The Kaprun Funicular Network and its Demise

STS Research Paper
Presented to the Faculty of the
School of Engineering and Applied Science
University of Virginia

By

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March 19, 2021

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 November 11th 2000, 155 lives were tragically lost in what has become known as the Kaprun disaster. The underground funicular running from the village of Kaprun (Austria) to the ski slopes of Kitzsteinhorn, once thought completely fireproof, caught on fire that morning, leaving only twelve survivors. The survivors were able to escape the fire by travelling downwards, towards and then past the flames, to avoid the smoke and fumes that were accumulating upwards. As previously mentioned, the funicular was thought to be fireproof, so no fire safety measures nor design practices were in place. Many argue that if such measures had been in place, such as a sign advising passengers to always escape downward in case of a fire, even if it meant going past the fire, most people could have escaped, saving countless lives (Carvel, 2008). Further, during legal proceedings, the unsuitable heating fan was ruled as the final cause of the accident (Godeysen & Uhl, 2014). Although both the lack of fire safety practices and the fan heater played a big role in the disaster, it is important to consider that no single one of these factors alone could have led to this catastrophic event. When blaming a single actor for the incident, one fails to take into account the importance of all the components of a technology. Without proper emphasis on all components of a technology, the technology will not be stable. By analyzing the Kaprun disaster case, I will use Actor Network Theory (ANT) to argue that the lack of fire safety protocols, the heating fan, and the hydraulic system all played equally important roles in the catastrophe, and not one of them can be singled out as its primary cause. I will begin by highlighting the lack of research into preventing incidents like this from happening again, and by demonstrating how all scholarly pieces focus on the lack of fire safety measures. I will then define ANT and explain how it can be used to analyze a technology such as the Kaprun funicular. Using this framework, I will show how, in the context of this network, no actor can be considered the single cause, and how the demise of the network was caused by a combination of actors (fire safety protocols, fan heater, and hydraulic system).

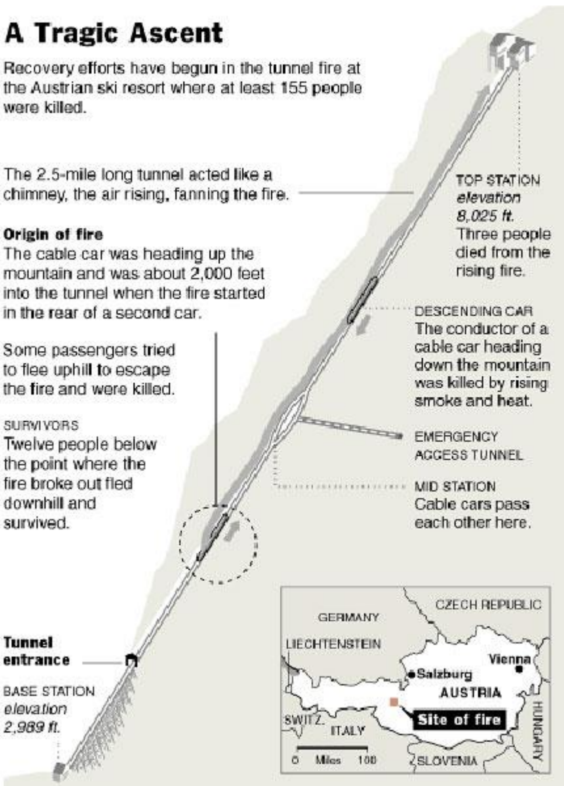
Background

In this section I will briefly explain the events that are known as the Kaprun disaster. The Kaprun disaster refers to the fire that occurred on November 11th 2000 in the tunnel of the Gletscherbahn (glacier train in German) Kaprun 2 funicular (cable railway) in Kaprun, Austria, not far from Salzburg. The resort is popular for its Kitzsteinhorn glaciers which allow year-round skiing. To allow greater capacity (passengers/hour) an underground funicular railway was opened in 1974, and later modernized in 1993. The railway had a length of 3,900 meters, 3,295 of which were inside the tunnel, and rose a total of 1,500 meters at about 30 degrees (Bennet & Berneys, 2004). The train travelled at 25 kilometers per hour, and the two carriages operated on a single track, balancing each other, with a section with two tracks in the middle as shown in Figure 1, allowing them to pass each other as one ascended and its twin descended. The trains were powered by low-voltage electrical systems as well as hydraulic tanks to brake. The attendant's only job was to operate the hydraulic doors from the cab at the front (or rear) of the train. Each train could carry a total of up to 180 passengers in the four compartments (Bennet & Berneys, 2004).

