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# NEXT LEVEL PRODUCT DEVELOPMENT: KI IM REQUIREMENTS ENGINEERING

DR. ALEXANDER GÄRTNER, DR. NORMAN FUHRMANN

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# AGENDA

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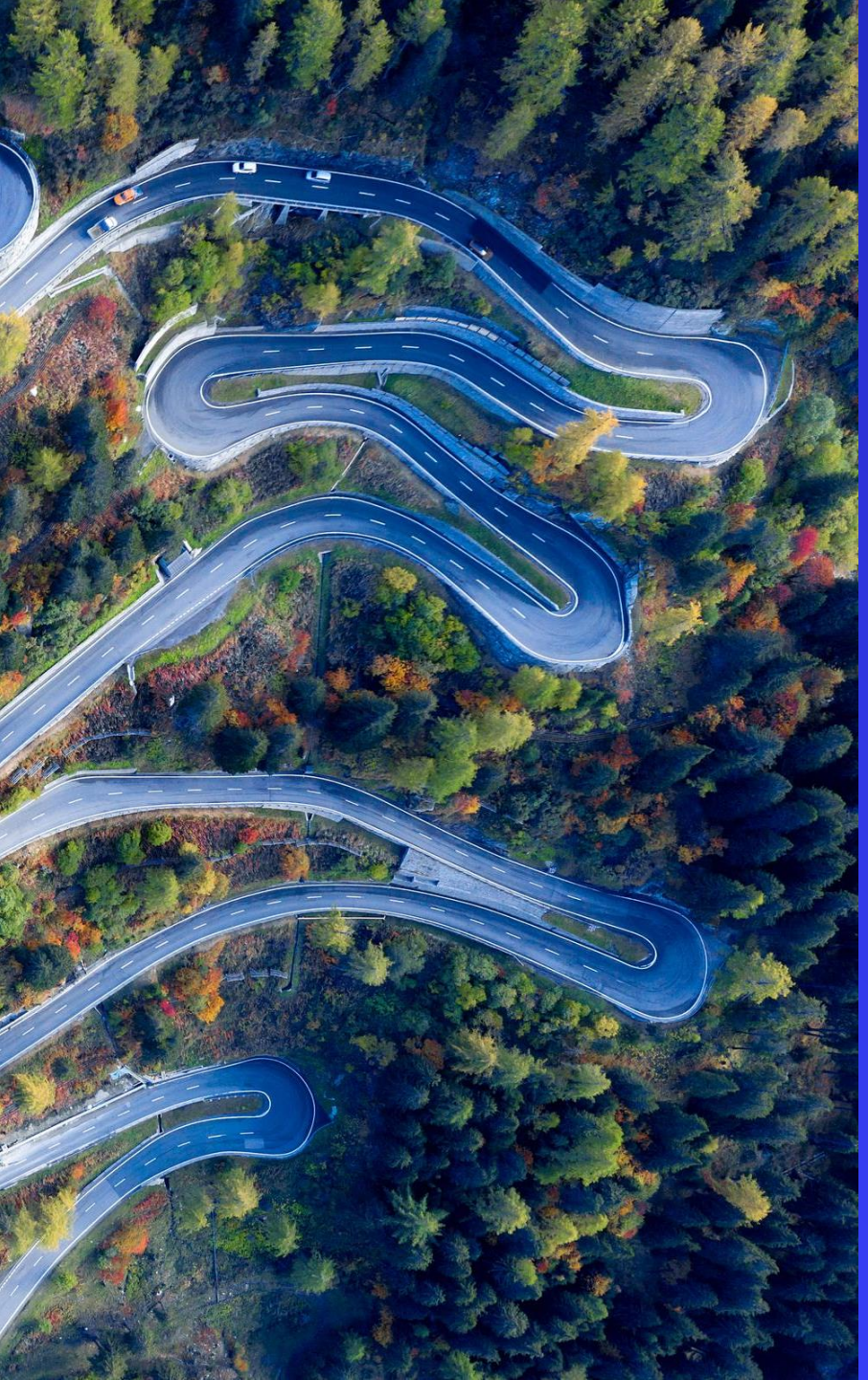
02 Technical Engineering Assistants

03 Requirements TEA

04 Results & Metrics

05 Summary & Outlook



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Agenda 01

# Introduction & Motivation

# Complexity is at a level where humans need assistants to deal with it

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**Require-ments** frequently changing

**>300 Million** Recalls impacted by SW defects in 2024

**500 - 600** Million Lines of code (2030)

**Cyber-security** risks

**Regulatory** demands

**Hundred of thousands** of requirements

**Complete-ness** of requirements

# Escalating costs of late-stage fixes and the widening competitive gap demand immediate AI adoption

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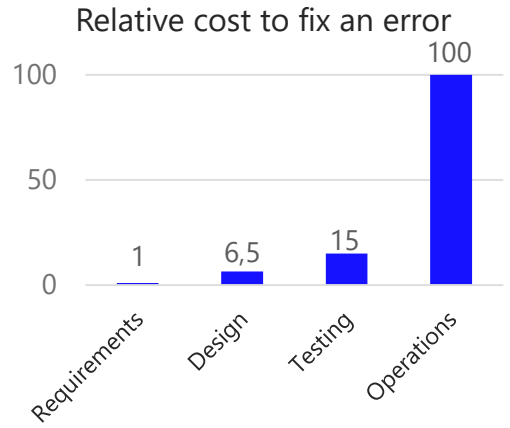
## ISSUES

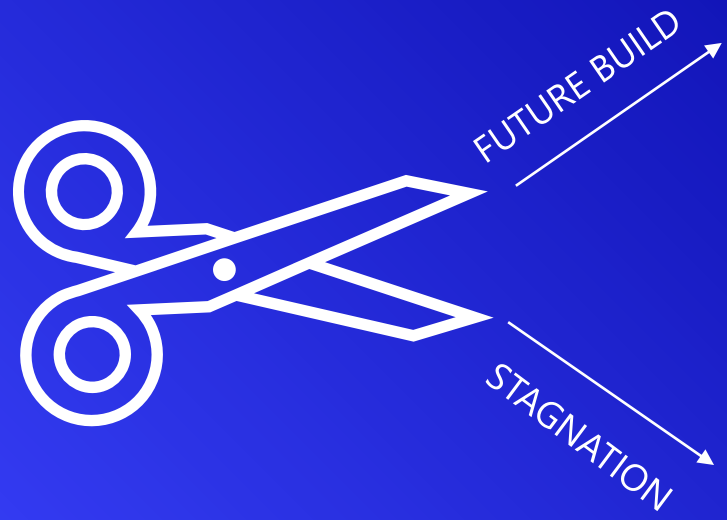
- Poorly worded statements lead to **misinterpretation and unnecessary iterations**
- Older requirements and expanding regulatory demands create **conflicting conditions**
- Missing **details** hinder thorough understanding and implementation

