

# CubeSat System Reference Model™ (CSR™) Role and Purpose

Space Systems Working Group (SSWG)

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# CSRM Project Objectives

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- 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 use 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

Phase 1  
CubeSat Framework  
Prelim. RAX Model [1]

Recent Efforts  
Phase 3  
Enterprise Modeling  
for CubeSats [3]  
RAX CubeSat Model  
Trade Studies [4]

INCOSE SSWG  
2007-2010  
Phase 0  
Modeled a Space  
System in SysML  
Hypothetical FireSat -  
SMAD

Phase 2  
RAX Behavior  
Modeling Power,  
Comm, State [2]

Current Efforts  
Phase 4  
Develop a  
CubeSat MBSE  
Ref. Model [5] - [11]



# Model-Based Systems Engineering (MBSE)

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- 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

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- 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

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## **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

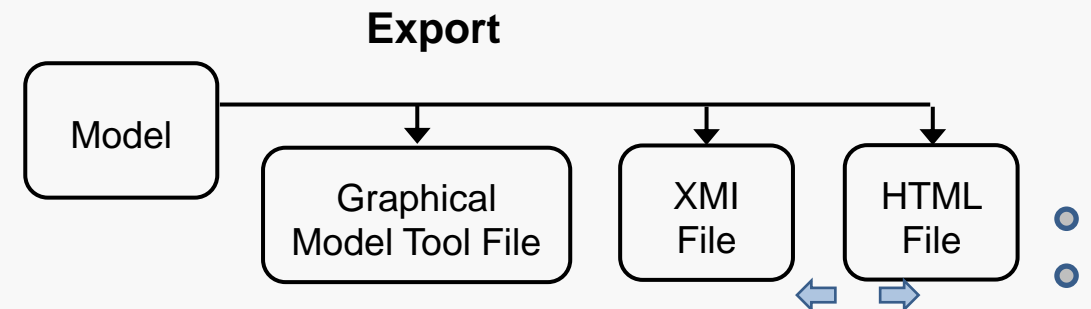
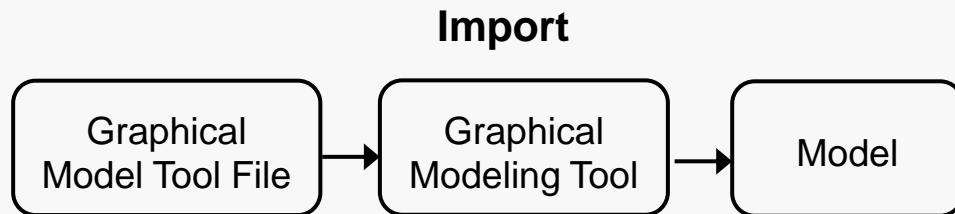
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- CSRM is founded on the normative CSRM Profile as described in the CSRM Specification PDF and captured in the CSRM Profile XMI file
- Normative
  - Normative content is the prescriptive part of the specification
  - The normative content must be implemented 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.



