MAKING SENSE OF SAFETY: A COMPLEXITY-BASED APPROACH TO SAFETY INTERVENTIONS

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The paper describes a case study carried out in an electric utility organization to address safety issues. The organization experiences a less than satisfactory safety performance record despite nurturing a culture oriented to incident prevention. The theoretical basis of the intervention lies in naturalistic sense-making and draws primarily on insights from the cognitive sciences and the science of complex adaptive systems.
Data collection was carried out through stories as told by the field workers. Stories are a preferred method compared to conventional questionnaires or surveys because they allow a richer description of complex issues and eliminate the interviewer's bias hidden behind explicit questions.
The analysis identified several issues that were then classified into different domains (Simple, Complicated, Complex, Chaotic) as defined by a Sense-Making framework approach.
The approach enables Management to rationalize its return on investments in safety. In particular, the intervention helps to explain why some implemented safety solutions emanating from a near-miss or an accident investigation can produce a counterproductive impact.
Lastly, the paper suggests how issues must be resolved differently according to the domain they belong to.

Key words: safety, complex adaptive systems, narrative research.

Le présent article décrit une étude de cas menée auprès d'une entreprise de services d'électricité afin de régler les problèmes en matière de sécurité. Le rendement de l'entreprise lié à la sécurité est insatisfaisant malgré une culture stimulante axée sur la prévention des accidents. Le fondement théorique de l'intervention repose sur la compréhension naturelle et fait essentiellement appel aux connaissances des sciences cognitives et de la science des systèmes adaptatifs complexes.
La collecte des données s'est fait en écoutant les récits des travailleurs sur le terrain. Il s'agit d'une méthode qui est préférée aux questionnaires ou sondages traditionnels puisque les récits offrent une meilleure description des problèmes complexes tout en évitant que les préférences de l'intervieweur soient sous -entendues dans les questions explicites.
L'analyse a permis de déterminer plusieurs problèmes qui ont été classés en différents domaines (simple, compliqué, complexe, chaotique) tels que définis par une méthode de travail logique.
L'approche permet à la direction de rationaliser son rendement du capital investi en matière de sécurité. Notamment, l'intervention permet d'expliquer pour quelles raisons certaines solutions de sécurité mises en œuvre à la suit e d'enquêtes d'accident ou de quasi-accident peuvent avoir un effet contreproductif.

Enfin, l'article laisse supposer que les problèmes doivent être résolus différemment selon le domaine auquel ils appartiennent.

Mots clés : sécurité, systèmes adaptatifs complexes, recherche narrative

INTRODUCTION

This case study describes the first phase of an intervention being carried out in a North American electric utility organization. The organization is undergoing important changes due to external and internal forces (evolution of the electric markets, increase of electricity demand, commitment to reduction of greenhouse gas emissions, aging infrastructure and loss of knowledge due to a retiring workforce).
Despite a historically good safety record and a culture oriented to incident prevention, this organization has witnessed over the last decade an increase in number of accidents involving its workers on the field, including fatalities.
The following quote from the organization's President and CEO testifies to the importance given to safety: "In terms of safety, I would like us to be world-class, which means that we have a better safety record than other companies, full stop. Not just a better record than other utilities."
The authors of this case study have been engaged with the assignment to make sense of the worrisome safety statistics. In particular, the management is wondering how it is possible that debilitating accidents and injuries keep on occurring despite the time and resources spent to make the system and the people within as safe as they can be.

1. THE APPROACH

The theoretical basis of the intervention described in this case study lies in naturalistic sense-making as developed by Cognitive Edge[1], a research and consulting group based in Singapore. The approach draws primarily on insights from the cognitive sciences and the science of complex adaptive systems.

Cognitive Edge has developed a Sense-Making framework, called *Cynefin* (Snowden, Boone, 2007), to classify systems and issues within systems:

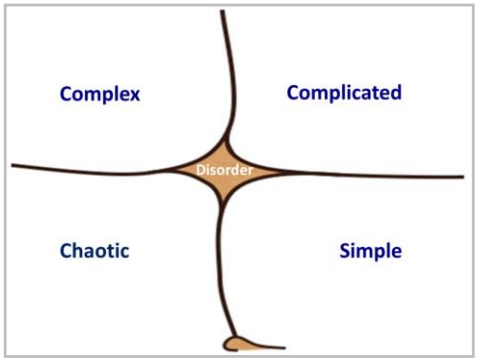

Figure 1 – Cynefin framework Domains

a) *Simple* systems are characterized by an easy-to-understand relationship between causes and effects of any given phenomenon or behaviour. Since everybody is able to discern the nature of this relationship, this is the domain of the *known knowns*.
b) In *Complicated* systems the relationship between causes and effects is not immediately discernible. *Experts* are able to make sense of complicated systems by using models to represent the forces at play. Different models can be applied to the same system and in fact several models can compete in terms of, among other things: richness of the representation, ability to accurately predict future behaviours, range of applicability, or sheer elegance. The quality of an expert dealing with a complicated issue can be

[1] Cognitive Edge Pte. Ltd. of Singapore (www.cognitive-edge.com)

summarized in their ability to select the optimal model to use. This is the domain of the *known unknowns*.

