Evaluation of EPLAN generation in a digital engineering tool chain for mechatronic components of transport systems

Master Thesis: Progress Update

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EPLAN Generation for Transport System Components

Thesis Work Overview

THESIS TIMELINE																															
Topic Title: Evaluation of EPLAN generation in a digital engineering toolchain of mechatronic components of transport systems																															
Sl.No	Task/Phase		October					November				Decemeber					January					February					March				
			W1	W2	W3	W4	W5	W1	W2	W3	W4	W1	W2	W3	W4	W5	W1	W2	W3	W4	W5	W5	W1	W2	W3	W4	W1	W2	W3	W4	W5
1	Thesis Planning / kickoff	Plan														x														
		Actual														x														
2	Literature review (State of the Art research)	Plan														x														
		Actual														x														
3	EPLAN Onboarding	Plan														x														
		Actual														x														
4	AML Onboarding	Plan														x														
		Actual														x														
5	DIAMOND Onboarding	Plan														x														
		Actual														x														
6	Create a structure of work. Phases of thesis work	Plan														x														
		Actual														x														
7	Developing information models	Plan														x														
		Actual														x														
8	Enriching Simulation artifact	Plan														x														
		Actual														x														
9	Development of export AddOn	Plan														x														
		Actual														x														
10	eBUILD Library Development	Plan														x														
		Actual														x														
11	Implemetation of data logistics	Plan														x														
		Actual														x														
12	Prototypical Application	Plan														x														
		Actual														x														
14	Thesis Writing	Plan														x														
		Actual														x														

Table:Thesis Overview Gantt Chart

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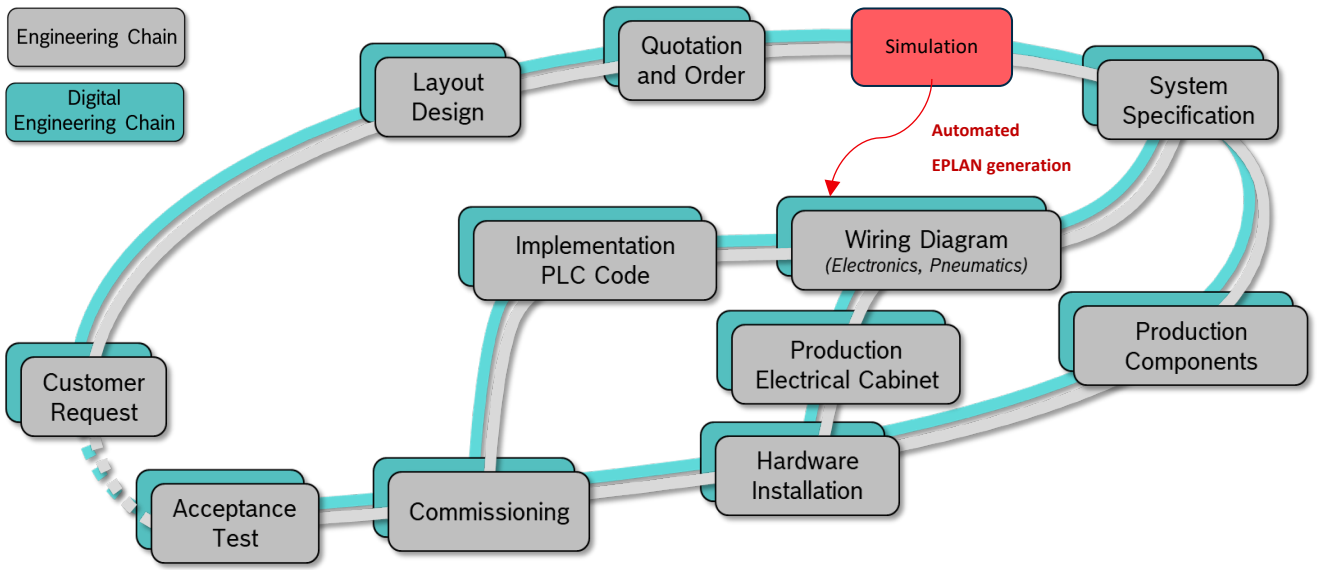
Objective

To investigate the utilization of simulation/ planning models for Bosch Rexroth's transfer system from Visual Components for the automated generation of electrical wiring diagrams within EPLAN and develop a systematic pipeline to facilitate this automation process.



