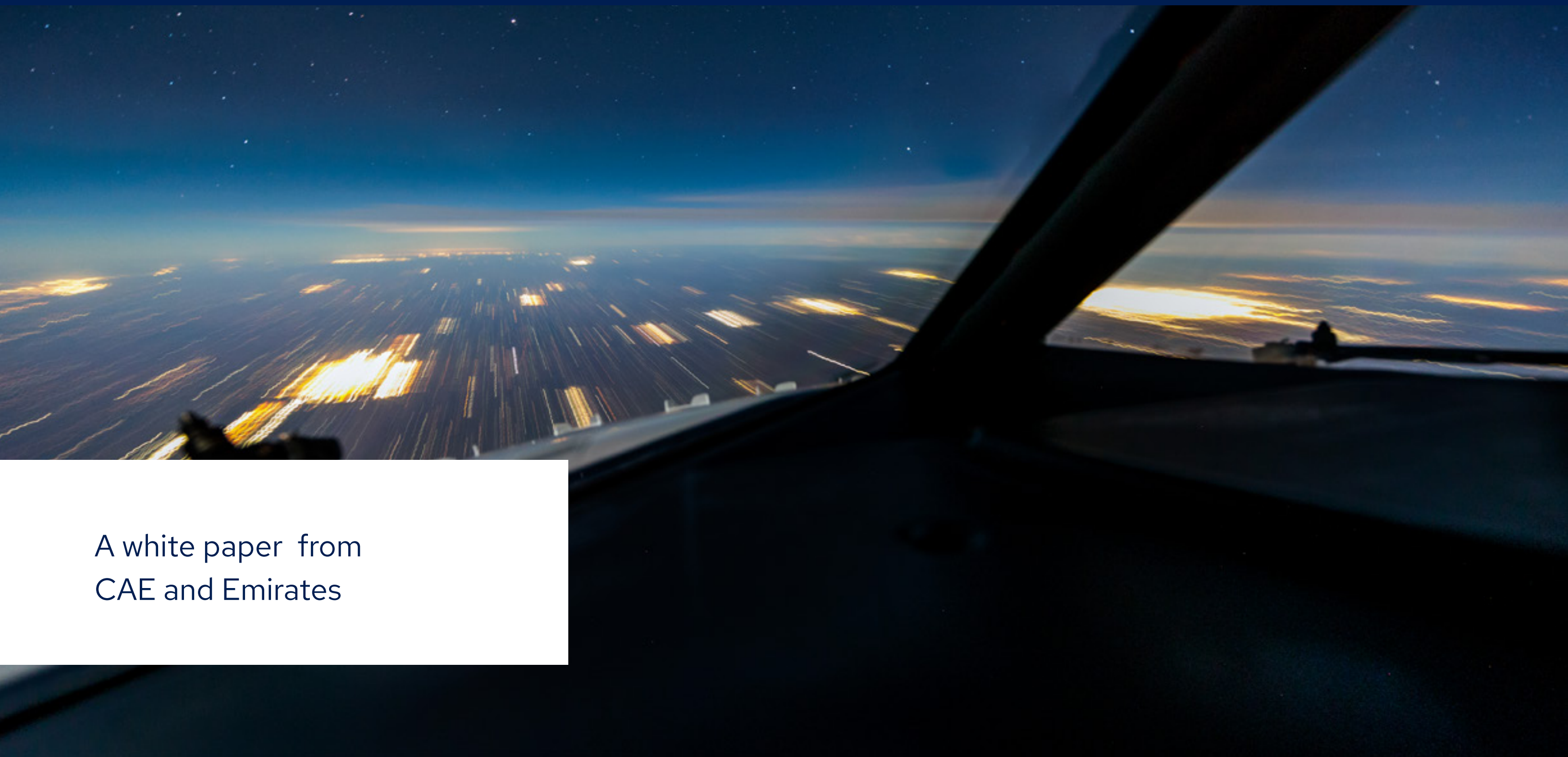
AVIATION TRAINING

Simulation for Experiential Training (SET) as an enabler for Evidence Based Training (EBT)



A white paper from
CAE and Emirates

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The framework – The future learning ecosystem for pilot training

The ways in which pilots train in the future will look very different to the ways in which they train today. This paper builds upon the ideas presented in the previous White Paper from CAE-Emirates on the future learning ecosystem for pilot training framework which outlined the main ideas and concepts to enable for the pilot training of tomorrow (Dahlstrom and Kennedy, 2022).

