Application of the Digital Thread through the Digital Engineering Framework for Integration and Interoperability

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Digital Engineering

- Umbrella Domain - Broad Terms
- Characterized by "authoritative sources of system data and models"
- Commonly uses an Authoritative Source of Truth (AST)
- Recognizes shared parameters across a variety of individual models

Research Question

- How do you effectively implement a forward-looking AST that enables a Digital Thread

Answer

- Digital Engineering Framework for Integration and Interoperability (DEFII)

Digital Engineering
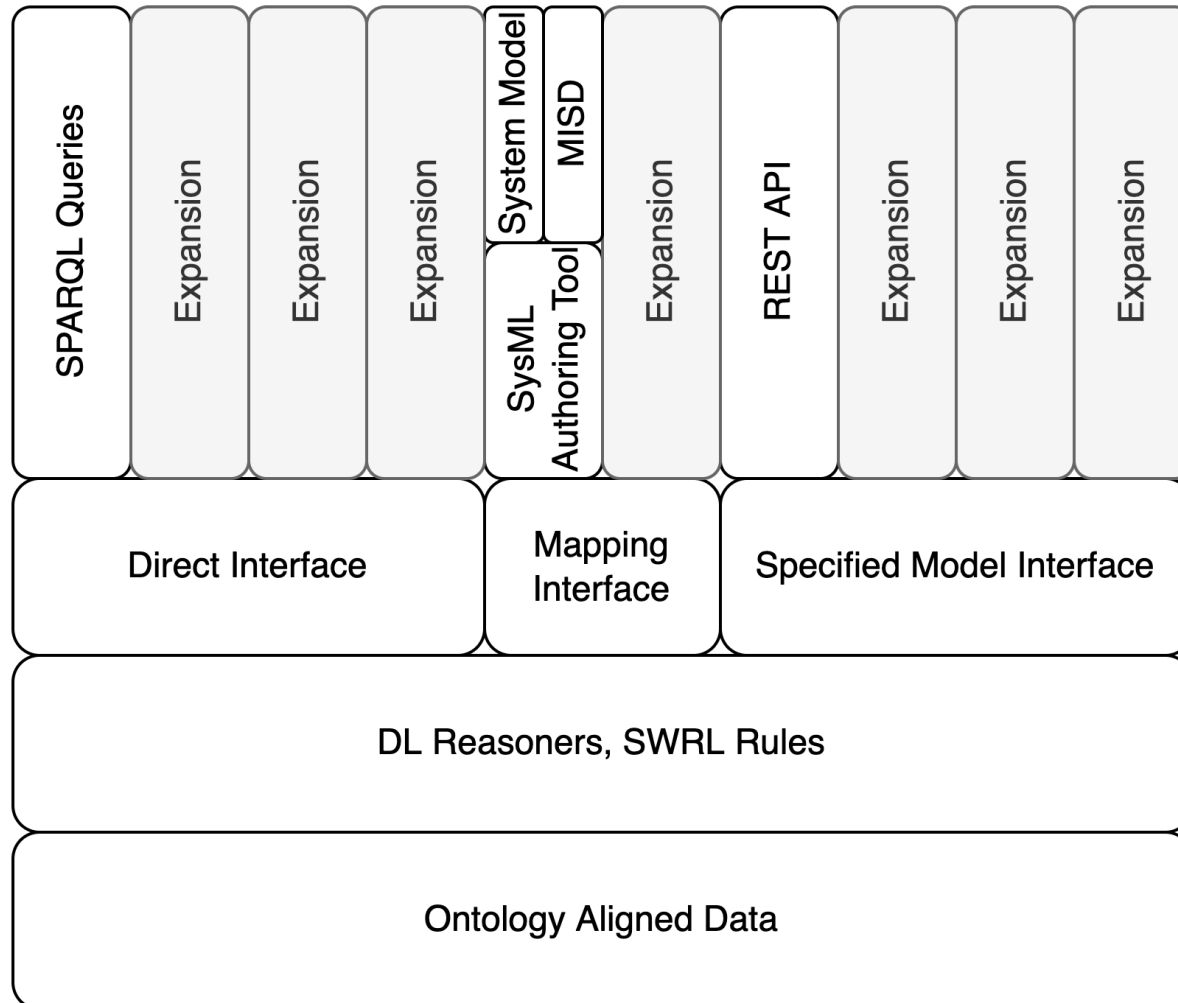
> Model Based Systems Engineering (MBSE)

> Discipline Specific Model Based Engineering (MBE)

https://ac.cto.mil/wp- content/uploads/2019/06/2018-Digital-Engineering-Strategy_Approved_PrintVersion.pdf

DEFII Framework

Digital Engineering Framework for Integration and Interoperability

- Foundation: Formal ontologies and data aligned to them
- Reasoners enrich data through axioms and rules setup in ontologies themselves

