
TOTAL - to summary					**600,000**

Construction Costs	Quantity	Unit	Rate		Total
Fuel Station					
Pumping Equipment	1	item	120,000		120,000
Fuel tanks	1	item	380,000		380,000
Washing & Valeting					
Drainage Requirements	1	item	600,000		600,000
Water Treatment	1	item	150,000		150,000
Washing Tunnels	1	item	710,000		710,000
Cleaning Belts	1	item	600,000		600,000
Buildings					
Reception	1700	m2	1,588		2,700,000
Wash & Valet & Maintenance Areas	1500	m2	1,733		2,600,000
Electrical Installlation	1	item	500,000		900,000
Security / Fencing /IT	1	item	500,000		500,000
Deduct Contingency allowance added elsewhere	1	item	-800,000		-800,000
TOTAL - to summary					8,460,000

Others	Quantity	Unit	Rate		Total
Section 48 Contributuions	3,200	m2	111	additional accomodation only	355,200
TOTAL - to summary					355,200

Contingency	Value	%	Value					Total
Construction	8,460,000	10%	800,000					800,000
Total - to summary								**800,000**

4. CIP 15.7.104 T1 HVAC & BMS Upgrades €7.4m Vs €4.8m allowed

E&Y have used a much lower rate m/2 for HVAC and which does not take into account nature of work within piers and a live airport environment.

The work in Pier 3 was previously tendered and his is used as a basis for the daa estimate.

The assumptions made by EY do not take into account site specific conditions and constraints as follows;

- The plant room location for the Pier 3 air handling plant is a reduced height mezzanine (essentially within part of the ceiling void of the Arrivals and Departures floors) with very restricted access. All air handing plant will be manufactured specifically to suit the spaces available and will have to be assembled in situ.
- Due to severe restrictions on what hot works (cutting, welding etc) can be undertaken, new pipework will be fabricated off site and then assembled in the plantroom spaces. Also, for the same reason removing life expired plant and pipework will require the use of hydraulic cutting equipment and some manual cutting.
- For exceptional hot works that do arise, this work will have to be done when the building is unoccupied and will require a lot of additional fire preventative measures to be put in place and the full time attendance of fire personnel.
- Due to noise issues most of the work in the mezzanine plantrooms will have to be done outside operational hours.
- To maintain passenger comfort, hire of heating & ventilating units will be required while central distribution systems are out of service.

The estimate for these works should be re-evaluated on this basis.

5. CIP 15.3.004 Landside Infrastructure Car parks €4.5m vs 2.7m allowed

The main variance is in the cost of the car-park equipment, €1.1m.

The existing system was installed in 2006 with a life of 10-years. The estimate allows for the most reliable equipment with minimum maintenance costs suitable for the busiest car park in Ireland. It also allows for emerging technology in relation to car park equipment, number plate recognition system, online reservation system, RFID (Radio Frequency Identification - toll tag) and emerging e-wallet technology. The daa costs are based on upgrade of system in 2006.

The estimate for these works should be re-evaluated on this basis.

Appendix 11 - Review of IT Investment Programme

Source: KPMG

KPMG

cutting through complexity

Dublin Airport Authority

Review of IT Capital Expenditure Programme

Final Report

16 May 2014

Contents

1. Executive Summary

1. Executive Summary
Overview

We have assessed all of the projects within the Technology and Business Systems Capital Investment Programmes (CIPS). In the majority of cases we have found the rationale behind the investment and the level of associated spend to be reasonable. This is in comparison to our experience of similarly sized IT footprints and benchmark information that we have.

Of the 41 projects we found 4 exceptions which were, in our view, either potentially understated or potentially overstated. These exceptions included:

- SQL (Potentially Understated)
- Oracle (Potentially Understated)
- Microsoft Server Licensing Upgrade (Potentially Understated)
- Systems Integration (Potentially Overstated)

The IT landscape in the DAA consists, in the main, of 3rd party products and specialist applications. Whilst this provides the DAA with a number of benefits (minimal bespoke code, no internal development team etc.), it commits the DAA to a continuous level of investment with regards to the lifecycle management (upgrade and refresh) of the IT landscape.

The usage of 3rd party products also increases the level of integration required between these applications to provide an end-to-end experience e.g. Management Information or Customer Experience which in turn further complicates lifecycle management.

The overall lifecycle management challenge (and associated cost) has increased due to the implementation of Terminal 2 which introduced a number of new applications and technologies which were not in the scope of previous Capital Investment Programmes.

1. Executive Summary
Underlying Principles

Throughout the document we provide a rationale for each project in the Capital Investment Programme. However there are underlying principles which the DAA use to underpin (unless stated otherwise) all of the projects. We have separated these into principles associated with Infrastructure, Hardware Lifecycle, Software Lifecycle and Cost Estimation and have highlighted them in the tables below.

Infrastructure Principles

- All systems are resilient to meet business needs with no Single Points Of Failure and distributed between minimum of 2 data centres
- Dev, UAT and Production instances available for key systems
- All network links are dual homed (up to access layer). All wan links are dual diverse route and multi-vendor
- Data growth expected in line with previous years

Hardware Lifecycle Management

- Typically platforms are refreshed in line with vendor support dates
- Expected life cycle for PCs – 4 yrs, Laptops – 3 yrs
- Expected server life - 3-5 years. This depends on the level of risk that can be afforded in the technology.
- HVAC / Data Center elements – 5 years
- Other hardware such as turnstiles, cameras, etc. are expected to have a longer lifespan than servers and in some cases are replaced on a break-fix basis

Software Lifecycle Management

- Application upgrades in line with vendor support dates
- Typically software needs to be upgraded every 5 years to ensure the version is supported by the vendor
- All applications are provided by 3rd parties, thus there is a significant dependency on their remaining current

Cost Estimates

- Purely CapEx costs and no internal resource costs are considered
- No allowance for general cost inflation
- Some projects are at an early assessment stage and accurate costs are difficult to calculate. The following assumptions are used in this case (where a project is similar to the original implementation)
    - Software upgrades: 30% of original cost
    - Implementation: 30-40% of original cost
    - Project Management: 20-30% of original cost
    - Testing: 20-30% of original cost

In our view all of the above principles are reasonable and are consistent with benchmarks we are seeing on the market place.

1. Executive Summary

Factors Driving Investment - Different Types of Investment Rationale

A significant proportion of the proposed investment is associated with Lifecycle Management and ensuring all systems continue to be supported. However as is illustrated below there are other factors driving the investment programme.

Reduced Business Risk

- Ensuring a fully resilient / highly available architecture
- More up to date Management Information
- Improving Communications and Collaboration

Lifecycle

- Hardware/Software moving out of Vendor Support
- Ensuring sustained levels of performance & Security

Revenue Generation

- Increasing all types of revenue including non-aeronautical thus positively impacting airline fees

Airport Growth

- Catering for future growth in passenger numbers

Reduced TCO

- Reducing annual OpEx without impacting service

Regulatory Requirements

- Meeting requirements from CAR e.g. WiFi coverage, queue lengths etc.

Operational Efficiency

- **Improving process efficiency by automation**
- **Supporting efficient ways of working e.g. mobile working**

2. Approach

2. Approach

During the course of the engagement we executed the following steps:

1. **Mobilise and Understand Context:**
   - This involved meeting with key stakeholders to:
     - Understand the overall context behind the 41 areas of investment
     - Determine the most appropriate documentation to use as the basis of our analysis
2. **Detailed Review of Investment Plan**
   - During this step we took away all documentation given to us and performed a desktop analysis of the material. We created a series of questions/queries to use as input to the meetings with key stakeholders in the IT Department of the DAA
3. **Meetings with Key Stakeholders**
   - We held a series of meeting with key stakeholders to discuss the following:
     - Scope/Rationale for each element of the CIP – functional scope of system or role of infrastructure. Architecture – WAN/DC etc.
     - Understanding the costs – getting supporting evidence
     - Understanding the cost drivers
   - We supplemented our analysis with notes taken during the meetings.
4. **Prepare Draft Report and Validate**
   - This step involved documenting this report and validating the findings with the key stakeholders in the IT Department of the DAA and against industry standard benchmarks

3. Summary of Analysis

3. Summary of CIP Analysis

CIP 15.8.008 – Infrastructure & Devices

Cost Element	Reasonable	Conclusion	Lifecycle	Airport Growth	Regulatory Requirement	Operational Efficiency	Reduced TCO	Revenue Generation	Reduced Business Risk
Physical Servers and Storage		■ Consideration has been given to the fact that there will be fewer physical servers due to virtualisation ■ Storage growth assumptions are as per benchmarks across similar industries ■ Lifecycle of ~5 years for servers ■ Good discount on hardware ■ Investment required to maintain High Availability and Resilience levels	✓	✓			✓		✓
Data Centres		■ Unavoidable requirement to upgrade devices at end of life. Alternative would be to host externally but this would be significantly more expensive once the investment into on-site data centres has been made.	✓						✓
Firewalls & Switches		■ The Firewalls being replaced are the cheaper model and ■ The spend on the new Commercial offering provides a highly secure environment with Revenue Generation potential. ■ It is assumed that ~40% of the access switch estate will require replacement during the timeframe of the CIP. This is reasonable and consistent with industry benchmarks as typically these switches are given a 5year support timeframe.	✓					✓	✓
Desktops & Tills		■ The prices are taken from a Framework Agreement which has been competitively sourced ■ Cognisance has been taken of the potential introduction of a virtual desktop environment and a BYOD (Bring Your Own Device) policy							✓

3. Summary of CIP Analysis

CIP 15.8.008 – Operating Platforms & Integration

Cost Element	Reasonable	Conclusion	Lifecycle	Airport Growth	Regulatory Requirement	Operational Efficiency	Reduced TCO	Revenue Generation	Reduced Business Risk
VMWare		■ All unit costs are based upon a discounted Framework agreement ■ Industry standard architecture	✓	✓			✓		✓
Linux		■ UAT servers are of a reduced specification ■ Matches current specification ■ Spend is dependent on results of a study and subsequent proposals for the best location to host the eBusiness Suite environment					✓		✓
SQL	Potentially Understated	■ The reasonable expectation that data volumes (and requirements to access data from applications) will grow significantly is not necessarily sufficiently supported by the second hardware upgrade in 2018, i.e. would assume more cores albeit they may be more powerful, this could impact on the scale of investment in software, e.g. a typical benchmark is that a 20% increase in the requirement for cores could equate to a 10% increase in direct software costs. ■ Although SQL 2008 moves out of mainstream support in 2014, it is still in extended support until 2019. This may provide sufficient capability to revisit the migration to SQL2012 (in 2015) and moving directly to SQL 2014. Given the scale of investment the decision not to go directly to SQL 2014 should be revisited in early 2015.	✓						
BI/Targit		■ Assumes 75 integrations over a 5 year period which is broadly in line with the number of integration delivered in previous years. ■ However, the exploitation of the Big Data solution may well contribute towards a reduction in the need to provide certain types of reporting from this capability over time. ■ Additionally, the re-use / re-factoring of existing integrations may contribute towards some efficiencies over time.	✓	✓		✓	✓	✓	✓
Other (MPLS)		■ Maintaining the stability and security of core infrastructure components is aligned to established lifecycle management practices. ■ The costs are estimated based on a current understanding of pricing for these devices, however, the procurement will not take place until 2016. There may be some decrease in costs at this point.	✓						✓

3. Summary of CIP Analysis

CIP 15.8.008 – Operating Platforms & Integration

Cost Element	Reasonable (Y/N)	Conclusion	Lifecycle	Airport Growth	Regulatory Requirement	Operational Efficiency	Reduced TCO	Revenue Generation	Reduced Business Risk
Oracle	Potentially Understated	■ The exploitation of Big Data to enhance Customer Experience, drive efficiencies etc. through the use of analytics and other BI applications is becoming normalised across all industries. And therefore , it is reasonable for the DAA to provide a foundation for this. However, Big Data solutions (typically) include consideration for large (often) unstructured data sets, including Internet based and Social Media, in order to facilitate e.g. better Customer experiences. This does not appear to have been included (volume / velocity). Appliance costs are based on acquiring 1/8th of the Oracle Exadata solution. However, whilst accepting that a) this appliance can be technically scaled and b) that no specific business requirements have been provided as yet and c) there is no evidence to support the device sizing such as it is, there is a high risk that the investment proposed currently is understated. ■ Developing a BI capability aligned to the exploitation of 'Big Data' typically requires an investment in creating / purchasing data models which are ultimately populated from source systems and then exploited by BI applications. Given the number of proposed integrations, coupled with the lack of definitive business requirements relating to the exploitation of the data, and without having evidence of how the data architecture / data models are to be developed / purchased or otherwise, there is a high risk that the costs associated with the implementation of the foundation are currently understated. ■ Quantifying benefit versus cost is difficult because it is different in each instance. However KPMG commissioned a review of 144 CFOs and CIOs globally and 71% say they plan to spend more than 5% of their sales on Data & Analytics/Big Data initiatives over the next 5 years.	✓	✓		✓	✓	✓	✓

3. Summary of CIP Analysis

CIP 15.8.008 – Licensing

Cost Element	Reasonable (Y/N)	Conclusion	Lifecycle	Airport Growth	Regulatory Requirement	Operational Efficiency	Reduced TCO	Revenue Generation	Reduced Business Risk
Microsoft Enterprise Agreement		■ Moving away from the Microsoft stack for the DAA would be unreasonable given the extent to which it is embedded within the organisation at this point. Re-entry (for most organisations) into such an agreements is usually inevitable. ■ However, more consideration should be given to the type of agreement that is needed rather than assuming that a traditional EA with some extras is suitable, for example, Hybrid Agreements incorporating Office 365 services may be appropriate. Additionally, using the organisation's requirement to use other MS products, e.g. SQL Server, may provide opportunity to 'burst its usage' of certain licences in the short /medium term and then true-up/down over a longer period.	✓				✓		
Microsoft Server Licensing Upgrade	Potentially Understated	■ Aligned to existing practices relating to lifecycle management. ■ Based on current volume licensing and OEM pricing. However more applications in the future will require more processing. ■ However, growth in the volume and velocity of data and the consequential growth in the requirements for new applications and services may drive higher infrastructure requirements, e.g. processors / cores, which may impact on licensing costs.	✓	✓					
Other (Oracle & VDI)		■ It is accepted that the current (Oracle) license capacity has been reached, however, specific requests for additional (new) licensing for projects is assumed ■ The growth in the requirements for Citrix, aligned to for example BYOD initiatives, is reasonable.	✓	✓					

3. Summary of CIP Analysis

CIP 15.8.008 – Network (Fixed & WiFi)

Cost Element	Reasonable (Y/N)	Conclusion	Lifecycle	Airport Growth	Regulatory Requirement	Operational Efficiency	Reduced TCO	Revenue Generation	Reduced Business Risk
Network Upgrades		▪ All costs are commodity costs ▪ The number of Wireless points can be justified by airport growth, lifecycle requirements, CAR requirements for connectivity and the airline’s expectation that passengers experience will be improved.	✓	✓	✓	✓			✓
Cabling		▪ This is a reasonable cost as the network needs to be maintained to reduce operational risk. The cost is consistent with “business as usual” spend in the airport on this activity. It is also consistent with the spend on Cabling in other similar organisations. Major changes will be funded and handled as part of the project to which they are associated.	✓						✓
Firewall Upgrades		▪ Required as Firewalls need to be replaced frequently to maintain security levels ▪ Specification of the devices has been maintained to current levels	✓						✓

3. Summary of CIP Analysis

CIP 15.8.009 – Airport Security

Cost Element	Reasonable (Y/N)	Conclusion	Lifecycle	Airport Growth	Regulatory Requirement	Operational Efficiency	Reduced TCO	Revenue Generation	Reduced Business Risk
Access Control		▪ The is potential to reduce the current annual maintenance charge from TDS by upgrading the hardware. ▪ The software upgrade costs appear reasonable when compared to the original implementation costs.	✓	✓	✓	✓	✓		✓
CCTV		▪ Software upgrade costs are 40% of original (consistent with industry benchmarks) ▪ Implementation costs are in line with the general principles ▪ Camera replacement cost represents the replacement of 2% of the camera stock annually (on a break-fix basis – they are repaired where possible)	✓	✓			✓		✓
Autopass / SEMS		▪ Software costs based on 30% of original implementation (including implementation) ▪ Turnstile costs are based on quotes from the vendor and include implementation and testing costs	✓	✓		✓	✓		✓
Baggage Image Labelling System		▪ The upgrade costs are a relatively small proportion of the original implementation costs. This is because the original implementation costs covered bespoke work which will not be required in an upgrade. ▪ Handhelds and printers are commodity pricing	✓	✓		✓			
X-Ray & WTMD		▪ No previous upgrade on which to base costs but the estimation is a conservative estimate in comparison to the original implementation costs. Software needs to be upgraded on 42 x-ray machines and 25 WTMD machines.	✓		✓	✓			

3. Summary of CIP Analysis

CIP 15.8.009 – Airport Operations

Cost Element	Reasonable (Y/N)	Conclusion	Lifecycle	Airport Growth	Regulatory Requirement	Operational Efficiency	Reduced TCO	Revenue Generation	Reduced Business Risk
Systems Integration	Potentially Overstated	■ This is dependent on the roadmap of SonicMQ – it works currently and does the job that is required ■ At an minimum an upgrade will be required – it is questionable as to whether it needs to be thrown out and replaced ■ It is valid to budget for some change as SonicMQ has changed owner and its roadmap is uncertain. At a minimum a study will be required to validate its position during the lifetime of the CIP period.	✓						✓
Airport Operating System		■ Major upgrade cost are estimated at 40% of the original costs ■ Cost of minor upgrades is consistent with the annual historical spend from 2011 to 2014	✓						✓
Airport Control Centre		■ Commodity cost for screens ■ Screens have a lifespan and some have required replacement recently – screens were bought in 2009 and 2011.	✓						✓
Airfield / Radio		■ Currently 2 of the 4 antennae on the roof require replacement. Radio is a crucial component of the communication system used by airport police, file services etc. throughout the campus. ■ Ops View system was last upgraded in 2013 and will therefore be due an upgrade during the timeframe of this CIP period	✓	✓					✓
Back Office Systems		■ This is an estimation but is based on past experience with new requirements such as SEPA. Impossible to anticipate these requirements. ■ The per annum cost may very over the CIP period depending on external drivers. ■ Upgrade costs are reasonable when compared to the previous CAST upgrade costs.	✓		✓		✓		✓

3. Summary of CIP Analysis

CIP 15.8.009 – Airport Operations

Cost Element	Reasonable	Conclusion	Lifecycle	Airport Growth	Regulatory Requirement	Operational Efficiency	Reduced TCO	Revenue Generation	Reduced Business Risk
FIDS		■ At a minimum the FIDS system will need an upgrade. The last upgrade cost €120K. DAA have sourced an alternative option to replace the system with a solution from the same provider but it will reduce annual maintenance costs. ■ The screens have a 6-8 year lifecycle and many will thus need to be replaced during the lifetime of the CIIP period. This includes all the screens in T2 and many of those in T1 (the check-in baggage and routing screens do not need to be replaced until 2020 or later) . The screens have a commodity price,	✓		✓		✓		✓
Queue Measurement Solution		■ Cost of sensors is well known – based on perpetual licensing and the value includes hardware, implementation and testing ■ The upgrade costs are high but this is due to a number of factors 1. the introduction of blu-fi technology is more accurate but more expensive, and 2. allowance added for the addition of new areas (greater scope than original implementation). There is a quotation from Lockheed Martin to validate the sizing.	✓	✓	✓	✓			
Mobile Applications		■ This is an estimation of less than 400 implementation days for a making a minimum of 4 applications mobile aware				✓			
Taxi		■ This cost is based on an assumption of using 30% of the external vendor costs from the original implementation, which is a reasonable assumption.	✓			✓			
CATV		■ Cost includes a rollout and implementation of CATV in T1. Improves customer experience and centralised control adds to efficiencies	✓	✓					
Telephony		■ Ringmaster upgrade costs in line with most recent Ringmaster upgrade costs ■ IP Telephony software upgrade costs are less than most recent upgrade – assumed that any minor upgrades are covered by software assurance ■ Costs for implementing Cisco IPT in T1 are an estimate but are based on T2 experience and the fact that there are currently 2400 telephones currently in T1	✓			✓	✓		

3. Summary of CIP Analysis

CIP 15.8.009 – Asset Care

Cost Element	Reasonable (Y/N)	Conclusion	Lifecycle	Airport Growth	Regulatory Requirement	Operational Efficiency	Reduced TCO	Revenue Generation	Reduced Business Risk

