Final version published as: Mavin, T. J., Roth, W.-M., Soo, K., & Munro, I. (2015). Towards evidence-based decision making in aviation: The case of mixed-fleet flying. *Aviation Psychology and Applied Human Factors, 5*, 52–61.

Towards Evidence-based Decision Making in Aviation: The case of Mixed-Fleet Flying

---APAHF in Practice---

Timothy J Mavin [a,*], Wolff-Michael Roth [a,b], Kassandra Soo [a] & Ian Munro [c]

[a] *Griffith Institute for Educational Research, M15 3.18, Griffith University, Mt Gravatt QLD 4122, Australia*

[b] *Faculty of Education, MacLaurin Building A557, University of Victoria, Victoria, BC, V8W 3N4, Canada*

[c] *Mount Cook Airlines, Christchurch Airport, New Zealand*

Abstract

Academic institutions and airlines have always worked together to develop and conduct research studies. However, most often the expertise or areas of interest of the academic have driven these studies. In this paper, we illustrate the results of an industry-university collaboration that generates data that the airline can use to engage in evidence-based decision making. The example used is issues emerging from mixed-fleet flying, generally related to reverse transition from glass to analogue cockpits.

Key words: Mixed-fleet flying, industry-university collaboration, field-relevant research methods, collaborative research design

Introduction

> *You know, after doing my training on the 600 I now have my doubts about mixed-fleet flying. Same airframe, same engines, the lot, but the flight decks are different, maybe too different?* (Training manager, ATR72 operations)

In this vignette, the training manager of an airline talks to a university-based researcher about the new aircraft his company had purchased. The company had been operating the ATR72-500 for a decade and recently purchased the newer ATR72-600, a "glass cockpit" variant of the former. Initial plans were for all pilots to fly both aircraft types concurrently, a possibility that the aircraft's developer had actively promoted. However, after having received his training on the new aircraft, the training manager had doubts about the regulations allowing pilots to fly both aircraft concurrently. For the airline, there was a compelling need to obtain evidence to assist in its decision-making process about moving to mixed-fleet flying (MFF). In this specific case, flying the ATR 72-500 and ATR 72-600 concurrently, there was no (independent) research evidence available.

Although research evidence for many dimensions of the aviation industry is widely available, there are two possible problems facing airlines today. First, airlines need to find how something formulated at a general level (i.e., studies concerning mixed-fleet flying) is applicable in the concrete situation. This issue is known from other disciplines, like teaching, where teachers generally do not see how research findings are relevant in their settings (e.g., Roth, 1998). For example, using top-down thinking, centralised governments implement policies that in some cases have classroom teachers applying practices that appear to generate little improvements in learning. Likewise in aviation, current trends may appear difficult to

*Corresponding author. Tel.: +61 7 3735 5604.
E-mail address: t.mavin@griffith.edu.au (T.J. Mavin)

understand and implement. For example, currently there is a "safety improvement initiative" by the International Air Transport Association (IATA) towards evidence-based training (EBT) (IATA, 2013, p. 5). It is based on the idea that, with increasing amounts of data now available to the aviation community, training improvements can be made. However, one source of data within EBT is the line-orientated safety audit (LOSA), which has been criticised for its approach to obtaining evidence (e.g. Dekker, 2003). Further, another underlying requirement for valid data is inter-rater reliability training for pilots. However, once again, the viability of this has been recently been questioned (Mavin, Roth, & Dekker, 2013; Roth & Mavin, 2013). Like the teaching community, aviation must continually address whether both research and new approaches to practice are worthy of possible implementation.

The second issue an airline may face is that current problems have not been researched to a satisfactory level. This issue is related to *establishing evidence* rather then *using it*. For some issues, current evidence is lacking, weak, or questionable. However, how does an airline, with skills primary in airline operations—not research—develop evidence to assist with making informed decisions? Furthermore, how does an airline reach out to those who can help, when there is currently criticism of the lack of unified work between regulators, operators and scientists?

