



KI & Robotics für eine effiziente Abfallsortierung

Barbara Mayer
Daniel Schall
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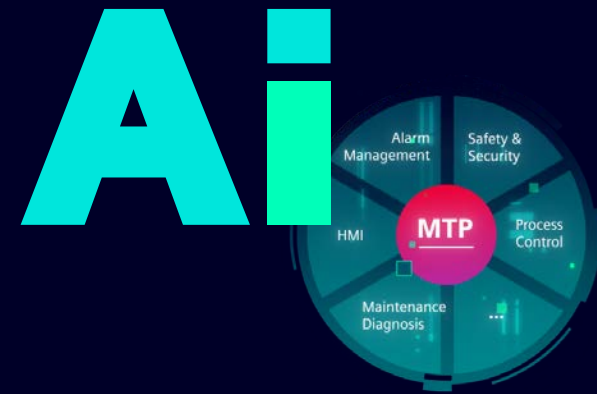


20 million tons of plastic waste per year in EU countries

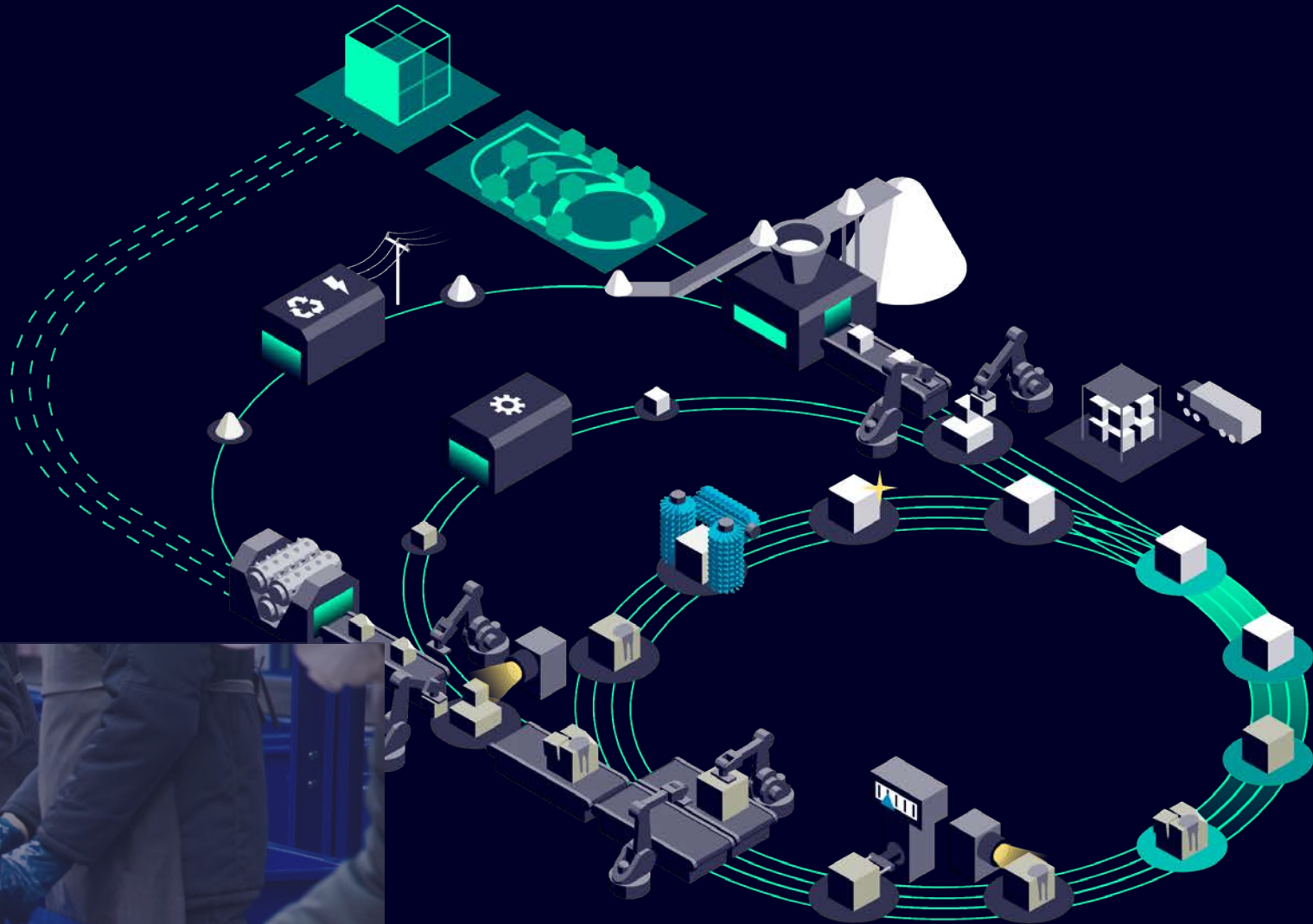


32,5 % recycled

Turning Trash into Treasure

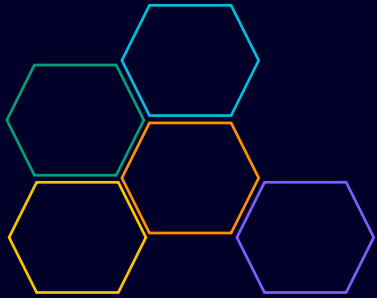


Sorting as Relevant Process Step in Circular Economy

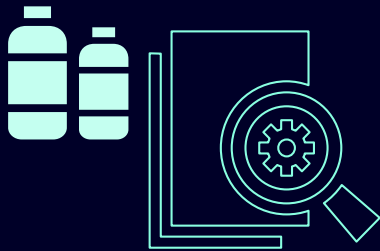


Current challenges on plastic sorting plants

Cross-vendor plants
Integration Challenges



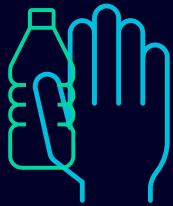
Emerging industry
Lack of Standardization



