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Utilization of the Integration Readiness Level in Operative Systems

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Abstract

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System integration is a daily routine for many environments related to information system technologies. Integrations are accomplished as a part of community development projects and in the military. Usually integration happens between two different systems and goal of the integration is to make the data transfer between systems fluent and without data loss.

This thesis addresses the case study research where the Integration Readiness Level (IRL) framework developed by National Aeronautics and Space Administration (NASA) was examined, and the goal was to research how it can be utilized and understood in the private sector. The research question was: how the Integration Readiness Level (IRL) can be understood and realized in operative systems. There has been previous research about how IRL can be used in space shuttle projects and Department of Defense (DoD) in United States. One goal of the study has been to provide information for the Protection of European borders and Seas through the Intelligent Use of Surveillance (PERSEUS) project about the IRL's utilization in different kind of Information System (IS) environments.

The case company is a limited company Nevtor Ltd, a company that delivers various kinds of technical consultancy, outsourced services and solutions, and training. The study was launched in April 2013 and it was executed by interviewing Nevtor's specialists, who has been involved with integration projects. Interviewees concentrated on evaluating if IRL framework can be used in business activities at Nevtor. Evaluation was based on IRL framework definition criteria's that were sent as a questionnaire in advance to candidates, to get deeper understanding of the upcoming evaluation. Unit of analysis was information systems integration projects (n=121) which were implemented, well documented and accomplished by experienced experts (n=5 in which n=3 valid). The research was accomplished as case study research and the data collection method was oral interviews. As a realization, the case study was suitable for validation and it answered the main question.

The results showed that the IRL framework is deemed useful, but this study proposed that it needs modification to be used in business activities at Nevtor. The current framework is for example missing time and cost definitions. The conclusions implied that the IRL framework could be a valuable tool for Business Continuity Management. The study generated a cross-analysis together with another study, where the new understanding and validation of IRL measures was proposed. The cross-analysis is included to this thesis as an extended abstract.

Keywords: integration readiness level, maturity, prescriptive metrics, business and information systems

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Tietojärjestelmäosaamisen koulutusohjelma

Tiivistelmä

Mantere Eeva

Integraatiovalmiuden hyödynnettävyys operatiivisissa järjestelmissä

Vuosi 2014 Sivumäärä 64

Erilaisten tietojärjestelmien integraatiot ovat arkipäiväisiä projekteja yritysten liiketoiminnassa. Integraatioprojekteja suoritetaan myös sotilaallisissa yksiköissä tai osana erinäisiä yhteisöllisiä kehitysprojekteja. Integraatio tapahtuu kahden erillisen järjestelmän välillä ja sen tarkoituksena on saada tieto siirtymään eheästi järjestelmästä toiseen.

Tämä opinnäytetyö käsittelee tutkimusta, jossa selvitettiin kuinka National Aeronautics and Space Administrationin (NASA) kehittämä integraatiovalmiutta mittaava viitekehys Integration Readiness Level (IRL) on ymmärrettävissä ja hyödynnettävissä yksityisellä sektorilla. Aikaisempi tutkimustieto pohjautuu vain NASA:n omaan toimintaympäristöön sekä puolustusvoimien sektoriin Yhdysvalloissa. Tutkimuksen yhtenä tavoitteena oli myös koota aineistoa Protection of European borders and Seas through the Intelligent Use of Surveillance (PERSEUS) projektille Integration Readiness Level (IRL) kehikon käytettävyydestä erilaisissa informaatioteknologian ympäristöissä.

Kohdeorganisaationa toimi Espoossa sijaitseva asiantuntija- ja ulkoistuspalveluita tuottava kotimainen palveluyritys Nevtor Oy. Tutkimus käynnistyi keväällä 2013 ja siinä haastateltiin Nevtorin asiantuntijoita, jotka ovat toteuttaneet järjestelmäintegraatioita. Asiantuntijat keskittyivät arvioimaan etukäteisaineiston, pdf-formaatissa olevan NASA:n kehittämän tarkastusmateriaalin eli IRL:n, validiteettia ja hyödynnettävyyttä Nevtorilla. Tutkimus toteutettiin laadullisena tapaustutkimuksena, jossa tiedonkeruumenetelmänä toimivat suulliset haastattelut.

Tutkimustuloksista käy ilmi, että viitekehystä pidetään hyödyllisenä mutta se vaatii muokkaamista voidakseen toimia osana Nevtorin integraatioprojekteja. Nykyinen viitekehys ei muun muassa ota kantaa aika- tai kustannussuunnitelmiin. Tutkimuksessa saatiin kerättyä kehitysehdotuksia toimivan viitekehyksen toteuttamiseksi ja niihin liittyvän toisen tutkimuksen tulosten seurauksena käynnistettiin jatkotutkimus. Jatkotutkimuksen tuotoksena syntyi ehdotelma uudesta integraatiovalmiutta mittaavasta mallista. Tutkimuksen tuloksista voidaan päätellä, että IRL:n käytöstä on hyötyä yrityksen toiminnan jatkuvuuden hallinnan suunnittelussa, kun se on muokattu ja nykyaikaistettu. Tämä tutkimusraportti sisältää myös tiivistelmän jatkotutkimuksesta, sekä tiivistelmän osaopintona suoritetusta kansainvälisestä katselmusprosessista. Katselmusprosessi on osa tapaustutkimus metodologiaa ja se keskittyy tutkimusraportin laadun parantamiseen.

Asiasanat: integraatiovalmius, viitekehys, kypsyys, liiketoiminta, tietojärjestelmät

List of Abbreviations & Symbols

AD	Active Directory
AES	Advanced Encryption Standard
BCI	Business Continuity Institute
BCM	Business Continuity Management
BCP	Business Continuity Planning
BRP	Business Resumption Planning
CM	Crisis Management
CTE	Critical Technology Elements
DCS	Data Center Services
DoD	Department of Defense
DR	Disaster Recovery
DRP	Disaster Recovery Planning
FIM	Forefront Identity Manager
GIF	Graphic Interchange Format
ID	Identifier
IEEE	Institute of Electrical and Electronics Engineers
IMM	Integration Maturity Metrics
IRL	Integration Readiness Level
IS	Information System
ISO	International Organization for Standardization
IT	Information Technology
LTD	Private Limited Company
MCS	Microsoft Consulting Services
MCSE	Microsoft Certified Solution Expert
NASA	National Aeronautics and Space Administration
NIST	National Institute of Standards and Technology
OSI	Open System Interconnection
PERSEUS	Protection of European borders and Seas through the Intelligent Use of Surveillance
RAM	Random Access Memory
R&D	Research & Development
SCCM	System Center Service Manager
SRL	System Readiness Level
SWOT	Strengths Weaknesses Opportunities & Threats
TCP	Transmission Control Protocol
TRL	Technology Readiness Level
V-TSP	Virtual Technology Solution Professional

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Preface

It has been an exciting journey for me to work on research project that evaluates something NASA (National Aeronautics and Space Administration) has created. The project made me find new kind of strength inside me and gave me personal growth and development.

Gratitude belongs also to PERSEUS project and Isdefe in Madrid, Spain, and Laurea University of Applied Sciences in Espoo, Finland for enabling participation for interesting research project.

D.Sc. (Tech) industrial engineering and management, Ph.D. (computer science and information systems) Rauno Pirinen, who guided me through this thesis in a role of supervisor. He also challenged me to write everything in English and took part in the research project.

My employer Nevtor also supported me during the research and study process. I was allowed to execute the study in my work community.

The greatest thanks go to my family. My daughter Lumi whose presence made me put an effort into my graduation. For the grandparents, especially my father, who looked after my daughter while I was in a lesson, or doing a presentation. Also for my dear friends Terhi and Ilmo who organized the well needed house holding and pampering during the roughest times while studying.

Espoo, May 2014

Eeva Mantere

1 Introduction

The purpose of this study is to provide research information and development of the Integration Readiness Level (IRL) model in order to get it validated to International Organization for Standardization, ISO/DIS 16290. There has been a previous research about how IRL can be used in space shuttles and Department of Defense (DoD) and how it would be suitable in use of the Protection of European borders and Seas through the Intelligent Use of Surveillance (PERSEUS) project.

DoD, also known as Pentagon, is the executive department of the government of the United States. It coordinates and supervises all agencies and functions of the government concerned directly with national security and the United States Armed Forces. PERSEUS's purpose is to build and demonstrate an EU maritime surveillance system by integrating existing installations and enhancing them with new technologies. These earlier studies have not provided information regarding its suitability from business perspective.

System integrations are a daily routine for many environments related to information system technologies. Even if the end users can see the updated and upgraded versions from the operation systems in their computers they probably won't ever think about how many tasks and steps that needed to be completed to make those systems work. Many people have suffered from application incompatibilities when the web browser has been updated to newer version and java won't work. Finding the right Random Access Memory (RAM) memory for personal computers is sometimes also hard because of the incompatibilities.

Individual users are not alone in situations where incompatibilities in systems can be found. Even newspapers have headlines about issues where a new ticketing system for train traffic crashed on the first day when it was released for customers to use. These kinds of failures can be disastrous not only for customers or the company, they can spread like a chain reaction in many direction. Therefore all kind of system integrations needs to be planned and executed well.

There are some alternative frameworks, e.g. the Microsoft Operational Framework (MOF) available, which are designed to guide the user through the system integration process, but they are designed to work on platforms specific to certain manufacturers of proprietary software. The goal of this study is to focus on whether the IRL, which is a cross-platform framework, on its nine levels can be valid for use in business activities in the private sector, especially at Nevtor private limited company (Ltd).

The research was accomplished as case study research and it contains qualitative elements. Case study is one of the most common used strategies in empirical research and it provides answers to inquiries like: “how” and “why”. The mostly commonly used data collection method is interview but for case study is typical to have different kind of information sources (Yin 2009, 18). The main objective of this research was to evaluate the IRL framework in the private sector, not to develop the framework itself. Data gathering was executed by interviewing three of five specialists, and the interviews were recorded, transcribed and analyzed.

Executing this study will give value not only for PERSEUS project and Nevtor’s business activities but also for all other participants involved with the study. Parallel to this study, another piece of research was conducted, that focused on evaluation of the Integration Readiness Level in the context of industrial system projects. Combining the results of these two studies with third research from Brian Sauser in a cross-case analysis generated proposal for the new IRL (Pirinen, Sivlén, & Mantere, in press).

In this study, academic books, studies and articles were used to gain deeper understanding when answering the main question. The key literature for answering the main question consists of the concept of systems readiness levels (Sauser, Forbes, Long and McGrory, 2009; Sauser, Verma, Ramirez-Marquez, & Gove, 2006), and the development of an integration readiness level (Sauser, Gove, Forbes, & Ramirez-Marquez, 2010; Sauser 2010). From the methodology point of view the key literature is based on the case study (Yin 2009; Dube & Pare 2003; Eisenhardt, 1989) and qualitative analysis (Denzin & Lincoln 2005; Miles & Huberman, 1994). The literature review follows themes: the Open System Interconnection model; Technology Readiness Levels and Integration Readiness Levels (Sauser, Verma, Ramirez-Marquez, & Gove, 2006; Sauser, Gove, Forbes, & Ramirez-Marquez, 2010). Specifically, the material is included in this case study as reference.

The next chapter describes the literature review of this study and the third chapter presents history and the basic principles of the readiness level frameworks. The fourth chapter presents the used research methodologies and the timeframe. The fifth chapter describes more carefully the contribution of the studies: cross-case study and the study of the review process. After chapter six which includes the conclusions and discussions, there are list of references, figures, tables and appendices. Glossary is presented in appendix.

The first study was fully written by the author and it was presented at a seminar together with student who presented her own study. The idea for the study was proposed by supervisor and the idea for a common presentation was implemented by author and another student.

The second study consisted of three writers where the research and writing were done mostly by supervisor. It was presented in seminar together by the author and the other student.

2 Readiness Level Framework

The following chapters present the readiness three readiness levels: 1) System Readiness Level (SRL), 2) Technical Readiness Level (TRL) and 3) Integration Readiness Level (IRL). First two readiness levels are described when the IRL is focused more thoroughly as it is the key factor in the study.

2.1 System Readiness Level

The System Readiness Level (SRL) metrics was formulated and introduced by the Systems Development & Maturity Laboratory (SysDML) at Stevens Institute of Technology. It is an aggregate measure that characterizes the progress that has been accomplished by a system under development based on the observable readiness characteristics of technology and integration elements (PERSEUS 2013, 9). It can identify potential areas that require further work to facilitate prioritization and it is meant to provide an assessment of overall system development.

