Aircraft ground deicing as a complex sociotechnical system: Towards a safer and more efficient communication process for aircraft ground deicing

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Abstract. The research essay will discuss if aircraft ground deicing can be characterized as a complex sociotechnical system. To enable this, the ground deicing working system will be depicted and qualitatively evaluated. The evaluation of the ground deicing showed that both complexity and socio-technical system properties are present in ground deicing operations. Therefore, techniques that model and analyze complex interactions in sociotechnical systems can be deployed in aircraft ground deicing setting to enhance the safety performance.

Keywords. aircraft ground deicing, sociotechnical systems, complex systems

1. Introduction

Centralized deicing pads make it possible to deice multiple aircraft at the same time in one facility. In this context, the actions of a variety of actors have to be coordinated with aeronautic communication systems while coping with time pressure and adverse weather conditions. Furthermore, procedures of the service provider, regulations of the aviation authority, airline procedures, environmental standards, are to be taken into account jointly when operating an aircraft ground deicing facility. To understand complex interactions and sometimes competing perspectives, the sociotechnical system approach has been proposed in the scientific literature.

The goal of this research paper is to discuss whether aircraft ground deicing can be seen as a complex sociotechnical system. The research paper is structured in the following ways: first, it will outline the methodology. Second, it will present and discuss characteristics of complex sociotechnical systems. Third, it will describe briefly the ground deicing working process and will discuss if this working system can be defined as a complex sociotechnical system.

2. Methodology

The following three-step methodology was performed as part of the research paper. First, an explorative literature review was conducted to identify definitions and characteristics of sociotechnical systems and complex working systems in the scientific literature. Second, a review of an observation study during the last deicing season was conducted to describe the aircraft ground deicing working system and

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their components. Third, the identified definitions and concepts of the complex sociotechnical systems have been applied to aircraft ground deicing operations.

3. Results

3.1 Exploratory literature review for complex sociotechnical systems

The sociotechnical system approach tries to understand the system through holistic thinking instead of taking apart each component and analyzing it separately. System is defined as a set of components that act together as a whole to achieve a common goal (Leveson, 1995). Consequently, it is also essential to focus on the interactions between the system elements instead of the components to understand the system performance.

Jackson (2009) states that a sociotechnical system consists of hardware and software technologies, human interfaces and human organizational systems. This means human, organizational and technical elements are present and interacting with each other and are intertwined. The literature review shows that there are different definitions and models for sociotechnical systems from different perspectives (Crayon et al. 2015).

For example, Sussmann (2012), who uses an engineering point of view for sociotechnical systems, focuses on large-scale systems such as transportation systems. Furthermore, besides the focus on interactions of technical components, the system view should extend to human, social, political and economic considerations. He argues that it is impossible to have an optimal complex sociotechnical system design because of the variety of individual behaviors and reasoning.

The cognitive system engineering's viewpoint acknowledges individual performance variety as a necessity to cope with complex systems (Hollnagel & Woods, 2005). They argue that human behavior has a crucial role for system safety and that human performance should be analyzed in terms of system performance. It emphasizes the importance of the context and the operators' capability to adapt to new situations (Praetorious & Lützhöft, 2010).

The literature also offers different definitions and frameworks for evaluation of complex systems from different theoretical underpinnings. Walker et al. (2010) reviewed how the term complex and the term complexity were used in the ergonomics literature and offers three views of complexity. (1) The attribute view; (2) The complex theory view; (3) The complex systems view. Vincente (1999) describes eleven dimensions of complexity that allow to evaluate qualitatively the work systems. Leveson (2011) distinguishes between four types of complexity based on the system theory's perspective: (1) Interactive complexity; (2) Dynamic complexity; (3) Decompositional complexity; (4) Non-linear complexity. Hollnagel (2008) offers a cognitive systems engineering perspective and offers a manageability-coupling diagram to characterize complexity of sociotechnical systems. The manageability relates to the tractability of the systems and coupling relates to degree of connection between subsystems and components.

3.2 Aircraft ground deicing as sociotechnical system

This section discusses, if aircraft ground deicing can be seen a sociotechnical system.

The system depiction in Figure 1 shows the actors that are involved in a ground deicing system. The system purpose is to de/anti-ice planes before take off to enable safe airport operations. There are four subsystems involved that are connected through different communication channels and interact with each other: 1) Deicing Control Tower; 2) Flight Deck; 3) Ground Deicing Team; 4) External units.

