Reverse Engineering of Published Work for Strategy Mapping

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ABSTRACT

As global risks evolve, evaluating literature on crisis management and response becomes essential for addressing systemic risks in transboundary crisis scenarios. Reverse engineering (deconstructing and recreating existing research to assess and improve its findings) offers a valuable tool for generating new insights into published work on crisis management. We explore the effectiveness of reverse engineering in evaluating the internal consistency of crisis response research, using a case study on the 2014 Oso/SR530 landslide response. Using the *Strategyfinder* software, we demonstrate how risk mapping can identify gaps in the original analysis and contribute to the development of more robust risk models, essential for developing effective strategy maps. Additionally, we identify key methodological challenges inherent in the process of reverse-engineering including data interpretation issues and model limitations and propose solutions to address these challenges. Unravelling these complexities lays the foundation for accurate risk modelling for the development of systemic risk mitigation strategies.

Keywords

Replication of research, Systemic risks, Strategy mapping, Disaster risk reduction, Strategy development

INTRODUCTION

There exists a substantial body of literature dedicated to crisis management and response and disaster risk reduction strategies. This literature spans multiple disciplines including public health, environmental science, urban planning, engineering, and social sciences reflecting the diverse and complex nature of risk. As global risks continue to evolve, particularly with the impacts of climate change, evaluating this body of literature becomes essential for conducting impact-driven research that results in implementable and sustainable disaster mitigation strategies. Replication, which involves conducting studies that closely adhere to the original research design, is a fundamental aspect of scientific rigor. It is essential for validating findings and ensuring the robustness of research outcomes (Jonas et al., 2024). However, in many disciplines only a minority of studies are ever replicated, often due to the need for substantial time and resources. More concerningly, published papers in top psychology, economics, and general interest journals that fail to replicate receive more citations than those that replicate (Serra-Garcia & Gneezy, 2021). This lack of replicated published work creates critical gaps in the evaluation of existing research underscoring the need to explore less time- and resource-intensive alternative methods for assessing original work.

Reverse engineering (Eden and Ackermann, 2003), albeit not a direct substitute for replication, offers a promising approach to assess the validity of published work. It involves deconstructing existing products or ideas to understand and recreate them often leading to innovation (Bell & Ibrahim, 2023; Kaufman, 2018). In the context of disaster risk reduction, conceptual reverse-engineering of risk enables a deeper understanding of how various contexts influence risk perceptions and decision-making processes (O'Sullivan and Mace, 2024). A recent publication (Gonzalez et al., 2024) used strategy mapping to reverse engineer a detailed scenario of a cyber-attack to critical infrastructure found in the last issue of Analysis of Crisis Scenarios developed by the Norwegian Directorate for Civil Protection (2020). Reverse engineering can be employed to analyse risk scenarios, facilitating the process of developing implementable mitigation strategies.

This study demonstrates that applying reverse engineering to published academic work can yield new insights into its internal consistency. It examines the methodological challenges of reverse engineering and offers recommendations for improving scholarly writing in crisis response. These insights can inform the development of enhanced strategies, which can then be compared with the original publication's responses to refine and strengthen them.

Learning from past crisis equips researchers and practitioners with the means to better prepare for future crisis response. Hans Jochen Scholl and Sarah L. Carnes from the University of Washington authored two publications on the response to the 2014 Oso/SR530 landslide disaster in the United States. For this study, we focused on their paper examining the managerial challenges during the early response (Scholl & Carnes, 2017), particularly the complexities of coordinating diverse response units amid limited information, high stress levels, and a lack of preparedness. The paper highlights critical points of failure in the initial response phases and identifies obstacles that led to a distorted operational picture and suboptimal resource allocation. The 2014 Oso/SR530 landslide risk scenario is a comprehensive case study that highlights critical factors in risk management, response coordination, and recovery efforts, making it ideal for reverse engineering to analyse systemic risk. Reverse engineering of Scholl & Carnes work (op. cit.) can generate valuable insights by developing strategy maps that address the interdependent complexities of systemic risk in the Oso landslide scenario. Comparing these strategies with the responses outlined in the original article could reveal gaps and inform improved strategies for future responses to similar events.

In this work-in-progress paper we focus on the reverse engineering process and highlight methodological challenges inherent in it. Unravelling these complexities could lay the foundation for accurate risk modelling that facilitate the subsequent development of systemic risk mitigations strategies.

SYSTEMIC RISK IN COMPLEX SCENARIOS

Systemic risk arises from interdependencies, where a disruption in one part of a system can trigger a chain reaction affecting other parts. Thereby, risk outcomes are risks themselves (Ackermann et al., 2007; Gonzalez & Eden, 2023). This type of risk has transgressive effects that often extend beyond their initial context impacting various sectors and systems with intra- and inter-sector cascading effects. The COVID-19 pandemic illustrates how systemic risk affects not only public health, but also the economy, education, governance, and social stability. Similarly, coastal disasters such as hurricanes, typhoons, and superstorms often precipitate secondary risks including outbreaks of waterborne and vector-borne diseases, mental health challenges, and disruptions to healthcare services. These risks are compounded by factors such as overcrowded evacuation shelters, damage to critical infrastructure, food insecurity, exposure to hazardous materials, and prolonged displacement further intensifying the need for better coordination among response agencies. In such situations, the diverse and interconnected interactions between agencies, responders, and resources create interdependent risks that lead to unintended and often counterintuitive consequences, which propagate throughout the system (Gonzalez & Eden, 2023). The ramifications of these consequences increase the likelihood of misalignments, information bottlenecks, and coordination breakdowns, further amplifying systemic risk.

