Effect of Learned Carelessness and Consciousness on Erroneous Takeoff Performance

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Abstract

Takeoff performance is derived from the basic aircraft weight and balance data, modified for operational, commercial and environment factors. There can be an error of commission or omission at any stage. Errors can have no significant impact on one hand to catastrophic impact on the other extreme end of the spectrum. Airlines and the manufacturers have addressed the issues and have formulated new policies, SOP's and enhanced technical modifications to trap the error. Despite the enhancements the errors continue to reoccur or occur due to a new reason, which was not addressed before. This paper examines humans from the behavioral aspect in error causation and as the last line of defense in the chain of errors. A new aspect for error causation and failure of humans to adhere to checklists, procedures is analyzed. The solution lies in simplistic methods that can help trap errors to prevent erroneous takeoff performance.

Keywords: Performance, Learned carelessness, mindfulness, pointing and calling, behavior, barriers, checklist, concentration.

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A number of serious incidents have been attributed to incorrect takeoff performance. A total of 20 occurrences were identified between the period 1 January 1989 and 30 June 2009 where the calculation or entry of erroneous takeoff performance parameters were cited as contributing to commercial jet aircraft accidents (Hughes, K. L., & Godley, S. T. 2011).

Humans and human factors play a critical role in aviation and systems engineering. According to Theory Z, systems work because (Cacciabue, Hjälmdahl, Luedtke, & Riccioli, 2011, p. 3,4):

(1) people learn to identify and overcome design flaws and functional glitches;

(2) people can recognize the actual demands and adapt their performance accordingly;

(3) people can interpret and apply procedures to match the conditions; and

(4) people can detect and correct when something goes wrong or when it is about to go wrong, hence intervene before the situation becomes seriously worsened.

Theory Z proposes that systems work because people are flexible and adaptive, rather than because the systems have been perfectly thought out and designed. Humans are no longer a liability and performance variability is not a risk.

The Problem

Humans are adaptive and flexible but are still prone to making errors. The reasons for the failure attributed to human factors have been investigated and various measures have been taken by the airlines and industry to eliminate the errors; however, either the error reoccurs or new types of error occur. The problem is that not every scenario can be defined and resolved by the airline and the manufacturer. New types of error or unexpected errors may occur; therefore, the human represented by the flight crew have to be trained to identify and mitigate the risk generated by these errors. Since errors are not intentional, and since we do not need a particular theory of errors, it is meaningless to talk about mechanisms that produce errors. We need to look at reasons for non-compliance of normal procedures. Inventing separate mechanisms for every single kind of 'human error' may be great fun, but is not very sensible from a scientific point of view (Cacciabue, Hjälmdahl, Luedtke, & Riccioli, 2011, p. 4). Repeated and error free operation can be achieved through enhanced awareness of the situation, preventing distractions and increasing concentration.

International studies

There have been three studies carried out primarily addressing the issue of erroneous takeoff performance.

1. ATSB (Australian transport safety board) transport safety report Aviation Research and Analysis Report –Takeoff performance calculation and entry error (study 1).
2. "Use of erroneous parameters at takeoff" study ordered from the LAA by the BEA and the DGAC, in which Air France and Corsairfly participated (study 2).
3. Performance Data Errors in Air Carrier Operations: Causes and Countermeasures (study 3).

The studies have analyzed human factors to determine their role in errors linked to FMS (Flight management system), memorization and decision-making. The study has not analyzed the role of human factor in routine tasks, which lead to behavioral changes.

The most common contributing safety factor identified related to (Hughes & Godley, 2011, p. 6):

1. Crew actions (39 per cent), including monitoring and checking, assessing and planning, and the use of aircraft equipment.
2. This was followed by absent or inadequate risk controls (31 percent), mostly

centered on poor procedures, non-optimally designed aircraft automation systems, inappropriately designed or unavailable reference materials, and inadequate crew management practices and training.

3. Common local conditions (27 per cent) involved inadequate task experience or recency, time pressures, distractions and incorrect task information.

Different airlines and aircraft types calculate takeoff performance using different methods. This means there is no single solution to ensure that such errors are prevented or captured. The two reports also discuss several error capture systems that airlines and aircraft manufacturers can explore in an attempt to minimize the opportunities of takeoff performance parameter errors from occurring or maximize the chance that any errors that do occur are detected and/or do not lead to negative consequences.

Study 1

Overall, the study determined that these types of errors occur irrespective of the airline, the aircraft type, the equipment, and the data calculation and entry method used.

They occur frequently, but are normally detected by the defenses put in place at both the organizational (airline) and individual (crew) level (Laboratory of Applied Anthropology, 2008).

