SAVOIR EDS: A Digital Capability for Avionics Architecture Co-Design

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** IRT Saint Exypery (System Engineering and Modelling) seconded from ADS*

DEFENCE AND SPACE

Context

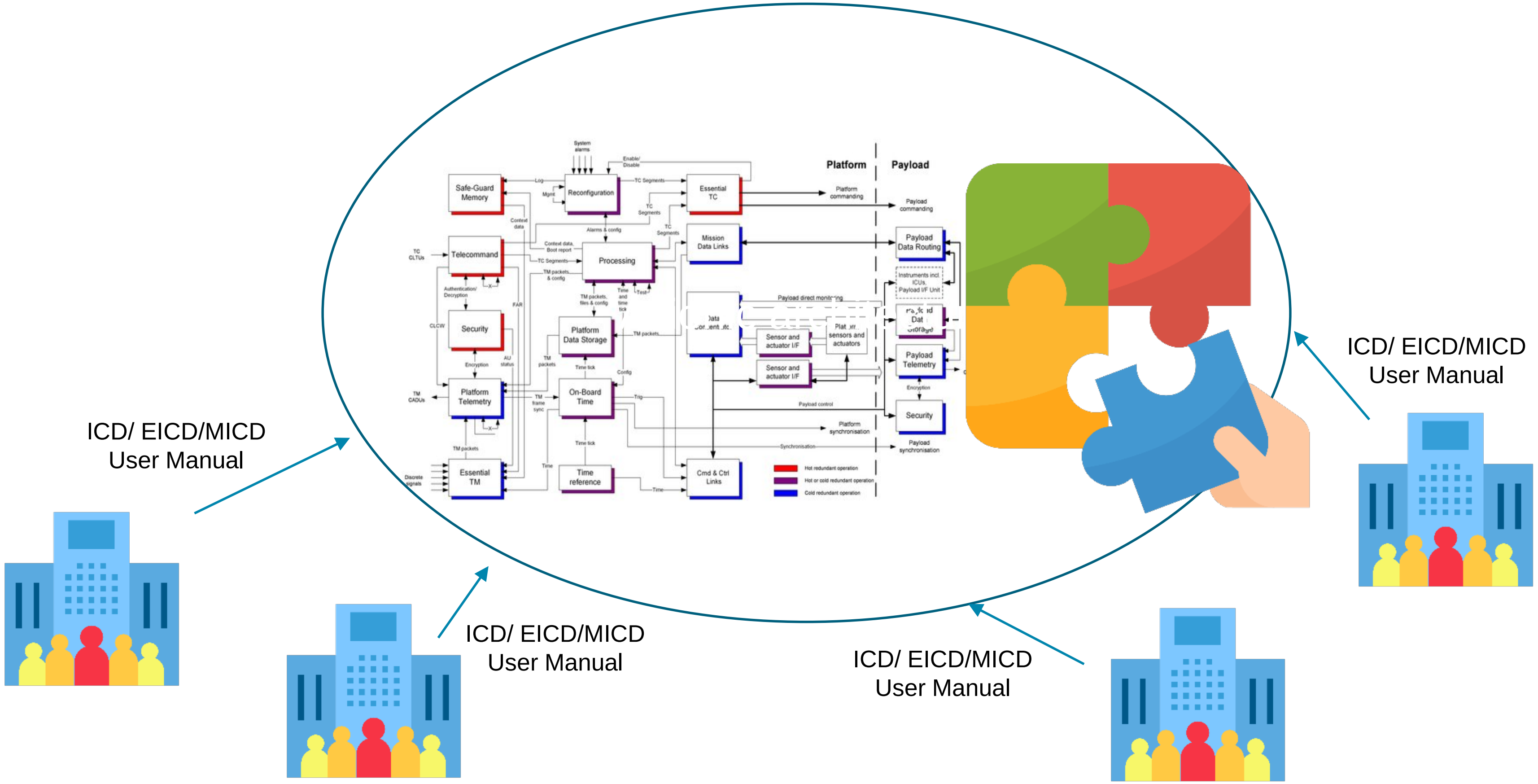
Design satellite avionics architecture based on supplier data in an extended enterprise

Problems to solve :

- ❑ Diversity of device types
- ❑ Lack of standard, disparity in exchange formats and file types
- ❑ Documents interpretation by manual transformation
- ❑ Fidelity level of data for the different phase of the process

Objectives :

- ❑ Needs assessment
- ❑ Make the link between the needs and the different phases of the process with associated level of fidelity- specified estimated, measured
- ❑ Develop a domain model
- ❑ Experiment



Needs

User story is proposed in a formal description.
Each sentence introduce the need with identification
- ❑ the user
- ❑ the reason of the need.

Associated information to each need are proposed to help elaborating the domain model

As electrical architect, I want signal and functional connexion so that I prepare electrical architecture/interconnection (reliability, redundancy, FDIR, compatibility) to elaborate the link list for harness design connection.	For each signal: Identifier, Driver/receiver (direction)., Type. Signal type properties metamodel shall contain: Transfer type, Operational range, Acquisition rate, Failure emission range, Voltage tolerance, Current., Rise/fall, Timing constraints, EMC class, Number of contact / signal type, Cross strapping (multi driver / receive)., Capability of the signal type.
As functional avionics architect , I want digital raw data (device acquisitions/commands) so that I design function avionics architecture (AOCS, FDIR, SW, simulation, etc.).	Device Acquisitions / Commands: Name, Description, Length., Digital raw data format (integer, float, enum, char, string), Engineering data format, Calibration description / transfert function per format (bit value, LSB, enum, etc.), Engineering data default value, Engineering data, Refresh period.
As DHS architect, I want transfer digital raw data so that I enable functional avionics architecture and configure I/O modules.	For each bus: Protocol definition (addressing, framing (message), dynamics). For each signal: Message identifier, Offset.
As mechanical architect, I want the physical layout, mounting details, mass information and mechanical constraints of the device so that I can accomodate the device in the overall spacecraft design.	Reference to a STEP (AP214) file for physical data. Additional drawing (for acceptance by engineers) . The coordinate system and point of reference must be identical in STEP and additional data. Various additional parameter that are not covered by STEP including : Mass and dimensions with accuracy, Material of structure, Center of gravity, Moment of inertia, Mounting surface requirements (area, roughness, coating), Mounting hole pattern, Mounting hardware, location and torques. Device constraints may concern vibrations, for example.
As thermal architect, I want the device's thermal device characteristics so that I can analyse ist contribution to the thermal spacecraft design and specify the thermal control system.	Thermal data with reference to the physical layout as applicable: Solar absorption., Thermal emission/dissipation, Thermal contact conductivity, Thermal capacity, Heat flow.(parameter may depend on the mode of operation)
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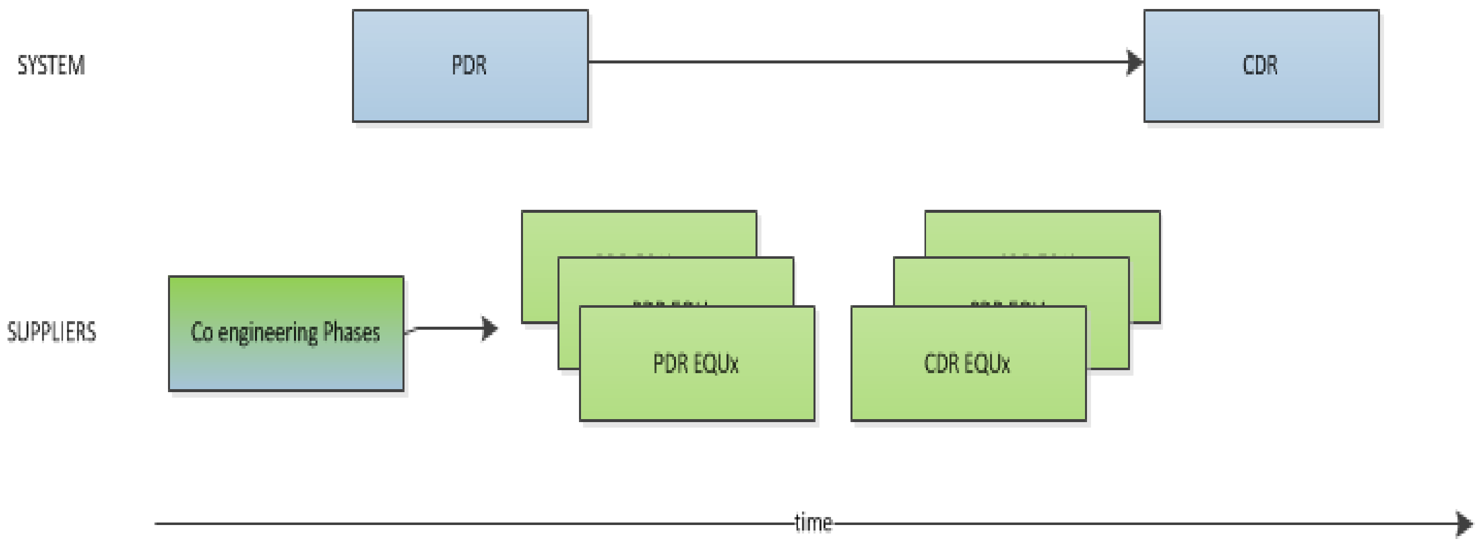
Process in extended enterprise

The space project management process is described in the ECSS-M-ST-10C.
Lifecycle of space project is composed of different phases:

- ❑Phase 0 Mission analysis/needs identification
- ❑Phase A - Feasibility
- ❑Phase B - Preliminary Definition
- ❑Phase C - Detailed Definition
- ❑Phase D - Qualification and Production
- ❑Phase E –Utilization
- ❑Phase F – Disposal

From a supplier point of view



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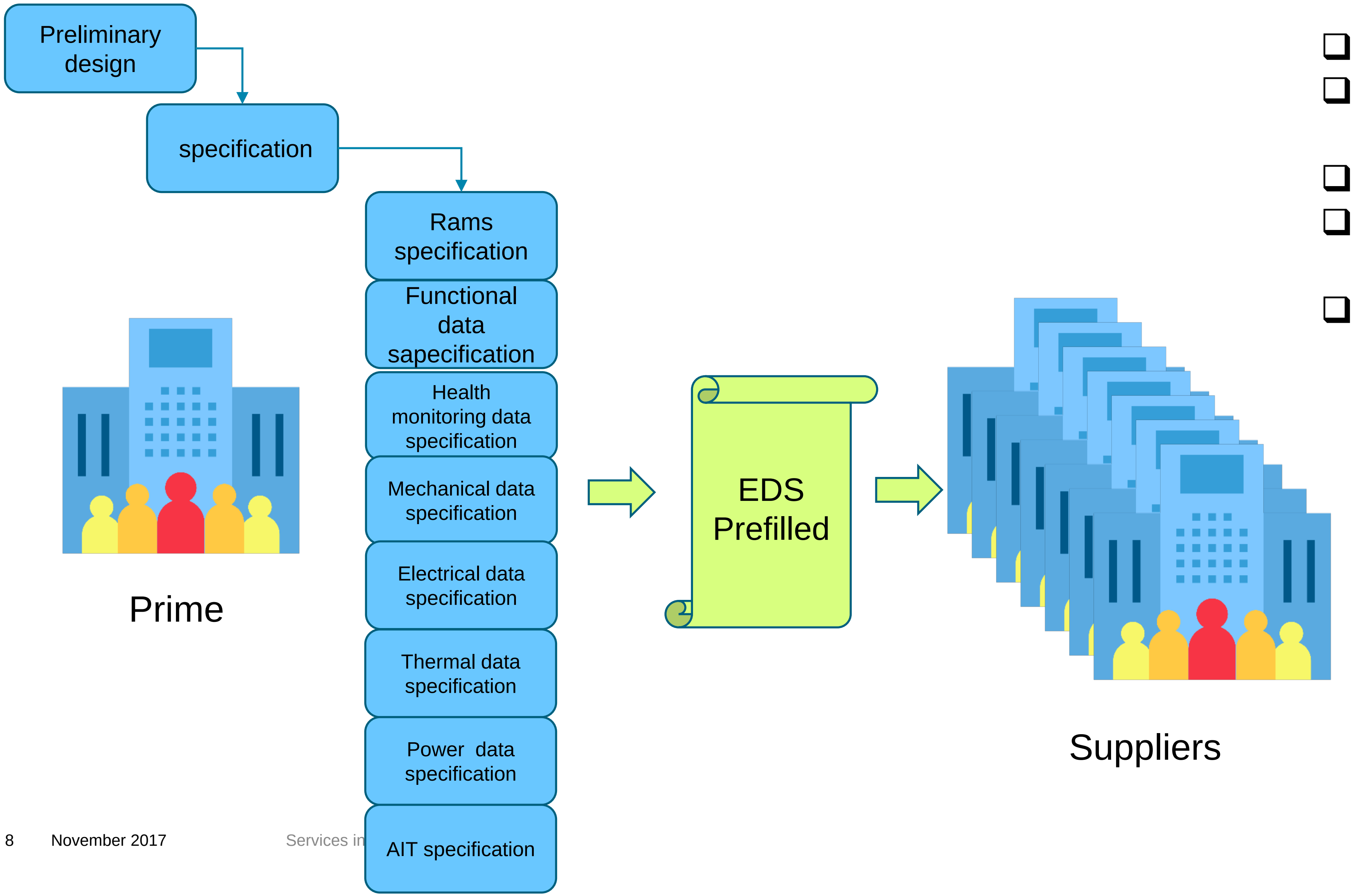
First step : EDS is prefilled with specification needs