Operational rigidity
Demand for adaptability



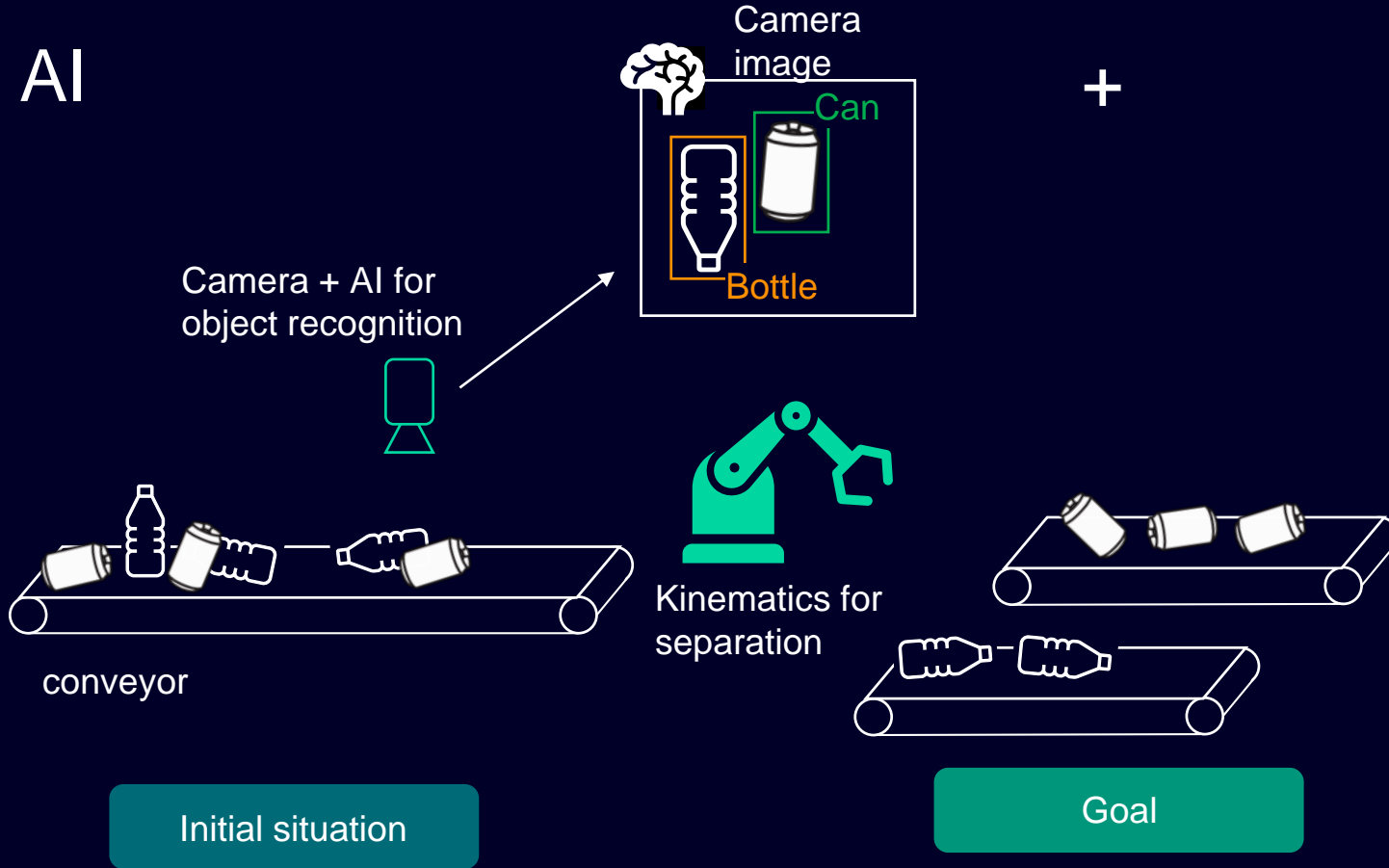
Manual
sorting processes



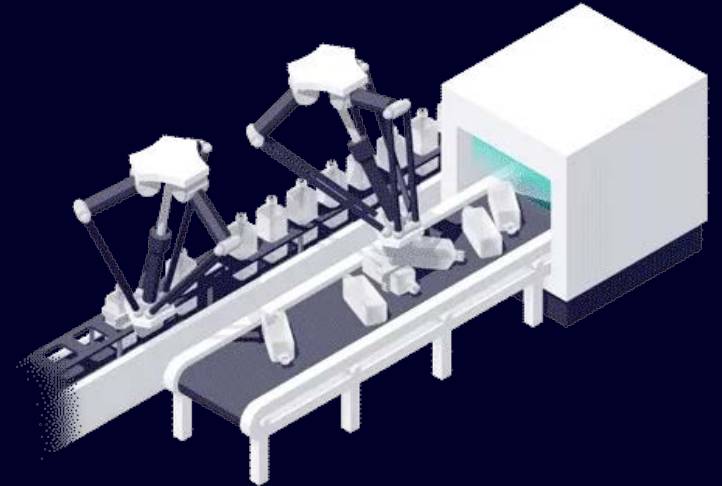
Handling operation based on AI

standardized interfaces, service oriented, open, standard automation components, programmable, user defined, modular approach

