INCOSE Semantic Technologies for Systems Engineering (ST4SE) Deliverables Technical Product Plan (TPP)

1 PROJECT NAME

Semantic Technologies for Systems Engineering (ST4SE) Project (see also Exhibit 1)

2 PROBLEM STATEMENT

MBSE models can be generated from, or validated against, model-based MBSE Patterns, as practiced by the INCOSE MBSE Patterns Working Group. This reduces effort and cycle time in re-generating and re-validating high credibility models and re-correcting oversights and discoveries that have been made in the past by others. The related problem to be addressed is that MBSE is frequently viewed as many engineers learning modeling languages and tools and creating models for their projects “from scratch” or from accumulated informal experience. As demand increases for model-based representations but simultaneously for validation and verification of authoritative models of critical systems for related high impact decisions, this is not a competitively sustainable paradigm. A key part of the problem statement is that “everyone creating their own models” is a currently dominant paradigm in the emerging MBSE practice, so that demonstration and facilitation of the MBSE Pattern alternative is needed. Addressing that need, this project is an outgrowth of INCOSE MBSE Patterns Working Group external INCOSE partner interactions with OMG (for SysML V2.0), NASA JPL (Mission Ontology and Semantic Technologies), ASME (Model V&V Standards Committee VV50 Model Life Cycle Working Group), V4 Institute (Virtual Model capability advancement and the ASELCM Pattern), and ASSESS (application of Model Characterization Pattern).

3 TARGET AUDIENCE

The target audience includes (1) MBSE Model Authors, (2) MBSE Model Users, (3) Engineering Leaders who influence methods and practices, and (4) System Acquirers and Owners who influence methods and practices. The INCOSE Patterns Working Group already involves some outside of U.S. participants. The initial domain of interest is System Engineering itself (Systems 2 and 3 of the ASELCM Pattern discussed below), as opposed to individual product or other engineered system domains.

4 PRODUCT CONCEPT & PROPOSED SOLUTION

Figure 1 is an OV-1 level context reference diagram used in the MBSE Patterns Working Group.

The project’s initial deliverables are model-based semantic patterns (data content at the top of the pyramid in Figure 1) of use to address the above problem statement, along with documentation and examples of use in various environments of use. Those environments, while not the deliverable of this project, include use of Semantic Technologies.

“Semantic Technologies” refers to information technologies (language standards, automated tooling, and related methodologies) that are concerned with explicated meaning represented by model data structures. Examples include OMG SysML® modeling language and tools, W3C OWL DL web ontological language and tools, and automated semantic reasoners or other Semantic Web technologies.

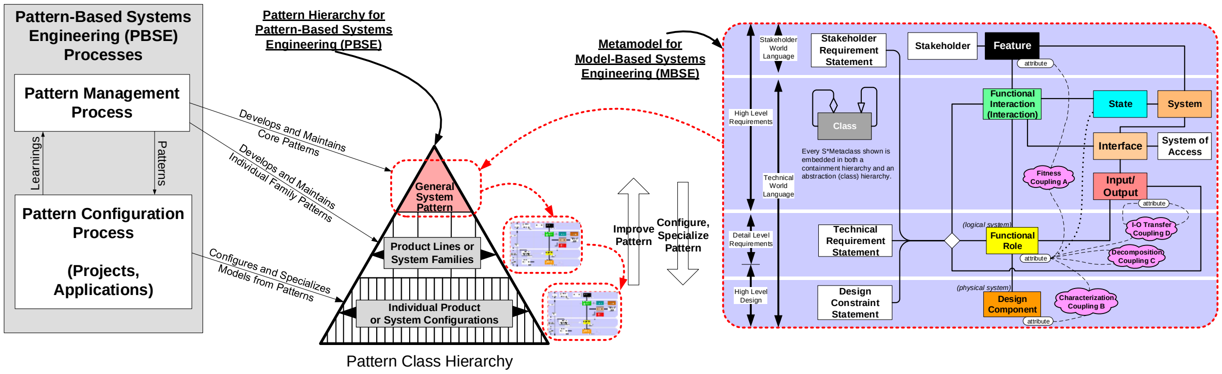


Figure 1: PBSE Diagram

The resulting class hierarchy of existing or typical MBSE Patterns is illustrated in Figure 2. Although the MBSE Patterns Working Group is sometimes involved in domain-specific product or similar example patterns (at the bottom of Figure 2), the main concern of Patterns Working Group as well as this project is the general methodology and therefore the more general patterns common across systems engineering as a discipline. Those general patterns fit in the sections above the lowest level shown in Figure 2. Like the MBSE Patterns at all levels of Figure 2, these data structures become the points of accumulation of organizational or group learning and common understanding (as well as variability) about the subject matter at that level. They are effectively reusable, configurable “product line” patterns for accumulation of learning across individuals, teams, enterprises, supply chains, and industry groups.

