LIFECYCLE MODELING LANGUAGE

Webinar

WEBINAR PRESENTATION

# UNVEILING SYSTEMS WITH LML

Unveiling Systems with Lifecycle Modeling Language (LML): A High-Hazard Facility Example

August 2023 Presentation
Michael deLamare

Lifecycle Modeling Organization

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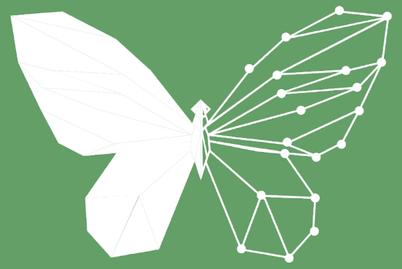
# ABOUT LMO AND LML

Lifecycle Modeling Organization manages and develops the Lifecycle Modeling Language (LML). LML is an ontology designed for all stakeholders in a system.

LIFECYCLE MODELING LANGUAGE



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# OUR SPEAKER

## MICHAEL DELAMARE

Principle Systems Engineer at Bechtel

Mr. deLamare has over 40 years applying systems engineering to space systems, defense systems, and to nuclear and chemical high-hazard facilities.

- Expert Systems Engineering Professional (ESEP) certification.
- SME on Systems Engineering
- Distinguished Scientists
- Plant Systems Design standard for ASME,
- LMO committee for the Lifecycle Modeling Language
- International Oil and Gas Providers (IOGP) Requirements Digitalization Expert Group (RDEG).

# Presentation Objective

- If we are to successfully achieve the vision for digital systems engineering, then there is a need to understand how a system is expressed in data.
- Using current systems engineering definitions and views:
- understand the information defining a system
- examine commonly used views in systems engineering practice
- show how the views are represented as data using the Lifecycle Modeling Language (LML)
- Define a system's data representation as a compilation of LML data classes

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# LML Matrix

This matrix is a starting point for the classes and their relationships used in this presentation

Choices for relationships will depend on:

- uses case
- reporting needs

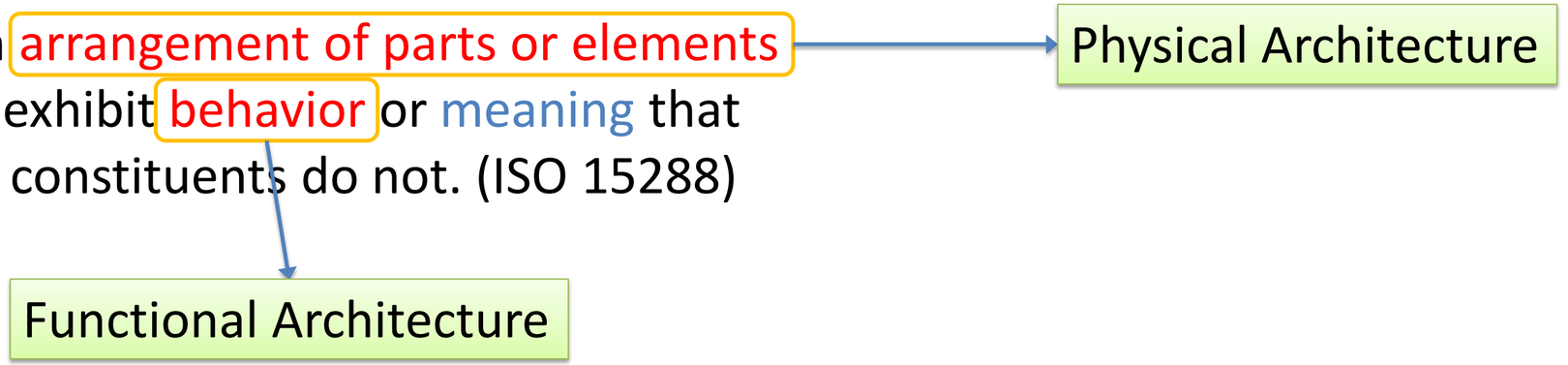
Classes

Relationships

| | Action | Artifact | Asset (Resource) | Characteristic (Measure) | Connection (Conduit, Logical) | Cost | Decision | Input/Output | Location (Orbital, Physical, Virtual) | Risk | Statement (Requirement) | Time |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Action** | decomposed by* related to* | references | (consumes) performed by (produces) (seizes) | specified by | - | incurs | enables results in | generates receives | located at | causes mitigates resolves | (satisfies) traced from (verifies) | occurs |
| **Artifact** | referenced by | decomposed by* related to* | referenced by | referenced by specified by | defines protocol for referenced by | incurs referenced by | enables referenced by results in | referenced by | located at | causes mitigates referenced by resolves | referenced by (satisfies) source of traced from (verifies) | occurs |
| **Asset (Resource)** | (consumed by) performs (produced by) (seized by) | references | decomposed by* orbited by* related to* | specified by | connected by | incurs | enables made responds to results in | - | located at | causes mitigates resolves | (satisfies) traced from (verifies) | occurs |
| **Characteristic (Measure)** | specifies | references specifies | specifies | decomposed by* related to* specified by* | specifies | incurs specifies | enables results in specifies | specifies | located at specifies | causes mitigates resolves specifies | (satisfies) spacifies traced from (verifies) | occurs specifies |
| **Connection (Conduit, Logical)** | - | defined protocol by references | connects to | specified by | decomposed by* joined by* related to* | incurs | enables results in | transfers | located at | causes mitigates resolves | (satisfies) traced from (verifies) | occurs |
| **Cost** | incurred by | incurred by references | incurred by | incurred by specified by | | | | | located at | causes incurred by mitigates resolves | incurred by (satisfies) traced from (verifies) | occurs |
| **Decision** | enabled by result of | enabled by references result of | enabled by made by responded by result of | enabled by result of specified by | enabled by result of | enabled by incurs result of | decomposed by* related to* | enabled by result of | located at | causes enabled by mitigated by result of resolves | alternative enabled by traced from result of | date resolved by decision due occurs |
| **Input/Output** | generated by received by | references | - | specified by | transferred by | incurs | enables results in | decomposed by* related to* | located at | causes mitigates resolves | (satisfies) traced from (verifies) | occurs |
| **Location (Orbital, Physical, Logical)** | locates | locates | locates | locates specified by | locates | locates | locates | locates | decomposed by* related to* | locates mitigates | locates (satisfies) traced from (verifies) | occurs |
| **Risk** | caused by mitigated by resolved by | caused by mitigated by references resolved by | caused by mitigated by resolved by | caused by mitigated by resolved by specified by | caused by mitigated by resolved by | caused by incurs mitigated by resolved by | caused by enables mitigated by results in resolved by | caused by mitigated by resolved by | located at mitigated by | caused by* decomposed by* related to* resolved by* | caused by mitigated by resolved by | occurs mitigated by |
| **Statement (Requirement)** | (satisfied by) traced to (verified by) | references (satisified by) sourced by traced to (verified by) | (satisfied by) traced to (verified by) | (satisfied by) specified by traced to (verified by) | (satisfied by) traced to (verified by) | incurs (satisfied by) traced to (verified by) | alternative of enables traced to results in | (satisfied by) traced to (verified by) | located at (satisfied by) traced to (verified by) | causes mitigates resolves | decomposed by* traced to* related to* | occurs (satisfied by) (verified by) |
| **Time** | occurred by | occurred by | occurred by | occurred by specified by | occurred by | occurred by | date resolves decided by occurred by | occurred by | occurred by | occurred by mitigates | occurred by (satisfies) (verifies) | decomposed by* related to* |

# System Defined

- A system is an arrangement of parts or elements that together exhibit behavior or meaning that the individual constituents do not. (ISO 15288)



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# Engineered System Defined

- A system is an arrangement of parts or elements that together exhibit behavior or meaning that the individual constituents do not. (ISO 15288)

Physical Architecture

Functional Architecture

Characterized Environments

- An engineered system is system designed or adapted to interact with an anticipated operational environment to achieve one or more intended purposes while complying with applicable constraints. (INCOSE SEH)

Requirements & Characteristics

Statements of Need or Objectives



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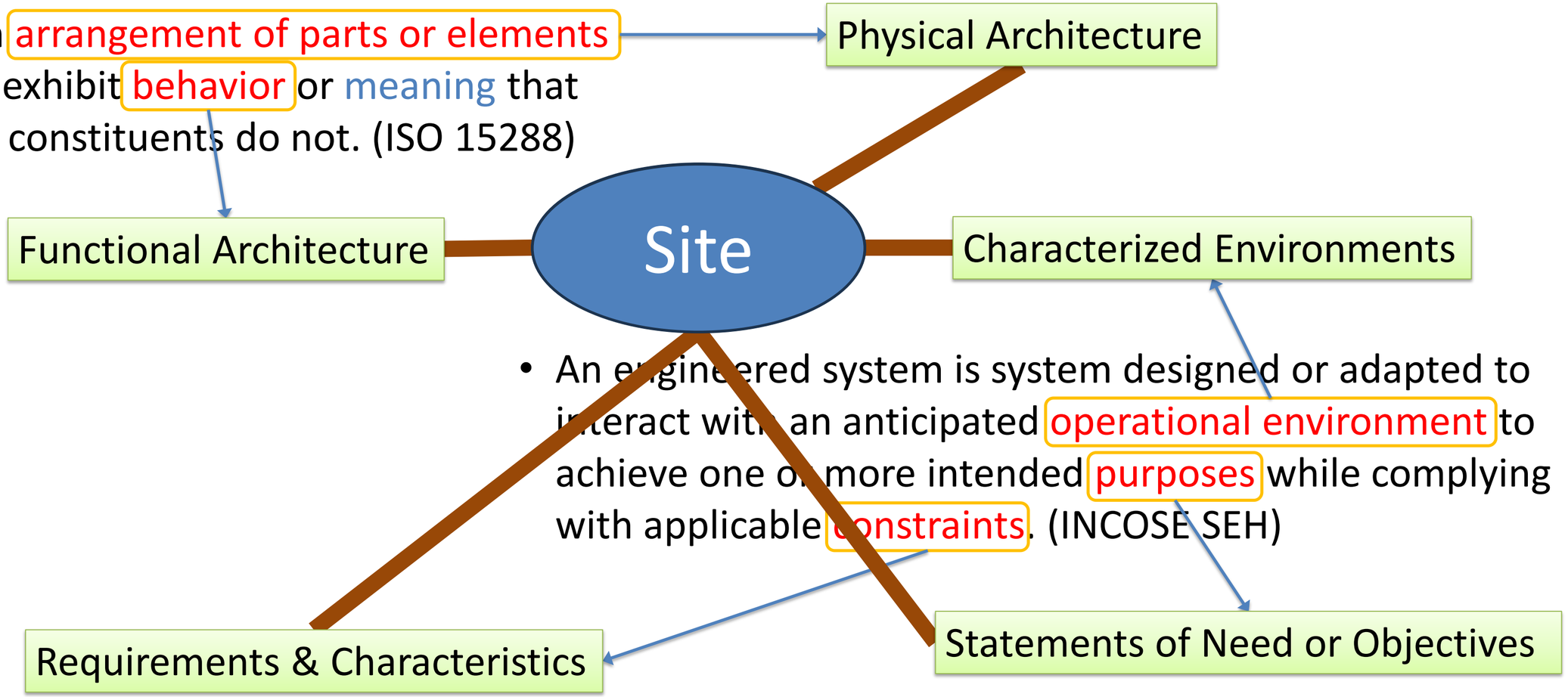
# System Defined

- A system is an arrangement of parts or elements that together exhibit behavior or meaning that the individual constituents do not. (ISO 15288)




- An engineered system is system designed or adapted to interact with an anticipated operational environment to achieve one or more intended purposes while complying with applicable constraints. (INCOSE SEH)

In a digital environment, how do we represent systems as data?