STRATEGY MAPPING

Traditionally, the systematic documentation of risks and the development of strategies to mitigate them have been accomplished using risk registers. Risk registers are tools that use matrices or scoring systems to prioritize risks based on their likelihood and severity (Kostirko et al., 2023). These registers are commonly used to ensure that the prioritized risks are actively managed and minimized by developing strategies to reduce their likelihood or impact. However, risk registers are often criticized for failing to depict the systemic risk associated with complex cross-boundary scenarios accurately (Ackermann et al., 2007; Zscheischler, 2023). Budzier (2011) attributes the problem with risk registers to their prioritization of measurable information at the expense of intuition, emotions, and a holistic understanding of organizational dynamics; aspects that are critical for comprehensive risk assessment. Furthermore, the dynamic nature of systemic risk complicates traditional risk management strategies necessitating new frameworks for assessment (Renn et al., 2020; Gonzalez & Eden, 2023).

In this regard, strategy mapping offers a viable approach that illustrates the cause-and-effect relationships between risk interdependencies. It involves creating a visual representation of strategic objectives and causal relationships among them (Bryson et al., 2014) with the aim of developing effective and implementable mitigation strategies. For a reliable representation of the risk system, it is essential to involve a well-chosen group of participants through participatory modelling, including stakeholders, experts, and powerbrokers (Gonzalez & Eden, 2023). While experts provide the relevant knowledge and technical expertise needed to understand the complexities of the risk system, powerbrokers make decisions or influence those with the authority to act. Meanwhile, stakeholders ensure that outcomes are rooted in real-world needs, increasing the likelihood of their adoption and sustainability. This participatory modelling approach fosters collaboration and promotes a sense of ownership and commitment among participants, which is crucial for the successful implementation of strategies.

We contend that reverse-engineering disaster scenarios in published work using *Strategyfinder* can yield valuable insights for assessing the internal consistency of the work, provide recommendations for writing scholarly articles on crisis response, and evaluate the methodological challenges of reverse engineering. Addressing these aspects could enhance the process of creating accurate strategy maps that inform the development of response strategies to address systemic risk. Accordingly, the following research questions have been formulated:

RQ1: Can reverse-engineering disaster scenarios evaluate the internal consistency of published works on crisis response?

RQ2: What methodological challenges arise when reverse-engineering disaster scenarios in published research, and how can they be addressed?

METHOD

Strategy mapping, supported by the *Strategyfinder* software, has been employed to extract insights from the paper "Managerial Challenges in Early Disaster Response: The Case of the 2014 Oso/SR530 Landslide Disaster" (Scholl & Carnes, 2017) and provide suggestions for future scientific writing. The article text was parsed to extract distinct risk statements ensuring each sentence was accurately identified and isolated for further analysis. Challenges associated with the parsing process were highlighted. Specific criteria were then established to segment response time into meaningful phases that account for the temporal dimension of crisis response. These criteria ensured that risk statements that are ambiguous in terms of time and duration were appropriately assigned to relevant time phases. A risk model for each time phase was constructed by reverse engineering the article text. This process revealed inherent methodological issues in the process of reverse engineering. Parsing and methodological challenges inherent in the reverse engineering process were identified and addressed, and recommendations for improving future risk scenario descriptions were proposed.

RESULTS

The selected academic publication (Scholl & Carnes, 2017) examines the managerial challenges experienced during the early disaster response to the 2014 Oso/SR530 landslide in Washington State which involved 119 agencies and over 1,000 responders. The study identifies key issues in coordination, communication, resource management, and the implementation of the National Incident Management System (NIMS) and the Incident Command System (ICS). The findings reveal initial response delays due to a lack of situational awareness, jurisdictional and coordination issues among multiple agencies, and difficulties in establishing a unified command structure. As the response effort scaled up, the study reveals that federal resources remained underutilized due to late requests from state and local authorities. Challenges in applying NIMS/ICS stemmed were attributed to a lack of training among local responders, confusion between ICS and Emergency Support Functions (ESFs), and variability in ICS implementation.

Parsing the article text

Parsing involves analysing a sequence of symbols or events to extract meaningful information (Hwang & Choi, 2019). Parsing Scholl et al.'s paper involves systematically analysing the manuscript to extract statements that describe risks. In this context, risk is defined as "a phenomenon that has the potential to deliver substantial harm, whether or not the probability of this harm eventuating is estimable" (Lupton, 2013). The parsing process aims to deconstruct the risk scenario into distinct risk statements that represent the elements used for developing a risk model (risk map) based on cause-and-effect relationships. The following paragraph, an excerpt from the Oso landslide risk scenario described by Scholl & Carnes (2017, p.4) illustrates the concept of parsing.

