EDGE AI Academy

Summer School

7-8 July 2025, Pisa, Italy

Edge AI Academy Summer School

Systematic Definition and Verification of Edge AI Requirements

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7-8 July 2025 Pisa, Italy

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Introduction

- **Definition** and **verification of** meaningful **requirements**
  - **skills to specify and validate** AI system behavior
  - **challenges** and **best practices** through **real-world examples**
- hands-on experience with a **practical, tooling-supported workflow using VeriACT**
  - **traceability and real-time dashboards enhance transparency**, quality, and control in requirement verification

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Outline

1 **Requirement Definition**

Defining Edge AI requirements terminology.

2 **Edge AI Practical Examples**

Showing examples of Edge AI requirements and its verification.

3 **Tool Supported Verification Flow**

Demonstrating systematic requirement verification in VeriACT.

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Outline

1 **Requirement Definition**

Defining Edge AI requirements terminology.

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Definition

Requirements =

- a statement that describes **a need or a condition that must be met** in order to achieve a specific goal or objective
- basis for **implementation** and **quality**

Target Group	stakeholder, customer, management
Abstraction Level	high
Characteristics of Good Requirements	natural language clear & concise, specific, measurable, achievable, relevant, time-bound

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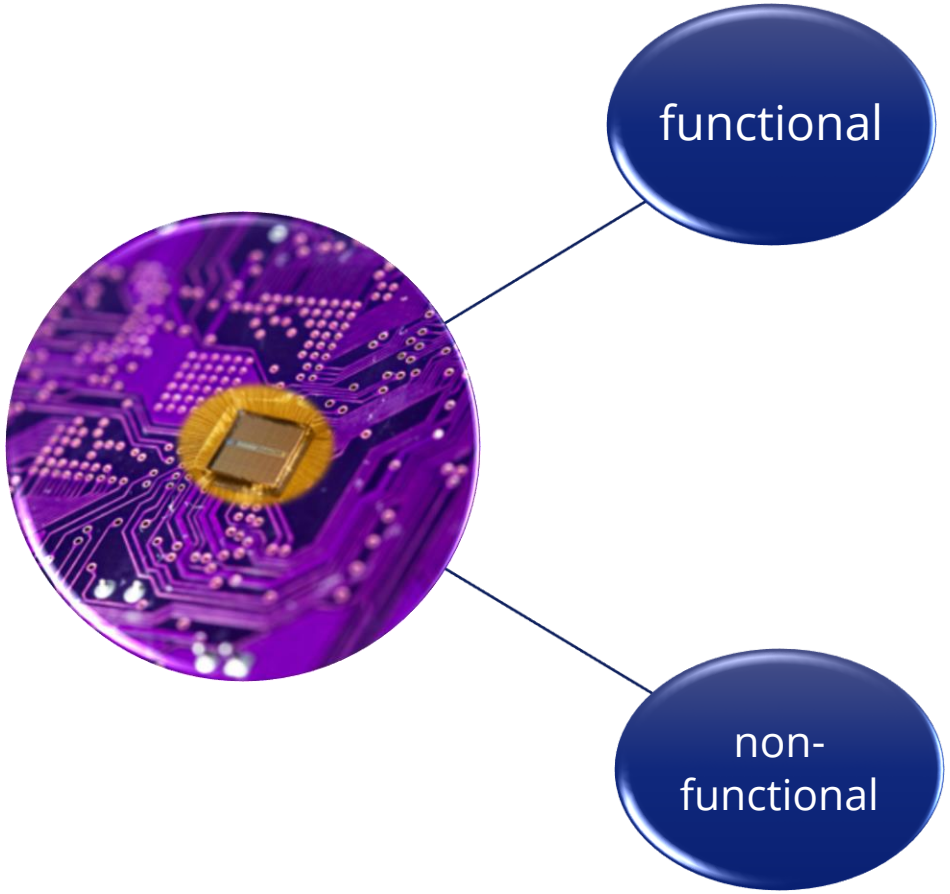
Requirements



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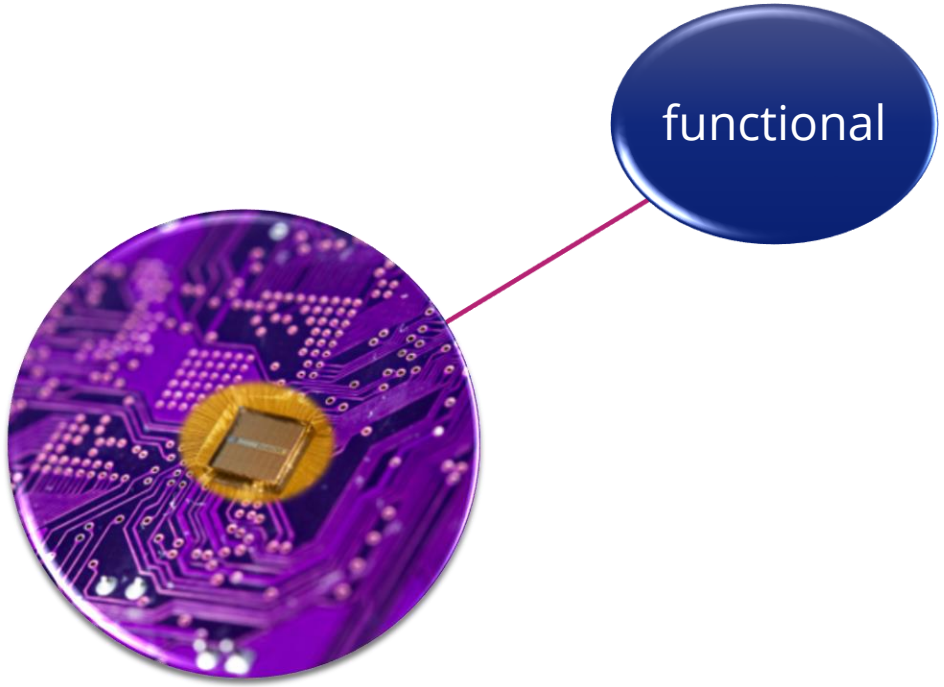
Requirements



- **what** an Edge AI system or its component **should do**
- **system features**, **capabilities**, and **behaviors** between input and output
- referred to **as quality requirements** imposing **constraints on the design or implementation** (such as performance requirements, security, or reliability)
- **related to user tasks** and **system operations**

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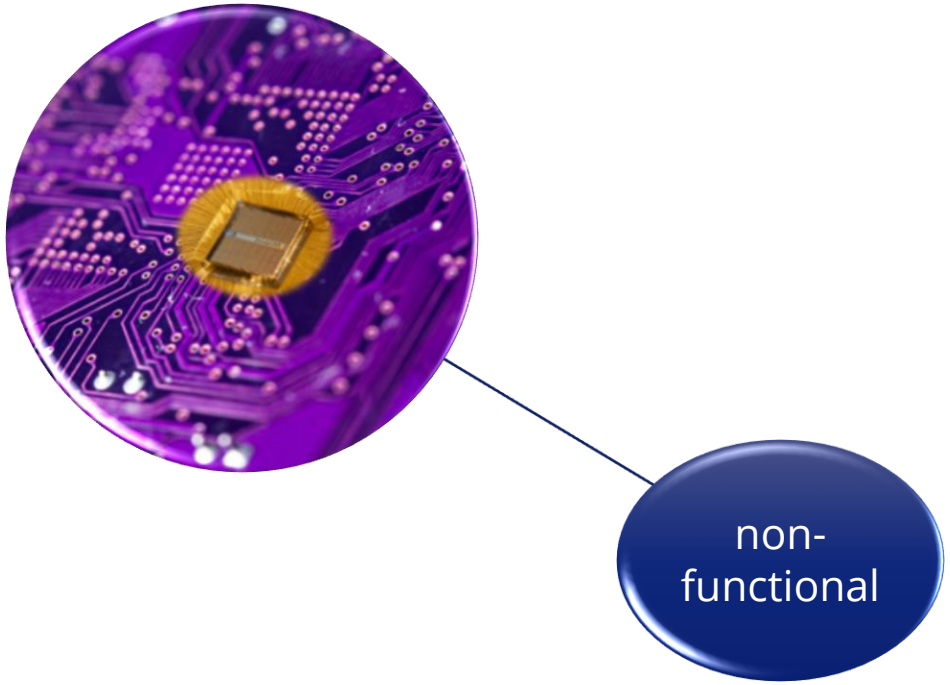
Requirements



