Using gaming and resilience engineering principles to energize a situated resilience training of front-end operators and managers

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ABSTRACT: The TORC project has developed an innovative and comprehensive training concept that enables organizations to appreciate, nurture and improve their inherent resilient and adaptive capacities, while operating in an environment dominated by compliance-oriented safety regulations and standards. A key element of the training is a serious game simulation of resilience dynamics in operations. The training is aimed at both operations and management to explore the space of manoeuvre in the context of compliance. By means of an after action review in an integrated training session, the mutual experiences and perceptions of applying team and organizational resilience capabilities (strategies, resources and competences) are evaluated. The training concept allows trainees to discover rudimentary resilience capabilities based on real-life cases, experience these in a safe environment and explore an alternative action repertoire as a response to new demands triggered by changing situations. TORC allows for systemic evaluation across different levels and different time horizons. The training was validated with industry partners in rail infrastructure, oil and gas, and air traffic management and proved to be an instrument allowing operational and management teams to experiment with resilient capabilities, to jointly reflect on what they experienced, and to apply the learning to be better prepared for future challenges.

1 SUMMARY

1.1 *Introduction*

Successful adaptation to surprise and complexity is a situated practice that cannot be expected to recur in the exact same way. Resilience in organizations is determined by the creative use of different strategies collaboratively applied by (multidisciplinary) teams in line with operational demands that can vary over time. These capabilities, are critical for the organization to succeed, since they allow for continued safe operations under uncertain and shifting circumstances in everyday and in crisis situations, and create innovative ways to deal with progressively changing circumstances. These abilities benefit from training and rehearsal, but there is always the risk of (adaptive) failure.

In parts of the resilience engineering literature, there is a tendency to comprehend resilient objects and subjects in a systemic and functional language that effectively burdens the front-line staff with the residual risk (Bergström et al. 2015).

Managerial mediation, intervention and intent are thus necessary to provide accountability, legitimacy and a defined space of manoeuvre commensurate with the margin of manoeuvre experienced in the operation. Managerial mediation of resilience is a capability that also benefits from, even requires, recording and rehearsing of successful practices to learn as an organization as a whole over time, and to make steering possible by improving input conditions for resilience in operations.

The Training for Operational Resilience Capabilities (TORC) concept approaches resilience from a double-hermeneutic position, insisting to *understand the understanding subjects*, rather than "explaining" them as objects.

Resilience does not unfold in a contextual void, but in the context of a different orientation: compliance to rules. Many industries nowadays operate in a context in which they have to adhere to laws and regulations (compliance requirements) to an ever increasing degree. There are situations when deviation from compliance is unavoidable or simply seems a safer choice. When moving outside of compliance boundaries, adaptation will result in dilemmas between operational demands and compliance requirements. Adaptations in practice therefore must be performed in line with these rules or by applying risk-based approaches (i.e. resilient strategies) that provide a demonstrably comparable level of safety. TORC training has been conducted in organizations based

on their pragmatic recognition of the TORC premise, enabling them to appreciate, nurture and improve their inherent rudimentary resilient and adaptive capacities, while operating in an environment dominated by compliance-oriented safety regulations and standards.

1.2 Objectives

Although the TORC approach departs somewhat from the main stream of the resilience engineering literature (Grøtan et al. 2015), aiming for organizations to function more resiliently under the imperative of compliance rather than aiming for an idealized description of a resilient system, it is sensitized by and has adopted some of the key principles of resilience engineering. The objective of this paper is to demonstrate that the pragmatic and situated approach of TORC can take advantage from resilience engineering principles. TORC defines a capability as the ability to orchestrate strategies, resources and competences into adaptations to match operations with changing realities.

1.3 Methodology

TORC training is constituted and conducted as a serious gaming approach. To energize and drive the training forward, an operationalization of key principles from resilience engineering in terms of strategies and tactics is applied, related to the ability to respond, the ability to monitor, the ability to anticipate and the ability to learn as defined by Hollnagel (2009).

