SCALES Final Project Report WP-E

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Abstract

The final report of the SCALES project provides a publishable summary of the results. In addition, it lists all deliverables, dissemination activities, eligible costs, deviations, bills and lessons learned.

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Publishable Summary

Traditionally, most safety indicators and metrics are related to deviations, failures or "after the fact" information. The progressive improvement of safety methods relying on these indicators has certainly contributed to the excellent safety score of aviation since the seventies of the last century. Today's systems and organisations must, however, function in rapidly changing environments where there can be a great deal of uncertainty. Under such conditions the main challenge is to find indicators that allow an organisation to act before something happens. Therefore, it is necessary to expand the scope of safety monitoring to make explicit the operational and organization picture regarding how the system operates under several constrains and adapts.

Resilience engineering is expected to complement these traditional approaches aiming to improve the ability of the system to continue operations under expected and unexpected situations. Safety is not seen as a competition with the core productivity business. On the contrary, safety is seen as an integrated part of the production processes. Enterprise architecture principles facilitate an effective modelling of system of systems, roles, functions and procedures within and across organizations. SCALES addresses the research question: ***What added value can the combination of Enterprise Architecture (EA) with Resilience Engineering (RE) bring to measure the resilience potential of the ATM system?*** Thus, the overall objective of the project objective is to identify indicators as early warnings signs and as measures to quantify the potential for the resilience of the ATM system. The purpose of the indicators is to provide actionable information to keep the system under control in case of small and catastrophic perturbations demonstrating practical benefits in specific real ATM cases.

The SCALES project has the following innovation and research objectives:

- Innovate the state-of-the art in RE with a SCALES Framework that combines principles from Enterprise Architecture EA with principles from RE.
  Indicator of achievement: This objective has been achieved with a SCALES Framework prototype that combines EA and RE principles.

- Define and develop SCALES Framework based on EA tailored to the ATM, integrated with a questionnaire addressing resilience abilities (monitor, anticipate, respond and learn) and properties (buffering capacity, flexibility and cross-scale interactions).
  Indicator of achievement: The objective is achieved through the definition of a tailored framework to the ATM and a new integrated resilience view with guidelines for future potential applications.

- Allow validation and monitoring of resilience in realistic case studies representing highly relevant technical and operational functions and typical for future ATM infrastructure.
  Indicator of achievement: During the project the framework has been validated using a representative set of case studies. The final version of the SCALES Framework contains these four case studies represented using the SCALES Framework approach.

- Promote and contribute to open European ATM enterprise architectures and resilience analyses showing how technical, social and regulatory aspects cannot be considered in isolation.
  Indicator of achievement: The SCALES Framework has been aligned with the European ATM Architecture (EATMA) and includes organizational, technical and operational aspects in different viewpoint to supporting the analysis of operations in context.

- Disseminate the results effectively within SESAR and the scientific community, and promote their future application through knowledge transfer towards industry and service providers. The SCALES Framework will be delivered as a web tool with open access to all potential users.
  Indicator of achievement: All SCALES technical deliverables and framework are delivered as "public" available for future use with a licence that facilitates use beyond the lifetime of the project.

The SCALES research approach follows a research process where product development, testing and gathering potential user´s feedback is iterated into several cycles. This cyclic research process builds on insights generated through the investigation of a field of work that are translated into concepts about what is useful for operators (what makes systems work). These concepts, in conjunction with other sources of knowledge, guide the development of tools to support the work investigated. The outcome of this process is a conceptual or functional prototype called the SCALES Framework that can be introduced to operators and evaluated in order to generate a new iteration of the research cycle. Through its fundamentally cyclical nature, the approach constitutes a discovery process in which understanding and developments are hypotheses about what would be useful, and aim at being revisited and potentially revised. In the implementation of this research approach, we consulted external operational experts and conducted interviews and observations during the development of the initial versions of the framework in order to verify that our conceptual structures were sound and to gain additional insights into the operational environments we sought to capture in our EA models. Once the framework reached a certain level of maturity we implemented the framework in a set of case studies from the ATM domain. The case studies helped us to establish a set of detailed models capturing real events that covered different aspects of ATM. A series of workshops with operational experts were held to validate the development activates at different stages and the result from these was a refinement in the framework before the next iteration.