People bring value to a company. In recent times this simple fact has led to successful companies working in partnerships collaborations with other organizations. *Collaboration* here is viewed not simply as a contractual consulting affiliation with others outside the company, but as "a cooperative, inter-organizational relationship that relies on neither market nor hierarchical mechanisms of control but is instead negotiated in an ongoing communicative process" (Lawrence, Philips, & Hardy, 1999, p. 481). The aim of inter-organisational collaborations is to (a) utilise existing resources or regions of strengths more effectively or efficiently, (b) learn from other organisations, and (c) develop expertise within one's own organisation with the assistance of the learning partners. The collaborative relationships can be arranged through either lose verbal agreements or elaborate contractual agreements, but must be based on an element of trust (Roth, 1998). In this paper, we discuss an innovative inter-organisational collaboration between an airline and a university that emphasises the practical application of human factors directly into operational issues that arise in the field.

A Move Towards Evidence-Based Decision Making

Over the past three years, the airline, the university, and the local regulator have been working together in an inter-organisational collaboration. So far, this collaboration has produced studies into pilot assessment, classroom-based instructor training, flight examiner training, debriefing, poor-performing pilots, and issues associated with MFF. For the airline, there was now a true business case for having a university involved in practice generally and, specifically, in the production of evidence on which to base decisions. As the airline's need for evidence drives the research agenda—rather then the university asking for airline participation—evidence produced can be used directly to improve the airline's operational decision making. For the university-based researchers, opportunities arise for (a) being involved in research that has both applied and empirical foci, (b) broadening the university's research focus, and (c) enabling researchers to publish timely research applicable to the aviation industry more broadly.

A fundamental requirement for the collaboration was all research must have a high degree of *ecological validity*, enabling the dual focus on empirical research that was directly applicable to the participating airline. Second, the airline requested findings be publishable in scholarly journals. This was an unusual request, with previous experience demonstrating that most companies feel uneasy about publicising company issues. However, the airline argued that researchers maintaining high scholarly standards via academic peer review far outweighed benefits of keeping data within the organisation. The aim of the collaboration was not to replace professional judgment, but to augment it. This aim was an orientation toward an evidence-based approach that aims at making best decisions supported by concretely relevant research.

The evidence-based decision making cycle adopted is a continuous process, with multiple projects operating at differing stages (Figure1). Stage 1 has the airline identify issues impacting current business practice, or where possible improvements to practice may occur. The second stage finds the airline and university-team in initial discussions concerning the problems. Accordingly, the second stage teases out pilot versus airline issues, focusing on clearly identifying questions to be answered. Whereas this may appear formal, almost all discussions take place over months in semi-formal meetings, with a majority occurring while other projects are actually in the data collection or journal-writing phase. The emphasis of Stage 2 is on problem statement and formulation, which must emanate from the airline. In Stage 3, the formal project is initiated and the research team—involving university-based researchers, the training manager, and, where applicable, other parties such as pilot unions—develop a robust research design. The design issues are central, for the research has to meet the dual goal of rigour in the academic context and high ecological validity to be applicable directly to the company context. Ethical clearance is also an integral aspect of the design, involving the airline, pilot/cabin crew unions, the regulator, and university-based ethics boards. It is important that pilots have the option of not participating in any research and that their non-participation will have no effect on their career within the company. The fourth stage of a project consists of data collection and analysis. In Stage 5, reports are written and manuscripts prepared for peer-reviewed journals. The following case concerning the issue of MFF is offered as an example of this process.

««««««« Insert Figure 1 about here »»»»»»

A Company Problem: Moving to Mixed-Fleet Flying

In many regions of the world, airlines find it necessary to have a mixture of aircraft *types*, such as the Boeing 777, Airbus 320, and ATR 72, to service the needs of customers. When a particular aircraft type is sufficiently similar in terms of systems and flying characteristics (termed "commonality") to another aircraft type, aircraft manufacturers apply to aviation authorities and regulators for a common "aircraft type certificate" or "type rating." This enables pilots—with specific training—to simultaneously fly both versions of the aircraft. Such flying of multiple versions of the same aircraft by the same pilots is referred to as mixed-fleet flying (MFF). Aircraft where this occurs include the Boeing 777-200/300, Airbus A319/320/321, and regional aircraft such as the Dash-8-100/200/300 series. Such configurations improve operational efficiencies, such as reducing overall number of pilots required and increasing rostering efficiency.

Stage 1—Identifying the Problem

The practice of transitioning pilots from an older variant of an aircraft to a newer variant is referred to as *forward transition*. During the introduction of the ATR72-600 for the airline, forward transition from the ATR72-500 to the newer aircraft appeared to present only minor issues to the pilot group and the transition program was deemed appropriate for pilots moving to fly the ATR72-600 (Figure 2 shows photographs of the flight decks of the variants). For the airline, having separate groups of pilots flying each variant made little commercial sense.