AI



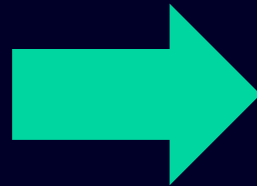
Automation



AI Solution Blueprint

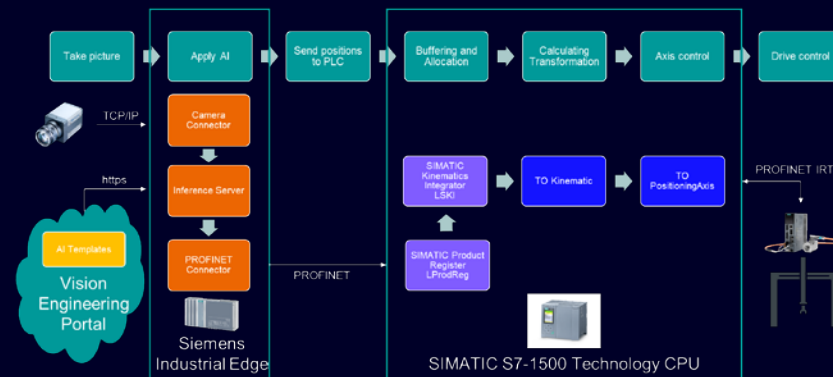
Having déjà vus

- Processing images
- Detecting objects
- Verifying product quality
- Postprocessing
- Sorting defect objects on a conveyor belt

