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P9. Task Switching Failure due to Cognitive Lockup in Airline Pilots

Task switching failure due to cognitive lockup in airline pilots

Capt. Amit Singh FRAeS

Abstract

Unstable approaches account for a high number of accidents during approach and landing. A large number could have been **avoided with a decision to go-around.** Studies have shown that operators of machines and even pilots are susceptible to what is called the Cognitive lockup. They deal with **one task at a time** even if the subsequent task involves more significant risk. The pressure of task completion is proven to trigger cognitive lockup. On an approach to land, the pilot is under the pressure of task completion, time pressure and framing effect. In this situation, if an approach is destabilized, the pilot should ideally carry out a go-around and reattempt a landing. This involves

Introduction

Why do pilots continue an unsafe approach and landing?

Despite intense and detailed training, why do pilots continue with an unstable approach and/or a long landing? Standard operating procedures (S.O.P.) have clearly defined flight parameters for compliance and the pilots are trained in the class room's and flight simulators.

Cognitive lockup

Moray and Rotenberg (1989) have defined the term 'cognitive lockup' as the tendency of operators to deal with disturbances sequentially. Cognitive lockup however does not occur when people can perform all their tasks consecutively.

Cognitive lockup can also be defined as holding on to a task or sticking to a problem.

In terms of the task-switching paradigm, cognitive lockup can be considered as reluctance to switch to an alternative task or problem. (Meij, 2004).

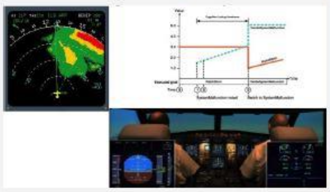
Methods

Experiments on cognitive lockup

Research on fault management in process control (Moray, N., & Rotenberg, I. 1989), reveals the onset of "Cognitive lockup" when faults in the system are simulated. When **multiple faults** are triggered, the sequence of preferred fault management by operators of thermal hydraulic systems is **sequential**.

The result of the research was that **operators liked to focus and complete one fault or if it can be replaced by stating one task at a time.**

Study



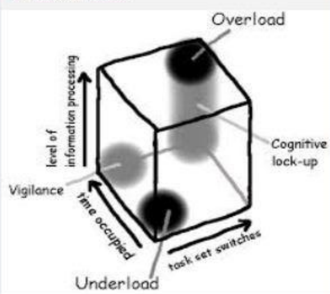
Pilots are faced with a thunderstorm over destination and subsequently given an engine failure.

Results

The cognitive lockup prevents the pilot from immediately switching task, from that of monitoring the thunderstorm to handling the engine malfunction. It takes the pilots 3 minutes to switch task, that of avoiding the thunderstorm to dealing with the engine failure.

Factors influencing cognitive lockup

1. Sunk cost fallacy
2. Task completion
3. Time task pressure
4. Framing effect



Discussion

Pilots approaching the destination have invested a lot of time in their task and it is nearing completion. A go-around at this stage will mean a failure to execute the mission and would lead to higher costs and time.

Company policies are focused on the primary objective of transporting passengers and goods to their destination in a timely manner. Therefore a go-around is considered a failure of meeting the company's objective too.

Conclusion

Carrying out a go-around can be inferred as task switching. Cognitive lockup prevents pilots from switching task from approach to go-around, especially when nearing task completion and completion of primary objective as framed in the policies, that of flying to the intended airport of landing.

Training has an effect of reducing cognitive lockup.

1. Increasing practice for task switching that of approach/flare followed by switching to the task of a go-around and reattempting a second time or divert.
2. The policy, if framed to depict a go-around and a diversion in a positive light will reduce the pressure of task completion from the pilots and they would be more prone to switching the task to go-around with ease.

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Task switching failure due to Cognitive lockup in Airline Pilots

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Abstract. Unstable approaches account for a high number of accidents during approach and landing. A large number could have been avoided with a decision to go-around. Studies have shown that operators of machines and even pilots are susceptible to what is called the Cognitive lockup. As per the definition, humans tend to deal with disturbances sequentially. Which means that they deal with one task at a time even if the subsequent task involves more significant risk. The pressure of task completion is proven to trigger cognitive lockup. On an approach to land, the pilot is under the pressure of task completion, time pressure and framing effect. In this situation, if an approach is destabilized, the pilot should ideally carry out a go-around and reattempt a landing. This involves switching to a second task, which holds higher importance. The pilot is unable to do so due to cognitive lockup since the current task is nearing completion. Training and framing of the task are two ways of eliminating the cognitive lockup.

