

“In Pursuit of Expertise: A paradigm shift in pilot training”

AAvPA / PACDEFF Keynote Presentation Summary

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With rapid advances in aircraft technology and increasing operational complexity, training must reflect the most relevant needs of current and future airline pilots. The current growing pilot shortage gives rise to a need to expedite the development of performance and expertise among new pilots. This presentation will explore the benefits of the Evidence-Based Training (EBT) concept in helping to address these industry challenges.

The EBT program aims to develop the competencies required to operate safely, effectively and efficiently in a commercial air transport environment, whilst addressing the most relevant training needs based on evidence gained through analysis of operational data. EBT is focused on building resilient human performance through the development of competencies, using realistic yet challenging scenarios to better prepare pilots for situations faced on line. EBT is a learning concept that promotes continuous development of pilot performance, based on both population and individual pilot training needs.

ICAO published the EBT concept in 2013, and many Civil Aviation Authorities have already begun to approve EBT programs, with more than 50 airlines currently engaged in EBT implementation worldwide.

Maximising Performance for Future Systems

In the next few decades, the aviation industry is likely to experience substantial changes in aircraft technology and operations (Airbus, 2018; Boeing, 2018). IATA (2017) has forecast a doubling of annual passenger numbers by 2036, with much of that demand being driven by the Asia Pacific market (Figure 1). Airbus (2018) reports that the industry is likely to see a doubling of traffic in the next 15 years, and Boeing (2018) has predicted that at least 635,000 more pilots will be required in commercial aviation by 2037 (Figure 2).

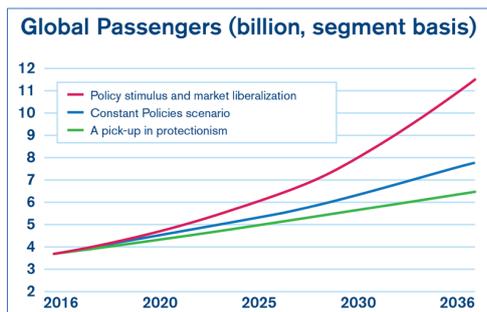


Figure 1. Passenger growth forecast (IATA, 2018) **Figure 2.** Pilot demand forecast (Boeing, 2018)

While this level of growth provides great opportunity for the aviation industry, it also presents a number of challenges. It is widely acknowledged that the forecast requirement for pilot numbers represents a growing skills shortage for the industry. Industry growth, accompanied by rapid technology developments, bring the challenge of increases in operational complexity and an increased pace of organisational change.

Since 1960, the aviation industry has maintained a continued reduction in the rate of fatal aircraft accidents (Airbus, 2018). In the last two decades, there has been a 95% reduction in the fatal accident rate, and a 70% reduction in the rate of hull losses (Airbus, 2018).

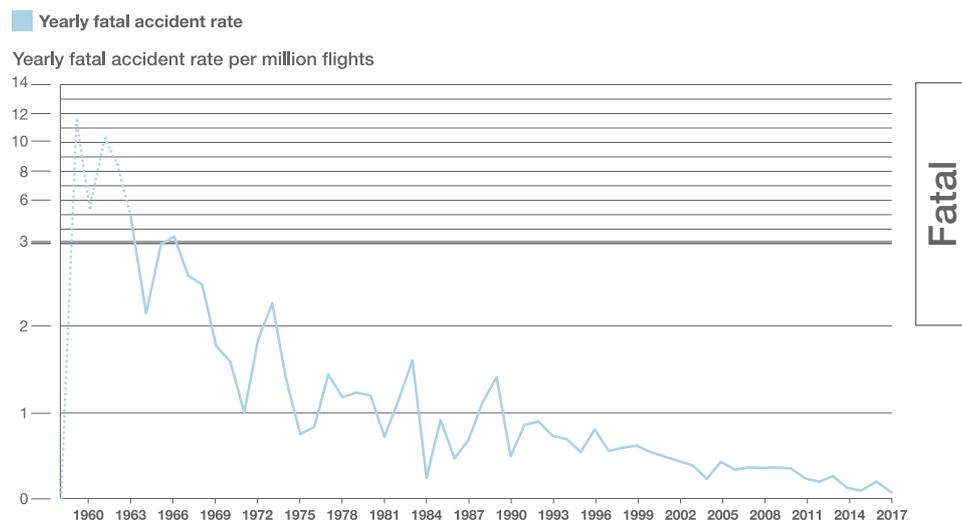


Figure 3. Annual fatal accident rate 1960-2017 (Airbus, 2018)