The work reflects on knowledge and interactions from different stakeholders of the air transport system (regulators, airlines, ANSPs, operators, airport). The EA contextualises a system of interest, its combination with Resilience Engineering and forms together with Resilience Engineering theories the SCALES Framework. Moreover, SCALES is supported by a web application developed by the project team showing how resilience related indicators could be identified. It relates to successful and unsuccessful ATC contributions using different viewpoints of a system. The web application is developed as semantic wiki. Guidance is included to safety practitioners for identifying resilience related indicators and using the SCALES Framework for analysis and as basis for decision making.

The SCALES Framework provides a system of systems approach modelling of interactions within and across organizations. The integration of the Resilience Engineering analysis supports the illustration of adaptations necessary for the ATM system to continue operations. We find the use of EA helpful as it helps to shift perspectives in the analysis. The SCALES Framework and associated web application are initially proposed as arena for identification and contextualization of resilience related indicators.

Through different iterations the development and intermediate results have been validated throughout with safety, resilience engineering academics and practitioners from various domains (aviation, oil and gas, nuclear and railway representatives) and levels. They have through validation activities; workshops, observations and interviews provided constructive feedback advice to our iteratively driven development. The final version of the SCALES Framework and main results include a set of architectural views of the Enterprise Architecture, a set of generic guidelines describing how the SCALES Framework can be applied, and a web application that implements the views and guidelines so that they can be applied in a practical setting.

Main results and innovations of the framework:

- One modelling tool prototype with a set of generic guidelines showing how resilience related indicators can be identified using different viewpoints. This prototype is developed as semantic wiki to further support the analysis of the system from different perspectives including organizational, human and technological aspects. It represents an advancement in theory as RE and RE provide confidence of the representativeness of the indicators as they are related to specific realistic operations.

- A new resilience viewpoint integrated in the modelling prototype connecting resilience theoretical concepts into practical application. It combines resilience abilities to monitor, anticipate, respond and learn from changes, as well as to, more concrete resilience engineering themes such as flexibility, cross-scale and cascades. This represents advancements on practical representations for resilience analysis.

- Application of the SCALES Framework to four cases integrated in the tool. These cases can be used as examples demonstrating how to use the tool. This promotes and facilitates utilization of architectural representation connecting design and operations.

As a conclusion, the SCALES consortium has developed a prototype for identification of resilience indicators. The SCALES application is still at speculative stage as there is limited analysis to support the findings (through validation workshops and experts consultations). More applications by outsiders to the project are required as supporting evidence. Therefore the outcome of the project can be seen as TRL2. The combination of EA and RE is valuable as it contextualise the indicators for specific operations. ATM system designers, safety manager and researchers can use the framework as foundation for identification of resilience related indicators. While the framework and most of the concepts are operationalized to the ATM domain, all viewpoints can be source of inspiration and to be adapted to other safety critical domains.

The experience and developments achieved during the project indicate a number of needs for further research:

- More cases are required and use of the proposed set of indicators as way to monitor and manage resilient performance

- Further developments can be proposed to enhance the proposed framework for example concerning assessment of the indicators

- Combination of the proposed approach and safety energy concept proposed within Resilience Engineering in terms on setting priorities on what to monitor and managing trade-offs while monitoring

- Use the propose framework to monitor everyday operations as way to prioritise indicators in an specific context

- Combine the proposed framework and weak signals initiative as way to early identify problems and opportunities

Further research is clearly needed to strength the use of methods to monitor as means to improve resilient performance.

1 Introduction

1.1 Purpose of the document

The purpose of this document is to:

- Summarise the technical results and conclusions of the project (Publishable Summary);

- Provide a complete overview of all deliverables;

- Provide a complete overview of all dissemination activities (past and in progress). Where appropriate, provide feedback from presentations. Describe exploitation plans.

- Provide a complete overview of the billing status, eligible costs, planned and actual effort (incl. an explanation of the discrepancies).

- Analyse the lessons learnt at project level.

1.2 Intended readership

The intended readers of this report are SJU, safety managers, safety practitioners and RE researchers. While the focus is on ATM, since our case studies have been taken from that domain, SCALES can also be useful to other safety critical domains. For these readers the document provides guidelines for use and application of SCALES Framework.