The SRL concept can address the concerns relevant at the operational system level. It includes the TRL and IRL scales to dynamically calculate a SRL index. SRL index is an index of maturity applied at the system-level concept. It contains objective of correlating this indexing to appropriate systems engineering management principles. Index was designed to be a function of the individual TRLs in a system and their subsequent integration points with other technologies, IRL (Sauser et al. 2006, 2).

2.2 Technical Readiness Level

The Technology Readiness Level was originally conceived by Stan Sadin 1974, and its levels were formally defined in 1989. It was developed by assessing the maturity of advanced technologies so the associated risks could be effectively managed, controlled and mitigated, or retired (Sauser et al. 2009, 1). It was developed to rate the readiness of technology for possible use in space flight. The scale is widely accepted ISO/DIS 16290 and “Definition of the TRLs and their criteria of assessment” are still under development.

It evaluates critical technology elements (CTE) across the earliest stages of technology and scientific investigation (level 1) to the successful use in a system (level 9) (PERSEUS 2013, 10). CTEs can be either hardware or software and their TRL definitions are similar. Examples and documentation needs to support the assessment differ. TRL articulates the key maturation milestones for integration activities but it measures only individual technology, not the system readiness (Sauser et al. 2005, 3).

2.3 Integration Readiness Level

The TRL was never meant to evaluate the integration of a given technology with another system. It was meant to measure the maturity of evolving technologies during its development that it could be incorporated to a system (Sauser 2010, 20). The initial system integration maturity metrics (IMM), termed as Integration Readiness Level (IRL), was developed by using four-level scale that is derived from a standard network model, International Standards Organization's (ISO) Transmission Control Protocol (TCP). Original TRL and IRL were scaled to 7-layer metrics but they evaluated the end of development and they didn't address the operational aspects of the integration (Sauser et al. 2010, 23).

Sauser et al. (2010, 23) presented that International Standards Organization's Open Systems Interconnect (ISO/OSI) model is a standardized model for inter technology integration. It is a highly technical standard which is solely intended for network system application, and if the layer descriptions are abstracted to conceptual levels, the model can describe integration in very generic terms (Sauser et al, 2010, 23). OSI conceptual levels and the 7-layer format of the Integration Readiness Level framework are presented side by side in table 1.

Table 1: OSI Conceptual levels and original IRL framework (Sauser et al. 2010)

Level	OSI Conceptual level	IRL Framework
7	Verified and Validated	The integration of technologies has been verified and validated with sufficient detail to be actionable.
6	Accept, Translate and Structure Information	The integrating technologies can accept, translate, and structure information for its intended application.
5	Control	There is sufficient control between technologies necessary to establish, manage, and terminate the integration.
4	Quality and Assurance	There is sufficient detail in the quality and assurance of the integration between technologies.
3	Compatibility	There is compatibility (i.e. common language) between technologies to orderly and efficiently integrate and interact.
2	Interaction	There is some level of specificity to characterize the interaction (i.e. ability to influence) between technologies through their interface.
1	Interface	An interface (i.e. physical connection) between technologies has been identified with sufficient detail to allow characterization of the relationship.

Table 2 The existing IRL framework (Sauser et al. 2009,4)

IRL		Definition	Description
PRAGMATIC	9	Integration is Mission Proven through successful mission operations.	IRL 9 represents the integrated technologies being used in the system environment successfully. In order for a technology to move to TRL 9 it must first be integrated into the system, and then proven in the relevant environment, so attempting to move to IRL 9 also implies maturing the component technology to TRL 9.
	8	Actual integration completed and Mission Qualified through test and demonstration, in the system environment.	IRL 8 represents not only the integration meeting requirements, but also a system-level demonstration in the relevant environment. This will reveal any unknown bugs/defect that could not be discovered until the interaction of the two integrating technologies was observed in the system environment.
SYNTACTIC	7	The integration of technologies has been Verified and Validated and an acquisition/Insertion decision can be made.	IRL 7 represents a significant step beyond IRL 6; the integration has to work from a technical perspective, but also from a requirements perspective. IRL 7 represents the integration meeting requirements such as performance, throughput, and reliability.
	6	The integrating technologies can Accept, Translate, and Structure Information for its intended application.	IRL 6 is the highest technical level to be achieved, it includes the ability to not only control integration, but specify what information to exchange, unit labels to specify what the information is, and the ability to translate from a foreign data structure to a local one.
	5	There is sufficient Control between technologies necessary to establish, manage, and terminate the integration.	IRL 5 simply denotes the ability of one or more of the integrating technologies to control the integration itself; this includes establishing, maintaining, and terminating.
	4	There is sufficient detail in the Quality and Assurance of the integration between technologies.	Many technology integration failures never progress past IRL 3, due to the assumption that if two technologies can exchange information successfully, then they are fully integrated. IRL 4 goes beyond simple data exchange and requires that the data sent is the data received and there exists a mechanism for checking it.
	3	There is Compatibility (i.e. common language) between technologies to orderly and efficiently integrate and interact.	IRL 3 represents the minimum required level to provide successful integration. This means that the two technologies are able to not only influence each other, but also communicate interpretable data. IRL 3 represents the first tangible step in the maturity process.
SEMANTIC	2	There is some level of specificity to characterize the Interaction (i.e. ability to influence) between technologies through their interface.	Once a medium has been defined, a “signaling” method must be selected such that two integrating technologies are able to influence each other over that medium. Since IRL 2 represents the ability of two technologies to influence each other over a given medium, this represents integration proof-of-concept.
	1	An Interface between technologies has been identified with sufficient detail to allow characterization of the relationship.	This is the lowest level of integration readiness and describes the selection of a medium for integration.

The highest levels from IRL framework are built from the ISO/TCP. TCP model is used in computer networking to create similarity and reliability in the integration of versatile network systems (Sauser et al. 2010, 23). The framework starts from lowest level of integration and moves all the way through to verification and validation. Table 2 presents the existing Integration Readiness Level framework and this is the format that was used for evaluation in this research.

As with the original 7-level TRL scale, IRL only evaluated the end of development and did not address the operational aspects of the integration (Sauser et al. 2010, 24). Sauser et al. (2009, 3) states that the IRL –scale were meant to: 1) Determine the integration maturity between two or more configuration items, components, and/or subsystems 2) Provide a means to reduce the uncertainty involved in maturing and integrating a technology into a system, 3) Provide the ability to consider the meeting of system requirements in the integration assessment so as to reduce the integration of obsolete technology over less mature technology, and 4) Provide a common platform for both new system development and technology insertion maturity assessment. Therefore, it was developed to consist of 9 levels where levels 8–9 are about the assertion of the application of an integration effort (Sauser et al. 2010, 28).

Sauser et al. (2010, 24) explains that IRL consists of 9 levels that can be understood as having three stages of integration definition: semantic (levels 1-3), syntactic (4-7) and pragmatic (8-9). Each level has decision criteria which are used to determine integration readiness. When an IRL test is to be executed, it is usually done by web survey to get complete results to evaluate possibilities to accomplish integration successfully.

The levels from 1 to 3 are considered fundamental when describing the three principles of integration: interface, interaction and compatibility. These three principles define the subsistence of an integration effort. The first level is the lowest level to determine the integration readiness and it determines that the interface between technologies has been identified to specify the relationships. The second level characterizes the ability to influence between technologies and represents the integration proof-of-concept. Level three is the first concrete step in maturity process and it represents the minimum requirements to provide successful integration. In other words two technologies are able to influence each other and communicate translatable data (Sauser et al. 2010, 26).

Levels from 4 to 7 verify integration’s efforts compliance with specifications and they are defined as conformance to rules. Level four checks and confirms that the received data is exactly the same data that was sent. The data can’t be sent if integration has encountered failure in level three. Level five designates ability at least for one integratable technology to control the integration itself. Control, in this context means establishing, maintaining, and terminating. Level six is the highest technical level to be achieved and it includes the ability to control integration and to specify information to be exchanged. It also specifies the unit labels the information translates from a foreign data structure to a local one. Level seven specifies that the integration meets the requirements such as performance, throughput, and reliability (Sauser et al. 2010, 25).

Levels from 8 to 9 are related to practical considerations and they describe assertion of the application of an integration effort (Sauser et al. 2009, 8). The purpose of level eight is to reveal any unknown errors that could not be discovered until the interaction of the two integrating technologies was observed in the system environment. Level nine determines how mature the component technology is and it defines that the integrated technologies are being used in the system environment successfully (Sauser et al. 2010, 25).

3 Phases of case studies

This empiric research was executed as a case study that contains qualitative elements, because its process was suitable for answering the main question and for supporting the other methods that were chosen to accomplish the research. The case study's data collection may be varied and include a combination of interviews, observation, and documentary analysis as well as questionnaires. The most frequently used data collection method is the interview but for case studies it is typical to have different kinds of information sources (Yin 2009, 18.)

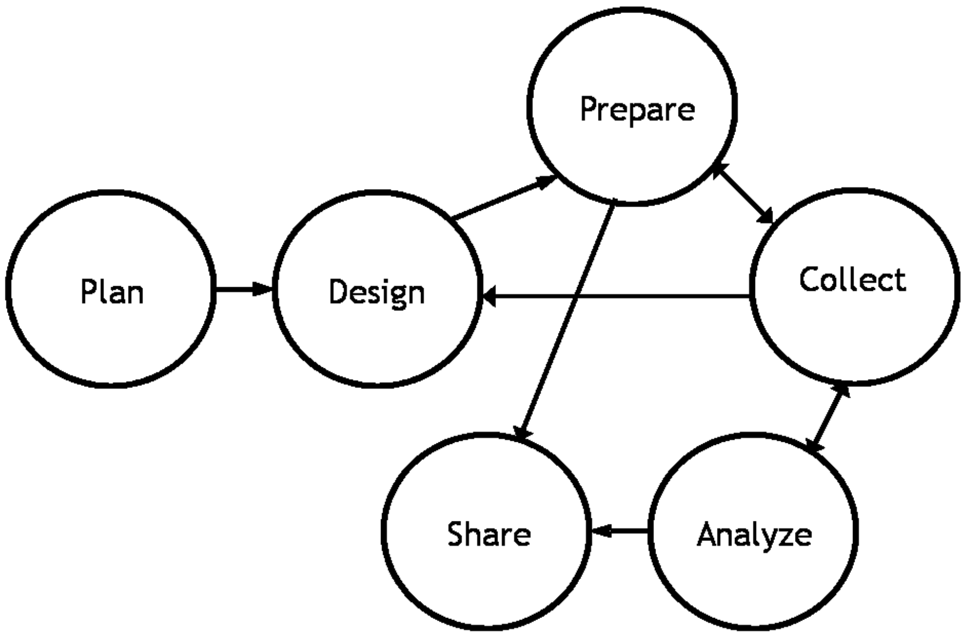

Figure 1: The case study process adapted (Yin 2009,1)

Figure 1 presents the case study process in a visual way. Following chapters determines the phases one by one.

3.1 Plan

According to Yin (2009, 3), the first phase of case study is Plan. It consists of 3 key elements. First you need to identify research questions or other rationale for doing a case study. Second, you need to decide to use the case study method compared to other methods and third you need to understand its strengths and limitations. This study was launched in the case study related seminar, in April 2103 at Laurea University of Applied Sciences. Therefore choosing and understanding the research method came naturally for this study.

In this study the planning consisted of identifying the research purpose as outputting effort and value for PERSEUS project, Laurea, researcher, Nevtor and all persons and partners who would be involved with the study. It meant also defining the research question: how the Integration Readiness Levels (IRLs) can be understood and realized in integration projects of information systems.

3.2 Design

Next step after planning is to design the case study. Designing consists of following steps: 1) Defining the unit of analysis and the likely cases to be studied 2) Developing theory, propositions and issues underlying the anticipated study 3) Identifying the case study design and 4) Defining procedures to maintain case study quality (Yin 2009, 24).

In this study the study question was already presented in the seminar, but the deeper clarification of the study's nature and the unit of analysis was started in May 2013. In this study, the unit of analysis is information systems integration projects (n=121) which are implemented, well documented and accomplished by experienced experts (n=5 in which n=3 valid). Because in this point it was already obvious that the study's contribution would be remarkable, the researcher wanted to avoid doing only a work plan, and intended to carefully design actions for all phases. Therefore the books and information related to case study theory was gathered and assimilated. The researcher wasn't yet in May 2013 aware of the review and triangulation but as the case study proceeded further, the Design phase was re-executed along Plan phase in January 2014 to cover the review and triangulation.