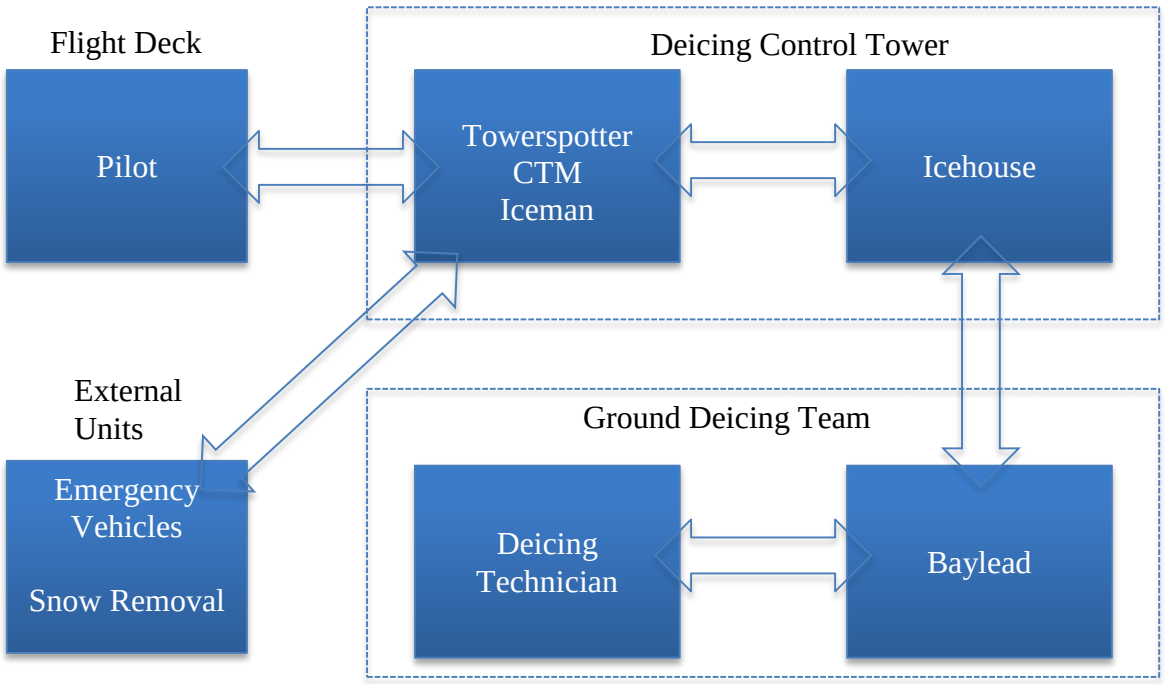

Figure1. *System components and their relationships for aircraft ground deicing*

The aircraft ground deicing system can be defined as a sociotechnical system since it comprises technical, human and organizational levels that are at once interactive and interdependent. In technical terms, radiotelephony communication and operations management software are necessary to coordinate the activities. Furthermore, the spraying of the de/anti-icing fluid is conducted via deicing trucks which are specially designed for this kind of operation. On the human level, there are different actors involved in the deicing pad (Technician, Baylead, Servicecar) and in the Control tower (Iceman, Icehouse, Coordinator Traffic Movement (CTM), Towerspotter). On the organizational level, the deicing operations are performed in a highly regulated environment, which has a direct impact on operations.

3.3 Aircraft ground deicing as complex system

This section discusses if aircraft ground deicing can be seen as a complex system.

Vincente (1999) complexity dimensions have been selected to evaluate the complexity for aircraft ground deicing operations. The following table shows the different complexity dimensions and applied short description for the ground deicing context.

Table 1. *Qualitative evaluation of aircraft ground deicing system complexity*

Complexity Dimensions	**Application to aircraft ground deicing**
Large problem spaces	High number of aircrafts and aircraft types in deicing season Different deicing treatments available
Heterogenous perspectives	Different perspectives between deicing tower and deicing pad Airlines wants to leave the deicing pad as quickly as possible
Social system	Actors on the deicing pad and in the deicing tower are involved
Distributed system	Actors in the control tower, the deicing pad, and the flight deck are remotely sited from each other
Dynamic system	System becomes dynamic when eight planes are deiced at the same time and up to 24 trucks have to be coordinated from the deicing tower
Hazardous system	Airplane can take-off with contaminated surfaces Possible accidents on the deicing pad can cost the lives Damage equipment (trucks, planes)
Coupling	Particularly the communication process between the ground deicing team and deicing control tower are tightly coupled
Automation	The ground deicing process is not highly automated Monitoring process safety critical for deicing operations
Uncertain data	The number of planes, conditions of the plane, weather conditions are uncertain
Mediated interaction	Ground deicing team and pilots rely on the coordination process of the deicing tower
Disturbances	The actors have to react to unanticipated events (degrading weather conditions, treatment changes, etc.)

Furthermore, one Montreal specificity makes the coordination process more complex as communication with the pilots can be conducted in either English or French (sometimes both) since the Montreal airport is a bilingual airport. As a consequence, code switching, using a second language instead of one's mother tongue and talking to pilots from different cultural backgrounds can influence the coordination process.

4. Discussion and Conclusion

This research essay discussed whether the aircraft ground deicing operations should be seen as a complex sociotechnical system.

First, it came to the conclusion that different scientific disciplines agree that the systems we build today are so complex that we need to deploy a system approach to improve the system performance. The review showed that the classical engineering point of view does not acknowledge sufficiently the key role of the human and its performance adaptation in safety-critical systems compared to the cognitive systems engineering perspective. Second, the sociotechnical analysis showed that that there are many different actors and stakeholders involved in the aircraft ground operations. It is important to acknowledge the interests and requirements of each of these stakeholders when making interventions to improve the overall system performance. Third, it described qualitatively if the ground deicing system operations can be seen as complex working system. We came to the conclusion that it has the properties of complex working system. Particularly, tight coupling of the actors through different communication channels, distribution of teamwork and operations during degrading weather conditions can make it difficult to manage the deicing operations successfully. Finally, the evaluation shows that the cognitive systems engineering perspective can be adopted and its techniques that model and analyze complex interactions in sociotechnical systems can be deployed in aircraft ground deicing context.

5. References

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