Institution: University of Westminster

Unit of Assessment: UoA 16; Architecture, Built Environment and Planning

Title of case study: Delay Cost Management in European Aviation

1. Summary of the impact

Delays in aviation cost European airlines billions of Euros each year. The Single European Sky initiative, a paradigm shift in the design and function of European airspace, was launched by the European Commission in 1999 specifically in response to increasing delays. For these measures to be truly effective, it is necessary to *quantify how and where* to reduce delays: reducing all delays is not possible; an unquantified approach is not optimal. We have designed an *ab initio* methodology for, computed and maintained the aviation industry-standard delay cost values that have been used across Europe by practitioners and policy makers since the early 2000s. A recent Eurocontrol report (2011) noted t*he 'University of Westminster Report represents the most recent and comprehensive appraisal of the cost of delays in the air traffic management system in Europe'.*

2. Underpinning research

The underpinning work is our development, from first principles, of a quantitative framework for calculating airline delay costs [1]. This is the industry benchmark reference document for strategic and tactical delay costs in aviation. Both this reference document, and its precursor report (produced by us in 2004), are cited by industry, academia and government. This work has been developed for EUROCONTROL's Performance Review Commission and through funding from SESAR[1]. The core cost components considered in our work are those associated with aircraft maintenance, fleet financing, crew costs, passenger costs to the airline and fuel burn (with associated carbon charges in certain contexts).

A key component of the work is 'dynamic cost indexing' (DCI): an area of research (and terminology) pioneered by the University of Westminster and dating back to research proposals submitted in 2006. This now fundamentally relates to a basic principle of SESAR (the '4D' trajectory) and is employed by some airlines that are more advanced in delay cost management (e.g. see Section 4). DCI is a primary example of the implementation of our cost of delay work: it is a method [2] for applying the cost of delay knowledge to adjust the trajectory of an aircraft (through use of the flight management system's 'cost 'index' setting) in real-time (hence the key term 'dynamic') in order to potentially save several millions of Euros per year with a moderate-sized fleet [3]. In 2008, we began the publication and dissemination of the DCI work by publishing a series of Technical Discussion Documents[2] aimed at airline practitioners (primarily, but not exclusively, ops control).

Importantly, and also differentiating our work from other research in this field, our models also address [5] strategic costs – those associated with the design of operations in advance of the tactical implementation (such as through putting 'buffer' into airline schedules). These results thus allow trade-offs to be made not only between different tactical solutions (on the day of operations) but between strategic and tactical solutions (e.g. putting too much buffer into schedules imposes opportunity costs). Tactically, our work also quantitatively informs [4] the formulation of another key operational principle of the ATM SESAR paradigm: the user-driven prioritisation process (UDPP).

More recently [6], our research embraces the novel application of complexity science in ATM. We use this avenue of our research to emphasise the need to move away from classical metrics and measures of central tendency, and to stress the importance of understanding the air transport

[1] SESAR is the air traffic management technological and research pillar of the Single European Sky. EUROCONTROL is the European coordinating body for air traffic control in Europe; it a founding partner of SESAR (with the European Commission). SESAR and EUROCONTROL coordinate the vast majority of research funding in European air traffic management.

[2] These are still made available for reference by EUROCONTROL: http://www.eurocontrol.int/eec/public/standard_page/proj_CARE_INO_III_Dynamic_Cost.html

network from a passenger-centric context rather than the historically-applied flight-centric context.

The specific strengths of our work, which have differentiated it from that of other research in the field, is that we have modelled the associated costs of delay for specific aircraft, for specific phases of flight, for a range of cost scenarios, as a function of delay duration, and including the reactionary ('knock-on') effect in the rest of the airline network.

This allows users to apply the findings to specific scenarios, unlike high-level, aggregate models, which are difficult to apply operationally or adapt to specific operations. This makes our research unique and the reason why it is cited beyond Europe and used by industry.

