Delegation and the Culture of Complacency in Air Traffic Control Systems

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

As the field of aviation continues to develop and the number of commercial flights increases, aviation safety becomes increasingly important. An essential part of aviation safety involves the air traffic control (ATC) system, such as that in San Francisco, California, where what could have been the worst accident in aviation history was narrowly avoided (Koenig, 2018).

The National Transportation Safety Board (NTSB) identified a number of causes of the near-miss incident in its incident report, ranging from the first officer's failure to tune the instrument landing system (ILS) to the thunderstorms that occurred during the first half of the flight (NTSB, 2018). However, the report failed to recognize the culture of complacency in aviation and the role that technology has in perpetuating this culture. As aviation continues to become safer and move towards more automation, the role of pilots and air traffic controllers is reduced to monitoring a rarely failing system rather than performing a task, creating an over-reliance on automation (Svensson, 2015).

If the role of technology in the culture of complacency in aviation continues to be overlooked, then the Federal Aviation Administration (FAA) along with its stakeholders will not be able to gather a comprehensive understanding of the Air Canada near-miss incident. This will inhibit future investigations and accident and incident prevention efforts. The analysis of the Air Canada incident will utilize the science, technology, and society (STS) concept of actor-network theory (ANT), which explores the technology-society relationship that examines power dynamics in heterogeneous networks. Heterogeneous networks are those comprised of human and nonhuman actors and include a network builder and a goal (Callon, 1987). In particular, I will use Bruno Latour's concept of delegation, which describes the reciprocal relationship between human behavior and technology, to demonstrate how technology plays in role in the culture of complacency in aviation. By exploring the relationship between flight crewmembers and ATCT controllers and the technologies they use, I will show how the goal of the San Francisco ATC system to ensure safety within and surrounding the area of the airport is being undermined (Latour, 1992).

Background

On July 7th, 2017, "Air Canada flight 759 was cleared to land on runway 28R at the San Francisco International Airport, but instead lined up with parallel taxiway C where four air carrier airplanes were awaiting clearance to take off from runway 28R" (NTSB, 2018, p.1). The incident airplane reached a minimum altitude of about 60 ft. above ground, a mere 13.5 ft. above the PAL115 airplane on the taxiway, before starting to climb (NTSB, 2018). The NTSB identified causes of the near-miss incident in its incident report, the first of which was the first officer's failure to tune the ILS frequency for runway 28R. Having previously flown into the San Francisco International Airport (SFO) at night, the crewmembers expected to see two parallel runways; their lack of awareness about the runway 28L closure led to the incorrect identification of taxiway C instead of 28R as the intended landing runway (NTSB, 2018). Without having tuned the ILS, the crewmembers could not take advantage of its lateral guidance capabilities to ensure proper alignment, and the cues indicating misalignment were not sufficient to overcome their belief, as a result of expectation and confirmation bias, that the taxiway was the intended landing runway (NTSB, 2018). Expectation bias is defined as "having a strong belief or mindset towards a particular outcome," and confirmation bias is defined as a "selective process that favors information relevant to the presently held view" (FAASTeam, 2012; Skybrary, 2017). In addition, as current Canadian regulations sometimes do not allow for sufficient rest for pilots, the pilot and the first officer were fatigued during the flight due to the number of hours that they had been continuously awake.

Literature Review

There is a scarcity of scholarly work examining the root causes of the Air Canada flight 759 (ACA759) near-miss incident; however, within the analyses that do exist, the focus is primarily on pilot fatigue, and insufficient regulations regarding such. When the entire air crew was sleep deprived by the last leg of the flight, it is easy to assume that fatigue, enabled by insufficient regulations, was the root cause of the near-miss incident.

In *Inattentional blindness and bias during visual scan*, Amit Singh explores the aspects of visual illusion and blindness that can jeopardize safety during critical maneuvers. He highlights the fatigued state of the pilot and his first officer, as well as their familiarity with the normally configured approach, meanwhile noting that "humans use their intuitive decision-making 90% of the time when they are tired" (Singh, 2019, p.8). He argues that the fatigued crewmembers had "aligned with a taxiway due to expectation and confirmation bias," and that inattentional bias, which "sets in when maximum attention is focused on a particular activity," caused them to be blind to the aircrafts on the taxiway (Singh, 2019, p.9-10). While Singh does a good job of exploring the psychological phenomena that are linked to fatigue, he does not make any connection between social factors that also induce these phenomena.

