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Title High Level Requirements Specification for SOSE Research



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Approved by This draft report is approved for release outside of the T-AREA-SoS project or European Commission



Summary The report describes the high-level requirements specification for systems of systems engineering research.



High-Level Requirements Specification for Systems of Systems Engineering Strategic Research Agenda

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1 INTRODUCTION

This report describes the high-level requirements specification for systems of systems engineering research. The purpose of this document is to provide a specification of high-level requirements that the consortium shall use to produce the T-AREA-SOS research agenda. The requirements are traceable to gaps and capabilities that are described in the Gap Analysis document, D3.1 (TAREA-PU-WP3-D-BU-12, V1 Sept 2012) (Henshaw et al. 2012). The high-level requirements were developed over the course of 12 months that included one workshop in Brussels, two panel sessions at INCOSE 2012 and SOSE2012, numerous group editing activities by the consortium members, analysis of the State of the Art Report (Deliverable D2.1) (Barot et al. 2012), the Gap Analysis Report (Deliverable D3.1) (Henshaw et al. 2012) and a survey of SoSE experts. The intent of this document is to provide a set of inter-related, high-level requirements for developing future European SoSE research and development agenda. Because of the inherent nature of the SoS arena, these requirements are necessarily interrelated.

For each of the gaps and capabilities described in D3.1, Table 3 (repeated below in section 3.2), this document identifies the initial set of high-level requirements for the development, evolution, maintenance and delivery of the agenda. This is a living document and the high-level requirements will be refined and improved as the T-AREA-SOS project progresses and further workshops are held with members of the expert community and other key stakeholders.

The document is structured into 5 main sections: the introductory section is followed by a section on the stakeholders consulted; section 3 provides an overview and initial structure for the requirements and also describes dependencies established to date between the requirements; section 4 provides the detail of the requirements identified to date and section 5 a brief conclusion to the report.

2 STAKEHOLDERS

There is a wealth of information in the literature about stakeholders and stakeholder management. The reader is directed to a paper by Achterkamp & Vos (2008) which provides an excellent overview of stakeholder categorization and management. An exemplar extract is provided below:

Freeman's definition stating that "...a stakeholder in an organisation is any group or individual who can affect or is affected by the achievement of the organisation's objectives..." [4, p. 46] takes a "landmark" position in stakeholder theory [5], [6], [7] and [8]. In the literature, this definition is usually cited as a starting point to give a more narrow view on stakeholders, in which finer-grained categorisations than "can affect" and "affected" are described. Just a few examples of these categorisations are stakeholders who have "potential for collaboration" and stakeholders who have "potential for threatening" [9], "fiduciary and non-fiduciary" stakeholders [10], "primary and secondary" stakeholders [6], "voluntary and involuntary" stakeholders (Clarkson, cited in [11]), or "actively and passively involved" stakeholders [12].

The T-AREA project intends to use the primary, secondary, tertiary grouping to categorise their stakeholders, recognizing that as the Strategic Research Agenda develops the categorization or allocation of Stakeholders to the various categories may change. The type and numbers of stakeholders consulted to date is described in detail in the Gap Analysis document, D3.1 (TAREA-PU-WP3-D-BU-12, V1 Sept 2012). A summary is provided below:

PRIMARY STAKEHOLDERS

- EU Commission
- Expert Community
 - Industry representatives
 - Academia

SECONDARY STAKEHOLDERS

- Funding bodies
 - National
 - International

TERTIARY STAKEHOLDERS

- SoS Developers
- Sos Operators
- SoS Users

The project used a variety of techniques to elicit user needs which have been translated into the high level requirements specification provided in this document: semi-structured interviews, questionnaires, case studies, state of the art review and workshops.

3 OVERVIEW OF HIGH LEVEL REQUIREMENTS SPECIFICATION

The T-AREA project has taken the view that the final finished system to be developed could be tagged as follows:

Establishment and Promotion of SoSE Strategic Research Agenda

For which the Operational Requirement could be stated as:

The system shall identify gaps in current research in Systems of Systems Engineering to be translated into clearly identified research programmes for implementation by the EU Commission (and other funding sources)

Both of the above are subject to revision as the T-AREA project progresses. For this version of the Requirements Specification, the focus is the development of the Strategic Research Agenda, which is a key component of the *SoSE Strategic Research Implementation System*.