3. References to the research

1. Cook A and Tanner G (2011), *European airline delay cost reference values* Commissioned by EUROCONTROL Performance Review Unit http://www.eurocontrol.int/documents/european-airline-delay-cost-reference-values

2.Cook A, Tanner G, Williams V and Meise G (2009), 'Dynamic cost indexing – managing airline delay costs' *Journal of Air Transport Management*, Vol 15, No 1, 26-35 http://dx.doi.org/10.1016/j.jairtraman.2008.07.001

3. Cook A, Tanner G, and Lawes A (2012), 'The hidden cost of airline unpunctuality' *Journal of Transport Economics and Policy*, Vol 46, No 2, 157-173 http://www.ingentaconnect.com/content/lse/jtep/2012/00000046/00000002

4. Cook A and Tanner G (2011), 'A quantitative exploration of flight prioritisation principles, using new delay costs', *Journal of Aerospace Operations*, Vol 1, No 3, 195-211 http://dx.doi.org/10.3233/AOP-2012-0018

5. Cook A, Tanner G and Enaud P (2010), 'Quantifying airline delay costs – The balance between strategic and tactical costs', 14th Air Transport Research Society (ATRS) World Conference, Porto, Portugal

6. Cook A, Tanner G and Zanin M (2013), 'Towards superior air transport performance metrics – imperatives and methods', *Journal of Aerospace Operations*, DOI 10.3233/AOP-130032

The following grants from EUROCONTROL (unless otherwise stated) funded research and dissemination. They were managed by Dr Andrew Cook in association with Graham Tanner.

(1) Dynamic cost indexing project (€205,000)
(2) Academic grant awarded for innovative studies (€111,000)
(3) Funding extension for production of 2011 delay cost report (€39,000)
(4) SESAR research network ('ComplexWorld') (€1.6 million*†)
(5) Passenger-oriented enhanced metrics ('POEM') project (€295,000*)
(6) Complex adaptive systems for optimisation of performance in ATM ('CASSIOPEIA') project (€598,000)

(7) Strategic allocation of traffic using redistribution in the network ('SATURN') project (€594,000)

(8) **'**ComplexityCosts' project (€594,000).

4. Details of the impact (indicative maximum 750 words)

This research has produced insights into the cost of delay and thus delay management. It has:

- explicitly quantified the non-linear relationship between delay duration and delay cost (e.g. two 15-minute delays will usually cost less than one 30-minute delay) (e.g. [1]);
- challenged, through calculations carried out with airline partners, the use of arbitrary punctuality performance targets and delay recovery rules (e.g. [3]);
- quantified the relationships between the various cost elements to help practitioners (airlines in particular) to move away from a historical focus on saving fuel (prompted by escalating prices) towards a proper consideration of the passenger and reactionary costs in operational delay

management, and the trade-offs with buffer schedule (e.g. [5]);

- informed policy-makers of the need: to focus on arrival delay rather than departure delay (the former incur most of the airline costs); to embrace the *passenger* context of performance metrics (as opposed to flight-centric methods); to accept the importance of variance in performance metrics rather than central tendency alone, and the associated impacts on strategic costs. This has challenged accepted norms in the industry (e.g. through [3], [4] and [6]) which we have used as a platform for building new collaborative stakeholder exchange.

Whilst academic citations of our work, and the corresponding impacts on scholarly practice, are readily available, the air transport industry in general, and airlines in particular, are far less prone to publish any materials relating to cost management practice, since the marketplace is intensely competitive. It is, for example, almost impossible to discover what an airline is paying for its fuel contracts, let alone to discover a detailed cost breakdown of its operational practices and cost benefit analyses. Nevertheless, from each of three types of industry user of our work we have approached one company as an **example** and asked them to disclose certain basic principles of how our research has impacted their business, on the understanding that we do not identify them in this document.

(i) Example impact – global supplier of decision-support software

Across multiple sectors, including air transport, this global company has more than 1000 clients worldwide. Our delay cost model parameters have been used in this company's airline operations optimisation software as a base model for driving scheduling and turnaround decision-making. On a case-by-case basis, our parameters have been used either as a platform for the development of airline-specific costs (our documentation has been intentionally focused at this pedagogical level) or for direct use in the absence of airline-specific values (which is often the case, as we have found in our one-to-one dealings with numerous airlines who approach us in confidence for costing advice). Such decision-support systems are in use with up to 6 European airlines.

(ii) Example impact – European air navigation service provider (ANSP)

This ANSP is one of the largest in Europe. Examples of ANSPs are NATS (UK) and DFS (Germany). In assessing airline impacts for its business planning, this ANSP uses our delay costs to evaluate, understand and illustrate the costs of delay to its airline customers and support conversations both internally and with customers about business priorities. In its cost benefit assessments, it uses the detailed material in [1] to inform its delay cost values used to develop investment plans and proposals. This ANSP's benefit modelling team is able to consider the *specific* impacts, such as for given aircraft types, thanks to the disaggregate values we have published, as summarised in Section 2.

