MODEL-BASED ENGINEERING DATA HUB ARCHITECTURE – CENTRALISED VERSUS DECENTRALISED – WHAT ARE THE PROS AND CONS? – ARE THERE ALTERNATIVES?

4TH MODEL BASED SPACE SYSTEMS AND SOFTWARE ENGINEERING (MBSE2023)

ANDREAS WORTMANN, 16.11.2023

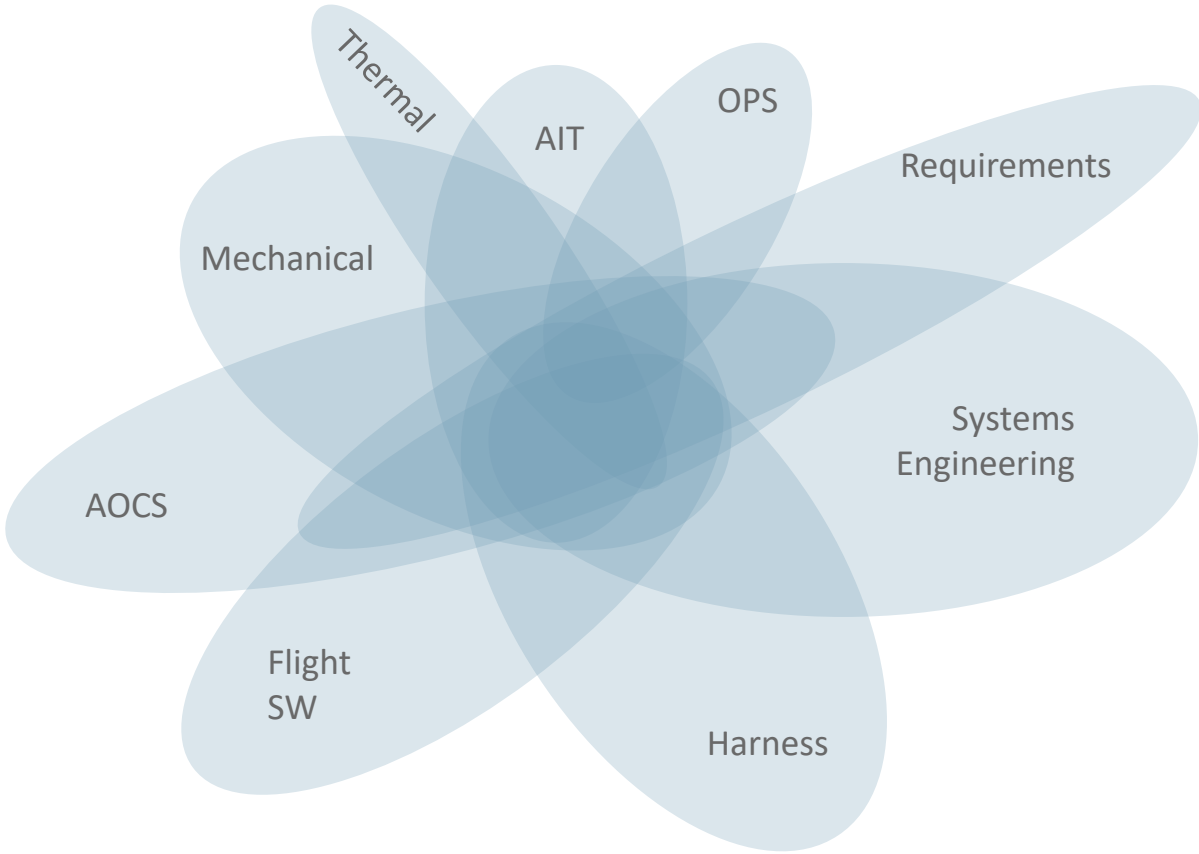
CROSS DOMAIN MODEL-BASED ENGINEERING

PROBLEM DESCRIPTION

- Clarify scope of Model-Based Engineering Data Hub
  1. Upload a design for distribution across organizations (“ESA Data Hub”)
  2. → **Use the hub as collaboration platform for engineers within an organization** ←

- Shared data / domain specific additional data
  - Data shared between one or more domains
  - Data specific to a domain
  - Data specific to a tool