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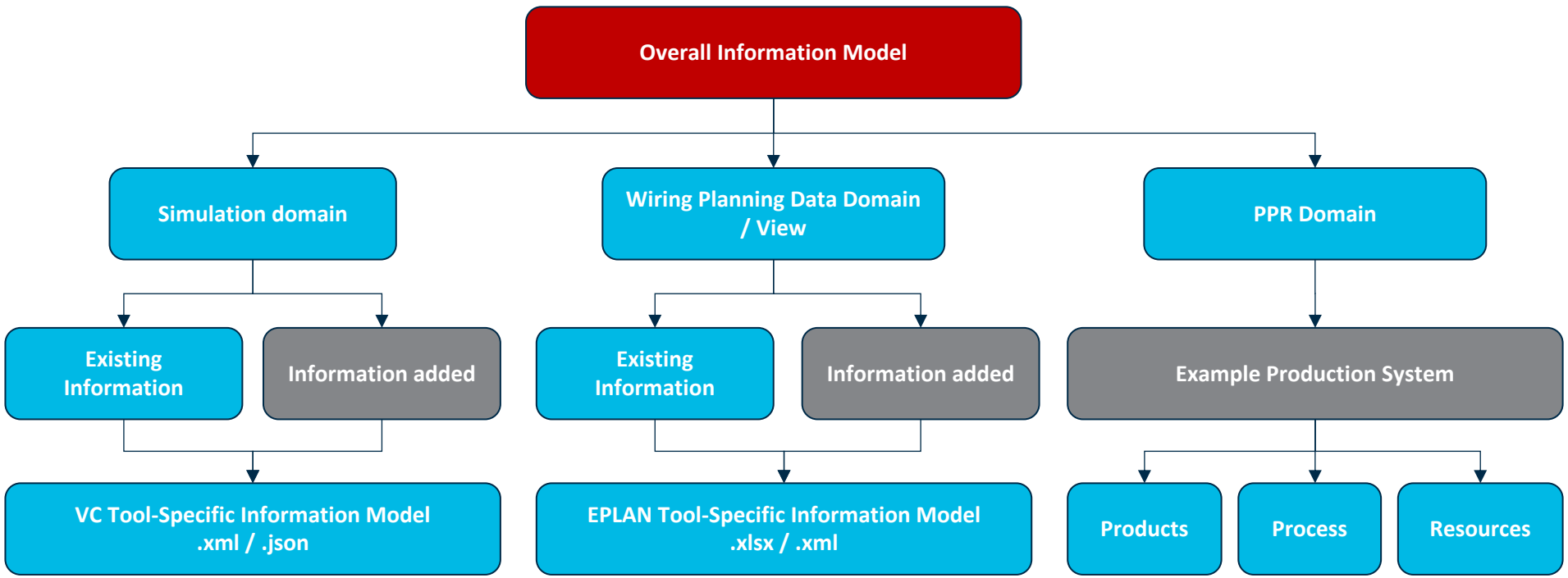
Main Task

Conceptual development and prototypical application of an enhanced **engineering data logistics integrating the wiring plan generation based on simulation models** within the over-all engineering of production systems.

Subtask 2 : Development of Information Models



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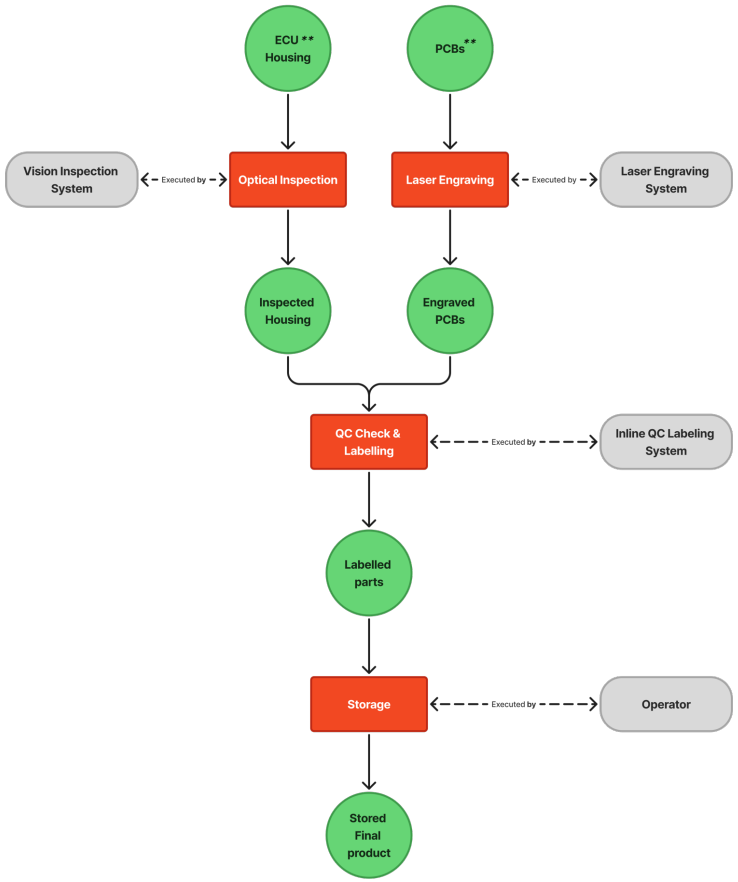
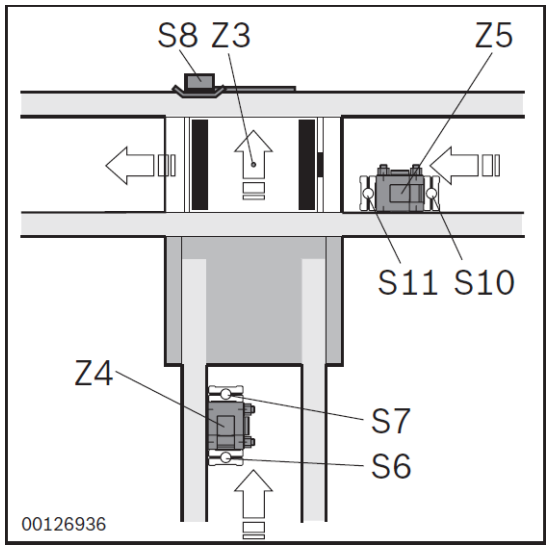
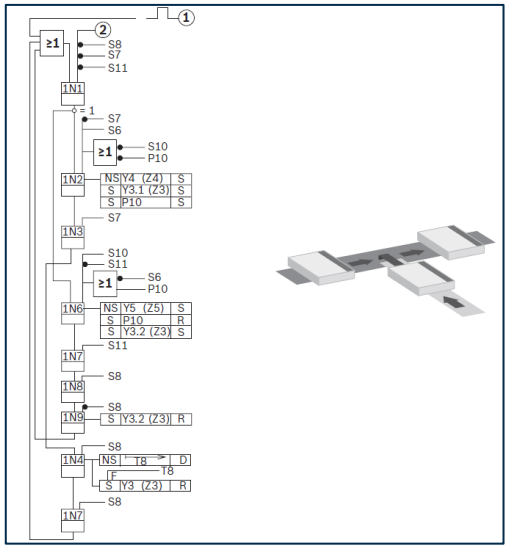
PPR diagram: Example Production System (Function Plan: TFE4)







The function plan considered for the production system is: **TFE4** – Separating and Infeeding

Function Plans : Function plans are standardized function groups for transfer systems that specify control tasks by formalizing the sequence of operations, interlocks, and timing relationships between involved components.