On the morning of November 11th 2000, the ascending train, carrying more than 150 passengers and a conductor, unexpectedly halted at 600 meters into the tunnel. This was due to the fire that had broken out in the lower cab, which consumed the hydraulic fluid. Twelve people were able to escape from the rear, and escaped downwards past the fire to safety, thanks to the advice of a fellow passenger, who had been a volunteer fireman for over twenty years (Timeline, 2000). Unfortunately, these were the only survivors, and the remaining passengers and conductor, the descending train conductor and its one passenger as well as three employees at the Alpine Centre (top station) all lost their lives in the tragedy. Figure 1 shows the funicular's specifications in addition to details about the fatal accident.

Figure 1

A Tragic Ascent



Literature Review

Several scholarly sources discuss the Kaprun disaster and its outcomes, however not many thoroughly investigate what caused the fatal fire. A number of papers explore forensic organization and post-mortem examinations to identify the victims, such as Harald J. Meyer's

The Kaprun cable car fire disaster – aspects of forensic organization following a mass fatality with 155 victims (2003). In the paper, Meyer (2003) quickly explains that "a fire erupted inside the underground cableway train leading to the high-altitude skiing area on the Kitzsteinhorn glacier above Kaprun, Austria". He also accurately points out that no fire extinguishing system existed in the tunnel, which prevented fire and rescue operations from begining until the fire had died out and the smoke had dissipated (Meyer, 2003). The rest of the paper goes on to explain how the victims were identified. In a similar paper Labovich et al. (2003) discuss management of the tragedy from a forensic medical perspective. The paper briefly introduces the case study indicating how "several conditions inside the tunnel contributed to the rapid expansion of the fire and high mortality of the passengers." (Labovich et al., 2003) The first thing noted is the shape and inclination of the tunnel, which essentially acted as a chimney. This not only fueled the fire by fanning it with air from the bottom entrance, but also made all attempts to flee upwards (away from the fire) in vain, as the toxic fumes and smoke rose in the tunnel-chimney (Labovich et al., 2003). Neither of the above mentioned papers takes into consideration the cause of the fire, essentially blaming the tragedy solely on the lack of fire safety measures.

While the previous papers focused primarily on the case study rather than the research question, other papers focus more on the technology and the research question. In *Lessons learned from catastrophic fires in tunnels,* Carvel (2008) aims to provide guidance to engineers involved in the design of underground transportation systems, for bringing the safety of all tunnels up to an acceptable level. Carvel (2008) reiterates how the lack of perceived risk contributed to the catastrophic fire in Kaprun. The wagons, made of non-flammable aluminum, were considered fireproof, but the fact that passengers, skis, ski bags and other elements are all flammable additions was overlooked. Because fire was not considered a risk, there was no signage for fire emergencies and escaping the tunnel, only for escaping the wagons in case of an incident (Carvel, 2008). Carvel (2008) explains:

> this oversight was one of the main contributing factors leading to the deaths of 155 people when the fire occurred. Had a significant fire been considered as a possible emergency, any adequately trained fire safety professional would have identified the risks associated with a train travelling up what is essentially a 3.3 km long chimney. (p. 2)

Carvel delineates 3 main "lessons" to be learnt from the Kaprun disaster: 1) all tunnels are different and require scenario dependent emergency actions, 2) no vehicle should be considered fireproof, 3) in sloped tunnels the only exit route is downhill, regardless of where the fire is located. These are valuable pieces of information, but they do not elucidate the cause of the disaster. All three of these papers put most of the blame on the lack of fire safety measures, neglecting to analyze why the fire took place, and how it could have been prevented. In what follows I will employ Actor-Network Theory to show how a multitude of factors contributed to the Kaprun disaster, and the lack of perceived risk is but one of them.

