Led Outdoor Activities as Complex Sociotechnical System

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Abstract: Popularity of Led Outdoor Activities (LOA) has increased significantly in the last couple of years. Although, more number of people were reported to engage themselves in LOA recently, the concept of LOA is not brand new. Led outdoor activity or LOA is defined as facilitated or instructed outdoor education and recreational settings (Salmon et al.2010) and includes activities such as hiking, kayaking, treks, rafting, canoeing, roped activities, snow sports etc. There are infinite number of groups all over the world who formally involve in organising such activities for people who desire to experience the thrill. Not only this, many schools and public communities un programmes such as Scouts as a part of their curriculum. The extent of acceptance of this concept, even though not completely safe, is evident by the fact that government provides official licence for conducting these activities. While these activities help the participants to experience the adventure, the increasing number of accidents has pushed it to become a topic of discussion among the researchers. Realising the consequences, they have argued that led outdoor activities must be considered as a genuine sociotechnical system. No doubt, the teams conducting such activities are well trained and professional, but it is not desirable to assume that accidents will not occur. Ignorance and lack of awareness may prove hazardous. This paper aims to realise LOA as a potential Sociotechnical system and highlight the failures of this system. Understanding the system and various actors involved will further help to comprehend what/who is responsible for the malfunctioning and how risk mitigation strategies must be employed.

Introduction

Tourism is a major source of revenue for any country. A person's preference to visit a place for relaxation depends on unique experiences that it offers. LOA contributes to a great extent in attracting the visitors. A survey reports that the number of people participating in nature-based outdoor activities has increased by 7.1 % in 2010 while the number of activity days grew about 40% (Cordell, 2012). However, this sector experiences injury, accidents and multiple fatalities every year. Death of a 7-year-old student in a pond while on school camp in Toolangi, Victoria and drowning of 12 students along with their teacher in Tongariro Park, New Zealand are two examples of such accidents (Carden et. Al, 2017). Therefore, the need to establish a sociotechnical frame is highly desirable. A complex system is the one where the overall stability of the system depends on factors other than its components. On the other hand, a linear system is one where the stability of the system can be completely defined by its component parts. Upon examining these incidents, it was found that the accidents occurred due to a linear sequence of human or mechanical errors. The previous research has identified a range of causal factors that contribute to accidents, the actual link between these factors in still unknown (Williamson et al., 2009). Because it is not possible to prevent people from participating in such activities, it is needed that interpretation of LOA as Sociotechnical System is done. Recently, many active attempts to do so has highlighted the lack of developed accident reporting system, maintained national LOA incident database and in-depth analysis of led outdoor activities. This paper attempts to present LOA as a potential Sociotechnical System by describing its social and technical components, and how they relate to each other, and presents an analysis method that can be employed to find the causes of failure. Further, it interprets who is to be blamed for such failures based on the Distributed Moral Responsibility or DMR theory.

Existing Literature

Due to popularity of LOA among people and unfortunate increase in number of accidents that take place during these activities, many researchers have demonstrated their interest in analysing the causal factors for such failures. Although, the work done in this area is not extensive, gradually many different perspectives of this domain are being introduced. According to Carden and his other group members (2017), LOA exhibits characteristics of complexity and of a sociotechnical system, both. His study mentions three works which identify human error and technical error to be the main reason of accidents. Additionally, it was found that none of the factors involved were regulatory or legislative. The undesired accidents and injuries are a result of multiple failures that take place across the system. It also includes everyday injuries (e.g. falls, sprains and strains) however, there is less data to demonstrate this (Salmon et al., 2013). Understanding these source in context with the LOA will contribute in relating the complex features of a system and what are the factors that contribute in ultimate failure of it.

