

MARS: Creating resilience in critical aviation infrastructure

Dr Fabian Steinmann, Lecturer in Organizational Resilience and Change at Cranfield University.



Introduction

The electrical substation fire at Heathrow in March 2025 and recent drone flyovers at European airports necessitated a complete airport closure and consequent diversion of hundreds of flights. As these events have shown, disruption to the aviation system, resulting in airport closures, will continue to occur. Closing a critical hub in the aviation system results in mass diversion events, and alternative airports must be identified quickly for multiple aircraft.

There are around 40 commercial airports in the UK with regular passenger flights, plus more than 100 smaller public-use airports, some of which are also capable of supporting commercial operations. London Heathrow and Gatwick are the UK's busiest airports, at their peak respectively handling around 1,300 and 950 aircraft movements per day.

The MARS team (**M**odelling **A**viation **R**esilience **S**cenarios for the UK Aviation System) developed a computational model of the 34 biggest airports in the UK, plus an algorithm to simulate diversion options and highlight potential bottlenecks in the aviation system.

"MARS is a unique piece of work that could support the scenario planning of mass diversion events in the UK aviation network," Dr Fabian Steinmann, Lecturer in Organizational Resilience and Change at Cranfield University.



MARS: Creating resilience in critical aviation infrastructure

What would you identify as the main impact of this work?

As well as keeping in touch with industry throughout the project, the team liaised with Eurocontrol, to find out what's being developed from their side and how MARS could support their efforts. The MARS tool is for scenario planning and could complement some of Eurocontrol's operational tools by demonstrating how factors such as runway utilisation, stand sizes and numbers, and contractual agreements limit the choice of alternative airports during mass diversion events.

Since Brexit, an added layer of complexity for diversions is that not every passenger will have a visa or the documentation required to enter European borders.

The project has received a lot of positive attention and feedback from academia, government and industry. Fabian has been invited to present at this year's [Airports UK Conference](#) in June 2025. He demonstrated the outputs of the tool and how they can be used as a conversation starter for targeted scenario planning.

"The MARS aviation resilience work now makes an important contribution to DAFNI's national database of critical infrastructure," DAFNI Team.

Key challenges that MARS aims to solve

The UK's aviation network operates at high capacity, leaving little buffer capacity or 'slack' in the system to accommodate diversions from other airports. Consequently, an airport closure can have severe ripple effects.

MARS sought to develop a model to support the industry when such diversion events occur. The project focused on disruptions that would require unplanned closure of an entire airport, such as a catastrophic IT failure, varying in duration. Other examples would include the increasingly prevalent extreme weather episodes we are starting to experience.

MARS: Creating resilience in critical aviation infrastructure

What was the key aim of the project?

The key aims of the project were to build a database capable of running large airport simulations and to design an algorithm capable of diverting planes in the case of a mass diversion event.

The MARS model allows users to select an airport to close from the 34 modelled, to alter the time of the day, to select the closure period in hours, and then to simulate the effect of the closure on the entire UK network. The aim was to model how the diversions could be absorbed into the wider UK aviation system without adversely affecting the operation at other airports.

“MARS is acting as a central and innovative tool around which the industry can have a targeted discussion about mitigation strategies and use for their contingency plans,”
Dr Fabian Steinmann, Lecturer in Organizational Resilience and Change at Cranfield University.



What did DAFNI allow you to do that you couldn't have achieved otherwise?

MARS is a unique piece of work that could support the scenario planning of mass diversion events in the UK aviation network.

DAFNI provided a trusted data depository to host the MARS algorithm, to enable other researchers to use and contribute to it. DAFNI's independent and secure function was key to the work.

The MARS aviation resilience work now makes an important contribution to DAFNI's national database of critical infrastructure.

MARS: Creating resilience in critical aviation infrastructure

The main outputs from MARS available on DAFNI are:

- A mock dataset allowing users to simulate varying scenarios for any of the 34 airports in the dataset
- The simulation tool, its algorithm, and documentation
- The heat map of diversions in a visualisation through Jupyter notebook

How could this work benefit society as a whole?

The MARS work has been very topical in terms of airport closures over the past years, and continues to be so. It is acting as a central and innovative tool around which the industry can have a targeted discussion about mitigation strategies; it supports and simulates airline and airport contingency plans.

Stakeholders consulted include Eurocontrol and the Department of Transport, the Civil Aviation Authority, and NATS air traffic control services, as well as the AirportsUK trade association.

How do you anticipate other researchers, policymakers and stakeholders using this work?

The MARS team are hoping to use the simulation tool and heat map of diversions as a conversation starter at the next nationwide aviation emergency exercise. Real-life events, such as the 2023 Luton car park fire, could be simulated to compare the actual outcome with the optimal diversion process generated by the algorithm.

Dissemination work includes LinkedIn, publication of a leaflet for other researchers to discover more about MARS, and a conference or journal paper focusing on the technical details instrumental to building the algorithm. In addition, Fabian was interviewed by Sky News when Heathrow was closed in March 2025.

MARS: Creating resilience in critical aviation infrastructure

The future

Next steps include:

- Adding more granularity to the dataset
- Adding the possibility to add more airports beyond the current 34, so that users can run scenarios with other airports closed.
- Future work around estimating the impact of severe weather on aviation resilience in recognition of the increase in extreme weather events.

There is currently no database which takes into account contractual agreements or provides a review of the buffer capacity in the system. This research provided additional insights into the true buffer capacity system and how mass diversion events destabilise the aviation system.

The team is also planning to expand the MARS tool beyond the UK and welcomes collaborations with researchers from different geographic regions.

Contact: f.steinmann@cranfield.ac.uk

Who's involved?

The MARS project brings together experts in security and resilience with those from computational engineering. Led by Principal Investigator: Dr Fabian Steinmann, Lecturer in Organizational Resilience and Change at Cranfield University, the cross-disciplinary project includes Co-Investigator Dr Irene Moulitsas, Reader in Scientific Computing, and Researcher Dr Desmond Bisandu, Research and Teaching Fellow in AI and Scientific Computing, both from the Centre for Computational Engineering Sciences at Cranfield University.

When did the project start and finish?

The project ran from March 2024 to April 2025.