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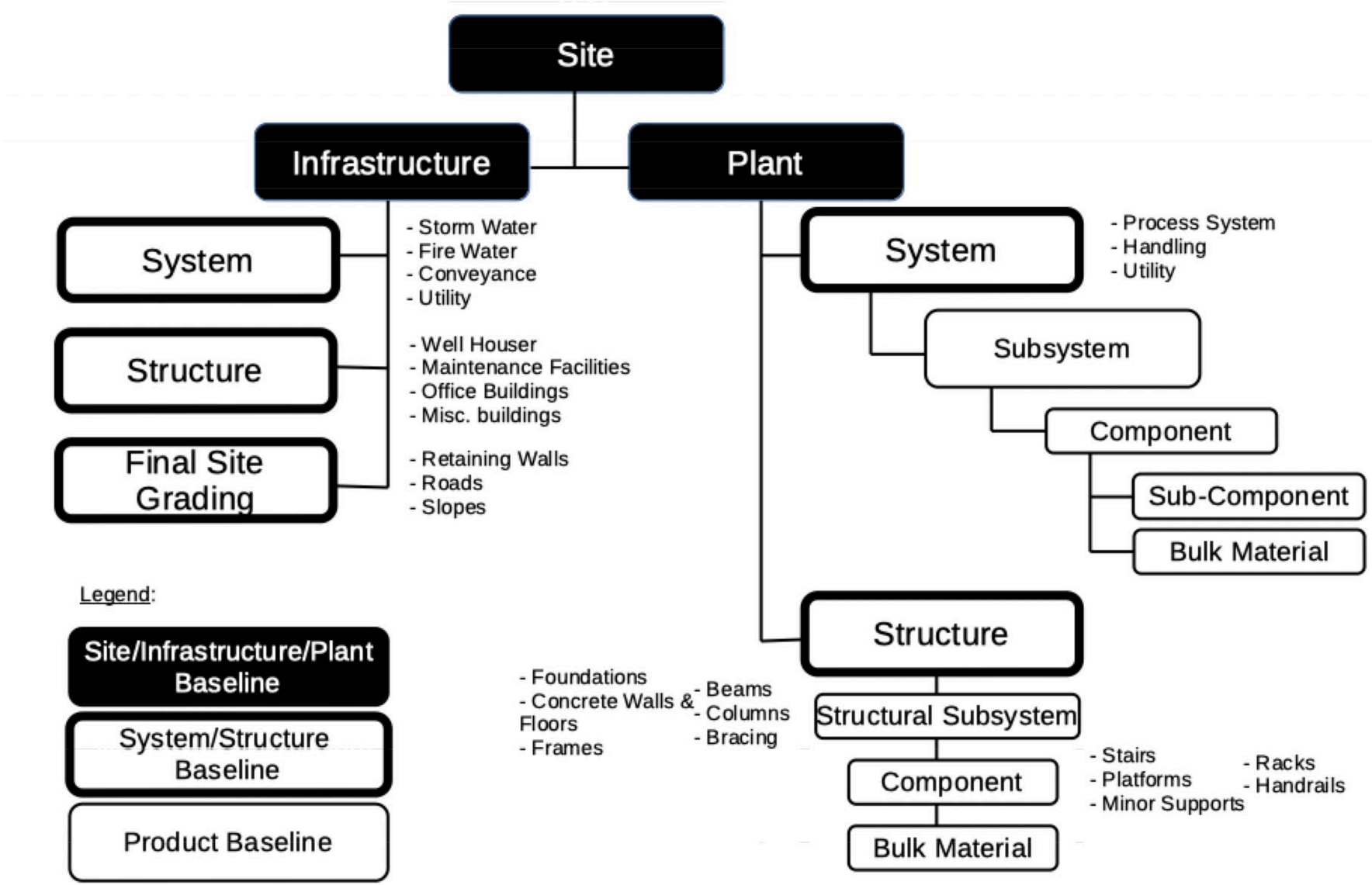
# PHYSICAL ARCHITECTURE

Lifecycle
Modeling
Organization

# Facility Taxonomy




ASME Plant System Design standard, PSD-1, draft

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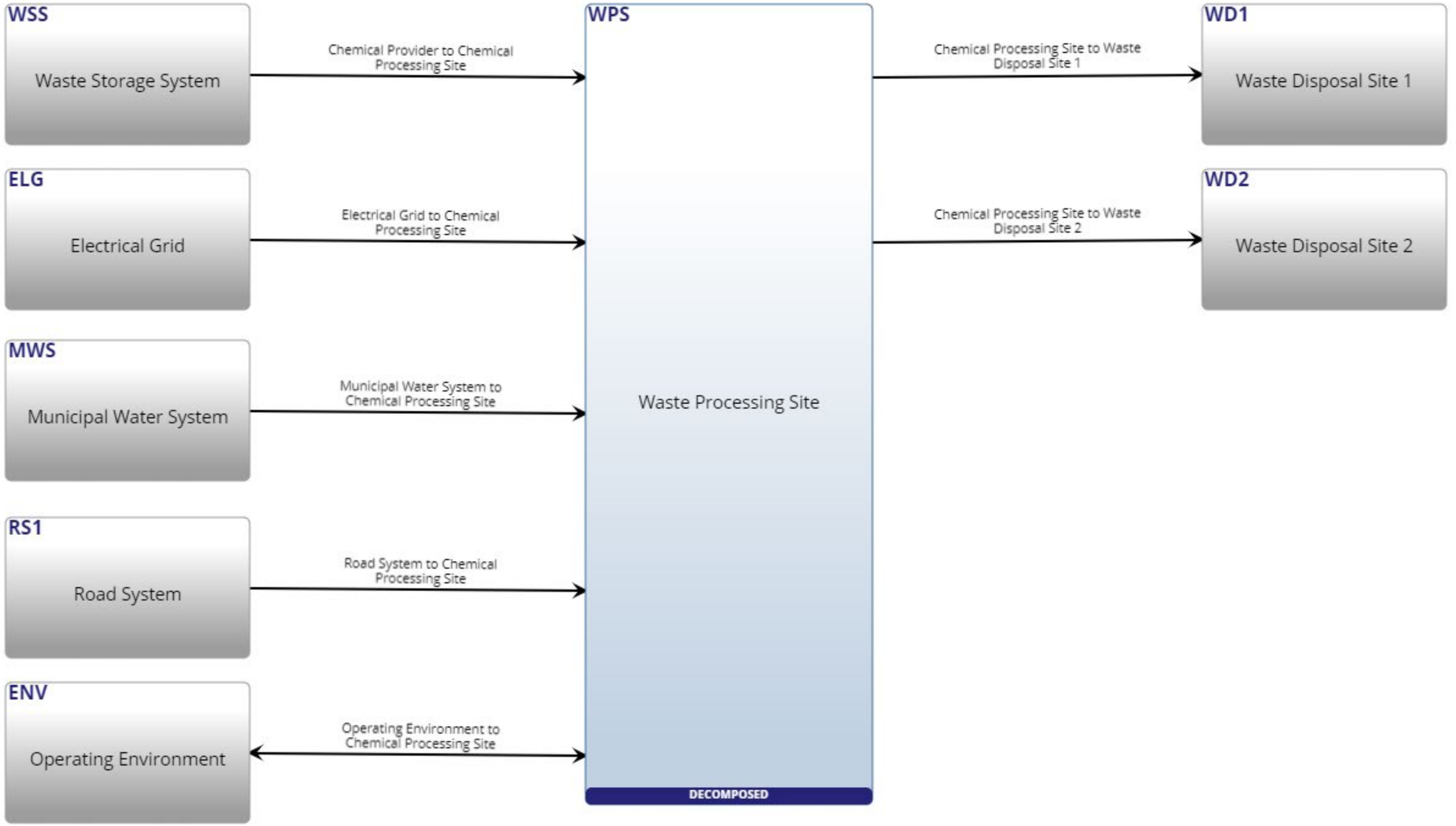
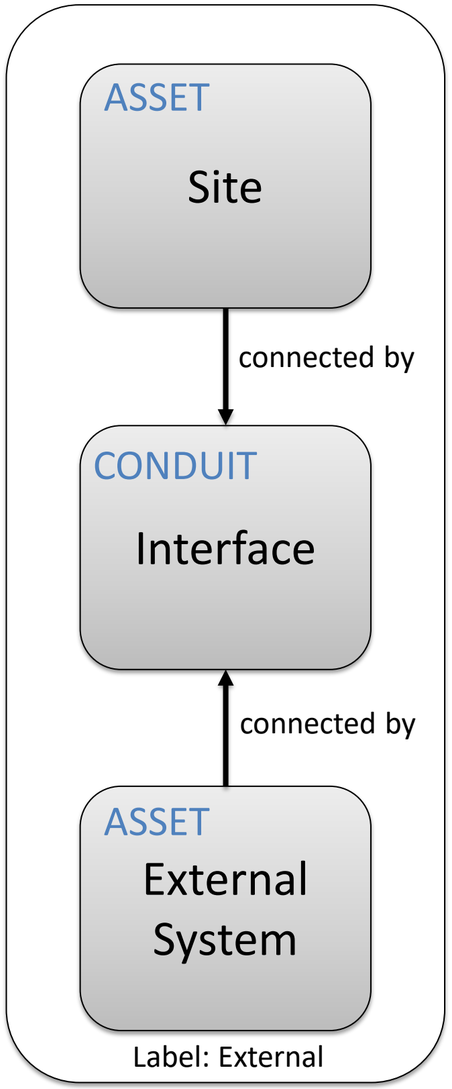
# Context Diagram

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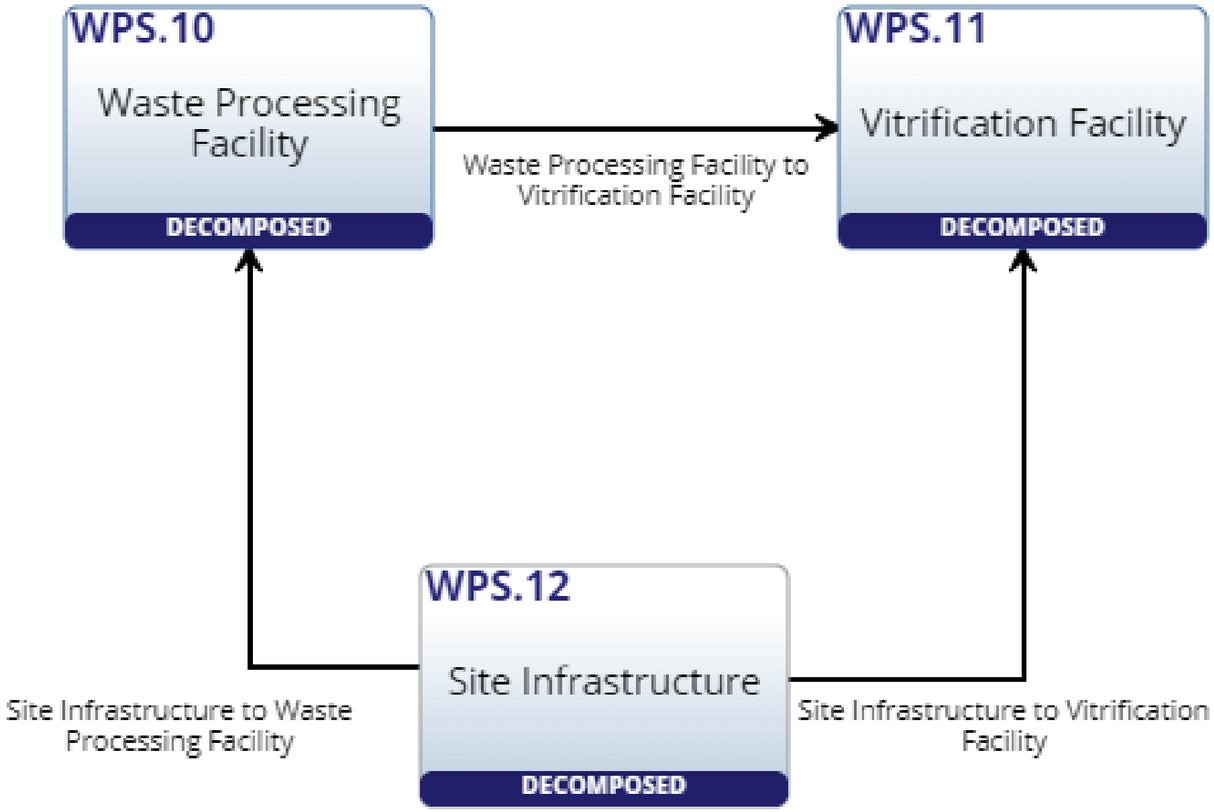
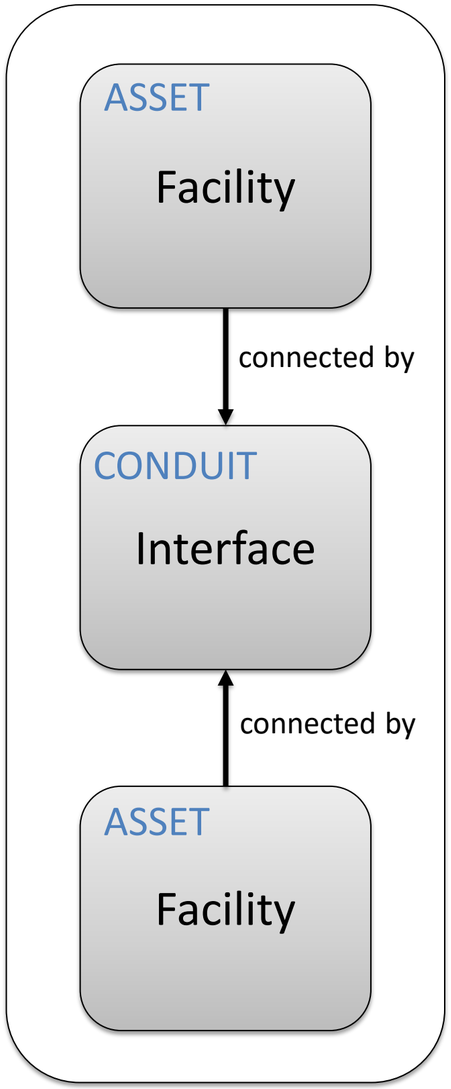
# Site Architecture