Erin Flynn-Evans et al. also recognize the threat of fatigue to safety-sensitive occupations but focus more on the political factors pertaining to work hours. They note that "had the pilots been employed by a United States airline, they would not have been allowed to fly at such a vulnerable time" (Flynn-Evans et al., 2019, p.1). Flynn-Evans et al. recognize the difficulties in creating an all-inclusive regulation and that there is "likely strong economic and practical cases for allowing transportation workers to operate during the biological night," but they argue that "scientific evidence [and events such as the Air Canada incident] do not support such allowances" (Flynn-Evans et al., 2019, p.1). While Flynn-Evan et al. build a supported case for the political downfalls related to the Air Canada incident, their analysis falls short in focusing too heavily on one area of blame. They fault the lenient approach to nighttime work hours without considering other key factors and causes of the near-miss incident.

The scholarly works of Singh and Flynn-Evans et al. provide valuable insight on psychological and political factors relating to fatigue, respectively, on the Air-Canada near-miss incident. However, they primarily focus on the state of the pilot, and they acknowledge neither the role of the air traffic control tower (ATCT) operator nor the role of technology used by each human actor. By overlooking this, the current scholarly works are unable to explore the interactions and associations within the heterogeneous network and the social factors that may result from these interactions. This means that the works are only analyzing one side of the incident and are unable to fully capture the root cause of the incident. In what follows, I will not only provide a more comprehensive view of Air Canada near-miss incident, but will also use Actor Network Theory (ANT) to explore the role of technology in the culture of complacency and how it played a role in destabilizing the San Francisco ATC system.

Conceptual Framework

My analysis of the Air Canada near-miss incident draws on the STS concept of ANT, which allows me to explore how the culture of complacency undermined the abilities of the San Francisco ATC system. ANT is a dynamic approach to science and technology; however, an actor-network is neither an actor alone, nor a network (Callon, 1987). Rather, it is simultaneously an actor whose activity is networking heterogeneous elements and a network that is able to redefine and transform what it is made of (Callon, 1987). Unlike other sociotechnical approaches, ANT equally considers both human and non-human actors through its understanding of an actor: “an actant [i.e. actor] – that is something that acts or to which activity is granted by another… an actant can literally be anything provided it is granted to be the source of action” (Cressman, 2009, p.3). This semiotic definition leads the focus of ANT to the relationships between actors and the way actors define and distribute roles (Cressman, 2009).

As part of shaping the relationship, delegation is used as a mechanism to explain power dynamics and how actors are related. Delegation as defined by Bruno Latour describes the reciprocal relationship between the social and the technical (Cressman, 2009).In any situation involving the use of technology, humans delegate work to the technology, and the technology in turn delegates how humans act within the sociotechnical network; technology acts as a script, “a prescription how to act,” to human behavior (Verbeek, 2011, pg. 204). Thus, “the social and the technical co-constitute each other – to read the social from the technical is similarly to read the technical from the social” (Cressman, 2009, p.10). Another important idea used in ANT is the notion of a “black-box.” Black boxes are networks that exist as a stable entity, and are used to simplify the inner complexities of a system or technology (Cressman, 2009). Typically, sub-actor-networks are black-boxed to simplify the understanding of the relationships within a larger actor-network. This simplification allows all actor-networks to be analyzed in a parallel manner, which is important for the association-centric definition of an actor.

In my analysis, I will be exploring two sub-networks, the San Francisco ATCT and the ACA759 airline, that combine to form the San Francisco ATC system during the night of the Air Canada near-miss incident. I will analyze the use of technology within each network, and use

Latour's concept of delegation to understand how automation-induced complacency served as a script that influenced human behavior and played a role in the near-miss incident.