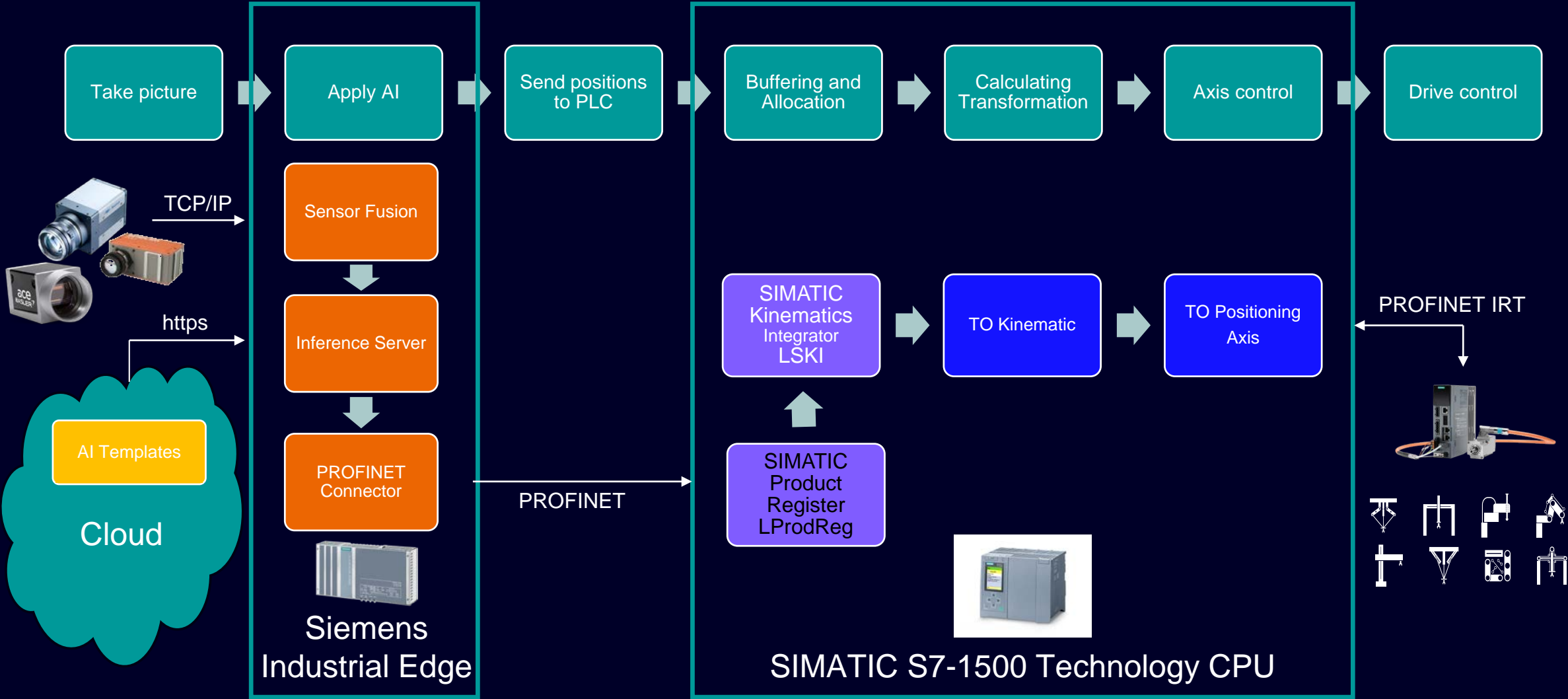


Scaling requires blueprinted concepts

- Provide a **solution architecture or concept** for complex and very complex problems.
- Generic and can be applied to **different fields of application**.
- Provide abstract solutions for **recurring problems** (scalability).
- Define a **Gold Standard**.