Prepare

Yin (2009, 65) states that in a case study, good preparation starts with the desired skills and some of them are critical and can be learned or practiced. Also the four additional topics should be included in preparation of every case study: 1) Training for specific case study, 2) Developing the protocol for investigation, 3) Conducting pilot cases and 4) Screening candidate cases.

The preparation phase in this study was launched at the end of the May 2013. It was executed by studying more about the researches related to readiness level frameworks: IRL, TRL and SRL. The plans for the data collection methods was also taken further by learning more about the oral interviews and the role of the interviewer. Preparing the data collection began also with getting introduced to the professional backgrounds of consultants who work at the case company. There was individual inquiry for the candidates who would be suitable for evaluating the IRL.

Criteria and qualification that affected the selection of candidates was that the candidate needed to be involved with information system integrations. The theme and the purpose of the evaluation were introduced and there were seven consultant candidates and specialists who appeared to be suitable for IRL framework evaluation. The IRL framework definition criteria's were sent as pdf-format to candidates to get deeper understanding of the upcoming evaluation. Some candidates withdrew their participation after re-evaluating their own professional experience and knowledge. The amount of suitable interviews was decreased to three. Scheduling for the individual evaluations happened at this stage.

3.3 Collect

Collection of the case study data consists of 4 tasks: 1) Following case study protocol, 2) Using multiple sources of evidence, 3) Creating case study database and 4) maintaining chain of evidence (Yin 2009, 98; Conrad & Serlin 2005, 206-207). The main question of this study facilitated the decision to do qualitative research. The question “how” defines that quantity based research is not an alternative for this study. In qualitative research, most commonly used data collection methods are interview, surveys, observation and knowledge that is based on different kind of documents and artifacts (Yin 2009, 98).

Yin (2009, 98) presents also seven reasons for choosing it as the main data collection method and for this study it was selected because of the following reasons: 1) Gained results are need to be clarified; 2) Deeper understanding for gained information are desired; and 3) Main question for research is uncharted.

The interviewer needs to be task oriented. Priority goes with data collection, not with curiosity. The interviewer also needs to emphasize confidentiality in a way that interviewees are not identifiable with their answers to the other interviewees. Interviewer needs to participate and study at the same time but needs to remain objective. The interviewer is not allowed to state own opinions and needs assume more “diplomatic” than technical role. Even if the interview is a certain type of conversation, the interviewer needs to take lead (Yin 2009, 107; Hirsjärvi & Hurme 2006, 98). Sometimes the interviewer may prepare the question asking event by giving explanations or information but the presence of highly differential roles is crucial (Fowler & Mangione 1990, 11).

Interview types can be categorized in to three different types depending on subject: structured interview, theme based interview and open interview (Hirsjärvi, Remes & Sajavaara 2003, 194). This study used the structured type of interview. In structured interview questions, thesis and order are predefined. Questions are rather short and exact without double meanings (Hirsjärvi et al. 2003, 189). Hirsjärvi et al. (2003, 197) presents, that interview can be executed in three different formats that are: individual interview, pair interview and group interview.

Information obtained through participant observation enables participants’ objective reporting of what they believe and do (Mack, Woodsong, MacQueen, Guest & Namey 2005, 14). In this study, the researcher stayed an objective outsider, as opposed to the interviewees who as insiders can be considered subjective.

For this case study, the most suitable format was individual interviews due to the nature of research questions and interviewees. Interviewees concentrated on evaluating if IRL framework can be used in business activities at Nevtor. Evaluation was based on IRL framework definition criteria’s and the experience of consultants who work at Nevtor and have been involved in integration projects. The interviews were held in June 2013. All interviews were recorded, transcribed and analyzed. Gathered data was saved carefully to the database in electronic learning environment and for the researcher’s computer. There were also portable memory stick that researcher kept to avoid any data loss of valuable interviews.

Following table in the next page describes the experience of the interviewees (n=3).

Table 3: Experience of the interviewees

M.H.	Has been designing, determining, testing and integrating different kind of IT infrastructure environments between 7 000 and 100 000 workstations.
T.T.	Has gained certifications such as Microsoft Certified IT Professional: Enterprise Administrator and Microsoft Certified Solutions Expert (MCSE) Private Cloud. His main focus has been to consult in System Center Service Manager (SCCM), Orchestrator and Operations Manager projects for companies where the amount of end users has varied between 1000 and 5000.
J.P.	Has been executing event management and database integrations regarding BMC Remedy ITSM, FIM, AD, SAP, SharePoint, telecommunication systems and monitoring tools.

3.4 Analyze

The analysis of evidence is the least developed and the most difficult aspects of doing case studies (Yin 2009, 126; Conrad & Serlin 2005, 208-209). Eisenhardt (1989, 8) states that analyzing data is the heart of building theories in case studies even if it is most difficult and least codified part of the process. The analysis of data depends very much on the integrative powers of the researcher (Benbazat, Goldstein & Mead 1987, 371). Benbazat et al. (1987, 372) also points out, that the key elements of data analysis are critical to the written results of case research.

This study was accomplished as case study research and it contains qualitative elements. Qualitative research as a site of discussion is difficult to define clearly because it has no theory or paradigm that is distinctly its own (Denzin & Lincoln 2005, 9). It analyses and describes burgeoning phenomenon. It is naturalistic and research acts as an instrument. Qualitative research finds patterns and diversity (Denzin & Lincoln 2005; Hirsjärvi et al. 2006, 26).

Researcher started analyzing in June 2013, by categorizing all answers from the interviewees to the groups by IRL levels. Then all answers were listened two times. First time to understand the entirety and second time to have more focused summary from specific level. The next step was to transcribe the given answers to a table, so that each level was in a row and each interviewee had his own column. When all recordings were transcribed to the tables, the author started comparing the answers to each other, in their own level and making notes when finding similarities. Unit of analysis in the study was information systems integration projects (n=121) which are implemented, well documented and accomplished by experienced experts.

The analysis part was executed by going through one level at time and by searching similarities and conjunctive actors. During the analyzing phase, it became evident that two of five interviews were not valid and they were omitted of the results (n=5 in which n=3 valid).This kind of technique is called pattern matching technique and it is one way of addressing internal validity (Yin 2009, 45) and it is one of the analytical techniques. Yin (2009, 34) presents that the others analytic techniques in case study are explanation building, time-series analysis, logic models and cross-case synthetic.

3.5 Share

The reporting phase, in the case study, means combining the results in order to get closure. It is important to define the audience and compose textual and visual materials. It is good practice to display enough evidence for the readers to come to their own conclusions. Reviewing and rewriting are needed to achieve high quality (Yin 2009, 164).

In this study the written research report was targeted for PERSEUS project and academic audience. Unwritten reports, as performances, in this study were targeted for the personnel and students from Laurea University of Applied Sciences. There was also one performance that was aimed for personnel of Nevtor. Therefore the content of the performances varied a bit depending for the audience. Nevtor's personnel received more down to earth information when the information that was aimed for academic audience consisted of more scientific approach. Knowledge sharing of this study and its results was launched in the end of November 2013 but the final share happened in the beginning of June 2014.

3.6 Review and Triangulation

Yin (2009, 98) states, that the case study research relies on multiple sources of evidence with data needing to converge in a triangulation fashion, and it benefits from the prior development of theoretical propositions to guide data collection and analysis. Triangulation in this study means that using multiple sources as evidence. On the other words it means using data sources, such as realization as data triangulation, interviews and using different evaluators like reviews, as investigator triangulation. In this study, the realization is presented later on. The research report has been reviewed and rewritten few times to improve the quality.

The review processes improved the information sharing in research report. The case company Nevtor became aware of the possibilities of developing the integration processes and the former tacit knowledge became visible and official information. The Laurea University of Applied Sciences was able to receive research results that generated possibilities for further investigations into the same theme and PERSEUS became able to receive knowledge of IRLs utilization. The study was reviewed in March 2014 and triangulation happened in April 2014.

Table 3: Allocated time plan

Phase	Time	Action
Plan	April 2013	Identifying research question, environment and method
Design	May 2013	Understanding methodology, setting steps
Prepare	June 2013	Examining competence of interviewees, sending surveys
Collect	June 2013	Executing two invalid interviews
Design	7.6.2013	Revising techniques of analysis
Collect	14.6.2013	Interview with T.T.
Collect	18.6.2013	Interview with M.H.
Collect	25.6.2013	Interview with J.P.
Analyze	July – December	Transcribing, pattern matching
Design	January 2014	Designing the becoming steps: review & triangulation
Share	From 30.11.2013	Presentations at Laurea & Nevtor
Review	March 2014	Quality improvement of the research report
Triangulation	April 2014	Realization and reviews
Share	May 2014	Sending research reports for audience

Allocated time plan in table 3 presents the research as linear but iterative study process.

4 Contribution

In this chapter, the first study describes the findings of the case study more thoroughly and the second study presents the cross-case analysis of two studies and the proposal of new understanding and realization of the integration readiness level.

4.1 Study I: Integration Readiness Level in Operative Systems

The title of the study was: Utilization of the Integration Readiness level in Operative Systems (Mantere & Pirinen, in press) and the research question focused to find out how the Integration Readiness Levels (IRLs) can be understood and realized in integration projects of information systems. The study began with getting introduced to the PERSEUS project at the

Laurea University of Applied Sciences in the spring of 2013, and it was positioned in the field of information technology services at the company Nevtor Ltd. in Espoo. Company delivers various kinds of technical consultancy, outsourced services and solutions, and training. The Company has reached Microsoft´s Gold Certified Partner –level, and has achieved Gold levels in Systems Management and Virtualization, and in Unified Communications. Nevtor is also Microsoft Consulting services (MCS) and Data Center Services (DCS) partner and has two Virtual Technology Solution Professional (V-TSP) persons. The company is continuously improving business processes, in order to achieve ISO/IEC 20000 certification after the summer of 2014.

ISO/IEC 20000 is a quality standard for IT Service Management and it is published by ISO, the International Organization for Standardization, based in Geneva. It aligns with best practice guidance contained within the ITIL framework and is compatible with other IT Service Management frameworks and approaches (ISO/IEC20000 2014).

In this study, data gathering was executed by interviewing three of five specialists, per a survey that was sent prior to the interviews. Interviewees became acquainted with the surveys and had face-to-face interviews with the researcher. The study's main question evaluated if integration readiness level can be used in business activities. To get more detailed insight of the main question, the researcher focused on three more specific questions in each level of IRL framework: 1) are all definition criteria valid; 2) which definition criteria are most important; and 3) is there anything special regarding improvement for any specific criteria. The scope of the study determined also how IRL's utilization is understood in Nevtor.

In this study, unit of analysis was as experience (n=5 in which n=3 valid). The main question defines that the unit of analysis for this study is based on the experience of the system integration projects (n=121),which were accomplished by consultants who work at Nevtor and have been involved in integration projects and have 13-18 years' experience working with system managements, architecture and technologies. Performed integration projects consist of e.g. mail server upgrade, mail server conversion to cloud services, data backup system implementation, and database transmission and storage solutions. The competence of the selected interviewees can be described as follows:

M.H. has been designing, determining, testing and integrating different kind of IT infrastructure environments for a worldwide telecommunication company that had approximately 100 000 workstations. In another project he was deployed the Microsoft operating system based IT infrastructure and workstation solutions for a company's production unit. The company consisted of 87 000 workstation worldwide and the amount of implemented workstations was approximately 7 000. He has also been working as a Project Manager in an integration project where an operative system was solidified and deployed for i a company in the Scandinavian banking sector. The amount of workstations was approximately 40 000.

T.T. has gained certifications such as Microsoft Certified IT Professional: Enterprise Administrator and Microsoft Certified Solutions Expert (MCSE) Private Cloud. He has been a technical lead for System Center based products at Nevtor. His main focus has been to consult in System Center Service Manager (SCCM), Orchestrator and Operations Manager projects for medium and large Finnish companies. The amount of end users has varied between 1000 and 5000.

J.P. has been executing event management and database integrations regarding BMC Remedy ITSM. He has also been integrating SAP, SharePoint and monitoring tools for upper level products. He has also been building return channel for the data in telecommunication systems. At the time of the interview, he was doing the integration between ForeFront Identification Manager (FIM), SAP, telecommunication system and Active Directory (AD).

