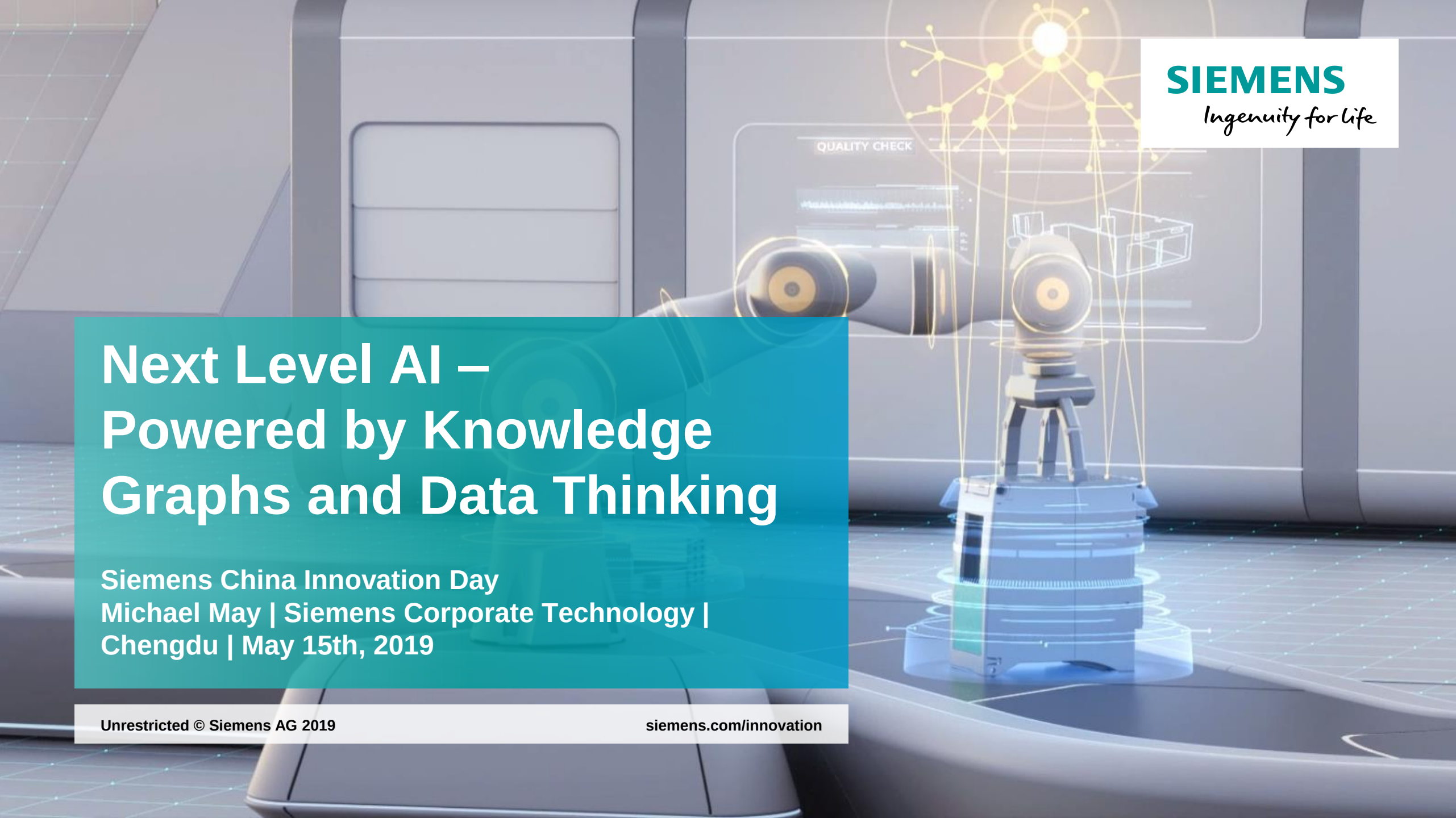

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Next Level AI – Powered by Knowledge Graphs and Data Thinking

Siemens China Innovation Day
Michael May | Siemens Corporate Technology |
Chengdu | May 15th, 2019

Additive Manufacturing

Autonomous Robotics

Blockchain Applications

Connected (e)Mobility

Connectivity and Edge Devices

Cybersecurity

Data Analytics, Artificial Intelligence

Distributed Energy Systems

Energy Storage

Future of Automation

Materials

Power Electronics

Simulation and Digital Twin

Software Systems and Processes

Next Level Industrial AI – Augmenting Human Intelligence

Product Configuration and Design – Augmented by Artificial Intelligence

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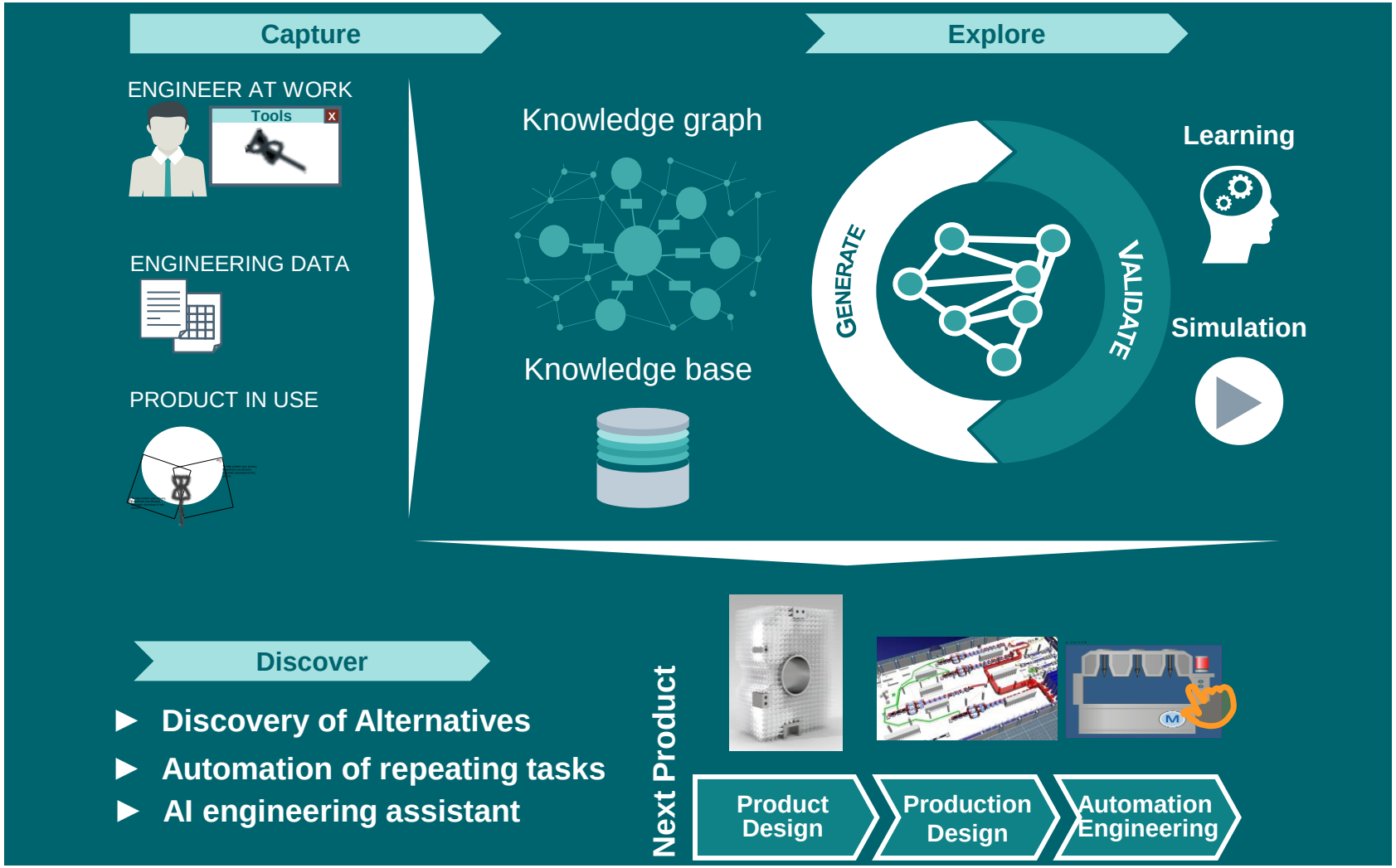
Teaching machines to augment human design capabilities



