



# MAYDAY

NAVIGATING  
AIRBORNE  
EMERGENCIES  
WITH AI

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*You are 12,500m above the ground, halfway through your flight, and everything so far resembles a normal trip. Suddenly, both engines fail, and the noise of the jet engines is transformed into absolute silence. Now the plane is essentially a 90-ton glider, dependent completely on the skill of the pilots to reach the ground safely.*

In 1983, this nightmare became a reality aboard Air Canada Flight 143, in an episode known as the Gimli Glider. Fortunately, the flight crew managed to glide the plane to an abandoned airstrip and land safely, relying completely on their expertise.

Though dramatic, such events are extremely rare thanks to the robust engineering of modern aeroplanes. Yet, when all engines fail and thrust is lost, the pilots' decisions become more critical than ever. Under intense pressure and without much time to take action, the crew must choose a safe landing site and define the right trajectory, knowing that a single miscalculation can end in catastrophe.

But what if a system could assist the pilots, offering real-time recommendations and a precise course to safety? UM academics Dr Ing. Jason Gauci and Dr Ing. Brian Zammit are conducting research on systems that can support pilots in navigating emergency situations with the aid of artificial intelligence (AI) and other technologies as part of the STELA Project – **Site Selection and Trajectory Generation for Emergency Landings of Commercial Aircraft.** [▶](#)

**Dr Ing. Jason Gauci**  
*Photo by Christopher Cauchi*



## THE LOGIC OF THE UNCLEAR

When faced with an emergency, pilots must quickly evaluate several factors: Are there airstrips or other suitable places for landing within the gliding range of the plane? Are there mountains, lakes, or densely populated areas in the vicinity? What are the current weather conditions? These variables are critical in evaluating the safety of a landing site, and STELA must be able to assess them to assist the pilot in making the best decision. But how can a machine do this?

According to Zammit, the STELA system was designed 'to replicate the thought process of a pilot in assessing the risk of different landing sites.' To do this, STELA implements a fuzzy logic framework. Instead of relying on simply yes-or-no decisions, fuzzy logic allows the system to capture and assign different levels of risk to various landing sites. Like human reasoning, this type of logic must handle uncertainty and incomplete information. For instance, a runway that is not ideal might be considered a good landing site if the weather in its area is clear or if there are no major obstacles in its surroundings.

The fuzzy logic framework has to be designed to account for the relative importance of the different parameters of the fuzzy logic. To do so, experienced pilots are presented with different emergency scenarios and are asked to describe their course of action and which variables are of greater importance in their decisions. The fuzzy sets and fuzzy rules of the framework are then tuned based on the pilots' answers so as to balance the different variables in the site-selection process. This tuning enables the computer to adapt to new situations and make informed decisions based on the answers collected.

One of STELA's most impressive features is its ability to identify non-conventional landing sites. When there are no viable airstrips within reach, the crew must find alternative landing spots such as fields or highways. For

this, STELA analyses terrain maps of the area and detects differences in the terrain's slope and roughness. This allows the system to identify regions that are flat, smooth, and mostly clear from obstacles, which are desirable features for a landing site.

## CHARTING THE COURSE

So far, we have seen how STELA finds and assesses the risks of different landing sites. The next concern is how to make the aeroplane reach a site and land safely. There are many possible trajectories between an aeroplane's initial position and a landing site, and executing a suitable descent path in a total loss of thrust scenario can mean the difference between success and an absolute disaster.

Zammit notes that 'once a trajectory is generated, the pilot can upload it to the automation systems of the aircraft and focus on communicating with the air traffic controller while planning what to do after landing.' That said, Gauci points out that 'the final decision is always up to the flight crew, as they might be aware of certain things that the system is not considering.' This approach ensures that the crew is still in control of the decision-making process, but it frees them to focus on other vital issues by automating most of the operation.

But what is a good path? Firstly, it must ensure that the aeroplane lands with the right amount of energy at the desired site. Moreover, difficult manoeuvres should be avoided to reduce the margin of error and ensure a smooth path. This can be achieved by minimising the number of turn manoeuvres and the bank angle of the plane. Additionally, the path should avoid other risks, such as flying over densely populated areas, mountains, or other obstacles.

There are many factors that impact the trajectory's choice: the aeroplane's speed, initial altitude and glide ratio, the terrain and weather, and more. To find the



**Dr Ing. Brian Zammit**  
*Photo by James Moffett*

best route, STELA explores a wide range of possibilities through what is known as a genetic algorithm.

### **AN ALGORITHM INSPIRED BY NATURE**


One of the most important mechanisms of biological evolution is natural selection. In nature, the individuals who are better adapted to their environment – the ‘fittest’ – are more likely to survive and pass on their genes to their offspring, naturally selecting the traits/genes that lead to better success in surviving. Genetic algorithms use the same principle to solve complex problems, which in the case of STELA, is to find the ‘fittest’ parameters for the aeroplane’s path. Here is a simple representation:

1. The algorithm starts by randomly generating a population of possible flight paths.
2. A ‘fitness’ function calculates a fitness score for each path.
3. The paths with the highest scores (i.e. the fittest) are selected to pass on their parameters to the next generation. These are the paths that are closest to the optimal solution in their generation.
4. A ‘crossover’ occurs when the parameters of each optimally selected path merge together. Following this, ‘mutation’ can occur, as in genetics, and introduce small changes in certain paths, allowing for more diversity and reducing the influence of the initial population on the final result.
5. This process is then repeated until the optimal solution is found or a maximum number of repetitions is reached.

The randomness introduced by the genetic algorithm allows for exploring less obvious paths, thus increasing the model’s robustness.

On the other hand, traditional deterministic algorithms use a mathematical model to find the best path and tend to converge quicker on a final solution; however,

they explore fewer trajectories and may miss safer alternatives. While the researchers made use of both these approaches, the genetic algorithm stood out due to its innovative application in the field and has shown great results in the test scenarios.

The STELA project is a great example of how artificial and human intelligence can interact to save lives. As AI quickly evolves, projects like this give us a glimpse into a future where humans and machines cooperate to improve the world. 

*The STELA project was led by Dr Ing. Jason Gauci from the Institute of Aerospace Technologies, in collaboration with Dr Ing. Brian Zammit from the Department of Electronic Systems Engineering and QuAero Ltd., a local aviation consultancy company. The project was financed by the University of Malta through the Transdisciplinary Research and Knowledge Exchange Complex (TRAKE).*

#### **Further Reading:**

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Rahman, A., Zammit, B., & Gauci, J. (2022). *A fuzzy-based site selection framework for emergency landings of commercial aircraft*. AIAA AVIATION Forum. Chicago, IL, United States. <https://doi.org/10.2514/6.2022-3221>