Towards Common Information Sharing
Study of Integration Readiness Levels

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Keywords: Common Information Sharing, Integration, Integration Readiness Level, Maturity, Operational Validation.

Abstract: This study focuses on integration readiness level (IRL) metrics and their definition, criteria, references and questionnaires for the operational and pre-operational validation of shared information services and systems. The study attempts to answer the following research question: how can IRL metrics be understood and realized in the domain of shared information services and systems? It aims to improve ways of the acceptance, operational validation, pre-order validation, risk assessment and development of sharing mechanisms as well as the integration of information systems and services by public authorities across national borders.

1 INTRODUCTION

This case study is based on the European Union's Common Information Sharing Environment (EU CISE 2020) research project, R&D-related research on work packages (n = 8) of the EU CISE 2020 research consortium and research agenda targets related to the public authority in Finland.

The study examines information sharing environments that foster cross-sectorial and cross-border collaboration among public authorities, the dissemination of the EU CISE 2020 initiative and steps along the Maritime CISE roadmap.

EU CISE 2020 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.

In this study, knowledge management is considered a discipline concerned with the analysis and technical support of practices used in an authority-related organization 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. In this sense, effective knowledge management is an increasingly imperative shared source of collaborative and rationale advantages and a key to success in public authority organizations bolstering the collective and shared expertise of its employees, actors and partners.

Information sharing is related to the ontology of information technology, data exchange capabilities, communication protocols, technological artifacts and digital infrastructures.

Although standardization is indeed an essential element in sharing information, information systems 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 organizational semiotics.

In this approach, the integration of information services or systems is understood as a complex process involving multiple overlapping and iterative tasks that address co-creativity 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 implementation of integration readiness viewpoints.

The EU CISE 2020 research domain prioritizes improvements in the integration process of a complex service or system. The term "external validity", in this study, refers to establishing the expanded domain in which the study's findings and conclusions can be generalized.

Pirinen, R..
Towards Common Information Sharing - Study of Integration Readiness Levels.
In *Proceedings of the 7th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2015) - Volume 3: KMIS*, pages 355-364
ISBN: 978-989-758-158-8

This study adopts the method of increasing understanding through information systems research and integration facilities, such as utility and communication, integration readiness and networked realization capability.

It makes the following contributions to the operational and pre-operational validation (POV) and utility of ISO standardization and interconnection: 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 IRLs in the context of EU CISE 2020 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 examine how existing IRL metrics and their definition, criteria, references and questionnaires are useful and can be employed to realize and validate integration and communication in information systems sharing.

At the micro level, this study was performed on shared information systems in the case of shared maritime systems and focuses on IRL's targets: 1) 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 and 2) 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 and dissemination processes, operational validation of information systems, improving integration success, achieving common ontological understanding and improving methods of information systems integration and sharing.

The overall target of this research is to address increasing trustworthiness such that related studies make sense and are credible for EU CISE 2020 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.

Internal validity in this analysis refers to the establishment of casual relationships. Causal relationships are interactions and relationships among shared IRL measures and information systems realizations from the perspective of integration readiness, information sharing across borders of various domains and the use of common shared information systems. For example, information is shared and education is collaborative and disseminated across national borders, an aim undertaken by maritime universities throughout the European Union.

In this study, learning by R&D related scope is described as an integrative way of learning in where an individual learns along with a workplace, school, and R&D community, such as EU CISE 2020 research consortium, as well as alongside an authorities organization and across borders and disciplinary silos, as in a collective learning space that can be regional or individual-global oriented.

The main doctrine of study is that the research dimensions include learning, and an authentic real-world research process and methodology are used for learning. Then, the objectives of learning by EU CISE 2020 can be associated through various formal and informal structures, such as R&D networks and actors, especially in developing students and learners to specialize in their areas of novel information sharing related expertise where applicable knowledge is produced and mobilized in the collective R&D-related learning processes

2 LITERATURE

The path-dependency of IRL development and key knowledge aspects are referenced from the related literature, for example, system engineering (Eisner, 2011), systems readiness levels (Sauser et al., 2006) and the development of an integration readiness level (IRL) (Sauser et al., 2010).

Following these works, this study focuses to how IRL metrics can be understood and realized in the context of the Common Information Sharing Environment (EU CISE 2020) using generally understood and related metrics and models for the realization and reasoning of IRLs development.

2.1 Open System Interconnection

The first widely understood and well-known model in IRLs development is open system interconnection (OSI) (Zimmermann, 1980).

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'.

Figure 1 describes the compressed structure of the OSI model as the first approach to IRLs development. Sauser et al., (2006) selected the OSI model, its layers and targets (Figure 1) as the starting point of IRLs 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).

2.2 Technology Readiness Level

Technology readiness level (TRL) metric includes nine levels (Sauser et al., 2006). The TRL metric was developed to assess technology and research interventions and has been included in numerous National Aeronautics and Space Administration and United States Department of Defence efforts.

