AVIATION TRAINING

Competency Scoring in Simulation for Experiential Training (SET)

A white paper from
CAE and Emirates

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The Framework – SET and EBT

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 Papers 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). It further develops the discussion for how Simulation for Experiential Training (SET) can be used as a means for Evidence Based Training (EBT) outlining ideas for the assessment of competencies using SET and how competency can be evaluated within this framework.

The argument to link Simulation for Experiential Training (SET) to Evidence Based Training (EBT) has been outlined in References 1 and 2 and so will not be expanded further here, although the background is important for the context of these ideas and recommended reading.

Not only operational data, but data from training can provide different and critically important perspectives for EBT. SET provides limited but a more focused framework as a tool for EBT than operational and simulator data from more advanced simulators. SET provides a controlled and a less complex platform where performance data can be selected rather than filtered from a large amount of data. With flexible and clever design of scenarios, the recorded interactions with the SET interface should be able to be translated into competencies.

Design Principles for Simulation for Experiential Training (SET)

The design principles underpinning assessment of competencies were introduced in References 1 and 2. In summary these principles were as follows:

- Use of information sources
- Variation in information density
- Periods of high and low workload
- Concurrent and parallel tasks and priorities
- Competing options at decision points
- Follow up of decisions and "effect control"

Proposed Parameters for SET as a Vehicle for EBT

Reference 2 also described the parameters proposed to be used with SET. Here the focus is placed upon how to practically make use of the parameters for the assessment of competencies, in particular:

- Workload Management (WM)
- Situation Awareness (including Monitoring) (SA)
- Decision Making (DM)

Principles for the design of the SET were subsequently developed as follow:

- Divide the scenario into different phases, focusing on different aspects of performance in each phase.
- In each phase use input data to identify parameters of relevance to competencies.
- Use a points-based system to score these parameters. The points system would be tested and adjusted to represent the weights of different aspects of performance.
- To score positively: Rather than marking down the trainee, identify positive aspects of performance. In other words, add points positively rather than focussing upon negative aspects of performance which would deduct from scoring. While both may be useful and should be used where relevant, positive scoring is the aim.
- The magnitude of points awarded will need to be considered and calibrated against each other to make sure that they reflect relevant pilot performance and the perceptions of pilots of a reasonable and fair scoring system.

SET in Action – The Operational Issue

The following is an example of the above parameters in action as illustrated in the Oceanic Fuel Leak SET which was deployed within Emirates Recurrent CRM training (see Reference 3). Briefly, the scenario is modelled on the accident that occurred to the Air Transat Airbus A330 at Lajes, Azores, on the 24th of August 2001, where a leak of the complete fuel supply resulted in both engines shutting down mid-ocean.

Note that the times mentioned for each phase of the simulation are estimates as the actual times are baked into the scenario planning and are part of the parameter tuning that is a feature of SET. Additionally, these phases can be easily verified through the data collected in the use of the simulation over a period of 12 months with 4000+ Emirates pilots. These data points provide a clear illustration of how SET was leveraged as a vehicle for EBT.