AI in Production Engineering – Fast and Efficient Engineering and Commissioning

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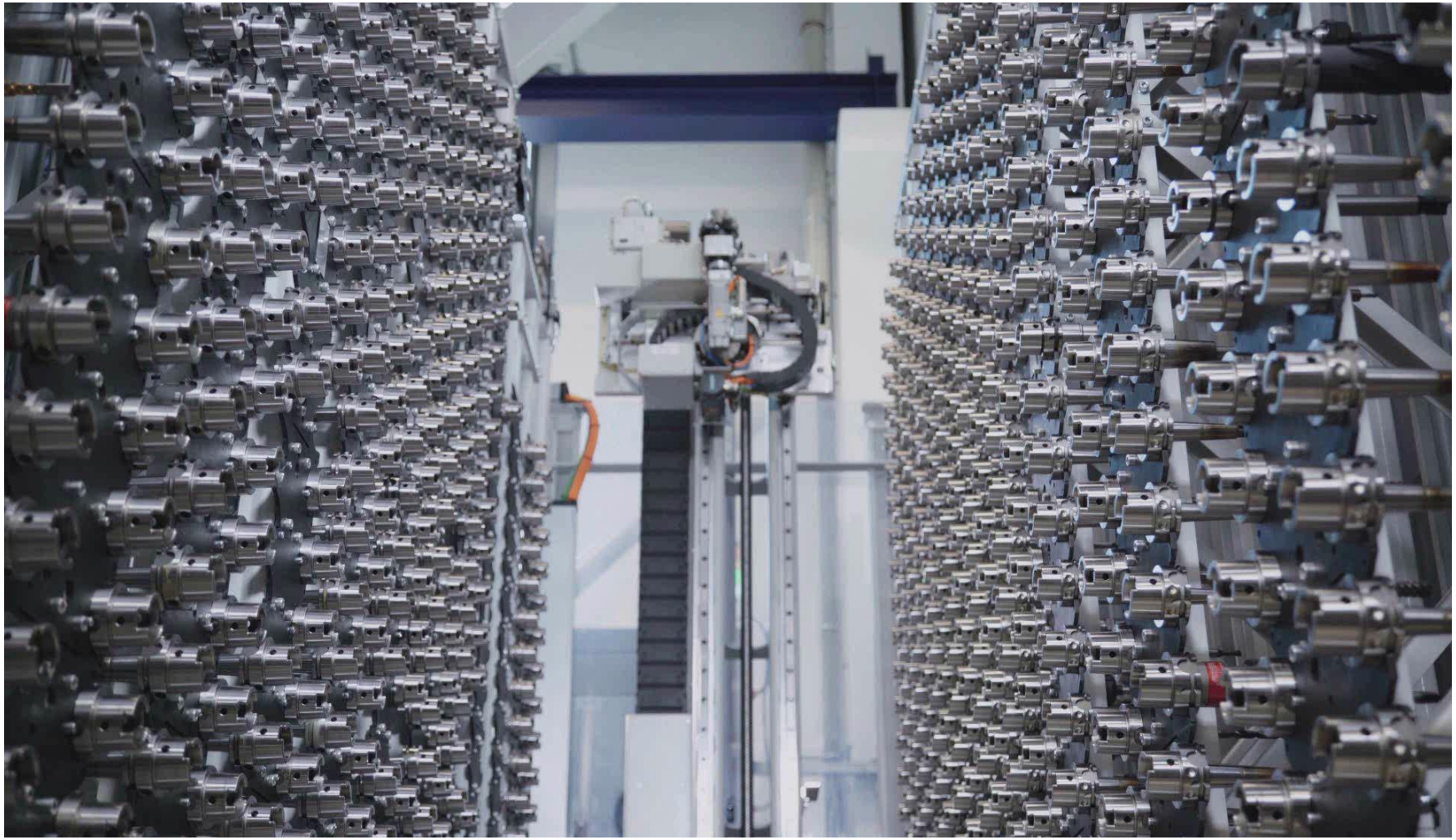
Optimizing machines throughput

- ML for tool relocation and changeover times
- Convex optimization methods to find exact optimal solutions
- Algorithm is implemented on edge device

► Productivity up by up to 20%



AI for Performance Optimization – AI Autonomous Learning of Turbine Control

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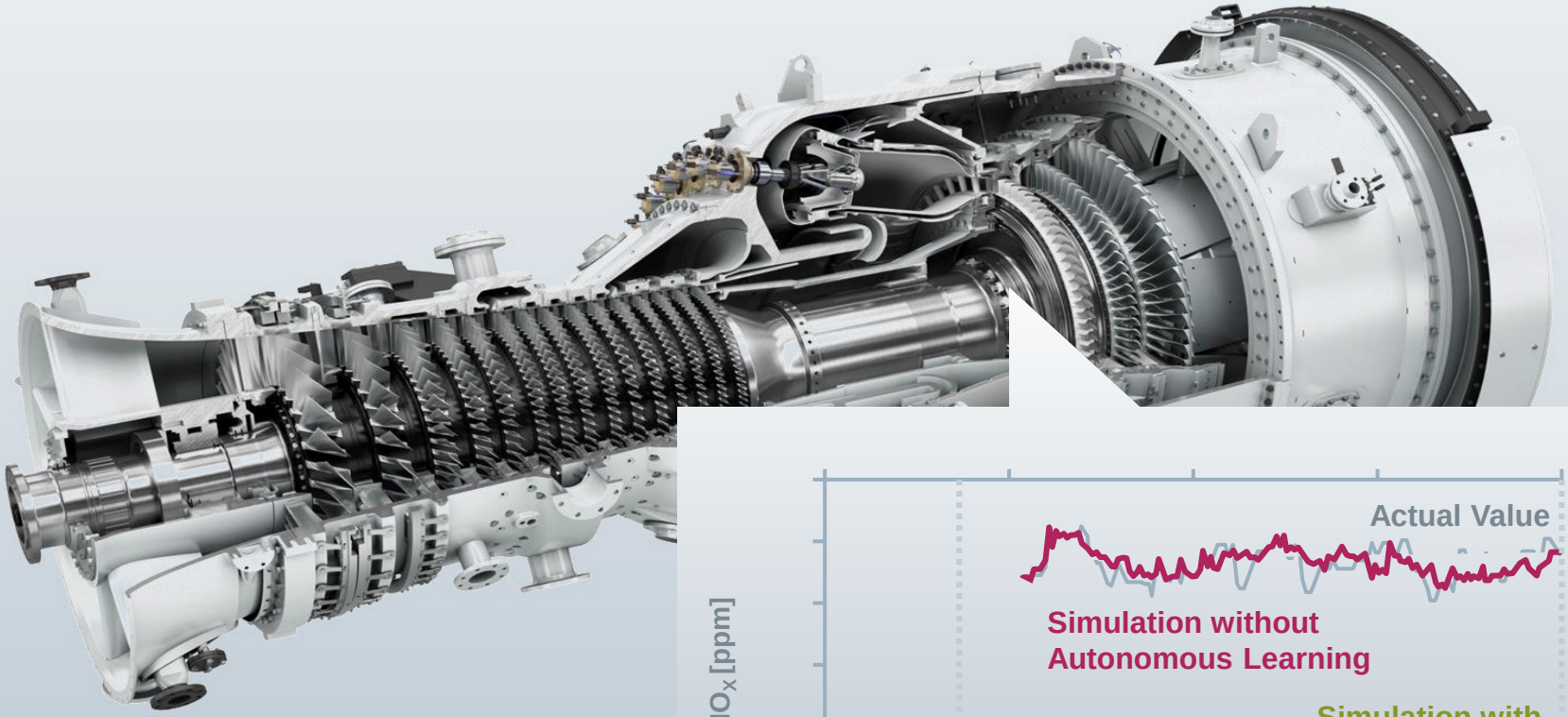
- AI learns from the behavior of a gas turbine in operation as well as fleet data
- Learns a control strategy that outperform manually tuned turbines
- Artificial Intelligence autonomously lowers the NOx emissions
- Deep Learning and Reinforcement Learning



