How do we maintain manual handling- and monitoring skills in an automated environment?

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Spring Term 2024

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Abstract

This study investigated how the industry can maintain manual handling- and monitoring skills over time as pilots become increasingly exposed to more and more advanced levels of flight deck automation. It investigated previous research on the subject which in broad terms concluded that humans do certain things better than machines and vice versa and that it is essential to have a balance between authority, ability, responsibility and control in the man-machine relationship. Ten industry professionals (pilots) were interviewed and the subsequent thematic analysis yielded three main themes. This was complemented by a literature review on the subject which was consistent with the results from the interviews. The results of the study showed that the industry does not fully consider the phenomenon of skill degradation and that operators in general manifest a laissez-faire attitude towards the retention of these skills. The natural conclusion was therefore to suggest mandating well thought-out manual handling scenarios in the simulator and to transfer applicable elements to normal line operations after having practiced them in the simulator.

Contents

Introduction

Pilots often find themselves surrounded by ever-increasing levels of advanced automation. For every new generation of aircraft that enters the market, pilot action and the possibility to intervene is in one way or another rationalized away with and replaced with technical solutions (Arbuckle et al., 1998). The advantages are obvious. A great deal of decisions pilots deal with in their line of duty are rule-based (*if* X happens, *then* we do Y). If an engine fails after take-off, there are several actions that must be completed in a specific order. If we are told to go around, then we go around by completing another set of actions. The truth of the matter is however that with added layers of complexity, we tend to make more mistakes (Michon, 1989). Minimizing the need of pilots having to complete long rule-based procedures unexpectedly and in stressful conditions is synonymous with a higher degree of safety. One can even argue that relieving the pilots of basic non-stressful duties such as rotating the aircraft during departure or maintaining the centerline during a normal landing is safer and more aptly done by a computer.

The line must however be drawn somewhere. Oliver et al. (2019) argues that it is unrealistic to outsource the craftmanship of flying an aircraft while simultaneously expecting pilots to be on top of their game in the rare occasion their manual handling- or critical thinking skills are needed (the paradox being that with evolving aircraft technologies, basic pilot training need to evolve as well to make up for lack of maintaining skills during day-to-day operations).

Lack of manual handling skills, or a reluctance to take control when needed, is cited as a contributing factor in many accidents. We also know through several experiments that humans are notoriously poor at monitoring, especially in monotonous environments and when we have a high degree of confidence in the system.

By issuing Advisory Circular 120-123 in 2022, the Federal Aviation Administration takes a clear position on the matter. Manual handling- and monitoring skills are on the decline and airlines are urged to modify their operating procedures to better cater for their retainment (FAA, 2022). This even includes finding ample opportunities for manual flight during normal line operations with paying passengers onboard.

IATA is on the same page and has issued Aircraft Handling and Manual Flying Skills, a document in which a worldwide survey exposed a series of interesting results among the pilot population, two of the most telling ones being that there is on many occasions a lack of practice and too strict an SOP to maintain a high level of proficiency (IATA, 2020).

Observing the fast-paced technological leaps that take place in the aviation world, the time has come to ask ourselves how we as humans can harmonize with all the automation that surrounds us while simultaneously not become a liability when we are needed the most. It is the take of this paper that this complex issue resonates in several areas ranging from how we view operational procedures to simulator training to general attitudes of accountability and how we attribute blame. Everything these days are done in the name of safety. The question is however if we in a sense have created a system with some inherently unsafe mechanisms built into it?

Previously conducted research

Lots of papers have been written on the issues that arise in the interaction between advanced automation and humans. Parallels can be drawn to other industries such as nuclear power plants, health care and self-driving cars. Independent of the source and field of study, all studies examined for the purpose of this paper lean towards suggesting that outsourcing what was previously done by humans to a machine is incompatible with maintaining or developing human skills in the area concerned. De Winter and Dodou (2011) discuss the Fitts list which is one of the original research projects dealing with humans in automated environments. The key point of the Fitts list (1951) is function allocation (who does what) and its central role in the design of human-machine systems. The list has received both praise and criticism but De Winter and Dodou (2011) argue that it has played an important part in its field since its introduction in 1951.

Table 1 The original Fitts list (Fitts 1951, p. 10)

Humans appear to surpass present-day machines in respect to the following:	Present-day machines appear to surpass humans in respect to the following:
1. Ability to detect a small amount of visual or acoustic energy	1. Ability to respond quickly to control signals and to apply great force smoothly and precisely
2. Ability to perceive patterns of light or sound	2. Ability to perform repetitive, routine tasks
3. Ability to improvise and use flexible procedures	3. Ability to store information briefly and then to erase it completely
4. Ability to store very large amounts of information for long periods and to recall relevant facts at the appropriate time	4. Ability to reason deductively, including computational ability
5. Ability to reason inductively	5. Ability to handle highly complex operations, i.e. to do many different things at once.
6. Ability to exercise judgment	

De Winter, J., & Dodou, D. (2011). Why the Fitts list has persisted throughout the history of function allocation. *Cognition, Technology & Work, 16(1)*, 1–11. https://doi.org/10.1007/s10111-011-0188-1, Table 1

The assumptions that the list make are valid in the sense that it has managed to capture the most important regularity of automation: if the machine surpasses the human, the function must be automated; if not, it does not make sense to automate (De Winter & Dodou, 2011). Another key finding by the authors was that *`Human tasks should provide activity´* and that human operators in the future air navigation and traffic control system should be active rather than passive ones. Activity in any task is conducive to alertness and helps to ensure that the human will keep abreast of the situation'. They compare this with more contemporary research which states that 'operators have a better mental model or awareness of the system state when they are actively involved in creating the state of the system than when they are passively monitoring the actions of another agent or automation`.

