Using Actor Network Theory to Analyze Issues in International Aviation Rules and Regulations

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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

On July 1, 2002, a Bahranian cargo jet and a Russian passenger flight simultaneously entered the same zone of German airspace. Undetected by air traffic controllers, the two aircraft converged on each other until the mistake was noticed by local air traffic control. However, insufficient response time and conflicting directions led both aircraft to execute evasive maneuvers in the same direction. Not one minute after the first emergency message, the two aircraft collided in midair above the town of Uberlingen, Germany. All 69 passengers on the Russian flight and both pilots of the Bahranian cargo jet were killed in the incident.

Current analysis places most of the blame for the incident on the air traffic controllers on shift at the time of the collision ("Investigation Report", 2004). However, less emphasis has been placed on the conflicting protocols and their origins in international aviation policy. Even more rare is conversation on the effectiveness of the International Civil Aviation Organization (ICAO), the UN special agency responsible for standardizing rules and regulations. By continuing to only consider factors involving only human actors, much understanding is lost about how policies developed by regulating bodies can contribute to aviation incidents. Drawing on Actor-Network Theory (ANT), I argue that the ICAO shares responsibility in this disaster. With the ICAO as a network builder, I will use Actor-Network Theory to analyze shortcomings in the civil and commercial air travel network such as incompleteness of network, network competition, and promotion of rogue actors.

Background

Despite belonging to Germany, the airspace above the small town of Uberlingen, Germany is controlled by the Swiss company Skyguide. On the night of June 1st, 2002, Peter

Neilson was the only controller on duty and was tasked with operating two workstations. Multiple factors such as drowsiness, overworking, and faulty radar equipment led to Neilson missing the occupation of a single flight level by two aircraft: a Bahranian Boeing cargo jet and a Russian Tupolev passenger jet . Upon this realization, the two aircraft were less than 60 seconds away from each other (Johnson, 2004). Neilson gave instructions to the Tupolev to begin descent immediately, a direction which contradicted the directions to ascend given by the automated Traffic Collision Avoidance System (TCAS). The Tupolev followed Neilson's orders over the TCAS directions. The Boeing cargo jet followed the onboard TCAS instructions, but Neilson was unable to process this as he was busy instructing the Tupolev. Both aircraft descended at similar rates until 8 seconds before the collision, when the Tupolev began to ascend in attempt to avoid colliding with the Boeing. The maneuver came too late and the two aircraft collided at a near 90 degree angle. There were no survivors of the crash. In the aftermath of the collision, legal actions were taken against executives of Skyguide. Three managers were convicted of manslaughter and were given suspended prison sentences. Peter Neilson was not convicted for any charges but left his job and was later murdered by the father of one of the crash victims (Person, 2004).

Literature Review

In the years since the disaster, numerous holistic analyses have been conducted to determine factors which contributed to the collision of the two aircraft. Most works focus primarily on human error and technical difficulties; however, a number of studies also account for systemic and latent errors within the larger air travel network. These studies often cite asynchronous policy and regulations as a major contributor to the events of the Uberlingen disaster.

Nunes and Laurson identify six contributing factors in the accident: Single Man Operations, Downgraded radar, Dual Frequency Responsibility, faulty phone systems, TCAS, and the self-defined "Corporate Culture" of pilots of different nationalities. In the latter, the authors focus on the Boeing's choice to obey TCAS automated directions and the Tupolev's choice to follow air traffic control directions. Their analysis cites this disparity as rooted in a national difference in protocol, as "European pilots are advised to follow TCAS whereas Russian pilots are trained to take both into account before rendering a decision. In most instances, the latter group will follow ATC." (Nunes & Laursen, 2004). The study also exposes another communication systems error; TCAS advises the pilot to perform an evasive maneuver but does not communicate this recommendation to air traffic control. When pilots decide to follow a TCAS instruction over a controller's directions, the controller is left out of the loop unless the decision is communicated by the commanding pilot. Nunes and Laurson claim this this gap in function contributed to the disaster (Nunes & Laursen, 2004). The paper by Nunes and Laurson addresses the cultural difference in training and protocol in high pressure situations but fails to address the fact that these differences are made allowable only by oversights in ICAO policy. Further, there is no speculation as to which of the factors contributed most to the events of the Uberlingen midair collision.

