CubeSat System Reference Model™ (CSRM™)
Role and Purpose

Space Systems Working Group (SSWG)

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CSRM Project Objectives

- International Council on Systems Engineering (INCOSE) Space Systems Working Group (SSWG) project
- Objectives of CSRM Project
  - Demonstrate Model-Based Systems Engineering (MBSE) as applied to a CubeSat Mission
  - Develop a CSRM that a university team can uses as starting point for their mission-specific model
  - Develop the CSRM as an Object Management Group (OMG) Specification

Project Phases

INCOSE MBSE Challenge Project

Initiated 2007

INCOSE SSWG

2007-2010

Phase 0

Modeled a Space System in SysML

Hypothetical FireSat - SMAD

Phase 1

CubeSat Framework

Prelim. RAX Model [1]

Phase 2

RAX Behavior Modeling Power, Comm, State [2]

Recent Efforts

Phase 3

Enterprise Modeling for CubeSats [3]

RAX CubeSat Model Trade Studies [4]

Current Efforts

Phase 4

Develop a CubeSat MBSE Ref. Model [5] - [11]

Model-Based Systems Engineering (MBSE)

- The formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.
  - The model is the single, authoritative, integrated repository of information.
  - Changes to the model are automatically populated into the system views

- MBSE is enabled by the following: 1) a modeling language, 2) an engineering methodology, and 3) a modeling tool

- Systems Modeling Language™ (SysML™), a graphical modeling language enables the visualization and communication of the essential aspects of a system design

- A Graphical Modeling Tool enables the construction of well formed models in compliance with the modeling language, e.g.:
  - Dassault Systèmes CATIA Cameo Systems Modeler
  - Sparx Systems Enterprise Architect

CSRM Pedigree

- Object Management Group (OMG) – An International Technical Standard Consortium - An International Voluntary Consensus Standards Body (VCSB)
  - The CSRM was developed in response to an OMG Request for Proposal (RFP)
  - In the past, OMG Specifications have been entirely document-based

- International Council on Systems Engineering™ (INCOSE™) – A Systems Engineering Organization and Professional Society
  - INCOSE and several others responded to the OMG RFP.
  - The INCOSE CSRM was selected to continue development

CSRM: A Standardized MBSE Approach to a Space and Ground System

CubeSat System Reference Model (CSRM) - A descriptive nomenclature that can be applied in several ways

- The logical architecture of a CubeSat space and ground system
- An exo-structure for population with mission-specific elements
- A repository of systems engineering artifacts based on a foundation of stereotypes

CSRM Purpose

- A mission-specific team can modify existing elements, can create new elements based on existing stereotypes, or even create new mission-specific stereotypes
- Retention of these logical elements provides a common baseline for comparing and evaluating different mission-specific implementations and for the sharing and reuse of design elements
- The CSRM logical elements are intended to be reused as a starting point for a mission-specific logical architecture, followed by the development of physical architecture

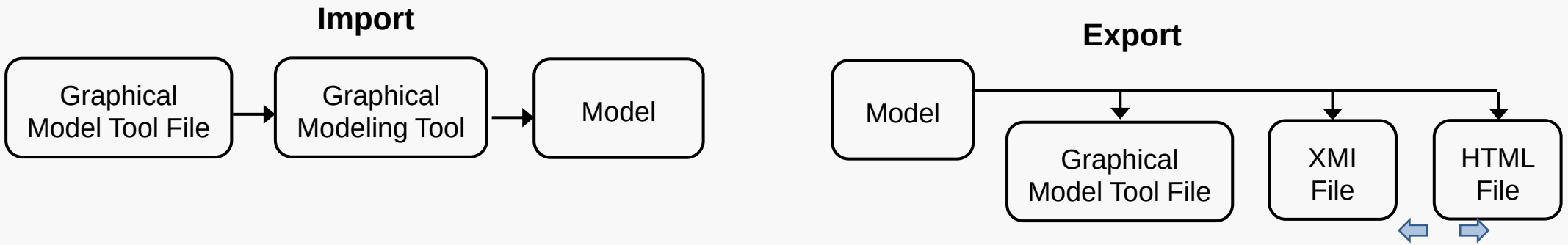
The CSRM architecture can be applied to SmallSats