Commercial forecasting suggested an extra 10 percent pilot workforce would be required to operate as separate fleets, with consequent increase in airline operating costs. Having pilots revert to the older variant of an aircraft is called *reverse transition* and an example is transferring from a "glass" environment to a traditional analogue cockpit. In our participant airline, whilst there were only minor issues with forward transition, there were certainly concerns from the pilots that the differences that existed between the flight decks of the two aircraft would make MFF problematic. At this point, the company was confronted with the issue of how to assure safety within its operation when pilots were asked to move back and forth between the two aircraft types. Even though the manufacturer and regulators around the world were overseeing and regulating MFF, there were no independent studies available to assist the airline in its decision making. This led to an initial review of potential problems.

«««««« Insert Figure 2 about here »»»»»»

Stage 2—Airline / University Discussions

During initial planning (including phone calls, email, Skype and face-to-face discussions) between the airline and university-based researchers—and given the lack of current studies into MFF relating to the ATR72—a two-prong design emerged. The first study was a survey deployed to pilots from the airline that had flown both aircraft types. Its aim was to obtain a broad perspective from these pilots and seek (a) their experiences during transitions from the 500 to the 600 and (b) their views on and concerns regarding MFF. A second study evolved exploring the issue of MFF in greater depth. While collecting data for another study, the training manager and university-based researchers worked on a whiteboard to develop a research design that was feasible within the airline context and would meet the rigour of scholarly research (Figure 3). This was to be a two-day simulator study with company pilots from the ATR72-600 flying the ATR72-500 simulators, using (a) the think-aloud protocol typical for identifying knowledge and problem-solving strategies of experts and novices alike and (b) stimulated recall sessions often used in technology environments subsequent to the simulator exercises. Whereas the survey would provide examples of forward transition issues, the purpose of the second study was to obtain concrete examples of the *type of* difficulties pilots might face when transitioning back to the ATR72-500.

«««««« Insert Figure 3 about here »»»»»»

Stage 3 – University Refines Method and obtains Ethical Clearances

Survey. The first stage of the study was planned as a survey of pilots' views on the transition to the ATR72-600 and on MFF. The survey questions were developed on the basis of previous studies of the glass cockpit (e.g., Wiener, Chute, & Moses, 1999). Part 1 used a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). Part two included open-ended questions relating to MFF, specifically investigating eight categories: overall perception of transition training, avionic suite, instruments, flight management system, standard operating procedures, electronic checklist, workload, and crew resource management. The other prime focus of the survey study was to identify potential problems in relation to MFF.

Simulator study. A two-day simulator trial using think-aloud protocols in a full flight simulator was initially planned (Figure 3). The benefits of think-aloud protocols have been well established in studies of expertise. However, it was anticipated that the yield of data from traditional think-aloud protocols might diminish during high workload situations; therefore a retrospective, video-stimulated debriefing session after each simulation was also conducted to allow pilots to articulate as much as they could about relevant situations. This retrospective debriefing was facilitated using the simulator debriefing tool—an integrated built-in fixed camera located in the simulator that records and transfers visual, audio, and flight instrument records of various aspects of the flight into the debriefing room (Figure 4). During the debriefing, the entire simulation would be played back to the pilots, who were instructed to pause the video at any time to talk about difficulties they experienced. All debriefing sessions were video recorded.

««««««« Insert Figure 4 about here »»»»»»

Stage 4 – Data Collection and Analysis

Survey study. Of the 29 pilots with experience on both aircraft types, 19 agreed to participate in the survey. Table 1 presents issues the participants viewed to be significant. The issues identified in the survey related to (a) presentation and layout of flight instruments, (b) transitioning between two different flight management computers, (c) aircraft-systems instruments and their functionality, and (d) differences in standard operating procedures (SOPS). It was determined that the simulator study should investigate these issues further.