**Three Notional Interfaces**
- **Direct Interface**: Direct invocation of the Semantic Web Technology (SWT) stack
- **Mapping Interface**: Tool Dependent Mapping
    -> Begins with tool and moves toward ontology
- **Specified Model Interface**: Tool Independent Access to ontology aligned data
    -> Begins with ontology and exposes data towards tools

(Dunbar et al., 2022)

Model Interface Specification Diagram (MISD)

- Creates tool agnostic interface for further design, analysis, and reporting tasks

- Bridge between ontology-aligned triple store and use of models of interest

- Based on Matt Cilli's approach to Assessment Flows
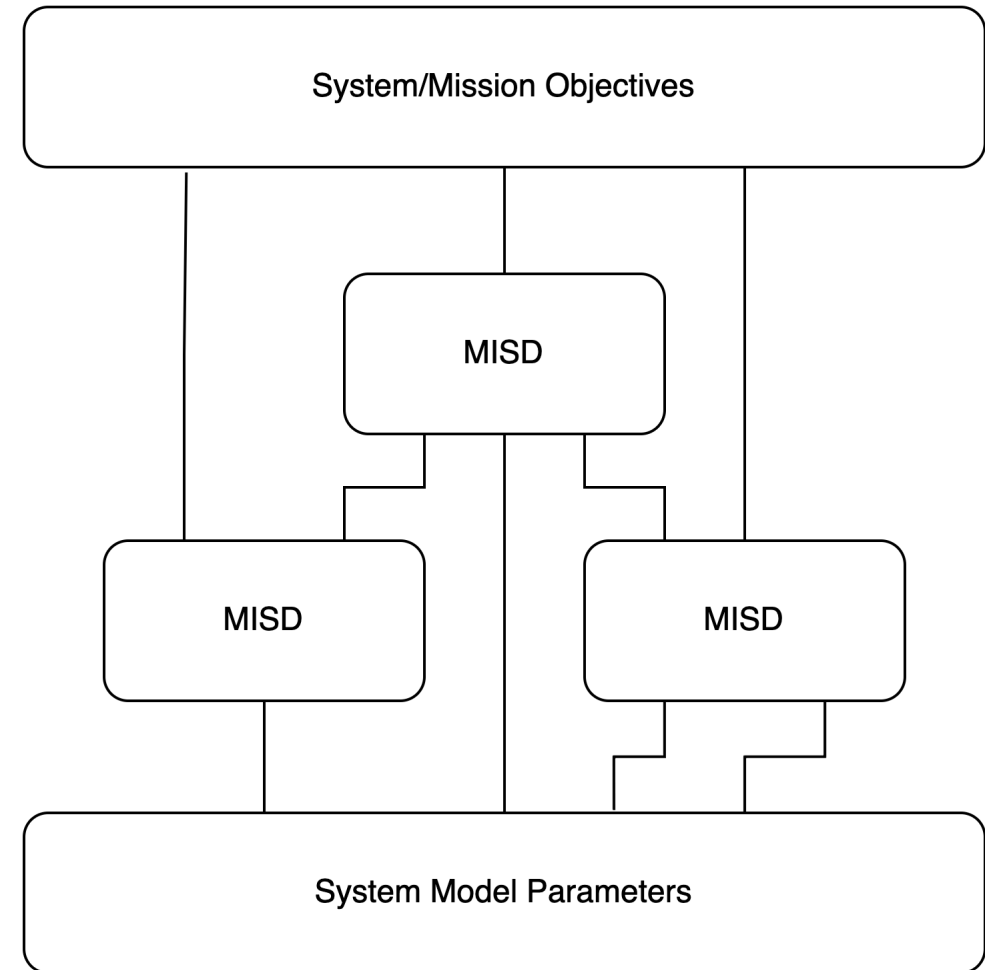
- Formalizes Model Data