1.4 Findings

The serious gaming approach was found useful and effective for both operator training, management training and integrated (combined) training. The artificial training setting and trigger points inspired by resilience engineering principles resonate sufficiently with the real operational experience. A "resilient repository" approach also provides a platform for capturing these experiences and using them as training artefacts. The serious gaming approach offers numerous possibilities for variation for replay, practice-induced after-action review, and for quantification of training results and progression over time.

1.5 Implications

The findings demonstrate that double-hermeneutic premises and resilience engineering principles can be combined in a gaming context, and that TORC training develops resilience at both operational and in managerial levels. It is an effective way of appreciating, invoking and developing the rudimentary resilience capability that is inevitably present in organizations.
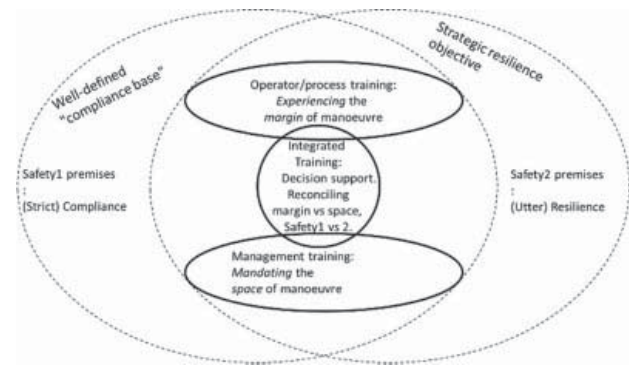

Figure 1. The TORC concept.

2 BACKGROUND: THE TORC PROJECT

The premise of the TORC concept is "resilience in the context of compliance", in which "compliance" signifies the dominant preoccupation with the absence of the sources of error and failure and "resilience" signifies the complementary preoccupation with the conditions necessary for the manifestation of adaptive capabilities in case the situation does not evolve as expected, drawing on resilience engineering principles.

The TORC training approach focuses on three distinct training arenas: operational training addresses the exploration of the required margin of manoeuvre in the "compliance vs resilience" space, managerial training addresses the assessment of a reasonable, accountable and acceptable space of manoeuvre, and integrated training addresses the active and dynamic reconciliation of margin and space of manoeuvre. All in all, the training program facilitates a process of continual attuning between the descriptive rules and the professional competence and craftsmanship in the organization in any given situation.

The TORC approach was designed for application in three different contexts: in a normal operational context in which pre-existing rules and procedures form the expectations of compliance, in an emergency context in which emergency plans form the compliance base, and in a "managing the unexpected" context in which the applicable set of rules and procedures must be re-interpreted instantly and situation-dependently.

Aiming for the objectives previously described, the TORC project selected serious gaming as the key training method. For this purpose, a board game was developed and piloted. The TORC board game proved to be an excellent sensitization device that supports and fuels operational, managerial and integrated training activities in terms of revealing existing adaptive practices as hypothetical but realistic situations are explored, and promotes joint reflection in after-action reviews, comprising both homogeneous and heterogeneous training groups.

The practical experience from piloting the TORC board game in different industrial contexts has revealed and explored new horizons and prospects for safety-relevant organizational training and knowledge

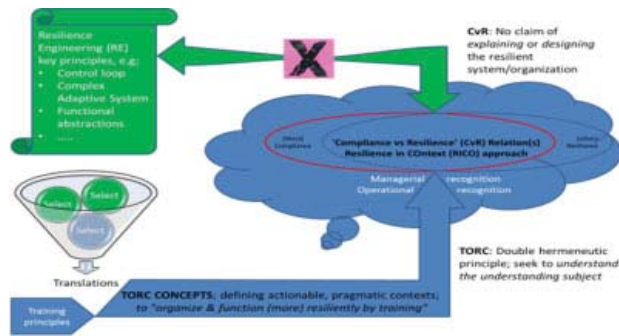Figure 2. The TORC concept and board game.

Figure 3. The TORC scientific position (Grøtan et al. 2015).

development beyond the traditional confines of safety training and management.