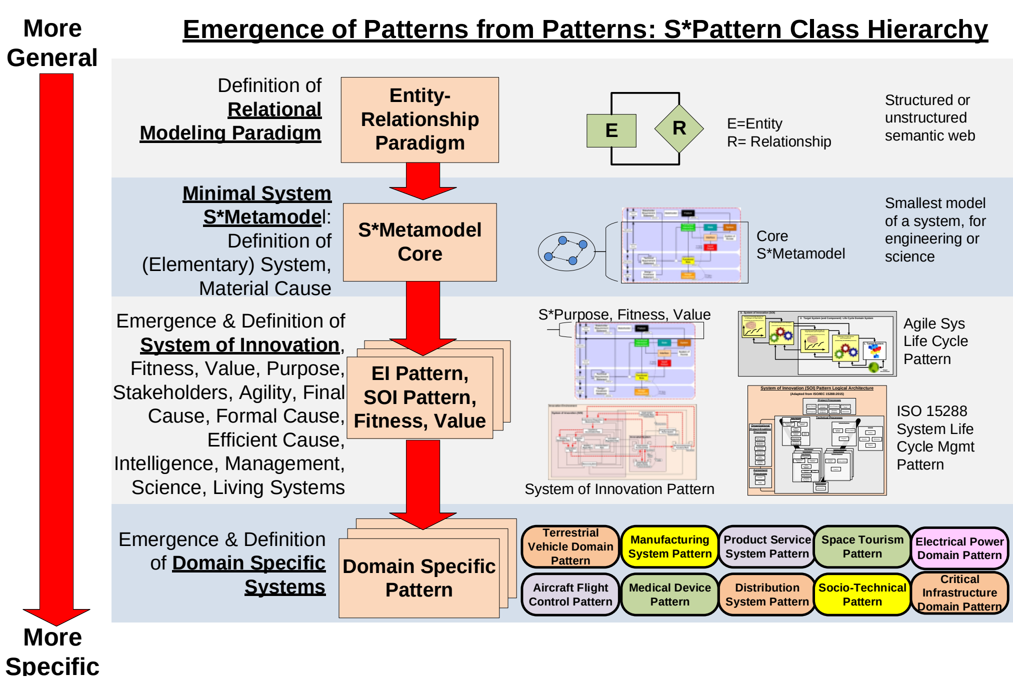


Figure 2: Resulting Pattern Hierarchy, Existing or Typical MBSE Patterns

4.1 FIRST (2019) DELIVERY: GAINING INCOSE EXPERIENCE IN NEW TERRITORY

This project is to deliver a series of MBSE Patterns, for use by both INCOSE members and others in their advance of systems engineering practice and outcomes. While use of MBSE Patterns, over the last twenty years, is itself relatively novel, this project includes additional aspects that are additionally novel (and therefore unfamiliar) for INCOSE, and are intended to be tested in themselves by this project:

1. The non-exclusive distribution of content through multiple channels in addition to INCOSE itself, even though INCOSE will hold a copyright for an INCOSE branded version
2. The ability of users to derive their own versions of the distributed items
3. The use of techniques associated with open software development and distribution, including public license to use at no license charge to the user

It is recognized that these aspects in themselves may present perceived risks through their relative unfamiliarity in INCOSE's experiences. Therefore, this project is structured to explore that space incrementally, beginning with a limited first asset distribution that has been targeted all year by the project team for December, 2019. The simple pattern asset to be distributed is the System Interface Pattern. It is a general MBSE pattern that can be specialized to individual interface types and has been studied by both a special Interface Patterns Team and the subsequent ST4SE JPL-OMG-INCOSE team. This simple pattern will allow the less familiar operational or business aspects listed above to become more familiar to INCOSE through experience. (See also Exhibits 2 and 3.)

4.2 SECOND (2020) DELIVERY: MODEL CHARACTERIZATION PATTERN (MODEL METADATA WRAPPER)

After evaluation of the experience of the first delivery described above, it is expected that the second pattern delivery in early 2020 will be chosen from a number of candidates in the pipeline of the team already. A leading candidate is the Model Characterization Pattern (MCP), developed in a Patterns Working Group collaboration with ASME, V4I, and ASSESS. This was previously briefed to the INCOSE Corporate Advisory board in 2017:

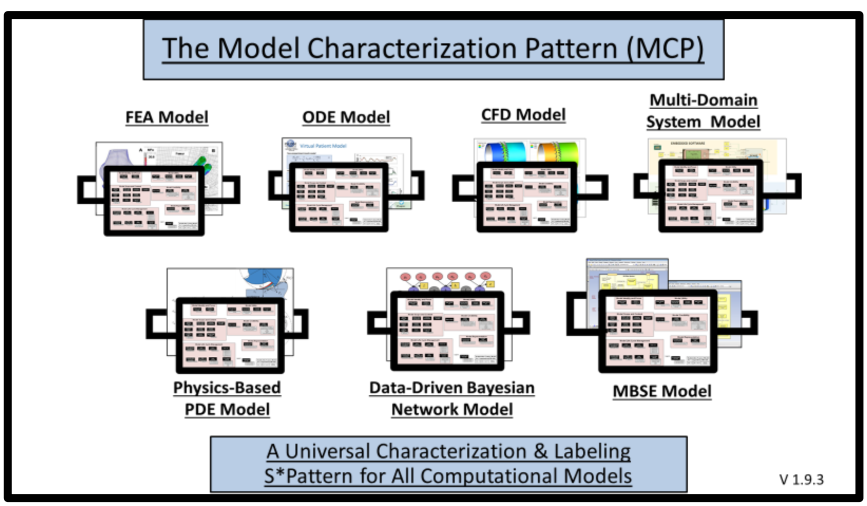


Figure 3: Model Characterization Pattern (MCP) – The "Model Wrapper"

As further described in the MCP Reference publication, this pattern enables the following uses:

1. Rapidly generate very systematic model requirements for new or existing models, for use in model development, verification, validation, and life cycle management.
2. More effectively plan new or improved computational models, and know when you need them, versus making use of existing model assets.
3. Lower the experience threshold needed to plan and manage computational models, including model VVUQ.
4. More effectively manage large collections of diverse computational models and related information.
5. Improve access to collections of models by exposing their characteristics to users more effectively.
6. More effectively share models across supply chains and regulatory domains.
7. Lower the cost and time necessary to obtain trusted/credible models in regulated or other domains.
8. Use or manage models that were generated by others; increase the range of others who can effectively use models that you generate; reduce the likelihood of model misuse.
9. Improve the accumulation and effective use of model-based enterprise knowledge.
10. Improve the integration of model-related work across specific engineering disciplines and overall systems engineering.
11. Increase ability to manage the integration of multiple computational models (e.g., using FMI), including their integrated VVUQ.

4.3 SIMILAR OFFERINGS, DIFFERENTIATIONS, OTHER OPTIONS CONSIDERED

Examples of other open source offerings:

Mozilla Firefox® web browser.
Thunderbird® email client.
PHP scripting language.
Python programming language.
Apache HTTP web server.

The above are executable computer software, not MBSE Pattern data structures.