«««««« Insert Table 1 about here »»»»»»

Part two of the survey—open-ended questions—showed that there where concerns amongst the more experienced ATR72-500 pilots transitioning onto the glass cockpit version. These pilots found the transition more complex/difficult than the less experienced pilots. Issues related to a belief that their performance had decreased, difficulties learning new standard operating procedures (SOPS), the flight management system (FMS), electronic checklists (ECL) and an overall reduction in the speed at which they could notice abnormalities. Other issues arose in relation to the glass cockpit not reducing workload. An interesting finding was the increased amount of communication required between crewmembers to assist in maintaining situational awareness. Whereas these issues may appear worrying, they are not uncommon for pilots initially undergoing forward transition. Studies in the 1990s showed that transitioning to a glass cockpit is initially difficult, with issues primarily occurring in breakdown of communication and coordination with flight deck automation.

Simulator study: Think-aloud protocol and stimulated recall. Three experienced company pilots participated voluntarily in the simulator study: a flight examiner (FE) to operate and run the simulator and a captain and first officer (FO) to fly the simulator. The captain had approximately 7,000 hours on the ATR72-500 prior to his transition to the ATR72-600 (13,000 total flight hours), and the FO had approximately 3,760 hours of experience (7,700 total flight hours). Neither pilot had flown the ATR72-500 since their transition to the ATR72-600 six months earlier. The FO had performed a two-hour preparation (i.e., reviewing ATR72-500 manuals) prior to this study, whereas the captain had not engaged in any special preparation.

Two four-hour simulator sessions were rostered on consecutive days in a CAE ATR72-500 full flight simulator with outside view. The motion feature of the simulator was turned off to better accommodate video recordings. Four simulations were designed to investigate issues arising from reverse transition, and were conducted in relation to operations and flight schedule of the airline: one normal day-light flight (Day 1), one normal night flight with a simple non-normal during the cruise (Day 2), unprepared night rejected take-off (Day 2), and a pre-briefed night engine failure after take-off (Day 2). Initial planning was for two sessions on Day 1 (Figure 3). However, the reflective session was extended due to the large amount of information recalled by pilots during the debriefing. To ensure flight performance deviations during simulation were due to cockpit differences rather than to terrain or route unfamiliarity, the pilots selected each simulated flight route.

Scenario 1: Normal flight (day). The two pilots flew one leg from Auckland to New Plymouth lasting approximately 70 minutes. The current weather was used for the simulation—day operation with thick cloud base starting from 3,000ft to 11,000ft. Destination weather cloud base was reduced to 1,300ft requiring the pilots to conduct an instrument approach. The captain was the pilot flying (PF, pilot controlling aircraft flight path and making decisions—though captain will always have ultimate authority when required) for the flight to New Plymouth, and the FO was the pilot monitoring (PM, monitoring flight path, reading checklists, and actioning aircraft systems when required by SOPS or at direction of PF).

Scenario 2: Normal flight (night) with minor malfunction (flight director bars failure). The flight was from Christchurch to Wellington. Like the previous flight, it was conducted in real time. The flight was conducted in simulated night conditions with no failures initiated by the instructor until the cruise phase where a minor failure was introduced. The failure was a flight instrument failure of the flight director (FD) systems. The purpose of inducing the FD bar failure was to increase the workload of the pilots during flight, and, specifically, during the missed approach—which was planned—at the destination airport.

Scenario 3: Rejected take-off (night) due to engine failure. During Scenarios 1 and 2, both pilots had discussed issues with the airspeed indicator at low speeds. This was immediately addressed by modifying the research design by introducing an unprepared rejected take-off. This manoeuvre required the pilots to recognise a malfunction and to determine if the speed was appropriate for either conducting a rejected take-off or continuing the take-off at speeds close to V1 (latest speed at which the decision to reject a take-off can be made). The simulator instructor and flight examiner assessed the success or failure of emergency detection.

Scenario 4: Engine failure after take-off (night). This scenario began immediately following the RTO scenario. The instructor restarted the flight scenario and introduced an engine failure after take-off.

Data collection and analysis. All video-recorded debriefing sessions and the simulation session were transcribed word for word. The videos were watched in their entirety. Transcripts were analysed following a data reduction method that involves identifying all issues arising for the pilots—verbalised in the simulator and during the debriefing session—which constituted the complete set of basic level categories. Comments were placed in a table and a narrative written on the issue. These issues where then categorised as relating to a specific area, such as *flight instruments* or *automation*.