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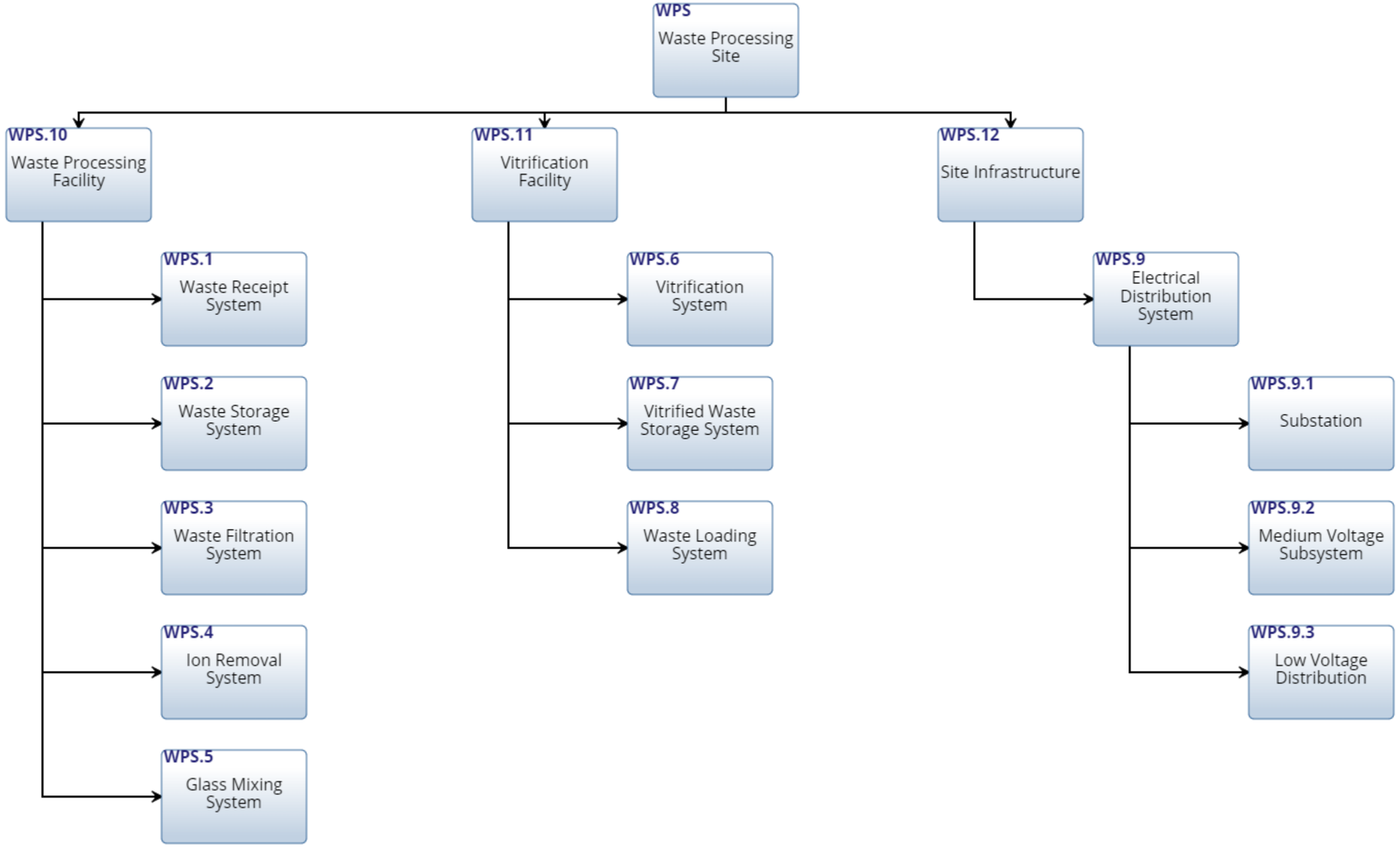
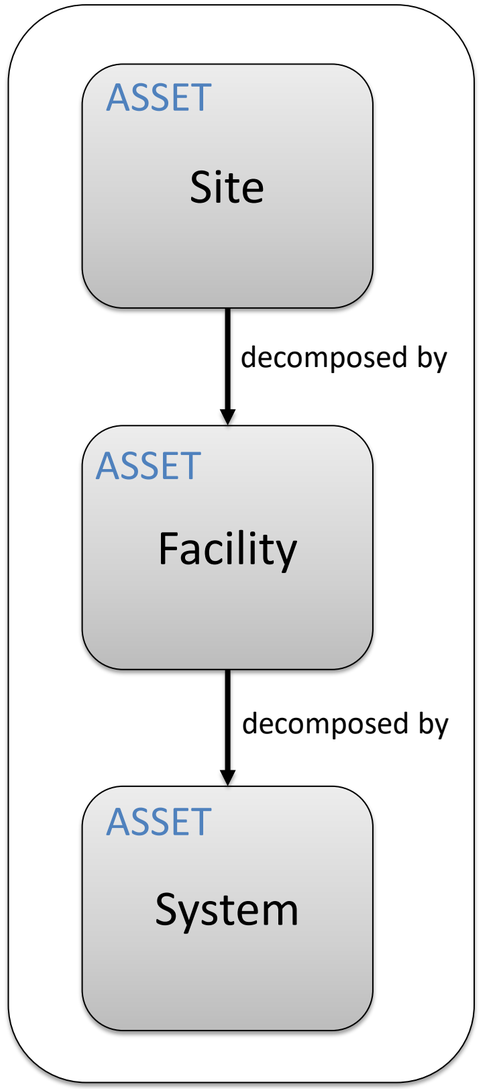
# Architecture Hierarchy

