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SoS in Disasters: Why Following the Manual Can Be a Mistake

Antonella Cavallo, Vernon Ireland
antonella.cavallo@adelaide.edu.au
vernon.ireland@adelaide.edu.au

Entrepreneurship, Commercialisation
and Innovation Centre (ECIC)
The University of Adelaide
Adelaide SA 5005, Australia

Abstract –*According to both the US Geological Survey and the World Bank, $280 billion dollars could have been saved if $40 billion dollars had been invested in disaster prevention. Natural and human-made disasters that have occurred over the last few years show that there is a gap in disaster prevention caused by the interconnected nature of risks, which cannot be foreseen with current risk management methods. In this paper we point out how disaster management could benefit from a SoS approach in emergency response and preparedness strategies. Using recent disasters as case studies, we identify some keys to success in managing a SoS in preparation, during and in the aftermath of a disaster. In particular, we discuss the idea of the interconnectedness of risks in independent and interdependent systems and the application of Boardman and Sauser's concept of "creative disobedience", which are fundamental for goal achievement of systems belonging to a SoS.*

Keywords: SoS dynamics, disaster management.

1 Introduction

In many countries, risks related to disasters are managed following a paradigm of traditional risk management. This is based on a cycle in which risk identification, risk evaluation, risk mitigation and policy adjustment [1, 2] are the four steps which are followed in a logic of continuous improvement towards the evolving system conditions. The corollary of this approach is that only identified risks can be managed and embedded into a policy. However, disasters are part of complex systems involving a network of risks, rather than linear causal relationships [3]. The difference between complicated and complex risks can be inferred [4] from Snowden and Boone's distinction between 'complicated and complex cognitive domains' [5]. In a risk network, there are some risks which can be identified and some which stay unforeseen. The former are 'complicated' as they can be ascertained a priori. The latter are 'complex' as they involve a higher degree of uncertainty which involves the cause-effect relationship to stay unknown until after the risk occurrence [6]. This approach is particularly effective in the case of linear causal relationships, i.e. when an identified cause is connected to one or more identified effects. However, there are at least two problems with this approach: first the way lessons learned are currently managed does not work as expected [7], which means that even after repeating the risk management cycle, some risks are left out and hence not managed. Second, a deterministic approach for risk assessment [8], does not consider the possibility of unforeseen risks due for instance to factors like climate change.

The fact that we need to come up with new approaches to face a complexity which includes risks that we cannot necessarily foresee has been recognised by many [3, 4, 9, 10]. Particularly, Boteler [11] highlights the need for holistic approaches in disaster management. Leveson [7] points out that safety is an attribute which applies to the whole system and not just to the individual components. Salmon [12] suggests that a disaster can be considered as a system which cannot be broken down easily into its components as it needs to be analysed as a whole.

From an organisational point of view, the system of a disaster involves several organisations, institutions and agencies such as the Red Cross, government, fire services and police. These are all systems in an evolving system of systems (SoS), which is the disaster context itself, immersed in ever-changing environmental and contextual conditions. The coordination of different agencies is often organised hierarchically and it can be challenging, particularly in the occurrence of an unexpected disaster. Problems can arise in areas such as communication, situation awareness and cultural issues [13]. Differences in the goal achievement criteria of each organisation can be an obstacle as well. For this reason, it is important that each agency is aware of the action scope of the others. Also it should be discussed previous to a disaster which agency is going to take the lead in the case of an emergency [13]. In the context of a disaster, agencies are expected to act on the basis of regulations and policies following command-control logics. In this paper, however, we argue that these formal rules correspond to an appropriate response to 'complicated risks', but that they are less valuable in the context of complex risks.

2 Complexity in recent disasters

The US Geological Survey and the World Bank estimated that $280 billion dollars could have been saved if $40 billion dollars had been invested in natural disaster prevention worldwide [Benson and Clay 2003 in 14]. Natural and human-made disasters have dominated global media reporting in recent times. The 9/11 terrorist attack, 2004 tsunami near Sumatra, Victorian bushfires in Australia, earthquake in New Zealand, flooding in New Orleans and earthquake, tsunami and nuclear disaster in Japan are just some of the catastrophic events which have occurred over the past few years. The number of natural disasters are believed to be increasing because of climate change [15, 16], but human mistakes are exacerbating their effects. For example, pre-existing management issues contributed worsening the nuclear disaster in Japan and flooding consequences in Queensland both in 2011 [17]. So what can entities such as government authorities or crisis monitoring agencies really do to prevent death, destruction, loss, mental illness and long-term effects in the world? Recent disasters have shown a lack of efficiency in managing situations before they turn into disasters. For example, in 2005 despite the adequate available information, the public officials of New Orleans failed to evacuate the population before flooding caused a landfall. By then the inhabitants did not have any way to escape and as a consequence hundreds of people lost their lives [18].

