“How to survive teamwork in MBSE?”

An example from a large scale project

Zürich, 18.09.2023

Martin Hoppe

INTIS

Who is Martin Hoppe

- Age — 56 years
- Profession — Systems Engineer @ INTIS GmbH martin.hoppe@intis.de
- Experience — 5 years in inductive charging systems for e-mobility
  28 years in naval shipbuilding
  (test and commissioning engineer, project manager combat system data network, requirements and systems engineering manager and a lot more)
  27 years of experience in applying systems engineering, the development of systems engineering tools,
  process tailoring and data interfaces with PLM systems.
- Others — INCOSE CSEP

INTIS

What INTIS does

- Charging technology for electromobility :
  - Contactless charging technology (inductive)
  - Conductive charging technology (DC fast charging)
  - For public and industrial applications

Driving inductive charging innovation INTIS

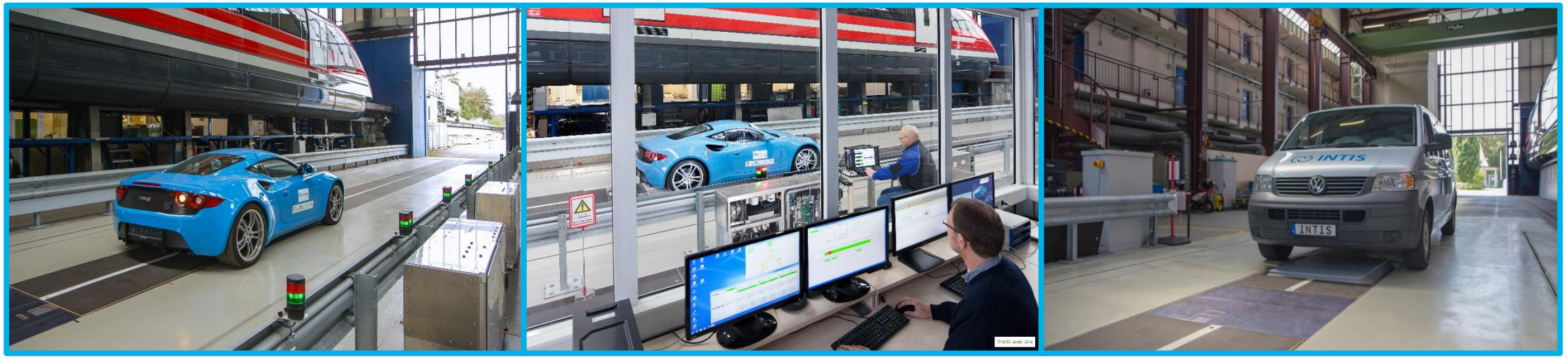
Source: INTIS GmbH/Gould

- Modular integrated energy solutions
  - With battery storage system and energy management
  - Grid-operated or stand-alone grids (decentralized energy supply)
  - Control energy, peak shaving, power factor correction, etc
  - Battery storage-supported charging of electric vehicles (reduces the required grid connection power

INTIS

About INTIS

- 100% subsidiary of the company IABG mbH from Ottobrunn, near Munich
- "Spin-off" of the Transrapid test facility Emsland, operated by IABG until 2011
- Utilization of the results from the Transrapid project



INTIS

A leading European technical and scientific service company - IABG

SCHWARZ Holding GmbH	**87,4%**	**12,6%**	**IABG Mitarbeiter-beteiligungs-AG (MBAG)**

IABG
Employees: approx. 1000

Automotive

Employees :
120

Development and operation of mechatronic test systems for OEM and suppliers

InfoCom

Employees :
130

Development and operation of secure luK systems

Mobility, Energy & Environment

Employees:
100

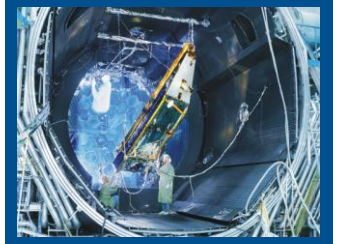
Solutions for environmental protection, electromobility and the energy transition

Aerospace

Employees :
160

Operational stability tests for complete cells and assemblies

Space



Employees :
130

Operation of ESA-coordinated space test centers in Ottobrunn and Nordwijk

Defense & Security

Employees :
370

Operation of military simulation and test systems for analyses and conceptual designs

INTIS

Project Scope – Systems to be developed


Mission System


Shipyard


Training System


Support System


How to organize the work of 170 team members in one MBSE model?