Simple and *Complicated* systems are both *Ordered*, meaning that actors (so called *agents*) within these systems are constrained by the systems. Ordered systems are deterministic and can be reduced to a set of rules.

c) In *Complex* systems it is not possible to identify *a priori* the relationship between causes and effects. This leads to unpredictable behaviours which cannot be modeled or forecasted. However it is possible to observe patterns emerging out of the co-evolution of systems and agents. This is the domain of the *unknown unknowns*.

d) *Chaotic* systems are characterized by the absence of relationship between causes and effects. Agents are not constrained by the system and their behaviour can be defined as turbulent. This is the domain of the *unknowables*.

Complex and *Chaotic* systems are both *Unordered*.

Finally the framework identifies a fifth domain, called *Disorder*, which is the state of not knowing what type of causality exists between causes and relationships. This is where to position all those systems that cannot be assigned to the other domains without further analysis or decomposition in smaller parts.

Different systems require different decision making approaches and solutions. Traditional management techniques have been developed to deal with Ordered systems, starting with Scientific Management (Taylor, Drucker) and later Business Process Reengineering (Hammer) and Systems Thinking (Senge). Unfortunately these approaches have limited value when applied to Complex problems. A Complex system has the following characteristics:

- It involves large numbers of intertwined and interdependent elements.
- It is very sensitive to small changes, which can produce disproportionately major consequences.
- Solutions cannot be imposed; rather, they arise from the circumstances. This is frequently referred to as emergence.
- The system can adapt itself according to its history or feedback.
- Though relationship between causes and effects can appear evident in retrospect, hindsight does not lead to foresight because the external conditions and the system itself constantly change.
- Unexpected and undesired consequences arise from well-intentioned practices.

This paper argues that worrisome safety issues reside in the Complex domain and therefore should not be addressed by relying solely on techniques developed for Ordered systems, namely best practices or expert models.

2. METHODOLOGY

Narrative research, in the form of stories collection and analysis, was employed for this intervention. A story is a recounting of events that can be easily contextualized in time and space. The purpose of a story is not to objectively ascertain a truth, but to reveal the set of feelings, beliefs and opinions of the story contributor. Explicit judgments, opinions and generalizations are not accepted as stories.

Stories are preferred compared to conventional questionnaires or surveys (Kurtz, 2009):

1. They avoid the bias that analysts inject when, in the process of designing the right questions to ask, analysts inadvertently look for confirmations to a set of hypothesis already set in their minds;

2. Story telling amongst peers allows issues to be raised that are not apparent, known, or may have been misinterpreted;
3. Stories have a dramatic descriptive power as people reveal in stories feelings and opinions that they would/could not reveal if asked direct question;
4. Stories are better equipped to describe complex situations due to their free-flowing structure.

The narrative capture involved two separate subgroups of tradespersons with the intention of collecting anecdotal evidence of safety related issues. The first subset involved 50 electrical tradespeople who contributed 136 stories. The second subset engaged 121 general tradespeople who contributed 183 stories. The stories were collected through a series of small group meetings. Only tradespeople and the two authors of this paper attended each meeting. The stories were collected in anonymous form and were individually validated by each contributor before interpretation and analysis.

Each story contributor was asked to 'signify' his or her stories by filling in a 3-part metadata form to provide meaning behind the story. *Signification* is a term used by Cognitive Edge which refers to the indexing of information against a predefined framework of meaning[2]. The form requires the contributor to characterize the story by replying to multiple choice questions about, among other things, the frequency of episodes like the ones described in the story, the feelings associated with the recounted episode, the gravity of the episode. The metadata form also requires the story contributor to give additional interpretation to the story by use of a graphical representation as in the following example:

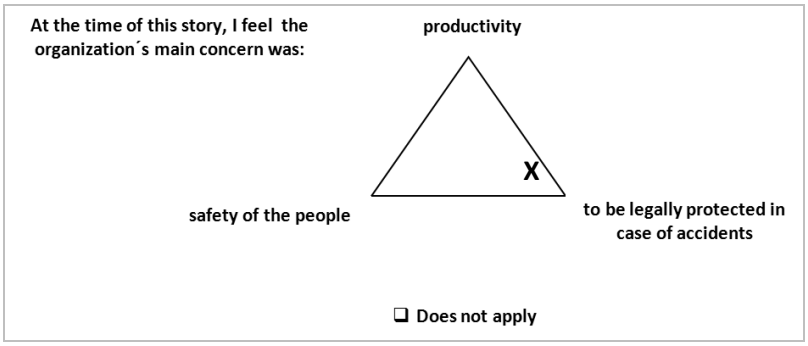

Figure 2 - Example of question in the Signification form

The use of triangular shape allows tension to be created amongst three equidistant alternatives; the respondent is forced to carefully consider his or her choice thus reducing conformity bias (i.e. the tendency to select a best, easy or expected answer on a mono-dimensional scale). The qualitative answer can be converted in a quantitative measure for each of the three alternatives. In the specific example of the figure above, if the maximum score for each variable is 100, then Productivity is assessed at 20, Legal Protection at 70 and Safety at 10.

The use of the interpretation form, supported by the SenseMaker Suite™, a software tool developed by Cognitive Edge:

a) allowed to distribute the analysis load across all the story contributors and made it possible to analyze the stories in relatively short time;
b) reduced any bias the authors might have introduced in the interpretation of the stories by letting each story contributor make sense of his or her own story;

[2] Aspects of the signification framework are patent pending – Cognitive Edge Pte. Ltd

c) engaged the participants and positively pre-disposed them for the next steps; involvement is a widely recognized antecedent of the long term success of any intervention.

3. RESULTS AND RECOMMENDATIONS

The qualitative and quantitative analysis of the stories and of the Signification forms revealed a number of trends or issues, which are represented in the Cynefin framework that follows. Some issues clearly resided in a domain. Others were positioned on boundary areas between adjacent domains to indicate the contemporaneous presence of characteristics typical of different domains (e.g. if an issue shows characteristics of both Complicated and Complex systems it gets positioned on the border between those two domains). The issues are colour coded according to the average 'tone' of the stories out of which that issue emerged (positive, negative or neutral). For any given issue, the size of its 'bubble' is proportional to the recurrence of that issue in the stories (i.e. issues appearing in many stories are represented in bigger bubbles than issue that appear only in few stories).

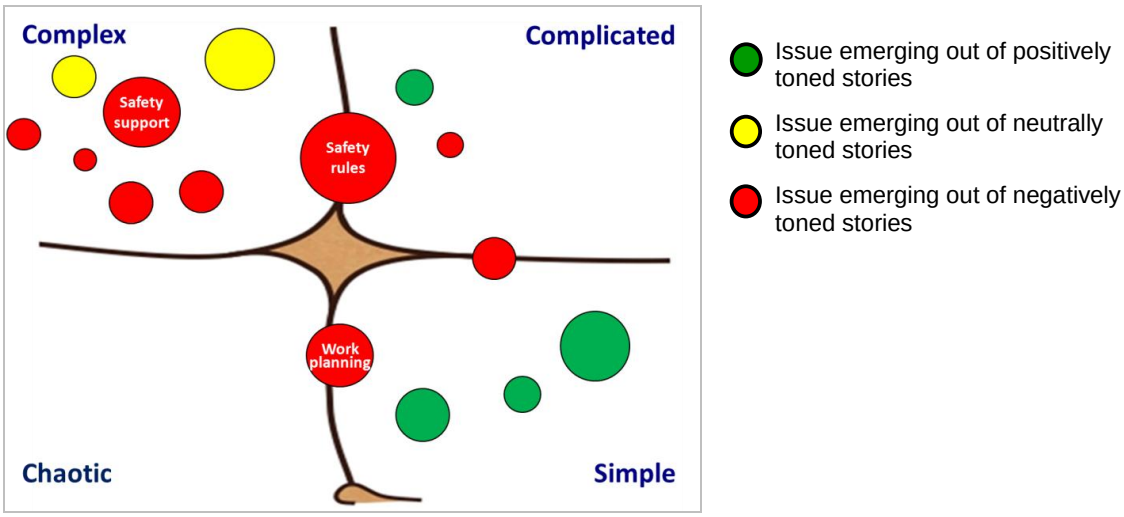

Figure 3 - Positioning of safety issues within the Cynefin framework

Seven out of the identified 15 issues reside in the Complex domain. They are mostly characterized by a negative tone (red color) whereas the few positively toned issues resided in the Ordered domains. Three issues are positioned on a boundary area between two domains.
For the purpose of this case study only the three most recurring negatively toned messages will be highlighted.

1. Safety support

"*Everywhere I turned there was someone taking my picture. I found it very distracting and it made me nervous. Am I doing this right? Will I be written up?*" (extract from a story)

Tradespeople experienced inconsistent, unpredictable behaviours when dealing with the safety support people, i.e. the people who are in charge of safety inspections and audit, safety policies and procedures, incidents investigations and discipline; some safety support

people were highly regarded and respected whereas others created confusion, distraction (a safety hazard in itself), and hindered crew productivity. The issue was positioned in the Complex domain because it deals with people's behaviours which cannot be modeled.