- **how** the system **performs**
- **quality attributes**, **performance**, and **constraints** defined in **ISO25010**
- based on defined **eight quality characteristics**:
  - functional suitability, reliability, performance efficiency, usability, security, compatibility, maintainability, and portability.
- **Support functional requirements** and impact **user satisfaction**

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Requirements

ISO 25010 – Product Quality Model

	Functional Requirements (FR)	Non- Functional Requirements (NFR)
Requirement	❖ mandatory	❖ “non”-mandatory
Objective	❖ to verify the functionality	❖ to verify the performance
Area of Focus	❖ on user requirement	❖ on the user's expectation/ experience
End Result	❖ demonstrator feature	❖ demonstrator properties
Capturing	❖ easy to capture	❖ hard to capture
Capturing Type	❖ captured in demonstrator	❖ captured as a quality attribute

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ISO 25010 – Product Quality Model

8 characteristics + 31 sub-characteristics

Functional Suitability
- Functional Completeness
- Functional Correctness
- Functional Appropriateness

Usability
- Appropriateness Recognisability
- Learnability
- Operability
- User error protection
- User interface aesthetics
- Accessibility

Performance Efficiency
- Time-behavior
- Resource Utilization
- Capacity

Maintainability
- Reusability
- Modularity
- Analyzability
- Modifiability
- Testability

Compatibility
- Co-existence
- Interoperability

Security
- Confidentiality
- Integrity
- Non-repudiation
- Accountability
- Authenticity

Reliability
- Maturity
- Availability
- Fault tolerance
- Recoverability

Portability
- Adaptability
- Installability
- Replaceability

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Outline

2 Edge AI Practical Examples

Showing examples of Edge AI requirements and its verification.

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Demo 1 – Smart Semiconductor Manufacturing Assistant (SSMA)

Support Efficient and Effective Quality Management

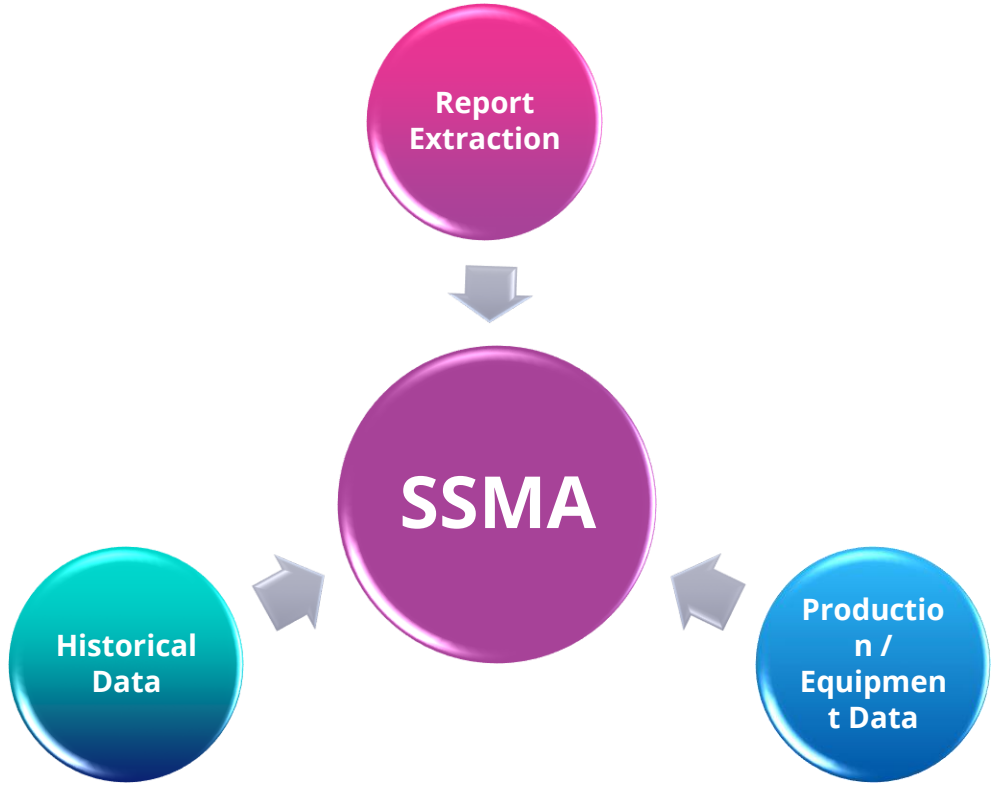
- quickly **identify**, **predict**, **classify** potential failure, failure **risks**, failure **causes**
- support domain experts in making **fast and informed decision**

Connect Domain Knowledge and data

- **human domain knowledge** are available in **technical documents**
- **Data** collected during **production**

Identify AI based causal links based on

- **production and equipment relevant data**



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Demo 1 – SSMA | Requirements

	Functional Requirements	Non- Functional Requirements
	SSMA Data completeness	**Maintainability: Modularity**
Definition	❖ a **web-based application** collecting and displaying **knowledge** and **data** from **defined sources** ❖ **user interface** supporting domain experts in making **informed decisions quickly** while ensuring **consistent levels of data detail** in collection phase.	❖ each module should perform a **distinct function** ❖ can be developed, modified, replaced or scaled **without requiring changes to other** modules
Target	❖ > 16 data sources	❖ max. 1 direct dependency
Others: (not covered today)	❖ document knowledge ❖ data extraction and analysis out of FailureTreeAnalysis graphs	❖ performance efficiency: time- behavior ❖ Functional Suitability: Functional appropriateness

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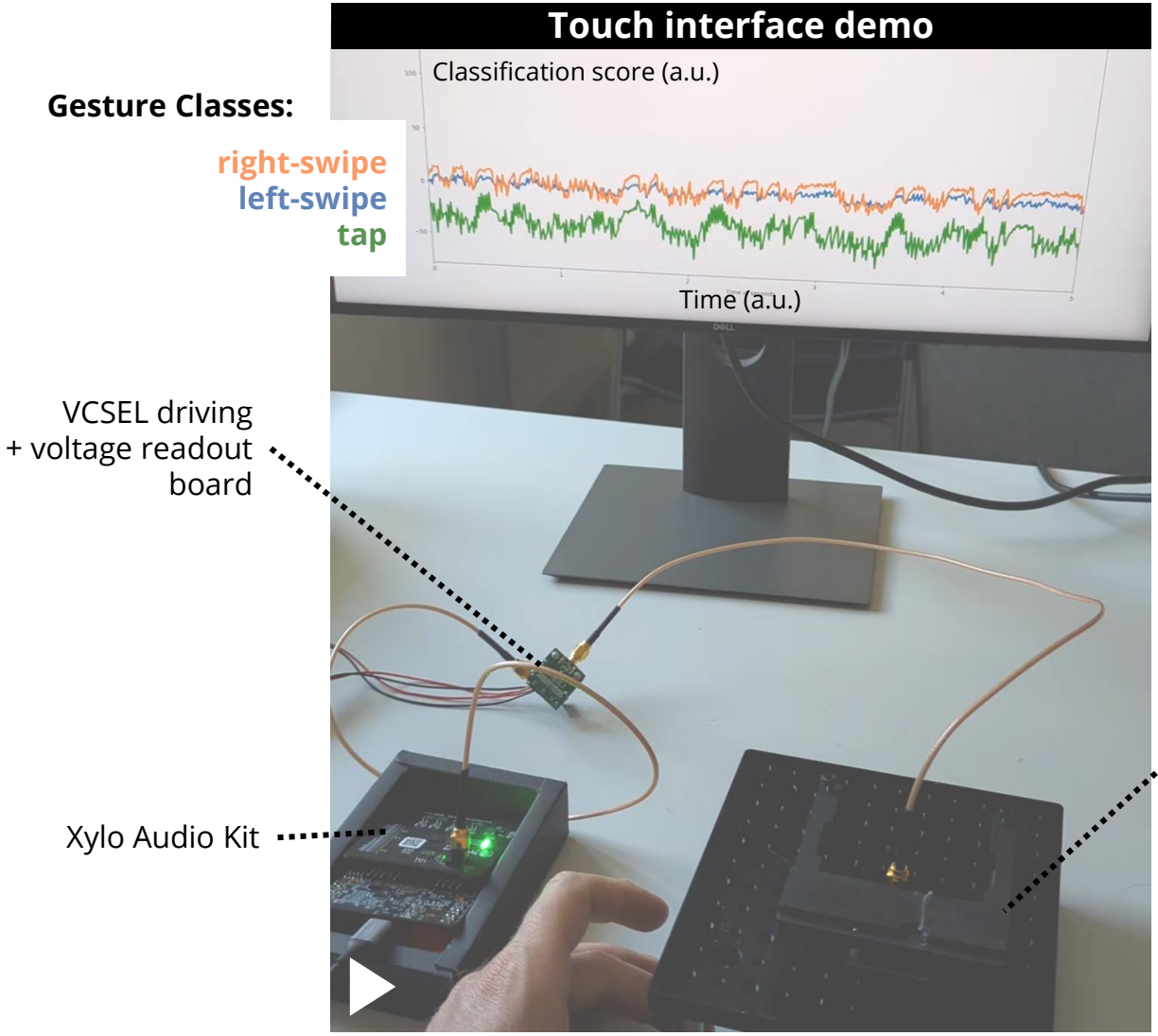
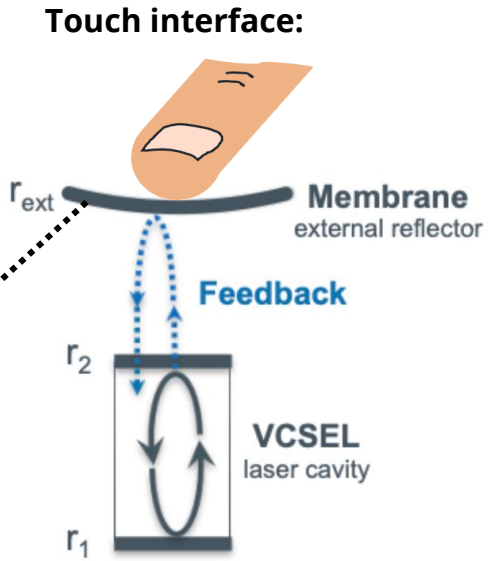
Demo 2 – Gesture Recognition