Workload of the crew is not distributed evenly. It has periods of high activity involving receiving and reviewing flight plans, obtaining weather information, the loading of passengers, cargo, and fuel; receiving/preparing load and trim sheets; maintenance requirements; air traffic control clearances; entering data into aircraft systems; completing checklists; and conducting briefings. There are periods of lull when the crew is awaiting completion of all activities and the final numbers, clearances to arrive. These periods of lull cannot be utilized for spacing out activity since the base values are not available to predict the numbers.

The flight preparation activity requires the collaboration and interaction of the cabin crew, refuellers, engineer, passenger services agents etc. both among themselves and with the flight crew. The flight crew needs to be aware of the progress of each activity so that the flight can depart on time, they are often unpredictable, demand immediate attention, and interrupt and distract the crews' responsibilities (Loukopoulos, Dismukes & Barshi, 2001).

A threat and error management analysis of 4,800 flights by The University of Texas determined that one-third of threats were related to airline activities. These included ground, ramp, dispatch, and cabin related actions; and operational pressures. Of these, 75 per cent occurred during the pre-departure phase of flight; 26 per cent of crew errors also occurred during this phase (Helmreich 2005).

Study 2

The study highlights that the observations show that the culmination of all activities lead to the production of the final load, whatever the airline and the equipment used. The final takeoff performance parameters are calculated on the basis of the final load sheet and entered/revised in the FMS. To prevent bunching of activities that lead to time and task pressures, airlines adopt different operating methods.

For weight data, the crew initially works out parameters based on a provisional or forecast takeoff weight and then if the final weight is more than the provisional weight, recalculate the takeoff performance. In most cases it leads to double data input.

The study of incidents highlights the ineffectiveness of the control functions. The controls are often item by item comparisons. But "one wrong item = one wrong item" is an accurate but inadequate control. In reality, there is no overall consistency check.

Study 3

The study observed that only 20 out of the 112 errors were trapped before they became consequential. The pilots trapped only 2 of the13 errors as a specific result of executing S.O.P. such as performing checklist and crosscheck. The pilots performing additional crosschecks on their own initiative and resolving suspicious or inconsistent performance data trapped the other 11 errors. The study highlights the fact that this non-procedural check is an important safeguard that draws upon the pilots' knowledge and experience. Cognitive and human factor analysis leads to the following categories of error causation.

1. Time pressure
2. Rushing
3. Not cross checking
4. Expectation bias
5. Disrupted/disruptive habit pattern
6. Distraction
7. Not being proactive
8. Fatigue
9. Workload spike
10. Prospective memory
11. Confusion

Summary of the reports highlights the facts that:

1. Crew is involved in most of the errors in calculating the takeoff performance.
2. The errors range from various FMS entries to performance calculation.
3. Ineffective cross check and checklist compliance leads to omission and

commissions errors.

4. Time, Task pressure and distraction is also a leading cause of errors.

5. There is no means of verifying the accuracy of the data, the pilot only checks for correctness of the data entry as received through various sources. The same applies for the takeoff performance parameters.

Improvements suggested in the reports are through creation of barriers.

1. Physical barriers,
2. Functional barriers (controls during item input),
3. Symbolic barriers (procedures, guidance) that require interpretive action to achieve their aim,
4. Incorporeal barriers (safety policy, user knowledge).

EASA issued a safety information bulletin (SIB) on 16 Feb 2016, SB no. 2016-12 with the subject “Use of erroneous parameter at takeoff”. The recommendation of the SIB includes prevention in the context of Crew Resource Management training, as well as raising flight crew awareness on the issue of automation overreliance, and the need to conduct appropriate consistency checks (e.g., mental gross error check, the pilots should know a few rules of thumb to detect large inconsistencies, and be encouraged to apply them during the pre-flight check, cross check of the EFB outputs).

Improve Situational awareness during takeoff roll to ensure detection of erroneous takeoff parameters. (e.g., low acceleration, sluggish and/or nose heavy rotation, rough idea of the runway position where V1 or Vr should be passed)

These barriers do not address the issue of why humans continue to make errors, and the fact that preventive strategies cannot be created for all possible events and combinations of events. Human is the last line of defense in the chain of errors; therefore there is a need to make the human more resilient and conscious of the situation, to take informed decisions.

Human failure to trap error

If cockpit checks and checklists were to be performed diligently, there would be no room for error. One of the reasons for errors to escape the human barrier is what is called "learned carelessness".

Checklists are used in aviation in order ensure that critical actions are carried out and they are confirmed and/or crosschecked by the crew. Checklists are carried out on every flight but incidents occur rarely. According to Frey and Schulz-Hardt(1997), (Aust, Moehlenbrink, & Jipp, 2011), procedures of this type can lead to the development of a psychological state called learned carelessness.