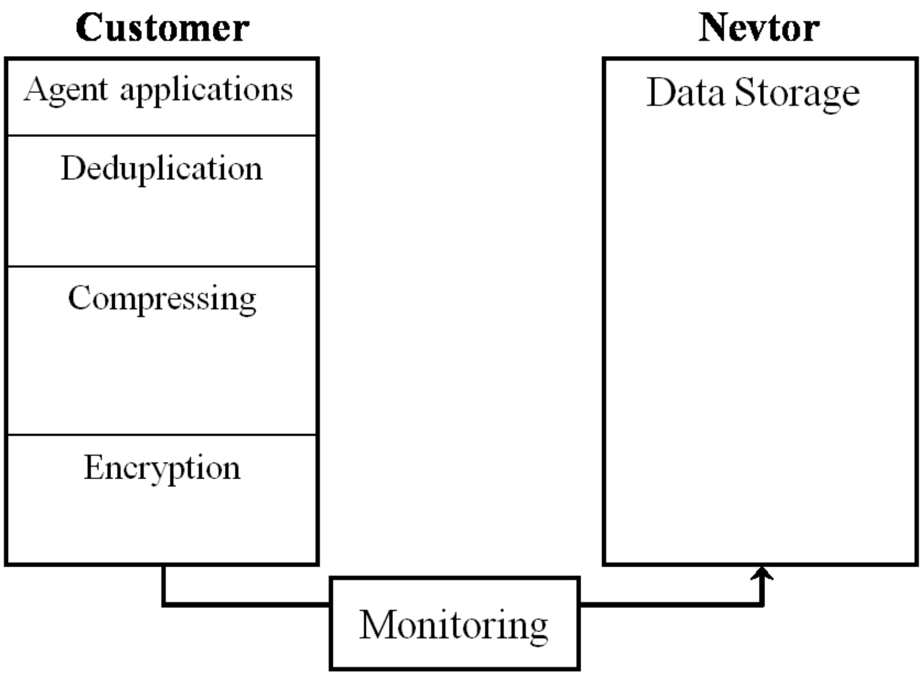

Figure 2: Nevtor’s backup solution

To get deeper understanding of solutions that Nevtor provides, Nevtor’s solution for data backup is presented in figure 2. Backup agents are installed for the client’s computers and servers. The agents do data gathering from workstations and servers. Deduplication, where the duplicated data is eliminated, happens in the customer’s environment. After that data is compressed and encrypted using Advanced Encryption Standard (AES). Data transfer from client to Nevtor's data center is monitored and load balanced. Data backup for workstations and servers is based on products of EVault technology, a technology that supports almost any combination of technologies, including Microsoft, IBM and Oracle databases.

First time, it runs full backup from all systems and compresses the data by as much as 50 percent. With subsequent backups, technology scans files on every protected system or server to identify new or changed block. Then the system combines the data and builds virtual full backups. These backups work with adaptive compression that shrinks transmitted data blocks from 40 to 90 percent. Encryption protects backup data inside the firewall, as it travels over the wire and while the data is at rest. At the front-end encryption, Nevtor uses National Institute of Standards and Technology (NIST) 256-bit AES. The connection itself is also encrypted and the data remains encrypted while in the data center.

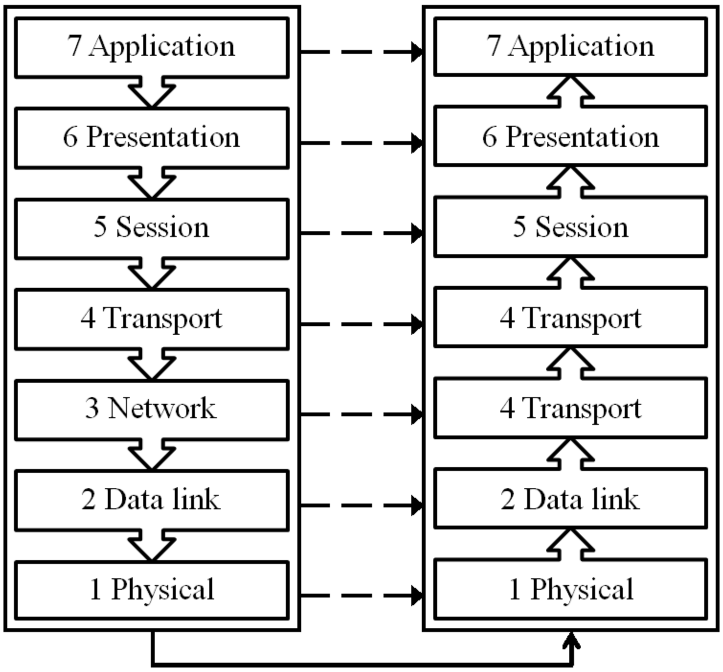

Figure 3: OSI /ISO model

System's data transfer can be described with the International Standards Organization's Open Systems Interconnect (ISO/OSI) model. Figure 3 visualizes the OSI model. The Application layer communicates with software applications. It presents the data for user in understandable format with the help of the presentation layer. In this example, the backup agents the data format that is compressed, such as Graphic Interchange Format (GIF) images, belong to the presentation layer. The presentation layer stands for as the standard interface to data application layer. Data encryption happens in that level. The session layer manages connection between applications and the flow control in the transport layer.

The session layer shrinks data blocks by 40 – 90 percent. Transport layer takes care of the data backups flow control. The network layer is responsible for routing of data to a remote location. In this example, it means the data backups from customer's premises to Nevtor's data center. The data link layer takes care of the problems related to duplicated frames, cells, or damaged packets that are received. It also provides the transfer by transmitting backup packets with the necessary synchronization and flow control. The physical layer is responsible for the ultimate transmission of data over network communications media. The physical layer consists of the physical connection endpoints at customer premises and Nevtor data center. All layer functions belong to the data backup processes.

The interviews were recorded, transcribed and analyzed. Findings were achieved by using IRL framework in analyzing part, by going through one level at time. As the analysis was executed by using pattern matching technique the results were classified by semantic, syntactic and pragmatic level to easily address the similarities and differences. In the first round the similarities were searched from the answers among the interviewees and in the second round, the most commonly occurred selections were compared to the findings from Brian Sauser and PERSEUS project. In the next chapters, there are tables assigned with letter P, for each level to present the questions which PERSEUS project proposed to be analyzed further, where their experts considered criterion especially critical for complying with the different milestones of the systems engineer cycle. Letter N stands for the result that was gained from Nevtor's consultants. Those criterions gathered more attention from the interviewees. The column with header Critical describes the value of criticality that was defined by Brian Sauer et al. (2009, 8). The higher the number, the higher the criticality it has.

Identifiers in tables can be explained by following:

1. IRL = Level criteria identifier
2. Definition = criterion that was evaluated
3. CA = critical assessment rate by Brian Sauser
4. R = Result
5. P = criterion which PERSEUS project proposed to be analyzed further
6. N = result that was gained from Nevtor's consultants

Semantic level

The semantic level defines three principles of integration: interface, interaction and compatibility. These levels define the subsistence of an integration effort (Sauser et al. 2010, 25). It is important to identify the right integration elements to evaluate schedule and budget. Without the right identification, the proper progress plan can be difficult to be made.

Table 4: Detailed IRL evaluation criteria level 1

IRL	Definition	CA	R
1.1	Principal integration technologies have been identified	0.58	P/N
1.2	Top-level functional architecture and interface points have been defined	0.39	N
1.3	Availability of principal integration technologies is known and documented	0.15	
1.4	Integration concept/plan has been defined/drafted	0.18	
1.5	Integration test concept/plan has been defined/drafted	0.12	
1.6	High-level Concept of Operations and principal use cases have been defined/drafted	0.06	
1.7	Integration sequence approach/schedule has been defined/drafted	0.06	
1.8	Interface control plan has been defined/drafted	0.03	
1.9	Principal integration and test resource requirements (facilities, hardware, software, surrogates, etc.) have been defined/identified	0.09	
1.10	Integration & Test Team roles and responsibilities have been defined	0.12	

In level 1, where are 10 criterions, there are several choices involved with interface between technologies. At this level, all interviewees agreed that there were many important choices but they had different points of views about the most important one. Two criterions that were mentioned most often were: 1.1 Principal integration technologies have been identified and 1.2 Top-level functional architecture and interface points have been defined. At this point, it became evident already that there are quite many software solutions that offer integration readiness tests themselves. In commercial scenarios it is very common to such solution to speed up and make the integration project easier. Interviewees' answers can be compared to selections from the PERSEUS project and to the criticality assessment by Brian Sauser. The table 4 shows that the gathered results (R) are in line with the results of research that were done at Department of Defense (DoD). They are also in line with the selection or PERSEUS project.

Table 5: Detailed IRL evaluation criteria level 2

IRL	Definition	CA	R
2.1	Principal integration technologies function as stand-alone units	0.18	N
2.2	Inputs/outputs for principal integration technologies are known, characterized and documented	0.52	P/N
2.3	Principal interface requirements for integration technologies have been defined/drafted	0.39	N
2.4	Principal interface requirements specifications for integration technologies have been defined/drafted	0.27	
2.5	Principal interface risks for integration technologies have been defined/drafted	0.06	
2.6	Integration concept/plan has been updated	0.06	
2.7	Integration test concept/plan has been updated	0.09	
2.8	High-level Concept of Operations and principal use cases have been updated	0.12	
2.9	Integration sequence approach/schedule has been updated	0.09	
2.10	Interface control plan has been updated	0.06	
2.11	Integration and test resource requirements (facilities, hardware, software, surrogates, etc.) have been updated	0.15	
2.12	Long lead planning/coordination of integration and test resources have been initiated	0.12	
2.13	Integration & Test Team roles and responsibilities have been updated	0.03	
2.14	Formal integration studies have been initiated	0.12	N

The level two consists of fourteen criterions that define the integration proof-of concept. The interviewees deemed that the most important decision criteria were the option 2.2 Inputs/outputs for principal integration technologies are known, characterized and documented. Other options were recognized as valid but weren’t deemed as relevant as the second criterion. PERSEUS and Sauser et al. (2009, 9) have also considered them as most relevant criterions that need more attention.

Table 6: Detailed IRL evaluation criteria level 3

IRL	Definition	CA	R
3.1	Preliminary Modeling & Simulation and/or analytical studies have been conducted to identify risks & assess compatibility of integration technologies	0.18	N
3.2	Compatibility risks and associated mitigation strategies for integration technologies have been defined (initial draft)	0.09	N
3.3	Integration test requirements have been defined (initial draft)	0.15	N
3.4	High-level system interface diagrams have been completed	0.48	P/N
3.5	Interface requirements are defined at the concept level	0.24	N
3.6	Inventory of external interfaces is completed	0.24	N
3.7	Data engineering units are identified and documented	0.06	N
3.8	Integration concept and other planning documents have been modified/updated based on preliminary analyses	0.18	

In the level three, almost all criterions were chosen but, two of them were considered to be most valid ones: 3.2 Compatibility risks and associated mitigation strategies for integration technologies have been defined (initial draft), and 3.4 High-level system interface diagrams have been completed. Level three results are presented in table 6. PERSEUS and Sauser et al. (2009, 9) have also kept the 3.4 as a criterion that needs most attention.

Actually, when comparing the semantic levels' results to the research: Defining an Integration Readiness Level for Defense Acquisition (Sauser et al. 2009, 10) a similarity can be found between the research findings. The interviewees found out that 1.1, 2.2, and 3.4 are the key elements when considering the fundamental components for the integration. The criteria of secondary importance, 1.2 and 3.5 Interface req's are defined at the concept level, are in line with Saucer's research results when analyzing the highest priority criteria.

Syntactic level

The syntactic level defines that the integration effort follows the pre-defined specifications. It is defined as conformance to the rules (PERSEUS, 15). This level contained ambiguous answers. All levels from 4 to 7 had various selections when interviewees estimated the validity and importance of criteria. Table 7 in level four presents the variable opinions of interviewees. Sauser et al. (2009, 10) deemed the 4.11 A rigorous requirements inspection process has been implemented as most important criterion but interviewees disagreed with that. Secondary most important criterion 4.5 Overall system requirements for end users' application are known/baselined, on the contrary was deemed to be most valid criterion.