The practical experience also confirms the underlying TORC presumptions with respect to: 1) the pragmatic value and recognition of "resilience in the context of compliance" and 2) the urge for management to explicitly mandate a "space of manoeuvre" that legitimates the professional expertise and craftsmanship-based adaptive capacity hallmarking resilience. This "shifting competence envelope" involves management in the accountability for situations that would not benefit from compliance-based practice, and prevents that an unrealistic pure compliance orientation persists tacitly in management as a "rational facade". This orientation is at risk of ignoring successful adaptations to cope with situations and penalizing unsuccessful adaptations, causing the organizational learning from new experience to go lost.

2.1 *The double-hermeneutical approach*

Resilience does not unfold in a contextual void, but in the context of a different orientation; compliance to rules. Many industries nowadays operate in a context in which there is a requirement for compliance to an increasing scope of laws and regulations (requirements for compliance).

Adaptations in practice therefore either have to comply with these rules or be performed in accordance with a risk management approach (i.e. resilient strategies) that demonstrates a level of safety comparable to a compliance situation. TORC training has been conducted in organizations based on their pragmatic recognition of the TORC premise, enabling them to appreciate, nurture and improve their inherent and rudimentary resilient and adaptive capacity, while operating in an environment dominated by

compliance-oriented safety regulations and standards. This pragmatic orientation is a key success factor for employing TORC.

TORC approaches resilience from a double-hermeneutic position (Giddens 1987), insisting to understand the *understanding subjects*, rather than "explaining" them as objects.

By implication, the concept of "Compliance vs Resilience (CvR) relations does not claim to explain the functioning of a resilient system as a whole in relation to concepts of, e.g., advanced control loops, complex adaptive systems or other functional abstractions derived from systems science. Rather, TORC takes advantage of the rich source of concepts and issues in e.g. the Resilience Engineering body of knowledge, provided that the selected parts can be applied into the CvR context and can be combined with recognized principles for training in general. Resilience Engineering principles as such are applied to energize the gaming process.

As a result of the TORC training programme, the teams organize and function more *resiliently*, although they are not necessarily following an idealized script of a resilient system according to resilience engineering philosophies.

3 THE TORC BOARD GAME

3.1 *Objectives*

TORC training is meant to create a mutual understanding of how resilience works within teams and across levels in the organization in order to deal with everyday operational variation. Resilience requires collaboration and open communication between organizational areas and levels. The TORC training program incorporates resilience training for operations, for management and an integrated session which combines both their perspectives on work as expected (imagined) and work as done.

Operational training will make operational trainees experience the 'margin of manoeuver' and explore different resilience strategies based on a case taken from operational practice. The case is only a starting point and takes an unpredictable course by means of 'action cards' driving the game.

Management training will make managerial trainees experience decision-making on the space for manoeuver in relation to the course of events in the case that was used in the operational training. Management assumes an operator role while at the same time closely assessing and monitoring the situation for continued stability from multiple viewpoints. Extensive communication with those in the situation, and those in peripheral areas which may be impacted by the situation, e.g. as the operation moves towards or across the boundaries of compliance, is critical for assessing and deciding when additional expertise is required and when a situation is escalating.

The main objective of *integrated* training is for management and operational teams to jointly experience

the trade-offs made from both their respective perspectives while discussing adaptive plans and strategies as the situation evolves over time. E.g. do different views need harmonization? Are resources adequate? Is decision support available?

3.2 Energizing the dynamics of the game

While playing the resilience game, each team shares their individual approaches and discusses alternative strategies to overcome unexpected situations in the reality of day-to-day work. This provides indications as to how the organization supports resilient performance and reveals the enablers and barriers. The game allows for experiencing the benefits and risks of resilient acting through real cases in a safe learning environment. By experiencing dilemmas and potential trade-offs between different operational goals, such as efficiency vs safety, reflecting operational realities, teams will have to try different strategies to overcome these operational challenges.