Analysis

To understand how technology played a role in undermining the goal of the SFO ATC system during the Air Canada near-miss incident, I will be using the NSTB official incident report to explore two sub-actor-networks: the SFO ATCT and the ACA759. To narrow the focus of this analysis, I will not be deconstructing or reconstructing each actor-network. In addition, I will only be focusing on actors that are directly relevant to the role of technology in each. For instance, while Air Canada work-hour regulations are important to note in the connection to pilot fatigue, these regulations are only indirectly associated with the technologies at hand. In the sub-sections that follow, I will first identify the relevant actors and responsibilities before moving on to analyzing how delegation between the humans and technology depicts the culture of complacency in aviation.

San Francisco Air Traffic Control Tower

I will begin by analyzing the SFO ATCT, focusing on how the airport surveillance system led the controller to overlook a landing discrepancy. The relevant human actor in this network is the ATCT controller, who had the responsibility of visually scanning the airspace and ensuring that ACA759 was on the correct landing trajectory. The relevant technological actor is the airport surface surveillance capability (ASSC) system. The ASSC system uses radar information to display aircraft and ground vehicles on the airport surface, and on approach and departure paths within a few miles of the airport. It fuses information from a number of radars to produce a display for controllers that improve their situational awareness and provide them with accurate data to be able to advise traffic (FAA, 2019). In addition, the ASSC system includes a safety logic system software enhancement that "predicts the path of aircraft landing and/or departing," and "visual and aural alarms [that] are activated when the safety logic projects a potential collision" (NSTB, 2018, p.20). In other words, the network delegates the responsibility of the controller to the ASSC in its ability to not only scan the surrounding airspace but also to provide an alert for any situation that is predicted to result in a collision. This delegation can be visualized through Figure 1 below.

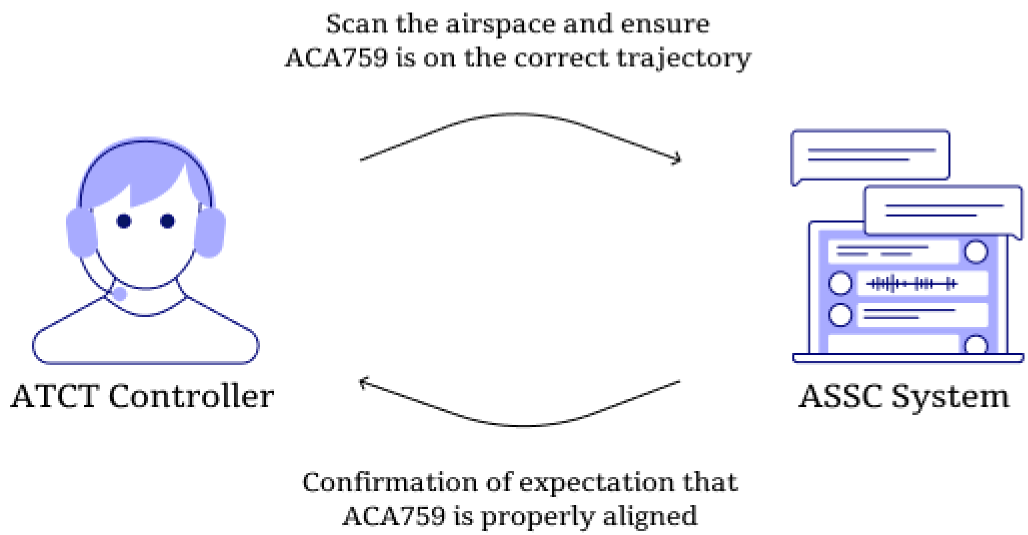

Figure 1: Diagram of the delegation relationship between the ATCT controller and the ASSC System

The top arrow represents the controller's task that is being delegated to the ASSC system, and the bottom arrow represents the modified response of the controller in the presence of the ASSC system.