Protégé® downloadable ontologies:

https://protegewiki.stanford.edu/wiki/Protege_Ontology_Library

The above pattern data structures are numerous specific domain ontologies, but not a systems engineering ontology.

There are model metadata lists, and a related ISO subproject within MOSSEC, but these are not of the same scope as the Model Wrapper Pattern, which may also inspire those efforts to improve their plans, of value the INCOSE community:

https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:smswg:smswg_19:mossec_ap243_standard.pdf

The project team is also considering non-INCOSE alternatives, but would prefer INCOSE as a copyright holder over other parties under consideration, on the condition of the team's goal that a first example copyright (for the simple Interface Pattern asset) can be established by the end of 2019.

4.4 ADDITIONAL DETAILS: RELATED REFERENCES

Additional information about MBSE Patterns in general and the initially targeted patterns for this project may be found in the following references:

1. Methodology Summary: Pattern-Based Systems Engineering (PBSE), Based On S*MBSE Models https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:patterns:pbse_extension_of_mbse--methodology_summary_v1.5.5a.pdf
2. INCOSE MBSE Patterns WG Web Site: https://www.omgwiki.org/MBSE/doku.php?id=mbse:patterns:patterns
3. Accelerating MBSE Impacts Across the Enterprise: Model-Based S*Patterns https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:patterns:accelerating_mbse_impacts_across_the_enterprise_using_model-based_s-patterns_v2.1.1.pdf
4. Model Characterization Pattern: https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:patterns:model_characterization_pattern_mcp_v1.9.3.pdf
5. Patterns in the Public Square" INCOSE Washington, DC, Panel with Regulators and DoD: https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:patterns:panel--is2018_schindel_et_al_v1.6.1.pdf

4.5 KEYWORDS

Semantic Technologies, MBSE Patterns, Model Metadata, Open Source, Public Licensing

5 COMPETITVE ANALYSIS

(Covered in Section 4.3 above.)

6 STAKEHOLDERS

The INCOSE MBSE Initiative identified the stakeholders in Figure 4 as having stakes in the success of the MBSE Transformation.

7 PRODUCT DISTRIBUTION APPROACH

Refer first to the discussion of multiple non-exclusive distribution channels in Sections 2 and 4.

☒ INCOSE online bookstore (this is optional to team; INCOSE holding a copyright is mandatory)

☐ Printed copies at local events

☐ Printed copies at international events

☒3rd party online distribution by: identify the 3rd party (ST4SE Team git hub site) (ASME) (ASSESS)

☐ 3rd party hard copy distribution by: identify the 3rd party

☒ Other: describe other distribution channel

Population <-- Size (Log)	**Stakeholders in A Successful MBSE Transformation (showing their related roles and parent organizations)**	Industry & Gvmt. Initiatives	Orgs. Internalizing MBSE, Including Gvmt Contractors & Commercial	Vendors of MBSE Tooling and Services	Academia and Researchers	Technical Societies, Other Non-Technical Organizations	
Model Consumers (Model Users):							
****	Non-technical stakeholders in various Systems of Interest, who acquire / make decisions about / make use of those systems, and are informed by models of them. This includes mass market consumers, policy makers, business and other leaders, investors, product users, voters in public or private elections or selection decisions, etc.	X	X			X	
**	Technical model users, including designers, project leads, production engineers, system installers, maintainers, and users/operators.	X	X			X	
*	Leaders responsible to building their organization's MBSE capabilities and enabling MBSE on their projects	X	X			X	
Model Creators (including Model Improvers):							
*	Product visionaries, marketers, and other non-technical leaders of thought and organizations	X	X		X	X	
*	System technical specifiers, designers, testers, theoreticians, analysts, scientists	X	X		X	X	
*	Students (in school and otherwise) learning to describe and understand systems				X	X	
*	Educators, teaching the next generation how to create with models	X	X		X		
*	Researchers who advance the practice		X	X	X		
*	Those who translate information originated by others into models	X	X		X	X	
*	Those who manage the life cycle of models	X	X		X	X	
Complex Idea Communicators (Model "Distributors"):							
**	Marketing professionals	X	X	X		X	
**	Educators, especially in complex systems areas of engineering and science, public policy, other domains, and including curriculum developers as well as teachers	X	X	X	X		
**	Leaders of all kinds	X	X	X	X	X	
Model Infrastructure Providers, Including Tooling, Language and Other Standards, Methods:							
*	Suppliers of modeling tools and other information systems and technologies that house or make use of model-based information			X			
*	Methodologists, consultants, others who assist individuals and organizations in being more successful through model-based methods	X	X	X	X		
*	Standards bodies (including those who establish modeling standards as well as others who apply them within other standards)	X				X	
INCOSE and other Engineering Professional Societies							
*	As a deliverer of value to its membership					X	
*	As seen by other technical societies and by potential members					X	
*	As a great organization to be a part of					X	
*	As promoter of advance and practice of systems engineering and MBSE					X	

Figure 4: Stakeholders

8 PRODUCT MAINTENANCE APPROACH

The materials to be addressed are expected to be the above-listed MBSE Patterns. Two key considerations are the use of open software development and distribution methods and the intention that the subject patterns be the focus of group learning. Therefore, the paradigm of ongoing attention is somewhat different than traditional “develop, release, maintain”. Instead, a “develop, develop, develop” approach is expected, as long as there is a community of users interested in updates. Beyond that demand-driven approach, a quarterly or annual review will be appropriate, dependent upon intensity of interest.

9 PRODUCT RETIREMENT CRITERIA

Relevance and applicability can best be ascertained based on frequency of download. Lack of interest over a period of two years would be a reasonable cause to consider retirement, with consultation to include partner organizations.

10 TEAM MEMBERS

10.1 TEAM LEADER

The chair of the MBSE Patterns Working Group providing this plan is Bill Schindel. Other team members are listed below.

