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Improving organisational resilience to disaster events: an FM perspective

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ABSTRACT

Background and aim – Improving the resilience of business organisations and critical infrastructure providers to disaster events is a major challenge facing many European organisations. Recent floods in Germany, Belgium and the Netherlands and earthquakes in Iceland, Italy, Romania and Greece have demonstrated the need for organisations to adopt a holistic view of their vulnerabilities, adaptive capacities and resilience planning. This paper focuses on the role that facilities managers could play in the development of disaster management and business continuity and resilience plans.
Methods / Methodology – The paper draws on data collected through an interpretivist, observational action research study to identify the key factors that affect organisational resilience to earthquakes. Literature reviews, interviews and workshops with end-user stakeholder organisations were used to identify physical and operational mitigation interventions that could help organisations better prepare for, absorb and recover from an earthquake.
Results – The paper presents a hierarchical model of organisational resilience and a generic resilience assessment and risk management framework that can help organisations better understand and manage their disaster risks. The paper delineates the role of facilities managers in assessing the impact that the disaster risks could have on hard and soft facilities management and in identifying mitigation interventions to support primary service or product delivery following a disaster event.
Practical or social implications – The paper makes a valuable contribution to the literature on organisational resilience to disaster events by highlighting the little researched role of facilities management in this context.
Type of paper – Research paper (full).

KEYWORDS
disaster management, business vulnerability, adaptive capacity, organisational resilience, risk management, multi-criteria modelling.

INTRODUCTION
The role of facilities managers in supporting improved organisational resilience to disaster events is an under-researched area, even though their contribution to understanding an organisation's vulnerability, resilience, risk, and adaptive capacity to disaster events is clearly recognised (FEMA 141, 1993; FEMA 396, 2003). This paper addresses this gap in knowledge by exploring the role that facilities managers should play in the development of disaster management and business continuity and resilience plans. The paper discusses the concepts of resilience, vulnerability and adaptive capacity as they apply to business organisations and draws on a literature review of organisational resilience and primary fieldwork from the European Union H2020 TURNkey project (https://earthquake-turnkey.eu/) to identify the key factors that affect organisational resilience to earthquakes. The literature review identified the complex relationships between vulnerability, resilience and adaptive capacity and

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highlighted the need for organisations to take action to prepare for, respond to and recover from a disaster event. Such actions need to consider pre-disaster event interventions aimed at improving resistance of the organisation's built assets, processes and systems to the impact of a disaster event as well as post-disaster plans for managing immediate response (e.g., life safety and business disruption) and business recovery. In developing such plans organisations, including their facilities management teams, need to understand their inherent vulnerability and resilience to a disaster event and the strategic options available to them to reflect their organisational circumstances and context.

TURNkey is an ongoing H2020 project to improve earthquake resilience (at the critical infrastructure, business, and community level) through the use of a multi-sensor-based information system that integrates operational earthquake forecasting (OEF), earthquake early warning (EEW) and rapid response to earthquake (RRE) protocols into a cloud-based Forecasting, Warning, Consequence and Response decision support platform: the TURNkey FWCR Platform (Figure 1). This paper focuses on the results for business organisations.