- ❑ Control, command, acquisition, parameters
- ❑ Dimensions constraints
- ❑ Power consumption constraints
- ❑ Thermal constraints
- ❑ Interface, multi receiver/ transmitter capability
- ❑ Test interface

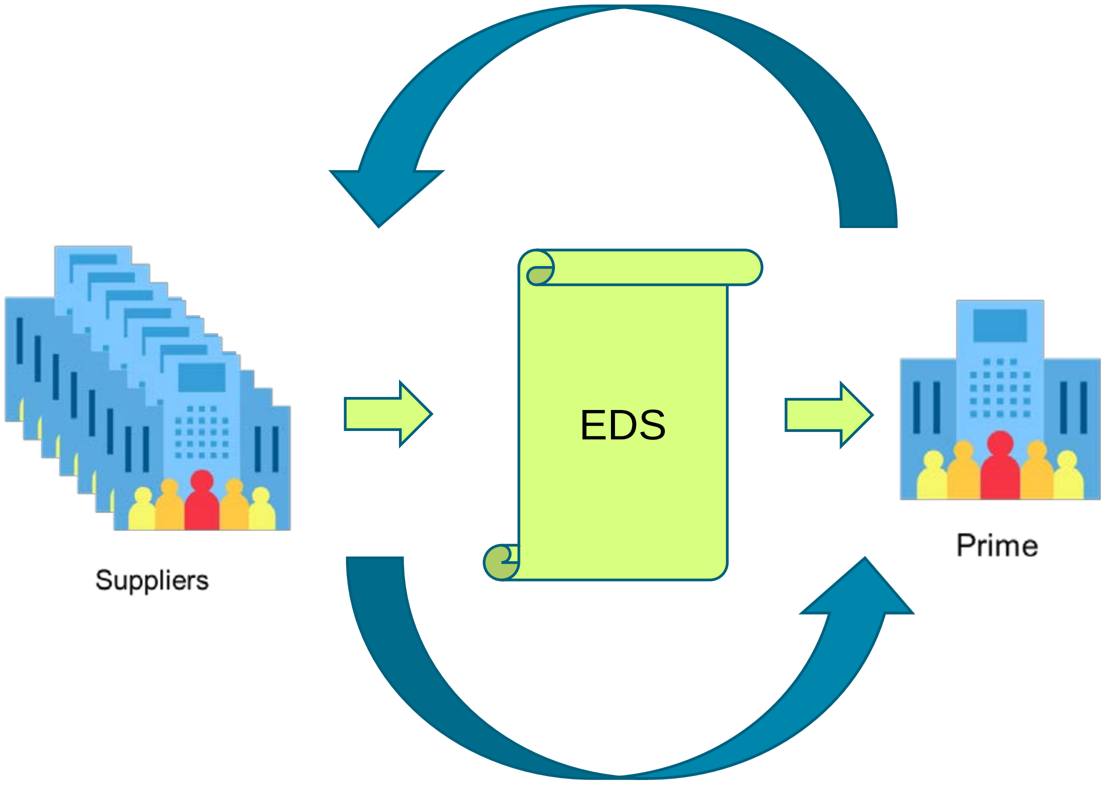
Depending of the type of device, select the classes of the model for the specifed device

Next step : EDS is completed with estimated values for the first feasibility analysis

Fidelity level : Specified by supplier with margins

Data

- Device model data (module and cross strapping)
- Functional data (identification, length estimation for buses load, refresh period)
- Health monitoring data
- Device modes
- Electrical interface
- Estimated power consumption
- power interface and on/off interfaces
- thermal estimation for dissipation,
- Geometrical data, mass
- Synchronisation interface



Analyse, simulation, optimisation

Analyse, simulation, optimisation from value specified by supplier on :

- Accommodation constraints
- DHS Sizing and communication architecture
- Thermal with a first estimation of heater and thermistors lines
- Electrical system interconnexion
- Power topology => control power architecture

First accommodation
=> Detect inconsistencies or issues to be solved before going next step in the design
:

AIRBUS

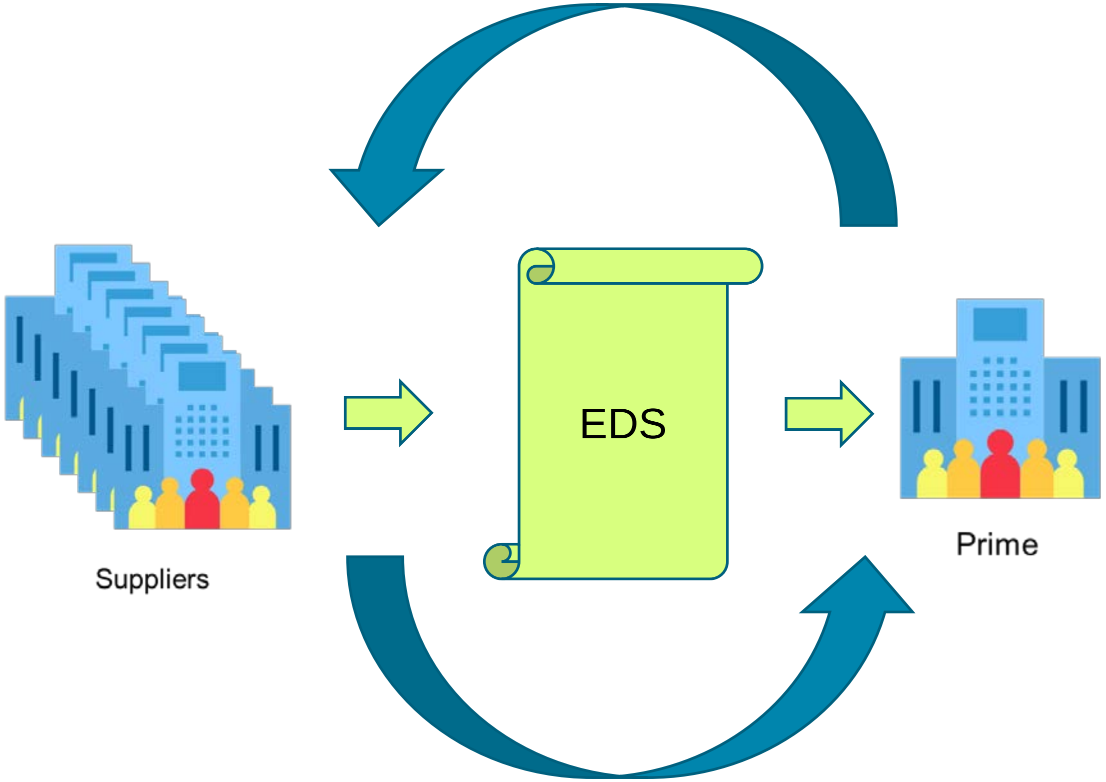
Next step : EDS is completed or level of fidelity increase

New Data

Fidelity level : Specified by supplier with margins

Design

- Electrical interface details: fix the allocation of these interfaces on a number of connectors
- Tests needs



- Design
- Electrical => harness

+ Consolidated Data

Fidelity level : designed by supplier or measured

Design

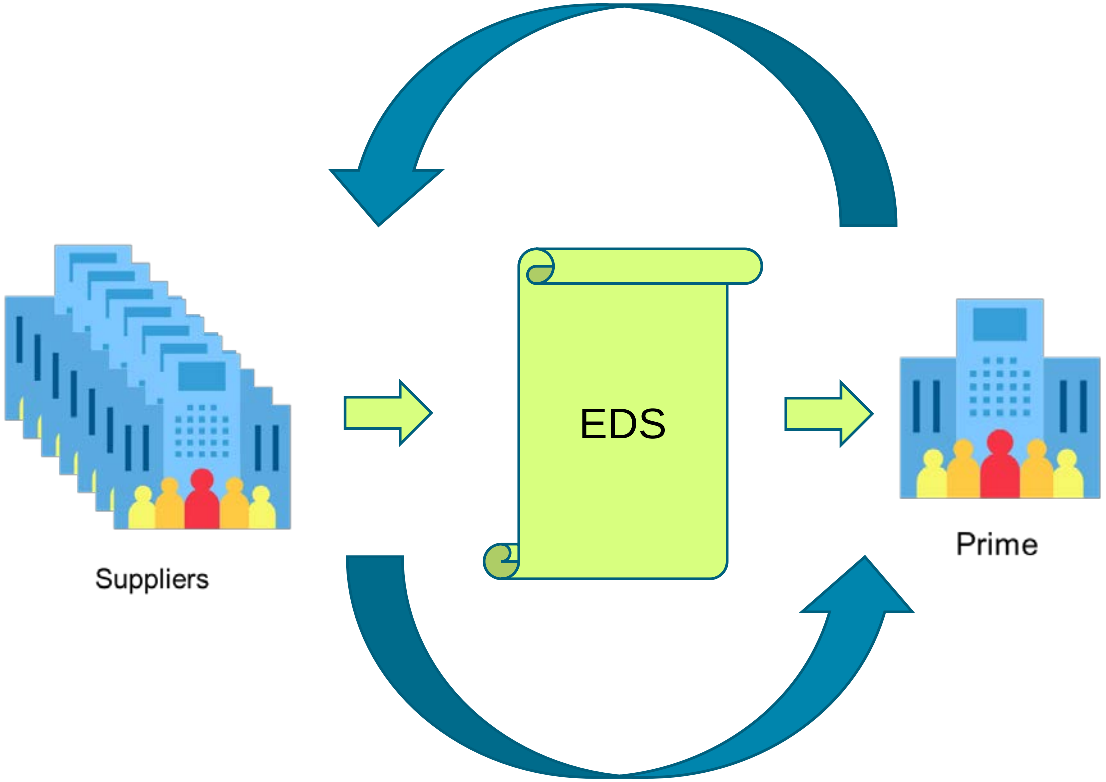
Next step : EDS is completed or level of fidelity increase

New Data

Fidelity level : Specified by supplier with margins

Design

- ❑ Functional data description
- ❑ Mechanical data (layout, size, tolerance..), SEU tolerance
- ❑ Thermal data (dissipation, heat fluxes)