Several decades later, Lisanne Bainbridge published a research paper which was named *Ironies of Automation* (1983). It is arguably one of the more iconic research papers published in this field and its application on modern aviation is clear. One of the key takeaways is that the more advanced a control system may be, the more crucial may be the contribution of the human operator. Adding another layer to that argument, Bainbridge (1983) continues to discuss the designer´s view of human operators and that they are unreliable and inefficient. She concludes that there are two ironies of that attitude. One, designer errors themselves can be a major source of problems (which in turn requires a human operator to sort things out). And two, all the while the designer tries his best to eliminate the human operator by automation, he still needs the human to complete tasks which he cannot automate.

She continues to discuss not only manual control skills, but also cognitive skills and long-term knowledge. Applying this to aviation is also interesting. We can from this study conclude that we are poor at monitoring for longer periods and that we need to use knowledge regularly to be able to retain it efficiently. For clarity, one may draw a parallel to various subjects taught in middle school which may not have been used since and thus has not been retained efficiently. We also tend to become less efficient in monitoring when the automation works efficiently. Bainbridge (1983) continues to discuss that, within her cohort, operators with substantial experience of manual control still exist, but as time progresses later generations of operators cannot be expected to have this.

Flemisch et al. (2011) bring into light the concept of ability, authority, control and responsibility in human-machine systems and that we cannot necessarily change one of them without having to change something else as well. For example, making a parallel with Bainbridge's work, we cannot expect a pilot to have extraordinary (or even sufficient) abilities if he is not allowed to exercise control on a regular basis. Also, to be responsible for something, you also need a certain degree of authority in the same area. There can also be a major difference between *subjective* (the way one feels about one´s own actions) and objective (the way one´s actions are being judged by others) responsibility of the machine-operator which in turn may lead to undesired consequences. Applying this train of thought to the aviation industry, one can see that the machine-operators (pilots) may perceive themselves as gradually losing control in ever-evolving flight decks but the responsibility for the safe outcome of the flight remains. Another important perspective on the matter is what Flemisch et al. (2011) call A2CR consistency, meaning that the double and triple binds between the four cornerstones (ability, authority, responsibility and control) are respected. This is mainly taken care of in the design process and it should ensure that

- there is not more responsibility than would be feasible with the authority and ability
- there is enough ability for a given authority
- that the control is done by the partner with enough ability and authority and;
- that more responsibility is carried by the actor or his representatives who had more control

Any failure to achieve a balance between the four immediately or eventually creates tension fields with possible negative results. The authors present an extreme case where automation completely controls the task at hand, but all the responsibility remains with the human. Another aspect which is easily recognizable in aviation is a situation where the human believes that control is largely with the machine, and the machine "thinks" that control is largely with the human, leading to a low mode awareness on the part of the human. To conclude, Flemisch et al. (2011) state that we should strive for a situation where we combine the strengths of the machine with that of the human. Technology still has to serve the human, not the other way around, and when societally agreed values such as human health are at stake, we should leave the authority with the human.

Crow et al. (2000) discuss that the design process of man-machine interfaces historically has been an informal process, lacking in analytical design. They point out that legislative text regarding airborne software systems state that *reviews* (which provide a qualitative assessment of correctness) shall be made of the product, whereas an *analysis* provide repeatable evidence of correctness. They argue, by cross-referencing to computer science, that a method called Formal Methods (FM) can be used in the field of Human Factors design of new and on-going systems. It relies heavily on mathematical logic which can be subjected to very powerful analyses using mechanized theorem provers and model checkers, thus eliminating many of the previous factors of uncertainty. They further examine the strength of combining Human Factors research with the application of Formal Methods and state that the Human Factors community provides an understanding of what needs to be done whereas the Formal Methods community provide tools that would be able to scrutinize those ideas. This evidence-based way of approaching a problem would probably inject new ideas into the industry with regards to the possible degradation of manual handling skills and monitoring.

Scrutinizing flight training, Casner et al. (2014) concluded through practical experiments in a Level D Boeing 747-400 flight simulator that given a well-rounded and structured initial flight training, pilots generally maintained a good level of instrument flying skills (hand-eye coordination) over time with few deviations from altitude, speed and course. The cohort for the experiment consisted of Boeing 747-400 pilots flying for a major American airline, meaning they were exposed to a high level of automation and conducted relatively few approaches on an annual basis. It can also be assumed that a unproportionally high percentage (compared to other pilots) of their workday consisted of monitoring the aircraft instruments in straight and level flight given the type of operation they were involved in.