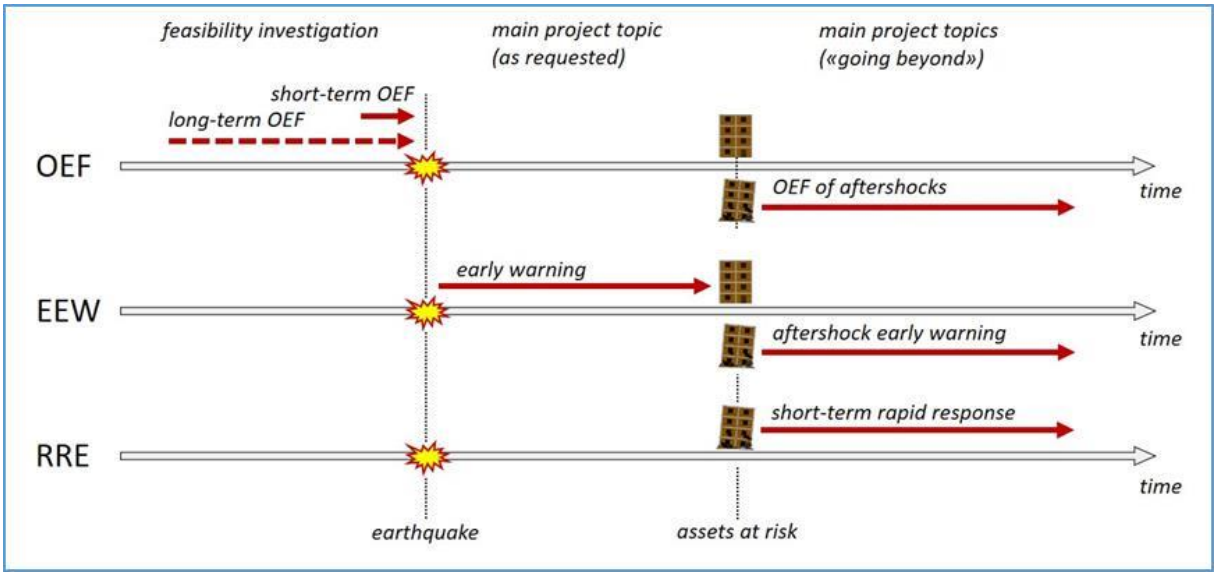

Figure 1 The TURNkey concept model (source: Jones et. al., 2021a).

The aim of the paper is to outline a conceptual resilience assessment and risk management framework to help facilities managers better understand the disaster risks that their organisation faces; the impact that these risks could have on hard and soft facilities management systems; and on the ability of these systems to support primary service or product delivery. The paper highlights the need for facilities managers to adopt a hybrid view of resilience when identifying and implementing adaptation and mitigation interventions to reduce disaster risks and/or improve organisational resilience. The paper first outlines the TURNkey project and positions it within a wider discussion of resilience before exploring the relationship between OEF, EEW and RRE and organisational resilience from a facilities management perspective. The paper then outlines a risk and resilience framework that facilities managers can use to help them better understand their organisation's vulnerabilities and resilience to a disaster event.

RESILIENCE, VULNERABILITY, RISK AND ADAPTIVE CAPACITY

The UNDRR (2022) defines resilience as ***"The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures***

and functions through risk management.". When unpacking this definition, the complexity of the different resilience perspectives proposed by Holling (1996, 2001) become apparent:

- Engineering resilience describes the behaviour of a system close to its equilibrium position. When an external stressor event pushes the system away from equilibrium, the inherent resilience of the system seeks to return the system to its equilibrium position once the external stressor is released (assuming the system's absorptive capacity hasn't been exceeded) with the speed of return to the equilibrium position used as a measure of inherent resilience.
- Ecological resilience describes the behaviour of a system away from its equilibrium position, where the strength of the external stressor is too great for the system to absorb and as such, the system reorganises to a new state of equilibrium. The magnitude of the external stressor that a system can absorb before reorganisation occurs is used as a measure of inherent resilience.
- Adaptive resilience (panarchy) describes the capacity (inherent potential) of a complex adaptive system to reconfigure (reorganise) to a desirable (transformational) or undesirable (destabilising) future state. Adaptive resilience is viewed as the opposite of the system's vulnerability.

The UNDRR (2022) defines vulnerability as ***"The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards."*** As such, vulnerability is related to risk, where risk is defined as the product of hazard, vulnerability, and consequence (Bakkensen et. al., 2016) and to resilience through the system's ability to resist and recover from the impacts (losses) associated with the hazard (Zhou et. al., 2016) through mitigation interventions to lower risk, losses, or impacts. To this end, Tiernan et.al. (2019) argued that resilience should be considered an umbrella concept that encompasses a range of responses to an external stressor that enables a system: 1) to remain stable when exposed to a stressor event; 2) to recover following the event; and 3) to adapt to new circumstances after the event.

Jones (2021) argued that business organisations should adopt a holistic approach to understanding their resilience to a disaster event that considers resilience as a hybrid concept viewed from multiple perspectives; with facilities managers contributing to this understanding through an assessment of the impact that a hazard event has on the organisation's hard (physical) and soft (socio-economic) facilities management systems to support primary business functions. This paper explores the role of facilities managers in supporting their organisation better understand its resilience, vulnerability, risk, and adaptive capacity to a disaster event through a generic risk and resilience framework.