1.3 Inputs from other projects

The SCALES project developments have used inputs from and aim to provide a contribution to the following external initiatives:

Table 1: SCALES relation to other projects

Project	Input to SCALES
EATMA	The SCALES Framework has applied ATM knowledge from the EATMA portal and architecture [1]. This is primarily related to roles and functional descriptions from ATM.
SESAR P16.01.02	This SESAR project has developed the Resilience principles used in the Resilience View of the SCALES Framework. These resilience principles are described in [2].
SESAR ATM Information Reference Model (AIRM)	Information models from the SESAR ATM Information Reference Model (AIRM) [3] are used to populate the Information Viewpoint of the SCALES Framework.
Skybrary	Skybrary [4] is a wiki with extensive material on ATM. This includes investigation reports and incident analyses and description of technical systems as well as procedures related to ATM. In SCALES we have employed Skybrary (together with EATMA) to strengthen our understanding of the ATM domain.

Project	Input to SCALES
Other projects and research networks	To ensure complementariness and avoid duplication of work SCALES builds on resilience knowledge generated by other SESAR initiatives such as: • ComplexWorld (resilience definition and boundaries) [5] • HALA! SESAR Research Network (resilience analysis and modelling activity) [6] • RESILIENCE2050 (FP7 project regarding resilience quantitative approach) [7] • SPAD (WPE project regarding modelling activity of LSSTS) [8]

1.4 Glossary of terms

This list defines the terms used in this document.

Term	Definition
Enterprise Architecture	Enterprise Architecture (EA) is an architectural approach that is typically applied on complex environments or systems. The approach involves decomposing the "whole" system into more manageable perspectives that can be focused upon for different purposes, including system analysis. The term system has a wide interpretation such that the scope and focus of the architecture could be a software application, a suite of software applications or a system of numerous interrelated elements (economical, social, technological, and so on). The characteristic of such systems, regardless of their complexity, is their socio-technical nature, and EA typically prescribes a holistic approach where the technology is not isolated from the human aspect; both are treated equally important.
Go-around	A go-around is a manoeuvre for accomplishing a missed approach procedure. This procedure is followed by a pilot when an instrument approach cannot be completed to a full-stop landing [9].
Resilience	"A system is resilient if it can adjust its functioning prior to, during, or following events (changes, disturbances, and opportunities), and thereby sustain required operations under both expected and unexpected conditions." [10].
Safety & Resilience	Resilience Engineering sees safety as "the ability to succeed under varying conditions". Resilience Engineering covers developments to proactively manage the adaptive ability of the systems/organizations to function effectively and safely [11]. Performing in a resilient way is challenging even for ultra-safe domains such as ATM. Resilience Engineering points to the difference between safety and resilience, describing organisations that are resilient, but not safe, e.g. fisheries, as well as organisations that are safe, but not resilient, e.g. railways [12];[13].

Term	Definition
Safety indicator	Proxy measures for items identified as important in the underlying model(s) of safety. As such they are uncertain and often only distantly connected to the idealized measures that rarely available in practice [14].
Indicators & potential for resilience	Resilience Engineering is concerned with monitoring and managing performance at the boundaries of competence/operation under changing demands (adapted from [15]).

1.5 Acronyms and Terminology

This list includes an explanation of the acronyms used in this report.

Term	Definition
ANSP	Air Navigation Service Provider
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
EA	Enterprise Architecture
EATMA	European ATM Architecture
RE	Resilience Engineering
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)

2 Technical Project Deliverables

Number	Title	Short Description	Approval status
D1.1	SCALES preliminary specifications and guidelines	This document contains the preliminary specifications for SCALES Framework. It describes the theoretical frame of reference including relevant literature, information from other relevant projects and applications taking into account test case go around.	Approved
D1.2	SCALES initial web tool framework	This document provides a link to the initial SCALES web report. The report is preliminary version of the SCALES Framework web tool. Guidelines are included in the web report itself. Detailed guidelines for use of the web tool are part of D1.1 SCALES Preliminary Specifications and Guidelines.	Approved
D1.3	SCALES final specifications and guidelines	The report encompasses relevant literature on Resilience Engineering and Enterprise Architecture, details on the development and application of the framework, a discussion around the approach and results achieved and finally the conclusions from this work.	Approved
D1.4	SCALES final web tool framework	This document contains the final version of the combination of Enterprise Architecture and Resilience Engineering principles as a web tool prototype for SCALES project (E.02.30), SESAR WPE funded project. This document provides a link to the final version of the SCALES web tool. Guidelines are included in the web tool itself. Detailed guidelines for use of the SCALES Framework are part of D1.3 SCALES Final Specifications and Guidelines.	Submitted
D2.1	SCALES case study descriptions	This document presents the case studies that will be used within the SCALES project. It describes the go-around manoeuvre and explains how and from where the events used in the case study were selected. The document concludes describing in detail the different go-around that have been selected and that will represent the core of the case study.	Approved

