INCOSE
Healthcare
Working Group
5th Annual Systems Engineering in Healthcare Conference
May 1-2, 2019
Minneapolis, MN

Decision-Driven Product Development

- Matthew Hause
- PTC Engineering Fellow
- MBSE Specialist

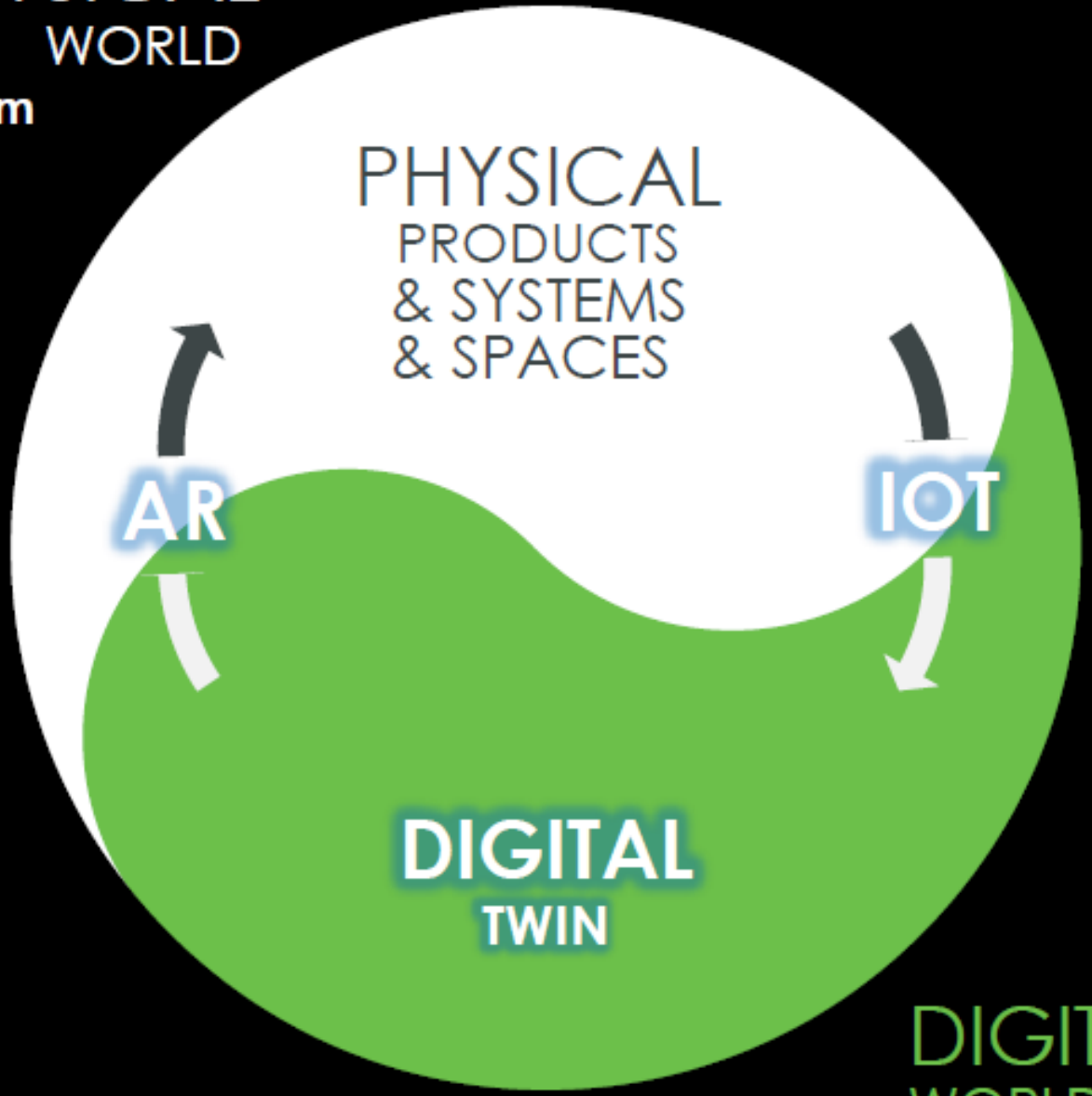
ptc

PHYSICAL WORLD

Industrial Innovation Platform

>$100M Revenue
> 50% Bookings Growth FY16
1,200 End Customers
250 OEMs/Resellers
Ecosystem of SI's, partners

IoT & ANALYTICS | thingworx
AUGMENTED REALITY | vuforia
INDUSTRIAL CONNECTIVITY | kepware



DIGITAL WORLD

PLM Solutions

>$1B Revenue
10% Bookings Growth FY16
28,000 End Customers
70% Direct Sales
30% VARs (~400)
Ecosystem of SI's, partners

CAD | creo
PLM | windchill
ALM | integrity
SLM | servigistics

AGENDA

- The Evolution of Systems
- Orthogonal Variability Modeling
- Product line Engineering
- Trade-off Analysis
- Conclusions

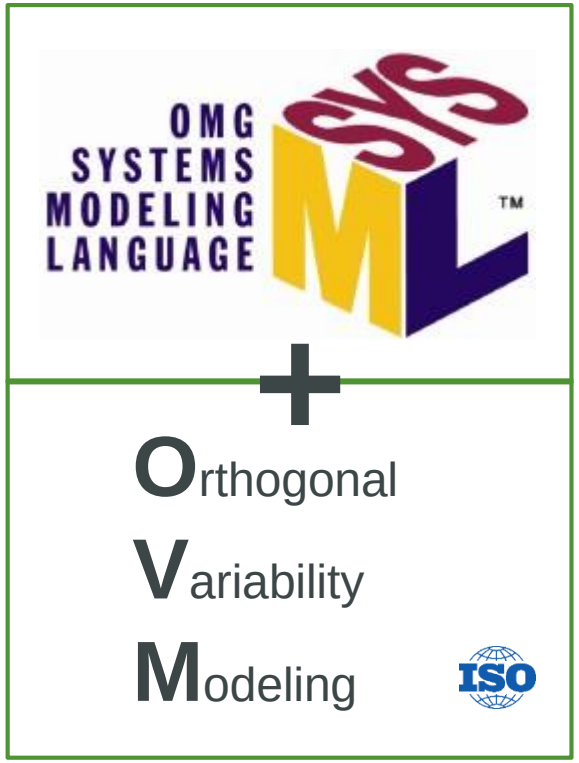
SYSTEM PRODUCT LINE ENGINEERING (PLE) CHALLENGES

- Increasing number of product families
- Increasing number of products in families
- Understanding product similarity
- Maximizing reuse
- Understanding product variations
- Deciding between options
- Development cycle time
- Commercial product needs
  - Customize existing capabilities to suit client requirements
  - Redeploy common systems & software to the Market

THE SOLUTION … MODEL-BASED PRODUCT LINE ENGINEERING

Designing a single system platform rather than as creating a multitude of products