Keywords: cognitive lockup, task switching, framing effect, unstable approach, long landing, go-around.

Introduction

Approach and landing are considered critical phases of flight. The statistical summary of commercial jet airplane accidents around the world, between 1959-2016 (Boeing, 2017), reveals that 48% of fatal accidents and onboard fatalities by the phase of flight occur during the final approach and landing. As per international air transport association (IATA) publication on unstable approaches (Unstable approaches 2nd edition, 2016), data from 2011-2015 shows that approximately 65% of all recorded accidents occurred in approach and landing phase of the flight, and Unstabilised approaches were identified as a factor in 14% of these approach and landing accident. Further, 31% of runway/taxiway excursion was a result of unstabilised approach.

The International Civil Aviation Organisation (ICAO) Safety report 2017 (ICAO safety report 2017, page 16) provides statistics on the accidents and the related risk factors for the year 2016. The top risk factors as per categories and numbers are depicted in Table 1 below.

Table 1. Categories and numbers

Sr. n.o.	Category	Number
1.	Controlled flight into terrain	2
2.	Ground safety	20
3.	Loss of control in-flight	8
4.	Injuries to and/or incapacitation of persons	18
5.	Operational damage	16
6.	Other	5
7.	Runway safety	41
8.	Unknown	3

The highest number of accidents as per categories is runway safety, which includes runway excursions and incursions, undershoot/overshoot, tail strike and hard landing events.

Approximately 65% of all accidents take place in the approach and landing phase. 83% of the accidents could have been avoided in the approach and landing phase, which amounts to 54% of all accidents, if a go-around was carried out. This is stated in the flight safety foundation Go-Around Decision-Making and Execution Project p 3 released in 2017.

Pilots are trained to carry out a go-around, but the practice is insufficient. As compared to the number of approach and landings, the number of go-arounds is approximately one sixth. At present, there is no training program which addresses cognitive lockout in any phase of the flight.

Boeing gives an analysis of the causes of landing overruns (Boeing magazine Aero Q3 issue 12 page 16), in Figure 1.

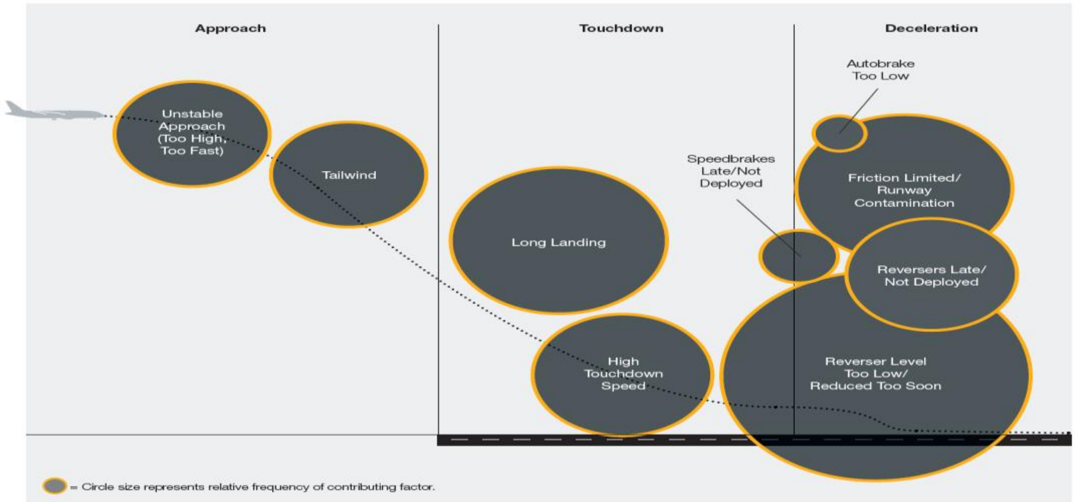

Figure 1. Factors affecting approach and landing overrun

Approach and Landing Scenario

In this paper we will consider two events, they are, unstable approach and long landing. Both these event are prior to landing at the destination, which is considered to be very close to task completion. The task is to fly from departure to destination. During the approach to land, approximately 95% of the flight has been completed and the two events amount to 70-80% of the remaining time, from beginning of approach to completion of flight.