Fig: PPR Diagram of Example Production System considered: Automotive Electronics Inline Quality Inspection and Traceability System

***** ECU :** Electronic Control Unit, **PCB:** Printed Circuit Board*

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Subtasks

Example Production System in Simulation Domain: TFE4

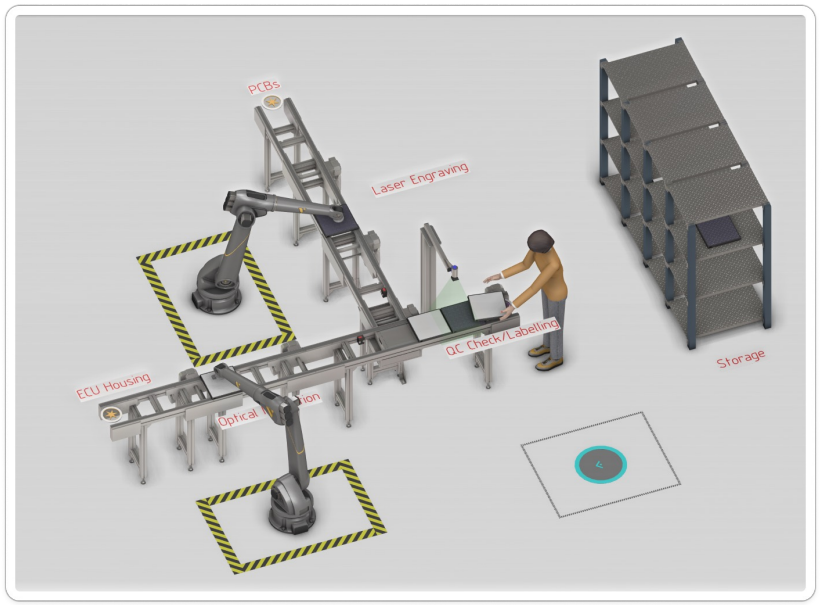

Fig: Function Plan TFE4 Ex. Production System modelled in Visual Components (Simulation Domain)

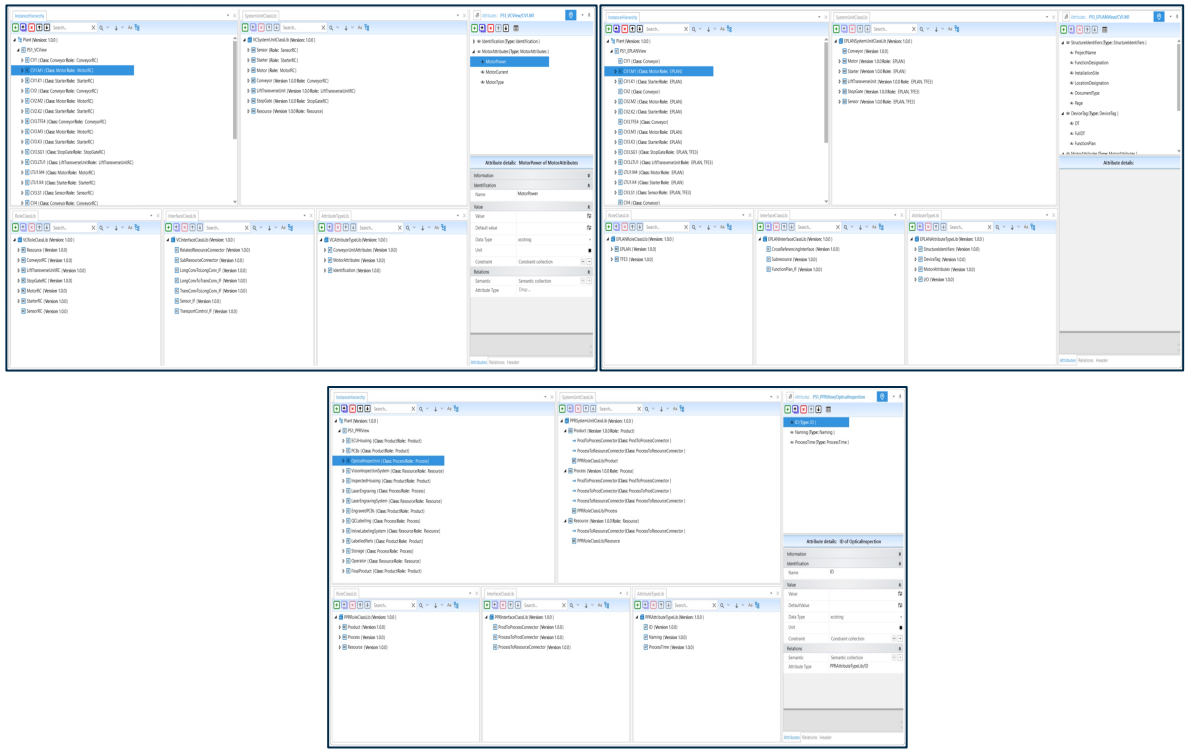

Fig: Ex. Production System in AML: a. Visual Components (Simulation Domain) View, b. EPLAN (ECAD) Domain, c. PPR Domain

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Subtasks

Example Production System in EPLAN Electric P8

To model the EPLAN schematics of the example production system, reusable macros (standardized schematic sections and symbols) are be created for each TS2 component used in the system.