- ML sensor architecture where **sensor output = Spiking Neural Network (SNN) classification scores**
- Demonstrates **raw data processing on a chip** at the edge with:
  - low latency
  - low power
  - low memory consumption
- Might lead to **enhanced human–machine interfaces** for a broad range of market products, e.g.
  - consumer electronics
  - automotive
  - intelligent homes and offices





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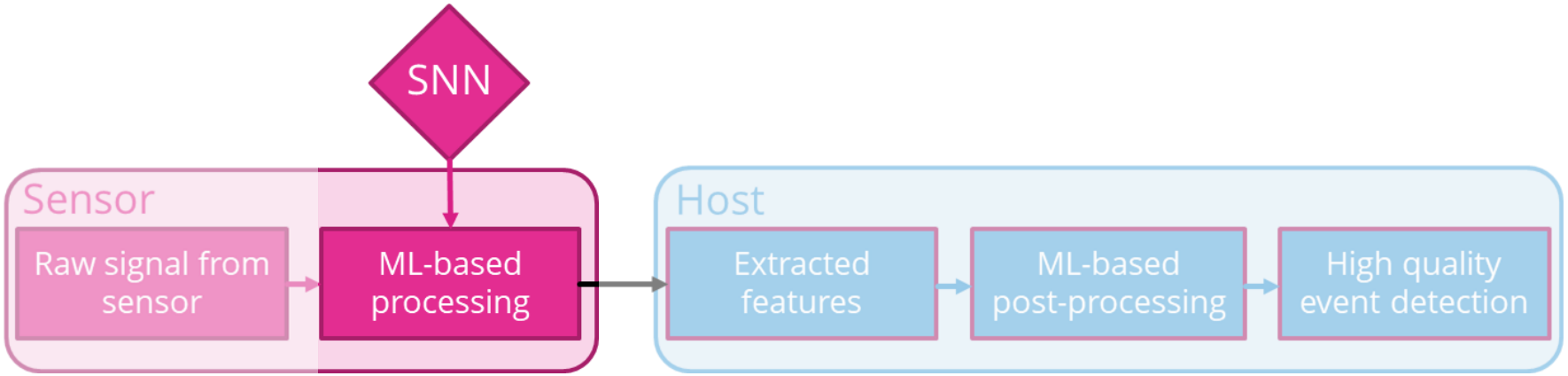
Demo 2 – Gesture Recognition

Spiking Neural Network (SNN) processor



ams OSRAM

SynSense

- ✓ Low-power processing at the edge: **50 µW** (SNN chip + AFE) (target: < 50 mW)
- ✓ Frame rate: **40 fps** (target: >20 fps)
- ✓ **Real-time processing** realized
- ✓ **HW/SW co-design** used

To show:

- ≥20% improved MAE (Mean Absolute Error) vs handcrafted algorithms
- ≥10% improved MAE vs base algorithm (without edge computation)

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Demo 2 – Gesture Recognition | Requirements

Functional Requirements

Accuracy

Definition

- accuracy of events detection and classification

Target

- ≥ 80%

Others:
(not covered today)

- Robustness to noises
- Hardware/Software co-design

Non- Functional Requirements

Performance efficiency: Resource Utilization (Power)

- how much the edge SNN chip consume power while used on raw sensor data

- ≤ 50 mW

- Performance efficiency: time-behavior
- Performance efficiency: resource utilization (memory)

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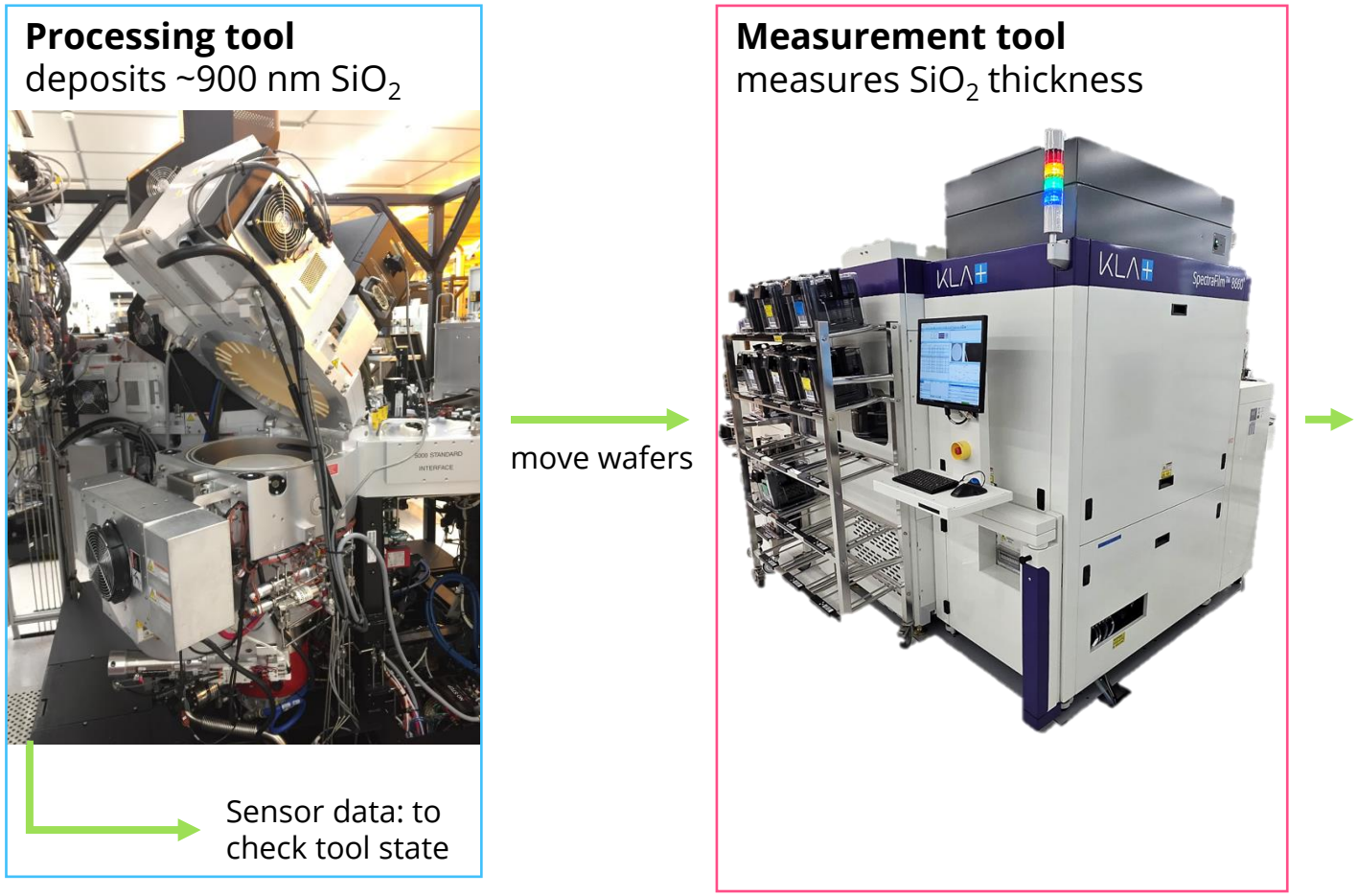
Demo 3 – Virtual Metrology | State of the Art: *Physical* !