In a time where information flows very quickly from one side of the earth to the other, people are increasingly critical of how disasters are managed and concerned with what can be done to prevent critical situations from turning into crises. Traditional risk management has developed preparedness brochures, simulations and other types of awareness programs (e.g. Red Cross, Country Fire Services, US Geological Survey). Most of these programs focus on specific risks and do not take into consideration the multi-causality of risks [19]. Many risk programs are also organized around manuals, rules and laws which are assumed to be followed in the case of a disaster. In reality, however, the disasters cited above demonstrate that these measures are not followed by all parts of society, including the various institutional, corporate and demographic groupings. For instance, despite the existence of regulations in Japan, Prime Minister Kan delayed disclosing important information about the radioactivity of the Fukushima power plant, causing a part of the population to move into the radioactive wake [20]. Costa Crociere, the company which owns the cruise ship which crashed in Italian waters earlier this year, was aware of the illegal sail-past practice, but it did not do anything to stop captains from continuing doing it [21].

While the last examples seem to suggest simply that the law should have been applied to avoid potential disasters, there are other situations where the ideal behaviour or response is not as easy to identify. For example, after the cyclone in 1977, many Indian laborers moved from rural Southern Indian to the coast, which was more likely to be hit by disasters [22]. This raises a number of difficult questions for risk managers. It seems straight forward that these people should not move to the coast as it will be more dangerous when the next natural disaster occurs. However, the correlation between disasters and poverty [14] suggests that they might have moved to the coast to access the minimal resources to live. In that case, 'life preservation' has to form an additional goal of a SoS in the case of a disaster.

In this context, the efficiency of disaster management depends on awareness of the SoS risk interdependencies and prioritization. In other words, risks need to be contextualized in their network and managed, taking into consideration the different patterns which can result as a consequence of a crisis. When the Icelandic volcano Eyjafjallajökull erupted in 2010, the authorities used the precautionary principle to stop most of the air traffic after the eruption. Although some airlines had verified the sky conditions and ascertained the absence of significant danger, they were not allowed to transport passengers for days, causing heavy economic losses. Eventually, authorities decided to reopen airports without having any more data about ash in the sky than when they decided to close them [3]. Like in the case of the Eyjafjallajökull, many institutions refuse to manage complex risks as they do not think to be able to cope with the complexity and uncertainty involved [3, 19]. The reason for this is because contingent programs are based on the identification and analysis of specific known risks, whereas high uncertainty requires the identification and analysis of different alternative risk patterns [19]. For this reason, we use the lens of Complex Risk Management to focus on the management of foreseeable and unforeseeable risks (also called 'unknown unknowns' or 'unk unks' in aerospace engineering [3]) and their effects in a disaster.

3 A SoS during the Fukushima Daiichi disaster

Reports on the Fukushima Daiichi disaster, which have been published since [20, 23], reveal the structure of a System of Systems (SoS), where the interconnectedness and interactions between the systems and their environment made risks evolve and develop into a network of unanticipated causes and effects over a very short period of time. Despite the fact that earthquake and tsunamis are not uncommon in Japan (in fact they have much better anti-seismic buildings than in Italy), neither the government nor the Nuclear Safety Commission (NSC) nor the company at the centre of the nuclear disaster, Tokyo Electric Power Company (TEPCO) had put in place adequate measures of disaster prevention [20].

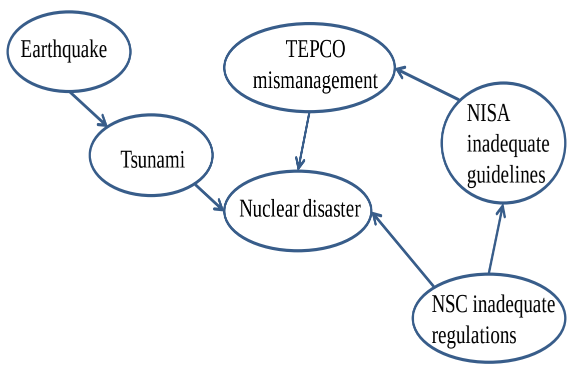

Figure 1. A partial risk network of the Fukushima Daiichi disaster inferred from [20, 23].