CSRM Formats

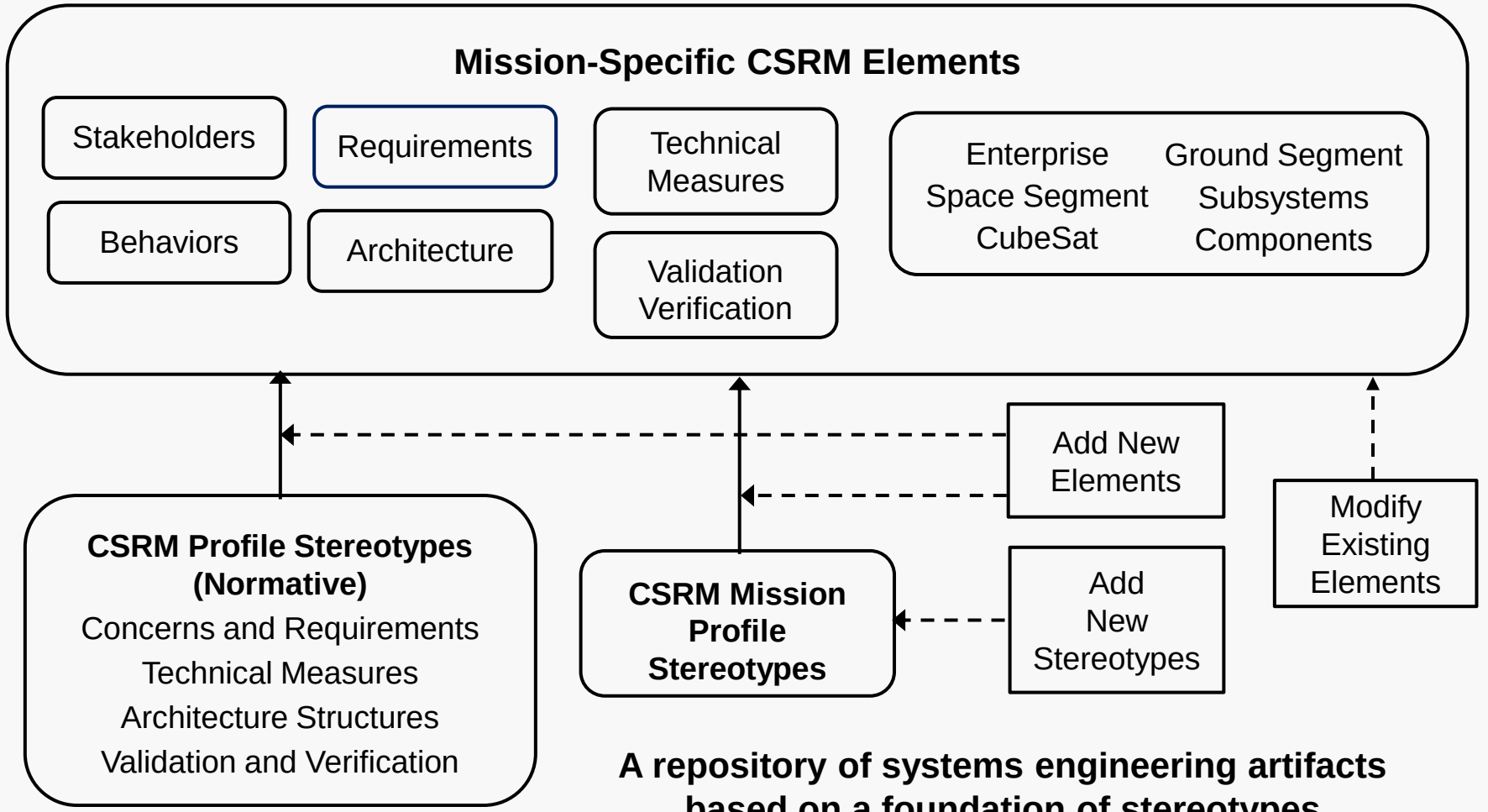
- CSRM is founded on the normative CSRM Profile as described in the CSRM Specification PDF and captured in the CSRM Profile XMI file
- Normative
  - Normative content is the prescriptive part of the specification
  - The normative content must be implemented to claim conformance with the specification.
- CSRM Specification PDF
  - Contains descriptions of the CSRM Profiles, the CSRM SysML element stereotypes used to create the CSRM elements.
- CSRM Profile XMI file
  - Contains CSRM Profile SysML elements stereotypes
- XMI File
  - XML Metadata Interchange (XMI) supports the export of models between graphical modeling tools. such as Cameo Systems Modeler and Enterprise Architect.