Each of the requirements to date have been structured as indicated in Table 1 below:

Requirement No.	A unique ID
Description	A one-sentence statement describing the requirement.
Type	Categorisation of the type of the requirement, [as initially indicated in Figure 1 below]
Rationale	A justification of the requirement.
Gap	The capability gap from which the requirement was adduced. (based on the numbering in Table 3 Target Capabilities and Gaps in in Deliverable D3.1, repeated below in Table 2)
Satisfaction Measure	A criterion for meeting the requirement.
Dependency	A list of other requirements on which this requirement depends.

Table 1: Template for Structuring T-AREA-SOS High-Level Requirements

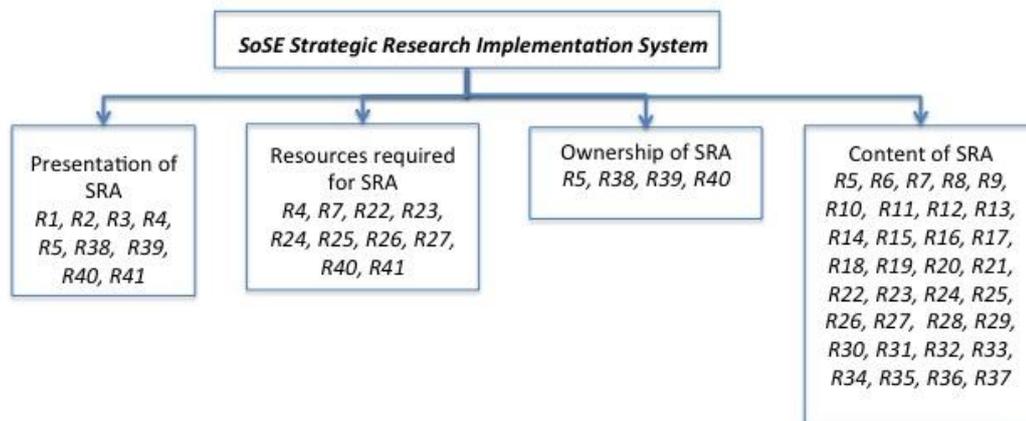


Figure 1: Categorisation of Type of High Level Requirements for the SOSE Strategic Research Implementation System

For ease of reference for the reader Table 3 from the Gap Analysis document, D3.1 (TAREA-PU-WP3-D-BU-12, V1 Sept 2012) is repeated below and labelled as Table 2 in this document, where the capabilities listed are those considered to-be ‘gaps’ in this requirements document and hence the high level requirements address these ‘gaps’. Please note that only level 2 capabilities are included in this repeated table as these are at a

level appropriate for the strategic agenda. Section 4 represents the translation from these gaps to the high-level requirements through the workshops, etc. as outlined above.

Level 2			
Ref	Capability	Parent(s)	Children
2-01	Agility through reconfiguration in dynamic SoS	1-01 1-02	3-01; 3-03; 3-04; 3-11
2-02	V&V for dynamic SoS	1-01 1-03	3-01
2-03	Prediction and analysis of emergent behaviour	1-01	3-11
2-04	SoS Measurement	1-01 1-02 1-03	3-01; 3-03; 3-07
2-05	Integration of corporate and engineering governance for enterprise SoS	1-02	3-03; 3-04; 3-16
2-06	Evolution and migration of legacy systems	1-03	3-01; 3-05; 3-06; 3-11; 3-12; 3-13
2-07	Modelling & Simulation for SoS	1-01 1-02 1-03	3-01; 3-02; 3-07
2-08	Dynamic composition of SoS	1-01 1-02	3-01; 3-03; 3-04; 3-11; 3-16
2-09	Prototyping SoS	1-01 1-02 1-03	3-13
2-10	Secure SoS implementations	1-01 1-02	3-01; 3-03; 3-08; 3-09; 3-10; 3-14
2-11	Economic resilience	1-01	3-03; 3-12
2-12	Assuredly safe SoS implementations	1-01 1-02 1-03	3-01; 3-03; 3-14; 3-15

Table 2: Capability gaps in developing and operating SoS, taken from the Gap Analysis report. The word, ‘gap’ should be interpreted as ‘more knowledge is required regarding concepts, models, techniques and metrics’.

