# ISASI FORUM

Air Safety Through Investigation

JANUARY-MARCH 2020

Journal of the International Society of Air Safety Investigators


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2019 Kapustin Scholarship winners meet Andre Kulpers, a Dutch physician and European Space Agency astronaut, following his ISASI 2019 keynote address. Shown, from left, are Elise Vondra, Alex Hall, Kulpers, Nur Amalina Jumary, and Stacey Jackson.


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AIR SAFETY INVESTIGATORS
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# PRESIDENT'S VIEW

*Participants of ISASI's 55th Reachout Workshop gather in Athens, Greece, on January 7-10.*

## *ATHENS REACHOUT WORKSHOP*

I recently had the opportunity to participate in the 55th ISASI Reachout Workshop, which was held at the Eleftherios Venizelos International Airport in Athens, Greece, from January 7–10. The workshop was hosted by the Greek Air Accident Investigation and Aviation Safety Board (AAIASB) and focused on accident investigation and aviation safety. Caj Frostell, ISASI international councilor, and I conducted the training session.

Antonios Athanasiou, AAIASB chair, opened the workshop. In addition, Capt. Akrivos Tsolakis gave a moving speech about Greece and ISASI. Tsolakis was the recipient of the Jerome F. Lederer Award at ISASI 2019 in The Hague, the Netherlands

There were 64 participants representing the AAIASB, Aegean Airlines, Olympic Air, Air Intersalonica, Air Mediterranean, Bluebird Airways, Ellinair S.A., Gainjet Aviation S.A., Helistar, I-Fly, Life Line Aviation, Lumiwings, Olympus Airways, Orange2fly, Sky Express, Superior Air, Swiftair Hellas, Athens International Airport, Goldair Handling, Skyserv Aero, Swissport, Egnatia Aviation, Global Aviation Academy, JetStream Aviation Academy, TAE Aviation Academy, the Hellenic Civil Aviation Authority, Fraport Greece, the University of Patras, other academia, and the Hellenic Air Force, Army, Navy, Coast Guard, fire service, and police.


*Workshop attendees include, from left, Odysseas Paxinos, doctor-consultant of the Greek Air Accident Investigation and Aviation Safety Board (AAIASB); Kimon Avgerinos, Jetstream Flight Academy head of training; Caj Frostell, ISASI international councilor; Frank Del Gandio, ISASI president; Antonios Athanasiou, AAIASB chair; and Grigorios Flessas, AAIASB member.*

The workshop provided ISASI instructors with a delightful opportunity to connect with AAIASB board members, as well as former AAIASB investigators Dr. Nikos Pouliezos and John Papadopoulos.

ISASI is appreciative of the sponsors' support that made it possible to organize the workshop. The sponsors that funded the seminar included Aegean Airlines, Olympic Air, Athens International Airport, and Sofitel Hotel.

ISASI has conducted Reachout Workshops since 2001, which provide subject-orientated training to individuals, government officials, and organizations responsible for aspects of air safety in regions where substantial gains for accident prevention may occur. To date, nearly 2,950 individuals have attended. The program is designed to assist aviation professionals who may not be able to attend formal training due to monetary or travel restrictions. Senior ISASI members who are requested to attend as instructors volunteer their time and expertise and do not receive compensation. The host organization provides travel, food, and lodging expenses for these ISASI participants. ◆

Frank Del Gandio
ISASI President

# Examples from Airbus: Black Swan Events

By Stéphane Cote, Director of Flight Safety, Accident Investigator, Airbus

*(Adapted with permission from the author's technical paper* The Paradox of Intuition—Black Swan Events: Examples from Airbus History *presented during ISASI 2019, Sept. 3–5, 2019, in The Hague, the Netherlands. The theme for ISASI 2019 was "Future Safety: Has the Past Become Irrelevant?" The full presentation can be found on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)*

What defines a black swan event? Black swan events are characteristically extremely hard to predict or rare and beyond the realm of normal expectations. In ancient Greece, it was assumed a black swan could not exist… until it was unexpectedly discovered in the wild much later.

## "Houston, we have a problem"

The Apollo 13 mission is a typical example of a black swan event in the aerospace industry. The objective of this mission was to land on the moon; but following an unexpected failure leading to the loss of the primary oxygen in the service module, the mission had to be aborted. Direct return to Earth was not possible, so the lunar module was used as a lifeboat while going around the moon. During the investigation into this event, NASA highlighted the effectiveness of crew training, especially in conjunction with ground personnel. Many lessons were learned from this accident, and all Apollo spacecraft were modified to incorporate safety enhancements.

## Airbus black swan events: some examples

We will now review the black swan events that occurred in Airbus history. For each event, we will detail the lessons learned and the product safety enhancements that were subsequently developed.

*Crossed roll controls, A320 (2001).* The root cause of this event was that input wires from one flight control computer (ELAC) had been inverted during maintenance (see Figure 1). This resulted in the captain's sidestick being inverted in roll. The issue remained undetected during maintenance and the preflight control check. At takeoff, the captain (PF) applied a lateral sidestick input to the right, but the aircraft banked to the left. The first officer promptly took over aircraft control, without the captain's expressed demand. Postevent, AMM improvements were introduced regarding flight control system maintenance, and the flight control check procedure was modified. The main lessons from this event are the importance of a flat cockpit hierarchy, first officer empowerment, and crew resource management (CRM).

*Total loss of hydraulics, A300 (2003).* This event was caused by a terrorist act. The left wing was hit by a missile during the initial climb (around 8,000 feet) (see Figure 2). This resulted in the loss of all three hydraulic systems in approximately 20 seconds. Subsequently all flight controls were lost, and slats and flaps were frozen at their current position. In addition, a significant amount of the left wing surface was missing, a fire had started, and the associated fuel tank was emptying. However, both engines were still running. The crew managed to learn how to control the aircraft pitch and roll using only thrust. The main lessons learned here are the remarkable airmanship and team work of this flight crew,

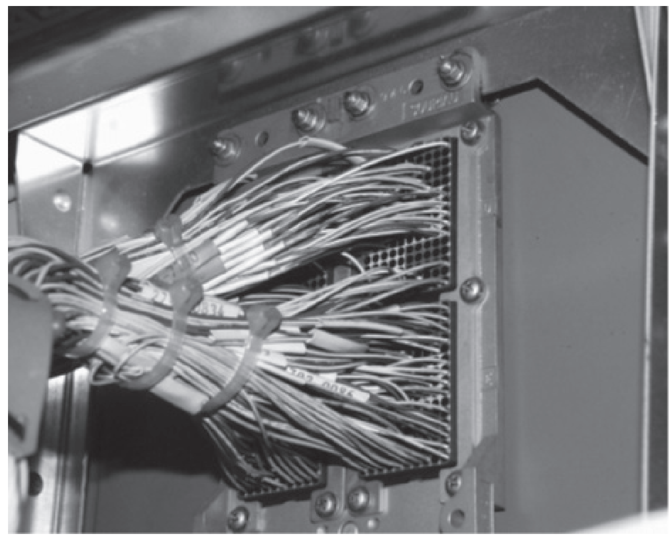


Figure 1. Crossed roll controls, A320 (2001)

Figure 2. Total loss of hydraulics, A300 (2003)

Figure 3. Rudder loss, A310 (2005)

which demonstrated that flying with only engines was possible in the current aircraft configuration. This also showed that on some occasions you may have to learn as you go, as some situations are unique and cannot be trained for in advance. Finally, this event highlighted the importance of learning from previous events, as this crew had knowledge of the Sioux City, Iowa, U.S.A., accident in which all hydraulic systems had also been lost.

*Rudder loss, A310 (2005).* During this event, the rudder was lost due to weakening of its structure (composite sandwich disbonding leading to reduced torsional stiffness) (see Figure 3). The flight was normal until the cruise, when sudden vibrations and a loud noise occurred and Dutch-roll oscillations started. The Dutch roll decreased and stopped when descending. On the ground, a major part of the rudder was found missing from the aircraft. The product enhancements that were developed following this event focused on reinforcing inspections and enhancing the design of sandwich rudders. Technology and design evolution (monolithic rudders) were introduced on new programs. Two important lessons were learned from this event: the importance of flight crew academic knowledge—in this occurrence, the crewmembers knew from their upset and recovery training (UPRT) that they needed to "slow down and go down" if faced with a Dutch roll in flight.

Figure 4. Emergency water landing, A320 (2009)

Regarding the structural aspects: Airbus determined that rudders need a health check inspection program, even when they are designed to be damage-tolerant.

*Emergency water landing, A320 (2009).* This aircraft (see Figure 4) encountered a flock of birds after takeoff, resulting in multiple bird strikes impacting both engines with subsequent significant loss of thrust on both engines. The APU was proactively started by the crew, which allowed retention of normal law and thus all flight envelope protections. The landing strategy had to be determined with limited or no time to prepare. The flight crew focused on the essential task of flying the aircraft given the emergency. The aircraft was flown occasionally within the alpha protection range, until an emergency water landing was performed. Following this event, a new QRH procedure "Emer Landing–All Eng Failure" was developed, new engine bird strike certification requirements were issued, and an APU autostart function was introduced on the A350. The lessons learned

***Stéphane Cote***

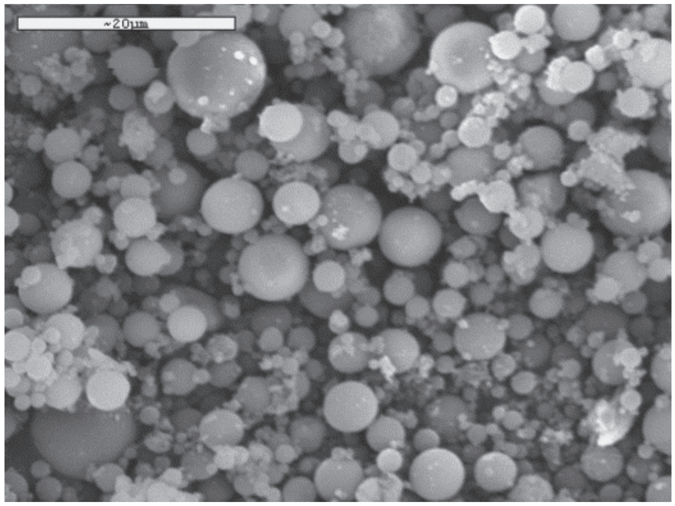



Figure 5. Fuel contamination, A330 (2010)

from this event were decision-making may be time-critical—in this case, due to the proximity with the ground. The importance (again) of appropriate task sharing and CRM: the captain flew the airplane and the first officer managed the engines. The need for flight crew knowledge of the systems, such as the decision to start the APU, ensured that the flight envelope protections remained available throughout the event.

*Fuel contamination, A330 (2010)*. During the descent, approach, and landing, this aircraft encountered a loss of thrust control affecting both engines. The investigation determined that the root cause was fuel contamination (see Figure 5), which was traced back to the refuel dispenser (truck). As a result of the contamination, both engines' fuel-metering valves were blocked. Engine 1 remained at approximately 70% N1 and Engine 2 at sub-idle. The fuel contaminants were composed of super absorbent polymer (SAP) combined with salt and water. An emergency landing was made (ground speed approximately 240 knots, Flaps 1). After the event, new operational guidance (a QRH procedure) was developed to assist flight crews. At the industry level, it confirmed that fuel uplift quality was critical as it may affect several or all engines. Therefore, the International Air Transport Association's Fuel Working Groups were formed. This resulted, as a lesson learned, in the decision to phase out SAP from fuel filters (deadline January 2020).

Figure 6. Uncontained engine disc failure, A380 (2010)

*Uncontained engine disc failure, A380 (2010)*. This A380 aircraft experienced an intermediate pressure turbine (IPT) disc failure to Engine 2 during climb. The airframe was impacted by disc debris, resulting in multiple structure and systems damage (see Figure 6). An in-flight turn back was performed, during which numerous ECAM alerts had to be processed. A safe landing was performed, followed by a controlled disembarkation. Several product enhancements were developed following this event:

- IPTOS function: automatic engine shutdown in case of IPT overspeed.
- Enhanced engine design and manufacturing process.
- ECAM enhancement, equivalent to scroller introduced on A350s.
- Additional fuel shutoff valve wiring routing precautions on new programs.
- OIS-optimized landing distance calculation based on actual aircraft capability.

In terms of lessons learned, the investigation confirmed that such events are best managed with effective work sharing consistent with the cockpit design, in this case two crewmembers. The aircraft

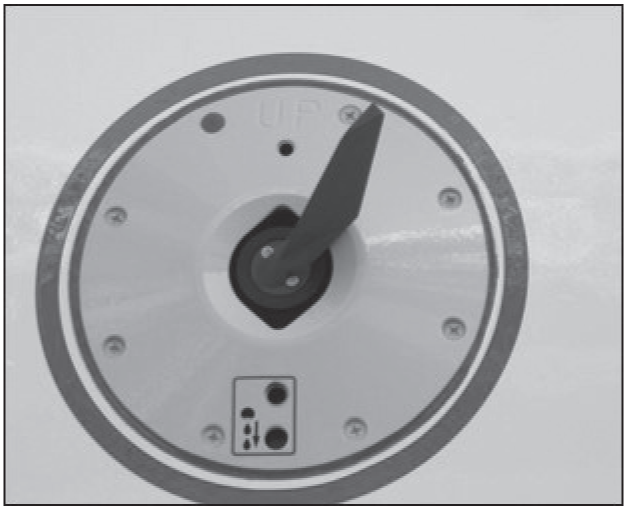



Figure 7. Angle-of-Attack (AOA) probe blockage, A330 (2012)

proved to be resilient to the uncontained engine failure. It maintained the autopilot and the flight envelope protections due to system redundancies. In addition, the ECAM functioned, even if operating beyond its design envelope. The flight warning system managed to process an unforeseen high number of failures.

*Angle-of-Attack (AOA) probe blockage, A330 (2012).* This A330 experienced a blockage of all three AOA probes (see Figure 7). They were fitted with a new configuration known as the conic plates. The three AOAs became blocked during climb (approximately FL100). When reaching FL310, the AP disconnected and the high AOA protection was unduly triggered, resulting in a commanded pitch down. The flight crew switched all three ADRs off and stabilized the aircraft at FL300. A diversion was then performed with the three ADRs switched back on. As a result of the event

- the conic plate configuration was removed,
- enhanced AOA monitoring by the flight control system was introduced, and
- development of new AOA probes was initiated.

