**Introduction of Technically Advanced Aircraft in Ab-Initio Flight Training**

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**Abstract**

The transition of pilots from a traditional cockpit to a modern glass-cockpit has been a training challenge for the last two decades. The arrival of Technically Advanced Aircraft (TAA) during the last decade has brought the opportunity to introduce this technology from the beginning of airline pilot training. In this project, three flight instructors responsible for the introduction of TAAs in ab-initio training at a flight school were interviewed on their initial experiences and concerns regarding the introduction. Subsequently, questionnaires were collected from the familiarization training of instructors on the new aircraft and from ab-initio students and instructors after three of the 18 flights leading up to the first solo. Finally, flight instructors involved in the introduction were interviewed. The results showed that anticipated problems with use of displays, aircraft speed, and use of side control proved to have limited impact on the training. The conclusion is that with extensive preparation, introduction of TAA in ab-initio training can be accomplished successfully. However, the expected benefits of this on training and questions on what might be lost in the process need to be addressed by further research.

**Introduction**

The most important training challenge in commercial aviation since the eighties has been the training of pilots transitioning from a traditional cockpit environment to that of a modern computerized cockpit with glass-cockpit and sophis-

Requests for reprints should be sent to Kay Chisholm, FAA Academy, AMA-530, P.O. Box 25082, Oklahoma City, OK 73125. E-mail to kay.chisholm@faa.gov.
icated automation (Billings 1997; Dekker & Hollnagel, 1999). The transitions produced unanticipated situations and reactions, sometimes resulting in incidents and accidents, and proved to the aviation industry that such a technology shift transforms work in the cockpit and cannot be treated as a separate subject or an add-on to existing training (Rignér & Dekker, 1999). Although the airline industry has invested in increasing the effectiveness of training for the modern cockpit, training new pilots for licensing has not changed at the same pace (Dekker & Johansson, 2000).

The transition to a modern cockpit environment often occurs late in the training of a new pilot, usually concurrent with the pilot being introduced to multi-crew and jet-transport flying. To avoid or alleviate problems with this transition Rignér & Dekker (1999), as well as Casner (2003a; 2003b), recommended that learning about the glass-cockpit should be introduced at early stages of pre-airline pilot training. Due to the restricted funding at collegiate or private level flight training this has often been difficult (Fanjoy & Young, 2003), with the consequence that there has been large variations in how well prepared for the modern cockpit new pilots have been when they enter an airline.

The arrival of modern cockpit technology in light general aviation aircraft seen in the last decade has provided the opportunity to introduce, from the beginning, a modern cockpit environment to pre-airline training. These aircraft, known as Technically Advanced Aircraft or TAA, are equipped with most of the technology found in large transport aircraft, except for a Flight Management System. According to a Federal Aviation Administration (2003, p. 9) report, a TAA is an aircraft, “in which the pilot interfaces with one or more computers in order to aviate, navigate, or communicate.” A more strict definition is also provided:

A TAA is defined as an aircraft that has at a minimum:

a. IFR –certified GPS navigation equipment (navigator) with moving map;
or
b. A multi-function display (MFD) with weather, traffic or terrain graphics

c. An integrated autopilot.

According to a report by the AOPA Air Safety Foundation (2005), many new TAA go beyond this definition, also including a Primary Flight Display (PFD) to replace the traditional “six-pack,” and coming close to the glass cockpit concept large transport aircraft. According to the same report, “Fleet sales to active flight schools and university flight departments in the last two years have generally been TAA” (p. 4).

Introducing TAAs in pre-airline training is a way to reproduce the technology shift that has already taken place in air transportation. The benefits of this seem obvious; the cockpit of a TAA resembles the future work environment and introduces the type of instrumentation and automated functions used in jet transport aircraft. However, since a technology shift transforms work, it is also likely to transform the learning of students and the teaching of flight instructors. In the previously mentioned report of the AOPA Air Safety Foundation (2005, p. 22), executive director Bruce Landsberg of the organization stated, “Technology
emerges as a doubled-edged sword, increasing pilot and aircraft capabilities but frequently at the price of increased workload and education."