The industry faces a substantial challenge in sustaining this improved safety performance, considering the human performance challenges forecast across the next two decades:

- A shortage of pilots and other skilled roles, and a lower average experience level within airlines
- Increased operational complexity and an increased pace of organisational change
- The need to ensure manual skills retention in highly automated systems
- Fewer predictable aircraft failures (more events faced by pilots may be unexpected or even 'unforeseeable')

In preparing to meet these current and future human performance challenges, training systems should adopt a structured, systems-based approach to training management. This may be achieved by:

- Understanding and training human performance in the context of the whole operational system and its challenges
- Developing effective systems to collect and analyse data to inform training
- Conducting formal, structured analyses of training needs
- Utilising an integrated system of core competencies and detailed performance indicators to measure performance
- Making training decisions based on scientific and industry evidence

The Evidence-based Training (EBT) concept focuses learning on identified training needs, through exposure to realistic, challenging operational scenarios; and by measuring individual pilots' performance using a structured competency framework (ICAO, 2013). The EBT training topics published by ICAO (2013) represent industry-wide, aircraft generation-specific, training needs identified through detailed analyses of flight safety and training data (IATA, 2014).

Evidence-based Training (EBT)

The EBT concept was developed as part of the IATA Training and Qualification Initiative (ITQI), starting in 2007. The rationale for the project was that despite progress in the design and reliability of modern aircraft, more needed to be done to improve safety and performance, through advances in pilot training.

An international working group was formed, to conduct a review of airline pilot recurrent training and checking. The international working group included aircraft manufacturers, airlines, civil aviation authorities, academic institutions, international aviation organisations, pilot representative bodies and training organisations (IATA, 2013).

The international working group established a new methodology for the development and conduct of recurrent training and checking: Evidence-based Training (EBT). The aim of the program is to identify, develop and evaluate the competencies required to operate safely, effectively and efficiently in a commercial air transport environment, whilst addressing the most relevant threats according to evidence collected through analysis of accidents, incidents, normal operations data and training (ICAO, 2013).

The EBT concept represents a paradigm shift in pilot training, which is focused on building resilient human performance through the development of underlying competencies. The development of these competencies through structured exposure to realistic, challenging scenarios, aims to expedite the development of expertise among pilots.

Developing Expertise

The development of expertise has been studied extensively, in a broad range of disciplines, particularly in sport, where even the smallest incremental improvements in performance are critical to successful outcomes. Expertise can be defined as the ability to sustain exceptional or outstanding performance in a particular domain (Ericsson & Pool, 2018; Magill, 1998). While expertise is specific to a domain, and not easily transferrable, there are some consistent broad characteristics associated with expertise (Ericsson & Pool, 2018; Klein, 2008; Magill, 1998):

- well-developed knowledge structures or mental models of their domain, which enable faster and more accurate situation assessment and problem solving
- the ability to prioritise what cues to attend to, making processing of information more efficient and effective
- automatic processing of basic skills, that is, skills are performed without conscious thought

Experts are able to recognise or match patterns and features of a situation to their knowledge structures and mental models built through past experiences, which helps in faster situation assessment, and more effective problem solving and decision making (Hoffman, et al., 2014; Klein, 2008; Klein et al., 2010).

These characteristics of expertise are developed through extensive exposure to varied, rich experiences, combined with deliberate practice, and performance feedback (Ericsson & Pool, 2018; Feltovich, Prietula, & Ericsson, 2018; Hoffman et al., 2014).