What could be seen however, was a degradation in cognitive skills while they were pre-occupied with hand flying the aircraft, meaning they would likely miss out on other important parameters such as failed aircraft systems or contradicting navigational information (or even the basic pilot duty of maintaining an awareness of aircraft position). In simple terms, most of their cognitive abilities were needed to manually fly the aircraft. Phrasing it differently, one can draw the conclusion that if they were to maintain a general situational awareness like what they have during normal line operations with all the automation engaged, it is safe to say that the precision of the manual maneuvering would degrade.

Casner et al. (2014) recommended that, given the findings of the study, pilots could benefit from more frequent practice of cognitive abilities rather than being given the opportunity to hand-fly the aircraft more often.

Automation surprises are naturally an unwanted side effect of increasing levels of automation sophistication. All operators (pilots) of a certain system cannot possibly now all possible combinations of how it is programmed to respond to inputs. Woods & Sarter (2000) identify three factors that, when converging, create the greatest chance of automation surprise:

- automated systems act on their own without immediately preceding directions from their human partner.
- gaps in users' mental models of how their machine partners work in different situations.
- weak feedback about the activities and future behavior of the agent relative to the state of the world.

In addition to studying the research that has been done in this field, it is a good idea to look at how the industry has evolved considering the progressive de-rationalization of the human being. There are a few notable accidents where faulty pilot behavior or a reluctance to take appropriate action have been determined to be contributing factors. Air France flight 447 is one example where the pilot, startled by the situation, over a prolonged period exerted continued back pressure on the side stick and thus was not able to recover from the stalled condition. Asiana flight 214 is another example where two professional pilots let the speed decay to 26 kts below Vref before acting (which unfortunately did not remedy the situation). We also see stricter SOPs emerging with regards to for example automation policies, use of flight directors and visual approaches. If a pilot makes a mistake while manipulating the controls, the solution oftentimes is to introduce more automation, limiting pilot latitude even more. Evidence-based training (EBT) could come in handy in some of these situations, letting forward-thinking airlines form their own training solutions to offset some of these issues.

To conclude, the research already conducted paints a picture where man and machine can and should co-exist. We do things differently and have inherently different qualities which are useful in different situations. What we do need to consider is the interaction between man and machine and that evolving technology should not outpace the need of hands-on training and innovative Human Factors-solutions.

This paper intends to complement current research by investigating modern pilots working in modern airlines and having them self-assess their position on the subject while simultaneously synthesizing available information from online sources. It intends to suggest solutions to declining hand-flying and monitoring skills and possible alternatives to strict automation policies.

Method

The combination of interviews and literature research was chosen to (to the extent possible) get the widest possible perspective. The combination of the two is meant to complement the other in creating a well-rounded picture of the situation. After some research, it was determined that a literature study on its own would fall short of investigating any possible discrepancies between industry-accepted training regimes and individual pilot perspectives. On the other hand, conducting only interviews would result in omitting important key concepts and it would be more difficult to claim a high level of validity without investigating the associated literature.

10 pilots from 6 airlines were chosen to participate in the interview part of the study. They were chosen based on experience (a minimum of 3 years in a commercial air transport environment) and recency (they were all active pilots at the time of the interview). All interviews except two were conducted via video-link and all answers were transcribed after the interview. The number of persons (10) were chosen to gain an as wide a perspective as possible while maintaining a reasonable workload. Names, airlines and other sensitive information have been anonymized for the sake of confidentiality. Types of aircraft flown after basic flight training are described in the broad categories of JET and TURBOPROP and are also categorized according to maximum take-off mass according to the table below for the purpose of indicating the operating experience of the interviewee.

L	Aircraft types of 7,000 kg or less
M	Aircraft types more than 7,000 kg but less than 136,000 kg
H	Aircraft types of 136 000 kg or more, except for aircraft types in the Super (J) category

Acronyms used for the purpose of discerning different aircraft in this study

LTP = Light turboprop
LJET = Light jet
MTP = Medium turboprop
MJET = Medium jet
HJET = Heavy jet

Participant data

Other than the interview questions, all participants were asked to provide the following information:

A) Number of years in commercial aircraft operations
B) Types of aircraft flown (according to table above)
C) Number of total flight hours
D) Number of airlines employed in

1	A) 14	B) 2xMJET, 1xLTP	3	C) 6000	D) 3
2	A) 26	B) 3xMJET, 2xMTP, 1xLTP	6	C) 12300	D) 5
3	A) 20	B) 1xMJET, 1xMTP, 2xLTP	4	C) 8000	D) 5
4	A) 12	B) 3xMJET	3	C) 5750	D) 3
5	A) 3	B) 1xMJET	1	C) 2500	D) 3
6	A) 12	B) 2xMJET	2	C) 7000	D) 2
7	A) 16	B) 2xHJET, 2xMJET	4	C) 8700	D) 4
8	A) 13	B) 4xMJET	4	C) 5500	D) 5
9	A) 4	B) 1xMJET	1	C) 2700	D) 2
10	A) 15	B) 1xLJET, 3xMJET, 1xMTP	5	C) 7500	D) 4
M	A) 13.5	B) 3.3	3.3	C) 6595	D) 3.6

The mean number of years in commercial aircraft operations (excluding instructor time in light piston aircraft) was 13.5. The mean number of aircraft flown (aircraft which require a type rating) was 3.3. The mean number of total flight hours (including own basic flight training and where applicable, time as an instructor on light piston aircraft) was 6595. The mean number of airlines employed in (excluding where applicable any employment as an instructor at a flight school) was 3.6.

