"Aviation safety is an Integral part of my career. Being part of TU Delft’s impressive record of research on Aviation safety, my career has been with a sense of purpose and a responsibility to equip students to deal with the status quo challenges on Aviation safety, developments, Investigations and Optimizations. As I retire from the faculty with a gratifying sigh of relief, It’s a pleasure for me write this article on my experience and career along the progressive stages of Aviation safety."

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THE FIRST SIGH OF RELIEF
By the end of the Second World War, at the Yalta conference, Churchill, Stalin and Roosevelt could not come to an agreement at the highest political level on a common blueprint for worldwide post-war commercial aviation.

The first sigh of relief was when the trio found a solution on the regulatory and organizational level by establishing the International Civil Aviation Organization (ICAO). On 4th April 1947, a convention came into force to "ensure the safe and orderly growth of international civil aviation throughout the world". Safety became embedded in the structure of international aviation as an integral aspect, dealing with air fares & fees, tariffs & treaties, certification & licensing of crews, aircraft & airports and providing air traffic services to enable interoperability and free access of any nation in the rapidly expanding aviation network. Harmonized cooperation between sovereign nations was laid down in a series of annexes, dealing with each of the elements of the aviation system as a basis for national legislation and regulations. Technology became the flywheel for progress. Safety was guaranteed worldwide through harmonization and standardization of technical and operational equipment, dealing with international standards, operating procedures, recommended practices, training, traffic control, navigation, communication and airport facilities. Ironically, the safety Annex became no. 13, providing a protocol for international cooperation on the investigation of major air accidents. Since then, there has been a rapid and continuous growth of aviation, expansion of global networks, rapid technology developments of metal aircrafts, jet engine technologies, and navigation & communication facilities. The first generation of jet aircraft saw steep learning curves with unanticipated midair disintegration –such as with the De Havilland Comet. Such air disasters however, also brought knowledge about metal fatigue, structural integrity and commonly applicable safety design principles. By the introduction of the second and third generation of jet aircraft with the glass cockpit, navigation displays and Flight Management Systems, safety records on accident frequency improved significantly. Air crash survivability further reduced the risk of flying, while victim care and family assistance enhanced public confidence. The fourth generation introduced Fly by Wire, Flight Envelope Protection and Safety Management Systems during operations. Aviation became a distinct class of high tech systems: NON PLUS ULTRA safe, characterized as beyond 10^-7 safe with respect to the accident rate. The introduction of the Boeing 787 and Airbus 380 has seen no hull loss yet, an unprecedented achievement towards zero defects and First Time Right principles.

THE SECOND SIGH OF RELIEF
A second sigh of relief could be heard when major air accidents – US Airways flight 1549 in the Hudson (see Figure 1) and Qantas flight 32 near Singapore (see Figure 2) - occurred without loss of life in situations beyond design conditions. Aviation has become a matured system where conflicting values –safety, environment, economy and sustainability-are carefully taken into consideration in complex trade-offs and risk assessments. Performance requirements on fuel economy, noise abatement, airspace and airport capacity demands, punctuality, efficiency and passenger rights prevail, laid down in European policy documents such as Flight path 2050 and framework projects on sin-

THE THIRD SIGH

However, a third sigh, this time, of disbelief went through society when a series of unanticipated major air crashes occurred in a relatively short period. Questions were raised about the inability to diagnose their causes, formulated as ‘Black Swans and Unknown Unknowns’. Inherent complexity and dynamic behavior was deemed so overwhelming that pro-active analysis would become impossible, limiting safety diagnosis of such systems to their ‘emergent’ properties during operations. The general public wondered whether aviation had become safety complacent, whether pilots were over reliant on automation, suffering from a loss of situation awareness. Should unmanned flight provide the answer in eliminating human error or should we inevitably accept occasional losses for the common good and desirable growth? Do we inevitably proceed on the road to Hyper Taylorisation and full automation? The sector itself responded slightly differently, aware of early warnings for changes that might impact the safety integrity of the aviation system. In order to comply with a steady growth, environmental constraints, changes in global markets, intercontinental networks and new business models, ambitious plans for the future have been developed, dealing with various forms of ‘Next-Gen’ approaches with a high level of investments in new technologies.

THE EXPERTS SPEAK

The need for ‘Next-Gen’ also left the safety investigation community with questions on how to deal with such changes, preserving the achieved level of safety, skills and competences of the investigators, adapting them to the second age of aviation. Risk is a social construct, aiming at consensus on acceptable level of risk, balancing safety versus other values such as economy and environment. Has safety become an operational constraint instead of a critical system value? As formulated by Deborah Hersman, chair of the National Transport Safety Board in the ‘Green versus Safe’ Air traffic safety symposium hosted by the LR Faculty, TU Delft (see Figure 3), “aviation is all about defying gravity, safely and surely. There is no credit from the public for past achievements. Airlines are only as good as their last flight. What happens today is a given and continued improvement is expected to safely defy gravity tomorrow”. Yannick Maligne, Senior Vice-President and Chief product safety officer of Airbus stated that we permanently must address the main threats to safety: ‘overconfidence at all levels, maintaining highest professional standards and focus on right things to do first’. We must capitalize from positive outcomes too like, providing feedback from reality, learning from new experiences etc. Safety investigations are problem providers for knowledge development. Design interventions can be evidence and knowledge based. Although there may be sufficient “low hanging fruit” we must aim for the high hanging fruit as well. We should apply a consistent approach by disseminating existing and introducing new energy state/landing performing based advisory systems. For aerospace engineers, safety is not only a virtual or social reality: safety is dealing with defying gravity, with physical energy, reality, and design tradeoffs. As Tom Haueter of NTSB said, “It’s the assumption that kills you”. Assumptions on design, modeling, performance, operations should be transparent and validated. Jean-Paul Trouadec of French BEA investigation agency said in the report on AF447: “we must reflect on the validity of human error notions and human performance models, since they did not generate expected behavior of the flight crew”.

THE FINAL AND MOST SATISFYING SIGH

Fortunately, as aerospace designers, we can fall back on two firewalls in the feed forward and feedback processes between design and operation: certification and investigation. We teach our own students principles of forensic engineering, safety investigation, system engineering principles, integrated and multidisciplinary design optimization methods. We have to substantiate our own responsibilities with providing industry and society with qualified designers, engineers and investigators to cope challenges of Corporate Manslaughter and Corporate Homicide Act and exorbitant claims. Finally, a personal and final sigh of relief: by the Honorary Doctorate of Deborah Hersman, our faculty has demonstrated dedication to safety that has made the aviation system NON PLUS ULTRA safe. Assured by the final sigh of relief that a responsible group of next generation students will take over, I, John Stoop (Aerospace safety advocate, 1976-2014) am retiring gracefully from the Faculty of Aerospace Engineering, TU Delft.