4 DESCRIPTION OF REQUIREMENTS

The requirements, developed from the gaps in Table 2 above, are conveniently structured into the following categories, created during the workshops:

1. Research collaboration
2. Validation and verification
3. Datasets
4. Method development
5. Patterns, metrics and ontologies

6. Reuse and retirement
7. Safety
8. Governance
9. Stakeholder and requirements management
10. Engagement and awareness
11. Strategy and research themes for SoSE

4.1 Research collaboration

These requirements are concerned with research collaboration that SoS researchers should conduct with researchers from other fields and the industry.

Requirement No.	R1 Researchers
Description	The strategic research agenda shall encourage the collaboration between systems of systems engineering researchers (in academia, public sector and industry), researchers from different fields, such as law, economics, business management, industrial systems, healthcare, politics, psychology, human-systems interaction and regulatory bodies.
Type	Presentation of the agenda
Rationale	Systems of Systems Engineering is a multi-disciplinary field of considerable complexity.
Gap	All gaps.
Satisfaction Measure	A sustainable multi-disciplinary international community of experts is set up.
Dependency	None.

Requirement No.	R2 Industries
Description	The strategic research agenda shall encourage SoS researchers to work closely with the industries in which SoS are found in order to understand the needs and complexities of real world problems and to ensure that their research is validated in real case studies.
Type	Presentation of agenda
Rationale	Systems of Systems Engineering is a young discipline addressing very complex systems in society, and comprehensive, well-established knowledge is required if SoS are to continue to deliver benefits without serious side effects.
Gap	All gaps 2-01 to 2-12
Satisfaction Measure	Representative case studies that demonstrate the unique characteristics of system-of-systems and can form the basis of further knowledge capture and dissemination.
Dependency	None.

Requirement No.	R3 Complex systems
Description	The strategic research agenda shall encourage SoS researchers and practitioners to collaborate with the field of complex systems analysis in the study of emergent and adaptive behaviours of SoS, and the consequences of these.
Type	Presentation of agenda, Content

Rationale	Systems of systems engineers can learn from complex systems practitioners.
Gap	Gaps 2-01, 2-02, 2-04, 2-05, 2-07, 2-08, 2-10, 2-11, 2-12
Satisfaction Measure	Generalised complex systems analytical tools and techniques are developed, validated and are used within the SoS community.
Dependency	None.

Requirement No.	R4 Simulation
Description	The strategic research agenda shall encourage SoS engineers to exploit simulation knowledge and techniques that are used in other fields that deal with complexity such as physics, biological and chemical sciences.
Type	Presentation of agenda, resources
Rationale	The simulation of complex systems has become the focus in biological sciences, chemical sciences, and physics. Systems of systems engineering can learn from these fields.
Gap	Gaps 2-02, 2-03, 2-04, 2-07, 2-08, 2-09, 2-12
Satisfaction Measure	Cross-domain collaborations are established; common simulation techniques and knowledge are established.
Dependency	R22 Ontologies.

Requirement No.	R5 Stakeholders
Description	The strategic research agenda shall emphasise that SoS involve diverse sets of stakeholders, and that many of the techniques involved in the full SoS lifecycle may be relatively new and may contradict conventional engineering and management wisdom, and therefore that SoS researchers should work with researchers from other disciplines such as the social sciences to improve acceptance.
Type	Ownership, Content, Presentation of agenda
Rationale	The complexity of SoS, allied to their need to evolve over their lifetimes and with the consequent turnover of knowledge, personnel and technology, demands that the multiple classes stakeholders necessarily must adopt the new comprehensive understanding that is being developed.
Gap	Gaps 2-03, 2-08, 2-11
Satisfaction Measure	Methods, techniques and tools that can handle multiple, possibly conflicting, stakeholder interests are developed, and that there is a clear, evident, shift in professional, published discourse about SoS.
Dependency	None.

Requirement No.	R6 Security
Description	The strategic research agenda shall focus on security as a major challenge for SoS, and potentially learn from areas such as network technology, encryption, defence and organizational studies.
Type	Content
Rationale	Security is a major challenge for all systems of systems.
Gap	All gaps 2-01 to 2-12

Satisfaction Measure	Methodologies and architectures that address trustworthiness of systems of systems are developed and prototyped.
Dependency	None.