Number	Title	Short Description	Approval status
D2.2	SCALES case study validation	This report describes the organisation and results of the SCALES validation activities. It starts with the identification of the elements at the basis of the SCALES Framework, and of the process for its application (that is, what has been validated). Then the report describes the also characteristics that are important for the potential users of the SCALES Framework, and that have been investigated during the validation.	Approved
D3.1	SID participation (poster)	Resilience potential and early warnings for Air Traffic Management in case of system degradation through Enterprise Architecture (SCALES) – project description	Submitted to the conference
D3.2	SID participation (scientific article)	This paper outlines the SCALES framework, its application to a concrete case and discusses preliminary findings regarding indicators and patterns.	Submitted to the conference
D3.3	SID participation (poster)	We developed a framework that supports the modeling of the ATM system through an architectural approach, the EA. The framework provides different and integrated views and prescribes how to apply them. The validation activities considered all the core elements of the framework.	Submitted to the conference

Table 2: List of project deliverables

3 Dissemination Activities

Dissemination activities in the SCALES project include actions to transfer the knowledge and prototype versions to target groups and to the public in general. It should be noted that all SCALES deliverables are public. The dissemination carried out in SCALES was mainly focussed on organisation and participation in dedicated events, technical presentations and publications as well as technical meetings under each project WP.

During the 30 months of the SCALES project several dissemination activities were carried out by the partners and are herewith reported. The main tasks were related with dissemination material development which include technical publications as well as the organisation of SCALES related events (workshop and training sessions) and participation in other relevant ones, including dedicated meeting with other EC projects and certification authorities. A project logo, templates and dissemination material were prepared. Dedicated materials have been developed for every event, namely technical training material and software SCALES demonstration which are fully supported with last issue of online version of the SCALES Framework.

Exchange with other EC projects have been achieved as Resilience2050, P16.06.01b and others such as alignment to European ATM Architecture (EATMA) and ATM Information Reference Model (AIRM). Presentations of SCALES to ANSPs such as AVINOR, NATS and LFV were provided.

The project comprised the participation in several and relevant events with publications. Three main events were organised in SCALES, the SCALES workshop in Norway, Lisbon and Rome in 2009 and 2010, respectively.

The SCALES partners have attended to several technical conferences, workshops and industrial fairs in some of which have presented technical presentations.

SCALES has achieved a quite good level of dissemination to a wide audience and geographical scope through a complete set of activities, material produced and partners fully engaged in the dissemination activities of the project.

3.1 Presentations/publications at ATM conferences/journals

Number	Activity/Event	Date	Audience	Message/Content	Channel	Feedback
1	SID 2013 SESAR Conference	2013-11-26	WP-E members and SESAR community	Project goals and structure	Poster	The idea of the SCALES Framework impressed the attendees to the poster session. Most of the questions were on the EA and how RE can be integrated in this model.
2	SCALES ATCO & PILOTS workshop	2014-10-08	SME pilot and ATCOs	Investigation of RE indicators related to Arlanda case	Workshop use of innovation games	The attendees remarked that the type of questions we explored are not studied in their organizations. In special the positive contribution to operations.
3	SID 2014 - Madrid	2014-11-27	WP-E members and SESAR community	Initial SCALES Framework - application of SCALES Framework ARLANDA case	Paper, presentation was introduction to framework and demon of the tool	Attendees very interested in the combination, relevant selection of the cases. Questions regarding how time aspects are addressed and dynamics.
4	Workshop at Luftfartskonferansen 2015 - Bodø	2015-01-28	Norwegian and international potential end users: National authorities, pilots, air traffic controllers, accident investigation board managers, technical and operational personnel	Discuss SCALES Framework and RE potential indicators. Capture interest to participate in the workshop.	Innovation game World Cafe	We actively used RE view and discuss potential indicators. Participants positive feedback on RE view