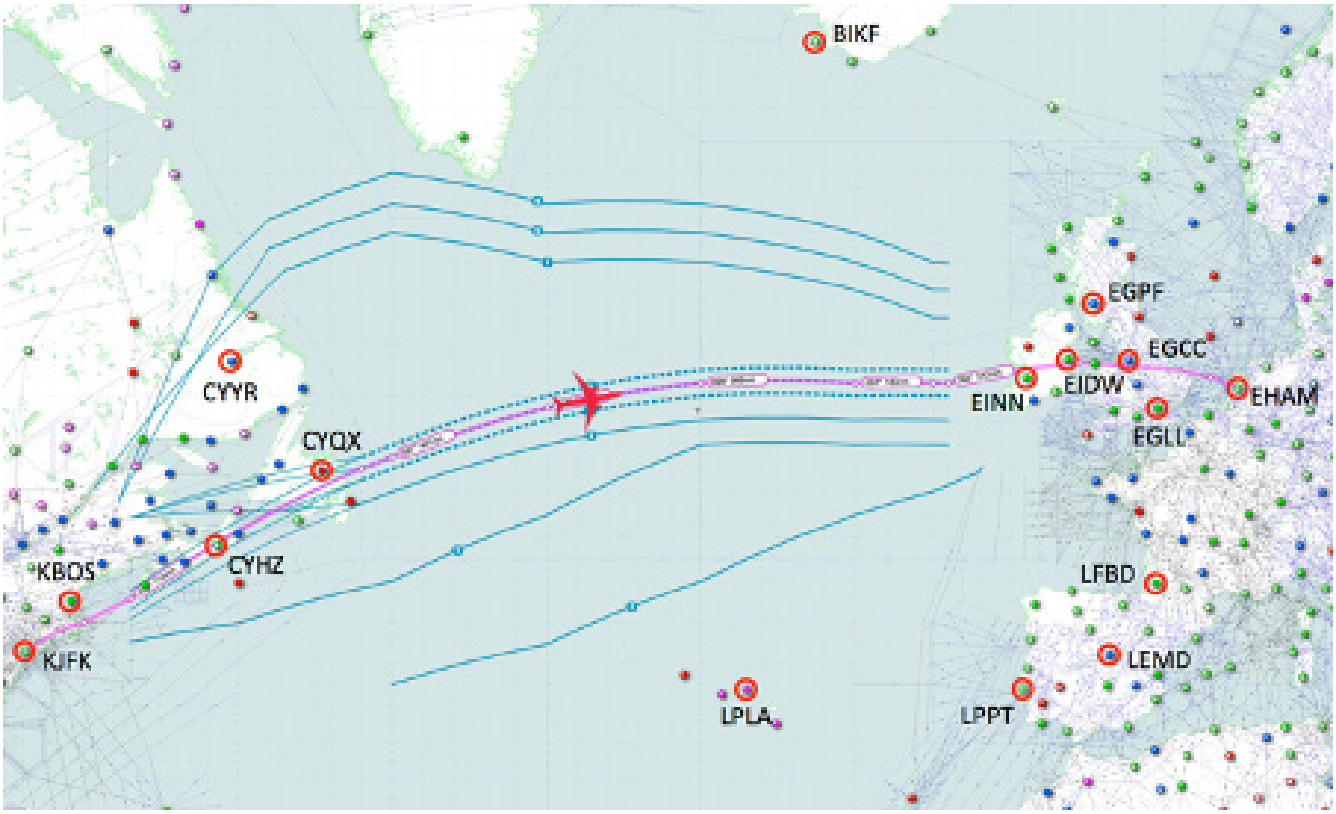

Figure 1: The map of the aircraft position at the start of the simulation provided to the trainees. This was provided as a hard copy artifact at the time of the initial Emirates session.

Fuel Leak Phase 1 – When nothing is happening, up until problem event starts (about 5 minutes)

The trainee(s) is clicking around, getting familiar with the interface, and is exploring functions. At the same time thinking about contingencies normally start, which leads to exploration (or at times over-exploration) of available airports for diversion, including weather, NOTAMs etc.

Workload Management

- Peaks and troughs of Workload.
  - While NOTAMS and the map may be studied in this phase some minimal activity in terms of exploration would be expected. Points would be accrued at a higher rate when this exploration is active.
  - In the same way activity right through this phase seem to indicate more clicking than reflection. If there is a time-period when there is no clicking, (say 15 seconds) then this could also possibly be used for deduction of points.
- Requesting weather for more than three airports (see Decision Making further down).
  - This seems to show a lack of focus on the "big picture" and understanding the interface and system at this point, with deductions of points for requesting weather for more airports at this point possible.
- Making runway and other calculations.
  - If the subject conducts more than a single run of the performance landing application, this could be inferred as a points addition for Decision Making but not for Workload management as it implies too much focus on a single detail while assessing the "big picture" is needed.

Situation Awareness

- Exploration of the interface – showing curiosity and awareness, getting an overview of the situation – simply clicking around on different screens.
  - Points given per screen visited, at least if all are visited at least once within the phase.
  - Possibly extra points if important screens are visited multiple times.
  - Dwell time on important screens could award extra points.
- Shifting around between screens to monitor and maintain awareness, points possibly linked to the number of shifts, between a minimum and maximum number.

Decision Making (information gathering)

- Requesting weather would normally be a second step. Therefore, scoring could reflect when this were too fast, as a trainee would be better off checking and learning the interface properly first.
  - Two points per weather request (for maximum three requests at this stage)

Note 1: The principles of assessing and scoring in this phase extends to the following phases.

Note 2: In this phase the trainees will probably spend some time reading the NOTAMs and looking at the map supplied with the simulation. (see figure 1 below). This makes it difficult to assess workload. For use with two trainees, we can expect one to stay with the screen, making the assessment of workload for the crew more relevant. If the NOTAMs and map in a later edition are displayed electronically then the number of times and dwell time on them could be measured and used as additional data.

