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Criteria proposal for critical software development processes selection for space projects in Very Small Entities

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Abstract. *Space software projects have different required quality according to their criticality, and their quality is highly influenced by their development lifecycle processes. Since 2010, ISO/IEC 29110 set of standards and guides has been used to assist and encourage Very Small Entities (VSEs), defined by ISO as organizations or projects having up to 25 people, in assessing and improving their software development process. This paper proposes a lightweight set of processes to be applied for critical space software development in VSEs, and the criteria for selecting these processes based on the profiles definition from ISO, applicable to space software and covering the features of the European Cooperation for Space Standardization (ECSS) set of space software standards.*

Key words: Software processes; Profiles; Very small entities.

1. Introduction

Standardization is a significant instrument for increasing quality and communication among stakeholders during planning and implementation of projects, while it also helps to reduce risks and costs associated, making business more profitable as less time is spent on non-productive work (Yilmaz, O'Connor, & Clarke, 2016). Standards published by committees, international technical entities or regulatory agencies influence the development of software, through guidelines for processes and software products considering their associated risks (MUNCH, ARMBRUNT, KOWALCZYK, & SOTO, 2012).

One of the possible uses of standardization for software development is the concept of Standardized Profile (SP), which is defined by ISO as a "set of one or more base standards and/or SPs, and, where applicable, the identification of chosen classes, conforming subsets, options and parameters of those base standards, or SPs necessary to accomplish a particular function". A possible analogy is that a profile is like a bill of materials composed of parts of standards such as ISO/IEC/IEEE 12207 or ISO/IEC /IEEE 15288. (ISO, 2015)

Although it is commonly assumed that the organizational performance is increased by using reference models for process assessments and improvement (Goldenson & Gibson, 2003), this is not a common practice, as they are usually adopted by just a small number of organizations, mainly large and medium-sized ones (Kalinowski, Weber, Santos, Franco, Duarte, & Travassos, 2015).

Most of the space software have been developed by small groups (Lahoz, Richter, & Rico, 2015), demanding particular attention to this scenario with establishment of process approaches suitable for small organizations. In Europe, 85% of the information technology (IT) sector's companies have up to 10 employees and in Brazil, IT companies with up to 19 people account for around 95% of companies. (Laporte, Séguin, Boas, & Buasung, 2013)

Agencies such as ESA and NASA have been proponents of space standardization for a long time, but frequently small organizations are not ready to comply with their stringent requirements. Most of the software development standards do not specifically aim the needs of small enterprises, although they represent the majority of software market. (O'Connor & Laporte, 2010)

Research has shown that small organizations usually lack the resources to implement the standards as they do not have the necessary resources and maturity in the development process (Laporte, O'Connor, & Paucar, 2015).

For many small software companies, it is a major challenge implementing controls and structures to properly manage their software development activities (Larrucea, O'Connor, Colomo-Palacios, & Laporte, 2016). Small organizations typically have limited ways to be recognized in their domain as producers of quality systems within budget and schedule, consequently they may be put aside from space projects (Rodríguez-Dapena & Lohier, 2017).

Very Small Entities (VSEs), defined as entities (enterprise, organization, department or project) with up to 25 people, have had their importance developing products and services recognized by industries worldwide (Laporte, Séguin, Boas, & Buasung, 2013), even though ISO acknowledged that many organizations are not ready to fulfil the whole set of requirements from standards such as ISO 15504/330xx (ISO/IEC, 2008) or CMMI (SEI, 2010). Therefore, the ISO/IEC 29110 series of systems and software engineering process standards and guides were developed, aiming a more realistic way of implementing process standardization (Larrucea, O'Connor, Colomo-Palacios, & Laporte, 2016).

The objective of this paper is to present the structure and basic contents of the proposal approach for selecting processes profiles from a new profile group, which we named VSE Critical Profiles, comprising simplified and flexible sets of processes for software development in VSEs within the space domain compliant with its quality requirements and considering their typical resources limitations.

2. Methodology

This work proposes an approach for critical software development in VSE, comprising the definition and application of a VSE Critical profile group based on ECSS-Q-ST-80C (ECSS, 2017a) and ISO/IEC 29110 (ISO/IEC, 2011b) standards and related literature.

The profiles approach is issued to give assistance for selection and appliance of processes for space related software development, helping to ensure that a development organization establishes appropriate processes and procedures that result in quality space software.

There is a potential risk in not using the full implementation of the space software specifications from the adopted standards, such as ECSS or NASA. Managing risks on projects includes risk assessment and a mitigation strategy for those risks. Consequently, a risk mitigation scheme must be designed to eliminate or minimize the negative impacts on the project according to the potential impact of this risk.

As a reference approach for determining the kind of assessment to be performed on candidate projects, *Order 8110.49 Chg 1 - Software Approval Guidelines* (FAA, 2011) was used, as in its Chapter 3 it contains information about determining the level of FAA Involvement in Software Projects. That content was reviewed, adapted and used as basis for the evaluation proposed in this paper.

3. Results and Discussion

This section comprises the proposal for the evaluation of VSE projects candidates to the usage of a minimal processes approach based on profiles definition, minimizing the risks by addressing specific profiles to projects given their associated risk based on an evaluation result.

3.1 Considerations for the Software Process Profiles

The following considerations may influence the profile level to be used in the software development process:

(1) The software criticality classification level(s), as determined by a dependability and safety analysis of the software products, using the results of system-level safety and dependability analyses.

(2) The product attributes (such as size, complexity, system functionality or novelty, and software design).

(3) The use of new technologies or unusual design features.

(4) Proposals for novel software methods or life cycle model(s).

