Study title: A Survey on Software Engineering and Systems Engineering interplay problems in Complex Systems/Systems of Systems architecting.

1. Demographics

1.1. Academic qualification/education

- ○ Bachelor (1)
- ○ Master (2)
- ○ PhD (3)
- ○ Other (4) _____

1.2. Engineering practice area

- ☐ Software Engineering (1)
- ☐ Systems Engineering (2)
- ☐ Mechanical Engineering (3)
- ☐ Electrical Engineering (4)
- ☐ Other (5) _____

1.3. Years of experience in Engineering projects

0 5 10 15 20 25 30 35 40 45 50

Years ()

1.4. Approximate number of engineering projects the respondent has been involved in

0 10 20 30 40 50 60 70 80 90 100

Number of projects ()	

5 1.5. Roles played within these engineering projects

- [ ] System Architect/Designer (1)
- [ ] Software Architect/Designer (2)
- [ ] Software Developer (3)
- [ ] Domain Expert (4)
- [ ] Project Manager (5)
- [ ] Program Manager (6)
- [ ] Quality Assurance (7)
- [ ] Other (8) _____

1.6. In the last 10 years, have you been involved in the architecting of engineered systems where multiple disciplines (e.g. mechanical, electrical, hardware and software-based) were involved?

- ○ Yes (1)
- ○ No (2)

1.7. Organization type

- [ ] Company (1)
- [ ] Research Institute (2)
- [ ] University (3)
- [ ] Government agency (4)
- [ ] Other (5) _____

1.8. Application area of the organization

- [ ] Transportation - air traffic management, rail network, integrated ground transportation, cargo transport, highway management, and space systems (1)
- [ ] Energy - smart grid, smart houses, and integrated production/consumption (2)
- [ ] Health Care - regional facilities management, emergency services, and personal health management (3)
- [ ] Defense - Military missions such as missile defense, networked sensors (4)
- [ ] Natural Resource Management - global environment, regional water resources, forestry, and recreational resources (5)
- [ ] Disaster Response - responses to disaster events including forest fires, floods, and terrorist attacks (6)
- [ ] Consumer Products - integrated entertainment and household product integration (7)
- [ ] Business- banking and finance (8)
- [ ] Media - film, radio, and television (9)

☐ Manufacturing (10)

☐ Biomedical (11)

2. Experienced project profiling

Please answer the following questions based on the most complex project you have been involved in the last 10 years, where there was interplay between the disciplines of Systems Engineering and Software Engineering.

In the next questions, you will be asked about the characteristics of the constituents or subsystems integrated in such project.

2.1. Overall, how would you characterize the following characteristics of the constituents (subsystems) of the system created in the project?

Autonomy (the degree to which the subsystems within a system are independent, stand alone and are individually useful, self-contained, and operationally independent).

	Operationally Interdependent 0 1 2 3 4 5 Operationally Independent
Autonomy ()	

Governance (the degree to which the subsystems of a system are governed (e.g., specified, managed, funded, developed, owned, operated, maintained, and sustained) in an independent, decentralized, and uncoordinated manner)

	Centrally Governed 0 1 2 3 4 5 Independently Governed
Governance ()	

Heterogeneity (the degree to which the subsystems of a system differ from each other in that they (1) have different goals, objectives, and requirements, (2) have different behavior and characteristics, (3) provide unrelated functionality, (4) belong to different application domains, and (5) are implemented using different technologies)

	Homogeneous — Heterogeneous 0 1 2 3 4 5
Heterogeneity ()	

Physical Distribution (the degree to which the subsystems of a system exist in different physical locations)

	Physically Contiguous — Extremely Distributed 0 1 2 3 4 5
Physical Distribution ()	

In the next questions, you will be asked about the General properties of the System created in such project.

2.2. Overall, how would you characterize the following properties of the system created in the project?

Complexity (the degree to which a system is difficult for its stakeholders to understand and analyze, especially due to having a large number of components connected by many complicated interfaces)

	Trivially Simple — Ultra-complex 0 1 2 3 4 5
Complexity ()	

Evolution (the degree to which, in terms of rate and impact, the goals and requirements for a system change over time)

	Highly static — Constantly Evolving 0 1 2 3 4 5
Evolution ()	

Size

	Trivially Small / Ultra-large scale
	0 1 2 3 4 5
Size ()	

Emergence the degree to which the new behaviors and characteristics of a system that result (i.e., emerge) from the interaction of the system's subsystems that are difficult to predict from the behaviors and characteristics of these individual subsystems

	No emergent behaviors / Unpredictable emergent behaviors
	0 1 2 3 4 5
Emergence ()	

2.3. Which terms were used by the development team to describe the system?

- [ ] System of Systems (1)
- [ ] Cyber-Physical System (2)
- [ ] Embedded System (3)
- [ ] Complex System (4)
- [ ] Cyber-physical Systems of Systems (5)
- [ ] Software-Intensive System (6)
- [ ] Other (7) _____

2.4. If the concept of 'System of Systems' was used to describe the system, were SoS-specific architecting guidelines or frameworks adopted for its implementation?

