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Toward a Measurable Application of Agile Model-Based Systems Engineering (MBSE): Based on CSRM Framework

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Need of measurable MBSE for CubeSat

- MBSE has been to support space industry and several open source are available
- Developed INCOSE SSWG and OMG-CubeSat Reference Model- (Kaslow 2016-2021)
- CSRM is reusable logical architecture for CubeSat mission

Progress toward measurable MBSE

- Value and benefits of MBSE remains inconclusive or subjective (*henderson2021value*)
- Most claims (86%) were not substantiated by a metric (*campo2023model*)



Goal

- ✓ Utilize MBSE usage across LC of CubeSat mission
- ✓ Entrance and Exit criteria- faster and cost effective development Key SE activities

MBSE for Space Application - Comprehensive Literature Review





Requirements Management: deals with customer need analysis and traceability of system requirement over the life cycle



Model Development: to create and develop system archetecture functional, logical, and physical models

Simulation and Analysis: deals perform system validation and verification, trade-off and risk analysis



Configuration Management: deals with interfacing data flow, change management, manage system across lifecycle



Collaboration and Communication: deals exchange of information interaction between stakeholder and developer

Phases of MSBE are proposed from SE Activities Identify *for a particular need* in space mission *model usage or technical support engineering activities*



Best practice of MBSE in space Three pillars of MBSE implementation

MBSE for Space Application - Comprehensive Literature Review



Challenges in General Space industry

- Lack of binding factor for global application
- ✓ Diverse MBSE methods-*126 papers*
- ✓ MBSE adoption lacks of success metrics
- Modeling Interpretation limitations
- ✓ Tool and Language limitation and so on



Challenges for a small mission- In CubeSat

- Disproportional cost and benefit implementation
- ✓ Adaptation and tailoring skill effort require

Integrated MBSE Framework



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Relevant Social Groups of CubeSat Developer

Based on expected : Mission success criteria

- Cost-to-risk ratio- risk tolerance
- Cost and schedule
- Mission tier
- Expected testing hour
- Type of parts used
- Orbit Operation Lifetime

	RISK TOLERANCE (RISK/RESOURCE LEVEL)	RISK CLASSIFICATION MISSION TIER	TESTING HOURS	PART SCREENING	ORBIT OPERATION TIME	USE CASES
GROUP A: RAPID DEVELOPMENT & COTS BASED	1A / 1B	Do No Harm / Class D	≥ 100 hrs	COTS acceptance only	< 3-6 months	Education and Technology Demo
GROUP B: HYBRID DEVELOPMENT (PARTIALLY COTS & IN- HOUSE)	2A / 2B	Class D/Class C	200–500 hrs	Selective review and enviromental test	< 12-36 months	Academic + commercial constellations,
GROUP C: CUSTOM, HIGH- RELIABILITY, AND DEEP SPACE MISSIONS	3A / 3B	Class C / Class B	500–1000 hrs	Full screening, qual-level testing	< 5-10 years	Deep Space exploration and Complex mission support

Mission Success Handbook for CubeSat Missions (2021) and Joshua Choe (2020)

MBSE Phases – Mapping across NASA Lifecycle



- Link CubeSat project deliverables directly to MBSE activities
- Support review-based progression
 - Avoid skipping key
 MBSE artifacts
 - Minimize rework,
 - Late design changes
- Enable measurable agility using model-based metrics at each phase

CubeSat Reference Model – As Input Parameters of SE activities



Sara's Black Box Model



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Review or Decision Gate Completion Indicators- (CSRM)



Key take away

- Objective-driven Systems Engineering (SE) activities -MBSE phases
- Alignment of MBSE phases with NASA lifecycle for CubeSat development
- Mission success criteria used as drivers for model artifacts
- Decision reviews (PRR, PDR, CDR, FRR) serve as key performance checkpoints

Future works

- Define threshold values and scoring methods for agility metrics
- Develop a digital dashboard/tool to calculate and visualize metrics across lifecycle phases
- Apply the framework to a real CubeSat startup or university mission to demonstrate enterpriselevel MBSE benefits

Laying the foundation for defining **MBSE** success in CubeSat missions Thank you for your Attention ! Rehobot **Bekele Buruso**

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Google form survey -Entry of SE Performance Indicators - Your input is appreciated!