2. Safety rules that do not make sense

> "*When we drill a small hole in concrete, we have to get all dressed up with masks and respirators. We do this even if it's raining and there's no dust. Redundant. Frustrating*." (extract from a story)

Tradespeople experienced the counterproductive effect of the introduction of some new or modified safety rules. Story contributors described the effect as the "dumbing down" of trained professionals and these rules as "knee-jerk" reactions, since they immediately followed an accident investigation. This issue was positioned on the Complicated/Complex boundary since these rules require a fairly sophisticated understanding of technical work procedures (expertise being a key element of Complicated systems) but fail to consider all possible relevant scenarios due to continuously changing work situations (importance of context being a key element in Complex systems).

3. Work planning and coordination

> "*We had multiple crews working at the site. We were supposed to be in charge of the work site. I'm not sure what happened but we had to wait for them to finish theirs. We lost time on our job.*" (extract from a story)

Tradespeople experienced work situations where basic planning and coordination tasks were expected but not performed, resulting in tradespeople forced to rely on their own initiative to figure things out. Story contributors describe this as a source of frustration and unnecessary scrambling. The issue was positioned on the Simple/Chaotic boundary since standard and easy to understand operating procedures (typical of the Simple domain) are in place but not always followed. The impact often creates unexpected delays as field workers deal with poorly planned or coordinated jobs. This increases the risk for people to consciously compromise safety at the expense of productivity (hence a shift into the Chaotic domain).

Recommendations

Each domain requires a different methodology to resolve its issues. There is little time to analyze Chaotic domain issues so quickly deciding how to get out of the unwanted situation makes sense. Simple domain issues are easy to understand; applying straightforward management problem-solving methods is sensible. Best practices, where developed and proven successful, can be implemented in order to achieve efficiency. Issues residing in the Complicated domain should be left for experts to resolve using their knowledge and skills. There can be more than one solution available and one can be chosen only after careful evaluation of different criteria. The practical method in the Complex domain is to probe the system through *safe-fail* (as opposed to fail-safe) experiments. Only by observing over time the reaction of the system to the probe is it possible to identify emerging patterns. This indirect approach to a solution requires patience and willingness to try more experiments. The authors' suggestions for the issues highlighted in the previous chapter are described.

1. Safety support (Complex Domain)

In order to understand the rationales behind the inconsistent behaviours denounced by the tradespeople, it is suggested to design a portfolio of safe-fail experiments aimed at probing the system in a controlled, observable way. Any idea that has even the remotest possibility of being useful can be the basis of a safe-fail experiment, as long as it is safe (i.e. outcomes must be easily reversible) and provokes reactions in the system. Experiments must conclude

in a short period of time (weeks or months) and must be monitored. Where positive patterns emerge, they need to be amplified; negative ones need to be dampened or curtailed.

2. Safety rules that do not make sense (Complicated/Complex boundary)
There is a need to raise awareness among experts (management, safety support people, human factors specialists, risk management analysts) that rules cannot have universal application. Design and evaluation of rules must be kept in the realm of experts, but feedback loops need to be introduced so that people on the field are able to highlight unintended consequences. Discretionary behaviour is welcomed and fuzzy boundaries must be found though consensual mechanisms and negotiations with impacted stakeholders. Experts need to recognize the constraints imposed by their own expertise.

3. Work planning and coordination (Simple/Chaotic boundary)
This issue raises the need to improve process execution. Managers need to apply management best practices: process evaluation, system performance audit, competency assessment, training, and, when needed, corrective discipline.

4. CONCLUSIONS

Narrative research was used to identify and make sense in a comprehensive way of issues that affect safety of the field workers in the organization. The authors believe that some of the issues would have not surfaced if traditional interviewing methods had been deployed, since stories contribute a richer descriptive power.
The Cynefin model identified the best suited decision-making methodology for each of the identified issue. Executing best practices and expert models in a disciplined fashion makes sense when dealing with Simple and Complicated domain issues. Issues in or bordering the Chaotic domain required fast action to prevent a catastrophe from happening. Complex domain issues require experimentation as a way to learn about and understand its patterns; patience is required to let the system find a practical and acceptable solution.
Applying an improper decision-making approach can cause counterproductive effects. As the authors discovered, the two most recurrent safety issues that emerged from the analysis (safety support and safety rules) seem to be a direct consequence of the organization's strong willingness to reduce safety incidents by introducing more rules to increase compliance. This approach is a typical Ordered side solution and fails to consider the complexity of work situations. Safe-fail experimentations (for safety support) and consensual expertise (for safety rules) have been suggested as ways to eliminate ambiguous, confusing and frustrating work situations that lead to unsafe practices.

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