## IMPACT



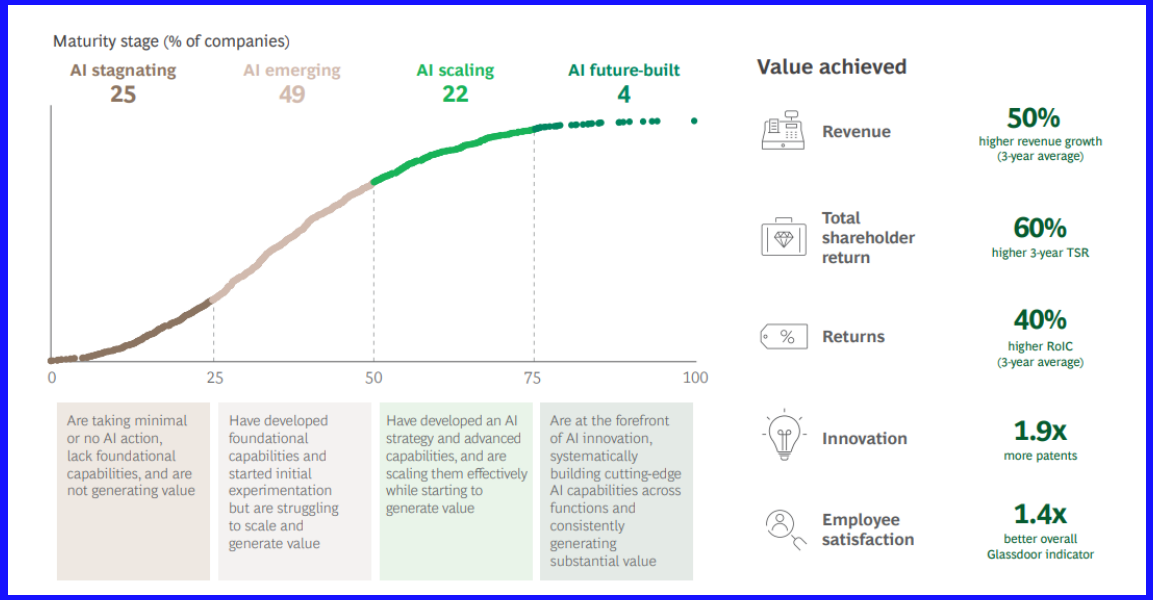

- Significant amount of project costs is spent for **debugging and fixing errors**
- The **lack of atomic, correct, complete & contradiction free specifications** contributes to this share

**CAPABILIY TO ADOPT AI IS DECISIVE**



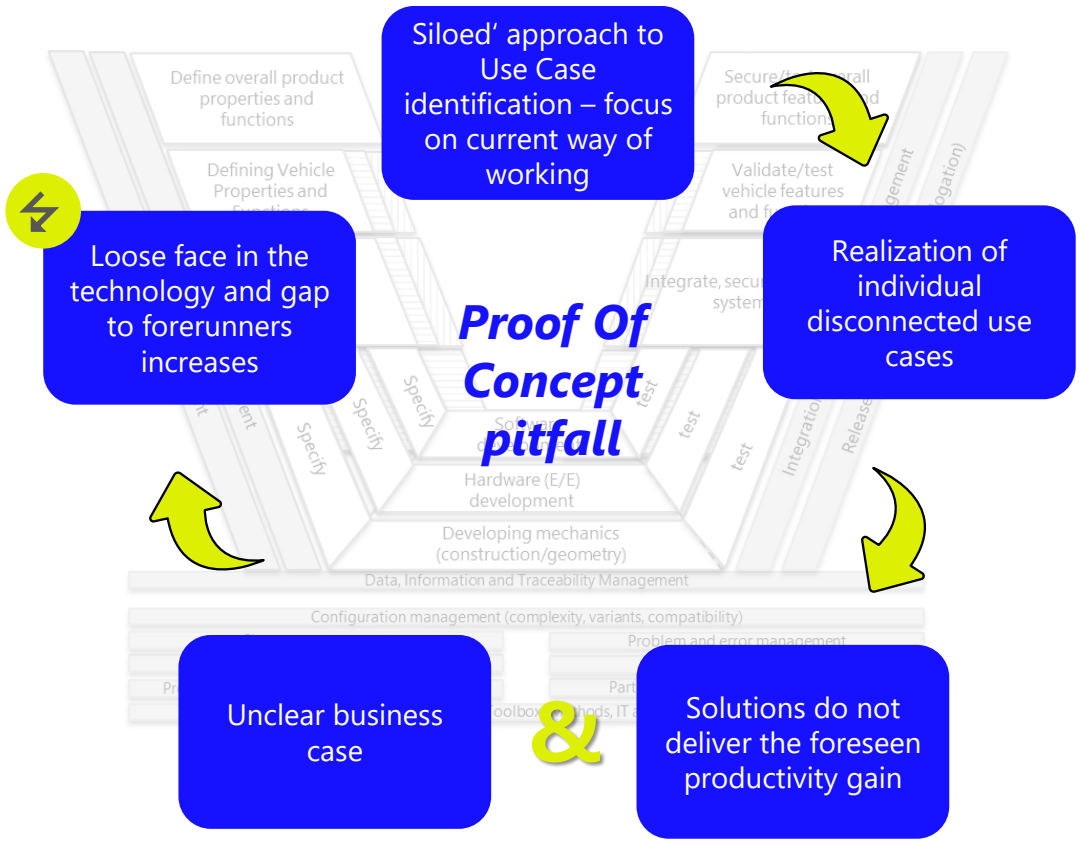
# Capability to adopt AI solutions has a pronounced impact on competitiveness in the future

**ONLY 26 % OF THE ORGANIZATIONS EXPERIMENTING WITH AI MOVE BEYOND THE POC STAGE**




Source: BCG 2024 – Where is the value in AI

## Typical approach



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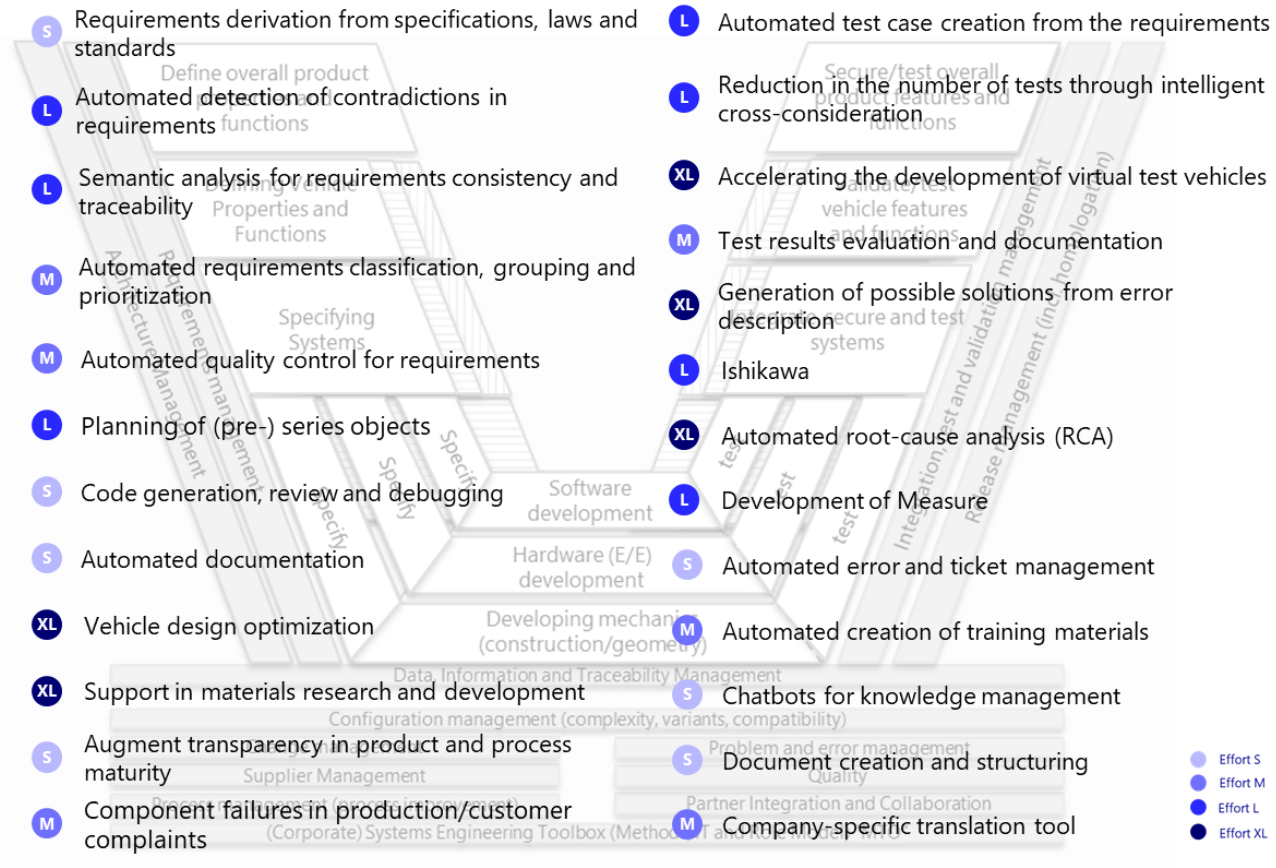
Agenda 02