- ❑ Functional , operational, AOCS
- ❑ Mechanical
- ❑ Thermal

+ Consolidated Data

Fidelity level : Designed by supplier or measured

Design

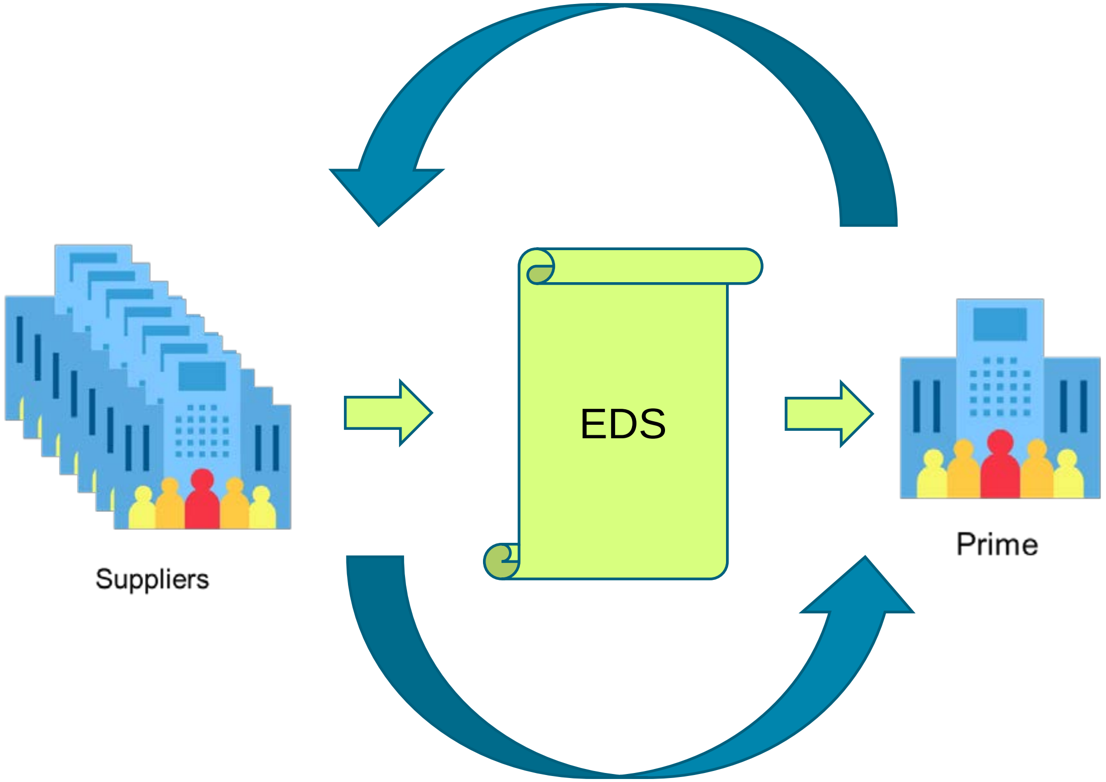
Next step : EDS is completed or level of fidelity increase

New Data

Fidelity level : Specified by supplier with margins

Design

- ❑ Functional protocol
- ❑ Detailed electrical interface, magnetic cleanliness



- ❑ Functional , operational, AOCS
- ❑ Electrical

+ Consolidated Data

Fidelity level : designed by supplier or measured

Design

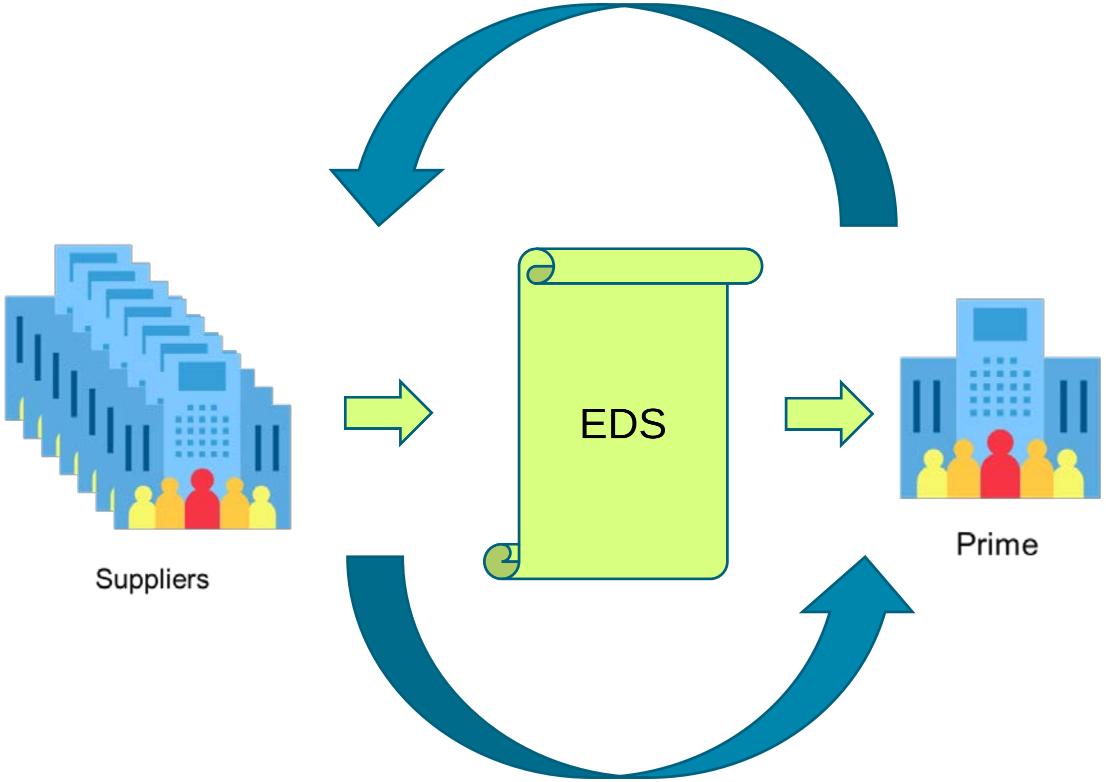
Next step : EDS is completed or level of fidelity increase

New Data

Fidelity level : Specified by supplier with margins

Design

- Calibration, modes and dynamics, reboot duration, in flight SW or calibration upgrade



- Functional , operational, AOCS
- DHS, SW, Simulation

+ Consolidated Data

Fidelity level : designed by supplier or measured

Design

Why a domain model ?

- ❑ Domain Model is a **formalization of the user needs (engineering know-how)**

- ❑ Domain Model captures equipment's information to be digitalized for co-engineering between prime and suppliers in the various system engineering disciplines (Thermal, Electrical, Mechanical, Functional, Power…)

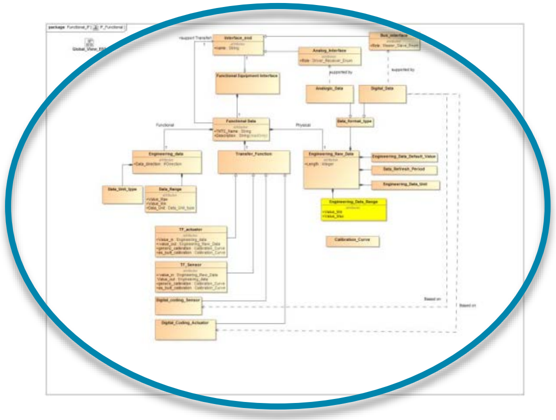
  - ✓ Cornerstone to foster digitalization of system engineering activities at prime level

- ❑ Domain Model is an input for concrete electronic exchange format definition

User Needs

What are the needs of the different engineering disciplines involved in the system design ?

Domain Model



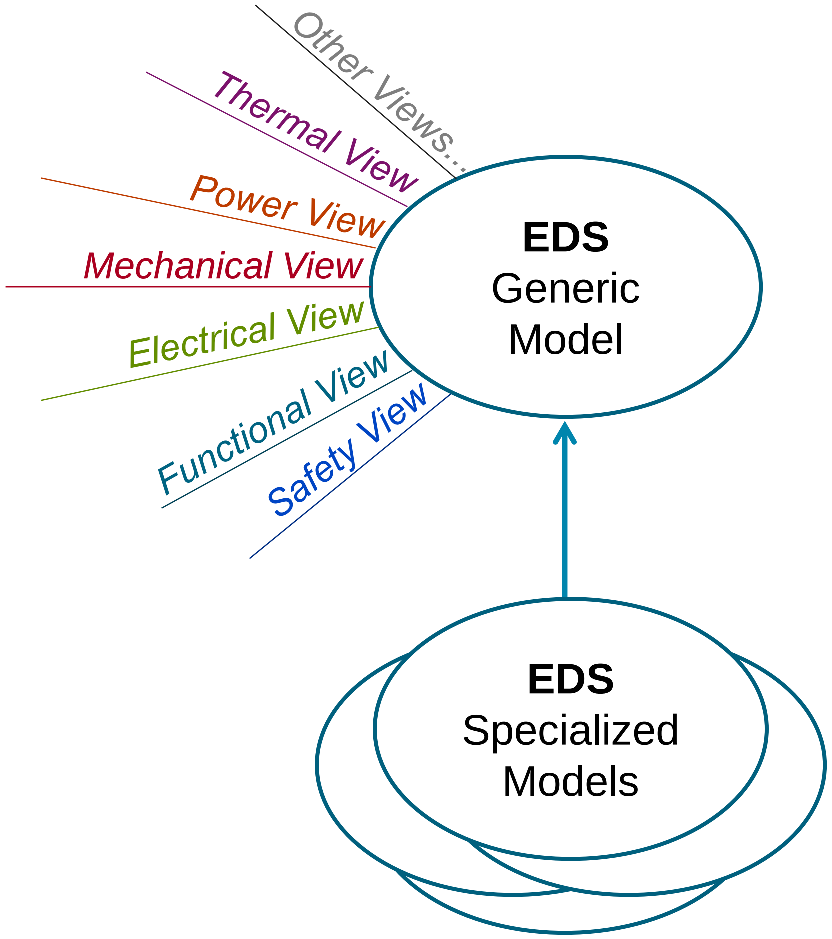
Capture information to digitalized for co-engineering between primes and equipment suppliers

Electronic Format

```
<?xml version="1.0" encoding="utf-8"?>
<xs:schema attributeFormDefault="unqualified" elementFormDefault="quali
  xmlns:xs="http://www.w3.org/2001/XMLSchema">
  <xs:element name="points">
    <xs:complexType>
      <xs:sequence>
        <xs:element maxOccurs="unbounded" name="point">
          <xs:complexType>
            <xs:attribute name="x" type="xs:unsignedShort" use="required
            <xs:attribute name="y" type="xs:unsignedShort" use="required
          </xs:complexType>
        </xs:element>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
</xs:schema>
```

Concrete implementation of the Domain Model - Electronic exchange format for equipment electronic Datasheet

EDS Domain Model Structure



Information to be captured for all equipment's

For specific equipment, specific information are added.