Results from the simulator study. The aim of the simulator study was to investigate potential problems with reverse transition from the newer glass version ATR72-600 to the ATR72-500. Along with the survey, this would give the company independent evidence allowing insight into potential problems of conducting MFF. Detailed analysis of the videos and transcripts revealed six categories of potential problems pertaining to reverse transition, including (a) flight instruments, (b) presentation, position and functionality of secondary instruments, switches and dials, (c) automation, (d) flight management computer (FMC), (e) electronic check list (ECL), and (f) general (Table 2). To assist readers in understanding how these categories emerged, the category of *presentation, position and functionality of secondary instruments, switches and dials* will be discussed.

«««««« Insert Table 2 about here »»»»»»

Over the two days, both pilots identified issues associated with the *presentation, position and functionality of secondary instruments, switches and dials.* For instance, the ATR72-600 had a newer electronic flight instrument system (EFIS), known as the Engine & Warning

Display (EWD); an advanced centralised system relaying important information to the pilot (Figure 5). Unlike the older ATR72-500 instruments that are always displayed, the compact EWD presents only the information that is important for the current phase of flight. It also assists the pilots in identifying malfunctions and identifying the correct procedures. However, the difference between the ATR72-500 and the ATR72-600 in functionality and positioning of instruments created problems. For example, the captain noted that, compared to the newer aircraft, the ATR72-500 had a significantly greater number of engine instruments: "I was looking across, going 'oh there's a whole stack of them'" (Captain, Day 1). Additionally, due to the positioning of the engine instruments, the pilots had difficulty identifying correct engine instrument during engine start; often referred to as "start scan." This issue continued into Day 2. By the end of the study, the problems with the engine instruments were improving, though slight issues still remained. At the end of Day 2, the FO and captain discuss the engine start procedures they had conducted.

FO: After four engine starts, two yesterday and two today, on the fourth one was the first time my eyes went directly to where they needed to go.
Res: Is that right?
FO: It has taken four starts. So when we started engine 1 [fourth start], I went straight to it.
Cap: I was the same, I've been aiming a little too high initially, and then I've brought my eyes down to the right area [the captain is talking about his visual aim]. I guess it's a little bit higher perhaps in the 600, I'm not sure.

«««« Insert Figure 5 about here »»»»

In both cases—for the captain and the FO—the differences in the position of the engine instruments created issues in relation to monitoring. Other issues relating to the EWD included pilots having difficulty finding flap indications, and position of the trim indicator. As can be seen in Figure 5, the positions of many of the indicators are reversed between the two aircraft types.

Stage 5—Writing Reports and Texts for Publication in Academic Journals

The final stage of the MFF study required the university team to write scholarly articles for review. The findings sections and the version submitted for peer review are the basis of the reports for the airline, which it can use in making decisions. In relation to the data already obtained in previous studies, the team wrote about MFF, not only in articles in applied journals, but also in broader theoretical papers concerning cognitive issues of flying an aircraft and moving between two versions. These journals, which sometimes include senior pilots as authors, have fed findings back to the airline to use for evidence-based decisions.

Company Decision and Recommendation

For the airline company, obtaining evidence that enabled relevant personnel to make informed decision about MFF was paramount. There existed numerous studies into pilots transitioning onto more advanced aircraft types—such as from analogue to glass cockpits—but there were few, if any, studies related to reverse transition generally. Furthermore, there were no studies on MFF for the ATR 72-500/600. The airline continued to take on recommendations from manufacturers, but was seeking greater clarity on the *types* of problems that may occur during the implementation of MFF. The survey study clearly showed that many pilots had concerns about MFF. However, the pilots in the think-aloud study where surprised regarding the ease of the reverse transition. As the captain noted, "I came into yesterday thinking it was going to be a lot harder than what it has been. I'd probably be sitting at about 80, 85% comfortable." However, the cognitive study showed, for example, delayed actions and missing or misunderstood calls that might become more serious than the captain and first officer realised. Accordingly, the company made the decision to move cautiously to the next step of reviewing the forward and reverse transition course based on additional areas identified in the two studies. Issues that the company is still addressing include:

1. The potential of implementing a closer alignment of the standard operating procedures of each type of aircraft;
2. The need to identify *recommendation* on consolidation requirements for a variant prior to conducting MFF;
3. The need to identifying recency requirements relating to (a) whether each aircraft type could be flown on the same day, and (b) time allowed between flying particular variants; and
4. The need for an appropriate *recurrent simulator training* program.