- MBSE + Modular Design + Variation
  - Common language improves
    - Communication
    - Collaboration
    - Stakeholder buy in
  - Architected modular design & reuse
  - System product lines designed up front
- Maximum commonality & minimal variation
  - Less duplicated effort with optimized reuse
  - Parallel working through ‘design by contract’
  - More commonality between designs and implementations
  - Managed product line complexity

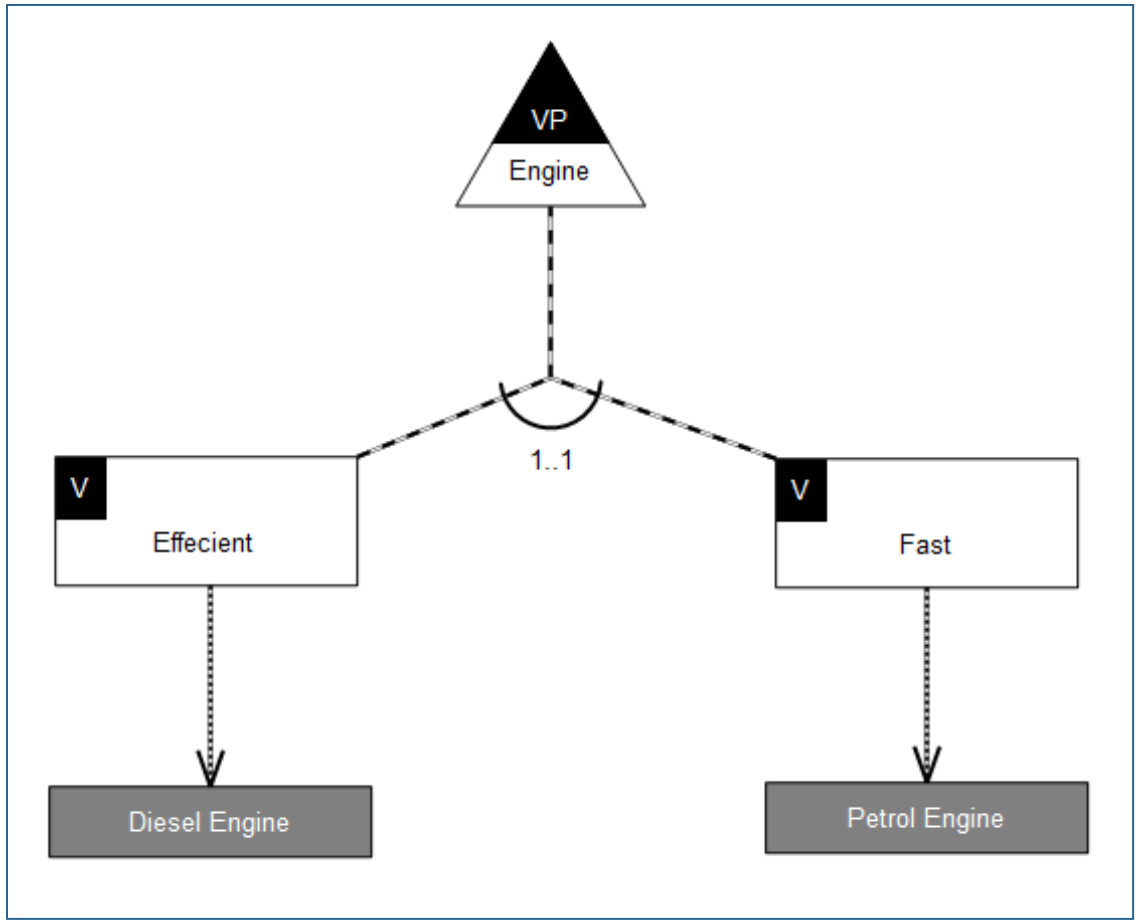


DECISIONS, DECISIONS, DECISIONS

- Decision based modeling
  - Investigate the choices
  - Establish the decision framework
  - Define the corresponding choices
  - Determine the trade-off criteria
  - Generate the product models
  - Analyze the product model(s)
  - Repeat as necessary
- Basically, figure out where you want to go before you start the journey

VARIANT MODELING IN OVM

- Variant Diagram
- Variation on all Diagrams
- Simple Notation
  - Variation Point
  - Variant
  - Variability Dependency
  - Mandatory/Optional
  - Requires Dependency
  - Excludes Dependency
  - Artifact Dependency
  - Alternate Choice



- OVM

PALUNO, The Ruhr Institute of Software Technology
Software Product Line Engineering (Pohl et al - Springer 2005)

THE PROBLEM: CONVERTING A QUARRY TO ELECTRIC

27th annual INCOSE international symposium

Adelaide, Australia

July 15 - 20, 2017

Volvo Construction Equipment

From Empire Strikes Back to Electric Site

An industrial example of using Enterprise Architecture to speed up systems development

Peter Sjöberg
Volvo Construction Equipment

Lars-Olof Kihlström
Syntell AB
Matthew Hause
PTC

www.incose.org/symp2017

ELECTRIC SITE, BACKGROUND

PROJECT GOAL

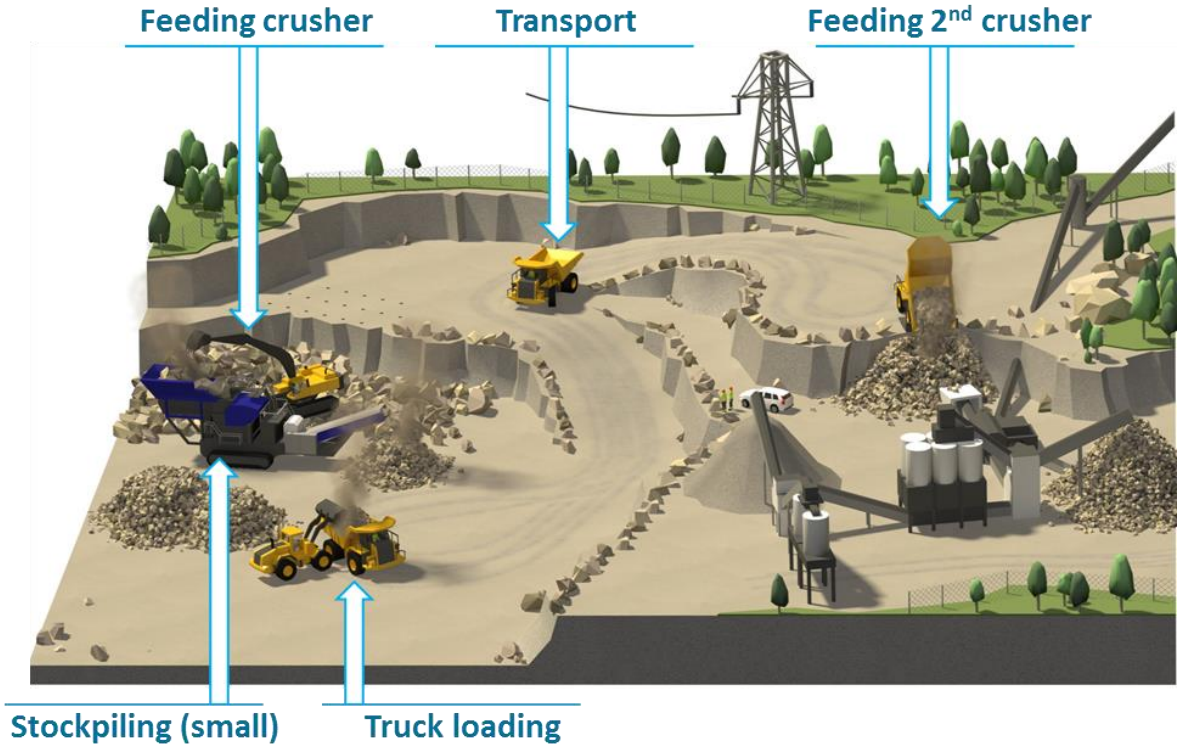
- The aim is to reduce CO_2 95% and the total cost of operation by 25%.
- Possible solutions:
  - Increase efficiency
  - Electrification
  - Hybrid