Conceptual Framework

To frame my analysis of the Kaprun disaster, I will draw on Actor-Network Theory, which will allow me to fairly analyze the different factors (or actors) which played a part in the tragic accident. Actor-Network Theory (ANT) was initially described by Michel Callon, Bruno Latour, and John Law in the 1980s (Muniesa, 2015). According to ANT, engineers exercise influence and power by practicing heterogeneous engineering through building and maintaining successful actor-networks. Here engineers are defined as network builders, and engineering is the activity of associating different entities ("actors") into a stable system ("network") to solve a problem or accomplish a goal. Each actor in a network has a particular meaning and purpose, which is unique to each network, as "ANT argues that both humans and non-humans actors be understood within a network wherein their identity is defined through their interaction with other actors." (Cressman, 2009) Similarly, no single actor within a network holds all the power, as power is measured by the strength of the relationship between the different actors (Callon, 1984).

According to Actor-Network Theory, a network is formed and maintained through the process of translation. Translation includes various stages: problematization, interessement, enrolment, mobilisation, and black-box. According to Callon (1984)"to problematise is simultaneously to define a series of actors and the obstacles which prevent them from attaining the goals or objectives that have been imputed to them." The following step, interessement, involves primary actors (or network builders) attempting to recruit the actors defined through problematization. During enrolment, the principal network builders strategize to assign specific roles to other actors, which the actors will have to accept and perform. Lastly, using mobilization, the network builders assume the roles of speakers and representatives of the network. When all these tasks lead to a stable network, it can be defined as a "black box". However, it is important to note that "translation is a process, never a completed accomplishment, and it may (as in the empirical case considered) fail." (Callon, 1984) In the analysis that follows, I will begin by identifying the actors of the Kaprun 2 funicular network, and then I will analyze the translation process to identify errors in the problematisation, interessement, and enrolment steps, which led to the failure of the network.

Analysis

In this paper, applying Actor-Network Theory (ANT), I identify the network as the Gletscherbahn Kaprun 2 funicular, and Gletscherbahnen Kaprun AG as the principal network builder. Using ANT, I argue that a multitude of actors contributed to the disaster and demise of the network, and that no single actor can be blamed for it. To analyze the network, it is important to define all the heterogeneous actors contributing to it. A large number of actors led to the preservation of the black-box network between 1974 and 2000, but for the purpose of this paper I will focus on actors that played a role in the demise of the network. As previously mentioened, the network builder, or primary actor is Gletscherbahnen Kaprun AG (GBK), specifically the management team and the employees that worked on the funicular. Other relevant actors are defined as follows: (i) *passengers* who elected to take the train as their mode of the transportation to the slopes (for the purpose of this paper, this group also includes ski gear and any luggage carried on-board); (ii) *conductor* that operated the doors and could communicate with top and bottom stations; (iii) *topography and altitude* between bottom and top station; (iv) *hydraulic lines* installed by (v) *German Mannesmann-Rexroth AG* (now Bosch Rexroth AG) ; (vi) *Austrian Swoboda Karosserie- und Stahlbau GesmbH* (now Carvatech) whose employees installed (vii) *Fakir Hobby TLB fan heaters* in the attendants cabins; (viii) *fire safety protocols* which were not included in the design. In the next sections, I will first delineate the relationship between the different actors, which is schematized in Figure 2, and then focus on how the rogue actors contributed to the network's failure.