Instruments

Each participant was asked 10 questions. The questions were designed to investigate the training history, current work practices, local cultural phenomena, changes in skills over time and the general attitude of the applicant towards the importance of retaining manual handling- and monitoring skills. The questions are inserted below and accompanied by brief explanations that sometimes were required during the interviews.

1. Do you feel more confident today than earlier in your career with taking manual control should anything unexpected happen to the aircraft state?

This question intends to investigate if the participant considers the recurrent training practices and operating procedures of his or her airline to maintain the skills acquired during basic training.

2. Do you feel more or less capable today than earlier in your career in discovering an unannounced deviation in course, speed or altitude?)

This question intends to investigate if the participant considers the recurrent training practices and operating procedures of his or her airline to maintain the skills necessary for effective monitoring (effectively an antidote to complacency).

3. In what way does your airline facilitate your abilities to manually handle the aircraft?

This question intends to investigate to what degree the employer of the participant combat automation complacency and also indicates the value of these skills attributed by airline management.

4. Do you feel that you get sufficient training in manually handling the aircraft while in the simulator (motivate your answer)?

This question intends to investigate to what degree the training department of the participants employer value the proper conservation of manual handling skills. It may help to see this from the perspective of the aviation core competencies, where effort is made to develop pilot skills within a range of set competencies, one of which is manual control of the aircraft.

5. Do you believe that your airlines´ procedures allow you to get sufficient training in manually handling the aircraft during normal line operations (motivate your answer)?

This question intends to investigate to what degree, if any, airline operating procedures hinder the participant from the possibility of practicing manual flight during normal line operations.

6. Do you believe that you award yourself sufficient opportunity to practice manual flying within the framework of your airlines′ operating procedures (motivate your answer)?

This question intends to investigate to what degree the participant (by his or her own initiative) uses the possibility to practice manual handling skills during normal line operations.

7. How would you describe the culture regarding use of automation in your airline?

This question intends to investigate the culture surrounding the use of automation at the participants current airline. In broad terms the answers should be placed on a scale from *loose* (plenty of hand-flying and a liberal automation policy) to *restrained* (lots of automation usage and a detailed and strict automation policy).

8. Do you notice any differences in awareness and abilities in how you or your colleagues view manually handling of the aircraft today compared to earlier in your career?

This question intends to investigate if the participant has spotted any macro trends, either within his or her own airline or in the industry as a whole regarding the use of automation.

9. If you could change anything in recurrent training or operative policies at your airline that would promote your ability to manually handle the aircraft, what would it be?

This question intends to investigate whether the participant has reflected on his or her own recurrent training or day-to-day operations and if anything can be done from a policy point of view to promote hand-flying skills.

10. If you could change anything in recurrent training or operative policies at your airline that would promote your ability to monitor the flight, what would it be?

This question intends to investigate whether the participant has reflected on his or her own recurrent training or day-to-day operations and if anything can be done from a policy point of view to promote monitoring skills.

Procedure

Stemming from the design of the interview questions, three themes were created to synthesize responses pertinent to the research question. They were

- The degree to which manual handling and monitoring skills are conserved over time
- The degree to which airline management shows propensity to adapt training scenarios and operating procedures to the modern flight deck
- The degree to which the respondent self-assesses his or her own engagement (and that of others) in the context of manual handling and monitoring skills

The answers from the respondents were coded either as supporting/maintaining a positive stance towards the premise of the question or not agreeing/not seeing evidence of it in their day-to-day operations. Out of the 100 answers given, four (4) were considered inconclusive and/or the respondent manifested an indifference in their response.

The literature study was conducted using key words in Google and Google Scholar which are affiliated with the subject. Results from other industries were largely excluded due to the high number of results from the aviation industry. Of the remaining results, the ones with a specific focus on skill degradation and its associated mitigation strategies were chosen. The phrases used were as indicated by the table below.

humans in an automated environment
human factors automation design
ironies of autmotation
Fitts list
Manual handling skills in aviation
how to preserve manual handling and monitoring skills in aviation
David Woods automation suprises

Having looked though the large number of articles, 55 articles were chosen for further scrutiny and in the end 9 articles were chosen on the grounds of being judged the most relevant for the research question.

Results

The original aim with the study was to investigate if pilot training in manual handling and monitoring skills is keeping an even pace with the evolving technologies we are surrounded with and if there are procedures and practices from elsewhere that, if implemented, would have a beneficial impact on how the industry conducts training and checking.

Main themes

Based on the results of the interviews three main themes were created, all of which have an impact on the initial research question.

The degree to which manual handling and monitoring skills are conserved over time

The thematic analysis showed that 5 respondents, or 50 %, self-assessed their manual handling skills as being better today than before. The other 5 respondents, or 50 %, self-assessed their manual handling skills as being worse today than before. It is worth noting that 4 respondents out 5 in the first group were in the bottom half of the cohort with regards to experience level (total flight time and years in the industry), whereas 4 respondents out of 5 in the second group where in the top half.

> Well, I do believe that the total experience of being in the aircraft means a lot, so yes, the answer is yes. [Pilot 3]
>
> Hard question, I would off the top of my head say no, I do a lot less manual flying these days than before. So, actually, no. [Pilot 6]

We can see from the excerpts that the reasons vary greatly and ranges from self-image and reduced cognitive abilities to automation complacency, change of employer and being well-versed with recurrent training scenarios.