Asset Tracking (GIS)		■ Asset Tracking (GIS) systems are now mandated in US airports and are increasingly implemented in airports across Europe
		■ DAA can realise additional benefits through an investment in GIS, including the following qualitative benefits:
		  ■ Increased customer satisfaction
		  ■ Increased staff satisfaction
		  ■ Increased situational awareness
		  ■ Reduced decision risk
		  ■ Mitigated information management “pain points” identified by DAA staff
		■ GIS technology also offers opportunity for quantitative benefits including:
		  ■ Cost savings due to process efficiencies – DAA staff can perform their business processes more efficiently when using GIS
		  ■ Cost avoidance – DAA can avoid unplanned incidents (e.g., utility line breaks, regulatory violations) through the use of GIS
		  ■ New revenue opportunities – DAA can optimise its commercial services and opportunities based on location analysis using GIS
				✓		✓			✓

Asset Care & Maintenance		■ These are key systems and it is consistent with industry practice to bring them under one IT governance structure. ■ Therefore it is advisable to bring all of these systems under the remit and standards of DAA IT. The costs are an estimate and will need a deeper assessment to be fully validated – although they have been based on the cost of bringing Autopass in under DAA IT. ■ Work Order system costs are an estimate also but is consistent with the average annual spend over the last 6 years ■ BSI upgrade cost negates the need for point-to-point integrations. Some spend is necessary and this is the most efficient solution. Costs are an estimate but are based on the original implementation costs.	✓				✓		✓

3. Summary of CIP Analysis
CIP 15.8.009 – Asset Care

Cost Element	Reasonable (Y/N)	Conclusion	Lifecycle	Airport Growth	Regulatory Requirement	Operational Efficiency	Reduced TCO	Revenue Generation	Reduced Business Risk
Baggage System		■ The estimate for this work is consistent with existing upgrades to T1. ■ The cost for integrating self-service check-in and baggage drop is an estimate but it incorporates changes required of suppliers of exiting systems (Cofely and Siemens) and appears reasonable.	✓			✓			
Energy Management		■ The costs are estimated at 50% of the original costs which is higher than normal but this is because it is expected to include a hardware upgrade.	✓			✓			

3. Summary of CIP Analysis
CIP 15.8.009 – Commercial

Cost Element	Reasonable	Conclusion	Lifecycle	Airport Growth	Regulatory Requirement	Operational Efficiency	Reduced TCO	Revenue Generation	Reduced Business Risk
Commercial System Upgrades		▪ There is no question that investment in these capabilities has revenue generating potential ▪ However, the level of investment and return is not quantified. ▪ In some cases the estimates appear low e.g. our experience of implementing CRM functionality is that it can be considerably more expensive. However, the scope of the CRM implementation is limited to B2B customers and the scope can be managed further to fit within budget.	✓					✓	
Car Park System		▪ It is clear that investment will need to be made into the Car Park system both for keeping the functionality current and for lifecycle management ▪ However, the level of spend is an estimate and will not be validated until clear requirements are in place. ▪ In terms of scale however, the level of investment appears reasonable. The Car Park will be responsible for a significant turnover during the CIP period. The Car Park implementation is a complex mix of Networks, Cameras, Backend Payments Processing Engine etc.	✓	✓				✓	
DAS Cellular		▪ T2 upgrade cost assumes 25% of original implementation and it is also assumed that some of the equipment can be reused for T1.	✓		✓			✓	

3. Summary of CIP Analysis
CIP 15.8.009 – Support Services

Cost Element	Reasonable (Y/N)	Conclusion	Lifecycle	Airport Growth	Regulatory Requirement	Operational Efficiency	Reduced TCO	Revenue Generation	Reduced Business Risk
Oracle		▪ Point upgrades are compulsory and the associated cost is consistent with previous years ▪ Lifecycle management will drive a major upgrade to eBusiness suite. DAA have 22 modules and the cost is therefore consistent with the market – the upgrade to R12 cost similar. ▪ Hyperion and BI will need to be upgraded in line with eBusiness Suite and again the cost are consistent with market expectations and with previous upgrades	✓						
BI / Forecasting		▪ The Passenger and Route forecasting system will allow the DAA to position itself to take advantage of future opportunities. The cost is also solid as it is a quotation from a recent procurement exercise. ▪ The successful pilot has highlighted the potential of the tool. The cost of deployment is well established.		✓				✓	

cutting through complexity

Appendix 14 - Report on T2 Outturn Expenditure

Source: ARUP

Dublin Airport Authority

Terminal 2 Dublin Airport

Response to the CAR Draft Determination May 2014

2 | 31 July 2014

Job number 237429-00

Ove Arup & Partners Ltd
13 Fitzroy Street
London
W1T 4BQ
United Kingdom
www.arup.com

ARUP

Document Verification

ARUP

Job title		Terminal 2 Dublin Airport			**Job number** 237429-00
Document title		Response to the CAR Draft Determination May 2014			**File reference**
Document ref					
Revision	**Date**	**Filename**	Arup Report to DAA Draft 1.docx		
Draft 1	26 Jun 2014	**Description**	First draft		
			Prepared by	Checked by	Approved by
		Name	Deirdre Chapman	Paul Coughlan	Paul Coughlan
		Signature			
Draft 2	18 Jul 2014	**Filename**	Second draft		
		Description			
			Prepared by	Checked by	Approved by
		Name	Deirdre Chapman	Paul Coughlan	Paul Coughlan
		Signature			
Final	30 Jul 2014	**Filename**	Final		
		Description			
			Prepared by	Checked by	Approved by
		Name	Deirdre Chapman	Paul Coughlan	Paul Coughlan
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
				Issue Document Verification with Document	✓

Contents

Appendices

1 Executive Summary

This Report sets out the reasons why CAR should allow the total of the outturn capital expenditure that DAA incurred building the Terminal 2 project.

1.1 Cost Plan 1 as a basis for the determination

It is submitted that CAR have incorrectly used Cost Plan no 1, issued in September 2006, as a regulatory budget, considering any spend over and above the estimate included in Cost Plan no 1 to be "overspend", while setting onerous and impractical conditions on allowing any expenditure not included within Cost Plan no 1.

It is further submitted that Cost Plan no 1 was not an estimate of likely maximum outturn cost, being based on a concept design and the information to hand at the time on material issues outside the control of the project, including site conditions, operational constraints and regulatory factors.

CAR should in fact base their allowance on the project outturn cost, rigorously reviewed against best practice in the procurement and cost management of large complex infrastructure projects, and validate this against appropriate benchmark projects, both in Ireland and abroad.

CAR should also allow the estimate made for construction inflation at the time of Cost Plan no 1. The inflation calculation was based on construction inflation forecasts at the time and the risk of construction inflation was passed to the Trade Contractors at tender stage. These tenders were generally returned in 2007, at the peak of construction inflation in the Irish market and DAA received no benefit from the reduction in inflation that transpired after 2008. This approach is in line with other projects in the Irish market and internationally.

1.2 T2 was a successful project

It is worth noting that the Terminal 2 project was an outstanding success measured against other Irish or international projects.

The project achieved and maintained excellent standards of safety for airport users and construction workers. It had no serious accidents or fatalities during 10 million man hours worked.

It was designed, constructed, commissioned and opened in less than five years, in the middle of a live congested airport environment, despite an elongated year-long planning approval process. By any comparison, including with large public projects in Ireland, or with international airport projects, it was delivered speedily and efficiently.

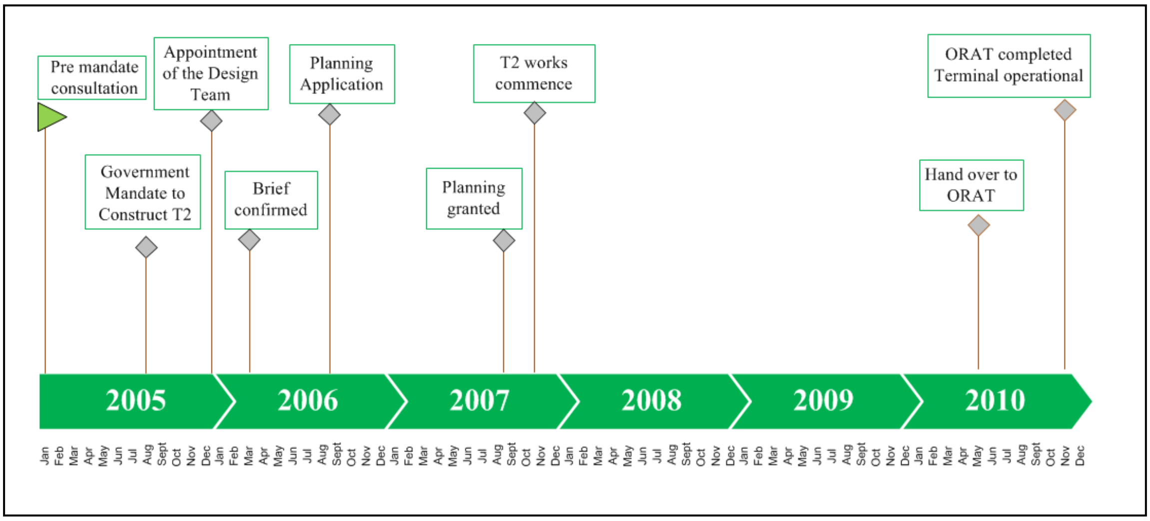
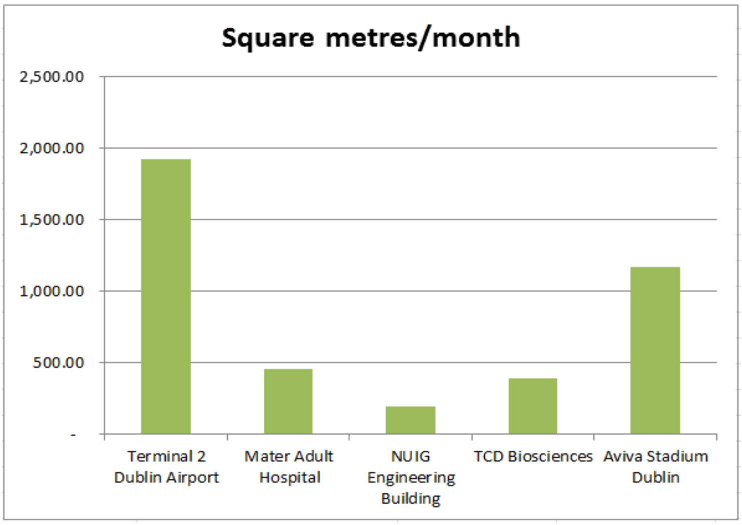
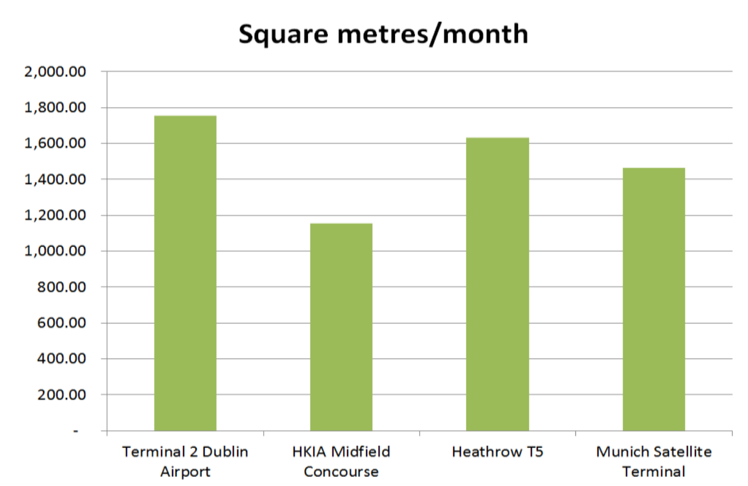


Figure ES.1

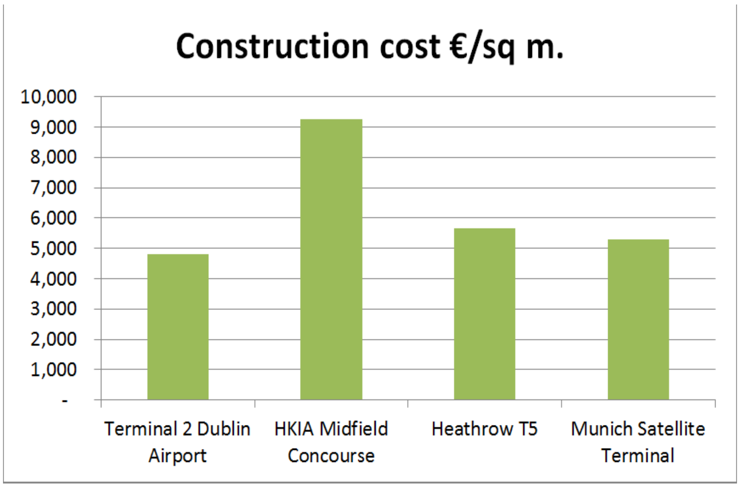


Significant Irish Projects



Aviation Projects

Figure ES.2



Aviation Projects

Figure ES.3

From a cost point of view, it was internationally benchmarked at concept design stage, and signed off by a government appointed verification process. Despite many factors outside the control of the project, and the fast-track delivery demanded by the chronic congestion in the existing terminal building, the outturn cost was just 8% over the concept design stage cost plan. It represents excellent value for money.

1.3 The drivers for success for this project

To understand the case for allowing the outturn capital expenditure, it is necessary to understand the project drivers, and the procurement and delivery strategies. To understand these, it is necessary to understand the environment in which these strategies were formulated.

In summer 2005 the Minister for Transport issued a policy direction to CAR supporting the construction as quickly as possible, of a new terminal and pier at Dublin Airport. The new terminal building was to be 50,000 square meters in size, and was to have an estimated cost of between E150 million and E200 million, depending on the design. The terminal was to be built by DAA and opened in 2009.

The design team immediately started a comprehensive stakeholder engagement process which included detailed discussions with Aer Lingus who were emerging a likely lead tenant for the new Terminal. Are Lingus had ambitious growth plans and it quickly became obvious that the proposed terminal was too small.

Following a three month review, an updated plan for the terminal was signed off in early April 2006. It called for a new terminal to be built in two phases, a first Phase of 75,000 square metres and a second phase with a further 20,000 square metres. The new pier, Pier E, was sized at 25,000 square metres.

This was a significant development in the history of the project. DAA was now faced with building a much bigger terminal and a new pier on a constrained site in the middle of a live airport. There were going to be significantly bigger impacts on landside and airside infrastructure. Passenger numbers were still increasing and there was pressure from airport stakeholders, government and the public to deliver the new facilities as quickly as possible.

1.4 Aligning the delivery strategy to the project drivers

In parallel with the concept design work, DAA and the design team were weighing up the options for the procurement and delivery of the project. All project delivery strategies balance early cost certainty against speed of delivery. The primary driver for this project was speed of delivery. A graphic comparison between the Traditional and Construction Management emphasis on the primary project drivers shows:-

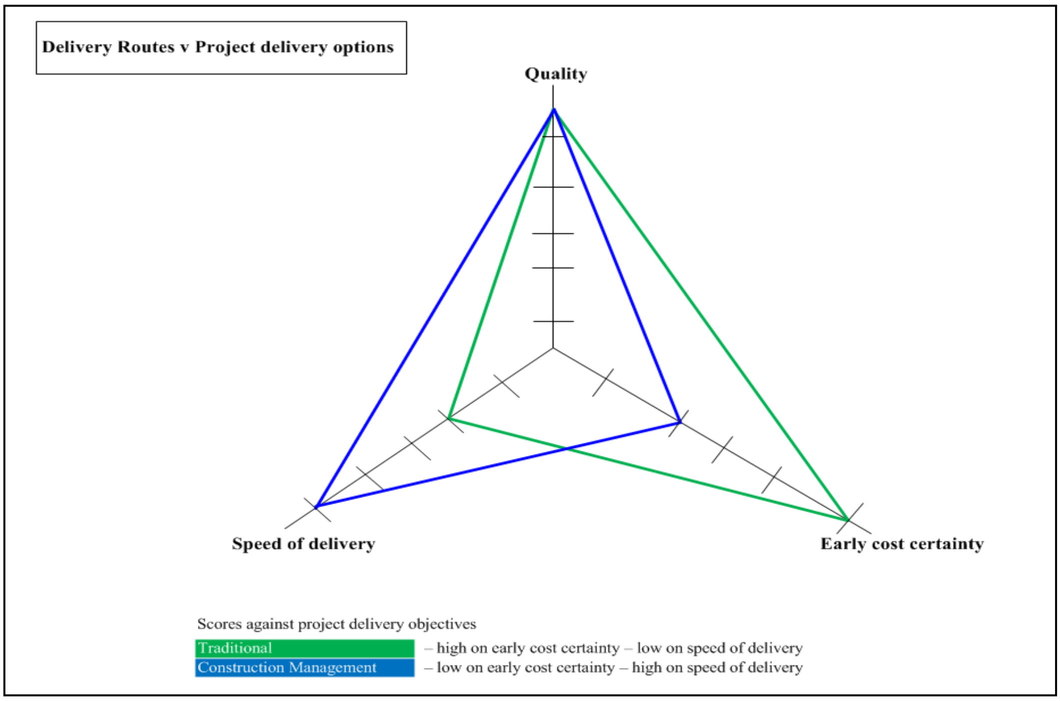


Figure ES.4

It was therefore decided to develop a "fast-track" procurement and delivery strategy which would overlap as many of the project activities as was possible. An optimal procurement route meant overlapping the design and construction. It should be noted that the project also successfully overlapped the planning process and design, and later, ORAT (Operational Readiness and Transition) and construction/commissioning to save time.

The procurement and delivery strategy chosen to accomplish this was a form of what is called "construction management" where separate contractors are appointed to carry out different “packages” of construction work in sequence following completion of the design of those packages. This allows the foundation works to be constructed while the detailed design of the terminal IT systems or fit-out is being carried out for example. The overall design concept is used to ensure that the different packages “fit” together as construction advances.

This construction management strategy meant that cost certainty would gradually increase as the project progressed. The construction packages are bought before a fully detailed and integrated design has been completed and other elements are not fully defined. The Client takes on many of the risks that could be bought out in a traditional approach such as environmental and ground conditions risk, logistics risk, interface risk between the packages and with the live airport environment, and regulatory risk.

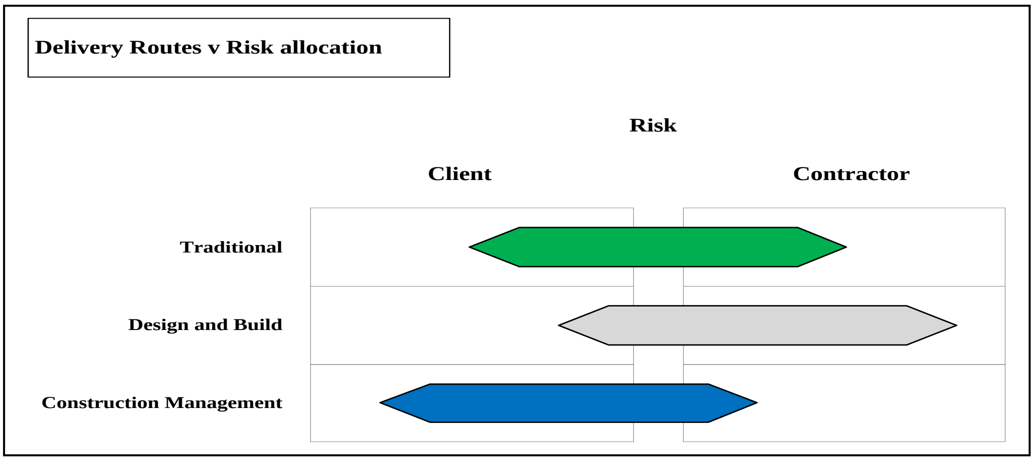


Figure ES.5

It is these non-design risks which are particularly significant in the case of the Terminal 2 project. Constructing a new terminal and pier together with new landside and airside access infrastructure, in essence a new airport facility, in the middle of a live, congested operational airport environment is a highly complex and risky undertaking. And these risks were not yet fully understood or defined when Cost Plan no 1 was made in September 2006.

1.5 Risk and Contingency on T2

However, it was decided within Cost Plan no 1 to make an initial estimate of the cost to the project of these risks which would not be bought out within the packages. This was described in the Cost Plan as a project contingency and it was based on a comprehensive risk appraisal of the project covering all the known and anticipated risks and a probabilistic Monte-Carlo model. This resulted in a Project contingency figure equal to approximately 15% of the total estimated cost of the packages included in Cost Plan no 1.

