Title (100 characters):

Evaluating Quality of the CubeSat Reference Model (CSRM) to Improve System Design

Abstract (500 words):

This paper will investigate the CubeSat Reference Model (CSRM) to objectively evaluate quality using metrics derived from Metamodel Quality Requirements and Evaluation (MQuaRE) [1]. Covering domain-specific gaps in the Systems Modeling Language (SysML), the CSRM profile [2] provides specialized model elements meant to improve the clarity, conciseness, and comprehensibility of model-based systems engineering (MBSE) implementation for CubeSat design. The construction of CSRM is an ongoing effort led by the International Council of Systems Engineering (INCOSE) Space Systems Working Group (SSWG) with a beta specification published by the Object Management Group (OMG) [3]. This work aims to standardize the design of CubeSat systems across the industry. By incorporating the CSRM into systems engineering (SE) processes, communication and collaboration will be enhanced by increasing transparency throughout an organization's product development teams.

Domain analysis realizes that external groups affected by CubeSats include governments, regulatory organizations, space agencies, research institutions, aerospace manufacturers, launch services providers, and various end users. With such a wide variety of invested individuals, eliciting quality requirements directly from the source(s) has proven to be an arduous task. In lieu of collecting relevant information via techniques such as interviews, MQuaRE characteristics; sub-characteristics; and metrics will be used to extract verifiable requirements. These elements will be mapped to high-level objectives that validate stakeholder concerns have been met by the CSRM. Verifying quality metrics against measurable requirements will give reference architecture (RA) contributors guidance to improve areas lacking in robustness.

This research will use quality properties of the metamodel to answer the following questions:

- Learnability: Are concepts adequately documented within the metamodel?
- Coupling of Concepts: How dependent are concepts on one another within the metamodel?
- Conceptual Coverage: Are CubeSat mission concepts adequately covered by the CSRM metamodel?

Leveraging the metamodel to calculate necessary measurements will drive the next iteration of the CSRM specification and mitigate any identified quality concerns. Understanding quality metrics of the RA will enable profile improvements focused in the areas of suitability, usability, modularity, and portability. To evaluate the CSRM metamodel quality, the profile will be compared against the beta specification to identify gaps in the model and provide recommendations for improvement. This work is anticipated to contribute to best practices and guidelines for the greater scientific community when constructing new domain-specific profiles

within an MBSE environment to increase consistency between natural language specifications and the re-usable metamodel.

This paper is structured to address the following:

- Industry Challenge and Research Overview
- Introduction to Technical Concepts
- Research Methods
- Quality Analysis Results
- Comparative Analysis Discussion
- Recommendations and Conclusion

Category: 13.01 – Systems Architecture, Engineering, and SoS

References:

[1] Kudo, T. N., Bulcão-Neto, R. F., & Vincenzi, A. M. R. (2020). *Metamodel Quality Requirements and Evaluation (MQuaRE)*.

[2]https://github.com/ObjectManagementGroup/CSRM/blob/main/Distro/CSRM%20Dassault%20Systemes/CSRM-Profile.mdzip

[3] Object Management Group. *CubeSat System Reference Model Profile (CSRM)* (Version 1.1). (2023). https://www.omg.org/spec/CSRM/1.1/Beta1/PDF