10.2 CONTENT CONTRIBUTORS

Steve Jenkins (NASA JPL), Hans Peter deKoning (ESA), Bill Schindel (ICTT System Sciences)

10.3 INDEPENDENT PEER REVIEWERS

Troy Peterson (MCP and Interface Pattern), Chris Paredis (Interface Pattern and MCP), Ann Hodges (MCP), Frank Salvatore (Interface Pattern)

10.4 CORE TEAM MEMBERS

Mark Blackburn (Stevens Institute)

11 PROJECT ASSUMPTIONS/GROUND RULES

Deliverables are for distribution without charge and may include INCOSE branding. INCOSE will hold a Creative Commons CC BY SA license related copyright (see Exhibit 4) and provide the deliverables under CC BY SA license under which users may create their own versions, also eligible for separate derived materials copyright under that license type. Items brought to INCOSE hereunder may already be under a CC BY SA copyright license from their authors or other upstream parties, but this does not prevent INCOSE from packaging its own copyrighted version as long as offered by INCOSE under equivalent terms and CC BY SA license.

12 PROJECT STRATEGIES/APPROACH

Use of open software development methods.

Team's goal is that initial (Interface Pattern) asset must be under INCOSE copyright no later than end of 2019 in order to proceed with INCOSE as copyright owner.

Different pattern assets may involve work with different collaborating societies or partners, as discussed earlier above.

13 MILESTONES & ACTION PLAN

Specify the expected milestones to be met, tasks to be accomplished, and planned completion dates. At a minimum, the following milestones must be addressed. Note that required milestones may be combined. Required INCOSE process reviewers are in parentheses, more can be added.

1. Create the initial version of the first two pattern deliverables and beta test them. (This was already accomplished by the team in 2019 or earlier)
2. Determine whether there is INCOSE leadership willingness serve as a copyright owner and allow for public distribution (at least by others) without license fees. (This does not require INCOSE distribution or INCOSE branding, but is mandatory to the existing project team if INCOSE is going to be copyright owner, and under CC BY SA licensing) (By end of November.)
3. Place first experimental asset (Interface Pattern) under an INCOSE copyright CC BY SA license style. (Must occur by first week of December, or activate alternative partner and rest of TPP is not applicable from an INCOSE product point of view.)
4. Initial Acceptance of Technical Product Plan:
   - Intellectual Property Review with the Publications Office (Associate Director for Publications)
   - Quality Review of Review Process with Technical Operations (Assistant Director for Technical Review)
   - IT & Distribution Review with INCOSE Information Technology (INCOSE Chief Information Officer)
   - Branding, Marketing, & Commercialization Review with Marketing/Communications (Director of Marketing and Communications)
   - Technical Operations Process Review (Assistant Director for Technical Information)
5. Final Acceptance of Technical Product Plan (Director Technical Operations)
6. Final Product Release Review (Director Technical Operations)
7. Periodic Reviews for Learning updates, Maintenance, Obsolescence, Improvement, and Retirement Assessment (e.g., yearly)

Note: During project planning, the author of the Technical Product Plan should check with each reviewer individually to determine how much review time will be required and account for this review time in the project schedule.

14 REQUIRED RESOURCES (INCLUDING VOLUNTEER TIME AND BUDGET)

It is estimated that 64 hours per year per pattern author will be required, originating a new pattern.

It is estimated that 8 hours per year per pattern reviewer will be required, maintaining a pattern.

These investments have already been made for the first two patterns.

It is estimated that four patterns per year will be authored and reviewed.

This project is not requesting INCOSE distribution, but allows for it if that is leadership’s wish.

15 COMMUNICATION OF PROJECT STATUS AND RISKS

This project team already meets twice monthly, and has been doing so for well over a year. We also have been holding full day face to face meetings at least twice annually.

The Patterns Working Group as a whole meets at least twice annually, and can report on the project at both the IW and IS meetings where we are already regular participants in the MBSE Workshops there.

The main risks of this project are believed to be lack of INCOSE experience with open source methods, which are conducted more “bottom up” than “top down”. The primary goal for the first period is for all parties to learn by experience whether this is a “fit”, and to be forthright with each other in that assessment.

16 SIGNATURES

1st Level of Approval by Assistant Director for Technical Information:

Typed name of AD for Technical Information

Name	Signature	Date

2nd Level of Approval by Director Technical Operations:

Typed name

Name	Signature	Date

Typed name

Name	Signature	Date

Typed name

Name	Signature	Date

Typed name

Name	Signature	Date

Technical Product Plan Revision History

Date	Revision	Description	Author
14 Nov 2019	1.2.1	Original draft, for feasibility determination with INCOSE leadership.	Bill Schindel
07 Dec 2019	1.3.1	Updates to pull other materials into TPP per conversation with INCOSE leadership	Bill Schindel

Exhibits:

- **Exhibit 1: INCOSE Patterns Working Group ST4SE Project Charter**
- **Exhibit 2: Flowchart—Asset Publication Administrative Aspects**
- **Exhibit 3: INCOSE Author IP Agreement for SPTSE Technical Products**
- **Exhibit 4: Creative Commons CC BY-4.0 License**

EXHIBIT 1: INCOSE MBSE Patterns Working Group

Project Charter April, 2019

1 PROJECT NAME:

The name of the project is the <u>Semantic Technologies for Systems Engineering (ST4SE) Project</u>.

2 PROJECT OBJECTIVES AND INTENDED OUTCOMES SUMMARY:

The objectives and intended outcomes of this project are to:

1) Improve shared systems engineering community-wide knowledge for more effective life cycle engineering of systems, through the identification, availability and distribution, and use of model-based ontological patterns and related semantic web technologies.
2) Optimize the compatibility and leverage enjoyed through the integrated use of existing, emerging, or evolving systems modeling languages and modeling tools, model-based ontological patterns, semantic technologies, and related standards.
3) Modularize the availability and use of the above components across different domains, levels of abstraction, life cycle stages, and business situations.
4) Lower barriers to understanding and effective use of the above, by providing educational opportunities and examples along with feedback to related suppliers, and by minimizing complexity and cognitive or other barriers to use by a larger community.
5) Develop effective means of collaboration across the participating organizations, meeting their expectations and needs as well as those of the systems community served.
6) Maintain and evolve the related community resources for continued effective use.
7) Improve leverage of existing technical resources—theory and practice as well as technologies for representing and using collaborative knowledge in various domains.

