DEFAINE

ModProd 2024

Christopher Jouannet

DEFAINE Partners

Fokker

GKN AEROSPACE

PE | GEOMETRY

KE-works

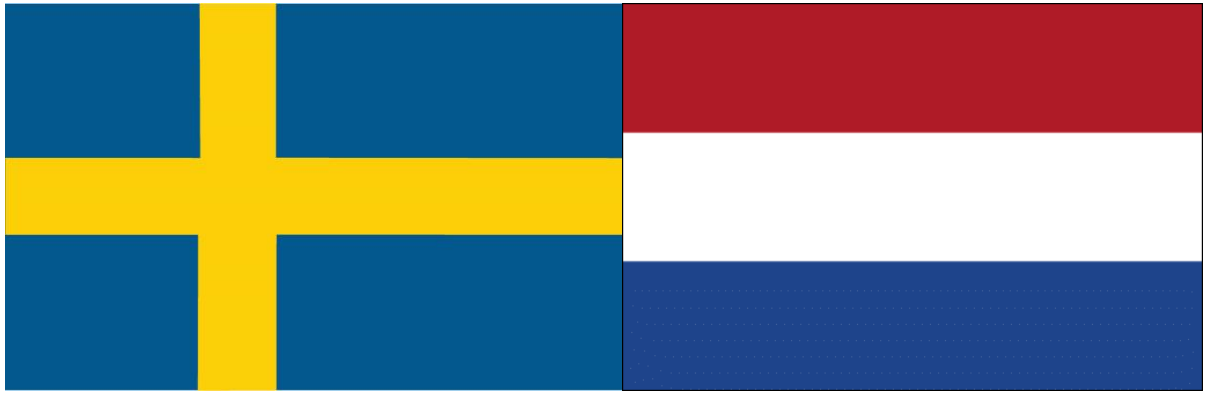
ParaPy

LINKÖPING UNIVERSITY

TU Delft

GKN AEROSPACE

SAAB



AVANCEZ 1829

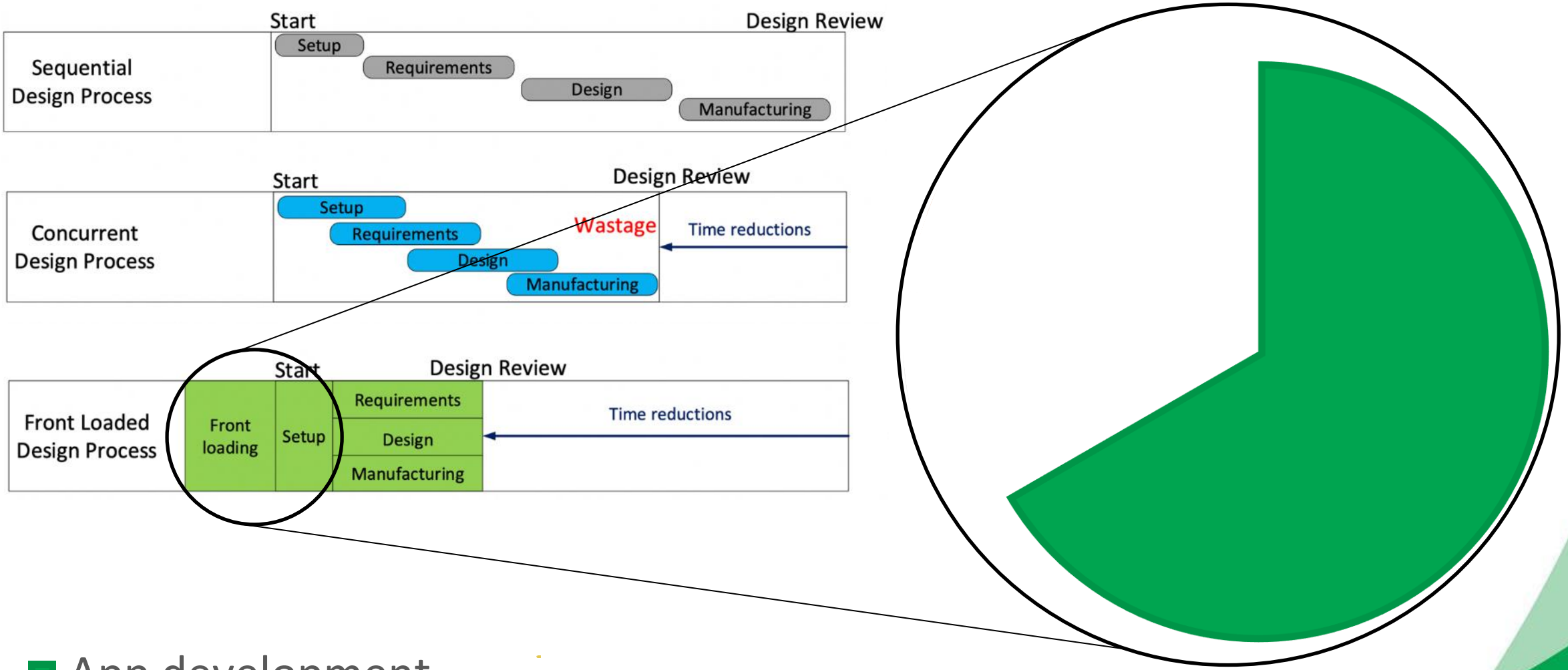
CHALMERS UNIVERSITY OF TECHNOLOGY

DEFAINE Objectives

- To reduce recurring cost in the design of aerospace systems and reduce the lead-time for design updates
- By enabling front-loading
- Via a software framework that allows design engineers to perform large-scale design exploration studies

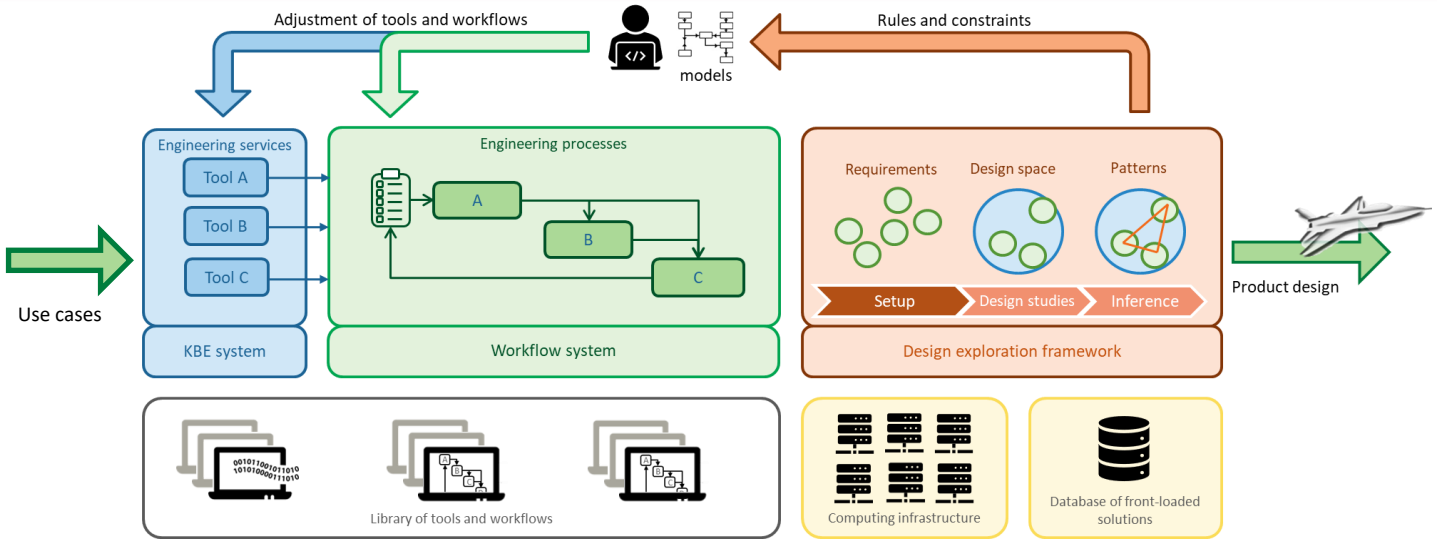
- Goals:
  - 10% cost reduction during design phase of aerospace systems
  - 50% lead-time reduction for design updates