Scenario Phase 2 – Detection and analysis, from start of problem event, in most cases to a warning message (about 5 minutes)

The problem event starts and requires that it is identified as soon as possible. By design, the simulation indicates symptoms of trouble a few minutes before the system directly warns the trainees that there is insufficient fuel to reach destination. This incremental fault indication is typical of complex systems, especially where there is a computer system monitoring the overall "health" of the system. The designers of these monitoring system are striving to reach a balance of not over or under alerting the operator. When discovered, there is ongoing parallel work with understanding the problem, finding a way to manage it and then arriving at a diversion option that is achievable with the remaining fuel and within the appropriate risk tolerance of the trainees.

Workload Management

- As this is an active phase long periods of inactivity should result in point deductions.
- At the same time too much intense clicking as well as looking at irrelevant information should lead to point deductions.
- We need to find some outer limits (not enough – too much) to settle the scoring for this. Once we have collected trainee data and can make use of averages of the input of these then we can say "you were in the lowest 10% of active…consider monitoring more", or "you were among the 10% most active … consider taking in and thinking about data more".

Situation Awareness

- Shifting around actively on important pages – especially fuel page / engine page / flight control page / FMS, since these are the relevant pages in this phase of the scenario.
  - Shifts between important pages can be awarded points, or at least some different levels of number of shifts.
  - Dwell time on page also becomes important at this stage and could be rewarded.
- If the trainees can identify the developing problem before the system directly warns them, then this would contribute additional scoring points.
- Focus on less important information could lead to point deductions (i.e. too much continued requests of weather, runway calculations etc.). While this may be a sign of preparing for diversion it may also indicate less focus on the technical problem at hand. Therefore, limits should be established for exploring the diversions at this stage. This is the phase where exploration should be least rewarded.

Decision Making (problem solving component)

- Identify the source of the fuel leak – as identified by frequent shifting between the engine and fuel pages in a limited time (e.g. five or more shifts during a minute – this still needs to be specified) and could include receiving the warning for engine shut-down (clearly showing that this is considered). Distinct markers would include:
  - Action executed before the fuel flow increases due to oil temperature down – This would receive the highest performance scoring.
  - If this were done before fuel flow is at max – A considerable reward for performance.
  - Action executed after fuel flow at max but before warning message – Performance rewarded.
  - If it were executed at the point or after the warning message issued – No reward.

Note: Magnitude of all these performance rewards still need further consideration.

Scenario Phase 3 – Mitigation through experimentation (about 5 minutes) – from warning message to taking action/ diverting

At this point the trainee(s) has identified the existence of the fuel leak and are trying to understand how to mitigate the effects. The results of their efforts will have a direct effect on their diversion options. The key to this phase is to determine where the leak is coming from, in general this is one of two locations: the tank or the engine area. A leak in the engine area is usually resolved by shutting the engine down, whereas a tank leak is dealt with by isolating the affected tank. In this case, the leak is from the engine and the trainees have to deduce this by using their basic knowledge of aircraft systems. The simulation is configurable, so the leak originates from the either the tank or the engine. A tank leak gives the trainees less diversion options since any fuel located in that tank will usually be considered lost. There are a number of hazards which the trainees have to contend with. For example, if the fuel pump is turned off without ensuring the crossfeed is opened, after a few seconds, the downstream engine will flame out.

Workload Management

- In this phase the focus should be on resolving the problem, so less clicking and more thinking. Like the previous phase we can imagine penalties for clicking around too much or for extended periods of inactivity.
- There should be less shifting around than in the previous phase. If the problem has been detected, we would expect more focus on some pages.
- Also, the focus of workload is important and overlaps with SA. We could imagine that going to certain irrelevant parts of the simulation could equal distraction and be penalised, or that focus on certain parts would be rewarded.

Situation Awareness

- Continued focus on the engine and fuel pages is expected here and should be rewarded.
- Also, experimentation with the fuel system shows exploration and should be rewarded, this could be rewarded here and/or in Decision Making.

Decision Making

- Testing of options with fuel pumps – clicking on them – this would show that the pilots are problem-solving (input for Decision Making)
- Engine shutdown warning coming up would be rewarded, but less by now than earlier, since this shows that engine shutdown is considered. – to demonstrate that this is considered
- From here onwards, there will be overlaps with the next phase. Looking for diversion options should be rewarded but only up to a certain point. After engine shutdown is executed, the diversion should be the sole focus.