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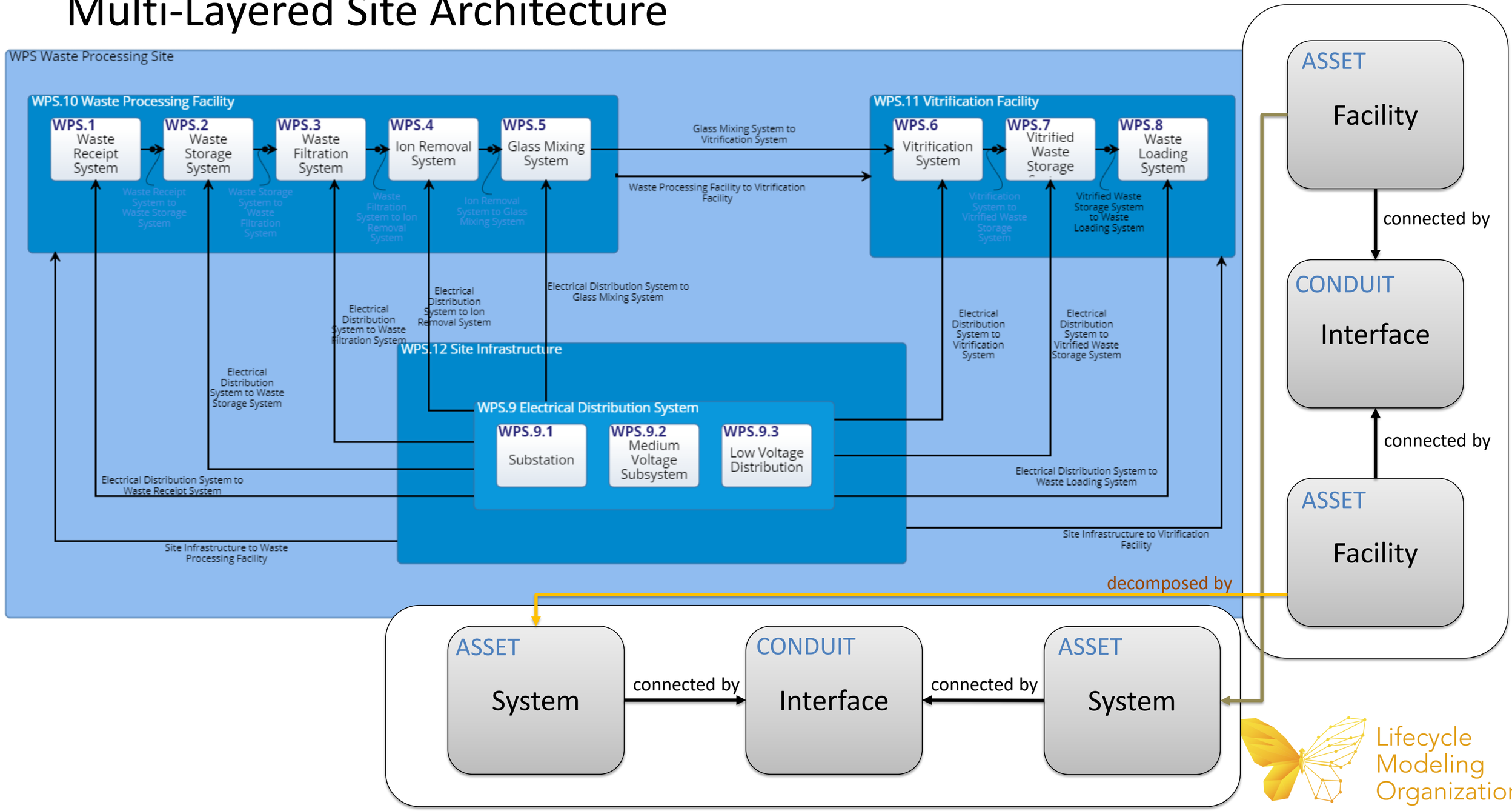
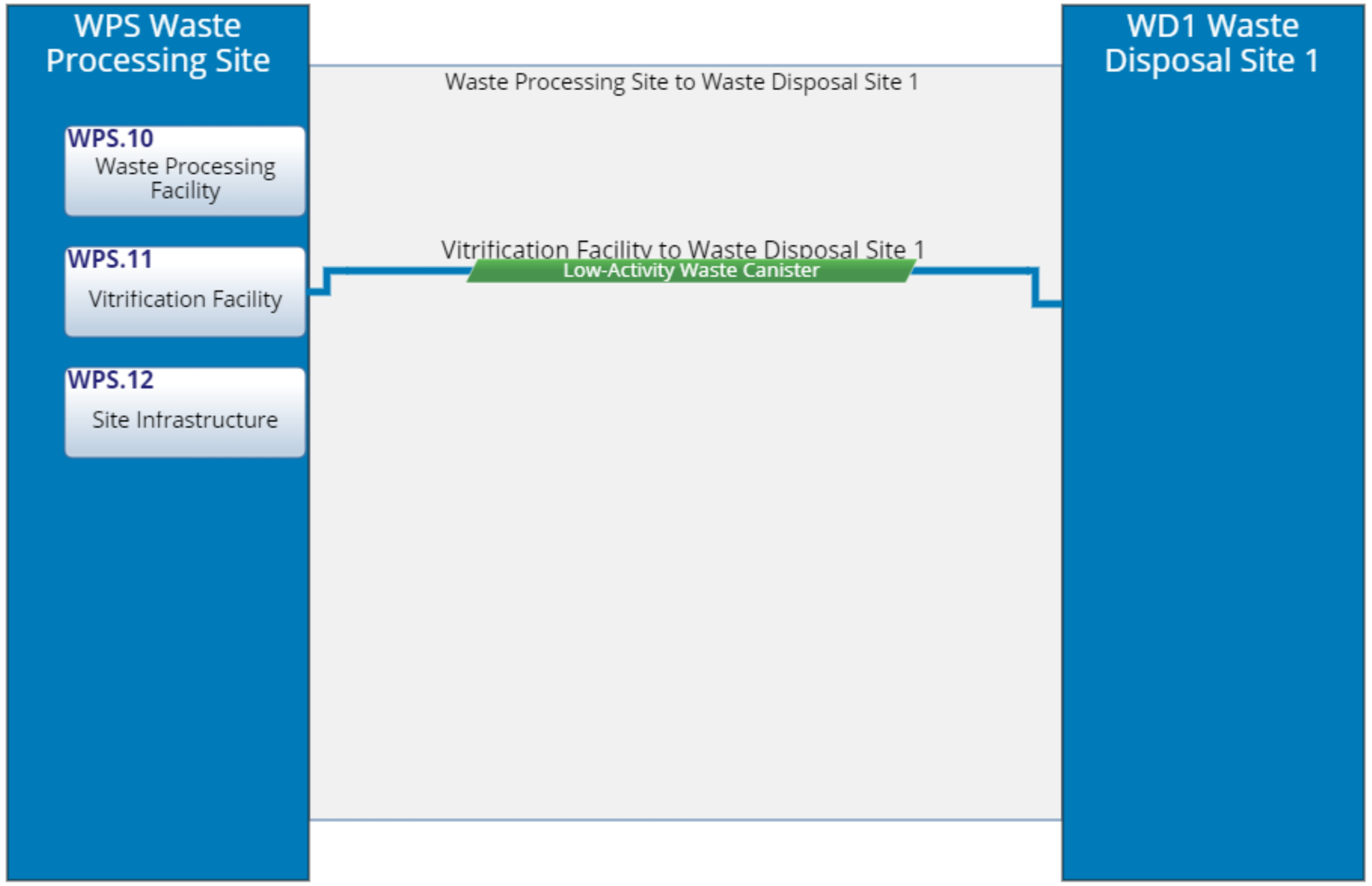
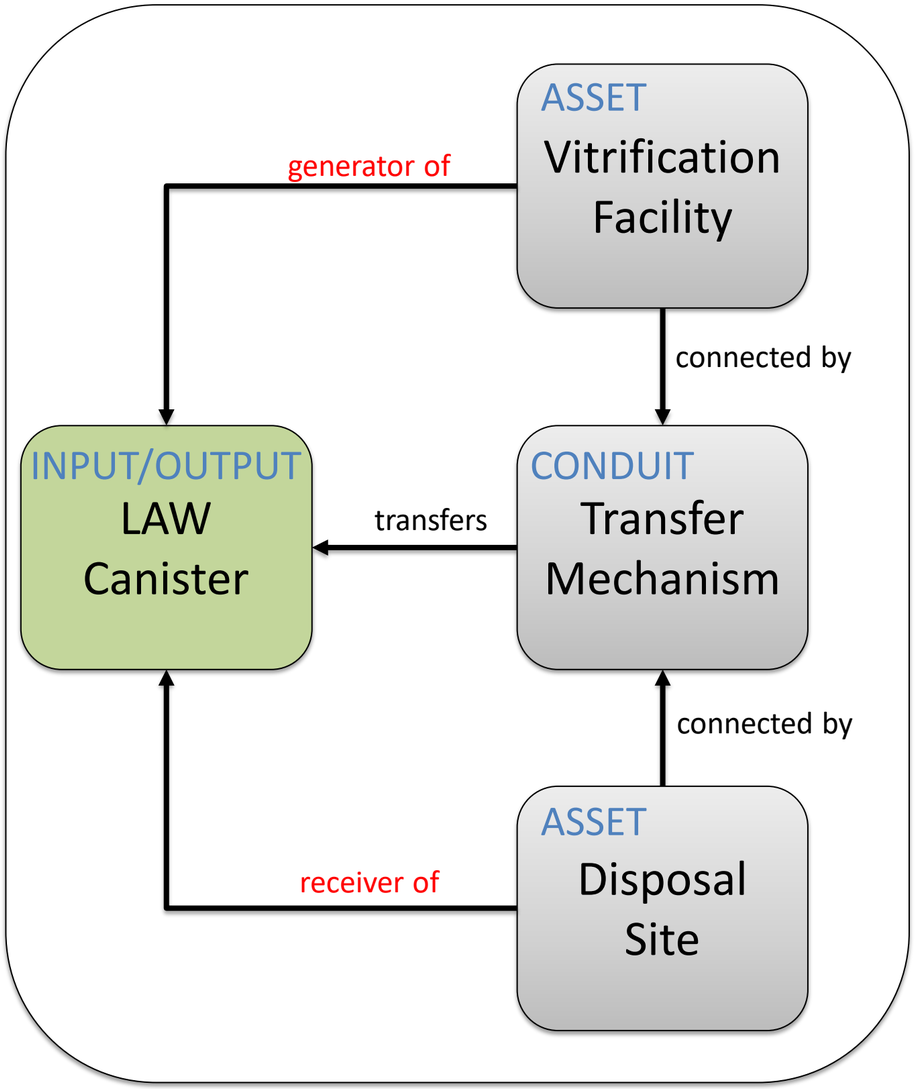
# Multi-Layered Site Architecture



# Interface Diagram

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# FUNCTIONAL ARCHITECTURE

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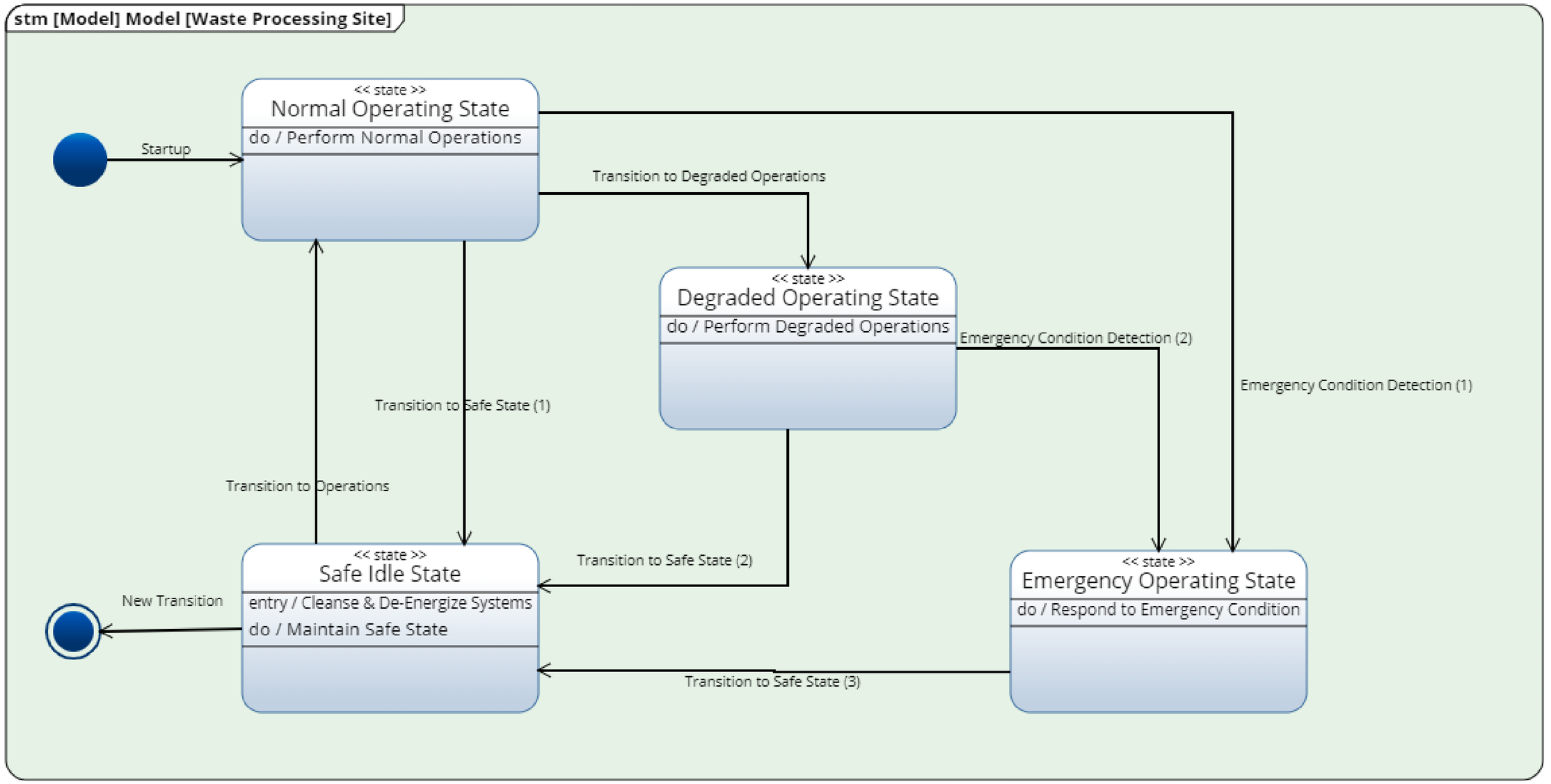
# State Diagram