The examination of preservation of monitoring skills yielded different results. 9 respondents, or 90 %, self-assessed their monitoring skills as being better today than before. Only 1 respondent, or 10 %, self-assessed his monitoring skills as being worse today than before (he was in the bottom 20 % of the cohort with regards to total flight time and years in the industry). The reasons for this also varied and ranged from being able to filter information better due to experience to working with better automation on more modern flight decks which consequently freed up cognitive abilities for monitoring.

> If you look at our airline from a historial perspective, we have always put more effort into the monitoring part of the flying. I believe we have good tools and during the last years we have also a lot on the pilot monitoring aspects. It even says that when the PF is on raw data PM is expected to be more assertive in their communication. So with regards to monitoring, to be a little conspiratorial, I think that we as an airline deep down knew that we had to improve and that is why we are good at it today. [Pilot 6]
>
> Well, I believe I have improved in that area. I think. I´ve become better at filtering away unnecessary information, to weed out the less important stuff. Filtering abilities improve with experience. [Pilot 2]

Synthesizing the excerpts, we can conclude that experience (knowing what is important in a particular stage of the flight) and more advanced and reliable automation (effectively acting in a monitoring role even while being the pilot flying) give pilots a steadfast stream of opportunities to enhance their monitoring skills. Neither of the respondents explicitly stated complacency as having a negative influence over time. The last excerpt above may however be interpreted along those lines and it can be attributed to a rigid SOP with very little leeway in terms of individual freedom and interpretation of operating procedures.

The degree to which airline management shows propensity to adapt training scenarios and operating procedures to the modern flight deck

The essence of this theme was to investigate whether airline management recognizes the need for the maintenance of manual handling- and monitoring skills and the theme comprised most of the interview questions leading to a multi-faceted array of answers. When asked in what way their employer promotes manually manipulating the controls during normal line flying the common thread among the respondents was *"not much, but they do not prohibit it either"*.

> Hm, well, that is a tricky question because I would like to say that they do not do anything outside of their stated scope of responsibilities. [Pilot 2]

> Hm, well visual approaches are encouraged when the weather allows and in appropriate airports. So there are no obstacles, they have not explicitly prohibited it either, we are sure able to perform them. And we are also practicing it in the simulator every 6 months. That is what comes to mind. [Pilot 4]

> Good question. I can´t think of anything in particular that they do to promote it, there is not a lot about it the manuals either. We do get a lot of it for free though as we have different job than in other airlines. That is not negative in m y opinion. [Pilot 8]

The above excerpts illustrate a sort of laissez-faire attitude towards maintaining a high and uniform level of manual handling skills among the pilot ranks. It shows that among the 6 airlines who were represented in the study, neither of them explicitly prohibited hand-flying but left it to the flight crew to decide if it was suitable to do so given the external circumstances. One of the airlines put so many restrictions on it (visual approaches) that it can be reasonably assumed that pilots experienced a higher mental threshold leading them to practicing it less frequently.

Similar results were yielded when the respondents were asked about simulator training. 8 out of 10, or 80 % of the respondents expressed a wish for more hands-on training while in the simulator while 2 out of 10, or 20 %, were satisfied with the amount of training that they received. This indicate a discrepancy between what pilots believe would be beneficial in their line of work and what lawmakers and airline managers provide them with.

> Yes, I do think so, our simulator training is really good. [Pilot 7]

> I would love to do more, but at the same time it is hard to simulate visual approaches in the simulator, it is not the same fidelity. Again, with our aircraft, where the flight path vector is visible all the time, stuff like that does not become very difficult. We should probably train more without flight path vector or flight director. I don´t think I have ever done that in this aircraft. [Pilot 8]

Approaching the question from a different angle, the respondents were asked if they had any opinions of their own regarding how they are trained in **manual handling skills** at their respective airline. 8 out of 10 of the respondents, or 80 %, responded with suggestions that would effectively alter the way recurrent training is performed. 1 out of 10 respondents, or 10 %, was content with the way training was performed and one respondent (10 %) had no opinion on the matter. In the large group in favor of change, three themes could be discerned and they were more frequent visits in the simulator, less stringent time constraints in the simulator (leading to the possibility of individual retakes on various items to boost pilot confidence) and a shift of focus from learning about all the technological advancements to turning everything off and rely on raw data and one´s own common sense.

> Well, it would be nice with some more hand-flying the simulator with two engines. You´re used to flying around in the simulator with one engine, I don´t know anyone who does a lot of flying with two engines, really [Pilot 1]

> Well, I think that instead of sim training every 6 months we should have a session every three months. Training flight, then three months later PC, then three months later another training flight. You tend to forget things after 6 months. [Pilot 4]

To stay on the matter, the respondents were further asked to assess their employers ability to train its crews in **monitoring skills**. The responses, as with the comments regarding manual handling skills, were in favor of change of existing training programmes. 6 out of 10, or 60 %, of the respondents assessed that a change to their recurrent training programmes would be beneficial for the continued development of their monitoring skills. 3 out of 10, or 30 %, of the respondents were content with the current layout of their recurrent training programmes and one respondent, or 10 %, gave an answer from where information could not be discerned.