- Specifies models – not tools

Parameter 1 ——— Model of Interest
Parameter 2 ———
Parameter 3 ———
.
.
.
Parameter n ———
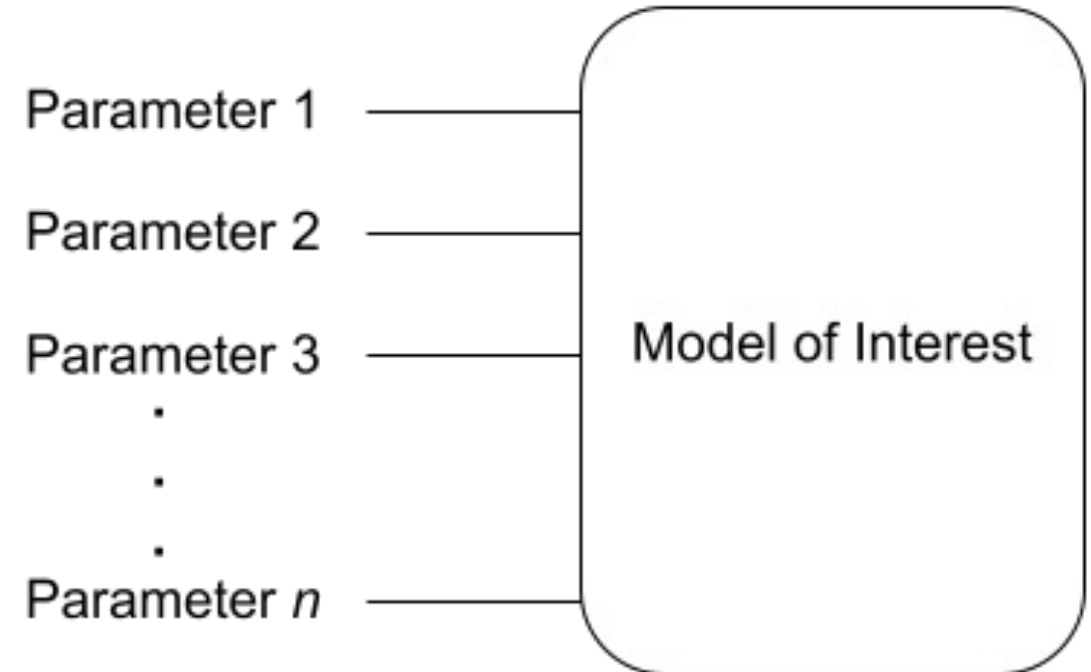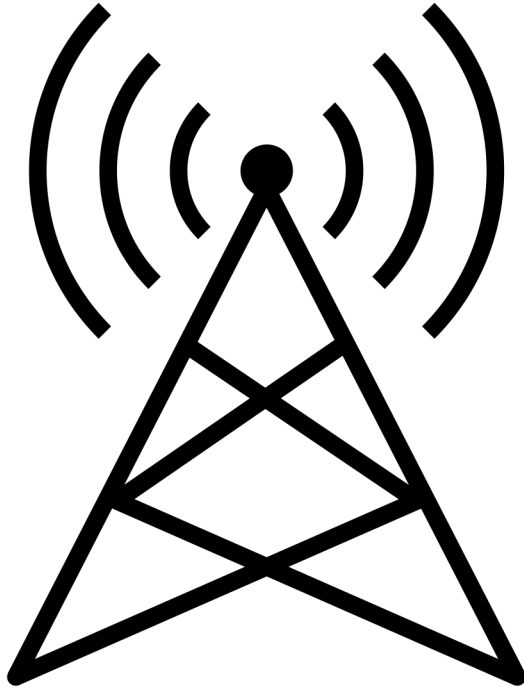
(Cilli, 2015) (Dunbar et al., 2022)

Assessment Flow Diagram (AFD)

- An Assessment Flow Diagram (AFD) aggregates several individual Models of Interest

- Shared parameters across models are explicitly identified

Telecom Use Case

Radio Tower Site – Three Models (Simplified)

Coverage Analysis
- Tx Power
- Transmission Line Type
  - Mainline
  - Shelter Jumper
- Transmission Line Length
  - Mainline
  - Shelter Jumper
- Antenna Type
- Antenna Height
- Frequency Band
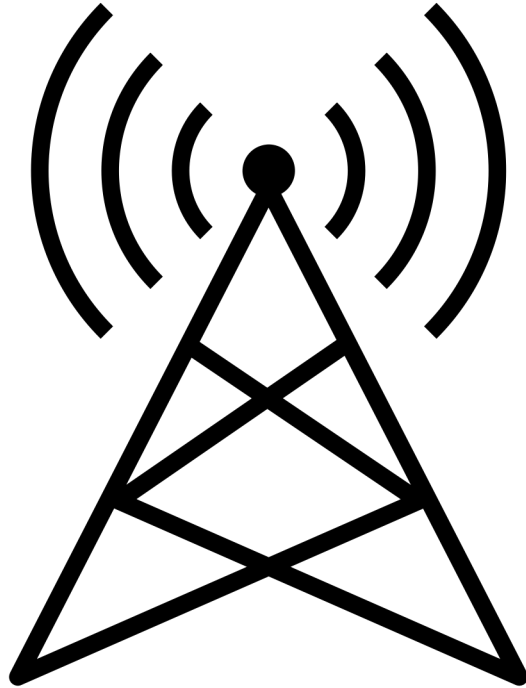
Tower Structural Loading Analysis
- Antenna Type
- Antenna Height
- Transmission Line Type
- Coverage Approval

FCC Licensing Application
- Tower Identifier
- Frequency Information
- Effective Radiated Power (ERP)