Number	Activity/Event	Date	Audience	Message/Content	Channel	Feedback
5	Presentation of SCALES Framework to P16.06.01b DEMO	2015-05-12	ANSP AUSTROCONTROL, AVINOR, LFV, NATS, IFATCA, EUROCONTROL	Intro to SCALES and DEMO on RE view and two cases	Face to face	P16.06.01b would like to see which parts of SCALES they will use in their project. Strong interest on indicators related to Resilience
6	ATACCS 2015	2015-10-01	WP-E members and SESAR community - ATM community	Present possible way to quantify resilience inspired by SCALES	Paper	Comments focused on how to find a good balance between costs and resilience improvements
7	ATACCS 2015	2015-10-01	WP-E members and SESAR community - ATM community	Workshop on "Resilience in ATM automation: a chimera or a reality?" - analytical comparison on resilience in complex socio-technical systems	DBL project members are the convenors for this event. It is a validation workshop for SCALES. It focusses on the issues of resilience *applicability and practicality*. The goal of the workshop is to bring together different European and WP-E projects (e.g. Resilience 2050, SPAD) to discuss their achievements *critically*.	Comments are related to all projects presented in the workshop: main comments regarded the limited applicability of the research results that are difficult to move from the laboratory or test case settings to systems of real complexity. Problems are related to scalability of the results and to complexity of the applications that makes their use very time consuming. Other main comments regarded the limited impact of the solutions, once these focus on practical guidelines and heuristic for process/system improvements. In such cases, there seems to be very little improvement over the state of the art, in spite of all the effort spent in research activity in resilience in recent years.

Number	Activity/Event	Date	Audience	Message/Content	Channel	Feedback
8	Workshop SCALES - Rome	2015-10-13 &14	Workshop with end user operationalization of framework - indicators related to case studies	Indicators related to four case studies	Innovation games two teams to identify indicators one using SCALES and another without SCALES	Correctness of data in SCALES view points and indicator information gathered results documented in D2.2
9	SID 2015 - Bologna	2015-12-01	WP-E members and SESAR community	Validation strategy and results	Poster	Attendees very interested in the adopted validation strategy and in the developed web-tool
10	SID 2016 – Delft	2016-11	WP-E members and SESAR community	Project results and added value	Paper	Planned publication
11	RESS or equivalent	2016	Researchers and practitioners interested in ATM	Method, findings and implications	Journal	Planned publication

Table 3: Summary of the presentations and publication to ATM audience

3.2 Presentations/publications at other conferences/journals

Number	Activity/Event	Date	Audience [e.g. scientists, domain, experts, general public, etc.]	Message/Content [main focus of the communication]	Channel [e.g. technical paper, presentation, keynote, flyer, etc.]	Feedback [feedback received, was it worth it, etc.]
1	Resilience Engineering Symposium 2014 prior to KoM	2013-07-25	RE community – scientific community and practitioners around the world most of safety critical domains represented	Project technical plan	Technical paper/presentation	Positive feedback, need to take into account dynamic and context. RE analysis & questions Use the model to derive transactions The model can be used to read between the lines Use different combinations and see things from different angles There is a need to make sense of the indicators Transactions, use EA as base for simulations and perturbations Simulations to generate scenarios, evolve to and what kind of disturbations we can manage. Problems with incident approach, an alternative is to look into work as performed/as imagine
2	Teleconference - SCALES project & Safety Science Innovation Lab	04-2015	International highly interdisciplinary group of scientists and experts: member of Sidney Dekker´s team in Australia	Discuss SCALES Framework and RE potential indicators	Teleconference	What will be the feedback from end-user on indicators? This is something SCALES would like to explore. The participant could follow-up the approach one participant from Dekker´s Lab.