"Unlike other emergencies and disasters such as earthquakes, high-wind storms, flooding, wildfires, and "regular" mudslides, for which responders in the Northwest region of the United States are routinely and relatively well prepared, the 2014 Oso/SR530 landslide marked an exception in terms of scale and scope, and finally, also duration (with regard to the recovery effort necessary). Responders' acquaintance to seasonal mudslides, particularly, after extended periods of precipitation, had made those emergencies a routine response endeavour. So, when the disastrous landslide occurred in the late morning hours of Saturday, March 22, 2014, the incident did not trigger an immediate non-routine response, since the order of magnitude of the slide was not

understood until much later that day, and its ramifications became only clear after days had passed by. As discussed elsewhere (Scholl, et al., 2017), situational awareness and a common operating picture were only slowly developing, so that responders initially acted mostly on information that presented itself right in front of them. Helicopter rescue crews, for example, although aware of the geographical extent of the disaster, focused first and foremost on searching for and rescuing lives rather than sharing information with other layers of emergency management to create a bigger picture. Likewise, although the responders on the ground palpably experienced the enormity of the damage, they hardly comprehended the enormous destruction along with the dilation and depth of the muddy and treacherous debris field right in front of them. Moreover, since the massive landslide had physically divided the whole valley into two separate entities within a minute's time by deeply burying the highway at a length of a mile, by disrupting the communication connections, and also by extirpating all identifiable landmarks, the management of the incident was highly difficult and complex from the first moment".

Deconstructing this paragraph yields the following distinct risk statements. Typically, risk statements consist of around 6-12 words describing risk. However, for the purpose of this paper we may use longer statements.

15 *The 2014 Oso/SR530 landslide marked an exception in terms of scale*

16 *The 2014 Oso/SR530 landslide marked an exception in terms of scope*

17 *The 2014 Oso/SR530 landslide marked an exception in terms of duration*

18 *Responders acquaintance to seasonal mudslides made those emergencies a routine response endeavor*

19 *The landslide incident did not trigger an immediate non-routine response*

20 *The order of magnitude of the slide was not understood until much later that day*

21 *The ramifications of the landslide became clear after several days*

22 *Responders initially acted mostly on information that presented itself right in front of them*

24 *Helicopter rescue crews did not focus on sharing information with other layers of emergency management to create a bigger picture*

25 *Responders hardly comprehended the enormous destruction in front of them*

26 *The whole valley was physically divided into two separate entities*

27 *Highway buried at a length of a mile*

28 *Disrupted communication connections*

29 *All identifiable landmarks extirpated*

30 *The management of the incident was highly difficult and complex*

69 *Situational awareness and a common operating picture were developing slowly*

Challenges in parsing risk statements

Parsing risk statements presents several challenges particularly in detecting ambiguities and dealing with complex sentence structures. For example, the Governor's request for a national disaster declaration is stated to have taken ten days, but no intermediate steps are detailed. Additional challenges include events such as the County EOC's operational issues, where disorganization and lack of collaboration by the County Medical Examiner spanned multiple days. However, no clear associations to specific events were provided. Moreover, FEMA's response is broadly described, highlighting their readiness to deploy resources but also delays caused by hesitations at the State and County levels. Beyond these ambiguities, complex, run-on, and verbose sentences can reduce the clarity and readability of risk descriptions. Unnecessarily lengthy and wordy constructions, as well as improperly structured or information-dense sentences further complicate parsing.

Mapping the risks

Deconstructing the text to identify and extract pertinent risk statements is a fundamental step in the development of a strategy map. The parsed statements are then entered manually into *Strategyfinder* to construct a risk model. As each parsed statement is entered into *Strategyfinder*, it is automatically assigned a unique ID number based on the order of entry. The numerical identifiers assigned to these statements are solely for reference purposes and do not carry additional significance. A risk model in *Strategyfinder* is depicted as a directed graph where nodes represent the risk statements and arrows indicate causal relationships. Causality refers to the relationship where one event happens because of (is caused by) a previous event (Cavique, 2023). It can be articulated either explicitly or implicitly within a text. Explicit causality is often identifiable through clear linguistic markers such as the noun “effect” or the adverb “so” or the verb “to cause”. In contrast, implicit causality necessitates interpretation as it lacks explicit causal markers. Extracting all relevant causal information, whether explicitly stated or implicitly implied, is essential to ensure the validity of the resulting model (Veldhuis et al, 2024). Failure to account for such information may compromise the accuracy and reliability of the model's representation. Figure 1 presents a risk model illustrating the preceding paragraph, excerpted from Scholl & Carnes (2017).

In Figure 1, the cause-and-effect relations can be illustrated through the following example. The cause effect sequence: 18→19→25 can be rendered as: *Responders' familiarity with seasonal mudslides led them to perceive such emergencies as routine, preventing an immediate, non-routine response to the landslide incident; this caused that the responders hardly comprehended the enormous destruction of the Oso-landslide*.