Table 7: Detailed IRL evaluation criteria level 4

IRL	Definition	CA	R
4.1	Quality Assurance plan has been completed and implemented	0.18	N
4.2	Cross technology risks have been fully identified/characterized	0.12	N
4.3	Modeling & Simulation has been used to simulate some interfaces between components	0.06	N
4.4	Formal system architecture development is beginning to mature	0.09	
4.5	Overall system requirements for end users' application are known/baselined	0.24	P/N
4.6	Systems Integration Laboratory/Software test-bed tests using available integration technologies have been completed with favorable outcomes	0.09	
4.7	Low fidelity technology "system" integration and engineering has been completed and tested in a lab environment	0.06	N
4.8	Concept of Operations, use cases and Integration requirements are completely defined	0.12	
4.9	Analysis of internal interface requirements is completed	0.09	P
4.10	Data transport method(s) and specifications have been defined	0.12	
4.11	A rigorous requirements inspection process has been implemented	0.27	

Levels 4 and 5 consisted of different kind of selections that interviewees deemed to be most important. For example in 4.2 Cross technology risks have been fully identified/characterized, interviewees agreed that it is very important if different kind of applications are used. But on the other hand if you are working with database environments that change daily, it is possible to fully identify those risks. The criterion 4.5 Overall system requirements for end users' application are known/baselined, draw also interviewee's interest from the modification possibility point of view.

"Overall system requirements for end users' application are known/baselined at this phase you should have some kind of description what you are going to provide example for end user application but still it go to be grown or minimized in the way as you are taking the environment in operational use. So yes you might have overall requirements but you still need to leave door open that customer or end user would like to add more functional services (M.H)."

The results in level 4 compared to PERSEUS and Sausers result, are in line when viewing the criterion 4.5 Overall system requirements for end users' application are known/baselined. Sauser et al. (2009,7) has stated in his research that for IRLs 4 and 5, less clarity can be seen in the identification of IRL decision criteria in what is most important. The same result can be seen in tables 7 and 8.

Table 8: Detailed IRL criteria level 5

IRL	Definition	CA	R
5.1	An Interface Control Plan has been implemented (i.e., Interface Control Document created, Interface Control Working Group formed, etc.)	0.33	P/N
5.2	Integration risk assessments are ongoing	0.06	N
5.3	Integration risk mitigation strategies are being implemented & risks retired	0.03	
5.4	System interface requirements specification has been drafted	0.39	P/N
5.5	External interfaces are well defined (e.g., source, data formats, structure, content, method of support, etc.)	0.27	N
5.6	Functionality of integrated configuration items (modules/ functions/ assemblies) has been successfully demonstrated in a laboratory/synthetic environment	0.21	N
5.7	The Systems Engineering Management Plan addresses integration and the associated interfaces	0.15	
5.8	Integration test metrics for end-to-end testing have been defined	0.12	
5.9	Integration technology data has been successfully modeled and simulation	0.06	

Level 5 consisted of many criterions that interviewees suggested to be accomplished in earlier stage. All criterions in level 4 and 5 were recognized as important considerations. It was mentioned to perform a test carefully before proceeding to the integration implementation and avoiding hindsights. For example 5.3 Integration risk assessments are ongoing, was considered to be performed on level 3 and to be monitored and updated continuously. Also the 5.5 External interfaces are well defined (e.g., source, data formats, structure, content, method of support, etc.), was considered to be moved to the level 4. PERSEUS has kept the 5.1 An Interface Control Plan has been implemented (i.e., Interface Control Document created, Interface Control Working Group formed, etc.), and 5.4 System interface requirements specification has been drafted, as criterions that needs most attention. The following comment is regarding the criterion 5.1.

“An Interface Control Plan has been implemented (i.e., Interface Control Document created, Interface Control Working Group formed, etc.) If we are using out of the box solution, it already exists on that tool. (J.P.)”

Table 9 Detailed IRL evaluation criteria level 6

IRL	Definition	CA	R
6.1	Cross technology issue measurement and performance characteristic validations completed	0.27	
6.2	Software components (operating system, middleware, applications) loaded onto subassemblies	0.45	N
6.3	Individual modules tested to verify that the module components (functions) work together	0.48	P/N
6.4	Interface control process and document have stabilized	0.09	
6.5	Integrated system demonstrations have been successfully completed	0.21	
6.6	Logistics systems are in place to support Integration	0.12	N
6.7	Test environment readiness assessment completed successfully	0.06	
6.8	Data transmission tests completed successfully	0.18	N

All interviewees agreed that there were two criterions in level 6 that were most important, those were 6.3 Individual modules tested to verify that the module components (functions) work together and 6.8 Data transmission tests completed successfully. According also to Sauser's (2010, 40) earlier research, 6.3 Individual modules tested to verify that the module components (functions) work together, is the most critical definition in level 6. When the technology elements are brought together and the interfaces are fully defined and made to function, there is an urgent need to initiate testing (Sauser 2010, 41). That definition is also important for the PERSEUS project team. Even if the 6.2 Software components (operating system, middleware, applications) loaded onto subassemblies, were deemed as valid by the interviewees, their opinion was also to move that definition to level 5 when testing simulations are done.

"Individual modules tested to verify that the module components (functions) work together is the most relevant point, but also Data transmission tests completed successfully is important (T.T.)"

Table 10: Detailed IRL evaluation criteria level 7

IRL	Definition	CA	R
7.1	End-to-end Functionality of Systems Integration has been successfully demonstrated	0.61	P/N
7.2	Each system/software interface tested individually under stressed and anomalous conditions	0.33	N
7.3	Fully integrated prototype demonstrated in actual or simulated operational environment	0.42	N
7.4	Information control data content verified in system	0.24	
7.5	Interface, Data, and Functional Verification	0.33	
7.6	Corrective actions planned and implemented	0.15	

In the level 7, the criterion 7.1 End-to-end Functionality of Systems Integration has been successfully demonstrated was determined as valid criterion but interviewees felt that it should be done earlier. The interviewees gave more attention for step 7.2. Each system/software interface tested individually under stressed and anomalous conditions, because it is quite hard to determine which conditions are sufficiently stressed and anomalous. They felt that it should also be accomplished in earlier stage where are more detailed tests done, for example in level 6. Also the criterion 7.3 Fully integrated prototype demonstrated in actual or simulated operational environment received more attention because it was perceived as difficult to determine/define a fully integrated operational environment.

“In our it world it is very hard and almost impossible to create simulated operational environment with all of those environment variables that are needed on that environment, for example: network access management, certificates, different kind of firewalls, different kind of network environments, different kind of databases and structured systems. Therefore I never want to create simulated operational environment because we cannot provide that (M.H).”

Pragmatic level

The pragmatic level addresses the operational context of the integration. IRL framework levels 8 and 9 facilitate the quality and satisfaction (Sauser et al. 2010, 24).

Table 11: Detailed IRL evaluation criteria level 8

IRL	Definition	CA	R
8.1	All integrated systems able to meet overall system requirements in an operational environment	0.85	P/N
8.2	System interfaces qualified and functioning correctly in an operational environment	0.61	P/N
8.3	Integration testing closed out with test results, anomalies, deficiencies, and corrective actions documented	0.39	
8.4	Components are form, fit, and function compatible with operational system	0.42	
8.5	System is form, fit, and function design for intended application and operational environment	0.42	
8.6	Interface control process has been completed/closed-out	0.24	
8.7	Final architecture diagrams have been submitted	0.36	N
8.8	Effectiveness of corrective actions taken to close-out principal design requirements has been demonstrated	0.24	
8.9	Data transmission errors are known, characterized and recorded	0.36	
8.10	Data links are being effectively managed and process improvements have been initiated	0.18	

In level 8, there were 3 criterions that gave more insight to interviewees. 8.1 All integrated systems able to meet overall system requirements in an operational environment, was deemed as valid but it was suggested to be moved to be done in level 7. 8.2 System interfaces qualified and functioning correctly in an operational environment, was evaluated to consist of the same kinds of tasks as in the first criterion. Also the criterion 8.7 Final architecture diagrams have been submitted was deemed very important. Anyhow there were 2 criterions that were considered to belong only to test phase, those were 8.4 Components are form, fit, and function compatible with operational system, and 8.6. Interface control process has been completed/closed-out.

Table 12: Detailed evaluation criteria level 9

IRL	Definition	CA	R
9.1	Fully integrated system has demonstrated operational effectiveness and suitability in its intended or a representative operational environment	0.82	P
9.2	Interface failures/failure rates have been fully characterized and are consistent with user requirements	0.64	P
9.3	Lifecycle costs are consistent with user requirements and lifecycle cost improvement initiatives have been initiated	0.24	N

Sauser et al. (2009,8) states that the final stage of integration maturity, IRL 9, can only be attained after a system has truly been stress tested to its limits by the operator and is impendent of the type of project undertaken. The interviewee's had difficulties to choose the most important criterion among the presented because in the system integration projects, that case company provides, the project team gives the decision criteria that need to be accepted. Those are the major outcomes of project that needs to be fulfilled before project.

Therefore the criterion 9.3 Lifecycle costs are consistent with user requirements and lifecycle cost improvement initiatives have been initiated, is the most valid criterion. Interviewees noted also that in integration projects, project owner usually defines the goals and the scope that the project team needs to achieve, for the project to be successful. That's why it should be possible to modify information in level 9. Eight identifiers (ID), definitions and proposals can be seen in table 13 as a research contribution of this study.

Research proceeded from beginning to end as linear but iterative process. The gathered data showed that some parts of framework could be used in business activities at Nevtor but it needs modification and to be made less complicated. The framework would be more flexible to be used within different platforms if terms were written in a more common language. The criterions can be understood in more than one way and it would be easier for the user if expressions were exact and described well. Order of the criterions could be rearranged. Compared to the current IRL framework, some tasks need to be performed in an earlier stage.

The interviewees felt that some criterions were more important than the others, and those more important criterions could be ether inserted to the beginning of criterion list in each level or highlighted that user give more attention to them. Interviewees felt also that there needs to be provisions for criteria inserted by the user. That could be solved by adding editable text fields, check boxes and bullet points for criterions. One thing that interviewees wished for was criteria with “yes” or “no” as the only possible answers, because it would help the user to determine the ongoing situation of the integration project.

The framework would be more flexible for different kind of integration projects if the interface related criterions were modified to multiple choice format. Some integration projects includes interface related customization, some projects excludes it. Modifying interface related criterion optional, would make the framework versatile. The interviewees felt, that some presented criterions belong to a test lab environment only and it might be good to add description for those to the questionnaire. Another option would be to make a separate sheet for a test lab to environment to avoid conflicts when moving the integration to production.

Last observation was that some criterions are also usually defined by project owner. It could be good to have a separate area for them to be inserted that their fulfilment is easily noted.
To come to final conclusion of the study, the gathered results and research contribution was analyzed with a structured planning method called SWOT-analysis. SWOT is abbreviation from Strengths, Weaknesses, Opportunities and Threats (Pahl & Richter 2009, 4). The analysis gives possibility to summarize the gained results and evaluate the IRL frameworks contribution for Nevtor Ltd.

The SWOT analysis presented that strengths in present IRL framework are purpose and usage in case where the systems will need to be built from scratch. IRL framework’s weaknesses are presented in table 13. Table also includes the proposals how to enchant them and make the framework more beneficial. As an opportunity: if IRL framework is modified and the given executed, it provides benefit for many actors, e.g. integration executer, project manager, and stakeholders. It also helps the integration project proceed smoother and flexible.

As a threat, the IRL framework in its present format, can take lots of time and resources when used in integration project for customer. Usually the customer needs to publicly ask for bids for providing some service and the estimation of costs and schedule play a big role when the decisions are made. As a proposal: modified IRL framework can work as efficient tool for all participants in integration project. It won’t only provide tasks for the person who executes the integration; it can also provide valuable information of the project progress for project manager or owner. In addition, more detailed future research of the IRLs metrics and questionnaires is necessary.

Table 13: Contribution of the study

ID	Definition	Proposals
1	Criteria definition needs to be lightened.	Criteria expressions could be written fluently and descriptively.
2	Some criterions need to be relocated.	Order of the criterions could be checked carefully to relocate criterions.
3	Some criterions are more important than others.	Criterions that are more important could be located before others.
4	There needs to be place for criterions that are inserted by user	Empty text fields and bullet points could be inserted to form.
5	Some criterions need to be yes or no typed criterions.	Selection types could be added to criteria.
6	Interface shouldn't be modified.	Criterion could be optional.
7	Some criterions belong to test lab environment only.	Test lab environment could be added as own sheet and include criterions that belongs only that phase.
8	Some criterions are usually defined by project owner.	Text fields and criterions that are blank could be included.