- 2300 related to the Proposal Documentation
- 1400 related to System Performance and Design
- 2300 related to the Contract Documentation
- 700 related to Process Areas such as SE, CM, RM, QS, PM,…

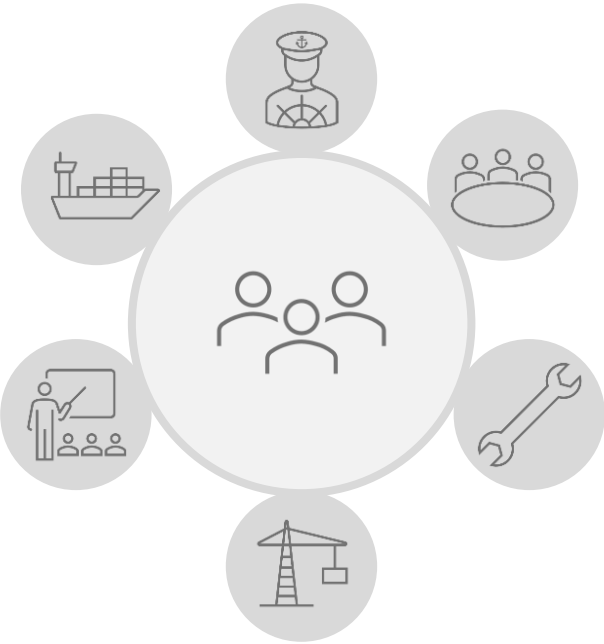
- Requirements traceability in Requirements Engineering, System Design and Project Management was essential to win the contract.

- 14 Month Preliminary Design
- Fixed Price Contract
- 7 Companies
- 10 Locations
- 5 Time zones
- 170 Team members
- 9 Nationalities

INTIS

How to organize and train 170 Team members to achieve the project goals?

- Delta Culture and Team Building
  - Native versus non-native language speakers
  - Different cultural backgrounds
  - Different educational backgrounds (development processes, systems engineering,…)
- Focus on the needs of Customers and End-users?
  - Procurement Organization (Evaluation Team)
  - User (Navy, Support System)
  - Internal customers (Mission System, Support System, Training System, Shipyard)
- System of Systems of Systems
  - The ship itself is a system of systems
  - The training system supports the shipyard, mission and support system
  - The mission system design influences the support system life cycle cost
  - The support system influences the mission system design



INTIS

Integrated Product and Process Development

Integrated Product and Process Development

- A management technique that integrates all acquisition activities, developed by the US DOD in the late 1990s.
- Integrates all acquisition activities starting with requirements definition through production, fielding / deployment and operational support.
- Optimization of the design, manufacturing, business and supportability processes.

Tenets

- Customer Focus
- Concurrent Development of Products and Processes
- Early and Continuous Life-Cycle Planning
- Proactive Identification and Management of Risk
- Maximum Flexibility for Optimization
- Use of Contractor Approaches

Integrated Product Teams (IPT)

- A team is a small number of people with complementary skills who are committed to a common purpose, set of goals, and approach for which they hold themselves mutually accountable.
- IPTs should contain members who represent all the stakeholders necessary to ensure that all customer requirements and functional concerns are represented and addressed up front in the developmental process.

MBSE Tool Integration

- The concept of IPTs must be reflected in the representation of information in the model and the required access and process control.

INTIS

170 Team members organized in 38 IPTs

Cross-functional Teams

- Proposal Management
- Systems Engineering
  - Configuration Management
  - Data Management
- Project Management
- Offset

Process Teams

- Construction
- Quality Assurance
- Risk Management
- Estimation
- Legal Support