Event 1. An aircraft on final approach is expected to be configured in terms of vertical and lateral position, speed, the rate of descent, bank angle etc. at or before crossing 1000' above aerodrome level in order to be considered stable for a safe landing. When either or a combination of these parameters are not within specified limits, the approach is considered unsafe and the pilot must discontinue the approach and carry out a manoeuvre called go-around to attempt another approach.

Event 2. In order to land safely, the pilot, when close to the runway, arrests the rate of descent by raising the aircraft's nose. This manoeuvre is called a flare. The pilot pulls the control column based on the depth perception and other parameters like speed and environment factors like winds and elevation of the aerodrome. The aircraft on a typical medium to long runway must touch down the wheels at or before 3000' from the beginning of the runway. If the aircraft touches down later than this value, it is called a long landing and there is a high risk of the aircraft not being able to stop within the runway length available. To mitigate the risk, the pilots must go-around and reattempt a landing.

Why do Pilots continue an Unsafe Approach and Landing?

The question arises, despite intense and detailed training, why do pilots continue with an unstable approach and/or a long landing? Standard operating procedures (S.O.P.) have clearly defined flight parameters for compliance and the pilots are trained in the class room's for theory relating to technical knowledge, Crew resource management (CRM) for non-technical skills, flight simulators for procedures and skills. Threat and error management is the focus of all training, and awareness of risks and measures to mitigate the risks is the key learning. The pilots who fly commercial airliners need to qualify for their initial and yearly recurrent training, and demonstrate their competence in terms of knowledge, skill and behaviour indicators. Despite these barriers, pilots continue to get trapped into continuing with an unstable approach and/or a long landing.

The pilots are performing the task of approach and landing. The mitigating task is that of carrying out a go-around procedure which can be performed at any stage of the approach or landing, even after touchdown of the aircraft wheels, till the time reverse thrust is not applied on the engines.

Pilot Training

Commercial airline pilots undergo intense training as a part of their qualification process to fly an aircraft. CRM is a training intervention to develop threat and error management skills. The training is both in-depth initial training and an annual recurrent training for the flight crew. The training topics include the following (Commission Regulation (EU) No 965/2012 on air operations, May 2017):

1. Human factors in aviation
2. Human performance and limitations
3. Threat error and management
4. Personality awareness, human error and reliability, attitudes and behaviours, self-assessment and self-critique
5. Stress and stress management;
6. Fatigue and vigilance;
7. Assertiveness, situation awareness, information acquisition, and processing.
8. Automation and philosophy on the use of automation
9. Monitoring and intervention
10. Shared situation awareness, shared information acquisition and processing;
11. Workload management;
12. Effective communication and coordination inside and outside the flight crew compartment;

13. Leadership, cooperation, synergy, delegation, decision-making, actions;
14. Resilience development;
15. Surprise and startle effect;
16. Cultural differences.

Cognitive Lockup

Moray and Rotenberg (1989) have defined the term ‘cognitive lockup’ as the tendency of operators to deal with disturbances sequentially. Cognitive lockup however does not occur when people can perform all their tasks consecutively.

Cognitive lockup can also be defined as holding on to a task or sticking to a problem. In terms of the task-switching paradigm, cognitive lockup can be considered as reluctance to switch to an alternative task or problem (Meij, 2004).

Accident of Eastern Airlines Flight 401

The accident of Eastern airlines flight 401 in 1972 is a good example of cognitive lockup. As per the NTSB report (NTSB,1973), the probable cause of the accident was “Failure of the flight crew to monitor the flight instruments during the final 4 minutes of the flight, and to detect an unexpected descent soon enough to prevent impact with the ground. Preoccupation with a malfunction of the nose landing gear position indicating system distracted the crew’s attention from the instruments and allowed the descent to go unnoticed”. The pilots got a landing gear warning signal during the approach to land. The crew cancelled the landing and began investigating the warning. In the process, the missed critical warnings about lowering altitude and the plane eventually crashed.