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

While these characterizations are useful in technology development, in this study, they address, to an extent, how this technology is integrated within complete information-intensive systems and applied services. We understand that, currently, many complex systems fail in the integration phase or should be updated, for example, in integration owing to the speed of technological development and new updates. We draw on Tan, Ramirez-Marquez and Sauser (2011) for an understanding of TRLs'.

2.3 Integration Readiness Levels

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.

The IRL metrics have been 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). IRLs were used to describe and understand the integration maturity of a developing technology using another technology or mature information systems.

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

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

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.

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 could increase, 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 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.

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 2, 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 2, the IRL metrics are described in the context of this continuum of study.

As shown in Figure 2, 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. 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)). In Figure 2, 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 also Tan et al., (2011)).

2.4 Combined Readiness Levels

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 et al., (2013). SRL is 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 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 2020, it is noteworthy that the reviewed literature on readiness metrics has similarities to a combination of decision-making items, a component of pre-operational or pre-order validation and procurement thinking. The integration viewpoints 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 in the domain of national and global information sharing and integrated infrastructures. This also includes 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)).

2.5 Operational Validation

In this study, information systems validation is an approach that an individual institution with respect to a specific validation depends on, for example, the rules, guidance, literature, regulation, standards, agreements, best practices and characteristics of the system, which is then validated. 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 use and collectively understood needs. The validation processes have similarities with methodological validation in a grounded approach (Corbin and Strauss, 2008) and especially, triangulation (Campbell and Fiske, 1959).

In this study, 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. One way to obtain an understanding of these practices in the analysed cases is to examine the canonical documents and standards accumulated in the practices of the actors in question and their customer networks (Davison et al., 2004). Examples of such documents include the following: requirements specifications; field regulations; validation plans; project plans; supplier audit reports; functional specifications; design specifications; task reports; risk assessments; infrastructure qualifications; operational qualifications; standard operating procedures; performance qualification; security qualification; and validation descriptions, reports and plans.

3 METHODOLOGY

First, we decide whether to continue with a case analysis or cross-case analysis (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: Utilization of the Integration Readiness Level in the Context of Industrial System Projects (Sivlén and

Pirinen, 2014); and Utilization of the Integration Readiness Level in Operative Systems (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 reported and comprise a research data continuum (cf. The Art of Case Study Research (Stake, 1995) and the description of multiple cases in Yin (2009)).

As a research continuum, this study employs a complementary case analysis, which means grouping together answers to various common questions and analysing different perspectives on central issues (Eisenhardt, 1989). In particular, formal and open-ended interviews were used (Sauser et al., 2010). Then, for the final cross-analysis, this case study fits a cross case of each interview question with a guided approach. Answers from different interviews are grouped by topic as per relevant data from the guide, which will not be found in the exact same place in each note and open-ended segment of the interviews (Robson, 2002). The selection of interviews constitutes descriptive analytics, as mentioned in Patton (1990) (p. 376).

In this study, a summary list of research attributes was made to validate and describe the methodological rigor in the performed case study (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 extended and improved (cf. Davison et al., (2004)). The list of included attributes was mainly extended from Dubé and Paré (2003).

The main research attributes of this study are as follows: 1) title of the study: Towards Common Information Sharing: Studies of Integration Readiness Levels (IRLs) 2) research questions: ‘How can IRL metrics be understood and realized in the domain of EU CISE 2020?” 3) unit of analysis: an experience of information systems integration that is implemented, well documented and experienced 4) importance of the study: contributes to research on IRLs and related development of the ISO/DIS 16290 standard series in EU CISE 2020 5) methodological focus: continuum of case study analysis, including triangulation and final cross-analysis 6) analysis form: mainly a qualitative analysis, saturation and triangulation 7) research target: information service-system dissemination 8) data collection methods: questions (n = 10) and interviewees (n = 6) (the research data were recorded, coded, reduced, archived and translated from Finnish to English) and 9) Lime survey questionnaires by ISDEFE, used to assess integration activities on a system maturity scale to evaluate a system; (questionnaires and comparison of research findings were based on Sauser et al., (2010)).

4 RESEARCH FINDINGS

In this study, evaluation is understood as an approach that an individual or institution takes with respect to the specific verification of information-intensive services or systems that depend on rules, guidance, literature, regulation, standards, agreements, best practices, trust management, risks, confidence and system characteristics. In this study, operational validation processes were related to determining whether the improved or developed service or product meets the requirements of the shared operational activity and whether the service or product satisfies its intended use and were collectively understood.