FACTORS THAT AFFECT ORGANISATIONAL RESILIENCE TO DISASTER EVENTS

ISO 22316 (2017) defines organisational resilience as ***"…the ability of an organisation to absorb and adapt in a changing environment to enable it to deliver its objectives and to survive and prosper…"***. As such, organisational resilience is built on a combination of actions taken to prepare for an event (e.g., disaster management planning) and processes in place to expedite a rapid recovery following the event (e.g., business continuity planning) (Denyer, 2017; FEMA 141, 1993; Gibson and Tarrant, 2010). Actions include gathering and processing hazard information to assess (and if possible, forecast) the potential impact of the hazard on the organisation, its supply chain and customers. Processes include identifying mitigation interventions to either reduce the impacts of the hazard or increase the likelihood of the organisation recovering from disruptions in a timely manner. Disaster management and business continuity plans need to reflect the organisation's service or products, operating structure, regulatory and legal frameworks, and whilst they tend to be unique for any given organisation their general format follows the 'plan, do, check, act' structure outlined in ISO 22301 (2019). However, whilst the ISO

standard provides a framework for improved organisational resilience, it does not explicitly provide the tools for organisations to either assess their antecedent resilience to a range of disaster events or to develop adaptation and mitigation plans to improve resilience. The TURNkey project is addressing this issue by exploring how organisations could potentially use EEW, OEF and RRE as part of their disaster management and business continuity planning.

Tierney and Webb (2001) published an early study on business vulnerability and resilience to earthquakes that drew on a questionnaire survey of 5000 businesses to identify how business organisations prepare for and recover from an earthquake. Tierney and Webb (ibid.) found that whilst most organisations did very little to prepare for an earthquake event, those organisations that took action that directly aided business recovery, reduced exposure and mitigated damage and disruption, including to the supply chain, recovered faster than those organisations that primarily focused on workplace preparedness. In a subsequent study, Tierney (2007) expanded on the above and explored in more detail what made some businesses more resilient than others. Tierney (ibid.) explored the inherent resilience of business organisations (defined as the organisational characteristics/factors that mitigate the effects of disasters on business operations) as well as their adaptive resilience (defined as the organisational characteristics/factors that enhance business options and adaptability following a disaster), and suggested that inherent business resilience is related to reduced vulnerability (the fewer risk factors an organisation displays, the more resilient it will be to disaster events) and engagement with business continuity and disaster management planning. The idea of measuring organisational resilience through a series of operational factors and organisational characteristics was further developed by Han and Nigg (2011) who proposed an analytical framework against which organisations could assess their inherent vulnerability and resilience to an earthquake and inform the development of disaster management and recovery plans. Whilst some of the factors suggested by Han and Nigg (2011) now appear a little dated, their checklist approach still forms the basis of the majority of disaster management and business continuity planning toolkits (e.g., the UNDRR Disaster Resilience Scorecard for Industrial and Commercial Buildings, 2022).

The logic of measuring a range of attributes at a single point in time and equating these to a measure of resilience was questioned by Gibson and Tarrant (2011) who argued that, whilst measuring organisational attributes could provide an appreciation of an organisation's resilience capability, its actual resilience would depend on how these capabilities responded to the specific context at the time of the disaster event. In essence, Gibson and Tarrant (ibid.) argued that organisational resilience should be viewed as an outcome of a dynamic complex system where the interactions between factors (and subsystems) provide multiple perspectives on the assessment and management of risk within different organisational contexts (e.g., maturity levels) and strategic objectives. Gibson and Tarrant (ibid.) also argued the need for organisations to develop flexible business continuity and disaster management strategies that identify mitigation actions to enhance both the resistance and reliability of critical business functions to continue to perform at an acceptable level following a disaster event and provide redundancy and flexibility to increase the speed recovery from a disaster event. In essence, Gibson and Tarrant (ibid.) argued the need for organisations to demonstrate a clear understanding of their disaster risks, related vulnerabilities and mitigation actions from multiple perspectives across multiple systems. These arguments are similar to those presented by Deyner (2017) who identified the need for organisations to adopt a range of strategic approaches to organisational resilience; suggesting the need to think beyond defensive resilience behaviours to protect the organisation and return to a pre-existing equilibrium point (engineering resilience) and embrace progressive behaviours to adapt to new opportunities in terms of service delivery and market opportunities (socio-ecological resilience). The TURNkey project is exploring the challenges that this wider view of resilience places on disaster

management and business continuity planning decision-making before, during and after an earthquake event.