In terms of lessons learned, this event shows the importance of the flight crew's continuous system monitoring: the crew detected an unusual characteristic speeds display on the PFD during the climb, which limited the startle effect at the AP disconnection, The event also highlighted the need for aircraft systems knowledge: the crew was aware of the systems that use AOA information, which allowed the crew to take immediate and effective action.

Figure 8. Loss of right-hand windshield in flight, A319 (2018)

*Loss of right-hand windshield in flight, A319 (2018).* Forty minutes after takeoff, while in cruise (FL321), the right-hand windshield of this A319 separated (see Figure 8). An immediate descent to a lower altitude was conducted, followed by a diversion to the nearest airport (Chengdu, China), where an uneventful landing was performed. The first officer and one cabin crewmember suffered minor injuries. An official International Civil Aviation Organization Annex 13 investigation, led by the Civil Aviation Administration of China (CAAC), is currently ongoing. An update will be provided in coordination with the CAAC and the French BEA.

## Conclusion

Black swan events are part of the aviation industry; and as unpredictable as they are, these exceptional events will happen in the future. Industry safety efforts (design precautions, SOPs, crew training, etc.) have allowed minimizing the impacts of such events. When relevant, Airbus will develop product enhancements (design, maintenance, procedures, etc.) after such events.

To sum up, the main lessons learned from these events are the following:

- Respecting the golden rules remains applicable.
- All trained pilot competencies (education and training) are key and will be needed.
- All available resources shall best be used.
- Capability to think outside the box may be required, taking the best of the available procedures. ◆

# Airmanship 2.0: Innovating Human Factors Forensics

Frederik Mohrmann

John Stoop

By Frederik Mohrmann, Aerospace Engineer and Aviation Training Expert, Netherlands Aerospace Center and 2012 Rudolph Kapustin Scholar; and John Stoop, Aerospace Engineer, Safety Investigator, and Professor of Forensic Engineering and Safety Investigation at Lund University, Sweden, and Deft University of Technology and Amsterdam University of Applied Sciences, the Netherlands

*(Adapted with permission from the authors' technical paper* Airmanship 2.0: Innovating Aviation HF Forensics to Necessarily Proactive Role *presented during ISASI 2019, Sept. 3–5, 2019, in The Hague, the Netherlands. The theme for ISASI 2019 was "Future Safety: Has the Past Become Irrelevant?" The full presentation can be found on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)*

Most of us are not surprised that the aviation sector is experiencing a shift in accident modes and causal factors. This illustrates itself in the very recent examples of the fatal B-737 MAX accidents in 2018 and 2019 (still pending completed investigations) and less recent but equally notable incidents such as an Emirates B-777 go-around accident in 2016, AirAsia's loss of an A320 in 2014, UPS A300 Flight 1354 in 2013, Qantas A380 Flight QF32 in 2010, and, last but not least, Air France A330 Flight 447 in 2009. There are other less known but equally troubling cases in which modern, well-equipped aircraft flown by air crews trained to legally required standards still result in deadly accidents.

Pending of course the outcome of the -737 MAX investigations, many recent accidents and incidents show a shift in accident causal factors. At the heart lies the overarching theme that increasing complexity of air operations introduces new emergent system behavior not always anticipatable and preventable by design. As such, maintaining a resilient air transport system demands more cognitively flexible and adaptable flight crews. However, these new higher-order competencies are in turn more strongly affected by fatigue and startle/surprise factors, accounting for the increased attention that these two phenomena are receiving. To boot, the industry has put pressure on all three fields: pilot demand driving down training efforts, fatigue on the rise due to circadian irregularity and extended work hours, and more reliable systems inducing automation complacency, which exacerbates startle and surprise potential.

As such, the current linear, Taylorist human factors (HF) investigation techniques, often focused on error and noncompliance, are not suitable to capture the new dynamics of human performance that present themselves in this era of an ever more complex aviation system. In order to understand and mitigate these new emergent system behaviors, HF forensics requires a shift in attitude, complementing existing error analysis with more in-depth pilot accounts, experiences, and reasoning. More than the cockpit microphone can record, HF forensics must shift to more proactive methods of investigation to capture this.

Recent research projects at the Netherlands Aerospace Center (NLR) have investigated these new HF, including investigating the effects of fatigue, startle/surprise in modern, complex incident and accident modalities, as well as evaluating the potential of countermeasures such as startle effect management training, mindfulness training, and new complexity-oriented problem-solving strategies. Besides developing effective countermeasures, these projects have also developed new methods of forensic investigation of such scenarios.

This contribution will present several practical forensic methods used in these proactive, simulated investigations collected over the past years, supplementing a new, future-proof HF investigation model. Both investigative methods as well as new cornerstones of human-machine interaction and human effectiveness will be presented. Some insight into developed mitigating methods will also be presented as positive outcomes of these proactive investigations. Hopefully, this may help investigators identify the more subtle emerging behaviors of this increasingly complex system before a new accident has to be its herald.

## Introduction: outliers or trends?

The 2019 worldwide commercial air transport system is one of the highest performing systems in the history of humankind. It is almost unfathomable how we can transport 4.1 billion passengers (2017 figures) at an accident rate of one per 6.7 million flights, with zero accidents in 2017 for International Air Transport Association (IATA) members. We speak of a nonplus-ultra-safe system approaching the mythical 10-7 accident rate, a theoretical safety performance limit. And yet we still have accidents, and these are not minor events in unforgiving circumstances far beyond our wildest dreams, caught in a flock of black swans or other unknown bird. A few telling examples follow.

## Air France 2009

During a flight from Rio de Janeiro, Brazil, to Paris, France, an Air France A330 experienced icing on the pitot tubes, resulting in inaccurate air data. The autopilot disconnected promptly, with the aircraft control law switching from normal law to an alternate law, followed by the autothrust system disengaging. The first and second officers who were on duty during this event were unable to maintain control of the aircraft, which was operating at an altitude where overspeed and stall speeds approach each other—in addition to a total lack of airspeed information and a control law that is seldom used. The resulting prolonged stall in a dark and clouded surrounding was not detected as such and resulted in the aircraft crashing into the ocean.

## Qantas 2010

After departing Singapore Changi Airport, a Qantas Airbus 380 experienced an uncontained engine failure of the Number 2 engine, with a separated fan blade damaging multiple hydraulic, electric, and structural systems along the left wing spar. This resulted in the malfunction of flight control systems, engine control systems, and fuel control systems, along with an incredible 53 ECAM failure messages. This flight featured five flightcrew members, as both a line and instructor check were being performed on this flight. After two and a half hours of diagnosing the state and ability of the aircraft, the crew managed to land the aircraft successfully in Singapore with one engine still operating near max thrust, with limited hydraulic braking available, failed antiskid, and only a half hour until the lateral fuel imbalance would no longer permit controlled flight. The ability of the flight crew to abstract the aircraft state, override system procedure requirements, and distill a unique landing performance strategy was critical to the prevention of an accident on par with Tenerife.

### Asiana 2013

While landing at San Francisco International Airport, an Asiana B-777 performing an autolanding failed to maintain sufficient airspeed during the approach and as a result descended below the glideslope. This resulted in the aircraft touching down on the seawall just prior to the runway threshold. The reason for the reduction in airspeed was the disengagement of the autothrust system, with the low-thrust settings used in a higher section of the approach when the aircraft was above glideslope, being held until seconds before the impact when the crew made a late attempt to recover engine thrust. The reason for an incorrect autothrust setting was related to the crew's insufficient understanding of the complex autothrust modes and their (dis)engagement conditions.

### AirAsia 2014

During a flight from Surabaya, Java, to Singapore, the pilots of an AirAsia Airbus 320 lost control of the aircraft and crashed into the sea. This specific aircraft experienced a malfunction of the rudder traveler limiter unit (RLTU) 23 times in the previous year, later attributed to a cracked soldered connection. During this flight, the system presented an RTLU failure four times. Normal procedures require resetting the RTLU, yet this time the captain elected to reset the two flight augmentation computers, which removed flight control augmentation and placed the aircraft in alternate law (manual control). Shortly after, the aircraft entered a stall. The accident report noted, "[The pilots] would have to rely on manual flying skills that are often stretched during a sudden airborne emergency."

### West Air Sweden 2016

During an uneventful night flight over Sweden, a West Air Sweden Canadair CRJ200 experienced a midflight loss of control resulting in a crash near Lake Akkajaure. During cruise with the autoflight system engaged, the left primary flight display (PFD) showed a rapid increase in pitch attitude, which was due to a failure of one of the attitude reference systems. This increase in pitch disengaged the autopilot system that was coupled to the captain's left-hand instruments, requiring the captain to take immediate manual control of the flight.

The PFD initially provided an indication of a pitch mismatch; however, this was removed when a declutter mode of the PFD was activated as the incorrectly indicated pitch exceeded, additionally prompting the captain for a nose-down control action. The captain obliged immediately, not having any strong outside references.

However, as the flight was still straight and level, the aircraft entered an uncontrolled dive, resulting in impact with the ground less than two minutes later. The crew's inability to detect the pitch mismatch, the system's rapid degradation of information to detect it, and the crew's rapid actions resulted in fatal loss of control.

### B-737 MAX 2018/2019

Two accidents only months apart involving a Lion Air B-737 MAX and an Ethiopian Airlines -737 MAX both featured similar malfunctions of the maneuvering characteristics augmentation system (MCAS), which uses an angle-of-attack sensor to prevent impending aircraft stall by providing inputs into the flight control augmentation system. In both events, the MCAS provided multiple and strong nose-down control inputs as the aircraft were climbing out after takeoff.

The MCAS was a new system modification introduced into the -737 MAX without explicit training for the pilots. MCAS controls pitch using automatic elevator trim controls, and a failure of the system should be treated as an elevator pitch trim runaway/failure. However, the failure of the MCAS was not part of the conversion training to the -737 MAX, and as such provided the flight crews with a failure for which they were not immediately proficient.

The Lion Air aircraft experienced an MCAS failure on the previous flight, resulting in an extreme flight profile that was only resolved after a third pilot suggested the stabilizer trim runaway procedure, although there were no indications that this was the problem. Unfortunately, the next flight experienced the same problem but was not able to resolve the problem in time. The investigations are still ongoing, yet the incidents show a similarity to the previous four accident examples. As a result of these accidents, the -737 MAX has been grounded worldwide pending investigation.

There are plenty more examples that the last 10 years can provide, with similar accounts where the existing sociotechnical system design of our cockpit operations still lead to a sometimes fatal accident or some lesser undesired state from which we still managed to recover. Currently, most of these accidents are categorized into basic accident categories (with controlled flight into terrain leading the list) and with a pilot's negative contribution to a situation assessed as "pilot error" with the occasional organizational culture issue at its flank. As a result, our industry has been quite focused on how to prevent controlled flight into terrain, developing advisory circulars, updated upset recovery and flight envelop systems, and adapted flight manuals.

However, are we as an industry truly convinced that we have found the root of the problem as we Band-Aid our operations in the wake of these accidents? Or have we reached a point in which we realize we are only treating the symptoms of a larger issue at hand? W. Vincente proposes a possible explanation of these accidents as presumptive anomalies: "Presumptive anomalies occur in technology, not when the conventional system fails in an absolute or objective sense, but when assumptions derived from science indicated either that under some future conditions the conventional system will fail (or function badly) or that a radically different system will do a much better job."

We should consider the possibility that the industry is experiencing presumptive anomalies in the pilot-automation sociotechnical system, which still operates as "designed" (trained) but that the conditions in which this design works has changed. We may not know yet for sure, but we cannot afford to make such global assumptions. If we are not willing to assess whether our operational paradigm has reached its limits, we will not be able to improve performance. As a result, as the commercial air transport industry grows at a rate of 6–7 percent a year, so will the number of global accidents if the accident rate stagnates around one accident per 4–6 million flights. If the number of flights increases by 6 percent and the accident rate in 2019 is one accident per 5 million flights, we will have 22 accidents in 2036, up from eight accidents in 2018. This means we will read about a major accident worldwide every two weeks, which will not answer for the public, especially in this age of information exchange and social media amplifying the public outcry against such accidents. This industry cannot afford such stagnation and must be willing to examine its limits to induce effective innovation in safety.

At the forefront of this assumption testing stands the aviation safety investigator, a professional who has learned to eat assumptions for breakfast. However, in order to challenge an existing paradigm, the investigator must have investigative tools from a contrasting paradigm to gain perspective. Put anecdotally: "If all you have is a hammer, everything looks like a nail."—Abraham Maslow

Put in context, if all you have is a human-error bandage, everything looks like human error. This paper wishes to empower safety investigators with a new perspective on the human-machine paradigm and give insight into tools and methods that may facilitate innovation in HF forensics. In 2012, BEA director Jean-Paul Troadec reflected on the investigation of the well-known Air France Flight 447, indicating the possible limits of the current HF forensic methods: "This accident has also taught us that hypotheses used for safety analyses are not always relevant, that procedures are not always applied, and that warnings are not always perceived. Only an improvement in the quality of feedback will make it possible to detect any weaknesses in the safety model."

Observing this from a broader perspective, the major implication of innovating the way we investigate our operational paradigm is that investigators are reempowered in a proactive role to provide direction for a whole new level of safety performance of our industry.

## The limits of our current HF model

In the beginning, becoming a pilot placed oneself right up there with the most daring, courageous, and progressive people of the time. Flying was a considerably dangerous undertaking that required pilots to have a more daring, innovative, and can-do mentality to weather the technical uncertainties and atmospheric conditions only partially understood and other challenges such as physiological limits, limited infrastructure, and a rapidly changing industry.

However, as the industry developed, flight operations were increasing more predictable, and at a fundamental level the "pilot" role in the system (usually fulfilled by an actual human being) was subjected to rigorous "Taylorization," stemming from the work-principles of Frederick Taylor: efficiency-driven principles developed during the Industrial Revolution. Operational features such as checklists, standard operating procedures, compliance checks, prescribed training programs, and sim/line checks are all manifestations of the industry's thoroughness in prescribing operations. And for good reason: the adventurous, authoritative, and risk-defying attitude that was necessary in the early days of aviation (up until the 1950s) was no longer conducive to the operations that were by then readily predictable, regulatable, and in need of consistent pilot performance.

The human operator moved from an "aviator" role toward a very useful element in our cockpit system, as he or she could be programmed for a multitude of tasks that could not be automated at the time. However, slowly but surely the *human* pilot was sought to behave as a *mechanical* element, but one you could talk to and give more complex tasks than the mechanics of the time. All this drastically improved aviation safety as accidents caused by ego-driven attitudes, slips and lapses, aircraft limit exceedances, and incorrect failure management slowly receded into the past. Basic and recurrent flight training steered toward conditioning new and old pilots in their predictability and compliance, for example, with the concept of "checks" being hard coded in pilot development.