It is important to understand that the contingency was not intended to represent an estimate of the likely maximum cost of the risks. This was the starting point for a risk management exercise that was continued throughout the project as part of the strict cost control processes already referred to. Projects of the scale of Terminal 2 typically have contingencies in the range 20% to 30% assigned to them at concept design stage in order to anticipate their maximum outturn cost. The 15% contingency included in Cost Plan no 1 is well below this range.

1.6 Changes to the project

Apart from the changes to the brief, the biggest impact on the project programme was the delay to the Planning process. A positive decision was received from Fingal but this was appealed to An Bord Pleanala and a final decision was received in August 2007, a delay of 9 months. DAA carried on with the design development and the procurement of packages during this time and enabling works were started on site, therefore the delay was mitigated as much as possible and the construction of the Terminal building which was scheduled to start on 2 April 2007 commenced on 3 October 2007, 6 months late.

The other major impact came from significant changes, relatively late in the construction and design stage, as a result of negotiations with the Fire Officer on the Fire Strategy for T2. The terminal and Pier could not open to the public until a Fire Cert had been issued. The Fire Officer took an onerous view of the guidance and regulations and, despite Arup having successfully designed and implemented other projects in accordance with our interpretation of the codes, additional fire safety measures were insisted upon. The Project team could have engaged in a protracted process of justifying the Arup interpretation of the codes to the Fire Officer and trying to win him over to our view. On other projects where time was not the primary driver this would have been the approach. For this project, in the interest of completing and opening the buildings, DAA agreed to the additional measures and instructions were issued to the Trade Contractors which caused a significant delay and financial impact to the project

To mitigate these delays, at the later stages of the project, detailed completion and commissioning programmes were developed and integrated with the DAA's ORAT plans to ensure that the opening date of November 2010 was achieved.

1.7 Determination on the basis of outturn cost

For aviation projects, the established principles that are applied by, for example CAA, are to allow overruns against budget where projects have been properly managed and every effort have been made to mitigate risk during all stages. The correct basis for the determination of the costs of T2 is the outturn cost and not Cost Plan 1 which was a Concept Stage estimate with many aspects of the delivery of the project still unknown.

The T2 project had particular challenges around delivering a complex project in a live airport environment in as short a timescale as possible, a nine month delay to the Planning process and changes required to obtain a Fire Cert. However, the appropriate delivery strategy was adopted, the project was carefully managed, risks were mitigated where this was possible and the project was delivered within 8% of the initial Concept Cost Plan. The project was a success in all aspects including its financial management and this should be reflected in the CAR Determination.

2 Introduction

2.1 Structure of the Report

This Report sets out the reasons why CAR should allow the total of the outturn capital expenditure that DAA incurred building the Terminal 2 project. The Report is structured as follows:

1. Section 3 contains a commentary on the history of the project. An understanding of that history and, in particular, the drivers of the project throughout the period 2005 to 2010, is key to understanding the case for allowing the full outturn capital expenditure.
2. Section 4 contains a description of the September 2006 Cost Plan for €609m which CAR has relied on in making an assessment of what capital expenditure should be allowed. This section sets out what was included in the cost plan (including the contingency allowance) and explains why CAR should not rely on this cost plan alone when making their assessment of allowable expenditure.
3. Section 5 explains in detail how the outturn expenditure related to the cost plan and explains the circumstances of how costs over and above the cost plan were incurred during the project.
4. Section 6 provides a point by point response to CAR's assessment cross referencing other Sections of the Report.

2.2 Relevant Sections of CAR's Draft Determination

Extract from CAR Determination May 2014

1. *(Ref 6.5) To derive the opening RAB, we have disallowed €183m of outturn capital expenditure that DAA incurred building Terminal 2 and during the period 2010-2014. In reconciling outturn capital expenditure with allowances set previously, the RAB Roll Forward Principles guided us. These were published in 2009, and we continue to believe that such principles protect current and future users from cost overruns on capital projects, while allowing the efficient development of the airport. We reject the suggestion of DAA, in its response to the Issues Paper, that we should disregard the principles as they are unduly penal. We believe that it is reasonable that expenditure above the allowance is only allowed into the RAB where:*
    - *costs changed due to changes in user requirements, and users were aware of and agreed to the higher costs; or*
    - *costs are strictly outside of DAA's control.*
2. *(Ref 6.6) We have allowed €773m of DAA's outturn expenditure on Terminal 2. This is the same as the 2007 allowance, but only about 83% of what DAA spent on the project.*

3. *(Ref 6.7) The 2007 interim review set the capital expenditure allowance for Terminal 2. It also outlined the approach to remuneration using a two-box solution. When the 2009 Determination was made Terminal 2 was not yet operational so reconciling spending to allowances was deferred until this Determination.*

4. *(Ref 6.8) DAA provided a report by AECOM that explains the cost variations in the Terminal 2 capital investment program. Less than 10% of the cost overrun is attributed to responding to user requirements (where the definition of user includes DAA itself); the rest is attributed to non-discretionary items.*

5. *(Ref 6.9) The explanations provided for the cost overrun have not prompted us to revise upwards the allowance for Terminal 2 capital expenditure allowed into the RAB. There is no evidence that users, which for our purposes does not include DAA, were made aware that changes they sought would result in higher costs and still supported the work proceeding after allowing for the extra costs. Moreover, we would be looking for evidence that the generality of users supported a chance of scope. It is to be expected that individual users might seek improvements if they think other users' requests and assume the regulator will require other users to bear the costs.*

6. *(Ref 6.10) DAA's reconciliation moves from its 2006 cost plan to a control budget onto outturn costs. Our July 2007 Interim Review Determination focussed specifically on the issue of what allowances we should make for a substantial capital investment program proposed by DAA, most of which related to the cost of a new terminal. The allowance that we ultimately made for Terminal 2 was about 5% less than DAA had sought in its original cost plan. Shortly after the Interim Review, DAA appears to have adopted a control budget for Terminal 2 18% higher than this allowance. The whole purpose of the Interim Review and setting an allowance for the project would be undermined were we allow the regulated entity to unilaterally increase the budget like this and expect to recover the extra costs from users.*

7. *(Ref 6.11) The outturn spend ultimately exceeded DAA's own control budget. AECOM's report claims there were over 8000 change orders and identifies a number of costs that it suggests were outside DAA's control. The question is whether any of the items identified were covered by the original allowance for project and programme contingency costs and/or whether they were risks associated with cost overruns for which the cost of capital already makes implicit allowance. In the case of Terminal 2 overruns we have concluded that they were covered already. None of the costs identified, including those associated with unforeseen environmental costs and planning obligations, appear to have been outside what a contingency allowance might be expected to cover. This contrasts with, for example, the Pier D project where the need to build an elevated walkway following planning restrictions had implications for the overall project budget that no reasonable contingency allowance could have covered.*

8. *(Ref 6.12) The Terminal 2 expenditure that we have allowed will enter the RAQB in two phases, consistent with the 2007 Interim Review. The RAB includes Box 1, €665m, since Terminal 2 is now open. Box 2 will only*

enter the RAB if and when passenger numbers exceed 33mppa. In the 2007 interim review Box 2 was originally set at €108m, with DAA allowed financing costs for it up to 2018. In 2018 the accumulation of financing costs will stop, by which time the amount of Box 2 will have increased to €167m. We have rejected the demands from Aer Lingus and DAA, in their responses to the Issues Paper, to change the split between Box 1 and Box 2 – Aer Lingus wanted us to increase the size of Box 2 while DAA argued all the costs should enter the RAB immediately. The Interim Review set out clearly the basis on which we would allow DAA to recover the costs of the project if it proceeded with building Terminal 2.

3 The story of Terminal 2and Pier E

3.1 Introduction

As a large complex construction project, the Terminal 2 project was an outstanding success because:

1. Safety: It had no serious accidents or fatalities during 10 million man-hours worked. This greatly exceeded typical incident rates in the Irish Industry.
2. Quality: The project was designed, built and commissioned at a consistently high level of quality. It had a trouble-free opening (in contrast to many recent international airport projects) and has performed at a high service level since. It is highly regarded functionally and aesthetically.
3. Programme: The project was designed, constructed, commissioned and opened in less than five years, despite a 1 year planning approval process. By any comparison, including large public projects in Ireland or international airport projects, it was delivered to a fast track programme. It was designed, built and commissioned at a consistently high level of quality, and in conformance to IATA Level of service C, which represents international best practice.

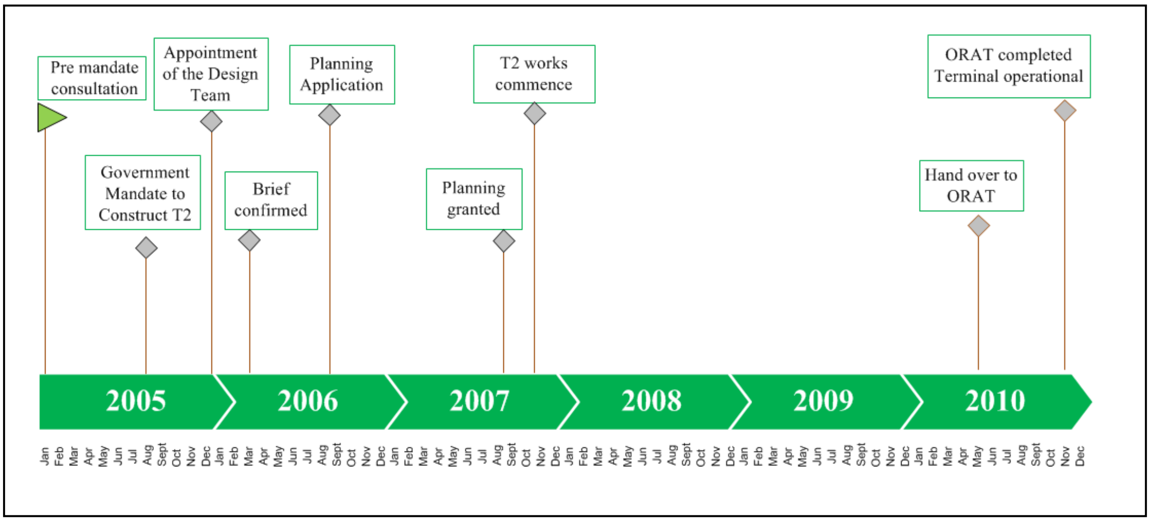
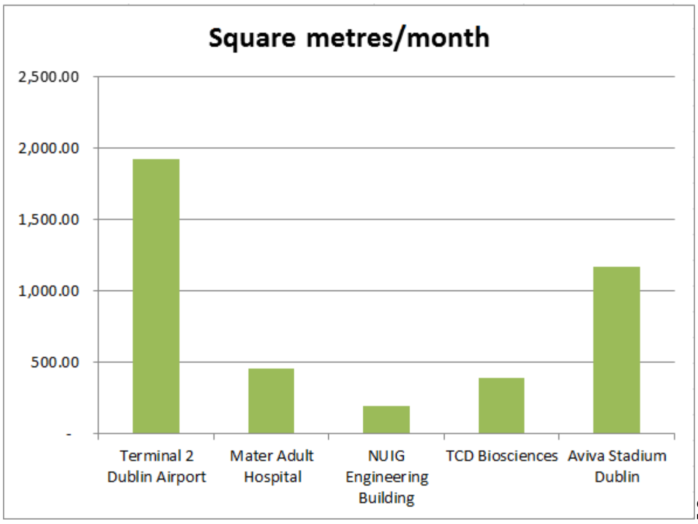
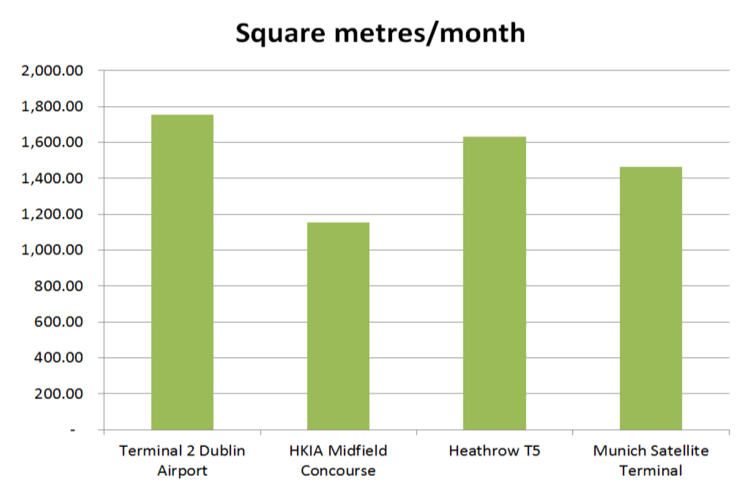


Figure 1

The speed at which the project was delivered is evidenced by the following comparison of Terminal 2 with other large construction projects in the state at the time. It can be seen that the delivery of T2 was indeed "fast-track" and an exemplar of delivering of a large complex construction project as quickly as possible



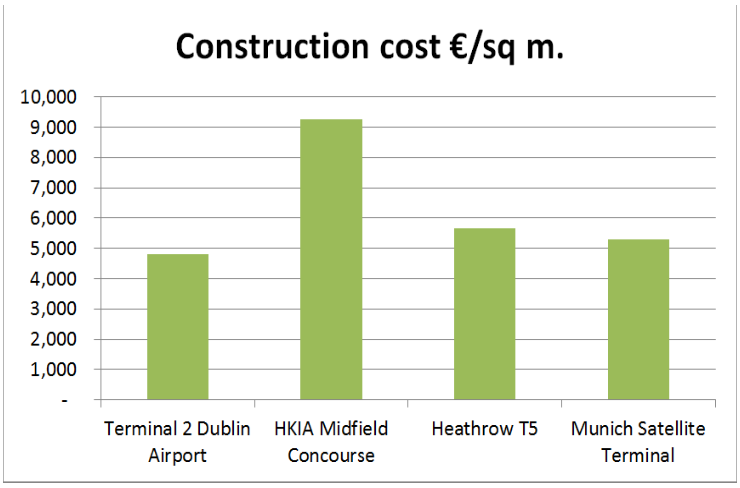
Significant Irish Projects



Aviation Projects

Figure 2

4. Cost: Internationally benchmarked at concept design stage, despite many factors outside the control of the project, it finished only 8% over the original concept design stage cost plan, and represents excellent value for money.



Aviation Projects

Figure 3

All of the above has been recognised in the many awards the project has received and in the very positive public regard for the project since it opened.

This section of the report tells the story of the project in a way that explains the way the outturn cost of the project evolved.

3.2 Government Mandate

In August 2005 the Minister for Transport issued a policy direction to the Commission for Aviation Regulation supporting the construction of a new terminal at Dublin Airport to ensure that the development of the National Aviation Sector would support the national economy. The policy direction indicated the importance of proceeding as quickly as possible with the building of a new pier for aircraft stands and the building of a new terminal.
At that time the project was envisaged to be 50,000 square meters and with an estimated cost of between €150m and €200M, depending of the design. The announcement stated that the terminal would be operational by 2009.

The announcement ended a two year period during which the government was considering who should build the new terminal. The need for a new terminal had arisen as a result of strong growth in passenger numbers at the airport. By the time the decision to proceed was made in mid-2005, the airport was suffering from chronic congestion at peak times, and passenger numbers were still growing at over 10% per annum.

The project proper started in January 2006. The plan for the terminal was based on earlier master-planning work and called for a new 50,000 square metre terminal building on the southern side of the approach road to the existing terminal located in an area occupied by car hire companies and by Corballis House

3.3 Airport Congestion

The announcement ended a period during which the government had been considering whether to ask DAA to build the new terminal or seek a third party to build it. The need for the new Terminal had arisen as a result of a prolonged period of strong growth in passenger numbers at the airport which coincided with a period of strong macro-economic growth in the Irish economy. By the time the decision to proceed was made in mid-2005, the airport was suffering from chronic congestion at peak times and the level of service was well below what would be expected from an international airport that also served as a gateway to Ireland.

3.4 Appointment of Design Team

After the announcement, DAA commenced the public procurement of a design team. This was in place by end 2005 and consisted of Arup (Project Manager and Engineer), Pascall+Watson (Architect), Mace (Construction Manager) and Davis Langdon PKS (Cost Manager). The organogram for the Project team was:

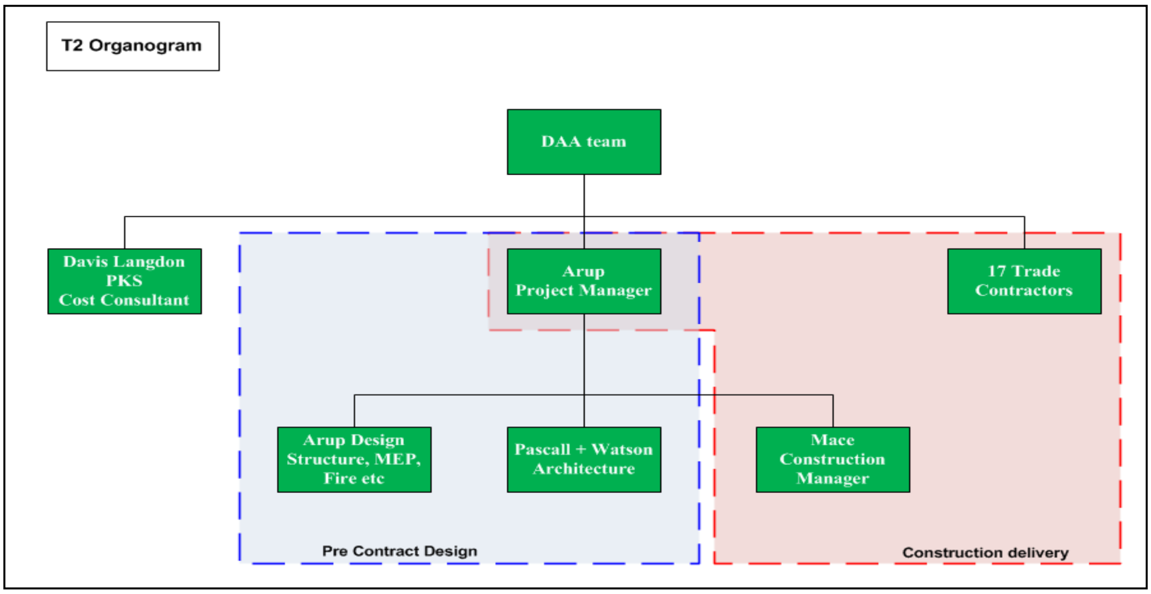


Figure 4

3.5 Development of the Brief

When the design team was appointed, the plan for the Terminal 2 project was based on a master-plan which had been prepared by Skidmore Owings and Merrill (Architect) and PM Group (Engineer) and reviewed and updated by Pascall+Watson (Architect) in mid-2005. The master-plan work envisaged the construction of a 50,000 square metre new terminal building on the southern side of the approach road to the existing terminal located in an area occupied by car hire companies and by Corballis House.

In early 2006, annual passenger numbers were still growing at over 10% per annum, the congestion in the existing terminal building, already chronic at peak times, was getting worse and the Airport Authority had been set a deadline of 2009 to have the new Terminal operational.

It was at this point that the brief for the terminal started to change. DAA's design team commenced a comprehensive stakeholder engagement process which included detailed discussions with Aer Lingus who were emerging as a likely lead tenant for the new Terminal. Aer Lingus were developing quite ambitious growth plans and it quickly became obvious that the proposed 50,000 square metre terminal building would be too small to cater for the expected growth, particularly in the busy hour rate (bhr). There followed a review of the brief which culminated in a recommendation (known internally within DAA as Gateway 1) by the design team in late March 2006 to build the terminal in two phases:

Phase 1:

- Terminal 75,000 approximately square meters
- New Pier: 25,000 approximately square meters

Phase 2:

- Expand Terminal to 92,000 square meters

This recommendation followed an extensive stakeholder consultation process and was accepted by DAA in early April 2006. The T2 Phase 1 design is based on a typical busy hour rate of 4,144 passengers (which was often rounded up to 4,200).

Concept design now started with the next milestone being the submission of a planning application to Fingal County Council. This was achieved in August 2006, just five months later, and directly afterwards the concept design was completed and Cost Plan no 1 was prepared.

It is important to note therefore that by April 2006, DAA was faced with the challenge of building a much bigger terminal, a new pier, and making significantly more changes to the landside and airside infrastructure that had been envisaged even four months before. Passenger numbers were still increasing and there was significant pressure from stakeholders, government and the public to deliver this new infrastructure as quickly as possible.

3.6 Concept Design Stage and Cost Plan

As stated above, it is incorrect to use Cost Plan no 1 as an estimate of likely maximum outturn cost. To understand what was included and not included in Cost Plan no 1 it is necessary to review the procurement and delivery strategy for the project.