Note the above objectives are not dominated by ontologies themselves (content), but instead by the methods, tooling, and capabilities to create and use them.

3 PROJECT STAKEHOLDERS AND RELATED PARTIES

Refer to <u>**Figure 1**</u> below. The backgrounds, needs, and expectations of the team's three directly collaborating organizations (discussed in <u>**Table 1**</u> below) must be met to have a productive collaboration. The needs and expectations of the other stakeholders in <u>**Figure 1**</u> must be met to succeed in having the impacts sought.

4 PROJECT DELIVERABLES:

1) Packaging Plan and User CONOPS:
   a. Ontologies modularization plan, identifying ontologies to be created or packaged, briefly summarizing their scope(s), along with known content sources to be considered for inclusion.

b. SysML v2 ontologies CONOPS, summarizing the high-level plan for users' integrated use of the emerging v2 toolset, its internal metamodel, OWL DL bidirectional transformer, specialized ontologies add-on capability, and semantic tools, across the life cycle of models. (Refer to **Figure 1** below.)
c. Documentation, education, and examples plan listing items to support the above CONOPS.
d. Simple demonstration and test plan appropriate to the project objectives and the information and tooling involved.

2) Approximate schedule and efforts projected to accomplish the above (insert in Section 8 below).
3) Packaged ontologies, with supporting documentation and initial test results.
4) Library organization of these patterns, and means of access to the Deliverables.

5 PROJECT OPPORTUNITIES AND RISKS

This project is defined with expectation of accelerating rate of progress of ST4SE work of the last year. It is important to understand why the project team believes the approach described here provides that acceleration.

There is opportunity in the availability of existing resources in the three collaborating organizations, per **Figure 1.** However, there are also background differences between the three organizations that must be adequately understand and addressed. It is not believed that these differences are direct conflicts or incompatibilities, but it is important to understand and accommodate them. Refer to the background comparisons of **Table 1** below and the resources of Table 1 and Figure 2 below. **Figure 2** lists additional resource opportunities and history.

6 POTENTIAL FOR INCOSE TECH OPS PRODUCTS

The Deliverables are not expected to be exclusive to INCOSE. There are multiple opportunities for INCOSE education or other member benefits from this project. If and as identified, these can be described in a related INCOSE Technical Product Plan.

Consistent with the preliminary work already performed by representatives of the collaborators, there is an expectation that targeted deliverables of this work will be made available on a basis similar to open source software:

1. A non-commercial common copyright owner will utilize one of the widely used "commons" licensing packages to make the assets legally available for use by others.
2. A public access repository (e.g., github) will be used to publish and make available the assets; a similar repository and development protocol will be used to manage the assets over their earlier and subsequent life cycle stages.

The copyright owner of (1) need not be the distribution entity or one of the collaborating entities listed, but INCOSE is the initially intended candidate to serve as the copyright owner, since it seeks to offer such other systems engineering assets already. In the event INCOSE ownership of the copyright is not feasible, other non-commercial entities that could serve as the copyright owner have already been identified.

7 PROJECT COLLABORATING ORGANIZATIONS AND REPRESENTATIVES

The following parties represent the three collaborating organizations listed in **Figure 1** and **Table 1** below:

1. Steve Jenkins, NASA JPL, leader of JPL ontologies and semantic technologies effort as used in the JPL Open CAESAR Project.

2. Hans-Peter de Koning, European Space Agency (ESA), member of the OMG SysML v2 Submission Team
3. Bill Schindel, ICTT System Sciences, Chair of INCOSE MBSE Patterns Working Group

Other individuals may be added to this project.

8 PREREQUISITE OR EARLY ACTIONS

Certain preparatory, qualifying, or otherwise early actions would be important to conduct first in order to validate assumptions, test potential areas of risk, and support the details of plans for what would follow:

1. S*Metamodel folks would need to practice use of OWL2 DL (plus use of OML to generate it) to represent S*Models and S*Patterns, to gain facility in these subjects and to determine suitability of the combination of ideas, technologies, and people.
2. Represent the S*Metamodel in OWL2 DL (this activity could be the way to carry out (1) above also provides learning about S*MTM by others).
3. Test ability to express Open CAESAR ontologies in terms of S*Metamodel constructs, see how much of this can be accomplished with what effort, and understand the origins and resolutions of any issues encountered in doing so. (This activity would provide learning opportunity for both groups.)
4. Test ability (when available) of emerging SysML V2 inclusion of OWL 2 formalization of ontologies to express Open CAESAR ontologies.
5. Describe and carry out a few CONOPS tests of downstream users of ontologies/patterns in their modeling or similar work. For example, the current Open CAESAR and Patterns WG work use somewhat different CONOPS in terms of when ontological/pattern constraints are expressed during use of actual modeling tooling (as a batch run against a completed model versus as a constraint, versus as a pattern configuration process leading to a configured pattern-valid model. (Use of checking reasoners after specific model construction, versus use of pattern configurators to build the specific model.) Each may have a good place, but they represent a modeler CONOPS difference between the two groups for now.
6. Firm up the copyright owner plan discussed in Section 6.

Although the team is relatively optimistic on the above steps, we recognize a few carry some risk and in the worst case might lead to either stepping back or re-planning. Addressing them as pre-requisite first actions would therefore be prudent.

9 PROJECT SCHEDULE:

Schedule, including meetings, milestones, and overall is to be determined by the team. It is suggested that key milestones include INCOSE, OMG, and JPL public events, along with regular periodic meetings, work sessions, and deliverables.