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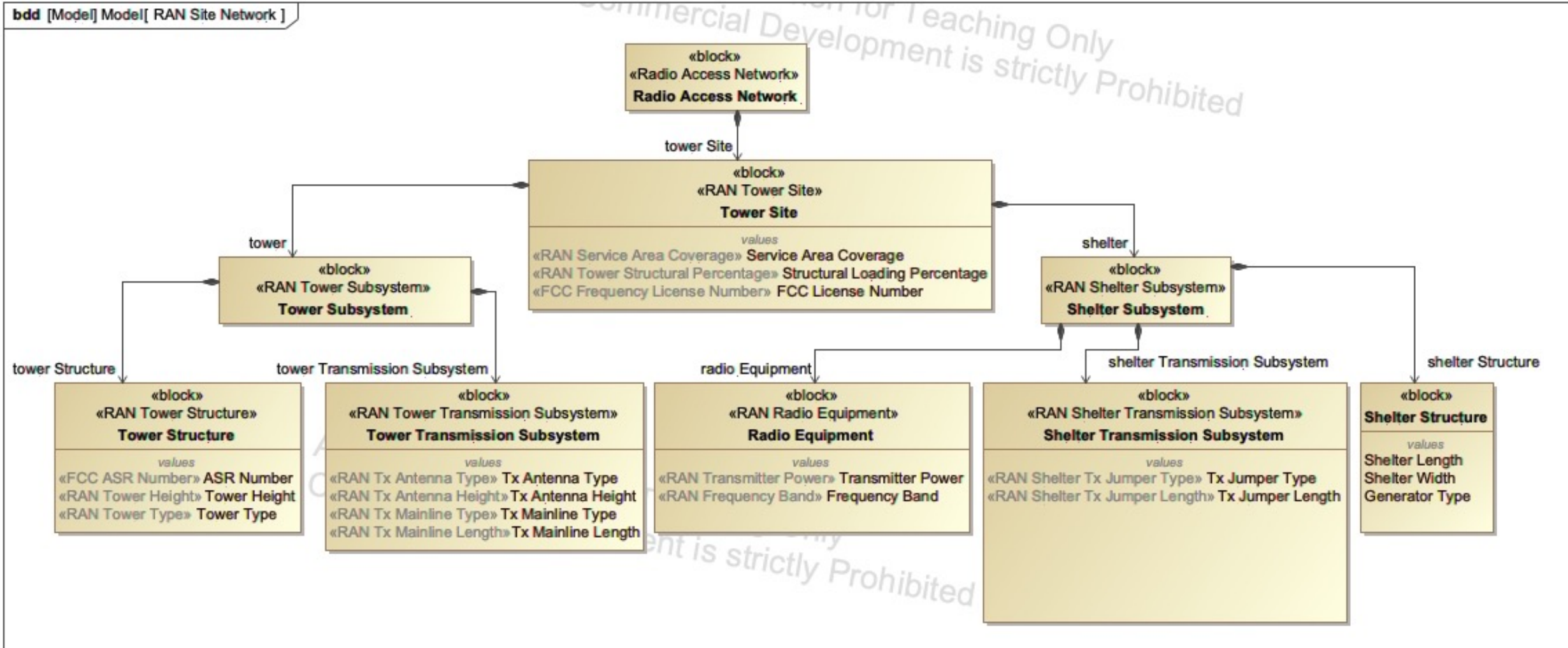- Coverage Approval

FCC Licensing Application

- Tower Identifier
- Frequency Information
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Radio Tower Site – Top Level Objectives

