# Contributing to aviation safety through avionics design

*Dr Ing David Zammit Mangion*

AS I FIND MY SEAT, stow my hand luggage and make myself comfortable, a typically confident voice comes over the intercom "Ladies and gentlemen …. your captain from the flight deck. Welcome to this flight to Los Angeles. We are currently making the final preparations for our departure and will shortly be on our way. Flight time today will be eleven hours and fifteen minutes and we shall be flying at an altitude of thirty nine thousand feet. ……." I have hardly settled down and been through the movie list of the in-flight entertainment than the aircraft is pushed back and we are on our way. Throughout the eleven hour flight, I have had lunch and dinner, watched three movies, listened to several sound tracks, seen icebergs and vast plains and had a nap. Soon we are starting our descent into Los Angeles International Airport and my thoughts stray to my itinerary ahead. We touch down, taxi to the gate, come to a full stop and the engines are shut down. The seatbelt light goes off. I stand up, collect my hand luggage, wait for disembarkation and finally find myself walking out of the aircraft and up the tunnel of the airbridge, onward to the rest of my journey.

Another flight has been safely completed. One of several tens of millions flown every year. Few, if any, of the few billion passengers flying every year give a thought of what goes into ensuring that over 400 people cramped inside a metal cylinder for the best part of half a day, hurtling along at over 800 kilometres per hour in an environment naturally hostile to the human being, are kept in relative comfort and safety. Of course, we think nothing of it. We take technology for granted. What we tend not to realise is that this is only achieved through success in engineering and the meticulous attention given to safety in every aspect of the industry, starting with the design process of the aircraft, right down to its manufacture, certification, operation and maintenance. The industry goes to great lengths to ensure safety and does so to a level that is difficult for the average passenger to comprehend. For example, a 2-engined jet can take-off on one engine should the other fail, safety-critical electronics are equipped in triplicate, just in case one breaks down and the aircraft is checked for damage and malfunction before and after every flight. Try to compare that with motoring. Cars do not have two engines to ensure that at least one will get you back home, nor does the average motorist extensively check out the car after each journey, but then this explains why air travel is the safest mode of travel.

Statistically, a serious accident in commercial aviation occurs about once in every 1 million flights. That implies that if an individual were to take 3 flights a day, one would expect to be involved in an accident only once in a thousand years (and even then, one would probably survive). Although this is a tenfold increase in the safety record of the 1960s, the aviation sector is focussing on further improving the present record by a target fivefold within fifteen years. This is desired not only to further improve the track record of air travel, but also because the traffic density is expected to triple from 2000 levels by 2020. Indeed, the Strategic Research Agenda (SRA), published by the Advisory Council for Aeronautics Research in Europe (ACARE), identifies safety as one of the five major challenges in air travel.

The aeroplane is a complex machine that has evolved remarkably in the hundred years of its existence. A major and core component of today's machine is its avionics systems. Avionics, which broadly refers to the electronic systems and instrumentation on board the aircraft, are effectively the brain and the nervous and sensory systems of the aircraft. Without avionics, the aircraft today is useless, incapable of completing its intended mission. Avionics systems provide the necessary functions to support navigation, communication, flight control, cockpit instrumentation, flight and system management…. virtually everything on board a modern aircraft has an electronic system associated with it. It would not be surprising, therefore, to expect that new avionics functions would be called upon to contribute to improving the safety record. Indeed, this is the case, with avionics featuring heavily in the 'key enablers' identified in the SRA that can support the challenge associated with improving safety.

A major area where avionics is contributing to improved safety in air transport is that of surveillance. In this context, surveillance refers to the monitoring of the situation and the environment. The concept of surveillance functions is to ensure that the aircraft does not enter into a situation that may jeopardise the safe continuation of the flight. To this effect, surveillance functions can be classified by the threat they mitigate or the entity monitored: traffic, terrain, weather, crew action (human error) and aircraft health. Traffic surveillance functions are associated with ensuring that the aircraft does not inadvertently enter a situation of potential conflict with other traffic. In simple terms, this means that the function identifies a potential risk of collision with other traffic. Likewise, terrain and weather surveillance function are intended to provide sufficient situational awareness and advice to allow the flight crew to successfully avoid bad weather, turbulence and high ground. The flight crew, being human, is vulnerable to human error and thus avionics systems surveilling their activity and warning them of any undesirable action will contribute to improved safety. The aircraft, being a machine, is also liable to malfunction or failure and the identification of a failure or its impending occurrence, together with an indication of the implications can also significantly contribute to improved safety. The formulation of prototypes of such new avionics functions constitutes what, in European jargon, is often referred to as down-stream research, which is very close to and focuses on, end-product design.