As soon as Gateway 1 had been passed and the brief was clear, DAA with its design team proceeded with the concept design of the new facilities. Programme continued to be the key driver and the next key milestone was the submission of a planning application to Fingal County Council. This was accomplished in August 2006 and a decision to grant planning permission was made by the council in October 2006. At this stage also, the Concept Design was completed and approved by DAA (known internally within DAA as Gateway 2) and the Cost Plan (September 2006) supporting the Concept Design was also completed.

Cost Plan No. 1 was developed as a Concept Design stage Cost report based on the information available at that stage. DAA described the Cost Plan in a previous submission as an indicative benchmark:-

> *….the Terminal 2 cost plan prepared by PKS and included as an appendix to the CIP confirms the indicative benchmark for the terminal. (See pages 2 and 8 of the PKS report), i.e. the cost of the terminal, not including fees, planning contributions, etc., is €310m which compares very favourably with the benchmark data and is at the bottom of the range of potential costs shared by the airlines (€308m-€351m).*
>
> **DAA March Statement of case submitted to CAR March 2007**

Cost Plan No. 1 was not an estimate of likely maximum outturn cost, being based on a concept design and the information to hand at the time on material issues outside the control of the project, including site conditions, operational constraints and regulatory factors.

CAR should in fact base their allowance on the project outturn cost, rigorously reviewed against best practice in the procurement and cost management of large complex infrastructure projects, and validate this against appropriate benchmark projects, both in Ireland and abroad (see Figure 3).

3.7 Independent Verifier Review

It was at this stage the Government appointed an independent firm of consultants to verify that the design and cost of Terminal 2 was in line with reasonable international norms. Following this review, the independent verifier confirmed that this was the case and the government gave DAA approval to carry on with the project.

3.8 Project Drivers

In parallel with the concept design stage, DAA and the design team were considering the programme constraints for the project and how best to meet these through the procurement of the construction and commissioning of the new facilities. Speed of delivery was the key driver for the project as passenger numbers were still increasing and the chronic congestion at the existing terminal continued to cause concerns.

In any large and complex construction project, there is a trade-off between the three drivers of quality, early cost certainty and speed of delivery. Safety is also a key driver for construction projects but this is seen as a given and therefore not negotiable in consideration of cost and programme. Taking safety as a given, the other three drivers can be represented as a triangle as shown below and the project strategy will inform where the trade-offs would occur.

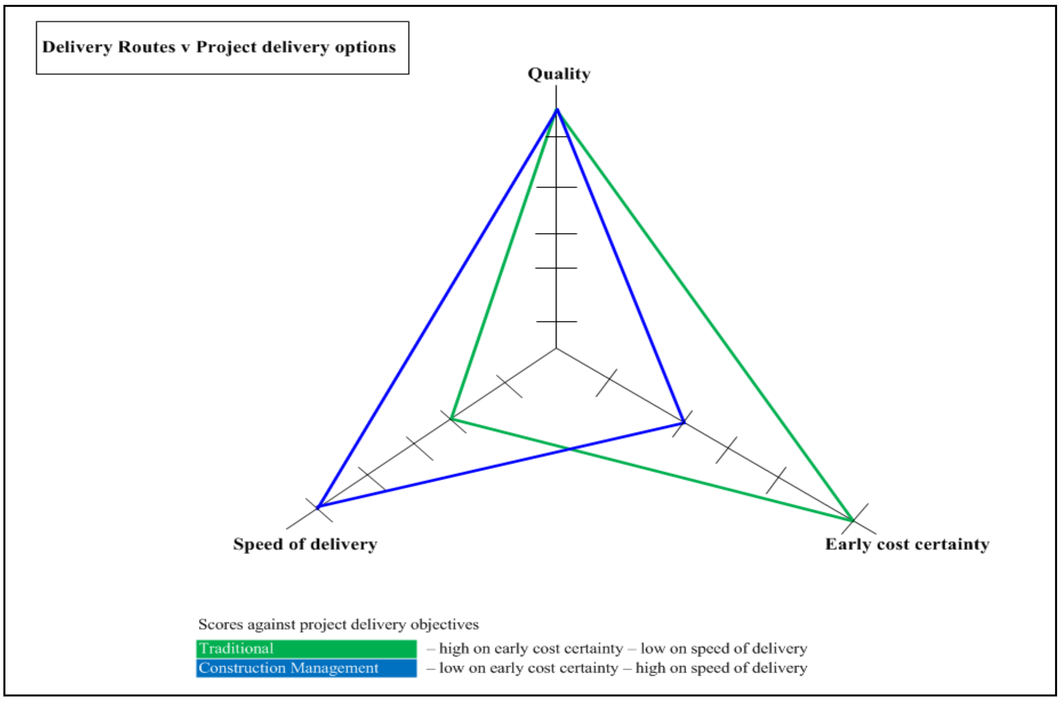


Figure 5

In looking at the options, it was obvious that there was a trade-off between speed of delivery and cost certainty.

In construction projects, cost certainty increases as the level of detail of the design increases. In "traditional" procurement, a fully detailed and integrated design is completed before prices, or "tenders", are sought from the market. Following this route gives earlier cost certainty, as there is no further design to be completed, and other variables can be investigated and well defined and then covered by a project contingency. However, a review of the time it would take for the project to be completed using this approach showed that it could be mid 2012 before the terminal was operational, three years beyond the original target opening date. This was considered to be unacceptable by DAA and the government. (The Terminal was actually opened in 2010, only one year later than the original target date set for a much smaller terminal).

This construction management strategy meant that cost certainty would gradually increase as the project progressed. This is not the same as saying that cost control was not a priority. In fact, as we will see later, strict cost control processes were used on the project. In addition, because of the importance of cost as a project driver to DAA and the stakeholders, a procurement strategy was adopted with the aim of reducing uncertainty around the outturn cost as quickly as possible whilst progressing with the project on site.

In a construction management approach, the total of the contract sums for the packages does not and cannot be equal to the anticipated outturn construction cost. This is because when these packages have been bought, the Client has not bought all the works necessary to complete the project.

For DAA and the government, an internationally acceptable level of quality was a non-negotiable driver. The terminal was to be designed, constructed and commissioned to appropriate international quality benchmarks such as those published by IATA. The level of service chosen for the new Terminal was Level of Service C, which is considered to be the minimum acceptable standard for new airport facilities. Once this quality benchmark was set, the remaining drivers remained those of cost and programme.

3.9 Programme and Procurement

A review of the time it would take for the design to be completed to a "traditional" level showed that it would take at least two years from grant of planning permission to be ready to commence construction and that, allowing for a three year construction and commissioning period and a further six months for Operational Readiness and Transfer (ORAT), it could be mid 2012 before Terminal 2 was operational.

Bearing in mind the government's wish that the new facility be operational in 2009, this was considered to be unacceptable. It was therefore decided to do two things:

- Progress the detailed design in parallel with the planning process, recognising that there was a risk that some re-design might have to be carried out after planning permission was granted.

- Develop a "fast-track" procurement strategy that would allow detailed design and construction/commissioning to progress in parallel.

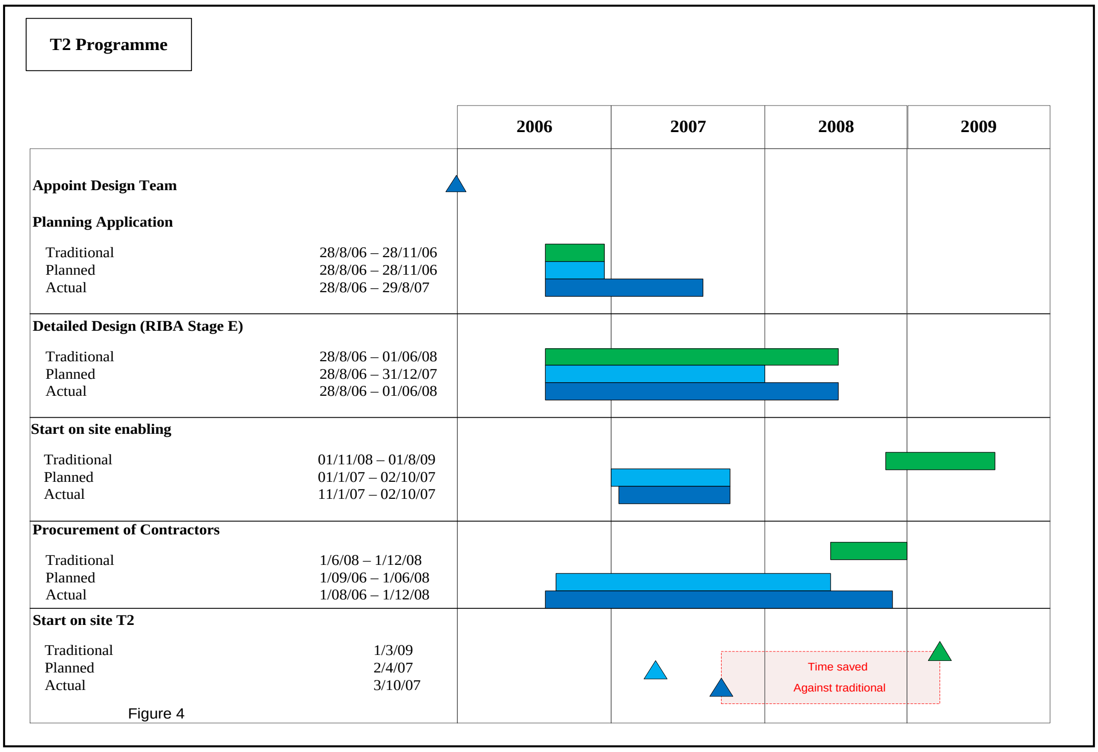


Figure 6

Through this approach the project was completed and the terminal was operational by the end of 2010, just over four years after completion of concept design and approximately 1.5 years sooner than if a traditional approach had been chosen

3.10 Construction Management approach

The procurement strategy that was eventually agreed was a form of what is called “construction management” where a series of contractors are appointed as soon as the design for that element of works is completed. A construction management approach can be implemented to varying levels of granularity. The number of contracts or “packages” can be up to 100 or more in this approach. On the Terminal 2 project, the preferred approach was to use between 5 and 20 contractors to complete the works. This decision was influenced by the need to use the OJEU procurement process for the project and by the desire to buy out as much construction interface and coordination risk in a competitive process while still driving the programme. (The project was actually built using 17 packages).

This was deemed to be the best balance between early delivery and keeping to a minimum the resources and costs associated with managing a large number of contractors many of whom would be working in parallel on the construction site.

The Trade contract packages were procured between the end of 2006 and 2008.

The timeline of the Contractor start dates was:-

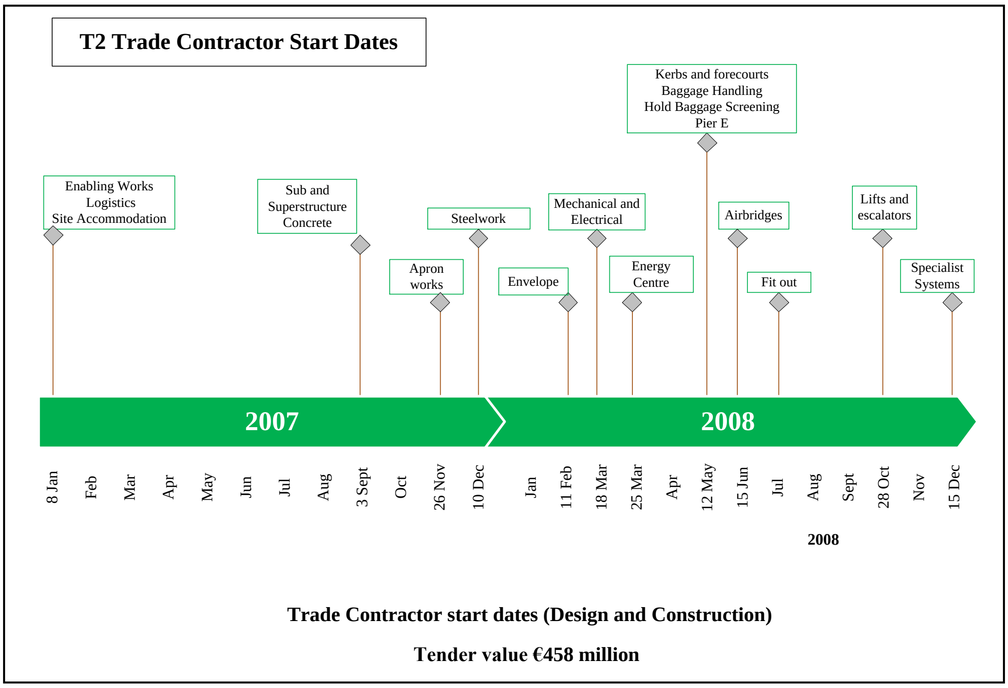


Figure 7

3.11 Implications of Construction Management approach on outturn cost

While the construction management approach ensured that the project was completed as quickly as possible, prioritising this driver and maintaining the required level of quality, meant that early cost certainty had to be sacrificed. This is not the same as saying that cost control was not a priority. That the outturn cost was only 8% more than the original controlled budget would be considered an excellent result by international standards, bearing in mind the scale and complexities of the project. But it meant that when the September 2006 Cost plan was finalised, it was just not possible to know what the final cost would be.

To fully understand this, it is necessary to review how the construction management process worked in practice and this has been described in previous submissions. It is also necessary to understand that role that the contingency sum and inflation played in the cost plan.

3.12 Contingency Sum (Sept 2006 Cost Plan)

In a construction management approach, the total of the contract sums for the individual contracts does not and cannot be equal to the anticipated outturn construction cost. This is because even when these packages have been bought on the market, the Client has not bought all of the works necessary to complete the project. As an integrated design has not been completed, there may be elements that are not yet defined when the packages are bought. Also, the Client takes on the interface and logistics risk for the packages in the sense that he must still pay the costs of these additional elements as the project progresses.

On the Terminal 2 project, an extensive probabilistic risk based contingency calculation was carried out in Sept 2006 which set the contingency at approximately 15%. This was based on the best information available at the time, when the concept design had yet to be completed and well before the planning and other regulatory processes had been completed, the operational interfaces had been worked out and the construction sequencing and logistics finalised. Many of these factors were outside DAA’s control and continued to be throughout the project.

3.13 Construction Inflation

As discussed in previous submissions, best procurement practice is to buy out inflation risk when entering into a construction contract. Not doing so would introduce a significant additional and complex variable into the valuation of works which is often difficult to conclude without this factor being involved.

Therefore all of the packages bought on the T2 project had construction inflation within the contract sums. The subsequent reduction in CPI was completely outside DAA’s control and unforeseeable when they bought the packages on the Irish construction market.

It is worthwhile to consider how you might minimise the downside risk around construction inflation while still maintaining a best practice approach. This would involve buying construction works as close as possible to the time when they will be carried out and on a project of the scale of Terminal 2 would have involved buying the works in much smaller packages through the project. This would have driven the project towards a much “purer” form of construction management, with say in excess of 100 packages. Even so, this would have only been possible for the building works elements. Many of the packages involved the purchase of large items of specialist equipment with long lead-in times and in these cases buying well in advance of installation could not have been avoided. Other packages involved buying contractor design to save time and waiting for the design team to complete detailed design would have introduced delays and further interface risk.

The main reason for not choosing this approach is that it involves a much more extensive and costly management effort to coordinate and deliver the required quality for the project. It also increases the interface (programme and cost) risks arguably by an order of magnitude and could have led to a significantly higher outturn cost and a later delivery of the project.

The Construction Cost Index published by the SCSI shows that construction costs were increasing to an index peak of 303.7 in the third quarter of 2008. By this time, all but two of the trade contractors had started work and therefore there would have been little, if any, benefit in terms of inflation risk buy-out if this approach had been adopted.

See SCSI Construction Cost Index – Appendix 1

4 Cost Plan No 1 and the Project Contingency

Following the feasibility and Option Appraisal stages and the preparation of the Planning Application, Cost Plan No. 1 was prepared for the project and published on 1 September 2006.

The scope of Cost Plan No. 1 included the construction cost of the Terminal Building, the Check-In Building and Pier E, the associated road and infrastructure works and the apron re-grading. It also included allowances for Professional Fees, Planning Contributions and Project Contingency. The Cost Plan total was

- **€609,364,344 @ August 2006 prices and**
- €569,146,297 @January 2005 prices.

This cost plan did not include for inflation beyond August 2006.

This Cost Plan was reviewed by the Independent Verifier and approved as a reasonable Cost Plan for the project.

The key aspects of the project that were reflected in the Cost Plan were;

- The size and the location of the facility within the campus.
- The retention of Pier C and its incorporation into the new Terminal Building. The extent of demolition and alteration work was not defined at this stage, a provisional allowance was included.
- A planned Construction Schedule from 1 May 2007 to an Operation Completion date of 28 September 2009, a duration of 29 months. This would require an average of almost €19m/month construction output over this period.
- 16 Trade Packages appointed using a Construction Management procurement route.
- Archeological survey and demolition of Corballis House
- The Cost plan was based on the Planning application level of design Development which was Concept design.
- A Quantified Risk based project contingency of €74m

The issues that had still to be resolved over the duration of the project were;

- **Planning permission**. A delay of 24 weeks resulted from an appeal of the Planning decision to An Bord Pleanala. This was reflected in the revised outturn budget of €690m adopted by DAA. This adjustment to the budget for inflation was calculated using best industry practice and an independent view of Construction Inflation.
- **Customs and Border Protection.** Although it was known that the project would incorporate CBP, discussions were required to sign off of the design, construction and handover. This project was separately funded from the T2 budget but the facility was incorporated into Pier E and was delivered in parallel by the T2 Trade Contractors. The implications of this were not clear at Cost Plan stage.

- **Fire Certificate** agreement and issue. The Fire Cert had not been granted for the project. The agreement of the Fire Strategy became protracted and was not resolved until relatively late in the procurement and design process.
- **Procurement of all trade contractors**. A project of this scale and pace was unusual in the Irish Market and would be a challenge in terms of the already overheated nature of the market and the capacity to resource to schedule. These factors were reflected in the tender returns received. Although this was mitigated in part by the international procurement process, there is always a heavy reliance on the local supply chain for labour and plant and the ability of contractors to resource the project adequately was an ongoing challenge at construction stage.
- **Completion of the design from Concept to 100% complete**. Design development carries an inherent risk of additional cost and a design development contingency of 5% was included for this risk. On this project the completion and co-ordination of design overlapped with construction and changes to design required reworking and coordination involving the various Trade Contractors and their supply chains.
- **Development of the construction sequencing, logistics plan and the operational interfaces with the Airport**. The Terminal and Pier were built on the airside/landside boundary and the boundary had to be maintained and secure at all times. Extensive traffic management was required as the passenger numbers to T1 continued to increase. Separate access routes were required beyond the site boundary to minimize the construction traffic on the existing access roads and to maintain access for increased numbers of staff, passengers and deliveries to T1.
- The fit out of the **DAA retail** unit was additional scope to the Cost Plan.

4.1 Project Contingency – a Risk based approach

At the Concept Design stages of a project there are established guidelines for the levels of contingency that are appropriate. As set out in the Aecom report, the established level of contingency for a project at Concept stage is 20 to 30%. This was considered to be a very broad range for a project of this scale.

Because of the particular challenges and the scale of this project it was decided to use the best industry practice and adopt a Quantified Risk Assessment (QRA) model to calculate an appropriate contingency allowance recognizing the unique drivers and features of the project. It was also agreed to continue to use a structured Risk Management process for the duration of the project.

The output of this process is a Risk Register and this is a useful tool to identify, quantify and value the extent of risk and uncertainty. Effective Risk Management also helps the achievement of wider aims such as;

- effective change management
- the efficient use of resources
- better project management
- minimising waste
- and supporting innovation

For Cost Plan No. 1 a Probability model was used. This Monte Carlo QRA simulation enables each variable to be represented by a probability distribution function rather than a single value. It allows impact ranges (e.g. minimum, most likely and maximum), which should be relative to base cost estimates, to be described by probability distributions. All range estimates were made relative to base cost estimates. Minimum and maximum values were plausible and realistic, with at least a 5 percent chance of occurring. The basic process is illustrated in Figure 8.

The reliability of the QRA results is influenced by the choice of probability distributions used to describe each variable's range estimate.