10 PROJECT REFERENCES:

1. Elaasar, Maged, “JPL Open CAESAR Initiative”, NASA JPL MBSE 2019 Symposium, Pasadena, January 2019. Retrieve from:

   https://www.slideshare.net/MagedElaasar/open-caesar-initiative?from_action=save

2. Seidewitz, Ed, "SysML v2 and MBSE: The Next Ten Years", Models 2018, Copenhagen, October 2018. Retrieve from:

   https://www.slideshare.net/seidewitz/sysml-v2-and-mbse-the-next-ten-years

3. "MBSE Patterns Working Group", INCOSE 2018 International Symposium, July, 2018. Retrieve from: https://www.omgwiki.org/MBSE/lib/exe/fetch.php?media=mbse:patterns:mbse_patterns_wg_mtg_slides_is2018_july_2018_v1.2.2.pdf

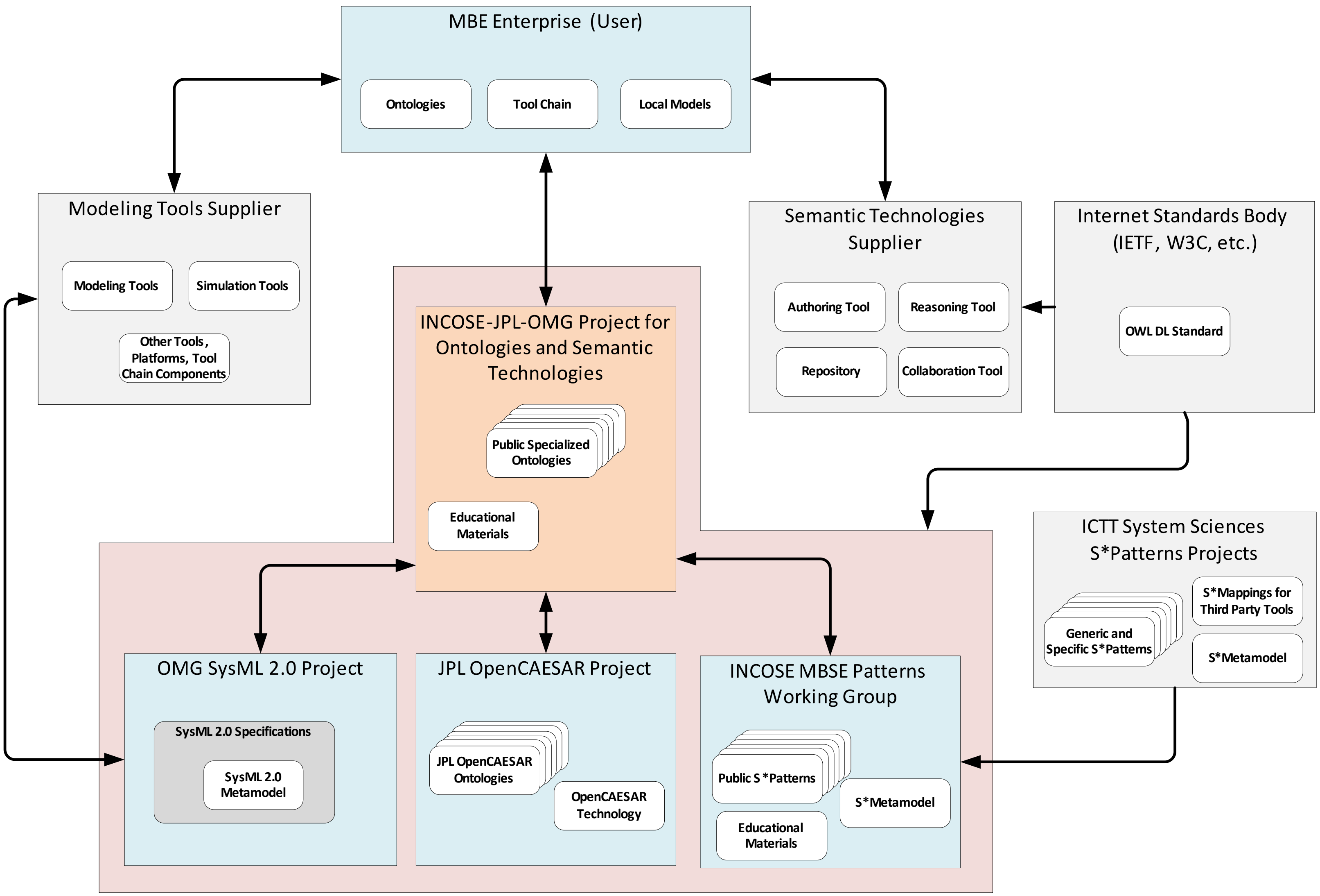


Figure 1: Interaction of three organizations in the planned collaboration project

Table 1: Current Situation--Different Historical Backgrounds and Emphases, Going Into Proposed Project (Not incompatible, but with different emphases)			
Ontological Patterns Source→	**OMG** **SysML v2 Submission Team**	**NASA JPL** **Open CAESAR Team**	**INCOSE** **MBSE Patterns WG**
Historical & Organizational Origin→	SysML originated from SysML Partners group, including INCOSE, OMG, tool vendors, OEM users. SysML v1 was first released in 2006 and has seen a number of incremental updates to current SysML v1.6 per March 2019. SysML v2 is a major update to SysML v1.x, including replacement of the previous UML-based Metamodel with a new minimalist SE-oriented Metamodel as well as a number of normative, extensible model libraries	Development and use of multiple JPL systems ontologies (base, mission, and other ontologies) in support of different JPL-engineered space missions over years of experience. Initial emphasis was internal to NASA, adding later public sharing projects and open collaborations in more recent years.	Formed as INCOSE WG, part of INCOSE-OMG MBSE Initiative, over six year period, with focus on S*Models and S*Patterns, based on 15 years' ICTT experience with S*Metamodel, to strengthen system modeling while reducing related effort. Most projects in partnership with other INCOSE WGs or partners outside of INCOSE.
Relevant Aspects Emphasized→	Align SysML Metamodel closer to SE needs vs. past software engineering emphasis of UML derived metamodel. Add bi-directional transformation capability between SysML v2 models and equivalent OWL DL ontologies, possibly supplemented with SWRL rules. This enables use of existing OWL DL automated reasoners to formally check standard and user-defined rules concerning consistency, completeness and model quality .	Special emphasis on ontological rigor and automated ability to inspect application models against ontologies, using post model authoring automated reasoners that are already available from third parties and heavily verified through other WWW applications. Ability to extend to other types of model checking (e.g., numeric) in future.	Special emphasis on physical science and semantics subset rigor to bring systems modeling closer to the history, tools, and methods of physical sciences, compared IT history of business process automation and databases. S*Metamodel emphasis on smallest model sufficient for life cycle purposes of engineering and science. Special emphasis on doing less model creation through use of trusted S*Patterns, invoked simultaneously with model authoring through use of S*Pattern Configuration process.