Since the introduction of advanced computer technology in the cockpit there has been research on how to effectively train for this environment (Roessingh et al., 1998; Dekker & Hollnagel, 1999). There also has been research regarding how to train student pilots for the modern cockpit. Fanjoy and Young (2003; 2004; 2005) studied collegiate flight training programs to see how glass-cockpit training was addressed in these programs. One of their conclusions was, although a vast majority of the flight training programs that they studied seemed to share the belief that flight automation training was critical to the success of their students, few applied comprehensive training in that area. Casner (2003a; 2003b) studied classroom training for cockpit automation and the transition from piston trainer aircraft to jet transport aircraft, using a computer based simulator of the flight management system of a modern jet. Casner concluded that “cockpit automation found in small training airplanes appears to provide a simple, cost-effective way of introducing cockpit automation to pilots who are still in the formative phases of their professional aviation careers” (2003 b, p.16). Craig, Bertrand, Dornan, Gosset, and Thorsby (2005) compared the use of TAAs, an adapted syllabus, and scenario-based flight exercises for training student pilots with traditional training. The first data from this project showed that students using TAAs had to repeat more (61% vs. 17%) flight exercises than those in traditional training before the first solo, but had to repeat less flight exercises during private pilot and cross-country phases of training (15% vs. 38%) and during instrument training (24% vs. 45%).

The aim of this research project was to study the extent and nature of the transformation of pre-airline pilot training as an effect of the introduction of TAAs. This included investigating the perceived, as well as the actual, benefits and problems of training, in addition to the identification and monitoring of potential flight safety risks. The project focused specifically on the first phase of the introduction, i.e. the training phase up to the first solo flight, since it was expected that this phase would represent the “leap” in the introduction of the new technology and as such would require the greatest efforts from students and flight instructors with adapting to it. However, the aircraft is planned for the flight training phases prior to instrument training, which then will be performed in a traditional twin piston-engine aircraft. Even though TAAs are increasingly being purchased by flight schools and university flight departments, a majority of these organizations still have an introduction of TAAs ahead of them. Thus, the findings of this project provide valuable contributions not only to the new field of knowledge in general aviation and aviation training represented by TAAs, but also to flight training organizations planning to introduce TAAs into their training.

Method

Participants

The participants were flight instructors and students at Lund University School of Aviation. The 17 flight instructors were all male and between 26 and 62 years of age. Their flight experience ranged from 470 to 28,500 flight hours and their instructor experience from 150 to 14,500 hours. The 12 ab-initio students were at the start of their 20-month Integrated Airline Transport Pilot training program. The
students were 20 to 30 years old and three out of twelve were female. Two were holders of a Private Pilot License (PPL), with 139 and 67 hours of experience respectively, one had a license for touring motor glider and 100 hours of experience, while the other students had minimal or no flying experience.

Aircraft

The aircraft to be introduced in the training was the Cirrus SR-20 G2. The aircraft is a TAA well beyond the FAA definition, with equipment including PFD, MFD (with moving map and traffic warning system), GPS, and advanced autopilot functions. It has a side control instead of a traditional yoke and a single power lever instead of the traditional two levers for throttle and propeller. A parachute is integrated in the airframe and designed to be used when a controlled landing is not an alternative. Higdon (2000, ¶ 1) stated in a review of the aircraft that it “stands out because of its size, its comfort, its equipment” and that it was “the best-handling, best harmonized flying machine since the Bonanza” (¶ 3). Yet Higdon was negative about using it for students and predicted that “getting the hang of basic airmanship while trying to manage this extremely slippery bird makes for more work than most students need to face early in their training” (¶ 4).

Procedure

Interviews with flight instructors prior to the introduction of the new aircraft. Semi-structured interviews with three flight instructors were performed to collect initial experiences of the aircraft and to map areas of concern. Those interviewed were the flight instructor responsible for the introduction, the chief flight instructor, and a senior flight instructor. They had been selected to prepare the introduction, i.e. to fly the aircraft to learn about its handling and performance, revise and adapt the training and training material, and to perform familiarization training on the new aircraft with other instructors. They were also included in a group of six flight instructors designated for the first course with the aircraft.

Questionnaires after familiarization training for flight instructors. Familiarization training together with a flight instructor trained on a new type of aircraft is not mandatory for flight instructors. According to the regulations, flight instructors are authorized with performing their own familiarization training. However, this familiarization training intended to give all flight instructors in the organization a well-calibrated and standardized first acquaintance with the aircraft. After receiving familiarization training, the experiences of 14 instructors were collected with a questionnaire. The questionnaire was based on the areas of concern brought up in the previous interviews and designed in cooperation with the flight instructor responsible for the introduction of the aircraft.