Number	Activity/Event	Date	Audience [e.g. scientists, domain, experts, general public, etc.]	Message/Content [main focus of the communication]	Channel [e.g. technical paper, presentation, keynote, flyer, etc.]	Feedback [feedback received, was it worth it, etc.]
3	Scientific conference Resilience Engineering Symposium - Lisbon	2015-06-22	RE community	SCALES workshop focusing on the Resilience view and its integration in the framework	Validation workshop for collecting feedback on SCALES Framework and associated tool	Workshop data gathered and documented in D2.2 both positive and negative feedback gathered. Good participation from researchers and practitioners from different domains.
4	Scientific conference e.g. Resilience Engineering Symposium - Lisbon	2015-06-24	RE community	Results added value in relation to contribution to RE. In particular, it addresses observations as means to provide input to the framework on everyday operations	Paper	Good participation from researchers and practitioners from different domains. They were interested in the practical use of the framework and on how the theoretical lessons can be translated into concrete supporting materials for performing observations in complex socio-technical systems (e.g. ACC in ATM)
5	11th USA-Europe ATM R&D Seminar	2015-06-22	ATM community	Workshop facilitated by Ivonne Herrera SINTEF, Norway; Rogier Woltjer LiU/FOI, Sweden ; Tom Laursen IFATCA, Denmark; David Woods OSU, USA;	Plan to discuss different aspects addressing resilient systems. Innovation game Open space	Good participation on reflection on resilience themes

Table 4: Summary of the presentations and publication to other conferences and events

3.3 Web presence

A project public website has been developed and launched under HALA network as http://www.hala-sesar.net/projects/blog/scales.

All public information regarding the project objectives and progress is available there as well the information related with the dissemination activities carried out by the partners in the project. All deliverables material of public access are available at the project website as far as possible.

The SCALES Framework is also available at: http://scales.sintef9013.com/fw/

The project public website has been regularly updated indicating events during the lifetime of the project.

3.4 Demonstrations

All possibilities to demonstrate the different versions of the SCALES Framework were used as opportunities to gather feedback on the framework. Feedback is included in Section 3.2 and documented in deliverable D2.2.

Workshop #1 - Rome
Workshop 1: in October 2014, there was a **Preliminary framework validation.** The main feedback provided by the professionals was that the SCALES approach facilitated in sharing the understanding between analysts and operational experts. Their suggestions focused on increasing in level of granularity, in refining models and in identifying additional candidate resilience indicators. Participants: The participants were strategically selected and had different operational background (e.g. ATCO supervisor, safety manager, ATCO working in different ACC sectors, pilot).

Workshop #2 - Lisbon
Workshop 2: **Resilience view and web tool validation** focused on those aspects improved thanks to the experts' feedback in Workshop 1 and was conducted during the Resilience Engineering Association Symposium in June 2015. The attendees to this workshop were safety managers and resilience experts in different safety critical domains. They provided feedback regarding the initial experience with the framework which was positive and found the concept of multiple views attractive. The framework appeared applicable to other domains. However, transition between the multiple views was considered challenging and information retrieval functionality was not sufficiently supported. Their suggestions hence focused on the improvement of user interaction when using the framework.
The participants were 12 professionals from different safety critical domains with different background (e.g. Safety management, Human Factors, Academy and operational personnel). The participants were randomly divided in 3 groups composed by 4 professionals in each group supervised by a SCALES member.

Workshop #3 - Toulouse
Workshop 3: **SCALES achievements validation** in September 2014 gave the opportunity to compare the preliminary projects achievements with other SESAR and European projects regarding the same topic. The attendees were safety managers and researchers, security experts in the ATM domain. They provided feedback regarding SCALES preliminary achievements, as well as the other projects, which seemed to be difficult to move from the laboratory to systems of real complexity. Problems are related to scalability of the results and to complexity of the applications that makes their use very time consuming. For these reasons they suggested to focus on practical guidelines and heuristic methods for process/system improvements.
The workshop attended by 48 participants with different background, from scientific to operational.

Workshop #4 - Rome
Workshop 4: The **SCALES final validation** in October 2014 focused on the whole framework and its applicability. Once again, the aim was to actively involve operational personnel for collecting feedback from their operative and daily experience. They appreciated the top-down, bottom-up approach of the framework, representation of interactions within and across units. The improved framework supported analysts´ understanding of system characteristics important for resilience. The WS provided some suggestions regarding the future work including refinements of resilience indicators and better description of process required to apply the SCALES Framework. The six high-level professionals attendees were safety managers, Human Factor experts and ATCOs in the ATM domain.

Table 5: Demonstrations through workshops

3.5 Exploitation plans

This indicates how the partners, as a consortium or as separates organizations, intend to use the results of the SCALES work, the intellectual property rights situations, and all other information relevant to exploitation and follow-up work.