CSRM Application

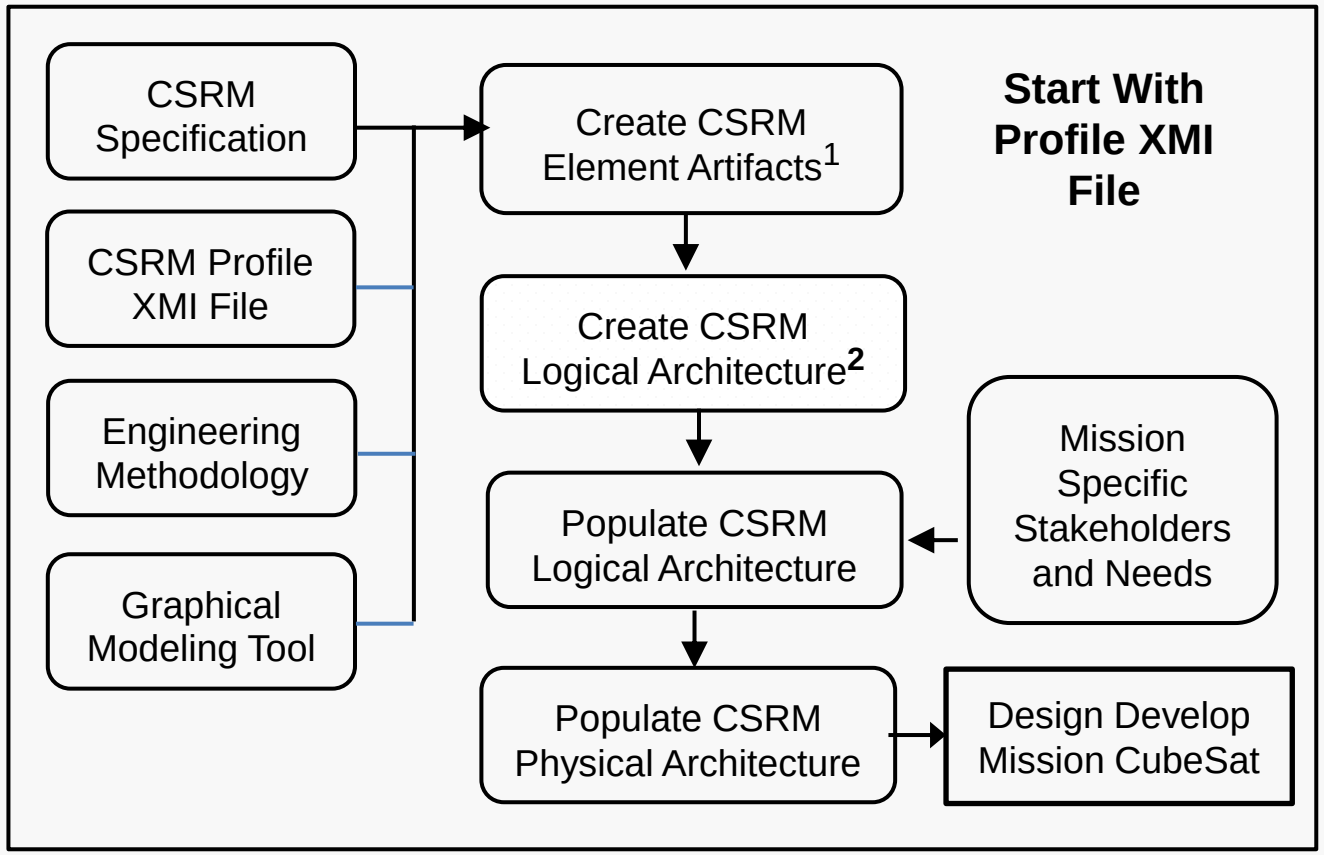
- CSRM Graphical Model Tool File
  - A static storage of a CSRM Model as saved by a graphical modeling tool and loaded/imported into a graphical modeling tool
- CSRM Model
  - A model of a CubeSat space ground system based on the CSRM stereotypes as dynamically instantiated in a graphical modeling tool
- CSRM HTML File
  - A static representation of a CSRM Model generated by a graphical modeling tool that can be explored/evaluated using a browser independently from any graphical modeling tool.