While a certain amount of proficiency can be developed through experience, repetition and trial and error, the learning process is made more effective and efficient with deliberate practice. Deliberate practice is not simply the repetition of tasks, or accumulation of experience by working for a number of years in a particular domain. It involves focusing practice on specific areas of performance that are identified as needing improvement. Deliberate practice involves the help of a coach and includes opportunities for self-reflection and exploration of alternative approaches (Feltovich, et al., 2018). The training goals relate to improving performance to a level that the individual hasn't previously reached, that is, continuous performance improvement rather than training to a minimum standard of proficiency. Scenario-based or problem-based training in a realistic context has been demonstrated to be an effective tool for accelerating the development of expertise (Hoffman et al., 2014).

Research on expertise, conducted across a range of disciplines (Ericsson & Pool, 2018; Feltovich, et al., 2018; Hoffman et al., 2014; Salas, et al., 2012; Williams, 2006), has identified tools that are effective in its development:

- Having specific, measurable performance goals
- Learning through exposure to challenging situations
- Scenario-based, or problem-based training in a realistic context
- Stretching performance beyond the person's 'comfort zone'
- Providing feedback and encouraging self-reflection
- Using mental rehearsal, visualization, 'what-if' scenarios
- Learning to manage stress / pressure (e.g. relaxation, breathing, self-talk, building confidence)

Training should be focused on specific aspects of performance that would benefit from improvement, rather than simply providing repetition of tasks or motor skills. That is, specific training needs should be identified, and these training needs should form the basis of training, in challenging, realistic scenarios.

Core Competencies

Within an EBT program, simulator-based training provides exposure to realistic and challenging scenarios, which involve the need to assess or diagnose situations, apply knowledge, and practise dealing with ambiguity. In doing so, this aims to expedite the process of developing expertise, rather than simply waiting for pilots to gain sufficient exposure to challenging situations on line. It also provides a means for training competencies in a structured way, as scenarios are designed to focus on specific areas of competence. Scenarios within an EBT program are not known to pilots in advance. Instead, pilots prepare for the scenarios as they would prepare for a regular line flight. This aims to develop skills in critical thinking, analysis, and response generation, and ultimately build confidence in dealing with unexpected situations.

In traditional training and checking programs, where scenarios or events are known in advance, pilots are almost always operating in a rule-based or rote-learned manner. When they know the problem that will be encountered, and have a solution prepared, there is no opportunity to practise diagnosing or analysing problems or generating suitable solutions.

Training should be focused on challenging, unexpected scenarios rather than rote-learned responses. The focus within the scenarios should be less on tasks and manoeuvres, and more on developing the underlying core competencies that will help pilots to handle any situations they face, even those that are unforeseeable.

The EBT concept focuses assessment and training on the following core competencies:

- Application of Procedures
- Communication
- Flight Path Management – Automation
- Flight Path Management – Manual
- Knowledge
- Leadership & Teamwork
- Problem Solving and Decision Making
- Situation Awareness
- Workload Management

Each competency is defined through detailed performance indicators, which describe how the competency is demonstrated in practice. The competencies represent both technical and non-technical skills, however it is important to note that within this framework each competency is equally important, and there is no separation of technical and non-technical skills. Non-technical skills are not simply used as 'reason codes' to explain a technical failure, as they are an equally important element of pilot competence and should be trained and assessed with the same emphasis as technical skills. The core competencies should be fully

integrated within all forms of pilot training, and properly embedded in the context of actual operations and the challenges that pilots face on the line.

Training Based on Needs

Rather than waiting for experience to develop through the accumulation of flying hours and ‘one-size-fits-all’ training programs, EBT aims to expedite the development of pilot expertise by focusing training on actual training needs, identified at an industry, airline and individual level.

In a two-day EBT simulator program, individual pilots’ training needs are identified in the first session, through an assessment of competencies during the Evaluation phase. The training needs form the basis of a facilitated debrief at the end of the session, and relevant scenarios are selected to form the basis of Scenario-based Training during the second session. The scenarios provide further exposure and training in the specific competencies that were identified as training needs (see Figure 4). In the In-seat Instruction phase, the trainer takes one of the pilot seats and conducts a short, role-played scenario, in which a number of scripted errors are made. The pilot in the other seat has the opportunity to practise skills such as monitoring, error detection, and intervention, which are training needs that have been identified at an industry level, and difficult to train effectively in traditional training programs.