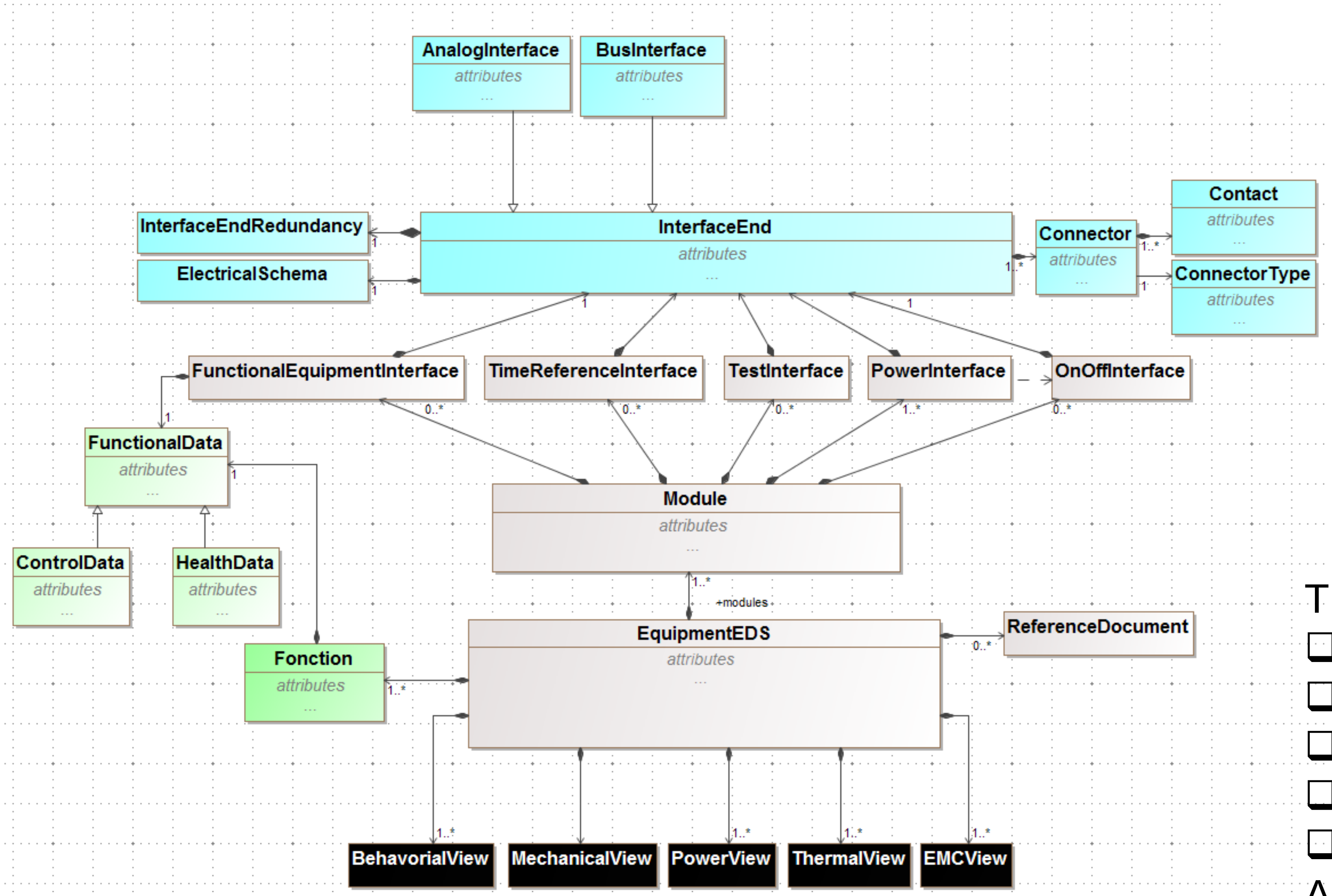
Two types of models

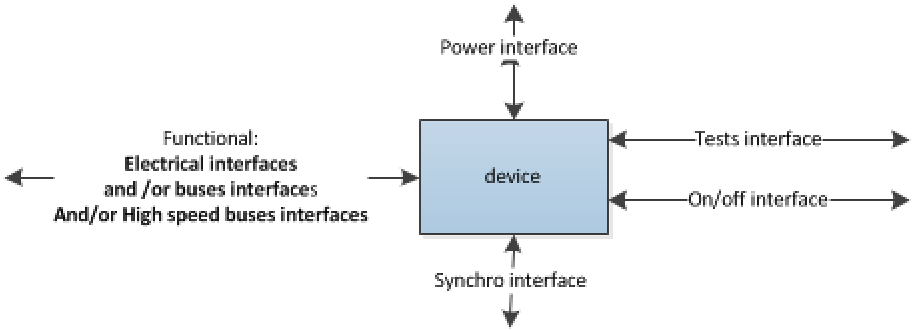
- ❑ A generic model that describes the views
- ❑ A specific model related to the performance properties of the equipment for its mission
  - ❑ number of cells of a solar panel
  - ❑ field of view, sun exclusion angle, acquisition time, false quaternion, modes for a Star Tracker
  - ❑ Max momentum, max speed, ripple torque for a Reaction wheel
  - ❑ Amplifier, output frequency, radio frequency modulation, central frequency for an RF device

Two types of devices

- ❑ Sensor/ actuator and computers with functional data
- ❑ Systems such as Remote Interface Unit and power unit and mass memories working as router of the data

EDS Generic Domain Model : Overview





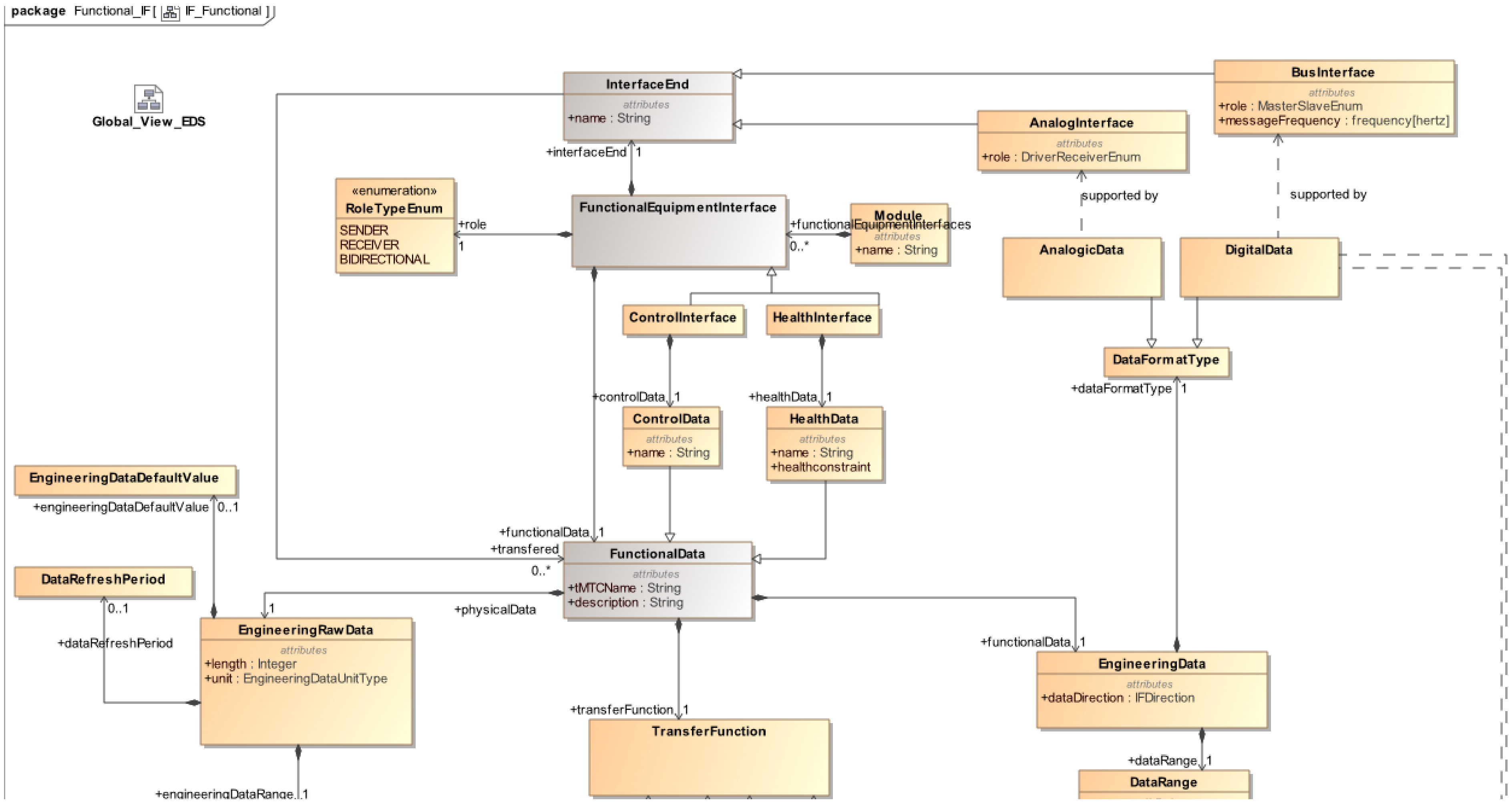
For each device there is at least:
- ❑ A power interface
- ❑ A functional interface

To which are added depending on the case:
- ❑ Synchronization interface,
- ❑ Test interface
- ❑ Relay interfaces for power supply.

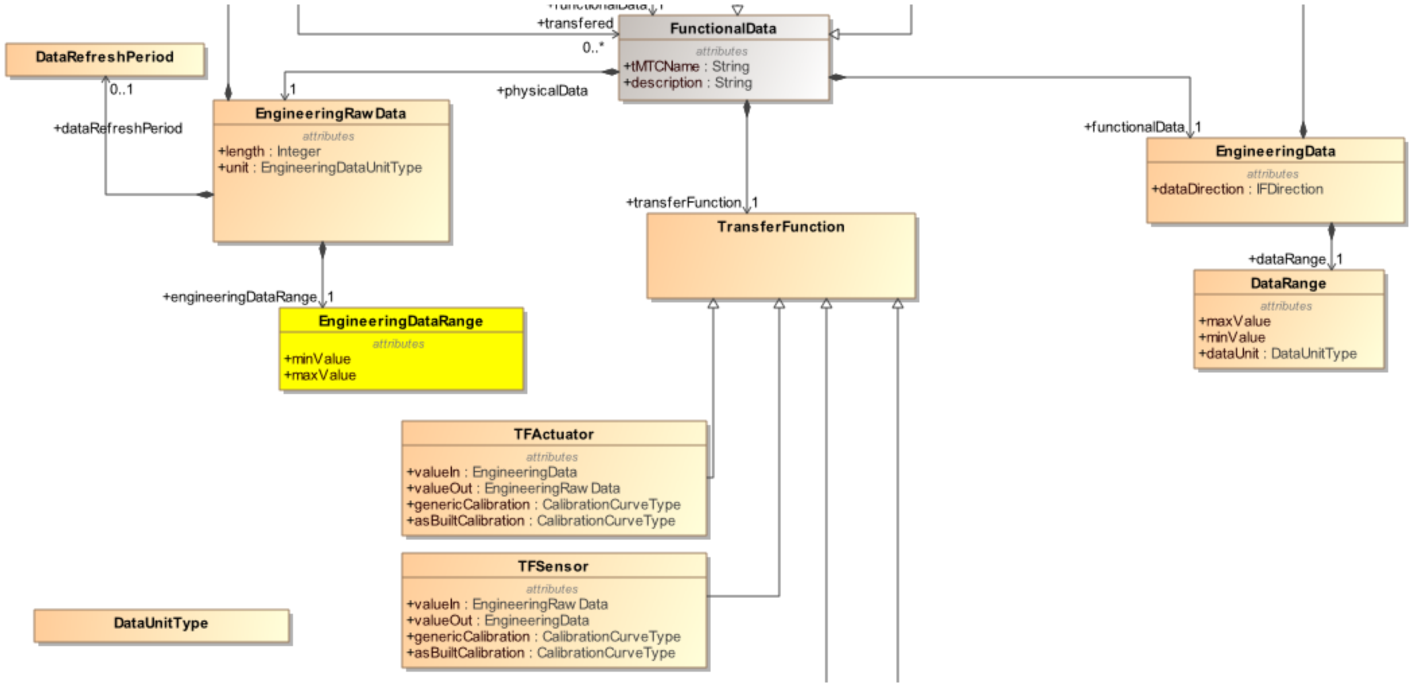
There is also a need to allow
- ❑ Power consumption
- ❑ Accommodation
- ❑ Thermal,
- ❑ Electrical
- ❑ Behavioral