- [ ] Yes, we had our own custom guidelines/framework (1)
- [ ] Yes, US Department of Defense (DoD) Systems Engineering Guide for Systems of Systems (2)
- [ ] Yes, ISO/IEC/IEEE 21840 in conjunction with ISO/IEC/IEEE 15288 (3)
- [ ] No, the concept of 'Systems of Systems' was used, but no SoS-specific guidelines/frameworks were used (4)
- [ ] Other (5) _____

2.5. Which of the following engineering disciplines were involved in the development of the system?

- [ ] Systems Engineering (1)
- [ ] Software Engineering (2)
- [ ] Mechanical Engeneering (3)
- [ ] Electrical Engineering (4)
- [ ] Other (5) _____

3. Problems linked to Systems Engineering/Software Engineering interplay in architecting activities.

Questions listed in this section investigate the problems posed by the interplay between Systems and Software Engineering when architecting Complex Systems or Systems of Systems, due to the differences in their respective disciplines. Please answer the following questions based on the System described in the previous section.

3.1. How were system-level and software-level requirements related to each other?

- ○ Software-level requirements were derived from system-level requirements (1)
- ○ Software-level requirements were elicited by taking into consideration, among others, system-level requirements (2)
- ○ Software-level and system-level requirements were elicited independently by separate teams (3)
- ○ Software-level and system-level requirements were elicited simultaneously by the same team (4)
- ○ Other (5) _____

What problems, if any, were posed to the architecting process when dealing with requirements at both system and software architecture levels?

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3.2. How were the architectural decisions, at system and software architecture levels, taken in the project?

- ○ System-level and software-level architectural decisions were taken independently, by separate teams (1)
- ○ Architectural decisions were taken at system level only (there was no intentionally designed software architecture) (2)
- ○ System-level and software-level architectural decisions were taken, together, by the same team (3)
- ○ Other (4) _____

3.3. What kind of problems, if any, were posed by the way system-level and software-level architectural decisions were taken?

- [ ] Architecture Documentation inconsistencies (1)
- [ ] Integration problems due to inconsistent system-level and software-level architectural decisions (2)
- [ ] Operational problems due to inconsistent system-level and software-level architectural decisions (3)
- [ ] Other (4) _____

3.4. How were the architectural decisions evaluated, at system level, with respect to functional requirements and non-functional requirements (quality attributes)?

- [ ] Do not know. (1)
- [ ] The architectural decisions were not evaluated. (2)
- [ ] The architectural decisions were evaluated when the System/SoS became operational. (3)
- [ ] The architectural decisions were evaluated, within the architecting process, by means of a simulated model of the architecture. (4)
- [ ] The architectural decisions were evaluated, within the architecting process, by means of verification of a formal (mathematical) model of the architecture. (5)
- [ ] The architectural decisions were evaluated by means of throw-away or evolutionary prototypes (6)
- [ ] Other (7) _____

3.5. How were the architectural decisions evaluated, at software level, with respect to functional requirements and non-functional requirements (quality attributes)?

- ○ Do not know (1)
- ○ There was no architecture evaluation in the project (2)
- ○ Software architecture was considered as implicitly evaluated by the system architecture validation (3)
- ○ Software architecture was evaluated evaluated against a set of requirements that are not related to the system requirements (4)
- ○ Software architecture was evaluated against the system requirements, after the system requirements and architecture were established (5)
- ○ Other (6) _____

3.6. What problems, if any, were posed by the way system-level and software-level architectures were evaluated?

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4. Interdisciplinary problems linked to the system's characteristics.

Questions listed in this section investigate the problems posed by the interplay between Systems and Software Engineers when (1) integrating independent constituents/subsystems and (2) dealing with desired or undesired emergent behavior.

In this context, Emergence is defined as "the degree to which the new behaviors and characteristics of a system that result (i.e., emerge) from the interaction of the system‘s subsystems that are difficult to predict from the behaviors and characteristics of these individual subsystems". Hence, desired emergent behaviors are those that, albeit being unpredicted, fulfill a specific system mission. On the contrary, undesired emergent behaviors are those with hazardous or damaging outcomes.

Please answer the following questions based on the System described in section 2.

4.1. If desired or undesired emergent behavior was an architectural concern, how was it addressed at system and software architecture levels?

- ○ Emergent behaviour was not a concern. (1)
- ○ Emergent behaviour was a concern, but it was not addressed by the architecture. (2)
- ○ Emergent behaviour was addressed by both system-level and software-level architecture (3)
- ○ Emergent behaviour was addressed only by software-level architecture (4)
- ○ Emergent behaviour was addressed only by system-level architecture (5)
- ○ Other (6) _____

4.2. What problems, if any, were posed by the way desired or undesired emergent behavior was addressed at system and software architecture levels?

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4.3. If independently developed and operated Constituents/Subsystems were incorporated in the system, what elements were provided to the system's architecting process by their interfaces' specifications?
*There were no independent Constituents/Subsystems to be considered in the system. (1)

- ☐ There were independent Constituents/Subsystems, but there were no interface specifications provided. (2)
- ☐ There were independent Constituents/Subsystems, but their interfaces were defined by the system architecture before their integration (3)
- ☐ Syntactic details (e.g. operation signatures) (4)
- ☐ Behavioural details (e.g. state transitions, pre/post-conditions of the operations) (5)
- ☐ Quality of Service details (e.g. non-functional aspects of operations) (6)
- ☐ Other (7) _____

4.4. In case interface specifications were provided: what problems were posed, if any, in the integration, at system and software levels, of the independent Constituents/Subsystems?

- ○ The specifications were too loose or inconsistent for the integration at a software-architecture level (1)
- ○ The specifications were not complete enough to analyse constituents' impact on system-level properties (2)
- ○ Other (3) _____

4.5. In case interface specifications were provided: what problems were posed, if any, by the way the evolution or changes of the independent systems were addressed at system and software architecture levels?

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