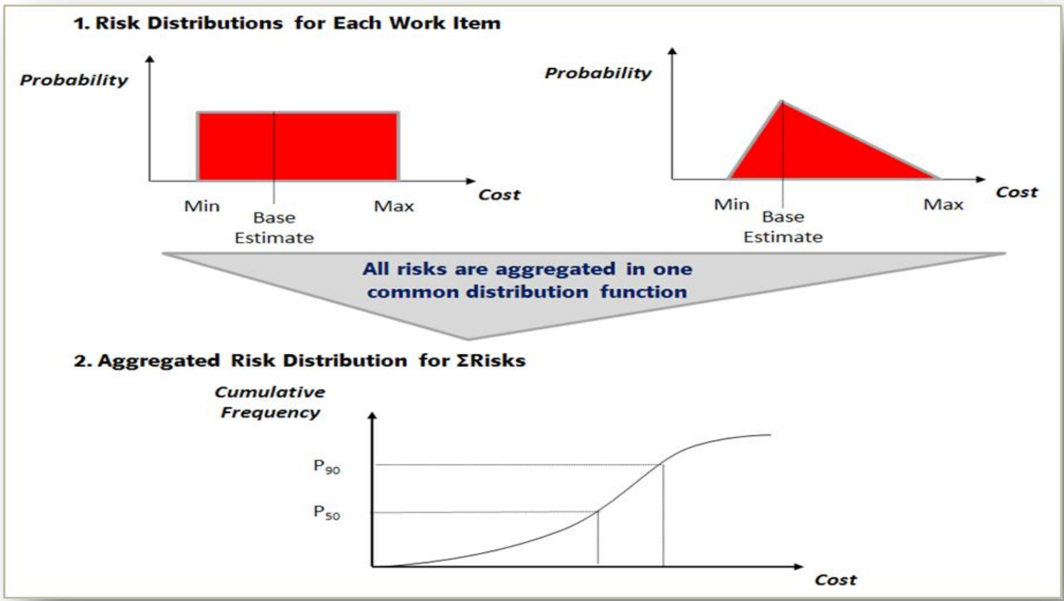


Figure 8 – Monte Carlo Simulation

The Monte-Carlo model was used to generate an appropriate contingency allowance. This considered the likelihood and potential impact of each risk. An 80th percentile allowance of €74m was generated from the Risk Register on T2 which equated to 15% of the construction cost, well within the norms for contingency at this stage of a project. The 80th percentile allowance means that there is an 80% probability that this allowance will be adequate to cover the risks.

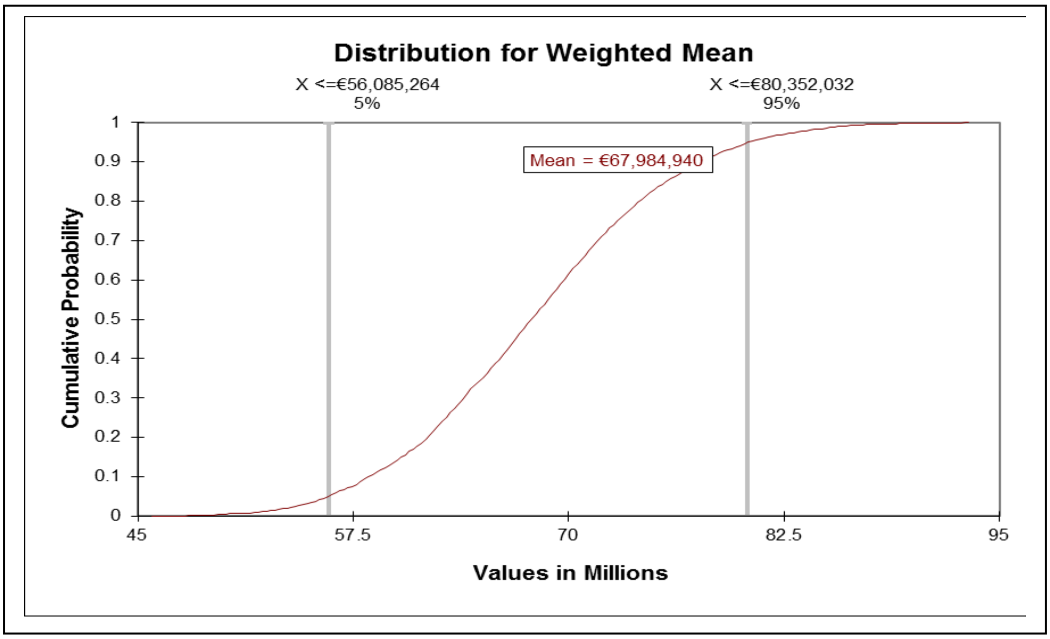


Figure 9

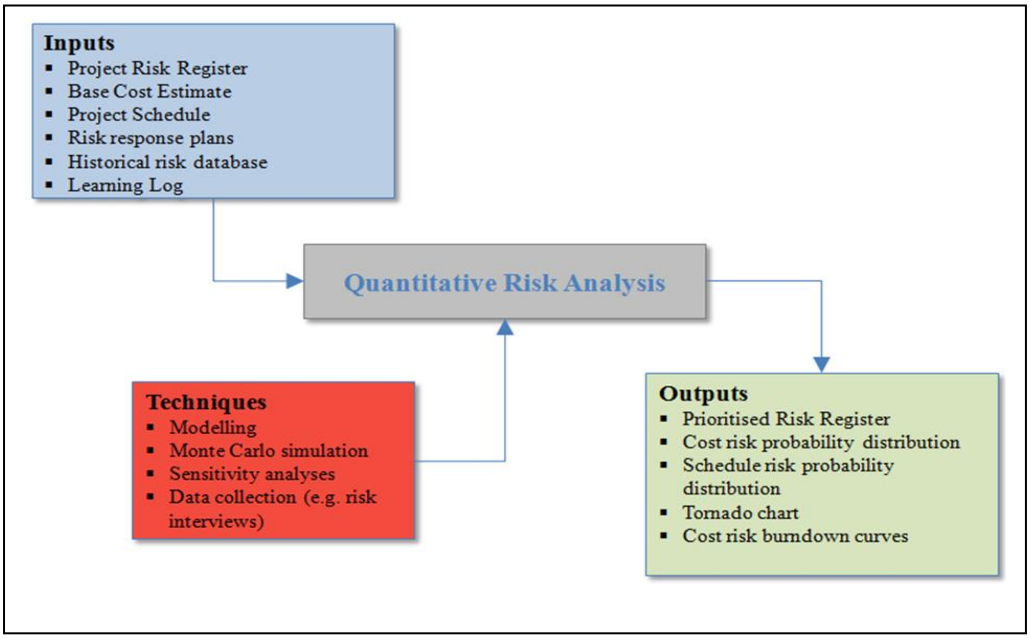


Figure 10

4.2 Risk Management

In addition to identifying each risk, an owner was identified and a mitigation plan put in place to manage the risks.

The report by the Independent verifier covered the construction and project contingencies and noted that the design contingency at 5% was appropriate for this stage and that the Project Contingency is risk based. Comments on the overall Cost Plan including contingency are;

"*The verification team has independently verified the benchmarking exercise and the cost plan and conclude that the estimated cost is within industry norms for this type of project in a European capital city.*"

A rigorous Risk Management process was maintained for the full duration of the project. Once the Trade Packages were more advanced, individual risk registers and mitigation plans were developed for each package so that a total of 16 Package risk registers (excluding Enabling works and Hold Baggage Screening) were managed. There were risk review meetings on each package monthly.

An overall project resister was also maintained for issues that were not package related. The sum of the probability calculation for the package and project risk registers was compared regularly to the remaining contingency to assess the adequacy of the allowances.

Where additions were required to package budgets that were to be funded from contingency, this required a presentation to and the agreement of the Project Board including the Chief Executive and the CFO.

5 How the outturn cost compared to Cost Plan No. 1

5.1 Contingency expenditure

The QRA model for T2 identified risks under a number of categories. These were

- Airport Operations
- Change/Scope change
- Cost
- Ground Conditions
- Procurement Route
- Programme/Schedule
- Stakeholder issues

On the T2 project, a total of €177m of instructions were issued to the Trade package contractors post contract. Of this €61m related to core scope which was not included in the tender packages because of the early procurement strategy. The balance of €116m related to events that were anticipated in the risk register.

The table below shows the allowances from the risk register under each category. We have shown;-

- the "most likely" costs from the model which totals €112.6m
- the "maximum anticipated" costs for the same items which totals €376.3m
- the "Monte-Carlo probability model" costs for the same items of €74m. This indicates that the combination of the likelihood factors applied and the Monte-Carlo modeling anticipated that an 80th percentile figure which was less than the "most likely" total for the items.
- The actual outturn costs which total €116.3m, approx. €4m higher than the predicted most likely costs.

The Monte-Carlo based Risk model for T2 indicated a P80 value of €74m. On a like for like basis the outturn cost of these risks was €116m. The areas of significant movement were

- Interface with airport operations
- The impact of the procurement route and
- Programme/schedule.

The plans for these three aspects of the project were not developed at Cost Plan stage and the actual cost turned out to be higher than the risk allowances. However, the project was carefully managed in line with industry best practice and additional initiatives such as early account close-out with the Trade

Contractors were adopted to minimise the financial risk to DAA of on-going claims and disputes. The account close outs were linked to appropriate cashflow management to ensure the efficient operation of the supply chain.

This table analyses the movement in the figures from the 80th percentile allowance to the actual costs.

	Airport Operations	Change/ scope	Cost	Ground Conditions	Procurement route	Programme /schedule	Stakeholder	Total
	€m	€	€	€	€	€	€	€
Risk register " Most likely cost"	2.2	37.1	12.00	6.70	17.00	37.40	0.20	112.60
Risk register " Maximum cost"	9.0	150.55	25.00	27.00	35.00	128.75	1.00	376.30
Cost Plan Risk Allowance (Monte Carlo probability model) @ 80th percentile	1.44	24.42	7.90	4.41	11.19	24.62	0.13	74.12
Actual outturn cost of Risk items	6.81	19.78	0.00	2.75	17.79	69.12		116.35
Difference from "most likely cost"	4.61	(17.32)	(12.00)	(3.94)	0.79	31.18	(0.20)	3.75
	210%	(47%)	(100%)	(59%)	5%	85%	(100%)	
Difference from "most likely cost x probability"	5.36	(4.61)	(7.90)	(1.65)	6.59	44.59	(0.13)	42.28
	370%	(19%)	(100%)	(38%)	59%	181%	(100%)	

Figure 11

For each category, the main reasons for the risk based expenditure were

1. **Airport Operations** – increased from €1.44m to €6.81m, an increase of 370%.

   a. **Traffic management** was required at all times to protect the safe access to the existing facilities for users. This was provided where possible by mechanical means and signage but traffic marshals were required to actively manage the traffic. It was critical that delays were not caused to passengers approaching the airport causing them to miss flights.

   b. As part of the traffic management strategy a **temporary access bridge** was provided and maintained to the construction compound and site. The peak time for construction workers arriving on site in the morning coincided with the busiest peak in terms of passenger numbers. The movement of operatives from the bus drop off areas to an effectively land locked site could not impact on traffic flows and so a steel pedestrian bridge was required to provide safe access.

   c. **Temporary roads** were required. Construction traffic used a dedicated haul road from the delivery compound across the R132. Also, to maintain traffic flows while the permanent bridge was constructed over the T1 access road, a temporary road was constructed through the check-in site. This allowed work to progress on the maximum number of work fronts to protect the construction programme.This road was removed once the T1 access road was opened again.

2. **Scope/change** – reduced from €24.4m to €19.8m, a reduction of 19%. There were a number of scope changes that were outside the control of DAA and had a major impact on the design and construction schedule.

   a. **South Apron Village.** The relocation of the ground handling staff from Pier C was negotiated and a temporary facility was provided called the South Apron Village. This included accommodation and charging bays and was constructed airside which is inherently inefficient due to the security screening required.

   b. **Fire Strategy Changes**. The design of the Fire Strategy for this building was based on Arup's experience and the well tested interpretation of standards of design. Example projects where Arup had successfully negotiated fire strategy solutions included;

      - Apple HQ, Cork
      - Lyric Theatre, Belfast
      - Giant's Causeway Visitor Centre
      - Dublin Airport Pier B connectivity
      - MacDonagh Shopping Centre, Kilkenny

      However, the interpretation of the standards by the Dublin Fire Officer was more onerous and despite lengthy negotiations there came a point where changes had to be made to ensure that a Fire Certificate would be granted before opening. These changes involved additional escape routes and changes to existing routes, revisions to the smoke extract capacity, additional zoning and fire-stopping, additional fire detection points and enhancement of fire rated ductwork.

      The Fire Officer also required a very extensive and time consuming test programme to confirm compliance with the certificate.

      These changes had to be incorporated in to the design and coordinated between the various Trade Contractors who had taken over design and coordination responsibility at this stage. The effect of the change was that time was lost on the schedule and the momentum of the project was interrupted. The knock on effect of these changes and the testing regime was significant delay to the overall project handover.

   c. **Garda National Immigration Bureau (GNIB) Changes**. Following extensive negotiations between DAA and with GNIB it became apparent that the booths provided for immigration would not be fully staffed and the queue area pre immigration would not be adequate. The queue area was designed on the basis of efficient use of the immigration booths. A decision was made to relocate the booths towards the landside boundary at a relatively late stage in the construction works. This impacted the construction schedule significantly.

3. **Ground Conditions** – reduced from €4.4m to €2.75m, a reduction of 38%. The following issues caused additional cost and an impact on the project;

    a. **Removal of existing services**. Despite carrying out the standard surveys of existing services before commencing work on site, additional obstructions were uncovered during the enabling contract. These were services which had been buried in concrete and could not be identified unless they were broken out by hand. Any damage to an existing service could have had an impact on the operation of the airport. The excavation, identification and removal of these uncharted services caused delay to the enabling works. These services had not been sleeved and identified as would have been expected when installed by the statutory service providers such as ESB.

    b. **Asbestos removal**. Asbestos was discovered in the ground during the apron re-grading works. This was removed from site but it caused a delay to the works as there are strict processes for the safe removal of asbestos to a licensed disposal site

    c. **Removal of fuel tanks and contaminated material at car hire**. Part of the scope of the project was to remove the physical facilities for the car hire companies that were located on the site when work began. When the underground fuel tanks were removed it became apparent that there had been significant leakage of fuel from the tanks in to the surrounding ground. All contaminated material had to be tested, disposed of and replaced with suitable fill. This had both a time and cost impact to the project.

4. **Choice of Procurement route** – increased from €11.2 to €17.8, an increase of 59%. The Construction Management route inherently carries more risk for the client than more traditional routes so a significant allowance was included. The issues that arose were;

    a. **Claims for the management of interfaces between package contractors**. Each contractor was given a clear scope of work and an overall project schedule at tender stage and would have made assumptions about access to working areas for the construction stage. A series of daily 7am meetings were arranged with all the contractors to agree the most efficient access arrangements to work faces for the day. There was a need to balance the most efficient working of the site against the contractor's contractual entitlement to delay and disruption payments but there were inevitably claims submitted for additional cost. This is a typical impact of the Construction Management procurement route and was mitigated as far as possible by daily meetings.

    b. Larger than anticipated **Logistics and welfare provision** due to the number of operatives on site and the colocation of client and project teams. At peak the construction spend on T2 was over

€30m per month. This required a large workforce of operatives, a sizeable supervision team and an extended working day. The Logistics package provided plant, delivery management, welfare and catering, waste away and safe work zones and access routes for operatives. The pace of the project required the client and management team to be co-located on site with the Contractor's teams and a mix of temporary buildings and existing building on the Aer Lingus complex were used.

5. **Programme/Schedule** – increased from €24.6m to €69.1m, an increase of 181%.

    a. **Delay and prolongation of Trade Contractors**. The changes that were instructed caused some delay. For many of the contractors, the peak of site activity was 2009, 12 to 18 months after their appointment to the project. The plans for construction scheduling and interfaces with the operational airport were continually developing in conjunction with the contractors. The Trade Contracts facilitate these changes by allowing that the contract sum can be adjusted.

    b. **Prolongation of Logistics and welfare**. When the Logistics Contractor was appointed in December 2006, it was anticipated that construction would be completed in mid 2009. The logistics provision was required throughout the completion, fire testing and commissioning stage and ran up to the Terminal becoming operational in November 2010. This was necessary to ensure the safe and efficient working of the site. Had the Trade Contractors each provided their own Logistics teams and facilities there would have been overlap, congestion and inefficiency and additional cost.

    For example, the Logistics Contractor ran a web-based delivery management schedule so that deliveries to site were managed and controlled across the day at a sensible level. The Trade Contractors booked a delivery slot in advance and could plan around their slot. Any other method would have led to clashes between deliveries from various contractors and their supply chains. Because the site was completing over €1m of value a day, up to 40 or 50% of this value was materials, a substantial amount each day.

5.2 Risk Mitigation

Risk Management requires that mitigation measures are considered for each risk item and this was carried out for the risk register items for T2.

In additional to this, a number of strategic risk mitigation measures were put in place on the project to reduce the exposure to additional cost or delay. These were;

1. **An early Account close-out strategy** was adopted which meant that DAA and the project team sought early engagement on the resolution of the cost of instructions and interpackage claims from the trade contractors. This allowed the closing down of financial risk to DAA and the maintenance of an appropriate cashflow to the supply chain so that resource issues did not

impact productivity. At the end of March 2010, 89% of the Trade Contractor accounts were agreed in principle or approved by the T2 Executive.

It is not unusual on substantial projects with a single Main Contractor to have a large difference between the parties in terms of financial entitlement and this often leads to claims and disputes that run beyond project completion.

For example, the following extract is taken from a publication dated August 2010 in relation to Dublin Port Tunnel.

> *"A protracted period of claims negotiations between the client and the design-build construction consortium of the Dublin Port Tunnel in Ireland has come to a close. A settlement, as recommended by the project's DRB (Disputes Review (or Resolution) Board), is reported as accepted by both parties to end more than* ***three and half years of wrangling since the twin-tube, four-lane highway tunnel opened to traffic in December 2006****. A report in the Irish Times newspaper suggests the final cost of the project, with all claims settled, is €789 million – some* ***€639 million for the final construction cost****, with an addition €100 million for property purchases, and another €50 million for project management, insurance and legal fees.*
>
> *The settlement reached is between Dublin City Council as the owner of the new 5.6km connection to the port, and the Nishimatsu-Mowlem-Irishenco consortium, which won the* ***43-month design-build contract*** *in June 2001.* ***The award tender price was €448 million****"*

2. **Principals meetings** were held regularly between DAA and senior reporesentatives from the Trade Contractors. These facilitated the implementation of initiatives for safety, productivity and account resolution
3. **Co-location**. It was more efficient to maintain site productivity by co-locating Client, Project and Contractor teams on site. The project adopted a "one team for the project" culture which was successful. At Cost Plan stage it was envisaged that each Trade Contractor would have approximately five desks. However, a package such as MEP with a final agreed value of approximately €95 million required a larger team on site including representatives of the Tier 2 suppliers.

4. **Design** – the Project Team established and monitored the contractors' design programme and reviewed design deliverables for completeness and coordination. The project schedule meant that information had to be "right first time" and the team managed compliance with information release schedules with respect to completeness and timeliness. Where Trade Contractors needed additional support with their design management and co-ordination this was provided by DAA to protect the design schedule.

5. **Change Mangement**. The project team change board met at least weekly, then reported on instructions required and sought approval from the Project Steering group weekly. At these meetings the impact of instructions on the different elements of the works were reviewed on a consistent and thorough basis.

   The project established change control processes that addressed the full impact of any change on a package, associated trade contractors and overall schedule. Change control included procedures that strictly defined delegated powers and requirements for client sign-off.

6. **Management of the work** as it proceeds – DAA provided sufficient on-site management resources to co-ordinate package interfaces, to monitor progress and to implement corrective action as required.

7. **Reporting and monitoring**. DAA established Cost reporting processes that closely monitored the impact of instructed changes, backed up by an actively administered risk management process. The scope of progress reporting was extended to include design deliverables and information release schedules.

8. **Logistics management**. The project team monitored packages to avoid the duplicate procurement of site establishment, plant and interface management resources by Logistics and by other trade contractors – not only to save money, but also to ensure that responsibility rested with a single party.

9. **Developing the design for procurement**. DAA ensured that the procurement of trade contractor packages was based on sufficient information to define the full scope of work and all critical interfaces with other packages.

   Pricing documents were prepared in detail to enable the project team to obtain enough price information to support cost reporting and the negotiation of variation costs.

10. **Collaborative working**. There was investment of time and effort by the client and project team into the development of relationships with trade contractors, including the issuing of instructions, administration of payment and problem solving. In managing these relationships, the project team and the client aimed to achieve a balance between contractual discipline and an appropriate level of flexibility, in order to maintain the commitment and co-operation of trade contractors to the design and construction schedule.