Analyses, simulation, optimization for tradeoff

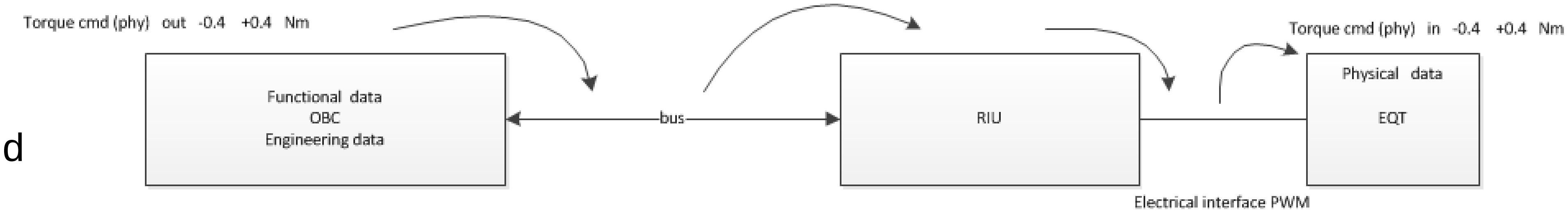
EDS Generic Domain Model : Overview Zoom in functional view



AIRBUS



RW Torque cmd



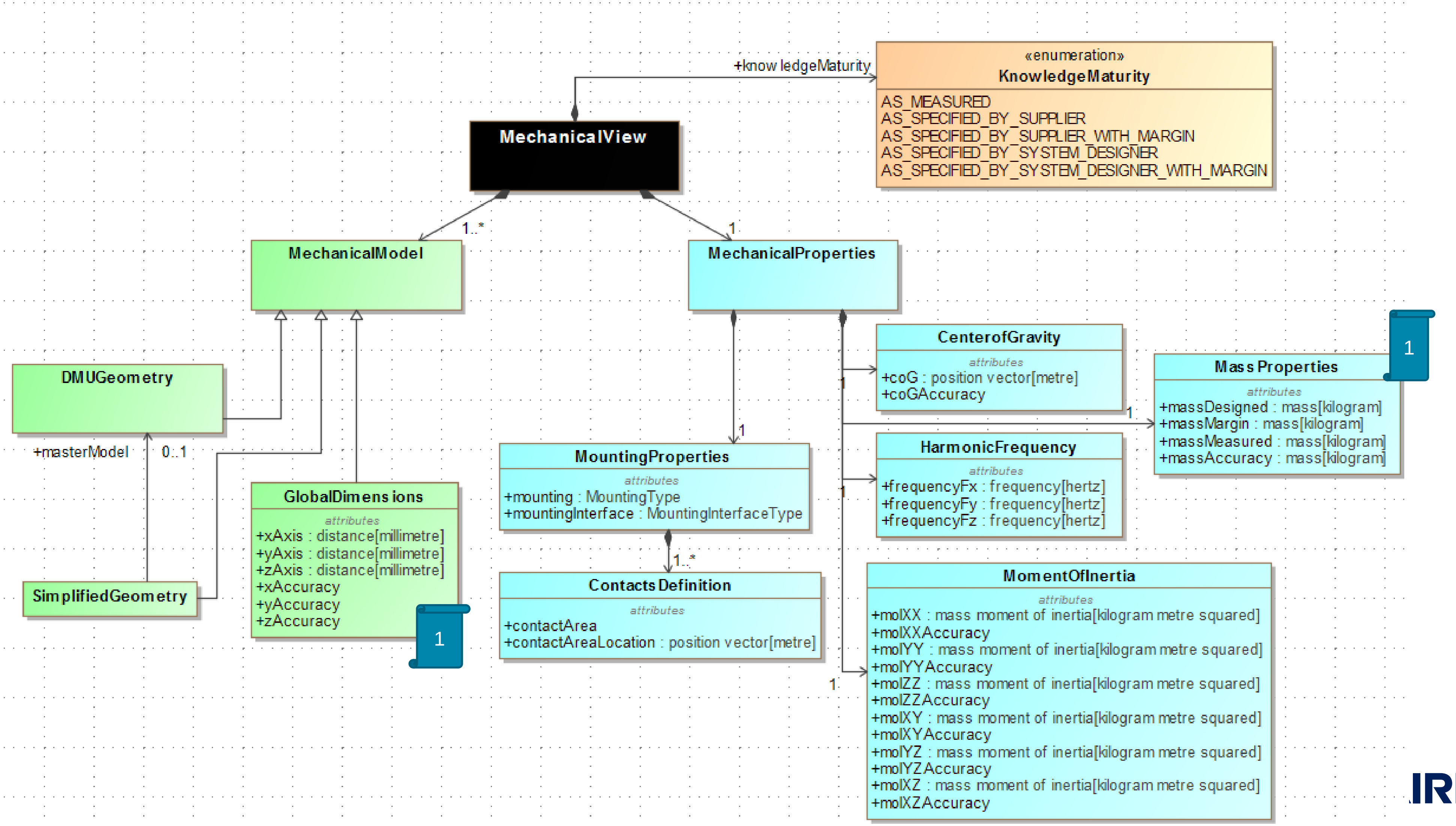
Sub-address: SA 24 R ***Data Words:*** 5

Data Word Contents:

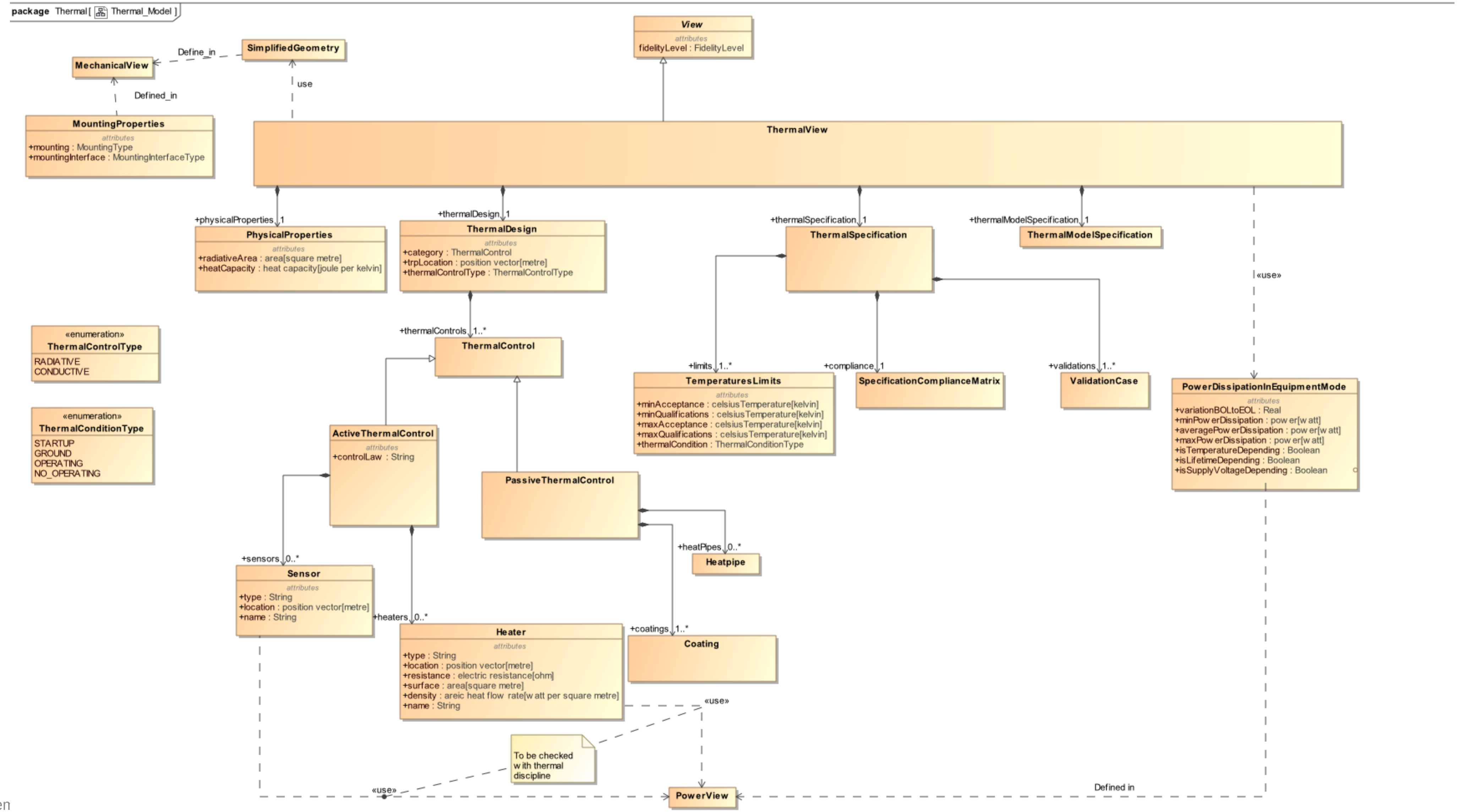
	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15
W1	1	1	1	0	1	0	0	0	0	0	1	0	0	1	1	0
W2	Dir1	x	x	x	Torque1											
W3	Dir2	x	x	x	Torque2											
W4	Dir3	x	x	x	Torque3											
W5	Dir4	x	x	x	Torque4											

% on PWM depending on the direction

EDS Generic Domain Model : Overview
Zoom in Mechanical View



EDS Generic Domain Model : Overview Zoom in thermal view



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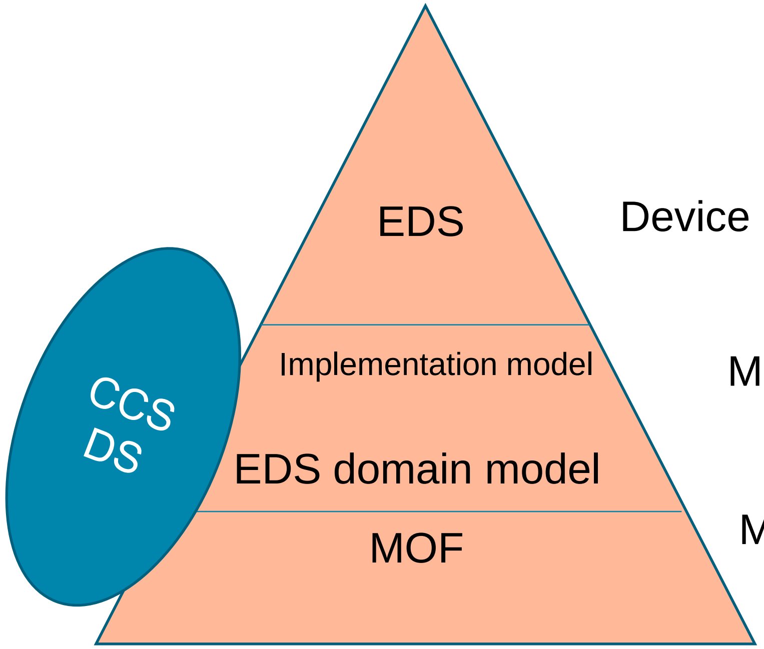
Modelling