AI in Production Planning – Recommending automation system configurations

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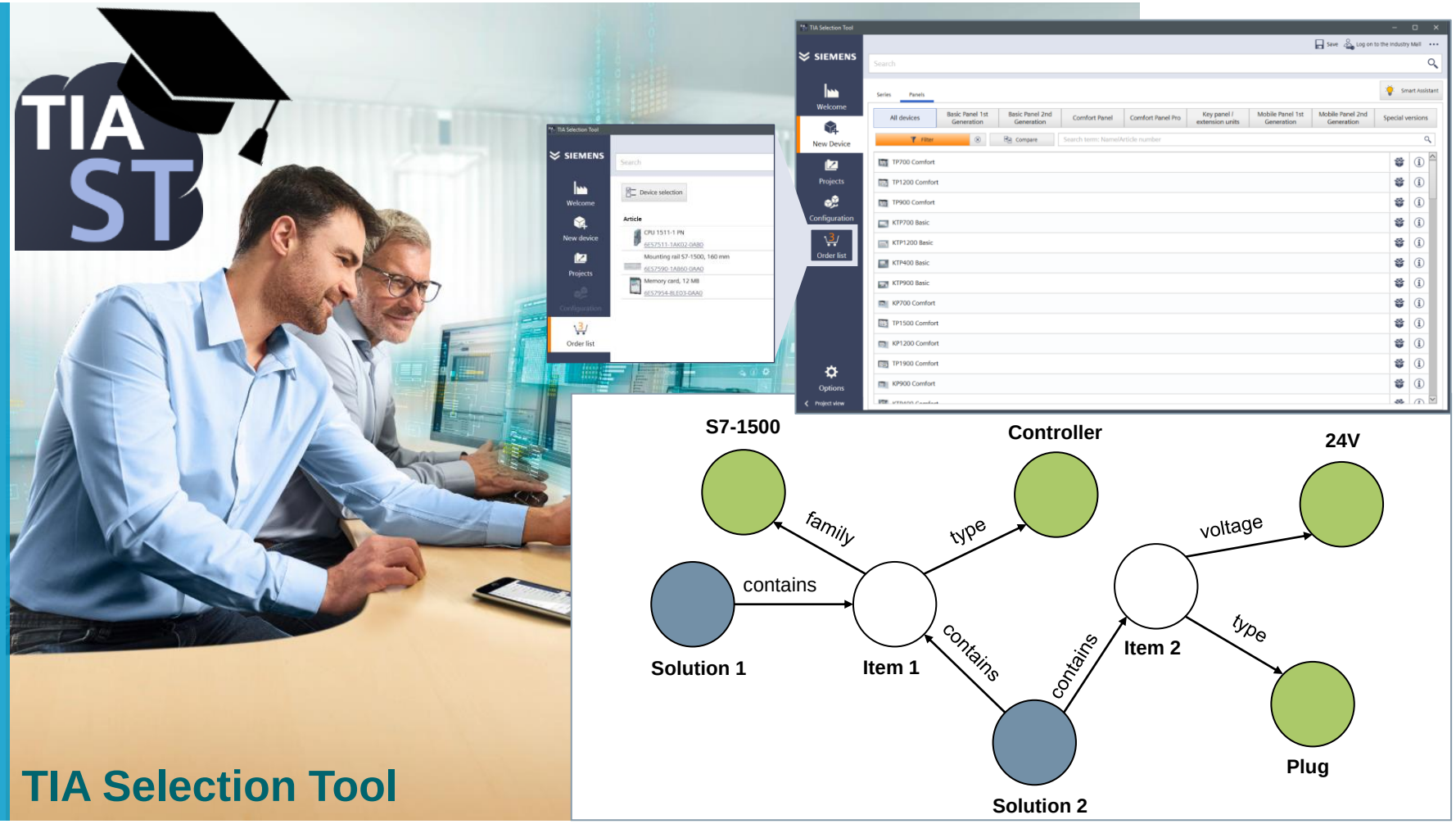
- Data: configurations from 90.000 customer projects
- A planning project can be represented as a knowledge graph
- Generates design-specific recommendations for automation equipment
- Combining planning history with deep domain knowledge



AI for Product Configuration – Safe design for Railway Interlocking Control Systems

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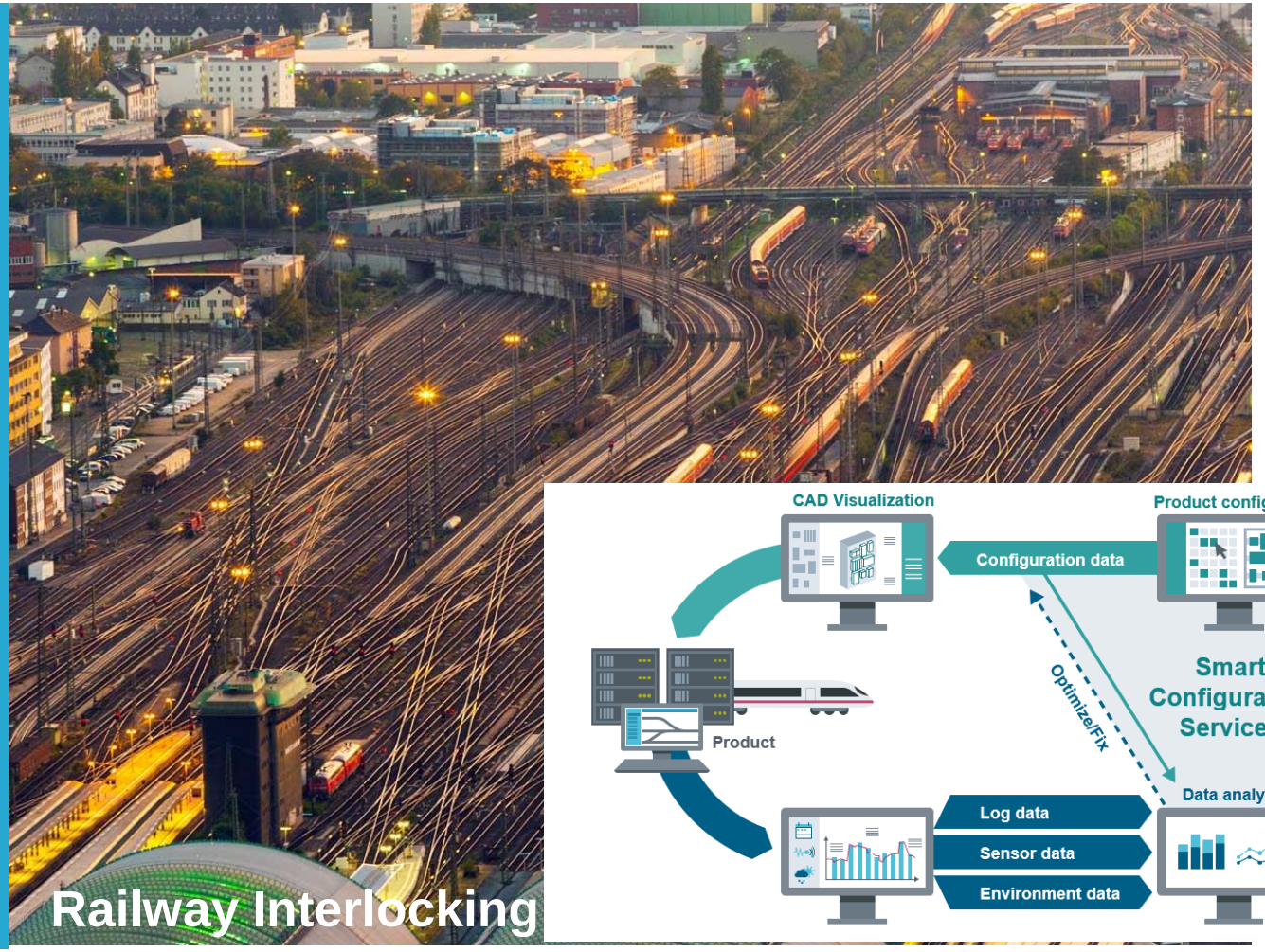
Challenge - $>10^{90}$ possible configurations and complex constraints of railway control equipment