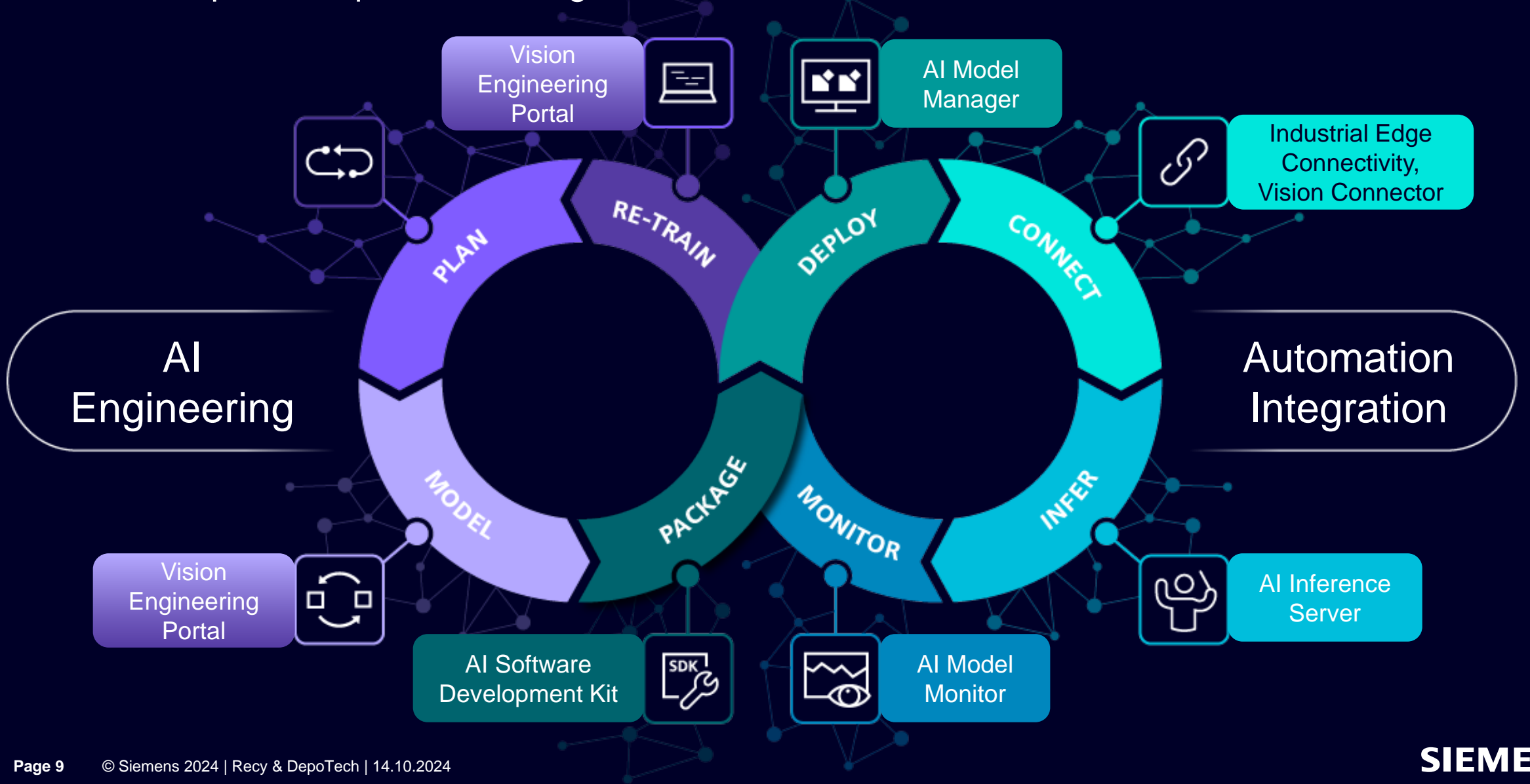


Workflow and communication between services

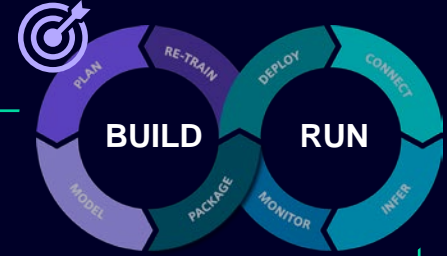


Siemens Industrial AI Portfolio

There is a repeatable pattern to integrate AI in automation



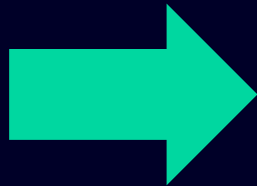
Vision AI - Vision Engineering Portal



How do I solve my vision AI case?

Do I need AI know how?

How do I achieve scalability?

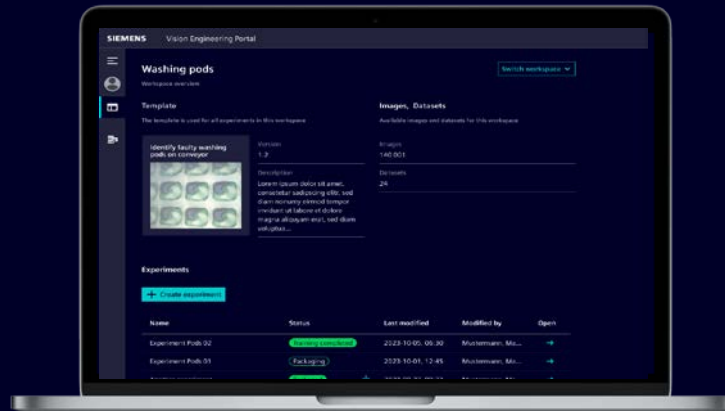


Vision Engineering Portal – VEP

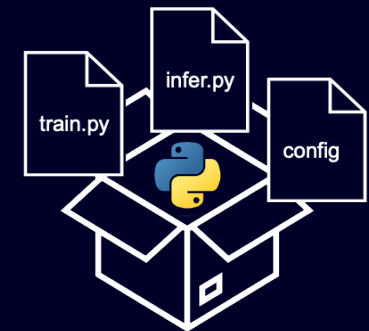
- Platform to train AI models for vision use cases
- Targeted towards domain experts
- High customizability of AI solution via use case templates
- Integrated process compliance
- Scalability via Industrial Edge, Industrial AI portfolio & Cloud

? IT ?

OT



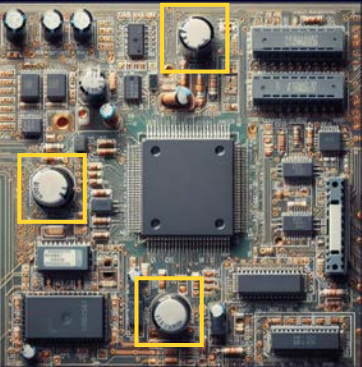
Easy to use platform targeted towards domain experts



Highly customizable use case templates

VEP Workflow - Create, train and manage vision AI models for Industrial AI use cases

1. Choose fitting use case template or bring your own



Select a template

Search: type to find template

Sort by: Creation date

Template details

Element Presence Check