- Each wafer undergoes **>100 processing steps** until finished product
- Many processing steps require **physical metrology step** – a check afterwards
  - Requires significant resources
  - Increases production time
  - Increases reaction time
- Processing tool delivers **~120 sensor readings**, used to **check processing tool health**



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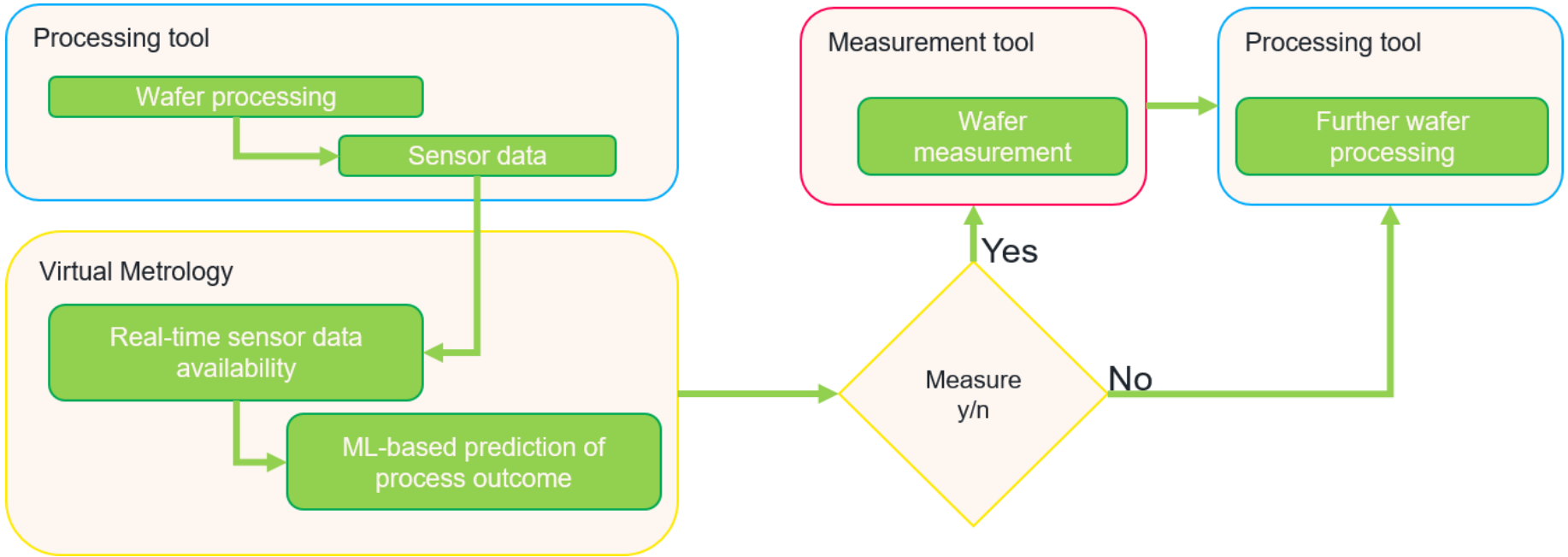
Demo 3 – Virtual Metrology | Goals & Objectives

Goal

- Prediction of **thin-film deposition** amount in **semiconductor manufacturing** (Silicon Oxide process in HDP-CVD, High-Density Plasma Chemical Vapor Deposition)

Objectives

- Use **≥ 5 sensor types** (temperature, pressure…) for prediction
- Optimize ML model until **model accuracy > 80%** of process variation
- Develop data pipeline/ infrastructure that provides an **uptime > 85%** (=equipment operational time)



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Demo 3 – Virtual Metrology | Requirements

Functional Requirements

Accuracy

Definition

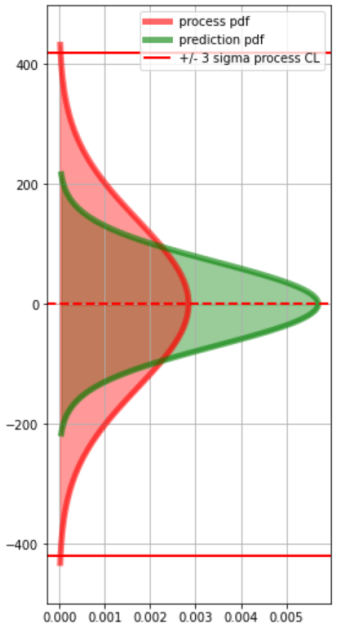
- **Purpose** How accurate is the prediction?
- **Calculation** mean total error / process variation (six standard deviations)

Target

- ≤ 80%

Others:
(not covered today)

- Breadth of Input Parameters
- Data completeness



Schematic representation of process variation and prediction error. The latter must be significantly lower!

Non- Functional Requirements

Reliability: Availability

- **Purpose** How reliable is the infrastructure? Do we get a prediction for each processed wafer, or are some predictions missing?
- **Calculation** #predicted wafers / #processed wafers

- ≥ 75%

- Maintainability: Reusability
- Usability: User Error Protection

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Outline

3 Tool Supported Verification Flow

Demonstrating systematic requirement verification in VeriACT.

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Verification Management – a tool driven approach

Introduction the verification flow and verification specific terminology.

Let´s walk through the system!
Objectives – Challenges – Workflow.

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SoftwareCUBE

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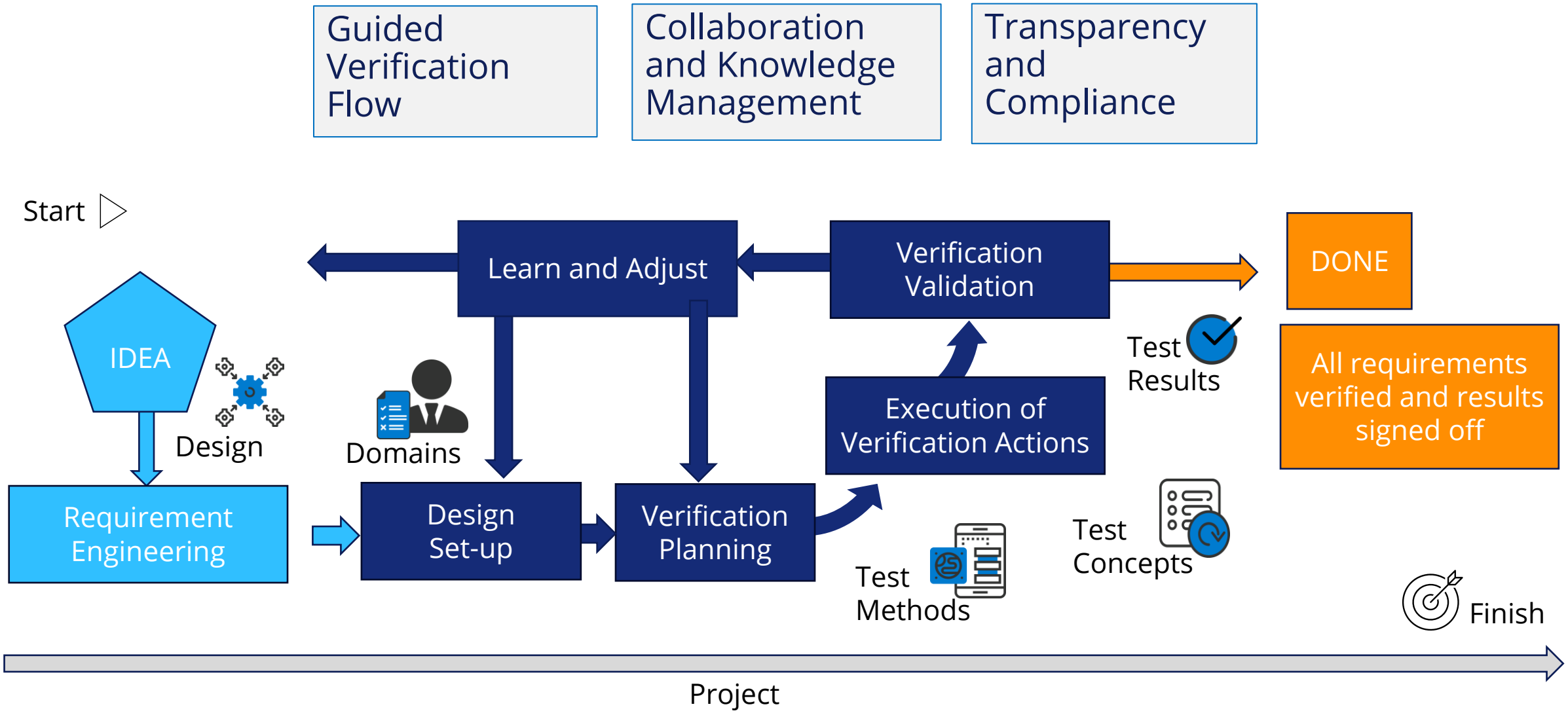
Overview