- Service Area Coverage Metric
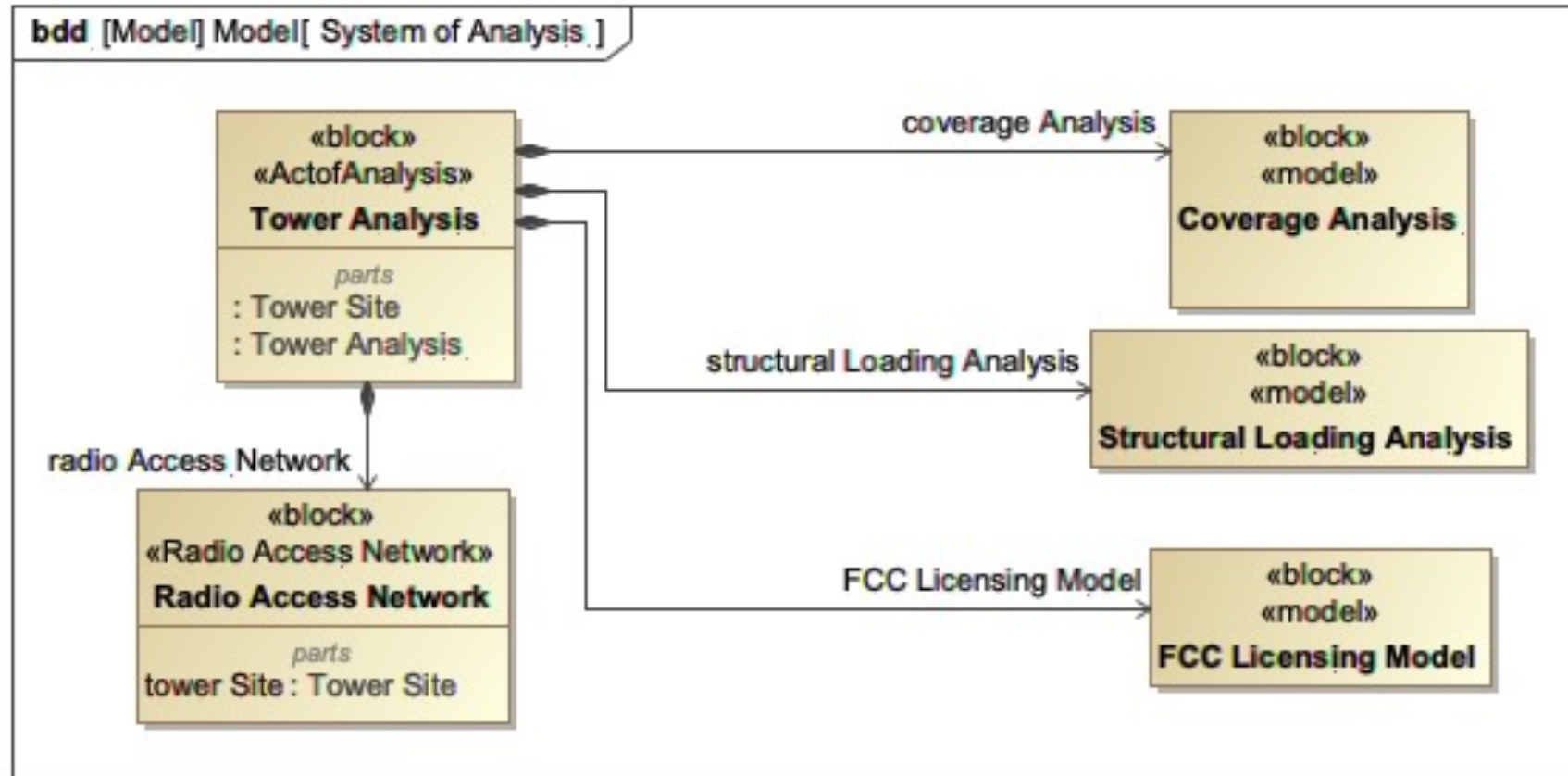- FCC License Number