- **Shared data/information must be ‘identical’ in all its uses to ensure system consistency.**



CROSS DOMAIN MODEL-BASED ENGINEERING

PROBLEM DESCRIPTION

- There is **not ONE tool** available to cover all domains and needs
  (and even if there was one, it'll probably not be the tool of choice for everybody, so we'll need to be open)

- **Different tools** with different …
  - Internal data representation
  - Data Interfaces to hook up with the Engineering Hub
  - Version control mechanism
  - User interfaces and user expectations to useability and user workflows
  - Technical means to 'guide' and 'restrict' model editing

DATA HUB ARCHITECTURE TOPOLOGY

ECSS-E-TM-10-23A (NOVEMBER 2011)

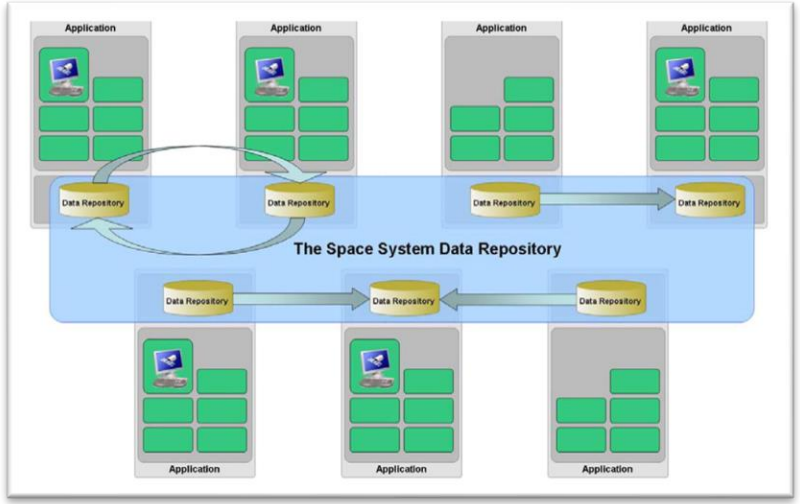
- Space System Data Repository
  - Different applications with different data repositories
  - Impossible and not desirable to standardize data bases
  - Various Data Exchange Scenarios are feasible

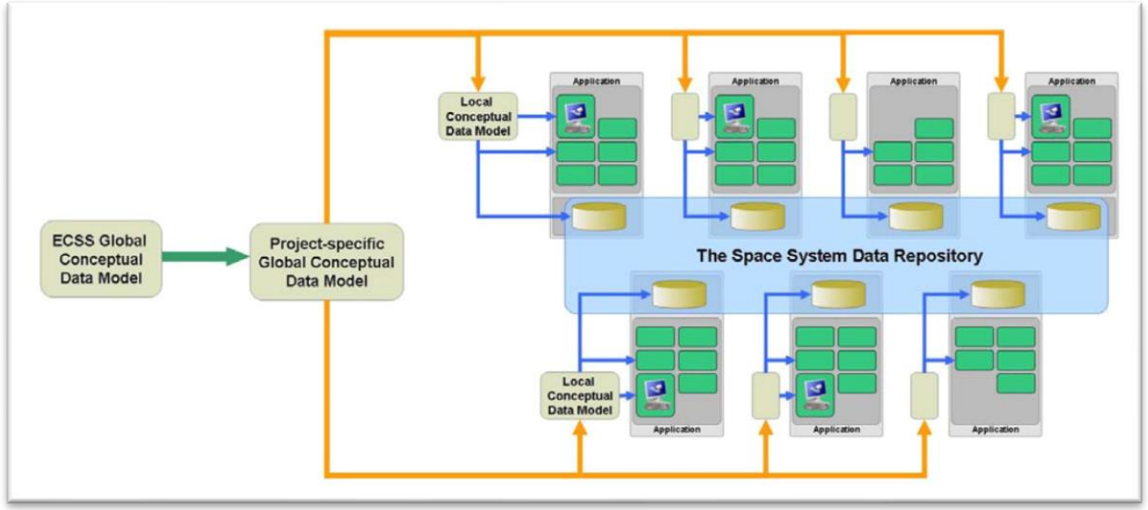
- Key is semantic interoperability
  - Exchange be defined independently of exchange format
  - Need for common semantics to correctly understand and map all the different data models

