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Towards Common Information Systems Maturity Validation
Resilience Readiness Levels (ResRL)

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Abstract: The intent of this study is on a proposal of resilience readiness level (ResRL) metrics towards their aspects, factors, definition, criteria, references and further questionnaires for the contribution of combined-total maturity measures and pre-operational validation of shared and adaptive information services and systems. The study attempts to answer the following research question: how can ResRL metrics be understood in the domain of shared information systems and services. It aims to improve ways of the acceptance, operational validation, pre-order validation, risk assessment and development of adaptive mechanisms as well as the integration of information systems and services by actors and authorities across national borders.

1 INTRODUCTION

In the operative environment of this study, knowledge management is understood as a discipline concerned with the analysis and technical support of practices used in an authority-related organization and decision-making to identify, create, represent, distribute and enable the adoption and leveraging of real-world practices, which were used in collaborative authority settings and, in particular, public authority organizational processes.

This study of resilience is based on the ongoing and cumulative data collection of three (n=3) preliminary research and development (R&D) projects: 1) European Union’s Common Information Sharing Environment (EU_CISE_2020), including R&D-related research on work packages (n=8) of the EU_CISE research consortium and research agenda targets related to the public authority in Finland; 2) Maritime Integrated Surveillance Awareness (MARISA) including eight work packages (n=8) as current H2020 project and EU_CISE continuum; and 3) From Failand to Winland, the Academy of Finland Strategic Research Council project as ongoing National Critical Research Project (#WINLandFI) covering five (n=5) work packages. The perspective of study is in contribution of information systems combined-total maturity validation and new resilience metrics.

The study addresses to information sharing environments that foster cross-sectorial and cross-border collaboration among public authorities, the dissemination of the EU_CISE initiative and steps along the Maritime EU_CISE roadmap. EU_CISE work entails the widest possible experimental environments encompassing innovative and collaborative services and processes between European institutions and takes as reference, a broad spectrum of factors in the field of European integrated services arising from the European legal framework as well as collaborative studies and related pilot projects: [EU_CISE_2020; Project ID 608385; Funded under FP7-SECURITY].

The overarching goal of MARISA project is to provide the security communities operating at sea with a data fusion toolkit, which provides a suite of methods, techniques and software modules to correlate and fuse various heterogeneous and homogeneous data and information from different sources, including Internet and social networks, with the aim to improve information exchange, situational awareness, decision-making, reaction capabilities and resilience. The expected new solutions will provide mechanisms to get insights from big data sources, perform analysis of a variety of data based on geographical and spatial representation, use techniques to search for typical and new patterns that identify possible connections between events,

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discover predictive analysis models to represent the effect of relationships of observed objects and phenomena: [MARISA: Project ID 740698; Funded under H2020].

The #WINLandFI research project will take you from Failand (failed future Finland) to Winland, in such as Finland where key security threats have been responded to with resilient policy-making. What kinds of security risks and threats could paralyse Finland so fundamentally that our country becomes Failand? The project data includes arguments that Failand becomes reality if two of the most fundamental elements of a functioning society fail food security and energy security, which both are closely linked to water security. In addition, this research data comprises reasoning for a setting of resilience that such failure is likely to result from the sum of four key components: long-term pressures, shocks and surprises, decision-making, and policy responses: [#WINLandFI; Funding ID 303623; Funded under the Strategic Research Council (SRC) at the Academy of Finland].

This "study of resilience" is challenged by adaptive nature of networked systems, they become increasingly difficult to understand, predict and control. However, no single agreed upon definition of the term "resilience" exists; there are numerous theories and literature to explain resilience and its sources, paths and impacts. In this study, the rationality and motivation to the proposal description of the resilience metrics is in usefulness of these themes and categories in data collections, data fusions, knowledge fusions, analysis and especially triangulation fashion in real R&D cases, research consortiums, and externally funded R&D, for implementation and design of thematic studies, domain configuration and its integration strategy.

