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## Striving to be resilient: What concepts, approaches and practices should be incorporated in resilience management guidelines?

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## ABSTRACT

Resilience management guidelines address disruptions, changes and opportunities, facilitate anticipation, adaptation, flexibility and provide a foundation for an effective crisis response. The objective and novelty of the study were to propose a holistic framework that enables to evaluate and prioritise concepts, approaches and practices that should be incorporated into European guidelines for resilience management. Based on a modified Delphi process, 51 items achieved a consensus of >80%. 84% of the items ( $n = 43$ ) were ranked as important; 13.7% ( $n = 7$ ) as essential; one ranked as somewhat important. The identified items encompass eleven categories as follows: 1) collaboration [11 items]; 2) planning [8 items]; 3) procedures [8 items]; 4) training [6 items]; 5) infrastructure [5 items]; 6) communication [3 items]; 7) governance [3 items]; 8) learning lessons [2 items]; 9) situation understanding (awareness) [1 item]; 10) resources [2 items]; and 11) evaluation [2 items]. The identified concepts, approaches and practices seem to be applicable to a wide range of domains and critical infrastructures, such as crisis management, air traffic management and healthcare, due to their generic and abstract characteristics. Important in the Delphi process is the engagement of potential end users in the development of resilience management guidelines to align this development to their needs. Therefore, the Delphi process involved policy and decision-makers, as well as practitioners and other personnel representing different critical infrastructures and academia, in prioritising concepts aimed at achieving resilient organisations, entities or communities.

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### 1. Introduction

Recent years have brought numerous disasters and crises that, in hindsight, clearly demonstrate the potential benefit of a more resilient and robust community (Woods, 2003; Birkland, 2006; de la Torre et al., 2012; Comfort et al., 2010; EUROCONTROL, 2013). One such event is the Deepwater Horizon disaster, which resulted in 11 fatalities and environmental damage from almost 5 million barrels of oil leaking out into the ocean. Studies and after-action reports following the disaster highlighted the need to improve organisational and individual awareness, and the need to develop resilient management strategies that can adapt to anticipated and unanticipated changes (Tinmannsvik et al., 2011; Colten et al., 2012). Another example is the Eyjafjallajökull

eruptions in 2010, which resulted in an approximate loss of 1 billion Euros. Public enquiries and studies following the aftermath of this event particularly emphasised that there is a clear need to improve emergency management at European level, building better tools for forecasting and anticipation, and improving the coordination across different organisations (Conin, 2010; Sultana, 2012). A third example is the Fukushima Daiichi nuclear disaster in 2011, from which a study reported that Resilience Engineering provides a critical proactive approach that is essential for improving safety in nuclear facilities. The study particularly highlights the need for the ability to manage unforeseen events (Kitamura, 2011). Current events causing increasing concern from an impact and resilience perspective are mass migration from areas of political instability and/or war zones and the incidence of cyber-attacks at national and international level.

The above examples are reminders of the urgent need to improve our ability to reveal, assess and manage resilience, both in everyday operations, and during crises (Hollnagel et al., 2011). By becoming more resilient, communities should be better able to withstand and recover from disturbances. Furthermore, they should be able to adjust plans and procedures prior to, during, and following new or unexpected

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disturbances, so that they can maintain their function as needed throughout the disruption (Hollnagel, 2009).

Resilience depends on many external factors, such as the scale of an event, the size of the population, the parties involved, the terrain, available resources, and so on. Hollnagel (2009, 2015) highlights four abilities of resilient systems and related services (Hollnagel, 2009; Hollnagel, 2015): (1) the ability to respond knowing *what to do* in the event of an emergency situation as well as opportunities; (2) the ability to monitor knowing *what to look for* regarding what happens in the environment, outside the boundaries of the systems as well of what happens within the system, its own performance; (3) the ability to anticipate knowing *what to expect* regarding potential future crises, that is associated with tactics and strategies which consider both opportunities and threats; and (4) the ability to learn from *what has happened*, i.e. learning from past experiences; resilience also considers how the effects of past learning are verified.

Recognising the need for more resilient and adaptive approaches for dealing with disasters and crises, there is already a tremendous amount of effort spent on improving resilience management, both in academia, and by practitioners working in fields such as emergency management, healthcare, disaster medicine, civil protection, aviation, and oil and gas.

Resilience management has gained extensive attention in the last decade, as the shift was made from crisis management to building the ability to anticipate and adapt when facing expected and unexpected events including threats, changes and opportunities (Scott et al., 2013; Fiksel et al., 2015; Hollnagel, 2015). Resilience management expands the scope of risk management, in addressing complexities that characterise the operation of large integrated systems, considering known as well as unforeseen threats (Linkov et al., 2014). It is concerned with the level of disturbance or crisis that a system can withstand without changing its functionality and the ability to survive and/or recover by adapting to the new situation (Standish et al., 2014; Teoh and Zadeh, 2013).

