Institution: University College London

Unit of Assessment: 19 – Business and Management Studies

Title of case study: An integrated decision-making framework for improving European air traffic management

1. Summary of the impact

An integrated decision-making framework developed by Professor Bert De Reyck for Eurocontrol, the European air traffic management organisation, was instrumental in reaching an agreement on the changes and technologies required to integrate Europe's air traffic management systems. This is as part of the European Commission's Single European Sky initiative, a multi-year redesign of the European air traffic network by 2020, to eventually handle 20 million flights with fuel savings of €6 billion per year. During the census period, the framework enabled key decisions on traffic synchronisation to be implemented, which facilitated a substantial increase in air traffic control efficiency, and increased air space capacity by 20%. The benefits of the research to the client organisation was recognised by multiple nominations for INFORMS awards.

2. Underpinning research

Professor Bert De Reyck's research on project management, project portfolio management, R&D project valuation and multi-criteria decision making allows organisations to value on-going and future projects using multiple objectives and criteria, while reconciling different stakeholders. The research relies on mathematical modelling, using management science/operational research techniques such as large-scale mathematical programming, decision analysis, and principal-agent modelling. The underpinning research includes work on valuing options and flexibility in R&D projects using decision analysis [c], planning R&D activities when there is a risk of technical failure [d], project valuation when stakeholders are risk averse [e], and project selection with multiple stakeholders having different objectives [a]. The research has been applied to various organisations in R&D-intensive industries such as pharmaceuticals, energy, and aerospace [a] [b] [d].

This case study focuses on the impact the research had on the European Commission's Single European Sky initiative. Europe's air traffic network is extremely congested and inefficient, due to the air traffic management system being fragmented and based around national practices. In order to handle the future increase in traffic, while maintaining safety and reducing the environmental impact, all European aviation players must cooperate to develop a modernised and unified system, which can be achieved by gradually introducing technological improvements to the system. These stakeholders, however, disagree not only on the benefit any proposed improvements would bring, but also on what the main objectives should be from these system enhancements.

In this context, Professor De Reyck developed a novel decision-making framework for Eurocontrol, the European Air Traffic Management organisation, for supporting the evaluation of interdependent system improvements by the multiple stakeholders, while accounting for various objectives [a] [b]. The main issue was to find a way to help the different stakeholders trade off various objectives, while taking account of the lack of data available, the need to go quickly and the issues involved in a multi-cultural and multi-discipline programme. The framework allows for both qualitative and quantitative expert assessments, trading-off objectives such as capacity, safety, security, environment, predictability and efficiency. It also identifies commonalities and differences in the stakeholders' perspectives and recommends a preferred course of action, ultimately allowing Eurocontrol to create a single unified European sky by 2020.

The underpinning research was undertaken by Professor De Reyck, professor at UCL's Department of Management Science & Innovation since 2007, in collaboration with Yael Grushka-Cockayne, a former PhD student of Professor Bert De Reyck, currently at the Darden School of Business (University of Virginia), and Professor Zeger Degraeve (Melbourne Business School). Professor De Reyck was the principal investigator.

3. References to the research

[a] Grushka-Cockayne, Y., De Reyck, B. and Degraeve, Z. 2008. “An Integrated Decision-Making Approach for Improving European Air Traffic Management,“ *Management Science*, 54 (8), 1395–1409. Submitted to REF2.

This article was published in *Management Science*, one of the flagship journals of INFORMS, and was also a finalist for the *Decision Analysis Society Practice Award*.

[b] Grushka-Cockayne, Y. and De Reyck, B. 2009. “Towards a Single European Sky“ *Interfaces*, 39 (5), 400–414. DOI: 10.1287/inte.1090.0436.

This article was published in *Interfaces*, the INFORMS journal that showcases high-impact applications of operations research, and was a finalist for the *Daniel H. Wagner Prize for Excellence in Operations Research Practice*, awarded by the Institute for Operations Research and Management Science (INFORMS).

[c] De Reyck, B., Degraeve Z. and Vandenborre R. 2008. “Project options valuation using Net Present Value and Decision Tree Analysis“, *European Journal of Operational Research*,184 (1), 341–355. Submitted to REF2.

This article was published in the *European Journal of Operational Research*, a highly regarded peer-reviewed journal.