In this specific operative environments, the term "resilience in information systems or services" is understood as a complex process involving multiple overlapping and iterative tasks that address to design theory and system theory as well as a multi-methodological approach that involves thinking, building, improving and evaluating a successful information system and its communication, which fits the needs of the applied domain, information sharing and resilience readiness viewpoints.

An expected contribution of information sharing related resilience is related to the alignment of ontology of information technology, data additivity capabilities, parallel communication protocols, nexus management and adaptive dynamic factors of high-value impacting technological artifacts, digital infrastructures and critical systems, e.g., ontology and semantic fusion capabilities taking advantage of Web Ontology Language (OWL) and Resource Description Framework (RDF) languages.

Although standardization is indeed an essential element in sharing information, information systems resilience and effectiveness requires going beyond the syntactic nature of information technology and delving into the human functions at the semantic, pragmatic, critical realist and social levels of institutional-organizational functions.

The research domain prioritizes improvements in resilience settings of a complex service or system. The term "external validity", in resilience viewpoints, refers to establishing the expanded cross-domain in which the study's findings and conclusions can be generalized. This study adopts the method of increasing understanding through information systems research and maturity-integration facilities, such as utility and communication, resilience readiness and networked realization capability.

The expected contribution of study addresses to the operational and pre-operational validation (POV) and utility of ISO standardization and interconnection followed: 1) improvement in metrics for information system and service integration; 2) advances in global procurement management and pre-order validation; 3) pre-operational validation in information system investigations; 4) progress in operational validation in information system implementation; 5) findings of methodological implications for the implementation of ResRL metrics and improved resilience; 6) usefulness of information system sharing and interconnection; 7) expansion of large and networked information-intensive services that can extend shared solutions and routes of shared information utilization and common global information and information system sharing; and 8) educational advances in R&D-related functions in higher education institutions, which in this case, can be shared across national borders.

The macro-level target of this research is to further the examination of how existing TRL, IRL and new ResRL metrics and their definition, criteria, references, questionnaires and guidelines can be useful and employed to realize and validate integration, communication and dynamic functionalities in information systems and information sharing.

At the micro level, this study was performed on shared information systems in the case of shared maritime systems and focuses on readiness targets as realizations and validation. Realization such as the usefulness, sharing and dissemination of an information system as a common digital service, product or solution involving shared information across appropriate borders of applied domains. Validation, that is, pre-operational validation, pre-order validation for procurements, internal validity and external validity, which can, for example, be useful in the national and global deployment-dissemination processes, operational validation of information systems, improving integration success, outsourcing, achieving common ontological understanding and improving methods.

The overall motivation of this research continuum is to address increasing trustworthiness such that related studies make sense and are credible for such as HORIZON audiences. The study design is based on a combination of a thorough understanding of the theoretical framework, studies in the related literature and experimental knowledge of the collaborative integration used to explain the research question as well as learning processes and their meaning. Validity in this analysis refers to the establishment of casual relationships such as nexus-mutual-impacts. Causal relationships appears in such as interactions and relationships among shared readiness measures and information systems realizations from the perspective of readiness levels, information sharing across borders of various domains and the use of shared information systems.

2 LITERATURE

The key knowledge aspects for development of ResRL metrics proposal included path-dependencies with the related literature, for example, system engineering (Eisner, 2011), systems readiness levels (Sauser, Verma, Ramirez-Marquez and Gove, 2006) and the development of an integration readiness level (IRL) metrics (Sauser, Gove, Forbes and Ramirez-Marquez, 2010).

Following these works, as continuum, the overall research question was that how can ResRL metrics be understood in the domain of shared information systems and services. First, here, how ResRL metrics can be understood and realized in the context of the Common Information Sharing in such as EU CISE, MARISA and #WINLandFI environments using generally understood and related metrics and models for the realization and reasoning of furthered common maturity development.

This study, thus far, showed that a technological readiness and integration readiness metric are two basic elements of the thinking, building, improving and testing of information systems, networked or distributed integration and ontology. This view is furthered by combined system readiness level (SRL) metrics, which have been described as a combination of TRLs function of technologies and IRLs of integrations, as introduced by (Sauser et al., 2006) and continued by (Luna, Lopes, Tao, Zapata and Pineda, 2013). Figure 1 describes an approach towards the combined-total maturity in Information Systems Maturity Validation in the context of this continuum of studies.