However, Bennett discusses the cultural differences in closer detail and links them directly to flaws in ICAO policy. Bennett focuses on factors outside the control of the crews and controllers involved in the collision and notes that ICAO SARPS are not compulsory in any sense. He states that nations with contrasting policies may "file a difference if they find it impractical to comply", meaning that governing bodies may determine their own aviation rules as long as they are properly documented within the ICAO (Bennett, 2004). Bennett determines this to be a latent error in the system and that the ICAO safety system is theoretically flawed by permitting non-conformity. Bennett cites three major defects in aviation regulatory systems: their fragmentation, non-exhaustive membership, and their inability to require the adoption of certain rules and regulations. At the time of the incident, the Russian Federation was not a member of a TCAS regulating body. Further, the paper points out that ICAO procedures ambiguously state that no rule should relieve the commanding pilot of responsible action. Bennett's work begins a dialogue on ICAO contributions to the Uberlingen mid air collision.

By adopting Actor Network Theory, the following analysis will build on Bennett's work by examining system defects as a product of insufficient relations between a network builder and the rest of the actor set. The analysis will contribute to current perception of the Uberlingen mid air collision by linking the accident to specific system defects and specific network dynamics between actors.

Conceptual Framework

As with many disasters within large scale transportation networks, the Uberlingen mid air collision involved multiple human and non-human stakeholders. The breadth of the stakeholder pool as well as the complex relationships between stakeholders suggests the accident is best analyzed through the social theory of Actor-Network Theory. Actor-Network Theory works as an approach to understand interactions between human and non-human actors (Cresswell, Worth, & Sheikh, 2010). ANT also allows for analysis of power dynamics within a closed network. Revolving around a network builder, this structure is made up of multiple human and non-human actors, both of which may have agency. The theory was first applied by Michael Callon and Bruno Latour in the early 1980's at the Paris School of Mines (Muniesa, 2015). Callon's definition of ANT relies on the sociology of translation, a mechanism to which Callon attributes the functioning and definition of a network. He describes this component as the process through which an actor in the network assigns other actors identity, interests, role, and course of action within the network. This leading actor is called the Translator-Spokesman or network builder (Callon, 1986). Translation is defined by four major movements: problematization, interessement, enrollment, and mobilization.

In the problematization movement of Callon's Actor-Network Theory, the network builder "determine[s] a set of actors and define[s] their identities in such a way as to establish themselves an obligatory passage point in the network of relationships they [are] building" (Callon, 1984). Problematization relies first on the "interdefinition" of actors, the step in which the network builder defines relevant actors and their identities. This includes self-definition by the network builder. A second fundamental of problematization is the definition of obligatory passage points by the network builder. This action, in simplest form, occurs when the network builder shows that the interests of all actors lie in addressing the core issue for which the network was created (Callon, 1984).

The next movement of translation, interessement, deals with how the network builder enforces these definitions and duties on the other actors in the network. According to Callon, "Interessement is the group of actions by which an entity attempts to impose and stabilize the identity of the other actors it defines through its problematization" (Callon, 1984). In a sense, the interessement movement is the recruiting of the necessary actors into a network.

After interessement comes enrolment. The concept of enrolment is less tangible than its predecessors as it functions primarily to aid the efforts of the first two movements. Enrolment is a collection of the multi-actor negotiations, tricks, and devices that allow for successful interessement (Callon, 1984). When interessement is successful it achieves enrolment automatically, however this is not always the case and usually this movement is needed in addition to the others.

Lastly, mobilization follows once each actor has accepted a role in the network. Mobilization refers to the step in which the network builders assert their position as group leaders and representatives for the network. Generally, this is achieved by putting into place a series of “intermediaries and equivalences which lead to the designation of a spokesman.” (Callon, 1984). This movement concludes the building of the network, and the finished product is a collection of relationships between heterogeneous actors in a network operating under the same constraints and motivation.

Callon’s process of translation can be directly applied to the aviation network built by the ICAO. Only after doing so, structural deficiencies may be determined and linked to current day issues within the governance of the ICAO. ANT is crucial for this analysis as the process of translation grants historical context to the network and actor set.