The research attributes of this study were as follows: 1) title of study: utilization of the Integration Readiness Level in operative systems: case study of the information systems integration project; 2) nature of study: explanatory study of IRL's in operative systems (operative solutions); 3) research approach: deductive investigation of IRL in Operative Systems Projects at Nevtor Ltd; 3) research questions: : how the Integration Readiness Level (IRL) can be understood and realized in operative systems; 4) unit of analysis: information systems integration projects (n=121) which are implemented, well documented and accomplished by experienced experts (n=5 in which n=3 valid); 5) importance of study: contribution to the research of IRLs and related (ISO/DIS 16290) standard; 6) methodological focus: case study analysis including triangulation and SWOT analysis; 7) form of analysis: a qualitative analysis, saturation and triangulation; 8) specifications of constructs: Integration Readiness Level; Systems Integration, Information Integration; and Enterprise Integration; 9) theoretical review: B. Sauser; W. Tan; J. Ramirez-Marquez; R. Govea; E. Forbes; R. Magnaye; E. Forbes; M. Long; S. E. McGrory; W. Nolte; R. Kruse; J. Bilbro; C. Dennehy; P. Desai; J. Holzer; C. Kramer; W. Nolte; R. Widman; R. Weinstein. Authors (n=19); 10) research domain: operative and implementation environment Nevtor Ltd; interviewees experience of systems integration included (n=57) years and (n=121) integration projects; covering (n=75) customer sites; 11) theoretical approaches: Integration Readiness Level (IRL); references by IRLs experts (n=3 valid); 12) Multiple case design: one organization, integrated projects background (n=over 300): in this study, every project represents a case and experiences of case; 13) replication logic: mainly literal replication logic; 14) data collection methods: questions to interviews (n=83) and interviewees (n=5 which n=3 valid). The research data was recorded, coded, reduced, archived and translated from Finnish to English; 15) questionnaire:

Lime Survey questionnaires by ISDEFE which were used to address integration activities in a System Maturity Scale to evaluate a system; and the questionnaires and comparison of results were based on Integration Readiness Level framework; 16) coding: each interview was first recorded and transcribed, answers were placed to table to mitigate interpretations; 17) notes: researcher used notes to clarify answers and responses (n=8); 18) number of researches in research group (n=2); 19) different roles of investigators: researcher as outsider (objective) and interviewees as insiders (subjective); 20) research associations: International Standards Organization (ISO/DIS 16290).

4.2 Study II: Samples and Development in Higher Education Institutions

This is an extended abstract about cross-analysis of two case studies and focuses on examining how the existing Integration Readiness Level (IRL) can be realized and validated in information systems integration projects. The study was written by three authors, supervisor, an anonymous writer and author. The study indicated the integration of externally funded research and development (R&D) integration and the development of R&D related collaborative learning in higher education institutions.

The scope of this study is to give contribution to the research of IRLs and related development of the ISO/DIS16290 standard series. It is achieved by 1) improving the IRL metrics, 2) increasing confidence in global procurement management 3) pre-operational validation in common ontology, 4) progressing operational validation in informative systems implementations, and by finding the methodological implications for the implementation of IRLs. The goal of this study was to create a proposal that combines the different selected readiness level functions in one global shared service.

The environment of the study consists of two case companies, Fifth Element Ltd. and Nevtor Ltd. in Espoo, which provided more specific information about understanding and realizing the IRL framework in information system integration projects in business cases (n=163). The target of this study is to bundle together the contribution of the studies that were executed in the companies and thus increase reliability when making them credible for PERSEUS audiences.

This study was executed as a multiple case study analysis that consists of triangulation and final cross-analysis. The analysis was accomplished mainly as qualitative analysis and included aspects of saturation and triangulation. The realization of IRL, in this study consists of usefulness, sharing and dissemination of an information system involved shared information over appropriate borders over applied domains. The validation of IRL in this study consists of operational validation, improving interaction success, achieving common ontological understanding, and improving methods of information system integration itself.

From a R&D point of view, the learning was key element for research process and methodology in this study. It happened in collaborative way where individuals and organizations learned simultaneously. Learning was across the borders and benefitted also the R&D consortium. Students had their hands-on with real-life projects that were intended to give utility for the PERSEUS consortium.

Figure 4 is a proposal of the new IRL framework, the validation guidelines for information systems integration. Its layers have been constructed based on earlier results in the case companies. The evaluation of IRL framework included the Lime Survey questionnaire checklist by ISDEFE. The new proposal of the questionnaire would include the expanded checklist that would allow for the removal of some of the subjectivity that exists in many of the maturity metrics.

Validation of Integration Readiness Levels

Layer	*Guidelines for IRL validation*	*Category*	*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.	Proof of 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 4: Proposal of new framework (Pirinen et al. in press.)

The first level, the Usefulness, consist of the plan, purpose and usefulness of the integration and it allows the criteria that are inserted by the user. Name of the second level is Modular Integration Strategy and it consists of the selection of the attributes for operational validation because the speed and diversity is very high even in a timescale of few years. The compatibility category is a layer that includes the high level system interface diagrams that have been completed in an integration project. It also includes the defined integration requirements at the concept level and an inventory of external interfaces. It is important to test the individual modules so that the module components function together and the performance characteristic validations are completed. All that happens in the level called, Proof of Functional Interactions. The validation level is comparable with the level seven, as where the activation level is comparable to level eight in the existing IRL framework. The final level, harmonization can be described in a way that the integrated systems have demonstrated operational effectiveness and suitability for the operational environment.

The main research attributes of this study were as follows: 1) the title of the study: “Samples of Externally Funded Research and Development Functions in Higher Education Institutions: Case Integration Readiness Levels”; 2) research questions: “How can the Integration Readiness Level (IRL) metrics be understood and realized in information systems projects?”; 3) unit of analysis: information systems integration projects (n=163) that are implemented, well documented, and experienced, including the two case studies of this cross-analysis; 4) the importance of the study: a contribution to the research of IRLs and related development of the ISO/DIS 16290 standard series; 5) the methodological focus: multiple case study analysis (n=2), including triangulation and final cross-analysis; 6) the form of analysis: mainly a qualitative analysis, saturation, and triangulation; 7) the research target of the first pilot study at Fifth Element (interviewees’ overall experience of industrial systems integration including n=118 years and n=80–100 integration projects covering n=70–80 customer sites); 8) the research target of the second pilot study, Nevtor (interviewees’ experience of systems integration including n=57 years and n=121 integration projects covering n=75 customer sites; 9) the data collection methods: questions (n=10) and interviewees (n=10; n=8 valid); the research data was recorded, coded, reduced, archived, and translated from Finnish to English; and 10) Lime Survey questionnaires by ISDEFE, which were used to assess integration activities on a System Maturity Scale to evaluate a system; the questionnaires and the comparison of research findings were based on (Sauser et al. 2010).

4.3 Study III: Review of studies

One of the procedures to follow in doing the case study report is related to the overall quality of the study. The procedure is to have the draft report reviewed by peers, participants and informants in the case (Yin 2009, 82). The author participated as anonymous reviewer to the review process where the goal was to improve quality of the research by helping the author to enhance accuracy. Review happened in March 2014 and it was based on another author’s research report. The aim of the review process was to elevate questions and proposals in a way that the author could improve the quality of the study report.

This study was also reviewed by three different instances. First reviewer was the supervisor who guided the study process. He also proposed improvement so the report could be sent to the call of papers in the Institute of Electrical and Electronics Engineers (IEEE) review. Second reviewer was the board of the IEEEE conference that rejected the manuscript and offered feedback to strengthen the research report so that it could be published in the future. Third reviewer was anonymous student who also gave valuable feedback for improving the study.

4.4 Summary

The target of the research was to find out if the integration readiness level can be used in private sector. The Interviews were recorded, transcribed and analyzed and the main research finding was as follows: if the IRLs and questionnaires are used, then useful contribution for validation of integration readiness is achieved. However, the questions were relatively wide and more fine grained forms and validation criterions (n=8) were proposed as research contribution of the study. The results provided answers to the research question. As a result of interviews, the gathered data showed that some parts of framework could be used in business activities at Nevtor.

If this IRL framework would be used at Nevtor, it would need modifications in all its levels. The IRL framework is a good concept if one needs to build up system integration from scratch. In Nevtor's business activities the systems that going to be integrated are quite much out-of-the box solutions where integration interfaces and framework tools are included. Some definitions, including test definition, were to be executed too late. Interviewees agreed that they should belong to an earlier stage. For example, all system tests need to be accomplished in a test environment before proceeding to production.

“Basically our business cases are quite short projects and this kind of approach will take quite lot of time to go through all those questions. In most of the cases we are actually using already made integration interfaces. There is quite much functionality in their place. There is out of the box tool that can be used to update data between different systems.
If we have that kind of project that we need to build integration from scratch, and then most of the questions are quite much valid. As a modified form we can use some of those questions. (J.P.) ”

If the IRL framework would be used as it is, it would extend the project deadlines because it has so many details to plan and check. Some criterions are already included in Nevtor’s information system integration projects. The present format would provide risks that would affect business. When thinking about the business case, e.g. where customer buys a data backup service for workstations and servers, there many service providers compete. The chosen company is usually selected based on cost efficiency and schedule. If the implementation project would be executed by following the present IRL framework, it might lead to the project failure. It would add more tasks and project processes for the entire integration project, because it doesn't consist of all elements that are needed for project definition to address all tasks. The framework is not entirely useless, it has good base structure and with modification, it can be beneficial for business. Well defined framework can act as a platform for integration projects, where systems are made from scratch and for integration project where systems need less attention than in building cases.

The study implicated together with another study, a cross-analysis where the new format of IRL was proposed. The study addressed the way of learning by information system's R&D and integration facilities e. g. utility and communication, integration readiness and networked realization capability.

The third achievement in this study process was a review process. The goal of the review process was to increase the quality and to make the end result of the research report more seamless. Reviewing other authors' research report gave new perspective and ideas to improve reporting. Review processes effected for better output and information sharing in research report.

5 Discussion

The following chapters are dedicated on discussion and auditing the stydy. Also the limitations and proposals for future studies are presented in last chapter of this study.

5.1 Discussion of the results

Many companies are struggling with incompatible software versions and outdated system technologies and they need to develop the systems to answer to business needs. If a company does not have an IT department of their own, or lacks skilled professionals, they need to outsource then integration or development project. This can be expensive and take a long time. There are tool and technologies to perform the integration, but usually they are designed for specific platforms or software solutions. These might appear to be makeshift solutions, when compared to cross-platform integration strategies, which enumerates and evaluates possible readiness for integration components.

The IRL framework could be a valuable tool for the Business Continuity Management (BCM). BCM is a set of processes that identifies potential impacts which threaten an organization. It broadly consists of Business Resumption Planning (BRP), Disaster Recovery Planning (DRP), Crisis Management (CM) and Business Continuity Planning (BCP). Usually these are in use only if company has suffered from disaster event. BRP is an operations piece of business continuity planning. DRP is focused on technological aspect of business continuity planning and it consists of the advance planning and preparations of business continuity in a case of disaster event. CM is the overall coordination of an organizations response to a crisis. Its goal is to avoid or minimize damage to the organizations profitability, ability to operate or reputation. BCP is a roadmap of strategy that is developed to continue operations and sustain the business activity under adverse conditions. It is an all-encompassing term consisting of disaster recovery planning and business resumption planning (Doughty 2001, 10.)

One of the Nevtor's clients is Finnpilot Pilotage Ltd. It provides pilotage services that ensure the safety and functionality of navigation and its task is to promote safety of vessel traffic and to prevent damage caused to the environment. The company is obliged to perform its core task under exceptional conditions. The amount of pilotage services is 26 000 each year. (Finnpilot 2014.)

The baseline for Finnpilot Pilotage is that it needs to provide service under any circumstances. Ship observation happens in real-time and exceptions in schedules do happen. Therefore it is mandatory for the company to have well defined BCP. They invested for Nevtor's Disaster Recovery (DR) service where the data is stored to cloud with the end point protection services described earlier. Data is secured many times daily and data restoring, in a case of adverse or exceptional conditions, happens fast and round-the-clock. The Finnpilot Pilotage is also able to use their business critical solutions remotely. Business activities needs to function all the time, no matter what has happened or otherwise consequences are significant. Nationwide vessel traffic might suffer enormous damages.

Finnpilot Pilotage Ltd is a good example of organization whose system needs to operate all the time. Analyzing and defining the risks before integration is critical. Therefore the integration needs to succeed and there is no room for mistakes. The IRL framework can provide significant benefit for system integrations and it already contains elements that can be combined with BCP.

5.2 Audit of research

The objective of this research was to determine how IRL framework can be understood and realized in Nevtor's business activities. The goal was to produce a research report where the answer to the research question is described. The goal has been reached, but not in a way that reflected the authors own hypothesis or expectations. The hypothesis was that the answers can be given and that there are some lessons to be learned. The hypothesis from amount of lessons to be learned was under estimated.