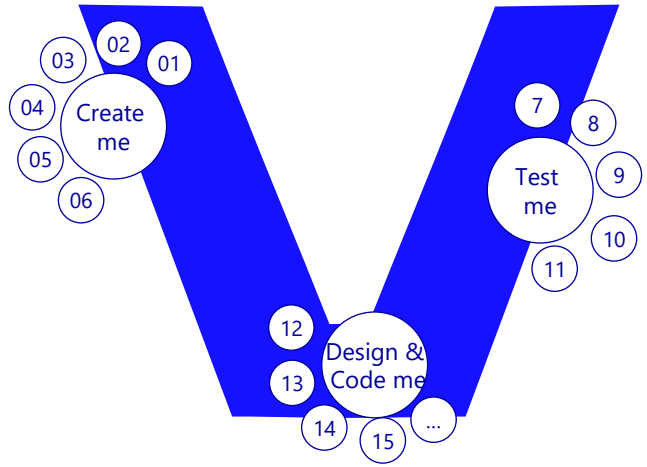
# Technical Engineering Assistants

# TEAs assist humans to handle complexity in engineering

## SINGLE AI USE CASES ALONG THE V-MODEL

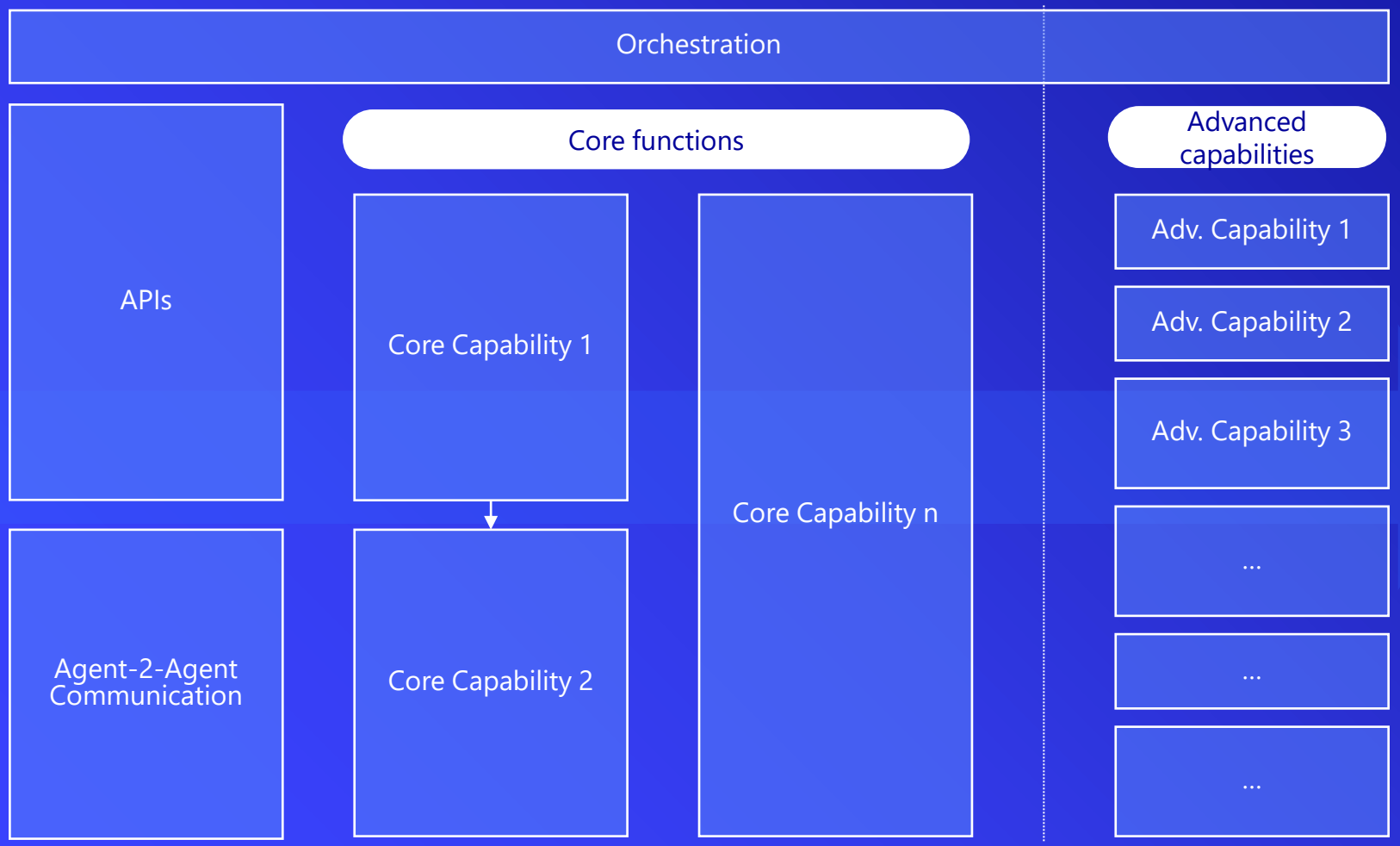



## ORCHESTRATION OF SINGLE USE CASES INTO TECHNICAL ASSISTANTS




- **TEAs** are combinations of **large language models with logic**
- TEAs act as an **orchestrator, connecting single use cases**
- Assist humans to **handle complexity** in engineering
- **Cutting edge solution** closes the gap to AI innovators

# A TEA possesses multiple capabilities and can apply them independently or interconnected




**Core functions**, such as an API, orchestration, basic capabilities form the foundation.

**Advanced capabilities** enable deeper automation and successively expand the capability of the engineering assistant. This enhances the efficiency, consistency, and intelligence of engineering tasks.