Solution - AI logic solver for determining configurations, optimization to find best configuration from Knowledge Graph

Outcome - Configurators secure correct interlockings and highest level of train control



Production execution – AI will enable autonomous machines

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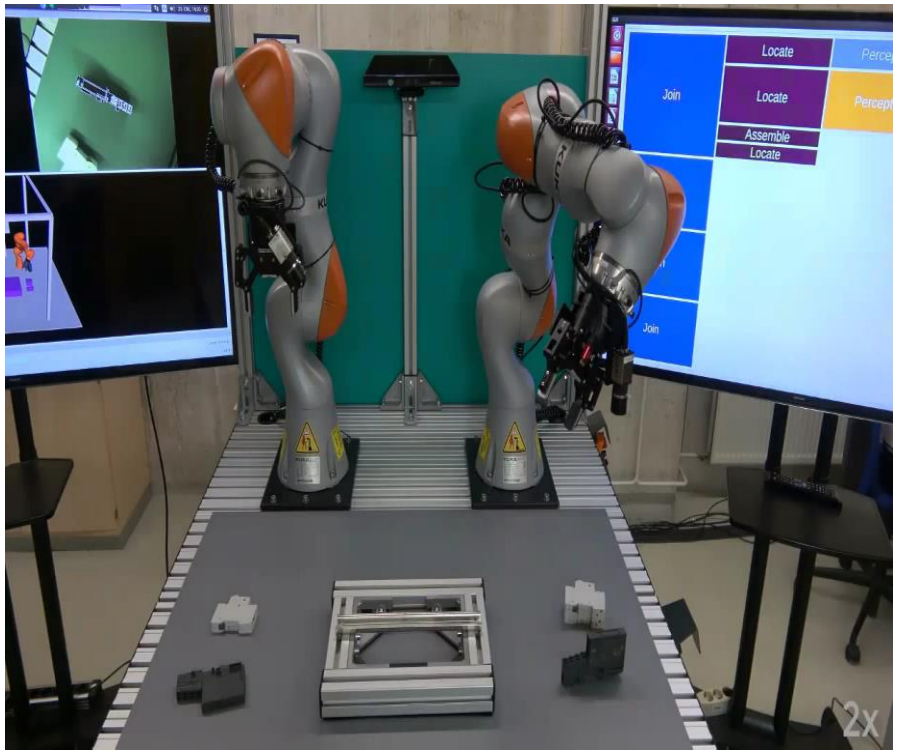
Industrie 4.0 Vision

- Object recognition using deep learning
- Learning to pick objects
- Matching of skills to tasks by reasoning on knowledge graph
- Autonomous action and motion generation

Self-adaptation (based on data)

Self-operation



Vision: Self-x without detailed programming or engineering
… and without human supervision

Knowledge Graph Adoption @ Siemens

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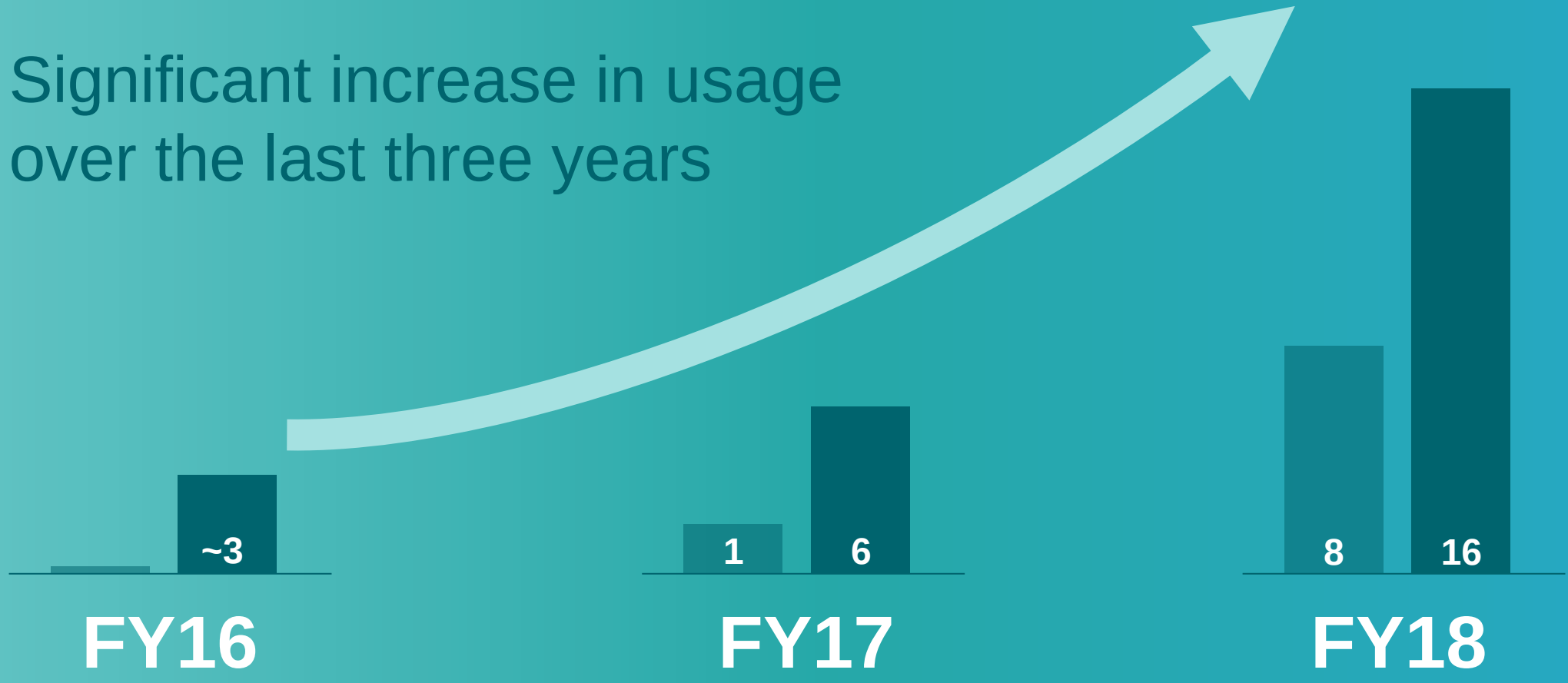
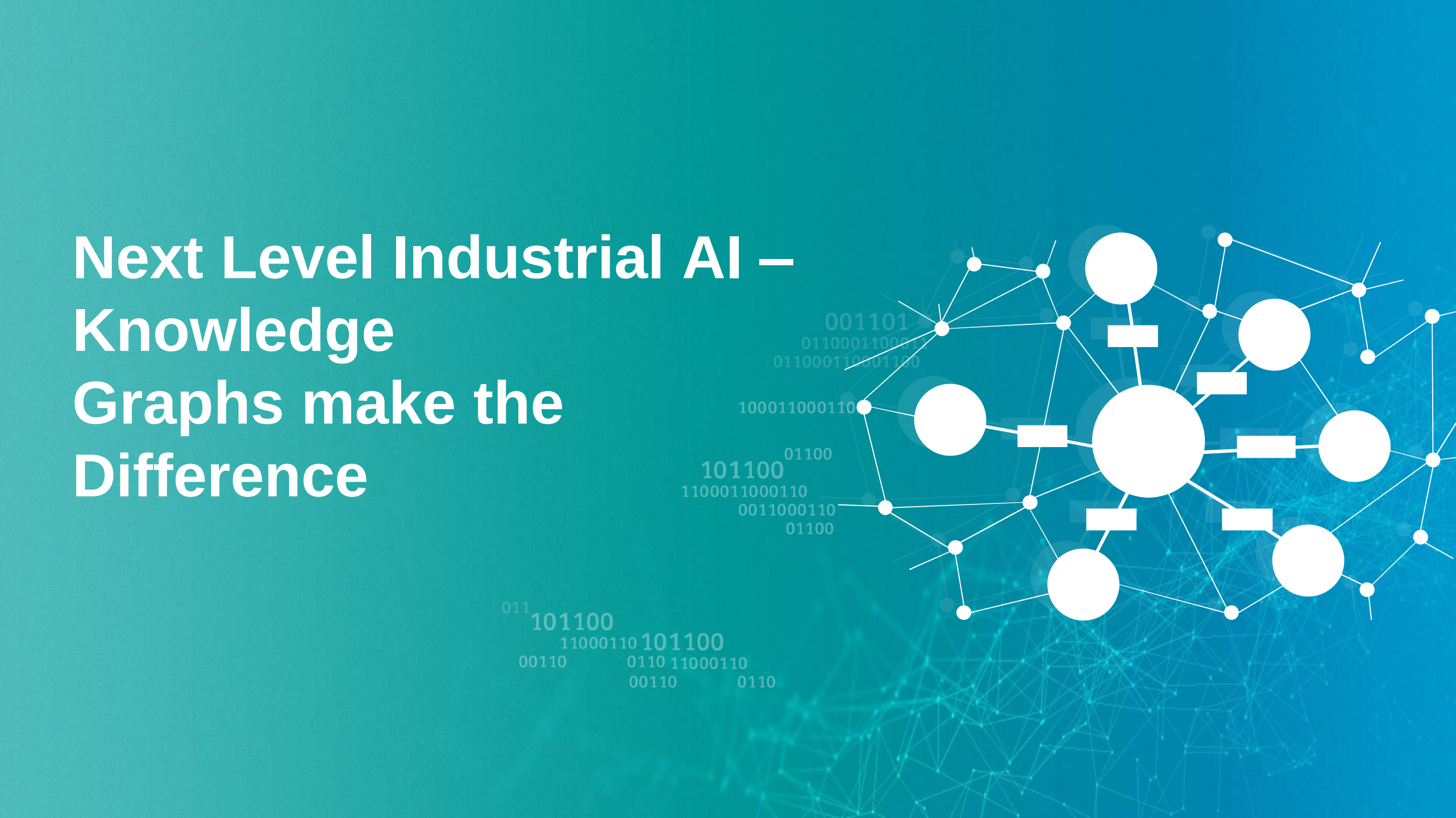
Significant increase in usage over the last three years