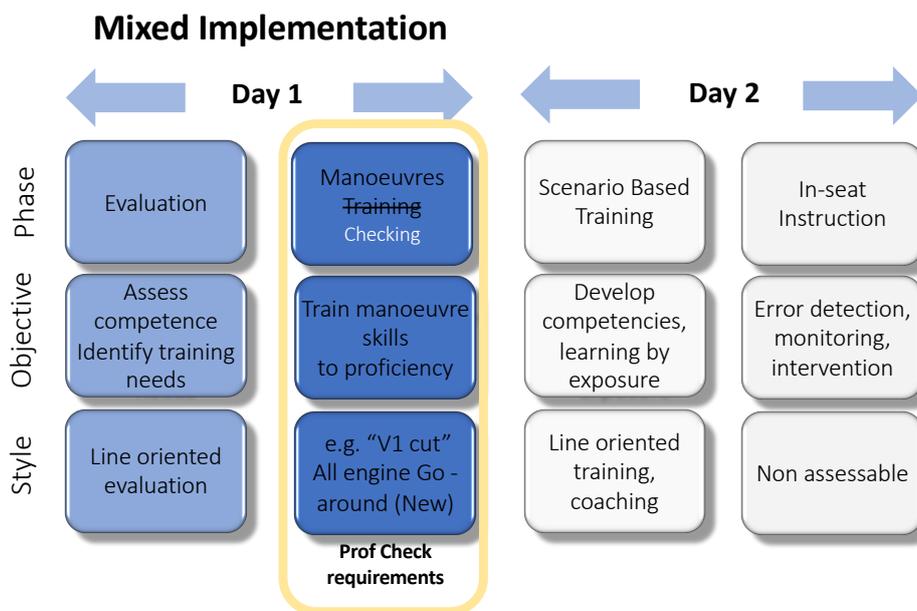


Figure 4. Evidence-based Training program structure

Training Based on Evidence

In addition to focusing on individual training needs, the EBT program is based on training needs identified at an industry level. “Evidence” in EBT refers to the analysis of large data sets, rather than making decisions about training needs based on a single high-profile accident or a small cluster of incidents.

The EBT training topics published by ICAO (2013) represent industry-level training needs, identified through an extensive data analysis completed by the international EBT working group. The working group included a large group of specialists in safety data analysis, and over four years they gathered substantial data from accidents, incidents, flight data analysis, Line Operations Safety Audits (LOSA) and other sources. This provided for a detailed insight into the threats, errors and undesired aircraft states encountered in modern

airline flight operations as well as their relationship to adverse consequences.

The analysis revealed that while there is some overlap in training needs across aircraft generations, there are also distinct differences in the patterns of risk in the later generation aircraft that are not addressed effectively through traditional training and checking programs (IATA, 2014).

In addition to the identified industry-level training needs, airlines may also have specific training needs related to the nature of their operation or pilot population. These needs may relate to specific competencies that require development among particular parts of the pilot population (e.g. different competency needs for Captains and First Officers), or they may relate to the types of challenges encountered within an airline’s operation. Evidence from both training and safety data sources can be considered when identifying population-level competencies in need of training, and/or to contextualise training scenarios with relevant operational challenges. When examining safety data, it is important to look deeper than standard safety performance indicators, which usually simply provide information about the outcomes of performance. Data should be coded and analysed at the level of specific threats, how they were managed or mismanaged, and the associated competencies involved. Normal operations monitoring programs such as LOSA can provide substantial detail on the types of threats and errors encountered in normal operations, how they are managed, and it can provide a profile of competency strengths and areas for development across the pilot population.

