Methods for the evaluation and optimization of the resilience systems, plants and infrastructures

- **Context of the research**

Risk-based approaches have been used to assess hazards in industrial plants and mitigate consequences associated with their impact. By identifying the components contribution to the overall system risk, the outcomes of risk assessment enable prioritized decisions to reduce risk. However, the uncertain nature and extent of hazards emerging in changing environments, makes risk-based approaches difficult to apply with success. This is particularly true for the complex, interconnected systems that make up today's critical infrastructures and calls for attention to the properties of resilience of systems, in the face of large uncertainties. Differently from the concept of risk, resilience is focused also on the ability to prepare and recover quickly from an accident or disruptive event, which may be known or un- known. Managing for resilience, then, requires ensuring a system's ability to plan and prepare for the potential occurrence of accidents and disruptive events, and then absorb, recover, and adapt in case of occurrence.
Resilience is nowadays considered a fundamental attribute for systems that should be guaranteed by design, operation and management. It is characterized in terms of four properties, i.e. robustness, redundancy, resourcefulness, rapidity and four interrelated dimensions, i.e., technical, organizational, social, economic. It can be considered a new paradigm for risk engineering, which proactively integrates the accident preventive tasks of anticipation (imagining what to expect) and monitoring (knowing what to look for), the in-accident tasks of responding (knowing what to do and being capable of doing it) and learning (knowing what has happened), the mitigative tasks of absorbing (damping the negative impact of the adverse effect) and the recovery tasks of adaptation (making intentional adjustment to come through a disruption), restoration (returning to the normal state).

The objective of the research is to study, develop and advance metrics, methods and frameworks of resilience assessment and optimization, considering the large uncertainties, the heterogeneities and all relevant attributes involved including equity of solutions.

- **Objective of the research**

Methodology study, development and advancement; software tool development; case study solution.

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The future of risk assessment

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ABSTRACT

Risk assessment must evolve for addressing the existing and future challenges, and considering the new systems and innovations that have already arrived in our lives and that are coming ahead. In this paper, I swing on the rapid changes and innovations that the World that we live in is experiencing, and analyze them with respect to the challenges that these pose to the field of risk assessment. Digitalization brings opportunities but with it comes also the complexity of cyber-phyiscal systems. Climate change and extreme natural events are increasingly threatening our infrastructures; terrorist and malevolent threats are posing severe concerns for the security of our systems and lives. These sources of hazard are extremely uncertain and, thus, difficult to describe and model quantitatively.

Some research and development directions that are emerging are presented and discussed, also considering the ever increasing computational capabilities and data availability. These include the use of simulation for accident scenario identification and exploration, the extension of risk assessment into the framework of resilience and business continuity, the reliance on data for dynamic and condition monitoring-based risk assessment, the safety and security assessment of cyber-physical systems.

The paper is not a research work and not exactly a review or a state of the art work, but rather it offers a lookout on risk assessment, open to consideration and discussion, as it cannot pretend to give an absolute point of view nor to be complete in the issues addressed (and the related literature referenced to).

1. Introduction

Safety is freedom, freedom from unaffordable harm, and, thus, a human right. Risk assessment has been the dominant paradigm for ensuring this right in the design and operation of industrial systems. Examples of areas of applications include the chemical process industry, the nuclear industry, the transportation sectors, the aerospace industry etc.

Risk assessment is a mature discipline. The structured performance of a risk assessment guides analysts to identify possible hazards/threats, analyze their causes and consequences, and describe risk, typically quantitatively and with a proper representation of uncertainties. In the assessment, the analysts make assumptions and simplifications, collect and analyze data, and develop and use models to represent the phenomena studied. For example, the failure modes of components due to a given earthquake, the heat fluxes on a structure due to a fire, the response of operators to an accident are all the results of conceptual models that attempt to mimic how a real accident would proceed, based on the knowledge available. The risk assessment of a system requires the consideration of a possibly very large number of scenarios with multiple failures of its components and, by so doing, provides an in-depth understanding and knowledge of the system failure modes with consequent increase of the awareness on risk and the attention to safety, which typically leads to an overall improvement of the safety of the system.

The World we live in is rapidly changing in many ways. Digitalization is bringing new opportunities of connectivity, monitoring and awareness, and is changing the way we communicate and socially behave. Mobility and social pressure are changing the landscape in which we live and operate. Continuous advancements in technical knowledge and technology are improving our production processes, products and services, as well as our environments, while changing the business and work/job scenarios. As the digital, physical and human worlds continue to integrate, we experience a deep transformation in industry, which far-reaches into our lives. The 4th industrial revolution, the internet of things and big data, the industrial internet, are changing the way we design, manufacture, supply products and services, the way we move and live in our environment. This is creating a complex network of things and people that are seamlessly connected and communicating. It is providing opportunities to make production systems and services more efficient and faster, and more flexible and resilient the complex supply chains and distribution networks that tie the global economy.

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Conceptual Framework for Developing Resilience Metrics for the Electricity, Oil, and Gas Sectors in the United States

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Abstract

This report has been written for the Department of Energy's Office of Electricity Delivery and Energy Reliability to support the Office of Energy Policy and Systems Analysis in their writing of the Quadrennial Energy Review in the area of energy resilience. The topics of measuring and increasing energy resilience are addressed, including definitions, means of measuring, and analytic methodologies that can be used to make decisions for policy, infrastructure planning, and operations. A risk-based framework is presented which provides a standard definition of a resilience metric. Additionally, a process is identified which explains how the metrics can be applied. Research and development is articulated that will further accelerate the resilience of energy infrastructures.