The promise of predictability rooted itself very deep within our cockpit design philosophies—so much so that in the 1980s and 1990s, the natural variance in pilot behavior was regularly and rigidly held accountable against the prescribed task sets and behaviors pilots were trained and told to do. This "deviant behavior" was labeled as "pilot error." Driven to reduce the influence that such pilot behavior variance had on safety, third- and fourth-generation commercial aircraft heralded new cockpit technologies such as integrated systems, fly-by-wire systems, centralized failure management, etc., to offload more and more tasks from the pilot and shift them toward increasingly more capable mechanical system elements.

As a result, the pilot's role slowly shifted from directly executing the flight to overseeing systems that would execute and coordinate with other operational stakeholders (ATC, aircraft, company, ground handling, passengers, etc.) and to serving as a flexible system element that offered redundancy for most if not all tasks executed by automation. Offloading to automated system elements was further promulgated as our industry felt more and more confident in an operation we could carefully map out, plan, and prescribe: the ultimate determinist system.

## Determinism at the core of our HF forensics

Our basic model of the human operator in the cockpit serves as a foundation of our HF forensics. The thoroughly prescribed tasks and behaviors for the pilots in our operations serve as a very rigid reference against which actions of a pilot can be benchmarked. The early days of HF forensics were quick to denounce aberrant pilot behavior into several broad categories: wilful noncompliance and human error, the latter being subjugated to further categorization in subsequent decades, including slips, lapses, various forms of complacency, decision errors, perception errors, crew interaction errors, and more recently organizational cultures and processes. The Human Factors Analysis and Classification System provides sufficient examples that illustrate the current scope of investigation, but the same determinist base can be observed in the International Civil Aviation Organization (ICAO) Annex 13 investigation guidance, which lacks a large set of classifications of physiological, behavioral, and social factors that can be found in a growing number of recent accidents (by way of reference those in the introduction of this paper). As an illustrative example, within the European ECCAIRS accident database, it is not possible to search for accidents that may have *surprise* or *startle effects* as a contributory factor while that very topic is taking center stage in safety discussions, with the European Union Aviation Safety Agency (EASA) prescribing startle or surprise management training in the near future.

During the era of comparably predicable operations in the 1980s, the existing HF forensic approach seemed reasonable. However, several concurrent developments in the cockpit operational domain will challenge the existing cockpit operational paradigm at its determinist, Taylorist roots, and with it the validity of the current scope of HF forensics.

## The changing nature of our aviation system today

Per 2019 statistics, the worldwide commercial air transport system is one of the highest performing systems in the history of humankind. This becomes clear when we observe just a few of the several key figures IATA provides in its 2018 annual review:

- 4.1 billion passengers transported,
- 41.8 million flights (1.3 takeoffs per *second*, every minute, every hour, every day),
- 1 accident per 6.7 million flights (worldwide, zero for IATA members),
- Pushing toward carbon neutral growth after 2020,
- Load factor exceeding 80%, and
- 6.7% increase in available seat kilometers.

In short, this industry is flying more people further, faster, cheaper, safer, and for a lower carbon footprint per passenger than ever before, and it's growing—fast. All this busyness has to contain itself ( for the time being) within the same planetary constraints below 45,000 feet and the earth's surface at zero feet. Furthermore, it must operate within our social constraints of expanding cities and increased quality of life with lower emissions and noise pollution requirements—not to mention the internal market constraints in which sharp competition among regions, manufacturers, airports, and airlines constantly drive the financial efficiency of our operations to be better than the day before. These natural and manmade industry constraints require the aviation system to grow in efficiency, and not just by scale.

And yet we all know this already; it's nothing new under the sun for those working in this industry. As a result, to perform at this level the aviation system features levels of complexity that are both impressive as well as daunting. In contrast to the aviation system of 40 years ago, it has developed tremendously. Taken from a basic systems perspective, the sheer amount of system elements, their functions, various modes of interactions, and multiplicity of contexts in which they must operate have all increased. At the ultimate executive tip of these operations is that our aircraft-pilot systems are sought to provide extremely high performance, reliably 365 days a year, and in various conditions (weather, routes, passengers, airports, cultures, etc.). Within the cockpit operations domain, this has resulted in several notable evolutions in technology, the human operator, and the interface between the two.

## Evolutions in cockpit technology

The above complexity has absolutely manifested itself in the design of aircraft and aircraft systems. With aircraft designs pushed to reduce carbon emissions, to fly more economically, and to fly within practically any and all weather conditions, it is no surprise that the systems to achieve this optimization have grown in number, integration, and autonomy. The introduction of such systems includes flight envelop protection and active upset recovery technology (e.g., MCAS), GPS-based navigation, automatic fuel-CG balancing systems, automated cabin atmosphere regulation, automated engine startup, electrical pumps replacing mechanical pumps—not to mention the advent of paperless cockpits and the use of tablet devices as digital kneeboards.

The increasing number of systems also features an increased integration of systems such as EICAS/ECAM fault management systems, which directly invoke QRH checklists to be executed. Similarly, digital checklists can detect the state of several aircraft system configurations and indicate whether checklist items are completed (e.g., "No Blue" callout during Airbus approaches). System integration is also heavily present in the flight management system (FMS), which can be directly provided a flight plan from an operator's flight planning department via a wireless connection at the gate. The FMS is then able to automatically calculate weight, balance, and takeoff performance and execute the entire flight navigation via integration with the autoflight system. The respective autonomy has increased as well, with many systems operating without direct crew intervention.

A clear example is flight envelope protection and PFD declutter modes, which automatically engage in primary flight control tasks. Another is the previously mentioned FMS, which flies along a preapproved flight path without the crew having to reselect navigation beacons or points. Further autonomy also lies outside of aircraft systems, for example, by automatic approval of Atlantic crossings with automated flightpath management systems on the ground, and in the future free-flight operations with aircraft autonomously interacting to manage the clearance between each other continuously. The promise of consistent performance from automation has never before seemed so appetizing in aircraft development as systems become "smarter" and can be programmed to act and react to many more cues and calculate actions to many more situations, perhaps even imitate some form of artificial intelligence.

## Evolutions in the piloting profession

The industry developments have also resulted in several notable shifts in the piloting profession. Boeing predicts that the next 20 years will require no less than 804,000 new pilots. At the same time, pilot salary has dropped by half in some cases, and in the U.S. the first 1,500 flight hours often pay even less than that, with salaries of US$20,000 not uncommon at the start of a career. Furthermore, flight training costs have risen proportional to oil prices, and state- or airline-funded training programs are becoming replaced with loans and pay-to-fly schemes.

In addition to this, pilot training efforts have also been diminished. Prescriptive, tightly controlled training syllabi for both ab-initio and recurrent training have, with a few exceptions, been reduced to the bare legal minimum. Aircraft familiarization has made way for simulator and line training; ab-initio training has made way for multipilot license training (MPL), reducing single-engine piston flying time from 200 to 120 hours, training directly toward a right seat in an A320 or B-737. Recurrent training features a preset list of topics to train, and the license proficiency check has become a memorized activity for most pilots.

Lastly, the (r)evolution in airline networks has its effect on the fitness of pilots. Routes are

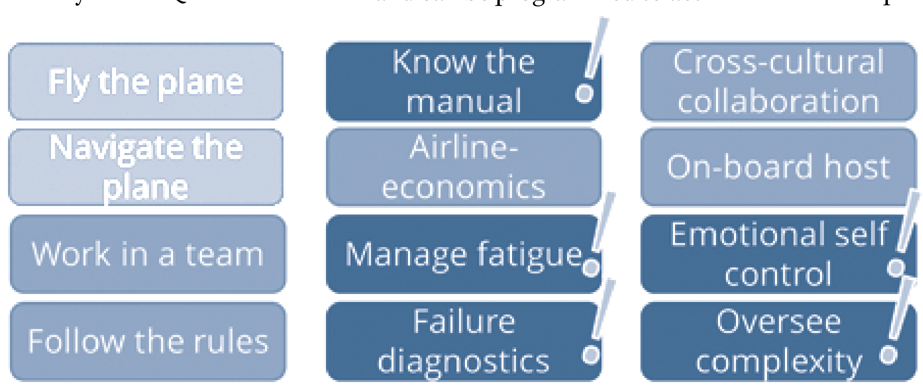



*Figure 1. A broad overview of pilot tasks. Light blue has been mostly automated. Dark blue is particularly challenging.*

extended to 12–15 hour flights (which even passengers find exhausting), busier airports extend their opening times, and low-cost operations make use of the less-popular 2:30 a.m. slots, with many airlines reducing the crew turnaround times to a minimum—sometimes requiring them to red-eye back instead of remaining at an outstation. Pilot fatigue is on the rise; fortunately though, awareness of the risks of fatigue are being realized by, for example, the implementation of fatigue risk management systems (FRMS) and regulators becoming increasingly concerned about flight crew fitness to fly. Figure 1 (see page 11) provides a crude overview of pilot tasks, where flying and navigating have greatly been automated. Dark blue shades represent recent areas of concern and research.

Figure 1 illustrates that many of the familiar pilot responsibilities of "aviate-navigate-communicate(-manage)" have reversed themselves to "manage-communicate-(navigate-aviate)." In any case, a low-paying job with financial stress and operating well outside a responsible circadian rhythm, among other stressors, including cultural diversity in the cockpit, forced living at airline hubs, and no career guarantees, illustrate a profession that puts increasing strain on the human as a living, breathing being.

*Table 1. Levels of Automation*

| | Information-Processing Functions | | | |
|---|---|---|---|---|
| Level of Automation | Monitor | Generate | Select | Implement |
| 1. Manual control | H | H | H | H |
| 2. Action support | H/C | H | H | H/C |
| 3. Batch processing | H/C | H | H | C |
| 4. Shared control | H/C | H/C | H | H/C |
| 5. Decision support | H/C | H/C | H | C |
| 6. Blended decision-making | H/C | H/C | H/C | C |
| 7. Rigid system | H/C | C | H | C |
| 8. Automated decision making | H/C | H/C | C | C |
| 9. Supervisory control | H/C | C | C | C |
| 10. Full automation | C | C | C | C |

Note: H refers to human, C to computer

## Evolutions in the pilot-technology interaction

The above-mentioned developments in technology, training, and operations have a profound impact on the way that humans and automated systems interact in the cockpit. It may already be clear that the designed interaction between pilot and automation is shifting from a pilot-centric design to an automation-centric design. Many tasks previously appointed to the pilot have been transferred to automation, and as automation has a higher level of autonomy, it in turn requires more time to communicate with the pilot as another crewmember, much like the human-machine teaming concept proposed by Sheridan's 10 levels of automation (see Table 1). "Implementation" was one of the first tasks to be offloaded to automation around the 1950s (autopilots), "Generate" has shifted since 1980s, "Select" since the 1990, with "Monitor" for the pilot in the most recent years, floating somewhere between levels seven to nine.

However, this shift from human to automation also catalyzes itself, which may best be illustrated in how the changes in technology and pilots affect each other.

How an increased level of automation affects the pilot:

- Increased autonomy of systems induces effects of knowledge decay as well as automation bias as pilots are less engaged and less familiar with the working (or failure) of the system.
- Increased integration of system induces automation bias as pilots cannot match the system's ability to assimilate information sources and tend to defer to it.
- Increased system reliability induces experience decay as pilots do not experience system failures or limits often enough. It also induces reduced monitoring/complacency as the lack of the need for monitoring is experienced.

How changes in pilot training/role affect technology:

- The drive to reduce training overhead costs implicitly supports higher levels of automation to reduce pilots' task and competency requirements.
- A broader set of users from various cultures/operations also drives an increased level of autonomy of systems to reduce risk of translation errors.
- A decay in knowledge and experience (also due to reliable systems and repetitive operations) stimulates automated failure management.
- Reduction of type training conversion costs and crew flexibility stimulates common cockpit philosophies (e.g., flying an A320 and A380 is much the same cockpit operation).

The self-catalyzation that is most apparent is the reduction/decay of crew knowledge,

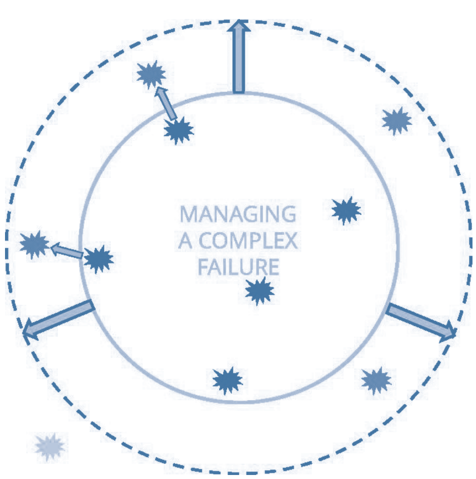



*Figure 2a.*


*Figure 2b.*

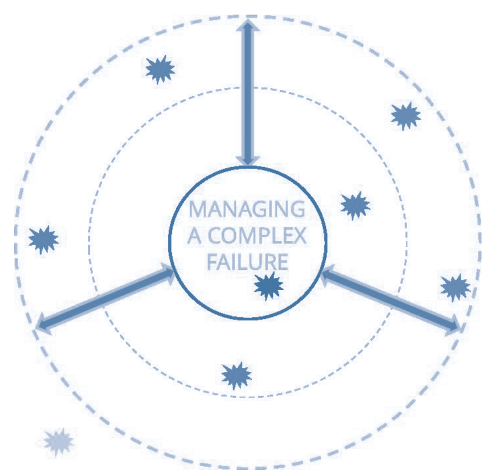



*Figure 2c*

experience, and cognitive flexibility, which has driven the expansion of automated, integrated, and autonomous systems even for once-basic pilot tasks such as speed management, navigation, and fuel management. This in turn results in pilots who are even more disengaged in such system activities and lack even more knowledge and ability to manage undesired system states.

### Different ingredients, same recipe (for disaster)

As noted, today's cockpit operation deals with very different human elements and very different (and more) automated elements than several decades ago. However, the basic recipe for a flight operation has remained unchanged. The operation is prescribed, trained, and coded (as applicable) and executed to be as consistent and predicable as can be—and corrected against the operation as designed.

So in theory, we should have no accidents caused by human or automated system elements. But why then do we have accidents that involve these system elements? In a conceptual sense, both the context and the pilots have changed, and the combination leads to a greater inability to manage the situation.