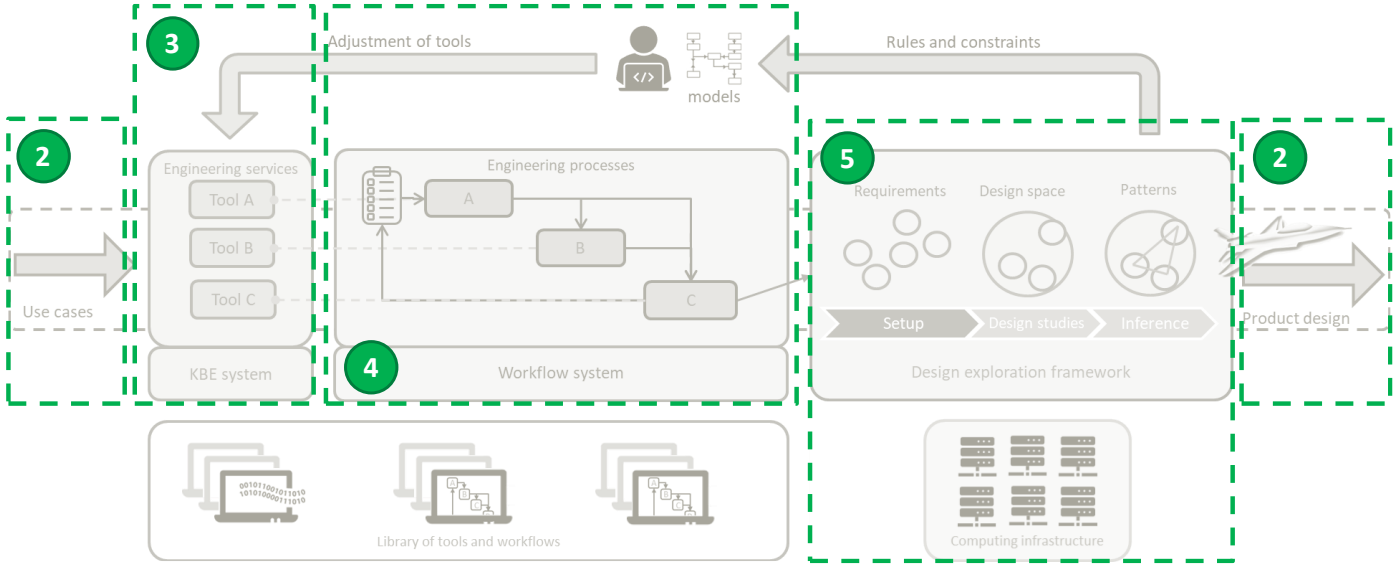
DEFAINE goals: Front loading



- App development

DEFAINE Overview





WP 2. Industrial use cases
WP 3. Engineering services and development methodologies
WP 4. Workflows and data exchange standards
WP 5. Design space exploration and AI

WP 1: Project Coordination
WP 6: Dissemination and exploitation

Industrial use cases

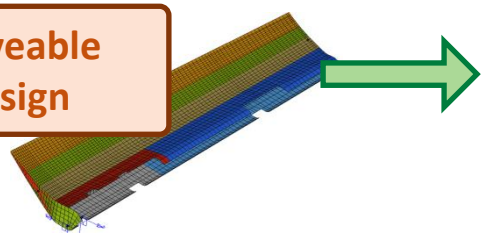
SAAB provides a UAV design case and performs on-board systems design

GKN AEROSPACE generates designs for aileron/elevator/rudder, EWIS architecture and engine.

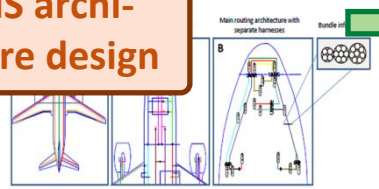
Resulting GKN capabilities can be applied across existing and future aircraft platforms