The game contributes to the awareness of resilient action and the sensemaking activity in this process. It identifies the space of manoeuvre for resilient action in the operation and identifies the conditions required to make resilience work in the organization. During the training, teams will:

- Experience resilience in action by simulating practices in real company cases
- Learn about resilience as an operational capability to cope with sudden or unexpected demands in work
- Collaboratively explore and decide on strategies to deal with unexpected situations in the operation
- Jointly explore and decide on resources to be deployed for supporting and backing up adaptive action
- Experience how the team and company network supports and cooperates in resilient action
- Reflect on applied capabilities and the learning from positive as well as negative outcomes

The game board elements, and the steps a team has to run through during the game, are depicted in Figure 4 and 5

3.3 Playing the game

Once the case has been introduced, team members take turns in leading the team through an operational challenge. They will select strategies and resources to deal with the operational challenge at hand and determine the required investment in close collaboration with their team. An example of a case used in a TORC game:

"A night crew executing rail maintenance activities reports a truck stuck on the tracks. Upon arrival the safety supervisor recognizes that it concerns a vehicle that is undetectable by traffic control. With morning rush hour approaching within two hours, the team has to consider a series of (un)conventional actions
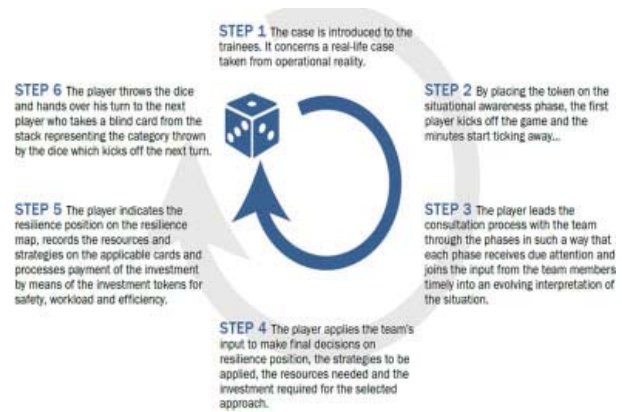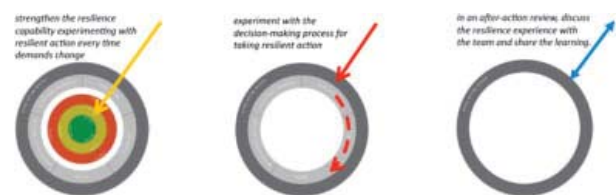

Figure 4.   TORC Game sequence.

Figure 5.   Phases in the TORC Game.

to prevent a rail traffic nightmare on one of the country's busiest hubs and avert financial penalties for not returning the track in time to the asset owner."

A guide to resilient acting (an overview of strategies and resources) is available to support the team's decisions. At the end of each turn, a new operational challenge is initiated by means of a random 'action card'. The range of actions, strategies and resources is customized to the specific context of operation.

In order to create awareness in the team about the trade-offs to be made, and to help them choose between options, the team is required to establish the investment needed for their preferred action. The investment value is represented by fiches in three investment areas: Safety, Workload and Efficiency. The team donates the investment value by means of fiches relative to the three investment areas.

As the game progresses, the team experiences that the chain of disturbances takes the operation through different modes of resilience (routine, extend and stretch). This resilient path of adaptive episodes is visualized by plotting the decisions on the resilience map (see Figure 6) to form the nodes of the resilience route the team took while working through the case. When gaming completed, the resilience path is discussed in the after action review with the team.

The management game may follow the exact same scenario and "game changers" as the operational game. The differences between preferred options, resilience mode perception and investment decisions provide key information for the integrated training session.