Figure 2a shows a circle that indicates a space in which the current operational concept assumes a pilot can manage a complex failure. However, we still observe accidents within this space, but how is this possible? Figure 2a shows that some accidents seem to be a "manageable" complex failure, but in fact are well outside of the designed (trained) ability of the pilot ( for example, the Qantas Flight QF32 or the B-737 MAX accidents) and require more competent pilots we assume we have, indicated by the yellow line. Furthermore, the ability of a pilot to manage complex situations has also been reduced ( fatigue, startle sensitivity), as is illustrated by the smaller circle in Figure 2b.

Combining these two developments in Figure 2c shows the ability gap that occurs when both effects are combined. As Vincente stated earlier, this is how the presumptive anomalies of loss of control may arise in our operations.

Analyzing several notable accidents of the past decade reveals several factors that may contribute to a flight crew's inability to manage a situation. Figure 3 provides a possible organization of these factors. These factors have been reproduced in recent research activities at the NLR. Several notable research initiatives such as the EU FP7 project MAN4GEN, a CAA UK investigation into pilot fatigue performance, an EASA-contracted global pilot fatigue data study, an EASA-contracted startle and surprise management collaboration with KLM, research into performance-based training such as evidence-based training, and Horizon 2020's FutureSky Safety: Human Performance Envelope project are just some of the R&D efforts that support the factors in Figure 3.

The above-mentioned factors particularly manifest themselves in operators that are out of the loop in a system that is not fully understood by the pilot, or perhaps even by the system and operational designers themselves. Both developments (pilot out the loop and increased complexity) are, ironically, the effect of attempts to prevent "human error" by design.

Unfortunately, the limitation of existing HF forensics prevents the industry from observing these HF as a natural effect of evolution of our cockpit operations, and many of these are bluntly labeled as human error, reinforcing the industry's efforts to reduce the pilot's room for error; the whole catalyzation repeats itself, worsening the problem: a good reason to evolve HF forensics methodologies.

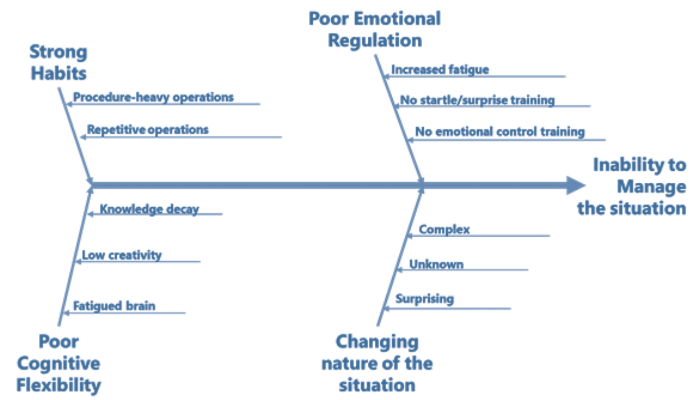



*Figure 3. Contributory HF of accidents of the past decade.*

However, there is an even more important reason to investigate and understand these "new" HF. Paradoxically, the very complexity and dynamics of our operational system has become the Achilles heel of the system itself. Yet as it stands, the complexity of our flight operations is here to stay and will most likely only increase—and with it the proportion of the total operational system behavior that we either do not understand or did not intend explicitly. Being able to maintain performance within such "opaque" systems requires pilots to be a dynamic element in the system, capable of coping with a situation not explicitly anticipated or trained before. A great example of this can be found in the case of Qantas Flight QF32. However, this dynamic behavior cannot be prescribed or investigated from the determinist, Taylorist vantage of the previous decades. That recipe does not longer hold.

### When determinism has reached its limits

The term error implies a known reference of nonerror. As such, for anything to be classified as a "decision error," for example, we must have a clearly defined reference for a correct decision in that specific moment and context. It would be incredible if we have explicitly designed and prescribed the correct decision for all situations, and precisely therein lies the great deceit of the determinist system—we do not have such a universal reference, and in particular we do not for the growing complexity of our operational system. Flying a complex commercial jet aircraft in 2019 cannot be examined the same way a game of chess can be examined.

From a philosophical standpoint, when one cannot predetermine the correct course of action in every and all situations, there must be an alternative strategy to maintain sufficient safety performance in those situations that lack an explicit manual. Such an alternative strategy relies on a learning element within the system, capable of detaching itself from hard-coded actions, and adjusts its behavior to cope with the situation. Such a learning element requires creativity, heuristic strategies, assumption testing, and an ability to resolve a set of situational variables to an effective new understanding of the system. Coincidentally, these are precisely the competencies in which human beings have historically excelled. Our cognitive evolution is clear evidence thereof. As such, the human pilot may be able to provide the dynamic behavior we seek.

Our determinist pilot model was designed for another age of aviation and has at best been innovated most recently in the 1980s and 1990s and at worst still reflects the man-machine task division of the 1960s. The past 10 years provide a wealth of evidence to suggest that this pilot model is no longer sufficient to manage the set of new operational challenges that this day and age of complexity bring with it. We have exceeded its design limits. The basic premise of a predictable operational system is no longer valid. Of course, we must not throw out the baby with the bathwater, but we must ascertain that there may be a time and place for a prescribed human operator, and a time and place for a new, more dynamic, resilient human operator model.

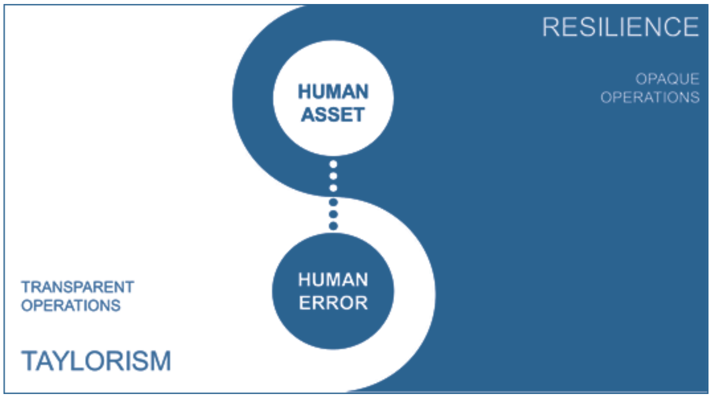



*Figure 4. Operational areas and their resolution strategies.*

## Introducing Airmanship 2.0

The increase in complexity requires a form of dynamic behavior in the cockpit operation paradigm, and the human pilot is a good candidate to deliver this new dynamic capability. If we accept that complexity is here to stay, the investigator should understand which behavior helps to conquer this. This chapter illustrates how this may be achieved by reconditioning the human pilot for a new role in the cockpit.

Figure 4 provides a schematic of the mix of operational conditions that commercial flight operations can fly into and which resolution strategies are most appropriate where.

Figure 4 clearly shows that a new cockpit operational paradigm should feature both determinist (Taylorist) elements, but should also provide flexibility to act when the situation has become “opaque”: unpredictable, ambiguous, complex. In transparent, prescribed operations, operator creativity, heuristics, and noncompliance are labeled as human error (unwanted deviation from a known reference). In contrast, that same human being can provide the very creativity, flexibility, and problem-solving ability you need when the situation becomes opaque: it is one and the same operator.

Qantas Flight QF32, United Flight 232, and the DHL A300 that landed in Baghdad after being struck by a surface-to-air missile are all prime examples of a human asset in the cockpit. However, it is most likely that human pilots have diverted from prescribed actions in many other cases to prevent an event from snowballing into an accident. Actual actions may be different from intended actions. Yet such everyday crew flexibility is not consistently captured in investigative databases, despite already existing as necessary redundancy to prescribed operations. These “silent heroes” are the focus of Safety II learning in which we learn from positive examples as well.

A resilience-based paradigm values and flags different pilot behaviors than a determinism-based paradigm. Table 2 offers a comparison between the two.

| | Determinist paradigm | Resilient paradigm |
|---|---|---|
| Safety by | Reproducibility | Adaptability |
| Most effective in | Transparent situations | Opaque situations |
| Promoted behavior | Respect procedures | Challenge assumptions |
| | Remain with all limits | Focus on understanding |
| | Focus on execution | Generate options |
| Undesired behavior | Noncompliance | Make assumptions |
| | Question procedures | No cross-checking |
| | Lack of punctuality | Lack of system interest/knowledge |

*Table 2. Comparison of determinist and resilient operational paradigms*

Resilient behaviors rely heavily on a human pilot’s ability to (1) appreciate the possibility of a given situation to lie beyond any prescribed solution (i.e., an opaque situation), (2) to detect this is the case, and (3) be competent in the ad hoc development of an effective solution using heuristics, option generation and an improved understanding of the aircraft and its state. The cognitive construct of “fluid intelligence” (the ability to arrange variables into a coherent mental model) lies at the core of these new behaviors. Such abilities in turn rely more heavily on a higher cognitive function of the pilot. Unfortunately, these functions are often the first to leave a human when he or she becomes fatigued, startled/surprised, or emotionally distressed. The authors of this paper propose to extend the airmanship model by three core behavioral principles of resilient behavior:

1. Humbleness to opacity of operations,
2. Emotional self-control, and
3. Adaptive mental models.

The adaption of Tony Kern’s airmanship model (see Figure 5) would be as follows (see Figure 6):

The most important concept in this change is that pillars such as discipline, proficiency, and knowledge, which are aspects of a determinist behavior, are nested within a shell of resilient behavior. In other words, it is safer to question a known situation and upon realizing it is a normal transition to a prescribed action that assumes an ambiguous situation is simpler than it is. Essentially this applies the well-known fail-safe principle to airmanship and embeds it into the basic philosophy driving pilot development.

Besides a difference in pilot behavior, the two paradigms also have different optimal role divisions between the pilot and the automation. Table 3 illustrates how these divisions could differ.

Table 3 illustrates how the two paradigms seemingly oppose each other directly. To some extent this is true, and combining the two poses a significant challenge. This is because changes must be made in several key areas: pilot selection and training, automation interface design, procedures and problem-solving strategies will all be subject to varying amounts of change for Airmanship 2.0 to become a reality.

Yet for accident investigators, this perspective on a new resilience-oriented operational paradigm can help restructure HF forensics for the accidents and incidents now. In this way, the HF investigator becomes equipped with investigative tools sensitive to HF that are the actual drivers of success and failure in today’s opaque situations, extending the already existing tools for transparent situations.

## Evolutions, HF, and forensics

The Airmanship 2.0 concept provides a framework to expand the HF forensic toolset to effectively investigate operations in opaque situations. The tools and methods are derived primarily from NLR engagements and research activities previously mentioned. These tools and methods are not completely polished and ready-to-use but rather serve to inspire subsequent adoption efforts. These are the following six tools and methods, which can be retraced back to Figure 3:

- Behavioral quantification technique,

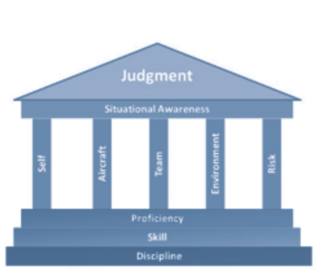



*Figure 5. Tony Kern's airmanship model.*

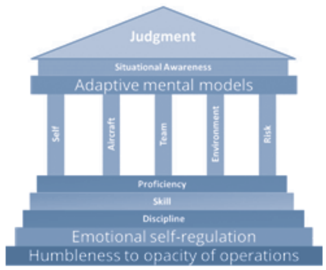



*Figure 6. The Airmanship 2.0 model.*

- Desired flight crew performance technique,
- Competency-based assessment,
- Startle and surprise management,
- Complex failure management, and
- Fatigue management.

## HF forensic concepts for resilient operations

*Behavioral quantification technique:* Within opaque systems, variance in crew behavior is inherent to maintaining safety performance. As such, in order to detect behavioral trends that are beneficial or detrimental, it is important to be able to compare different situations and actions at a behavioral trend level, detaching it from the context of the situation. For example, this would permit comparing complex failure-management techniques across airlines, aircraft types, and failure types.

This technique is based on the Extended Contextual Control Model (ECOM) first proposed by E. Hollnagel and D.D. Woods. ECOM stems from cognitive system engineering and is a method that could map out and categorize crew cognitive processes. In the MAN4GEN project, this method was adopted to "code" cognitive behavior of crews as they resolved complex, ambiguous flight scenarios in a fourth-generation aircraft simulator. Furthermore, the same methodology was adapted to assess a complex failure-management technique as one of the outputs of the MAN4GEN project.

Crew behaviors and remarks were categorized based on their association with a possible phase of the management technique. This "plotting" was subsequently followed by an exercise that clustered behavior observations per phase, depending on the time-separation between the observations. The final analysis step consisted of analyzing the division of a crew's attention between different phases as behaviors overlapped and switched between phases. The resulting quantification of time spent on phases, the order of execution, and the switching frequency between phases lend themselves to statistical analyses of these behaviors to identify behavioral trends in the crew's complex problem-solving behavior that were improving or deteriorating the safety of the simulated flight.

*Desired flight crew performance (DFCP) technique:* This technique was first developed in the MAN4GEN project but has been used in several subsequent projects, including startle and surprise and mindfulness-related simulator evaluations. The method was codeveloped by NLR and Boeing R&D to create a performance benchmark that was suited to the specific, ambiguous scenarios that were used in these studies. The method essentially walks through the scenario as designed and indicates all crew actions that are safety-enhancing in this specific scenario. This method allows the equivalent valuing of different solutions to the same scenario. The DFCP is populated with observations from audio, video, and flight data recordings and is not based on interview or crew recollections as it focuses on actions, not perceptions. An excerpt from a DFCP from the MAN4GEN project is shown in Figure 7 (see page 16).

The DFCP method may seem like a determinist approach, but rather it is sensitive to the specifics of a situation (in the case of accident investigation) and therefore is able to value behavior that may deviate from standards or procedures as long as it contributes to safety in that situation. The DFCP was used in conjunction with the ECOM behavioral assessment method, which was employed in the MAN4GEN project, to compare many crews flying the same simulator scenario.

*Competency-based assessment:* Another framework for observing flight crew behavior in opaque operations are competency-based assessments. Two common frameworks are NOTECHS and the ICAO core competency framework, both stemming from resilience training applications aimed at preparing crews precisely for the opaque operations that need them. The value of competencies lies in the fact that they prescribe effective crew action at a higher abstraction level (with observable behaviors as detailed examples of a competency), which contrasts with the much more narrowly constrained frameworks of procedures, standard operating procedures, and checklists.

A list of the ICAO core competencies is presented, as well as an example of observable behaviors for the "Problem Solving and Decision-Making" competency (see Table 4, page 16).