Sociotechnical System Design (STSD) methods offer a way to analyse a system by considering human, social and organisational and technical factors (Baxterand Sommerville, 2010). Rasmussen’s Cognitive Systems (Rasmussen et al., 1997) and Hutchins’ Distributed Cognition (Hutchins’, 1995) are two popular methods for analysing a sociotechnical system. The researchers suggest that Rasmussen’s risk management framework is apt for analysis of LOA system (Salmon, Cornelissen, Trotter, 2011; Salmon, Goode, Lenne, Finch and Cassell, 2013; Carden, Goode, Salmon, 2017; Goode, Read, Mulken, Clacy, Salmon, 2016). Main actors identified in this case are instructors, participants, faulty equipment, environment and inadequate narration of the activity by the instructor. Salmon and his other team members (2009) utilized this identification to further extend the scope of the study by suggesting appropriate accident causation model. Meyer’s model that describes how various contributory factors relate to each other is considered simple and useful. It describes how factors involved correlate to each other. These sources will help in deducing a method that could be referred to analyse LOA. Following the pre-established framework will supply knowledge to identify the actors involved in LOA and hence lay basis for an ameliorated system.

To understand any sociotechnical system, it is first required to understand the definition of the sociotechnical system. A sociotechnical system consists of components (social and technical) that contribute to a common goal. (Hughes, 1989). Mumford (2006) stressed the values that such a system embraces, along with the involvement of people and organizations that adopt a system similar to or same as a sociotechnical system. He mentions the concept of "open systems" which implies that the environment in which the sociotechnical system exists is affected by how the system behaves. Also, it is equally important to understand the 9 driving principles of an ideal sociotechnical system. According to Mumford (2006), "[Sociotechnical design] is more a philosophy than a methodology" (p. 317).

Understanding and analysing the sources of technical and social failure is not adequate. Most challenging aspect of analysing any sociotechnical failure is identifying the nodes involved(actors) and assigning the responsibility. According to the concept of Distributed Moral Responsibility (DMR) (Floridi, 2006), the responsibility must be distributed among all the nodes of the system that give rise to Distributed Moral Actions (DMA). Allocation of moral responsibility and therefore the allocation of praise and reward or blame and punishment is a difficult task (Floridi, 2016).

Combination of all the sources used for this paper delivers in-depth insight of how a system can be attributed as a one that involves social and technical aspects working together to attain the overall stability. These sources are related to each other directly or indirectly and will be used to derive the basis of presenting the LOA as a sociotechnical system. Analysing a system quintessentially involves various important steps. Mumford's paper will help to understand and establish the primary principles of a sociotechnical system.

Lyme Bay Canoeing as a Led Outdoor Activity: System Description

Occurrence of accidents is one of the significant problems in LOA domain. This paper highlights what are the major components of LOA from sociotechnical perspective, what role they play, and the causal factors that can be associated with one or more actors of the system. Based on several studies done previously, it was concluded that Rasmussen's risk management framework is well suited for LOA (Salmon et al., 2013). According to this framework, any work-system comprises of different levels that contribute to the overall success of the system. In this case, government, regulators, company, company management, staff and work are the levels that interact with each other. And therefore, the decisions taken are a joint effort towards which actors at these levels contribute. DMR (Distributed Moral Responsibility) favours the distribution of responsibility to all the nodes of a system (Floridi, 2016). Similarly, Rasmussen's framework argues that all the levels of a system are co-responsible for shaping the performance of a system and therefore, accidents and safety are shaped by decisions of all the actors and not just one singular component. To see how this strategy can be implemented, this paper will analyse Lyme Bay Canoeing incident (Salmon et al., 2009) using the concepts of Rasmussen's framework and point out various factors that resulted in this incident.

Analysis

Lyme Bay Canoeing sea incident took place in the 1993 in United Kingdom. The activity group consisted of eight students, a school teacher, a junior instructor and a senior instructor. During this outdoor activity, four individuals were reported dead. If we analyse this incident, the main actors/entities of this system are the instructor, students and a teacher as participants of the activity, the organization that planned this activity and mainly the equipment used during the activity. Other actors/entities are emergency responders, members of public, supervisors, parents of students and school. Some additional participants that might contribute in such activity are environmental factors and regulatory bodies. These entities can further be classified into persistent entities, entities that exist throughout the duration of LOA, and temporary entities, entities which come into picture when various other entities interact with each other (Carden et al., 2017).