Research and development in aeronautics requires a mix of very specialised and multi-disciplinary skills. This mix of skills is very much sought after and highly regarded in industry and professional engineering circles. It is, perhaps, the pinnacle of the profession, for it is this mix of qualities that has sustained the continuous progress and achievement in aviation. Aviation enjoys a high profile with the general public and it is often considered as a showcase of technological achievement and capability. This is clearly reflected in political circles, for all leading countries take pride in their strong capability in the field, whilst emerging countries strive to develop the capability.

The involvement of the University of Malta in the field of safety avionics reflects the quality and potential of the institution and strategically also contributes to the country's innovation portfolio. We are entrusted with the national responsibility of representing Maltese interests in EU Framework Programme 6 on matters relating to aeronautics and have very successfully led the country to participations worth ¤ 850,000, with further bids in the 2005 calls that may overall top the ¤ 1 Million mark in the 4 years of the framework programme. Most of these funds are involved with research in avionics and on-board electronic systems. This is a significant achievement for the country and indeed also for the University of Malta, which is the major national participant in these activities.

I have had the pleasure of leading the University of Malta into the field of aeronautics, an effort that is also reflected in the success of our participation in Framework Programme 6. We have, for several years, been collaborating with Cranfield University in the development and evaluation of aircraft monitoring systems and have developed a niche expertise in safety and crew alerting systems that are used in situations of high workload such as the take-off environment. The two universities are now jointly involved in a large EU programme involving the major European players in avionics, including Airbus, Thales Avionics, BAE Systems and Diehl Avionik Systeme. The programme focuses on the design of prototype, next generation safety systems for commercial aircraft. Building on its experience of developing prototype systems, the University of Malta is tasked with developing new functions to mitigate the risk of collision with other traffic during take-off and landing, whilst Cranfield University will be developing the cockpit instrumentation, referred to as the human-machine interface in technical terms. The University of Malta's work will involve the development of new concepts of surveillance and new complex algorithms that detect the hazard of a potential collision and advise the pilot on an optimal escape route to ensure the collision is averted.

These algorithms will be implemented in software and evaluated formally with the help of pilots on flight simulators to demonstrate the function and capability of the new system. The programme will continue into 2009, by which time, the new capabilities developed will be available for further development into new products that may reach the market in the first half of the next decade. Runway collisions are rare, but can have catastrophic effects with a high number of fatalities. Indeed, the worst air disaster of all time involved a runway collision, resulting in over 500 fatalities. If the new system we are contracted to develop will successfully avert a repeat occurrence even just the once, it will have been well worth the while researching into developing the new technologies required to mitigate such hazards. I have met many engineers involved in the design of aircraft, systems and components and all have one common character: a deep sense of pride in their work and great satisfaction in seeing their creations on board aircraft. One day, we may also be able to walk into a cockpit and tell the pilot with pride "The University of Malta was involved in the development of the concept of your instrument there". Until then, we remain happy to continue contributing to global knowledge that supports a safer record in air travel, so the general public will be able to live longer and travel more often to maintain the already excellent level of safety in flight.

---

DR ING DAVID ZAMMIT-MANGION graduated with a Bachelor's degree in Electrical Engineering from the University of Malta and worked in the semi-conductor manufacturing industry before joining the University in 1992 to lecture in electronics and electronic systems. Graduating with a Master's degree in Electronic System Design from the College of Aeronautics, Cranfield University in 1996, Dr. Zammit-Mangion returned to Cranfield to conduct research in aircraft performance monitoring and cockpit display design. He was awarded a doctorate degree for his work in 2001. He has since continued his research in the field of aviation safety, airborne surveillance systems and cockpit display design and has been involved in a number of large research contracts in aeronautics. A Chevening and Commonwealth scholar, Dr Zammit-Mangion is a member of the Advisory Council for Aeronautics Research in Europe, represents Malta in Brussels on issues relating to research in aeronautics and is also Lecturer of Avionics at Cranfield University.