UAV design

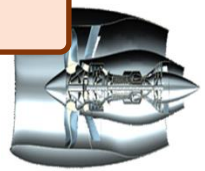
Moveable design

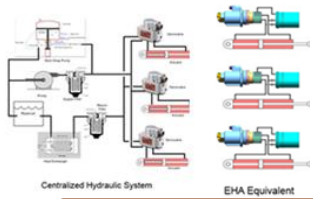


EWIS archi-tecture design



Aero engine design





On-board systems design

Displacement

New Single Aisle

Business jets

Electric & hybrid-electric

UAM

UAV

FCAS

Multi-tier aircraft design challenge

OEM

SAAB

Concept aircraft design

Early simultaneous involvement of suppliers

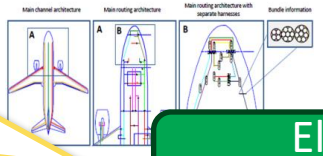
Data exchange and collaboration

TIER-1 SUPPLIER

Fokker Elmo

GKN AEROSPACE

Early risk detection in design process

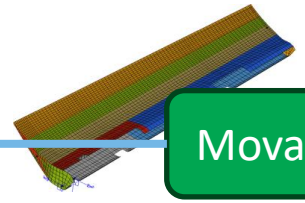


Electrical Wire Interconnection System

TIER-1 SUPPLIER

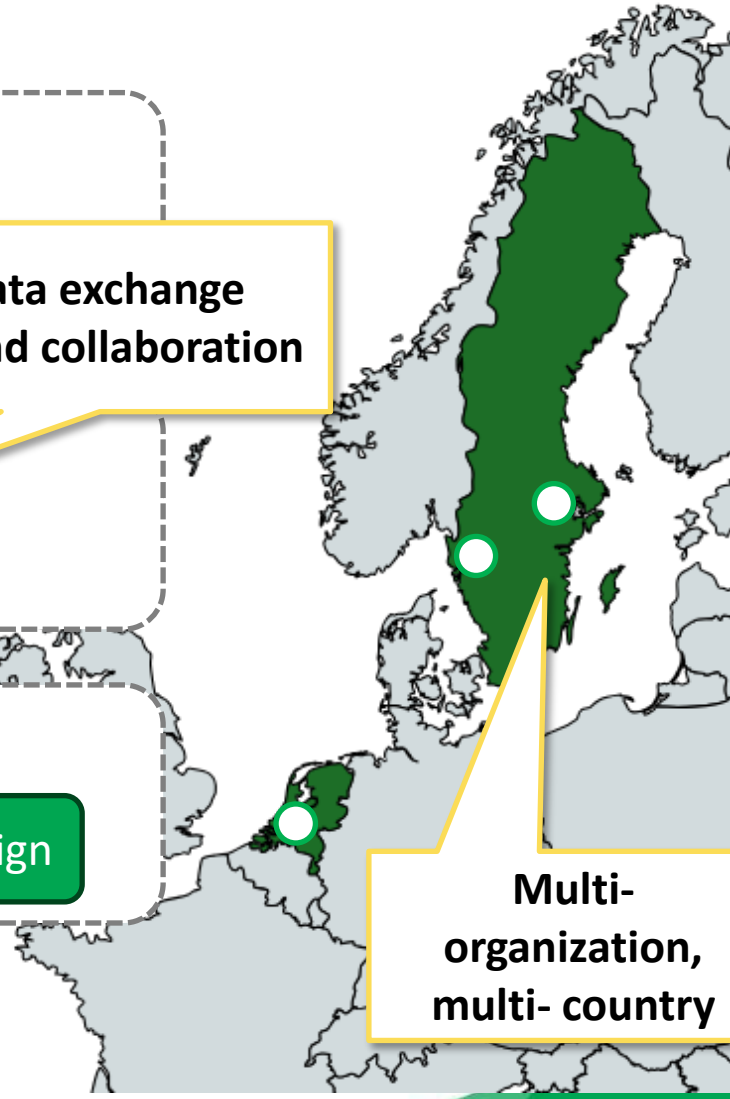
Fokker Aerostructures

GKN AEROSPACE



Movable design

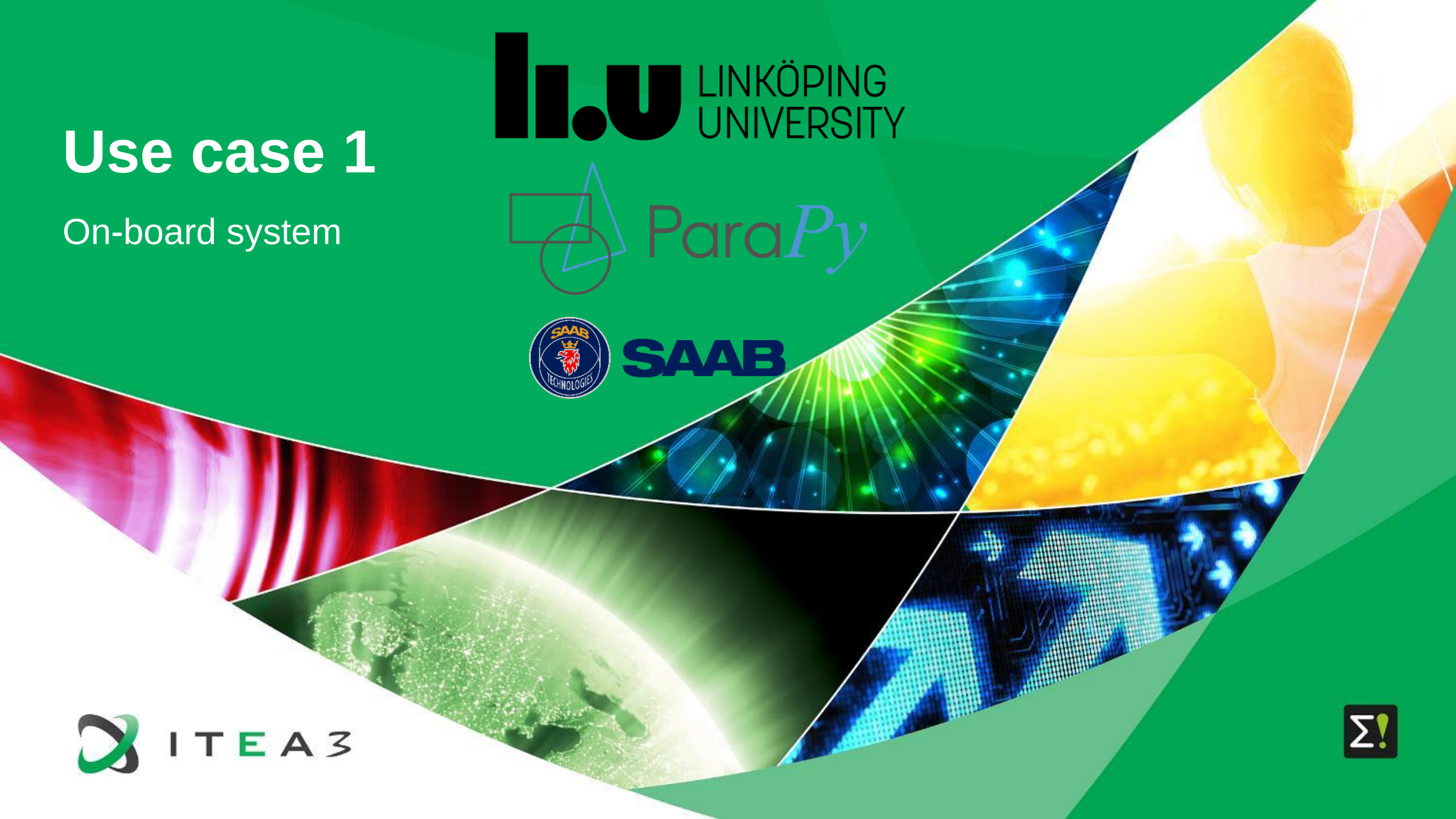
From single design towards front-loaded set of optimized designs