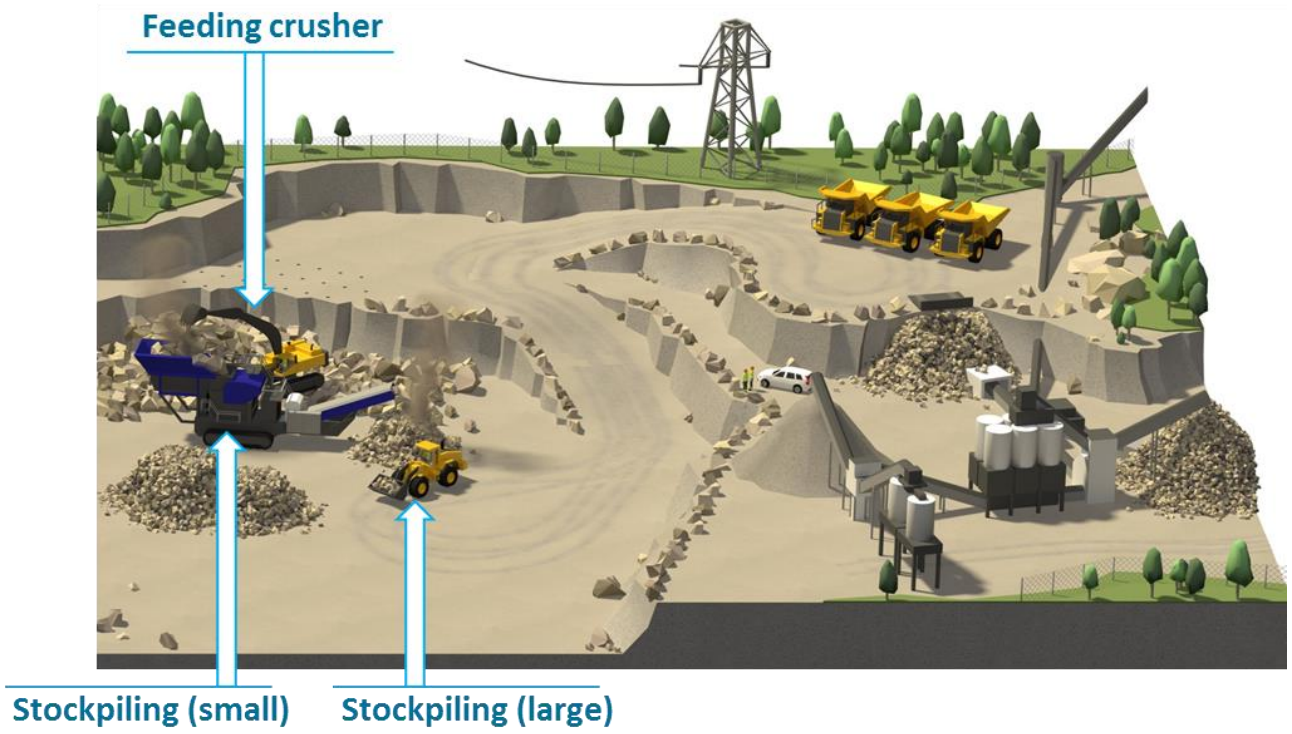
POSSIBLE SOLUTIONS

- Replace diesel engines with electric engines and batteries
  - Requires a battery package of 15 tons for a 50-ton truck.

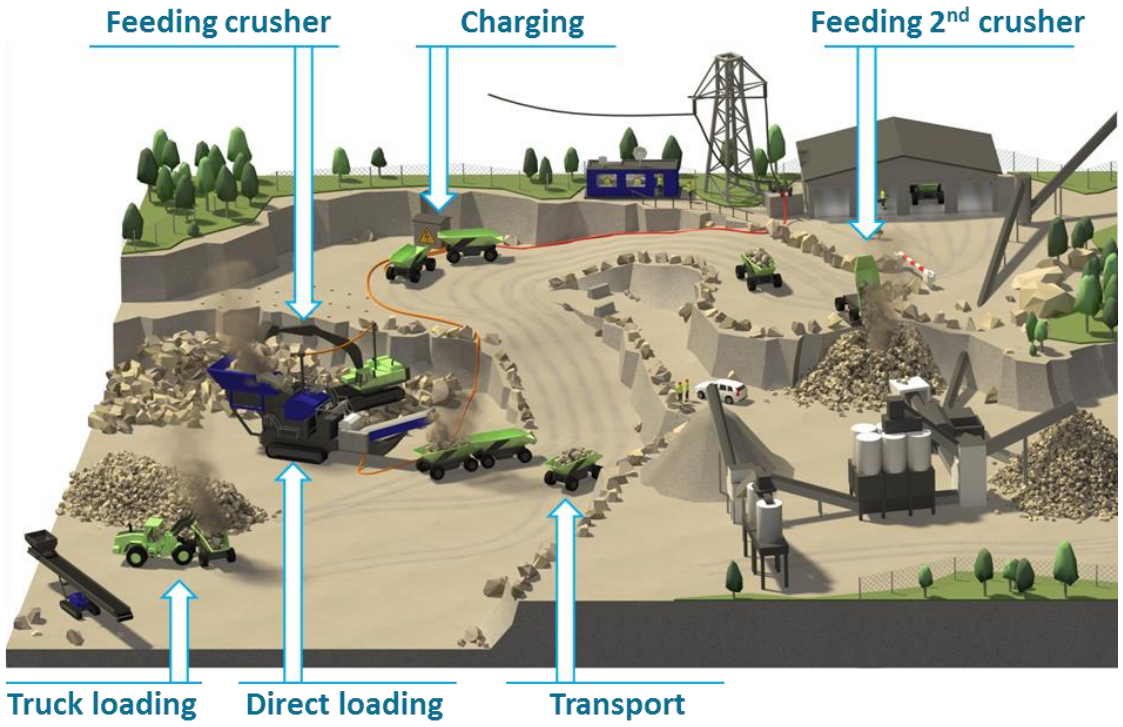
- Make the haulers smaller, (15 tons) and have more machines to reach the productivity target.
  - More suitable given the battery performance of today and regarding the robustness of the total solution. It also scales better.
  - However, going from 2 to approximately 6 machines increases the workforce cost for the operation.
  - Requires the haulers to be autonomous. The need for the wheel loader to be able to perform several different tasks that change from shift to shift will not make a pure autonomous electric solution suitable.