Analysis

The international aviation agency system may be thought of as such a network. In what follows, I will use actor network theory to demonstrate that the ICAO’s actions contributed to the events of the Uberlingen disaster. In what follows, I will use the ICAO as a network builder and offer specific examples for its execution of each translation movement. Then, I will identify vulnerabilities and flaws in the network which contributed to the Uberlingen mid air collision.

First, it is important to formally define the network and its relevant actors. The organic actors in this network are as follows: 1) *Regulation agencies* (Including ICAO, JAA, FAA) who are responsible for the creation and following of aviation rules and regulations. 2) *Governing* *bodies*, such as states, countries, and other representative bodies with their own legislature and aviation agencies. 3) *Private corporations* (including private air traffic control and airlines) whose commercial interests must abide by the imposed rules and regulations. 4) *Human capital* (including air traffic controllers, pilots, and passengers in civil aviation) who must also comply to these rules.

Non-human actors can also be identified in this network. The most prominent of these non-human actors are 1) *Civil aviation infrastructure* (including aircraft, airports) which carry out the functions of airlines and other private corporations. 2) *Air traffic infrastructure*, which includes the equipment used by both private and public air traffic controllers. 3) *On-board technology* such as the TCAS system which aids pilots in completing their duties.

Translation can be used to reenact how this specific network formed around this set of actors. The phase of problemization is easily traced back to 1944 with the birth of the provisional ICAO. Created by the UN, the ICAO can be seen as the network builder created to solve the specific issue of safety in the civil aviation sector. The ICAO then realizes the need to incorporate the various aviation agencies and governments around the world in order to unify aviation rules and standards. At the 1944 Chicago convention, a constitution is signed with a specific problem and actor set in mind. The goal is to “create policies in support of a safe, efficient, and secure civil aviation sector… among the nations and peoples of the world” ("Appendix: Convention on International Civil Aviation", 2010).

The interessement stage is handled inductively, as nations becoming a part of the UN tend to simultaneously join the UN special agencies, without exception. Therefore, the process of joining this network is well defined by the politics behind the United Nations, which need not be described in full at this point in time.

However, the movement of enrolment is ill-defined for the network built by the ICAO, and this lack of structure subsequently leads to the issues which contributed to disasters such as the Uberlingen mid air collision. Membership in the ICAO has continued to stay non-compulsory, and membership spans only as far as the UN. Further, once enrolled in the ICAO there is no legal requirement to accept its rules and regulations, making the ICAO more of a suggestion system than a proper governing body (Bennett, 2004). Due to these two characteristics of the ICAO's structure, it is entirely acceptable for an actor to refuse interessement and enrolment. This leads to entities acting on their own behalf and in the manner which is most convenient to themselves. With no proper device for enrolment, the network built by the ICAO loses the majority of its problem solving power.

The ICAO asserts itself as a group representative through a democratic process. The ICAO council ensures that each actor in the network is equivalently represented through an Assembly vote which happens every three years. Through this process, the ICAO council directly represents the entirety of the actor set, and this along with the backing of the United Nations has pushed the ICAO to the front of the aviation policy network ("The ICAO Council"). With the signing of the Chicago Convention, the ICAO became the largest aviation agency in the world, and this has since promoted enrollment and compliance from many other nations.

In what follows, the ICAO will be used as a network builder in order to analyze the shortcomings of this network, which is composed the actors as previously mentioned.

Promotion of Rogue Actors

A major flaw of the current network is the promotion of rogue actors by the network builder. The ICAO exists to recommend Standards and Recommended Practices (SARPS) to member aviation agencies. However, if a country or agency finds a SARP out of line with their own beliefs of best practice they may "file a difference" with the ICAO (Bennett, 2004). Once this step is completed, the filing agency is then no longer required to comply with the original standard or practice. While this may be beneficial for exceptions, it is frequently abused by member organizations. An alarming example can be found with the State of Israel, whose aviation agency complies with 63% of Annex 2 SARPS (Rules of the air) and under 1% of SARPS related to Air Traffic Services ("Filing of Differences"). In allowing network actors to act in this way, the network builder is hampering the ability of the network to solve the problem for which the network was designed.