Reduction of iterations throughout the entire development process

Quality improvement throughout the entire development process

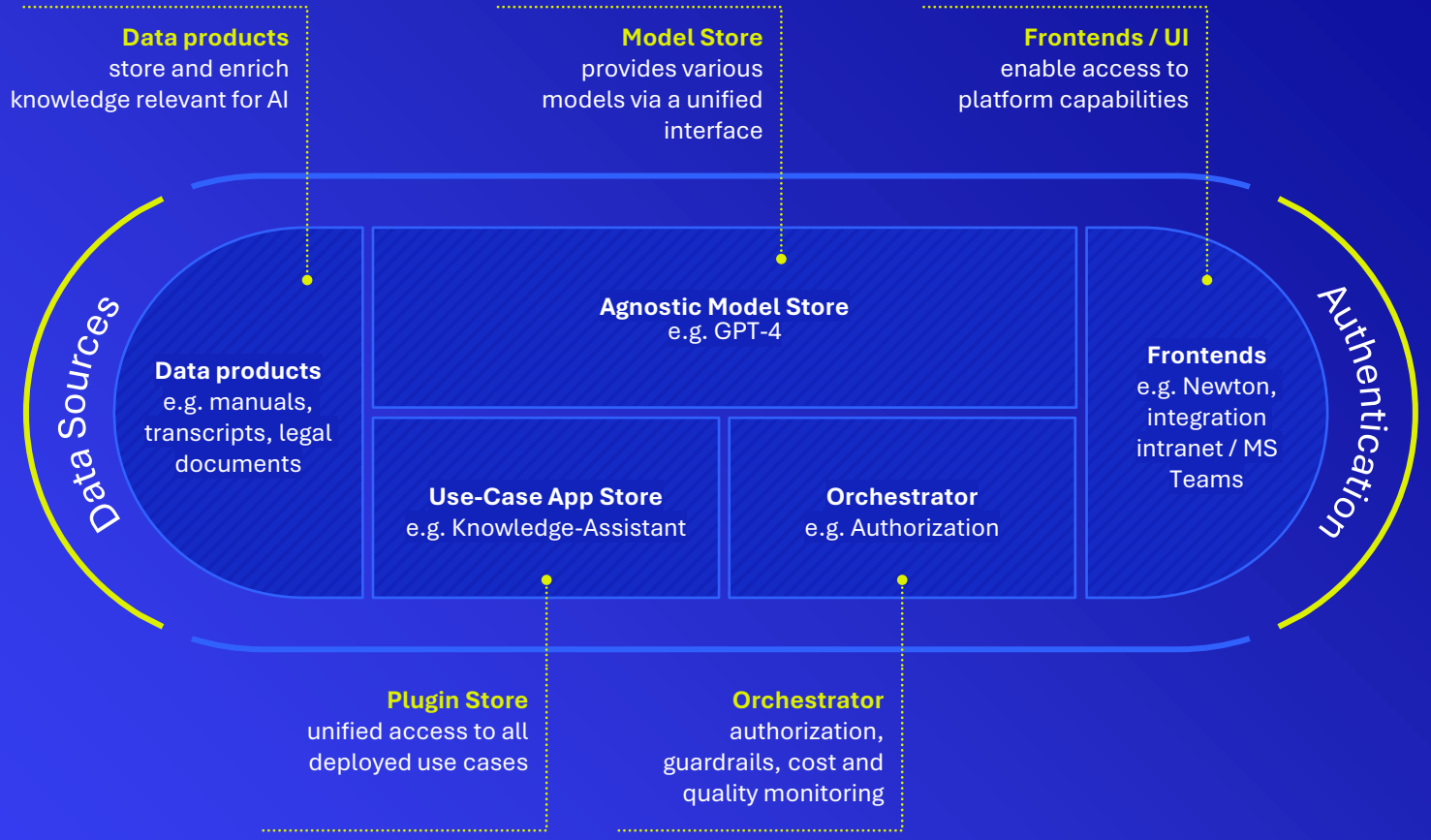
Measurable time and cost savings

# The Intellicore Framework

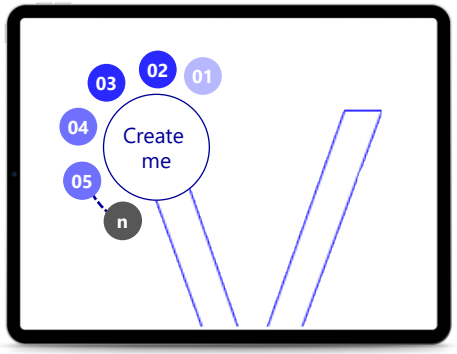
## A Scalable, Flexible and Secure AI Architecture

Data Product Store, Model Store, Plugin Store and Orchestrator working together to manage AI-driven interactions across the company.

Whitepaper:
Unleashing the
Power of Agentic AI



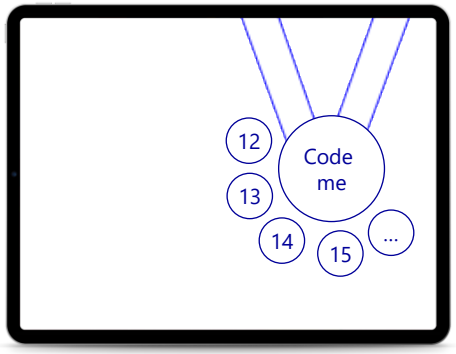
# MHP's Technical Engineering Assistants (TEA)




**Requirements Engineering TEA**

**Create me…**

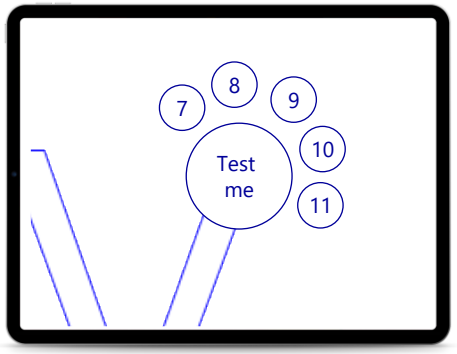
Combining AIs translating language into requirements, free of contradictions, fully traceable




**Design & Coding TEA**

**Code me…**

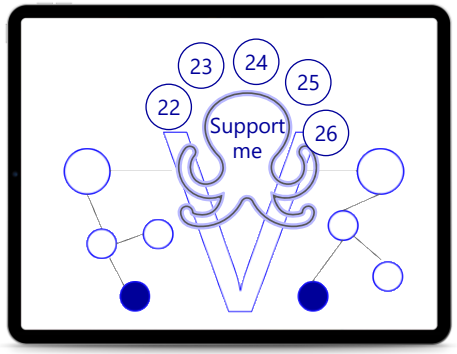
AIs generating design solutions and code




**Test & Integration TEA**

**Test me…**

AIs automating test definition & execution, supporting error analysis & solution generation




**Support TEA**

**Support me …**

AIs knowing and maintaining dependencies

**TECHNICAL ENGINEERING ASSISTANTS** foster seamless assistant-engineer collaboration in requirements definition, concurrent development, and integrated verification & validation, supported by virtual assistants leveraging corporate knowledge

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# Requirements TEA*

*Technical Engineering Assistant

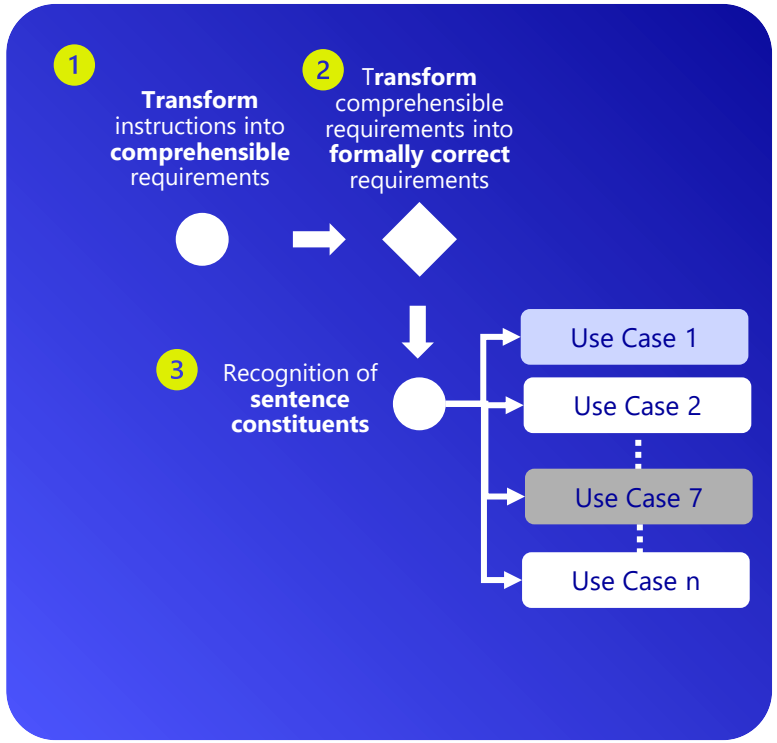
# MHP approach to AI assisted Requirements Engineering and Test management