Sharpness label validation template

Solder Joint Classifier

Moist Anomaly Classification

Tide pod border segmentation

Tide pod detection

Select

2. Upload data and create a dataset

2. Select/deselect images from your dataset

Target number: 0 Selected images: 5

New dataset

Dataset 2 version 1.0.2

Image resources

Images from Workspace 0

Dataset 2 version 1.0.1

Current workspace: Workspace 0

Sort by

Selected all images

bottle_68.jpeg cable_3.jpeg transistor_84.jpeg cable_12.jpeg bottle_75.jpeg bottle_64.jpeg capsule_27.jpeg

hazelnut_11.jpeg hazelnut_16.jpeg cable_31.jpeg transistor_28.jpeg bottle_5.jpeg cable_3.jpeg hazelnut_4.jpeg

Pending changes: 2 images to add Discard changes Save changes

Previous Next

3. Label data

Annotate 15 images

bottle_3.jpeg

Annotations (1)

All OK

Discard Apply

4. Train model

Get data Prepare data Train model Evaluate results

Summary

Model type	Object detection	Count (images)	Count (instances)
Dataset	Dataset 2 (v1.0.2)	Total: 5	-
		Unlabeled: 3	-
		Labeled: 2	5

Training: Not started

Start training

Note: splitting into train, test, and validate datasets is done automatically according to a default split ratio.