Device Model

Meta Model

Meta Meta Model
Meta Object
Facility

CAMEO SYSTEMS MODELER™

SysML QUDV ISO/IEC 80000

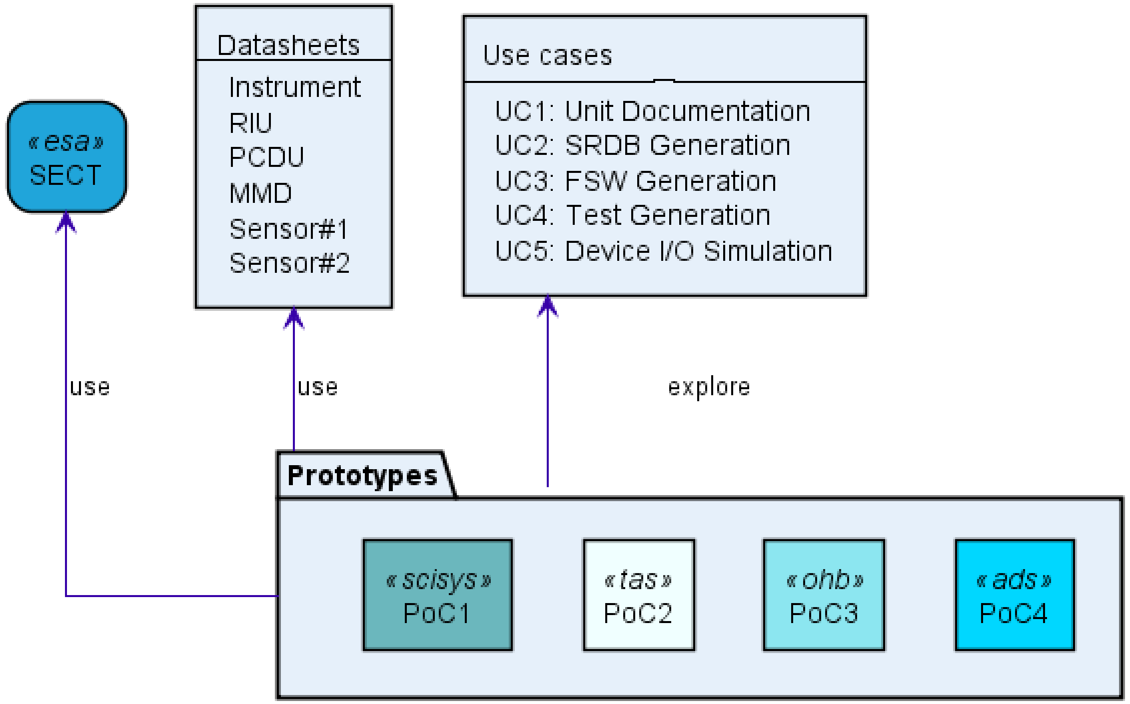
Ecore automatic transformation

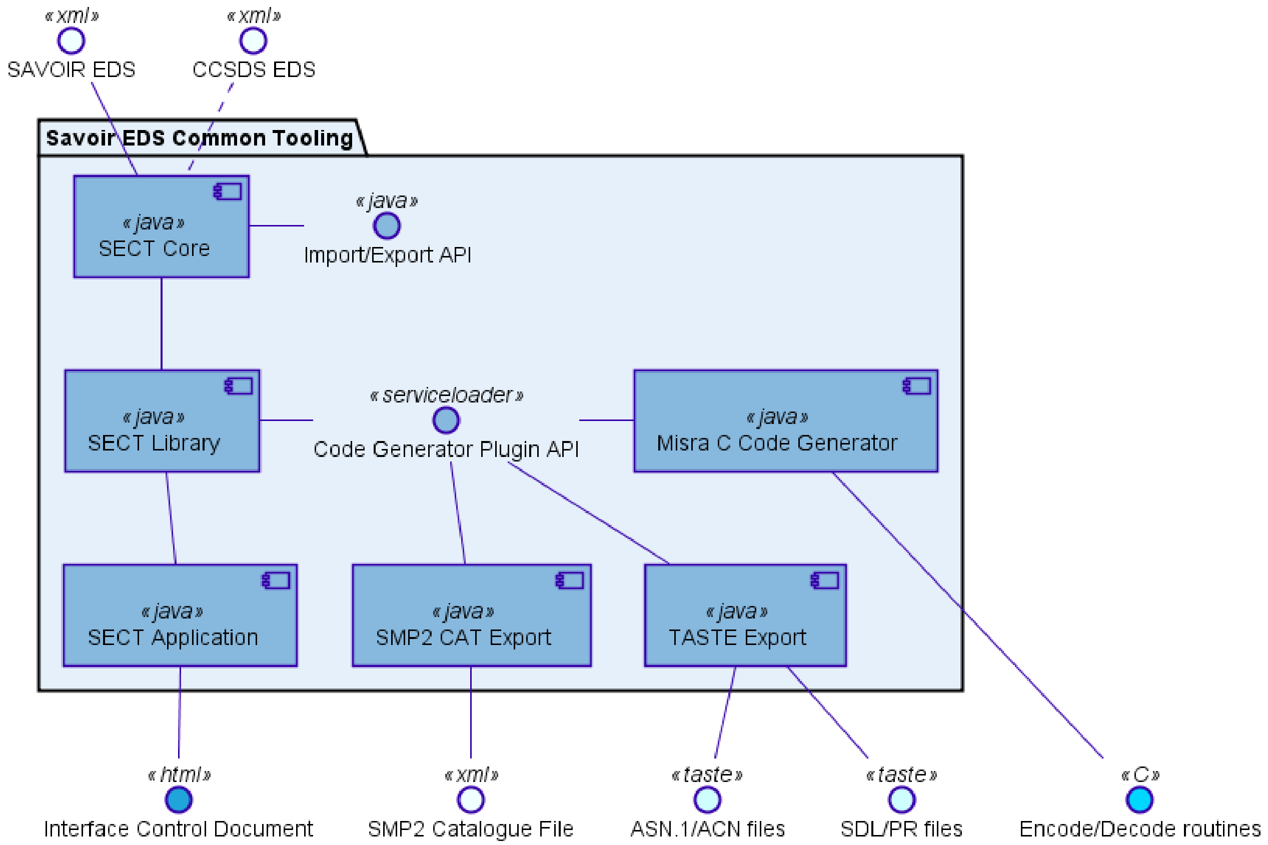
emf
ECLIPSE MODELING FRAMEWORK

AIRBUS

Next steps : tooling and use cases

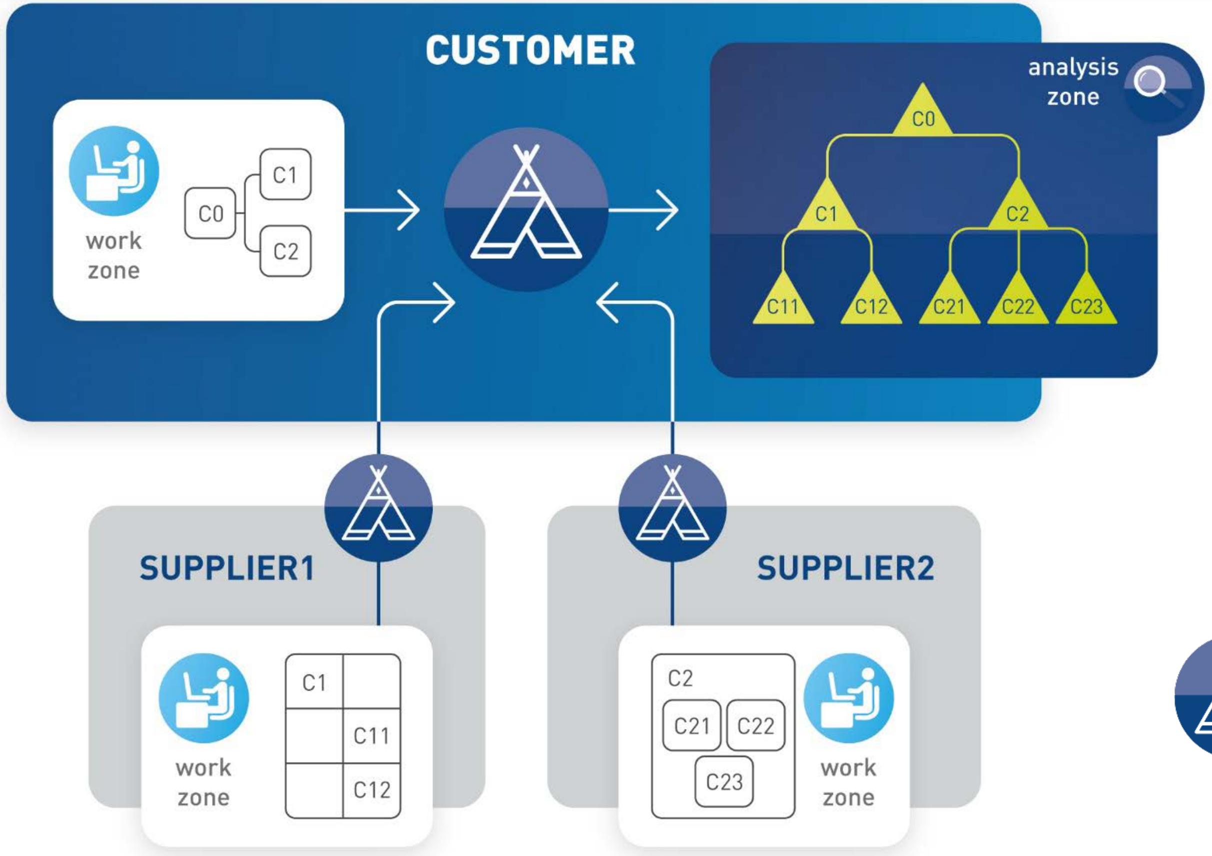
- IADCS (berlin Space)
- RTU(Ruag)
- ASTRO Star Tracker (Jena Optronik)
- PCDU (TAS)
- ASTRIX (ADS)
- MMD (DSI)