In Japan, the Nuclear Safety Commission (NSC) oversees the Nuclear and Industrial Safety Agency (NISA). NSC's inadequate regulations impacted on the guidelines that NISA imposed on TEPCO [20]. So, for example, NSC's regulations did not take into consideration the possibility of electricity outages as it was judged that temporary blackouts would have been quickly solved. As a result of poor regulations and controls, TEPCO managed the disaster inappropriately, contributing to worsening the nuclear disaster which had been caused by the tsunami following the initial quake [20, 23] (Figure 1). Here we could assume that if more regulations had been put in place, then the disaster would have had reduced dimensions. However, the fact that appropriate regulations were available at an international level and that TEPCO for different reasons did not happen to abide by them should open a question about the effectiveness of international control and monitoring institutions. In this case, the decision not to abide by the international law had been consciously taken at the corporate and at the institutional level.

Command-control logic failed at different levels during the Fukushima disaster. When the disaster happened, the two most important people in TEPCO's top management were away on holidays or on business travel. For different reasons, they were not able to go back immediately to Fukushima, causing a slowdown in decision-making and information sharing between the government and TEPCO's management [20]. The nuclear disaster involved a complexity that TEPCO was not prepared to face, to the point that the government had to call in external nuclear experts to help to manage the disaster [20]. However, there was a decisive point where the hierarchical logic of decision-making was broken by a subordinate who would not have normally had the authority to ignore the orders. In the middle of the disaster, the situation in the Daiichi plant was still extremely uncertain and the decisions taken seemed to be distant from their operational impacts. The lack of adequate information and the misuse of the available data put the decision-makers in a difficult position [20]. It was not clear which effect their decisions or the lack of decisions would have had on the whole system. So, at one of the most critical points of the crisis, a key decision about stopping or continuing the water injections to reduce the temperature of Unit 1 could not be taken.

Tensions between the government and TEPCO top management and then between the latter and the site management, made the decision even more complex. At some point the government authorized the injections, while the liaison of the company to the government said that they had to be stopped until a strategy to manage the crisis had been decided. However, the Fukushima Daiichi site management was convinced of the importance of continuing the water injections. In fact, during a teleconference, Fukushima Daiichi Director Yoshida decided to formally accept the orders to stop the water injections, but secretly told his staff in charge of this operation to continue the water injections. By doing this, he helped the company to manage the conflict with the government, whilst importantly preventing the worsening of the nuclear crisis [20].

This is an example of what Boardman and Sauser call 'creative disobedience' [24] which is, and must be, implicit in paradoxical situations such as crises. The idea is that in complex systems where available information is often not available at every level of the hierarchy, subordinates need to understand the main goal of their mission to the extent that they are able to act independently of orders for the highest of the system goals. In the case of Fukushima, Yoshida was probably in a more informed 'cognitive domain' [5] than the other people who were in a position of taking a decision. The complexity of this scenario raises some very interesting questions about the SoS dynamics during the disaster.

4 Why systems thinking in the crisis

In the midst of the uncertainty, Yoshida had a good intuition, but what if things had gone differently? The case of the Japanese crisis is just an example. There are others in which extreme uncertainty pushed people to make decisions against the manual. However, in the end the resulting effects of the disaster were interpreted by authorities as a result of the operators' misbehavior.

Much legislation is built around the responsibility of individuals managing the disaster. If on the one hand, this gives a decision-making framework to the responsible authorities, on the other it can push these to take decisions away from an informed common sense. This effect is caused by a hierarchical and command-control way of thinking which is based on the assumption that situations, risks, projects, disasters, systems can be broken down into manageable entities. By doing this, the sense of the effects on the overall system is lost.

As Gilpin and Murphy note [19], it is important to understand to what extent the whole can be reduced before we start losing essential information about the system. Current regulations are very likely to have unforeseen negative effects [25] if a global perspective is not taken. There is a big limitation, though. Thinking in terms of system of systems about a disaster can be overwhelming, especially when a generalization is attempted. In fact, some authors state that systems theory is not adequate for a crisis as it would involve the system being subject to "rationalism and control" [19] which, as our examples show, might not be enough to protect a system from a crisis. This is true when the SoS is considered with a command-control lens, i.e. a hierarchical one. Indeed, it is not realistic to have a central control for a SoS in a disaster because each organization and institution has a separate set of goals, i.e. it is independent and obeys the organisation's peculiar hierarchy.

