AVIATION TRAINING

A future learning ecosystem for pilot training

A white paper from CAE[1] and Emirates Airlines[2]

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The future of pilot training

The ways in which pilots train in the future will look very different to the ways in which they train today. In recent years, society's approaches to education and learning have been changing and will continue to do so even more. Advances in technology, underpinned and informed by science, particularly the learning and behavioural sciences, have been a major driver for this change.

This shift in the approach to pilot training has also been influenced by non-technical aspects, such as people being motivated by autonomy and having self-control in how they learn. Harnessing the power of 'community in learning' via chat and social nudging has compounded this motivation and has provided additional useful learning content outside of formal Learning Management Systems (LMS). However, the freedom to access on-demand learning 'anytime and anywhere' has acted as the strongest enabler. Objectives for pilot training are becoming increasingly focused upon retention of knowledge and the ability to recall learning when the pilot really needs to use it in the actual flight operations environment.

Combined with existing training material, new simulation technologies are forming a **future learning ecosystem** that will reshape the training experience from one focused on organisational control to one that supports the trainee's drive to learn. As educational best practice has moved towards more interactive and explorative learning, it is unsustainable for the aviation industry to expect previous training methods and approaches will continue to produce effective results. Given the new generations of learners who have grown-up with today's technology this outcome appears even more inevitable.

In the coming years, we expect to witness a renaissance of new methods to illustrate and simulate situations for training, enhancement of training approaches and methods, whilst improving quality and reducing costs of the training itself.

The future learning ecosystem

Conceptually, the **future learning ecosystem** is illustrated in Figure 1 as a series of matrices mapped upon each other. The bottom matrix is one of regulations, audit requirements and guidance, which due to the need for regulatory compliance forms the fundament of the learning ecosystem. Also here is the operational evidence of events in the industry and in a particular airline.

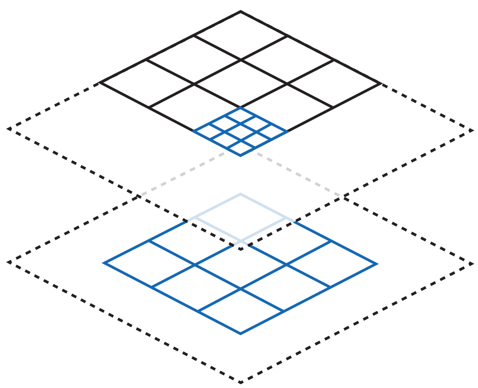

Figure 1: The future learning ecosystem

The next layer represents the translation of regulations, requirements, and guidance into KSA (knowledge, skills and attitudes). These are the competencies which the training needs to address to achieve compliance and respond to the evidence from operations. This layer may include items beyond that of regulations including weak signals from the system (for example, observations, comments, and sentiments) that should ideally be acted-upon.

Finally, the top layer represents the learning material itself including different learning technologies and methods to deliver training. This maps onto the lower layers to represent responses to the training needs arising from these levels. At this level we find manuals, reference books, simulators etc. It is here that a modern training matrix should have material such as short explanatory texts (simplifying and referencing manuals) and video clips (for illustration of procedures, scenarios, management of situations, etc.).

In addition to full flight simulators (FFS), lower fidelity simulation technology (for example, desk-top simulation of exercises) will allow learners to practise in a simple and accessible way.

The top layer should have a wide range of material, responding to and referencing lower layers. With a full matrix of materials, courses can be sliced out of the matrix of material. A conversion course will represent a slice of material of relevance for a new pilot; a command course would represent another selection and slice. In this way, all training material will be transparent and available for all pilots and can be accessed at any time, but for specific courses relevant parts are put together to meet requirements and training needs. Note that the lower levels of the learning ecosystem can be invisible to the learner, allowing them to focus on their training, and the focus of training to be driven by the training system without being explicit to the pilot – thus removing what in many ways are distractions from learning.

The material in the matrix top layer should be of such quality that it is used even when not mandated or is from a course that does not requires the material to be used. This is already the case for some short and explanatory texts shared between pilots and for the video clips made available for training in some airlines. This means that formal, structured and organisationally controlled learning would be complemented by individual, informal and self-controlled learning. The key is to produce high-quality engaging training material and make it accessible enough to facilitate the individual's drive to learn. This can be further supported by offering pilots opportunities to trade in class training time against individual control of their own learning and time.

Simulation for experiential training (SET)

Aviation has not embraced modern technologies and methods for learning and training that have been developed in other parts of society. However, with the advent of CBTA (Competency Based Training and Assessment), the goals for pilot training have been clarified with the primary focus on the specific competencies established by the industry. Complementing handling and procedural skills with that of resilience – managing unusual and unexpected situations – has also supported an increased focus on crew resource management (CRM) or non-technical skills (NTS) training.

Over recent years, training technologies and methods have been expanded with simpler 'procedures trainers' and updated versions of Computer Based Training (CBT). In the spectrum of training methods – ranging from a text to read by yourself to a session in a full flight simulator – there is still a great need for more methods that meet different types of training needs.

Simulation for experiential training (SET) is one methodology that can be used to develop both procedural and CRM skills in the context of operational scenarios. Identifying operational situations that are rich in learning potential and putting them in a 'simple simulation' format can allow much more emphasis on different aspects of learning and far more variations of similar but slightly different scenarios to be trained than can ever be possible with limited and costly resources in the form of simulators with higher levels of fidelity. It is fully possible to use SET for a range of purposes, from allowing pilots to try out a new procedure in simple format, to testing them in complex decision-making scenarios without the pressure and cost of using a full flight simulator.

