A BLACK HOLE
At this point all you have is a mangled wreck, some witness statements, and a deceased pilot. This is a very common starting point for an aviation accident investigator. From here, this case becomes a complicated puzzle involving everything from local weather patterns, to health certificates to maintenance records. Despite these challenges, investigators are societally charged with a paramount responsibility in determining the root cause of the accident; the essential first step toward preventing recurrence.

It is precisely this prevention of recurrence that instigates an imperative feedback process within aerospace engineering and innovation. However, the potential value of this process has in the past and the present been overlooked, or rather overshadowed by more pressing innovation; this again is partially attributed to a sense of technical accomplishment. In this article I will draw examples from my growing exposure to this discipline to illustrate how safety engineering is a truly warranted knowledge frontier in aerospace engineering, and why it suits our faculty’s academic ambitions so well.

In 2010 I was introduced to Professor John Stoop (ATO), in his courses Forensic Engineering and Safety Engineering. It didn’t take long for me to realize that there was much more to this discipline than National Geographic’s program “Air Crash Investigation” (although I highly recommend anyone to watch it!). I quickly rearranged my coursework and master aim toward safety studies, starting with an internship at the National Transportation Safety Board (NTSB) in Washington D.C. Rekindling an old internship relationship between the faculty and the NTSB, I worked at the Department of Research and Engineering, Materials Division. I received components from field investigations to perform elemental, fractographic and certification analyses. It was a great opportunity to play an active and important role in these investigations; I was responsible for the complete laboratory investigations and the official NTSB lab reports.

Some investigation reports are already public. Others, such as the accident which introduced this article, are still being investigated. I was also able to work on the scene of a crash of a military helicopter, and pass the two week long accident investigation course given by the NTSB. All in all this was a fantastic opportunity to experience the dirty details of aviation safety. In retrospect, I can say that almost every single department at A&E can in one way or another be technically involved in such an investigation: it is truly multidisciplinary. However, accident investigation is only a starting point, from which other safety questions arise.

CHANGES IN THE WIND
The tremendous progress in flight safety that the aerospace sector has achieved in the past semicentury, is reflected in unfathomable statistics. In 2011, the accident rate was 1 in 2.7 million (IATA, 2012). Add to this the chance you survive such an accident is 95.7% (The Huffington Post, 2009). Put into perspective: you would
need to fly every day, for almost 7,400 years, to be in a plane crash, and this isn’t even taking into consideration the survival rate. And it’s only getting better; According to the Air Safety Network, 2012 was the safest year in aviation since 1945, when considering the number of accidents (ASN, 2013).

So you may wonder: “Why should I be worried about the feedback from accidents?” Indeed it would seem things are fairly well under control. However, there are three reasons which may broaden your perspective:

1) **Risk perception**
   Consider the definition of risk. There are two main defining properties, the probability of an outcome, and the consequences of that outcome. In risk analysis, the quantification of these properties offers a platform for risk comparison and grading. However, such risk scores require cognitive effort and knowledge, and therefore are not intuitively understood by people. People have a limited sense of what they “feel” is risky or not. Probability is particularly vague when it drops below 1%, and long-term consequences, e.g., smoking, pregnancy, also often fade out of view. On the other hand, short-term, acute consequences are more quickly understood, because of more vivid and explicit expectations, certainly fuelled by our increased exposure to media. Consider the lottery. The lottery works because people cannot attribute value to the odds, but have a very intuitive thoughts on what they will spend the 200 million euro on. The same goes for aviation accidents: the public has a much greater aversion to aviation accidents than to driving a car, because they disregard what they do not know (the probability), and base their judgement almost completely on a potential outcome. For this reason, people will continue smoking and try the lottery, and aviation accidents will remain unacceptable in public perception despite the actual risk being smaller than many other activities that are regularly performed without hesitation.

2) **Aviation growth**
   During the SAFE symposium recently organized by the VSV, Captain Harry Nelson, Former Experimental Test Pilot, illustrated that if the current major accident rate were maintained until 2031, the world would experience one major aviation accident every three months. To prevent this, the accident rate in terms of flights must at a minimum decline inversely to the growth in traffic. However, more reduction must be achieved to decrease the rate in terms of time (the rate which improves public perception). A very real example is the explosive growth in air traffic in India and south-east Asia. The greatest safety concerns are overworked and underpaid flight crews due to a pilot shortage, and significant lapses in traffic separation and management due to lagging air traffic management infrastructure struggling to keep up with the huge traffic demands (India Today, 2013).