[d] De Reyck, B., Leus, R. 2008. “R&D project scheduling when activities may fail“, *IIE Transactions*, 40 (4), 367–384. DOI: 10.1080/07408170701413944.

This article was published in *IIE Transactions*, a highly regarded peer-reviewed journal and the flagship journal of the Industrial Engineering Society.

[e] Chronopoulos, M., Siddiqui, A. and De Reyck, B. 2011. “Optimal investment and operational decision making under risk aversion and uncertainty“, *European Journal of Operational Research*, 213, 221–237. Submitted to REF2.

This article was published in the *European Journal of Operational Research*, a highly regarded peer-reviewed journal.

Evidence of the **quality of research** is provided by publications in key peer-reviewed journals and award nominations as described above.

4. Details of the impact

Aviation is a strategically important sector that makes a vital contribution to the EU‘s overall economy and employment, supporting 5.1 million jobs and contributing €365 billion to European GDP. Despite the recent economic crisis, global air transport over the long term is expected to grow by around 5% annually, doubling by 2030. As traffic increases so do concerns about capacity and safety. Airport and air traffic network capacity is increasingly a constraining factor in European air transportation, resulting in delays costing airlines €1.3–1.9 billion per year (European Commission, *SESAR, The Future of Flying*, 2010, www.sesarju.eu). Without a new integrated system, current systems will not be able to cope. This will result in a potential 3.7 million flights per year not being accommodated, causing a yearly loss of approximately €50 billion euros. Isolated improvements in national practices and systems cannot resolve this problem, due to segregated systems, lack of standardisation and restrictive regulations [3]. However, previous attempts to reach an agreement to improve air traffic management systems in Europe had failed due to the complexity of reconciling the conflicting objectives of the many international stakeholders. The research in section 2 was instrumental in resolving this issue.

The significance of the impact of research was recognised in the many nominations received for its benefits to the client organisation from the Institute for Operations Research and Management Science (INFORMS) and through its publication in the journal *Interfaces* as an exemplary case of research with substantial impact outside academia [4]. In particular, the research was a finalist for the *Daniel H. Wagner Prize for Excellence in Operations Research Practice*, the *Decision Analysis Society Practice Award*, and the INFORMS *Case Competition Award*. Eurocontrol’s Head of Airport Research and Director of the Single European Sky programme, writes that “the research […] had a major impact on one of our major European projects, SESAR (Single European Sky Air Traffic Management Research)" [2].

Impact on the development of the Single European Sky initiative

The integrated decision-making framework developed by Professor De Reyck and described in section 2 was instrumental in reaching an agreement on which changes and improvements will be made in Europe's air traffic management systems, and which new technologies will be chosen for implementation. The selected set of improvements now forms the Master Plan of the Single European Sky (SES) initiative for harmonising air traffic [1]. This represents the successful development of a collaboration to cope with the forecasted increase in air traffic while maintaining safety, protecting the environment, and improving predictability and efficiency, ultimately leading to the successful completion of the European Commission's Single European Sky initiative. When fully realised, the SES will handle more than 20 million flights per year, with the highest level of safety in the world and cost reductions of €6 billion per year. Additionally, there will be fuel savings, lower CO_2 emissions, fewer delays and additional capacity, generating an estimated additional GDP of €419 billion for the European economy, and 320,000 jobs [3]. The framework developed through our research has created the necessary conditions for this to occur.

The integrated framework accommodates the requirements of a consortium of stakeholders from 30 public and private organisations, as well as 20 associated partners, including representatives from airspace users, airports, air navigation service providers, the supply industry, safety regulators, military, pilots and controllers associations and research centres. Its application has led to a shared understanding of the problem, achieved a joint commitment to action, and was used to reach several key decisions towards the ultimate implementation of the Single European Sky. As a result, implementation of these decisions, as part of a decades-long programme, was well underway from 2008 onwards. Some of the key impacts of the underpinning research, including the milestones achieved between 2008–2013, are described below.