5.3 T2 Expenditure profiles and the impact of delay on a fast moving project

The expenditure profiles for T2 demonstrate the rate of progress that was achieved with a peak average monthly expenditure profile of €25m on construction costs in 2009. To achieve this rate of progress, resource and materials management was required and logistics support had to be maintained to ensure productivity.

The incorporation of change in to such a challenging delivery target would have been very disruptive. DAA did not make significant changes to the scheme, the changes that were required were driven by statutory requirement such as the Fire Certificate.

Where changes were required, the change process had to be agile and reactive and not cause any delays or impacts. Weekly meetings were held to agree instructions to the contractors and the project team including DAA had to make decisions immediately so that any impact of change was minimised. DAA could not await a lengthy process of discussions with all stakeholders before instructing the contractor, this would simply not have been possible.

Based on an average monthly expenditure profile of €25m, one days delay to the site would have cost the project €1m of lost production plus the overtime premium of completing the work out of hours to recover the time.

Figure 12

6 Response to the draft Determination

Summary of the response to the points raised by daa

Extract from CAR Determination May 2014

1. *(Ref 6.5) To derive the opening RAB, we have disallowed €183m of outturn capital expenditure that DAA incurred building Terminal 2 and during the period 2010-2014. In reconciling outturn capital expenditure with allowances set previously, the RAB Roll Forward Principles guided us. These were published in 2009, and we continue to believe that such principles protect current and future users from cost overruns on capital projects, while allowing the efficient development of the airport. We reject the suggestion of DAA, in its response to the Issues Paper, that we should disregard the principles as they are unduly penal. We believe that it is reasonable that expenditure above the allowance is only allowed into the RAB where:*
    - *costs changed due to changes in user requirements, and users were aware of and agreed to the higher costs; or*
    - *costs are strictly outside of DAA's control.*
2. *(Ref 6.6) We have allowed €773m of DAA's outturn expenditure on Terminal 2. This is the same as the 2007 allowance, but only about 83% of what DAA spent on the project.*

For aviation projects, the established principles that are applied by, for example CAA, are to allow overruns against budget where projects have been properly managed and every effort have been made to mitigate risk during all stages. The correct basis for the determination of the costs of T2 is the outturn cost and not Cost Plan 1 which was a Concept Stage estimate with many aspects of the delivery of the project still unknown.

The T2 project had particular challenges around delivering a complex project in a live airport environment in as short a timescale as possible, a nine month delay to the Planning process and changes required to obtain a Fire Cert. However, the appropriate delivery strategy was adopted, the project was carefully managed, risks were mitigated where this was possible and the project was delivered within 8% of the initial Concept Cost Plan. The project was a success in all aspects including its financial management and this should be reflected in the CAR Determination.

CAR should also allow the estimate made for construction inflation at the time of Cost Plan no 1. The inflation calculation was based on construction inflation forecasts at the time and the risk of construction inflation was passed to the Trade Contractors at tender stage. These tenders were generally returned in 2007, at the peak of construction inflation in the Irish market and DAA received no benefit from the reduction in inflation that transpired after 2008. This approach is in line with other projects in the Irish market and internationally.

3. *(Ref 6.7) The 2007 interim review set the capital expenditure allowance for Terminal 2. It also outlined the approach to remuneration using a two-box solution. When the 2009 Determination was made Terminal 2 was not yet operational so reconciling spending to allowances was deferred until this Determination.*

Response from DAA

4. *(Ref 6.8) DAA provided a report by AECOM that explains the cost variations in the Terminal 2 capital investment program. Less than 10% of the cost overrun is attributed to responding to user requirements (where the definition of user includes DAA itself); the rest is attributed to non-discretionary items.*

5. *(Ref 6.9) The explanations provided for the cost overrun have not prompted us to revise upwards the allowance for Terminal 2 capital expenditure allowed into the RAB. There is no evidence that users, which for our purposes does not include DAA, were made aware that changes they sought would result in higher costs and still supported the work proceeding after allowing for the extra costs. Moreover, we would be looking for evidence that the generality of users supported a chance of scope. It is to be expected that individual users might seek improvements if they think other users' requests and assume the regulator will require other users to bear the costs.*

   On the T2 project, a total of €177m of instructions were issued to the Trade package contractors post contract. Of this €61m related to core scope which was not included in the tender packages because of the early procurement strategy. The balance of €116m related to events that were anticipated in the risk register.

   Apart from the changes to the brief, the biggest impact on the project programme was the delay to the Planning process. A positive decision was received from Fingal but this was appealed to An Bord Pleanala and a final decision was received in August 2007, a delay of 9 months. DAA carried on with the design development and the procurement of packages during this time and enabling works were started on site, therefore the delay was migrated as much as possible and the construction of the Terminal building which was scheduled to start on 2 April 2007 commenced on 3 October 2007, 6 months late.

   The other major impact came from significant changes, relatively late in the construction and design stage, as a result of negotiations with the Fire Officer on the Fire Strategy for T2. The terminal and Pier could not open to the public until a Fire Cert had been issued. The Fire Officer took an onerous view of the guidance and regulations and, despite Arup having successfully designed and implemented other projects in accordance with our interpretation of the codes, additional fire safety measures were insisted upon. The Project team could have engaged in a protracted process of justifying the Arup interpretation of the codes to the Fire Officer and trying to win him over to our view. On other projects where time was not the primary driver this would have been the approach. For this project, in the interest of completing and opening the buildings, daa agreed to the additional measures and instructions were issued to the Trade Contractors which caused a significant delay and financial impact to the project.

6. *(Ref 6.10) DAA's reconciliation moves from its 2006 cost plan to a control budget onto outturn costs. Our July 2007 Interim Review Determination focussed specifically on the issue of what allowances we should make for a substantial capital investment program proposed by DAA, most of which related to the cost of a new terminal. The allowance that we ultimately made for Terminal 2 was about 5% less than DAA had sought in its original cost plan. Shortly after the Interim Review, DAA appears to have adopted a control budget for Terminal 2 18% higher than this allowance. The whole purpose of the Interim Review and setting an allowance for the project would be undermined were we allow the regulated entity to unilaterally increase the budget like this and expect to recover the extra costs from users.*

   It is submitted that CAR have incorrectly used Cost Plan no 1, issued in September 2006, as a regulatory budget, considering any spend over and above the estimate included in Cost Plan no 1 to be "overspend", while setting onerous and impractical conditions on allowing any expenditure not included within Cost Plan no 1.

   It is further submitted that Cost Plan no 1 was not an estimate of likely maximum outturn cost, being based on a concept design and the information to hand at the time on material issues outside the control of the project, including site conditions, operational constraints and regulatory factors.

   CAR should in fact base their allowance on the project outturn cost, rigorously reviewed against best practice in the procurement and cost management of large complex infrastructure projects, and validate this against appropriate benchmark projects, both in Ireland and abroad.

7. *(Ref 6.11) The outturn spend ultimately exceeded DAA's own control budget. AECOM's report claims there were over 8000 change orders and identifies a number of costs that it suggests were outside DAA's control. The question is whether any of the items identified were covered by the original allowance for project and programme contingency costs and/or whether they were risks associated with cost overruns for which the cost of capital already makes implicit allowance. In the case of Terminal 2 overruns we have concluded that they were covered already. None of the costs identified, including those associated with unforeseen environmental costs and planning obligations, appear to have been outside what a contingency allowance might be expected to cover. This contrasts with, for example, the Pier D project where the need to build an elevated walkway following planning restrictions had implications for the overall project budget that no reasonable contingency allowance could have covered.*

For this project it was necessary to develop a “fast-track” procurement and delivery strategy which would overlap as many of the project activities as was possible.

The procurement and delivery strategy chosen to accomplish this was a form of what is called “construction management” where separate contractors are appointed to carry out different “packages” of construction work in sequence following completion of the design of those packages. This allows the foundation works to be constructed while the detailed design of the terminal IT systems or fit-out is being carried out for example. The overall design concept is used to ensure that the different packages “fit” together as construction advances.

This construction management strategy meant that cost certainty would gradually increase as the project progressed. The construction packages are bought before a fully detailed and integrated design has been completed and other elements are not fully defined. The Client takes on many of the risks that could be bought out in a traditional approach such as environmental and ground conditions risk, logistics risk, interface risk between the packages and with the live airport environment, and regulatory risk.

It is these non-design risks which are particularly significant in the case of the Terminal 2 project. Constructing a new terminal and pier together with new landside and airside access infrastructure, in essence a new airport facility, in the middle of a live, congested operational airport environment is a highly complex and risky undertaking. And these risks were not yet fully understood or defined when Cost Plan no 1 was made in September 2006.

However, it was decided within Cost Plan no 1 to make an initial estimate of the cost to the project of these risks which would not be bought out within the packages. This was described in the Cost Plan as a project contingency and it was based on a comprehensive risk appraisal of the project covering all the known and anticipated risks and a probabilistic Monte-Carlo model. This resulted in a Project contingency figure equal to approximately 15% of the total estimated cost of the packages included in Cost Plan no 1.

It is important to understand that the contingency was not intended to represent an estimate of the likely maximum cost of the risks. It was the starting point for a risk management exercise that was continued throughout the project as part of the strict cost control processes already referred to. Projects of the scale of Terminal 2 typically have contingencies in the range 20% to 30% assigned to them at concept design stage in order to anticipate their maximum outturn cost. The 15% contingency included in Cost Plan no 1 is well below this range.

The Monte-Carlo based Risk model for T2 indicated a P80 value of €74m. On a like for like basis the outturn cost of these risks was €116. The areas of significant movement were

- Interface with airport operations
- The impact of the procurement route and

- Programme/schedule.

These items were identified on the risk register, however the probability factored allowances made at Cost Plan No. 1 stage were less than outturn costs because of the continued increase in airport traffic, the management of the interfaces between contractors and the delays caused to the project due to Planning and Fire Cert issues.

8. *(Ref 6.12) The Terminal 2 expenditure that we have allowed will enter the RAQB in two phases, consistent with the 2007 Interim Review. The RAB includes Box 1, €665m, since Terminal 2 is now open. Box 2 will only enter the RAB if and when passenger numbers exceed 33mppa. In the 2007 interim review Box 2 was originally set at €108m, with DAA allowed financing costs for it up to 2018. In 2018 the accumulation of financing costs will stop, by which time the amount of Box 2 will have increased to €167m. We have rejected the demands from Aer Lingus and DAA, in their responses to the Issues Paper, to change the split between Box 1 and Box 2 – Aer Lingus wanted us to increase the size of Box 2 while DAA argued all the costs should enter the RAB immediately. The Interim Review set out clearly the basis on which we would allow DAA to recover the costs of the project if it proceeded with building Terminal 2.*

   See Item 3 above.

Appendix A

SCSI Construction Cost Index

SOCIETY OF CHARTERED SURVEYORS IRELAND

SOCIETY OF CHARTERED SURVEYORS IRELAND

QS Data Sheet

Construction Cost Index

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Jan	185.0	211.0	232.5	237.9	246.2	260.0 (R)	269.1	284.4	297.0	300.2	298.9	304.1	299.7 (P)	302.19 (P)	
Feb	185.5	211.8	232.6	238.0	247.8	260.1 (R)	269.8 (R)	284.4	298.2	298.5	299.4	295.7	300.1 (P)	302.68 (P)	
Mar	186.2	213.2	231.5	238.0	249.5	260.2 (R)	270.6 (R)	284.7	298.7	297.8	299.3	295.3	300.5 (P)	302.96(P)	
April	186.4	215.8	231.6	242.2*	251.4	262.4 (R)	275.9 (R)	286.8	300.2	297.4	300.5	296.0	301.3 (P)	302.96 (P)	
May	187.0	215.8	231.6	242.2*	252.7	262.7 (R)	276.3 (R)	287.4	301.3	296.9	302.7	297.0	301.8 (P)	302.85 (P)	
June	187.1	215.8	231.7	242.2*	253.0	262.8 (R)	276.9 (R)	288.0	302.0	296.4	302.4	296.8	301.7 (P)	303.21 (P)	
July	187.4	220.0	237.6	242.5	255.0	263.6 (R)	277.3 (R)	291.3	303.1 (R)	296.4	303.9	299.3	302.1 (P)	303.29 (P)	
Aug	187.5	227.1	237.7	242.5	255.6	264.0 (R)	277.3 (R)	292.1	303.7 (R)	296.4	304.3	298.6	301.8 (P)	303.92 (P)	
Sept	188.2	227.2	237.7	242.5	255.9	264.6 (R)	278.5 (R)	292.3	303.7	296.5	304.3	298.8	301.2 (P)	304.06 (P)	
Oct	210.4	232.2	237.7	242.5	258.6	268.7 (R)	282.5	292.4	303.7	297.1	303.3	298.8	301.5 (P)	304.30 (P)	
Nov	210.4	232.2	237.7	242.5	259.2	268.6 (R)	282.9	292.8	303.5 (R)	297.2	303.2	299.2	301.7 (P)	304.27 (P)	
Dec	210.5	232.1	237.8	242.5	259.8	268.7 (R)	283.3	293.3	302.0	297.2	303.5	299.5 (P)	302.28 (P)	303.61 (P)	

Notes: January 2004 to September 2005 – these figures have been revised from those previously published (Marked R).
* April /May/June 2003 figures revised to include backdated increase of 3% from 1st April 2003 under The Sustaining Progress National Agreement.
It is emphasised that the index is based on costs and therefore does not necessarily reflect Tender Prices. The Indices should not be used for projecting Tender Prices without taking into account all relevant factors. The Index numbers exclude VAT. The Index is issued for the Guidance of Quantity Surveying members of the Society.

Where figures are marked (P) these are provisional. These figures are reviewed bi-annually to check labour and material cost increases and any back-dated increases which may be applicable.
(R) Revised

Appendix B

Inflation Calculation

OUTTURN COST ESTIMATE _ TERMINAL 2 Revision A

PACKAGE	Costs @ MID POINT 2006 levels						Out-turn	1.00	1.05	1.10	1.16	1.22		Transfer to Enabling for disruption/ delay	Revised Total
	revised 06	**revised 07**	**revised 08**	**revised 09**	**revised 10**	**revised total**		**2006**	**2007**	**2008**	**2009**	**2010**	**TOTAL**		
Package 1		3,200,000	3,200,000			6,400,000		0	3,360,000	3,528,000	0	0	6,888,000		6,888,000
Package 2		3,104,797	6,209,593	6,209,593	3,104,797	18,628,779		0	3,260,036	6,846,076	7,188,380	3,773,900	21,068,392		21,068,392
Package 3		5,130,502	0	0	0	5,130,502		0	5,387,027	0	0	0	5,387,027	1,000,000	6,387,027
Package 4		6,572,752	11,516,404	4,943,652	0	23,032,807		0	6,901,390	12,696,835	5,722,895	0	25,321,119		25,321,119
Package 5		6,812,256	19,976,015	13,163,759	0	39,952,029		0	7,152,868	22,023,556	15,238,697	0	44,415,121		44,415,121
Package 6		5,128,107	24,563,671	19,435,564	0	49,127,341		0	5,384,512	27,081,447	22,499,094	0	54,965,053		54,965,053
Package 7		0	13,421,463	17,256,166	3,834,704	34,512,332		0	0	14,797,162	19,976,169	4,661,106	39,434,438		39,434,438
Package 8		2,255,933	22,058,006	22,809,984	3,007,910	50,131,832		0	2,368,729	24,318,952	26,405,407	3,656,133	56,749,221		56,749,221
Package 9		2,009,086	26,759,086	43,387,280	18,637,280	90,792,731		0	2,109,540	29,501,892	50,226,199	22,653,730	104,491,362		104,491,362
Package 10		0	1,837,733	3,062,889	1,225,156	6,125,777		0	0	2,026,101	3,545,676	1,489,184	7,060,961		7,060,961
Package 11		0	4,606,418	4,606,418	0	9,212,835		0	0	5,078,575	5,332,504	0	10,411,079		10,411,079
Sub-total - terminal						**333,046,965**		**0**	**35,924,103**	**147,898,596**	**156,135,021**	**36,234,053**	**376,191,774**	**1,000,000**	**377,191,774**
Package 12		475,213	2,172,402	3,326,490	1,629,301	7,603,405		0	498,974	2,395,073	3,850,827	1,980,426	8,725,299		8,725,299
Package 13		0	17,874,760	33,763,436	15,888,676	67,526,872		0	0	19,706,923	39,085,398	19,312,785	78,105,105		78,105,105
Package 14		0	0	5,278,142	9,802,263	15,080,404		0	0	0	6,110,109	11,914,711	18,024,820		18,024,820
Sub total - Pier E						**423,257,646**		**0**	**36,423,077**	**170,000,592**	**205,181,355**	**69,441,975**	**481,046,998**	**1,000,000**	**482,046,998**
Package 15		0	7,821,764	14,221,389	6,399,625	28,442,778		0	0	8,623,495	16,463,035	7,778,784	32,865,314		32,865,314
Package 16		1,897,288	11,380,263	9,482,975	0	22,760,525		0	1,992,152	12,546,739	10,977,728	0	25,516,620		25,516,620
total - Construction budget						**474,460,949**		**0**	**38,415,229**	**191,170,826**	**232,622,119**	**77,220,759**	**539,428,933**	**1,000,000**	**540,428,933**
Public Art				35,000	35,000	70,000		0	0	0	40,517	42,543	83,060		83,060
Fees						0		0	0	0	0	0	0		0
Fees 1	8,894,231	17,265,226	10,435,713	4,180,911	2,873,194	43,649,274		8,894,231	18,128,487	11,505,374	4,839,927	3,492,385	46,860,403		46,860,403
Fees 2	200,000	777,500	1,067,500	980,000	771,818	3,796,818		200,000	816,375	1,176,919	1,134,473	938,150	4,265,916		4,265,916
DAA Direct Costs		0	0	0	0	0		0	0	0	0	0	0		0
Security		50,000	150,000	200,000	100,000	500,000		0	52,500	165,375	231,525	121,551	570,951		570,951
displacement tennants		0	500,000	500,000	0	1,000,000		0	0	551,250	578,813	0	1,130,063		1,130,063
Planning Contributions		2,750,000	4,317,084	3,134,167	1,567,084	11,768,334		0	2,887,500	4,759,585	3,628,190	1,904,800	13,180,074		13,180,074
Project Contingency		3,000,000	15,353,167	34,059,500	21,706,334	74,119,000		0	3,150,000	16,926,866	39,428,129	26,384,184	85,889,179	- 1,000,000	84,889,179
		0													
Total						**609,364,375**		**9,094,231**	**63,450,091**	**226,256,194**	**282,503,692**	**110,104,370**	**691,408,578**	-	691,408,578

VOWD figures above have been adjusted above to refect a 6 month delay

Note :

Increase of	17,914,112	relates to 6 month delay (26 weeks)
Actual delay 24 weeks	16,536,103	
Revised outturn	690,030,569	

Appendix C

Cost Plan No 1 Risk Register

ARUP

Terminal 2 Project Risk Capture Form

Probability	Impacts
V High = 5	Severe = 5
High = 4	Major = 4
Medium = 3	Moderate = 3
Low = 2	Minor = 2
V Low = 1	Insignificant = 1