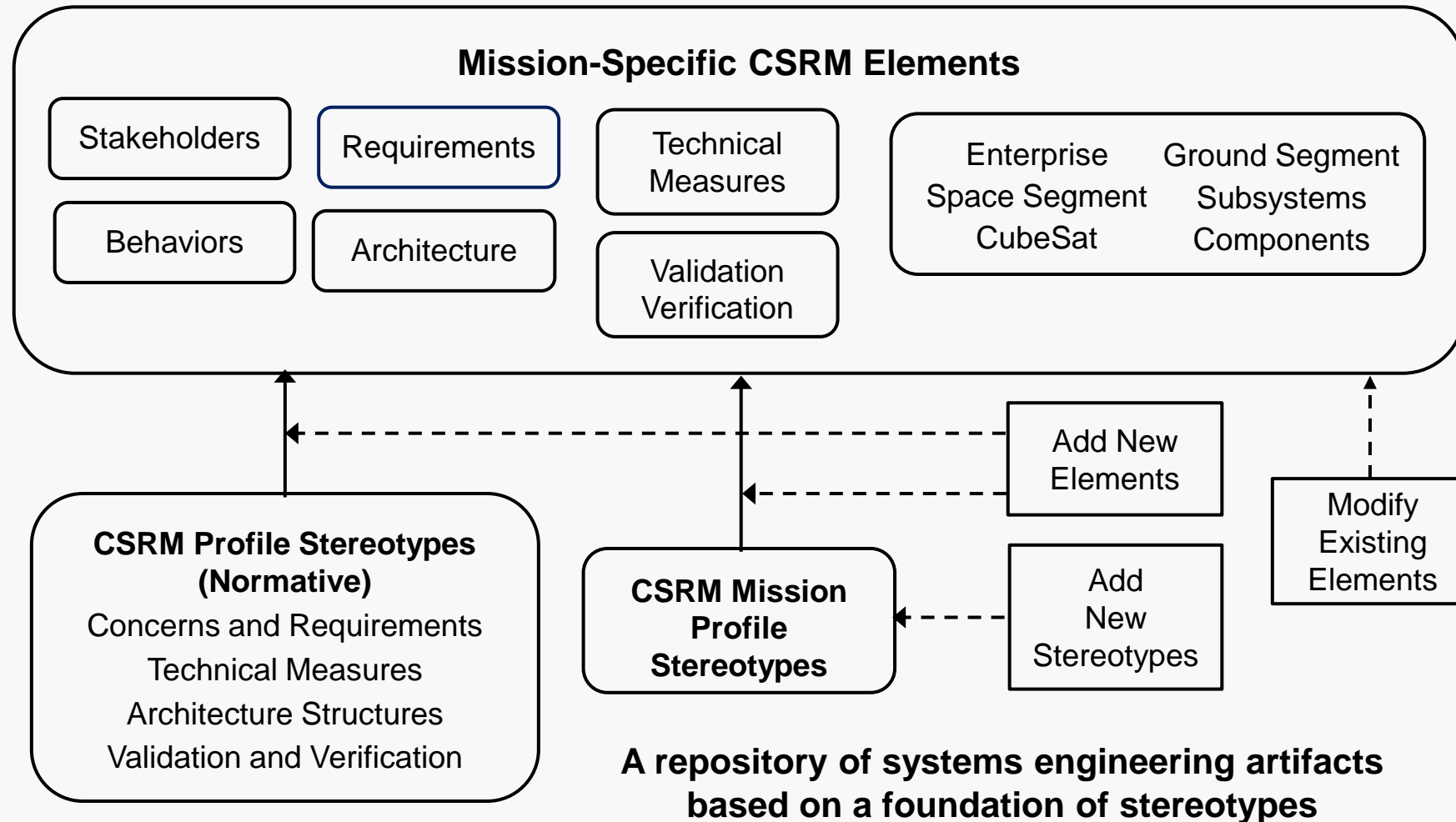
# CSRM Application

- 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.