This relationship is evidenced in the controller's recounting of the event, documented in the NTSB report. During his post-incident interview, the controller stated that traffic was normal before the incident, but that he was handling another air carrier's tug operator at the time that ACA759 called to confirm whether runway 28R was clear for landing. Despite being preoccupied, the controller checked the radar monitor and the ASSC display, and rescanned runway 28R before confirming that it was clear. It is important to note that research has found that "when operators are required to multitask, complacency levels varied with automation reliability" and that "an allocation strategy appears to favor his or her manual tasks as opposed to the automated task" (Merritt et al., 2019, p.2). This suggests that the controller allocated more attention to handling the tug operator than to confirming ACA759's landing clearance. When the controller checked the radar and ASSC displays, he reported that he saw the "ACA759 data symbol just to the right of the runway centerline, which was normal for the FMS Bridge visual approach to runway 28R" (NTSB, 2018, p.6). When no alarm sounded, the ASSC system effectively told the controller that there was no imminent danger, and as the display matched his scan of the runway, it is clear that the controller assumed that everything was going as planned, despite the ACA759 data symbol briefly disappearing from the system's depiction area. This is evidence of confirmation bias resulting from automation-induced complacency. Had the ATCT controller been more critical of the ASSC display, he would have questioned the disappearance of the ACA759 data symbol from the display and noticed that the aircraft was deviating from its intended landing path. It was only when the controller heard the transmission "where is that guy going," "he's on the taxiway," that he noticed the issue and directed the incident airplane to go around (NTSB, 2018, p.19).

Air Canada Flight 759

Next, I will analyze the ACA759 flight, focusing on how the flight management system led the flight crewmembers to believe that they were on the correct landing trajectory. The relevant human actors in this network are the pilot and first officer (the crewmembers). They had the responsibility to follow the designated landing procedures and to complete the necessary set-up. The relevant non-human actors are fatigue and the flight management system (FMS). An

FMS is a “multi-purpose navigation, performance, and aircraft operations computer designed to provide virtual data and operational harmony,” and to decrease pilot workload (Skybrary, 2016). It includes the instrument landing system (ILS), which provides the crewmembers with vertical and lateral guidance, as well as other final approach aids. It is important to note that for most FMS landing approaches, the tuning of the ILS frequency and other final approach aids are automated but in this case, the pilot and first officer were performing an FMS Bridge visual approach, the only approach in the company’s Airbus A320 database that required manual tuning (NTSB, 2018). The delegation between the human and technical actors can be visualized through Figure 2 below.

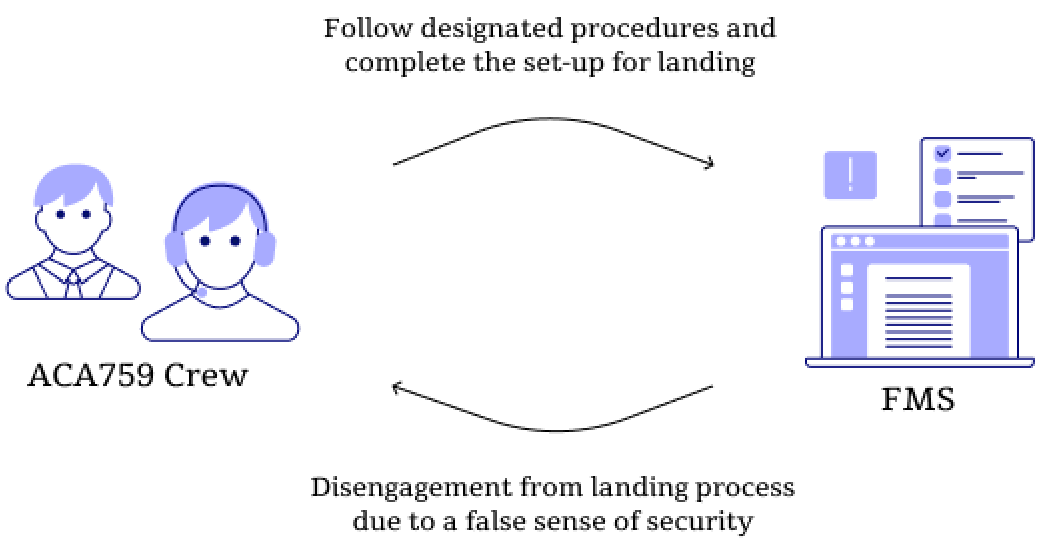

Figure 2: Diagram of the delegation relationship between the ACA759 crew and the FMS

The top arrow represents the crewmembers’ task that is being delegated to the FMS, and the bottom arrow represents the behaviors of the crewmembers in the presence of the FMS.