(iii) Example impact – major European airline

This example illustrates how a major European airline (in this case not a flag carrier) uses our work directly, as opposed to through a third party (as in (i)). Based on our research findings and methods, this airline has produced a 16-page guidance newsletter for distribution to all its pilots, developed in consultation with the University of Westminster. The calculations presented demonstrate numerous impacts of current operational practice and illustrate to pilots the specific cost benefits of changing some of these practices in day-to-day flight planning, using a mixture of both direct values from our reporting and other values adapted specifically to this airline's operational context, using the University of Westminster methodology.

(iv) Example impact – building new stakeholder cooperation and debate, informing policy

We have held several workshops focusing on various aspects of our work, which have been attended by both airlines and ANSPs (in addition to public bodies and academics). As an example, over 50 delegates attended a workshop and seminar on ATM performance assessment in London. In an industry in which operational practice is usually closely guarded, we have facilitated open discussion around our quantitative research findings, challenging the 'rules of thumb' often used by airlines and demonstrating that they are not cost-effective. (The airline cited in (iii) attended such a workshop and went on to produce the guidance newsletter mentioned.) Participants in such workshops are either already members of, or subsequently invited to join, our international airline

Working Group on delay cost management (which currently numbers appx. 30 airlines around the world).

The Performance Review Body (PRB) of the Single European Sky manages the SES Performance Scheme, which has legally binding targets on EU Member States. We are in liaison with the PRB with respect to the Performance Scheme, e.g. with a view to the ultimate inclusion of passenger-centric metrics therein, such metrics being currently missing. Our final reporting from the 'POEM' project (see Section 5) will be shared with the PRB for this purpose, further building on [6] with examples of how flight-centric metrics, central tendency measures and classical approaches alone do not furnish the best insights into (fully policy-oriented) performance.

5. Sources to corroborate the impact

Published sources:

(i) ATM performance review

- EUROCONTROL Performance Review Commission (2003-2013, eleven editions), An Assessment of Air Traffic Management in Europe during the Calendar Year *20xx* [2002-2011][3]
- EUROCONTROL Performance Review Unit (2012), ATM Cost-Effectiveness (ACE) 2010 Benchmarking Report with 2011-2015 outlook
- EUROCONTROL/Federal Aviation Administration (2012), 2010 US/Europe Comparison of ATM-Related Operational Performance

(ii) ATM performance targets

- Ente Nazionale per l'Aviazione Civile (2012), Addendum to THE ITALIAN PERFORMANCE PLAN for Air Navigation Services Reference Period 1 2012-2014
- EUROCONTROL Performance Review Body (2011), SES II Performance Scheme: Assessment of National / FAB Performance Plans with Performance Targets for the period 2012-2014

(iii) Values used with European-wide ATM cost-benefit analyses

- EUROCONTROL (2011), Standard Inputs for EUROCONTROL Cost Benefit Analyses, Edition 5.0
- NATS/Irish Aviation Authority (2012), UK-Ireland FAB Cost-Benefit Analysis, Appendix I. To support: COMMISSION REGULATION (EU) No 176/2011
- EUROCONTROL (2008), Airport CDM Cost Benefit Analysis

(iv) Policy, regulatory, consultation

- Department for Transport (2009), Adding Capacity at Heathrow Airport: Impact Assessment
- Mayor of London/Greater London Authority (2011), A new airport for London. Part 1 – The Case for New Capacity
- EUROCONTROL (2011), Single European Sky (SES) Regulation: justification material for the draft implementing rule on the 2nd phase of the air-ground voice channel spacing
- CAA (2004), Supporting Paper 3: Service Quality. Supporting papers for Initial Proposals for NATS' Price Caps
- EUROCONTROL Performance Review Commission (2010), Performance Scheme: Initial EU-wide Targets Proposals. Consultation document produced by the PRC upon the invitation of the European Commission DG-MOVE.

5.2 Corroboration sources – professional referees

Programme Manager, Long-Term and Innovative Research (SESAR WP-E), and Head Performance Review Unit, both at EUROCONTROL HQ.

[3] Our 2004 and 2011 benchmark reference documents for delay costs in aviation have been referenced by EUROCONTROL's Performance Review Commission in their definitive annual Performance Review Reports since 'PRR6' (published in 2003, drawing on findings of our pre-release reference document).