Risk and Opportunity Description														Quantitative Cost Modelling					
Risk ID	High Level Category	Sub-Level Category	Discipline / Work Package / Stakeholder	Work Packages	Phase when risk will occur / impact	Risk or Opportunity Event	Cause	Consequence	Opportunity	Status	Likelihood *current likelihood of occurrence of risk*	Cost	Time	Likelihood	Min	Most Likely	Max	Most likely total	Actual
~~T2_046~~	Design Risks	Standards	Standards			Budget drives reduction in design standards adversely affecting quality	Budget drives reduction in design standards	Effect on quality. Redesign and programme delay	Threat	Closed				0%					
T2_064	Design Risks	Standards	Design responsibility			Derogations from design standards not approved resulting in programme delay and additional cost	Derogations from standards (e.g. Part M) not approved	Programme delay whilst await approvals and additional cost	Threat	Active	1	2	3	5%					
T2_097	Stakeholders	Airlines	Brief			Ryanair lease constrains future Phase 2 development	Ryanair lease constrains future Phase 2 development	Cost of changing lease, programme delay etc.	Threat	Active	1	4	3	5%					
T2_067	Construction	Airport Operational Impact	Phasing			Misconceived construction phasing adversely affects construction access	Operational situation affects construction phasing (e.g. Pier C)	Redesign, cost and programme delay owing to alternative construction sequence	Threat	Active	4	4	4	62%	50,000	1,000,000	5,000,000		
T2_140	Design Brief	Airport Operational Impact	Brief			T1/T2 interoperability issues not considered increases cost and programme delay	T1/T2 interoperability issues not considered	Redesign, additional cost and programme delay	Threat	Active	4	3	2	62%	100,000	500,000	1,000,000		
T2_104	Construction	Airport Operational Impact	Construction		*T2_066, T2_068*	Phased T2 construction works compromise airport operations	Defining relocation of aircraft operations to accommodate T2 phased construction works. Agreement on stand allocation during construction period	Airport operations compromised. Direct cost associated with provision of temporary stands. Programme delay whilst phase construction	Threat	Active	4	4	3	62%	50,000	200,000	1,000,000		
T2_107	Construction	Airport Operational Impact	Construction		*T2_066*	Requirement for continued operation of landside vehicle and passenger movements to T1 whilst construct T2 forecourt compromises airport operations	Requirement for continued operation of landside vehicle and passenger movements to T1 whilst construct T2 forecourt	Airport operations compromised.	Threat	Active	5	2	2	85%	50,000	200,000	1,000,000		
T2_108	Construction	Airport Operational Impact	Construction			Use of heavy plant airside compromises airport operations	Restricted use of mobile cranes/heavy plant machinery airside	Airport operations compromised. Programme delay whilst phase construction	Threat	Active	5	2	3	85%	50,000	200,000	500,000		
T2_125	Construction	Airport Operational Impact	Construction		*T2_066*	Requirement to keep T1 retail access road operational through construction phase compromises airport operations	Requirement to keep T1 retail access road operational through construction phase	Airport operations compromised. Compensation costs	Threat	Active	5	3	3	85%	50,000	100,000	500,000	2,200,000	
~~T2_066~~	Construction	Airport Operational Impact	Phasing			Misconceived construction phasing adversely affects airport operation	Operational situation affects construction phasing (e.g. Pier C)	Effect on airport operations	Threat	Closed				0%					
~~T2_068~~	Construction	Airport Operational Impact	Phasing			Misconceived construction phasing adversely affects cost and programme	Misconceived construction phasing (e.g. Pier C)	Cost and programme	Threat	Closed				0%					
T2_105	Construction	Airport Operational Impact	Construction		*T2_066*	T2 ground works compromise airport operations	Impact on adjacent structures from T2 ground works (e.g. affect T1 operations	Airport operations compromised. Programme delay whilst phase construction	Threat	Active	2	2	2	17%					
T2_124	Construction	Airport Operational Impact	Construction			Unknown impact of construction works on existing potable underground reservoir results in cost of sub-structural works or relocation	Unknown impact of construction works on existing potable underground reservoir	Cost of sub-structural works/relocation.	Threat	Active	1	1	1	5%					
T2_006	Design Risks	Approvals/ Consents	Planning Application			T2 solution incompatibility with Master Plan delays receipt of FCC consent	Emerging T2 solution is not perceived by FCC to be compatible with communicated Master Plan	Planning consent caps operational capacity of terminal	Threat	Active	2		4	17%					
T2_023	Design Risks	Approvals/ Consents	DAA			DAA approvals take longer than expected	DAA approvals delayed	Programme delay. Increased costs	Threat	Active	2	2	3	17%					
~~T2_024~~	Design Risks	Approvals/ Consents	Internal Planning			Speed of design development results in solution which does not comply with planning	Planning (internal): Speed of design development produces solution that would not be compliant with planning	Programme delay and additional cost whilst redesign and resubmit	Threat	Closed				0%					
~~T2_025~~	Design Risks	Approvals/ Consents	Planning Application			Requests for additional information delays programme	Planning (external): Requests for additional information	Programme delay	Threat	Closed	2	2	4	17%					
~~T2_026~~	Design Risks	Approvals/ Consents	Planning Application			FCC councillors don't adopt local area plan resulting in programme delay	Planning (external): FCC councillors don't adopt local area plan	Programme delay	Threat	Closed				0%					
~~T2_027~~	Design Risks	Approvals/ Consents	Planning Application			Onerous FCC specification for submission data delays programme	Planning (external): FCC has onerous specification for submission data	Programme delay	Threat	Closed				0%					
T2_028	Design Risks	Approvals/ Consents	Planning Application			Appeal to ABP lead to programme delay	Planning (external): Appeal to ABP takes longer than scheduled	Programme delay and additional cost	Threat	Active	2	2	3	17%					
T2_030	Design Risks	Approvals/ Consents	Planning Application			Planning application rejected resulting in programme delays and inflationary costs	Planning (external): Approval rejected	Programme delay and additional inflationary costs	Threat	Active	1	4	4	5%					
T2_032	Design Risks	Approvals/ Consents	Planning Application			Unanticipated archaeological finds results in cost of expert excavation and programme delay	Archaeological issues (castle, demolished house beneath Pier E & Corballis House)	Cost of exploration, licensing etc & consequential delays. Delay to period of demolition, further investigation & resolution	Threat	Active	2	3	3	17%					
T2_033	Design Risks	Approvals/ Consents	Planning Application			Onerous planning conditions result in programme delay	Planning (external): onerous conditions to approval	Redesign, additional cost and programme delay	Threat	Active	1	4	3	5%					

Risk and Opportunity Description														Quantitative Cost Modelling					
Risk ID	High Level Category	Sub-Level Category	Discipline / Work Package / Stakeholder	Work Packages	Phase when risk will occur / impact	Risk or Opportunity Event	Cause	Consequence	Opportunity	Status	Likelihood *current likelihood of occurrence of risk*	Cost	Time	Likelihood	Min	Most Likely	Max	Most likely total	Actual
T2_034	Design Risks	Approvals/ Consents	Planning Application			Planning contributions and charges increase project costs	Planning (external): contributions and charges	Additional cost	Threat	Active	2	4		17%					
~~T2_035~~	Design Risks	Approvals/ Consents	IVC			Unclear IVC brief results in programme delay and additional redesign costs	Unclear Independent Verification Consultant (IVC) brief	Programme delay & additional cost of design	Threat	Closed				0%					
~~T2_036~~	Design Risks	Approvals/ Consents	IVC			IVC validation of scheme takes longer than expected	Independent Verification Consultant (IVC) requests additional info/assurances and/or fails to validate scheme	Programme delay & additional cost of design	Threat	Closed				0%					
~~T2_045~~	Design Risks	Approvals/ Consents	Planning Application			FCC requirements for public space increases costs	FCC requirements for public space	Additional cost	Threat	Closed				0%					
~~T2_083~~	Design Risks	Approvals/ Consents	Planning Conditions			Onerous planning conditions results in increased cost of spoil removal, treatment etc.	Onerous planning conditions (e.g. re. removal of spoil)	Additional cost of treatment, removal, movement hours/transportation etc.	Threat	Closed				0%					
~~T2_085~~	Design Risks	Approvals/ Consents	Planning Application		*T2_005*	2-phased planning application leads to programme delay	2-Phased planning application	Programme delay (esp. if brief changes and have to resubmit)	Threat	Closed				0%					
~~T2_086~~	Design Risks	Approvals/ Consents	Planning Application			Planning process takes longer than expected	Planning process takes longer than expected (currently 10 months)	Programme delay	Threat	Closed				0%					
~~T2_089~~	Design Risks	Approvals/ Consents	Building Height			Uncertainty re. building height limits leads to programme delay	Uncertainty re. acceptability of building height limits (e.g. for operational sight lines)	Programme delay	Threat	Closed				0%					
T2_150	Design Risks	Approvals/ Consents	Planning Application			Cost of moving/rebuilding/reconstruction of Corballis House	Planning appeals	Refusal to demolish and requires incorporation and redesign	Threat	Active	2	4	4	17%					
T2_138	Design Brief	Change	Brief			Cost of having to provide more than one baggage reclaim hall	Customs requests more than 1 baggage reclaim hall	Additional cost of providing baggage reclaim hall(s)	Threat	Active	1	5	4	5%	5,000,000	10,000,000	20,000,000		
T2_013	Design Brief	Change	Brief			Change of anchor tenant changes design requirements	Aer Lingus no longer anchor tenant	Brief, as developed, does not cater for alternative tenant(s). Cost of redesign and associated works	Threat	Active	2	5	5	17%	1,000,000	5,000,000	20,000,000		
T2_139	Design Brief	Change	Brief			Cost of providing in-line arrival screening	Requirement for in-line arrival screening	Redesign docks to accommodate screening. Additional cost and programme delay	Threat	Active	2	4	2	17%	1,000,000	5,000,000	10,000,000		
T2_078	Design Risks	Change	Brief			Change in baggage screening legislation results in added cost of more expensive equipment	Change in legislation governing baggage screening equipment	Cost of providing more expensive equipment and floor space	Threat	Active	3	4	3	37%	1,000,000	3,000,000	10,000,000		
T2_012	Stakeholders	Change	DAA				T2 terminal is not perceived as stand-alone as per government mandate	Additional cost of design changes and associated works. Programme delay	Threat	Active	2	5	5	17%	500,000	2,000,000	10,000,000		
T2_018	Design Risks	Change	Dublin Metro			Uncertain alignment & configuration of Dublin Metro results in cost of redesign and associated works	Uncertainty regarding alignment and configuration of Dublin Metro	Cost of redesign and associated works to accommodate alignment of Metro	Threat	Active	2	4	3	17%	300,000	1,000,000	2,000,000		
T2_060	Design Brief	Change	KPIs			Unclear project KPI priorities	Changing project KPI priorities (e.g. time cost, quality	Cost and programme overruns	Threat	Active	2	5	5	17%	100,000	1,000,000	20,000,000		
T2_091	Project Management	Change	Brief			Uncontrolled design changes results in increased costs and programme delay	Design changes not controlled/clear	Additional cost and programme delay whilst redesign etc.	Threat	Active	5	5	3	85%	100,000	1,000,000	10,000,000		
T2_141	Stakeholders	Change	DAA			Stakeholder staff changes leads to cost of redesign and programme delay	Key staff changes in stakeholders changes brief	Redesign , additional cost and programme delay	Threat	Active	5	4	4	85%	100,000	1,000,000	10,000,000		
T2_144	Construction	Change	Planning Application			Planning conditions specify provision of infrastructure outside DAA control	Planning conditions specify provision of infrastructure outside DAA control	Redesign, additional cost and programme delay	Threat	Active	3	4	4	37%	500,000	1,000,000	5,000,000		
T2_010	Design Brief	Change	Brief			Uncertain demand forecasts affects CIP	Changes to passenger demand	Impact on overall DAA Capital Investment Programme (CIP)	Threat	Active	3	4	4	37%	50,000	500,000	2,000,000		
T2_075	Design Brief	Change	Brief			Insufficient space to meet design objectives	Insufficient space to meet target standards	Compromised design. Additional cost of redesign and associated works to satisfy design requirements within fixed envelope.	Threat	Active	5	3	3	85%	100,000	500,000	1,000,000		
T2_079	Design Risks	Change	Brief			Unclear legislation re. electricity supply to tenants results in cost of providing ESB infrastructure	Unfavourable interpretation of legislation, which means DAA cannot supply electricity to tenants using own	Cost of providing ESB infrastructure on airport campus	Threat	Active	5	3	2	85%	100,000	500,000	1,000,000		

Risk and Opportunity Description														Quantitative Cost Modelling					
Risk ID	**High Level Category**	**Sub-Level Category**	**Discipline / Work Package / Stakeholder**	**Work Packages**	**Phase when risk will occur / impact**	**Risk or Opportunity Event**	**Cause**	**Consequence**	**Opportunity**	**Status**	**Likelihood** *current likelihood of occurrence of risk*	Cost	Time	Likelihood	Min	Most Likely	Max	Most likely total	Actual
T2_080	Stakeholders	Change	Brief			Dublin Metro project does not proceed requiring highway modifications to cope with increased traffic	Dublin Metro project does not proceed	Increased road traffic into campus requiring highway modifications and additional parking	Threat	Active	3	2	2	37%	100,000	500,000	1,000,000		
T2_090	Design Risks	Change	Legislation Changes			Changing legislation results in redesign costs and programme delay	Changing legislation and subsequent changes to design standards	Additional cost and programme delay whilst redesign etc.	Threat	Active	3	3	3	37%	100,000	500,000	1,000,000		
T2_121	Construction	Change	Brief			Uncertain construction security requirements increases associated costs	Undefined construction security requirements	Additional cost of providing security measures	Threat	Active	4	3	3	62%	50,000	500,000	1,000,000		
T2_003	Inter-Project Stream Interfaces	Change	T2 Scope	All		Unclear boundaries with other projects delays planning application	Lack of definition of boundary/ interface between T2 and other projects work scopes	Delay to submission of planning application. Cost underestimate and cost & programme overrun	Threat	Active	3	3	2	37%	50,000	300,000	1,000,000		
T2_008	Design Brief	Change	Security	All		Required changes to security requirements from internal sources	Potential for security brief change (internal)	Increased cost and programme delay	Threat	Active	4	3	2	62%	50,000	300,000	5,000,000		
T2_009	Design Risks	Change	DoT			Required changes to security requirements from Regulator	Potential for security brief change (regulatory)	Increased cost and programme delay	Threat	Active	3	3	2	37%	50,000	300,000	5,000,000		
T2_014	Stakeholders	Change	Brief			Brief challenged by non-tenant airlines affecting cost, programme and service levels	Brief is challenged by non-tenant airlines	Effect on cost, programme and service levels	Threat	Active	2	3	3	17%	50,000	300,000	5,000,000		
~~T2_020~~	Design Risks	Change	Airfield			No operational hydrant fuel line requires redesign of stand layout	No hydrant fuel line in operation	Cost of redesigning stand layout. Programme delay. Operational limitation to Pier E capacity	Threat	Closed	2		3	17%	50,000	300,000	500,000		
T2_115	Commissioning	Change	Commissioning			Lack of designer input into systems integration results in increased costs and programme delay	Insufficient input from designers/ contractors to achieve commissioning requirements	Additional cost and programme delay. Tenant compensation costs	Threat	Active	3	2	3	37%	100,000	300,000	500,000		
T2_118	Design Risks	Change	Design			Lack of maintenance input into design results in redesign costs and programme delay	Lack of maintenance input into design	Cost of redesign (e.g. space for machinery). Access strategy compromised leading to programme delay	Threat	Active	2	3	3	17%	50,000	300,000	1,000,000		
T2_135	Design Risks	Change	Design			Increased scope of IT enabling works leads to additional cost and programme delay	Increase in scope of IT enabling works to facilitate tying into existing nodes	Additional cost and programme delay	Threat	Active	5	3	2	85%	100,000	300,000	1,000,000		
T2_065	Design Risks	Change	Tenants			Standards for tenants not yet established increasing cost of redesign/rework and adversely affecting quality	Standards for tenants not yet established	Additional cost of redesign/rework. Effect on quality. Inappropriate design.	Threat	Active	5	2	3	85%	50,000	200,000	500,000		
T2_132	Design Brief	Change	Brief			Brief challenged by non-anchor airline tenant airlines requires cost of redesign and associated works	Brief is challenged by non-anchor airline tenants	Brief, as developed, does not cater for tenant(s). Cost of redesign and associated works	Threat	Active	4	3	3	62%	50,000	200,000	300,000		
T2_119	Design Brief	Change	Design			Brief dictates inappropriate location of plant for maintenance delays gaining access for periodic maintenance	Brief dictates inappropriate location of plant for maintenance (airside v. landside)	Delays gaining access to plant for periodic maintenance	Threat	Active	3	2	2	37%	50,000	100,000	250,000	35,900,000	
~~T2_019~~	Design Risks	Change	Dublin Metro			Uncertain connectivity with Dublin Metro results in additional cost of design and associated works	Uncertainty regarding connectivity with Dublin Metro	Additional cost	Threat	Closed				0%					
NEW	Design Risks	Change	Design				Insufficient space allocated to Ground Service Equipment (GSE) and containers	Cost of providing storage solution (incl. real estate)		New	4	4							
	Design Risks	Change	Design				Services clash with structures above baggage hall	Change 2.4m solid beam to truss (cost of steel & smoke venting)		New	3								
	Design Risks	Change	Design				Commercial negotiations with tenants	Delay to design developments. Cost of changing room layouts		New	5	4	3						
T2_127	Design Risks	Change	Utilities			Utilities providers unable to supply required capacity results in cost of additional infrastructure or reduced project scope	Utilities (water, drainage, gas, electricity) providers unable to supply required capacity	Cost of additional infrastructure. Reduced scope	Threat	Active	2	3	3	17%	100,000	500,000	1,000,000		
T2_004	Design Brief	Change	Brief	All		Multiple inputs into & evolving nature of project brief results in continual changes	Multiple input to brief and related changes	Change and consequential effect on cost and programme	Threat	Active	3	3	3	37%	100,000	500,000	5,000,000		
T2_054	Design Risks	Consents/ Approvals	IAA			Requirement for IAA approval of mobile/tower cranes delays programme	Delay in approval of mobile/tower cranes by IAA	Programme delay	Threat	Active	3	2	2	37%	50,000	200,000	500,000	1,200,000	
~~T2_062~~	Commercial	Contracts	Contract management			Limited choice of contract form results in uncompetitive tendering & inflated tender prices	Limited choice of form of contract resulting in bespoke form of contract	Tendering not as competitive as expected leading to inflated tender prices	Threat	Closed				0%					
T2_143	Inter-Project Stream Interfaces	Coordination	Planning Application			Failure to coordinate non-T2 planning application delays programme	Failure to coordinate non-T2 planning application required to deliver project	Programme delay	Threat	Active	3	1	3	37%					
T2_131	Construction	Costing	Construction			Construction inflation and CPI differential increases scheme cost	Construction inflation differential from CPI	Increased scheme cost	Threat	Active	5	5	1	85%	1,000,000	10,000,000	20,000,000		
T2_145	Financial	Costing	Construction			Request by union-affiliated workforce for higher rates of pay increases outturn cost	Union-affiliated workforce request higher rates for working on prestigious project	Increased outturn cost	Threat	Active	5	4	3	85%	100,000	2,000,000	5,000,000	12,000,000	