Understanding of the value of the IRL was gained. Interviews gave more knowledge about the practical integration projects at the case company Nevtor. Seminars at the Laurea helped to share the knowledge and information for other students, teachers and professionals. The research report was written approximately six times and each time, including this one, gave more insight of the research and implicated improvements for the quality of the report.

First plan was to hold seminars at Laurea and spread the information for work community by internal newsletter. There came a change of plans and one seminar was added to be held at Nevtor. Content of the seminar was different from that at Laurea, and it included more information from the business point of view. The author learned valuable lesson, she received more understanding and suggested ideas about utilizing the IRL framework in Business Continuity Management (BCM).

Because of the seminars, reviews, triangulation, cross case analysis, other words the entire research process, many participants learned together, thus we can talk about collaborative learning. There is different kind of opinions how the collaborative learning is understood. Sometimes it includes more or less any collaborative activity within an educational context. Sometimes the activity is joint problem solving, and learning is expected to occur as a side-effect of problem solving. It is measured by the elicitation of new knowledge or by the improvement of problem solving performance. (Dillenbourg 1999, 2). This study included both definitions. The study generated professional growth for persons who learned together and spread the information over organizational boundaries. It contributed the understanding of research execution and being and being the researcher. It also gave knowledge for individual participants.

According to reference Yin (2009, 41), a case study’s validity can be tested with four different tests that measure construct validity, internal validity, external validity and reliability. Yin also states that construct validity can be explained as identifying correct operational measures for the concepts being studied. In this case study multiple data sources were used, such as the artifacts, interviews, academic books, journals and articles to cover the construct validity. Internal validity is described as seeking to establish a causal relationship. Certain conditions are believed to lead to other conditions, as distinguished from spurious relationships. According to presented tests, in this specific case study the internal validity is not a threat because the researcher stayed in an objective role during the research.

External validity defines the domain where study's findings can be generalized (Yin 2009, 41). In this study the external validity gets fulfilled with the findings and the results of study. Yin also presents that reliability can be demonstrated in a way that the operations of a study can be repeated with same results. The purpose of data collection process is to increase reliability by maintaining a chain of evidence for research report (Yin 2009, 123). Research questions needs to be linked protocol topics. Case study needs to have citations to specific evidentiary sources in case study database.

The database reveals the actual evidence and also indicates the circumstances where the data was gathered. In this study, the case study was selected for research method and it followed the case study protocol. All phases are presented and described in the research report. All gathered data was saved to database and the allocated time plan presented when each phase of the study was executed. Research report includes citations from the interviews to present the rationalization of presented findings. Therefore the reliability of this study is in order, all the data collection procedures can be repeated with same result.

5.3 Limitations and future research

This study was executed in one company that provides integrations in operative systems. The proposal was based on the results that were collected from Nevtor and another company that presents the industrial system projects. The study collected answer from the completed integration projects overall inside Nevtor but it didn't compare the integration projects to each other or to answers collected from industrial system projects.

There are some alternative frameworks, e.g. the Microsoft Operational Framework (MOF) available, which are designed to do system integration, but they are designed to work on platforms specific to certain manufacturers of proprietary software. The purpose of this study was to focus whether the IRL, which is a cross-platform framework, can be valid for use in business activities.

This research focused on evaluating the usefulness of IRL framework in private sector. It was very interesting from the beginning till the end it implicated many ideas for researches in future and improvements for integrations in business processes. IRL is a tool to determine the integration maturity and it reduces the uncertainty involved in maturing and integrating a technology into a system. SRL consists of TRL and IRL and therefore all aspects of system integrations needs be evaluated carefully.

Executing a study of utilization of IRL in the business continuity management could provide results that strengthen the bounds between business and IT (Information Technology) departments.

Developing only IRL isn’t enough, also TRL needs evaluation before the maximum benefit can be offered for private sector. This indicates that the all aspects of SRL need to be studied properly and more research is needed.

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Figures

Tables

Appendixes

Appendix 1: Glossary

AD
Active Directory is Microsoft's trademarked directory service that includes the most Windows Server operating systems as a set of processes and services.

AES
Advanced Encryption Standard is a specification for the encryption of electronic data. It is a symmetric block cipher that can encrypt and decrypt information by using cryptographic keys of 128, 192, and 256 bits in blocks of 128 bits.

BCM
Business Continuity Management is a set of processes that identifies potential impacts which threaten an organization.

BCP
Business Continuity Planning is a roadmap of strategy that is developed to continue operations and sustain the business activity under adverse conditions.

BRP
Business Resumption Planning is an overall process of ensuring company is able to function after an emergency or during a disaster event.

CM
Crisis Management is the overall coordination of an organizations response to a crisis. Its goal is to avoid or minimize damage to the organizations profitability, ability to operate or reputation.

CTE
Critical Technology Elements is a new or novel technology that acquired platform or system depends on

DCS
Data Center Services is a portfolio of solutions from Microsoft and its partners to help transform the data center into a business asset.

DoD
Department of Defense is the executive department of the government of the United States. It coordinates and supervises all agencies and functions of the government concerned directly with national security and the United States Armed Forces.

DR
Disaster Recovery consists of process, policies and procedures for recovering organization’s vital technology infrastructure after disaster.

DRP
Disaster Recovery Planning is focused on technological aspect of business continuity planning and it consists of the advance planning and preparations of business continuity in a case of disaster event.

ID
Identifier is a name that identifies a unique object or a unique class of objects and it may be for example a word, number, letter or symbol.

IEEE
Institute of Electrical and Electronics Engineers is a worldwide professional that is dedicated to advancing technological innovation and excellence.

IMM
Integration Maturity Metrics consists of five maturity levels and the implementation maturity matrix. It is used to help an organization in assessing and determining the degree of maturity of its implementation processes.

IRL
Integration Readiness Level was created to measure integration maturity of a given technology with another system.

IS
Information System is an integrated set of hardware and software components for collecting, filtering, creating, storing, and processing data.

ISO
International Organization for Standardization is an organization that promotes worldwide proprietary, industrial and commercial standards.

IT
Information Technology is the application of computers, computer networks and telecommunications equipment to store, retrieve, transmit and manipulate data.

LTD
Private Limited Company is a company that gives limited liability to its shareholders. Shareholders may not be able to sell their shares without offering them first to the other stockholders.

MCS
Microsoft Consulting Services helps organizations to deploy and adopt Microsoft technologies

MCSE
Microsoft Certified Solution Expert is the standard for IT professionals and it focuses on the ability to design and build technology solutions.

NASA
National Aeronautics and Space Administration is independent U.S. governmental agency that is responsible for aeronautics and aerospace research and for the nation's civilian space program.

FIM
Forefront Identity Manager is a state-based identity management software product from Microsoft which integrates with Active Directory and Exchange Server. It provides identity synchronization, certificate management, user password resets and user provisioning from a single interface.

GIF
Graphic Interchange Format is a bitmap image format that is compressed to reduce transfer time and it supports up to 8 bits per pixel for each image.

PERSEUS
Protection of European borders and Seas through the Intelligent Use of Surveillance is a project whose purpose is to build and demonstrate an EU maritime surveillance system.

RAM
Random Access Memory is a form of computer storage that allows information to be read and written quickly **from random locations on a memory module.**

R&D
Research & Development is a specific unit of activities and its target is to discover and create new knowledge about scientific and technological topics. Primary goal is to uncover and develop new products, processes, and services.

SCCM
System Center Service Manager is software by Microsoft to allow organizations to manage incidents, problem resolution, change control, and asset lifecycle management.

NIST
National Institute of Standards and Technology is a measurement standards laboratory that promotes and maintains measurement standards.

OSI
Open System Interconnection is a standardized model that characterizes the internal functions of a communication system by partitioning it into the layers

SRL
System Readiness Level is an aggregate measure that characterizes the progress that has been accomplished by a system under development based on the observable readiness characteristics of technology and integration elements.

TCP
Transmission Control Protocol is a network protocol that enables two hosts to establish a connection and transport data in the same order in which they were sent.

TRL
Technology Readiness Level was developed by assessing the maturity of advanced technologies so the associated risks could be effectively managed, controlled and mitigated, or retired.

SWOT
Strengths Weaknesses Opportunities & Threats are used as analysis tool, to evaluate project or business venture.

Appendix 2: Lime Survey

Testing - Integration Readiness Level

Responses collected from this survey will be used to address integration activities in a System Maturity Scale to evaluate a System.

This Integration Readiness Level (IRL) questionnaire will be filled in for each pair of interacting technologies integrated in a System or in a System of Systems. Subject matter experts or technicians of both technologies (hw/sw systems) should introduce agreed answers.

Some fields for collecting general information about technologies and industries involved will be presented. Then IRL questions (decision criteria) will be presented by nine levels, just check all that apply for each level. Your participation will be highly valuable !!

There are 22 questions in this survey

General information

Basic data about a pair of interacting technologies integrated in a specific System or System of Systems (SoS).

1 [GI0]Name of the System or SoS

Please write your answer here:

2 [GI1]First interacting technology

Please write your answer(s) here:

Hardware/software system name

Company or industry responsible

Subject matter expert (e-mail)

3 [GI2]Second interacting technology

Please write your answer(s) here:

Hardware/software system name

Company or industry responsible

Subject matter expert (e-mail)

4 [GI3]Comments and remarks

Please write your answer here:

Level 1

An **Interface** between technologies has been identified with sufficient detail to allow characterization of the relationship. This is the lowest level of integration readiness and describes the selection of a medium for integration.

5 [L1]Decision criteria

Please choose **all** that apply:

- ☐ Principal integration technologies have been identified
- ☐ Top-level functional architecture and interface points have been defined
- ☐ Availability of principal integration technologies is known and documented
- ☐ Integration concept/plan has been defined/drafted
- ☐ Integration test concept/plan has been defined/drafted
- ☐ High-level Concept of Operations and principal use cases have been defined/drafted
- ☐ Integration sequence approach/schedule has been defined/drafted
- ☐ Interface control plan has been defined/drafted
- ☐ Principal integration and test resource requirements (facilities, hardware, software,surrogates, etc.) have been defined/identified
- ☐ Integration & Test Team roles and responsibilities have been defined

6 [L1t]Comments and remarks

Please write your answer here:

Level 2

There is some level of specificity to characterize the **Interaction** (i.e. ability to influence) between technologies through their interface. Once a medium has been defined, a "signaling" method must be selected such that two integrating technologies are able to influence each other over that medium. IRL 2 represents integration proof-of-concept.

7 [L2]Decision criteria

Please choose **all** that apply:

- ☐ Principal integration technologies function as stand-alone units
- ☐ Inputs/outputs for principal integration technologies are known, characterized and documented
- ☐ Principal interface requirements for integration technologies have been defined/drafted
- ☐ Principal interface requirements specifications for integration technologies have been defined/drafted
- ☐ Principal interface risks for integration technologies have been defined/drafted
- ☐ Integration concept/plan has been updated
- ☐ Integration test concept/plan has been updated
- ☐ High-level Concept of Operations and principal use cases have been updated
- ☐ Integration sequence approach/schedule has been updated
- ☐ Interface control plan has been updated
- ☐ Integration and test resource requirements (facilities, hardware, software, surrogates, etc.) have been updated
- ☐ Long lead planning/coordination of integration and test resources have been initiated
- ☐ Integration & Test Team roles and responsibilities have been updated
- ☐ Formal integration studies have been initiated

8 [L2t]Comments and remarks

Please write your answer here:

Level 3

There is **Compatibility** (i.e. common language) between technologies to orderly and efficiently integrate and interact. IRL 3 represents the minimum required level to provide successful integration. This means that the two technologies are able to not only influence each other, but also communicate interpretable data. IRL 3 represents the first tangible step in the maturity process.

9 [L3]Decision criteria

Please choose **all** that apply:

- ☐ Preliminary Modeling & Simulation and/or analytical studies have been conducted to identify risks & assess compatibility of integration technologies
- ☐ Compatibility risks and associated mitigation strategies for integration technologies have been defined (initial draft)
- ☐ Integration test requirements have been defined (initial draft)
- ☐ High-level system interface diagrams have been completed
- ☐ Interface requirements are defined at the concept level
- ☐ Inventory of external interfaces is completed
- ☐ Data engineering units are identified and documented
- ☐ Integration concept and other planning documents have been modified/updated based on preliminary analyses

10 [L3t]Comments and remarks

Please write your answer here:

Level 4

There is sufficient detail in the **Quality and Assurance** of the integration between technologies. Many technology integration failures never progress past IRL 3, due to the assumption that if two technologies can exchange information successfully, then they are fully integrated. IRL 4 goes beyond simple data exchange and requires that the data sent is the data received and there exists a mechanism for checking it.