RESEARCH METHODOLOGY AND/OR METHODS

The TURNkey project is using an interpretivist, observational research methodology in the form of Participatory Action Research (PAR) to link the needs of the end-users of the TURNkey FWCR platform with those responsible for its design and development. The TURNkey PAR is running over 3 cycles where end-users engage with the TURNkey research and development team in the design, testing, evaluation and reflection of the platform as it develops (Figure 2).

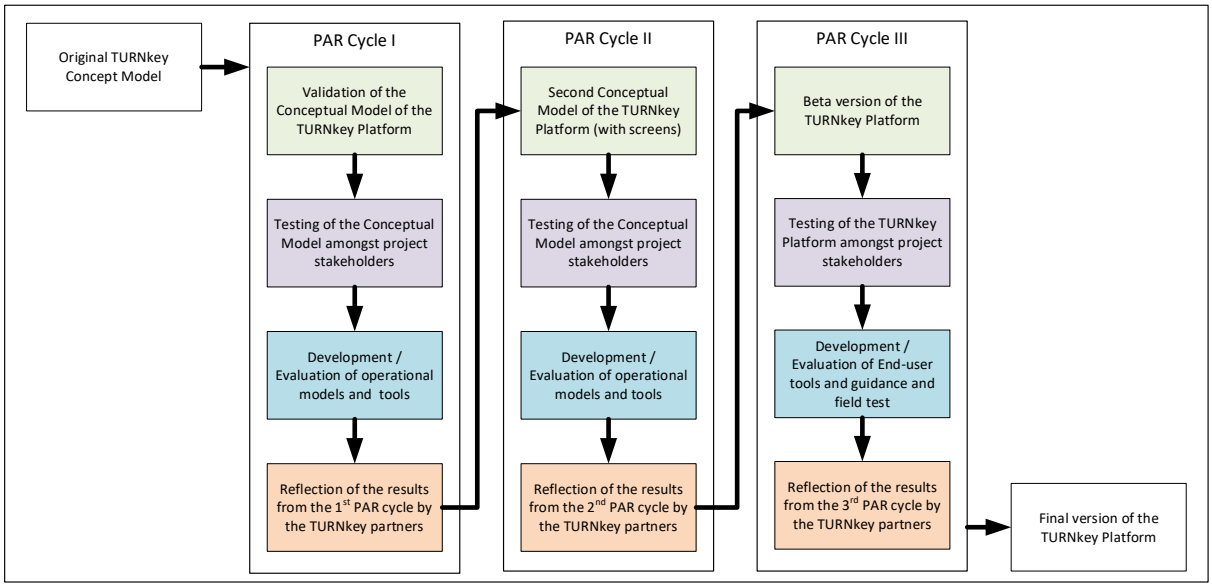

Figure 2 The TURNkey participatory action research methodology

The results of each PAR cycle are presented as a series of generic end-user use cases that describe how the platform could be applied to business organisations before, during and after an earthquake to improve the organisation's resilience to an earthquake. This paper focusses on the results from the 2nd PAR cycle where the generic use cases were mapped against current understanding of organisational resilience to a disaster (earthquake) event derived from a review of three internationally recognised resilience rating systems; REDi™; UNDRR's Disaster Resilience Scorecard for Industrial and Commercial Buildings; and the Relative Overall Resilience model.

REDi™ (Almufti and Willford, 2014) is a rating system for resilience-based earthquake building design that uses a four-category resilience framework to identify interventions that reduce earthquake risks (relative to code-designed buildings), support re-occupancy and rapid functional recovery, and reduce direct financial losses. The framework uses 64 resilience risk criteria grouped into 16 themes across 4 generic resilience categories: 1) building resilience which seeks to minimise damage to structural, architectural and engineering services components; 2) organisational resilience which seeks to support contingency planning for utility disruption (e.g., reduced repair times) and business continuity (reduced disruption to primary function); 3) ambient resilience that seeks to reduce the risks from external earthquake induced hazards (e.g., damage to surrounding buildings or infrastructure, cascading hazards); and 4) loss assessments that seek to evaluate financial losses and downtime as a way of justifying increased costs associated with mitigation measures (loss assessments are based on a modified version of FEMA's PACT methodology). In identifying potential mitigation actions, the REDi™ (ibid.) framework maps the criteria against different levels of occupant safety, downtime, and direct

financial losses; using threshold measures to categorise resilience as either platinum (the highest level), gold or silver (the lowest level).