According to Williamson et al. (2009), there is little substance if accidents are explained in terms of events, acts or errors. Rather a dynamic approach must be adopted that focuses on mechanisms that lead to accidents. For this purpose, many researchers have adopted Rasmussen's risk management framework for analysis. To apply Rasmussen's framework (Rasmussen et al., 1997) for analysis of a such a led outdoor activity, six levels were adapted to represent the activity's scope. Each level can be treated as a subsystem or as an aspect of the whole domain (Carden et al., 2017). Through discussions, researchers have placed various entities involved in LOA under these levels. According to Carden (2017), the six levels are defined as follows:

1. Equipment and surroundings: Includes factors associated to equipment used and the physical environment where the activity took place.
2. Physical processes and instructor/participant: Includes decisions made by instructors, participants or other actors such as supervisors, emergency responders and members of public.
3. Technical and operational management: included actions, decisions, activities issued by supervisory members of the management team who provide the activity to take place.

4. Local area government, activity centre management planning and budgeting: includes actions and decisions by members working in local government and at senior levels of management. These actions usually take place before the incident and involve large degree of managerial work.
5. Regulatory bodies and associations, schools and parents: includes activities or actions undertaken by regulatory bodies or associations and the school involved. It also includes the factors that initiated due to the decisions taken by the parents.
6. Government policy and budgeting: includes actions or decisions that relate to provision of LOA. For example, funding and policy development.

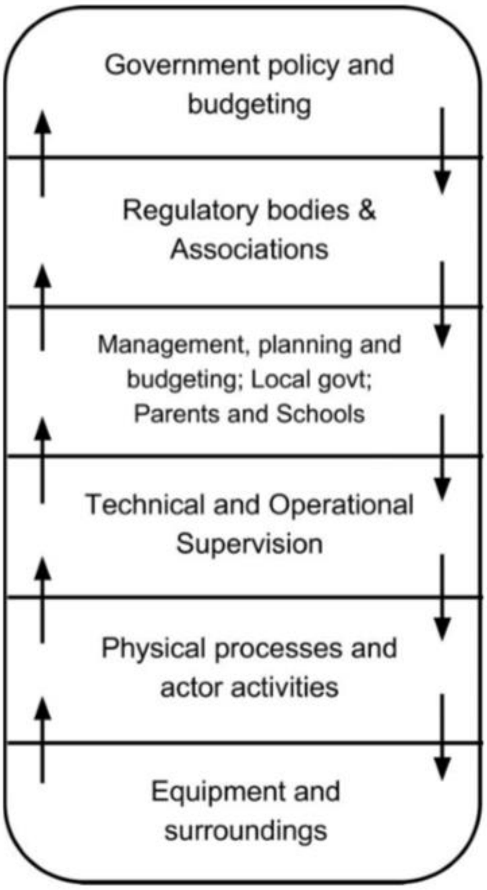


Figure 1. Rasmussen’s Risk Management framework

(Adapted from Rasmussen framework analysis, 1997)

Further, Rasmussen suggests the use of Accimap method to graphically present the above system and related system failures. This method classifies each action, induced by the components of the system, into one of the six levels of Rasmussen's framework.