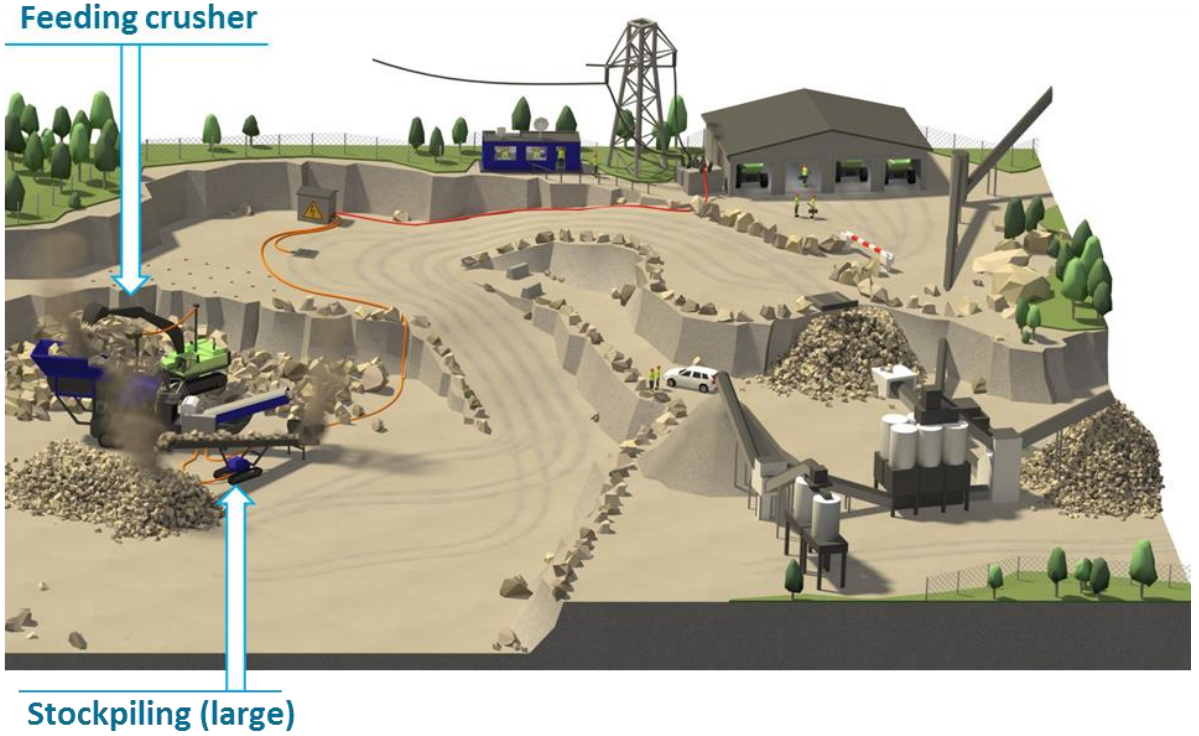
ELECTRIC SITE, TODAY





ELECTRIC SITE, FALL 2018



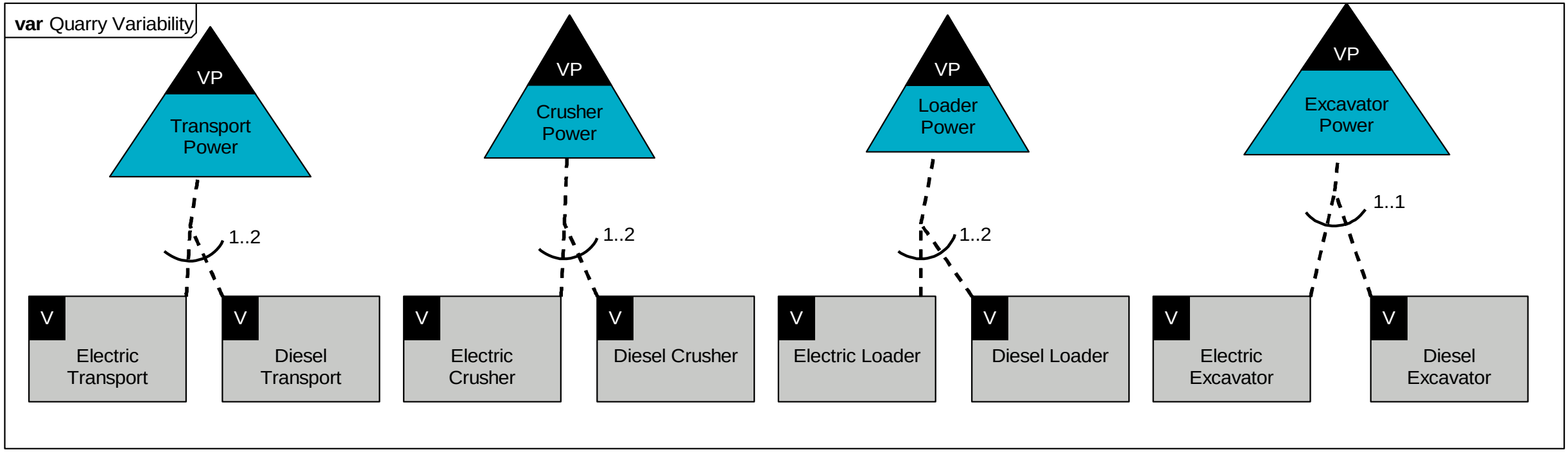


THE MODELING APPROACH

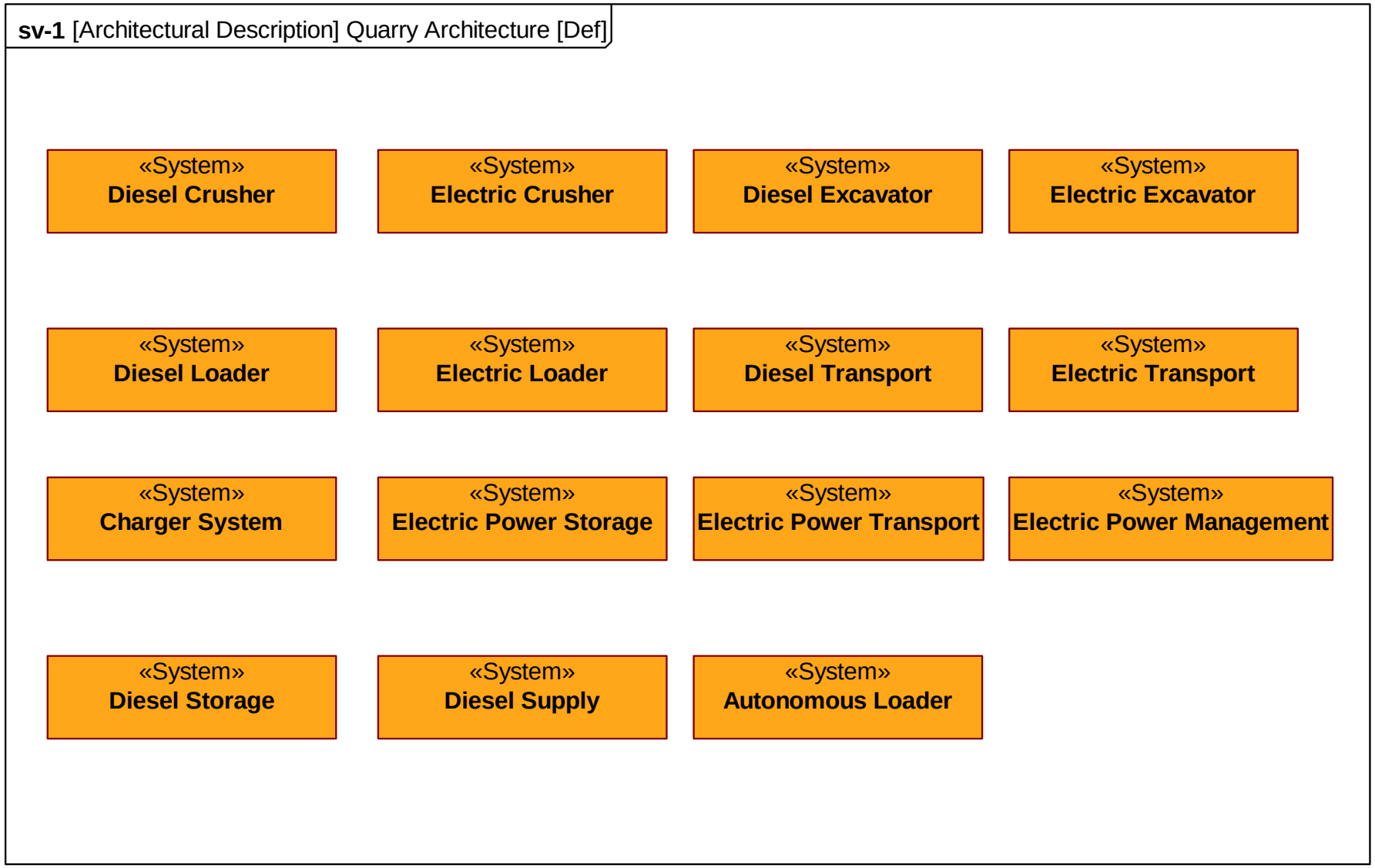
Questions to be Answered, in order to make the model provide the expected benefit

- What is the purpose of the project and the model?
- What are the constraints that need to be considered?
- How should the model be structured?