Scenario Phase 4 – Diversion

The diversion consideration is essentially an exercise in trainee risk management. There is not a "best place" to go to, but rather a "least worst" diversion airport. Each of the available airports have NOTAM, weather, landing performance or locality hazards (isolated islands for example) which have to be assessed.

Workload Management

- In this phase we should expect less clicking and more thinking on some screens, by now the trainee should now what the problem is and be focused on diversion. This may however, again, require some reading of NOTAMs and looking at the map.
- If there is more than casual focus on other screens than those relevant to engine shutdown, then a penalty on performance could be imposed.

Situation Awareness

- Until the engine shutdown has been carried out there should be focus on engine/fuel screens, as well as continuing to consult the weather and performing calculations for diversion.
- After engine shutdown, focus should be only on screens relevant for the diversion.
- The intention is to shut down and then divert, so that means that before diversion weather should have been checked as well as fuel / FMS pages. Thus, some level of checking should go rewarded, some lower level should not.
- There should be rewards for checking airports and conducting landing performance calculations for diversion.

Decision Making

- If the engine is still running when activating diversion, then no reward. If engine shut down before, then some reward.
- Reward for making use of cross-feed of fuel after shutting down engine (if this happens before shutting down engine then a significant penalty and associated comment should be provided as this would be repeating what happened in the actual incident that this SET was based upon).

Alternates

- Choice of alternates between Gander, Lajes, Keflavik, Shannon and Dublin
- Dublin is not an option – lowest reward for DM.
- Gander is the best option – highest reward for DM.
- Keflavik and Shannon are equal – medium reward.
- Lajes mostly equal to Keflavik and Shannon but being on an island with minimal proximity of support should put it below these in reward.

Overall possible parameters scenario

The scoring philosophy has been to reward rather than penalise. However, if this were to be revisited the following could be other possible scoring parameters:

- Failure to use log tab could have a penalty associated with it.
- Throughout the exercise, never having checked a screen could be penalised.
- Having a percentage of dwell time on certain screens deviating from a norm could be penalised or achieving the norm could be rewarded (a norm could be set or later developed form trainee data).
- There are probably a few more possible parameters for the overall perspective and this is information that the instructors would be able to provide.

Further Potential

As has been considered previously, gathering this type of trainee data allows a second dimension of potential feedback to open-up. This would allow provision of feedback to trainees on their performance in relation to other trainees, expanding the usefulness of the data. Receiving data-driven feedback that you are among the 10% that were fastest, slowest, to make the diversion decision should be important information, also perhaps prompting a conversation with an instructor. There may be good reason for this: However, if any trainee consistently ends up in the 10% categories, then further investigation and consideration of the reasons why this has happened should be required.

Also, the identification of time trends, would allow a trainee who displays a certain performance in first use of SET scenarios to be tagged for support by an instructor given that the trend is similar to previous trainees that ended up with unsuccessful performance. Possible examples include:

- A trainee who exhibits large variations in Workload Management may need support in training on how to focus and follow up on issues of priority.
- A trainee that misses important information may need support with regards to technical knowledge or with managing monitoring and attention.
- A trainee that makes very quick decisions based on limited knowledge, as well as someone that consistently takes too long to make decisions could be identified for additional coaching by an instructor.

Summary and conclusions

This paper continues the development of applying competency scoring for EBT within SET. It describes various possibilities for scoring but will have to be discussed with the developers of the SET as well as with instructors/pilots delivering the training. That said, the potential for Competency Scoring in Simulation for Experiential Training (SET) is extremely promising and technology for training will continue to develop in this direction in the future.

References

1. Dahlstrom, N. and Kennedy, R.J. (2022) A future learning ecosystem for pilot training: A white paper from CAE and Emirates. https://www.airside.aero/magazine/articles/a-future-learning-ecosystem-for-pilot-training

2. 2. Dahlstrom, N., Cameron, M. and Kennedy, R.J. (2022) Simulation for Experiential Training as an enabler for Evidence-Based Training: A white paper from CAE and Emirates Airlines. https://www.airside.aero/magazine/articles/simulation-for-experiential-training-as-an-enabler-for-evidence-based-training

3. Cameron, M. and Kennedy, R.J. (2018) Mid Fidelity Simulation: Expanding Experience into Expertise. Presented at Flight Safety Foundation (FSF) International Air Safety Summit (IASS). November 12 – 14, Seattle (USA).

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