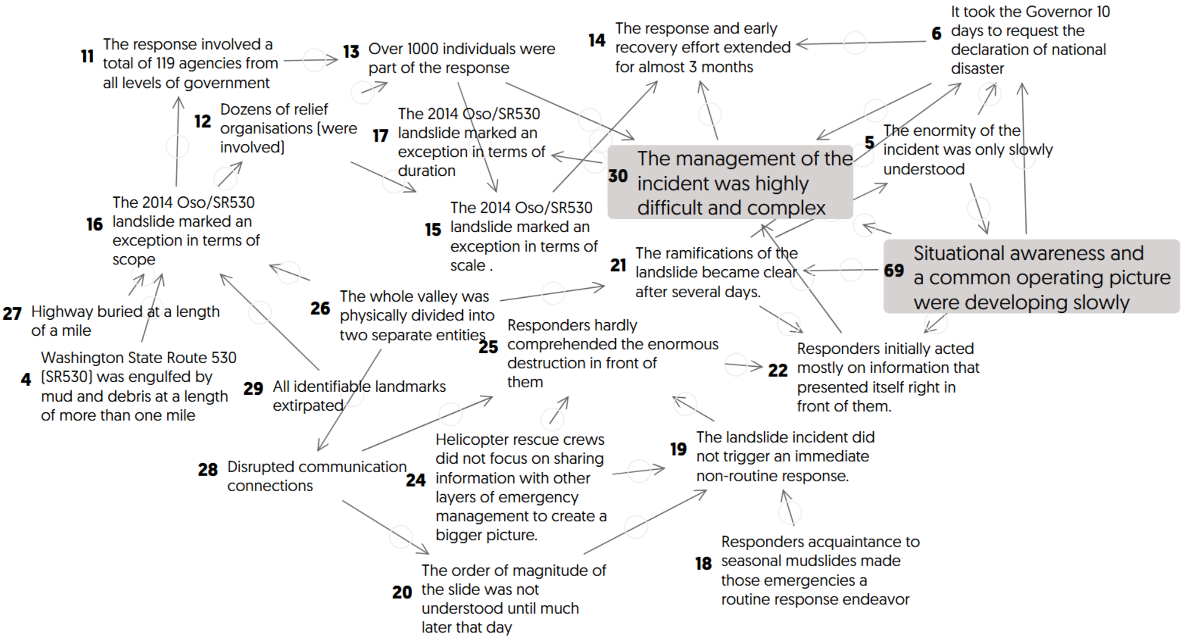

Figure 1: Risk model developed in *Strategyfinder*. #30 and #69 are formatted with the *Strategyfinder* category Goal: They are indeed candidates for *negative goals*, i.e., outcomes which must be addressed/mitigated/reversed for improved disaster response.

Accounting for the temporal aspect of response activities

A significant challenge in depicting causal relationships pertains to the temporal dimension of risk scenarios. Risk scenarios often overlook the incorporation of event timing as well as the timing and interdependences of decisions made by different response organizations (Comes, 2013). One of the primary challenges in reverse engineering the Scholl & Carnes paper (op. cit.) lies in accounting for the timeline of events. For example, the formation of a unified command structure is described as occurring over multiple days and phases, yet no precise temporal markers are provided. Likewise, the integration of volunteers is noted as occurring early on, but no specific timeframe is provided making it difficult to extract and classify risk statements with precision.

Beyond the fundamental requirement that causes must temporally precede their consequences, it is necessary to address statements that pertain to elements influenced differently depending on the stage of crisis management. The coordination efforts in the described scenario began with local responders but shifted as the scale of the disaster became apparent. A regional Type-3 Incident Management Team (IMT) eventually took over, followed by a State-level Type-2 IMT as the response effort grew more complex. This transition highlights differing management structures across stages of the response. Another example relates to the resource request processes, which were initially described as slow and cumbersome until the State-level IMT stepped in and streamlined processes. Moreover, poor information sharing mechanisms improved later with the establishment of more systematic integration and dissemination processes. Therefore, the management structure, resource request mechanisms, and information sharing protocols were all influenced differently depending on the stage of crisis management. The lack of a temporal dimension that explicitly delineates when each risk was experienced underscores the risk that a reverse-engineered model may inadvertently depict crisis management as a static process, failing to capture its dynamic evolution over time. This may ultimately lead to overlooking certain factors that may have contributed to risk consequences and misunderstanding how one decision impacts others over time. Temporal analysis of decision-making enables the development of robust and flexible strategies that move beyond short-term gains that fail to consider broader inter-organizational impacts and supports the early identification of potential conflicts of interest (Comes, 2013). To address this problem, we propose a chronological framework for analysing response activities based on the nature and focus of activities during the response timeline.