Resilience management guidelines are required in order to delineate what needs to be implemented in order to enable all entities and/or systems to adapt to the crisis and extend the capacity to work; e.g. graceful extensibility (McAllister, 2013; Jukić et al., 2015; Woods, 2015). The guidelines provide advice on how stakeholders can make more informed decisions on choosing, designing and implementing mechanisms that ensure the ability to adapt in a flexible manner to respond when crises occur and continue to function effectively (Walker et al., 2002). Resilience management guidelines address risks and opportunities, facilitate planning and decision-making processes, and provide a foundation for systems and communities to build an effective and holistic response to potential crises (McAllister, 2013). Ensuring the appropriateness of guidelines to the specific needs and characteristics of the target populations is an ambitious task that requires the involvement of relevant and representative stakeholders in the development process (Walker et al., 2002). Extensive efforts are being made to develop resilience management guidelines that can be successfully implemented in different entities and systems (Arbon, 2014; Zhang and Luttermelt, 2011). These efforts have resulted in a wide, scattered and sometimes overlapping diversity of concepts, approaches and practices for resilience management, ranging from abstract theoretical principles that have yet to be implemented, to practical rules of thumb that are used in everyday practices (DARWIN, 2015). Despite their heterogeneous nature, these concepts, practices and approaches are important contributions to the field of resilience engineering, and provide crucial input to the future establishment of European guidelines for resilience management; accordingly, five research projects in complementary ways such as DARWIN (<http://www.h2020darwin.eu/>), IMPROVER ([www.improverproject.eu](http://www.improverproject.eu)), RESOLUTE (<http://www.resolute-eu.org/>), RESILIENS ([www.resilens.eu](http://www.resilens.eu)), and SMR (<http://ciem.uia.no/project/smart-mature-resilience>) address this topic.

Among the diverse topics that have been identified as relevant components of resilience management are: collaboration (O'Sullivan et al.,

2013), planning, regulations and procedures (Desouza and Flanery, 2013), as well as resilience training (Robertson et al., 2015).

However, work is required to identify and streamline the various concepts, approaches and practices, and to assess their suitability to be incorporated into such guidelines.

The work reported in this paper is part of the European research project DARWIN, which aims to improve responses to expected and unexpected crises affecting critical infrastructures and social structures through the development of resilience management guidelines for both man-made incidents (e.g. cyber-attacks) and natural events (e.g. earthquakes). DARWIN strives to augment the current knowledge by cataloguing and operationalizing resilience concepts, approaches and practices that were identified and delineated in previous studies. This includes the comprehensive work that was initiated and developed under the international frameworks of the "UNISDR, Hyogo Framework for Action 2005–2015" (Innocenti and Albrito, 2011), its successor "The Sendai Framework for Disaster Risk Reduction 2015–2030" (Iitsi-Selmi et al., 2015), as well as the "City Resilience Framework" (CRF, 2016). These frameworks outlined priorities and guiding principles for achieving disaster resilience, promoted risk reduction actions that may be implemented by all relevant stakeholders, provided means for understanding the complexity of resilience, as well as a common language for sharing knowledge and experiences. A significant component of these frameworks was a strong encouragement to develop practical guidelines that support implementation of risk reduction measures and engage all relevant stakeholders in actions that promote resilience.

DARWIN aims to build on the results of the former studies in order to transform them into operational resilience management guidelines. The goal is not to develop alternate frameworks, but rather to build on the existing ones and further delineate what needs to be done in the form of guidelines. DARWIN strives to facilitate progress beyond risk assessment and management into operational activities that should be implemented in practical and actionable resilience guidelines, in order to promote and strengthen resilience management. Potential interactions between different operational domains and the related infrastructures, and between them and the public, shall be considered and integrated in the generic guidelines and in their associated operationalisation and implementation. DARWIN's goal is to develop resilience management guidelines that are relevant and/or can easily be adapted to various domains. Specifically, within the scope of the DARWIN project, the guidelines will be adapted to, implemented and validated in two very different domains – healthcare and Air Traffic Management. Within the scope of the project, the applicability of the developed guidelines will be reviewed in varied scenarios, such as function of a local airport as well as distribution of medicines and medical supplies by healthcare services following an earthquake or an epidemic. The guidelines will provide descriptions and examples of methods and guides for their application, as well as tools, training modules and other applicable solutions to support their operationalisation.

The target beneficiaries of DARWIN are infrastructure operators which include service providers and related stakeholders who are responsible for critical infrastructures that might be affected by a crisis as well as the public and media. Examples include: European and national agencies, policy makers, service providers, first responders and industry and enterprises. The first phase of the project was to identify concepts, practices and approaches of resilience management based on a comprehensive systematic review of literature from a wide range of disciplines, and interviews with relevant stakeholders involved in crisis management as well as with members of DARWIN's Community of Crisis and Resilience Practitioners (CoCRP), which were collated in a deliverable – D1.1 (DARWIN, 2015).

The objective of the present study was to evaluate the results of the deliverable in order to determine and prioritise which of the identified items should be incorporated into European guidelines for resilience management.

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