Turning Variability into Emergent Safety: the Resilience Matrix for Providing Strong Responses to Weak Signals

Fabrizio Bracco[1], Tommaso Francesco Piccinno[1] and Giorgio Dorigatti[2]

[1] DiSFor, Dept. of Educational Sciences,
Unit of Psychology - University of Genova, Italy
fabrizio.bracco@unige.it
piccinnotommaso@gmail.com
[2] Ormes Consulting srl
Genova , Italy
dorigattig@ormes.it

Abstract. Resilience is the ability to provide strong responses to weak signals. Weak signals are uncertain information that could be read as a warning of future changes, both mishaps and opportunities. They could be the first symptoms of a big change, but they are embedded in a variability that is hidden in normal operations and difficult to distinguish from random occurrences. We propose a model, the Resilience Matrix, which could help systems cope with these weak and potentially resonant signals by means of a cyclic information transfer along the system. Front-line operators should be able to notice weak signals, understanding how the current variability is a threat that is not mitigated by available procedures and barriers. This information should be shared and managed at the group level and then, if necessary, it should be transferred at the organizational level, where procedures and barriers should be formally redesigned according to the new information. These procedures should then be tested for their effectiveness at the group level and transferred as new skills for operators by means of training. This cycle is aimed at empowering people, groups and organizations, helping them to turn variability into a source for resilience.

1 INTRODUCTION

Resilience is usually defined as a system's ability to react and recover from a major mishap, safely continuing the core task of operations (Westrum, 2006). In this paper, we will focus on the proactive nature of resilience, considering it as the ability to pay attention to the ordinary variability of the system's components. The monitoring of this performance variability can prevent what Hollnagel (2004) defined as functional resonance, i.e. an unwanted outcome emerging from uncontrolled sources of entropy. We ground this proactive point of view on the ability to provide strong responses to weak signals (Weick and Sutcliffe, 2001). By weak signals we mean unclear information, hidden in the "normal" variability of system's elements, which could be considered as a warning of future resonance. Weak signals are sources of variability and could be read in foresight as the first signs or symptoms of a relevant change, while in hindsight they would be interpreted as unambiguous factors that triggered the accident causal chain. However, weak signals are not always clues about future events, and here is one of the main trade-offs of system's managers at every level: how to notice and cope with those signals that are most likely to evolve into a functional resonance? A second trade-off concerns who is in charge to act upon these signals: at which system level should the actors respond? A third trade-off is related to the adaptation to the cultural background of the system: how radical should be the cultural change imposed to system to enhance its resilience? If it were too drastic the system could trigger a counteraction, if it were too mild the system could not develop any resilience.

2 THE RESILIENCE MATRIX

Here we present a model of Organizational Resilience called the Resilience Matrix, combining both the category of signals trade-off, and actors trade-off. It is a 3x3 matrix that can be sketched on an orthogonal plane having "signal variability" on the y axis and "actors that should provide a response" on the x axis (individual, group or organization). The plane can be divided into nine sectors each of which representing a different response a system could provide, taking into account the specific signal and the actor. We argue that system resilience could emerge from the proper information flow along all these sectors. Taking into account the Resilience Matrix, we can see along the y axis the continuum of signal's variability and tractability. As stated by Hollnagel (2012, 14) "in order to do their work, people – individually and collectively – must therefore adjust what they do to match the conditions". This means that practitioners' performance will change according to the kind of signals they are dealing with. We propose to match the Skill-Rule-Knowledge (SRK) hierarchy by Rasmussen (1983) with the tractable-intractable continuum by Hollnagel (2004). Either single workers or groups or the organization, could be engaged in the management of these tractable or intractable signals.