The following ECAD schematic pages are generated to represent the mechatronic components of TS2 systems:

Page type - Electrical Schematic multi-line:

- Conveyor Drive: Motors, Starters, Terminals
- Conveyor Drive: Digital Input/Output module
- Lift Transverse Unit, Stop Gate: Valve terminal Output Modules
- Sensor: Input modules

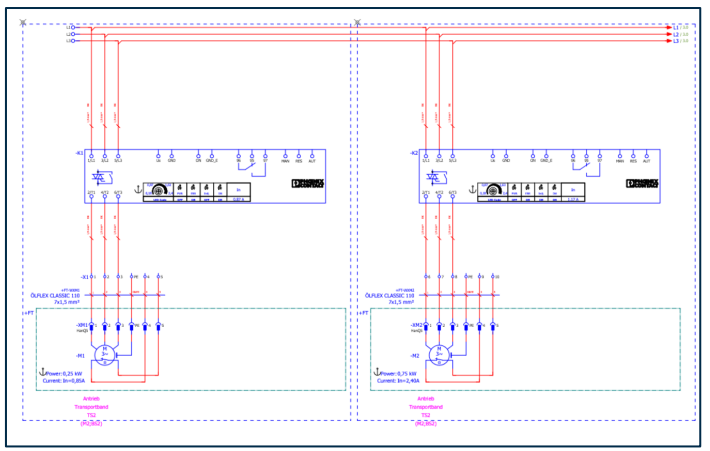

Fig: TS2 Conveyor Drive Motor, Starter, Terminal Strip represented as a Window Macro

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Subtasks

Example Production System in EPLAN Electric P8

The following pages are to be generated to represent the mechatronic components of TS2 systems:

Page type - Fluid Power Schematic:

- Lift Transverse Unit, Stop Gate- Pneumatic Valve terminal

The macros required to generate the above schematic pages for the mechatronic components of the TS2 system were created.

Based on these macros, macro typicals, typical groups incorporating placeholder objects and configuration variables were developed.