This paper continues to make the argument for the need to further develop and improve pilot training through using Simulation for Experiential Training (SET) as an enabler for Evidence Based Training (EBT).

Examples of Simulation for Experiential Training (SET)

Simulation for Experiential Training (SET) is a means of presenting learning experiences via a continuum of training devices ranging from simple simulation on a tablet computer to highly immersive virtual reality environments (Dahlstrom and Kennedy, 2022).

In the past five years at Emirates airlines, 'Domain' (flight deck specific exercises) and 'Non-Domain' (a range of systems including a ship simulation, spaceship, nuclear power plant, etc.) SET have been applied in recurrent flight operations training (see Dahlstrom, 2020). In particular, the "operational problem", which was deployed in 2018 at Emirates as part of initial and recurrent CRM training (see Cameron and Kennedy, 2018). The clear potential for SET as a means for data-driven, evidence-based, was realised hence the further ideas and discussion presented in this Paper.

CAE have recently embarked on collaboration with the leading gaming company, Behaviour Interactive, to develop a range of experiential training products which will be transitioned into the world of pilot training in the coming months (Press Release, 2022).

SET and Evidence-Based Training (EBT)

The argument to link Simulation for Experiential Training (SET) to Evidence-Based Training (EBT) can be summarised as follows. Firstly, EBT has been promoted as the way forward for pilot and other training in industry, often contrasted with task-based training. The intention with EBT is to train what is relevant based on industry events and other operational sources of data.

While operational events are the primary source for EBT, most of operations are fortunately uneventful. It is in training, especially in scenarios in a Full Flight Simulator (FFS) that pilot performance is tested to its limits and where expertise is developed. This means that data from training can provide different and critically important perspective for EBT. This is the reason for increased interest in making use of data output from simulators: An example of this is the SOQA data that is held within a system such as CAE RISE.

While SOQA already is a source for data input to EBT in some airlines, it should be noted that this source provides a large amount of data that can be difficult to manage in terms of categorisation, analysis and extraction of useful feedback. SET provides a more limited but also more focused framework as a tool for EBT. With the opportunity for flexible design of experiential training, clever crafting of scenarios should be able to link events and with associated parameters by measuring their interaction in terms of time, frequency, patterns etc. Compared with the FFS, the SET environment provides a more controlled and less complex platform, where data of use for performance parameters can be selected rather than filtered from a large amount of data.

A pilot career is based on a successful negotiation of all the training elements that they experience from the first day of ground school to their last landing on retirement. Not achieving the required standard is something that heavily motivates pilot attitudes. Pilot behaviour in training or evaluation tends to be centred through a couple of drivers: Firstly, compliance over resilience; experimentation is generally avoided. Secondly, in training there are no surprises, there is a lesson module with a well-defined timeline of activities and events. In evaluation, however, it is remarkably difficult to generate true surprise, as there is a powerful career motivation to solicit the scenarios and expected behaviours by any means possible. The experience with SET has shown that because there is no jeopardy attached to the event, there is no motivation to "game" the scenario, even to the point of not looking over the shoulder of the next trainee on the same table.

Design principles for Simulation for Experiential Training (SET)

In their work on SET, the authors have identified what appear to be underlying principles for design of simulation scenarios. As with SET itself, these are focused on the development of cognitive skills and primarily linked to the competencies of workload management, situation awareness, and decision making. Some of the design principles have come up as general and some as contrasts to how training is often delivered in an FFS. While these may be well known, they do not seem to be represented in literature. A few examples of such principles that have been identified are outlined below:

Use of information sources

By following interaction with the SET in a scenario, information on which information sources pilots use most in terms of time and frequency would be known. Also, following certain events the following search of information would show preferred information sources, possibly demonstrating different understanding of available information. It would be possible to trigger an event in a SET scenario at a certain time, and thereafter register what information that was accessed, for what time etc. This could reveal biases towards certain information sources, especially in high workload or ill-defined scenarios.