It is important to understand that SET is not just a low-budget version of a simulation experience with higher fidelity. SET has unique advantages that have been documented in academic and scientific literature. SET provides a clear focus on distinct aspects of learning without distracting realistic features. There is evidence that for some situations and competencies, higher fidelity simulation has a small or insignificant effect on skill transfer and that reducing complexity may support attention and memory load, especially when new knowledge and skills are being trained. Simply put, there is limited evidence that more fidelity always equates to better learning rather this depends on the content of what is being trained.

When using SET for generalised aircraft situations or even domain general scenarios (for example, nuclear power plant, marine ship, space rocket, etc.) there can be an increased focus on the skills required for high performance. When training decision-making it may be an advantage to remove the support of technical, domain-specific knowledge of aircraft and procedures and focus on the process of decision-making, for example, in the context of a situation with a ship at sea. This generalisation of competencies also makes them more applicable in a wide variety of situations and less linked to narrow, specific situations often covered by procedures.

In addition, SET can collect data and provide feedback on pilot performance, both to the pilot and to the training system. If some pilots are struggling with a SET for an 'in-flight fire scenario', it may show that further training on the associated checklists is necessary. If a 'fuel leak scenario' is causing trouble, it may indicate insufficient understanding of the linked technical systems or the procedures for this. Applications of a non-domain SET for training of airline pilots have found that strategies and patterns for decision-making could be collected from any well-designed simulation.

Embedded training

In addition to SET, there are other concepts that will form part of the future Learning EcoSystem. This includes embedded, sometimes referred to as blended, training which at its simplest would incorporate training content into the actual operation itself. In other words, this would mean using time "at work" or operational time when there are no requirements on performance, to train. This idea arose from a discussion with William Voss (former Chairman of Flight Safety Foundation) who noted that the armed forces in the USA are increasingly using this method for operational readiness training.

On a practical level, embedded training simply provides 'bitesize' training modules in operational situations. We can imagine a flight from Dubai to Beijing, that will require crossing the Himalayas, with its associated risks. Once reaching cruising altitude and a low workload phase of flight, the system could propose that one of the pilots review the drift down procedures, as per a short module, perhaps including an element of simulation.

Not only would a pilot cover a required training module, which is logged towards their training records, the pilot would do this in a relevant operational situation, that increases training effectiveness in the form of understanding and remembering the content. In addition, this raises situational awareness for a potential operational risk situation. In this way, embedded training can support a pilot with knowledge at a time that it is operationally relevant, and the context reinforces learning, improving both operational safety and training. Over time a pilot could cover parts of the recurrent training syllabus in flight, when relevant and supporting situational awareness for that flight. This would also save training time on the ground, especially on distance learning that would otherwise have to be covered during time at home.

Artificial intelligence

An individual's drive for learning will be supported by adding a layer of intelligence on top of the matrix with training material. When a pilot watches a video of a new procedure, artificial intelligence (AI) functions could offer similar videos of recent procedural changes, an explanatory text, or an opportunity to try the new procedure in a scenario with the help of SET, recommendations based on training history ("long time since you covered topic x"), current peer interest ("your colleagues are current looking at this document/video") could add to this.

AI technology allows us to capture training needs from user behaviour outside of formal learning management systems and the training environment. For example, a search for content in an e-manual or website could be linked to one or more learning objectives with a machine learning (ML) engine. The ultimate aims of AI in this context are to increase quality, accessibility and efficiency of training. If the training ecosystem can not only allow but encourage and drive individual training, much has been won compared to the situation of today – where pilots often see training as something forced upon them and too often it becomes a matter of ticking the right boxes.

Use of AI could also support organisational goals in highlighting to individuals where they may need to focus their attention when their performance is at risk of not reaching required standards. The current manual "trend analysis" could be done by analytic functions and point a pilot to where they need to reinforce their knowledge and skills. As an example, a pilot receiving consecutive grade 3s in training may be pointed to reading material, videos, and simulations to improve this competency. Similarly, all competencies could be monitored by AI for trends and then linked to training recommendations of interventions from the system. As stated before, data from simulation – from full flight simulation to SET – could also collect data and provide training recommendations.

Finally, linking pilot performance and training in this way could provide data on effectiveness of training – to see if pilots perform better after having made use of training recommendations and interventions. Also, patterns of performance could be identified over time to create awareness and understanding of trends of performance. Although this sounds advanced, it is nothing more than has been applied in sports for some time (for example see the film "Moneyball" highlighting the use of statistics in baseball that has now spread to most of the other "elite" sports).

Summary and conclusions

This paper has described the potential benefits of a **future learning ecosystem** for pilot training based-upon simulation for experiential training (SET), embedding training into operations, and leveraging Artificial Intelligence (AI) technology. As it is always difficult to measure training quality, it is important to emphasise that a more systematic data-driven approach would also allow much better assessment and measurement of training quality. Although it is challenging to collect data that capture the complexity of performance, linking training closer to performance will provide a significantly improved method for following-up on effectiveness of training.

Full-scale implementation of the learning ecosystem would provide effective preparation for face-to-face training: Hence a full training day of ground school could be turned into a four-hour session of discussion and interaction based on what has been viewed and practiced with SET. Trainees could then go back and continue to prepare for session in a full flight simulator (FFS). In fact, when the concept is effectively implemented it should reduce the number of FFS sessions required.

A learning ecosystem that simultaneously improves training quality through relevant and interesting material, accessibility and focus on trainee drive whilst also reducing cost is a realistic vision that the aviation industry will increasingly move towards in the years ahead.

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