Conclusion

Modern airlines—like many industries—are faced with increased levels of complexity. Senior managers at the frontline of operational decision making are either faced with clear and easy-to-make decisions, or decisions that rely on less-than-obvious evidence. One issue relates to dealing with evidence based at a general level and transferring it to practice. This paper shows how an airline can work closely with university-based researchers to conduct applied human factors research, with an aim of generating data for assisting in evidence-based decision making. Whereas many researchers may have their own areas of expertise and interest, and airlines may feel obliged to assist in generating new knowledge for the broader industry, there is a compelling argument for the airline to drive the agenda. In this paper, we describe one possible solution to this problem, which exists in collaboration. Because of the disciplinary demands and rigour in studies to be published, the airline obtains high-quality evidence, gathered under conditions that accord with scientific rigour. This dual perspective therefore meets the needs for both the airline and the university.

References

Dekker, S. W. A. (2003). Illusions of explanation: A critical essay on error classification. *International Journal of Aviation Psychology, 13*, 95–106

International Air Transport Association (2013). Evidence-Based Training Implementation Guide July 2013. Retrieved from: http://www.iata.org/whatwedo/ops-infra/itqi/Documents/ebt-implementation-guide.pdf

Lawrence, T., Philips, N., & Hardy, C. (1999). Watching whale watching: Exploring the discursive foundations of collaborative relationships. *Journal of Applied Behavioural Science, 35*, 479–502.

Mavin, T. J., Roth, W-M., & Dekker, S. W. A. (2013). Understanding variance in pilot performance ratings: Two studies of flight examiners, captains and first officers assessing the performance of peers. *Aviation Psychology and Applied Human Factors*, *3*, 53–62.

Roth, W.-M. (1998). Science teaching as knowledgeability: A case study of knowing and learning during coteaching. *Science Education, 82*, 357–377.

Roth, W.-M., & Mavin, T. J. (2013). Assessment of non-technical skills: From measurement to categorization modeled by fuzzy logic. *Aviation Psychology and Applied Human Factors, 3*, 73–82.

Wiener, E., Chute, R., & Moses, J. (1999). Transition to glass: Pilot training for high-technology transport aircraft. Accessed January 18, 2014 at http://wayback.archive-it.org/1792/20100201142111/http://hdl.handle.net/2060/20000032979

Table 1.

Responses from current pilots flying the ATR/600 that were deemed significant

Level of significance	Question
Agreement	
More experience on the ATR72-600 was associated with strong agreement on the statement (ps < .01).	I found the transition from 72-500 to 72-600 complex/difficult
More experience on the ATR72-600 was associated with a moderate agreement for the following the statements (ps < .05).	The 72-600 SOPs are very different from the 72-500 SOPs. Learning 72-600 SOPs during transition line training was very challenging. Compared to before flying the 72-600, I find that I have to increase verbal communication with crewmembers in order to maintain situational awareness of self and others.
Dis-agreement	
Pilots more experienced on the ATR72-600 are more likely to strongly-disagree with the following statement (ps < .01).	I found the transitional line training very helpful and it could not have been done any better.
Pilots with experienced on the ATR72-500 are more likely to disagree with the following statements (ps < .05).	My flight performances have improved since flying the 72-600. The integrated functions of FMS are a great idea. The electronic checklist ECL is more helpful than the paper checklist during non-normal operations. The glass cockpit has reduced my workload during normal operations. I notice abnormalities faster now, than I did back in the 72-500 cockpit. The transition line training prepared me to fly confidently during my first 72-600 flight. The glass cockpit has reduced my workload during normal operations.

Table 2.

Typical issues faced by pilots initially transitioning back from the ATR72/600 to the ATR72/500

Area	Type of issue	Specific example
Flight instruments	General comments	First take-off required high concentration due to positioning of primary flight instruments. e.g. ASI, VSI
		A lack of information overall is observed.
	Size of the artificial horizon	The artificial horizon appeared small.
	Air speed indicator (ASI)	ASI appearance is small.
		Difficulty reading ASI at low speed call of *70 knots* with "little needle movement until just before 70 knots".
		No other issue found apart from slow movement around 70 knots.
	Instrument scan	Instrument scan is different. Crew looking in "other places subconsciously" for instruments.
	Skid-ball appearance	Skid-ball is more apparent on 500. The 600 skid-ball is more "incorporated in the overall picture".
	Navigation display	Select of preferred navigation presentation lead to orientation issues.
	Minimum descent altitude (MDA)	An expectancy that MDA appears on each pilots screen after one pilot selects MDA. When a pilot selects MDA on the 600 it appears on both pilots instruments.
	Terrain button	Difficulty finding switch for *terrain* to be presented on navigation display.
	Ground speed indication	Initial difficulty finding ground speed indication on navigation display.
Presentation, position and functionality of secondary instruments, switches and dials	EFIS switches	Pilots have difficulty finding switches.
		Pilots have difficulty remembering functionality of some switches.
	Brightness controls	Captain having some issues with the brightness control for the EFIS.