Variation in information density

In an FFS scenario there need to be some carefulness with not overloading trainees with information, given the need to use time effectively and avoid setting up trainees to fail – both related to cost and the FFS as a precious resource. In a SET scenario, the focus can be to explore information overload or underload situations; for example, how pilots sift through large amounts of information, make sense of incomplete information, find errors, extrapolate from limited information etc.

Periods of high and low workload

While pilots are encouraged to be proactive, the training they receive often condition them to be reactive. The need for efficient use of time in the FFS means that the tempo of events often is high, not allowing any low workload periods or shift between workload states. The effective use of low workload periods, especially important in highly safe and automated operations, is because of this rarely trained. Also, the shifts between low-high and high-low workload conditions carry their own risks, which can be designed into SET scenarios and trained.

Concurrent and parallel tasks and priorities

This is an aspect of SA and decision making that is trained in FFS scenarios. It is still a mainly cognitive skill, and one that can be supported by use of SET. With focus on this, shifts between tasks of different priority can be designed into a scenario, allowing practice of the drop-delay-delegate-do framework. Also, time delays are an important aspect to train as in some situations, information will be delayed and need to be kept in mind to be followed up on. This aspect can also include distractions, which can be more disruptive and frequent given the no-risk [jeopardy free] aspect of how SET is aimed to be delivered as training.

Competing options at decision points

Since scenarios delivered in an FFS involve the risk of failure for a trainee, they may not include the kind of ill-defined decision-making situations that can occur in line operations. Allowing competing options, without any clear "correct" one, can develop decision making skills in terms of analysing problems and choosing among options. Linked to EBT, feedback on what pilots choose may reveal needs for further information and training.

Follow up of decisions and "effect control"

Due to time pressure in the simulator a scenario may not get to play out long after the decision point, not allowing practice of following up a decision and ensuring that it plays out as expected (i.e. "effect control" - Did the decision have the desired effect?). SET can allow secondary problems to arise, lead up to situations that need to be re-evaluated, let consequences play out and let effects of a decision play out with a time delay to see if the decision is followed up.

Overall, these design principles demonstrate that whilst the FFS will always provide the overall most complete and effective training experience, SET can provide specific training benefits in a "safe-to-fail" environment. The element of exploration that can be added to training via SET can support competence development or retention by providing a narrative of relevance to the trainees. This can contribute towards making FFS training more efficient. An example of this can be found in the operational problem. Aircraft fuel systems are complicated and typical real world aircraft abnormal checklists relating to this fault are necessarily long with multiple "if-then" conditionality statements. If trainees understand the general principals of what the checklist is attempting to achieve, then their comprehension of the checklist steps become better embedded – they will know why each step is there and where the hazards are of checklist indiscipline lie. SET can complement development of competencies and in some ways develop resilience in a different and better way compared with how training is often delivered in an FFS.

In addition to the above, SET could complement the scarce resource of FFS time. SET can present scenarios that would not have priority in an EBT matrix; the high-risk, rarely (maybe once ever) occurring situations. Such scenarios may include vague and ill-defined situations where the ideal outcome is not immediately visible, providing the classic context where Naturalistic Decision Making (NDM) would take place.

SET Parameters for EBT

The proposed first ideas for parameters to be used with SET as a vehicle for EBT are preliminary. There will certainly have to be some trial and error to develop reliable parameters for this purpose. Nevertheless, some parameters of use can be imagined even at this early stage of development. With the support of the previously outlined principles some parameters are suggested below but it should be possible to develop more from these and from other creative thinking around this.

It should be stated that the data in the SET will always be limited compared the large amounts of data collected in an FFS. As such, the way to provide input to EBT via SET will depend on limited data and the design of scenarios and interaction will be critical to be able to develop useful parameters.