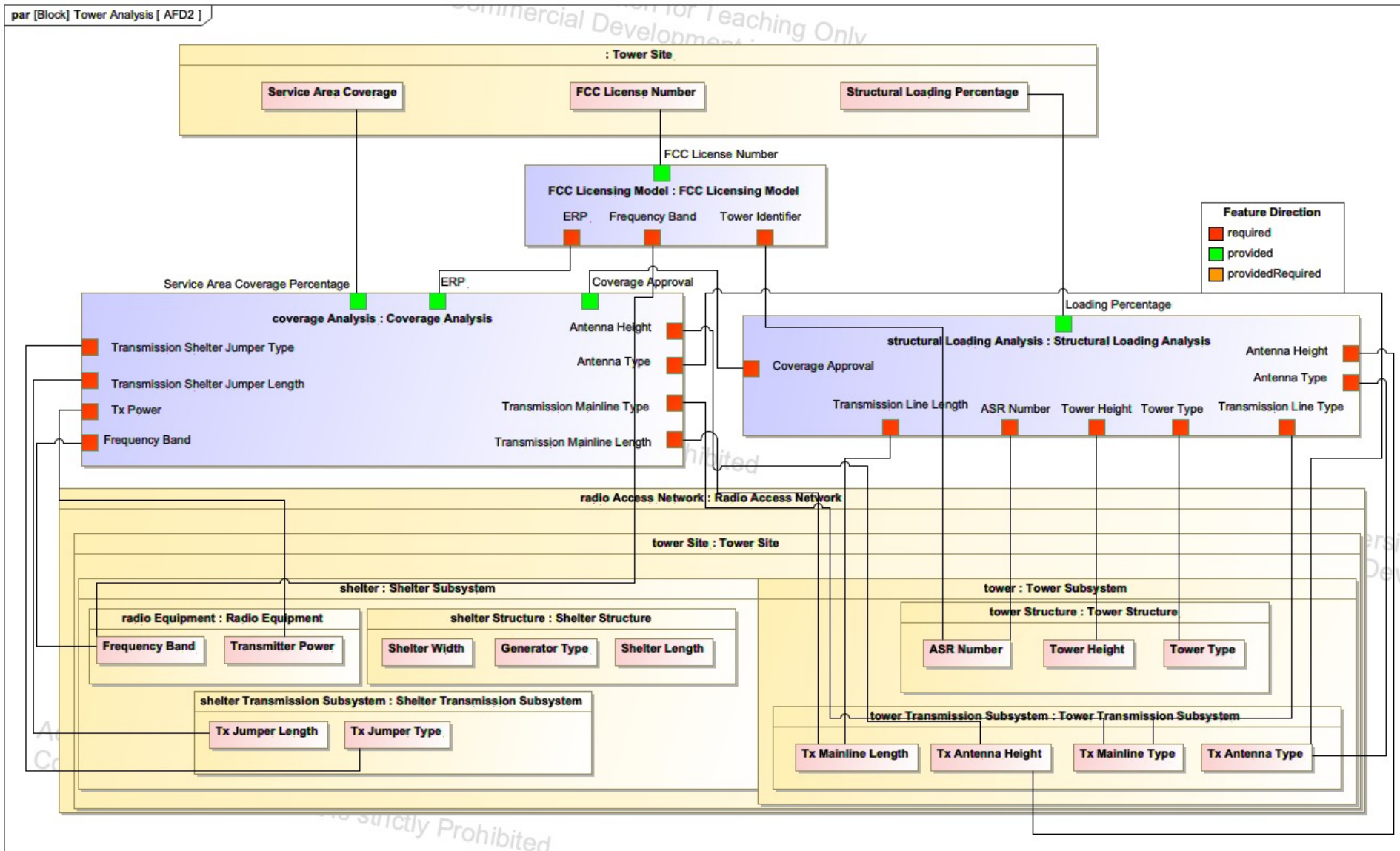- Structural Loading Percentage