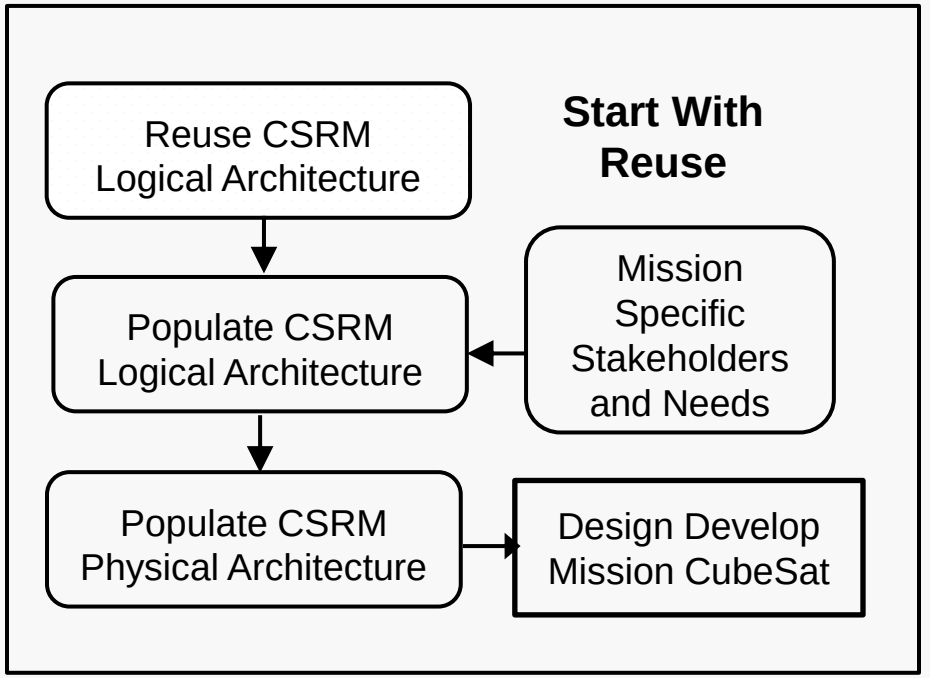


CSRM Elements



Economies Through Reuse





1 - A repository of systems engineering artifacts based on a foundation of stereotypes and the engineering methodology

2 - An exo-structure for population with mission-specific elements

Status

- The normative artifacts have been summitted to the OMG Architecture Board and the Space Domain Finalization Task Force.
  - CSRM Specification PDF
  - CSRM Profile XMI file
- The non-normative CSRM model is in the final stages of validation
- Mission Engineering
  - Identify Mission Engineering MBSE methodologies
  - Identify the key elements of terminology, and map/align with the CSRM terminology for each methodology
  - Analyze the CSRM for additional artifacts which could be added to the containment tree for the key elements that do not map to the CSRM

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