When analysing data at an airline level, conclusions should not be made based on small quantities of data, or small changes in safety statistics. Evidence should be examined across large data sets and corroborated using multiple data sources before making decisions about training needs. When analysing evidence, and prioritising training needs, it is also important to recognise that training is not the solution to all organisational or safety issues, and that system design solutions should be considered where possible, in order to have a more effective and sustainable influence on performance outcomes.

Learning from Positive Performance

Traditionally, many organisations’ safety efforts have focused almost solely on analysing adverse events, or “what goes wrong”. It is important to understand and learn from adverse events, and prevent similar occurrences in the future, however, if the sole focus of safety analysis is on what goes wrong, organisations are missing out on valuable learning about how work is really done, and why things go right. Figure 5 provides a representation of the relative proportion of failure and non-failure events in a system where the probability of failure is 1 in 10,000 (in commercial aviation, the probability of being in a fatal accident is 1 in 10^{-7}) (Eurocontrol, 2013).



Figure 5. “The imbalance of things that go right and things that go wrong” (reproduced from Eurocontrol White Paper, 2013, p.6).

When changing a system or introducing new technology, it is important to understand what makes the

current system work effectively and ensure that this is considered when making changes. When system designers and managers imagine how work is performed, it is generally imagined that it is in accordance with what the system designers intended and aligned with the way procedures are documented. Work is often imagined to be linear and sequential, organised and simple. However, most safety-critical work is associated with substantial complexity, variability, and ambiguity. People adapt their performance to manage this variability, and maintain safe, effective operations. Without understanding how human performance contributes to maintaining safety and operational effectiveness, including in normal operations, it is not possible to know what these variations and adaptations are, and how people are making the system safe and effective.

Normal operations monitoring programs such as LOSA provide a highly valuable source of data on human performance and the health of operational systems. While LOSA has occasionally been criticised as simply being a method for error counting, it provides a methodology with enormous potential for examining and understanding resilience within systems. That is, it can be a valuable source of data about human performance within systems, including how work is really performed, 'what goes right', why things work, and how people adapt effectively to variability and complexity. It can also be a valuable source of data to understand expert performance (e.g. expert strategies, rules of thumb, and techniques).

In addition to studying normal operations, much can be learned from studying serious incidents or events in which effective crew performance has contributed to successful management of a challenging situation. One example of a challenging event which was managed successfully can be found in an incident involving an Airbus A321 near Pampaloma, Spain in 2014 (BFU, 2015). The aircraft's angle of attack probes had frozen while passing through weather during the climb, leading the probes to report too high an angle of attack. As a result, the angle of attack protections led the aircraft to command a continuous nose-down pitch. The crew managed the event very effectively by systematically working through the problem, initially working out a way to control the aircraft by adapting their control inputs to the new behaviour of the aircraft. They then communicated and worked together with maintenance engineers on the ground, to trouble-shoot and find a solution, removing the need to continuously pull back on the side stick. The solution involved placing the aircraft into Alternate law, to remove the envelope protections. The crew used the remaining flight time to familiarise themselves with this new aircraft state and prepare for landing.

The investigation report provides some detail about the crew's actions, which enables others to learn from the positive performance that contributed to the effective management of the event. However, in many other published investigation reports, successful human performance receives very little attention, in favour of a focus on what went wrong, and positive performance is often summarised in one or two sentences. Whilst it is important to understand failures, and focus on preventing further occurrences, it is also important to learn from positive performance.

Over many years, the industry has developed effective approaches to investigating and analysing failure, and many organisations are reasonably good at celebrating and praising success. To compliment this, we now need to become effective at studying success.

Summary

While preparing to address the performance challenges of the future, it is possible now, within the current regulatory framework, to implement the four principles discussed:

- learning based on underlying competencies to build resilience;
- examining the evidence / data to understand training need;
- focusing training on identified training needs, both individual and population-level; and

- learning from positive performance.

These principles may help to create a future in which pilots visit the simulator looking forward to learning, rather than fearing failure. In this future, non-technical skills no longer stand alone from technical skills, and EBT is no longer an alternative training program. Instead, these principles have simply become a normal part of aviation training.

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