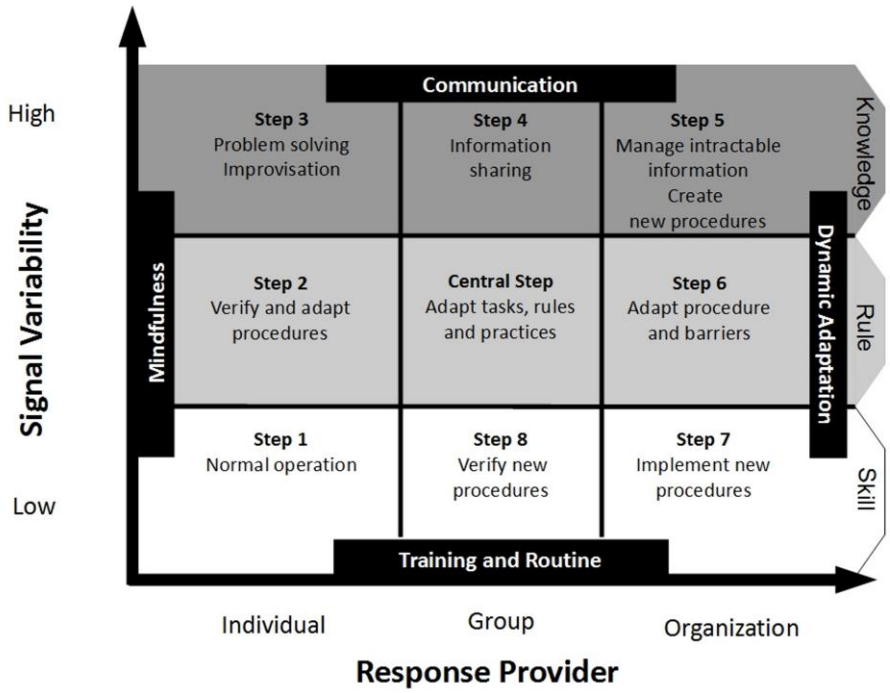

Fig. 1 – The Resilience Matrix

When the signals to be managed are tractable, known, and predictable, it is sufficient to carry out the well-learned and automatized procedures at the Skill level. In other circumstances signals are variable but also containable within the ordinary performance, their variability is predictable and the procedures can be effective in damping down on it. This condition could be performed at the Rule level. When the signals are intractable, operators should perform more complex cognitive processes, in order to activate the adequate problem solving strategy for the novel and unpredicted situation. In this third kind of situation we are at the Knowledge level. Those involved in the management of the signals (whether persons, groups or the whole organization), should find a balance between a fast, efficient, rigid, and automatized Skill-based coping, and a resource-demanding Knowledge-based level, where the flexibility is necessary to cope with the signals' variability and intractability. This balance has been well described with the Efficiency-Thoroughness-Trade-Off (Hollnagel, 2009), where the very nature of complex systems requires the operators to be aware of their position in between these two extremes. As will be described later, this balance is the core of the first trade-off: how to respond to those weak signals that will probably develop into a

functional resonance, without wasting resources in chasing every kind of signal? It is trivial to say that everybody want to save resources when possible.

The X axis is concerning the actors involved in the management of the signals. They could be single operators, or groups or the organization itself. Each actor has a different perspective on the system, different power of action and functions. At the single operator level, the front-line practitioners notice weak signals sooner than at the other levels. They are the most sensitive “detectors” of variability, but they are also limited in their power of action and they could cope with the intractable events just in the current situation. If a stronger and more accurate response is needed, they must move the signal management at the group level. The team is able to analyze and discuss about signals variability, and it could modify internal procedures, rules and activities, in order to take into account the new source of variability. However, the group is limited in its power of action if the resonance control requires a higher management, at the organizational level. At this further level the information concerning weak signals is deeply analyzed and it is possible to provide even big structural changes. However, it has the limit to be slower than the other levels to provide a response and it cannot process every kind of signals. This means that individuals and groups should be trained to report to the organizational level just those signals that they consider to be potential threats that they cannot manage at their level. This is the core of the second trade-off we presented: who is in charge to act upon these signals? How should they process it? The proper response provider should intervene according to the kind of signal, single operators for quick and easy management, groups for deeper revision of procedures, the organization for wider changes that require a broad view over the system’s dynamics.

At this point, we can describe the nine steps that, in our view, characterize the cycle for enhancing safety along the matrix. The beginning of the resilience cycle takes place at the single operator’s level, performing skill-based control of tractable signals (step 1). The complex system is characterized by unpredictable variety, but this could be tractable within the available procedures. Therefore the operators could move to the Rule-based management of variable but tractable signals (step 2). If the signals become more and more intractable, the single operator will be able to move from the Rule to the Knowledge level, when facing intractable and variable situations (step 3). This will need a good capacity to notice the unpredicted source of variability and its potential functional resonance with other elements in the system. Practitioners could cope with them looking for a solution by themselves, but it is generally better to share this information with the other actors of the system (step 4). At this point the group should decide the right path. If the signal variability is concerning work-group procedures and habits, it is possible to adapt tasks, rules and practices to the new information (central step) and move to the implementation of the new procedures in the everyday practices (step 8), going back to Skill-based management of now tractable signals. Otherwise if the group acknowledges that the intractable signal involves procedures, tasks and

resources that can be controllable only at a higher level, it will move the information to the organization (step 5). Here the organization is involved in the management of new and intractable information coming from the group and it needs to devote resources to accomplish this. The effort is high and the organization cannot endure too much at this level, since it needs to find new barriers (physical, normative, technological) and constraints adapting the procedures or creating new ones. This lets the organization move from the Knowledge to the Rule level (step 6). When the procedures have been enriched in order to cope with the weak signals, the organization can move to the Skill level and monitor the implementation of these solutions (step 7). Here the group will provide feedbacks about the manageability of the solutions, the possibility to transfer them into the skills of the workers (step 8). The resilience cycle ends when the new variety is embedded into the barriers, procedures, and practices, it is normalized and will become part of the operational skills of front-line operators. These are the nine steps of Resilience Matrix: the eight steps turning around the central step. The rationale of the Matrix is that a real resilience is an emergent property of a system where all the actors are involved in the right way, acting upon the right kind of signals. Every actor is part of an information flow along the system, enabling it to eventually provide strong responses to weak signals.