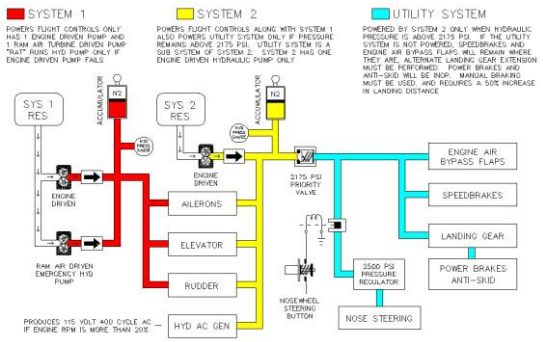
Multi-organization, multi- country

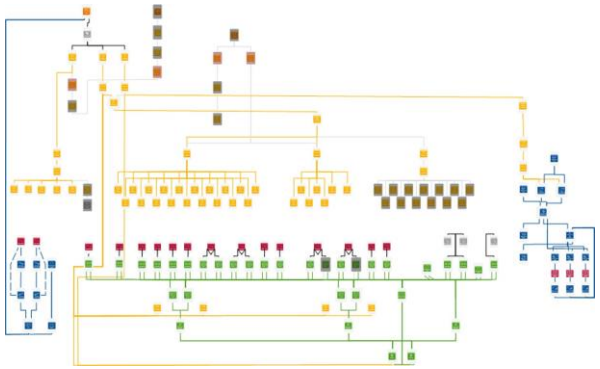
Use case 1

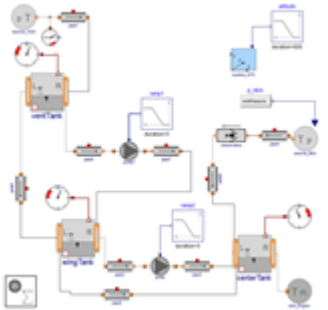
On-board system



Current way of working







Architecture and technology

Steady State

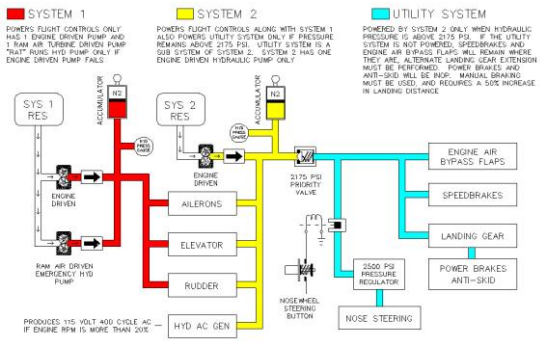
Time Domain

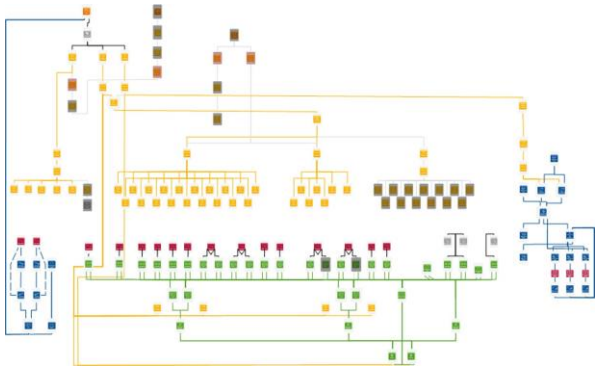
~1 week

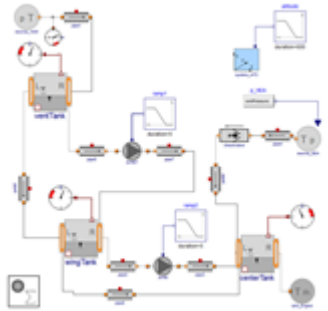
~1 week

~1 week

DEFAINE achievement



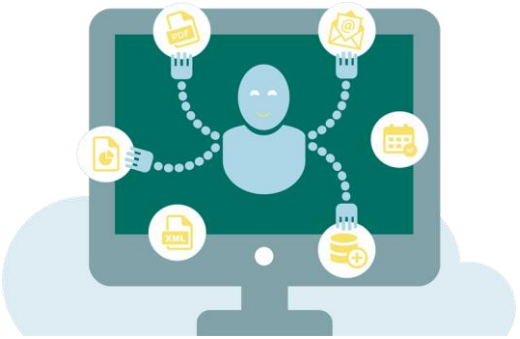




Architecture and technology

Steady State

Time Domain



Asystor APP created with:

- ParaPy SDK – Web GUI
- ParaPy Cloud

New architecture creation:~5min
Architecture instantiated in Steady State:~5min
Reduction achieved about 97%

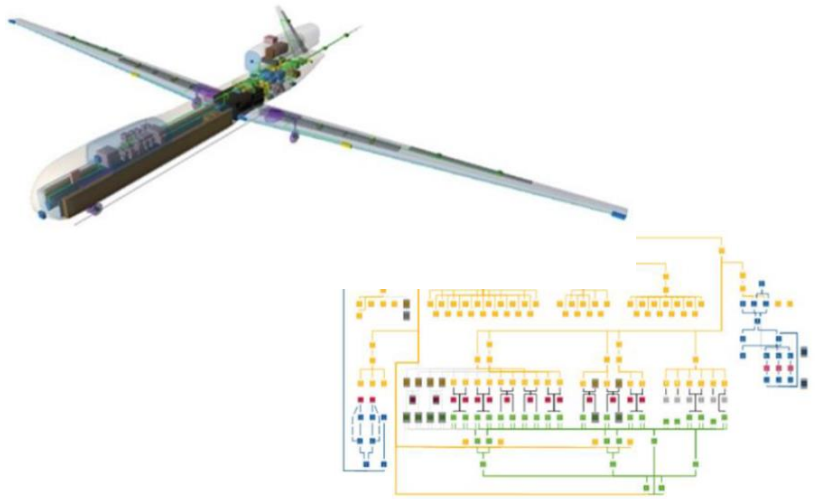
Transient model creation about ~3hours
Reduction achieved about 95%

Demonstrator: Systems Architecture Design

Collaborating partners: Saab, ParaPy

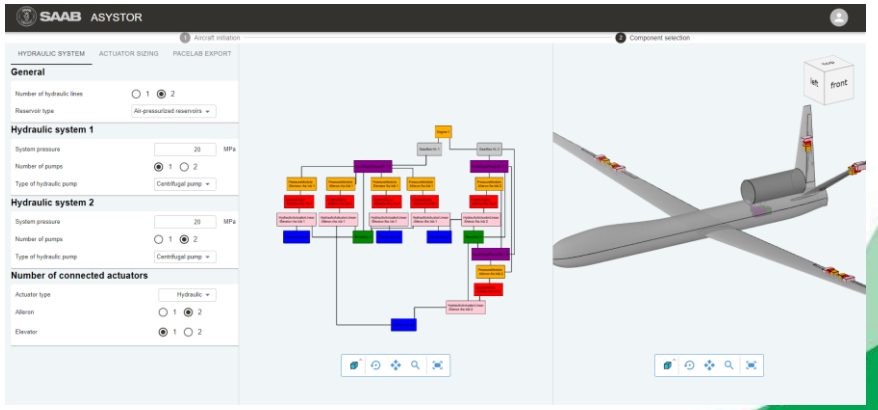
SOTA challenges:

- Systems Architecture Design takes a lot of time because knowledge is spread across multiple software tools and engineers.
- Companies prefer web applications but lack the expertise to develop and deploy these



Achievements

- 40x speed up in *setup time of design studies*
- *15x speed up in transient model creation*
- Develop and deploy a web user interface within 2 days