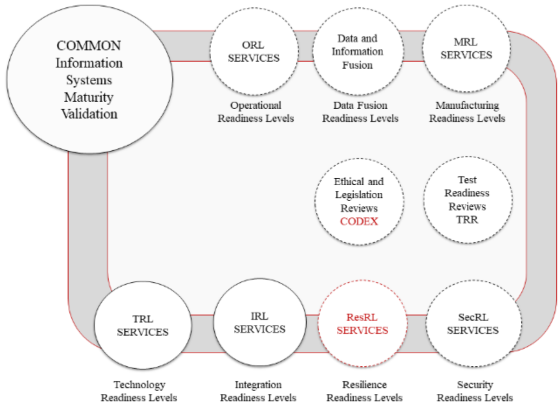

Figure 1: An Approach towards Common Information Systems Maturity Validation.

In Figure 1, described Common Information Systems Maturity Concept and SRL metrics are understood here as the collector of metrics represented by a single SRL metric defined on the basis of the amalgamation of other existing readiness levels, thus providing a method to chain and utilize different readiness level metrics.

An aspect of SRL's significance is that it gives credibility to the quantitative collection of readiness levels and opens possibilities to expand SRLs by incorporating other readiness-level and validity metrics, such as the manufacturing readiness level, software readiness level, SRLs, and information systems maturity as well as validity on an overall scale [see also (Tan et al., 2011)].

In the context of EU_CISE information sharing, MARISA data fusion and #WINLandFI resilience and learning, it is noteworthy, that the related literature on readiness metrics has similarities to a combination of decision-making items, such as a component of pre-operational or pre-order validation and procurement management viewpoints.

The first widely understood and well-known model regarding of our ResRLs proposal development was open system interconnection (OSI) (Zimmermann, 1980), described in Figure 2. For related IRLs development, Sauser et al. (2006) described this development path as follows: 'it was necessary to develop an index that could indicate how integration occurs' (p. 6). This index 'considered not only physical properties of integration, such as interfaces or standards, but also interaction, compatibility, reliability, quality, performance and consistent ontology when two pieces are being integrated'.

Open System Interconnection Model - OSI 7 Layer Model			
Layers and descriptions			*Research and realization targets*
7	**Application**	Includes application and processes to access the networked services, e.g., information systems sharing, information sharing, remote file access, and directory services. Solutions for common information and information systems sharing.	Study of information systems integration that comprises the networked and shared common business and operative solutions and shared data structures over networks, such as implemented and integrated industrial and operative systems; (experimental research targets).
6	**Presentation**	Syntax layer; formats the data to be presented to the application layer, e.g., data encryption, data conversion, character set translation, term information, and data compression applications.	Study of data format solutions in information systems integration, e.g., ASCII (American Standard Code for Information Interchange), JPEG (Joint Photographic Experts Group), and archive file formats; (proof of sharing).
5	**Session**	Allows session establishment between processes in different stations and nodes, e.g., session establishment, maintenance and termination, logging, and name recognition.	Study of information systems integration through sessions and initialization between networked processes, e.g., NFS (Network File System), Java RMI (Java Remote Method Invocation), and RPC (Remote Procedure Call).
4	**Transport**	Ensures that message is delivered error free, e.g., host-to-host flow control, message segmentation, session multiplexing, and message traffic control.	Study of protocol for integration, e.g., TCP (Transmission Control Protocol), which provides reliable data transfer services for interaction and communication.
3	**Network**	Deciding which physical path the data takes, e.g., packets, routing, subnet traffic control, and logical-physical address mapping.	Study of connection elements for integration, e.g., IP (Internet Protocol), IPX (Internetwork Packet Exchange), routing protocols, and routers; (proof of compatibility).
2	**Data Link**	Provide reliable data delivery over physical nodes, e.g., frames, frame traffic control, frame sequencing, frame error checking, and media access control.	Study of data delivery over networked nodes for integration, e.g., switch and bridge, PPP (Point-to-Point Protocol) and WAP (Wireless Application Protocol).
1	**Physical**	The unstructured raw bit stream over a physical medium, e.g., physical structure, cables and volts, data encoding, and transmission technique.	Study of electrical and physical specifications of data connection for integration, such as Ethernet and LAN (Local-area Network).