Design Teams

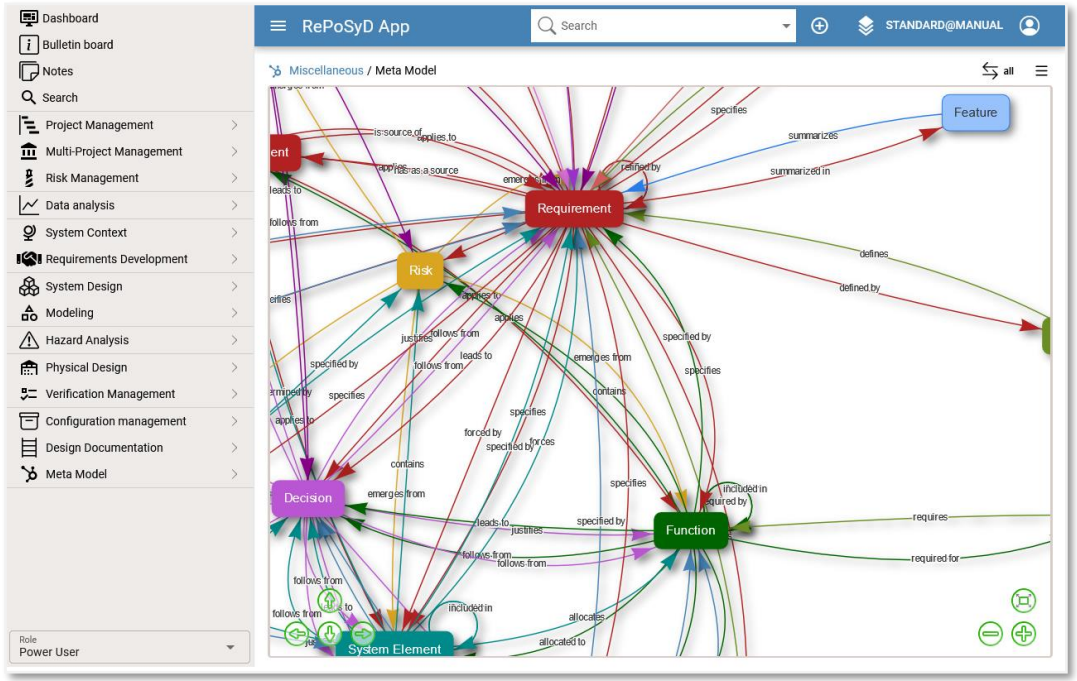
- Mission System
  - Ships Theory
  - Signatures
  - Command and Surveillance
    - CCIS
    - Communication System
    - Navigation System
    - IPMS
  - Platform System
    - Hull Structure
    - Propulsion System
    - Electrical System
    - Auxiliary System
    - Outfitting and Furnishing
- Support System
- Shipyard

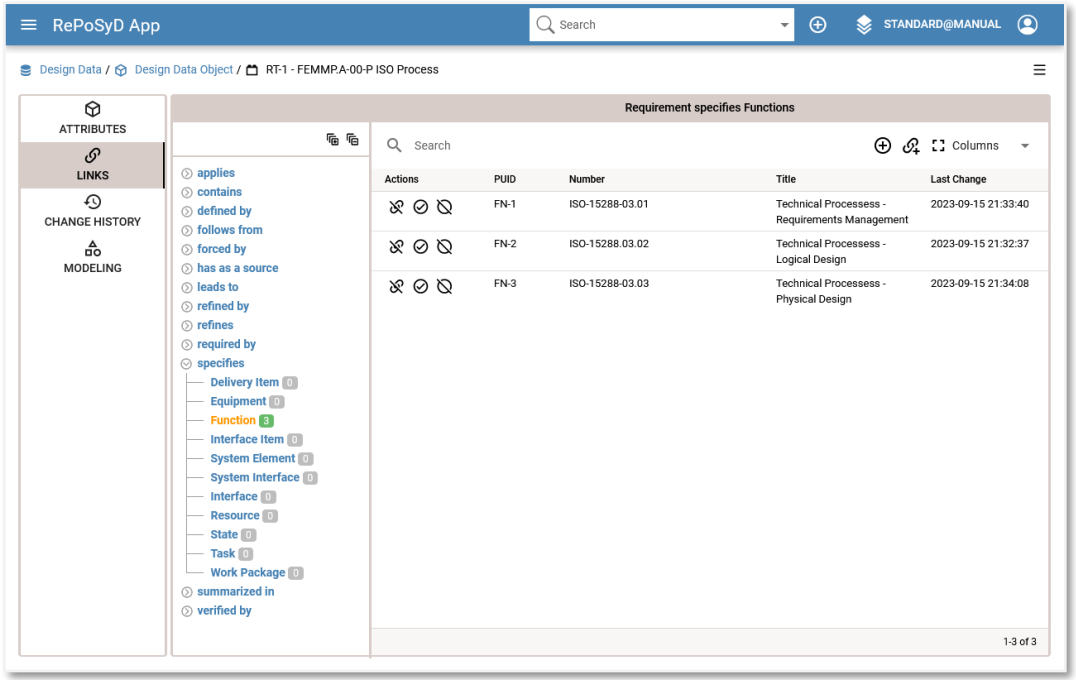
Design/Process Teams

- Integrated Logistic Support
- Crew and Training
- Facilities
- Logistic Engineering
  - Life Cycle Costing
  - Supportability Analysis
    - Availability / Reliability / Maintainability
    - Logistic support Analysis
  - Maintenance Planning
- Documentation and Data
- Supply Support