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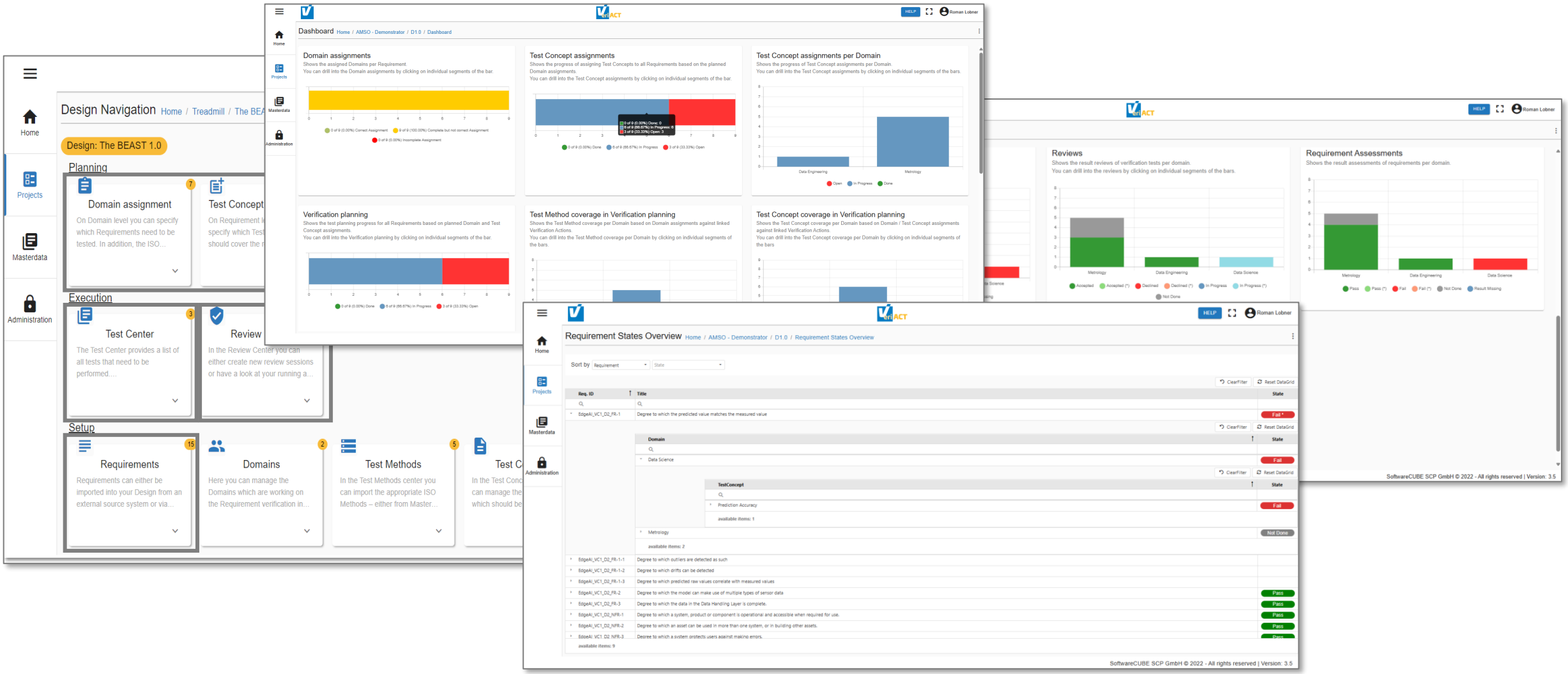
Dashboards - Project Status at a Glance



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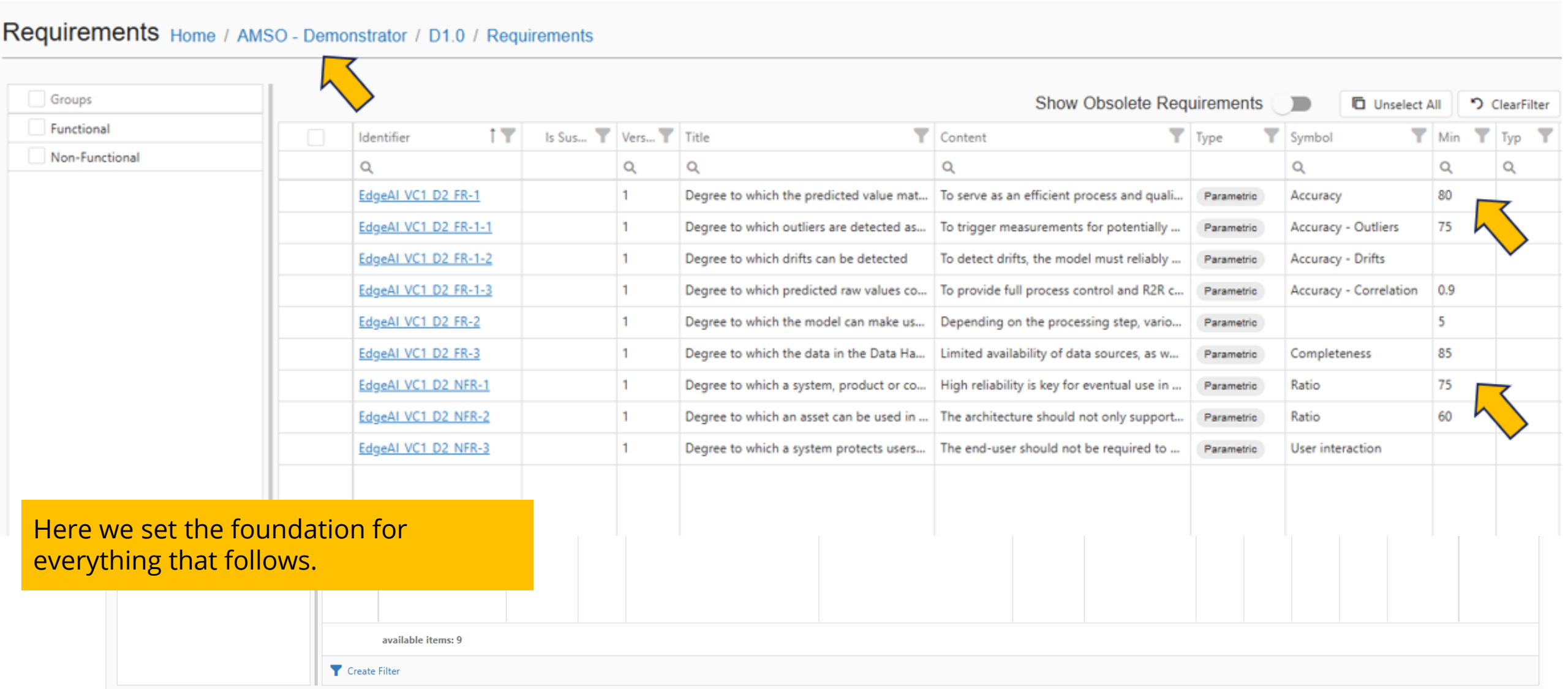
Design Set-up



Here we set the foundation for everything that follows.