Figure 2: Interpretations of OSI 7 layer model (Zimmermann, 1980; revised form Pirinen et al., 2014).

Figure 2 describes the compacted structure of the OSI model as the first approach to our ResRLs proposal development. As well, Sauser et al. (2006) selected the OSI model, its layers and targets, Figure 2 as the starting point of overall maturity readiness levels development. The OSI model has been widely referenced in computer networking to structure data transmitted on a network and allows for the integration of various technologies on the same network, networking theme (Beasley, 2009) and system approach to computer networks (Peterson and Davie, 2012).

Much of the early works in this field involved defining the risks and costs associated with various TRLs. The related literature indicates that TRLs addresses the evaluation of the readiness and maturity of an individual technology. Hence, TRL metrics adopt a given technology from the basic principles as well as concept evaluation, validation, prototype demonstration, and finally, completion and successful operations.

These TRL characterizations are useful in technology development, they address, to an extent, how this technology is integrated and on needed changes adapted within complete information-intensive systems and applied services. In addition, we recognised that, currently, many complex systems fail in the integration phase and especially in case of "adaptive change needed on demand" and then, these readiness functionalities of resilience are proposed for further development and discussions.

The Horizon Work Programmes includes TRL guidelines, which are widely referenced and used in H2020 proposals and evaluation. Figure 3 describes the TRL metrics with methodologies used the R&D context of study.

<table>
<tr><th colspan="2">Technology Readiness Level (TRL) metrics</th></tr>
<tr><td>Layers</td><td>Descriptions, factors and methodology</td></tr>
<tr><td>TRL (9)</td><td>Actual system proven in operational environment | competitive manufacturing in the case of key enabling technologies, or in space | last mile research | action research | field study | dissemination strategy and realization of canvas |.</td></tr>
<tr><td>TRL (8)</td><td>System complete and qualified | networking and integration services | infrastructure providing a framework for dealing with data having characteristics as variety, volume, velocity and complexity | components and modules with the right capabilities to quickly and concurrently access and process data in the storage | external data sources and legacy systems functions | tools for the user | action research | organizational adaptions and changes |.</td></tr>
<tr><td>TRL (7)</td><td>System prototype demonstration in operational environment | systems functions and objects | multilingual information | entities, relations, temporal and spatial parameters | contextual information | system-to-system interfaces | communication measures | external systems demonstration | authorization issues | operational validation | identity and access mgmt. | design science research |.</td></tr>
<tr><td>TRL (6)</td><td>Technology demonstrated in relevant environment | industrially relevant environment in the case of key enabling technologies | adapters and gateways for the integration | user refinement technology | field study | feasibility study | design science research |.</td></tr>
<tr><td>TRL (5)</td><td>Technology validated in relevant environment | industrially relevant environment in the case of key enabling technologies | the basic technological components are integrated so they can be tested in a simulated environment | supporting elements in a simulated operational environment | artifact | design science research | development research | field study | feasibility study |.</td></tr>
<tr><td>TRL (4)</td><td>Technology validated in lab | following successful proof-of-concept work | components are integrated | test results and estimations of differences between validation and expected system goals | artifact | laboratory accounting | development research |.</td></tr>
<tr><td>TRL (3)</td><td>Experimental proof of concept | laboratory tests | measure parameters | test environment | active R&D initiated | experimental critical functions | components availability and stability | technology transition | development research | scenario analysis | strategy analytic and canvas |.</td></tr>
<tr><td>TRL (2)</td><td>Technology concept formulated | application articulated | basic principles | design of artifact | practical applications can be invented | publications or other references | limited to analytic studies | analysis to support the concept | case study analysis | design science research | development research | canvas |.</td></tr>
<tr><td>TRL (1)</td><td>Basic principles observed | applied research and development | studies of a technology's basic properties | scenario and proactive studies | case study analysis | studies of a technology's basic properties | scientific research begins to be translated into applied R&D | idea | proposal | scope |.</td></tr>
</table>

Figure 3: Description of TRL metrics and used R&D methodology in the study.