3.4 The integrated training session

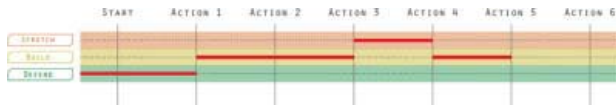The comparison between the outcomes of the operational game and those of the management game
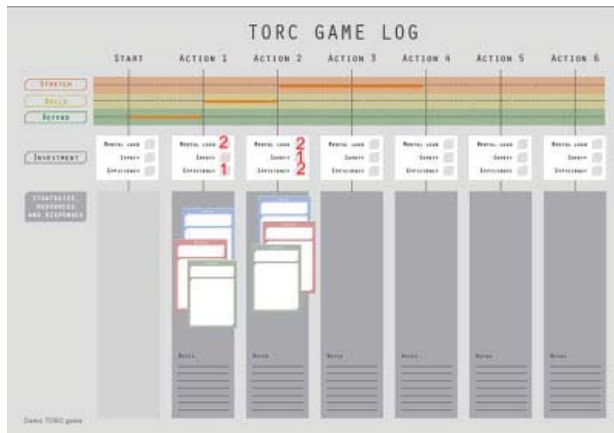
Figure 6.   Plotting the resilience path.

Figure 7.   TORC resilience log sample.

provide interesting insights in the space of manoeuver perceived at the two levels. The differences between the choices and the considerations for the decisions are shared between the teams in order to reconcile the perceptions regarding the space of manoeuver. The training program is concluded with an after action review to discuss and record the findings, any observations regarding resilience enablers and barriers which may suggest changes to the management system, and any observations on the training process.

The "moves" in the game are recorded in the TORC resilience log (see Figure 7). This log is used to track all the playing cards used by the team during the TORC training (i.e. strategies, resources, actions). Other elements of the game are also tracked, such as the indications of workload/safety and efficiency and the extent to which the team operates in the *defend*, *build* or *stretch* areas during the game. The game moderator analyses and compares the use of different strategies and resources between turns of individual teams collected on the log as 'Actions') and discusses notable differences and progression over time, as well as the 'resilience path' the team went through.

4   SENSITIZATION ENERGIZED BY RESILIENCE ENGINEERING PRINCIPLES

4.1   *The space of manoeuver*

A capability implies shifting the need of competences within a defined space of manoeuvre. TORC employs a scale derived from Woods (2015):

Defend (R1): Resilient action takes place to deal with everyday operational surprise within the boundaries of the normal operation.
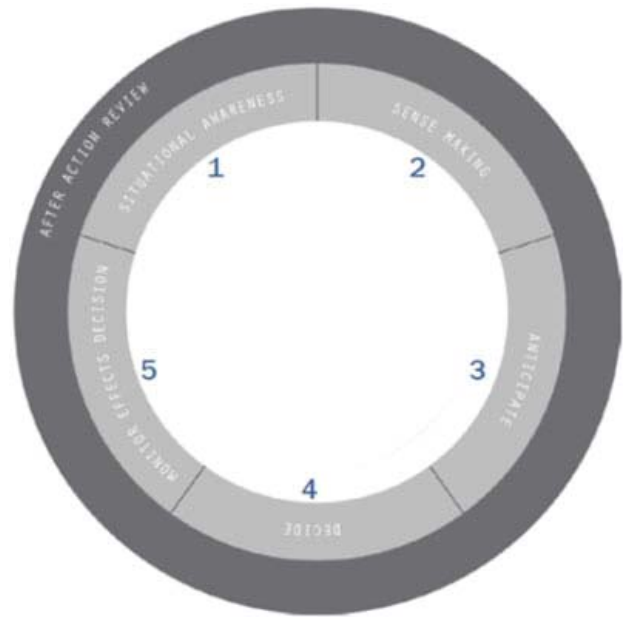

Figure 8.   Mental steps within TORC game.

Build (R2): the organization provides additional defences by means of robustness added to the normal operational model at spots where there are known vulnerabilities or procedures need to be interpreted.

Stretch (R3): on a case-by-case basis, controlled acting outside of the operational model is an option e.g. through a Management of Change process when responding to unexpected situations if the available work permits, procedures and resources no longer support necessary action.

Sustain (R4): a state in which the organization accommodates resilient action within and between organizations as an operational capability, governed by a controlled resilience process which allows for proposing compensating measures immediately across the modes.