INTIS

A common Design Language for Team Members – The sematic Model





Consistent application of the information and language model in

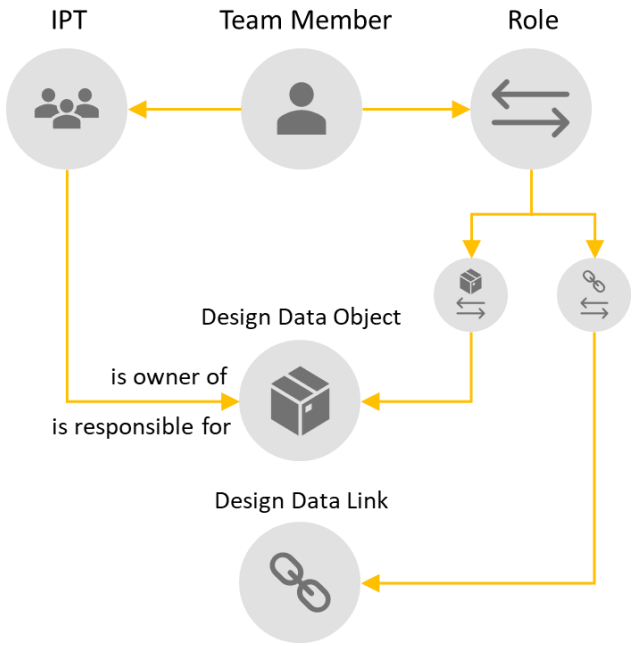
- process definition;
- the user interface of the MBSE tool;
- Training materials, style guides;
- internal/external presentations;
- in/external design documents.

INTIS

Access Control System - IPTs and Roles

Access Control

- Access control for Design Data Objects based on IPT memberships and responsibilities.
- Team member can have multiple memberships.



Process Control

- Process control is implemented by a role system and transactions.
- Roles and transactions are individually assigned to different types of Design Data Objects (e.g., Requirement, Function,…).
- This allows, for example, freezing the system structure without preventing team members from changing the descriptions of the elements.

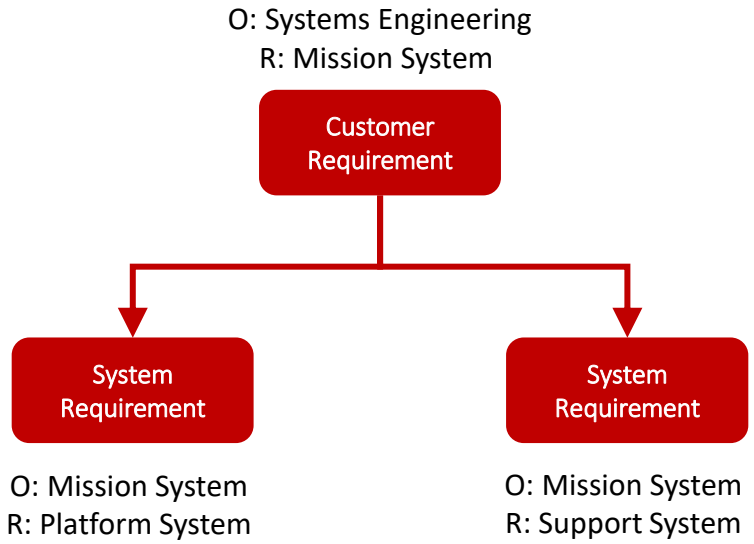
Write access is granted

- if the team member is a member of the owning or responsible team and
- a role is assigned that allows the requested transaction(s).

INTIS

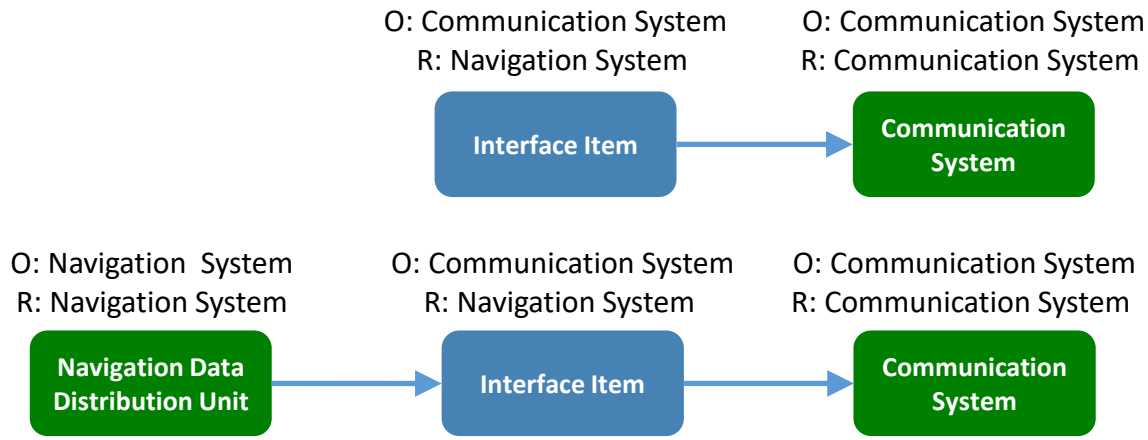
Working with Ownerships and Responsibilities