In addition, integration, nexus as mutual causalities and impacts of integration processes which are owing increasing speed of technological development, effects of new updates and needs of more resilient systems for relevant adaptive needs were implicated (Tan, Ramirez-Marquez and Sauser, 2011).

The IRL metrics were introduced by the Systems Development and Maturity Laboratory at the Stevens Institute of Technology and developed to assess the progress of information system integration and communication in the engineering field. The study aimed at realizing and validating IRL metrics in the extended context of the ISO DIS 16290 standard development framework by the International Standards Organization.

A reason underpinning the present IRLs research is that the TRLs do not accurately capture the risk involved in adopting a new technology and that technology can have an architectural difference related to integration readiness and system integration. In this environment, because the complexity of a system or information increases, and a practical situation often involves a service-oriented network and shared systems, it is reasonable to employ a reliable method and ontology for integration-resilience readiness. This also allows other readiness levels to be collectively combined for the development of complex information-intensive systems in information sharing and the integration of systems as a common shared system.

The IRL metrics are defined as a 'systematic measurement of the interfacing of compatible interactions for various technologies and the consistent comparison of the maturity between integration points' (Sauser et al., 2006) (p. 5). IRL metrics are used to describe of the integration maturity of a developing technology using another technology or mature information systems.

IRLs contribute to TRLs by checking where the technology is on an integration readiness scale and offering direction to improve integration with other technologies. In general, just as TRLs has been used to assess risks associated with developing technologies, IRLs was designed to assess the risk and development needs of information systems integration.

Sauser et al. (2006) described IRLs development path dependency that is based on the OSI model as follows: 'to build a generic integration index required first examining what each layer really meant in the context of networking and then extrapolating that to general integration terms' (p. 6). With this description, as shown on the left-hand side of Figure 4, IRLs were defined to describe the increasing maturity of the integration between any two technologies between 2006 and 2010 through the development of an integration readiness level (Sauser et al., 2010) and using a system maturity assessment approach (Tan et al., 2011). On the right-hand side of Figure 4, the IRL metrics are described in the context of the continuum of study.

The integration and data fusion standpoints can also be related to a modular implementation strategy as an approach that addresses challenges related to the mobilization, steering and organization of multiple stakeholders in wide-scale R&D collaboration. Here, the focus is on the challenges of realizing large-scale technological and information-intensive systems, which are understood not as standalone entities, but as those integrated with other information systems, communication technologies and technical and non-technical elements as well as in a data and information fusion functions.

It is also included with the fact that an integrated system can be a shared system in a network of shared information [cf. building nationwide information infrastructures (Aanestad and Jensen, 2011) and the case of building the Internet (Hanseth and Lyytinen, 2010)].

In Figure 4, the description of IRL metric includes nine levels (Sauser et al., 2006). The IRL and TRL metrics are developed to assess technology and integration by research interventions included in numerous of National Aeronautics and Space Administration and United States Department of Defence efforts.

As shown in Figure 4, IRL layer 1 represents an interface level: it is not possible to have integration without defining a medium. In turn, selecting a medium can affect the properties and performance of a system. Layer 2 represents interaction, the ability of two technologies to influence each other over a given medium; this can be understood as an integration proof of the concept, such as facilitating bandwidth, error correction and data flow control. Layer 3 represents compatibility. If two integrating technologies do not use the same interpretable data constructs or a common language, then they cannot exchange information and data fusion if difficult. Layer 4 represents a data integrity check. There is sufficient detail in the quality and assurance of the integration between technologies, which means that the data sent are those received and there exists a checking mechanism. In addition, the data could be changed if part of its route is on an unsecured medium [cf. realizations (Beasley, 2009) and understanding of layers (Sauser et al., 2010)].