Maybe more flying without flight path vector [Pilot 5]

Not anything I can think of with regards to training [Pilot 7]

The excerpts, in general, again suggest a discrepancy between what lawmakers and airline management provide in terms of recurrent training with that of the opinion of those who are exposed to it.

The degree to which the respondent self-assesses his or her own engagement (and that of others) in the context of manual handling and monitoring skills

This theme emerged from the notion that having a liberal and understanding attitude on the part of airline management does not necessarily mean that flight crews entertain their manual handling- and monitoring skills to a high degree. When asked to assess the culture surrounding the use of automation (ranging from maximum use of automation to very little use of automation) in their respective airline, 5 out of 10, or 50 %, of the respondents assessed the pilot group they belonged to as having a liberal stance towards the use of automation and a will to develop their manual handling skills. The other half of the respondents expressed that they assess their pilot group as being too keen on using automation and that more manual flight would benefit their collective skill set.

> I would say that the task at hand demands a lot from you, you need to be able to hand-fly the aircraft from time to time so you can´t work here if hand-flying is not your thing. [Pilot 3]

> At airline XX, we had two groups, one group where people were terrified of hand-flying and one group that gladly hand-flew but did a very poor job from time to time. Hot and high and many go-arounds. At airline YY, it was a lot more manual handling, people would disconnect a lot and do many visual approaches [Pilot 10]

Skills may decay over time despite good intentions and liberal operating procedures. When asked to turn to themselves and assess whether they believe that they themselves take enough opportunity to manually fly the aircraft, 0 out of the 10 respondents answered that they take plenty of opportunities in various weather conditions and operating environments as allowed by their airline´s operating procedures. 1 respondent out of 10 answered that he is fairly good at it if not too tired and another one answered that he takes a fair amount of opportunities when the weather is good.

> It´s rare, we are much too lazy [Pilot 8]

No. To be honest, I´m too convenient. [Pilot 7]

One can discern an interesting discrepancy between what the respondents believe to be the general culture in their working environments, that is, effectively the behavior of their peers, versus their own stance towards the issue. They overwhelmingly believe that they themselves need to practice manual handling skills more often while their peers seem to take the opportunity to do so more frequently.

Literature

The literature part of the study showed that the underlying reasons for lack of manual handling and monitoring skills could be narrowed down to a few categories. The reason for the specific categorizations below is that they indicate working patterns, training philosophies and general strategies which may or may not be in use today (and if they are, could be developed even further) but would be beneficial to the retainment of manual handling and monitoring skills.

Mumaw et al. (2020) discuss the importance of finding strategies of freeing up attentional resources rather than emphasizing pilot vigilance or simply just asking pilots to make an effort in sustaining effective monitoring over time. Trainers should also avoid the encouragement of attention switching but rather emphasize completion of for example approach briefings in due time so that effective and unhindered monitoring during the approach phase of the flight can be performed. This is seconded by Sumwalt et al. (2002) who point out that as a majority of the monitoring errors occurs in a vertical phase of flight (climbs, descents or approach), it is advisable to concentrate as much of non-monitoring chores to the cruise portion of the flight as possible. They also conclude that training efficiency could be increased by introducing subtle unannounced automation failures to provide the pilot monitoring with exposure to unexpected events.

Oliver et al. (2019b) points at a lack of practice in mindful organizing. Pilots become detached from their highly automated environment and thus are less capable of diagnosing abnormalities once they occur. They will have a smaller repertoire of previous events to draw conclusions from and are therefore more likely to be overwhelmed when abnormal situations require manual input. We can therefore see that **strategies** in workload management and **exposure** to more non-automated events (or a failure of the automation) would likely increase pilot monitoring ability.

Mumaw et al. (2020) also discuss the CBSD-concept (Concept, Briefing, Simulation and Debriefing) and propose shorter cycles than what is seen today to increase learning. This is in line with Haslbecks et al. (2014) findings where lack of recency and everyday practice are the main reasons for poor manual handling skills. They propose a remedy of additional simulator sessions and, in the case of long-haul pilots (where applicable) mixed-fleet flying to increase total exposure to more demanding flight phases such as approach and landing.

Dissecting *how* we train pilots reveal that there are limitations in fidelity (Oliver et al. 2019b). They continue to discuss that the industry tends to avoid scenarios which are outside of the normal flight envelope and when an accident occurs, the operating envelope tends to shrink making pilots even more deprived of unusual aircraft behavior. We can therefore conclude that **recency** in actual hand flying and more out of the ordinary **training scenarios** would be beneficial to the retainment of manual flying skills.