Experiments on Cognitive Lockup

Research on fault management in process control (Moray, N., & Rotenberg, I. 1989), reveals the onset of “Cognitive lockup” when faults in the system are simulated. When multiple faults are triggered, the sequence of preferred fault management by operators of thermal hydraulic systems is sequential. The result of the research was that operators liked to focus and complete one fault or if it can be replaced by stating one task at a time. There is a strong cognitive lockup, which restricts the operator’s information capability. The subsequent fault is noticed but no action is taken, till the handling of the first one is completed.

Study 1

The project, HUMAN Model-based Analysis of Human Errors During Aircraft Cockpit System Design was initiated in 2008, to develop a methodology based on a cognitive model of the crew behaviour, to support the prediction of human errors in ways that are usable and practical for human-centred design of systems operating in complex cockpit environments (Cacciabue, Hj lmdahl, Luedtke & Riccioli, 2011)

The study identified cognitive lockup as a serious error causing mechanism for airline pilots. Scenarios from human factor perspective with operational relevance were developed, wherein the combination of contextual factors would induce cognitive lockup.

The simulated cognitive model was based on Rasmussen's three behaviour levels (Rasmussen J,1983) in which cognitive processing takes place that of skill based, knowledge-based and behaviour based. The decision-making module, also called the goal management, determines which goal is executed. In the decision-making process, cognitive lockup was found as a relevant error producing mechanism (EPM). EPM has been modelled in the decision-making process, as task switch cost (TSC) representing the difference the goal priorities must have prior to switching goals.

Scenario

In the scenario, the aircraft is in cruise phase and a thunderstorm is presented very close to the destination. This attracts the attention of the pilot, as it is not clear if there is a need to divert to the alternate or not. The pilot keeps monitoring the movement and intensity of the thunderstorm. During this monitoring phase, a failure is introduced in one of the aircraft engines. The pilot recognizes the failure but does not react and continues to monitor the thunderstorm. After a while, the urgency to handle the engine malfunction is realized and the pilot begins to solve the engine malfunction task.

The cognitive lockup prevents the pilot from immediately switching task, from that of monitoring the thunderstorm to handling the engine malfunction. Figure 2 (Cacciabue, Hj lmdahl, Luedtke & Riccioli, 2011), shows the goal priorities of each goal over time during thunderstorm avoidance.

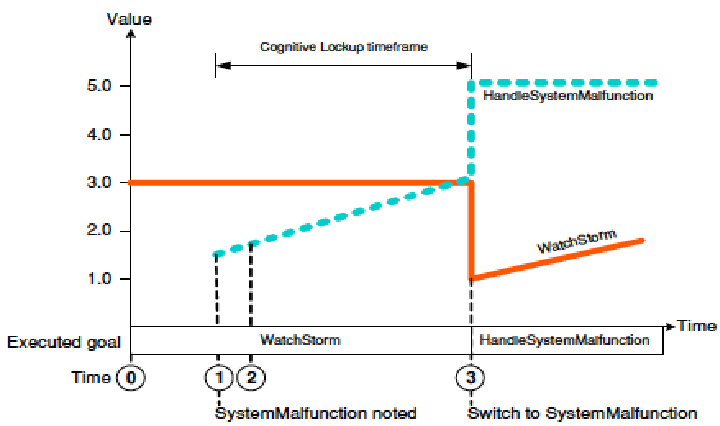

Figure 2. Goal priorities during thunderstorm avoidance

Study 2

Another study was presented at the proceedings of the 4th workshop human cantered processes (2011) with the topic as “the effect of time pressure and task completion on the occurrence of cognitive lockup. “Mental set and shift” by Aurther T.Jersild (1927), analyses the relationship between mental set and shift. The more homogenous and uniform the mental task, the less will be the demand for adjustment. Human beings cannot perform two tasks simultaneously and must prioritize and shift between tasks. This results in an added expenditure of time and energy. The mental set comes into being through practice and a more comprehensive mental set can be formed through more or less practice. If two tasks are well practiced, the losses are less.

Factors influencing cognitive lockup

Sunk Cost Fallacy

Individuals commit the sunken cost fallacy when they continue a behaviour or endeavour as a result of previously invested resources (time, money or effort) (Arkes & Blumer, 1985). This fallacy, which is related to status quo bias, can also be viewed as bias resulting from an ongoing commitment.