Next Level Industrial AI – Knowledge Graphs make the Difference



Industrial Knowledge Graph

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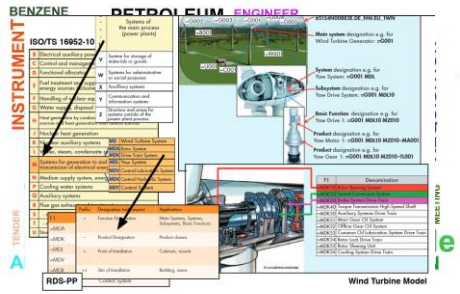
Domain Vocabulary



Industry Ontology

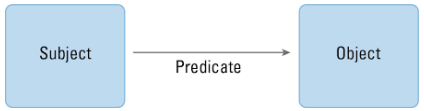
$$\text{SubClassOf}(\mathit{TwoRotorTurbine}\ \text{ObjectMinCardinality}(2\ \mathit{hasPart}\ \mathit{Rotor}))$$
$$\text{SubClassOf}(\mathit{TwoRotorTurbine}\ \text{ObjectMaxCardinality}(2\ \mathit{hasPart}\ \mathit{Rotor}))$$

$$\mathit{Equipment}(?x) \leftarrow \mathit{Turbine}(?x)$$
$$\mathit{hasSpeed}(?x,?y) \leftarrow \mathit{hasRotorSpeed}(?x,?y)$$
$$\mathit{hasPart}(?x,?z) \leftarrow \mathit{hasPart}(?x,?y) \wedge \mathit{hasPart}(?y,?z)$$
$$\mathit{Packaging}(?y) \leftarrow \mathit{Conveying}(?x) \wedge \mathit{followedBy}(?x,?y)$$

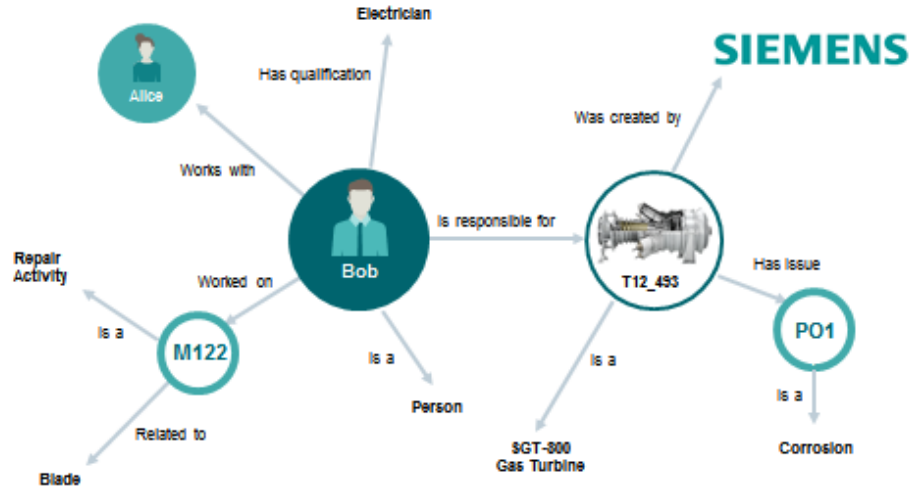
Industrial Content

TEAMCENTER Active Workspace
SIEMENS
SAP
Bentley Advancing Infrastructure
MindSphere

Graph Database



Industrial Knowledge Graph



Adapted from https://enterprise-knowledge.com/what-is-an-enterprise-knowledge-graph-and-why-do-i-want-one/

So what's new?

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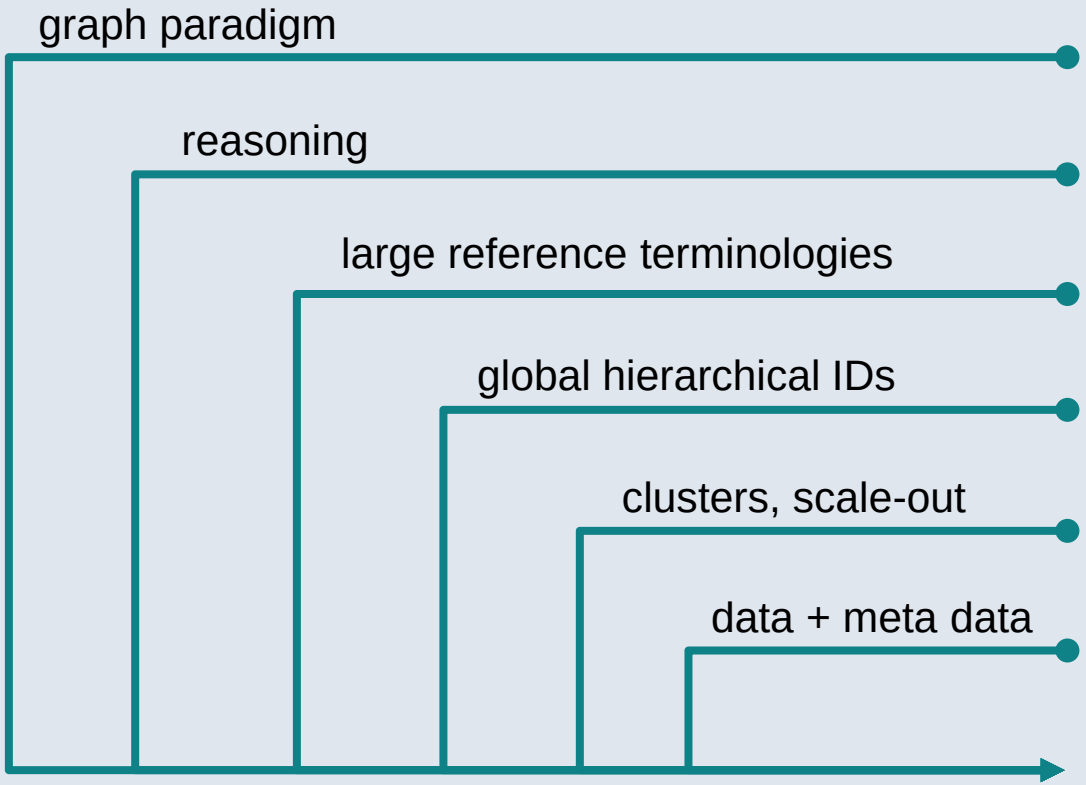
Knowledge graphs combine existing ideas in a package that works in practice for large organisations.