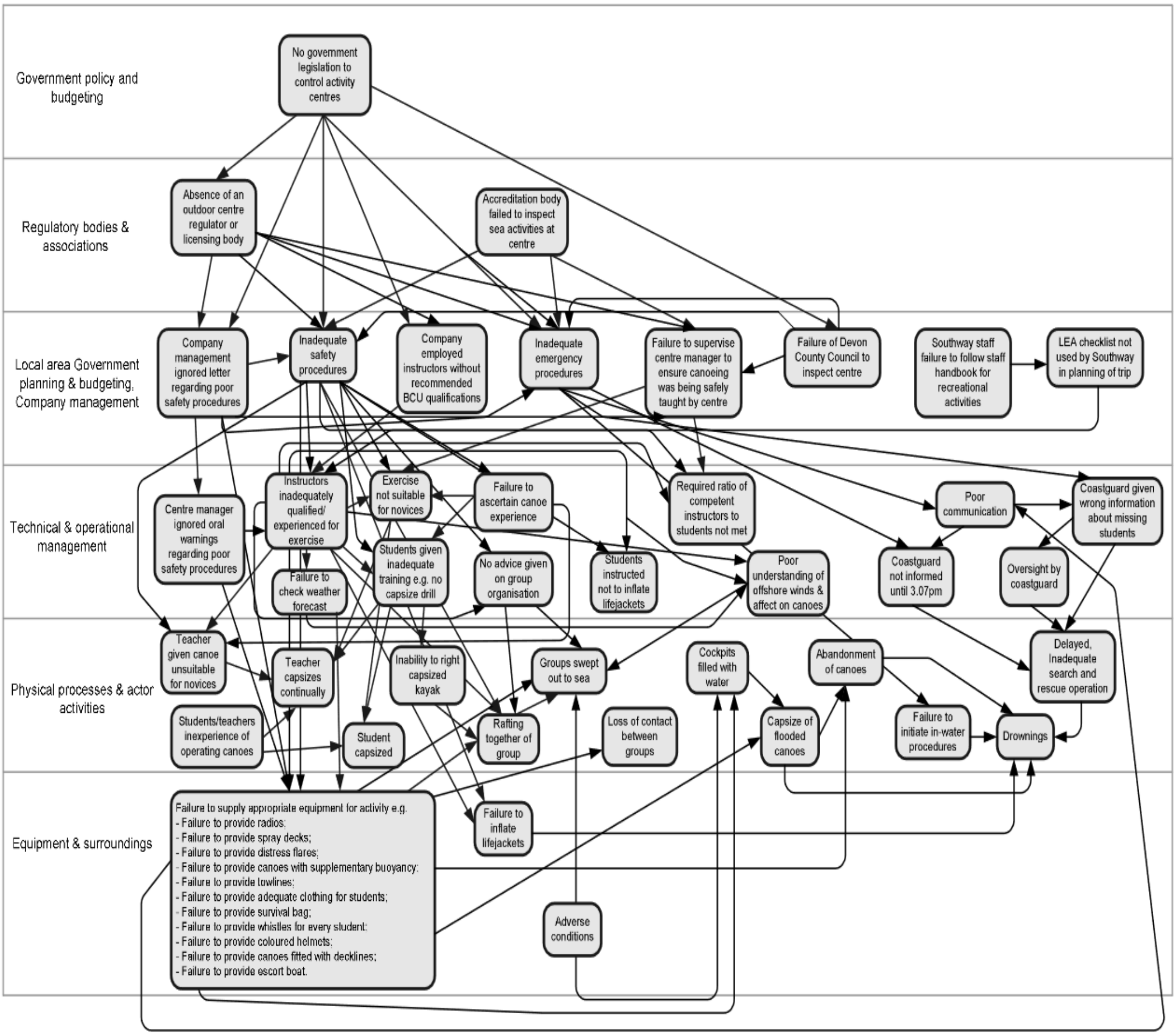


Figure 2: Accimap Analysis

(Adopted from Salmon, 2009)

According to Rasmussen's framework, the events, factors and actors of Lyme Bay Canoeing incident can be discussed as follows:

1. Equipment and surroundings

Lack of adequate equipment is the major contributing factor to this accident. Improper tools and lack of supporting equipment such as radios, distress flares, towlines and survival bags on this activity is the main reason for technical failures involved in this sociotechnical system. Lack of spray decks, insufficient clothing of students, non-inflated life jackets and ignorance of lack of expertise level that students held were the main casual factors at this level. Surroundings also contribute to this level where seashore winds made it difficult for the students to follow the intended sea path.

2. Physical processes actor activities

At this level, the factors like instructor’s and student’s inefficacy to respond to unfolding events during the activity, play a crucial role. Since they were inexperienced, they were incapable of handling the unexpected situations. Moreover, when the two group, instructor and teacher, and junior instructor and students, separated, they could not establish contact with each other again due to lack of radios and distress signals. The organisation of response mechanism was also not efficient. The information about the incident was not delivered on-shore until 3 hours it took place. Also, the coast guards committed few mistakes while carrying out the rescue operation.