	Clock	Positioning of clock for FO was found to create a minor issue of confusion (Captain no issue identified).
	Third QNH setting	Difficulty finding dial to change QNH on standby altimeter.
	Instrument display	Captain comments on lack of colour and bland appearance of analogue instruments.
	Data card	There was initial difficulty setting up the flight data card.
	Position of trim indicator	Captain mentioned on more then one occasion difficulty finding trim indicator.
	Engine instruments	Initial surprise at number of instrument…"oh there's a whole stack of them".
		During engine start pilots have initial difficulty finding instruments to follow.
	Communication & navigation switches	Captain feels more comfortable with radio and navigation switching on the 500.
	Starter cut-out	Lack of an aural "click" when engine-start switch disengages makes FO miss starter-cut-out.
	Flap	Difficulty finding flap indicator due to being in different position.
Automation	Autopilot engaged light.	Difficulty in initially finding autopilot engaged light on artificial horizon.
	Speed modes	During take-off, speed/bank (automatic on the 600) confused.
	Vertical speed control	Vertical speed control on autopilot difficult to find in dark.
	Speed confusion	During practice engine failure after take-off, pilots use 600 procedures. However, at clean up altitude, with autopilot engaged, aircraft begins a descent rather then maintaining level off altitude and accelerating
Flight management computer (FMC)	Programming sequence	Major difficulty finding trigger to commence programming FMC.
	Different fuel scales	Having fuel in one FMC that was in 1000kg verse 1.0.

	FMC difference change flow of briefing	The FO discusses that because data is first put into the FMC on the 500 compared to the 600, it changes flow of the briefing.
Electronic check list (ECL)	General use	No issue identified converting back to paper checklist from ECL. Some comments on change of personal flow.
	Take-off configuration warning	Slight confusion about take-off configuration warning difference between both aircraft. The 600 has a visual warning where the ECL “approves” whereas the 500 only has a it comes up ‘take off configure’, ok”.
General	Personal preferences	Outside of standard operating procedures are personal preferences. Both pilots describe struggling to get a flow going when they were in the 500.

Figure 1. Photo of ATR72/500 (top) and ATR72/600 (bottom).

Figure 2. The training manager and university-based researchers brainstormed at a whiteboard to design the research to be conducted in the simulator associated with debriefing sessions.

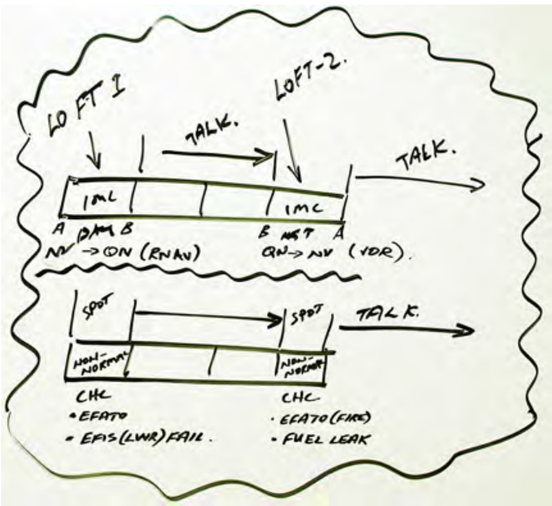

Figure 3. Pilots and research team discuss the simulator exercises with the aid of the debriefing tool in the background.

Figure 4. Different layout and positioning of secondary instruments on ATR72-500 (left) and ATR72-600 (right). The ATR72-500 on the left shows (a) standby airspeed indictor (b) standby altimeter (c) primary engine instruments (d) flap indicator (e) trim and indications. On the ATR72-600 the electronic flight instrument system (EFIS) known as the Engine &Warning Display (EWD) displays the instruments however some are in a in a different position or in compact mode (some instruments displayed only when dictated by EWD unit).