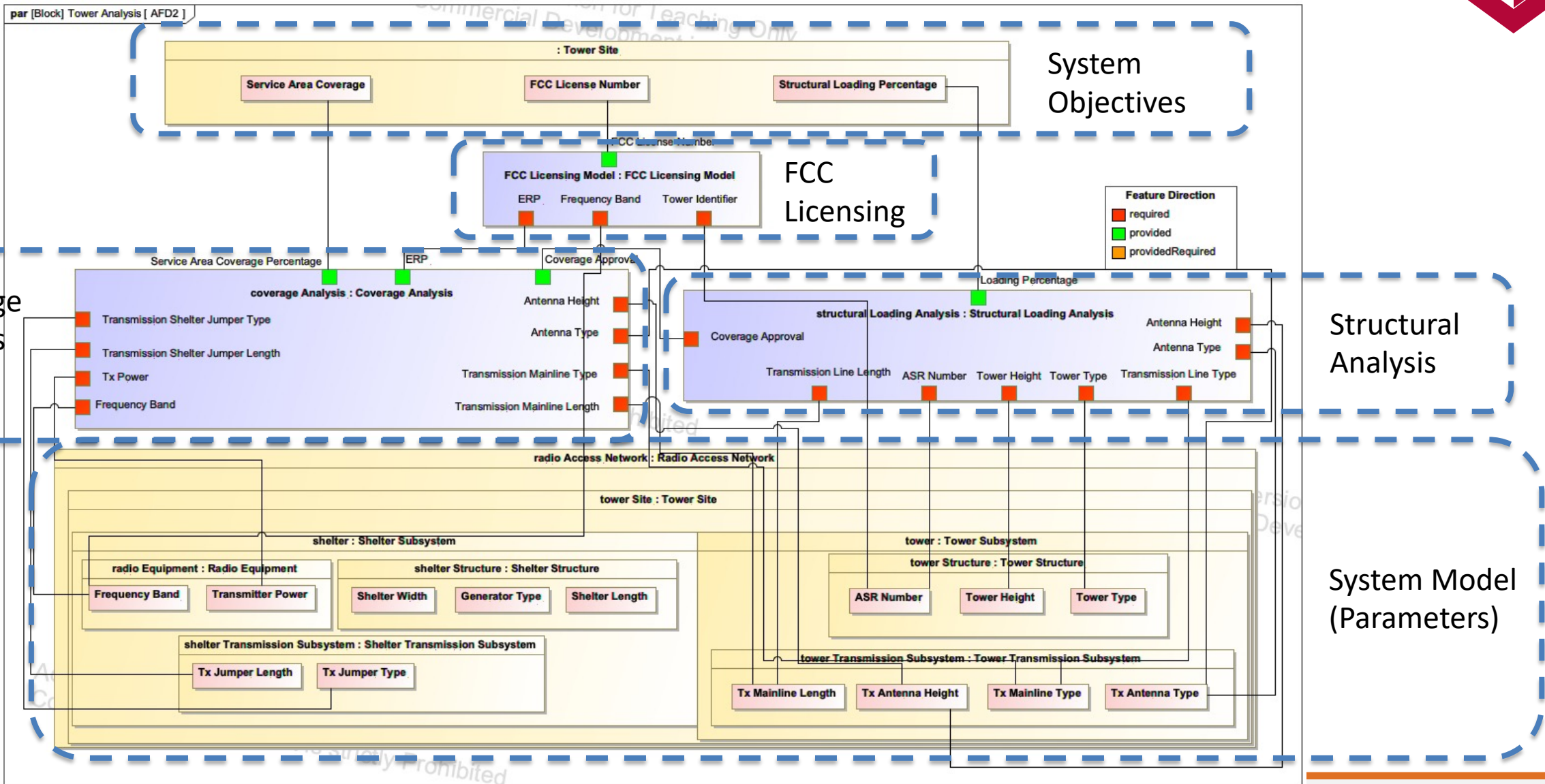# Telecom System Under Design BDD

Tower System of Analysis BDD

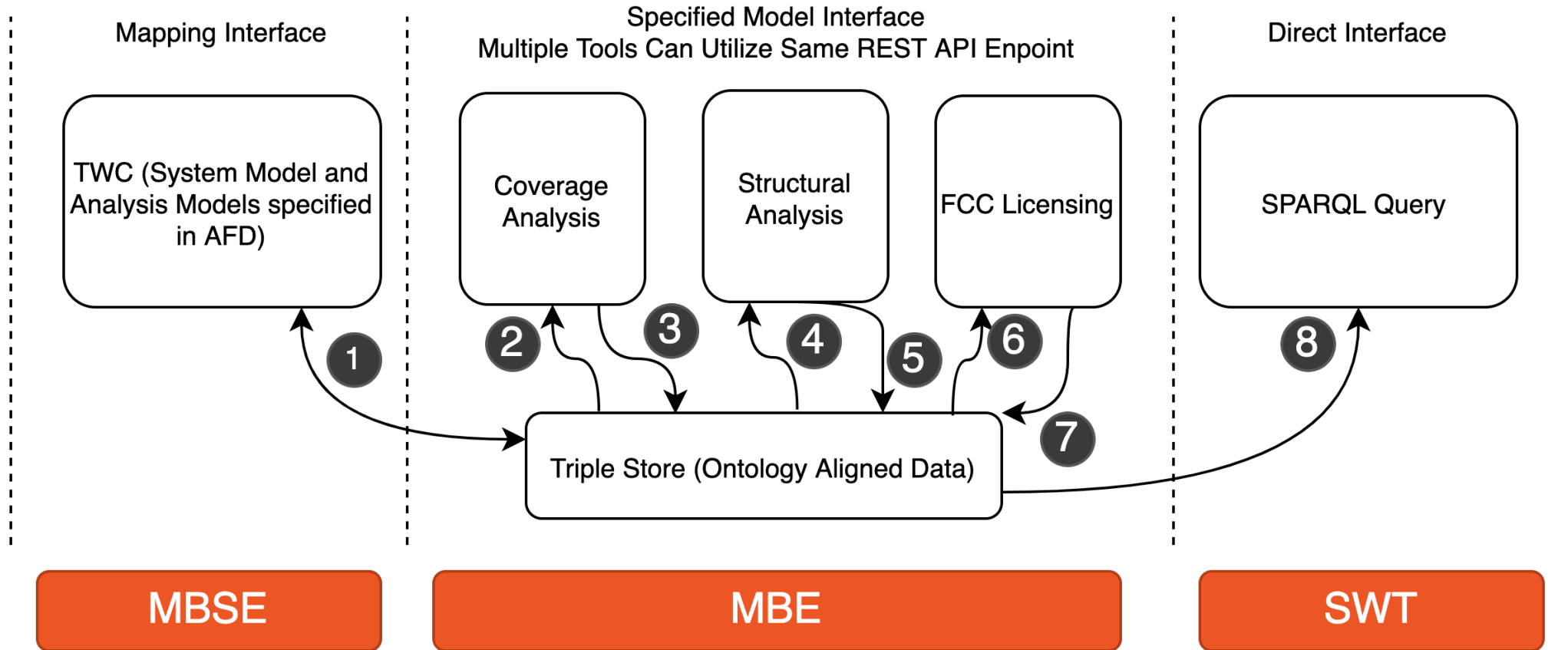# System of Analysis Assessment Flow Diagram (AFD)