Requirement No.	R7 Standards
Description	The strategic research agenda shall focus on collaboration with the international standards community to develop new standards for technical and semantic interoperability to enable local and worldwide multi-level infrastructure consistency.
Type	Content, Resources
Rationale	Systems of systems engineering requires new standards due to its unique characteristics, and due to the global spread of these systems, international standards will be required.
Gap	Gaps 2-01, 2-02, 2-04, 2-07, 2-09, 2-10, 2-12
Satisfaction Measure	Semantic interoperability standards for systems of systems are developed.
Dependency	R2 Industries, R8 Formal methods, R9 Safety, R22 Ontologies

4.2 Validation and verification

These requirements are concerned with validation and verification techniques for SoS.

Requirement No.	R8 Formal Methods
Description	The strategic research agenda shall include research investigations on formal methods for performing verification and validation of SoS throughout the SoS lifecycle.
Type	Content
Rationale	Verification and validation is important in dealing with emergence issues.
Gap	2-01, 2-02, 2-04, 2-06, 2-07, 2-08, 2-10, 2-12
Satisfaction Measure	Formal methods for performing verification and validation that address the unique characteristics of SoS are developed, tested, and used by the community.
Dependency	R22 Ontologies

Requirement No.	R9 Safety
Description	The strategic research agenda shall produce new certified and/or assured safety and reliability methods and standards for the systems of systems lifecycle.
Type	Content
Rationale	A majority of systems of systems, particularly those critical to the safety and security of society (energy, healthcare, etc.) require high levels of safety and reliability.
Gap	2-02, 2-04, 2-10, 2-12
Satisfaction Measure	International standards and methods that address reliability and safety issues in systems-of-systems are developed.
Dependency	R7 Standards, R8 Formal methods

Requirement No.	R10 Real-time validation
Description	The strategic research agenda shall develop methods to support real-time validation as SoS evolve over time, including situations where the systems knowledge at the SoS level is incomplete during design and development.
Type	Content
Rationale	Research in V&V should investigate how to validate systems that constantly evolve. Due to the highly adaptive and changing nature of SoS, researchers should revisit the definition of verification and validation in relation to SoS.
Gap	2-02, 2-04, 2-10,2-12
Satisfaction Measure	International standards and methods that address real-time validation.
Dependency	R8 Formal methods, R22 Ontologies

4.3 Datasets

These requirements are concerned with SoS datasets.

Requirement No.	R11 Datasets
Description	The strategic research agenda shall develop methods for creating, exploring and exploiting very large, distributed, incrementing data sets in order to identify primary variables, relevant factors, and consequential effects in political, economic and social arenas. Particular attention shall be paid to human visualization and understanding in these new methods.
Type	Content
Rationale	There is a real problem in the assimilation of data for management and governance purposes. If people hold ultimate responsibility for the performance of SoS, they must be given the wherewithal to exercise this responsibility
Gap	Gaps 2-01, 2-04, 2-05, 2-08, 2-10, 2-11, 2-12
Satisfaction Measure	New data visualization and analytical tools are developed.
Dependency	R8 Formal methods

4.4 Method development

These requirements are concerned with the development of methods, techniques and tools to support various SOSE processes.

Requirement No.	R12 Prototyping
Description	The strategic research agenda shall focus on the development of new methods for prototyping SoS (including their organisational components) that recognise the unpredictability of such systems.
Type	Content
Rationale	Due to their nature and characteristics, prototyping systems-of-systems is currently very difficult (due to non-linearities, etc.) and expensive (due to the simulation effort required). New approaches are required
Gap	Gaps 2-01, 2-03, 2-04, 2-05, 2-06, 2-07, 2-08, 2-09, 2-10, 2-12

Satisfaction Measure	New prototyping concepts, theories and approaches that address the uniqueness of systems-of-systems are developed and verified.
Dependency	R4 Simulation, R6 Security, R22 Ontologies

Requirement No.	R13 Lifecycle Engineering
Description	The strategic research agenda shall move towards investigating more general approaches to the lifecycle engineering of SoS, evaluating any proposed approach across different projects and application domains.
Type	Content
Rationale	The majority of systems of systems share similar characteristics and problems; it is likely that particular domains will have their own characteristics, which could be embodied as variations of a common core approach. The potential gains in efficiency and effectiveness that might accrue from this justify further research.
Gap	Gaps 2-01, 2-02, 2-03, 2-04, 2-07, 2-09, 2-12
Satisfaction Measure	Cross-domain approaches are developed.
Dependency	R2 Industries, R3 Complex systems, R22 Ontologies