Creating temporal risk models

Risk statements extracted from the publication were categorized into three phases based on the identified criteria: Immediate response, escalation and coordination, IMT transition and scaling up, and start of recovery. The three phases are defined as follows:

Phase 1: Immediate response (Day 1-2)

19 *The landslide incident did not trigger an immediate non-routine response*

22 *Responders initially acted mostly on information that presented itself right in front of them*

25 *Responders hardly comprehended the enormous destruction in front of them*

69 *Situational awareness and a common operating picture were developing slowly*

32 *Local responders primarily organized and executed the response*

Phase 2: Escalation and coordination (Day 3-10)

Events where the scale of the disaster becomes clearer requiring escalation of resources, mutual aid, and broader coordination efforts. Examples include:

60 *The landslide spanned several jurisdictions and several federal agencies*

69 *Situational awareness and a common operating picture were developing slowly*

117 *Local responders in the impact area had had no formal training in ICS and NIMS-related structures, procedures, and principles prior to the incident*

126 *Lack of preparedness at local levels*

35 *Confusion about how to request resources and support from outside the jurisdiction and County*

Phase 3: IMT transition and scaling up

Events focused on increasing organizational capacity, scaling up operations, and transitioning leadership to more experienced teams. Examples include:

50 *On day 2, responders from neighboring jurisdictions arrived at the disaster site, expanding operational capacity*

51 *On day 5, it became clear that the incident was larger than any Type-3 IMT could handle, prompting a shift to a higher-level IMT*

55 *Washington National Guard (WANG) had over 100 personnel on the ground on various missions (on day 7), increasing operational capacity*

58 *On day 20, the first Type-2 IMT was replaced by a second Type-2 IMT, signaling a transition to more experienced leadership*

69 *Situational awareness and a common operating picture were developing slowly, underscoring the importance of real-time intelligence for scaling operations*

Examining the above categorization highlights the dynamic nature of crisis response, where events of the same category occur across multiple time phases (e.g., frictions remained throughout the response, State-level type-2 IMT was activated on day 5, situational awareness and a common operating picture were developing slowly, etc.). Cross-phase statements suggest that some points were restated across different phases, possibly due to their ongoing relevance throughout the response efforts. For instance, the statement "situational awareness was developing slowly" spans three categories, indicating its significant cross-phase impact.

Given the equal significance of both category and time phase, we adopted a dual-structured approach: events were first grouped by category and subsequently ordered chronologically within each phase. This process necessitates a precise articulation of the risk scenario, ensuring that events are clearly described not only in terms of their occurrence but also in relation to their specific temporal markers. This dual-structured approach not only facilitates the reverse engineering of the model but also identifies cross-phase risk statements that may require more attention due to longer impacts. Figure 2 below illustrates the number of risk statements in each phase of a dual-structured temporal risk model, categorized by criteria and timing. Cross-phase statements are included in all applicable stages.

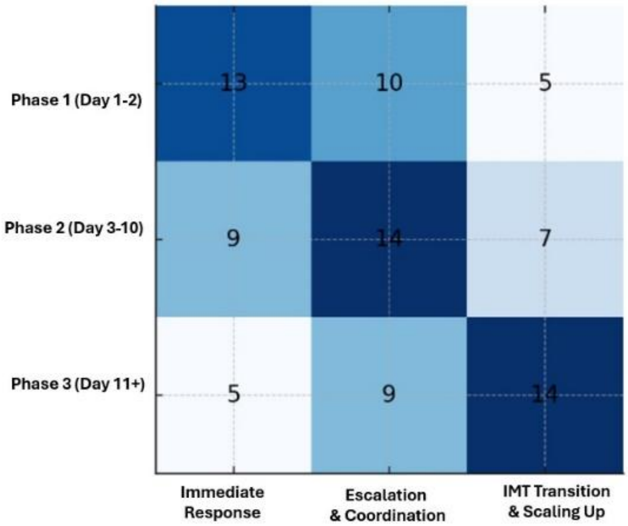

Figure 2 Temporal risk modelling

Examining cross-phase statements in the Oso landslide scenario suggests that system-focused strategies such as mandatory ICS/NIMS training, digital resource request systems, and standardized response protocols are necessary. In contrast, the mitigation strategies outlined in the original article emphasize human factors including relationship-building, information sharing, and real-time interagency collaboration. This comparison highlights the ability of reverse engineering to generate new insights that complement existing mitigation strategies offering a more comprehensive approach to crisis response.

Methodological challenges in reverse engineering

Strategy mapping is a powerful tool for visualizing strategic objectives, helping organizations enhance their effectiveness by aligning resources, goals, and actions. It enables the identification and prioritization of key goals leading to better decision-making and improved overall performance (Bryson et al., 2014). A goal refers to a desired outcome in its own right rather than a means to a desired end. Understanding causality helps in identifying goals by revealing the cause-and-effect relationships between actions and outcomes, thereby allowing organizations to set strategic objectives that drive desired results. Figure 3 illustrates the process of refining a strategy as a teardrop, where broad exploration of options narrows through key issues, with each step causally leading to the formulation of focused, targeted outcomes.