- Application of Procedures
- Flight Path Management–Manual
- Flight Path Management–Automatic
- Situational Awareness
- Workload Management
- Leadership and Teamwork
- Communication
- Problem Solving and Decision-Making
- Knowledge (added by EASA during implementation in EASA regulations)

Competency assessment is also the basis of evidence-based training (EBT), a new form of training that challenges flight crews with unfamiliar scenarios to assess and train at a competency level instead of only using repetitive task-reinforcement training. The ab-initio version application of competency-based training is the MPL. The application of these new training frameworks for investigation is that a framework such as ICAO's list core competencies and behavioral markers provides a ready-to-use behavioral observation system that can be used as a performance reference for situations beyond the prescribed, transparent operation.

| | Determinist paradigm | Resilient paradigm |
|---|---|---|
| Safety by | Reproducibility | Adaptability |
| Most effective in | Transparent situations | Opaque situations |
| Pilot role | Monitor automation<br>Some manual flight<br>Execute procedures<br>Optimize flight | Search for information<br>Continuously (re)build understanding of the situation<br>Reassess execution options |
| Automation role | Autonomous execution<br>Provide need-to-know info<br>Self-optimize<br>Workload reduction | Help rebuild mental models<br>Support option-generation<br>Transparent execution |

*Table 3. Comparison of determinist and resilience optimal role divisions in the cockpit*

NLR has used ICAO's core competencies as a performance indicator to compare crews in the FutureSky Safety project "Human Performance Envelope," in which the research was also focused on the reliability of such behavioral assessment techniques. This research is being continued to support the standardization of instructor rating behavior within EBT programs. As such, similar reliability efforts should be made if competency assessments are to be determined during incident/accident investigations.

*Startle and surprise management:* One of the most salient cues of an opaque situation is a cognitive mismatch (expectations do not match reality), which is experienced as a "surprise." In contrast, a "startle" is a purely physiological reaction of the sympathetic nervous system in which the body immediately reacts to intense sensory inputs (e.g., a loud bang or flash). Although different in their nature, both surprise and startle have the same effect: an emotional reaction in the limbic brain (e.g., fear), a stress reaction initiating from the amygdala, and a degradation of cognitive ability in the neocortex. As opaque situations become more frequent (also due to pilots' unfamiliarity with increasingly rare nonnormal operations), startle and surprise have been in the spotlight in aviation safety, HF, and training arenas.

As an EASA research initiative, NLR, in collaboration with KLM, has performed extensive research into startle and surprise, and in particular which management strategies may be effective. The research indicates that a startle or surprise reaction is not preventable; however, its effect on the operator's performance can be significantly reduced with the effective management strategy consisting of the following three steps:

**DFCP list for both experiments.** The items in ***bold-italic*** denote the safety critical items.

| NLR DFCP (22 items) | Flight segment # | DLR DFCP (20 items) | Flight segment # |
|---|---|---|---|
| Verbalize tailwind | 1 | Verbalize tailwind | 1 |
| ***GA due to tailwind*** | ***1*** | ***GA due to tailwind*** | ***1*** |
| execute G/A actions (flaps, gear) | 2 | execute G/A actions (flaps, gear) | 2 |
| verbalize HDG fail | 3 | verbalize HDG fail | 3 |
| ***Immediate manual reversion*** | ***3*** | ***Immediate manual reversion*** | ***3*** |
| Verbalize surge/stall | 4 | Verbalize surge/stall | 4 |
| MI for surge stall (pull back TLs on affected eng) | 4 | Immediately reduce thrust | 4 |
| MI for eng failure on 1 | 4 | ***Run correct AbnCL, ENG STALL*** | ***4*** |
| ***no cycling of fuel on 3 and 4*** | ***4*** | no idle on 1 and 2 at low speed/climb | 4 |
| Run ENG FAIL NNC | 4 | | |
| Run SURGE NNC | 4 | | |
| Operate engines below surge | 6 | Operate engines below surge | 6 |
| mayday call | 4 | mayday call | 4 |
| inform cabin crew of bird-strike | 4 | inform cabin crew of bird-strike | 4 |

*Figure 7. The DFCP excerpt from the MAN4GEN project.*

1. Relax: Counter the sympathetic stress reaction to reengage the neocortex with breathing exercises, physical awareness (e.g., feel one's back against the seat), and checking colleagues.
2. Observe: Rebuild a (new) mental model by actively and consciously taking in information about the situation/aircraft state, without judgement. Basic observation ("here and now").
3. Confirm: Discuss a possible situation/aircraft state and generate options of moving forward in the newly understood situation.

The Relax-Observe-Confirm (ROC) was trained and assessed with NLR and KLM and deemed by many pilots to be effective. Not only the procedure, but also the basic awareness of the cognitive decay that occurs during a startling or surprising event has made flight crews more effective in coping with them.

Another related study was contracted by a U.S. airline investigating the benefits of mindfulness training for pilots. This study trained a group of pilots in mindful behavior and compared their DFCP performance against a control group of pilots. The study hypothesized an improvement in several ICAO core competencies as well as startle and surprise management and assesses precisely these competencies in a complex, opaque scenario. Initial evidence shows promise that the following mindfulness training results would improve pilot abilities to cope with opaque operations:

- Improved emotional regulation,
- Improved nonjudgement,
- Improved observing (attention),
- Improved open awareness (monitoring more sensory info/emotions/thought), and
- Improved cognitive flexibility (task/situation/concept switching).

These behaviors show distinct similarity with the elements of ROC, and both may be useful references to assess a pilot's ability to effectively (re)engage his or her ability to observe, adjust understanding (cognitive engagement), and suppress overreaction and jumping to conclusions. Of course, the above-mentioned self-control behaviors are second to managing any dire threats (e.g., aircraft stall, imminent terrain impact, loss of aircraft control). However, it should be noted that most situations present at least 30 seconds to a minute for effective self-regulatory actions. The EASA study scenario taught pilots that even a decompression permits a thorough ROC execution before donning emergency oxygen equipment.

*Complex failure management:* Complementing startle and surprise management in opaque situations, NLR has also researched, operationalized, and validated the effectiveness of complex failure-management strategy in the MAN4GEN project. Based on behavioral differences between high- and low-performing flight crews observed in an opaque flight situation with a complex, ambiguous failure, the MAN4GEN project distilled a basic three-step operational philosophy to manage such situations. High-performing crews differed from low-performing crews in that they

1. Managed time criticality, so that the crew has time to

| Problem Solving and Decision-Making |
|---|
| "Accurately identifies risks and resolves problems." |
| ▪ Uses the appropriate decision-making processes |
| ▪ Seeks accurate and adequate information from appropriate sources |
| ▪ Identifies and verifies what and why things have gone wrong |
| ▪ Employ(s) proper problem-solving strategies |
| ▪ Perseveres in working through problems without reducing safety |
| ▪ Uses appropriate and timely decision-making processes |
| ▪ Sets priorities appropriately Identifies and considers options effectively. |
| ▪ Monitors, reviews, and adapts decisions as required |
| ▪ Identifies and manages risks effectively |
| ▪ Improvizes when faced with unforeseeable circumstances to achieve the safest outcome |

*Table 4. Example of a competency with observable behaviors*

2. Manage uncertainty, such that the crew can
3. Plan for contingencies and changes.

These three steps echo a basic humbleness that pilots have with respect to the opacity of the situation and to jump to conclusions as other crews did. A subsequent operationalization of this philosophy led to a six-step process in which evaluation crews were trained and supported with a quick reference card (see appendix A with the full article text on ISASI's website). The basic six steps are

1. Stabilize Flight Path,
2. Immediate Threats,
3. Short-Term Plan,
4. Identify Situation,
5. Appropriate Actions, and
6. Long-Term Plan.

Validation simulator exercises showed that using ECOM and DFCP analysis techniques, crews that behaved according to these trained guidelines outperformed crews that did not act accordingly. Not only the execution of all aspects of the strategy, but also the correct order of the strategy was related to better performance. The above-mentioned strategy is clearly a more cognitive process, and as such should in most cases succeed the startle and mindfulness behaviors that are responsible for restoring the pilot's cognitive ability before engaging in problem solving.

As such, investigators may be able to refer to the above problem-solving philosophy, detailed strategy, and reference card (see Appendix A with the full article text on ISASI's website) to structure behavioral analysis of crews facing similarly opaque, complex failure management.

*Fatigue management:* The last HF to be briefly addressed is fatigue. Fatigue is not a new factor in HF forensics; however, it may arguably be posed as a threat with increased leverage within opaque situations. The fundamental requirement of cognitive functioning of the crew to operate in opaque systems infers that all factors that affect this functioning are pertinent for these resilience-based operations, as is also the case with startle and surprise.

Research at NLR confirms that fatigue is still a difficult to quantify/measure factor, due to the huge individual variation in sensitivity to fatigue-inducing factors, as well as the variation of the effect that fatigue has on performance. However, one thing is certain, the number of factors that are becoming relevant to assessing the presence of fatigue has grown. ICAO Document 9966–Appendix B provides a good list of factors to consider when investigating fatigue. Other documentation, guidelines, and research underpinning FRMS are a good source of rough investigative checklists for fatigue. As with startle and surprise, it is important to realize the leverage fatigue has on these operations and may warrant investigation even if there are no clear telltale signs of fatigue as the main causal factor to an incident or accident.

### The changing nature of HF forensics

The previously discussed management methods have implications for the nature and arena of HF forensics. Fundamentally, effective HF forensic investigation of the risks of opaque systems requires two major shifts:

1. As human performance in such opaque operations is greatly affected by subtler higher cognitive and psychophysiological factors, investigations should shift from reactive "black hole in the ground" investigation to proactive investigations of incidents, normal operations, and simulated flights (e.g., training). This provides pilot self-reflections, cross-examination of crews, debriefing information, and instructor observations in training cases.
2. As resilient operations require dynamic pilot behavior to maintain performance in opaque systems, investigation into "normal" operations should be conducted as equivalently as "incident" operations. This has to do with the fact that, particularly as opaque operations become more commonplace, crew abilities (either learned or instinct/experience based) to resolve opaque situations can readily be learned from. By increasing the contrast between behavior that worked and behavior that didn't work, effective behavioral patterns within opaque operations become sharper and more robust and can be more readily consolidated into proposed strategies.

This day and age of aviation can provide HF investigators precisely this wealth of information. The advent of EBT and MPL training that of competency building using opaque scenarios can be an incredible source of information about crew (in)effective strategies in opaque situations. Preceding EBT, A(T)QP programs also feature line-oriented evaluation sessions in which the same HF investigation can take place. Further adaptions of LOSA, airline internal investigations, ASRS/voluntary incident databases and regulatory audits to include competency-level assessments as well as sensitivity to surprise and fatigue may contribute to a very large body of data from which effective behavioral strategies in opaque situations may be distilled.

At KLM, a novel approach to learning from operational experience is an initiative called Flight Story in which the airline facilitates crews' sharing their notable experiences with colleagues to improve safety by positive examples instead of only accidents.

By increasing our sensitivity to the factors that determine performance beyond our determinist transparent operations, we may be able to intervene effectively based on proactive, performance-based investigation rather than reactive fault finding.

> **"Your assumptions are your windows on the world. Scrub them off every once in a while or the light won't come in."**
>
> —Isaac Asimov

### The future investigator as driver for global safety improvement

In the past, safety investigations have served as problem providers for knowledge-deficiency identification and knowledge development. Referring to the quote of Vincenti at the beginning of this paper, we may state that by embracing empirical findings, as investigators we materialize the notion of serendipity: disclosing by accident something that has not been observed before. New concepts such as Airmanship 2.0 may do a much better job where conventional concepts have been stretched to their limits.

We have proposed that investigators should shift their focus to proactive investigation, but we also propose an even greater change in perspective that the investigator may take. Considering the real possibility that the existing determinist operational paradigm has limits and that these limits may have been exceeded, it challenges investigators to not only investigate accidents against

*(Continued on page 30)*

# Flying Over Conflict Zones:

By Marieke van Hijum, Senior Investigator, Dutch Safety Board

*(Adapted with permission from the author's technical paper* Flying Over Conflict Zones: Follow-up Recommendations MH17 Crash Investigation *presented during ISASI 2019, Sept. 3–5, 2019, in The Hague, the Netherlands. The theme for ISASI 2019 was "Future Safety: Has the Past Become Irrelevant?" The full presentation can be found on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)*

On July 17, 2014, 298 people lost their lives when the Malaysia Airlines airplane they were in crashed near Hrabove, Ukraine. The disintegration of the airplane during the flight was the result of the detonation of a warhead above the left-hand side of the cockpit. The airplane crashed over the eastern part of Ukraine, an area in which an armed conflict arose in April 2014. Initially, the conflict mostly took place on the ground; but from the end of April 2014, it expanded into the airspace. The crash of Flight MH17 immediately raised the question why the airplane was flying over an area where there was an ongoing armed conflict.

The MH17 crash report published by the Dutch Safety Board in October 2015 responded to this question and explained the decision-making process with regard to flying over conflict zones at the time. The report contained 11 recommendations for better management of the risks associated with flying over conflict zones. Due to the global importance of the recommendations, they were addressed to the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA), all states, and all airlines.

This paper presents the main results of the follow-up investigation. The Dutch Safety Board published the report on the follow-up investigation in February 2019.

## Follow-up investigation

In all its investigations, the Dutch Safety Board evaluates how organizations have implemented its recommendations. Given the size of the disaster and the great value the safety board attaches to the formulated recommendations, the board started an investigation into the follow-up to the recommendations regarding flying over conflict zones in the beginning of 2018. The investigation focused on whether the 11 recommendations from 2015 were followed up and whether the parties concerned were successful in eliminating the safety shortcomings underlying the recommendations. The Dutch Safety Board stresses that this follow-up investigation only serves as a recap to the recommendations and therefore does not address the cause and circumstances of the crash of Flight MH17.

The subject of flying over conflict zones is not an obvious subject for an aviation accident investigation. From 2014 to 2015, the Dutch Safety Board carried out its investigation into the crash of Flight MH17 in accordance with Annex 13 of the Convention on International Civil Aviation, which sets out the international regulations on independent accident investigation. Although this annex is intended for investigations aimed at increasing civil aviation safety, it was also possible to carry out an investigation within that framework in which the essence of the risk was more about security. This follow-up investigation confirms that entities that conduct independent investigations on aviation accidents can also contribute to improving safety in the context of security risks.