Questionnaires for students and flight instructors during flights up to first solo. A questionnaire was also used to collect the experiences of the students and instructors for the flights up to the first solo. It was based on available information from interviews and the previous questionnaire and designed and revised between flights in cooperation with the flight instructor responsible for the introduction. Three flights out of the 18 leading up to the first solo were selected. The first flight chosen for the questionnaire was exercise 104, the fourth flight for the students. Level turning was practiced in this flight and it was chosen since it represented
the first flight where the students themselves handle the aircraft most of the time in the air. In the second selected flight, flight exercise 111, power-off landings were practiced. Finally, the third flight exercise, flight 118, contained practice of take off and landings as preparation of the upcoming first solo. Repeating the same questions provides stable answers that facilitate generalization beyond the particular flights and provides opportunities to see trends of learning.

_Interviews with flight instructors after introduction of the new aircraft._ To complement questionnaire data three semi-structured interviews were performed after the first solo, including following up on flights after the first solo and the skill test for PPL. Since the PPL skill test was performed by external examiners, it was expected to provide a calibration of the views of the instructors on the introduction of the new aircraft.

The flight instructor responsible for the introduction was interviewed again since he had monitored the whole introduction. The second instructor was the course manager, who was expected to have an overview of the experiences of students and instructors. The third instructor was the flight safety pilot, who also was an instructor on this course. The two instructors interviewed prior to the introduction were not interviewed again due to potential bias towards a successful perception of the introduction.

Results

_Interviews with flight instructors prior to the introduction of the new aircraft_

The three instructors spent 15 flight hours and ample time on the ground during four months to prepare the introduction of the new aircraft. The initial experiences of the aircraft brought up five areas of concern; the computer-driven instrumentation (PFD and MFD), the speed of the aircraft, the use of side control, the work environment and the safety of the aircraft.

Adapting instrument scanning to the PFD included expected problems of not finding the right information at the right moment and specific problems with the presentation of speed and altitude on tapes. The altitude and speed of the aircraft is highlighted in a box on the tape. The consequence is that as numbers roll on the tapes they are partly covered by the box and, especially at low speeds, this was considered a problem. The increased precision provided by the tape presentation was another problem, since this created excessive focus on the numbers on the screen. One instructor commented that when flying at 1500 feet with a traditional altimeter he knows that he is at about the right altitude. Seeing on the PFD that he is flying at 1480 feet made him wonder why he could not stay at the correct altitude. The access to large amounts of information on the MFD was seen as potentially detrimental to the attention and mental workload of the students. Due to this, it was decided that prior to the first solo the students should only be allowed to have engine information presented on the MFD (unless other information would be needed for flight safety reasons). Due in part to the same reasons use of automation was also planned to be restricted until later stages of training.
The new aircraft, like many TAAs, operates in a higher speed range than traditional single piston-engine trainer aircraft and the instructors anticipated that this would have consequences for the training. Consequently, power settings and speeds recommended by the manufacturer frequently had to be reduced, approach points had to be changed, and flight profiles modified. Still, the effect of the higher speed range on the training of new students was a concern. The side control was experienced as unproblematic by the instructors, besides concerns that it would strain muscles in the arm during intense maneuvering. The aircraft frequently needs trimming in the roll-axis and with the trim-button being used for both roll and pitch, it was considered that accidental trimming in the pitch-axis could occur.

The flight instructors were convinced that the improved work environment (space, seats and headsets with active noise reduction) would lead to an improved learning situation and more effective preparation of the students for modern jet transport aircraft. Absence of dual instrumentation, a feature of the previous aircraft, did not seem to be of concern to the instructors. Looking at the PFD and MFD and monitoring the use of the side control from the right seat was considered unproblematic. The information available on the MFD was considered to improve safety and could be used as back-up on cross-country flights if a student would get lost. The parachute of the aircraft did not seem to be of importance for the perception of safety. Contrary, one instructor brought up the risk of such a device resulting in over-confidence, the problem of knowing when to deploy the parachute, and argued that a crash with a parachute might be no better than a controlled emergency landing.