Table 1: Current Situation--Different Historical Backgrounds and Emphases, Going Into Proposed Project (Not incompatible, but with different emphases)			
Ontological Patterns Source→	**OMG** **SysML v2 Submission Team**	**NASA JPL** **Open CAESAR Team**	**INCOSE** **MBSE Patterns WG**
Scope of Information	SysML v2 goals include diverse improvements based on 1.x experiences. Given the stated SysML v2 interest in improving the environment for engineering, it is assumed that metamodel interests may go beyond designed system, but could also be addressed by partitioned ontologies (target engineered system, planning, engineering, etc.), using the planned specialized ontologies addition capability. It is not known to writer if that is current plan.	Provide multiple separate but related JPL systems ontologies (base, mission, engineering, and other ontologies) intended as specialized add-ons when needed. Term "pattern" has been used for meaningful fragments of a whole ontology—slightly different use of the term "pattern" than in INCOSE Patterns WG.	"S*Pattern" term refers to scope of whole S*Metamodel or less, not just model fragments. S*Patterns at whole system level, as well as pieces; not distinguished from Ontology. Emphasis has been on making S*Patterns friendly, intuitive, easy to configure, Feature-based, with formal checking rules in real time and more limited than OWL DL (of interest to enhance in this project). Separation (but connection) of ontologies for basic SE foundation (S*MTM), domain systems of interest, manufacturing systems, operations systems, etc.
Historical Patterns, Ontologies, Metamodels, Domains, Past Uses, Maturity→	SysML v1.x used metamodels derived from UML. Approximately 12 years of experience in the SysML v1.x series, domains including mil/aero, automotive, other, on COTS and open source tools from multiple tool suppliers.	Use on NASA JPL science missions over multiple years, missions. Recently expanded to include collaboration with other enterprises in different domains.	Wide variety of S*Patterns created across diverse domains listed in Figure 2 below, over last 15+ years. Includes experience with S*Metamodel mapping to other languages and toolsets over same period.

Table 1: Current Situation--Different Historical Backgrounds and Emphases, Going Into Proposed Project (Not incompatible, but with different emphases)			
Ontological Patterns Source→	**OMG** **SysML v2 Submission Team**	**NASA JPL** **Open CAESAR Team**	**INCOSE** **MBSE Patterns WG**
Modeling Languages:	SysML, with v2 in progress.	Models in SysML, mapped to OWL DL for reasoning, other queries.	S*Metamodel mapped to multiple third party or standards-based languages and tool schema, including but not limited to SysML. S*Metamodel is tool and language neutral, through formal mappings to each.
Technologies, Toolsets:	SysML tools developed by third party COTS and open source suppliers, to comply with SysML specification. Related OMG standards-based technologies (e.g., MOF, etc.)	Third party COTS SysML Modeling Tools; JPL CAESAR integration technology; ontology authoring tools; reasoning & query tools	Multiple third-party COTS modeling tools, engineering and requirements toolsets, simulators, PLM platforms, other tool chain components. (e.g., Magic Draw/CSM, Enterprise Architect, IBM Rhapsody, Siemens TeamCenter PLM, IBM DOORS, others)
Downstream Modeling User CONOPS	Some form of utilization of OWL DL capability is being included in SysML v2	Following specific model construction, modeler runs reasoners on model to determine any exceptions to ontologies invoked.	During specific model construction, applicable pattern (ontology) is applied by the Pattern Configuration Process, to construct a conforming model.