Requirement No.	R14 Adaptive Tools
Description	Methods, tools, and frameworks in SoSE should be designed for adaptation, either through self-synchronisation by systems or through controlled reconfiguration of the SoS enterprise. The adaptive nature of constituent systems should be modelled and simulated using tools and techniques that enable one to demonstrate syntactic and semantic interoperability within SoS lifecycles.
Type	Content
Rationale	The majority of systems of systems share similar characteristics and problems, and the need for adaptation is one of them.
Gap	Gaps 2-01, 2-02, 2-03, 2-08, 2-09
Satisfaction Measure	Methods, tools, and adaptation frameworks that are designed for adaptation are developed.
Dependency	R2 Industries, R3 Complex systems, R22 Ontologies

Requirement No.	R15 Adaptive SoS
Description	Approaches and concomitant tools should be developed to determine how a SoS should adapt to maintain its effectiveness in a changing environment.
Type	Content
Rationale	Self-adaptive systems of systems run the risk of generating incompatibilities and unexpected failures, leading to the emergence of more unpredicted behaviours.
Gap	Gaps 2-01, 2-02, 2-03, 2-08, 2-09
Satisfaction Measure	The development of tools that can determine how a SoS should adapt.
Dependency	R2 Industries, R3 Complex systems, R22 Ontologies

Requirement No.	R16 Prediction
Description	New methods that can address the complexity of SoS should be developed. These methods should support the prediction of possible output behaviours that are not predictable using current methods and models.
Type	Content
Rationale	Self-adaptive systems of systems run the risk of generating unexpected failures. Techniques to highlight such risks and their likely consequences are important.
Gap	Gaps 2-01, 2-02, 2-03, 2-08, 2-09
Satisfaction Measure	The development of tools that can predict possible output behaviours.
Dependency	R2 Industries, R3 Complex systems, R22 Ontologies

Requirement No.	R17 Model-based Engineering
Description	New methods, especially those associated with model-based systems engineering, should be developed to address particular properties of SoS and in transitioning existing techniques used for large complex systems to address SoS problems.
Type	Content
Rationale	Current model-based systems engineering approaches fall short in addressing SoS problems.
Gap	Gaps 2-01, 2-02, 2-03, 2-04, 2-07
Satisfaction Measure	The development of tools that can addresses particular properties of SoS.
Dependency	R2 Industries, R3 Complex systems, R22 Ontologies

Requirement No.	R18 Multi-notation Modelling
Description	Methods should be developed to effectively manage, integrate and support multi-notation modelling. System models should be developed to visualise, represent, and analyse the inner workings of the SoS as well as forming the building blocks of an Enterprise SoS Architecture (ESoSA).
Type	Content
Rationale	System models should be developed to visualise, represent, and analyse the inner workings of the SoS as well as form the building blocks of an Enterprise SoS Architecture (EA).
Gap	Gaps 2-01, 2-02, 2-03, 2-04, 2-07
Satisfaction Measure	The development of system models that can visualise, represent, and analyse SoS.
Dependency	R2 Industries, R3 Complex systems

Requirement No.	R19 Cost Estimation
Description	New tools and methods for effort and cost estimation for evaluating novel SoS instantiations need to be developed to take into account the complex nature of SoS.
Type	Content
Rationale	There is currently a lack of techniques that can accurately

	estimate the effort and cost for SoS projects.
Gap	Gaps 2-01, 2-02, 2-03, 2-04, 2-07, 2-11
Satisfaction Measure	The development of system models that can visualise, represent, and analyse SoS that the community can utilise.
Dependency	R2 Industries

Requirement No.	R20 Emergent Behaviour
Description	New systems engineering methods are required that evaluate emergent behaviour and enable management to exploit emergent effects to create solutions in systems-of-systems.
Type	Content
Rationale	Emergent behaviour is always a part of a SoS, and if known in advance, could be used to improve the strength of the overall system.
Gap	Gaps 2-01, 2-02, 2-03, 2-08, 2-09, 2-11
Satisfaction Measure	Effective methods developed and validated.
Dependency	R12 Prototyping, R15 Adaptivity