3. Technical and operational management

At this level, managerial failures contribute to the causal factors. In particular to this incident, the management body failed to take into account the feedback sent by previous participants of the activity. The feedback directly pointed out the shortcomings of the overall organisation of the event. Not only this, the management even ignored the verbal feedback according to which the process of teaching canoeing was inadequate. In addition to this, the instructors seemed underqualified and were not well-aware of the weather conditions on sea. He even failed to check the weather forecast compromising everybody’s safety.

4. Local area government planning and budgeting, Company management

This level represents the mismanagement of the managerial body where it failed to take notice of the letter sent by the previous employees which states that the procedures followed were not safe. This level also includes the fact that the school did not plan the trip properly and not much time was spent on how safe it is to take the trip at that point of time. They did not abide by the local authority checklist for planning this trip.

5. Regulatory bodies and associations

Absence of a regulatory body purported the unskilled organisations to continue with the unsafe procedures of canoeing. It is believed that in presence of a regulatory body, the complaints logged previously about unsafe procedures of canoeing would have been taken into account by the regulators and upper management representatives.

6. Government policy and budgeting

At government level, the absence of any legislative or control body contributed to the main causal factors. In the presence of a licensing body, this accident would have been avoided as it should have prevented the execution of reported unsafe practices.

Discussion

Method

In the previous section, Rasmussen's framework along with Accimap classification method was used to analyse the Lyme Bay Canoeing incident. This method assisted to classify the factors involved in this led outdoor activity. According to Salmon (2014), Accimap method helps to successfully identify all the factors that contribute across various levels and hence favours to alleviate the possibility of accidents. Another advantage of this method is that it leads to identification of failures that occur across the system and the way they influence the overall degree of safety and efficiency. For example, identification of unskilled instructors and inability to address the complaints logged by previous employees is beneficial for further developments in the system.

Evaluation: complex or not?

Figure 2 demonstrates how various factors are linked to each other. The results cannot be traced back to incapable instructors or novice participants only but the chain of events preceding the activity is altogether responsible for the failure of the system. One significant discovery of this analysis is that the actors involved may not only be the ones who directly participate but actors that are outside the system also contribute towards the final results. For example, government workers, school staff, student’s parents. Therefore, Accimap analysis presents a scenario where social elements and technical elements are highly interdependent on the subsystems or levels involved. Identifying the interdependence between the socio and technical aspect is one of the main characteristic of a sociotechnical system (Carden et al., 2017). For example, to prevent any major accidents, it is required that instructor and participants must be aware of the use of equipment to send distress signal to the base station. In turn, an operator at the base station must be capable to use the receiving device to identify the message sent by the participants or the instructor. To further establish the fact that Lyme Bay canoeing LOA is indeed a complex system, the comparison of the factors and elements against the properties of a sociotechnical system is as given below.

Table1. Examination of Lyme Bay Canoeing incident LOA against the complexity criteria

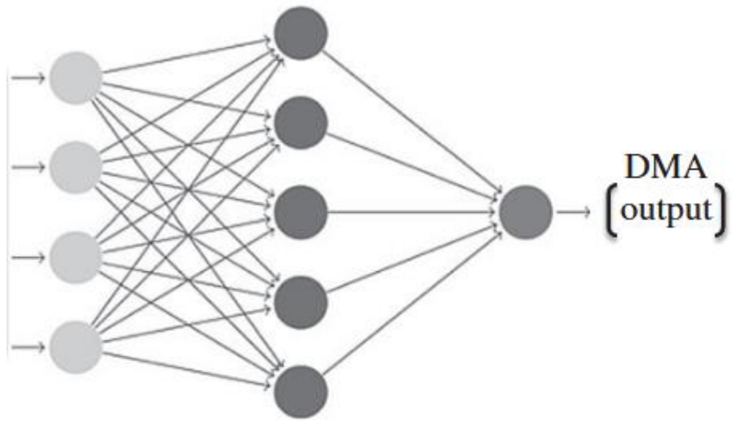
Characteristic of Complex System	**Example of characteristic in the Lyme Bay Canoeing Incident**
Large number of elements	The factors shown in the figure two demonstrate the variety of elements or actors that are involved in this LOA. The outside actors like government workers, base station worker etc also impact the system.
Dynamic Interactions between elements	After analysis, it is evident that dynamic interactions between the various actors of this system played important role. For example, communication between the activity team and the base station, the exchange, the immediate instructions being given to junior instructor from senior instructor for being together while he was helping the school teacher to recover.
A complex system's past is co-responsible for its present behaviour	Addressing the complaints logged by previously employed employees regarding unsafe procedures and practices would have prevented this accident and hence affecting the present behaviour of the system
Each element in the system is ignorant of the behaviour of the system as a whole	The instructor might be able to describe all the parts and impacts, yet he would not be able describe all the known parts to the participants before starting the activity.
Complex systems are open systems: it is difficult to define the border and elements that interact with it	Factors such as surrounding environment, winds affecting the waves in the sea, upstream and downstream speed, etc keep entering and exiting the system.