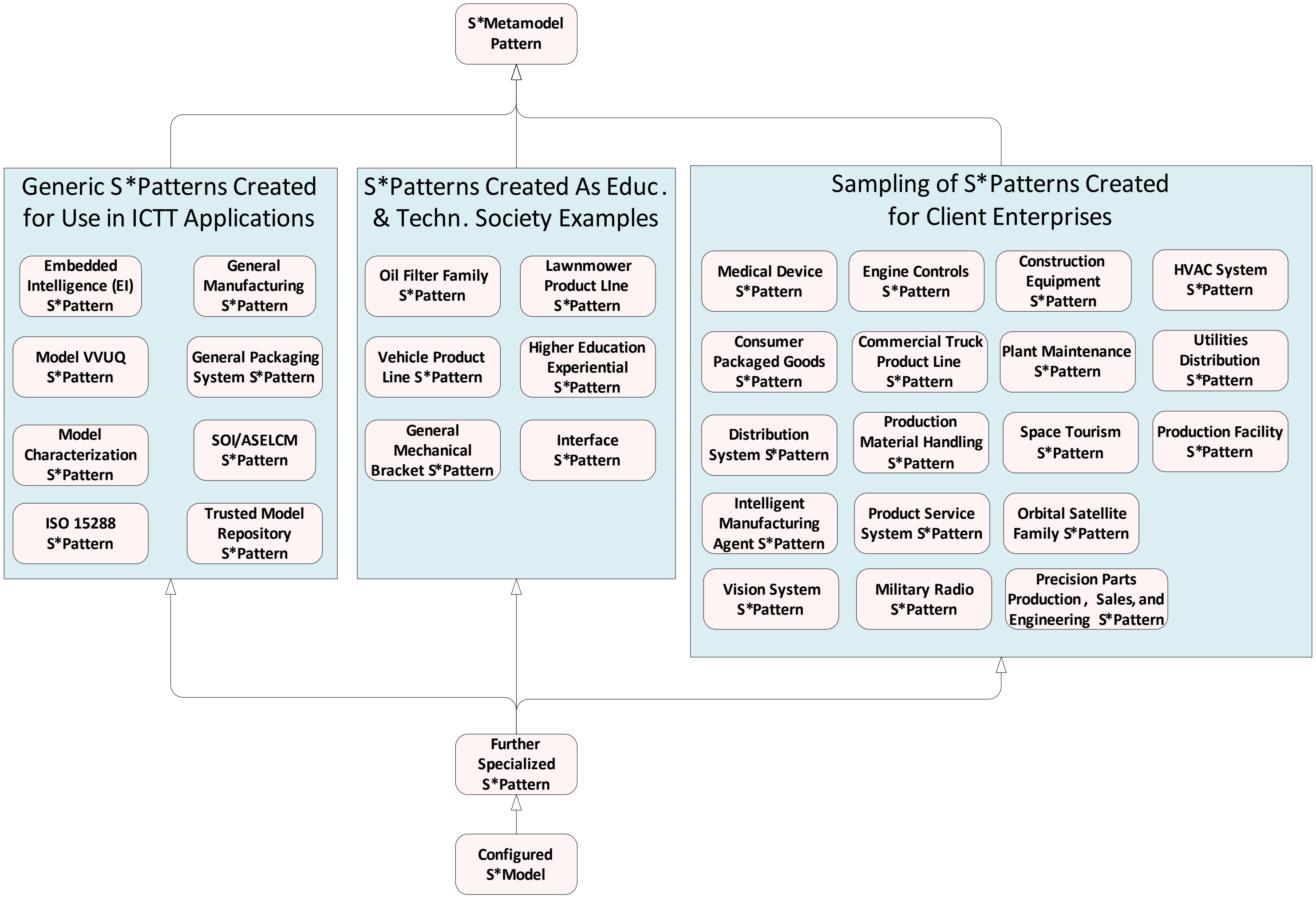
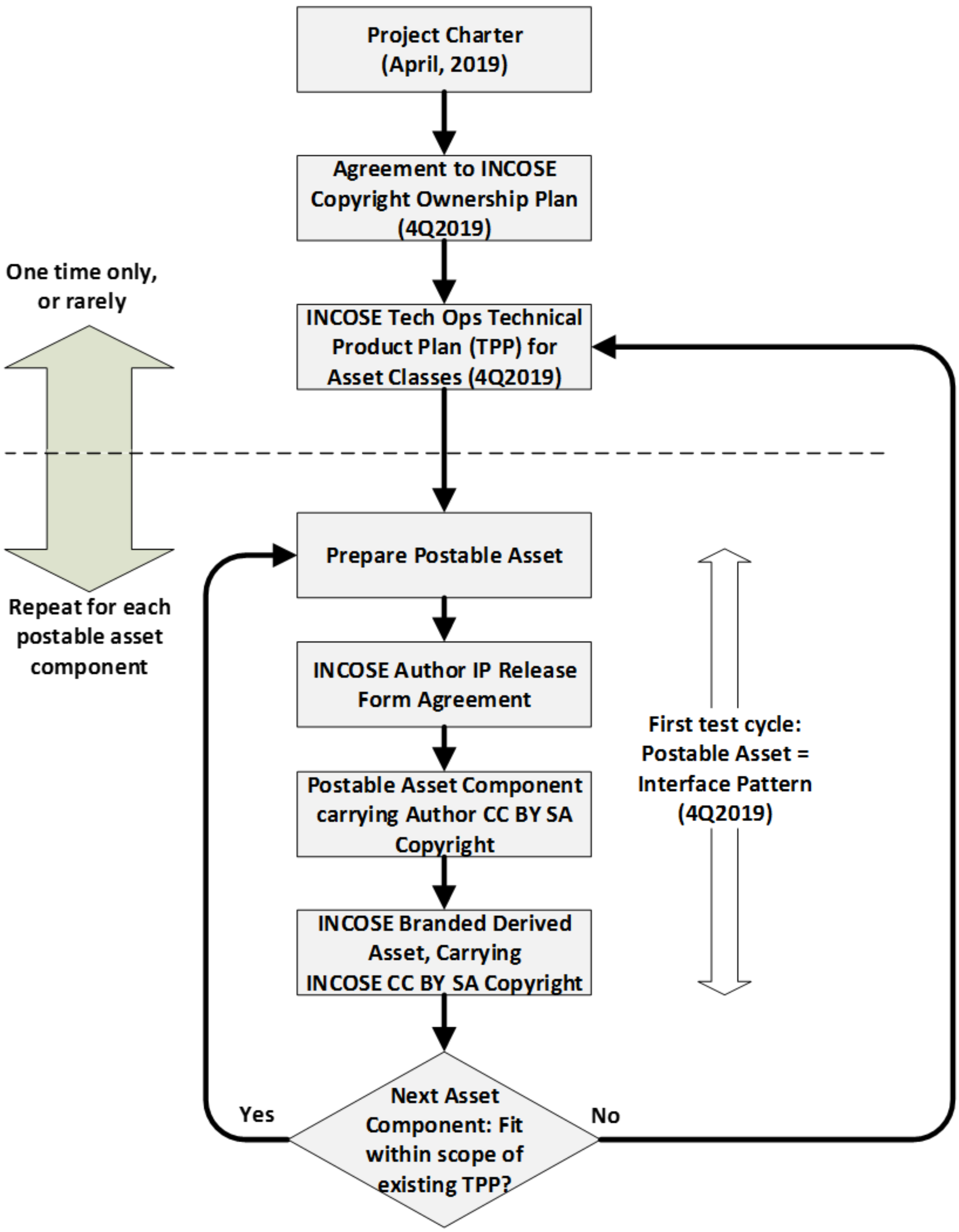


Figure 2: Sampling of S*Patterns Created in Past Work by INCOSE Patterns WG and ICTT System Sciences

EXHIBIT 2: Project Administrative Aspects



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