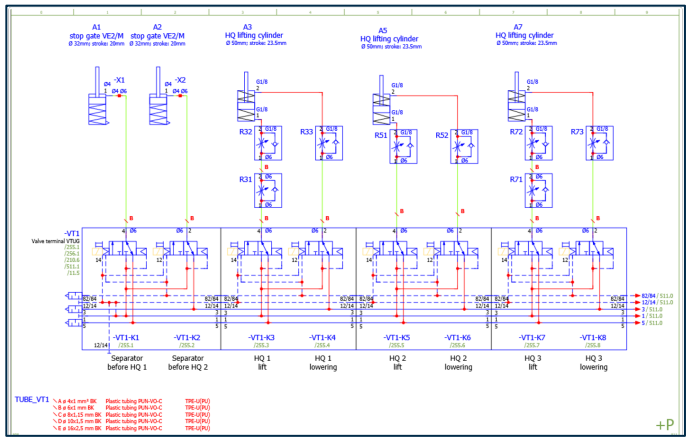

Fig: TS2 LTU- Valve Terminal Fluid Power Schematic

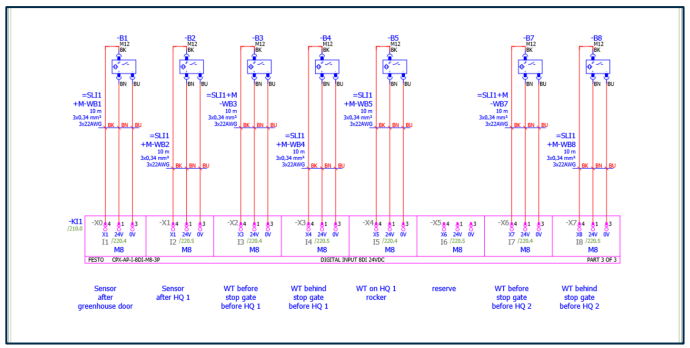

Fig: TS2 Sensor- DI module Electrical Schematic

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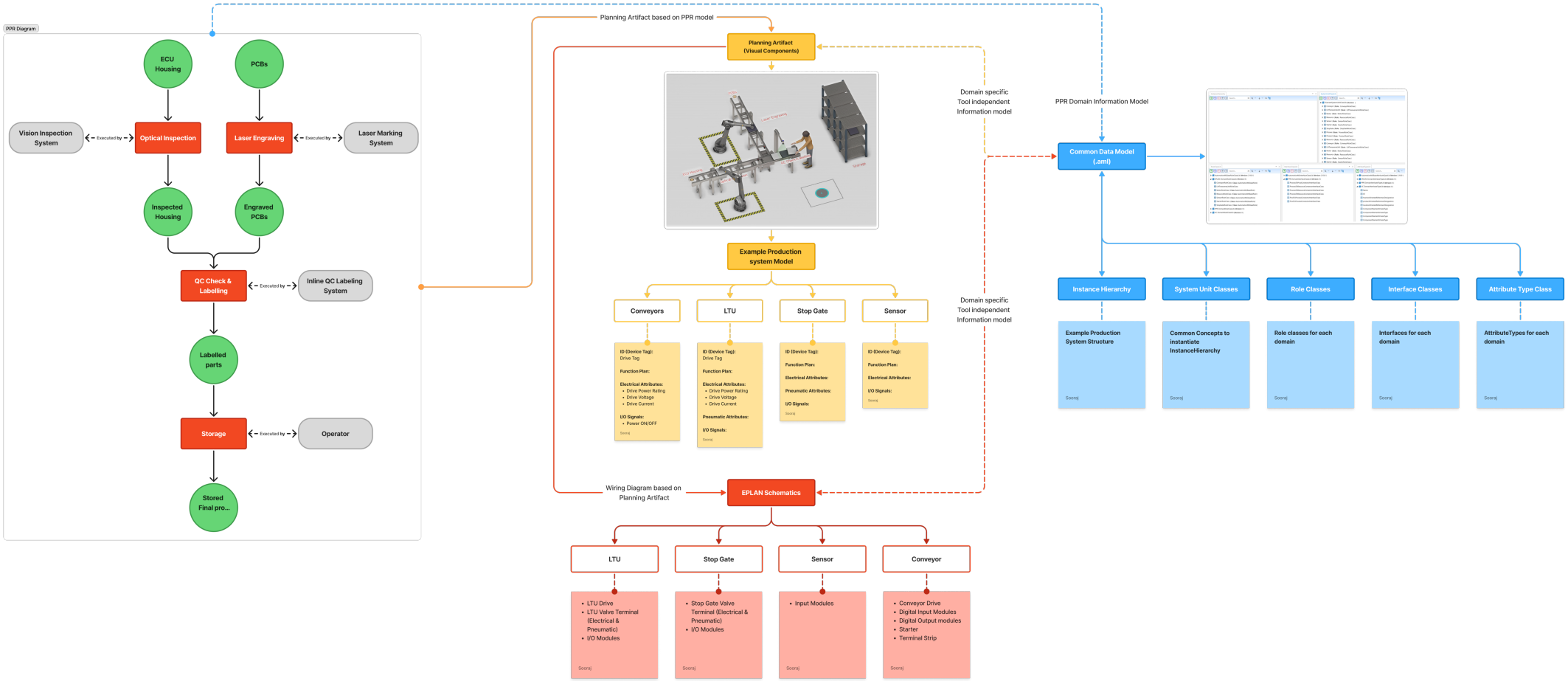
Overall Information Flow between domains for an Eg. Production System



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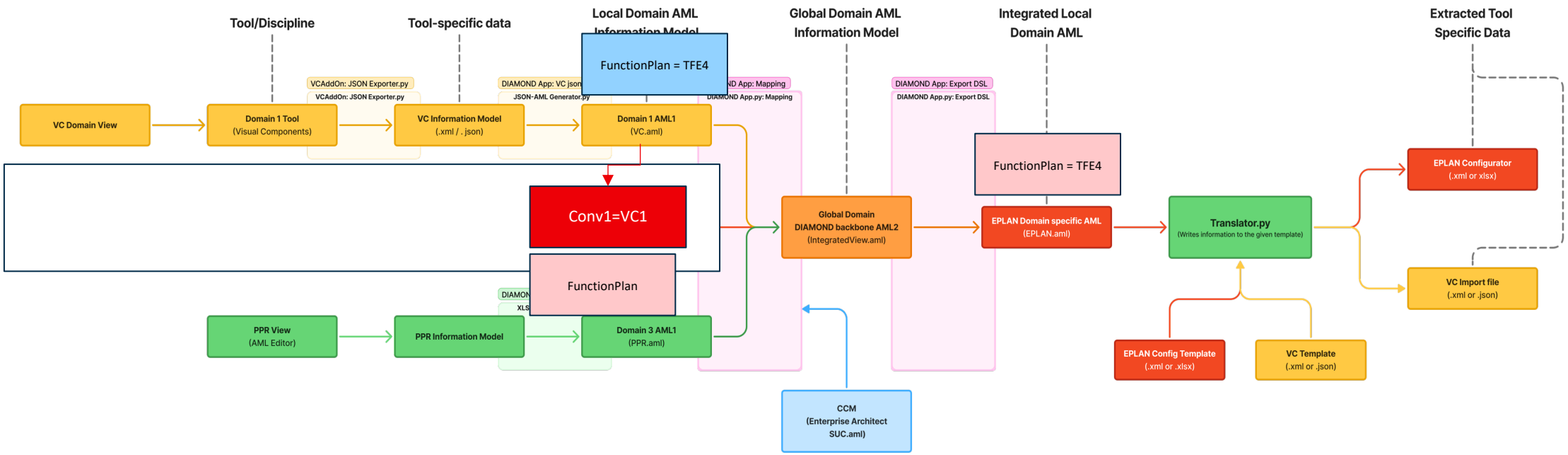
High Level Engineering Data Logistics Workflow



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EPLAN eBUILD (Cloud based Schematic Generator)

EPLAN eBUILD Workflow:

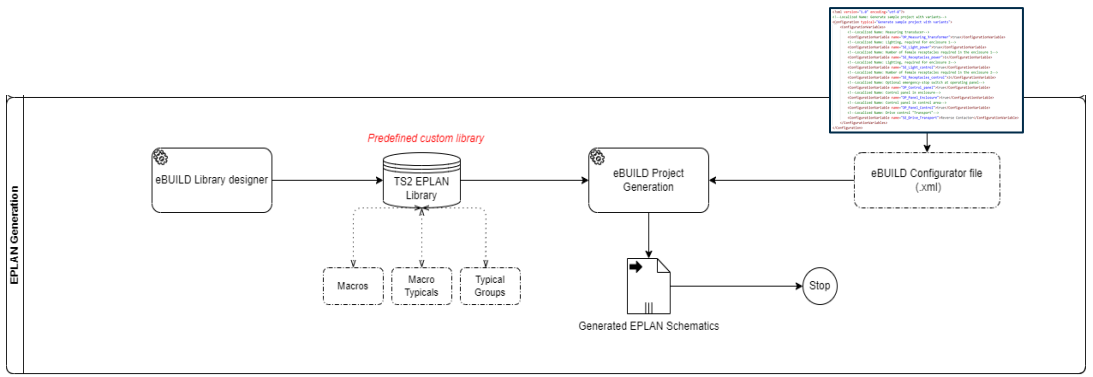

Fig: EPLAN eBUILD Project generation from predefined libraries and configurators

```xml
<?xml version='1.0' encoding='utf-8'?>
<Configuration typical="Ex_TS2_Drive_typical_group">
  <!--Localized Name: Ex_TS2_Drive_macro_typical-->
  <ConfigurationVariables>
    <!--Localized Name: Function Designation [=]-->
    <ConfigurationVariable name="function_designation">TS2</ConfigurationVariable>
  </ConfigurationVariables>
  <!--Localized Name: Ex_TS2_Drive_typical_group-->
  <TypicalInstance name="Ex_TS2_Drive_macro_typical">
    <Instance>
      <ConfigurationVariables>
        <!--Localized Name: LocationDesignation [+]-->
        <ConfigurationVariable name="location_designation">ConveyorUnit1</ConfigurationVariable>
        <!--Localized Name: Motor Power-->
        <ConfigurationVariable name="motor_power">0,18 kW</ConfigurationVariable>
        <!--Localized Name: motor_current-->
        <ConfigurationVariable name="motor_current">0,60 A</ConfigurationVariable>
        <!--Localized Name: Starter Current-->
        <ConfigurationVariable name="starter_current">0,60 A</ConfigurationVariable>
      </ConfigurationVariables>
    </Instance>
    <Instance>
      <ConfigurationVariables>
        <!--Localized Name: LocationDesignation [+]-->
        <ConfigurationVariable name="location_designation">ConveyorUnit2</ConfigurationVariable>
        <!--Localized Name: Motor Power-->
        <ConfigurationVariable name="motor_power">0,25 kW</ConfigurationVariable>
        <!--Localized Name: motor_current-->
        <ConfigurationVariable name="motor_current">0,85 A</ConfigurationVariable>
        <!--Localized Name: Starter Current-->
        <ConfigurationVariable name="starter_current">0,85 A</ConfigurationVariable>
      </ConfigurationVariables>
    </Instance>
    <Instance>
      <ConfigurationVariables>
        <!--Localized Name: LocationDesignation [+]-->
        <ConfigurationVariable name="location_designation">ConveyorUnit3</ConfigurationVariable>
        <!--Localized Name: Motor Power-->
        <ConfigurationVariable name="motor_power">0,37 kW</ConfigurationVariable>
        <!--Localized Name: motor_current-->
        <ConfigurationVariable name="motor_current">0,95 A</ConfigurationVariable>
        <!--Localized Name: Starter Current-->
        <ConfigurationVariable name="starter_current">0,95 A</ConfigurationVariable>
      </ConfigurationVariables>
    </Instance>
```

Fig: EPLAN example eBuild configuration file (.xml)

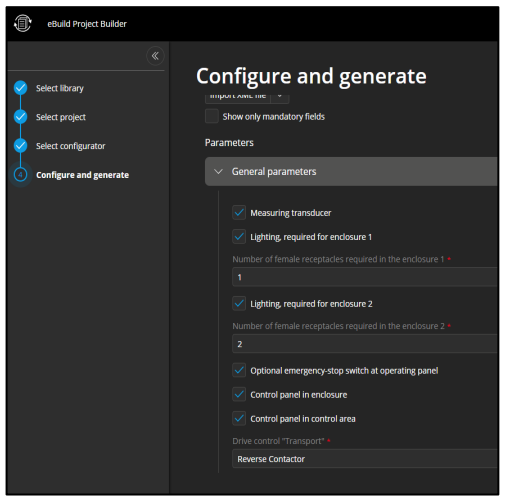

Fig: eBUILD Configurator UI

- **eBUILD Project Generation**, utilizes preconfigured library consisting of macros, macro typicals, typical groups and configurators to automatically generate EPLAN schematics based on a configuration file.
- eBUILD Project Generation supports .xml / .xlsx import of configurations for schematic generation.
- Values for these placeholder configuration variables, generation rules, constraints in the configuration file is derived from the EPLAN domain export from the integrated Common Data Model (CDM)

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Modification of TS2 Simulation Objects in VC to facilitate data export

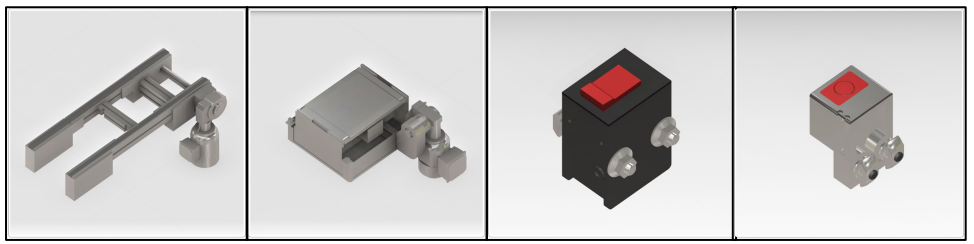

Fig: a) Conveyor Unit, b) Lift Transverse Unit, c) Stop Gate, d) Switch Bracket (Sensor)