Workload Management (WLM)

From the design of scenarios there will be expected periods of high or low workload, which can then be compared with the activity via the interface. As an example, after a time-critical event is triggered in the scenario, it would be expected to see an increase in interaction with the interface. If not, this may provide data on workload management.

Also, in periods of low workload the trainees would be expected to make use of the time to proactively check systems and prepare for possible events, for example to check alternates. If this cannot be detected it also provides information on workload management.

The frequency and patterns of shifts between information sources as well as the amount of interaction via the interface may also provide input to workload management. For specific scenarios, and certain phases of scenarios, a sample of input in a given time period may provide a snapshot of workload management and a series of snapshots compared between trainees may allow identification of different strategies to manage workload. Design of scenarios should be able to set up or enforce certain situations where this is possible.

Monitoring and Situation Awareness (SA)

Monitoring may be represented as a parameter in general form in SET by using data that overlaps with that imagined for workload, e.g., shifts between information sources, time on each source etc. It does however seem as if specifically designed aspects of scenarios may provide more precision, i.e., in the operational problem, how often were systems monitored before the leak is manifested, how often the fuel page is accessed after the fuel leak has been triggered.

If a scenario is designed to enforce certain actions linked to monitoring, then those actions would also be logged and can provide confirmation of monitoring (e.g. looked and acted equals process of information). With specific design of a scenario an expected pattern of seeking of information can be expected, and then identified, confirming, or disconfirming expected monitoring behaviour. Also, with increasing amounts of data collected patterns of effective and less effective monitoring can emerge when data is linked to outcomes of performance.

For SA the same type of data can be used – However it may need to be used for specific data and at specific times. If certain screens and data are manipulated in response to the development in a scenario, it can relate to SA. When monitoring systems, checking weather for diversion airports, following up on fuel state etc. this can be related to etc.

Decision Making (DM)

When it comes to decision making, this includes not only the point where a decision is made but also the building up towards a decision and management of it. This would be linked to previous aspects outlined for monitoring and SA, but with more focus on interaction with specific pieces of data to provide information on the process of decision making.

An example of this is already contained in the operational problem that was deployed at Emirates (Cameron & Kennedy, 2018), if the engine is not turned off (and thus isolating the fuel leak and protecting the remaining fuel) before diverting then that is an important aspect of the decision making to be recorded and analysed as input for EBT. For this specific decision other aspects can be connected as well, e.g., it would be possible to follow how many airports were checked for weather, where less than three may be considered a shortcoming in the decision-making process. Even some very basic data extracted from the scenario yields some noteworthy data; where the fuel leak was successfully isolated the diversion choice was not universal, as can be seen in the following Figure.

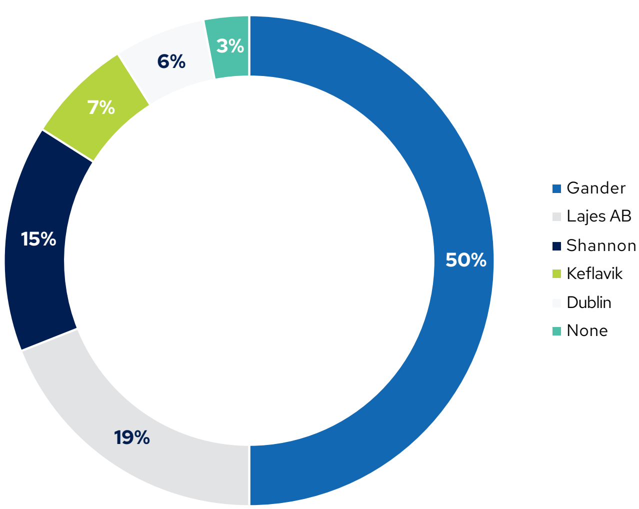

Figure 1: Percentage of Participants

The scenario was run with identical parameters for all the subjects, yet the diversity of diversion airport choice suggests variable underlying risk assessment strategies.

Similarly, not looking at something at all through the whole scenario, or in a specific part of a scenario, could be related to SA and decision making. This may not be able to capture performance with any precision but could register what shouldn't have happened, i.e. disregard of some data at certain times of importance for a decision.