4.2   *The cognitive and social process of each decision*

The process driving the TORC game requires the individual trainee to take a number of sequential steps, mentally as well as physically, by moving a token on the board to make the process visible to other players, as illustrated in Figure 8. These steps are equivalent to the trainee's mental *and social* process in everyday operational practice when an unexpected situation occurs.

TORC applies the following mental steps for resilient action:

1. A seemingly stable situation may unexpectedly change. Is there anything you hear, smell, see or anything you can think of that may explain what is happening? Act upon these early warnings signs of disturbance!

2. How may this changing reality affect you, your team and the work to be completed? Might it affect stakeholders outside of your team? What strategies and resources will you need to deal with the situation?
3. What is the impact of the selected strategies and resources? What is it that you will be facing, and what will you have to take into account?
4. Carefully consider your decisions and action plan and adapt your work process in a controlled way. What did you gain? At what cost?
5. Monitor the impact of your decisions locally and throughout the delivery process.

4.3 *The resilient strategies offered*

Resilience strategies are the methods by means of which resilient resources can be mobilized into operational capability, e.g. in terms of a set of adaptive actions ("adaptive clusters"). For instance by optimally utilizing the resources through (re)designing resilience-oriented interaction, through crew composition changes, by providing resilience-oriented operational tools and procedures, by reallocating resources or by adapting work processes. Outcomes of applying these strategies may be, at an individual level, a knowledgeable, timely available and well-rested crew member able to cope with emerging demands and stress. At team level it may result in a crew showing supporting behaviour and mutual understanding. At organization level it may result in higher levels of trust and improved financial buffers.

Initially, the framework suggested by Lay, Branlat & Woods (2015) was applied to categorize the resilience strategies. Based on further literature research, additional strategies, heuristics, patterns tactics and practices to enable resilience were reviewed for applicability to the TORC scope. The selected strategies and tactics were used to build the abilities to respond, monitor, anticipate and learn in situations requiring resilient action. Discussions with industry partners and further exploration resulted in several changes to the Lay et al., 2015 framework as illustrated in detail in figure 9:

1. Adapt work process
2. Add (human) resources
3. Manage priorities
4. Make sense of developments
5. Support active reflection on developments
6. Reallocate resources
7. Acknowledge viewpoints team members
8. Learn in action and share information
9. Appoint leading person in team
10. Create liaison for decision support.

The practices included vary in applicability: some apply at the level of the individual or team, while other practices apply to the (operational) level or across the organization. The selected set of practices is non-exclusive and non-exhaustive and can be amended or supplemented by the trainees during the game.

Figure 9. TORC strategies and tactics (example).

4.4 *Evaluating the TORC game*

Furthermore, several measures were developed to assess the impact of the TORC training implementation. A framework for interrogating impact was defined including the validation of measurement methods. The TORC Resilience Impact Assessment provides companies with the means of identifying the impact of the implementation of resilience resources and strategies in their company and thereby ensures the long-term value of the TORC training intervention.

The TORC Resilience Impact Assessment Framework has three analysis methods and four levels of analysis in line with Kirkpatrick's (1994) evaluation framework. It has four distinct categories which, when applied to resilience interventions or resources, attempt to assess the following:

1. Reaction – Assessing impact through the elicitation of perceptions and attitudes of those impacted directly by the resilience intervention
2. Learning – Assessing impact through the elicitation of new knowledge and learning of those impacted directly by the resilience intervention
3. Behaviour – Assessing impact on the behaviour of those impacted directly by the resilience intervention
4. Results – Assessing impact on the results that the organisation uses to evaluate its performance.

A questionnaire was developed targeting perceptions and attitudes, which focuses on 'Reaction' (what do you think of this training), 'Learning' (what have you learned from this training), 'Behaviour' (what do you do differently as a result of the training), and 'Results' (what has this meant in terms of your job/role). Observations and audits (linking attitudes

Figure 10. TORC Resilience Impact Assessment

and learning to behaviour) would target just the 'Behaviour' category from Kirkpatrick's framework. This category is looking at collective or individual behaviour by observing it directly to see how people are working, are they doing things correctly, or by observing indirect artefacts or evidence of resilient behaviours in practice.