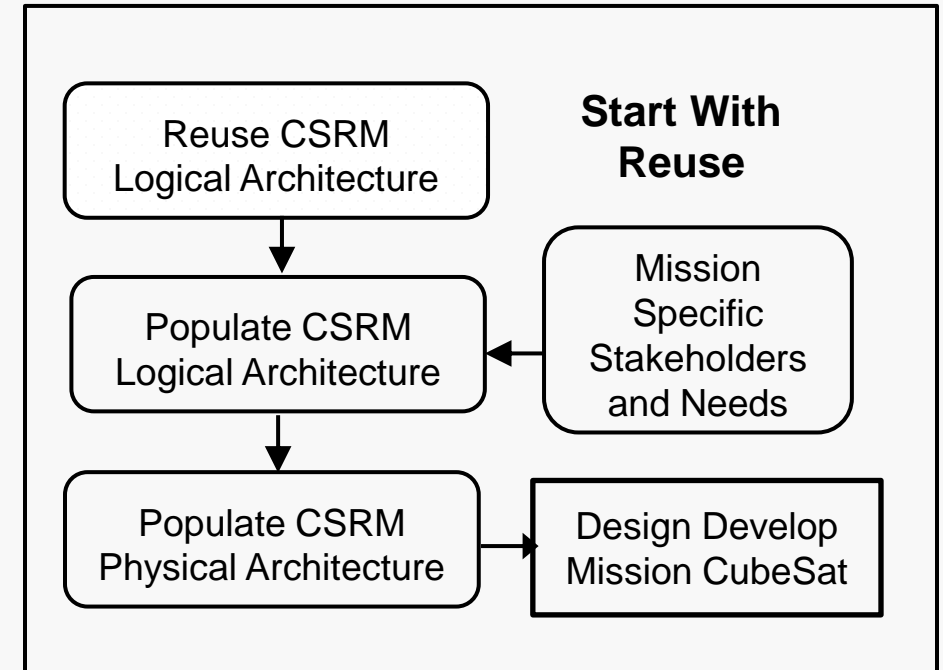
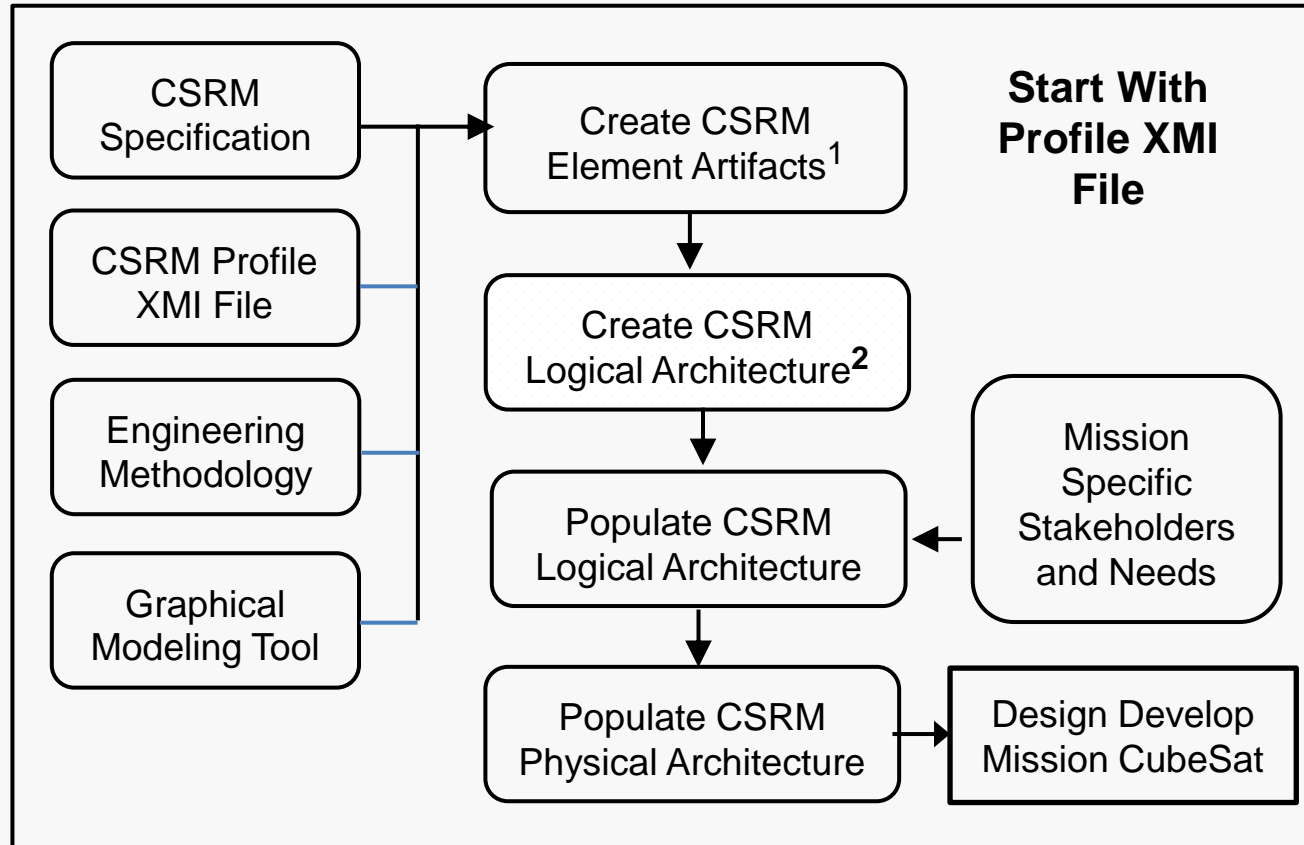