Integration Readiness Levels (IRLs)		
Layers and definitions		***Descriptions in context of this study***
9	Integration is mission-proven through successful operations, e.g., harmonized operative and industrial realizations.	Integration of the information system and its sustainable maturity management is achieved; information system sharing and information sharing is realized.
8	Integration completed and mission qualified though tests and demonstrations, e.g., test bed, living lab, and final validation.	Integration for service-based sharing level; integration of the information system is realized, implemented, and described, and actor-specific services are activated.
7	The integration and technologies have been verified and validated with sufficient detail to be actionable.	Integration of communication and interaction; readiness for completing the information system integration is achieved and actor-specific services are validated.
6	The integration technologies can accept, translate, and structure information for its intended application.	Readiness of technological functionalities for completing an integration is realized.
5	There is sufficient control between technologies necessary to establish, manage, and terminate the integration.	Integration process management facilities are validated and implemented. Quality system for integration management is activated.
4	There is sufficient detail in the quality and assurance of the integration between technologies.	Readiness of technology for integration management functions is achieved.
3	There is compatibility between technologies to orderly and efficiently integrate and interact, such as a common language.	Compatibility in the infrastructure, architecture level, and ontology is achieved.
2	There is some level of specificity to characterize the interaction between technologies through their interface.	Infrastructure and architecture outlines are planned and agreed; integration "proof of concept" is activated.
1	An interface between technologies has been identified with sufficient detail to allow characterization of the relationship.	Usefulness, scope, and need for integration are understood, and medium is described.

Figure 4: Integration readiness levels (Sauser et al., 2010; Pirinen et al., 2014).

In Figure 4, IRL layer 5 represents integration control: establishing, maintaining and terminating integration, for example, possibilities to establish integration with other nodes for high availability or performance pressures. Layer 6 represents the interpretation and translation of data, specifying the information to be exchanged and the information itself as well as the ability to translate from a foreign data structure to a used one. Layer 7 represents the verified and validated integration of two technologies, such as the integration achieving performance, throughput and reliability requirements. Layers 8 and 9 describe operational support and proven integration with a system environment, corresponding to levels 8 and 9 of the TRLs (Sauser et al., 2010). In IRL, level 8, a system-level demonstration in the relevant environment can be performed (the system is laboratory-test proven). Level 9 denotes that the integrated technologies are being successfully used both in the system environment and operations [see Tan et al., (2011)].

In this study, the term "resilience" following with Latin world "resilier" was extended as the study of proactive-response ability and learning to rebound, recover or jump back in the addressed critical fields of national and cross-border decision process systems and models. Here, the term "resilience" can be address foremost to an ability of critical, institutional, organizational, hardware, software or operative service-systems to mitigate the severity and likelihood of failures or losses, to adapt to changing condition, and respond appropriately after the evidence of failure, fact-finding, proactive preparedness, consideration of response, and scenario-based alignment and progress of action competencies. Note literature: Resilience Engineering (Atooh-Okine, 2016) and viewpoints of robustness, persistence and resilience (Kott and Abdelzaher, 2014).

3 METHODOLOGY

First, we decide whether to continue with a case analysis (Pirinen, 2014) or cross-case analysis according to (Patton, 1990). The first two pilot studies (Pirinen et al., 2014) were conducted on integration projects in the context of industrial solutions and operative systems: Industrial System Projects (Sivlén and Pirinen, 2014) and Operative System Projects (Mantere and Pirinen, 2014).

We begin with a case analysis, which involved writing a case study for each integrated unit. These results are documented and comprise a research data continuum [according to the Art of Case Study Research (Stake, 1995) and the description of multiple cases in (Yin, 2009)]. A description of our overall continuum of R&D based environments and data collection of externally funded projects between 2007 and 2017 is briefly introduced in the Table 1.

As a research continuum, this study employs a complementary multiple-case analysis, which means grouping together answers to various common questions and analysing different perspectives on central issues as resilience themes in (n=3) projects EU_CISE, MARISA and #WINLandFI.

A summary list of research attributes was made to validate and describe the methodological rigor in the performed case study analysis (Dubé and Paré, 2003). While the level of achieved methodological rigor has been used in different cases with respect to specific attributes, the overall assessed rigor can be still extended and furthered [cf. (Davison et al., 2004)].