  → SSO – Space Systems Ontology

- ECSS (on purpose) does not detail on the realization

  → 2 datahub studies (ADS & Rhea) ongoing focusing on use case “ESA Data Hub”



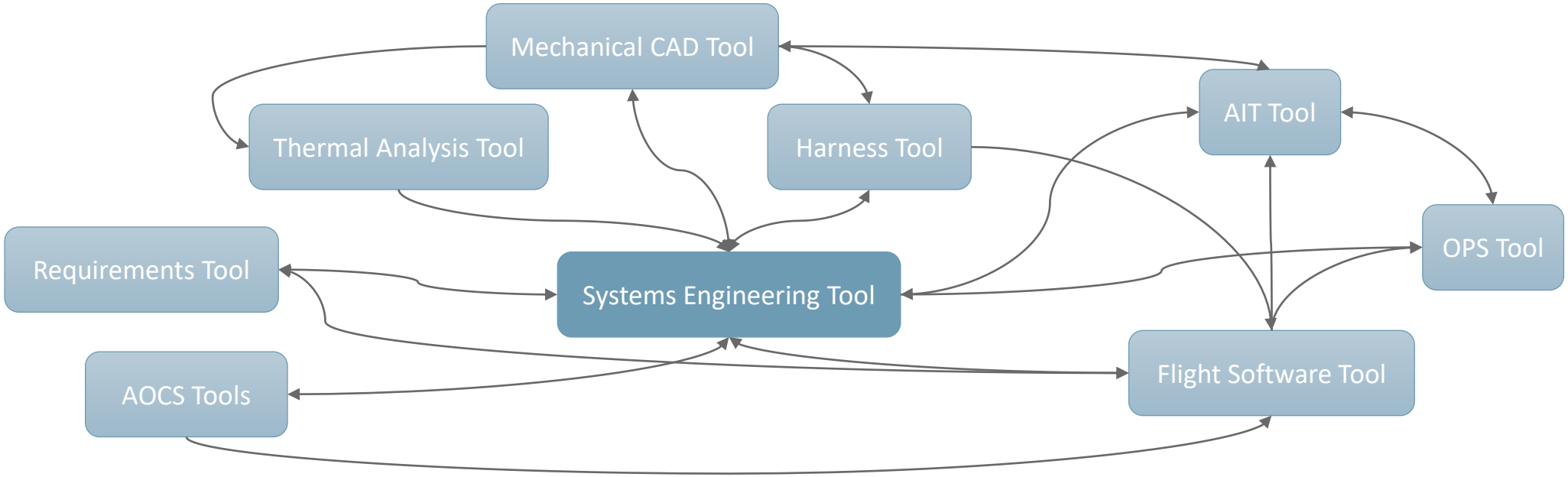


DATA HUB ARCHITECTURE TOPOLOGY

INTEGRATION OF SYSTEMS ENGINEERING AND OTHER DOMAIN-SPECIFIC TOOLS

Architecture Problem: **Where is the (shared) data stored? And how is it synchronized or distributed?**

- **Isolated tools with controlled workflow** (‘digital thread’)
  - Each tool operates in isolation with import/export functionality.
    Design data is exported from one tool and imported into another for continued processing.
    The process which data is exported/imported may be controlled by an additional software tool.