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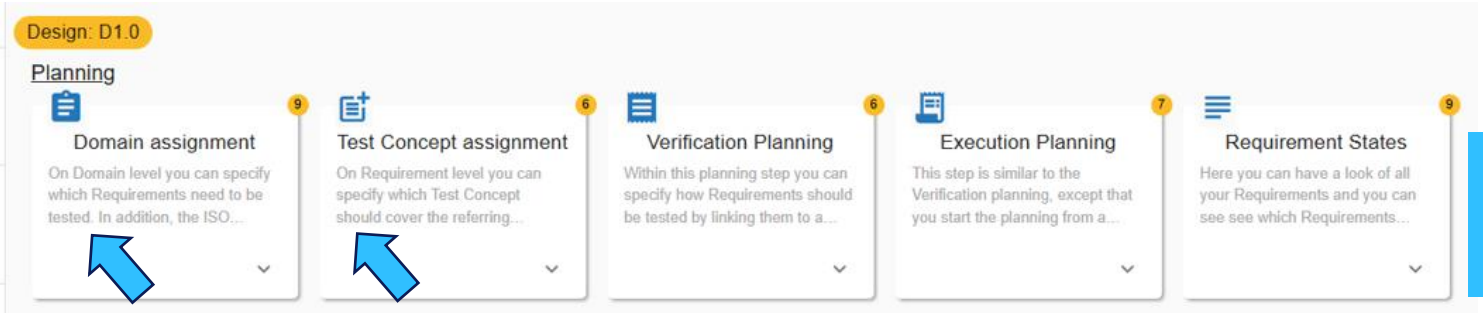
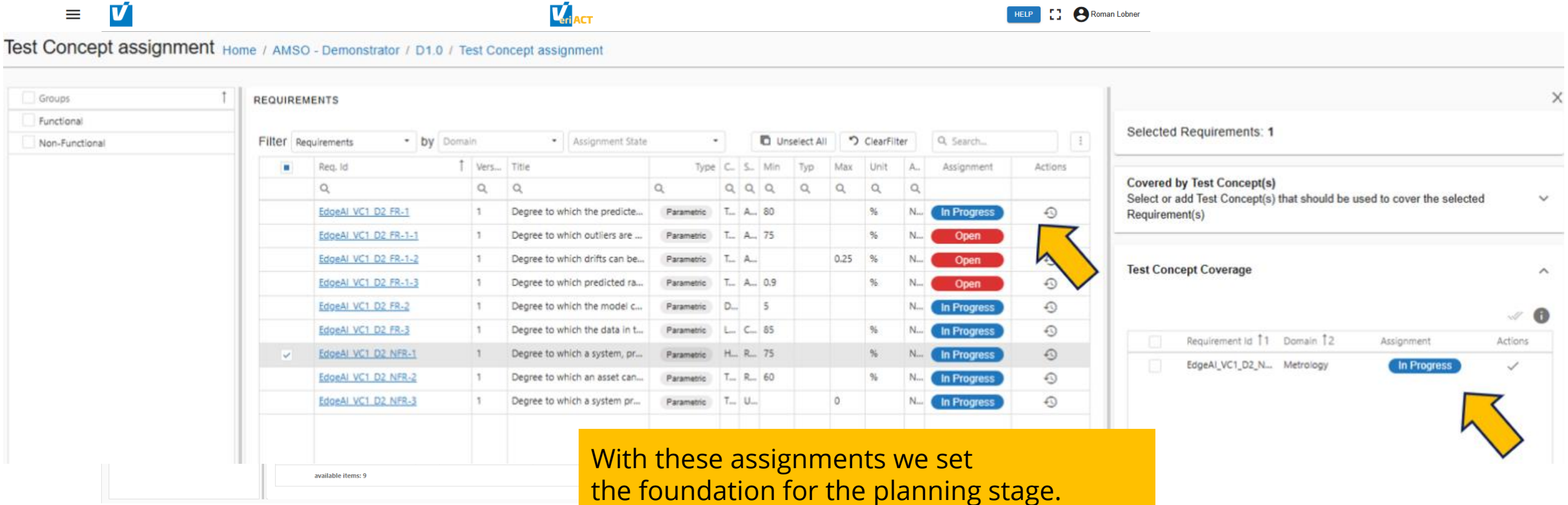
Domain and Test Concept Assignment



We now break the entire verification process down into clear, manageable steps.



With these assignments we set the foundation for the planning stage.