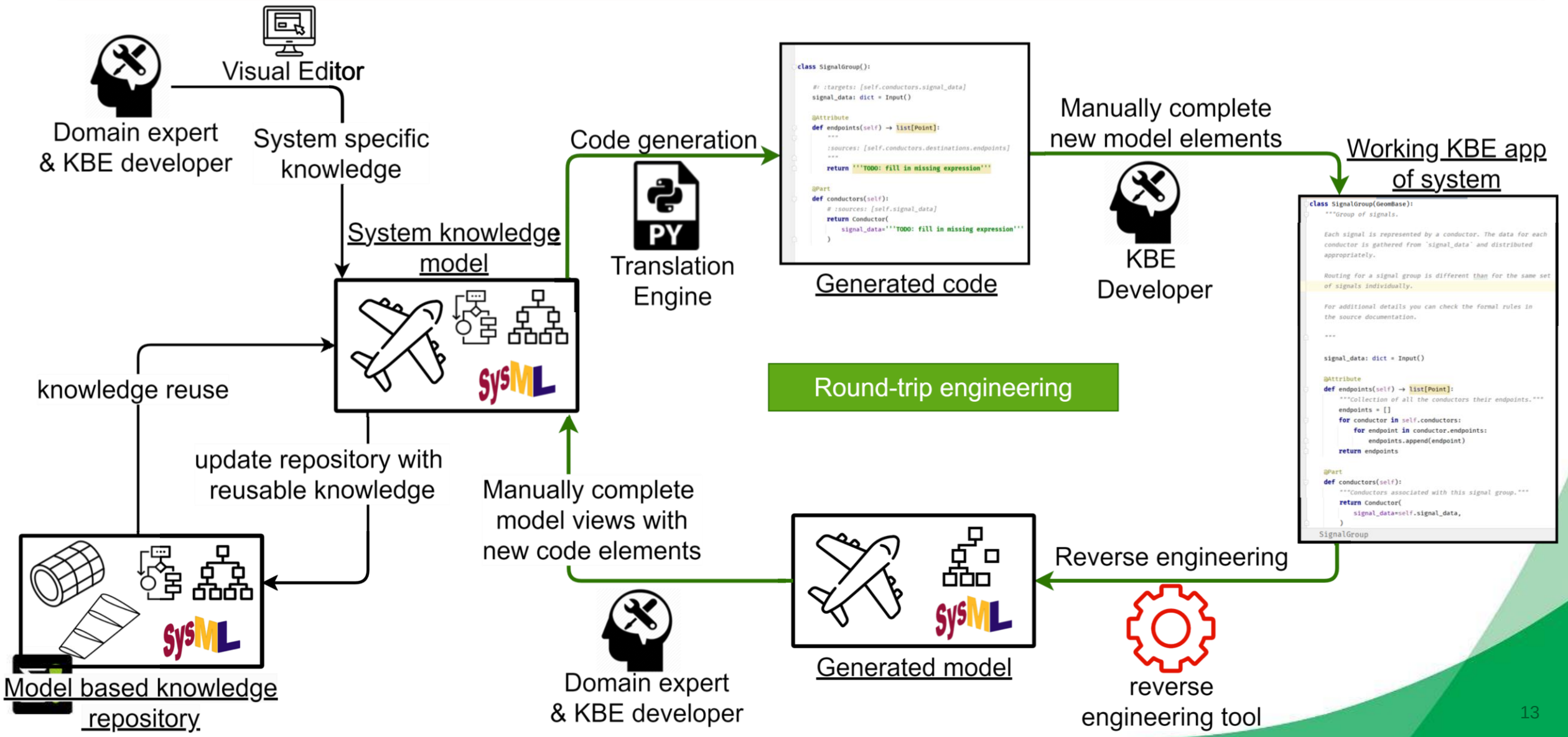
Enabling technologies within DEFAINE

- ParaPy SDK – Web GUI
- ParaPy Cloud
- GraphRemaping (Presented tomorow)

Technology development

KBE app development

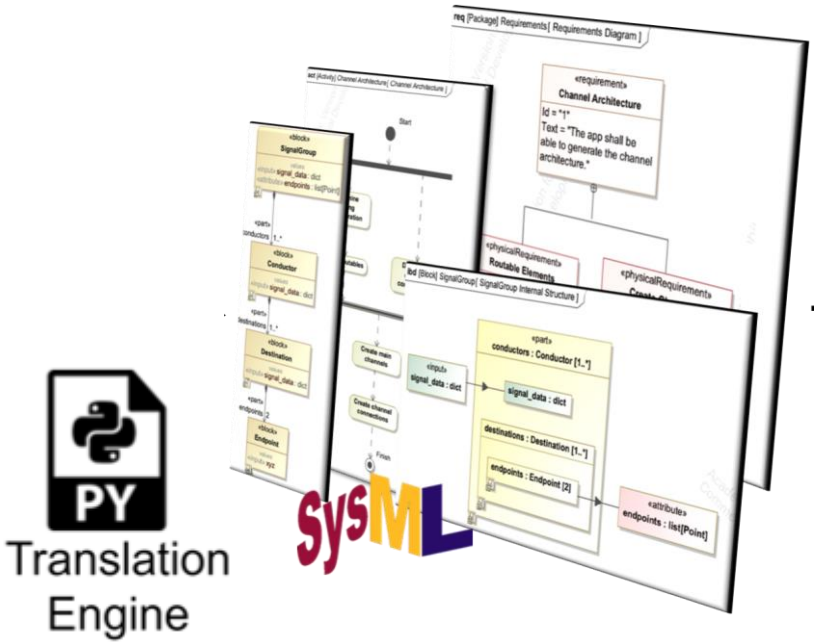
MBSE Demonstrator – Round-trip engineering



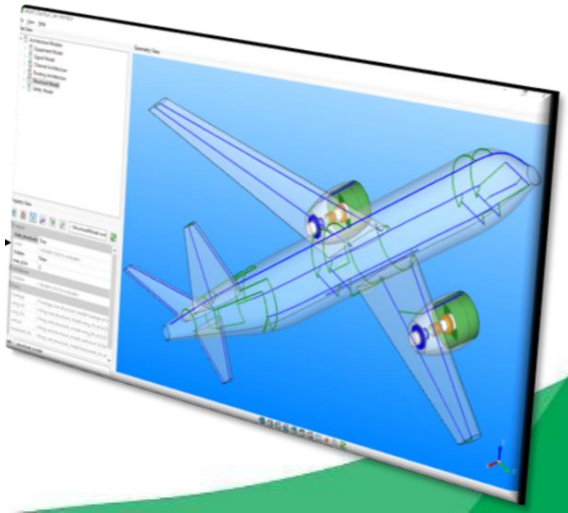
MBSE Demonstrator

Collaborating partners: TU Delft, GKN Fokker Elmo

- Achievements
  - Translation engine successfully used for Architecture Modeler based on Knowledge Model (MBSE approach)
  - 98% time reduction for KBE application skeleton code.
  - Improved TRL level for the Architecture Modeler from TRL2 to TRL3.

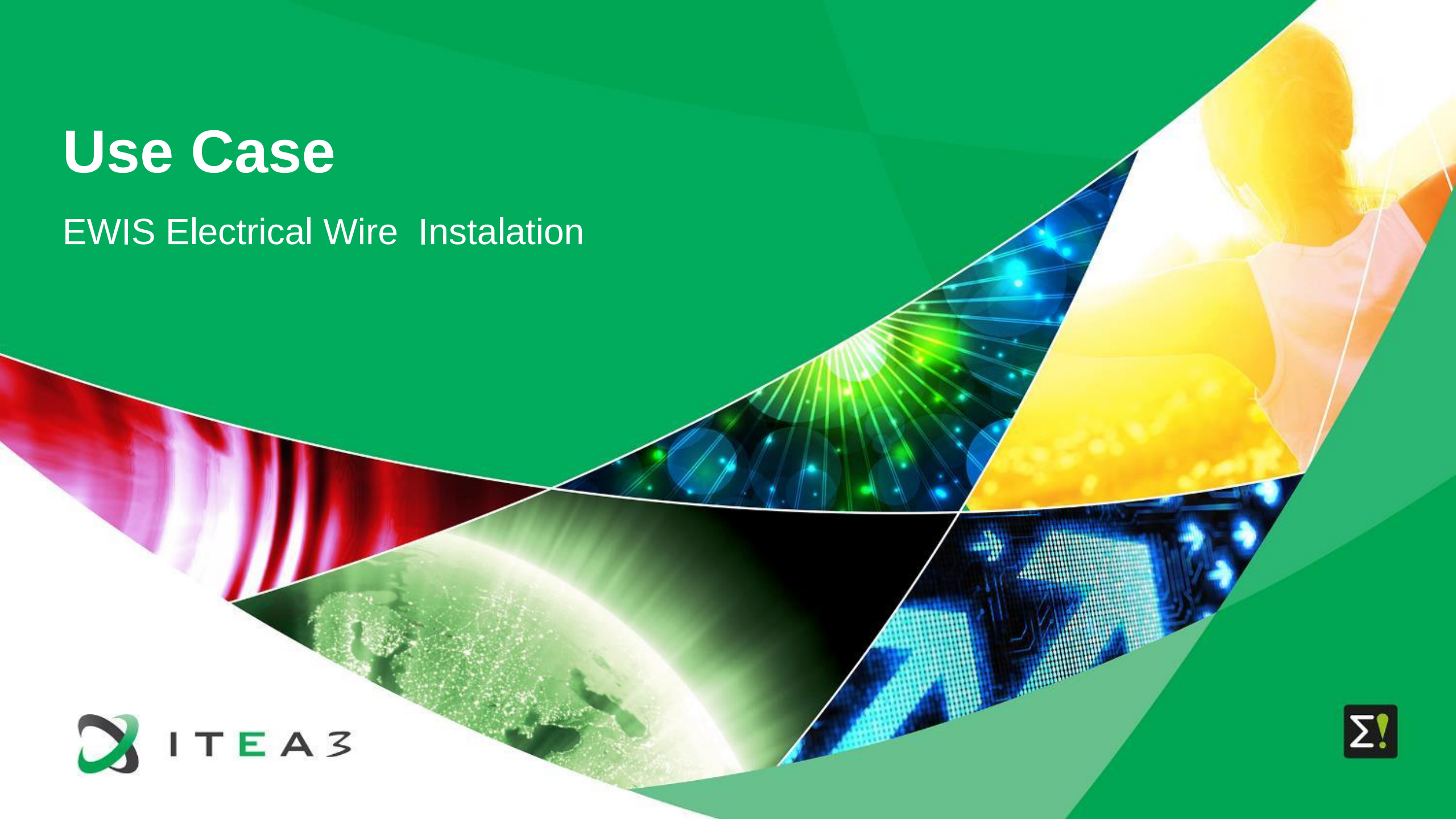


- Enabling technologies within DEFAINE
  - ParaPy KBE system
  - SysML visual editor (Magic Systems of Systems Architect)