# CSRM Elements

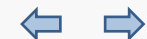


# Economies Through Reuse

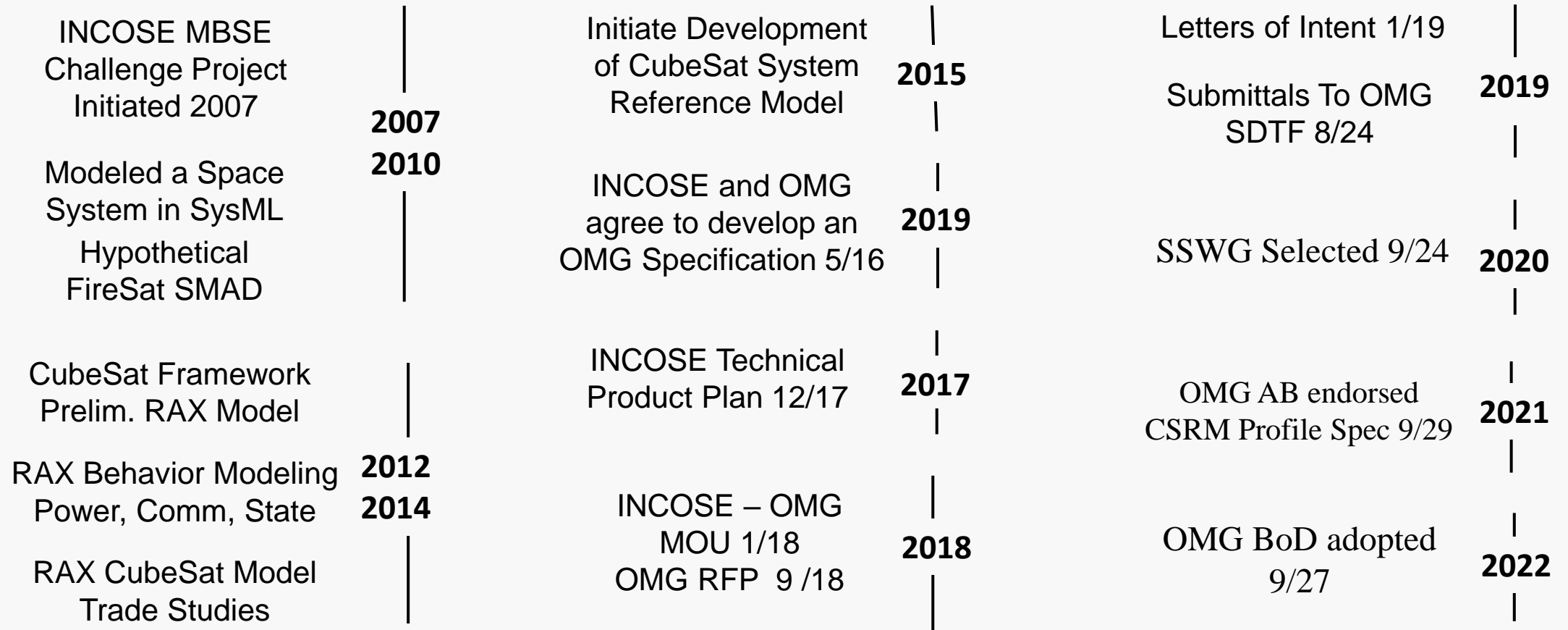


**1 - A repository of systems engineering artifacts based on a foundation of stereotypes and the engineering methodology**

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



# CSRM Development Timeline



# Status

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- The normative artifacts have been submitted 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



# NDIA Systems Engineering Excellence Group Award

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- Object Management Group Space Domain Task Force & INCOSE Space Systems Working Group CubeSat System Reference Model Team received the National Defense Industrial Association Lt Gen Thomas R. Ferguson, Jr., Systems Engineering Excellence Group Award



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