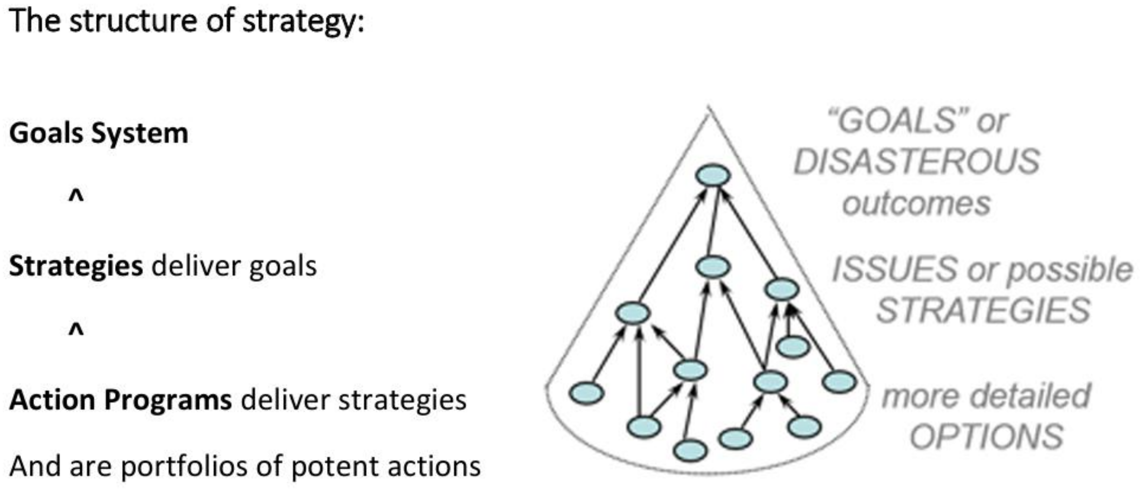

Figure 3 Developing a strategy map. (Courtesy from Eden, 2024, p20)

Interpreting causality during the analysis of risk scenarios can be influenced by factors such as the writing proficiency of the authors and the analytical capabilities of the individual conducting the review. As a result, the process may inherently involve a degree of subjectivity. Misinterpretations may distort the understanding of causality leading to inaccurate conclusions. Therefore, predefined rules must be followed to avoid arriving on inaccurate conclusions.

Analysing the cause-and-effect relationships in the selected publication highlighted the necessity of establishing more precise and accurate rules. First, a causal relationship should be explicitly expressed using terms such as "causes," "contributes to," or "ramification of" to establish a direct link between statements A and B. Goals should be recognized as independent desired outcomes rather than instrumental means to an end. Additionally, causality must maintain temporal consistency, avoiding the attribution of future events as causes of past occurrences. When technical jargon is used in the publication, coding should align with its standard definition to prevent misinterpretation. Assertions and facts serve as primary drivers in causal analysis, often structured hierarchically as interconnected consequences of the physics of the situation. Potential incompetence-related factors should be considered as mitigation options within these hierarchical structures. This means that if there are factors related to incompetence (such as lack of training, poor decision-making, or insufficient knowledge) that could have contributed to an outcome, they should be analysed as possible reasons for failure. These factors should then be incorporated into the causal structure as potential points where interventions (such as additional training or improved procedures) could mitigate similar issues in the future. Finally, when statements share identical input and output relationships, they can be merged to simplify causal models. However, this should be done after the coding process to preserve the integrity of distinct meanings.

An illustration of how these rules are applied to risk statements is shown in Figure 4.