Requirement No.	R21 Modularized Architecture
Description	There is a need to develop dynamic and evolving architecture that can be modularized and easily modified to accommodate emergent behaviours as they are being discovered.
Type	Content
Rationale	SoS needs to be robust against emergent behaviours.
Gap	Gaps 2-01, 2-02, 2-03, 2-08, 2-09
Satisfaction Measure	The development of dynamic architectures.
Dependency	R12 Prototyping, R15 Adaptivity

4.5 Patterns, metrics and ontologies

These requirements are concerned with the development of SoS patterns, metrics and ontologies.

Requirement No.	R22 Ontologies
Description	The strategic research agenda shall address extensions to Systems Engineering ontologies and metrics with specific reference to the distributed, heterogeneous, simulation, management and governance of SoS throughout the lifecycle.
Type	Content, Resources
Rationale	There is a need to ensure that researchers and practitioners are able to address the governance and control of the SoS lifecycle, including those of global span.
Gap	All gaps, 2-01 to 2-12
Satisfaction Measure	Systems of systems engineering concepts are created, shared with and understood by a wide cross-domain audience.
Dependency	R1 Collaboration, R2 Industries, R5 Stakeholders, R7 Standards, R9 Safety

Requirement No.	R23 Patterns
Description	The strategic research agenda shall enable research to be conducted to develop, apply and document patterns, such as design patterns in software engineering. These should address all levels of the NCOIC Interoperability Framework.
Type	Content, Resources
Rationale	A set of reusable patterns will preserve and enable the reuse of SoS knowledge.
Gap	All gaps, 2-01 to 2-12
Satisfaction Measure	A set of SoS design patterns developed and maintained.
Dependency	None.

Requirement No.	R24 Pattern Maintenance
Description	The strategic research agenda shall enable the classification, maintenance, and deployment of patterns within an organisation or enterprise to be investigated so that practitioners can identify appropriate patterns and access them in a suitable form for particular applications within those enterprises.
Type	Content, Resources
Rationale	There are many benefits of pattern usage in SoS design and development, e.g., common SoS pitfalls can be avoided.
Gap	All gaps, 2-01 to 2-12
Satisfaction Measure	Pattern adoption by SoS practitioners.
Dependency	R23 Patterns

Requirement No.	R25 Metrics
Description	The strategic research agenda shall enable develop metrics and combinations of metrics that can enable System Architects to distinguish between architecture patterns in order to identify the 'best' choice for different SoS challenges.
Type	Content, Resources
Rationale	SoS practitioners need to be able to make well-informed decisions when choosing architecture patterns.
Gap	All gaps, 2-01 to 2-12
Satisfaction Measure	Objective metrics developed for pattern selection.
Dependency	R23 Patterns.

4.6 Reuse and retirement

These requirements are concerned with the reuse and retirement of SoS.

Requirement No.	R26 Reuse
Description	Technologies that embrace and maximise the re-use of existing systems, particularly software assets and other costly hardware assets shall be developed
Type	Content, Resources
Rationale	Techniques to maximise the re-use of existing systems can save cost, reduce risks, save time and minimise wastage.
Gap	All gaps, 2-01 to 2-12
Satisfaction Measure	Appropriate reuse of existing software assets.

Dependency	None.
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Requirement No.	R27 Retirement
Description	The strategic research agenda shall investigate systematic methods for SoS retirement.
Type	Content, Resources
Rationale	The retirement of a SoS may affect other dependent systems.
Gap	All gaps, 2-01 to 2-12
Satisfaction Measure	Demonstrated seamless retirement of SoS with minimum side-effects.
Dependency	None.

4.7 Safety

These requirements are concerned with safety aspects in SoSE.