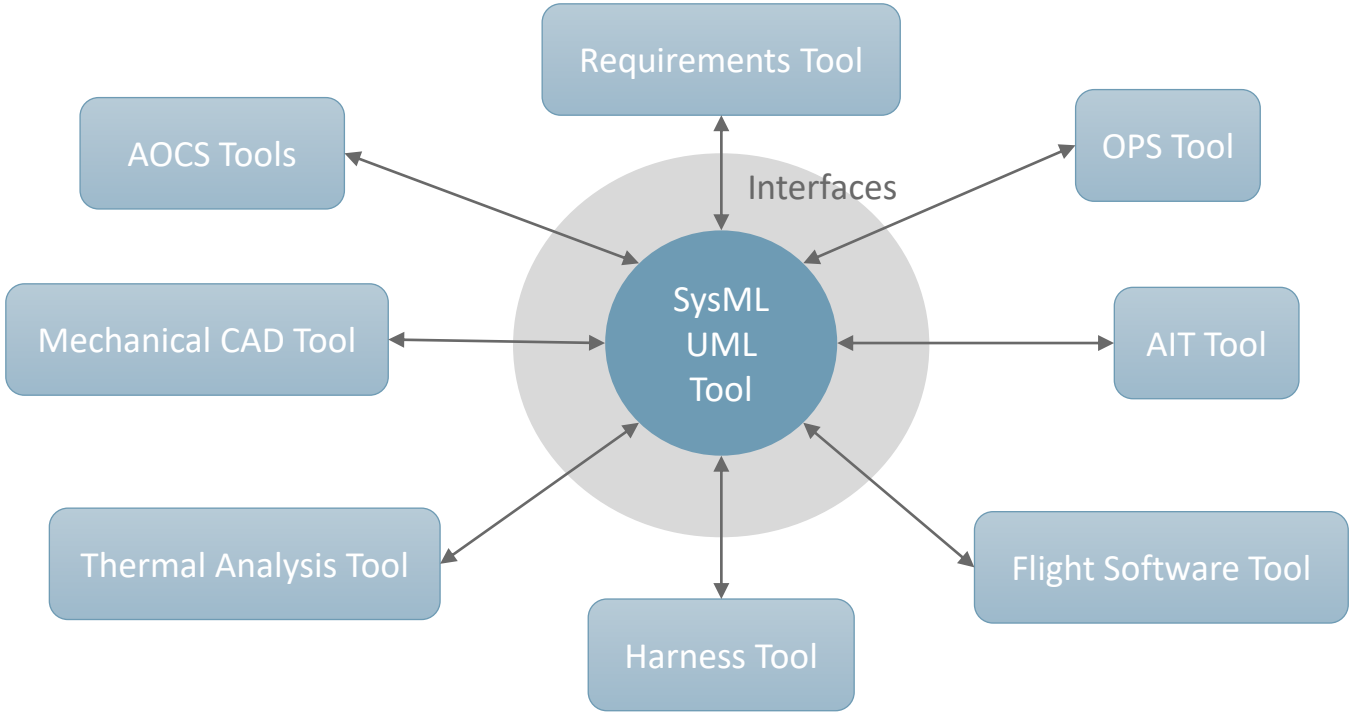


DATA HUB ARCHITECTURE TOPOLOGY

INTEGRATION OF SYSTEMS ENGINEERING AND OTHER DOMAIN-SPECIFIC TOOLS

Architecture Problem: **Where is the (shared) data stored? And how is it synchronized or distributed?**

- **A Central Systems Engineering Tool**
  - A systems engineering tool holds all data and domain-specific tools connect to it for retrieving/updating their data (e.g. typically UML/SysML based tools are proposed here)