Questionnaires after familiarization training for flight instructors

The questionnaire was returned by all of the 14 flight instructors going through the familiarization training. The training consisted of two flights, handling of the aircraft (maneuvering at slow speed, stall and recovery, traffic circuits, and landings) and a cross-country flight (to practice use of the PFD, MFD, and GPS-panel). For the questionnaire, a Likert scale from 1 to 9 was used, with different labels selected for the end points of the scale (Nählinder, Berggren & Persson, 2005) and the instructors were requested to provide comments to the questions. The results are shown in table 1 and commented below.

Table 1

<table>
<thead>
<tr>
<th>Questions</th>
<th>Mean (Std.dev.)</th>
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</thead>
<tbody>
<tr>
<td>Preparation for training (not well-very well prepared)</td>
<td>4.6 (2.2)</td>
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<tr>
<td>Difficulty of training (very simple-very difficult)</td>
<td>3.4 (1.3)</td>
</tr>
<tr>
<td>Performance during training (not good-very good)</td>
<td>6.7 (1.2)</td>
</tr>
<tr>
<td>Time pressure during training (none-great)</td>
<td>2.6 (1.8)</td>
</tr>
<tr>
<td>Time spent looking at PFD/MFD (little-plenty)</td>
<td>6.7 (1.1)</td>
</tr>
<tr>
<td>Effect of PFD/MFD on performance (worse-better)</td>
<td>4.9 (1.4)</td>
</tr>
<tr>
<td>Misunderstanding/confusion due to PFD/MFD(none-often)</td>
<td>3.9 (1.7)</td>
</tr>
</tbody>
</table>
Disturbed by other information on PFD/MFD (none–often) 3.8 (1.6)
Experience of use of tape presentation (not good–good) 5.1 (2.2)
Effect of precision on PFD on performance (worse–none) 5.0 (2.7)
Perception of speed (low–high) 5.1 (1.5)
Effect of speed on performance (worse–none) 8.2 (0.8)
Maneuvering with side control (not good–good) 7.4 (1.7)
Difficulties with side control (plenty–none) 7.0 (1.8)
Handling of other controls (simple–difficult) 2.6 (1.1)
Extent of using automation (little–plenty) 5.0 (2.6)
Handling of automation (simple–difficult) 3.2 (1.8)
Work environment of aircraft (not good–very good) 8.2 (0.8)
Projected success of aircraft in flight training (not good–very good) 7.3 (1.3)
Familiarization training (not sufficient–sufficient) 6.1 (2.6)
Safety compared to previous aircraft (less–more safe) 4.9 (1.8)

Eight instructors commented on problems of finding the right information at the right moment on the PFD/MFD, with one stating that he happened to read altitude as vertical speed in feet. Five comments on the speed all stated that it was not a problem. The side control was commented by nine instructors: four about potential strain on muscle of the arm, three on the aircraft being sensitive in the roll-axis and two on the need for trimming. Other comments on controls brought up problems with closing the door and difficulties with finding or handling the Emergency Locator Transmitter (ELT), brakes, parking brakes, circuit breakers, alternate warm air, and alternate static air. Comments on the work environment included two concerns on the strength of the construction and one on the aircraft being sensitive to judgment errors regarding speed and attitude when landing. In addition, one instructor stated that students would become less skilled with flying and more skilled with information management and automation. Another stated that he was not sure if training with the new aircraft would cover the knowledge needed when flying an aircraft at a flying club, landing on grass strips or navigating in poor visibility with traditional instruments. The rating of the aircraft as more or less safe compared to the previously used aircraft was neutral. Safety risks were commented by twelve instructors; four on stall-properties of the aircraft, two on the risk for stall in the touch-down phase, two on the risk of looking too much on the instruments and one on the PFD/MFD not being stable and having to be restarted often.

Questionnaires for students and flight instructors during flights up to first solo

From 35 flights, 33 questionnaires were returned from the students and 34 from the instructors. One student holding a PPL did not fly flight 118, which led to the loss of one student and flight instructor questionnaire respectively. One student did not return two questionnaires; one instructor did not return one questionnaire. The questionnaires used the same scale as that for the familiarization
flights and comments from both students and instructors were requested. After the first flight, questions on changes between flights were added and questions on the PFD/MFD separated.