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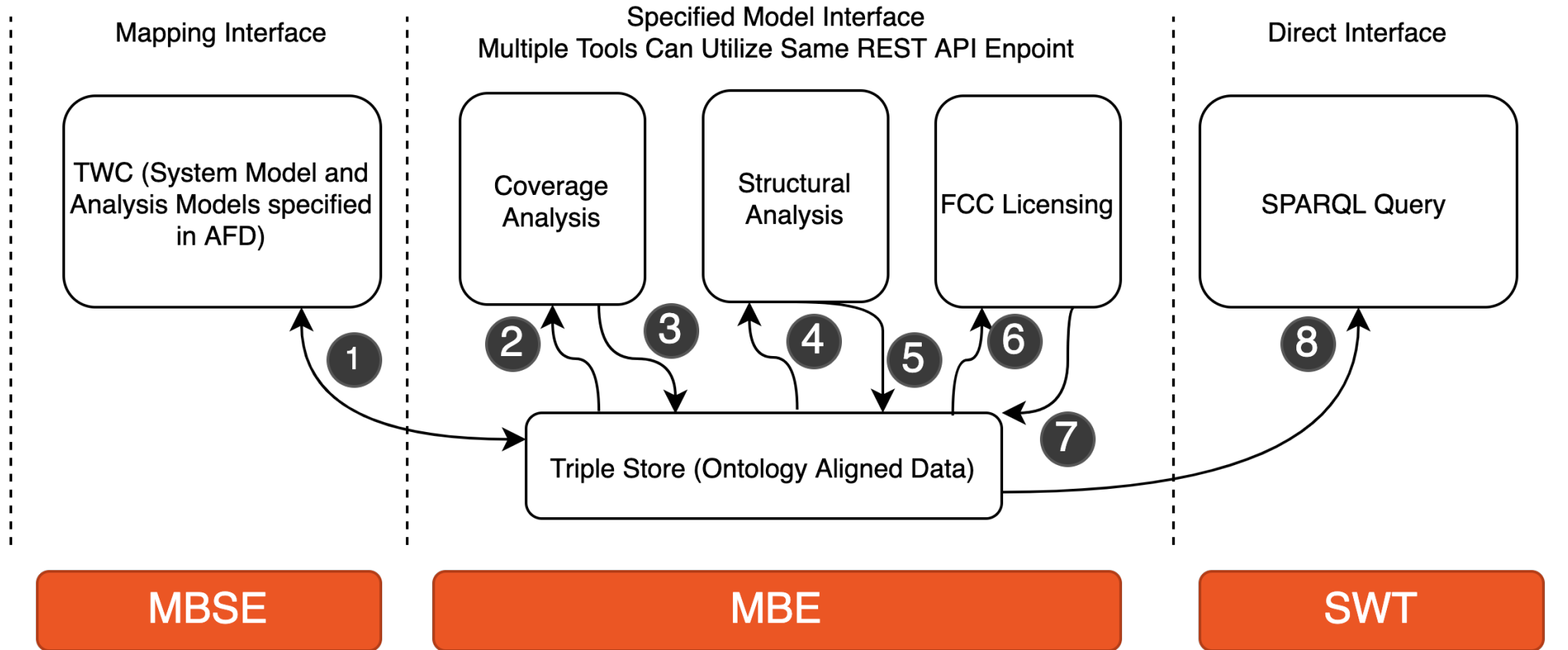
Digital Thread

REST API Service

- Individual models or entire AFD can be called via REST API endpoint

- Straightforward integration with external tools due to ubiquity of http services

- Multiple tools can use same REST API endpoint

```
 1 ▼ {
 2 ▼     "Coverage Analysis": {
 3           "Transmission Shelter Jumper Type": "0.25",
 4           "Transmission Shelter Jumper Length": "20",
 5           "Tx Power": "100",
 6           "Frequency Band": "700",
 7           "Transmission Mainline Length": "350",
 8           "Transmission Mainline Type": "1.25",
 9           "Antenna Type": "SC479-HF1LDF",
10           "Antenna Height": "325",
11           "Coverage Approval": "False",
12           "ERP": "",
13           "Service Area Coverage Percentage": ""
14       },
15 ▼     "Structural Loading Analysis": {
16           "Coverage Approval": "False",
17           "Transmission Line Length": "350",
18           "ASR Number": "A25J6Y",
19           "Tower Height": "400",
20           "Tower Type": "Guyed",
21           "Transmission Line Type": "1.25",
22           "Antenna Type": "SC479-HF1LDF",
23           "Antenna Height": "325",
24           "Loading Percentage": ""
25       },
26 ▼     "FCC Licensing Model": {
27           "ERP": "",
28           "Frequency Band": "700",
29           "Tower Identifier": "A25J6Y",
30           "FCC License Number": ""
31       }
32   }
```

Digital Thread

Conclusion

- DEFII Framework provides a graph-based method for integrating tools

- Users can configure the DEFII framework via SysML models – broad SWT knowledge across workforce unnecessary

- Digital Thread can be implemented using an ontology-aligned AST and standard interface types

Future Work

- Explore additional functionality enabled by a graph representation of the system

- Explore additional functionality enabled by formal ontological knowledge representation

References

Cilli, Matthew V. "Improving Defense Acquisition Outcomes Using an Integrated Systems Engineering Decision Management (ISEDM) Approach." ProQuest Dissertations and Theses, 2015. http://ezproxy.stevens.edu/login?url=https://www.proquest.com/dissertations-theses/improving-defense-acquisition-outcomes-using/docview/1776469856/se-2?accountid=14052.

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Wagner, David A., M. B. Bennett, R. Karban, N. Rouquette, S. Jenkins, and M. Ingham. "An Ontology for State Analysis: Formalizing the Mapping to SysML." In *2012 IEEE Aerospace Conference*, 1–16. Big Sky, MT: IEEE, 2012. https://doi.org/10.1109/AERO.2012.6187335.

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