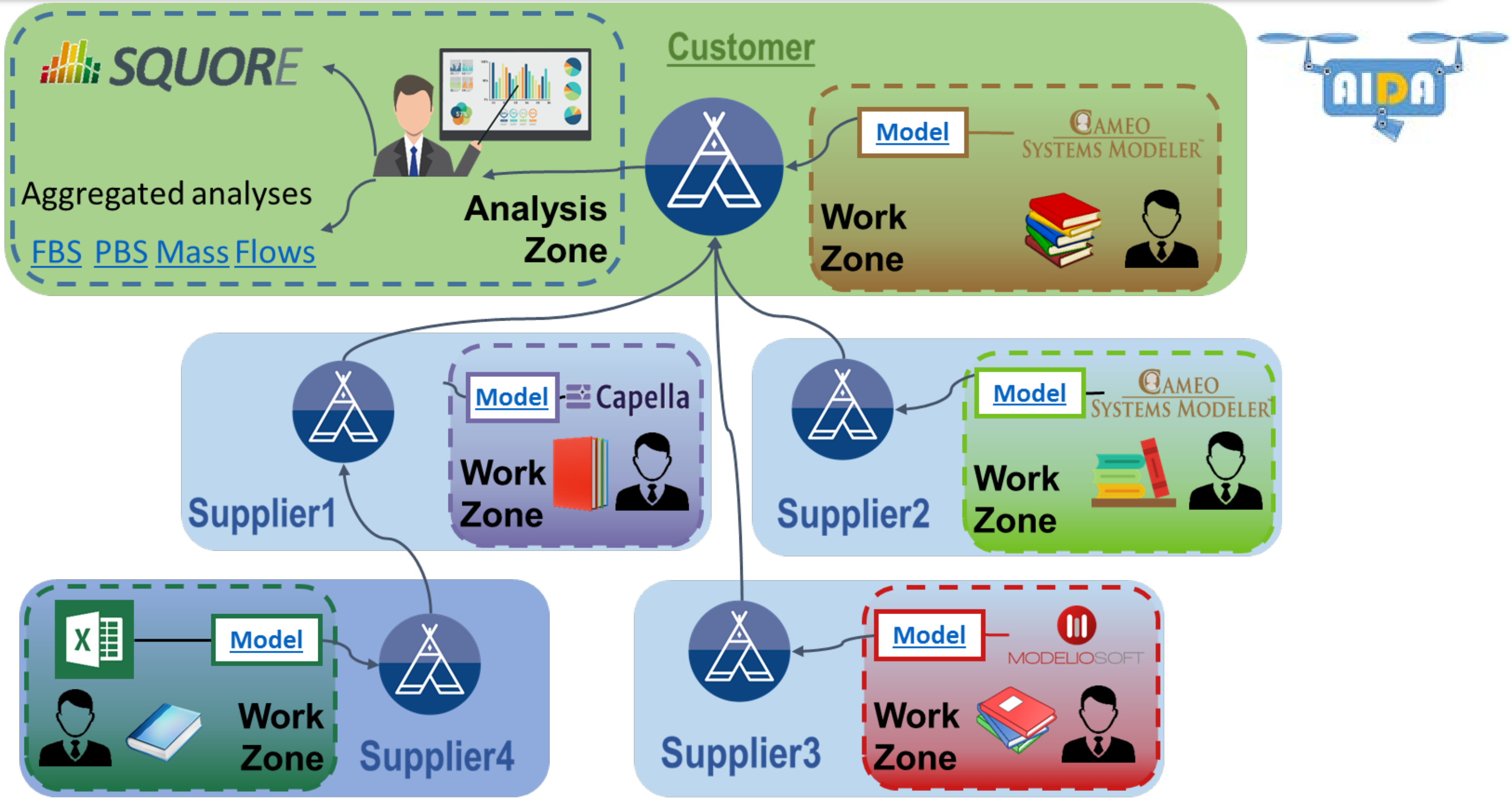


Introduction
TeePee objective

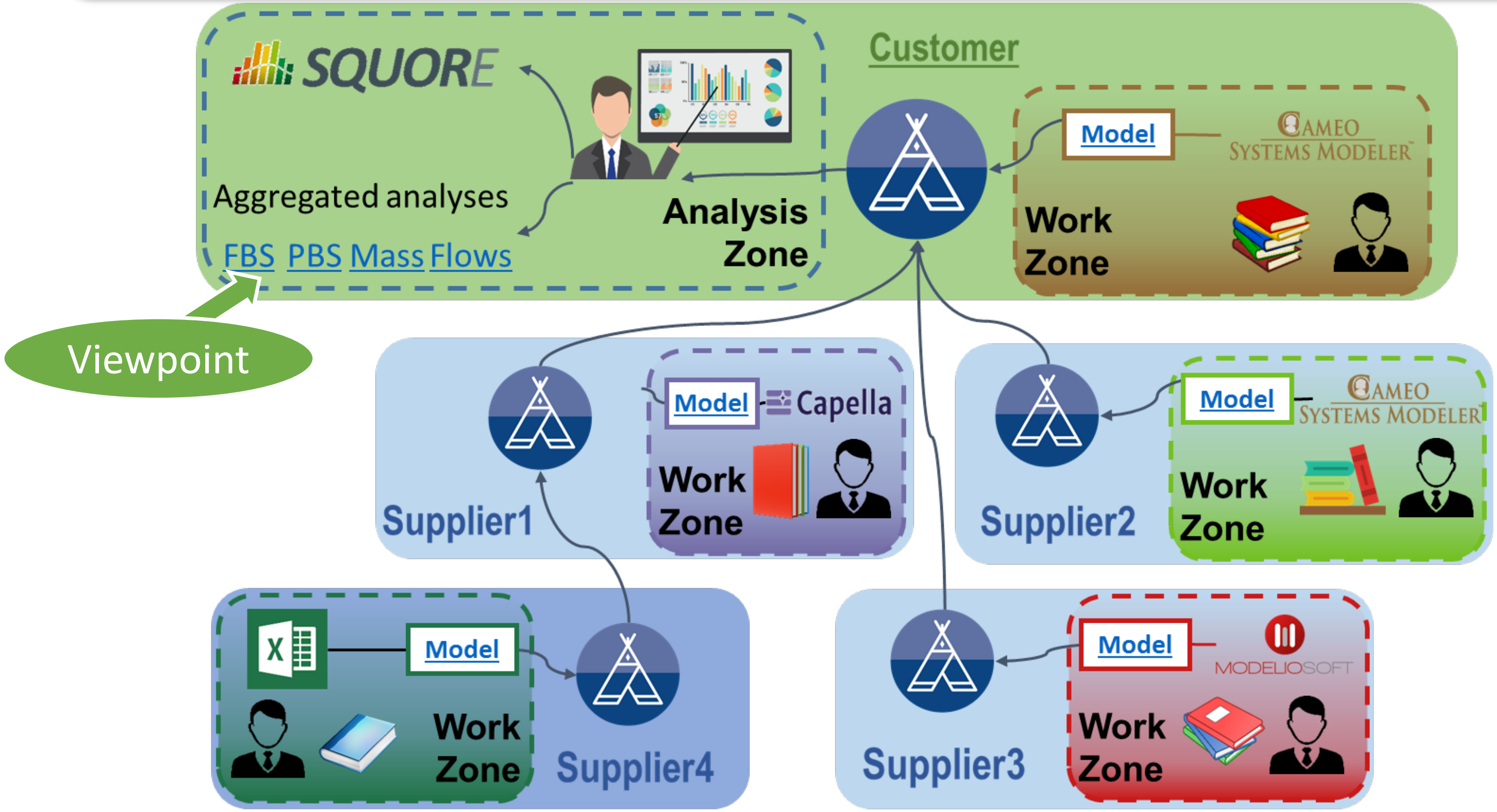
To build the **digital continuity** for Systems Engineering artifacts within an **Extended Enterprise** for analysis purposes, by tackling **heterogeneity** of methods and tools, as well as **confidentiality** of data.



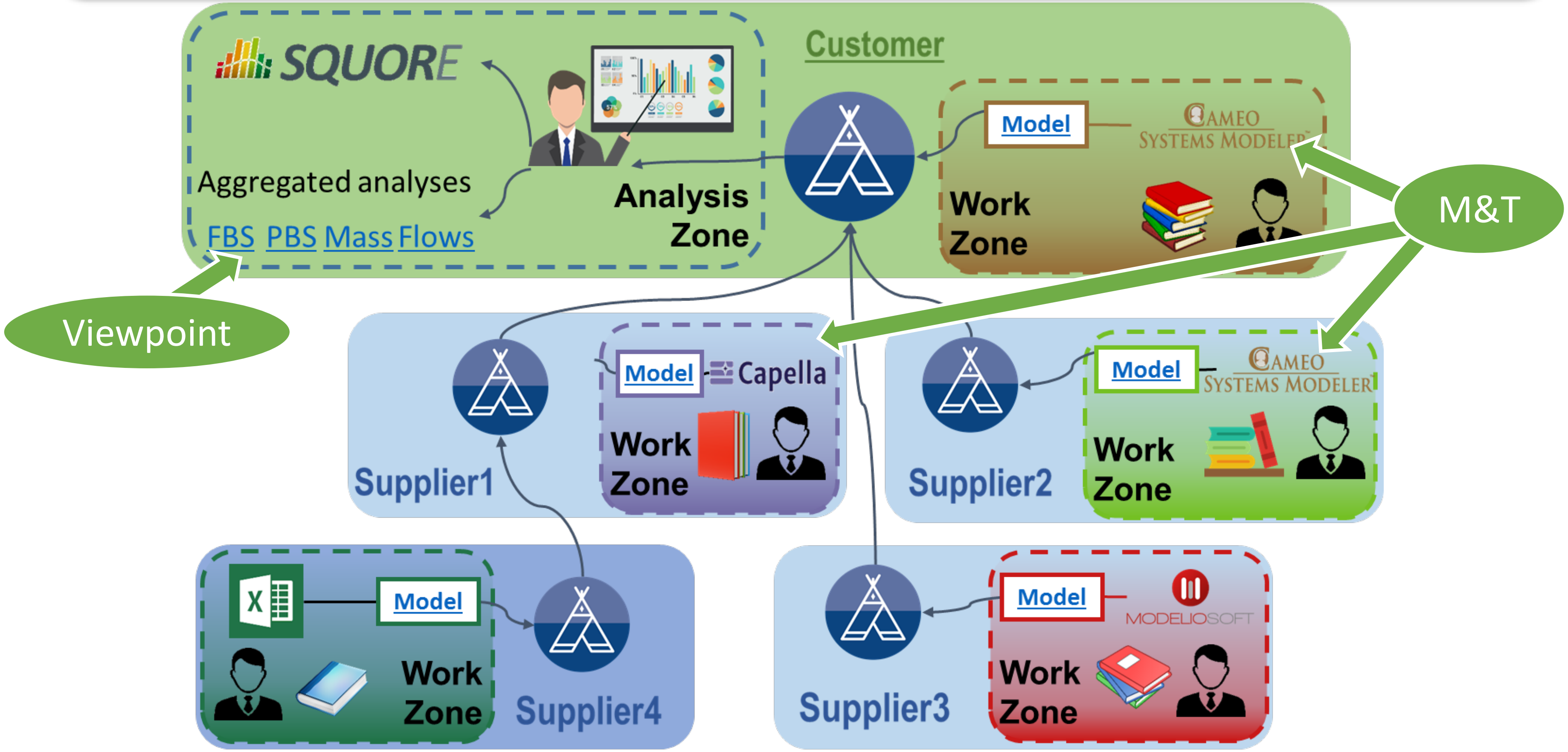
MOISE has decided to build a digital continuity for SE data in Extended Enterprise by experimenting on AIDAuse case.



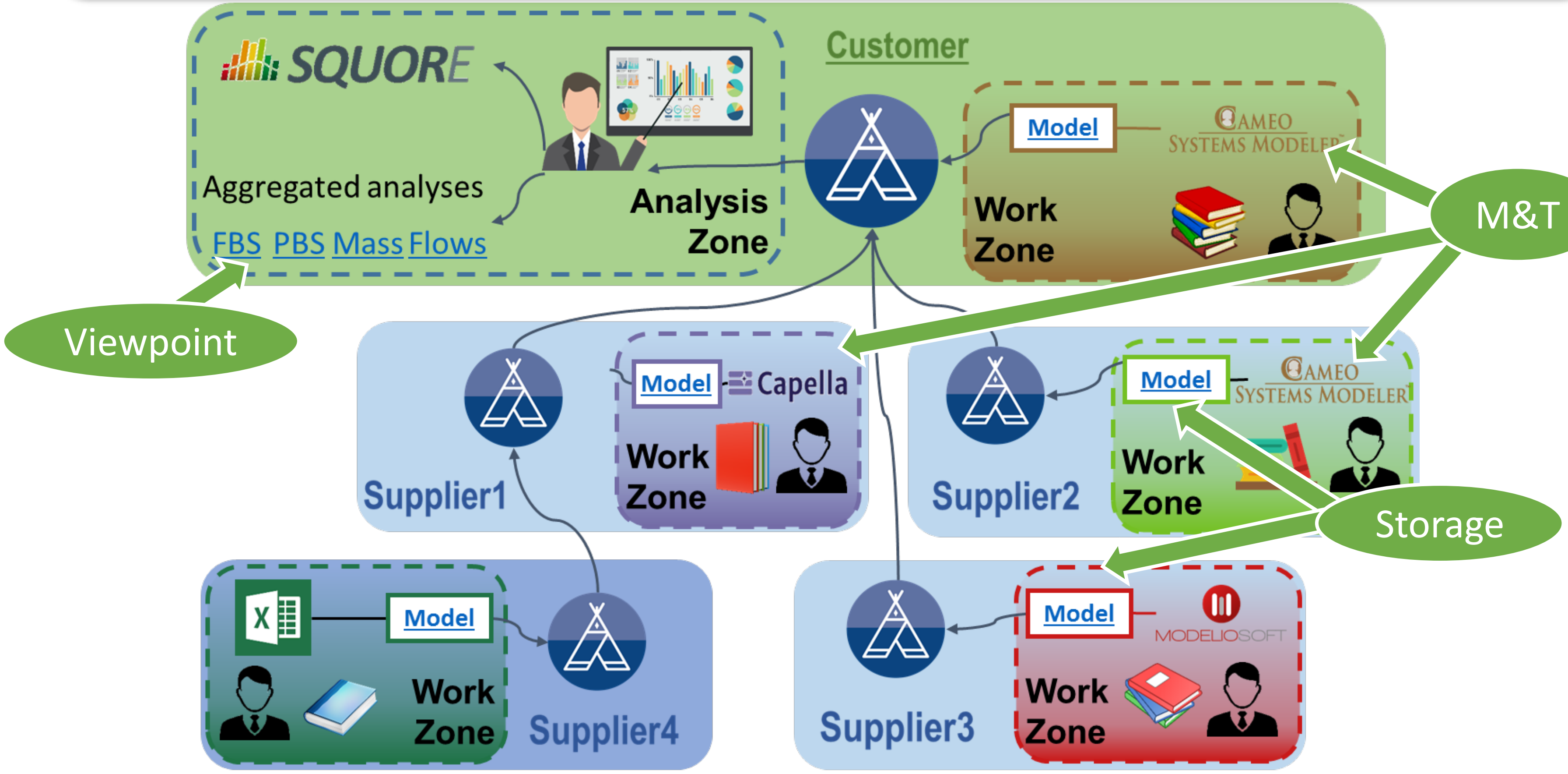
- Selection and definition of **federated analyses** to be accomplished with a focus on **structural analyses**