Table 2
*Results from questionnaires after three selected flights, means and standard deviations for ratings of students and instructors (shaded).*

<table>
<thead>
<tr>
<th>Questions</th>
<th>Flight 104</th>
<th>Flight 111</th>
<th>Flight 118</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation (not well-well prepared)</td>
<td>7.6 (0.8)</td>
<td>8.0 (1.1)</td>
<td>7.7 (1.7)</td>
</tr>
<tr>
<td></td>
<td>7.6 (1.0)</td>
<td>7.7 (1.0)</td>
<td>7.6 (1.1)</td>
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<tr>
<td></td>
<td>3.9 (1.5)</td>
<td>6.1 (1.5)</td>
<td>4.8 (2.1)</td>
</tr>
<tr>
<td>Difficulty (very simple-very difficult)</td>
<td>5.5 (1.7)</td>
<td>5.6 (1.6)</td>
<td>5.6 (1.7)</td>
</tr>
<tr>
<td></td>
<td>7.5 (0.9)</td>
<td>6.7 (1.1)</td>
<td>7.3 (1.1)</td>
</tr>
<tr>
<td>Performance (not good-very good)</td>
<td>7.1 (0.9)</td>
<td>6.3 (1.4)</td>
<td>6.7 (1.0)</td>
</tr>
<tr>
<td></td>
<td>2.1 (1.6)</td>
<td>2.7 (1.8)</td>
<td>2.4 (1.5)</td>
</tr>
<tr>
<td>Time pressure (none-great)</td>
<td>3.3 (1.5)</td>
<td>4.0 (1.8)</td>
<td>2.9 (1.3)</td>
</tr>
<tr>
<td>Spare time (none-plenty)</td>
<td>4.6 (2.6)</td>
<td>2.4 (2.3)</td>
<td>3.1 (2.5)</td>
</tr>
<tr>
<td>Step-by-step or automated actions</td>
<td>5.6 (2.7)</td>
<td>5.8 (2.0)</td>
<td>6.5 (1.6)</td>
</tr>
<tr>
<td>Forced to “shut off” information (never-often)</td>
<td>2.2 (1.2)</td>
<td>2.4 (1.7)</td>
<td>2.1 (0.9)</td>
</tr>
<tr>
<td></td>
<td>2.9 (1.4)</td>
<td>3.1 (2.0)</td>
<td>1.7 (1.0)</td>
</tr>
<tr>
<td>Forced to interrupt other tasks to maneuver the aircraft (never-often)</td>
<td>1.5 (0.7)</td>
<td>1.2 (0.5)</td>
<td>1.2 (0.6)</td>
</tr>
<tr>
<td></td>
<td>1.5 (0.9)</td>
<td>1.9 (1.5)</td>
<td>1.5 (0.8)</td>
</tr>
<tr>
<td>Use of PFD (less-more)</td>
<td>-</td>
<td>4.5 (2.2)</td>
<td>4.8 (1.8)</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>4.4 (1.6)</td>
<td>4.6 (1.0)</td>
</tr>
<tr>
<td>Misunderstanding/confusion PFD (none-often)</td>
<td>2.5 (1.8)</td>
<td>1.8 (1.4)</td>
<td>2.0 (1.9)</td>
</tr>
<tr>
<td></td>
<td>2.4 (1.4)</td>
<td>2.2 (1.7)</td>
<td>1.7 (1.2)</td>
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</table>
A repeated-measures analysis of variance showed a within-subject significant difference in the ratings of “Difficulty” and “Performance” (across the three flights) by both students and instructors, with flight 111 rated higher on “Difficulty” (F[2, 38]=3.57; p<.05) and lower on “Performance” (F[2, 38]=4.75; p<.05). Ratings on the category “Disturbed by information on the PFD” dropped significantly (F[2, 36]=4.02; p<.05) after the first flight. Maneuvering with side control was rated higher for successive flights and difficulty lower. Even though not significant at the 5% level, this tendency is clear (F[2, 38]=2.67; p<.10, and F[2, 38]=3.18; p<.10, respectively).
Flight 104 resulted in six comments from four students on problems regarding the presentation of information, two on difficulties with finding information, one on the precision of the altitude presentation, one on the speed presentation as confusing, and two that were positive to the PFD. Four of the instructors commented on the use of PFD as unproblematic, while one commented on excessive focus on the displays and one that the student had monitored Ground Speed (GS) and True Air speed (TAS) rather than Indicated Air Speed (IAS). One instructor commented that use of side control became strenuous due to intensive maneuvering and one student commented that the trim made him slant right. Flight 111 resulted in four students commenting positively on the PFD, although one student stated that he likes traditional instruments better. The speed was commented by seven students as unproblematic, although one brought up the difference between start and landing speed and one the problem of reducing the speed, i.e. the aircraft being “slippery”. Flight 118 received few comments, one on improvements in finding information on the PFD, one on preference of traditional instruments, three positive comments on speed, and one bringing up the problem of speed reduction.