Marieke van Hijum

## Developments after the crash of Flight MH17

On a global level, ICAO launched various initiatives aimed at better management of the risks associated with flying over conflict zones. These initiatives have included amending standards, recommended working methods, and manuals (henceforth referred to as ICAO documents) in order to embed and promote the sharing of threat information and the performance of risk assessments. Some of the proposed amendments have now been implemented, while others are yet to be carried out. This is a long-term process due to the involvement of 192 ICAO member states with differing views and interests. The first steps toward amending the ICAO documents were taken in 2014, but it will take until at least 2020 for all of the foreseen amendments to be implemented.

Another important ICAO initiative is the publication of a manual offering support to states, airlines, and other parties concerned in the performance of risk assessments with regard to flying over and near conflict areas. Since it is not possible to provide a thorough explanation in international standards of how the risk assessments should be performed, the publication of a manual containing guidelines for performing risk assessments is a valuable initiative. There is no obligation attached to the manual. ICAO has indicated that it will provide workshops and presentations in order to bring the manual to the attention of those concerned. Through the

# Follow-up Recommendations from MH17

publication and dissemination of the manual, ICAO is helping to increase the quality and harmonization of the implementation of risk assessments for flying over conflict areas by states and airlines.

Although none of the Dutch Safety Board's recommendations are addressed to EU institutions, in response to the crash of Flight MH17, the European Union Aviation Safety Agency (EASA) and the European Commission have launched initiatives aimed at better management of the risks associated with flying over conflict zones. EU member states now exchange relevant intelligence information in order to arrive at a joint assessment of the risks associated with flying over conflict zones. The advantage of this cooperation is that intelligence information and risk analysis capabilities of both larger and smaller states are combined. If the outcome of the assessment is that the risk for a certain area is considered "high," EASA publishes a Conflict Zone Information Bulletin. These bulletins are not only used within the EU, but also as an informationby states and airlines based outside of Europe. This European initiative thus contributes to a better global understanding of the risks. Various states (such as the United States, the UK, France, and Germany) also publish information about conflict zones across the world, for example in the form of a notice to airmen (NOTAM). NOTAMs also serve as important information sources for states and airlines around the world.

On a national level, several states have taken initiatives that contribute to better management of the risks related to flying over conflict zones. In the Netherlands, an agreement has been drawn up regarding the sharing of threat information for civil aviation. The Netherlands has translated the text of the agreement into English and made this translation available to serve as an example to other countries inside and outside Europe, as well as to ICAO. In addition, the Netherlands has taken the lead in initiating amendments to the ICAO documents. To support the ICAO Secretariat in effecting the work program, the Netherlands has seconded a senior safety expert at ICAO for a two-year period (2017 and 2018). This way, the Netherlands, in collaboration with various other countries, contributes to ensuring that the subject of flying over conflict zones remains on the international agenda.

Airlines now play a more active role in gathering information about the risks that conflict areas pose to civil aviation than they did at the time of the crash of Flight MH17. They also have access to more and generally better threat information. Risk assessments are performed in a more structured manner, and some airlines explicitly state that they take uncertainties and risk-increasing factors into consideration as part of the risk assessment process. Furthermore, there is evidence to suggest that, if there are doubts about the safety of a flight route, airlines are more inclined not to fly. IATA has made risk assessment relating to flying over conflict areas part of its prescribed management systems in order to manage the risks for aviation. Airlines that are members of IATA are periodically tested on their implementation of these systems. However, the results of these audits are not published, meaning that the extent to and manner in which airlines have given the risks of flying over conflict areas a place in their management systems is unclear.

## Areas of attention for the years to come

This follow-up investigation has also shown that not all of the amendments proposed by the Dutch Safety Board have been implemented. The full assurance provided by ICAO standards has not yet been achieved (status Dutch Safety Board report published in February 2019). Moreover, these amendments will need to be incorporated into the states' national legislation.

In the past years, no or minimal changes have been made to the airspace management by states involved in armed conflicts in their territory. The board realizes that states involved in an armed conflict will have difficulty when it comes to guarding the safety of their airspace. This indeed turns out to be the case in practice. With the exception of Ukraine, states have not implemented airspace restrictions related to the overflying of conflict zones. Although ICAO is in a position, as an intergovernmental organization, to urge and support states to safeguard the safety of their airspace, ICAO is not doing so.

Another area of attention is that airlines are indicating that the level of detail of the information available is not always sufficient in order to perform an adequate risk assessment. There are also obstacles in relation to sharing nonpublic information. Conditions for exchanging threat information include a proper information network and mutual trust. For access to relevant information, a good relationship and mutual communication between airlines and the intelligence services of the state in which the airline is based are essential. However, these are not a given everywhere in the world.

The mechanisms that have been created for the purposes of sharing threat information and risk classifications are better suited to tackling long-term conflicts than to tackling new conflicts or sudden escalations of existing conflicts. Information sharing about abrupt changes in the threat level occurs on an ad hoc basis and through informal networks. As a result, it is not guaranteed that airlines can timely access accurate information about new threats and adjust their flight paths accordingly.

The Dutch Safety Board considers public accountability for flight routes chosen to be the final link in keeping airlines focused with respect to their responsibility for performing thorough risk assessments for flying over conflict areas. However, airlines do not or hardly account publicly for their chosen flight routes, and this is not being encouraged by IATA either.

Throughout history, safety and security have been separate worlds—worlds with their own laws and regulations, for which the responsibilities were assigned to various parties and departments within organizations. However, as the crash of Flight MH17 shows, safety and security are intertwined. To manage the risks related to flying over conflict zones and other risks at the interface of safety and security as good as possible, closer cooperation between both worlds is necessary.

This follow-up investigation has shown that over the past few years, important steps have been taken with the aim of better management of the risks associated with flying over conflict areas. It is important that the amendments already implemented are perpetuated and that parties take the announced follow-up steps. Vital to this is the willingness of parties to actively inform each other about threats and potential threats in order to protect civilians and passengers across the world. ◆

# Flying Over Conflict Zones:

By Kas Beumkes, Senior Policy Advisor, Aviation Safety and Security Division, Civil Aviation Directorate, Ministry of Infrastructure and Water Management, the Netherlands

On Oct. 13, 2015, the Dutch Safety Board published the final report on MH17 following the crash of Malaysia Airlines Flight MH17 on July 17, 2014. This report contained 11 recommendations aimed at better controlling the risks associated with flying over and near conflict areas. These recommendations have been addressed to the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA), states, and airlines.

The Dutch Cabinet sent its response to the Dutch Safety Board on Dec. 8, 2015, (Parliamentary Papers II 2015-2016, 33 997, No. 56), in which the recommendations are endorsed. The recommendations logically have a strong international component. As a result, the follow-up of the recommendations depends on the cooperation between and the joint approach of all international partners involved. The Netherlands is actively promoting this. The Dutch Parliament was periodically and extensively informed about the progress of the follow-up of the recommendations via debates and answers to parliamentary questions and letters.

## Follow-up investigation

The Dutch Safety Board launched a follow-up investigation in 2018 to gain insight into whether risk management for flying over conflict areas has improved since the crash of Flight MH17 and to gain insight into the extent to which international organizations, states, and airlines have followed the recommendations and have addressed the underlying safety deficiencies.

In the follow-up investigation, the Dutch Safety Board finds that since the crash of Flight MH17, various parties have taken important steps to better manage the risks associated with flying over and near conflict areas. The changes introduced have also led to a better control of these risks, and the related risk management has been given a concrete place in the safety thinking of the aviation sector. The board notes that not all of the intended changes have been realized yet and concludes that permanent attention is needed to maintain the course that has been taken and sees the following three focal points:

- Practice shows that states in which there is an ongoing armed conflict will not implement restrictions for their airspace on their own initiative. States involved in an armed conflict will have difficulty when it comes to guarding the safety of their airspace. Although ICAO, as an intergovernmental organization, is in this position, ICAO does not take an active role in urging states to ensure the safety of their airspace and to support them in this.
- Information sharing in rapidly escalating conflict situations occurs ad hoc and through informal networks. In this way, states and airlines do not ensure that threat information is shared timely and that airlines are in the position to take measures. To ensure access to relevant information, it is essential to maintain a good relationship and reciprocal communication between an airline and the intelligence services of the state where the airline is established.
- The public accountability of chosen flight routes by airlines is the final link in keeping airlines attentive to their responsibility for performing thorough risk assessments related to flying over or near conflict zones. Airlines account only little or not at all for their chosen flight routes. IATA does not stimulate this either.

## Response to the follow-up investigation

The Dutch government agrees with the findings of the Dutch Safety Board that not all intended changes have been realized, that it is important to consolidate the changes already implemented, and that the parties are taking the announced next steps. It is essential here that the follow-up of the recommendations depends

*(Adapted with permission from the author's technical paper* Flying Over Conflict Zones: The Way Forward from MH17 *presented during ISASI 2019, Sept. 3–5, 2019, in The Hague, the Netherlands. The theme for ISASI 2019 was "Future Safety: Has the Past Become Irrelevant?" The full presentation can be found on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)*

# The Way Forward from MH17

on the cooperation between and the joint approach of all the international partners involved. In addition, it is important that parties willingly and actively inform each other about possible threats to protect citizens and passengers worldwide.

From the 11 recommendations of the Dutch Safety Board, addressed to ICAO (six), IATA ( four), states (two), and airlines (one), one recommendation is assessed as "adequate," six as "partially adequate," and four as "inadequate" (see Appendix D of the follow-up investigation). The cause of the number of partially/inadequately appreciated recommendations (10 out of 11) can be explained by the fact that the proposals as such have already been prepared and are well advanced but have not yet been fully completed. The development of proposals by international organizations takes a lot of time because these organizations, in particular ICAO, must recommend proposals to tackle regulatory actions—first of all with the member states to be prepared, discussed, and then supported by a large majority. This takes place through structured consultation, whereby the implementation of change proposals is scheduled at fixed times of the year to limit the administrative burden for the member states. As a result, according to the Dutch Safety Board, it will certainly take until 2020 before all the changes that are now envisaged have been implemented.

The four recommendations with "inadequate" assessment are diverse in nature, and progress depends primarily on the commitment of the international world community of states, IATA, and the wide variety of airlines worldwide. This process often leads to globally formulated proposals, which means that it is not to be expected that all recommendations in the future can be assessed entirely satisfactory to the wishes of the Dutch Safety Board. In addition, the Dutch Safety Board indicates that only a very limited part of the target group has been surveyed and draws its conclusions based on this (12 national civil aviation authorities and 36 airlines from 18 different countries from within and outside Europe; Appendix A, page 75 [editorial note: page 69 in the English version] under Surveys). ICAO has 192 member states, and IATA has around 290 members from 120 countries.

Regarding the three focal points mentioned by the Dutch Safety Board, the following is noted:

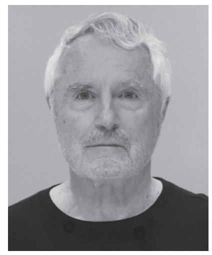
- States involved in an armed conflict may have difficulty monitoring safety in their airspace. Since in these countries the authority of the national government is often weak or factually absent, the Netherlands has promoted at ICAO and IATA that other countries and airlines seek cooperation on a regional scale to share information. A more practical effect is expected from this than relying on the information from the aforementioned states. The new ICAO manual Doc. 10084 describes examples of good practices on cooperation on a regional scale.
- In the field of information sharing and risk assessment, the Netherlands remains actively committed to the completion of the international actions that are necessary to comply with the recommendations. At the national level, the Netherlands has signed an agreement with government services and airlines for sharing civil aviation threat information that is functioning satisfactory (see evaluations, Parliamentary Papers II 2016-2017, 24 804, No. 95 and Parliamentary Papers II 2017-2018, 24 804, No. 97). The third evaluation has taken place. The Civil Aviation Directorate from the Ministry of Infrastructure and Water Management will continue to explain the functioning of the agreement, which is included as a good practice in the aforementioned ICAO manual Doc. 10084, in various workshops on a European and international scale.
- In order to provide public accountability for the chosen flight route as the final link for airlines, the Dutch Safety Board finds that, unlike most airlines worldwide, the major Dutch airlines post their flight routes on their websites. It also states that the passenger can request information about the flight route from the airline. The Civil Aviation Directorate will continue to plead with IATA to address this on a wider scale.
- The Dutch government will continue to work nationally, in European, and internationally with the parties involved to better manage the risks associated with flying over and near conflict areas. The focal points of the Dutch Safety Board are part of this commitment. ◆

Kas Beumkes

# The Paradox of Intuition: Training Pilots for Unexpected Events

By Laurie Earl, Coventry University, the UK, and Jim Sheffield, Victoria University, New Zealand

Laurie Earl



Jim Sheffield

*(Adapted with permission from the authors' technical paper* The Paradox of Intuition—A Neuroscience Approach to Training Pilots for Unexpected Events *presented during ISASI 2019, Sept. 3–5, 2019, in The Hague, the Netherlands. The theme for ISASI 2019 was "Future Safety: Has the Past Become Irrelevant?" The full presentation can be found on the ISASI website at www.isasi.org in the Library tab under Technical Presentations.—Editor)*

On Jan, 15, 2009, US Airways Flight 1549 hit geese shortly after takeoff from LaGuardia Airport in New York City, N.Y., U.S.A. Both engines lost power, and the crew quickly decided that the best action was an emergency landing in the Hudson River. In testimony before the U.S. National Transportation Safety Board, Capt. Chesley Sullenberger maintained that there had been no time to bring the plane to any airport and that attempting to do so would likely have killed those on board and more on the ground. Exactly 3 minutes and 28 seconds had elapsed from the time of the bird strike to landing on the water—the crew had made a split-second decision in a highly volatile moment. The NTSB ultimately ruled that Sullenberger had made the correct decision.

As technology moved from analogous cockpits to fly-by-wire technology, the aviation industry began to see many more such black swan events, a term coined in 2007 to explain events that were unusual, that surprised the crew, or that had never happened before so for which the crew couldn't be trained.

This paper explores how pilots make decisions in complex situations when they can't rely on procedures and where generating multiple options doesn't always make sense. Primarily we examine how intuition influences decision-making and why tacit knowledge plays a more important part than originally thought. Tacit knowledge is that piece of the iceberg that's below the surface—we don't notice it, and we can't easily describe it. In other words, it's how we think and decide in the world of shadows, the world of ambiguity.

We consider how hidden impulses affect judgement and the influence of experience and knowledge on decisions made under extreme circumstances. This discourse examines how the expert has built up a repertoire of patterns that aren't based on facts or rules or procedures. Instead they're built on all the events and experiences they've lived through and heard about. This is the basis for intuition.