## KEY CHAIN OF USE CASES

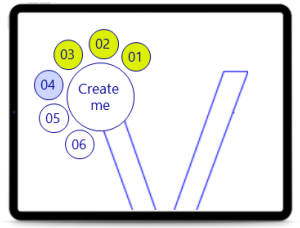
- Deriving requirements from **specifications, laws and standards**
- Formalized **Requirements**
- Creating **clean** requirements **basis**
- Identifying **conflicts**
- **MoSCoW classification of requirements**
- **Completeness of requirements**
- …

- **Test case generation** based on structured requirements
- **Reducing test efforts** through cross consideration
- **Test result interpretation**
- **Root cause analysis** and solution description
- …

## TRANSLATION INTO TEA'S

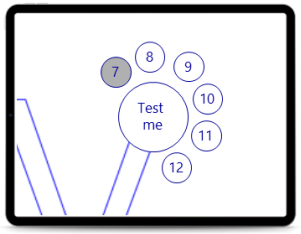



**Create me…**



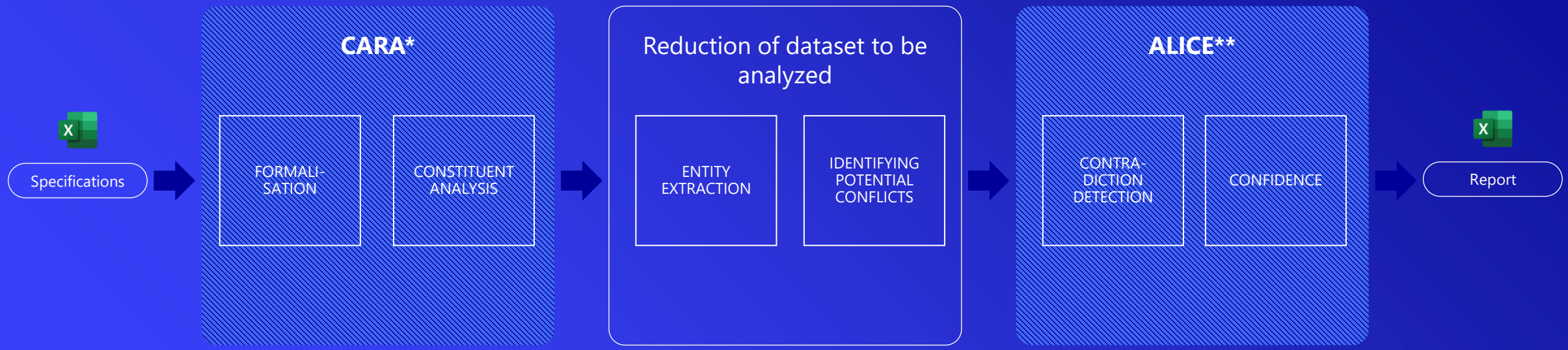

Requirements Eng. TEA

**Test me…**




Test & Integration TEA

# The workflow MHP implemented consists of formalization followed by contradiction detection




*Constituent Analysis and Requirements Articulator

**Automated Logic for the Identification of Contradictions in Engineering

# Key outcome of CARA are formalized and according to Sophisten/Incose Guidelines broken-down requirements

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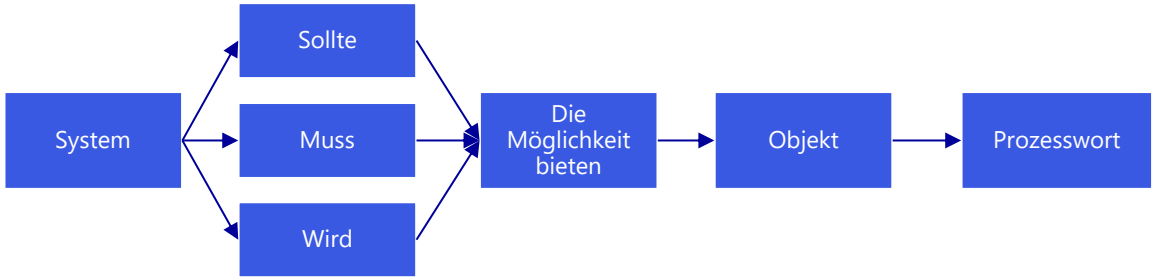
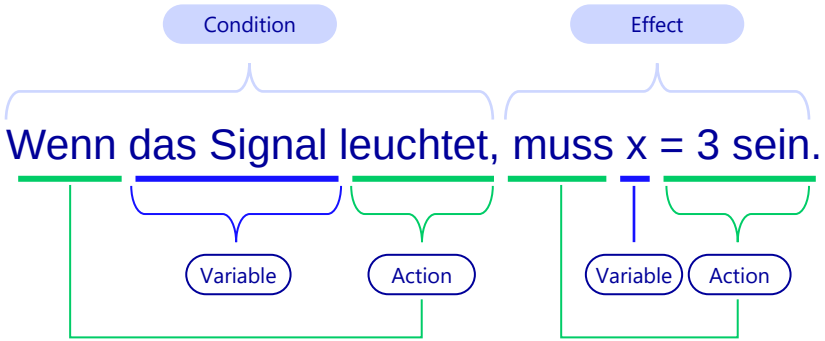
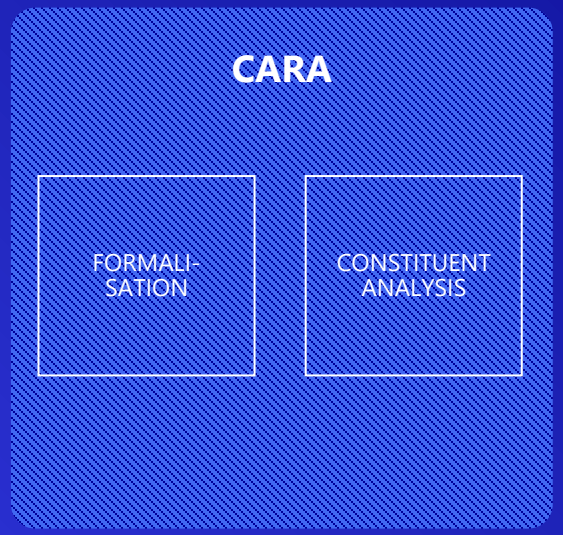
**1** Analyse Input