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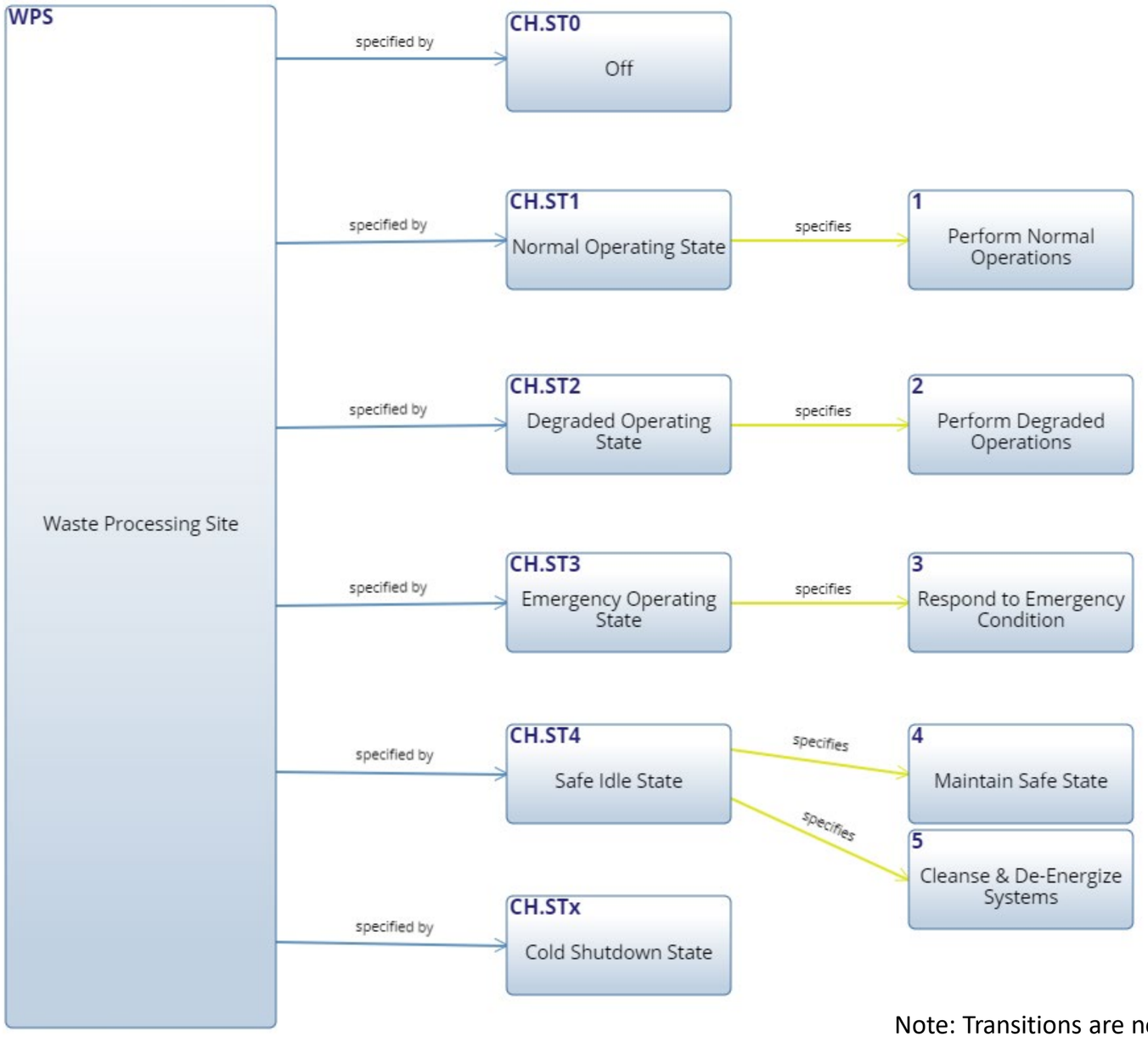
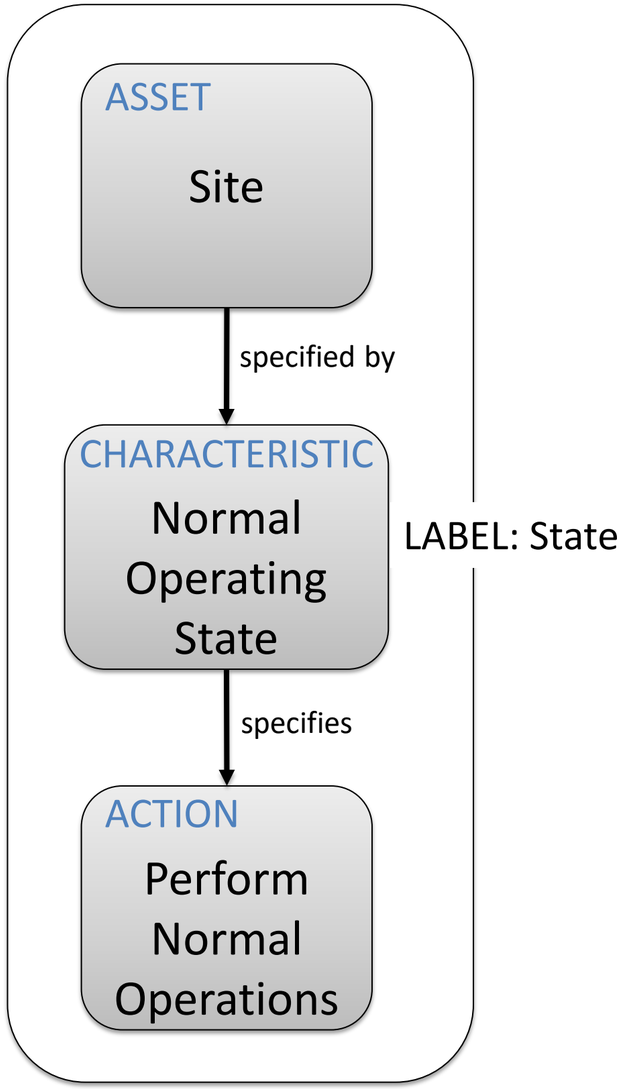
# Data View for State Diagram




Note: Transitions are not shown for the sake of diagram simplicity

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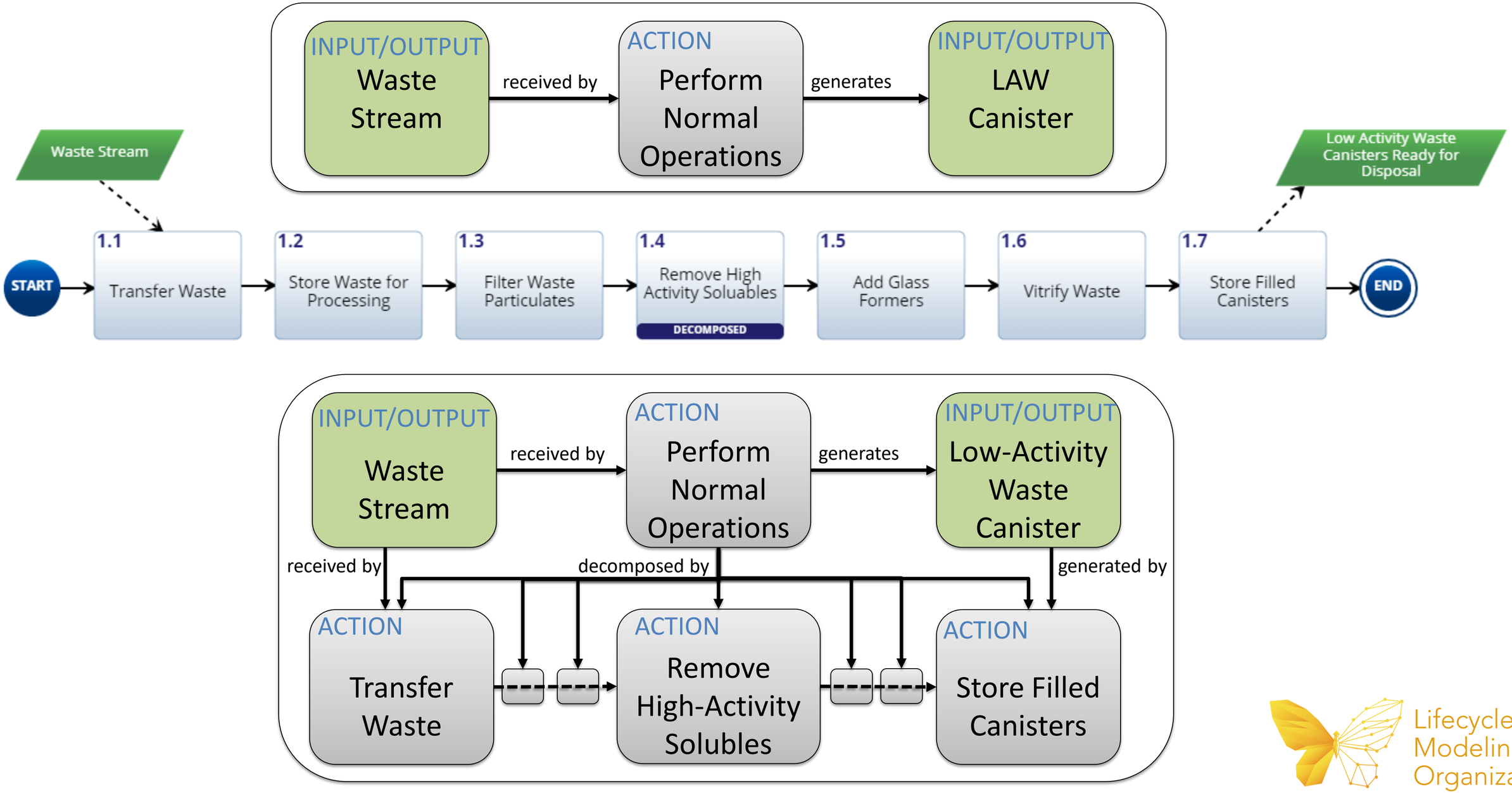
# Functional Behavior

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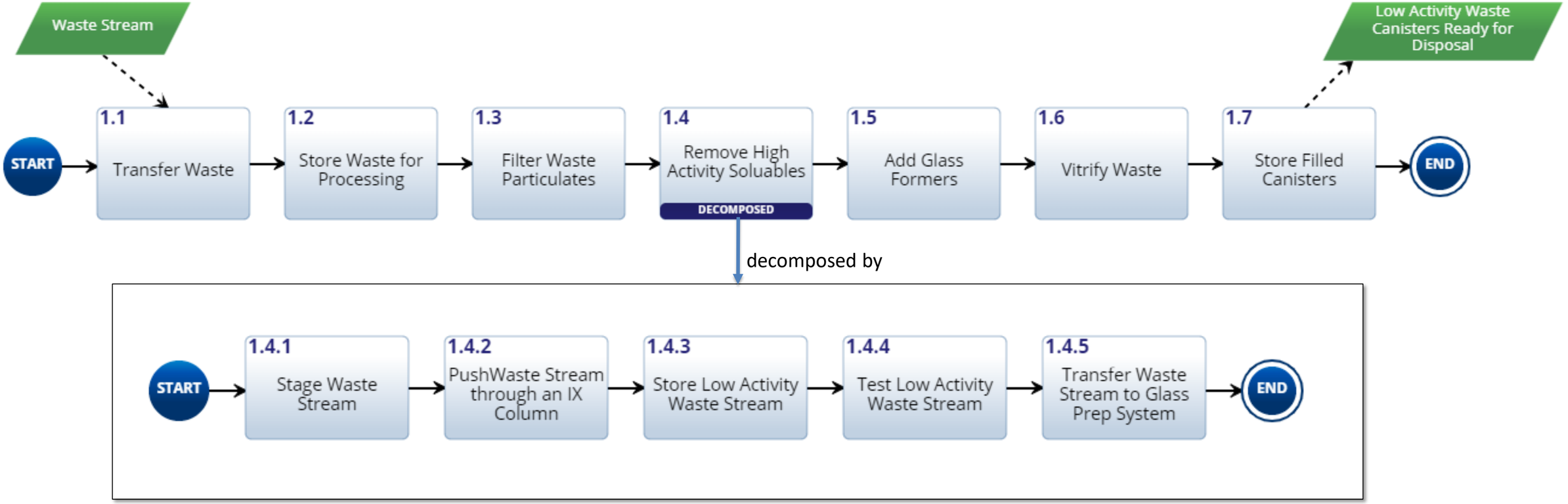
# Decomposed Function