Humans are "cognitive misers" (Wickens & Hollands, 2000) which means that they follow the path of the least cognitive resistance. A reduction in effort is positively reinforcing and therefore, increases the likelihood of future shortcuts in the absence of negative consequences.

The underlying motivation is assumed to maximize pleasure while minimize discomfort. Once learned carelessness has developed it will distort a person's perception, selection, and interpretation of subsequent information in favor of the monopoly hypothesis. This top-down information processing impairs motivation and capability to detect incidents. The result is unreasonably risky behavior.

Study 4

A study was conducted in a low-fidelity flight simulator. The pilots' primary task was to check flight plans on the Advanced Human Machine Interface, a multifunction displays and graphical user interface for the Advanced Flight Management System, for errors (Korn & Kuenz, 2006).

The system allows for flight plan creation, editing, trajectory generation and negotiation with air traffic control via data link communication. Advanced Human Machine Interface serves as an ecologically valid testing environment for the study of learned carelessness in pilots because multi-function displays are being increasingly incorporated into modern cockpit layouts.

All flight plans contained approaches to Frankfurt airport (Germany) from one of four orientations. Participants had to check for six possible errors:

1. The flight plan did not end on the runway,
2. The aircraft had already passed the first waypoint of the flight plan,
3. The generated trajectory contained an undesired circle back to its first waypoint the aircraft had already passed,
4. The cruise flight level was set to 0 feet,
5. The glide slope intercept altitude was incorrect, and
6. The runway altitude was incorrect.

Frey and Schulz-Hardt (1997) assert, that an increasing number of incident-free repetitions of a procedure should increase carelessness on a cognitive and behavioral level. There was no difference in pilot’s performance observed between their first and last 30 flight plan inspections in the buildup phase. As predicted, after processing 150 error-free flight plans, pilots overlooked significantly more errors during the test phase than those who had repeatedly encountered erroneous flight plans.

The difference was not because of a response bias. The study observed that the carelessness was introduced on a cognitive level only. Eye movement is a direct measure of attention allocation in the research of automation complacency and related concepts (Parasuraman & Manzey, 2010). Observers viewed participants eye movements during flight plan inspection to determine whether checks were performed. The results provide evidence that in the inspection paradigm careless pilots exhibited dissociation of fixation and attention allocation called “looking-but not- seeing” (e.g., Thomas & Wickens, 2006). A possible explanation for this result is impression management (Goffman, 1956). Because the task was self-worth-relevant, participants may have felt the need to present themselves as responsible pilots by performing checks but nonetheless, doing so carelessly.

The standard operating procedure requires the takeoff performance to be calculated independently and crosschecked with each other. After the correct values are verified and crosschecked for accuracy, they are entered in the FMS. The performance parameters are checked and crosschecked once again before a takeoff. Learned carelessness can be triggered at any stage of the flight when interacting with any element of takeoff performance. The purpose of a checklist, cross check and confirmation of communication is lost due to overfamiliarity and incident free experiences.

Mindfulness

Pilots need to be in a high state of mental awareness in the cockpit while calculating the takeoff performance and inserting the same in the FMS. The calculation of takeoff parameters requires picking up data accurately from various sources, calculating the takeoff performance and inserts them in the FMS before cross checking them. Pilots must avoid distractions and other nonessential or non-related activity since at this stage the accuracy of data is important. The pilots therefore, must be mindful. The concept of mindfulness stems from Buddhist and meditative traditions and is commonly defined as ‘paying attention in a particular way, on purpose, in the present moment, and nonjudgmentally’ (Kabat-Zinn, 1994, page 4). Mindfulness is also described as a ‘mental mode characterized by attention to present-moment experience without judgement, elaboration, or emotional reactivity’ (Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010, p. 54).

Mindful individuals are described as having a heightened contact with moment-to-moment experience and all stimuli, experiencing few distortions and less reactivity related to emotional valence (Bishop et al., 2004; Brown, Ryan, & Creswell, 2007). Although the term mindfulness is used in different ways, most theories acknowledge that being mindful can be an inherent trait, but also a trainable skill. In broad terms mindfulness training (MT) refers to all techniques and activities with the aim of heightening the level of mindfulness (Tang, Holzel, & Posner, 2015).

Mindfulness has also become a popular tool for performance enhancement for elite groups. For example, there are now MT programs specifically tailored for soldiers (Jha et al., 2010).