In this study, the multiple-case study approach was used; the method is well explained in many references, e.g., the case research strategy in studies of information systems; building theories from case study research (Eisenhardt, 1989); case studies and theory development in the social sciences; qualitative data analysis; the real world research (Robson, 2001); and "case study research design and methods" (Yin, 2009).

Table 1: A continuum of externally funded R&D.

R&D Project		Funding
1	RIESCA	SF-TEKES-SEC 2007-2013
2	MOBI	SF-TEKES-SEC 2007-2013
3	PERSEUS	EC-FP7-SECURITY-261748
4	AIRBEAM	EC-FP7-SECURITY-261769
5	ABC4EU	EC-FP7-SECURITY-312797
6	EU_CISE_2020	EC-FP7-SECURITY-608385
7	MARISA	EC-H2020-740698
8	#WINLandFI	SF-ACADEMY-SRC-303623

According mainly to Dubé and Paré (2003), the main research attributes of this study are as follows: 1) title of the study: Towards Common Information Systems Maturity Model: Resilience Readiness Levels (ResRL); 2) research questions: 'How can ResRL metrics be understood in the domains of EU CISE 2020 (information sharing), MARISA (data fusion) and #WINLandFI (resilience and learning)"; 3) unit of analysis (UoA): an experience of samples of resilience aspects of information systems integration and data fusion cases which are implemented, well documented and experienced; 4) importance of the study: contributes to research on information systems maturity, ResRL metrics and related development of the ISO/DIS 16290 standard series in EU CISE 2020, MARISA and #WINLandFI projects; 5) methodological focus:

discovery of a continuums of case study analysis, including triangulation (Campbell and Fiske, 1959) and final cross-analysis; 6) analysis form: mainly a qualitative analysis, saturation and triangulation (Patton, 1990); 7) research target: information service-system standardization and dissemination; 8) data collection extensions and methods: MARISA strategy canvas (n=38 participators and n=4 parallel sessions) graphical canvas representations produced (n=4) of high-value elements of authorities and stakeholders that connects determination of development targets, purchase choices and continuums for utilization of innovative data fusion functionalities, product and service; and 9) the Academy of Finland Strategic Research Security Programme namely From Failand to Winland (#WINLandFI) data collection of co-creative work including n=62 stakeholders and n=82 documents.

4 RESEARCH FINDINGS

In this operative environment, described in Figure 1, information systems maturity validation is understood as an approach that an individual institution with respect to a specific validation depends on, for example, the rules, guidance, regulation, legislation, standards, agreements, adoption model, best practices, ethical-legislation codex, and characteristics of the system, which aspects are then validated as an obligatory prerequisite for activation.

Before activation, the validation processes are used to determine whether the improved or developed service or product meets the requirements of the activity and whether the service or product satisfies its intended trust-based use, collectively agreed and with understood needs. The validation processes have similarities with methodological validation in a grounded approach and especially in a triangulation.

Study revealed that there are certain similarities between the activities performed in practical validation and the type of documented information produced for the validity of integrated information systems. Obtained understanding of these practices case analysis addressed to the canonical documents and standards accumulated in the practices of the actors in question and their operative experiences continued with CANVAS settings. As examples of such experienced documents included following: users and stakeholders needs; requirements and specifications; field regulations; validation plans; project plans; supplier audit reports; functional specifications; design specifications; task reports; risk assessments; infrastructure and architecture experiences; operational qualifications; standard operating procedures; performance qualification; security qualification; and validation descriptions, plans and reports.

Study discovered that the term "resilience", "functionalities of resilience" and "resilient learning" are depending on case, evolution path, institution, cultural and development paths, event mechanisms, integrations, and applied technology.

Here, the term "resilience" concentrated to a proactive view of response design and achievements of surviving capabilities for unexpected changes and manners to enhance the capability at all levels of concept of operation (CONOPS) and event mechanism to create adaptive decision-making paths that are robust yet flexible. See the outcomes as aspects of ResRL proposal description of event mechanisms in comprised to Figure 6.