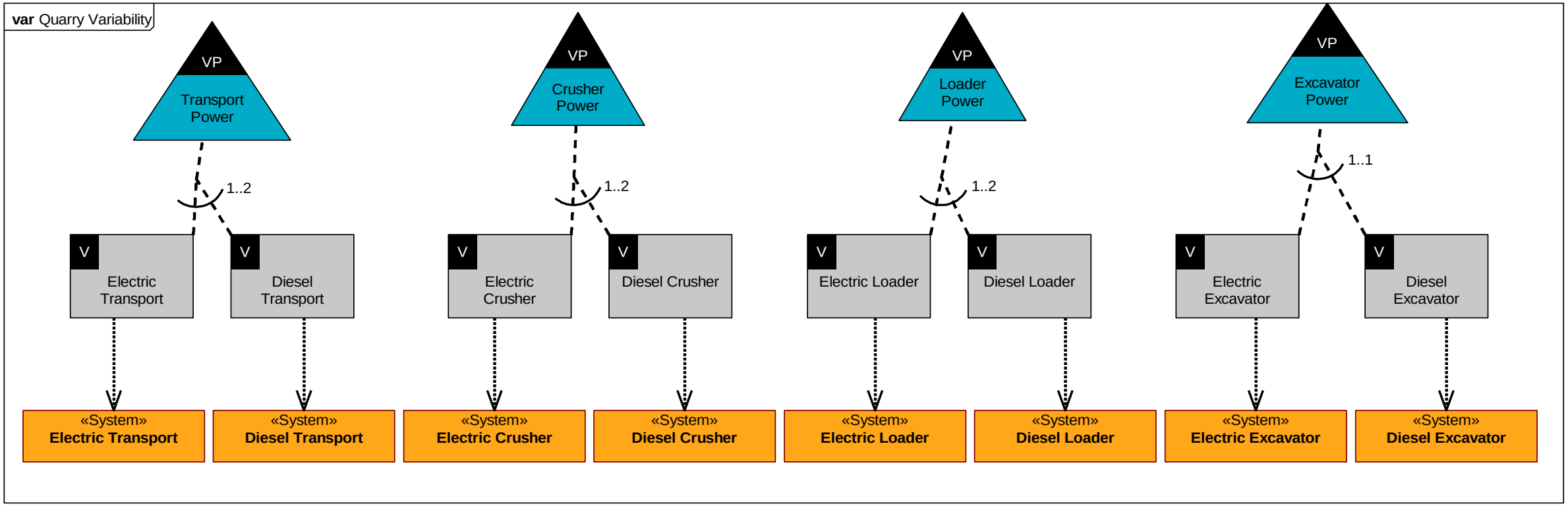
QUARRY TYPES



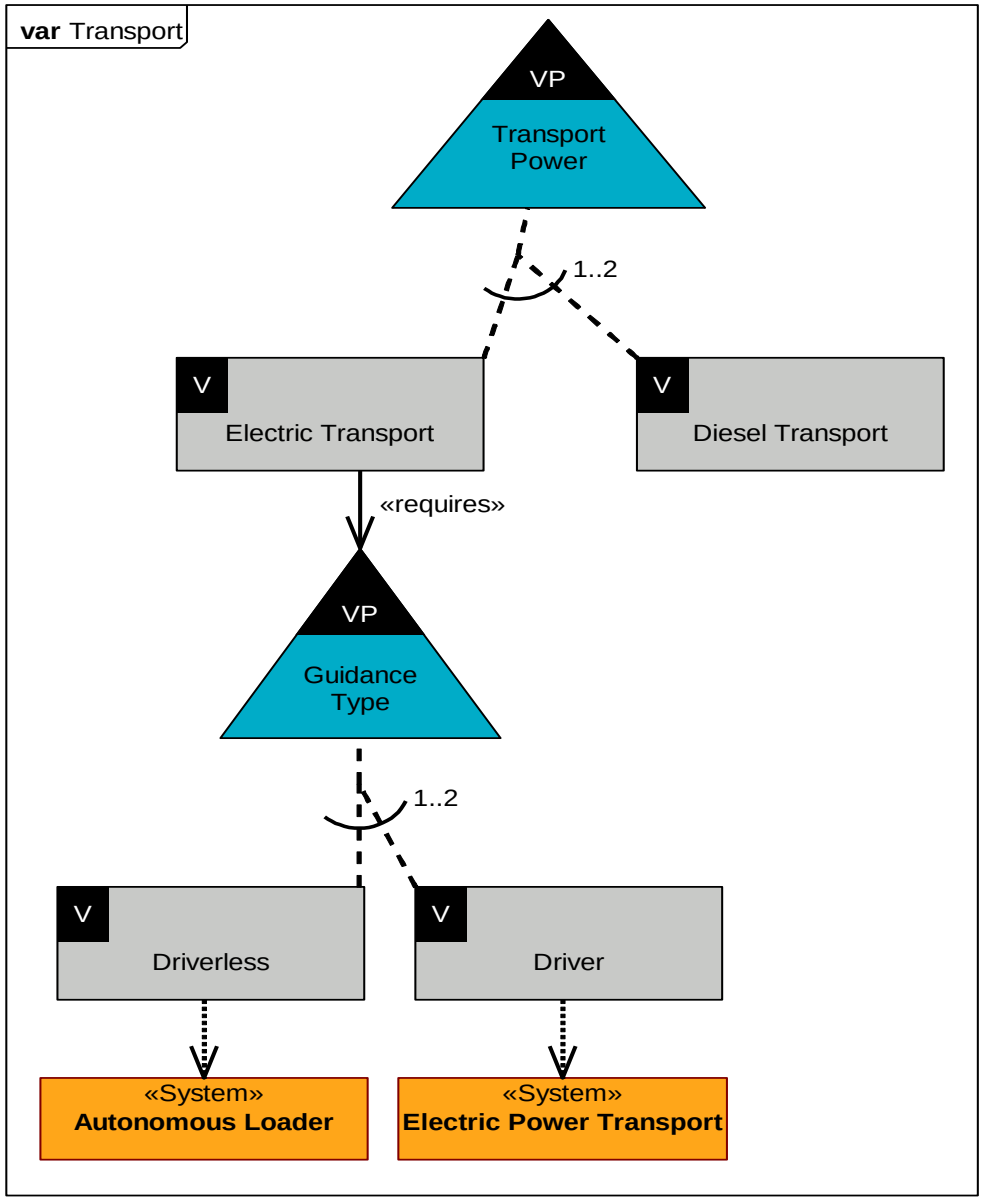
QUARRY SYSTEMS



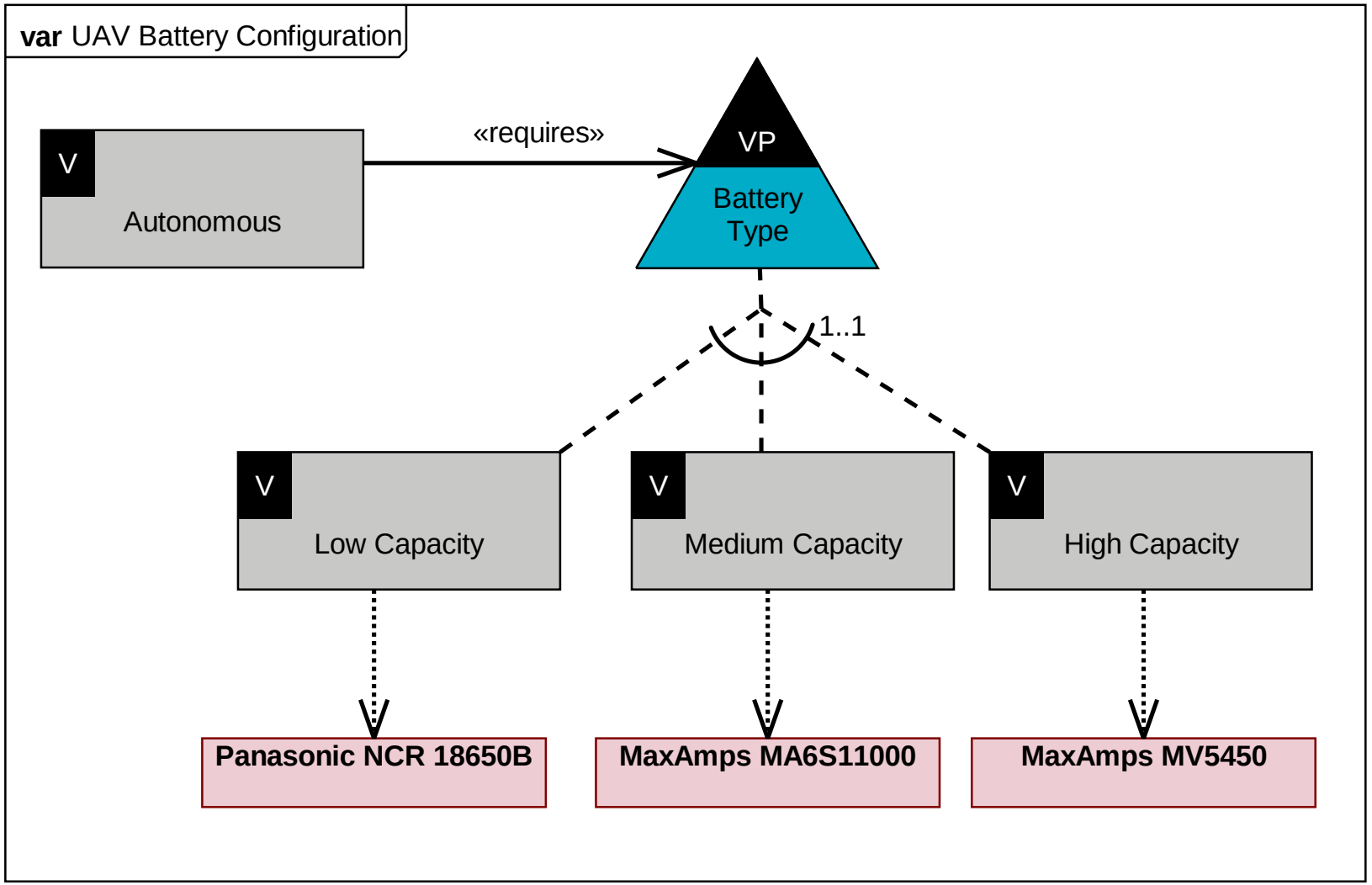
QUARRY TYPES



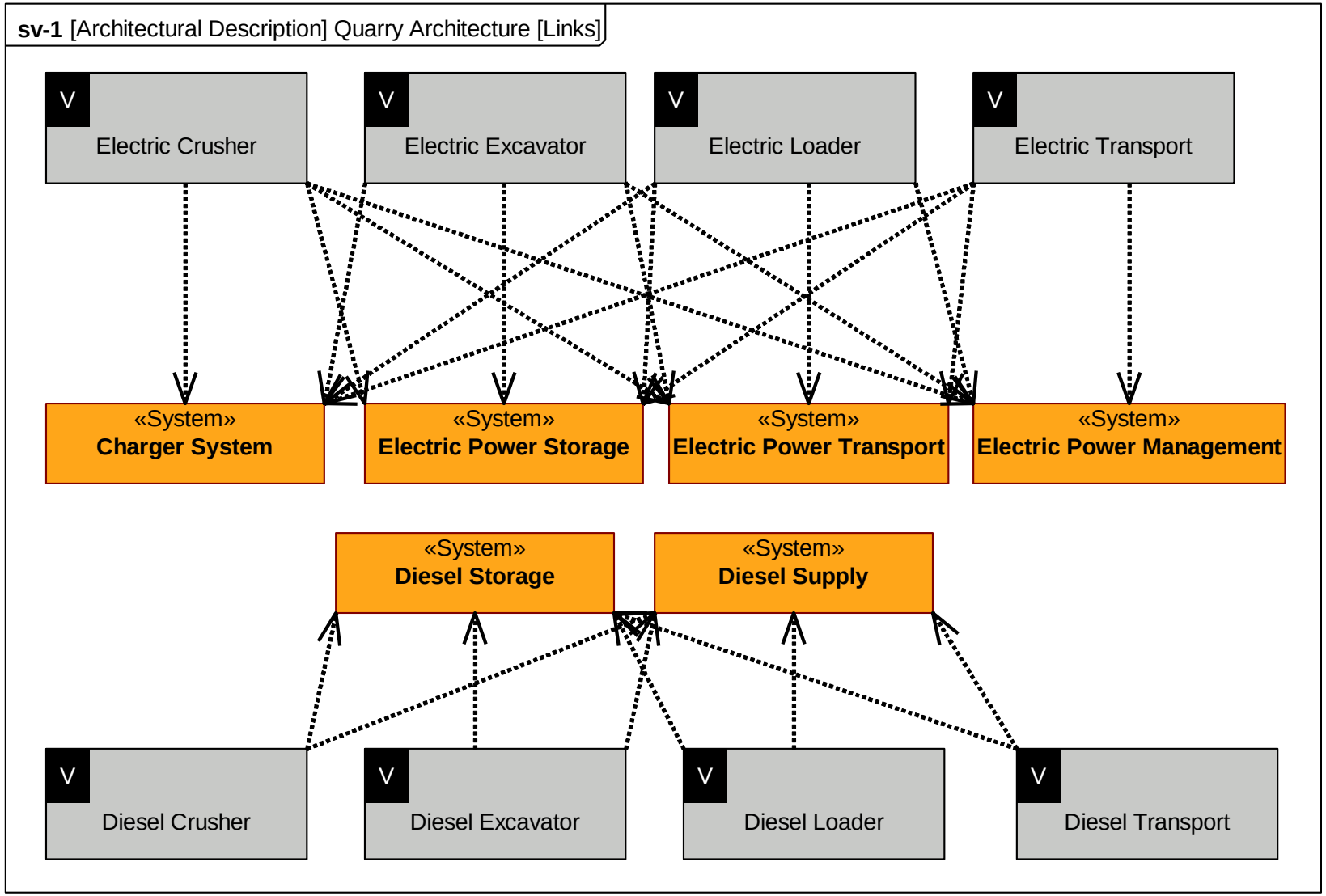
TRANSPORT SYSTEM



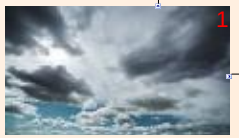
BATTERY SIZE



DEPENDENCIES



«ResourceArtifactRole»
rd : Road



«NaturalResourceRole»
whtr : Weather

«ResourceRole»