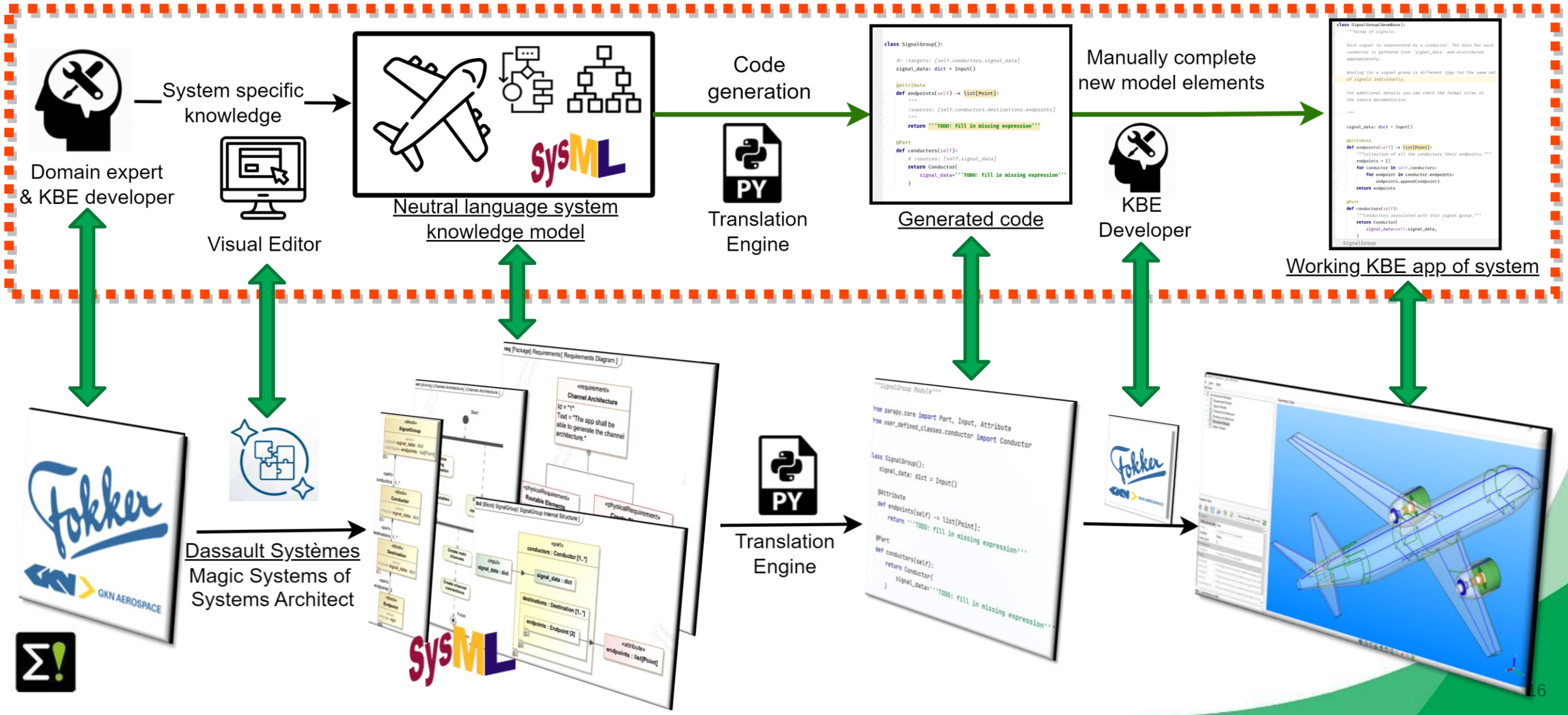


Use Case

EWIS Electrical Wire Instalation



MBSE Demonstrator – Example use-case



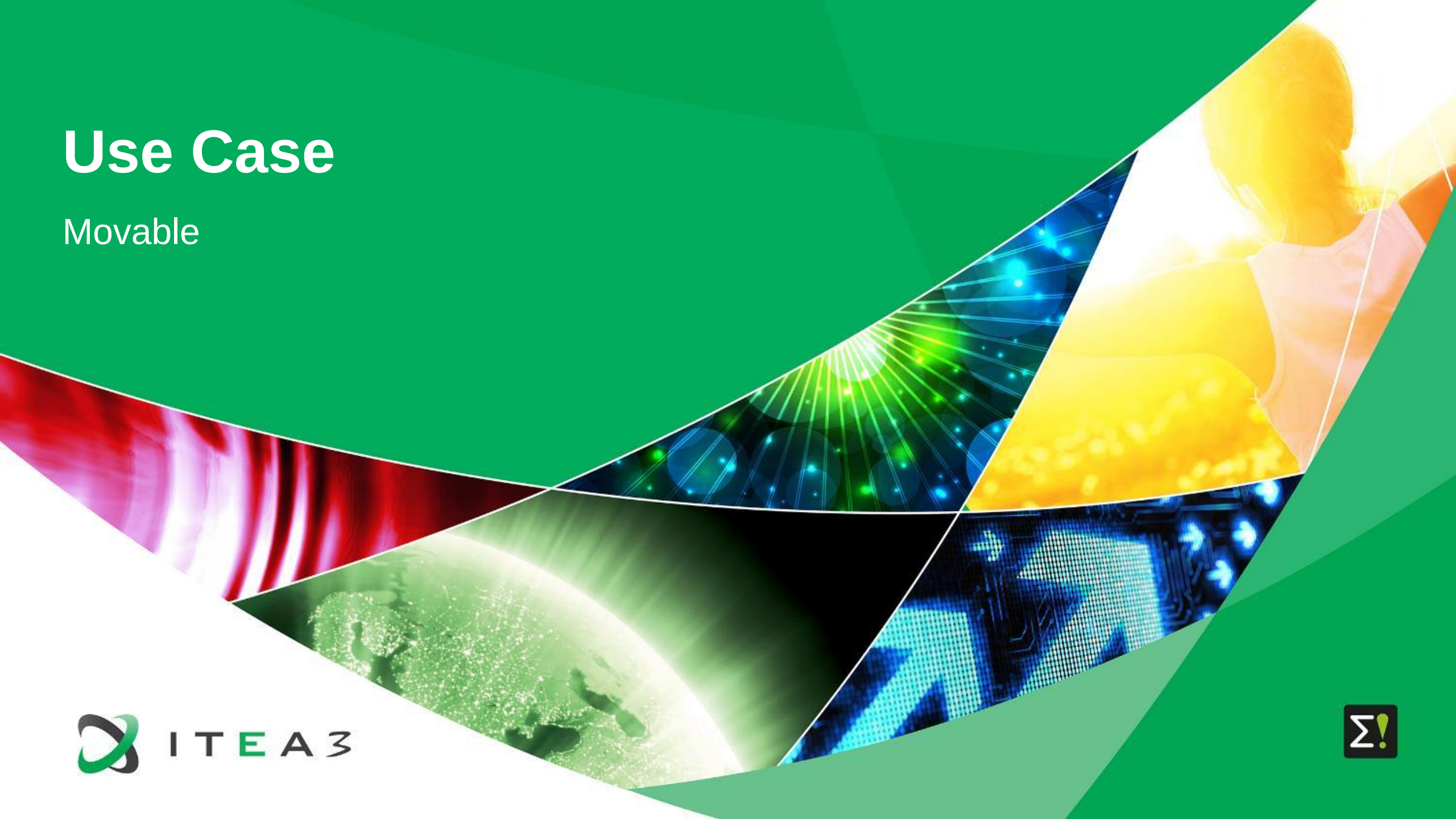
MBSE Demonstrator – KPIs & Achievements

Knowledge modelling time: the MBSE method takes almost the same time as the past knowledge capture approach.