**2** Formalize according to template



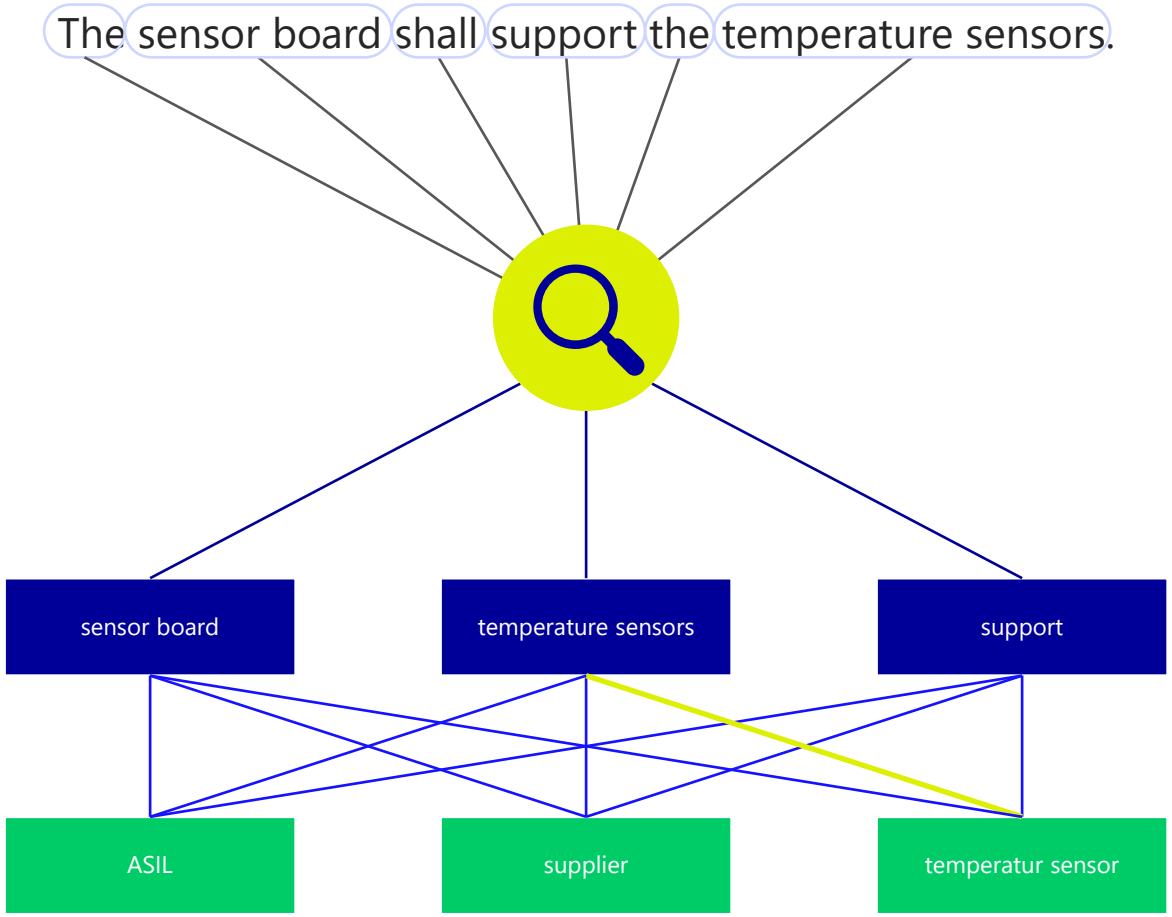

**3** Constituent analysis

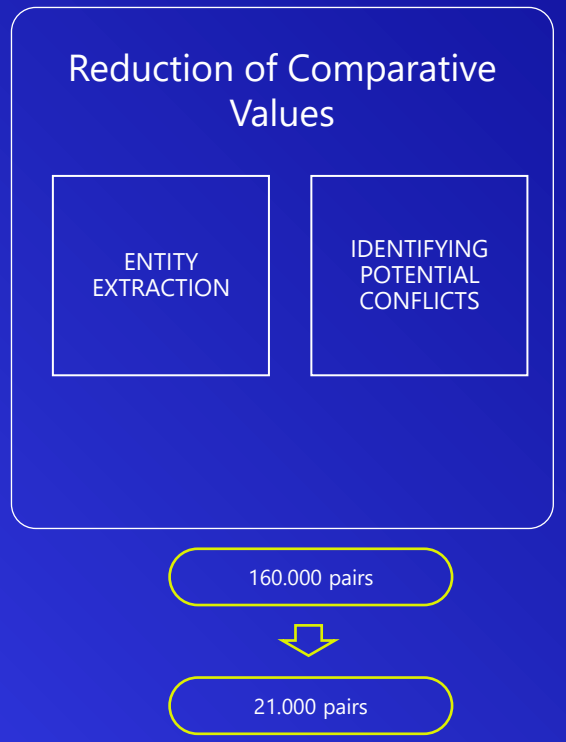


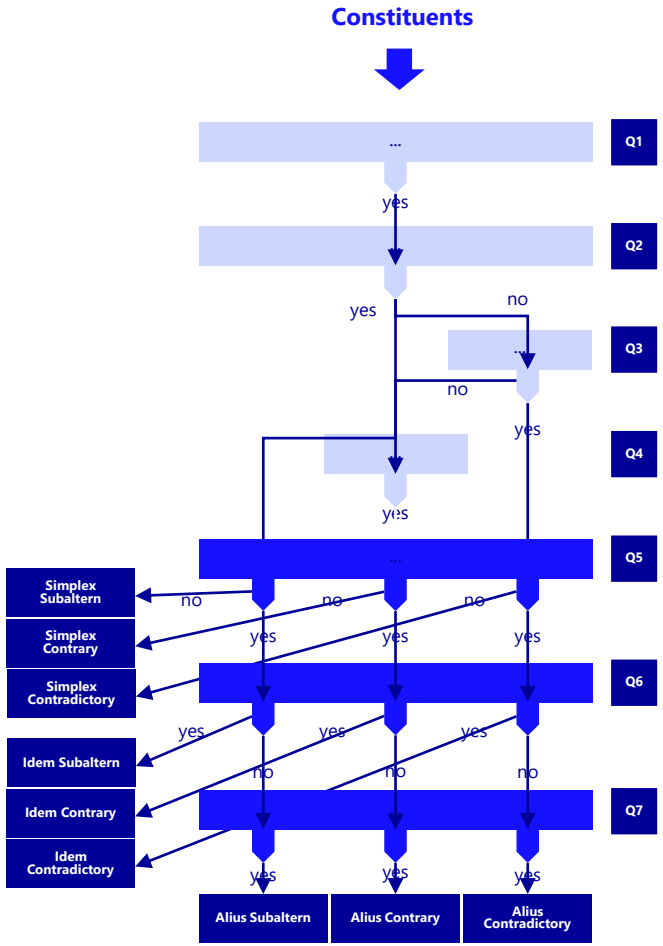

600 requirements anlyzed

# Smart data reduction: To accelerate the final analysis, entities were extracted and potential conflicts were pre-mapped



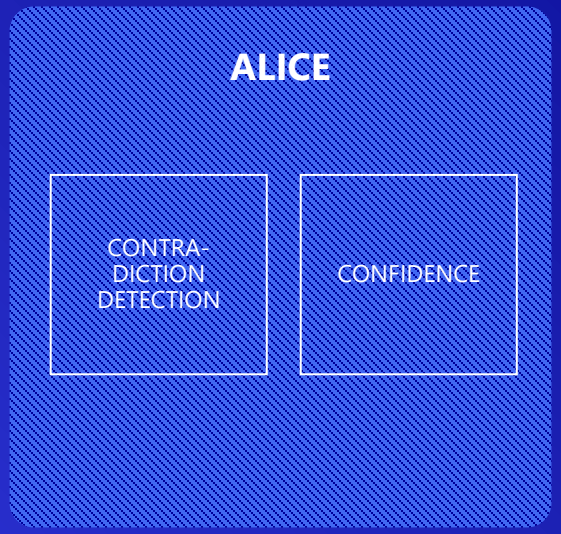



# Most importantly, CARA provides the foundation to unlock additional capabilities such as contradiction detection with ALICE




Important: Verification of contradictions by an Engineer

Especially useful in safety –relevant requirements




7 potential contradictions

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# Results & Metrics

# Sample results of the analysis of one document with 600 requirements – formalization and preparation of a clean data base

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Analysis of a single Specification Document

600 requirements formalized with CARA, and constituents derived, clean basis created.