3) **System dynamics**
   This last aspect is the most novel, and most relevant to our engineering faculty. In the past two decades commercial aircraft have become increasingly complex. As more and more (sub-)systems are introduced to manage a safe, efficient and economical flight, pilots are being assisted by an ever increasing level of automation. In the past, the introduction of computers in aircraft systems facilitated crew workload reduction, which was relevant at the time. However, more recent accidents suggest that this automation growth also dissociates the crew from actually performing the flight, and results in many having difficulties regaining flight and system control when an unexpected upset occurs. The problem does not have a single root cause. Training, automation design, financial pressures on airlines, crew fatigue, etcetera; all contribute to the current state of the aviation system. From a holistic perspective, this emergent behaviour can be attributed the result of changing system dynamics and interactions. Considering crew workload reduction: the initial short term benefits are quicker crew recuperation and their allocation to secondary tasks, such as fuel optimisation. A less expected behaviour is “automation complacency”, which describes pilots casually accepting suggestions and trusting automation, biased by a low failure rate. Hence, active cross-checking, verification and understanding of the automated processes quickly goes by the board, resulting in questions such as “what is it doing now?”. However, projects to identify these sys-

Figure 1. My presentation at the ISASI seminar in Baltimore, in 2012.
tem shortcomings are picking up speed. ICATEE (International Committee for Aviation Training in Extended Envelopes), the NASA Ames Flight Cognition Laboratory and MAN4GEN (Manual Operations of 4th Generation Airliners) are strong examples of developments aimed at resolving this modern flight safety problem.

I was introduced to the MAN4GEN project after attending several interesting symposia, presentations and lectures on modern aviation safety. MAN4GEN is a European consortium including Airbus, Boeing, EASA, NLR, DLR and others, aimed at investigating flight crew operations in modern cockpits. My thesis literature work was already focussed on flight cognition and automation, and I was quickly able to start my MSc thesis internship in May 2013 at the head institute, the NLR. I will be investigating the role of automation in the provision of information to flight crews. My work will conclude how information provision affects the quality of the choices crews make during unexpected occurrences.

IMMERSE YOURSELF!
My internship and thesis are only two examples of how an aerospace student can pursue his studies in aviation safety. There are many other ways to explore aviation safety. I will end with two other significant relevant activities I have undertaken.

Parallel to my experiences at the NTSB, I was selected as a recipient of the Rudolf Kapustin Scholarship Award, the second Delft student to ever do so after Michiel Schuurman in 2003 (who is now investigator at the OVV, the Dutch Safety Board). This annual scholarship from ISASI (International Society for Aviation Safety Investigators) permitted me to attend the annual week-long conference in Baltimore. Next to learning from other speakers, I was given the opportunity to describe myself and my essay to the full audience of over 250 worldwide investigators. This was a fantastic time get to know and be known in this field. As part of my scholarship, I have also completed an SCSI training course in human factors, and in the near future will attend another course offered to me in the UK. There is a very clear demand for young engineers in aviation accident investigation. If you are interested in accident investigation and aviation safety, consult my references at the end of this article.

In addition to my studies, I have recently immerses myself in Safety Management Systems. Currently, as the Safety Manager of the Delft Student Gliding Club, I am developing and implementing such an SMS as an EASA requirement for Approved Training Organisations, from 2015 onward. This work also introduces me to yet another cornerstone of aviation safety; prevention. At the moment, our SMS is a leading example within the Dutch general aviation community, and I look forward to improving the safety of our operations with it.

In my experience the field of aviation safety is probably the most multidisciplinary study for aerospace engineers at the moment. I myself expect to further my studies toward human factors and cognition, as I believe it to be one of the most promising fields of aerospace engineering in the future. I would like to end with a quote which I hope will inspire other aerospace engineers to also explore aviation safety studies:

“Take nothing for granted; do not jump to conclusions; follow every possible clue to the extent of usefulness… Apply the principle that there is no limit to the amount of effort justified to prevent the recurrence of one aircraft accident or the loss of one life.” (Accident Investigation Manual of the U.S. Air Force)

References