Managing Customer Requirements



- The structure of customer requirements does not necessarily match the team or system structure.
- All customer requirements are owned by the IPT SE for configuration control.
- The ACL system grants permission to the responsible IPT to refine a customer requirement as needed.

Managing Interface Items



- The IPT that needs the interface item owns it, defines the requirements and assign the IPT, that is to provide the item as the responsible IPT.
- The IPTs periodically filter for “open ends” they are responsible for and link the interface items accordingly.
- The ACL system grants permission to the responsible IPT to link the interface item with its source.

INTIS

IPT Systems Engineering – The „How to Team“ and Process Police

- Establishes the tailored process definition for the project.
- Is the responsible group for implementing the System Engineering Process as defined in the SEMP.
- Is involved into the practical design and process work of all disciplines.

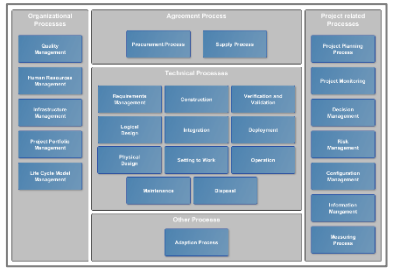
- Knows the toolbox Systems Engineering.
- Acts as the top-level "How to" team of the project.
- Enables those technical areas that require a close collaboration among IPTs to achieve the best "integrated solution".

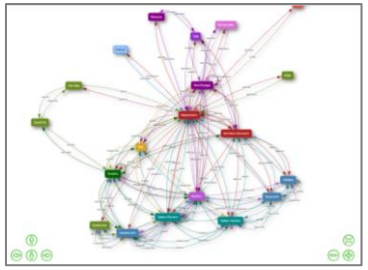
- Provides initial SE and Process Training for all project members at all organizational levels.
- Performs cross-functional training classes for process steps.
- Assists team member with on-the-job training

- Promotes, challenges and protects the IPTs.
- Monitors the work with the tool, the level of detail and data quality.
- Prevents teams from going too fast, to slow or taking unintended shortcuts.

INTIS

Process results and overlapping Contents (incomplete)





System Requirements

Contracted Requirements

Proposal Documentation Requirements

System Reports

Contracted Requirements Document

Compliance Statement & Traceability

Preliminary System Specification

Integrated Master Schedule

WBS Index and Dictionary

Management Plans

Decisions

Drawings (Reference)

System Elements

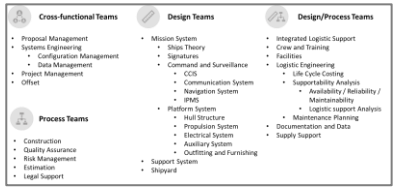
Work Packages (incl. break down)

Compliance Statement

Standards / Rules & Regulations

Functions

Interface Item



Cross-functional Teams

Process Teams

Design Teams

Design/Process Teams

INTIS

Project Results – Systems to be developed


Mission System


Shipyard


Training System


Support System

When 170 well-trained team members (with 9 different nationalities from 7 companies in 10 locations in 5 time zones)
work together (in the areas of requirements engineering, system design and project management)
in a semantic model supported by a team with the right understanding (SE is a toolbox and rather than a process)
and the right tool (luckily not all at the same time)
they create

- 75.000 Design Data Objects
- 270.000 Design Data Links
- 11.000 Requirements
- 40 Use cases and 480 Functions
- 420 System elements and 3.200 Physical elements
- 7.000 Work packages and 4.500 Tasks
- 450 Standard and Rules & Regulations
- 1.500 Illustrations and 1.200 tables
- 1.600 Abbreviations and 300 Definitions, …

- 56 Files (~5 meters)
- 500 Documents
- 26.000 Pages in ANSI A+E
- All documents were generated as “ready-to-use” documents from the model.
- No additional postprocessing was required.

- Most important document was the requirements traceability matrix with more than 700 pages.

INTIS

Thank you for your attention

The biggest advantage of not applying systems engineering is that errors will (continue to) catch us completely by surprise and we don't have to worry about them months in advance.

Systems Engineering Handbook, UK MoD , 2009

INTIS