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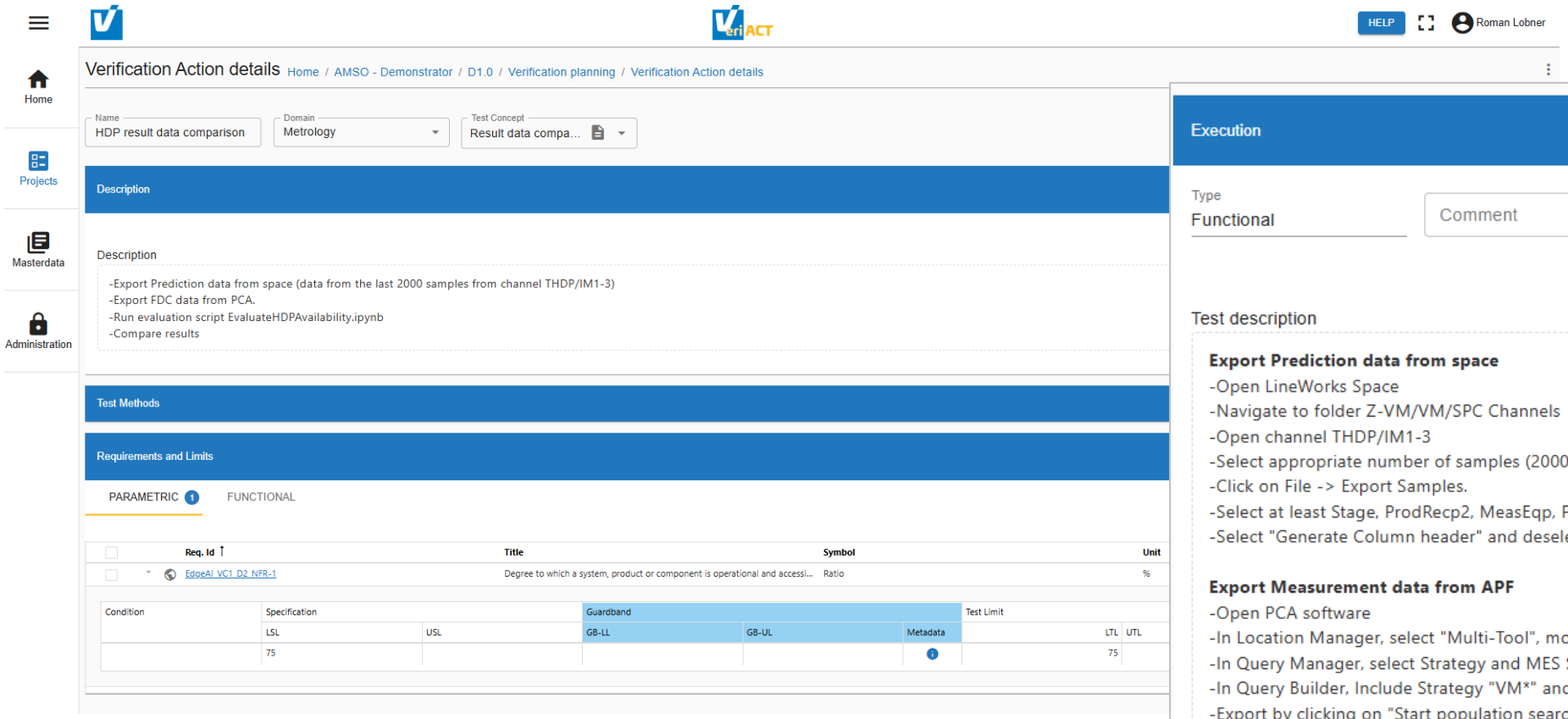
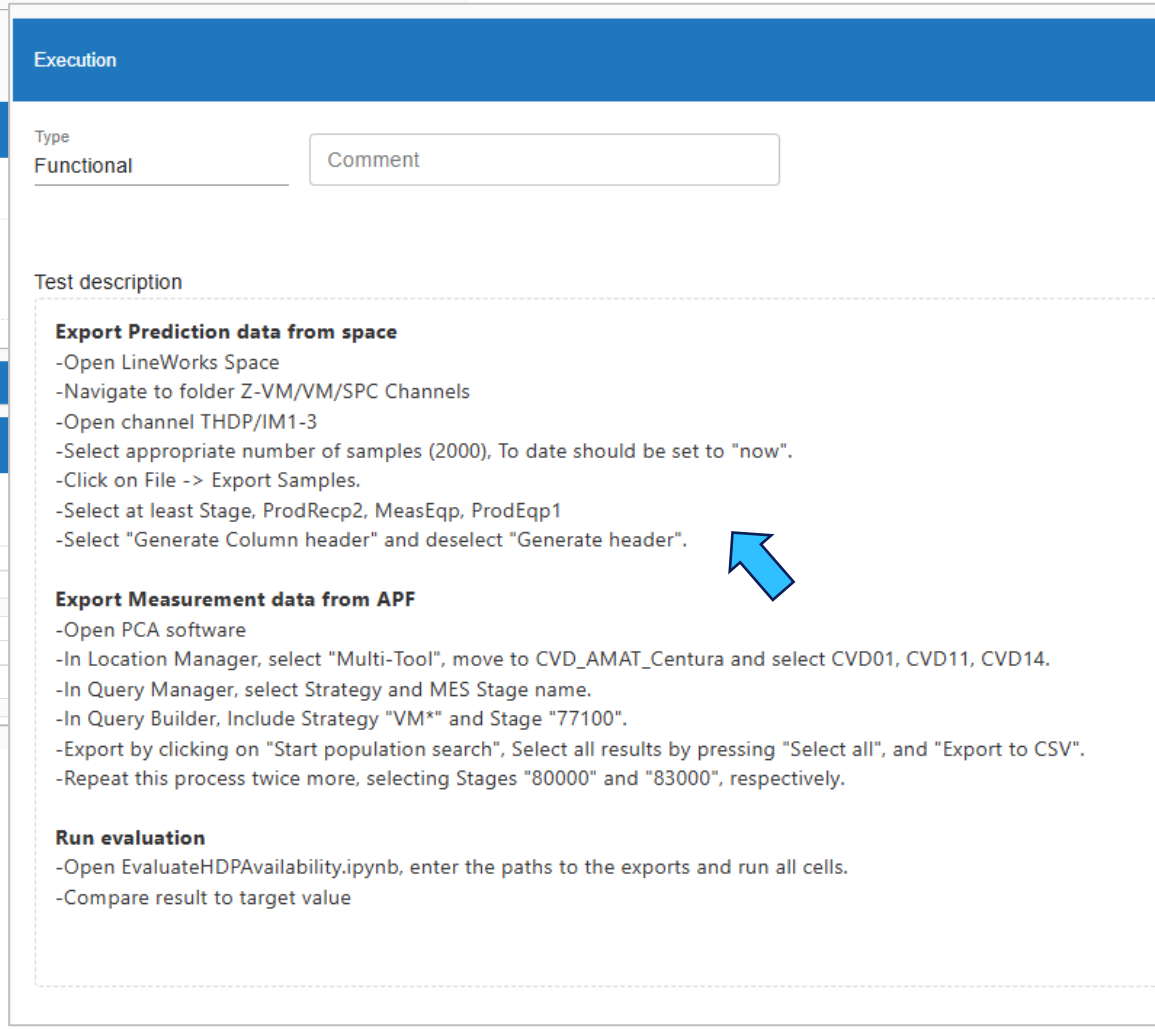
Verification Planning





Verification Actions describe each individual test procedure in detail, fulfilling previously described test concepts.

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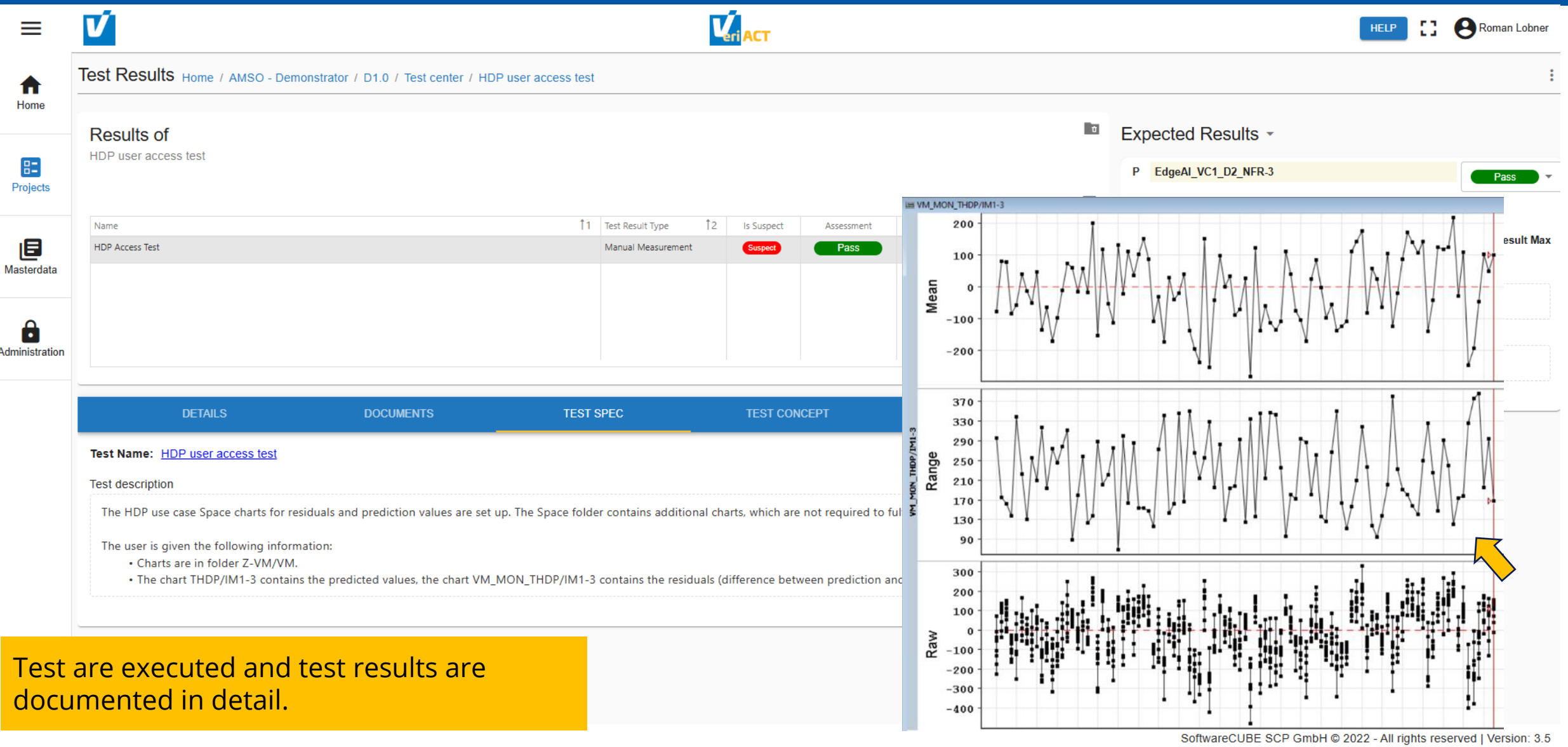
Execution of Tests in the Test Center



Test are executed and test results are documented in detail.