Interviews with flight instructors after introduction of the new aircraft

The three instructors unanimously expressed that the introduction had been less problematic than they had expected it to be. According to the course manager 3 flights had to be re-flown out of approximately 18 flights each for 12 students, all of them take-off and landing flights just before the first solo. (Approximately 18 since some flights were cancelled for the two students who already had a private pilot license.) The highlighting of numbers and precision of the PFD turned out not to be a problem at all for the students and a passing one for instructors. The course manager stated that in the beginning the amount of information on the PFD was beyond the capacity of the students, referring to students who had monitored the wrong speed on the PDF. The speed of the aircraft turned out to be less of a problem than expected. Two instructors commented that the aircraft is sensitive before touch-down; a marginal speed decrease below the landing speed necessitates the instructor to intervene. Three confirmed tail strikes in the initial stages of the training, although none causing significant damage had confirmed this problem. (These events raised the awareness of the problem among instructors and subsequently no tail strikes occurred.) The course manager stated that the aircraft is “slippery”; particularly during descent, speed reductions are difficult. According to the course manager there had been initial skepticism expressed towards the side control and its construction. However, the instructors all agreed that the use of the side control and other controls had been unproblematic. While initial concern had been expressed on the difficulties of recognizing when the aircraft is about to stall this also proved not to be a problem. The work environment of the aircraft was collectively praised as providing an improved learning environment. Regarding safety, the issue of potential over-confidence due to the information available on the MFD, primarily the moving map, was brought up.

The planning and preparation of the training and training material (particularly the hints for instructors) were unanimously seen as the main reason for the successful introduction. The instructor responsible for the introduction emphasized detailed planning of flight exercises to the pace of students’ learning as a significant contributing factor. Considered as important was that a group of six flight
instructors were designated and given time to prepare for the course. Preparations continued with instructor meetings before and after each flight and opportunities to try out flight exercises before they were performed with students. The documentation of meetings and practice flights in the form of hints for instructors was considered of great importance. The instructors quickly became well coordinated and calibrated, adding confidence to the instructors and avoiding otherwise common frustrations of students experiencing different training with different instructors.

Among the more recent experiences mentioned, was an event immediately after the first solo, when a student engaged the flight automation and then was unable to disengage it. After the PPL examination flights, the examiners commented on the students as being highly skilled on instrument flight but overall, they were overly focused on the instruments. Their knowledge of technical systems was considered below the normal standards of the flight school and their awareness of fuel planning and management even more so.

Discussion

The results of this study showed that the introduction of TAAs in ab-initio training can be accomplished successfully, with few problems for students and flight instructors. That three students needed to have an extra flight with touch and go training before the first solo is normal at this flight school and indicated that the progress of this course has not deviated significantly from that of previous courses. Comments showed that the concerns during the preparations for the introduction did translate into problems for some students, but never for a majority of the students. Credit for the successful introduction belongs to the preparation that took time and resources beyond the regulatory requirements (preparatory flights to try out aircraft, revision of training material, coordinated familiarization training, and allocating a selected group of instructors with time for preparing and following up). New technology often promises increased capabilities (for training: same as before, but now simpler and better) and safety, but the transformation of work changes how the performance breaks down and creates possibilities for new forms of accidents (Dekker, 2004). The promise of new technology applied to the introduction of TAAs in training implicates that only minimal preparations should be necessary. However, in its report, the Federal Aviation Administration (2003, p. 6) concluded that TAAs provide “potential for increased safety,” but to achieve it, additional training of specific TAA systems is necessary. The time and resources available for this introduction seem to have made it possible to prepare for the transformation of work and to avoid the initial pitfalls of the shift in technology.