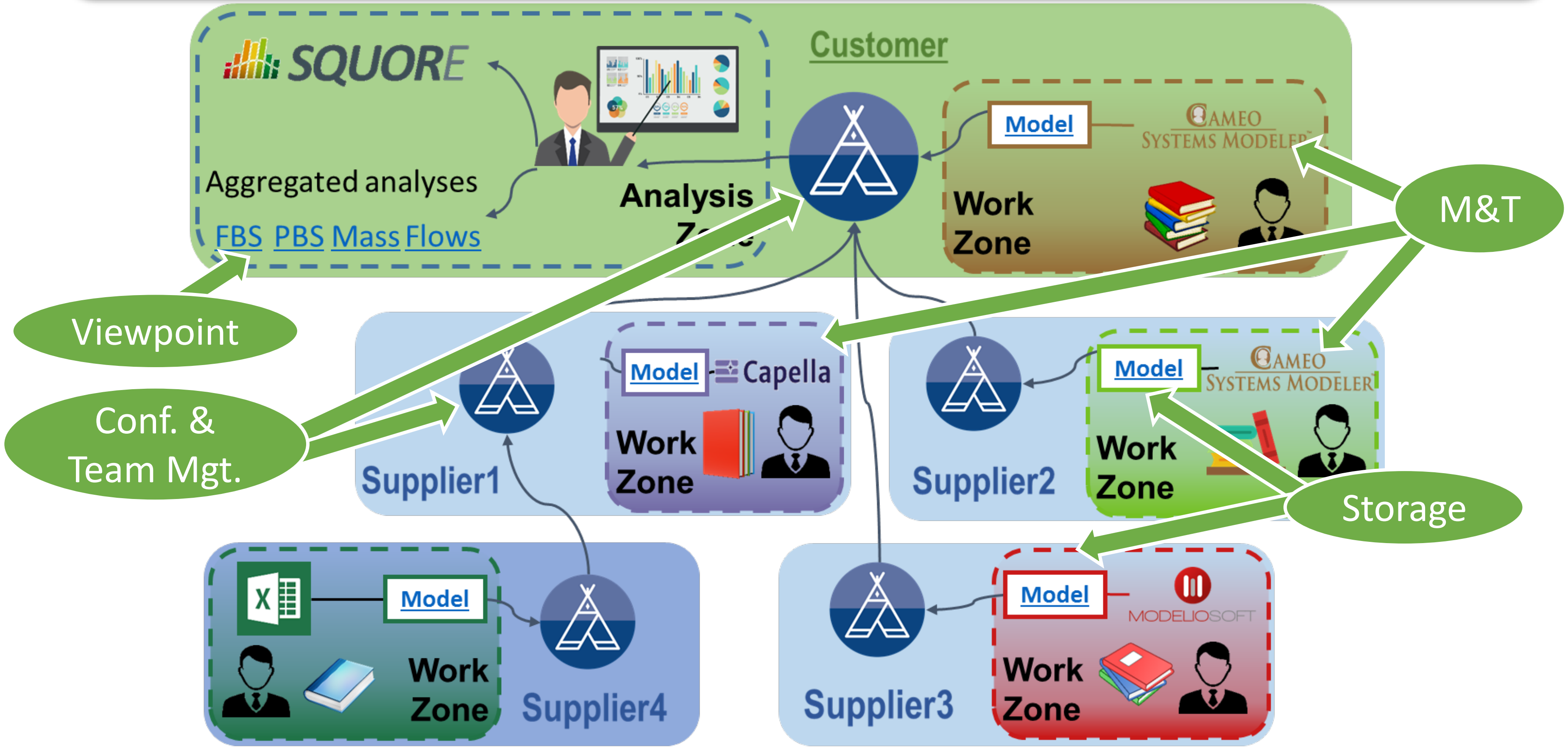
➢ Use of **heterogeneous Methods and Tools** that need to be mapped on **the viewpoint of the selected analysis**



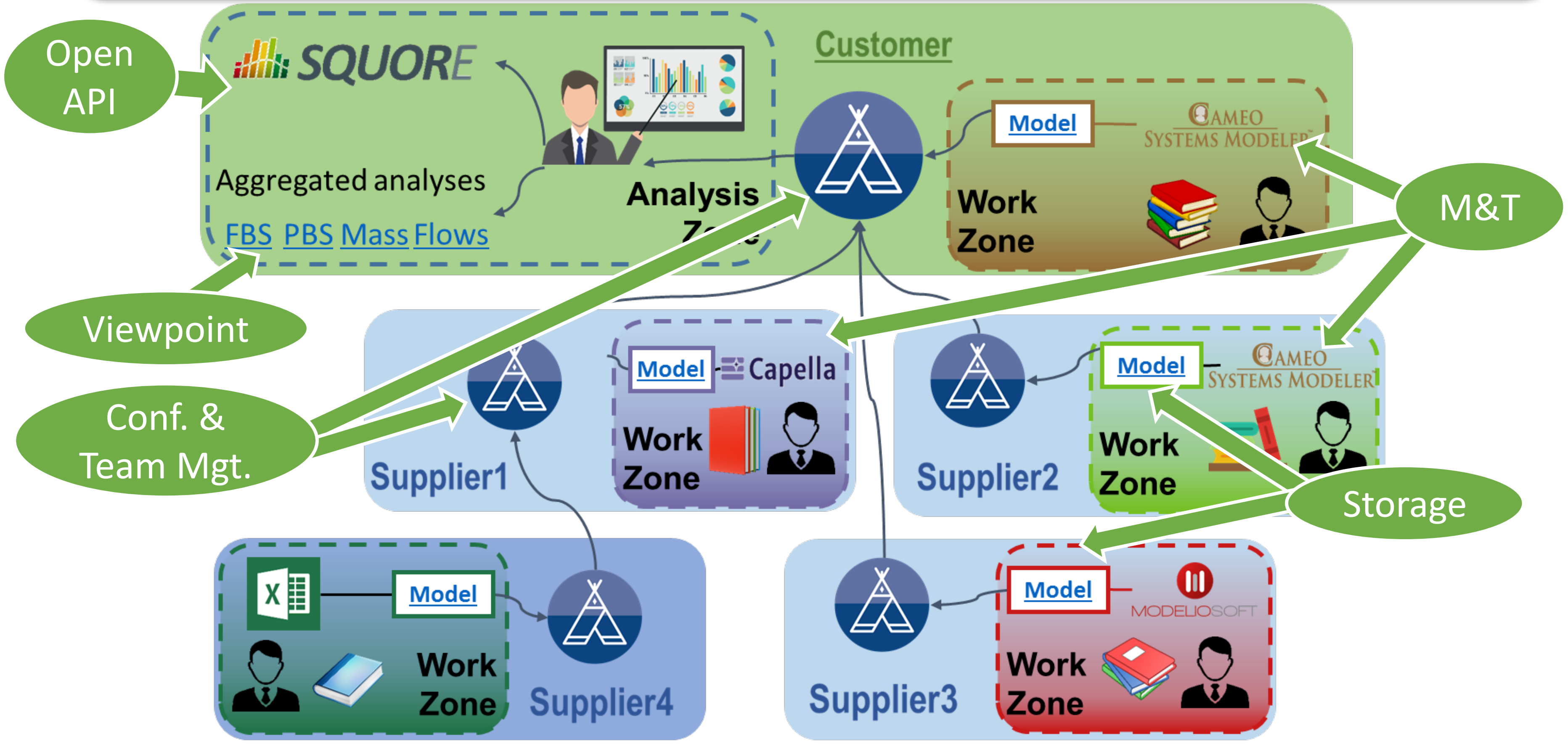
- Storage of **Source-of-truth data** by their **owners**, within each company



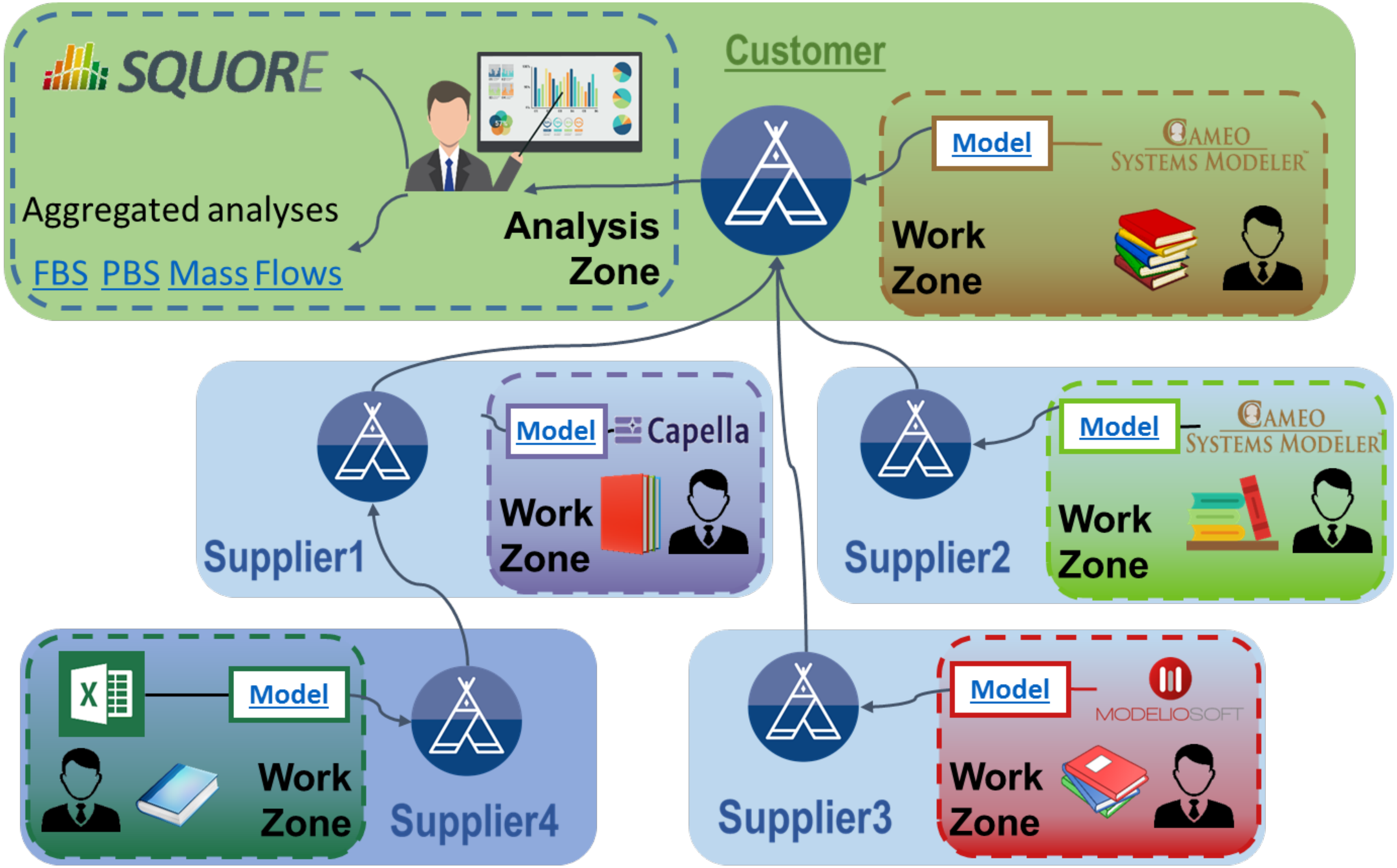
- **Publication** of Suppliers' data for an analysis with regards to a **project baseline**
- Access to the published suppliers' data, by the customer, with read-only privilege



➢ Generation of KPI with Squore software from federated data, including checking of validation rules.



Introduction
TeePee demo



Thank you