Semantic networks

Logic-based knowledge representation

Ontologies

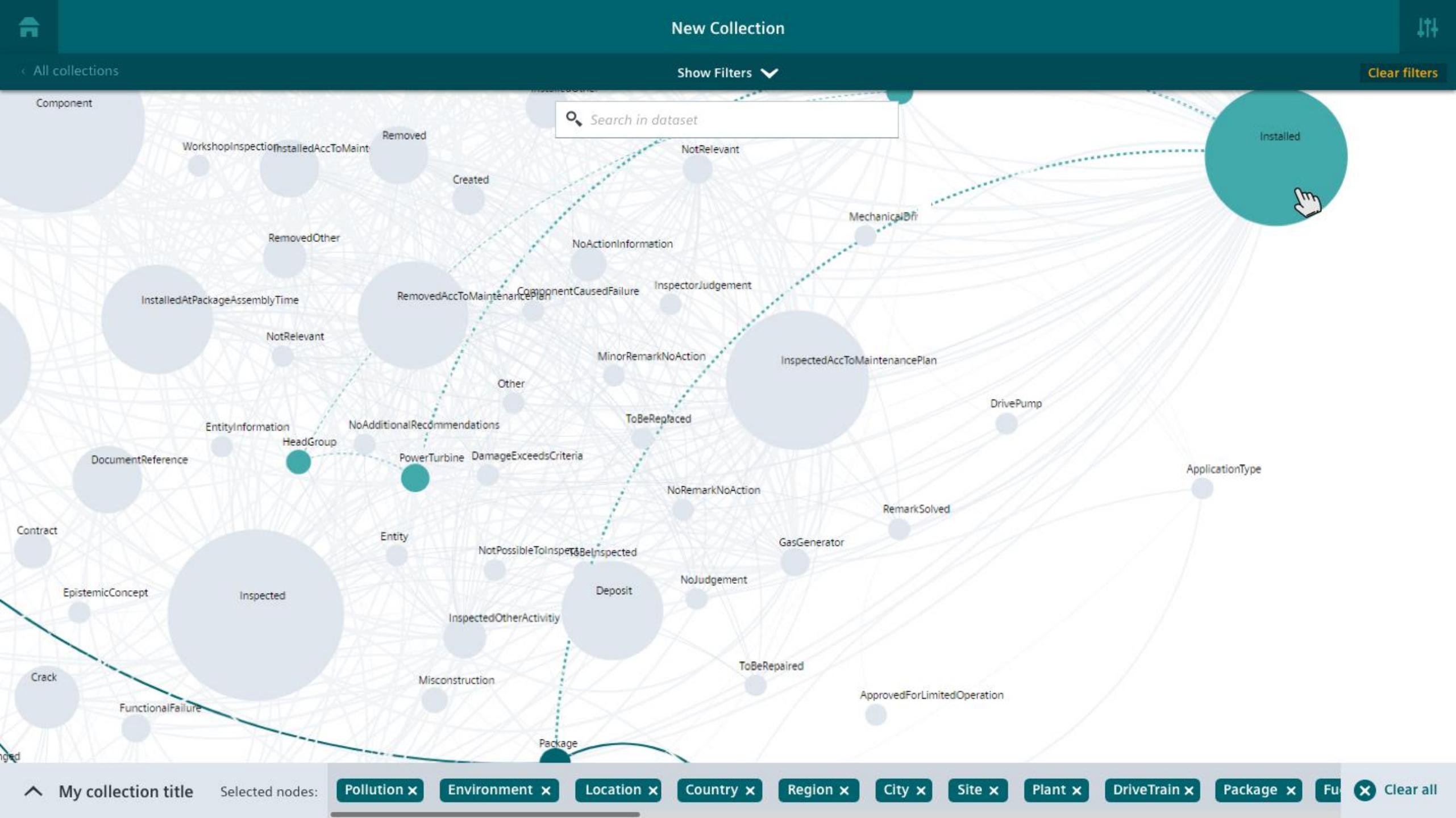
Linked Open Data

Big Data

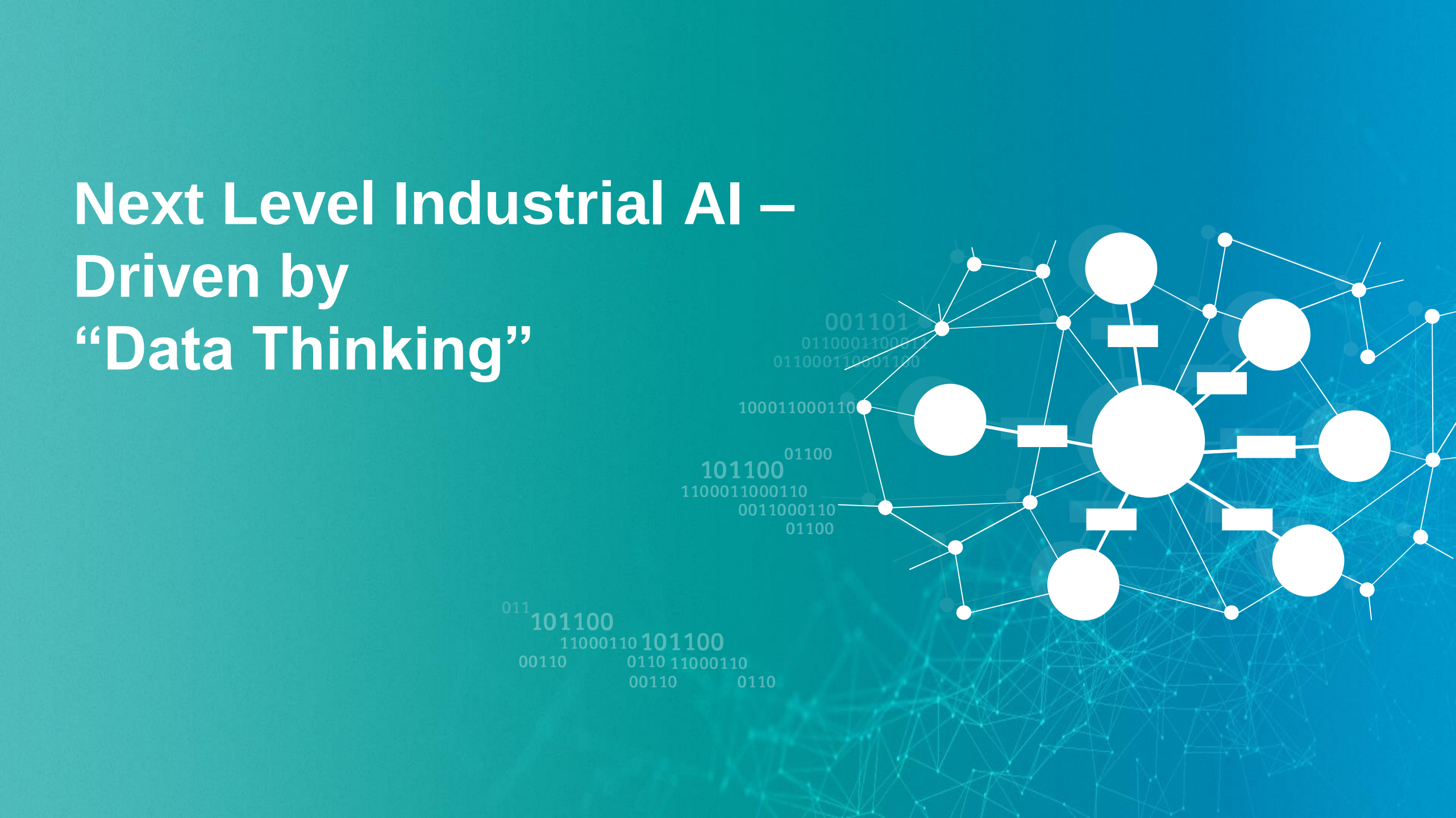
Smart Data

Knowledge Graphs

Scale to real world problems!