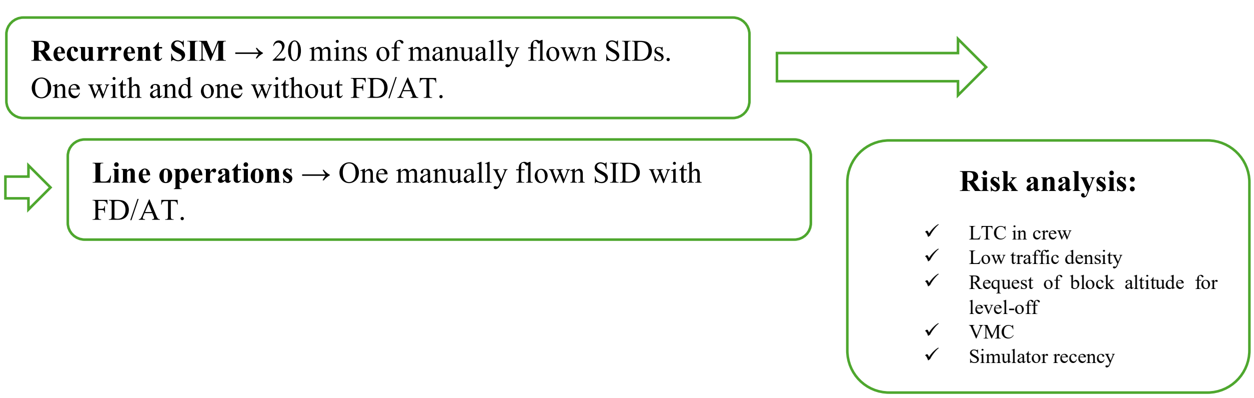
Discussion

This report intended to examine if industry strategies are in place to sufficiently cater for the retainment of manual handling and monitoring skills among pilots. The results reveal that there are dissonances between what experienced line pilots (the interviewees) believe to be the most beneficial practices to enhance their skill sets and what they are exposed to in their daily operations. Similar tendencies in the interview- and the literature part of the study can be seen, with the literature showing that there is a need for the industry to rethink its take on recency and how we avoid becoming too reliant on automation.

Rewinding back to the first theme (the degree to which manual handling and monitoring skills are conserved over time), the study has shown that they generally do not improve over the course of a pilot´s career and thus has the potential to become a liability if a certain pilot is faced with a situation requiring the use of those skills. This we do know and there are relatively simple remedies. First, recurrent simulator training needs to have time allocated to a variety of manual handling exercises (this would be beneficial for the monitoring role, too) and this should be strictly training and no checking. Further, modern simulator handling exercises are usually constructed with a limited amount of imagination. They mostly consist of several pre-set UPRT situations which are the same year in and year out and one or a few manually flown approaches, sometimes even with flight director and, in the case of Asiana airlines, auto thrust available (NTSB, 2014). Some airlines have begun to realize that this type of training is needed but it is not yet an industry standard.

Many pilots tend to only talk about visual approaches when discussing the retainment of manual handling skills. The take of this report is that we need to expand the scope and realize that while it is good to hand-fly the aircraft the last couple of thousand feet in sunny conditions, it is not by any means an exhaustive solution to the problem at hand. While conducting visual approaches is better than not hand-flying at all, it upholds a very narrow skill set. Airlines, operators and legislators must find ways to safely allow pilots to maintain these skills in other ways than what we do today.

Below follows an example (constructed by the author) of one of several ways an individual airline can implement procedures that would enhance manual handling- and monitoring skills while upholding a high degree of safety.



➪ **Line operations** → One manually flown SID without FD/AT.

In the example, 20 minutes of simulator time can be allocated to a simple task; hand-flying the same Standard Instrument Departure, twice. One time with flight director and auto thrust and one time with raw data only and manual thrust. Following the return to normal line operations, the same (or a similar) Standard Instrument Departure can be flown in real life. Again, with full flight guidance and auto thrust the first time and then without any flight guidance and auto thrust the second time. The example is created to slowly coerce pilots away from their comfort zone and it should naturally only be performed after a risk analysis. The obvious risks of level busts and a high workload can be mitigated in several ways, including those stated below.

- Having a Line Training Captain in either seat
- Designating low density airports from which this can be practiced (and include local ATC)
- Requesting a block altitude for level-off to allow for slight under/overshoots and extra separation to other aircraft
- Only do it in Visual Meteorological Conditions or similar (good) weather
- Only do it within a certain time frame (for example, within 8 weeks of the simulator training)

An additional benefit is that monitoring skills would also be enhanced. The amount of scenario compositions are many and this paper proposes that a three-year cycle can be applied to three broad training scenarios. The first one can be as described above. The second can be instrument approach practice with similar prerequisites and the third one can focus on visual approaches. The author´s employer require that two real or simulated CAT II-approaches are performed before every biannual simulator training event to uphold important skills such as procedural knowledge and crew coordination. Retaining manual handling- and monitoring skills should be equally important. The above proposal would in the author´s opinion cover the aspects of **recency** well enough without incurring too big a burden on line trainers, management and/or crew scheduling. It would also partially fulfill the goal of increasing **exposure** to events other than normal line operations by increasing the burden on the pilot monitoring and also serve as a stark reminder to effectively manage their workload **strategies** accordingly.