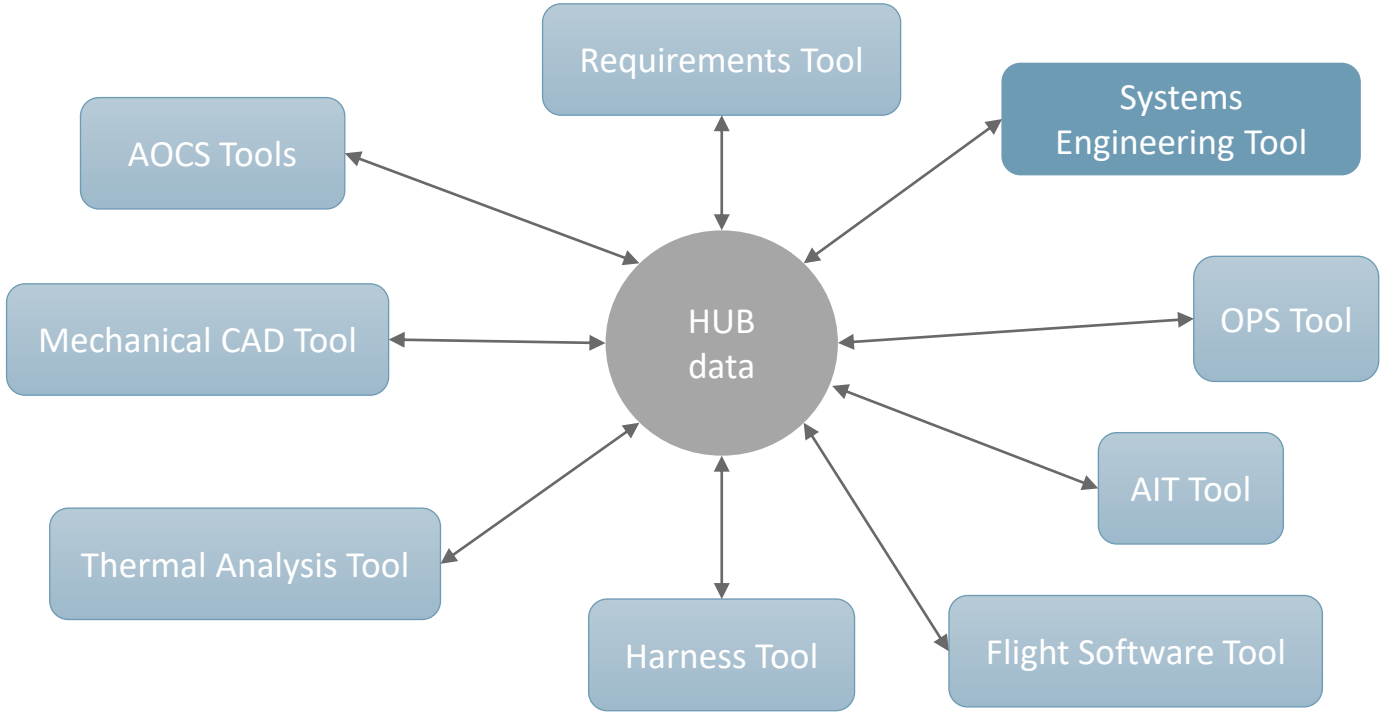


DATA HUB ARCHITECTURE TOPOLOGY

INTEGRATION OF SYSTEMS ENGINEERING AND OTHER DOMAIN-SPECIFIC TOOLS

Architecture Problem: **Where is the (shared) data stored? And how is it synchronized or distributed?**

- **Centralized data model**
  - A central database (the hub) holds all data shared by at least two different domain specific tools. The hub is accessed by various domain-specific tools which synchronize their respective subset with it.

