Modern critical infrastructures are becoming increasingly smarter (e.g. the smart cities). Making the infrastructures smarter usually means making them smarter in the normal operation and use: more adaptive, more intelligent etc. But will these smart critical infrastructures (SCIs) behave smartly and be smartly resilient also when exposed to extreme threats, such as extreme weather disasters or terrorist attacks? If making existing infrastructure smarter is achieved by making it more complex, would it also make it more vulnerable? Would this affect resilience of an SCI as its ability to anticipate, prepare for, adapt and withstand, respond to, and recover? What are the resilience indicators (RIs) which one has to look at?
These are the main questions tackled by SmartResilience project. The project answered the above questions in several steps by:

- identifying existing indicators suitable for assessing resilience of SCIs
- identifying new smart resilience indicators including those from Big Data
- developing a new advanced resilience assessment methodology based on smart RIs and the "resilience in cube (the innovative project tool providing the possibility to define one compound resilience indicator), including the resilience matrix
- developing the interactive SCI Dashboard tool
- applying the methodology/tools in 8 case studies, integrated under one virtual, smart-city-like, European case study. The SCIs considered (in 8 European countries!) deal with energy, transportation, health, and water.

This approach allowed benchmarking the best-practice solutions and identifying the early warnings, improving resilience of SCIs against new threats and cascading and ripple effects. The benefits/savings to be achieved by the project have been assessed by the reinsurance company participant. The consortium involves seven leading end-users/industries in the area, seven leading research organizations, supported by academia and lead by a dedicated European organization. External world leading resilience experts were included in the Advisory Board.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far

SmartResilience has yielded 5 major break-through results:

1. Method:
   An innovative state-of-the art concept enabling quantitative assessment of resilience. The concept aims combines the advantages of approaches oriented towards the easy-to-understand communication of the assessments results (such as “resilience very high” or “resilience level red”) with the advantages of the in-depth assessment approaches, providing many, but often difficult to understand results (e.g. detailed textual reports from complex resilience exercises). This main elements of the indicator-based concept are the “resilience cube” at the top, and the assessment methodology allowing to (a) assess resilience in a given moment in time and monitor it over the time, (b) analyze it during a particular adverse effect scenario, (c) benchmark it, (d) stress-test it, (e) analyze it in a system of multiple infrastructures and, last but not least, (f) optimize it a transparent and intuitive way. The concept is public, presented in publications and presentation and is being summarized in a book under preparation with the publisher (Springer).

2. Tool:
The concept is applied within a web-based system, the main elements of which are the resilience indicator database (over 4,000 indicators available, over 3,000 indicators and almost 1,000 issues), the web-suite of tools (over 20 different, combining those pertinent and developed within SmartResilience project with the “external” ones) and repository of the application cases, the later in itself supporting future analyses.

3. Applications:
The concept has been practically applied in 19 case studies in which over 300 different resilience assessments were made, about 30% of those made for the stakeholders outside the project (e.g. in
other DRS EU projects or the institutions supporting the partners in the projects – e.g. ministries). The concept has been discussed and agreed with over 50 different organizational stakeholders, setup at 7 external-to-the-project “MySmartResilience” sub-sites.

4. Standard:
The project results, at the end of the project, are being embedded into the new ISO 31050 standard currently under development.

5. Beyond-the-project use:
The “life-after-the-project” of the project results will be practically ensured by the dedicated “resilience rating agency”, the creation of which is initiated at the end of the project (ensuring free-of-charge use after the project), and the educational platform running under the umbrella of the site of one of the academic partners in project.

The main results of the projects are already used in the follow-up EU projects and other initiatives.

CHALLENGES:
Once work on the project started, the greatest difficulties/challenges were (a) lack of standardized, indicator-based resilience assessment methodology for “non-smart” critical infrastructure – the project had to propose an approach equally applicable to smart and non-smart critical infrastructure, (b) lack of “mandate” to prescribe the indicators – i.e. the project has been in the position to propose, but its proposals were not binding in any way to any of the, e.g. infrastructure owners, and (c) lack of understanding of possible use of indicators – the indicators-based SmartResilience approach is primarily intended for use in scenario analysis (pre & post), what-if analysis and monitoring of resilience management. Hence, the infrastructure owners, insurers and national resilience agencies could naturally profit more than, e.g. first responders in the “heat of the absorb/respond phases” of the resilience cycle.

SMARTRESILIENCE TOOL:
The ResilienceTool can be used free-of-charge, registration is managed by ERRA, apply at http://erra.eu-vri.eu/registration.aspx.

Progress beyond the state of the art and expected potential impact (including the socio-economic impact and the wider societal implications of the project so far)

SmartResilience will significantly improve the resilience of critical infrastructures, such as energy & water supply, transportation and information and communication grids etc., by providing a uniform and comprehensive methodology of risk and resilience assessment. SmartResilience provides the basis for proactive innovations. The project will therefore raise the future viability of critical infrastructure. As SmartResilience follows a holistic approach to resilience, not only technical issues have been addressed. The project’s approach also covers human factors, societal and economic aspects. SmartResilience therefore provides solutions that are suitable to enhance the societal resilience in European countries and the organizational resilience among European infrastructure providers.