Study 5 Mindfulness-Based Mental Training in a High-Performance Combat Aviation Population

This study tested the feasibility and value of mindfulness training (MT) in a Norwegian military combat aircraft squadron (Meland, 2016). Flying safely requires focusing attention, situational awareness and discipline. Failing to identify important changes or pay attention to what is relevant in a given situation can have serious consequences in aviation. Self-regulation of attention is considered the gateway to perception and is fundamental to vigilance, emotion regulation, and cognitive skills (Jha, Krompinger, & Baime, 2007). Previous research has shown that 75% of pilot errors result from poor perceptual encoding (Jones & Endsley, 1996). However, controlling attention is a finite capacity (Warm, Parasuraman, & Matthews, 2008), which is vulnerable to aging (Craik &

Salthouse, 2000), multitasking (Ophir, Nass, & Wagner, 2009), and stress (Kuhlmann, Piel, & Wolf, 2005). Despite rigorous selection procedures and continual task training in high-performance aviation, workers in such dynamic environments will always need methods to cultivate attentional skills to prevent attrition and future accidents.

One potential method of regulating attention that is currently drawing a substantial amount of interest worldwide is mindfulness training (MT).

MT was carried out in 3 basic ways for duration of 20-45 minutes:

1. Yoga
2. Body scan
3. Sitting meditation

Result: The results showed that the participants experienced a perceived increase on all the factors of mindfulness. The largest increases reported were in the factors measuring the ability to observe, act with awareness, and be nonreactive. 90% of the participants reported beneficial cognitive effects. This included improved concentration, re-focus, planning and prioritization. The level of mindfulness remained higher throughout the whole 2 years of the follow-up period.

Japanese 'Shisa Kanko' Techniques To Modern Cockpits

Japan operated one of the busiest high speed tail networks in the world with train speeds reaching 200 mph. What is interesting to know is that there have been no fatalities or injuries onboard the Central Japan Railway Company System since their operations began in 1964. They have carried over 10 billion passengers in that time, operating in densely populated cities, crisscrossing motor vehicle and passenger routes, in a country famously known for its earthquakes.


(Albright, "Pointing and Calling")

They use an ancient technique called “Shisa Kanko”, which is a pointing and calling (Jicosh, 2008) method that combines looking at something, pointing at it, calling out the observation, and listening to your own voice. The pointing and calling technique has been credited with reducing accident rates at these Japanese railway companies by 30 percent.

In 2011, (Shinohara, Naito, Matsui, & Hikono, 2013, pp. 129-136) the Osaka University set out to validate the method in a study with the impossibly long title, “The effects of ‘finger-pointing and calling’ on cognitive control processes in the task-switching paradigm.” Their report notes that many modern work environments involve an enormous amount of information compiled by automated systems, all of which is funneled to a human being with relatively simple decisions to make. While these decisions can be thought to be simple enough — i.e., apply the brake in response to a speed limit sign — the cost of making a mistake can be catastrophic. These decisions can become much more stressful in a “task-switching paradigm,” that is when the decision is based on more than a true/false option. They anticipated that finger pointing and calling would improve accuracy, but they also believed it would slow down the process. Of 8,000 trials carried out, the overall error rate was very low, just 2.5%. But when finger-pointing and calling was required, errors virtually disappeared.

Conclusion

The three specific studies conducted by leading global institutions have highlighted various issues, which lead to erroneous takeoff performance. They have also analyzed the human and cognitive factors but do not provide a solution to reoccurrence of error caused by pilot's noncompliance with procedures that are meant to trap errors.

The fact of the matter is that however sophisticated system that is built to enhance safety, there is always a human element and humans are the masters in the working system. These systems would have worked perfectly in an ideal environment for which they were designed but the fact is that there are a number of variables, which can by themselves or in combination with others create a situation, which can be comprehended by the human intelligence only and an appropriate decision taken. Rather than focusing on failures and building additional measures to prevent them, we need to analyze why normal actions or procedures, which are safeguards, not performed. Humans are cognitive misers by nature and due to the repetitive nature of the job, tend to rely too much on memory for procedures and checklists. There is a tendency to take shortcuts. Repeated successful outcome leads to learned carelessness. Skipping checklists, cutting short procedural application, inadequate or no crosscheck are examples of learned carelessness, which can lead to erroneous takeoff performance. Introduction of mindfulness orientates the human physical and cognitive part to the current surroundings and cuts out the unnecessary clutter in the mind, which is a major cause of distraction. When the human is in control of his body, senses and mind, he is fully aware of the functioning of every process that he is involved with, thereby taking conscious and informed decisions. Pointing and telling looking but not seeing and calling out without verification. The subject is forced to look at the parameter by pointing and calling out the variable. This enhances consciousness and improves accuracy. The role of the human as the last line of defense is thus effective when he is mindful and conscious while performing his duties.

What still needs to be worked on is to develop a heuristic for determining the accuracy of the parameters. Experienced pilots can determine this but with pilots with low experience, the incorrect variable presented to them will in most cases be used with any further analysis. Training plays a key role in enhancing safety.

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