KPI	Definition	Target (2024)	Benchmark	2023-03
KBE application development	Reduce time in: **- Initial application (skeleton)**	50% reduction	20minutes implementing manually (10 blocks)	20seconds using translation engine (10 blocks) ~ 98% reduction
Market access	Software product releases [-]	8 updates	0 updates for AM	3 updates for AM

Use Case

Movable

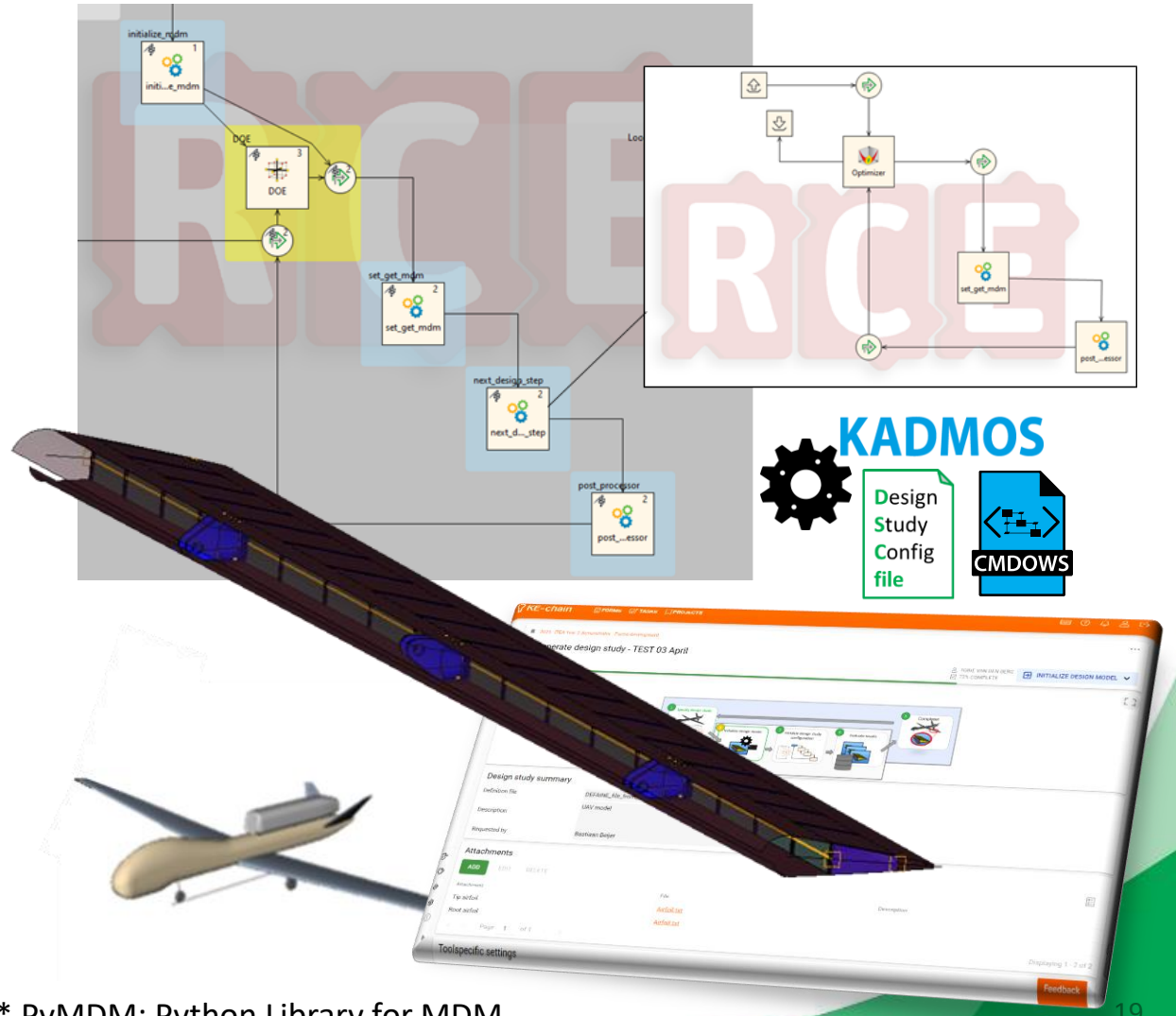


Demonstrator Movable Design

Collaborating partners GKN Fokker, TU Delft, KE-works

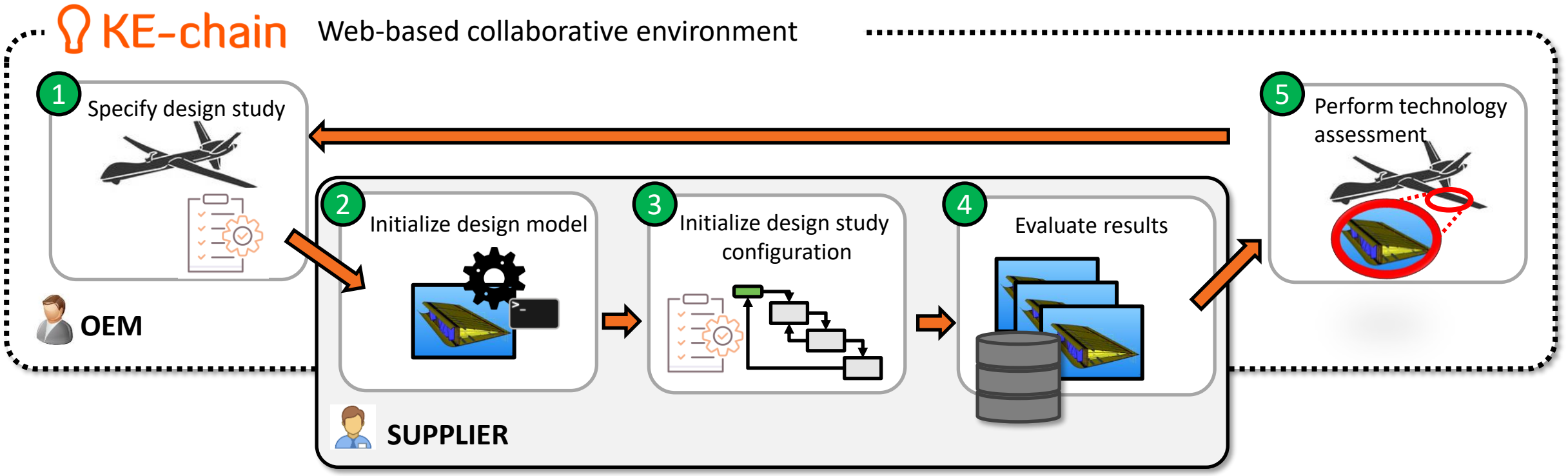
- Achievements
  - 75% reduction in workflow setup time
  - 99% reduction in workflow update
  - Multi-tier design case
  - Enabler for large scale design studies

- Enabling technologies within DEFAINE
  - Dynamic workflow reformulation through Design Study Configuration file
  - KADMOS, CMDOWS, RCE
  - MDM* Parapy KBE app; PyMDM** client
  - KE-chain, pykechain
  - DEFAINE data exchange format



* MDM: MultiDisciplinary Modeler, ** PyMDM: Python Library for MDM

Movable use case



KPIs: Movable tech demonstrator

KPI	Definition	Target (2024)	Benchmark (2021)	Measured (03-2023)
Development time of KBE applications and simulation workflows	Simulation workflow set up	75% reduction	45hrs	11hrs (75% reduction)
	Simulation workflow update	90% reduction	34hrs	0.1hr (99% reduction)

Disciplinary model integration in MDM

- **Hours > Minutes**
- By integration of disciplinary analysis as MDM models, removing the need to setup their execution in workflows and allowing for stand-alone MDA.