Proposal of Resilience Readiness Level (ResRL) metrics

Layers	*ResRL*	*Aspects and factors*			
7	**Responsibility**	social and ethical; actors engagement; roles; attitude; action competence and capability; education in organization and higher education; responsibility of citizens, actors and authorities; mutual trust; action formats; path-dependency; cultural dependency; knowledge mgmt.; information sharing; transparency; confidence; sustainability; implication, proactive view and scenario quality.	- NETWORK - INTELLIGENCE - ADAPTION -	LEGISLATION - ETHICAL	MATURITY
6	**Mutual impacts**	nexus & interactions; cooperation validation; regulation; standards; collective resources; ontological alignment; cyber systems; external actors mgmt.; collective training and awareness; network updates; collective R&D&I activities; cognitive maps & tools; impact animation; proactive activities; global databases and services; capability sharing mgmt.; and expertise community.			
5	**Situational intelligence**	situational awareness & analytic system; cognitive computing; guidance services; resilient learning; machine learning; action competence & skills; recovery automation; belief-false-bias recognizance; pre-operational validation; priorities & decisions; adaption strategy; tensor analysis and applications; continuous belief functions; graphical models; simulation; and reasoning of target.			
4	**Operation resources**	concept of operations; human in loop; situation analytic & data fusion tools; reaction capabilities; response deign & logic; performance & adaption indicators; data mgmt.; network mgmt.; resource mgmt.; disaster recovery; replication mgmt.; priorities; asset mgmt.; control mgmt.; configuration and change mgmt.; vulnerability mgmt.; incident mgmt.; risk mgmt.; and value mgmt.			
3	**Mutability**	modular strategy; configurable mechanisms-entities-services; adaption models; dynamic systems; divergent communication routes and methods; encryption mgmt.; mean time between failures; manual disaster control functions; socio-technological interactions; task and sharing mgmt.; location and time mgmt.; situational information functions; modular compatibility; disruption identification; independent networks; and adaptive, dynamic and resilient systems engineering.			
2	**Modularity**	compatibility; parallel functions; clustering; high-availability; data & information refinement; manual-automation-redundancy functions; diagnostic structures; renewable components; component availability; replicative providers; reimbursable mgmt.; modularity design; device data & modular structure control; configuration settings and mutability control.			
1	**Events Mechanisms**	components; devices; drivers; kernel functions; technological compatibility; parallel options and devices; serialization and transactions; pool of interfaces; routing paths and network functionalities; manual modes; attributes; parameters; sensors; and logs.			

Figure 6: Proposal of ResRL metrics.

The operative focus of the term "resilience" was in monitoring and revising risk models and using of resources proactively in the face of disruptions or pressures of ongoing activities such as control, operations, production, learning, service, or trade-industry interactions.

The term "resilience" addressed also to an ability to recover from, or building new positions to, misfortune or adaption of mandatory change. Aspects of "resilience" included typically four aspects: 1) proactive plan and prepare, 2) absorb disturbance, 3) recover from, and 4) adapt to known or unknown threats.

Here, outcome for genealogies of the term "resilience": empirical and multidisciplinary R&D results contributed rather to practical-operational basis and associated necessitate revisions of its theoretical views such as modular strategy: the second level of ResRL proposal describes these factors for modularity in Figure 6.

According to feedback and lessons learnt so far: study exposed advantages and challenges towards standardization and maturity validation, mainly related to the ISO DIS 16290 and authority-based decision-making interconnections and mechanisms.

Development of ResRL metrics is promising area of maturity, as remark for future, more studies for scaling ResRL to nine level model as compatible with TRL and IRL metrics is needed, hence, it can make more balanced for comparisons to the overall scale of information systems maturity metrics.

It is noteworthy that the proposed ResRL metrics are challenging in global procurement management such as in national-international agreements and descriptions of work. Then, more fine grained descriptions and shared understanding for pre-operational validation of ResRL metric and resilience functionalities are needed, such as terminology development settings in way of a web ontology and resource description languages.

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