The UN developed "The Disaster Resilience Scorecard for Industrial and Commercial Buildings" (UNDRR, 2020) to help building owners, operators and managers understand the resilience of their organisation to disaster events. The Scorecard uses 116 criteria grouped into 10 themes: 1) organise for resilience; 2) identify, understand and use current and future risk scenarios; 3) strengthen financial capacity for resilience; 4) pursue resilient urban development; 5) safeguard natural buffers; 6) strengthen institutional capacity for resilience; 7) increase social and cultural resilience; 8) increase infrastructure resilience; 9) ensure effective disaster response; and 10) expedite recovery and build back better. Whilst not all the criteria are applicable to all organisations, those that are, are scored on a 0-5 scale to give an indication of the overall resilience of the organisation to a disaster event.

Lee et.al. (2013) used the Relative Overall Resilience (ROR) model developed by McManus (2008) to develop a model of organisational resilience based around two factors (adaptive capacity and planning) represented by 13 indicators and 53 criteria that could be used as the basis for identifying an organisation's resilience strengths and weaknesses that need to be managed as part of a journey towards becoming more resilient. Full details of the review and mapping can be found in Jones et. al. (2021a).

The review of the scorecards (undertaken independently by the authors) was combined with a review of the role of OEF, EEW and RRE in earthquake resilience (see Jones et. al., 2021b for the review) to provide a conceptual framework against which the TURNkey FWCR platform's potential to enhance organisational resilience could be assessed (Figure 3). The framework was used in conjunction with 5 virtual demonstrators (videos explaining the potential application of the TURNkey FWCR platform before, during and after an earthquake event) in a series of virtual workshops (6) with end-user stakeholder groups to explore the potential relationship between the TURNkey FWCR platform and organisational resilience. Workshops spanned a range of organisations (manufacturing, service delivery, public authorities) from the private and public sectors. Workshops were semi-structured in nature, taking the form of conversations with various individuals responsible for disaster management and/or business continuity planning within their organisation. The results from the workshops were reviewed by TURNkey project members (researchers and end-user stakeholders) at the individual work package and overall project level as part of their reflection on the degree to which the TURNkey FWCR Platform was demonstrating its potential to improve organisational resilience to an earthquake. The 2nd PAR cycle took place between June 2020 and June 2021.

PRELIMINARY RESULTS

The conceptual framework presents organisational resilience to an earthquake as a hierarchy model grouped under physical resilience (where the goal was to minimise downtime through damage limitation and control); operational resilience (where the goal was to minimise disruption) and economic resilience (where the goal was to minimise losses). Physical resilience was further subdivided into structural, non-structural and production systems, which in turn were subdivided into vulnerability assessments, control protocols (to minimise cascading impacts – e.g., fire), and repair time. Operational resilience was subdivided into risk and contingency planning (subdivided into assessment, disruption, management), supply chain and external relationship (subdivided into backup systems, logistics, service contracts) and disaster management (subdivided into employee safety, scenario planning, emergency response, recovery plans). Economic resilience was divided into financial resilience (subdivided into insurance, liquidity, direct losses); corporate image (subdivided into safety, trust, corporate social responsibility) and adaptive capacity (subdivided into training, customer relationship, community

engagement). The consolidated organisational resilience hierarchy model and TURNkey FWCR Platform is shown in Figure 3.