Direct workflow automation

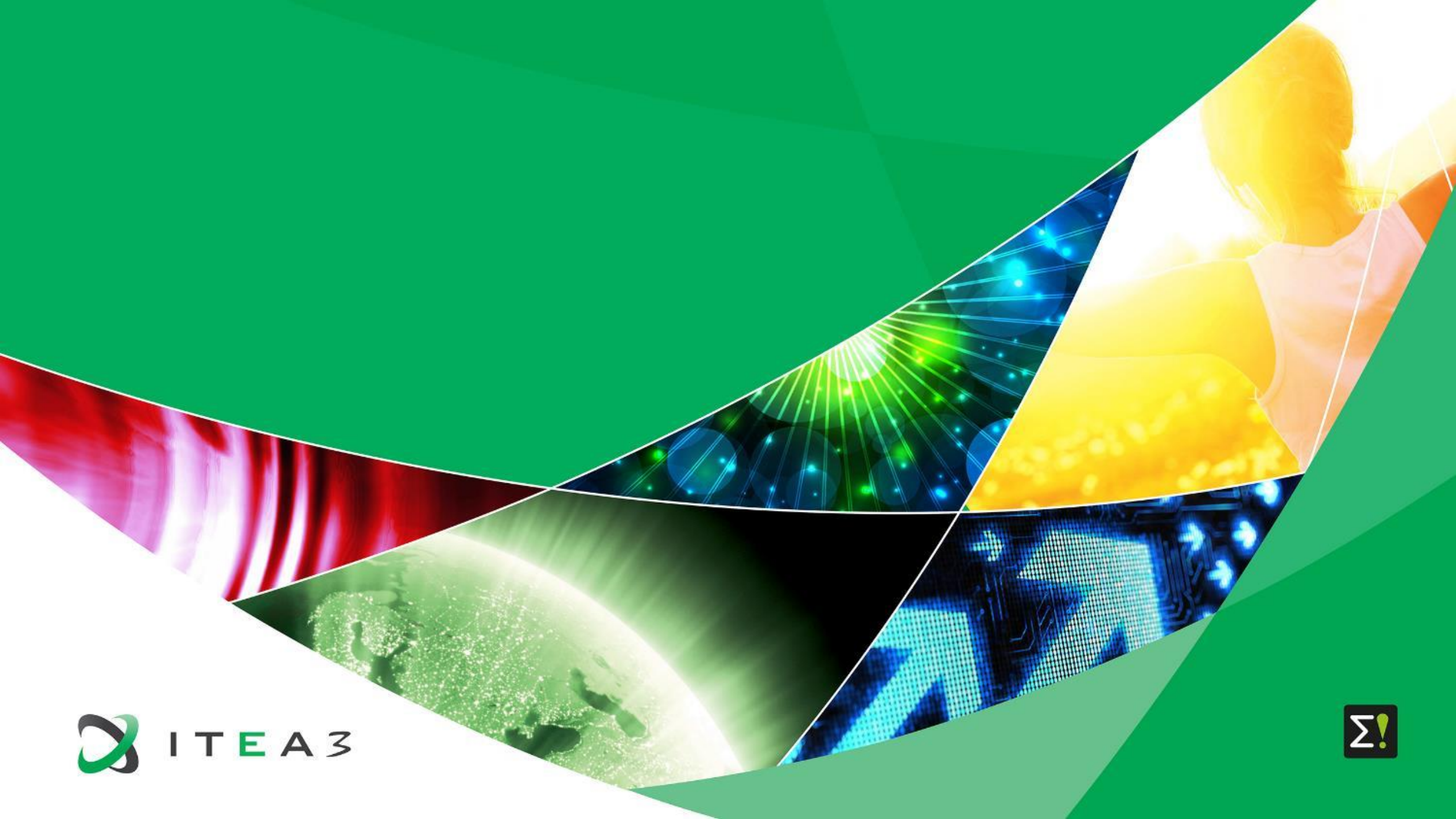
- **34 hours > 4-8 hours**
- Workflows can be automatically generated using scripts (Python and Optimus), however setup time is still significant because it is not fully reusable

Dynamic workflow generation

- **34 hours > Minutes**
- Using the new Design Study Configuration (DSC) format, the *pymdm* client and *configuration_file_handler packages* and technology KADMOS, CMDOWS, RCE, DSC and KE-chain

Optimization

- **Next step**
- RCE offers limited optimization capabilities and has some automation restrictions. Workflow generation from CMDOWS will be implemented in Optimus in future iterations.



Demonstrator: Response surface modelling and Machine Learning

Collaborating partners: GKN Aerospace, Chalmers, Linköping

- Achievements
  - Traded several Number of design objectives simultaneously.
  - Demonstrated a Front Loading approach by building surrogate modelling previous to business proposals.

- Enabling technologies within DEFAINE
  - Parametric Modelling using KBE
  - Response surface Modelling (Evaluation of several objectives using Machine Learning algorithms and a Non Linear Evolutionary optimisation algorithm)
  - Visualisation of Multidisciplinary Design Space Exploration results

KPIs: Demonstrator: Response surface modelling and Machine Learning

KPI	Definition	Target (2024)	Benchmark (2021)	Measured
Number of design objectives traded simultaneously	A measurement of how many design objectives that are possible to trade at the same time.	>20	3	Over 20
Design space sampling quality (-> RSM quality)	Improving how points are sampled within the design space in order to get a more substantiated distribution of points.	Improve	N/A	20 to more than 100% better
design space dimensionality	Number of dimensions (Parameters) and parameter types (Number, Discrete, etc.)	Increase	Calculation of Margin of Safety between previous methodology and developed methodology	45% (27% average)

Final Words

Main contributions up to today

1. Application of DEFAINE tech to individual use cases have led to significant improvements in the design process. Some highlights:
   1. Reduced setup time of design studies for aircraft systems architecture
   2. Reduced application development time by means of MBSE
   3. Reduced moveable design workflow setup time by means of automated Multidisciplinary Design Analysis
2. Nested optimization strategy using dynamic workflow reformulation to deal with varying product model architectures.
3. Formalizing the SysML definition and its mapping on ParaPy KBE system, enabling automatic KBE code generation.
4. The setup and deployment of web applications require engineers to have knowledge of the Python programming language only.

Some Key Achievements

- **Reduced lead-time:** Using the collaborative DEFAINE Front-loaded engineering environment, DEFAINE Date exchange format and automations in workflow execution and (re-)configuration
- **Reduced recurring cost:** Through use of underused hardware and licenses as part of implementing the DEFAINE frontloading methodology
- **Design space dimensionality:** Using the DEFAINE DSE Toolset trade-studies can be performed that were not possible before.