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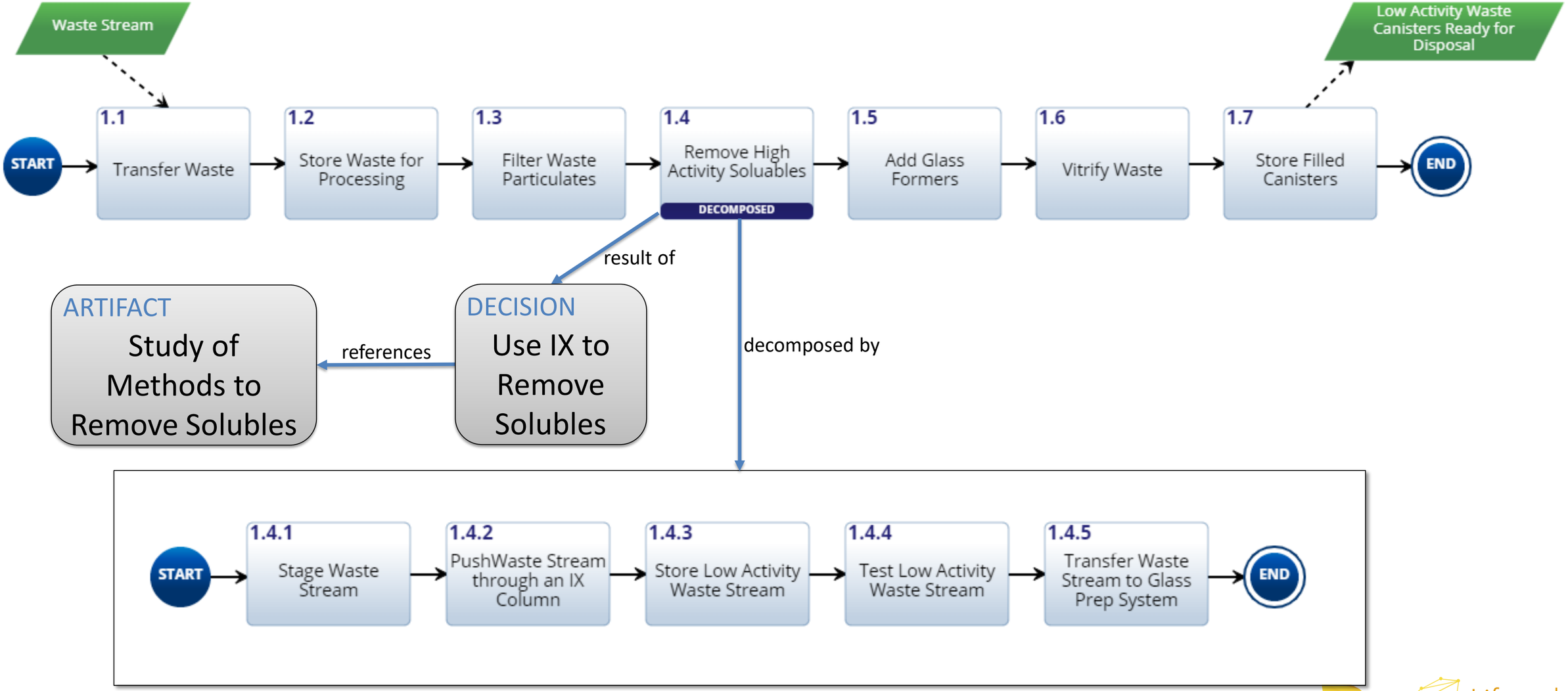
# Linking Decisions

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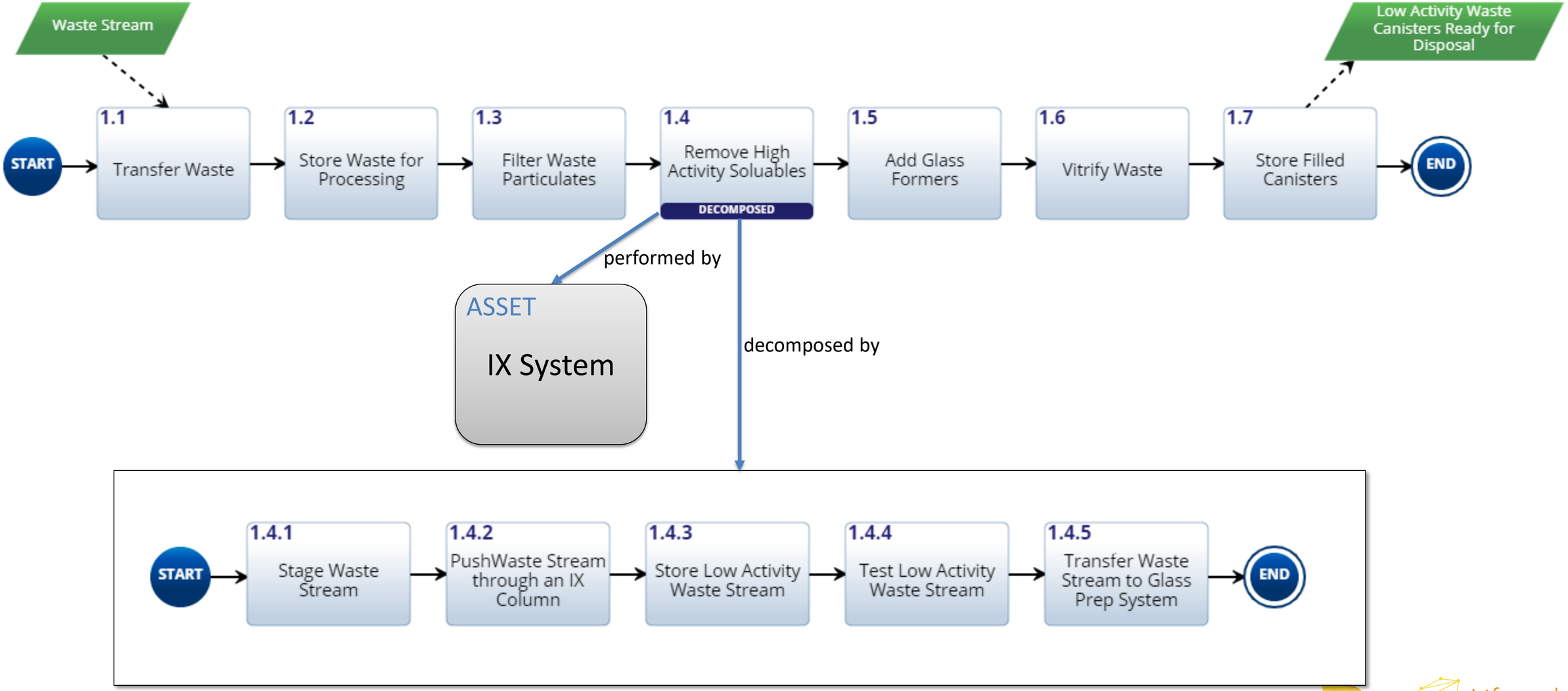
# Linking Functions to Assets

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# CHARACTERISTICS

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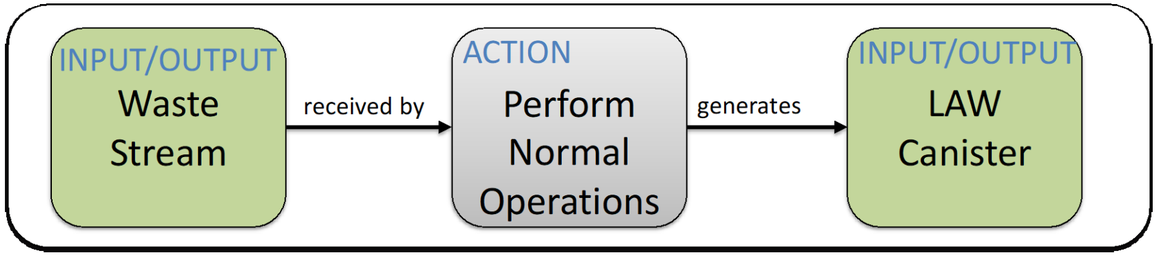
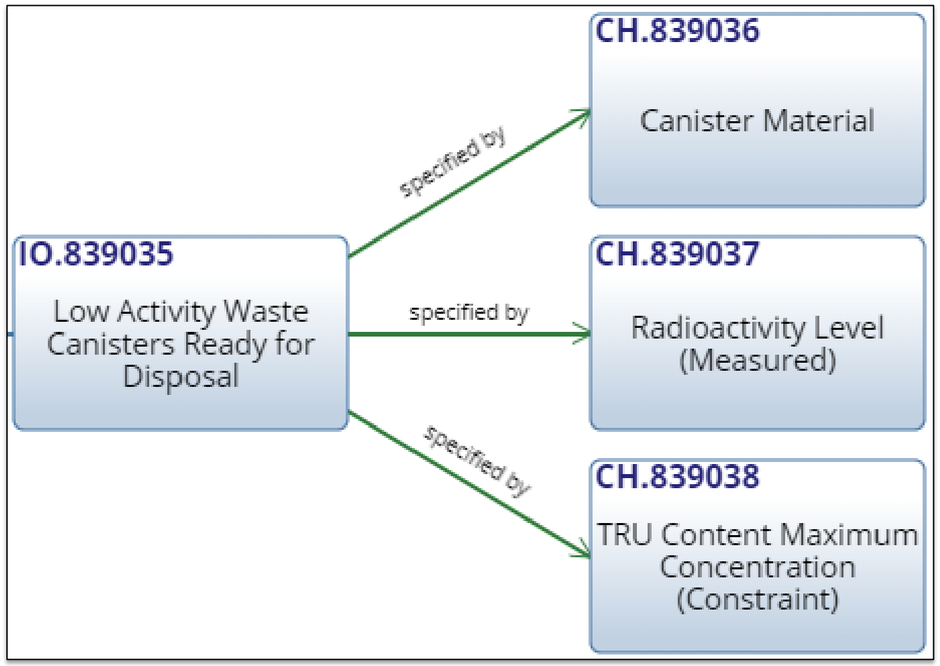
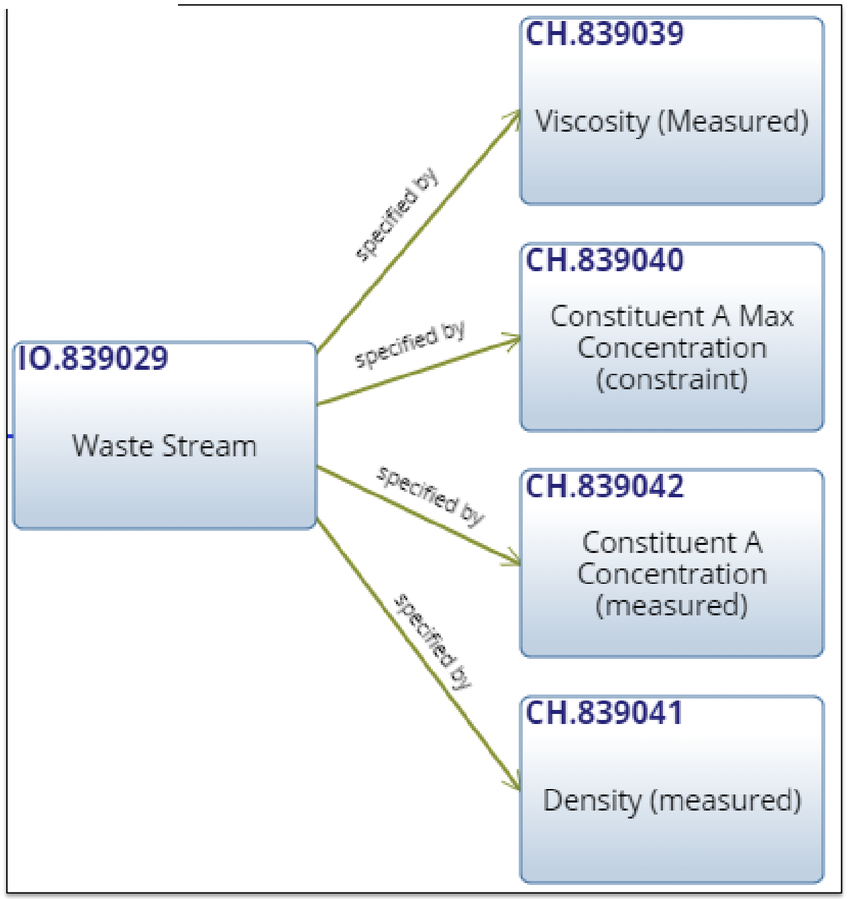
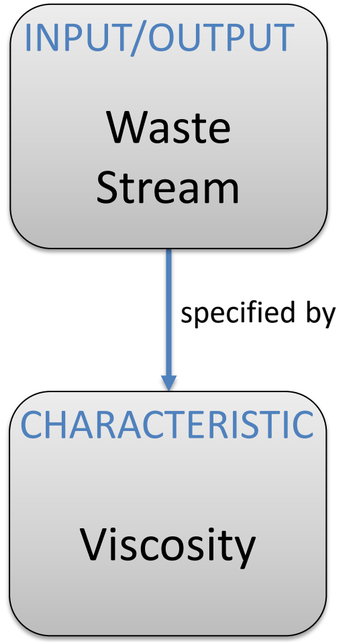
Organization