The study addresses the validation and utility of ISO standardization mainly related to the ISO DIS 16290 and interconnections as follows: 1) improvements in the metrics for information systems integration such as IRL metrics 2) advances in global procurement management such as increased trust and confidence in agreements and descriptions 3) pre-operational validation in information systems investigations such as improved common ontology 4) progress in operational validation in information systems implementation 5) findings of methodological implications for the implementation of IRLs as a description of the analysed categories 6) usefulness to information systems sharing and interconnections in which integration is demanding 7) expansion of large, networked information-intensive services that can extend shared solutions and routes of big data utilization as well as common global information sharing and 8) educational advances and challenges in research-related learning in higher education functions, especially in the case of shared university functions across national borders in the European Union.

This study found that the current form of IRL metrics is useful for integration purposes and realizations on an overall scale. However, IRL metrics (Sauser et al., 2010) were not understood as a complete solution to integration maturity determination, but rather a specific operational validation path and tool for communication between all the critical project’s parties and mutual confidence and trust such as for pre-order validation.

Validation of Integration Readiness Levels (IRLs)					
Layers	***Guidelines for IRL validation***	***Categories***	***Scales***		
7	Integrated system has demonstrated operational effectiveness and suitability for intended and representative operational environment achieved and integration-related failure rates have been fully characterized, and realization is consistent with integration requirements and sustainable maturity management activated.	**Harmonization**	QUALITY ASSURANCE	SECURITY GOVERNANCE	MATURITY
6	Integrated systems are able to meet overall system requirements in an operational environment; system interfaces qualified and functioning correctly in an operational environment. Components are form-, fit-, and function-compatible with operational system and for the intended solution and operational environment.	**Activation**			
5	End-to-end functionality of systems integration has been successfully demonstrated. Fully integrated prototype demonstrated in real or simulated operational environment; each software interface tested individually under stressed conditions and interface, data, and functional verification completed.	**Validation**			
4	Individual modules tested to verify that the module component functions work together, software components, operating system, middleware, loaded applications, subassemblies, cross-technology issue measurement, and performance characteristic validations completed.	**Functional Interactions**			
3	High-level system interface diagrams have been completed; interface requirements are defined at the concept level; and inventory of external interfaces is completed.	**Compatibility**			
2	Input and output requirements for integration technologies are characterized; main interface requirements for integration technologies and interface requirements specifications for integration technologies have been defined. Proof of concept, such as infrastructure, architecture, and modular integration strategy are activated.	**Modular Integration Strategy**			
1	Integration technologies have been identified, and top-level functional architecture and interface points have been defined. Purpose and appropriate needs for useful integration are recognized, understood, and described.	**Usefulness**			

Figure 3: Validation of integration readiness levels (revised form Pirinen, 2014).

Evaluation Concept of Integration					
Layers	***IRL Categories***	***Description of Evaluation Concept***	***Scales***		
7	**Harmonization**	Harmonization: information technology and information systems and services are evaluated everyday (in live with real-world high-value impacts) by practitioners and researchers; (experimental research targets).	QUALITY ASSURANCE	SECURITY GOVERNANCE	MATURITY
6	**Activation**	Activation of artifact (information intensive service or system) integration: organizational impacts; proof of production; economical value returns; proof of commercialization; (proof of sharing).			
5	**Validation**	Analytical validation of artifact (information intensive service or system): e.g., technical performance; efficiency; socio-technical and organizational outcomes.			
4	**Functional Interactions**	Evaluation of artifacts (service or instantiation): e.g., efficiency, utility, performance, better, faster, cheaper, and factors to innovation.			
3	**Compatibility**	Evaluation of prototype compatibility based on the best option of a system or a prototype for testing of operability and usefulness which is co-designed; (proof of compatibility).			
2	**Modular Integration Strategy**	Evaluation of model's usefulness, methods and constructs; enable triangulation of evaluation methods and techniques.			
1	**Usefulness**	Evaluation of usefulness; significance of something e.g., information resource, research program or artifact (service) for someone.			

Figure 4: A proposal for evaluation of integration.

When IRL metrics were used at an acceptable level, they contributed to the project's goals in the designated time schedule and significant strength in the integration was achieved. The first reflected research finding was that some criteria of reference by Sauser et al., (2010) are more useful than others and the most important criterion could be either inserted at the beginning of the criteria list at each level or marked in some way such that users pay more attention to them. The second finding was that integration quality, security governance and maturity appear as scales rather than levels (see the described scales in Figures 3 and 4).

This first IRLs validation guideline for information systems integration is described in Figure 3 and the description of the evaluation concept in Figure 4. The evaluation of usefulness denotes the significance of; for example, information resources, research programs or artifacts as the service of information system (see usefulness level 1 in Figures 3 and 4). Evaluation in level 1, (Figure 4), focuses on the systematic determination of merit, worth and significance.