Baseline for automated for identification of contradictions – based on constituents

Baseline for automated test case generation

# Sample results of the analysis of one document with 600 requirements – Smart data reduction as a prerequisite for contradiction detection

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Contradiction analysis of a single Specification Document

160,000 requirement pairs analyzed using entity analysis.

21,000 requirement pairs analyzed with ALICE.

7 potential contradictions identified.

# Sample result of the comparison of two documents containing requirements

Contradiction analysis of two specifications of two subsystems

2 Requirement specifications of two subsystems within the same product have been analyzed with CARA and ALICE.

14 potential contradictions identified with ALICE.

2 potential contradictions identified with GPT4o-only.

# Performance analysis: Runtime, token consumption & model efficiency

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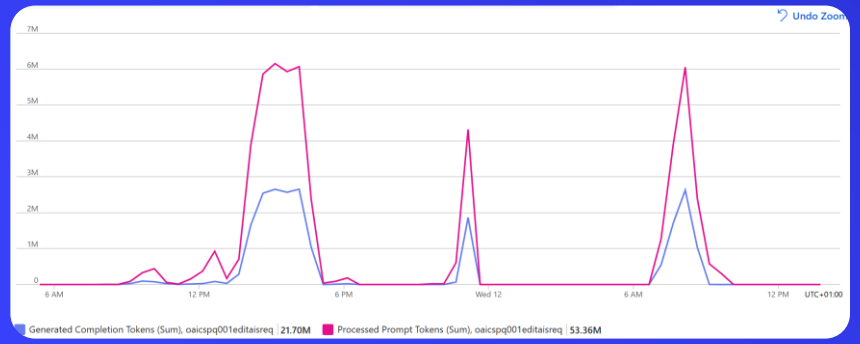
## Duration

- Ca. 5 hours – not optimized for performance

## Consumption




- ~75M tokens for ~600 original requirements

- With GPT-3 with ALICE we reached 76% accuracy in an unrelated benchmark.
- With GPT-4o without ALICE we reached 75%.
- With GPT-4o and ALICE we reached 87%.

→ Smaller and cheaper models in combination with ALICE can reach similar results.

## Benchmark

| Requirement 1 | Requirement 1 CARA | Requirement 1 Constituents | Requirement 2 | Requirement 2 CARA | Requirement 2 Constituents | Expected Contradiction Type | Testresult general ALICE Diss | GPTT4 mit Original Req | ALICE Combined | Confidence |
|---|---|---|---|---|---|---|---|---|---|---|
| Wenn es regnet, muss das Auto stehen | Wenn es regnet, mus | "conditions": [ { | Wenn es regnet, muss das Auto fahren | Wenn es regnet, mus | "conditions": [ { | idem_contrary | WAHR | Yes | 1 | 3 |
| Das Auto muss stehen, wenn es regnet | Das Auto muss stehe | "conditions": [ { | Das Auto muss fahren, wenn es regnet | Das Auto muss fahre | "conditions": [ { | idem_contrary | WAHR | Yes | 1 | 3 |
| Das Auto muss stehen, wenn es regnet | Das Auto muss stehe | "conditions": [ { | Wenn es regnet, muss das Auto fahren | Wenn es regnet, mus | "conditions": [ { | idem_contrary | WAHR | Yes | 1 | 3 |
| Das Auto muss stehen. | Das Auto muss stehe | "conditions": [], "contexts": [], | Das Auto muss fahren, wenn es regnet | Das Auto muss fahre | "conditions": [ { | idem_contrary | WAHR | Yes | 1 | 3 |
| Wenn es regnet, muss x gleich 3 sein | Wenn es regnet, mus | "conditions": [ { | Wenn es regnet, muss x ungleich 3 sein | Wenn es regnet, mus | "conditions": [ { | idem_contradictory | WAHR | Yes | 1 | 3 |
| Wenn y gleich 4 ist, muss x gleich 3 sein | Wenn y gleich 4 ist, n | "conditions": [ { | Wenn z gleich 4 ist, muss x ungleich 3 sein | Wenn z gleich 4 ist, n | "conditions": [ { | alius_contradictory | WAHR | No | 1 | 2 |
| Das Auto muss rot sein | Das Auto muss rot se | "conditions": [], "contexts": [], | Die Autotür muss blau sein | Die AutotÃ¼r muss b | "conditions": [], "contexts | simplex_subaltern | WAHR | No | 1 | 2 |
| Das Signal muss gleich drei gesetzt werden | Das Signal muss glei | "conditions": [], "contexts": [], | Das Signal Chern muss gleich 10 gesetzt werden | Das Signal Chern mu | "conditions": [], "contexts | 0 | WAHR | No | 1 | 2 |
| Wenn x gleich drei ist, muss y gleich 4 sein | Wenn x gleich drei ist, | "conditions": [ { | Wenn x gleich vier ist, muss y gleich 5 sein | Wenn x gleich vier ist | "conditions": [ { | 0 | WAHR | No | 0 | 3 |
| Wenn das Auto rot ist, muss y gleich 4 sein | Wenn das Auto rot ist | "conditions": [ { | Wenn das Auto blau ist, muss y gleich 5 sein | Wenn das Auto blau i | "conditions": [ { | 0 | WAHR | No | 0 | 3 |
| Nach Ablauf der Zeit CbnHeatg_TiMaxAtStg7OfHeat | Wenn die Zeit CbnHe | "conditions": [ { | Wenn die vom HMI gewünschte Heizerstufe | Wenn die vom HMI g | "conditions": [ { | alius_contrary | FALSCH | No | 1 | 2 |
| Wenn die Botschaft ausfällt oder das Signal gleich 0 ist, | Wenn die Botschaft a | "conditions": [ | Wenn das Signal gleich 0 ist, muss x gleich 6 sein | Wenn das Signal glei | "conditions": [ { | alius_contrary | WAHR | Yes | 1 | 2 |
| Wenn die Botschaft ausfällt oder das Signal gleich 0 ist, | Wenn das Signal glei | "conditions": [ | Wenn das Signal gleich 0 ist, muss x gleich 6 sein | Wenn das Signal glei | "conditions": [ { | alius_contrary | WAHR | Yes | 1 | 3 |
| Wenn die Botschaft ausfällt oder das Signal gleich 0 ist, | Wenn die Botschaft a | "conditions": [ | Wenn das Signal gleich 0 ist, muss x gleich 3 sein | Wenn das Signal glei | "conditions": [ { | 0 | WAHR | No | 0 | 3 |
| Wenn die Botschaft ausfällt oder das Signal gleich 0 ist, | Wenn das Signal glei | "conditions": [ | Wenn das Signal gleich 0 ist, muss x gleich 3 sein | Wenn das Signal glei | "conditions": [ { | 0 | WAHR | No | 0 | 3 |
| Bei 30 Grad muss x = 5 sein | Bei 30 Grad muss x g | "conditions": [ | x muss gleich 6 sein | x muss gleich 6 sein. | "conditions": [], "contexts | idem_contrary | WAHR | Yes | 1 | 3 |
| Bei 30 Grad muss x = 5 sein | Bei 30 Grad muss x g | "conditions": [ | Wenn 30 Grad sind, muss x gleich 5 sein | Wenn es 30 Grad sin | "conditions": [ { | 0 | WAHR | No | 0 | 3 |
| | | | | | | | 76% | 75% | 87% | |