Task Completion

The project completion hypothesis—have shown that individuals become more willing to allocate resources to the invested option as goal attainment nears and goal completion becomes more important than economic concerns (Boehne & Paese, 2000). Garland and Conlon (Garland and Conlon,1998) stated: "as progress moves forward on a project, completion of the project itself takes increasing precedence over other goals that may have been salient at the time the decision was made to begin the project". When task completion is high, the probability of cognitive lockup increases.

That means, in case people deal with a task, and another more urgent task is triggered, people tend to stick to the current task when they have almost completed this task. People have the tendency to stick to their current task when 90% or more of the total stages of a task have been completed (Boehne and Pease, 2000; Garland and Colon, 1998).

Time and Task Pressure

There are typically two types of pressure on pilots. Time pressure and task pressure. Since the aircraft is constantly moving, there is a finite amount of fuel, which relates to time. Nearing the destination, the fuel remaining is sufficient to approach and land and an additional fuel to divert, if required, and hold for 30 minutes prior to landing at the alternate. The fuel remaining at approach is approximately 25% of the total fuel uplifted and the fuel required for approach approximately 85% of the total fuel required for approach and landing. From the perspective of time, approximately 95% of the flight is completed and the two events amount to 70-80% of the remaining time.

Time pressure is dependent on the number of tasks to perform at a given time. Time pressure is high when there is a perception that the time is scarce. According to a study on man-machine system design (Beevis, 1992), people experience time pressure when the time required to execute the task is more than 70% of the total time available to complete the task.

Study on the Influence of Time Pressure

A study was conducted in order to investigate the influence of time pressure and task completion on cognitive lockup. Furthermore, the aim was to identify critical situations in cockpit environments that would allow for designing cockpit systems that would help pilots avoid critical situations and decrease the probability of cognitive lockup.

The research was carried out at TNO human factors research institute, Utrecht (Schreuder & Mioch, 2011). The task required two types of fire to be extinguished in a computer simulation. One was the normal fire and the second was an urgent fire. Fires were of different types and they needed to be treated differently. The time to react and the time to extinguish the different types of fire were also variable. The results of the experiment indicated that although time pressure can influence decision-making, people are able to assess the priority of different task while dealing with the task and switch to the more important task if necessary when facing time pressure.

The experiment, however, supported the hypothesis that task completion would have an effect on cognitive lockup. The results showed that people who have almost completed the task tend to finish the task even when a more urgent task is triggered. In other words, if task completion is high, the probability of cognitive lockup is also high. It was also observed that the effect of cognitive lockup was reduced in the second attempt as compared to the first one.

Risk Perception

Framing Effect

Framing effect (Tversky & Kahneman, 1981) is a decision problem based on the decision maker's perception of the problem, formulation of the problem and partly by norms, habits and personal characteristics. A problem can be framed and presented with a positive and a negative connotation, despite having the same end result. There is a tendency for the decision maker to shift from risk aversion to risk taker. The pilots are trained and the policies are defined to indicate that the primary task is to fly from departure to destination and divert to alternate aerodrome if landing at the destination is not possible. The pilots flying the approach are under self-imposed task pressure to land at the destination and the diversion to alternate is taken in a negative connotation. However, if the policy is redefined to word that the primary task of the pilot is to fly from departure to alternate aerodrome if landing at the destination is not possible, then the pilot's task completion pressure is substantially reduced.

Conclusion

Pilots approaching the destination have invested a lot of time in their task and it is nearing completion. Task pressure of completing the flight and the framing of the policy with the primary task of landing at the destination increases the possibility and effect of cognitive lockup. As a result, the pilot will continue with the first task, that of landing at the destination, despite being unstable on approach or when performing a long landing. Carrying out a go-around can be inferred as task switching. This task will be carried out provided there is enough time to realize the consequences of persisting with the primary task. Since there is not enough time and the task completion is within sight, the pilots will continue and land.

Training has an effect of reducing cognitive lockup by increasing practicing task switching that of approach/flare followed by switching to the task of a go-around and reattempting a second time.

The policy, if framed to depict a go-around and a diversion in a positive light will reduce the pressure of task completion from the pilots and they would be more prone to switching the task to go-around with ease.

Cognitive lockout is the primary reason for the reluctance to go-around. If task switching practice is increased, as compared to other tasks, in the trainings, there will be a significant drop in the number of unstable approaches and long landings.

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