New Collection
All collections
Show Filters
Clear filters
Search in dataset
Component
Removed
WorkshopInspection
InstalledAccToMaint
NotRelevant
Installed
Created
MechanicalDri
RemovedOther
NoActionInformation
InstalledAtPackageAssemblyTime
RemovedAccToMaintenancePlan
ComponentCausedFailure
InspectorJudgement
NotRelevant
MinorRemarkNoAction
InspectedAccToMaintenancePlan
Other
DrivePump
EntityInformation
NoAdditionalRecommendations
ToBeReplaced
HeadGroup
DocumentReference
PowerTurbine
DamageExceedsCriteria
ApplicationType
NoRemarkNoAction
RemarkSolved
Contract
Entity
GasGenerator
NotPossibleToInspect
ToBeInspected
NoJudgement
EpistemicConcept
Inspected
Deposit
InspectedOtherActivity
ToBeRepaired
Crack
Misconstruction
ApprovedForLimitedOperation
FunctionalFailure
Package
My collection title
Selected nodes:
Pollution
Environment
Location
Country
Region
City
Site
Plant
DriveTrain
Package
Clear all

Next Level Industrial AI – Driven by “Data Thinking”



AI for industrial applications – data and know-how feed algorithms

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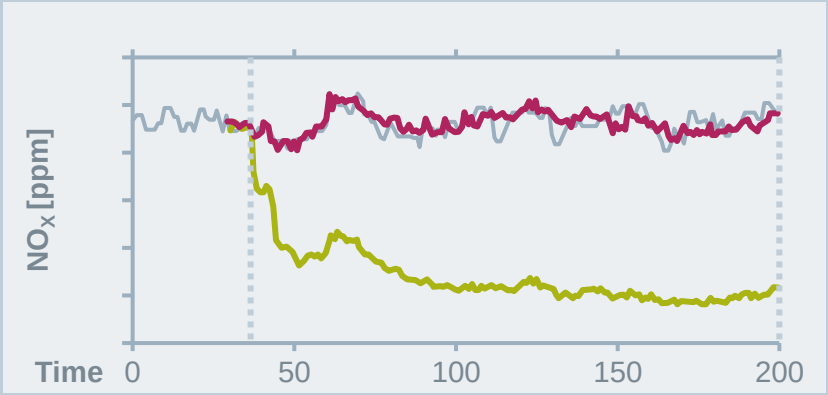
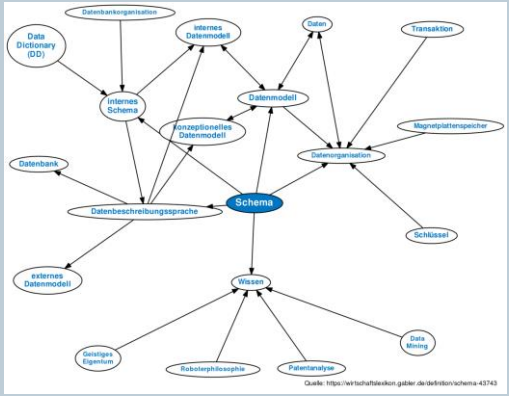
Machine data



Domain Know-How

Public data sources

Context Know-How



Data is Key for Knowledge Graphs – but becoming data-driven is not easy …

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Companies accelerate their investments in Big Data and AI

Investment in Big Data/AI	2018	2019
Greater than $500 m	12.7%	21.1%
$50 – 500 m	27.0%	33.9%
Under $50 m	60.3%	45.0%

But …

… they are failing in their efforts to become data-driven

Created a data-driven organization	2017	2018	2019
Yes	37.1%	32.4%	31.0%
No	62.9%	67.6%	69.0%

People and processes are the main challenges

Principle challenge to becoming data-driven	2018	2019
People	48.5%	62.5%
Process	32.4%	30.0%
Technology	19.1%	7.5%

Biggest challenge to business adoption	2018	2019
Lack of organizational alignment/agility	25.0%	40.3%
Cultural resistance	32.5%	23.6%
Understanding data as an asset	30.0%	13.9%
Executive leardership	7.5%	7.0%
Technology solutions	5.0%	5.0%

Harvard Business Review, Feburary 2019, https://hbr.org/2019/02/companies-are-failing-in-their-efforts-to-become-data-driven#comment-section

Why we need a data strategy: 80% of time in AI projects is spent for data preparation and not for analytics

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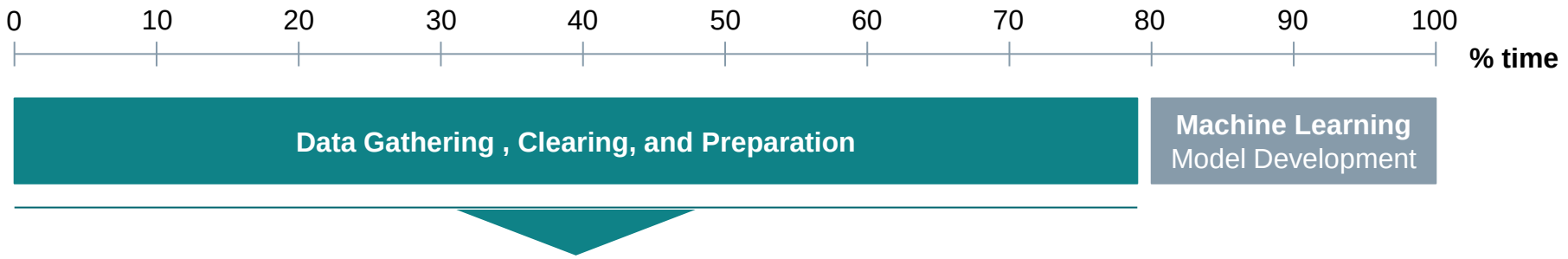
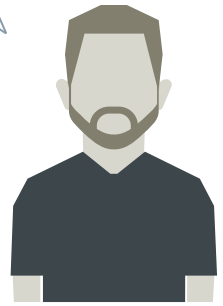
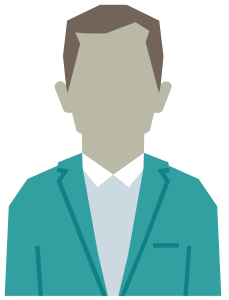


"We have supported >100 data analytics projects last year. In total approx. **€ xx Mio. have been spent just for data preparation**"



Data scientist

"I expected a first prototype for my use case **in 6 weeks**. It finally took **6 months** before I saw some first models. Are we really digital?"



Customer

Engineer

"By reducing the amount of double data in my stock I can reduce XYZ"

Ambition:

Reduce cost and time for data provisioning

Business benefits:

- Grow digital business
- Time to market
- Cost down
- Risk down

Co-creation with customers in Siemens AI Lab China

Siemens AI Lab China is aiming to

- be the AI driven knowledge exchange and co-creation hub in Asia
- support Siemens global AI innovation network together with AI Lab Munich and AI Lab Berkeley
- bridge customers' AI hopes with Siemens' real world solutions.

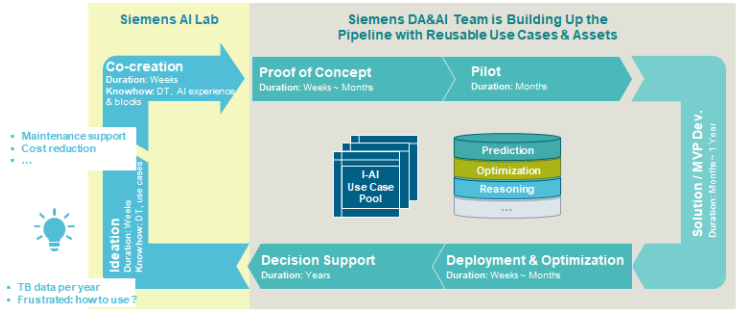
In **Siemens AI Lab China**, customers will team up with Siemens experts in **Data Analytics & AI** and **Design Thinking** based on Siemens 30 years experience of use cases and solutions across different industries.