**GPT 4.0**

- 1% false positives
- 23% false negative

**ALICE**

- 8% false positives
- 7% false negative

# Impact of Requirements Engineering powered by AI

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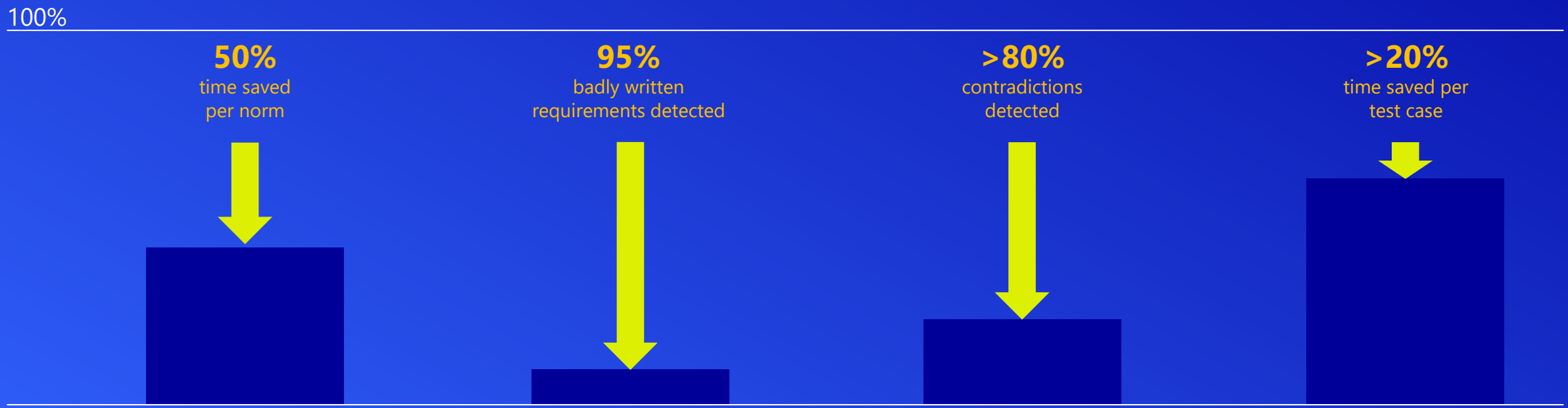
DERIVING REQUIREMENTS → ASSESSING THE QUALITY OF REQUIREMENTS → IDENTIFYING CONTRADICTIONS BETWEEN REQUIREMENTS → DERIVING TEST CASES FROM REQUIREMENTS



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# Summary & Outlook

# The potential of increasing efficiency in Engineering is massive

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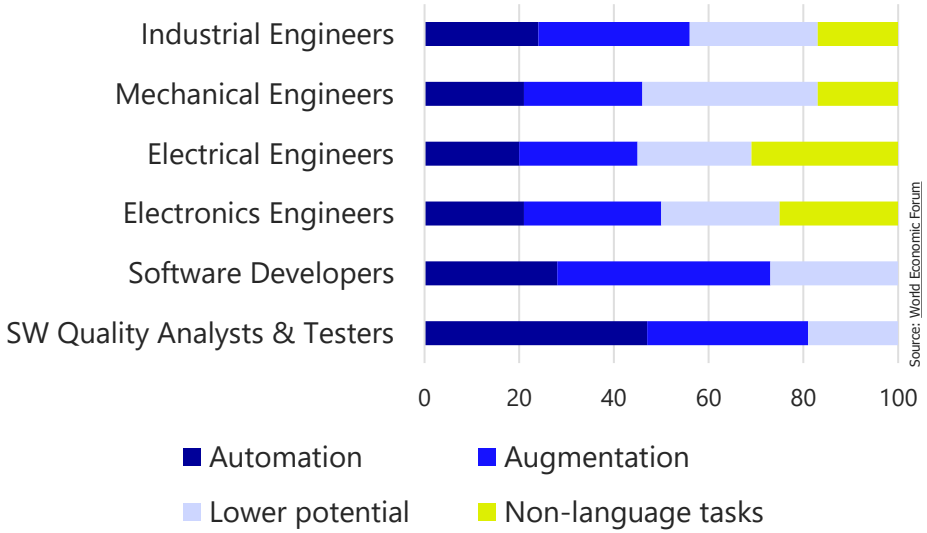
## A significant number of tasks can be automated and augmented:



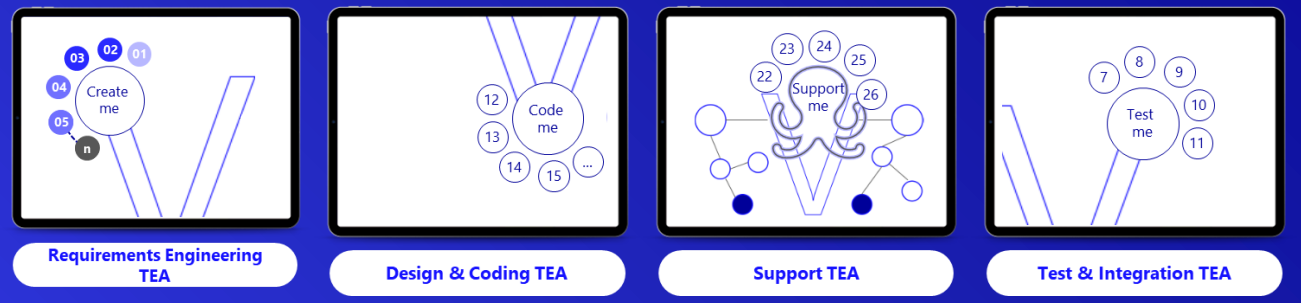

**27%**

of engineering tasks can be automated

**32%**

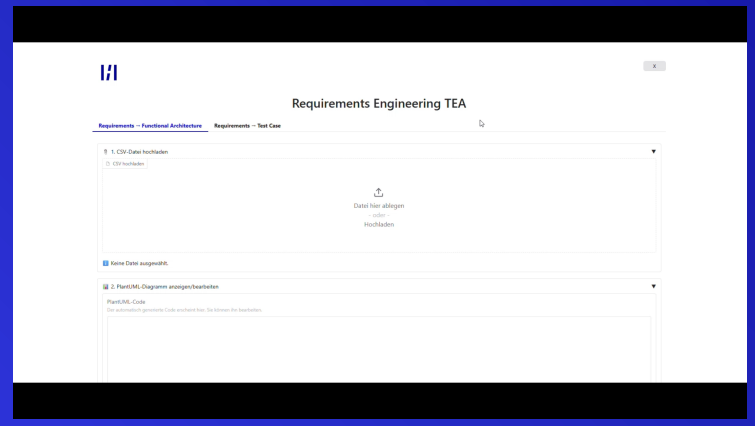
of engineering tasks can be augmented

## MHP's approach is to systematically combine isolated use cases to Technical Engineering Assistants…




… in order to automate tasks and increase every engineer's efficiency in their daily business.

**What's next ?**



X

# Requirements Engineering TEA

**Requirements → Functional Architecture** | **Requirements → Test Case**

1. CSV-Datei hochladen

CSV hochladen

Datei hier ablegen
- oder -
Hochladen

Keine Datei ausgewählt.

2. PlantUML-Diagramm anzeigen/bearbeiten

PlantUML-Code

Der automatisch generierte Code erscheint hier. Sie können ihn bearbeiten.

Closing

# Thank you!

**Dr. Alexander Gärtner**
Senior Consultant

Digital Product & Engineering (DPE)
Alexander.gaertner@mhp.com
Mobile: +49 152 5586 7148

**Dr. Norman Fuhrmann**
Senior Manager

Digital Product & Engineering (DPE)
Jan.fuhrmann@mhp.com
Mobile: +49 152 55248183

**MHP Management- und IT-Beratung GmbH**

Film- und Medienzentrum l Königsallee 49 l D-71638 Ludwigsburg
Telefon +49 (0)7141 7856-0 l Fax +49 (0)7141 7856-199
E-Mail info@mhp.com l Internet www.mhp.com