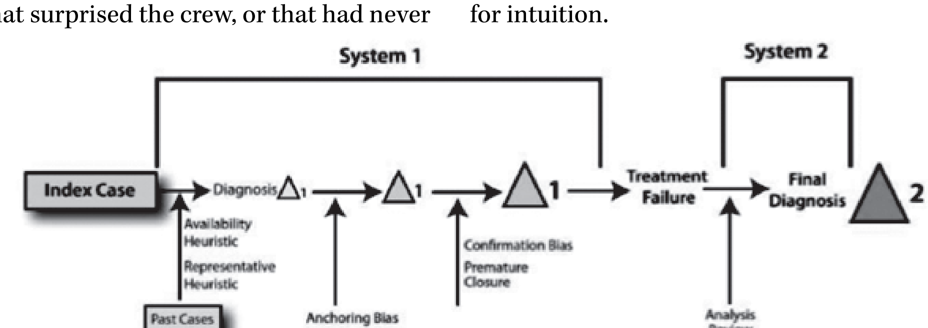



Figure 1. Bias awareness (Source: Bloxham, 2012)

The paradox of intuition is that emotion ("gut feelings") must inform reason (cognition), and reason must inform emotion (giving a rational response). We explore this paradox through the lens via a research framework (the dual-process model) that plays an important integrating role in the current behavioral decision-making literature (see Figure 1). While the terminology and application domains of the dual-process and dual-systems models vary, there is consensus on core concepts. Research suggests that "Our preferred theoretical approach is one in which rapid autonomous processes (Type 1) are assumed to yield default responses unless intervened on by distinctive higher-order reasoning processes (Type 2). What defines the difference is that Type 2 processing supports hypothetical thinking and loads heavily on working memory."

In a similar model, studies describe a neuroscience approach in a conceptual model to understanding the cognitive process. A pilot perceives stimuli, interprets this, assesses the situation (appraisal), and selects and executes actions.

Criticisms of the dual-processing methodology point to the vagueness of their definition and the lack of coherence and consistency in their approach but demonstrate that there is a clear empirical basis for dual-processing distinction in the fields of reasoning and decision-making.

What's apparent is that by using this methodology pilots can be trained in effective decision-making from a neuroscience perspective. In other words, they can be trained to understand what's happening in their brains and discovering, recognizing, and planning for adverse events. Currently, we're intent on reducing errors and less intent on building expertise.

So what exactly happens in the brain when we're faced with an unexpected event for which we have no processes or structure to respond? The startle/surprise effect testifies that "Surprise is an emotional and cognitive response to unexpected events that are difficult to explain, such as subtle technical failures or automation surprises that are baffling. Surprise could impair the crew's troubleshooting capabilities."

The emotional response that happens in the amygdala is stronger than the rational response that occurs in the dorsolateral prefrontal cortex. Therefore a "knee-jerk reaction" based on the emotional response can occur, particularly in those with less experience. The ability to control the conversation between what we feel and what we think sits at the crucial intersection between these two different ways of thinking in the form of the anterior cingulate cortex—the trigger between them.

Making decisions in dangerous circumstances requires the intuitive brain to size up the situation and form the initial impulse about what to do. The analytical brain then can be used to process the mental simulations to see if the option will work. Pilots often refer to the skill to think during a crisis as creating a "deliberate calm," which blends intuitive pattern matching with analytical thinking.

> *"Deep in crisis mode, it's easy to feel overwhelmed. It's common to feel you have no options and no time. You actually have more of both than you realize. It's just a matter of knowing how to create time and free up your mind."*
> —Capt. Richard de Crespigney

Analytical thinking occurs in the prefrontal cortex of the brain. It's where calculations are computed, logical sequences processed, and rational thinking takes place. This part of the brain also can turn off impulses, which is what Sullenberger did when he decided not to act on his first thought—to return to LaGuardia—but decided instead to land in the Hudson River.

Along with understanding context and noticing information, cues, and data in the environment or the lack of certain cues, an expert often also has the ability to tune out unnecessary information. Sometimes leaders can successfully employ cognitive shortcuts by utilizing heuristics, or rules of thumb. Often referred to as "resilience," experienced flight crews understand implicitly the response to an event. Furthermore, thinking resiliently encourages us to consider how we might turn a problem into an opportunity.

Marcus Aurelius said: "What stands in the way becomes the way." What he meant by this was that any obstacle can be used as an opportunity for creative problem solving. So when attacked by superior forces at unexpected locations, Aurelius didn't resort to anger or panic, but instead he undertook a creative search for his available options. In turn, these options might inform future strategies, and, in keeping his cool, he was further developing his resilient habits.

In the same way, de Crespigney, after seeing an overwhelming amount of error messages come up, started to think about what they had rather than what they didn't have working. He wrote, "Invert the logic—if you're overwhelmed by what's going wrong, turn the problem on its head. Go simple, be creative, and work with what you have, not what you've lost."

Currently the International Civil Aviation Organization (ICAO) has listed LOC-I as one of the top three safety priorities due to a number of events involving inappropriate decision-making and implemented new regulations that include recommendations to incorporate startle and surprise in training programs to prepare flight crews for unexpected events. Previously airlines have practiced human factors and joint cabin crew/flight crew scenario-based training; simulated exercises, for example, engine failure after takeoff; and debriefing. They've examined some research and studies on training from past events as well as human factors technical design innovations such as Airbus inhibiting distracting and unnecessary alarms on takeoff till the aircraft reaches 1,500 feet. What's missing is realistic or challenging scenarios, such as startle, managing startle, and unexpected events training using metacognition.

> *"By exposing ourselves to difficult situations and undergoing difficult training, we can protect ourselves from being startled when others around us are."*
> —Capt. Richard de Crespigney.

We've now learned, through the psychological practice of cognitive behavioral therapy, that such "thought management" skills are genuinely teachable. By using metacognition (thinking about thinking), we can tailor the thought processes at hand and train better decision-making and the control of our emotional response. One perspective is that we're really teaching people to align their assumptions and thoughts with reality. So for example, if a storm damages our roof, we can get angry and think "why me?" or we can rationally assume that "well, this was likely to happen to someone, so why not me?" The assumption that bad events can happen to us, not just to someone else, helps us avoid an irrational and unhelpful anger response.

Barriers in the way of self-control in decision-making can include cognitive overload or underload due to the active nature of the brain. This may be particularly problematic when pilots aren't mentally prepared, for example, after a long period of automated flight. Loss of a fitting frame may lead to a complete "loss of grip" on the situation, as there is no frame in place to guide perception, appraisal, and action. Other barriers include emotional or physical exhaustion, stress and fatigue, and ego depletion.

The dual-process model domain can apply to aviation, the military, and health. Dual-process theory supports simplified models that can be readily taught to learners across a wide range of disciplines. In particular, an understanding of the model allows for more focused metacognition, i.e., the decision-makers can identify which system they're currently using and determine the appropriateness and the relative benefits of remaining in that mode versus switching to the other. The dual-process model complements more detailed approaches such as neuroergonomics. This is based on associative processes in intuitive judgment and neurological processes (i.e., emotion vs. reason) that are experienced by decision-makers in naturalistic settings.

Training based on the dual-process model may include decision scenarios presented in the form of "serious" video games and checklists. "Metacognitive moments" embedded in complex decision processes serve as the occasion both for possible transitions between System 1 and System 2 and for critical reflection on how cognitive biases may reduce situational awareness. Metacognition is a cognitive bias-awareness strategy that pilots can be trained to use to deliberately detach themselves from the immediate flight context, which allows them to reflect upon the thinking process and switch perspectives as required.

One of the factors that facilitate pilot performance in surprising situations is domain expertise, or accumulated knowledge and skills through practice and experience. By applying and testing hypotheses based on frames in a large number of situations, these frames become more accurate and more fixed in memory, which allows one to easier relate new situations to those that have previously been encountered and to make decisions in a quick manner. To some extent, this is practiced already; but by repetition and recognizing such situations, pilots can apply learned coping strategies, such as taking a moment to "breathe" and reflect or returning to more transparent and understandable configurations or autopilot modes.

## Variable training.

Researchers and aviation safety organizations emphasize the need for training with a variety of situations or scenarios. Training variability can be applied to reduce predictability so as to stimulate sense-making activities and to improve reframing skills. Training variability is also thought to increase the number and elaborateness of available frames. Experiencing examples of a concept in a variety of situations may improve one's understanding of the concept, facilitating the transfer of the knowledge and skills to new situations. In contrast, one-sided training of a small number of situations or (combinations of) failures may increase the risk of an inappropriate selection of these frames in stressful situations (current training).

## Practical training.

Literature indicates that theoretical training should be enhanced with practical experience and feedback on performance so that the frame-related knowledge is linked to other knowledge, environmental cues, and actions. Scenario-based training is based on the concept that knowledge can't be fully understood independent from its context. Practical training may also be used in combination with exposure to a manageable amount of stress or startle to make skills more robust to the effects of stress.

Essentially this paper explores how the human mind makes decisions and how to make those decisions better in a complex aviation environment in which accidents are becoming less predictable. We explore why these intuitive decisions are sometimes wrong, but often right. One researcher argues, "There is a thin line between a good decision and a bad decision." This paper is about that line. ◆

# ISASI Kapustin Scholarship Essay

*The following essay is the second of four from the 2019 Kapustin scholarship winners that were presented during ISASI 2019. The number of scholars selected each year depends upon the amount of money ISASI members donate annually to the scholarship fund. Details about scholarship applications and additional information can be found on the ISASI website at www.isasi.org. Application and essay deadlines are mid-April of each year.—Editor*

# Air Safety Cybersecurity: Why Cybersecurity Is a Threat for Air Safety

By Nur Amalina Jumary, 2019 Kapustin Scholarship Recipient,
University of New South Wales, Australia

## Aviation a "System of Systems"

Aviation today uses complex, integrated systems of information and communication technology to facilitate its daily global operations. At the 13th Air Navigation Conference of the International Civil Aviation Organization (ICAO) in 2018, aviation was conceptualized as a "system of systems." This concept is defined as a collection of different sets of systems consisting of people, products, and processes required for the completion of tasks, none of which are dispensable. Such a system has been enabled by digital technology. Digitalization automates processes by connecting digital technology, information, and people. The digitalization of aviation has allowed for an increased level of operational efficiency and the means to keep up with increasing commercial demands of international air travel. Despite optimizing operations, digitalization has introduced new vulnerabilities to the industry, namely in the domain of information security or cybersecurity. The interconnectedness of the systems means an increased level of interaction with different information systems, beyond what the industry has traditionally defined as its security parameter (Boeing, 2012), which leaves it at risk for new security threats that may potentially become a concern for air safety.

## Information Security in Aviation

Innovations in the design and manufacturing process have brought about "E-enabled" aircraft that are built with onboard information and communications technology that communicate with external networks to exchange data during flight, while on the ground, or anywhere in the world (ALPA, 2017). E-enabled systems present on widely used commercial aircraft like the Airbus 380 and the Boeing 787 Dreamliner communicate with numerous networks around the globe, all with varying degrees of security. At present, there are no common cyber standards for aviation systems (AIAA, 2013), which means the risks present in data communication, such as the transfer of flight and system data using wireless technology or maintenance and diagnostic functions that are performed remotely, are yet to be effectively managed.

The threat to air safety as a result of vulnerable information security is far from novel. In 2006, the U.S. Federal Aviation Administration (FAA) was forced to shut down a portion of its air traffic control (ATC) systems after a cyberattack caused disruption in its mission support functions. An audit of the FAA's air traffic control cybersecurity protection measures found that the use of commercial software and Internet protocol technologies in a bid to modernize operations put the system at a high security risk as operations were not properly secured to prevent unauthorized access. An inspector general report presented to the FAA by the U.S Department of Transportation warned that it is a matter of time before attacks to ATC systems would do serious harm to ATC operations (Baldor, 2009). The reliance of aircraft in communicating with ATC is a vital aspect of air safety, thus any threats that could potentially compromise the system's integrity should be properly identified and managed.

Although there is yet to be a serious cybersecurity incident or accident relating to ATC more than a decade since the incident discussed earlier, in 2015 a security expert in the United States was detained after allegedly hacking into the in-flight entertainment system on a United Airline's Boeing 737-800 and on one occasion had successfully overwritten a code to issue a "climb" command. In 2017, another cybersecurity expert working with the U.S. Department of Homeland Security

Nur Amalina Jumary

successfully hacked into a parked Boeing 757 through radio frequency communications (Flight Safety Australia, 2017). The recurrence of a cyberattack indicates that there has not been enough progress made by the aviation community or support from governments to expand the notion of safety as the industry has known it to encompass systems onboard and on the ground with strong information security. The FAA has taken initiatives to improve information security by tasking its Aviation Rulemaking Advisory Committee to provide cybersecurity recommendations, which included testing and updating cybersecurity protections (FAA, 2016). On the legislative level, the Cyber AIR Act was reintroduced in Congress in 2017 but has yet to be enacted (GovTrack, 2017). The aviation industry is cognizant of the threats and the consequences of a lax information security system, but reforms and changes are made at a rate much too slow for the industry to have any regulatory or legislative framework to effectively manage the safety risks that have been identified.

## Challenges for Investigators

*Adopting a generative attitude to air investigation*

Air safety investigators are responsible for providing recommendations to improve air safety after ascertaining causes of aviation accidents or incidents with the aim to prevent similar occurrences in the future. Inherent to this investigation philosophy is the use of a proactive systems safety approach to air safety (Dempsey, 1999), even though practically investigators are carrying out investigations postevent. With the security threats and hazards that surround cybersecurity and safe air transport, this approach is not enough, as investigators have to launch into a retrospective investigation driven by data collected through research. To date, there has not been a major occurrence that has significantly compromised air safety as a result of a cybersecurity attack. However, this lack of precedence is compensated by a vast collection of occurrences captured through the mandatory occurrence (incidence) reporting systems established by ICAO Annex 13. The challenge for investigators is to adopt a generative attitude (Hudson, 2001) where they would access and review large volumes of data and proactively review occurrence data to identify and quantify the threats due to lapse in information security. This allows investigators to put forth recommendations to improve air safety cybersecurity.