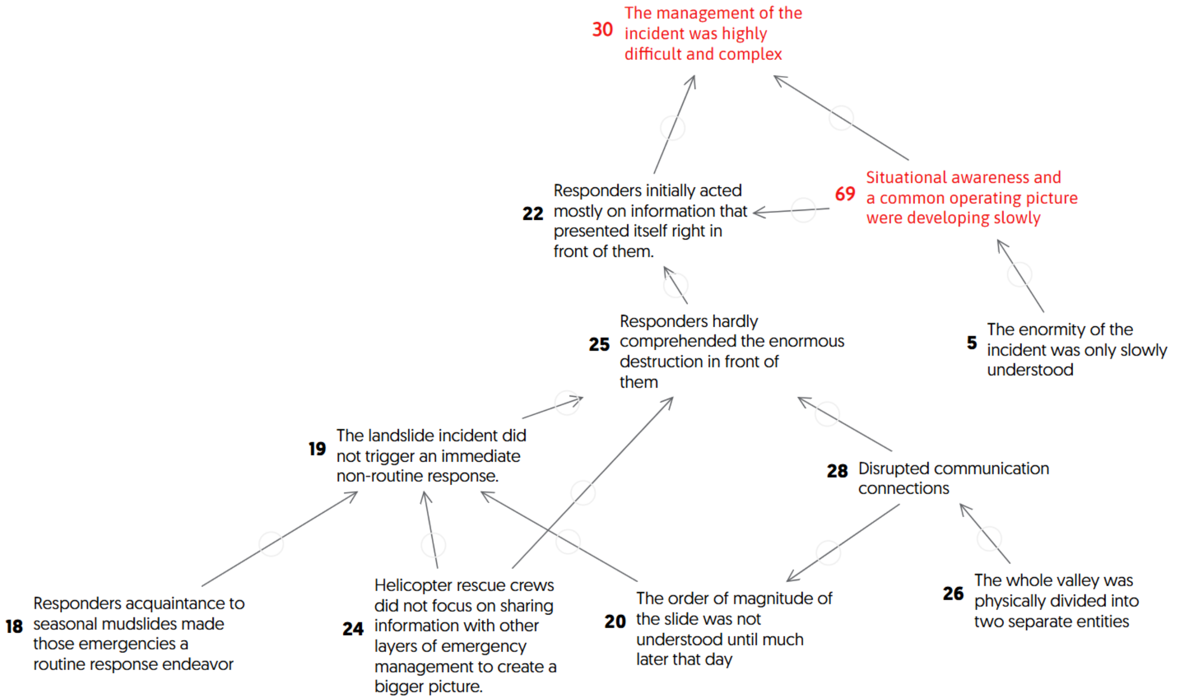

Figure 4 Application of rules to risk statements. The figure shows a risk model created with *Strategyfinder*. The risk model is a directed graph, where nodes represent the risk statements and arrows indicate causal relationships.

Our suggested solution for accounting for the temporal dimension of the response activities is to develop a strategy map using the *Strategyfinder* software for each temporal phase. This phased modelling approach enables a more accurate representation of the evolving nature of crisis management and facilitates the analysis of the effectiveness of decision making.

IMPROVING SCHOLARLY WRITING AND METHODOLOGY IN CRISIS RESPONSE RESEARCH

Recommendations for describing risk scenarios

To ensure clarity and precision in describing risk scenarios, we propose the following guidelines. These guidelines focus on structured language, clear cause-and-effect relationships, and transparency in the presentation of risk data

- **Clarity and precision**: Ambiguities in describing response activities should be avoided by explicitly stating the sequence of events, responsible entities, and contributing factors. Timelines and intermediate steps should be clearly defined when delays or responses are described.
- **Use of structured and concise language**: Run-on sentences and excessive verbosity should be avoided. Information should be presented in a clear, well-organized manner, with complex ideas broken into shorter, more digestible sentences.
- **Incorporation of specific and measurable details**: Time frames, response durations, and specific decision points should be quantified to enhance accuracy and reduce vagueness. For example, ‘three days were taken by the County EOC to coordinate with FEMA’.
- **Use of standardized terminology**: Consistent definitions should be applied, and subjective or vague descriptions should be avoided. For example, clarification should be provided on what ‘delays’ mean in terms of time or impact.
- **Improvement of readability through logical organization**: Risk statements should be structured logically by using categorized sections for example, when different aspects of risk scenarios are described.
- **Clarification of roles and responsibilities**: The roles of different agencies and officials in risk responses should be specified, and broad or generalized descriptions such as ‘FEMA’s response was delayed’ should be avoided unless responsible parties are explained.
- **Transparent addressing of uncertainty**: If causal relationships or contributing factors are unclear, limitations should be explicitly stated instead of associations being left vague.

- **Avoidance of overloaded sentences**: Information-dense statements should be broken down into separate, more focused sentences to ensure clarity and ease of understanding.

Temporal analysis

Although the publication explicitly mentions the timing of many events, several others remain vague as their timing is either unclear or unspecified. The absence of a clear timeline specifying when each risk occurred highlights the danger that a reverse-engineered model might mistakenly present crisis management as a fixed process, rather than reflecting its evolving nature. As a result, key factors influencing risk outcomes could be overlooked, and the interrelationship of decisions over time might not be fully understood (Comes, 2013). Therefore, special criteria should be defined to enable risk statements to be grouped chronologically. In the case of (Scholl & Carnes, 2017), adopting a dual-structural approach with criteria and time phases ensures a clear and systematic evaluation of cross-phase statements.

Proposed rules for reverse engineering

Causality rules are already well-established in systems dynamics. However, while coding the selected publication, the authors recognized the need to refine reverse engineering rules to ensure greater clarity and improve their applicability and effectiveness in the analysis of risk scenarios. For a detailed explanation of the reverse engineering process using *Strategyfinder* including the updated reverse engineering rules, see (Eden, 2024).

CONCLUSION AND FUTURE WORK

Reverse engineering offers valuable insights into the internal consistency of academic work on crisis management and response. However, the effective application of reverse engineering to published work requires careful consideration of the temporal dimension of crisis response and the causal relationships between risk statements. The reverse-engineering process revealed several methodological challenges, including the need to account for the timing of crisis response events to accurately capture risks. Additionally, parsing difficulties and the identification of causal relationships emerged as critical considerations for accurate risk modelling. Addressing these challenges is crucial for enhancing the clarity and utility of scholarly writing on crisis management. The guidelines proposed in this study range from improving precision in risk descriptions to emphasizing structured language and clear causal connections. Integrating these insights into future studies will provide a solid foundation for developing more robust and flexible risk models, which will in turn support the development of impact-driven strategies that account for systemic risks.