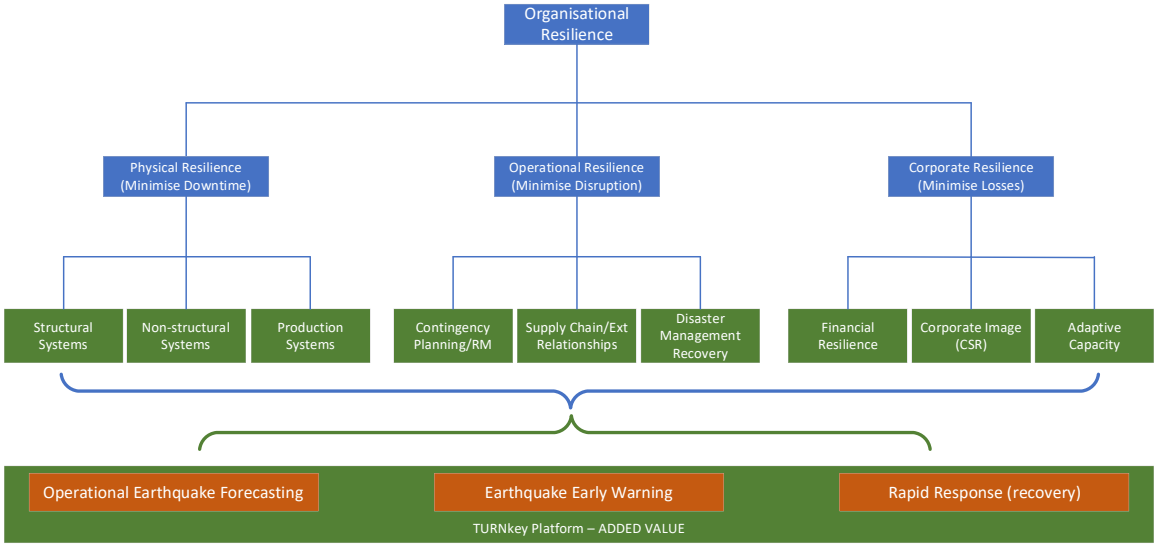

Figure 3 Organisational resilience model and TURNkey FWCR Platform (source Jones et. al., 2021b)

The mapping process and resilience hierarchy was used to inform discussions with end user stakeholders and develop a set of use cases that described the actions that could be taken to improve organisational resilience before, during and after an earthquake. As a consequence of these discussions, the TURNkey FWCR platform is expected to have a positive impact on organisational resilience at the physical, operational and economic levels. At the physical level TURNkey's ability to run dedicated earthquake simulation scenarios (part of the OEF capabilities) that reflect the physical attributes of an organisation will allow potential vulnerabilities to be identified and mitigation interventions investigated and actioned as part of built asset management plans. TURNkey's early warning capability would allow auto control of hazardous systems, reducing the potential for cascading impacts and TURNkey's rapid response capabilities would allow real-time inspection of damage levels and prioritisation of repair activities to minimise downtime. At the organisational level, TURNkey's simulations would feed directly into contingency management and risk planning, and when combined with training, could be used to test disaster management and business continuity plans. TURNkey's early warning system could impact employee safety through the issuing of an alert to take precautionary action and TURNkey's rapid response facility could issue automated emails activating disaster management and recovery plans. Also, if the TURNkey system is used within the wider community, two-way communication between the organisation and emergency responders and civil protection could ensure a coordinated response with external stakeholders. At the economic level, TURNkey's simulations can provide an estimate of economic losses, both as a direct consequence of the earthquake's impact on the organisation and, if the system is applied at a regional level, on its supply chain. This will allow more focused business continuity plans to be developed that, for example, address stock levels and recovery logistics. TURNkey's rapid recovery capability would also provide information to the organisation's customers and wider community, protecting its corporate image and adding to adaptive capacity. These potential benefits are currently being evaluated in the 3rd PAR cycle through a final set of workshops with key business organisations.

DISCUSSION

The review of the organisational resilience literature identified the need for organisations to consider resilience as a complex concept viewed from multiple perspectives that extends beyond the narrow