*Training challenges due to the need for an enhanced skill set*

Another challenge that air safety investigators face is the need to undergo further training in order to acquire the relevant skills to identify cybersecurity breaches. Air safety investigators have a high level of technical skill and knowledge in the aviation domain (Braithwaite & Nixon, 2018), but an investigation is a complex task that draws upon a broad range of skills. The product security director of Airbus Americas revealed that Airbus had not equipped their aircraft with any cybersecurity information as pilots surveyed by the manufacturer preferred not to be informed of such threats during flight (ALPA, 2017), possibly due to the perceived increase in workload. In the event of a total hull loss, the flight data recordings may not reveal accurately the state of events that led to the accident if there was an external presence that was able to overwrite the pilots' inputs. While there is value in having investigators know what they are looking for in regards to causes of incidents or accidents, there is equal value in having investigators be aware of what they do not know given a novel situation.

An important facet of training that has to be acknowledged is the limitation of training itself. It is highly misleading to expect investigators to have expertise in all aspects of aviation ranging from human factors to aircraft systems and cybersecurity. Subject-matter experts are used in the industry exactly because it is unreasonable to expect investigators to have both depth and breadth of knowledge in all areas of aviation, especially in its fast-changing nature. Airbus also faces a challenge of finding talent that has dual-expertise in aircraft design and cybersecurity (ALPA, 2017), and investigation bureaus face a similar challenge with their investigators. In the area of cybersecurity, the call to equip investigators with an enhanced skill set is part of a "total system" approach. This will ensure that aviation evolves in tandem with the systems that comprise it in order to establish a cybersecurity culture in which cyberthreats are recognized and communicated, and importantly in which the risks are managed effectively.

## Integrating Information/Cybersecurity Management and Safety Management Systems

A strategic way in moving forward is to adopt a proven methodology, one the aviation industry has used in the past. Aviation has benefited from implementing a robust, systematic approach to managing safety. The way the industry involves organizational structures, policies, and procedures and accountabilities to control safety risks in operations has been studied and replicated in other industries like health care (Kapur, Parand, Soukup, Reader & Sevdalis, 2016), and even cybersecurity at its nascent stage (Seawright, 2018). Having an "information/cybersecurity management system" integrated to the current safety management system (SMS) would allow the industry to continue managing threats that have been previously identified as well as new ones that arise through innovation in aviation. The advent of this digital era of aviation brings with it new hazards and threats, all of which do not appear to be fully realized. Thus, having an information/cybersecurity management system that responds to the new vulnerabilities the industry faces integrated with the existing SMS would be an effective approach in managing safety risks.

In summary, there is a general consensus in the industry that a harmonized approach is the most effective way to manage the threats relating to information security in aviation (Boeing, 2012). Individual organizations like the European Union Aviation Safety Agency have made amendments to make it mandatory for manufacturers that are seeking certifications to provide evidence that threats leading to unauthorized access of electronic information or systems are addressed (2019). Similarly, Boeing is establishing a Cyber Technical Center to support the cybersecurity needs of its customers (2012). Efforts made by individual agencies are important, but synchronizing these individual efforts to establish a strong cybersecurity culture would effectively manage information security concerns, thereby maintaining air safety. Central to this system safety approach is providing the necessary education for investigators to gain the knowledge to identify and recognize threats that are contemporary to the industry, and subsequently the proper trainings for them to acquire skills to provide recommendations to improve air safety. ◆

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## Call for Papers to ISASI 2020 in Montréal, Qué., September 1–3

With "20/20 Vision for the Future" as the ISASI seminar theme, the ISASI 2020 Committee is inviting interested individuals to submit abstracts for papers that address the future of aircraft accident investigation. Presentation topics that support the theme may include but are not limited to

- Recent accident/incident investigations of interest.
- Novel investigation techniques for aircraft, helicopter, and drone accidents.
- Data investigation methods, techniques. and future developments.
- Airport investigation methods and techniques.
- Future investigator selection criteria and training needs.
- Future of aircraft data capture and retrieval and protection of safety information.
- Future developments in underwater wreckage recovery, and
- Future evolution of family assistance.

We are also interested in papers that address the challenges surrounding the recent B-737 MAX accidents. While it is not our intent to discuss the accidents themselves, we are hoping to generate thought and discussion on the effect the accidents have had on the industry as a whole and on the traveling public. Presentations must be in English and should be 25 minutes long. There will be an additional five minutes for questions at the end of each presentation.

Abstracts should include the author's current résumé (1 page only) and be sent to isasi2020papers@shaw.ca.

Important dates:

**March 20, 2020**—Last date for receipt of abstracts.

**May 8, 2020**—Presenters informed of acceptance and provided with additional instructions.

**May 22, 2020**—Draft program for the 2019 seminar technical program will be published.

**July 10, 2020**—Last date for receipt of completed paper and PowerPoint presentation.

Any papers not received by the deadline will be removed from the program and replaced by another speaker. If you have questions related to the paper topics or any other inquiries about the program, please contact the ISASI 2020 program chair at barb.dunn@isasi.org. ◆

## Deadline for 2020 Lederer Award Nominations Is May 31

Nominations from ISASI members in good standing for the esteemed Jerome F. Lederer Award are open until May 31, 2020. The annual award recognizes outstanding contributions from any individual or group to technical excellence in accident investigation. Each nominee is eligible for consideration for three years if not selected, and the ISASI member can renominate that person or group for a second three-year period. For more information go to http://www.isasi.org/Awards/JerryLedererAwardNominationForm.aspx. ◆

## Kapustin Memorial Scholarship Applications Due April 15

Applications for the 2020 ISASI Rudolph Kapustin Memorial Scholarship must be submitted on or before April 15, 2020, according to ISASI Secretary Chad Balentine, who serves as the Scholarship Committee chair. He noted that this worthy program is designed to encourage and assist college-level students interested in the field of aviation safety and aircraft occurrence investigation. ISASI funds the Rudolf Kapustin Memorial Scholarship through donations and will provide an annual allocation of funds for the scholarship if funds are available. Applicants must be enrolled as full-time students in an ISASI-recognized education program, which includes courses in aircraft engineering and/or operations, aviation psychology, aviation safety, and/or aircraft occurrence investigation, etc. Applicants must have major or minor subjects that focus on aviation safety/investigation. A student who has received the annual ISASI Rudolf Kapustin Memorial Scholarship is not eligible to reapply. Students who wish to apply should go to https://www.isasi.org/Documents/Forms/Rudolf%20Kapustin%20Memorial%20Scholarship%202020.pdf for guidelines and the application form. ◆

## ISASI Officer Nomination Announcement

The 2020 International Council election will take place between July 1 and Aug. 21, 2020, and the results will be announced at the ISASI annual seminar. Nominations will be accepted from May 1 until June 25, 2020. The ISASI officer positions available for nominations are ISASI president, vice president, secretary, treasurer, international councilor, and U.S. councilor. Please e-mail any nominations to isasi@erols.com. All persons nominated must be members in good standing. If there are any questions, please contact Troy Jackson at troy.airsafety@gmail.com. ◆

## ISASI–ICAO Working Group Prepares for New Meetings

ISASI Vice President Ron Schleede reported on two updates for the ISASI–ICAO (International Civil Aviation Organization) Working Group:

- ISASI will be participating in the sixth meeting of the ICAO Accident Investigation and Prevention (AIGP) meeting (AIGP/6) on May 11–15, 2020, in Montréal, Qué., Canada. Bob MacIntosh, ISASI treasurer, and Mark Clitsome, former director of investigations–Transportation Safety Board of Canada and former chair of the AIGP, will represent ISASI. The Society's efforts at the previous AIG Panel meetings assisted with the development of significant updates to ICAO standards and recommended practices and guidance materials. Our participation is deeply appreciated because of the extensive experience and expertise of our members.
- The ISASI–ICAO Working Group is preparing a letter in response to a state letter from ICAO regarding the third High Level Safety Conference to be held in Montreal in June 2021. We are accepting an invitation to attend and contribute. ◆

## ESASI Sets 2020 Meeting in Budapest, Hungary

Steve Hull, secretary of the European Society of Air Safety Investigators (ESASI), reported that the European Society's Executive Committee announced that registration for ESASI 2020 is now open. The ESASI 2020 meeting will take place in Budapest, Hungary, on June 3–4, 2020, with the theme "Maintaining the Momentum."

The meeting will consist of a one-day seminar to share experience, best practices, and future developments, followed by a workshop on "the dissemination of information from a safety investigation."

For more information, please go to https://esasi.eu/esasi-2020.

The ESASI Executive Committee looks forward to meeting you in Budapest. ◆

## MENASASI Board Meets in Abu Dhabi

Following the first day's presentations during the Middle East Northern Africa Society's (MENASASI) sixth seminar in Abu Dhabi, United Arab Emirates (see page 32), MENASASI conducted a board meeting. The officers and board members brought new members to represent other countries in the Middle East North Africa (MENA) region, which has 22 countries in the area. The board had in-depth discussions regarding increasing membership, how to hold similar seminars in other MENA countries, and how to raise funds.

Khalid Al Raisi, who was appointed the acting MENASASI president following the retirement last year of Ismaeil Mohammed Al Hosani, was elected and approved as the new president. Ismaeil Mohammed Al Hosani was the first president and founder of MENASASI. ◆

***MENASASI board members conduct a business meeting during which Khalid Al Raisi, center, is elected MENASASI president.***

## MARC Plans Annual Spring Meeting

Mid-Atlantic Regional Chapter (MARC) President Frank Hilldrup reported that the annual spring meeting and dinner is set for April 30, 2020, from 6:00 to 9:30 p.m. at the Crowne Plaza/Dulles Airport hotel in Herndon, Virginia, U.S.A. The guest speaker will be Capt. Craig Hoskins, vice president, safety, security, and technical affairs, Airbus America, Inc. ◆

## In Memoriam

Robert "Bob" Charles Matthews, age 73, unexpectedly passed away on Sunday, Dec. 15, 2019, at INOVA Fairfax Hospital in Virginia, U.S.A. He was born on July 12, 1946, in Melrose, Massachusetts, to James and Theresa Matthews.

Bob taught fourth and sixth grades in Portsmouth, New Hampshire. After the 1973 school year concluded, he moved to Virginia to pursue a lifelong career with the federal government. While working, he achieved his Ph.D. in policy analysis and political economy from Virginia Tech in 1986. He continued teaching, and even taught business government relationship part time at the University of Maryland as an adjunct assistant professor from 1987 through 2002.

Bob's main career was with the U.S. Federal Aviation Administration (FAA). He began working with the FAA in 1989. He was the senior safety analyst in the FAA's Office of Accident Investigation and Prevention where he became known worldwide as a "walking encyclopedia" for accident investigation reports. In 2009, he was a member of the Commercial Aviation Safety Team (CAST) that received the Collier Award administered by the U.S. National Aeronautic Association. The award is presented to those who have contributed "the greatest achievement" in aviation. In 2011, he received the FAA's Champion of Safety Award. One year later, he and his work colleague, Frank Del Gandio, retired.

Bob then took on the role of an aviation consultant-analyst, providing analysis of airline and general aviation accidents and accident trends. His professional experience included nine years in national transportation legislation with the U.S. Department of Transportation, two years as a consultant with the Organization of Economic Cooperation and Development in Paris, France, and several years as an aviation analyst for the Office of the Secretary at the U.S. Department of Transportation

Del Gandio, ISASI president, said, "Bob was an 'analyst extraordinaire,' a longtime member of ISASI, and a frequent presenter at our seminars. In his position at the FAA, he reviewed all significant safety rules and FAA initiatives. In addition, he conducted analysis on a broad range of airline and general aviation accidents and related safety issues both domestically and internationally. Bob leaves his wife, Barbara; daughter, Tara; her husband Tom; and three grandchildren." ◆

Bob Matthews

# Airmanship 2.0: Innovating Human Factors Forensics

(Continued from page 17)

the existing paradigm, but also to consider other operational paradigms entirely.

This shift positions the investigator in a role that challenges our industry safety assumptions at its very roots. This does not necessarily imply that the paradigm should be doubted at every corner, but it should enable the industry to guard itself against blind spots in our investigation of our industry.

As Isaac Asimov once put it: "Your assumptions are your windows on the world. Scrub them off every once in a while or the light won't come in." ◆

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# MENASASI HOLDS SEMINAR IN ABU DHABI

*Shown are participants of the sixth Middle East Northern Africa Society seminar at the Hilton Capital Grand Hotel in Abu Dhabi, United Arab Emirates.*

The Middle East Northern Africa Society (MENASASI) held its sixth seminar at the Hilton Capital Grand Hotel in Abu Dhabi, United Arab Emirates, on Nov. 26–27, 2019. Acting Assistant General Director Mohmmed Al Dossari opened the reginal seminar, and Acting MENASASI President Khalid Al Raisi followed.

ISASI President Frank Del Gandio gave a presentation on the evolution of ISASI and aviation safety. There were another 18 other speakers who discussed past accident/incidents and other safety-related issues, including

- Abdula Shabra, Human Factors Investigator, AIB, Kingdom of Saudi Arabia (KSA)—*Who Hit the Cat? Investigation Analysis Models*
- Edma Naddaf, President, Aviation and Corporate Psychology Consultancy, UAE—*PTSD Risk for Investigators*
- Mohammed Aziz, Coordinator of SQS, Middle East Airlines, Lebanon—*Effective Implementation of Accident Investigation Reports*
- Khalid Al Raisi, Acting MENASASI President—*Accident Investigation in the UAE*
- Sundeep Gupta, Accident Investigator, Product Safety, Airbus—*Airbus Support to Investigations*
- Ibrahim Al Addasi, Chief Accident Investigator, GCAA-AAIS—*Oxygen Generator Incident Investigation*
- Iain Frazer Bough, Senior Manager, Emergency Response, Etihad Airways—*Airline Special Assistance Team*
- Sebastien Barthe, Head of Information and Communication, BEA—*Postaccident Communication*
- Enor Hazim Fairaq, Performance Engineer, Aviation Investigation Bureau, KSA—*International Recorder Investigations Group Air Meeting 2019 Takeaways*
- Khallid Saud Al Humaidan, GCAA Policy and Regulation, UAE—*Safety Systems: The First Line of Defense*
- Shehab Hassan, Deputy Director, Aircraft Accident Investigation Administration, Egypt—*ME Investigator Training Challenges and the Benefits of RAIO*
- Hans Meyer, Senior Air Accident Investigator, AAIS, UAE—*Controlled Ditching: A Helicopter Accident Investigation*
- Anthony Wride, Captain, Etihad Airways—*Are You Ready for This?*
- Salah Mudara, MENASASI Treasurer and Membership, Bahrain—*Emergency Response*
- Ousamma C. Jadavel, American University of Technology, Lebanon, and Mohammad Aziz—*On the Next Generation of Air safety Persons: Some Reflections and Deliberations* ◆