# Specifying Input/Output Characteristics

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# REQUIREMENTS

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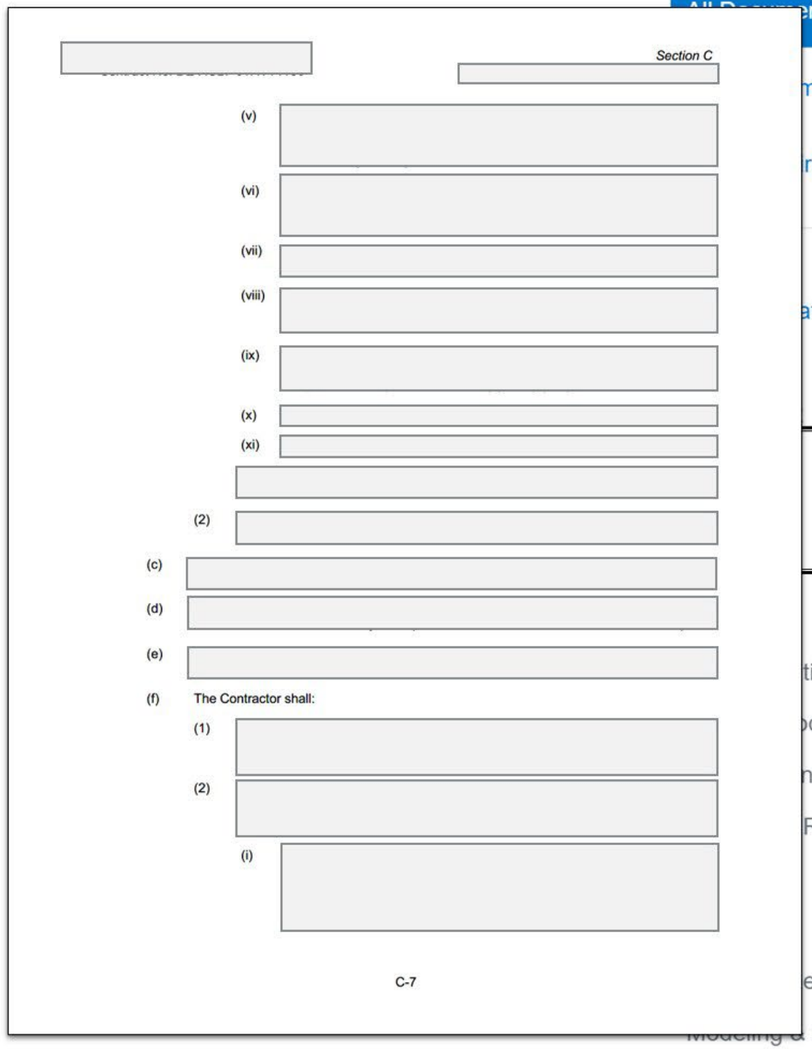
# Requirements




Import & Parse

MENU | Diagrams | Database | Dashboard | Documents

Filter | Hierarchy

New Requirement | Auto Number | Baseline | Quality Check | Open | Report

Contract Title.docx

| | |
|---|---|
| nt Entities | 989 |
| ments | 2 |
| rements | 987 |
| atic | 3 |
| | 0 |
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| ntal Requirement | 0 |
| Requirement | 0 |
| | 0 |
| | 0 |
| equirement | 0 |
| Modeling & Simulation | 0 |
| Objective | 0 |
| PG Test | 0 |

C.3.(f) The Contractor shall:

C.3.(f).(1)
Statement

C.3.(f).(2)
Statement

C.3.(f).(2).(1)
Requirement

C.3.(f).(2).(2)
Requirement

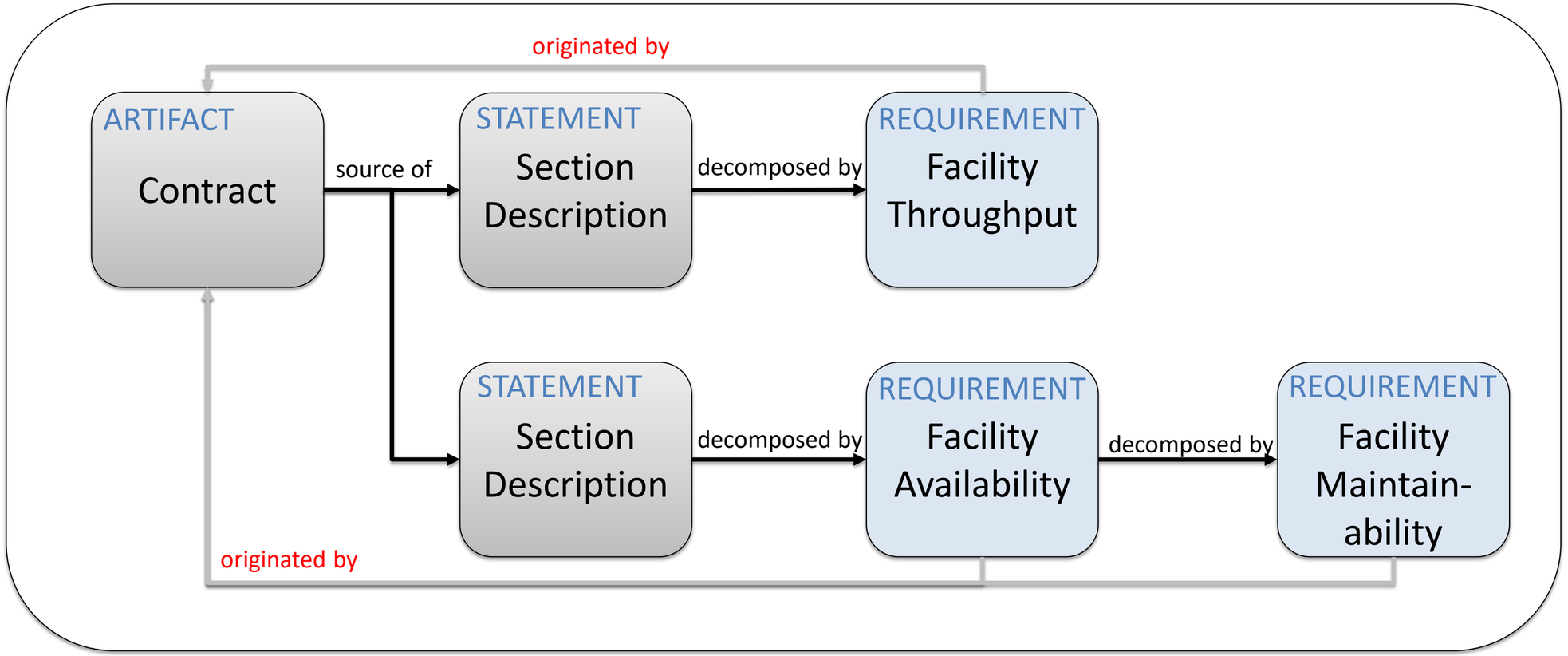
C.3.(f).(2).(3)
Requirement

C.3.(f).(3)
Requirement

C.3.(f).(4)
Requirement

C.3.(f).(5)
Requirement

# Imported Document as Data

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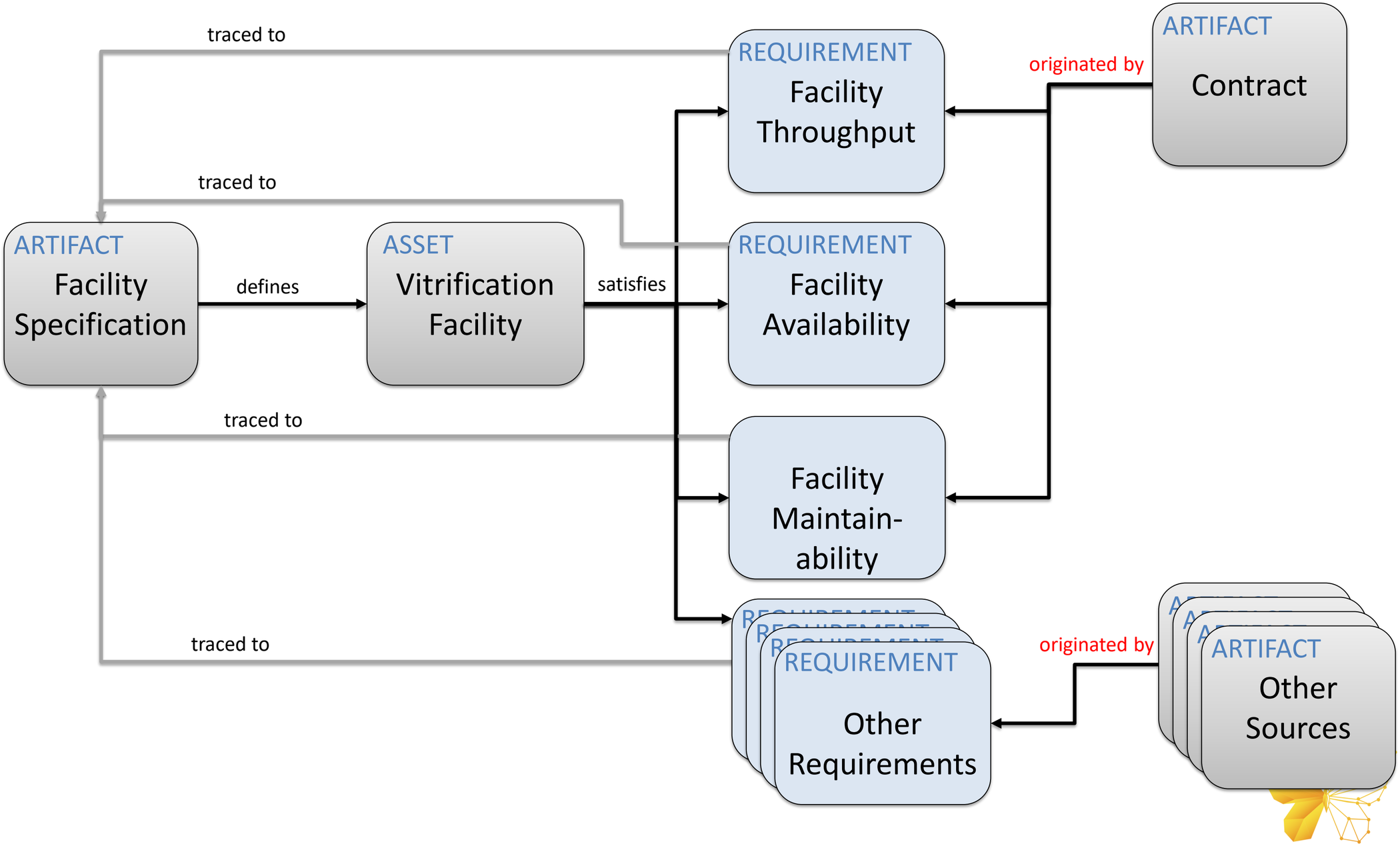
# Allocation and Specification