11 [L4]Decision criteria

Please choose **all** that apply:

- ☐ Quality Assurance plan has been completed and implemented
- ☐ Cross technology risks have been fully identified/characterized
- ☐ Modeling & Simulation has been used to simulate some interfaces between components
- ☐ Formal system architecture development is beginning to mature
- ☐ Overall system requirements for end users' application are known/baselined
- ☐ Systems Integration Laboratory/Software test-bed tests using available integration technologies have been completed with favorable outcomes
- ☐ Low fidelity technology "system" integration and engineering has been completed and tested in a lab environment
- ☐ Concept of Operations, use cases and Integration requirements are completely defined
- ☐ Analysis of internal interface requirements is completed
- ☐ Data transport method(s) and specifications have been defined
- ☐ A rigorous requirements inspection process has been implemented

12 [L4t]Comments and remarks

Please write your answer here:

Level 5

There is sufficient **Control** between technologies necessary to establish, manage, and terminate the integration. IRL 5 denotes the ability of one or more of the integrating technologies to control the integration itself; this includes establishing, maintaining, and terminating.

13 [L5]Decision criteria

Please choose **all** that apply:

- ☐ An Interface Control Plan has been implemented (i.e., Interface Control Document created, Interface Control Working Group formed, etc.)
- ☐ Integration risk assessments are ongoing
- ☐ Integration risk mitigation strategies are being implemented & risks retired
- ☐ System interface requirements specification has been drafted
- ☐ External interfaces are well defined (e.g., source, data formats, structure, content, method of support, etc.)
- ☐ Functionality of integrated configuration items (modules/functions/assemblies) has been successfully demonstrated in a laboratory/synthetic environment
- ☐ The Systems Engineering Management Plan addresses integration and the associated interfaces
- ☐ Integration test metrics for end-to-end testing have been defined
- ☐ Integration technology data has been successfully modeled and simulation

14 [L5t]Comments and remarks

Please write your answer here:

Level 6

The integrating technologies can **Accept, Translate, and Structure Information** for its intended application. IRL 6 is the highest technical level to be achieved, it includes the ability to not only control integration, but specify what information to exchange, unit labels to specify what the information is, and the ability to translate from a foreign data structure to a local one.

15 [L6]Decision criteria

Please choose **all** that apply:

- ☐ Cross technology issue measurement and performance characteristic validations completed
- ☐ Software components (operating system, middleware, applications) loaded onto subassemblies
- ☐ Individual modules tested to verify that the module components (functions) work together
- ☐ Interface control process and document have stabilized
- ☐ Integrated system demonstrations have been successfully completed
- ☐ Logistics systems are in place to support Integration
- ☐ Test environment readiness assessment completed successfully
- ☐ Data transmission tests completed successfully

16 [L6t]Comments and remarks

Please write your answer here:

Level 7

The integration of technologies has been **Verified and Validated** and acquisition/insertion decision can be made. IRL 7 represents a significant step beyond IRL 6; the integration has to work from a technical perspective, but also from a requirements perspective. IRL 7 represents the integration meeting requirements such as performance, throughput, and reliability.

17 [L7]Decision criteria

Please choose **all** that apply:

- ☐ End-to-end Functionality of Systems Integration has been successfully demonstrated
- ☐ Each system/software interface tested individually under stressed and anomalous conditions
- ☐ Fully integrated prototype demonstrated in actual or simulated operational environment
- ☐ Information control data content verified in system
- ☐ Interface, Data, and Functional Verification
- ☐ Corrective actions planned and implemented

18 [L7t]Comments and remarks

Please write your answer here:

Level 8

Actual integration completed and **Mission Qualified** through test and demonstration, in the system environment. IRL 8 represents not only the integration meeting requirements, but also a system-level demonstration in the relevant environment. This will reveal any unknown bugs/defect that could not be discovered until the interaction of the two integrating technologies was observed in the system environment.

19 [L8]Decision criteria

Please choose **all** that apply:

- ☐ All integrated systems able to meet overall system requirements in an operational environment
- ☐ System interfaces qualified and functioning correctly in an operational environment
- ☐ Integration testing closed out with test results, anomalies, deficiencies, and corrective actions documented
- ☐ Components are form, fit, and function compatible with operational system
- ☐ System is form, fit, and function design for intended application and operational environment
- ☐ Interface control process has been completed/closed-out
- ☐ Final architecture diagrams have been submitted
- ☐ Effectiveness of corrective actions taken to close-out principal design requirments has been demonstrated
- ☐ Data transmission errors are known, characterized and recorded
- ☐ Data links are being effectively managed and process improvements have been initiated

20 [L8t]Comments and remarks

Please write your answer here:

Level 9

Integration is **Mission Proven** through successful mission operations. IRL 9 represents the integrated technologies being used in the system environment successfully. In order for a technology to move to TRL 9 it must first be integrated into the system, and then proven in the relevant environment, so attempting to move to IRL 9 also implies maturing the component technology to TRL 9.

21 [L9]Decision criteria

Please choose **all** that apply:

☐ Fully integrated system has demonstrated operational effectiveness and suitability in its intended or a representative operational environment

☐ Interface failures/failure rates have been fully characterized and are consistent with user requirements

☐ Lifecycle costs are consistent with user requirements and lifecycle cost improvement initiatives have been initiated

22 [L9t]Comments and remarks

Please write your answer here:

Appendix 3: Answers

Level	J.P.	M.H.	T.T
9	All there are quite much valid. Most important question is Lifecycle costs are consistent with user requirements and lifecycle cost improvement initiatives have been initiated	I didn't choose any of these questions because normally in these kind of system integration projects, are having project team that gives the decision criteria that needs to accepted that what are the major outcomes of project that needs to be fulfilled before project. won't provide any of those meanings that	All are valid
8	All integrated systems able to meet overall system requirements in an operational environment should done earlier in level 7. Components are form, fit, and function compatible with operational system I left out because the answer for that is actually already included in integration test phase. Same goes with: Interface control process has been completed/closed-out Data transmission errors are known, characterized and recorded should be also included for integration testing.	3 of them is valid: All integrated systems able to meet overall system requirements in an operational environment System interfaces qualified and functioning correctly in an operational environment is almost same one than the first one. Final architecture diagrams have been submitted. I choose these three ones after quick reading. Other ones are somehow however too wide tasks because I would really like to keep focus on what I can do. So in Mission qualified perspective I would like to have decision criteria that has it been qualified to have yes or no options. I cannot think of create on independent task on based on these components what should be done.	All of these are valid.
7	Four of six are valid. Not valid ones are: Each system/software interface tested individually under stressed and anomalous conditions should be done at level 6 when we do more detailed testing when we are doing end to end testing. End-to-end Functionality of Systems Integration has been successfully demonstrated should be done earlier.	Each system/software interface tested individually under stressed and anomalous conditions is not valid because it is very hard nowadays to tell which is still enough rich level for this destressed and anomalous conditions. So it is very hard to describe. Fully integrated prototype demonstrated in actual or simulated operational environment in our IT world it Is very hard and almost impossible to create simulated operational environment with all	All of these points are valid

		of those environment variables that are needed on that environment. Example network access management, certificates, different kind of firewalls, different kind of network environments, different kind of databases and structured systems therefore I never want to create simulated operational environment because we cannot provide that.	
6	Others are valid but: Cross technology issue measurement and performance characteristic validations completed because that should be solved actually earlier in level 4 or 5 when we have studied integration technologies. Software components (operating system, middleware, applications) loaded onto subassemblies should be done earlier in level 5 when testing and simulations are done. Logistics systems are in place to support Integration is not valid action.	6 of 8 are valid ones. Those that are not, are: Interface control process and document have stabilized because in our IT environment, interfaces are as they are. You slightly have small option to modify or tailor them but is best practice nowadays to not to modify so much the interface. Integrated system demonstrations have been successfully completed. In our integrated systems demonstrations have already been done before we even start using interface because system that we are building up has been defined from applications and service provided guidelines	Individual modules tested to verify that the module components (functions) work together is the most relevant point. But also Data transmission tests completed successfully is important.
5	An Interface Control Plan has been implemented (i.e., Interface Control Document created, Interface Control Working Group formed, etc.) If we are using out of the box solution, it already exists on that tool. Integration risk assessments are ongoing should be done already at level 3 and should be monitored and updated all the time. System interface requirements specification has been drafted. That should be done already earlier, actually in level four. External interfaces are well defined (e.g., source, data formats, structure, content, method of support,etc.) Should also be done in level four.	An Interface Control Plan has been implemented (i.e., Interface Control Document created, Interface Control Working Group formed, etc.) In our It world we normally have already readymade control interfaces and we have already readymade operation guidelines put to modified or use them. Yes it has been implemented, it has been created and yes there is already readymade transformed guidelines how we can test, modify or use them. System interface requirements specification has been drafted. Yes in our work, example; Microsoft or Linux, IBM work, test requirements are already defined before we start to use the system because the system is standardized for providing interface what we are going to use.	All are valid and it is important to have all tests completed.

	Functionality of integrated configuration items (modules/functions/assemblies) has been successfully demonstrated in a laboratory/synthetic environment should be tested and verified that everything is actually working as they should be.	Functionality of integrated configuration items (modules/functions/assemblies) has been successfully demonstrated in a laboratory/synthetic environment. This is the first test lab environment that normally has been built before we start to integrate the system.	
4	Modeling & Simulation has been used to simulate some interfaces between components Cross technology risks have been fully identified/characterized us also important if different kind of software components are used.	Quality Assurance plan has been completed and implemented is valid, Formal system architecture development is beginning to mature is also valid. Systems Integration Laboratory/Software test-bed tests using available integration technologies have been completed with favorable outcomes – yes without that you cannot continued. Low fidelity technology "system" integration and engineering has been completed and tested in a lab environment I also agree with that but there some other things to look closer: Cross technology risks have been fully identified/characterized. In our business environment you can't never do that because if changing databases, if changing monthly basis are depending on are those major applications service providers not changing the functionalities of those technologies. If you are independent technology provider, you still have to rely on 3-4 major big technology providers so you can never say that they have been fully identified because functionalities behind solutions might be changing side 3-6 months. Overall system requirements for end users' application are known/baselined at this phase you should have some kind of description what you are going to provide example for end user application but still it go to be grown or minimized in the way as you are taking the environment in operational use. So yes you might have overall requirements but	All are valid but there is one that is most important and that is: Cross technology risks have been fully identified/characterized

		you still need to leave door open that customer or end user would like to add more functional services. A rigorous requirements inspection process has been implemented I would not like to add so much time and effort on for this task in this level.	
3	Valid ones are: Preliminary Modeling & Simulation and/or analytical studies have been conducted to identify risks & assess compatibility of integration technologies. It could give output for the next question about Compatibility risks and associated mitigation strategies for integration technologies have been defined(initial draft) High-level system interface diagrams have been completed Inventory of external interfaces is completed Data engineering units are identified and documented	Integration test requirements have been defined (initial draft). High-level system interface diagrams have been completed. Interface requirements are defined at the concept level	Compatibility risks and associated mitigation strategies for integration technologies have been defined (initial draft). Data engineering units are identified and documented. All points are valid but not that important than mentioned ones
2	All of the key points are quite much valid but the most valid key point is “Formal integration studies have been initiated” because if you leave something out of the forma study you need to update all the documents later on. Study will give more focused output of the questions and that’s why it is point number 1.	Most valid key points are: Principal integration technologies function as stand-alone units because if anyone of these functionalities is not working as it should be as stand alone unit, the system would crash. Inputs/outputs for principal integration technologies are known, characterized and documented. Principal interface requirements for integration technologies have been defined/drafted. High-level Concept of Operations and principal use cases have been updated. Others could be used but are they so relevant in this phase? They take quite much time and effort. But what I don’t know: are they useful in this phase.	The most important is: Inputs/outputs for principal integration technologies are known, characterized and documented. Others are useful and valid but not so important.
1	I choose: Interface control plan has been defined/drafted because when you are using out of the box integration tools you usually have them normally ticked ready. Nowadays quite many softwares are offering integration interfaces and tools framework as out of the box solution.	Top-level functional architecture and interface points have been defined Is the most relevant point but also the Principal integration technologies have been identified is important.	All are valid and some of them are really relevant.