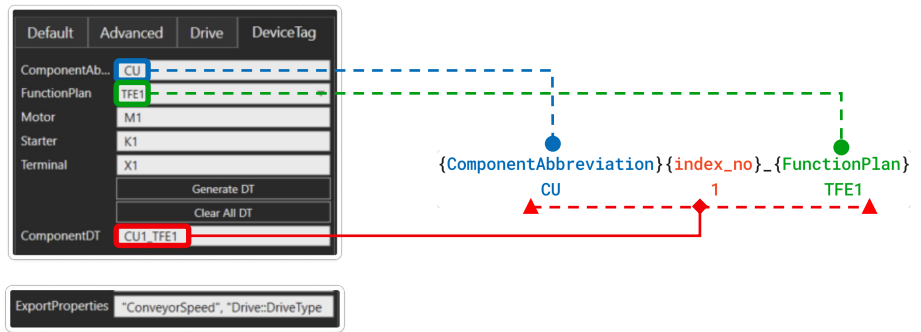

*Fig: **Top-** Device Tag generation for Conveyor unit and sub resources. **Bottom-** Export Properties string attribute to notify python exporter the attributes to be exported.*

- Extended TS2 Simulation objects by adding electrical attributes identified for EPLAN generation and in accordance with Transfer System 2 product documentation.
- Implemented internal python logic to generate a unique identifier Device Tag (DT) for each instantiated simulation object.
- Introduced an export string property, consisting of comma separated attribute list of each component, that specifies which component attributes and behaviors shall be included by the exporter add-on during data export.

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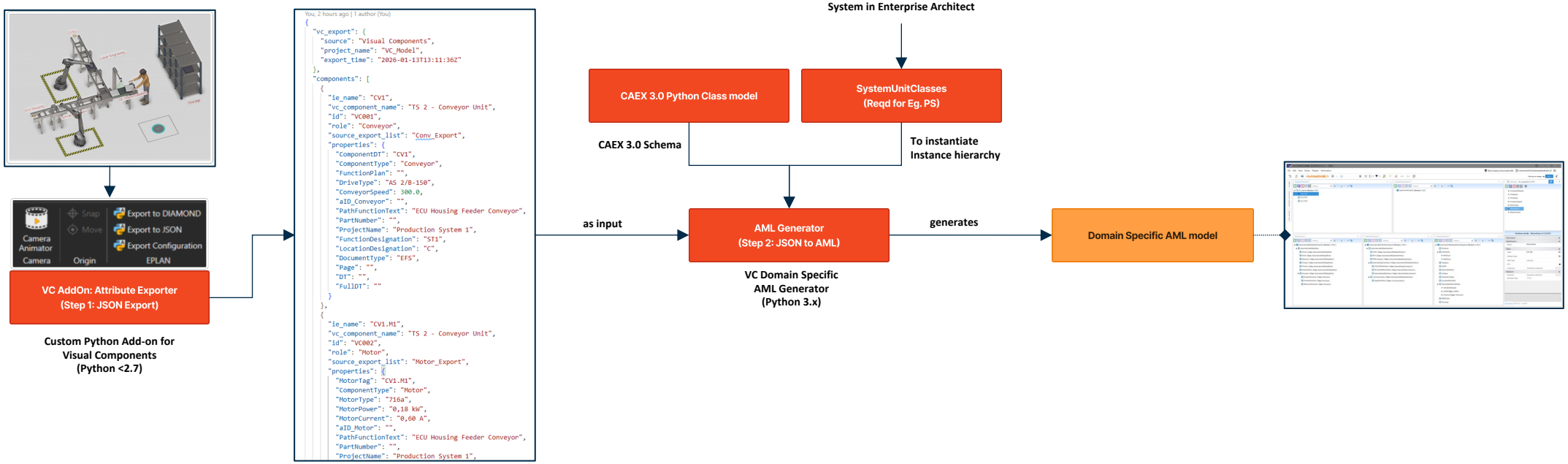
Domain-Specific AML Generation Pipeline from Visual Components

- A custom python based AddOn for Visual Components was developed to extract relevant information of the mechatronic components present in the planning artifact and export it to a Domain specific data format.
- The exported data is transformed into a domain-specific AutomationML instance hierarchy using predefined mapping schema and the System Unit Classes (SUCs) of the example production system exported from the Enterprise Architect Common Concept model (CCM).



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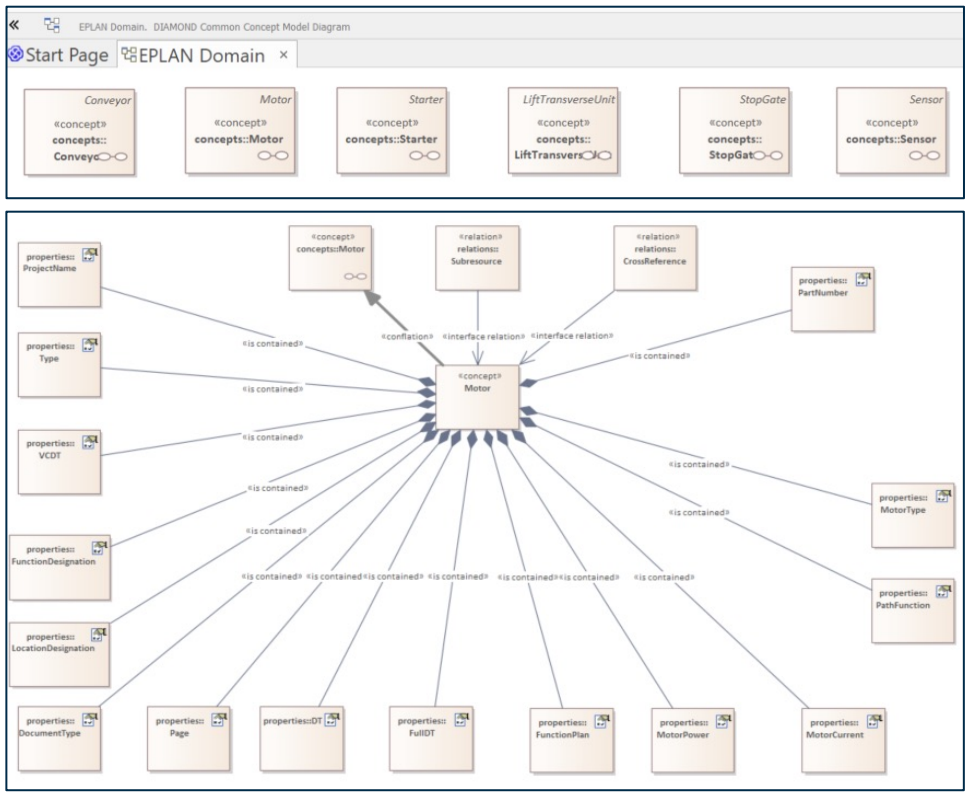
SUC generation from Common Concept Model in Enterprise Architect (EA)