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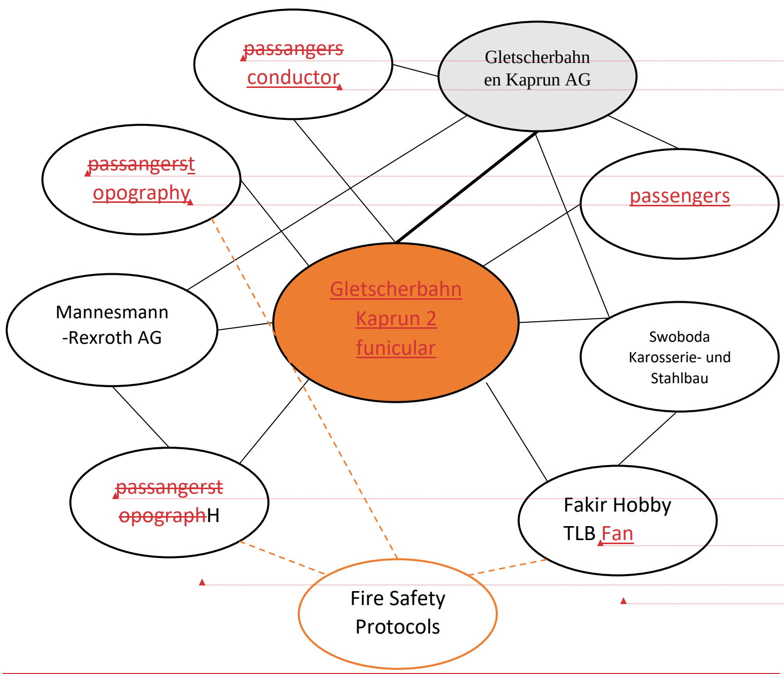
Figure 2

The Kaprun funicular network



Translation

In order to understand the power dynamics and relations between these actors, and how they all contributed to the Kaprun disaster, it is important to understand how they are associated and the roles they play. To do this, I will retrace the process of translation for this network. In 1994, GBK began the problematization process by determining that a renovation to the funicular would make the system more effective and give the trains a sleek, futuristic look, attracting more passengers and catering to them. During the problematization process, GBK determined that a fan heater should be installed in the conductor cabin to keep the conductor warm. New hydraulic lines were also to be installed. While they actors identified these acots, GBK failed to identify a

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fire safety protocol actor (Causes). Although the train had run without any accidents for over 6 years (and almost 20 before renovations), the lack of this actor made the system a ticking time bomb just waiting to go off.

During interessement, the network builder GBK recruited several of the previously identified actors. The German Mannesmann-Rexroth AG was recruited to install new hydraulic lines in the trains. The Austrian Swoboda Karosserie- und Stahlbau GesmbH (Swoboda) was selected to renovate the trains and include heaters in the conductor's cabin. Swoboda had previously installed heaters on Salzburg's funicular Festungsbahn (Godeysen & Uhl, 2014). Such actors are recruited by aligning their interest with the problem definition, and sharing the profit. When interests are aligned and agreed upon, enrolment begins. Throughout the enrolment then mobilization phases, ideally the actors would perform their roles by prioritizing these agreed upon interests. Unfortunately, this is not always the case, which leads to some actors going rogue, putting the stability of the network in danger. In the following sections I will delineate how rogue actors led to the demise of the Kaprun funicular network. `

Fan Heater

The fan heater in the lower cabin of the ascending train, installed in 1993 by Swoboda, has been confirmed as the starting point of the fire, but cannot be ruled its sole cause. According to initial reports the heater's ventilator "had either become stuck or was blocked" due to a technical defect, causing the fire to ignite (Heater caused, 2001). Further investigation showed that the heater was not faulty, but simply not suitable for use in a funicular. Employees at Swoboda had installed a Fakir Hobby TLB heater (produced for household use) in the cab, instead of the approved Domo fan heater (Kaprun, n.d.). According to the investigation report, Swoboda's purchasing department chose the private household Fakir heater after discovering that the recommended Domo heater was unavailable. Other Swoboda departments remained unaware of this purchase and delivered the heater to GBK with manuals for the Domo fan heater (Godeysen & Uhl, 2014). This lack of transparency between departments at Swoboda proved detrimental for the whole network, as the incorrect information eventually reached the network builder and was assumed to be true. Although two managing directors were legally accused, they were acquitted as they were unaware that a different heater than the recommended had been purchased (Furst, 2017).