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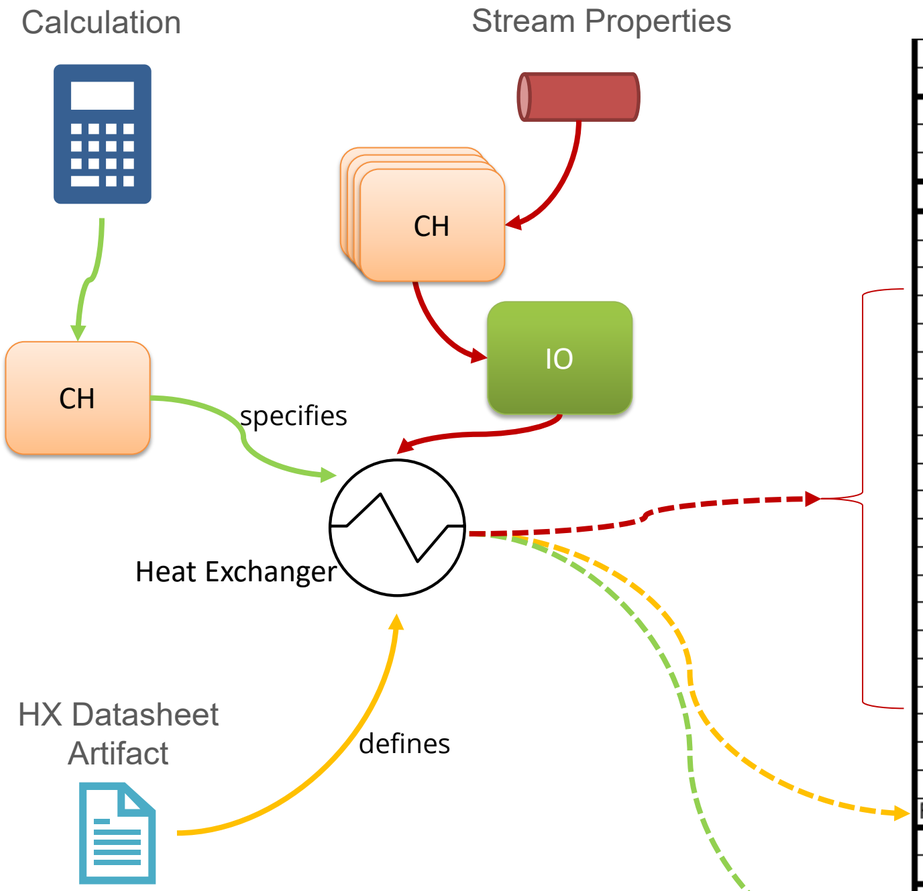
# Characteristics Flowdown




| Case 4 - G-F - Maximum actual volumetric flow rate for shellside (NOTE 2) | | | | | Enquiry/ PO No. | |
|---|---|---|---|---|---|---|
| | | | | | Item No. | HA-331101/HA-331201 |
| Service of Unit | Gas/Gas Exchanger | | | | No. Required | 2 (NOTE 1) |
| Size | Type | BEM (NOTE 7) | Connected | Parallel 2 | Series | 2 |
| Surf./Unit (Gross) | m² | Shells/ Unit 4 (NOTE 8) | Surface/Shell (Gross) | | | m² |

**PERFORMANCE OF ONE UNIT - CASE 4 [G-F]**

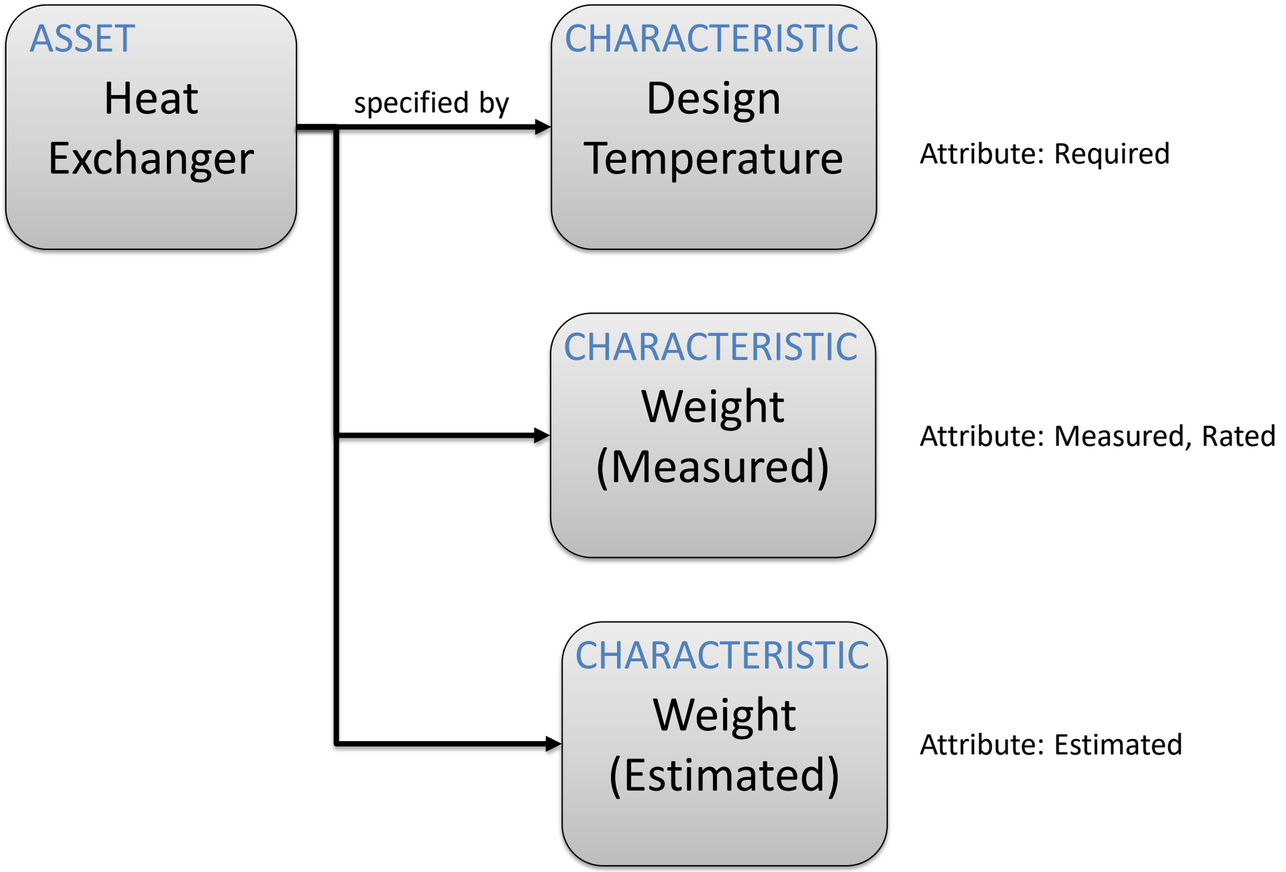
| Fluid Allocation | | Tube Side | | Shell Side | |
|---|---|---|---|---|---|
| | | Inlet | Outlet | Inlet | Outlet |
| Fluid Name | | HC VAP FROM TEG OUTLET SCRUB. | | HC VAP FROM COLD SEP | |
| Fluid Quantity, Total | kg/h | 444668.1 x1.1 (NOTE 4) | | 444434.4 x1.1 (NOTE 4) | |
| Vapour | | 444668.0 | 444521.4 | 444426.7 | 444434.4 |
| Liquid | | 0.1 | 146.7 | 7.7 | - |
| Steam | | - | - | - | - |
| Water | | - | - | - | - |
| Noncondensable | | - | - | - | - |
| Temperature (In / Out) | °C | 19.8 | 1.3 | -4.0 | 14.4 |
| Density | kg / m³ | 33.55 | 35.94 | 27.33 | 24.22 |
| Viscosity | cP | 0.0121 | 0.0116 | 0.0111 | 0.0116 |
| Molecular Weight, Vapour | kg/kgmol | 16.35 | 16.34 | 16.34 | 16.34 |
| Molecular Weight, Liquid | kg/kgmol | 137.16 | 113.60 | 113.78 | - |
| Molecular Weight, Water | kg/kgmol | - | - | - | - |
| Specific Heat | kJ/kg K | 2.552 | 2.594 | 2.483 | 2.446 |
| Thermal Conductivity | W/mK | 0.0369 | 0.0345 | 0.0326 | 0.0349 |
| Latent Heat | kJ/kg | | | | |
| Inlet Pressure | bar(g) | 44.4 | | 32.8 | |
| Velocity (NOTE 11) B01 | m/s | | | | |
| Pressure Drop, Allow./ Calc. | bar | 1.00 | | 1.00 | |
| Fouling Resistance (NOTE 5) | m² K/W | 0.00020 | | 0.00020 | |

| Heat Exchanged | 5750 x1.1 (NOTES 4, 5) B01 | kW | MTD | °C |
|---|---|---|---|---|
| Transfer Rate, Service | Dirty | | Clean | W/m² K |

**CONSTRUCTION OF ONE SHELL**

| | | Shell Side | Tube Side | Sketch (Bundle/Nozzle Orientation) |
|---|---|---|---|---|
| Design/Test Pressure | bar(g) | FV/90 | FV/90 | |
| Design Temperature | °C | -45.6/80 B01 | -45.6/80 B01 | |
| No. Passes per Shell | | | | |
| MOC + Corrosion Allowance | mm | | | |
| Connections | In | | | |
| Size & | Out | | | |
| Ratings | Inter. | | | |

# Differences in Asset Characteristics

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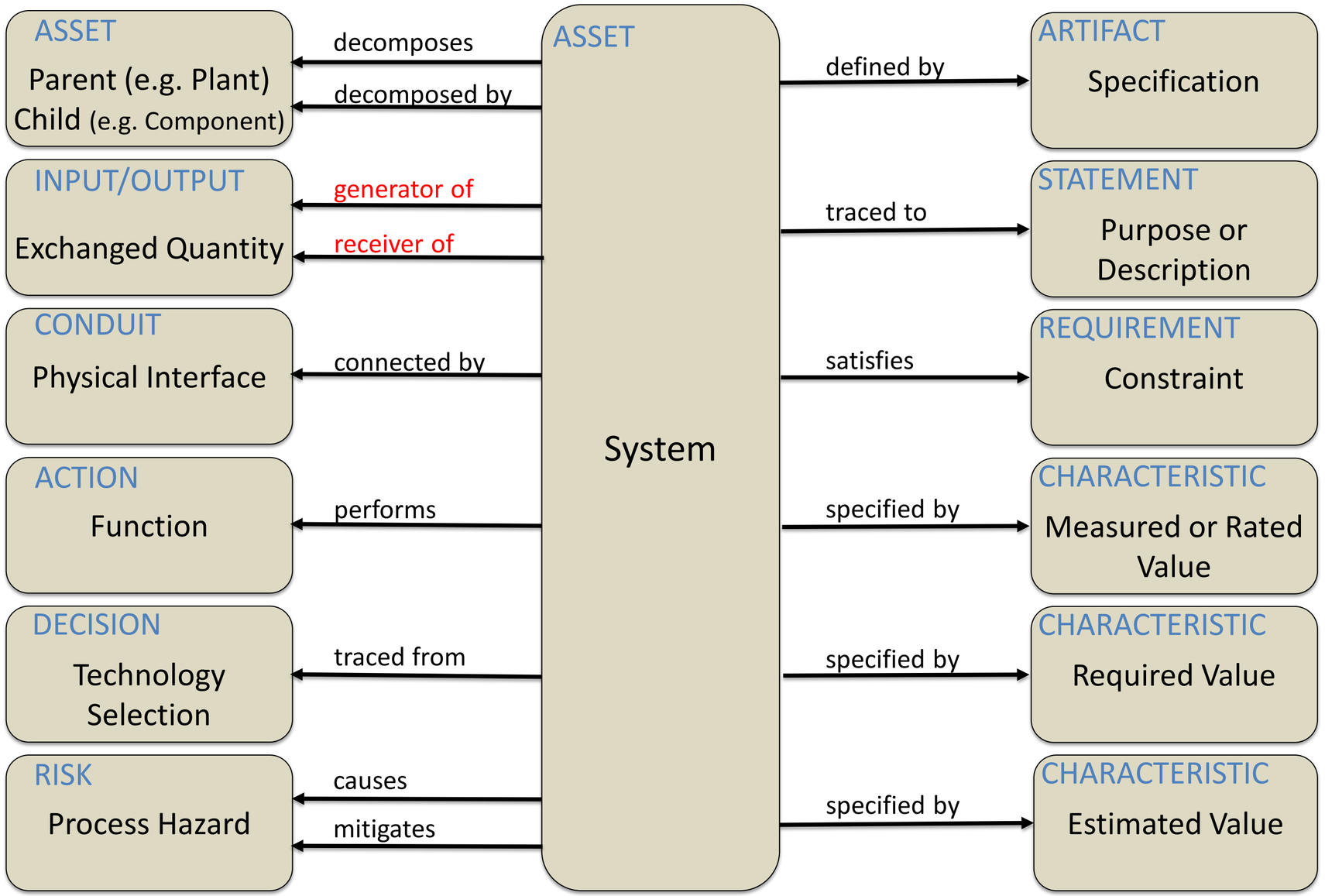
# SYSTEM REPRESENTED AS DATA
## (A GENERALIZATION USING LML)

Lifecycle
Modeling
Organization

# What is a System? (A Data Viewpoint)

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# THANK YOU

We hope you can make it to our next webinar!