Requirement No.	R28 Certification
Description	When integrating constituent systems to SoS, new approaches to certification through well-defined standards are required. The strategic research agenda shall address this issue.
Type	Content, Resources
Rationale	Safety is a critical aspect of a SoS. Since SoS qualification is a high priority for effective research, realistic discussions with relevant certification authorities and standard bodies is essential for dealing with SoS safety issues.
Gap	2-10, 2-12
Satisfaction Measure	New approaches to certification through well-defined standards are developed.
Dependency	R2 Industries

Requirement No.	R29 Safety Analysis
Description	The achievement of system safety has a crucial influence on the SoS's final acceptance. Safety analysis techniques should be developed to analyse deviations of multiple information flows in SoS.
Type	Content, Resources
Rationale	Safety should be methodically analysed along the system lifecycle. Traditional system analysis is simply not possible for SoS, because it is impossible to identify all the possible configurations in a SoS and, thus, impossible to exhaustively test all conditions, as is required by conventional safety qualification.
Gap	2-10, 2-12
Satisfaction Measure	The development of safety analysis techniques that can analyse deviations of multiple information flows.
Dependency	R2 Industries.

4.8 Governance

The requirements in this section are concerned with SoS governance.

Requirement No.	R30 Resource
Description	Research shall be conducted to understand the underpinning resource allocations, arrangements, culture and capabilities within the participating organisations that are necessary to achieve the required resilience and produce subsequent desired emergent behaviour within the SoS.
Type	Content
Rationale	SoS are inherently complex. The ability to identify the necessary capabilities of participating organisations, and manage the resource allocations to ensure resilience and future desired behaviour will increase the reliability and success of the SoS.
Gap	2-05
Satisfaction Measure	An increased understanding of information required for governance in participating organisations to ensure the reliability of the SoS.
Dependency	None.

Requirement No.	R31 Engineering Management
Description	Research shall be conducted to investigate the feasibility of engineering management to assure the key stakeholders in the SoS that the engineering functions delivering the SoS will not produce any surprises and will manage risk effectively, and the delivered SoS will function as expected.
Type	Content
Rationale	Keeping key stakeholders informed and reassured is an important aspect of engineering management and is increasingly difficult as the size and complexity of the SoS project increases.
Gap	2-05
Satisfaction Measure	A report on the feasibility of effective SoS engineering management.
Dependency	None.

Requirement No.	R32 Effectiveness Measures
Description	General and universally accepted measures of SoS effectiveness shall be developed to enable regulation, governance, operation, and benchmarking of SoS performance.
Type	Content
Rationale	Universally accepted measures for regulation, governance, operation and benchmarking will help improve the quality of SoS in general and identify potential problems, particularly when the SoS is internationally distributed.
Gap	2-05
Satisfaction Measure	Universally accepted measures are developed.
Dependency	None.

Requirement No.	R33 Business Models
Description	Development of new business models and contract principles is essential as there may be contradictions between the different contracts that an organization signs, particularly where it is a participant in different SoS. The strategic research agenda shall address this issue.
Type	Content
Rationale	SoS is inherently complex and involve a large number of participants, with new interactions involving new business models. The nature of the network of contracts that binds the SoS together may introduce constraints that hinder the effectiveness of the SoS.
Gap	2-05
Satisfaction Measure	The development and evaluation of new business models.
Dependency	R2 Industries.

Requirement No.	R34 Governance
Description	Methods shall be developed in order to provide both strategic SoS governance and more localised, system-specific governance, with appropriate, overlapping sets of metrics for each class of governance
Type	Content
Rationale	SoS is inherently complex and involve a large number of participants, often operating at different scales within the SoS. Coherent, co-ordinated governance of SoS operations at these different scales requires extensions to current governance thinking to ensure the continuing integrity of the SoS.
Gap	2-05
Satisfaction Measure	The development and evaluation of new methods to govern SoS as a whole and govern individual components of the SoS.
Dependency	None.

Requirement No.	R35 Risk Management
Description	Because of the high level of dependency in SoS, some of which is not apparent under normal operating conditions, it is possible for emergent behaviours to have significant impact well beyond that which might have been anticipated. Better prognosis is required to understand the full implications of trigger events and principles, or strategies, for mitigating economic impacts are required.
Type	Content
Rationale	Interactions that only have significance during abnormal conditions may create a snowball effect that can result in significant economic impact.
Gap	2-05
Satisfaction Measure	The ability to understand the full implications of trigger events.
Dependency	None.

4.9 Stakeholder and requirements management

The requirements in this section are concerned with stakeholder and requirements management in SoS projects.