mgmnt : SiteManagement

«ResourceArtifactRole»
extComm : ExternalCommunications

«ResourceRole»
wl : WheelLoader

«ResourceRole»
chrg : ChargingStation

«ResourceArtifactRole»
siteComm : SiteCommunicationResource

«ResourceArtifactRole»
infra : SiteElectricityInfrastructure

«ResourceRole»
lgstcs : LogisticsSupport

«ResourceRole»
xa : XA15

«ResourceArtifactRole»
grid : ElectricityGrid

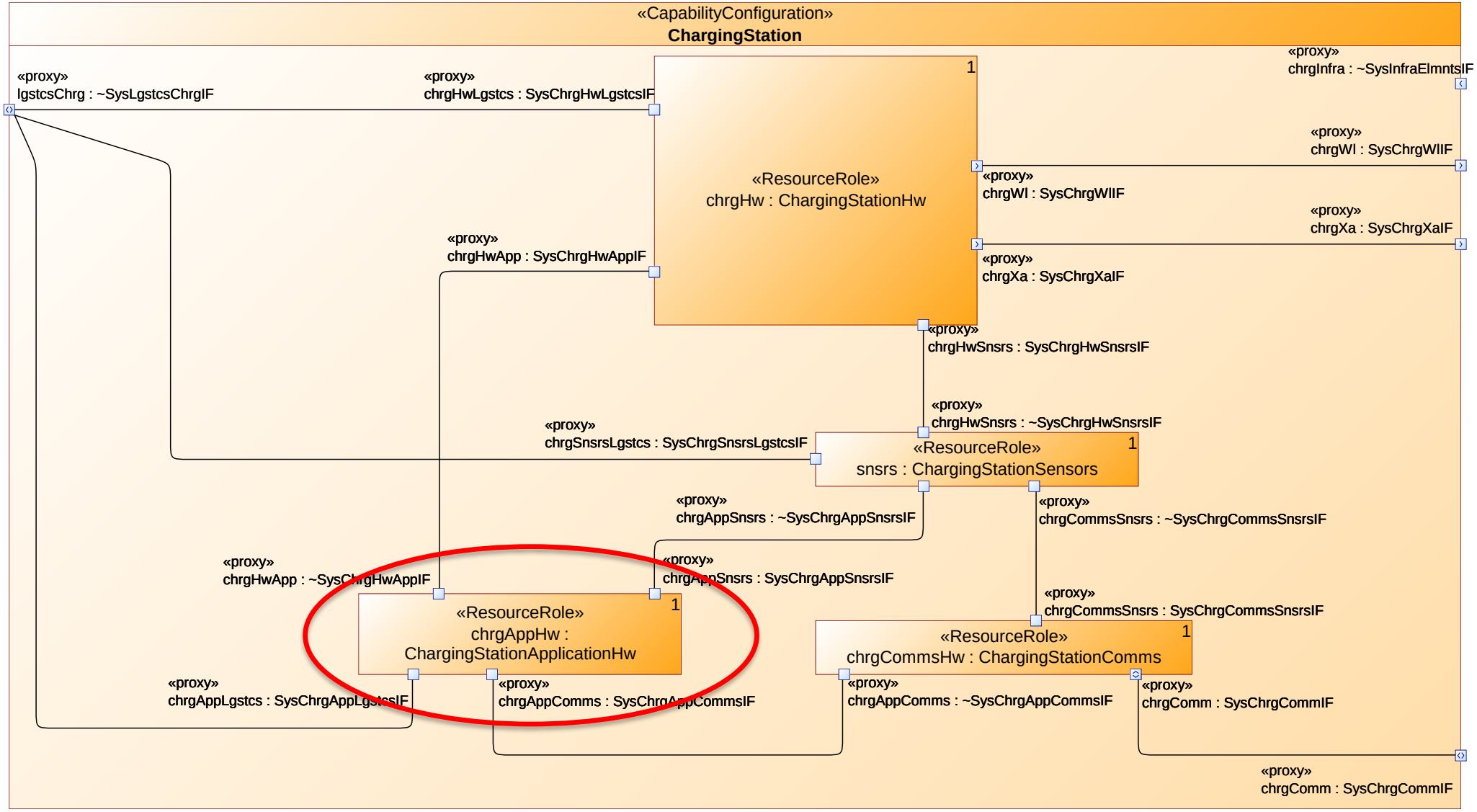
«ResourceRole»
fac : MaterielFacility

«NaturalResourceRole»
facStrg : FacilityStorage

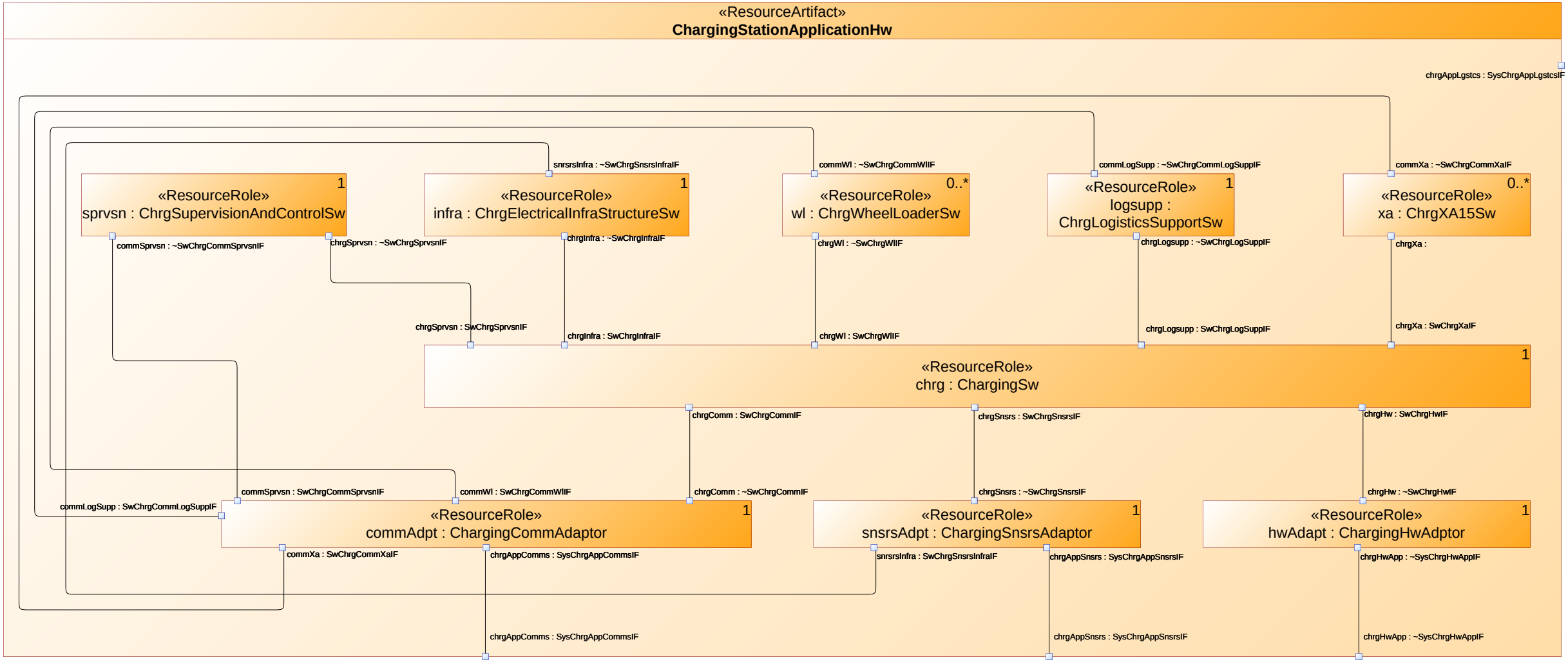
«NaturalResourceRole»
dscrdfac : DiscardMaterielFacility

FROM SITE SOLUTION TO SOFTWARE SOLUTION

CHARGING STATION ARCHITECTURE



CHARGING STATION SOFTWARE ARCHITECTURE

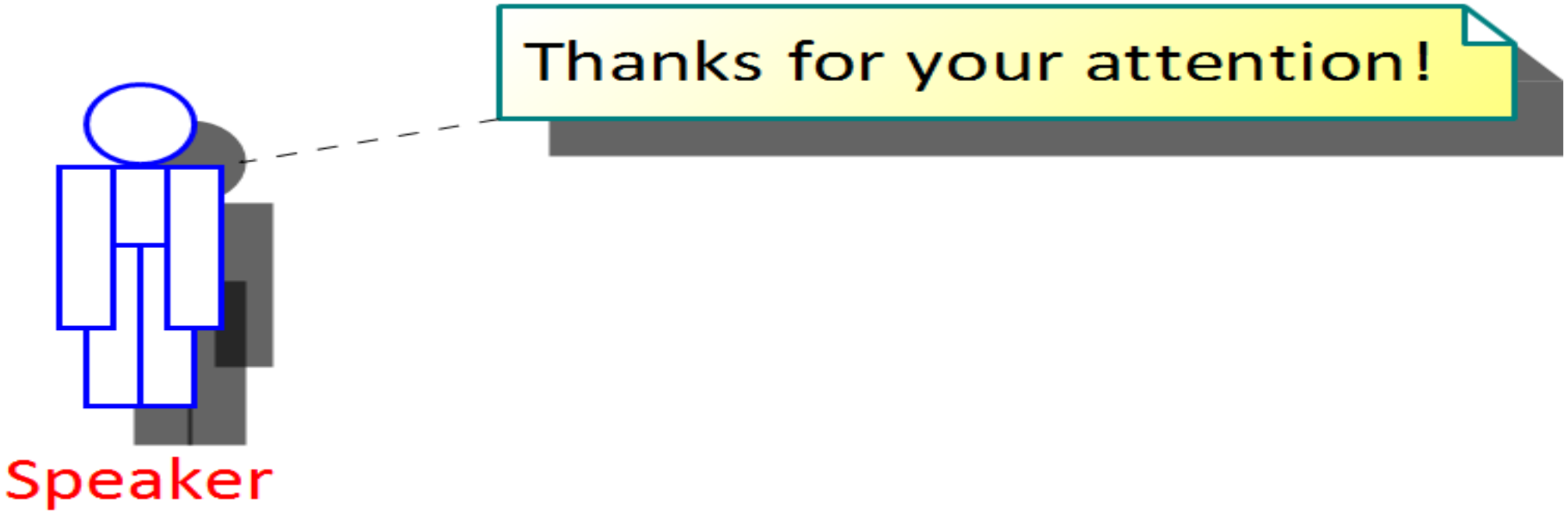


WHAT'S NEXT?

- The initial configuration is complete
- Now trade-off analysis needs to be done
  - Maximum capacity of the quarry
  - Total number of transporters
  - Total time between charges
  - Total cost of operations
  - Efficiency gained
  - CO2 Emissions
  - Etc.

https://www.youtube.com/watch?v=FRh2QZaVwoQ&t=22s

QUESTIONS AND ANSWERS



THE DIGITAL ENGINEERING JOURNEY

Thank you for attending!

Share your experiences at #HWGSEC