The study revealed, that in the shared system context, IRL metrics can provide a common language and a method that improves the organizational communication of scientists, engineers, management and any other integration stakeholders within documented systems engineering guidance and overall confidence. However, one difficulty is that the IRL criteria can be interpreted in multiple ways: it would be easier if expressions were more formal and more elaborate, for example, the types of activities needed. On the other hand, integrations included diversity and it was found that descriptions should include more case-sensitive data: there needs to be a place for criteria inserted by users. In other words, the questionnaires by Sauser et al., (2010) are appropriate but should be left open-ended for resiliency and trust-related aspects. Therefore, plan, purpose and usefulness are placed in the first layer as category usefulness in Figures 3 and 4.

Thus, IRL questionnaires should be complemented with an expanded checklist that would allow for the removal of subjectivity in many of the maturity metrics. It was also found that each IRL metric may have been differently interpreted by the participants and some decision criteria may belong to a different IRL scale, thereby altering its criticality. The study revealed that some of the presented criteria belonged to a test lab environment; this can be improved by adding descriptions of them to the questionnaire or creating a sheet for the test lab to avoid conflicts when moving integration to production. This indicates that the scale for the pre-operational validation concept depends on the case, development path and system architecture. Then, using a modular strategy and alignments of attributes for operational validation were considered because the speed and diversity of applied technological development is high even on a three-year scale. A modular integration strategy is described in level 2 (Figures 3 and 4).

In Figures 3 and 4, the compatibility category includes high-level system interface diagrams that have been completed in an integration project, where interface requirements and an inventory of external interfaces are defined at the concept level. The proof of the functional interactions phase comprises the testing of individual modules to verify that the module component functions work together and software components, the operating system, middleware, loaded applications, subassemblies, cross-technology issue measurement and performance characteristic validations are completed. Here, the evaluation of prototype compatibility can be based on the best option of a system or prototype to test operability and usefulness collectively designed. In Figure 3 and 4, the final systems validation for IRLs between layers five and seven and activation follow Sauser et al., (2010) and the OSI model. This includes an evaluation of artifacts, such as the service or information system; an evaluation of efficiency, utility, performance and better, faster, cheaper factors and functions of innovation; analytical validation of artifacts, such as the service or information system (e.g. technical performance, efficiency, simulation, formal verification, socio-technical outcomes and organizational impacts); and activation of artifacts such as service or information systems and integration (e.g. proof of production, value returns, proof of commercialization and real-world and high-value impacts).

Finally, the harmonization category denotes that operational effectiveness and suitability for the operational environment, integration-related failure rates and recovery from failure have been fully characterized; the realization is consistent with integration requirements; and sustainable maturity functions have been activated for continuity management. Information technology and systems or services are evaluated on a daily basis with real-world high-value impacts by practitioners and researchers on harmonization and realization.

The maturity scale (Figures 3 and 4) comprises the IRLs related to maturity, as described in Sauser et al., (2010), and information systems' continuous management maturity, which is based on appropriate requirements, The scale provides a model that improves the continuity of information systems and services. This viewpoint extends to the management of solutions where the failure rate increases with time. For example, this can be useful for system recovery in the case of disruptions and interruptions in production process-related systems.

In Figures 3 and 4, the quality assurance scale describes procedures, processes and systems used to guarantee and improve the quality of operations. In this study, the quality assurance scale was used to jointly define operation-enhancing and appropriate procedures, methods and tools, and then, monitor and develop operations in a systematic manner. In this study, quality refers to the suitability of procedures, processes and systems in relation to strategic objectives such as integration strategy. Quality assurance and related systems combine knowledge-based structures with the body of knowledge.

So far, prescriptive metrics such as IRLs have been introduced and used in engineering management to assess the integration progress and success of engineering and related scientific determinations.

IRL metrics, explored in this study, have still two major challenges: human subjectivity and confidence in data estimates. However, IRL metrics can be increasingly and commonly needed to measure project and system integration and demonstrate the magnitude of achieved performance and integration level while allowing for a successful evaluation of integration and systems harmonization.

5 DISCUSSION

The study has significant implications for further discussion of common information sharing. The results achieved, so far, do not necessarily address sub-levels and utility levels, such as user interface or security readiness, which are approached and described here as scales. The success of integration is highly dependent on users' and actors' experience and understanding, e.g., the amount of work needed for successful and sustainable integration, including all necessary sub-solutions.

There are many reasons for future integration progress and discussion: the number of systems, interconnections and interface elements increases over time; the system complexity increases and the resulting integration becomes challenging to maintain, e.g., number of updates and life cycles.

During the information systems evolution, while each of the systems for digitalization and integration may formally go through the development process, e.g., IRLs requirements, the overall integration analysis, development and corresponding requirements are clearly increasingly due to following elements which are ever more present: 1) operational and managerial independence of operations 2) commercial value of data 3) challenges of border and cultural aspects 4) emergent strategies and behavior 5) trust building and 6) evolutionary and development path-dependency.

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