view of resistance and stability of the system to an external stressor to a wider consideration of the flexibility and adaptive capacity of the system to reorganise once the external stressor is removed. This view poses a number of challenges to facilities managers. From a physical resilience perspective, the facilities manager needs to understand the impact that an earthquake would have not only on the potential damage to building structures, infrastructures, and contents, but also, on the impact that such damage would have on the organisation's ability to deliver their primary function over the short, medium and long term. While such a statement might seem obvious, it is currently missing from many of the models used (e.g., loss functions) to predict an earthquake's impact. Further, in order to fully grasp the potential impact of an earthquake on the business's primary function, the facilities manager also needs to understand the organisation's nonphysical vulnerabilities, including its FM services (e.g., support logistics, security, outsourced contracts, maintenance/repair functions) and how these might be affected by local and regional issues (e.g., access to specialist contractors or supply chains) immediately following an earthquake event. Further, in addition to understanding the organisation's vulnerabilities to an earthquake, facilities managers also need to be able to identify and develop mitigation interventions (to both hard and soft FM systems) that can be implemented either as part of ongoing built asset management plans (through enhanced maintenance or retrofit refurbishment) or specific operational mitigation responses as part of the organisation's risk management plan. To help facilities managers understand their role in resilience planning, the authors have developed a generalised conceptual model of organisational resilience to a disaster event (Figure 4) drawn from discussions with end-users of the hierarchical model presented in Figure 3 and the strategic approaches to resilience modelling discussed in the literature review.

Facilities managers (and the wider organisation's management team) need to adopt a hybrid view of resilience that considers the impact that a disaster event could have on all the organisation's systems including: the organisation's hard FM assets (e.g., built assets); its soft FM assets (e.g., security assets); and its facilities services supply chain, which collectively enhance or inhibit the organisation's resilience and adaptive capacity. This holistic view reinforces the approach proposed by Tierney (2007) and Gibson and Tarrant (2011).

Assessing the antecedent vulnerability and resilience conditions involves identifying the level of risk of the asset set to the impact that a hazard event would have. From a facilities management perspective, this involves using the best available hazard information to understand the consequences of a hazard event on the functional performance of the asset measured against its ability to support the primary business function. Assuming that the loss of overall functional performance is not acceptable to the organisation, the facilities manager needs to identify potential mitigation interventions that seek to either lower the asset set's vulnerability, or improve the asset set's resilience, to the hazard threat. Such mitigation interventions could include actions to improve the resistance or stability of the asset set, for example identifying physical changes to existing buildings to bring them up (or as close as possible) to current design code standards (engineering resilience); changes to security assets (e.g., additional personnel) to manage disruption caused by a disaster event; or changes to supply chain service contracts to ensure flexibility in service delivery to meet changing (post-disaster event) demands (socio-ecological resilience) and reorganisation (panarchy). Such changes may be a direct result of the impact of the disaster event on the FM service model or as a consequence of a change in the way primary services are designed and delivered to make them more resilient. This forward-looking view to enhancing recovery and possible market re-orientation is in line with the strategic resilience strategies suggested by Deyner (2017).