Future research could focus on using *Strategyfinder* to develop strategy maps that account for systemic risks associated with the response to the Oso landslide crisis. These systemic risks can be uncovered through precise reverse engineering of the risk scenario. Comparing the newly developed strategies with the original responses outlined in Scholl and Carnes's publication has the potential to enhance future responses to events like the Oso landslide.

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REFERENCES

Ackermann, F., Eden, C., Williams, T., & Howick, S. (2007). Systemic risk assessment: a case study, *J. Oper. Res. Soc.*, 58(1), 39-51.

Bell, R., & Ibrahim, Z. B. (2023). Reverse Engineering: A fresh perspective on defining translation and remodeling the process. INContext: Studies in Translation and Interculturalism, 3(1).

Bryson, J.M., Ackermann, F., and Eden, C. (2014). Visual Strategy: Strategy Mapping for Public and Nonprofit Organizations. Wiley.

Budzier, A.. (2011). The risk of risk registers - managing risk is managing discourse not tools, *Journal of Information Technology*. doi: 10.1057/JIT.2011.

Cavique, L. (2023). Causality. *IGI Global*. https://doi.org/10.4018/978-1-6684-9591-9.ch001.

Comes, T. (2013). Robust emergency management strategies: Supporting interdependent decisions. *Proceedings of the 46th Hawaii International Conference on System Sciences*, pp. 184-193. IEEE.

Eden, C. (2024) Strategyfinder – sf RISK METHOD – SYSTEMIC RISK Detail, *Strategyfinder Consulting*

Software GmbH. ISBN: 978-3-903556-07-2

Eden, C., and Ackermann, F. (2003). Cognitive Mapping for Policy Analysis in the Public Sector, *European Journal of Operational Research*. 152, 615-630.

Eden, C., & Gonzalez, J.J. (2023). The Strategic Management of Disaster Risk Mitigation. doi: 10.1007/978-3-031-34207-3_1.

Gonzalez, J. J., & Eden, C. (2023). Devising Mitigation Strategies With Stakeholders Against Systemic Risks in a Pandemic. *Proceedings of the 20th International Conference on Information Systems for Crisis Response and Management*, Omaha, NE, USA.

Gonzalez, J.J., Abbas, R. and Paulsen, S. (2024). Accounting for systemic risk in analysis of crisis scenarios, *Proceedings of the 21st International Conference on Information Systems for Crisis Response and Management*, Münster, Germany.

Hwang, C., & Choi, S. (2019). U.S. Patent No. 10,481,947. *Patent and Trademark Office*, Washington DC.

Jonas, R., Jonuschies, I., Matthiesen, S., Gericke, K. (2024). Replication studies in engineering design – a feasibility study. *Proceedings of the Design Society*. DOI: https://doi.org/10.1017/pds.2024.14.

Kaufman, J. (2018). Replication and fabrication of crafted and natural artifacts by reverse engineering using single camera photogrammetry. doi: 10.17635/LANCASTER/THESIS/394.

Kostirko, D., Zhao, J., Lavigne, M., Hermant, B. M., & Totten, L. (2023). A rapid review of best practices in the development of risk registers for public health emergency management. *Frontiers in Public Health*. https://doi.org/10.3389/fpubh.2023.1200438.

Lupton, D. (2013). Risk (2nd ed.), Routledge.

Norwegian Directorate for Civil Protection. (2020). *Analysis of Crisis Scenarios 2019*. Retrieved April 5, from https://www.dsb.no/siteassets/rapporter-og-publikasjoner/rapporter/analyses-of-crisis-scenarios-2019/.

Renn, O., Laubichler, M., Lucas, K., Kröger, W., Schanze, J., Scholz, R.W., Schweizer, P.-J.. (2020). Systemic Risks from Different Perspectives. *Risk Analysis*. doi: 10.1111/RISA.13657.

Scholl, H.J., Ballard, S., Carnes, S.L., Herman, H., and Parker, N. (2017). Informational Challenges in Early Disaster Response: The Massive Oso/SR530 Landslide 2014 as Case in Point. 2498-2508. doi: 10.24251/HICSS.2017.302.

Scholl, H. J., & Carnes, S. L. (2017). Managerial Challenges in Early Disaster Response: The Case of the 2014 Oso/SR530 Landslide Disaster. *Proceedings of the ISCRAM2017 Conference*.

Serra-Garcia, M., and Gneezy, U. (2021). Nonreplicable publications are cited more than replicable ones, *Science Advances*, 7 (21). doi: 10.1126/sciadv.abd1705.

O'Sullivan, A., and Mace, L. (2024). Reverse-Engineering Risk. *Erkenntnis*. doi: 10.1007/s10670-024-00788-6.

Veldhuis, G. A., Blok, D., de Boer, M. H., Kalkman, G. J., Bakker, R. M., & van Waas, R. P. (2024). From text to model: Leveraging natural language processing for system dynamics model development. *System Dynamics Review*, 40(3), e1780. https://doi.org/10.1002/sdr.1780.

Zscheischler, J. (2023). Accounting for systemic complexity in the assessment of climate risk. https://doi.org/10.5194/egusphere-egu23-5017.