Requirement No.	R36 Requirements Management
Description	Techniques shall be developed to identify stakeholders, associated SoS requirements, and manage conflicts.
Type	Content
Rationale	Effective stakeholder and requirements management is paramount to the success of SoS projects, which often have a large number of requirements and stakeholders.
Gap	2-05
Satisfaction Measure	Effective stakeholder and requirements management techniques for SoS are developed.
Dependency	R2 Industries.

Requirement No.	R37 System Visualisation
Description	Effective visualisation methods should be developed so that stakeholders can interact with an SoS model to represent/visualize their system of interest within the overall SoS and how their related roles, procedures, interactions, interfaces etc fit within the overall SoS.
Type	Content
Rationale	Visualisation can help provide an overview of the SoS as a whole and highlight problems.
Gap	2-05
Satisfaction Measure	Effective visualisation methods are developed and tested in real use cases.
Dependency	None.

4.10 Engagement and awareness

The requirements in this section is concerned with public engagement and increasing the awareness of practitioners and the public about SoS.

Requirement No.	R38 Research Communication
Description	The strategic research agenda shall enhance communication of research results with other researchers and practitioners, and shall increase awareness of the public about the field, its significance and impact on society. This shall make use of all relevant communication channels, including new social media as well as more orthodox channels.
Type	Presentation of agenda, Ownership
Rationale	There is need to share systems of systems experience with a wider community.
Gap	All gaps 2-01 to 2-12
Satisfaction Measure	Systems of systems engineering concepts are shared with and understood by a wide cross-domain audience.

Dependency	None.
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Requirement No.	R39 Funding Bodies
Description	The strategic research agenda shall address the need to make government, regulatory bodies, standards organisations and funding agencies aware of the significance and impact (both present and potential) of research in systems of systems engineering.
Type	Presentation of agenda, Ownership
Rationale	Due to the scale of SoS, any significant research in the area can be costly and hence require support from various stakeholders.
Gap	All gaps 2-01 to 2-12
Satisfaction Measure	Government and funding agencies are aware of the significance and impact of SoS research.
Dependency	R41 Research quality

4.11 Strategy and research themes for SoSE

The requirements in this section are concerned with research excellence, strategy and research themes for SoSE.

Requirement No.	R40 Research Quality
Description	The strategic research agenda shall have provisions to ensure that the quality of research produced by funded projects is of a very high quality.
Type	Presentation of agenda, Ownership, Resources
Rationale	To ensure that SoS research gains acknowledgment as a credible research field in engineering.
Gap	All gaps 2-01 to 2-12
Satisfaction Measure	The project outcome should provide direct benefits to the industry, proven by case studies and industry usage of the methods developed, or provide significant scientific and engineering contribution, proven by high impact publications in good quality journals.
Dependency	R40 Regulation

Requirement No.	R41 Themes
Description	Research themes shall be set up according to the gaps areas identified in the gap analysis report. These themes can be prioritised based on their priority as identified by the expert community. In particular, research in the following areas should be emphasised: engineering for emergence, architecture patterns for SoS, multi-heterogeneous modelling and multi-notation approaches, enterprise SoS, governance and policy, trade-off techniques for integration of legacy and managing evolution, and metric identification/validation.
Type	Presentation of agenda, Resources
Rationale	To ensure that SoS research progresses to support the main gap areas in the field.

Gap	All gaps 2-01 to 2-12
Satisfaction Measure	The project outcome should provide direct benefits to address gaps identified by the expert community, proven by case studies and industry usage of the methods developed, or provide significant scientific and engineering contribution, proven by high impact publications in good quality journals.
Dependency	None.

In addition to the SRA requirements listed here, we recognise that there are requirements for maintenance and on-going evolution of the SRA and this forms part of the remainder of the T-AREA-SoS project.

5 CONCLUSION

All identified requirements can be traced to either gaps or capabilities in D3.1 that can be further traced to broad research themes also reported in D3.1. Also it should be noted that the requirements specify high-level desirable properties of the future T-AREA-SOS Strategic Research Agenda.

Despite these provisos, it is believed that these requirements represent a set of inter-related topics for the strategic research agenda that will lead to a broad-fronted understanding of the roles and necessary behaviours of SoS that operate within the EU, and of the infrastructural developments necessary to support their efficient and effective performance, and will give the EU a degree of innovative leadership in the exploitation of the benefits that SoS can bring in the foreseeable future.

6 REFERENCES

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