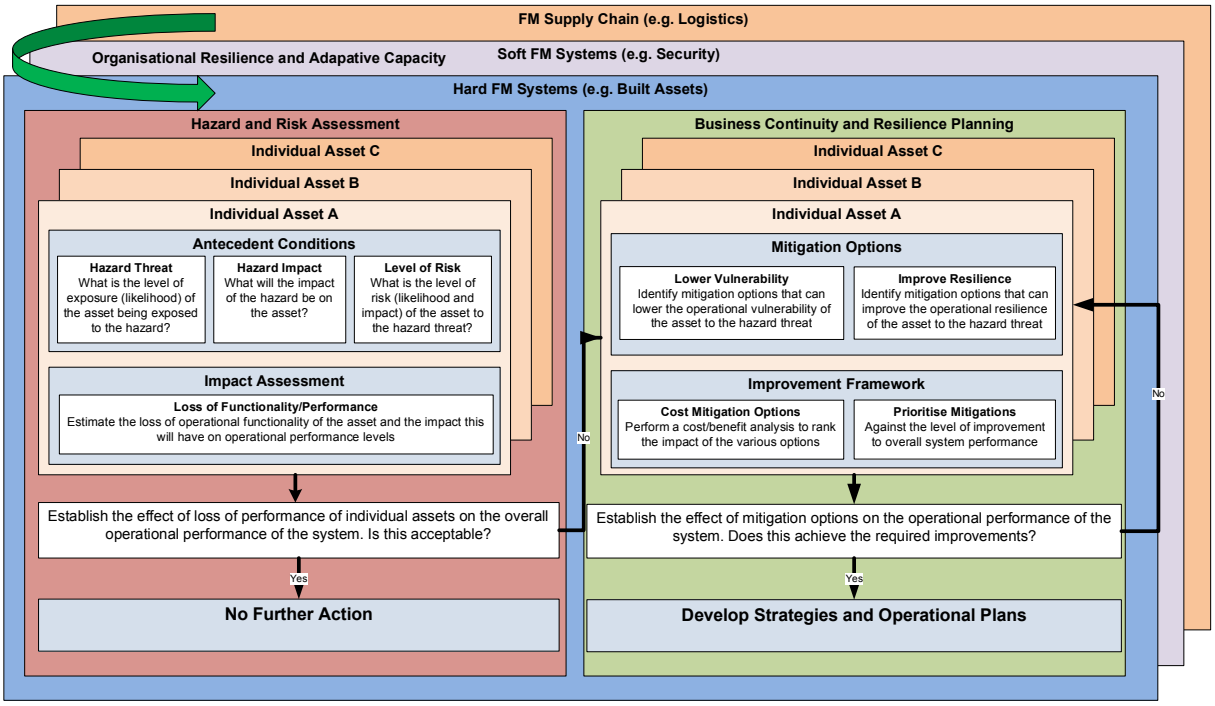

Figure 4 Organisational risk and resilience concept model from an FM perspective (adapted from Morga et. al., 2020)

It is likely that the hazard and risk assessment phase of the resilience improvement framework will generate a wide range of potential mitigation interventions, and these will need to be prioritised depending upon their costs and benefits to the organisation. Costs should include both the direct and indirect costs associated with the intervention, whilst the expected benefits should include reduced losses and if applicable, increased income (e.g., from more resilient ways of working during normal times) associated with the intervention. Those mitigation interventions that provide the greatest potential improvement to the organisation's operational performance can then be implemented through the organisation's strategic and operational plans (built asset management strategy, disaster management plans, emergency recovery plans and business continuity plans) which describe the actions that would be taken to prepare for, respond to and recover from a disaster event generated by the hazard threat as suggested in ISO 22316 (2017).

Finally, in applying the risk and resilience framework the facilities manager (and wider organisation management) needs to understand how the interaction/feedback between the different systems (complex adaptive system) affect each other to arrive at a holistic understanding of the resilience and adaptive capacity of their organisation to the hazard threat (Gibson and Tarrant 2011; Holling, 2001).

CONCLUSION

The TURNkey FWCR platform represents an attempt to draw together in a single location an earthquake forecasting/simulation, early warning and rapid response system. As part of the development of the system, the authors explored the potential impact that the TURNkey FWCR platform could have on organisational resilience to an earthquake. The potential impact was explored through a series of end-user use cases which identified a number of operational areas that overlap with the role of a facilities manager.

The authors have argued that business organisations should be considered as complex adaptive systems where resilience to disaster events is realised through a combination of the ability of their physical

systems, operational processes and organisational context to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner. Within this broad understanding of resilience, the authors have argued that the facilities manager's role needs to extend beyond a narrow consideration of the impact that a disaster event has on the ability of the organisation's physical assets to continue to support primary business function to encompass a wider understanding of the impact that the disaster event has on the ability of facility management operational and service processes to minimise operational disruption, increase speed of recovery and reduce losses. This paper has presented a simplified hierarchy model of organisational resilience derived from existing metric scorecards which helped inform discussions with potential TURNkey end-user stakeholders about the role that TURNkey could play in improving their resilience to earthquakes. The paper has presented preliminary results from these discussions that relate to the potential role that facilities managers could play in identifying mitigation interventions to reduce vulnerability, improve resilience and enhance adaptive capacity. To assist the facilities manager in this process the paper has outlined a resilience assessment and improvement framework that can act as a conceptual model at both the organisational (system) and operational (sub-system) levels.

In using the resilience assessment and improvement framework the facilities manager is required to consider the wider business and community context within which the organisation operates, and in particular to explore the impact that a disaster event could have on the organisation's hard (physical) and soft (socio-economic) systems and on the interactions between these systems that collectively supports the organisation's ability to absorb, adapt and recovery from a disaster event. However, to effectively address these issues facilities managers need adopt a hybrid view of resilience that encompasses engineering resilience, socio-ecological resilience and adaptive resilience.

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