Research and development: The consortium partners belonging to this group include SINTEF, and DBL. They target the academic world with educational activities, and industry and public administration with their applied research.

- Publications: One of the main metrics for research partners is scientific publications, and by publishing scientific results in high ranked conferences and journals their position as leading research partners will be strengthened. As mentioned in the dissemination section, two final publications of SCALES are previewed to take place a journal to be proposed for the recognised journal of Reliability Engineering and System Safety (RESS). The RESS is one of the journal with highest impact and most widely high quality spread research within safety and reliability. A second publication is foreseen as form of paper for SESAR Innovation days 2016

- Educational activities: SCALES contributed to enhance knowledge in the area of resilience related indicators. The results will be implemented into the curricula for students in different lectures (masters level in Safety Management at Norwegian University of Science and Technology where the Project Coordinator teach). Additionally, training material will be offered for different user groups (management level, practitioners, etc.), as well as specialised seminars and ATM structures and institutions.

- New business: SCALES project has been used as reference project for future projects e.g. DARWIN (Expect the unexpected and know how to respond) H2020 research and innovation project and PACAS (Participatory Architectural Change management in ATM Systems) SESAR 2020 Exploratory Research project, results and lessons learnt from SCALES are intended to be incorporated.

- Future projects: Results and know-how from SCALES will be exploited within new national and international projects, as well as contract based projects from industry.

Leadership and innovation: A series of games and techniques for managing innovation have been used during the complete project. Innovation is essential to motivate people to collaborate, experiment and integrate ideas. SINTEF will continue managing collective creativity through collaborative problem solving, discovery driven learning and integrative decision making as experimented and evolved during the SCALES project.

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4 Total Eligible Costs

Date	Deliverables on Bill	Contribution for Effort	Contribution for Other Costs (specify)	Status
15-09-2014	D0.0; D3.1; D0.2; D1.1; D1.2 D0.3	224623 EUR	10056,64 (Other direct cost reported CBF); total bill 234,679.64 EUR	Paid
11-12-2014	D0.4; D2.1	114898 EUR	4680,61 (Other direct cost reported CBF); total bill 119,603,50 EUR	Paid
10-11-2015	D0.5; D3.2; D0.6; D0.7; D2.2	88489 EUR	10 691,50 (Other direct cost reported CBF); total bill 99,180,50 EUR	Paid
In process	D0.8; D0.9; D3.3; D1.3; D1.4; D3.4*; D0.10	127 574 EUR	4 181,81 (Other direct cost reported CBF); total bill 131 755,52 EUR	Not billed
GRAND TOTAL		555.609 EUR (Effort)	29 610 (Other direct costs CBFs): total bills contribution 585 219,16 EUR	

Table 6 Overview of billing

Company	Planned person-days	Actual person-days	Total Cost	Total Contribution	Reason for Deviation
SINTEF	353**	414	501 167 ,37	375 875,52	Person hours cost EURO rate changed during the project life time, we had personal involved with different costs than originally planned. Additional semantic wiki develop to complement the EA architecture.
Deep Blue Srl	506**	506	279 124,85	209 343,64	
GRAND TOTAL			780 292,22	585 219,16	

Table 7: Overview of effort and costs per project participant
* D3.4 overview over dissemination activities included in D0.10 as agreed with Project Officer
**Update person days transferring from D2.2: 7 person days for SINTEF and 14 person days for Deep Blue to transfer to travel budget

5 Project Lessons Learnt

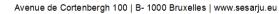| What worked well? |
|---|
| Open and transparent collaboration between partners |
| Use of innovation management and innovation games along the project to create an environment where diverse and conflicting ideas are explored |
| Run experiments (learn through trial and error) during workshop as means to create solution together with end users. |
| Change direction to find best direction forward when a solution is not providing optimal results e.g. EA complemented with semantic wiki |
| Creative resolution rather than top-down decisions in the project integrate disparate and even opposing ideas into an improved solution |
| **What should be improved?** |
| Towards the end too many parallel activities at the end of 2015 hampering publication in relevant journals |
| Consortium should include end-user. |
| More experiments and possibility to face-to-face interaction given the multidisciplinary need for the project |

Table 8: Project lessons learnt

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