(5) The knowledge and previous success of the organization in software development to comply with the objectives of space software standards (ECSS).

3.2 Determining the Profile Level Applicability (PLA) In Software Projects

3.2.1 General

This section provides the criteria for determining to what extent apply the presented profiles in determining the software aspects for a given project:

- When the Software Product Assurance (SwPA) should be involved (for example, planning, development, integration/verification, or final software approval).
- The extent of SwPA involvement in the project (for example, how many reviews are conducted; how much surveillance is delegated; and how much and what types of documented data are reviewed, submitted for approval and approved).
- The areas for SwPA involvement, parts of the software processes where the SwPA should focus its involvement to ensure fulfillment of the appropriate objectives (for example, focus on plans, design, or code).

3.2.2 Determining the PLA

This section discusses the criteria for determining the Profile to be used in the software development in a project. An assessment has to be carried out and documented at the start of the software development project to enable the SwPA to plan and address the project details as early as possible. There are two major areas of criteria:

a. Software criticality classification criteria.

The first criterion for determining the PLA for the software aspects of a project is the software criticality classification of the software product being developed or modified, which comes from a system-level analyses that leads to the criticality classification based on the severity of failures consequences.

The software criticality classification is used as a starting point, applied as shown in Table 1. For example, a Level D software project would initially indicate a PLA ONE; however, a Level A project might lead to PLA THREE or N/A. For the cases where the proposed profiles are considered not applicable (N/A), the project is supposed to adopt the original standards of the given area, ECSS in this case.

Table 1: Software criticality classification criteria

Software criticality classification	Profile Level
D	ISO/IEC 29110 or ONE
C	ONE or TWO
B	TWO or THREE
A	THREE or N/A

Source: author

b. Organization criteria.

Table 1 shows ambiguity for all software criticality classifications. Therefore, it is necessary to look at other relevant project criteria for determining the PLA. In this work, the project criteria proposed are divided in organization and product. The organization aspects are summarized in Table 2, the product aspects in Table 3, and the uses of those tables are explained in section 3.2.3.

Table 2: Organization Criteria

#	Criteria	Scale	Grade			Score
			Min		Max	
1.	Developer critical software experience					
1.1	Experience with space software development.	Scale:	0	5	10	
		Experience:	< 2 yrs	2 - 4 yrs	4 yrs	______
1.2	Experience with ECSS system.	Scale:	0	5	10	
		Experience:	< 2 yrs	2 - 4 yrs	4 yrs	______
1.3	Experience with other critical software standards.	Scale:	0	5	10	
		Experience:	< 2 yrs	2 - 4 yrs	4 yrs	______
2.	Demonstrated software development capability					
2.1	Capability assessments (i. e.: SEI CMM, ISO 9001)	Scale:	0	5	10	
		Ability:	Low	Med	High	______
2.2	Development team experience average based on relevant software development experience.	Scale:	0	5	10	
		Experience:	< 2 yrs	2 - 4 yrs	4 yrs	______
3.	Developer software service history					
3.1	Entity software quality assurance organization and configuration management process.	Scale:	0	5	10	
		Quality:	Low	Med	High	______
					Organization Score:	______

Source: author

Table 3: Product Criteria

4.	System and software application					
4.1	Complexity of the system architecture, functions and interfaces.	Scale:	0	5	10	
		Complex:	High	Med	Low	______
4.2	Complexity and size of the software and safety features.	Scale:	0	5	10	
		Complex:	High	Med	Low	______
4.3	Novelty of design and use of new technology.	Scale:	0	5	10	
		Newness:	Much	Some	None	______
4.4	Software development and verification environment.	Scale:	0	5	10	
		Environ:	None	Older	Modern	______
					Product Score:	______

Source: author

3.2.3 Criteria description

1. Developer Software Certification Experience

1.1 Experience with space software development.

Time (in years) during which the developer entity has worked with space software projects.

1.2 Experience with ECSS system.

Time (in years) during which the developer entity has worked with ECSS system based space software projects.

1.3 Experience with other critical software standards.

Time (in years) during which the developer entity has worked with critical software projects.

2. Demonstrated software development capability

2.1 Capability assessments (i. e.: SEI CMM, ISO 9001)

Previous capability assessments reports results.

2.2 Development team experience average based on relevant software development experience.

Team's experience in software projects considered similar to the project under evaluation.

3. Developer software service history

3.1 Entity software quality assurance organization and configuration management process.

Evaluation of the entity's organization and processes maturity.

4. System and software application

4.1 Complexity of the system architecture, functions and interfaces.

Number of different functions and interfaces of the system under development.

4.2 Complexity and size of the software and safety features.

Number of safety features and their size.

4.3 Novelty of design and use of new technology.

Number or percentage of new features and/or methodology of the system under development.

4.4 Software development and verification environment.

Maturity of the development and verification environment.

3.3 **Adequate profiles selection**

As result of the software development project assessment the Profile Level Applicability (PLA) shown in Table 3 is determined, allowing the selection of adequate profiles to be used for the software development lifecycle processes.

Table 3: Profile Level Applicability

	Software Criticality Level			
Project Classification	**A**	**B**	**C**	**D**

suitability				
Low	N/A	THREE	TWO	ONE
Medium	THREE	TWO	TWO	ONE
High	THREE	TWO	ONE	ISO/IEC 29110

Source: author

4. Conclusion

Based on the Profile Level Applicability (PLA) results, VSEs are able to use a profile from the VSE Critical Profile Group, which considers their limitations, comprising a simplified and flexible set of processes.

The next steps of this work are: conduction of software projects case studies; and evaluation of the completeness, applicability and usability of the proposed VSE Critical Profile Group for critical space software.

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