At the time of landing, the pilot and first officer were both sleep deprived and had been unable to take advantage of controlled rest due to thunderstorms during the flight. As part of his duties, the first officer was tasked with programming required FMS descent settings, including entering the ILS frequency into the navigation page (NTSB, 2018). However, in his state of fatigue, the first officer overlooked this step, and the pilot failed to verify that it was complete. Issues of complacency in using FMS are particularly evident during mode changes (i.e. an airplane leveling after a descent), with pilots failing to notice “the automation mode, the disruption in navigation information, etc.” (Bhana, 2010, p.48). If the first officer had been closely monitoring the approach, “he might have realized, among other things, that the ILS frequency and identifier and the runway 28R extended centerline were not depicted on his primary flight display” (NTSB, 2018, p.43). In fact, four minutes prior to the incident a Delta Air Lines pilot successfully landed on the correct runway by “cross-check[ing] the lateral navigation guidance [and staying on it] all the way to the runway” (NTSB, 2018, p.9). This shows the importance of staying actively engaged with the technology, rather than falling victim to the automation-induced complacency. In their fatigued states, the ACA759 pilot and first officer allowed themselves to be distracted and not fully engaged, giving in to the sense of security that an FMS provides. With the system essentially acting as the pilot, the decreased workload led the ACA759 pilot and first officer to be complacent and reduce the effort spent seeking out negative evidence that could have disconfirmed the belief that taxiway C was runway 28R (NTSB, 2018, p.50).

Interaction between Sub-Networks

Nonetheless, it was the interaction between these two networks and respective actors that ultimately led to the near-miss incident. In his analysis, Latour specifies delegation as an interaction between human behavior and some sort of technology. Although the ATCT involves both human and technical actors, it is at its core a technological system. Thus, I will treat it as a black-boxed technological system in order to explore the delegation that occurred between the crewmembers and the ATCT. That being said, the relevant human actors in this combined network are the ACA759 crewmembers. They have the responsibility to follow designated landing procedures and to ensure that the aircraft is properly aligned with runway 28R. The relevant technical actor is the SFO ATCT, which facilitates communication between the airport system and incoming and outgoing air traffic. In other words, the ATCT is a technology that instructs pilots what to do. Below is a diagram that illustrates the delegation relationship between the ACA759 crewmembers and the SFO ATCT.