In the Uberlingen mid-air collision, the Russian pilots onboard the Tupolev followed instructions given by air traffic control over those given by TCAS. This was direct result of the policy of training Russian pilots to obey human orders over automated orders. In contrast, the SARP involving this choice states that the pilot "should follow the RA" and "maneuvers opposite to the sense of the RA must be avoided" (Bennett, 2004). Here a RA, or resolution advisory, refers to the automated warning produced by the TCAS system. If the Russian pilots had been operating under this SARP, they would have obeyed the TCAS instructions to ascend and would have missed collision with the Boeing cargo jet.

An Incomplete Network

Another potential source of network volatility is the incompleteness of the actor set. Currently, the ICAO contains all UN member states and their aviation agencies. However, this is not an exhaustive set of states with activity in commercial air travel, and this list has been shorter at certain points in history. Similar networks such as the European Civil Aviation Conference

(ECAC), Eurocontrol, and the Joint Aviation Authorities (JAA), all of which exist to strengthen cooperation in air navigation, also have limited membership.

The direct consequences of this non-exhaustive membership can be seen in the Uberlingen collision. At the time of the disaster, Russia was a member of the ICAO but was not a member of ECAC, Eurocontrol, or JAA. The other countries involved in the incident were members of all of these organizations. The ECAC, Eurocontrol, and JAA all aimed to increase compliance with ICAO SARPS and other similar guidelines, however their membership was not mandatory and many countries declined this membership (Bennett, 2004). Additionally, each regulating body had slightly different versions of each rule and regulation, choosing to reflect their own views of safety and efficiency instead of agreeing on one singular verbiage. The result was that no two agencies had the same rules and regulations unless they fully subscribed to the same set of regulating agencies. The Russian Federation's lack of capacity in European regulating bodies shows a partial unenrollment in the network, and this lack of influence lead to adoption of policies such as the ones which contributed to the Uberlingen disaster.

Failure to address network competition

Lastly, a fundamental issue in the network is the failure of the network builder to address competition between actors. Although rarely mentioned, another contributing factor to the incident was the division of airspace above Uberlingen itself. The town's location directly north of the German-Swiss border generated disputes between the two nations on fair allocation of airspace. At the time of the disaster, the majority of this airspace was allocated to the swiss military, which left only a small passageway for domestic flights. Control over this corridor was a point of contention between Germany, Austria, and Switzerland, and the three countries called the area the "Bermuda Triangle" of the sky because of how difficult it was to control. High traffic in the area resulted in many near misses, so many that numerous parties involved in the incident were not surprised with the events of the accident (Bennett, 2004).

The conflict between these actors over allocation of airspace took place within the network, however it was not addressed by the ICAO as the network builder. This is in part due to the focus of the ICAO in policy and unification of rules and regulations. Too, the inability of the ICAO to enforce compliance suggests that even if they had attempted to exert influence on these actors it may not have been completely effective in preventing the accident from occurring.

Returning to the argument of Nunes and Laurson, we can now see that the argument misses an entire dimension of analysis. Nunes and Laurson focus on specific non-human actors as the main contributors of risk in the network. Their conclusion states that the failure of these components in parallel created the conditions necessary for such an event to take place. However, by approaching the situation with ANT, it becomes apparent that the underlying rules, regulations, and relationships built by the ICAO were more responsible for creating this high risk environment, and that the failure of these technological components would not have led to disaster if the appropriate safety policies had been in practice. Further, the complete dependence of aviation agencies on technologies such as TCAS constitutes an issue by itself, and the Uberlingen disaster exemplifies what might happen as a consequence.

Conclusion

In this paper I have used Actor-Network theory to explore policy related contributors to the Uberlingen mid-air collision. Through this framework, I identified the ICAO as a promoter of network vulnerability and as a promoter of rogue acting within the network. Moreover, the incompleteness of the actor as well as the incompleteness of neighboring networks both contribute to the vulnerability of the network. Lastly, the failure of the network builder to address conflict between actors greatly contributes to the failure experienced during the disaster. After this analysis, it is clear that the structural deficiencies of the ICAO contributed greatly to the Uberlingen disaster in a number of ways. This analysis should function to expose the reader to issues in international aviation policy and the dangerous inconsistencies in rules and regulations between different governing bodies.

References

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