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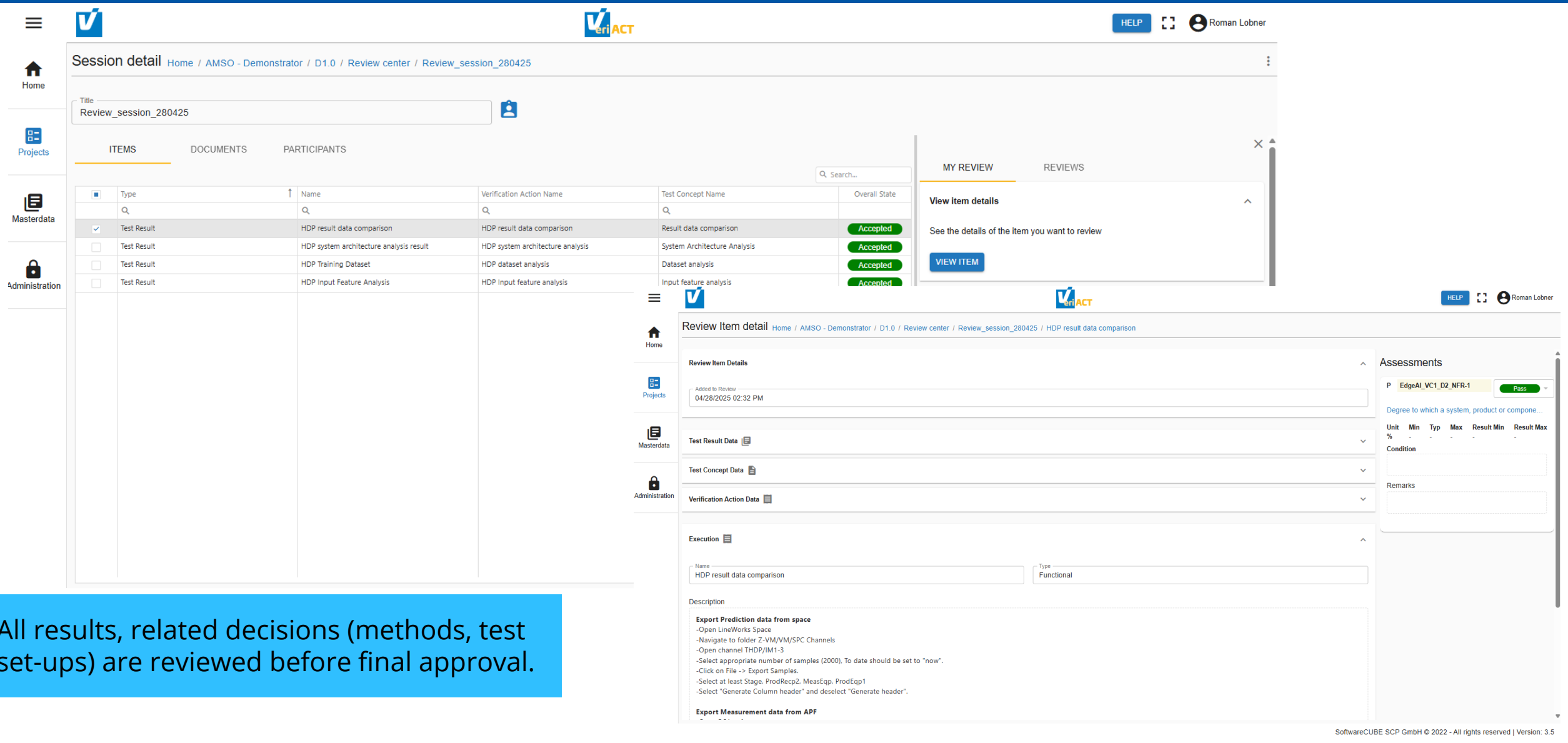
Review Center



All results, related decisions (methods, test set-ups) are reviewed before final approval.

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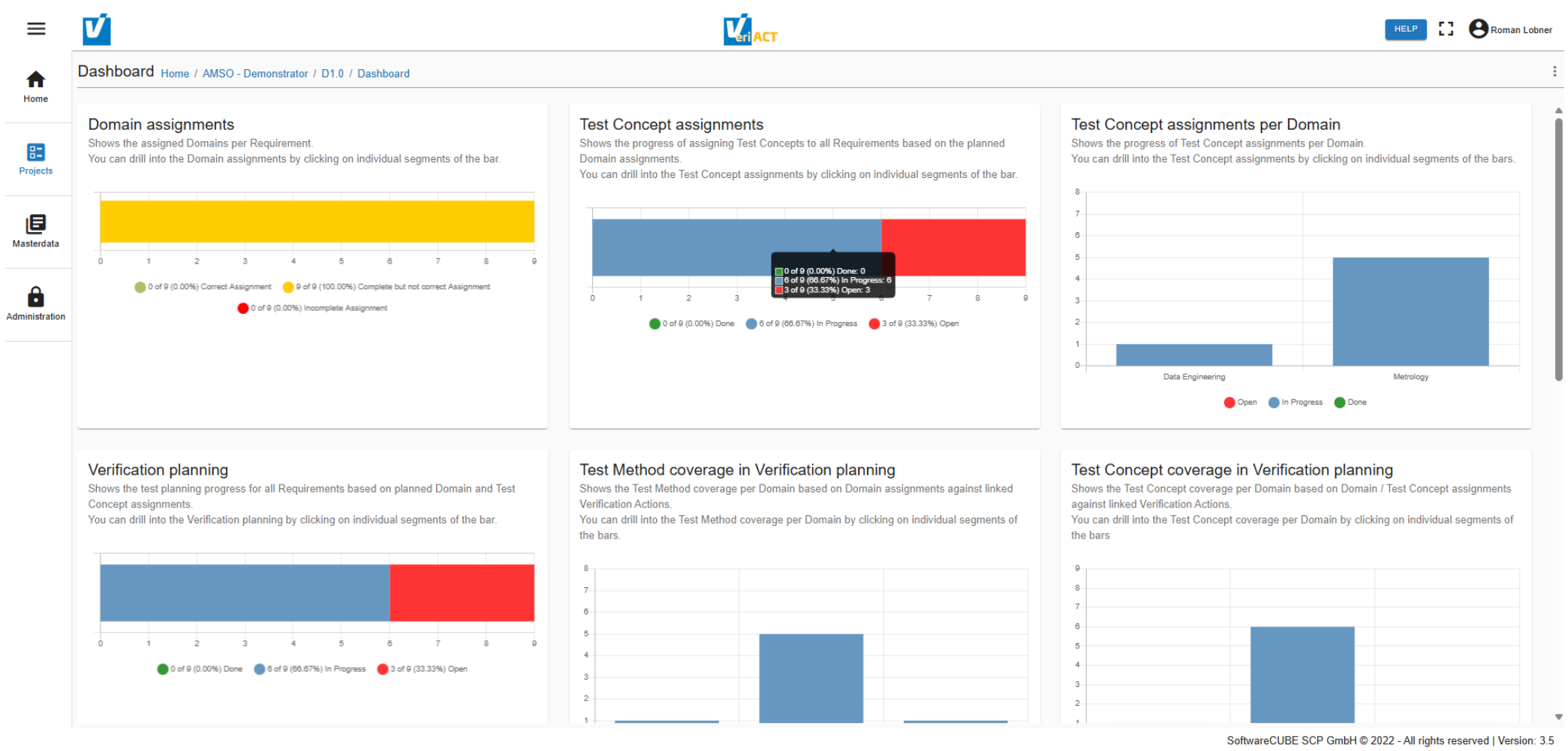
Conclusion



Collaboration, Transparency, Tracability

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Thank You

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EAI

https://edge-ai-tech.eu/

The two-day innovative educational initiative is designed for students, young researchers, and professionals eager to expand their understanding and skills in these cutting-edge technologies.

Participants will engage in interactive discussions, hands-on sessions, and lectures covering foundational concepts and innovative applications of edge AI across various domains with leading experts, gain insights into real-world applications, and work on team-based projects to foster collaboration and innovation.

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EDGE AI Academy 2025

Summer School Objectives

- The EDGE AI Academy Summer School aims to empower participants with advanced knowledge, hands-on experience and an in-depth understanding of edge AI, which combines Artificial Intelligence (AI) with edge computing and the Internet of Things (IoT) to process data closer to its source.
- Edge AI technology is gaining prominence due to its ability to enhance real-time decision-making, reduce latency, improve data privacy, and diminish reliance on continuous internet connectivity.
- The topics will extend to RISC-V architectures as ultra-low-power high-performance RISC-V-based processors and ultra-low-power vector-based accelerators are advancing smart IoT and edge AI computing capabilities.

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