Characteristics like dynamic interactions, component ignorance, undefined boundaries of the system produce uncertainty in the system. High degree of uncertainty is an inherent feature of a complex sociotechnical system (Carden, 2017). The above table demonstrates that this LOA is indeed a complex sociotechnical system.

Responsibility Distribution: Who is to be blamed?

Identification of causal factors is not enough but inspecting which element primarily contributes to the cause and hence assigning the responsibility is equally important. The concept of DMR states that the assignment of responsibility can be understood if the system is seen as a sum of various components rather than considering it as a single responsible system. According to Floridi (2016), "Attributing moral responsibility, … means focusing on which agents are causally accountable for a morally distributed action [accident], rather than whether agents are fairly commendable or punishable for [accident]" (p. 6). There are various ways suggested by researchers for assignment of responsibility. One of the methods used by Floridi (2017) is multi layered neural network. To apply this model, the elements of the system must satisfy three conditions. First, the nodes or elements of the system must be independent or autonomous. Second, they must be able to interact with each other. Third, they must be able to learn from their interactions. Applicability of these conditions to the Lyme Bay Canoeing incident is quite evident. This LOA system consists of independent elements or nodes (instructor, students, teacher, school staff, parents) that can interact with each other and can conclude their actions depending on their interaction.

Input



Agents Hidden layers

Figure 2: Multi-agent system as multi-layered neural network

(Adapted from Floridi's multi layered neural network model (2016))

According to the multi-layered neural network model, the backward propagation can help to distribute the responsibility to all its nodes/agents to improve the outcome. If we consider the case of Lyme Bay Canoeing incident, the agents nodes will be represented by the actors such as instructor, students, teacher, school staff, government workers, technical equipment etc. The hidden layers may correspond to the degree of uncertainty that was introduced due factors such as changing environment. The back-propagation procedure is continued till the expected state of improvement is not attained.

The back-propagation method offers features that helps to solve the responsibility assignment problem in a multi agent system. However, there are few drawbacks of this approach. According to Floridi (2016), assigning the responsibility to all the nodes with the aim to improve the performance may be unfair because some agents may not be directly involved. Another disadvantage is the problem of "risk aversion". When everybody is held equally responsible, some may actively adapt it while some may ignore it assuming that other nodes will take care of the unexpected results.

Conclusion

The paper identified various strategies through which the accidents during LOA can be prevented. Although, a lot of accidents keep occurring in the field of led outdoor activities, very little importance is given to figure out the causes behind such incidents. After analysing the Lyme Bay Canoeing incident, it was found that any led outdoor activity is a convoluted system. After defining the activity as a sociotechnical system, elements involved in it, causal factors responsible for the accident and comparing the features of the incident with that of a complex sociotechnical system, it is evident that any LOA is not as simple as it seems. The social and technical elements involved and the way they interact with each other is the paramount feature of Lyme Bay canoeing incident. For future, in attempts to make LOA safer and technically efficient, it is necessary that it is treated as a potential sociotechnical system and is approached appropriately to ameliorate the existing settings and prevent further accidents.

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