UPRT training, which serves as the basic protection barrier between LOC-I accidents and successful outcomes, while obviously serving a good purpose, needs to be complemented with more scenario-based out-of-the-envelope training. Profiled accidents such as Asiana 214 (NTSB, 2014), Air France 447 (BEA, 2012) and Turkish 1951 (Dekker, 2009) were all recoverable, but from outside the normal flight envelope. They also took the crews by surprise and the associated *startle effect* was a contributing factor to the tragic outcomes of each accident. To create more out of the ordinary **training scenarios** in the simulator, training departments could benefit from presenting more subtle (and sometimes not so subtle) faults which are not necessarily associated with the task at hand. Drawing from experience, most malfunctions encountered during line operations are naturally unexpected, but many of them do not necessarily startle the crew either. Examples of such training events can be

- Uncommanded speed brake deployment on final approach
- Subtle (gradual) incapacitation of a flight crew member
- Failure of the autopilot to capture the localizer
- Wind shear during departure
- A runway incursion on short final

These examples are not especially strange or unique. The learning experience would be in experiencing them while being mentally pre-occupied with a completely different training scenario. The interviews revealed a high degree of discrepancy between what is provided to the pilot community in terms of training and what the pilots themselves believe would be beneficial in their line of work. We can see that a liberal automation policy does not necessarily equal a high degree of manual practice and thus does little good in providing tools for upholding recency. This is probably a natural effect of wanting to stay inside one´s comfort zone, provide the best possible experience for the passengers and maximize cognitive abilities on the flight deck. The analysis of the interviews matched the literature study very well in that they both showed evidence of a degradation of skills over time. That is why the suggestion to create recurrent mandatory manual handling scenarios is such an important one.

Taking on the perspective of upper management, there might very well be a conflict of interest in providing their crews with ample training opportunities. A very strong reason as to why we have a high level of safety in the aviation industry is advanced automation. Disconnecting it seems counterintuitive at first glance. This is where the paradox lies, but at some point, we need to accept that with the level of authority and responsibility given to flight crews, there should be a reasonable chance to maintain an equally high level of ability. This will in one way or another come at a cost. It will cost money to investigate how this should be done. It will take time and resources to implement plans and evaluate the results. Lastly, it will certainly be considered an operational risk. An airline with hundreds of flight crews would increase exposure to level busts, navigational errors and other related errors tremendously with this type of training. All in the name of preventing an accident that might never happen. This leaves us with the natural option of conducting extended manual training in the simulator only. This would of course be better than doing nothing at all but it would fall short of the intents of this paper. The idea (extended manual handling during line operations) would also strike differently across the board. One of the interviewees shared a situation where several go-arounds were reported in a short time frame at airline X. The solution was to prohibit visual approaches and come up with a multitude of restrictions to come to terms with the problem. Later in his career, the same sequence of events unfolded at airline Y. Management then issued a memo urging pilots to practice visual approaches to raise the collective skill level. Two diametrically opposed solutions to the same problem which are probably rooted in the culture of the respective airline.

By dissecting the associated core competency (Aeroplane Flight Path Management, manual control), we can see from the results of this study that sections OB 4.1 through to OB 4.7 places demands on pilots for which they are hard-pressed to find enough opportunities to regularly practice, either by their own choice or by abiding under strict SOPs which does little to enable enhancement of these skills.

Aeroplane Flight Path Management, manual control Controls the flight path through manual control	OB 4.1 Controls the aircraft manually with accuracy and smoothness as appropriate to the situation OB 4.2 Monitors and detects deviations from the intended flight path and takes appropriate action OB 4.3 Manually controls the aeroplane using the relationship between aeroplane attitude, speed and thrust, and navigation signals or visual information OB 4.4 Manages the flight path safely to achieve optimum operational performance OB 4.5 Maintains the intended flight path during manual flight while managing other tasks and distractions OB 4.6 Uses appropriate flight management and guidance systems, as installed and applicable to the conditions OB 4.7 Effectively monitors flight guidance systems including engagement and automatic mode transitions

From IATA (2023) *Competency Assessment and Evaluation for Pilots, Instructors and Evaluators. Guidance Material, Second Edition.*

Limitations

The interview part of the study was conducted within a confined geographical area (all respondents were based in, and had the most experience, from European operations except for one which was based in the Middle East). It was therefore very hard to create an accurate picture of an average pilot put in a global perspective. Geographical and cultural differences are a reality in aviation despite the level of standardization the industry has reached. The interviewees included in this study have varied backgrounds, but most of them stem from the same part of the world, leading to the risk of missing out on other practices from elsewhere. The format of the interviews was casual and with no requirement to grade experiences or other phenomena on a numerical scale. The natural form of analysis is therefore a qualitative thematic one and with this comes the risk of subjective assessments and a risk of missing out on recurring themes that would have been picked up by other actors. Adding a quantitative analysis may or may not have supplemented the results in a positive way. The literature review was mostly confined to aviation. Plenty of literature was available in this domain which naturally led to lack of cross referencing to other industries such as health care and the car industry. Having done this to some extent could possibly have nuanced the study a bit better.

Conclusion

This study has found that the industry does not to a sufficient degree cater for the proper retainment of manual handling- and monitoring skills. Possible consequences include not upholding the desired level of safety should aircraft automation completely or partially fail. The threshold to the pilot decision of manually taking control should the automation act up in any way or otherwise show erroneous values is also higher if recurrent training in manual handling is insufficient.

The findings of this study can be used to alter recurrent training programmes so that they conform more with what pilots believe would be beneficial for their continued development and what the literature suggests would generally enhance pilot abilities.

Further research would preferably be directed towards efficient risk management in the context of practicing manual handling- and monitoring skills as the industry would be unlikely to accept any reduction in safety for the sake of practicing these skills during line operations.

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