Beijing
(AI Lab China location)

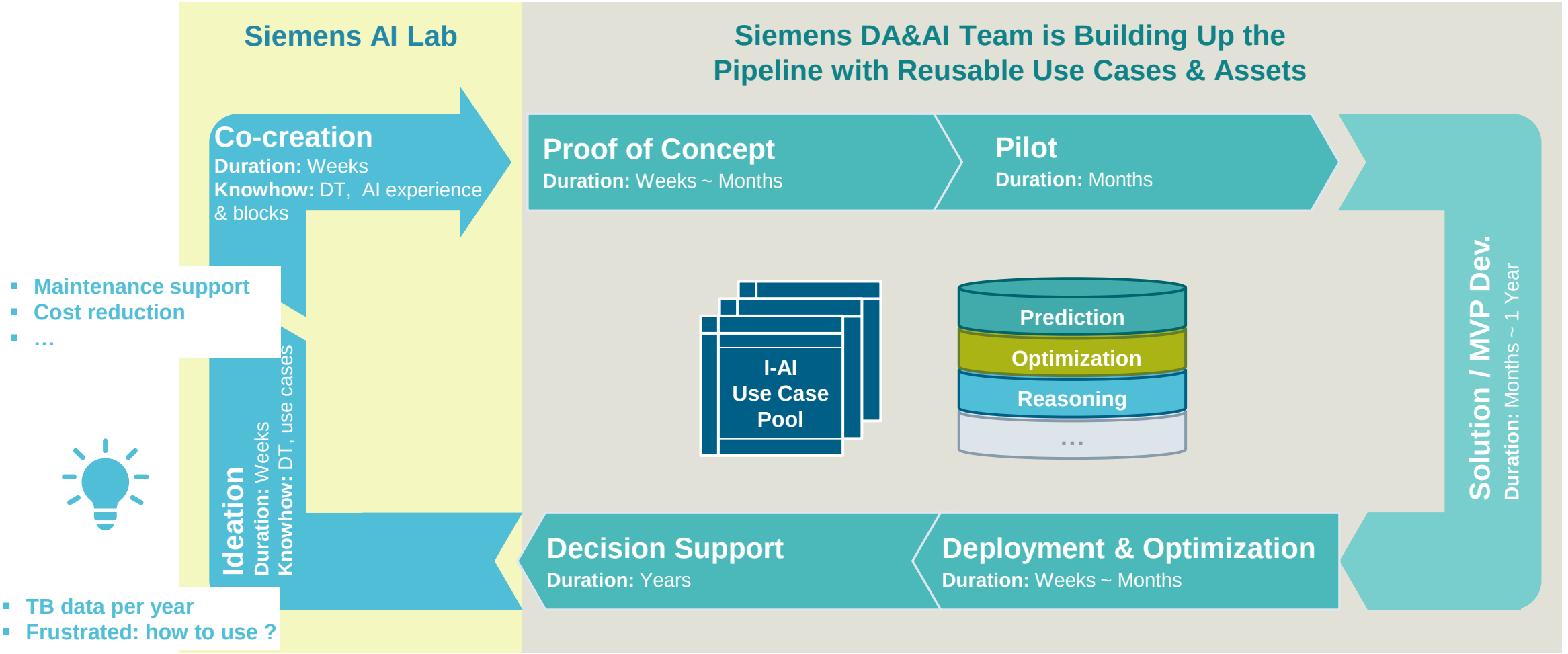
Suzhou
(On demand Service)

Shanghai
(On demand Service)

Customer Site
(On demand Service)



How to scale up data analytics & AI business in China



Siemens AI lab China: programs of FY19

	I. Starter Pac	II. Innovation Pac	III. Co-Creation Pac	IV. Booster Pac
	Day 1 Intro to Data-driven innovation	Day 1 Define	Day 1 Preparation	Week 1 Value proposition
	Day 2 Intro to Design Thinking	Day 3 Ideation/Prototyping	Day 3 Hacking II	Week 6 – Week 9 Developing MVP
	Day 3 Build your own demo	Day 4 Ideation/Prototyping	Day 4 Hacking III	Week 10 –Week 11 Pivot/persevere
		Day 5 BizzMo	Day 5 Demo + pitching	Week 12 Demo + pitching
Target audience	Sales, service, marketing, etc.	Sales, service, product managers, etc.	Sales, service, product managers, data scientists, etc.	Sales, service, product managers, data scientists and developers, testing, etc.
Outcome of programs	Sense and knowledge of AI	Executable requirements	Feasible solutions/ Prototype	Minimum viable product

AI Lab China is ready for co-innovation!

Next Level of Industrial AI – Frameworks for Rapid Industrial AI Adoption

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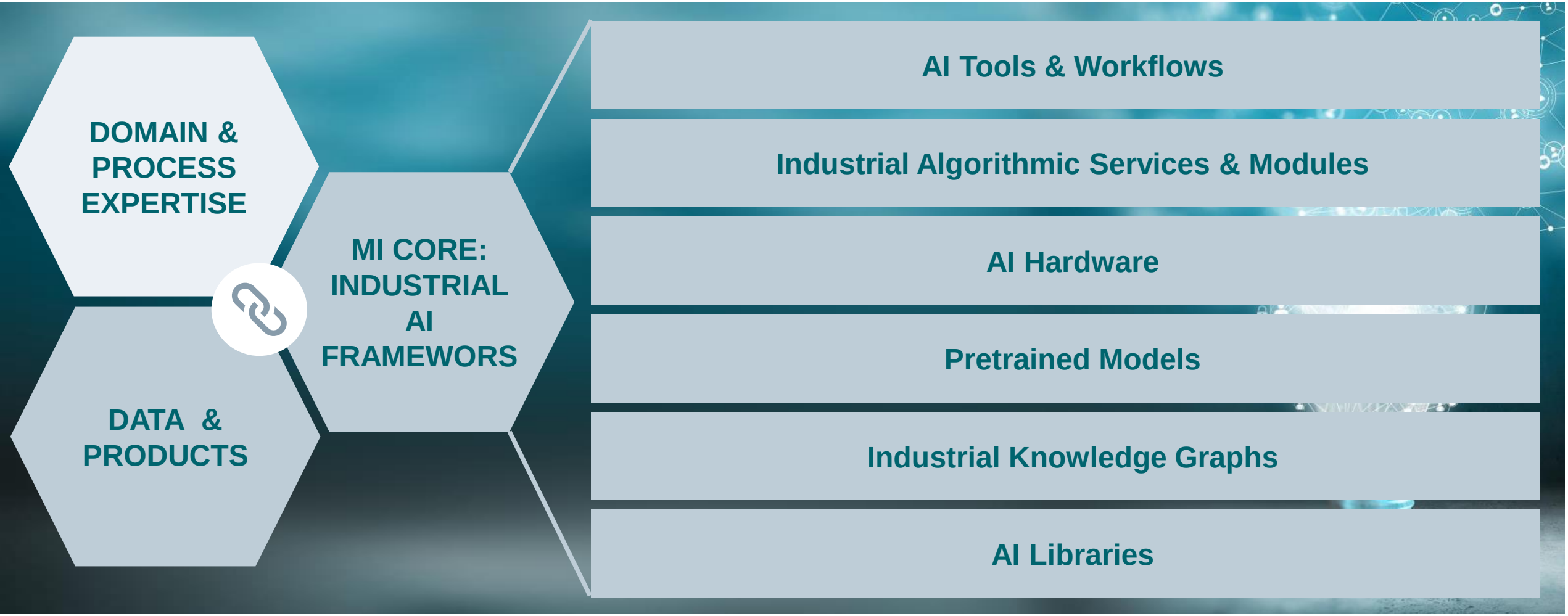

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Thank You!