It can be argued that, because the funicular was not legally a vehicle, the installation of the Fakir residential heater was legitimate. However, the argument is moot as the heating device had to be disassembled and reassembled to be placed in the cab, invalidating the VDE safety certification "no matter what the fan was used for" (Godeysen & Uhl, 2014). Following the revelation of these findings, many newspaper headlines put the blame solely on the heater. For example, CNN wrote "*Heater caused ski train disaster*" (2001). Furthermore, the Heilbronn Prosecutor's Office concluded that [the accident] "could have been avoided if Swoboda had installed vehicle-appropriate heating fans which existed on the market." (Godeysen & Uhl, 2014) This is not entirely true, because, as I have previously mentioned, the demise of the network was caused by multiple actors, not just the heater. In 2004, prosecutors pointed out that not only "the heater should have never been installed", but it also "should not have been so close to the hydraulic pipes." (Alpine, 2004)

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Hydraulic System

The hydraulic system used for the brake system and for the operation of the train's door also contributed to the network's failure. The system included 42 US gal hydraulic tanks as well hydraulic as lines mounted by Rexroth (Godeysen & Uhl, 2014). The pipework was installed right behind the control console, very close to the fan heater (Causes, n.d). The pipes were made of plastic, and, shortly after the fire was ignited, they started melting from the heat. As the plastic pipes melted, the hydraulic oil started leaking at around 190 bar (Godeysen & Uhl, 2014). Hydraulic oil is extremely flammable, and this, coupled with the chimney effect, escalated the fire and intensified its spread. As the fire burned through the hydraulic oil, fluid pressure sharply decreased, causing the train to halt. The train stopped at around 600 meters, due to a standard safety feature that would brake the funicular in case of fluid pressure loss. This loss in fluid pressure also made it impossible for the attendant to open the train doors, as they were hydraulic (Bennet & Bernays, 2004). With this evidence we can gather that, although the fire originated from the fan heater, the hydraulic system contributed greatly to the spread and ferocity of the fire.

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Fire Safety Protocols

Finally, I will reiterate how the lack of fire safety protocols contributed to the network's failure. The new cable cars were made largely of aluminum, with very little flammable material, so they had been deemed fireproof (Carvel, 2008). This of course did not take into consideration the flammability of passengers (including gear) as well as other unforeseen flammable elements, such onboard electric power, hydraulic systems, and fan heaters. Funicular train expert Joseph Nejez satted that "designers throughout the years had a perception that a fire could not occur since no fire occurred in a funicular cabin prior to the Kaprun disaster." (Kaprun, n.d.) Since fire had not been considered a risk, no fire exits had been planned in the tunnel, and no appropriate signage existed, leaving passengers with no clear way out. Furthermore, neither the conductors nor the station operators had been educated on protocols to follow during a fire emergency. The failed identification of fire safety protocols as an actor, together with the fan heater issues and the hydraulic system, eventually contributed to the demise of the network.

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Conclusion

In this paper, I have used Actor-Network Theory, a theoretical and methodological approach to social theory, to define the Kaprun funicular network and identify the key actors in its demise. Using ANT, I have established that the Kaprun disaster cannot be blamed on just one actor, but was due of the combination of a faulty fan heater, misplacement and inadequate casing of the hydraulic system, and a lack of fire safety measures and protocols. To reach this conclusion, I analyzed scholarly papers regarding tunnel safety, as well as documents from and about the legal proceedings that followed the tragedy. Additionally, I consulted documentaries and newspaper articles to thoroughly understand the situation from the public's viewpoint as well. With this thorough analysis of evidence, and application ANT, it became obvious that most sources were biased and grossly simplified the situation by only identifying one rogue actor. It is my hope that, through this paper, readers will understand that all technologies/networks rely on a multitude of actors, which all need to work synergistically to ensure the success of a given network.

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