1. Better risk assessment of different areas of critical infrastructures (energy grid, water supply, transport, communication, etc.) by taking into account interdependencies
2. More effective and comprehensive methodology using uniform and consistent data from known
Critical Infrastructure Protection threats in an integrated manner to develop a resilience level based on summations of various “indicators” (technical and non-technical, i.e. human factors)

3. Meeting the needs and requirements of public bodies.
4. Improving the tools for resilience assessors (development up to Technology Readiness Level 4)

The overall SmartResilience methodology and the tool (“Smart Critical Infrastructure Dashboard”) has been tested and improved in 19 realistic use cases.
<table>
<thead>
<tr>
<th>c. ORGANIZATION / BUSINESS</th>
<th>Periodic organizational review of the relevant risks, reports about previous events</th>
<th>Budget and plans for preparedness</th>
<th>Availability of action plan and competent personnel for immediate reaction to event</th>
<th>Availability of enough emergency response budget and resources</th>
<th>Debriefing of the event and the response operations to personnel directly involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>d. SOCIETAL / POLITICAL</td>
<td>Exchange of knowledge about risks (including risk perceptions in the society)</td>
<td>Seeking information from authorities on threat assessments and preparing</td>
<td>External alert and communication, Coordination between actors</td>
<td>Contact/liaison with authorities/media and regular communication</td>
<td>Communication with local governments and stakeholders to transform the previous practices</td>
</tr>
<tr>
<td>e. COGNITIVE / DECISION</td>
<td>Decision criteria of individuals (Risk perception)</td>
<td>Ability (biases previous knowledge used)</td>
<td>Situational awareness ability of the individuals</td>
<td>Transparency in response and recovery decision</td>
<td>Improvement in decision making</td>
</tr>
</tbody>
</table>

**CORE DCL**

- Phase 1
  - Issue C1.1
    - Indicator R1.1.1
    - Indicator R1.1.2
    - Indicator R1.1.3
  - Issue C1.2
    - Indicator R1.2.1
    - Indicator R1.2.2
  - Issue C1.3
    - Indicator R1.3.1
    - Indicator R1.3.2

**User DCL (Use Case Specific)**

- Phase 1
  - Issue C1.1
    - Indicator R1.1.1
    - Indicator R1.1.2
  - Issue C1.2
    - Indicator R1.2.1
    - Indicator R1.2.2
    - Indicator R1.2.3
  - Issue C1.3
    - Indicator R1.3.1
    - Indicator R1.3.2

**Recommended DCL xyz**

- Phase 1
  - Issue R1.1
    - Indicator R1.1.1
    - Indicator R1.1.2
    - Indicator R1.1.3
  - Issue R1.2
    - Indicator R1.2.1
    - Indicator R1.2.2
  - Issue R1.3
    - Indicator R1.3.1
    - Indicator R1.3.2

**Legend**

- DCL xyz - Dynamic Checklist
- Issue xxx - Issue
- Indicator yyy - Indicator
- Optional
- Mandatory

**Functionality of the infra better than before (e.g. a**
possible-outcomes-of-case-of-an-infrastructure-exposed-to-an-adverse-event-between-improvement-and-complete-failure.png

integration-concept-for-risk-and-resilience-management-proposed-and-pursued-in-the-new-iso-
**Methodology**

1. Resilience as "one number" and the ResilienceCube

2. Assessing resilience of an infrastructures over time – the Resilience Level (RL)

3. Assessing resilience of an infrastructure during an adverse event – the Functionality Level (FL)

4. Assessing resilience of "multiple infrastructures": Multi-level resilience assessment

5. Modeling interaction and dependencies, visualizing resilience

6. Comparing resilience of different infrastructures: Benchmarking

7. Checking resilience: Stress-testing

8. Optimizing resilience: Multi-Criteria Decision Making (MCDM)

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**Analyses/Assessments**

**Case Study XYZ**

**Scenario ABC**

- Resilience Level (RL) Assessment and Monitoring
  - Dynamic Checklist RL1
    - Assessment X ➔ Assessment Report X
    - Assessment Y ➔ Assessment Report Y
  - Time Analysis

- Functional Level (FL) Assessment and Monitoring
  - DCL – FL1
    - Assessment F ➔ Functional Assessment

- Resilience Improvement Investment
  - Alternatives ➔ Alternative Scoring

- Resilience Interdependency
  - Visualization 1 ➔ Visualized Interdependencies X
  - Visualization 2 ➔ Visualized Interdependencies Y

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**Resilience Joint Evaluation and Test Report (JET report)**

for the case study "SmartResilience Project: HOTEL: Energy supply system"
**Last update:** 29 February 2020  
**Record number:** 264063