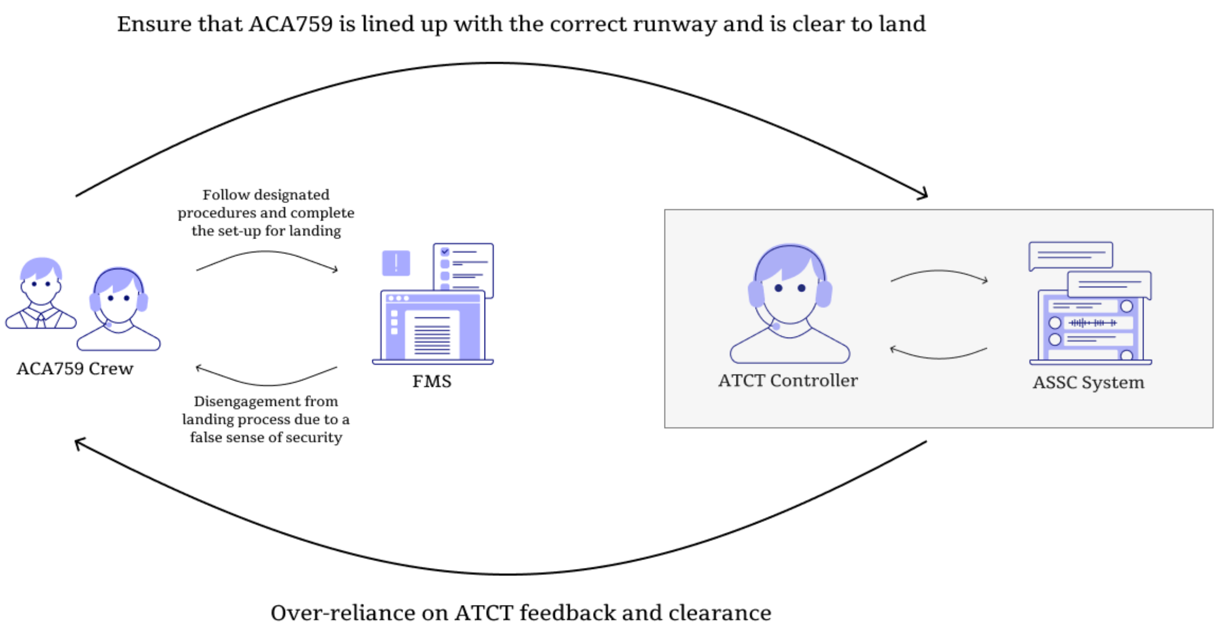

Figure 3: Diagram of the delegation relationship between the ACA759 crew and the ATCT

The diagram combines Figures 2 and 3 and shows the ATCT as a technological system. The top arrow represents the crewmembers' task that is being delegated to the ATCT, and the bottom arrow represents the behaviors of the crewmembers in the presence of the ATCT.

Through the guidance of both the ATCT and the FMS, the pilot and first officer's roles shift from being active to being more passive during the landing experience. Rather than managing the entire descent, their responsibilities become more relaxed towards a monitoring role – checking displays and listening for feedback from the ATCT. With expectation and confirmation biases at an all-time high, there was no room for critical thinking and realization of the circumstances. The problem in this case was that the pilot and first officer were not actively engaged in monitoring the FMS due to their fatigue, the rarity of incidents and the inaccurate feedback from the ATCT. The failure of the ATCT in particular is ironic because many pilots report feeling safer and more comfortable flying with a tower present (M. Feeley, personal communication, October 9, 2019). Some companies even refuse to fly into airports that are not towered (M. Feeley, personal communication, October 9, 2019). These different technologies promote the expectation of being safer, and with this expectation comes complacency and over-reliance, particularly in performing multiple tasks at once, as is the case when landing an aircraft.

The prevalence of delegation and the complacency that follows in each of these sub-networks illustrates the overarching culture of complacency in aviation. Others may argue that it is not the technology that induces automation complacency but the lack of well written guidance and procedures for the technology (Bhana, 2010). The FMS Bridge approach instructions do not clearly emphasize the need to manually tune the ILS and may easily be missed when scanning the page. However, proper adherence to standard operating procedures (SOPs) is another problem in and of itself, regardless of presentation. It would be unwise to rely on well written procedures to quell complacency, as "intentional crew non-compliance was a factor in 40 percent of the worldwide accidents [that would not have occurred if the crew maintained proper SOPs]" (NBAA, 2015). In addition, this viewpoint overlooks extraneous factors such as multitasking and fatigue. I argue that it is necessary to understand the effect of technology in different situations, and how it plays a role in the culture of complacency and in the quiet feeling of security. In the case of the Air Canada near-miss incident, the ATCT controller fell victim to complacent behavior when multitasking, and the fatigued crewmembers were left susceptible to confirmation bias from information provided by the ATCT and the FMS.

Conclusion

In exploring the interaction between humans and technology within two subnetworks of the larger San Francisco ATC system during the ACA759 near-miss incident, I claim that technological delegation of human behavior plays a role in the culture of complacency in aviation. The ASSC system provides ATCT controllers information about the location of an incoming plane and reduces their role from actively following the plane's landing trajectory to more passively checking on the ASSC display. The FMS essentially provides crewmembers an automated landing process, guided by approach aids. And the SFO ATCT, when considered as a technical system, provides crewmembers landing confirmation and clearance. The technology in each of these networks influenced the human actors towards complacent behavior, particularly in the presence of fatigue and multitasking.

With the advances in aviation technology and the continued shift towards increased automation, complacent behavior delegated by these technologies must be taken into account. In understanding the script that technology provides, NTSB officials will be able to analyze and explore incidents and accidents through a different angle. Thus, without realizing the influence of technology on both conscious and unconscious behavior, it is neither possible to gain a comprehensive understanding of the Air Canada near-miss incident nor to thoroughly learn how to mitigate future risks.

Word Count: 3678

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