Organisational data as part of results is targeting the accident and incident data that the organisation will already collect and supplements this with some additional metrics which focus on results.

The metrics specified provide organisations with a tool to measure and assess the impact of their own resilience investments, and measure the outcomes of a TORC intervention process over time. Figure 10 illustrates the TORC Resilience Impact Assessment Framework.

The validation of the framework has been carried out by a multidisciplinary group of experts on the basis of specific guidelines and pre-identified criteria. The validation panel was composed of both research and industry consortium partners. The validation was complemented and finalised as an iterative process. The objective of the validation activities was to evaluate the three parts of the framework (Questionnaire, Observations and Audits, Organisation Metrics) by assessing the clarity, the completeness and the usefulness of the framework as a whole. To achieve this objective, a dedicated validation methodology has been defined to ensure that all feedback is correctly taken into account and used to improve the framework.

The TORC assessment methods were partly tested after the implementation of the TORC training. Given that actual behaviour change will only occur over time can be observed during work activities outside the training context (expected approximately 3 months after the TORC training) – as is the case with changes in organisational outcomes (i.e. Level 4: Results) – these outcomes can only be established after the TORC project has ended. Therefore the evaluation forms developed for this purpose within the TORC project have not been tested. However, these can still be used for future validation by the partners outside the scope of the research project.

5 EXPERIENCE, TRAINING RESULTS

From TORC training experience so far it has become apparent that "trivial cases" generate a lot of energy

and activity in the training sessions which illustrates that the trainees recognize the phenomenon of resilience and that the "energizing" principles selected for TORC are effective. The training sessions cause "rudimentary resilience" to be invoked, augmented and developed. TORC training demonstrates and visualizes "resilience in action". It allows for resilience to be discussed as a critical capability complementary to compliance and provides the organization with a platform to create a shared understanding between frontline workers and management about the conditions required for effective operational resilience in a high-compliance environment.

6 DISCUSSION

6.1 *Suitability of existing frameworks*

A resilience capability requires adaptivity and shifting competences. The model of "graded" resilience derived from Woods (2015) to cope with changing and more unique demands has proven to be a very workable basis to explore real life operational cases in industry and help trainees to be aware of potential boundaries to their mandate. R1-R3 were selected for the current game, but TORC can be expanded to explore R4 as well when a company resilience strategy requires this.

While the framework suggested by Lay et al. (2015) formed a useful starting point for the development of the TORC methodology, it required further completion, informed by input received during exploration sessions with industry partners and pilot training sessions, to fill gaps with the operational practice, and the terminology required adjustment for use in actual operational practice.

The strategies in their own right were not sufficiently actionable and required explicit capabilities to be identified for use in the game.

6.2 *Open doors; deepening the TORC impact*

It is obvious that the TORC approach energized by resilience engineering principles has met the expectation by clearly manifesting the margin of manoeuvre and the reconciliation between operational staff and management as key conditions for effective adaptive practice, and made it tangible and actionable as indicated in Fig. 3.

Furthermore, beyond the original intent, TORC opened up a wealth of experience in relation to organizational reflexive processes with major potential for further exploration in two phases.

The TORC impact and applicability can be extended by deepening the encounter with operational practices to understand the origin of these processes and their roots into professional competence and communities of practice. Furthermore, by deepening the managerial "confrontation" following from the need to explicitly express and account for the acceptable space of

Figure 11. Example of deepening the TORC impact

manoeuvre, additional sophistication can be built into the conceptions of the "learning organization".

7 CONCLUSION

The TORC project has delivered an operational training to explore and improve resilience capabilities engaging both operations and management. A serious game approach enables a realistic simulation of industry partner operations when coping with emerging and unexpected changes in demand. The integrated approach and systematic after action review delivers mutual recognition by operational and management trainees of different perceptions and necessary improvements of resilience capabilities as a result of the training. The TORC evaluation framework assists in assessing learning effects and impact.

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