The ratings of both students and instructors suggested that difficulties with learning how to operate the aircraft were not connected to its specific properties as a TAA; while flight 111 proved more difficult than other flights, ratings of use of PFD/MFD, speed and side control decreased or remained at the same level compared to those of flight 104. The concerns for the PFD identified in the first set of interviews (finding information, indication of altitude and focus on instruments) were replicated in the comments of the students and instructors after flight 104 but disappeared with increasing experience. Ratings on these problems remained
low from the first flight to the last. These initial problems suggested that familiar-
ization training on a part-task trainer or on a computer could be helpful in order to
facilitate the use of the PFD and MFD. The higher speed range became a priority
during preparations but turned out not to be problematic; perception of speed was
rated neutral and its effect on performance marginal through all flights. However,
touch-down speed was confirmed by three tail strikes as a problem; although not
an initial concern it was commented during familiarization training. This subse-
quently prompted increased instructor attention on the risk of tail strike. Even
though the ratings on the use of the side control suggest that it was not problem-
atic from the first selected flight, the ratings improved in the subsequent flights.
Regarding the work environment, the fact that dual instrumentation is not avail-
able on the aircraft seemed to have no negative effect on the training according
to the instructors. Ratings on safety were neutral compared to the previous type
of aircraft used at the school.

Improvement of training is the main expected benefit from the new aircraft, a
training that more effectively produces competent first officers for large jet trans-
port aircraft. The assumption seems to be that the smaller aircraft will be able to
simulate the environment of a larger aircraft (use of PFD, increased focus on
system management, use of side control and automation) and thus provide more
relevant training for the student (Casner, 2003b). This assumption is questionable
since it is not clear how different levels of fidelity in simulation connect to different
levels of learning. Caird (1996) stated that, “for decades, the naïve but persistent
theory of fidelity has guided the fit of simulation systems to training.” The potential
transfer effect of initial pilot training with TAAs to later stages of pilot training
needs to be investigated to see if it brings temporary or long term benefits to
pilot’s skills.

Although the issue of transfer of training needs further attention, other bene-
fits of using TAAs were more evident. The flight instructors were unanimously
positive regarding the work environment in the aircraft and the effects they
expected it to have on their own teaching as well as on the learning environment
for the students. (Effects regarding less noise and vibrations and improved space
were stressed, particularly when performing the fourth or fifth flight of the day.)
The instructors were similarly convinced that training with modern displays would
prepare the students better for their future work environment in a modern jet
transport aircraft. Combined with the fact that the training progression was similar
to that of previous courses and the limited problems with the use of the new tech-
nology, this indicates that TAAs can provide an improved learning environment
combined with a potential for positive transfer of use of new technology to later
stages of pilot training. However, the “doubled edged sword” of technology men-
tioned previously is present also in these benefits. While pilot and aircraft capa-
bilities may be increased by the new displays and controls, the extent to which
these may also provide a potential for increased workload and new ways for stu-
dent pilots to fail is still not known.

While this study has shown that TAAs can be successfully introduced in ab-
initio training, further research on the expected positive outcomes is required.
The problem of trying to restrict use of the features available in a TAA was illus-
trated by the student engaging automation during one of the first solo flights. The
transition to a traditional twin-engine aircraft in later stages of the training will also be of interest, since students trained on TAAs might begin their careers flying aircraft with traditional cockpits. Expressions of risk compensation should also be considered, where design features intended for increased protection and safety (parachute, moving map) is converted into mechanisms for accepting greater risk and smaller margins. In addition, the question of whether there are training qualities lost in the transition to TAAs should be investigated. The comments from the PPL examination on students being too focused on the instruments and lacking in technical knowledge and fuel planning can be interpreted as indications that information readily available on displays shortcut or truncate active information management; the student knows how to work the system, but not how it works. To ensure that the introduction of TAAs will bring the expected benefits to pilots’ training and that important cognitive skills will not be lost, these issues should be addressed.

The main conclusion from this study is that with extensive preparation, introduction of TAAs in ab-initio training can be accomplished successfully, offering an improved learning environment as well as a potential for both increased safety and positive transfer of training with modern technology to later stages of pilot training. However, the confirmation of the expected benefits of increased safety and transfer of training as well as questions on what might be lost in the process need to be addressed by further research.

References