Modelled Common Concepts Diagram in EA for each view with defined attributes, relations to generate AML System Unit Classes (SUCs) for the Eg. Production System using RAMI 4.0 toolbox Add In.



TS2 Component: Motor			
VC_View		EPLAN_View	
VC_attribute	**Value**	**EPLAN_attribute**	**Value**
Motor::MotorTag	CV1.M1	*VCDT*	CV1.M1
Motor::ComponentType	Motor	*SUC_Type*	Motor
Motor::MotorType	716a	*MotorType*	716a
Motor::MotorPower	0.18 kW	*MotorPower*	0.18 kW
Motor::MotorCurrent	0.60 kW	*MotorCurrent*	0.60 kW
EPLAN::aID_Motor	VC001	*ID*	VC001
EPLAN::PathFunctionText	Feeder Conveyor	*PathFunctionText*	Feeder Conveyor
EPLAN::PartNumber	1000254	*PartNumber*	1000254
EPLAN::ProjectName	PS1	*ProjectName*	PS1
EPLAN::FunctionDesignation	ST1	*FunctionDesignation*	ST1
EPLAN::LocationDesignation	C(Cabinet)	*LocationDesignation*	C(Cabinet)
EPLAN::DocumentType	EFS	*DocumentType*	EFS
EPLAN::Page	5	*Page*	5

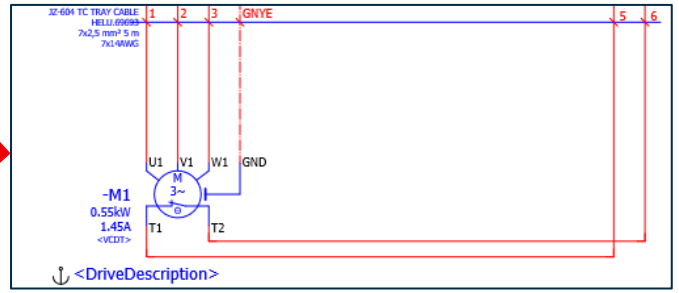


Fig: Left: *EPLAN Domain DIAMOND Common Concept Model Diagram for the Eg. Production System (CC: Motor) ,* ***Right****: Motor Concept Attributes in VC_View and EPLAN_View*

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Next Steps/ Work in progress

- Utilizing the knowledge from DIAMOND PPR-AML tool to integrate the domain specific views and generate global domain integrated AML information model / DIAMOND Common Data Model.
- Implementing a python-based exporter to EPLAN domain specific model from DIAMOND backbone followed by implementation of configuration template-based python translator to map information exported from DIAMOND backbone to create the eBUILD configurator file.
- Developing EPLAN eBUILD library for typical groups (Fluid power schematic, Electrical multi line schematic) and configurator for the TS2 components: Conveyor drives, Lift Transverse Unit, Stop gate and Sensors.
- Validating the complete engineering data logistics pipeline using a simplified simulation system and subsequently apply the validated approach to the example production system.

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Open points

- EPLAN – How can automatic numbering of Device Tags (DTs) for the generated eBUILD schematics be achieved? At present the generated schematics does not generate automatically numbered DTs for devices.
- EPLAN - How can interruption points be defined and connected with required cross-referencing for generated schematics using typical groups? (How can this cross-referencing information be included in eBUILD?)

Interruption points denote the continuation of auto connecting lines through multiple columns or pages of the schematic. Interruption points are used where certain potentials or signals must be spread over multiple schematic pages.

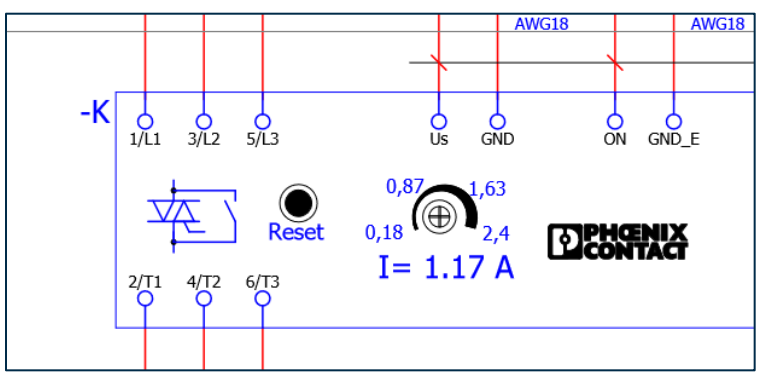

Fig: Eg. Motor starter DT (-K) not numbered automatically

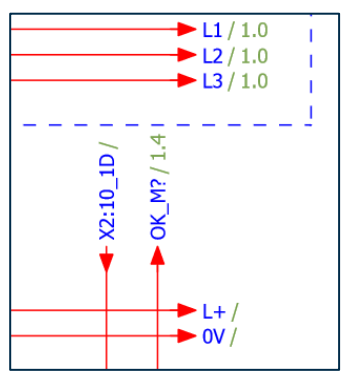

Fig: Eg. Interruption points for the AC Power rails

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