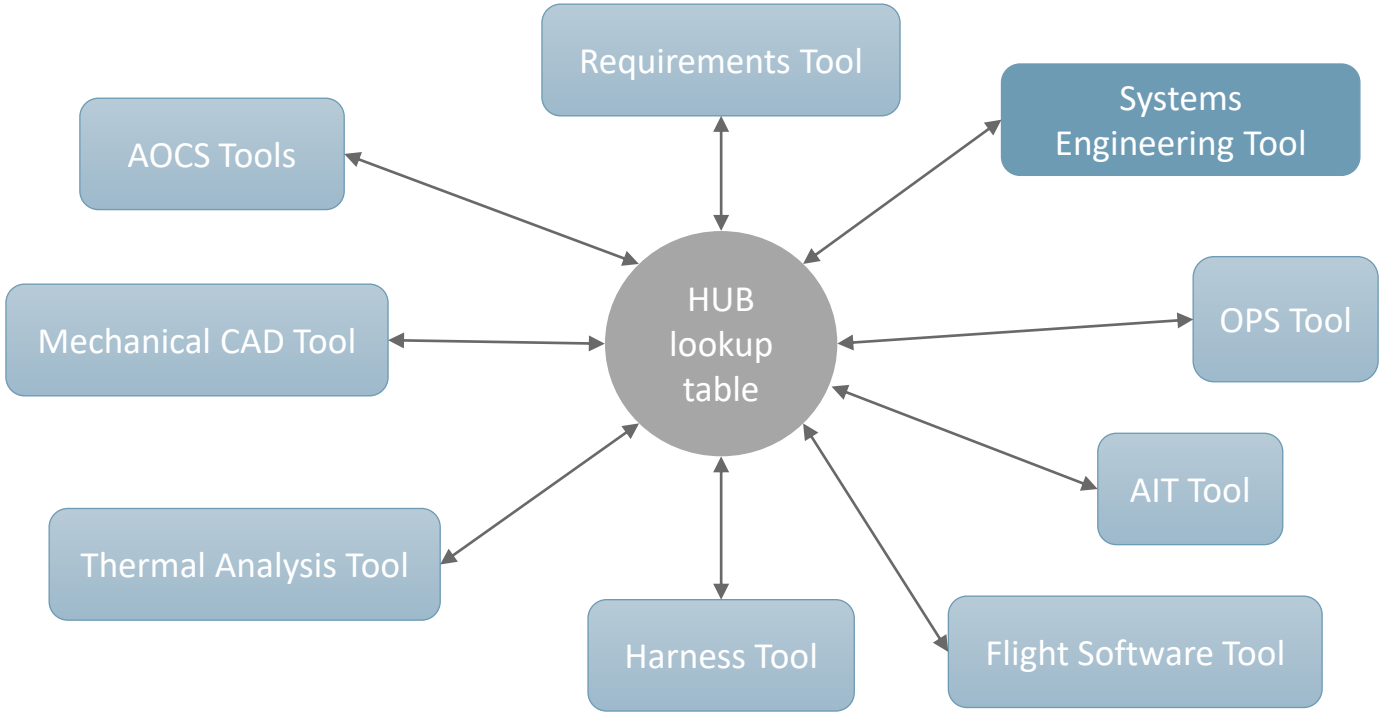


DATA HUB ARCHITECTURE TOPOLOGY

INTEGRATION OF SYSTEMS ENGINEERING AND OTHER DOMAIN-SPECIFIC TOOLS

Architecture Problem: **Where is the (shared) data stored? And how is it synchronized or distributed?**

- **Decentralized data model**
  - All data is stored within the respective domain specific tools.
    A central comprehensive lookup table (the hub) holds references between artifacts stored in different tools.



QUESTIONS

CROSS DOMAIN MODEL-BASED ENGINEERING

There are multiple different domain specific tools involved which need to align to efficiently cooperate

- **Which subjects need to be considered across multiple domain specific tools?**
  - Incomplete and partial models (during development)
  - Partial reuse in different projects/missions/context
  - Access Rights (“Who is allowed to see which data?”) (role-based vs. property-based access rights)
  - Ownership of data (“Who is allowed to change/create/delete data?”)
  - Cross-domain queries and assessments
  - Update in data schema or meta-model (backwards compatibility vs. model migration)
  - System scalability
  - Synchronization of a consistent data-block vs. every artifact modification is to be synchronized
  - Variant management
  - Support of development branches (branch/diff/merge)
  - …
- **And how are these to be prioritized?**

QUESTIONS

CROSS DOMAIN MODEL-BASED ENGINEERING

There are different feasible architectures sketched before.

- **Are there any other architectures known, implemented, feasible or thought of?**
  -
  -
- **Are there known / established tools on the market (that fit our use-case)?**
  -
  -
- **How does collaboration work practically among different disciplines? (workflow?)**
  -
  -

QUESTIONS

CROSS DOMAIN MODEL-BASED ENGINEERING

There are different feasible architectures sketched before.

- **Which experiences have been made with a any of these architectures / tools?**
  - **Are there known and established tools available?**
    - …
  - **Are there significant (“showstopper”) issues known with any specific architecture?**
    - …
  - **How does one or another architecture scale?**
    - …
  - **How do you handle changes in the data model (conceptual data model, meta-model, language)?**
    - …
  -

QUESTIONS

CROSS DOMAIN MODEL-BASED ENGINEERING

The “ESA Data Hub” use case is investigated in two studies.

- **What’s the difference between the ESA use-case and the industry-internal use-case?**
  - Synchronization / data upload / data download frequency
    - ESA: every few weeks
    - Internal: every few minutes
  - Need for variants and/or development branches (?)
    -
    -
  -

THANK YOU!

… looking forward to
fruitful and enlightening discussions

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