3 TRADE-OFFS, BLAME CULTURE AND RESILIENCE

In this paper we propose a model to cope with several trade-offs. First of all, the system is engaged in the dilemma concerning what the “right” weak signals are, i.e. how to recognize those signals that could develop into a functional resonance. Escaping the hindsight bias, righteousness concerns the signals that are collectively considered potentially resonant, given past experiences and system properties. This collective mindfulness is only achievable by means of trust and open information sharing among the group members. Nothing but shared experience, reflection about practices, open discussion stimulating the requisite imagination can allow people to become sensitive to potentially resonant signals. A resilient system should adopt an analysis method able to take into account this complexity in order to provide strong and effective responses. This is the only way to prevent mishaps.

A resilience culture will enable the system to cope with another trade-off: which actor should intervene in a certain situation? Complex systems should be able to cope with different signals and to identify the correct actors to provide a response. The sharp end is where variability can be detected, but the group and the organization levels are where these signals should be treated and mitigated. There are several factors that could block a free movement from the single to the group and the organization level. For instance, a lack in the Informed Culture, a bad communication among group members could inhibit a free sharing of information concerning weak signals, and this will decrease the capacity of the group to foresee threats. A rigid and bureaucratic

organization could impair the development of the decision making process from the group to the organization level. This will affect the Learning and Flexible Culture. The movement along the steps in the Resilience Matrix is promoted by the Just Culture, enabling a shared responsibility, an effective information circulation, a Reporting Culture and a flexible adaptation of barriers and procedures to prevent the functional resonance. In a resilient system there should be no fear to be punished, both economically and socially, and people would share their information and openly communicate. In this way, it would be possible to move, on the X axis of the matrix, from the individual level to the group level and to cope more effectively with intractable events.

A third trade-off is the one between the new culture we wanted to enhance and the traditional Italian work culture, biased by blame and hindsight, together with a legislation which is oriented to the search for individual responsibilities. In cultural anthropology, there is a difference between the shame society and the guilt society (Benedict, 1947). The shame culture has typical traits of eastern countries and, in some way, of Anglo-Saxon and north-European countries. It controls people's behavior by forcing them to protect their reputation and avoid the shame after some deviant or inappropriate action. It tends to promote a strong introjection of the norm and reinforce a sense of shared responsibility. This could be the proper cultural ground for Resilience culture to grow, based on mutual trust, openness, and commitment. The guilt society is grounded on the creation and the reinforcement of the expectation of a punishment after a specific forbidden behavior. The Italian cultural model seems to be closer to the guilt society, where the Blame Culture present in many organizations reinforces the search for a scapegoat. This work context makes people afraid of taking responsibilities, they try to do as little as possible because the less they do, the lower the probability to be blamed will be. Moreover, system safety is perceived as something depending on others, they do not feel in charge of taking care of it, they perceive safety as something to accomplish just to avoid punishment. After a mishap, this kind of culture will look for the scapegoat, there will not be any organizational analysis, it will provide more stringent rules directed towards the punishment of human errors and violations, making the system more rigid. As a consequence, these additional rules and rigidity will make it even harder to work. In order to promote Resilience Engineering in an Italian organization, it should be necessary to cope with a political, cultural and normative system that lead people to adopt the opposite behaviour, where the legislation and the organization of work and safety are almost incompatible with this new perspective. In our view, this is the major challenge to face in the promotion of Resilience Engineering in Italy.

4. PUTTING THE RESILIENCE MATRIX INTO PRACTICE

As a practical example of the implementation of the Resilience matrix and the coping

with the three trade-offs we just described, we present a resilience engineering project developed in an Italian chemical plant department. The intervention was aimed at increasing the safety of the department without reducing its productivity and promoting operator's well-being. The project also wanted to enhance proactive behaviors towards weak signals in the three kinds of respondents: individuals, groups and organization. At the individual level we trained operators to notice and report weak signals in their operational context, discussing human performance variability, procedures and barriers effectiveness and developing the requisite imagination to foresee possible sources for resonance, looking at the variability from the sharp-end point of view. Moreover, we highlighted the importance of an internal locus of control about safety and we linked the increase of responsibility with the increase of power of action of every practitioner. At the group level we focused on reporting procedures, shared tutoring, providing tools and contexts for information sharing, and group's problem solving and decision making skills. We aimed at improving communication skills, we showed the biases of hindsight analyses of accidents and we discussed about the nature and effects of a blame culture. In addition, we tried to promote a group-based mutual support of practitioners, helping them to cope with stress and lack of motivation. At the organizational level, an intranet interactive platform was developed for collecting salient information to increase safety and a Resilience Engineering Program was planned to implement responses for the most relevant warnings. In addition, we linked safety and well-being, providing the organizational level with some hints about the development of a safety culture ad the decrease of the organizational cynicism among workers. The intervention is still in progress but operators' high involvement into the program and the positive feedbacks of operators and management are encouraging "strong" signals of a cultural change.

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