Influence on Eurocontrol

The research carried out by Professor De Reyck was commissioned by Eurocontrol, the European air traffic organisation, who were asked to provide technical support, draft regulations and assist in its implementation through the SES Air Traffic Management Research (SESAR) programme. Using De Reyck's framework, for the first time in the history of European air traffic management, all aviation players came together in defining, committing to and implementing a pan-European programme. The framework is now integrated into the SESAR programme, and used as standard methodology for evaluating new technologies and operational improvements. As the Head of Airport Research at Eurocontrol and Director of the SES programme confirmed, "the developed framework […] is now integrated into Eurocontrol's standard methodology", and that "the framework has […] evolved to fit with the changing nature of the programme" [2]. Professor De Reyck's decision-making framework has had a significant impact on Eurocontrol, and thus on European aviation, by allowing the former to resume its visionary role as facilitators in European aviation decision making.

Impact on technology

The first agreement reached using the framework concerned Eurocontrol's CL-03-02 operational improvement cluster, which described proposed changes to arrival and departure support for airports with precision area navigation, designed to improve the safety, capacity, and the efficiency of terminal area airspace operations. Reaching an agreement around these proposals was challenging because of the sheer number of stakeholders involved, including the airports, airlines, aircraft manufacturers, equipment manufacturers, air navigation service providers, and communities around airports. Thanks to the use of the framework, agreements were successfully reached on five new technologies and procedures: Precision Area Navigation (P-RNAV), Arrival and Departure Management (AMAN/DMAN), Wake Vortex detection (WV), Time-Based Separation (TBS) and Basic Continuous Descent Approaches (B-CDA). These cases are described in detail in [a] and [b] in section 3.

P-RNAV offers the ability to define routes for the on-board flight information management system that best meet the needs of the airport, the air traffic controller and the pilot. This results in shorter, more-direct routes and improved route adherence and predictability. When environmental issues play a major role, the route can be designed to bypass densely populated areas. Although all stakeholders believed that there were clear environmental and safety benefits from implementing P-RNAV, the larger airports feared a negative impact on capacity because they anticipated a reduction in the number of holding aircrafts and thus a possible reduction of runway utilisation. The framework helped to reach an agreement on the implementation of this new technology. Similar consensus issues existed around the implementation of AMAN/DMAN, which assists the air traffic controller by recommending the optimal arrival and departure sequence, thereby increasing capacity and predictability, but reducing the airlines' control over departure and arrival times. Similarly, WV and TBS, designed to avoid dangerous interactions between airplanes taking off, had advantages and disadvantages for each stakeholder involved. Finally, a continuous descent approach was designed to reduce nuisance to local communities and environmental impact (by lowering fuel consumption when landing), but caused concerns for airports, who felt that B-CDA might have a negative impact on capacity.

Impact on increased air traffic efficiency

By 2012, these technologies and operational changes had been implemented at most major European airports [1], and Europe-wide traffic synchronisation exercises were held to validate their impact. It was found that the traffic synchronisation agreed on through Professor De Reyck's decision-making framework led to the following impacts ([5], p. 15):

- Air traffic control efficiency improved, with a 50% reduction in radio telecommunications, a 75% reduction in the need for vectoring;
- Air space capacity increased by 20%;
- Runway throughput improved by 4%;
- Fuel burn was reduced by 2%.

In addition to these Europe-wide improvements, there were also some dramatic local improvements. For instance, the application of AMAN at Heathrow has led to a reduction of aircraft stack holding time (aircraft circling an airport before its turn to land) by 78–87% ([6] p. 14).

5. Sources to corroborate the impact

[1] European ATM Master Plan Edition 2, October 2012. PDF available on request.

[2] Integration of framework into decision-making at Eurocontrol corroborated in statement provided by the Head of Airport Research at Eurocontrol and Director of the Single European Sky.

[3] Benefits of the Single European Sky initiative: see pp. 2–4 of *A Blueprint for the Single European Sky*, Eurocontrol, 2013; PDF available on request.

[4] Links to award nominations, including [b], a finalist for the INFORMS Daniel H. Wagner Prize for Excellence in Operations Research Practice; and [a] for the INFORMS Decision Analysis Society Practice Award, as well as finalist and runner-up for an INFORMS Case Competition Award: https://www.informs.org/Recognize-Excellence/Award-Recipients/Bert-De-Reyck.

[5] Impacts of implementation of key decisions: SESAR Annual Report 2012, available on request.

[6] *The SESAR Programme*. Presentation delivered by Patrick Ky, then Executive Director, in Washington DC on 25 June 2013. http://www.euintheus.org/wp-content/uploads/2013/05/SESAR-Event-Slides-June-25-2013.pdf.