Risk and Opportunity Description														Quantitative Cost Modelling					
Risk ID	High Level Category	Sub-Level Category	Discipline / Work Package / Stakeholder	Work Packages	Phase when risk will occur / impact	Risk or Opportunity Event	Cause	Consequence	Opportunity	Status	Likelihood *current likelihood of occurrence of risk*	Cost	Time	Likelihood	Min	Most Likely	Max	Most likely total	Actual
~~T2_039~~	Design Brief	Customer Requirements	Accessibility			Unclear accessibility requirements increases cost and delays programme	Accessibility: Unclear design requirements	Programme delay and additional costs	Threat	Closed				0%					
~~T2_044~~	Design Brief	Customer Requirements	Service Levels			Sensitivity of level of service increases scope and associated cost	Sensitivity to level of service	Additional cost of larger scope	Threat	Closed				0%					
T2_077	Design Brief	Customer Requirements	Baggage Handling			Unclear baggage screening requirements results in added cost of more expensive equipment	Unclear requirements regarding baggage screening equipment	Cost of providing more expensive equipment and floor space	Threat	Active	2	5		17%					
~~T2_081~~	Design Brief	Customer Requirements	Brief			Unclear expandability requirements results in opportunity to reduce costs at Phase 2	Unclear Phase 1 brief to account for Phase 2 (expandability)	Opportunity to reduce costs at Phase 2	Opportunity	Closed				0%					
~~T2_082~~	Design Brief	Customer Requirements	Brief			Unclear expandability requirements results in additional cost at Phase 1	Unclear Phase 1 brief to account for Phase 2 (expandability)	Additional cost at Phase 1 (e.g. space provision)	Threat	Closed				0%					
~~T2_001~~	Design Brief	Demand Forecasts	Demand Forecasting			Uncertain demand forecasts affect definition of busy hour rate	Uncertain demand forecasts	Undefined busy hour rate affecting cost and programme	Threat	Closed				0%					
~~T2_129~~	Construction	Equipment & Materials	Pier C			Opportunity to retain /reuse Pier C materials and plant	Opportunity to retain /reuse Pier C materials and plant	Reduced cost	Opportunity	Closed				0%					
T2_042	Design Brief	Feasibility	Sustainability			Inability to develop coherent sustainability strategy results in missed opportunities and adverse public relations	Extent of sustainability strategy	Public criticism & missed opportunities	Threat	Active	2			17%					
T2_047	Design Brief	Feasibility	Funding			Scheme cannot be delivered to budget adversely affecting service quality	Funding not available to deliver current scope to programme	Reduced scope. Effect on service quality. Redesign and programme delay	Threat	Active	2		4	17%					
~~T2_099~~	Stakeholders	Government TPA	Government TPA			Government TPA recommendations affects project scope	Government Third party assessor (TPA)	Programme delay whilst satisfy recommendation. Reduction in scope to suit revised budget	Threat	Closed				0%					
T2_072	Construction	Ground Conditions	Construction			Ground contamination is greater than expected increasing cost of sampling, treatment and disposal	Ground contamination (activity and quantity) greater than anticipated	Higher cost of sampling, treatment & disposal	Threat	Active	2	4	3	17%	500,000	5,000,000	20,000,000		
T2_016	Construction	Ground Conditions	Site Investigation			Uncertain ground conditions (no SI) results in additional cost of design changes and programme delay	Uncertain ground conditions at time required to fix cost plan and design	Cost of design changes. Programme delay	Threat	Active	2	3	2	17%	300,000	1,000,000	5,000,000		
T2_113	Design Risks	Ground Conditions	Design	EW		Uncertainty re. ground services results in additional costs and programme delay	Uncertainty re. relocation of services in ground	Additional cost and programme delay	Threat	Active	5	4	3	85%	100,000	500,000	1,000,000		
T2_073	Construction	Ground Conditions	Construction			Uncertain groundwater levels results in increased cost of temporary works	Uncertain groundwater levels	Increased cost of temporary works	Threat	Active	2	2	2	17%	50,000	200,000	1,000,000	6,700,000	
~~T2_017~~	Construction	Ground Conditions	Site Investigation			Uncertain ground conditions (no topographical survey) results in additional cost of design changes and programme delay	Uncertain topography at time required (ongoing topographical investigations)	Cost of design changes (e.g.vertical realignment of pier/apron). Programme delay	Threat	Closed	2	2	2	17%					
T2_116	Commissioning	Handover	Commissioning			Inability to access systems for T&C delays programme	Access to systems (e.g. baggage handling, security) denied by contractors for T&C	Programme delay	Threat	Active	2	2	3	17%					
~~T2_007~~	Stakeholders	Integration	CBP			CBP pressure to integrate	Customs & Border Protection (CBP) - pressure to integrate in T2 Pier E	Increased size and associated cost. Programme delay whilst redesign and additional construction	Threat	Closed	4	5	4	62%					
T2_049	Operational Interface	Integration	Design responsibility			Technical integration within T2 results in additional cost	Design /construction integration within T2	Redesign, additional cost and programme delay	Threat	Active	2	2	2	17%					
T2_050	Inter-Project Stream Interfaces	Integration	CIP projects			Technical integration with other CIP projects results in additional cost and programme delay	Insufficient technical integration with other CIP projects	Additional cost and programme delay	Threat	Active	2	1	1	17%					
~~T2_093~~	Operational Interface	Integration	T1 Interface		*T2_050*	Technical integration with T1 & non-T2 projects results in cost of scope changes and programme delay	Technical integration with T1 and non T2 projects	Cost of scope changes and programme delay	Threat	Closed				0%					
~~T2_095~~	Inter-Project Stream Interfaces	Integration	Campus Infrastructure		*T2_052, T2_053*	Desktop study of campus infrastructure affects T2 design strategy	Results of desktop study of campus-wide infrastructure (e.g. MEP services, transportation & energy supply)	Affects T2 design strategy and cost change, programme delay	Threat	Closed				0%					
~~T2_053~~	Inter-Project Stream Interfaces	Inter-dependencies	Infrastructure Projects			Failure to deliver infrastructure changes delays programme	Failure to deliver infrastructure changes (e.g. ESB)	Programme delay	Threat	Closed				0%					
T2_069	Construction	Logistics	Construction			Construction traffic to/from off-site compound adversely affects airport operations	Disruption to traffic from construction activity	Effect on airport operations. Cost of mitigating construction access adverse effects	Threat	Active	3	4	1	37%					

Risk and Opportunity Description														Quantitative Cost Modelling					
Risk ID	High Level Category	Sub-Level Category	Discipline / Work Package / Stakeholder	Work Packages	Phase when risk will occur / impact	Risk or Opportunity Event	Cause	Consequence	Opportunity	Status	Likelihood *current likelihood of occurrence of risk*	Cost	Time	Likelihood	Min	Most Likely	Max	Most likely total	Actual
~~T2_070~~	Construction	Logistics	Construction			Unavailability of on-site construction compounds adversely affects airport operations	Unavailable space for on-site construction compound	Cost of providing alternative infrastructure/ transport. Production inefficiency costs.	Threat	Closed				0%					
~~T2_002~~	Design Brief	Optioneering	Optioneering			Evaluation of design options takes longer than expected	Evaluation of design options takes longer then expected (Gateways 2 & 3)	Programme delay	Threat	Closed				0%					
~~T2_106~~	Construction	Other Projects	Construction		*T2_066*	T2-T1 interface works compromise airport operations	T2-T1 interface works	Airport operations compromised.	Threat	Closed				0%					
T2_136	Design Brief	Other Projects	Brief			Other projects request accommodation of additional infrastructure	Other projects request accommodation of additional infrastructure (e.g. below ground service routeings)	Additional cost	Threat	Active	4	3	3	62%					
~~T2_048~~	Operational Interface	Pier B					Pier B interface	?????	Threat	Closed				0%					
~~T2_005~~	Project Management	Planning	Planning Application			Two-phase planning process results in programme delay	Two-phase planning permission scenario	Programme delay	Threat	Closed				0%					
~~T2_110~~	Construction	Planning	Construction		*T2_068*	Phasing of operational areas' release for construction delays programme	Uncoordinated phasing between release of operational areas for construction	Programme delay	Threat	Closed				0%					
~~T2_111~~	Construction	Planning	Construction			Airport operations define and constrain construction programme	Airport operations define and constrain construction programme	Programme delay	Threat	Closed				0%					
~~T2_130~~	Project Management	Planning	T2 Projects			Inadequate decision making process during construction delays clarifications to site and programme	Inadequate decision making process during construction (2 contractors with conflict)	Delayed clarifications to site leading to programme delay and additional cost	Threat	Closed				0%					
T2_057	Project Management	Procurement	Procurement			Inappropriate procurement structure increases cost and delays programme	Adverse market response to proposed procurement structure	Increased cost, programme delay etc.	Threat	Active	3	4	4	37%	1,000,000	5,000,000	10,000,000		
T2_058	Project Management	Procurement	Costing			Degree of cost certainty at time of commitment to construct reduces degree of cost control	Degree of cost certainty at time of commitment to construct	Variable cost outturn	Threat	Active	4	4	2	62%	1,000,000	5,000,000	10,000,000		
T2_128	Construction	Procurement	Procurement			Uncertain market conditions increases cost of materials	Uncertain (specific) market conditions	Cost of materials different from expected	Threat	Active	4	4	2	62%	100,000	5,000,000	10,000,000		
T2_071	Supply Chain	Procurement	Procurement			Shortage of suitable contractors	Shortage of suitable contractors	Uncertain partnerships leading to poor coordination & effect on quality and subsequent claims	Threat	Active	4	4	3	62%	100,000	2,000,000	5,000,000	17,000,000	
T2_061	Project Management	Procurement	OJEU			Failure to implement OJEU processes in accordance with tight programme	Challenge to implementation of OJEU processes in accordance with tight programme	Programme delay	Threat	Active	2	2	3	17%					
~~T2_100~~	Project Management	Procurement	Procurement			No agreed procurement structure leads to programme delay	No agreed procurement strategy	Programme delay	Threat	Closed				0%					
~~T2_101~~	Project Management	Procurement	Procurement		*T2_057*	Selected procurement structure does not suit market conditions or contractor expertise	Selected procurement does not suit market or contractor expertise	Inflated tender prices & delivery compromised	Threat	Closed				0%					
~~T2_102~~	Project Management	Procurement	Procurement		*T2_057*	Selected procurement structure reduces programme timeframe	Selected procurement benefits programme	Opportunity to reduce programme timeframe	Opportunity	Closed				0%					
~~T2_059~~	Project Management	Responsibilities	Design responsibility			Inappropriate allocation of design responsibilities results in additional cost, programme delay and reduction in quality	Appropriate allocation of design responsibility	Additional cost, programme delay, quality	Threat	Closed				0%					
T2_149	Legal / Regulatory	Safety	Construction			Failure to satisfy DAA H&S officers increases scheme cost and delays programme	Failure to satisfy DAA H&S officer (e.g. emergency evacuation arrangements for baggage hall)	Redesign, additional cost and programme delay	Threat	Active	2	1	2	17%					
T2_151	Design Risks	Schedule	Design			Programme delay increases pre-construction phase costs		Increased pre-construction phase costs	Threat	New	4			62%	1,500,000	9,000,000	36,000,000		
T2_152	Construction	Schedule	Construction			Programme delay increases construction phase costs		Increased construction phase costs	Threat	New	4			62%	3,000,000	9,000,000	36,000,000		
T2_015	Project Management	Schedule	Programming			Aggressive project programme affects ability to deliver & reputation	Aggressive programme	Missing milestones, cutting corners, perception of failure, quality impacts. Increased capital cost of achieving	Threat	Active	4	4	4	62%	1,000,000	5,000,000	10,000,000		
T2_076	Design Brief	Schedule	Brief			Brief incomplete at time of planning submission requires application to be resubmitted	Brief is not developed in alignment with design process.	Redesign, additional cost and programme delay	Threat	Active	5	5	3	85%	1,000,000	5,000,000	20,000,000		
T2_022	Design Risks	Schedule	CAR			CAR consider project scope is excessive resulting in significant delays to receipt of approvals	CAR (Commission for Aviation Regulation) decide project is excessive in terms of scope	Delay to approvals leading to major project delay. Redesign costs.	Threat	Active	3	4	5	37%	200,000	1,000,000	3,000,000		
T2_029	Design Risks	Schedule	Planning Application			Judicial review delays programme and increases direct costs	Planning (external): Judicial review	Programme delay and additional direct costs	Threat	Active	2	4	3	17%	200,000	1,000,000	5,000,000		
T2_031	Design Risks	Schedule	Planning Application			Cost of moving/rebuilding/reconstruction of Corballis House	Conservation issues (I.e. Corballis House)	Programme delay. Cost of moving/rebuilding/reconstruction Corballis House or disruption costs.	Threat	Active	2	4	3	17%	200,000	1,000,000	5,000,000		

Risk and Opportunity Description														Quantitative Cost Modelling					
Risk ID	High Level Category	Sub-Level Category	Discipline / Work Package / Stakeholder	Work Packages	Phase when risk will occur / impact	Risk or Opportunity Event	Cause	Consequence	Opportunity	Status	Likelihood *current likelihood of occurrence of risk*	Cost	Time	Likelihood	Min	Most Likely	Max	Most likely total	Actual
T2_056	Stakeholders	Schedule	Stakeholder Management			Lack of stakeholder consideration results in funding problems and programme delay	Lack of stakeholder consideration & adequate support	Programme delay & funding problems	Threat	Active	3	4	4	37%	150,000	1,000,000	2,000,000		
T2_037	Design Risks	Schedule	DCC			Onerous DCC Fire Officer requirements delays programme and increases cost	DCC Fire Officer: onerous requirements	Redesign, additional cost and programme delay	Threat	Active	2	4	3	17%	50,000	500,000	1,000,000		
T2_051	Project Management	Schedule	Design responsibility			Unclear allocation of design responsibility results in additional cost and programme delay	Interface with contractor re. Design responsibility	Additional cost & programme delay	Threat	Active	4	4	3	62%	100,000	500,000	1,000,000		
T2_063	Inter-Project Stream Interfaces	Schedule	Construction			Interface between different T2 contracts adversely affects programme, cost and quality	Interfaces between different T2 building packages/contracts	Programme delay and additional cost caused by claims. Effect on quality	Threat	Active	2	3	3	17%	50,000	500,000	1,000,000		
T2_112	Design Risks	Schedule	Construction			Unforeseen problems associated with temporary works results in increased cost of services	Unforeseen problems associated with temporary & enabling works (e.g. T1 services to Pier C)	Programme delay. Cost protection/diversion of services. Effect on airport operations and compensation costs	Threat	Active	5	3	3	85%	100,000	500,000	1,000,000		
T2_117	Commissioning	Schedule	Commissioning			Unavailability of maintenance contractors at T&C & prior to handover delays programme, compromises	Unavailability of operations & maintenance contractors (Facilities Management) at T&C and prior to	Programme delay. Increased operating costs. Effect on airport operations	Threat	Active	2	4	3	17%	100,000	500,000	1,000,000		
T2_120	Design Brief	Schedule	Brief			Lack of waste management brief results in increased costs and programme delay	Lack of waste management brief	Additional cost of waste management. Programme delay whilst receive related approvals	Threat	Active	2	3	2	17%	100,000	500,000	1,000,000		
T2_134	Construction	Schedule	Construction				Lack of information re. routing of existing comms. cables in ducts.	Delay to construction owing to unforeseen infrastructure	Threat	Active	5	3	3	85%	100,000	500,000	1,000,000		
T2_146	Political	Schedule	Construction			Insufficient management of industrial relations delays programme	Insufficient management of industrial relations	Programme delay	Threat	Active	3	3	3	37%	100,000	500,000	1,000,000		
T2_147	Legal / Regulatory	Schedule	Construction			Introduction of HSA directives leads to redesign costs and programme delay	Introduction of HSA directives governing construction phase	Redesign, additional cost and programme delay	Threat	Active	2	3	3	17%	50,000	300,000	1,000,000		
T2_148	Construction	Schedule	Construction			Major H&S incident delays programme and has negative effect on public relations	Major H&S incident	Programme delay. Negative effect on public relations	Threat	Active	3	2	3	37%	50,000	300,000	1,000,000		
T2_021	Design Risks	Schedule	IAA			IAA requests for additional information delays receipt of approvals	IAA ask for additional information. Approvals received later than expected	Programme delay	Threat	Active	2	2	3	17%	50,000	200,000	500,000		
T2_052	Inter-Project Stream Interfaces	Schedule	CIP projects			Failure to commission key non-T2 infrastructure enhancements results in programme delay	Failure to deliver key infrastructure enhancements (e.g. power, roads) outside of T2 project	Redesign, additional cost (e.g. M50 junction upgrades) and programme delay	Threat	Active	5	4	4	85%	50,000	200,000	250,000		
T2_055	Construction	Schedule	Tenants			Movement of tenants during project implementation results in compensation payments and programme delay	Movement of tenants (e.g Pier C car rental, DAA maintenance, Corballis House) to undertake works	Compensation costs and programme delay whilst contest objections	Threat	Active	3	2	2	37%	50,000	200,000	500,000		
T2_133	Construction	Schedule	Construction			Insufficient design and construction integration with retail tenant fit-out leads to programme delay and additional cost of fit-out	Insufficient design and construction integration with retail tenant fit-out	Programme delay. Partial opening of retail space. Claims. Additional cost of fit-out	Threat	Active	3	2	1	37%	50,000	200,000	500,000	37,400,000	
~~T2_114~~	Stakeholders	Schedule	Stakeholder Management			Lack of stakeholder approval prior to planning application results in programme delay	Lack of stakeholder approval prior to planning submission	Programme delay	Threat	Closed				0%					
T2_137	Design Risks	Schedule	Design			Design programme not achieved	Design programme not achieved	Programme overrun. Cost increase from claims	Threat	Active	3	1	3	37%					
~~T2_092~~	Design Brief	Scope	T1 Interface		*T2_003*	Unclear interface with T1 results in cost of scope changes and programme delay	Unclear interface with T1	Cost of scope changes and programme delay	Threat	Closed				0%					
~~T2_094~~	Design Brief	Scope	T2		*T2_003*	Unclear T2 boundary results in different cost and programme delay	Unclear T2 boundary (physical and functional)	Cost different from expected and programme delay. Unknown effect of interfacing projects (existing infrastructure, buildings, leasing	Threat	Closed				0%					
T2_096	Design Brief	Scope	Design			Unclear strategy re. Pier C affects T2 design scope	Uncertain strategy re. scope of work to Pier C to integrate into T2 design	T2 (Pier C elements) scope and cost change. Programme delay	Threat	Active	2	2	3	17%					
T2_123	Design Brief	Scope	Brief			Uncertain requirements re. landscaping earthworks increases associated costs	Uncertain landscaping requirements	Additional cost of landscaping	Threat	Active	4	3	1	62%					
T2_074	Construction	Site Conditions	Construction			Contamination of water courses during construction delays programme and adversely affects public relations	Construction contamination of water courses	Programme delay, cost & -ve public relations	Threat	Active	2	1	2	17%					
~~T2_142~~	Construction	Site Conditions	Construction			Unforeseen condition of Pier C leads to cost of redesign and programme delay	Unforeseen condition of Pier C revealed during construction phase	Redesign , additional cost and programme delay	Threat	Closed				0%					
~~T2_103~~	Supply Chain	Skills	Procurement		*T2_071*	Competition from concurrent major projects affects T2 resource pool	Competition from other major projects affects resource pool	Inflated tender prices & delivery compromised	Threat	Closed	0	0	3	0%					
~~T2_109~~	Supply Chain	Skills	Contractor(s)			Competition from concurrent major projects affects T2 resource pool, leading to programme delay	Concurrent projects compete for resources etc.	Construction programme delays	Threat	Closed				0%					
T2_011	Design Brief	Stakeholder	Baggage Handling			Difficulty in satisfying baggage handling user requirements	Difficulties in satisfying baggage handling user expectations	Increased cost and programme delay	Threat	Active	4	3	3	62%	50,000	200,000	1,000,000	200,000	
T2_038	Design Risks	Standards	DoT			Onerous or uncertain DOT security requirements results in increased cost and programme delay	DOT: security: onerous or uncertain specification	Redesign, additional cost and programme delay	Threat	Active				0%					
T2_040	Design Risks	Standards	Accessibility			Uncertainty re. achieving best accessibility practice delays programme	Accessibility: Achievement of best practice	Redesign, additional cost and programme delay	Threat	Active	1	3	2	5%					
T2_041	Design Risks	Standards	Security			Introduction of new security standards increases cost	Introduction of new security standards	Redesign, additional cost and programme delay	Threat	Active				0%					
~~T2_084~~	Design Risks	Standards	DoT		*T2_009, T2_038, T2_041*	Changing DoT security requirements increases cost of security provision	Onerous/changing DoT security requirements	Cost of providing necessary security measures	Threat	Closed				0%					

Risk and Opportunity Description														Quantitative Cost Modelling					
Risk ID	**High Level Category**	**Sub-Level Category**	**Discipline / Work Package / Stakeholder**	**Work Packages**	**Phase when risk will occur / impact**	**Risk or Opportunity Event**	**Cause**	**Consequence**	**Opportunity**	**Status**	**Likelihood** *current likelihood of occurrence of risk*	Cost	Time	Likelihood	Min	Most Likely	Max	Most likely total	Actual
~~T2_087~~	Design Risks	Standards	Building Regs.			Uncertainty re. building regs results in increased cost of compliance	Building Regs. Part L revision in process. Uncertainty re. compliance	Additional cost and programme delay achieving compliance	Threat	Closed				0%					
~~T2_088~~	Design Risks	Standards	Fire Engineering			Following fire-engineered solution leads to programme delay	Fire engineered solution cf. prescriptive guidance	Longer approval process leading to programme delay	Threat	Closed				0%					
~~T2_098~~	Design Risks	Standards	Legislation Changes			Historical events up until design freeze dictate revised requirements	Historical events between now and design freeze	Cost of changes to building design to accommodate revised requirements/legislation	Threat	Closed				0%					
T2_122	Design Risks	Standards	Airfield			Unacceptable existing apron gradient results in cost of apron grading & programme delay	Unacceptable existing gradient for aprons	Cost of apron grading. Programme delay	Threat	Active	1	2	1	5%					
T2_126	Stakeholders	Third Parties	Environmental Protests			Environmental protests delay programme whilst obtain planning consent	Environmental protests/objections (air and noise pollution)	Programme delay whilst resolve objections	Threat	Active	2	1	4	17%					
T2_043	Design Risks		Planning Application				Acceptability by ABP of level of development of urban design	Planning and consequent programme delay	Threat	Active	1	2	4	5%					
NEW							Insufficient space to meet target baggage handling requirements (esp. south west corner of T2; Module 1, pier C)	Cost of providing more substantive weather protection for baggage handling operations exterior to baggage hall (e.g. compliance with Part L of Building Regs.)	Threat	Active	5	3		85%					
NEW							Insufficient space to meet target baggage handling requirements (esp. south west corner of T2; Module 1, pier C)	Cost of providing an extended remote transfer link into & out of T1	Threat	Active	5	3		85%					

Appendix 16 - Explanation of CAR's Error RE: Capital Remuneration Application

Source: daa

Exists in MS Excel Format Only