Current benefits and further potential

This section considers how SET can be applied to other so-called non-technical competencies.

Communication (and Cooperation)

Communication as part of SET could be implemented as text protocols, free text and instructor interaction or with voice/speech analysis. All these could add contact and interaction with cabin crew, ATC, operations centre, maintenance, medical advice etc.

The simplest way for this would be a protocol where the communication is predicted and prompted, with little or no flexibility to go outside of the protocol. An added step to allow some flexibility would be the use of keywords to allow some responses outside of the main flow of the protocol-driven communication.

This has been used in other simulations tested by the authors and this provides an additional dimension to the simulation experience, as the flexibility can make the scenario come alive. It also allows for individualisation for the trainee as workload can be adapted to how a scenario is managed. The requirement to have a trainer involved would however require manpower and limit independent use of SET.

It also possible to consider the concurrent use of two devices for MFS scenario, which would be linked to the same scenario and make communication and coordination between trainees possible in a context more like the one in the cockpit.

Another application that could provide additional input for EBT is analysis of communication. This has been researched in terms of speech time, turn-taking, prosody etc. This can then be turned into parameters for communication and even a communication score. Applications for this type of analysis have been developed by industry and thus they could be a candidate to provide such input. Regardless of method for communication as part of SET, the use of communication could provide data that also allows input to EBT with regards to how the communication plays out.

Leadership

This competence is more complex and may not be possible to capture in the simpler SET scenarios. However, with the more complex scenarios such as the ship simulations, the group dynamics and leadership skills can be practised and observed by the instructors running the scenario. It would however be very challenging to develop an algorithm that could offer a leadership score in these more complex simulations, but the experiential value for the participants is considerable. Once again, they gain the opportunity to practice their leadership within a crisis management context without being scored for their experimentation with leadership styles.

Further potential

Although not a primary objective, it is imaginable that SET scenarios could be used as a link to technical competencies. If some trainees would be struggling with a SET in-flight fire scenario, it may show that further training on the associated checklists is necessary. If a operational problem is causing trouble, it may indicate a lack of full understanding of the linked technical systems or the procedures for this.

The power of data provided by the SET can be amplified once data has been collected for a part of the pilot population, allowing comparisons of the parameters that capture performance. With SET it will probably not be possible to identify individual behaviour and change it immediate effect as in training aimed at procedures in an FFS. It may however be used to identify best practice as the collected data and outcomes of many trainees can reveal which behaviours that lead to successful outcomes.

If the development of parameters is successful, these may also be used to provide input for assessment of competencies. This can be done by providing them as input for an instructor, who then makes an assessment. However, with increasing amounts of data and sophistication of analysis it may be possible to have some form of automated assessment of competencies for SET.

An even more visionary potential is that some form of eye-tracking could be possible when using SET on a tablet, perhaps via the device camera supported by some form of simple wearable technology. This would open a new data source and new potential for understanding pilot performance via SET, providing more input for EBT.

Summary and conclusions

This paper has presented ideas and preliminary plans on how SET can be used as an enabler for EBT, both with regards to its original purpose of developing competencies, but also by providing data for the training system. SET would do that from a perspective that would be different than that of training in an FFS or other high-level device.

With a focus on providing a "safe-to-fail" environment and offering the opportunity of exploration, different behaviours could be trained and observed via SET. This could complement other data sources for EBT in a way that would provide important benefits to the understanding of pilot performance and training.

Based on the broad view of SET and EBT outlined in this document, the aim is to develop parameters for the operational problem and implement them in a day-to-day operational training setting. This will allow testing and further development of these ideas, so that SET as a vehicle for EBT can move forward to provide important information and feedback to the training system.

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The Emirates story started in 1985 when the airline launched operations with just two aircraft. Today, it operates the world's biggest fleets of Airbus A380s and Boeing 777s, offering its customers the comforts of the latest and most efficient wide-body aircraft in the skies. Emirates inspires travellers around the world with its global network of destinations across six continents, industry leading inflight entertainment, regionally-inspired cuisine, and world-class service.

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