There is an underlying risk network in every SoS in which risks have an impact beyond the individual systems which have triggered the risk occurrence [26]. For example, the nuclear disaster in Japan has had consequences on near countries (outgoing arrows in Figure 2). This raises a number of questions about the management of global risks as highlighted by Beck [26] who talks about 'world risk societies' to indicate those communities which share risks beyond political borders. Gaps and overlaps [27] emerge from the comparison between risk networks of a disaster and the organisational structure of different agencies dealing with disasters.

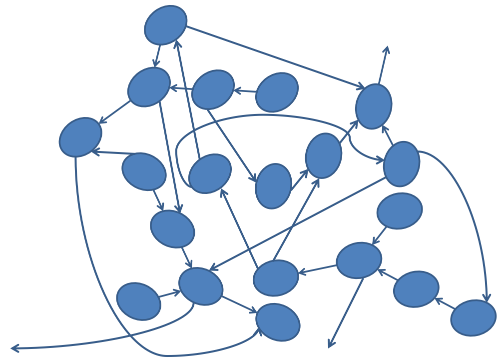

Figure 2. Stylized risk network for a disaster.

If we superimpose risk domains of a disaster on the organisational structure of the agencies managing disasters, we get two pictures which do not appear complementary (Figure 3). Big circles represent risk domains, whereas small circles with a stylized organisation chart in the middle correspond to organisations managing disasters. We assume that all organisations, institutions, communities, etc. belong to a system of systems.

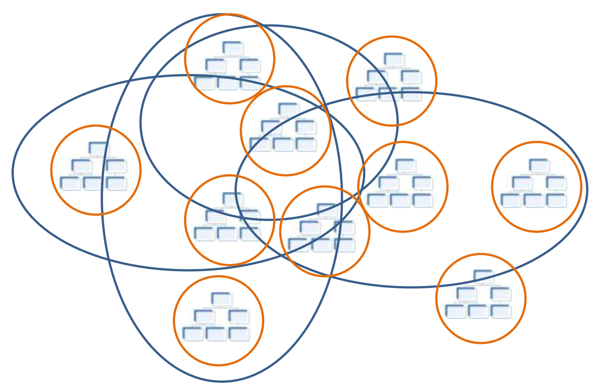

Figure 3. Example of risk domains and hierarchical systems in a SoS configuration.

That organisations need to work together to manage a disaster is clear to the most. However, what we are saying here is that they need to do it in a more integrated way, as has been acknowledged also by some humanitarian organisations [28]. Being aware of the ontology of complexity as explained at the beginning of this paper and acknowledging the fact that organisations operate in a system of system can support organisations in working towards a new way of integrated cooperation. For example, we know that in complex projects, the probability of success can be increased by getting team members to share goals and values [3]. Then, a SoS approach is a viable method when the goals of a SoS have been agreed in advance within different organisations and when it is possible to have an inductive approach to problems together with a deductive one, i.e. command-control. This involves individual organizations and individual members having the maturity and autonomy to allow them to take decisions away from predefined frameworks, but still appreciating and understanding the long-term goal of the underlying organization.

5 Conclusion

This paper suggests that current disaster management frameworks should be changed into paradigms which involve a SoS vision of situations potentially turning into disasters. Instead of using command-control management techniques, the perspective should be also inductive so that goals can be negotiated and organizations can achieve a higher degree of effectiveness in disaster SoSs. Such an approach would also allow a better integration of all functions planning and operating during a disaster.

Moreover, a global perspective supported by complexity science and systems theory shall focus on hazards taken in their risk network context. We need to be aware of global risks and have an approach which aims to mitigate some risks and to accept the uncertainty that others involve. As the number of disasters increases and technology development induces incalculable system evolutions [29] (e.g. nuclear disasters), we need to change our way to think about disasters. We need to collaborate with other ‘risk societies’, discuss priorities and goals and decide together which risks to manage. Finally, we need to get used to the fact that we cannot control everything and that disasters may happen. This will not necessarily mean that we failed.

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