Previous Next

5. Validate results and deploy to the shopfloor

Experiment gifted testive

Workspace 0

Experiment 3

Created date: 19 Jan 2024, 16:28 Dataset 2 (v1.0.2)

False Positives (rel.): 0.07

Quality Score: 0.43

False Positives (rel.): 0.07

False Negatives (rel.): 0.4

Critical Misclassifications: 10

Reviews: 64

Error Distribution: pie chart

Absolute Maximal Defects: bar chart

Experiment gifted testive

Created date: 10 Jan 2024, 09:29 Dataset 2 (v1.0.2)

False Positives (rel.): 0.83

Quality Score: 0.43

False Positives (rel.): 0.83

False Negatives (rel.): 0.99

Critical Misclassifications: 8

Reviews: 64

Error Distribution: pie chart

Absolute Maximal Defects: bar chart

Previous Create package



Labeling

Big effort and adaption need

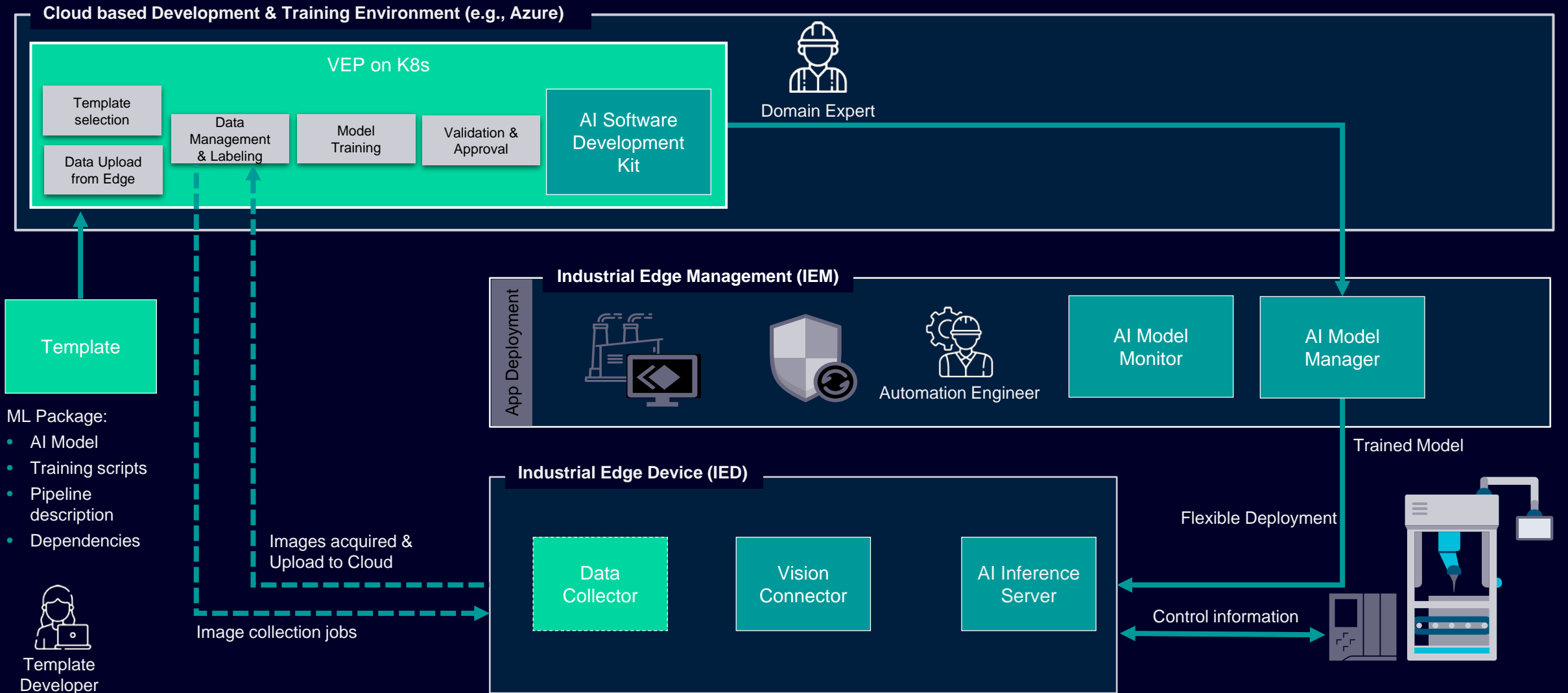
Impact of

- products to be inspected/sorted
- camera, background, light conditions

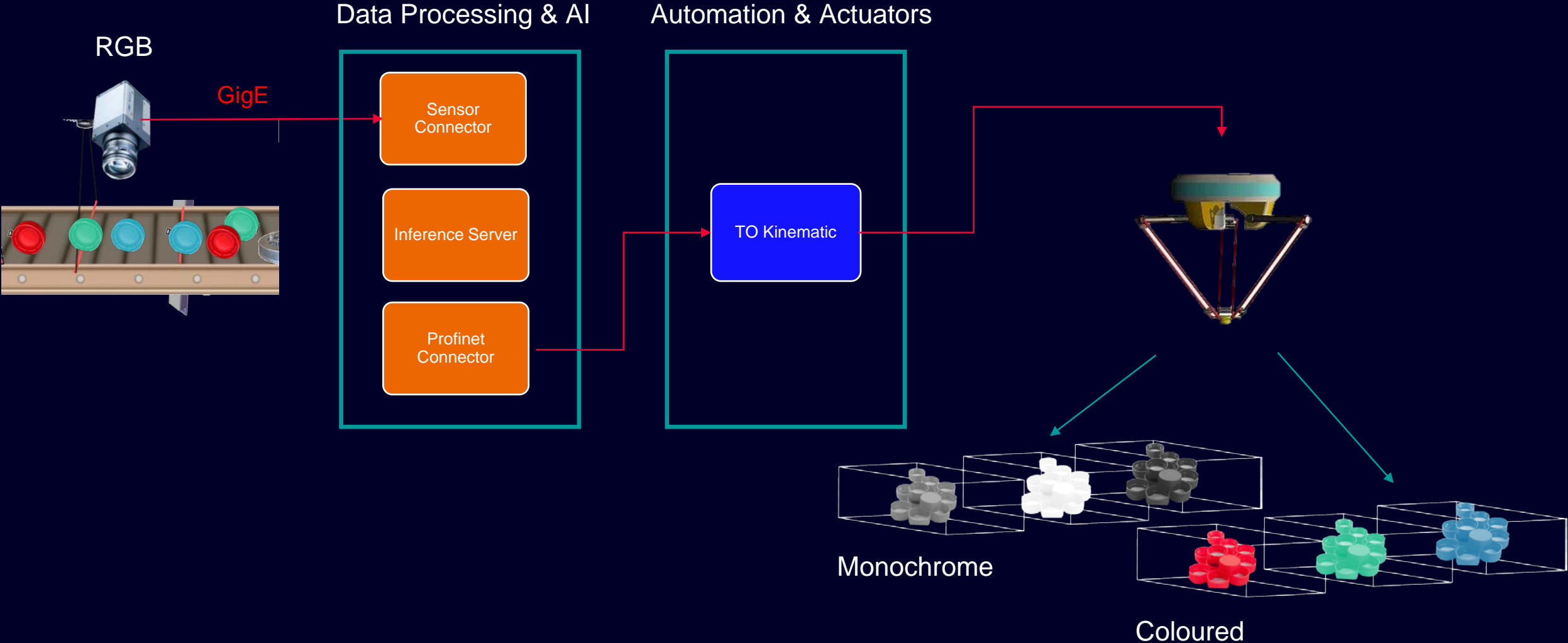


VEP engineering for industrial edge

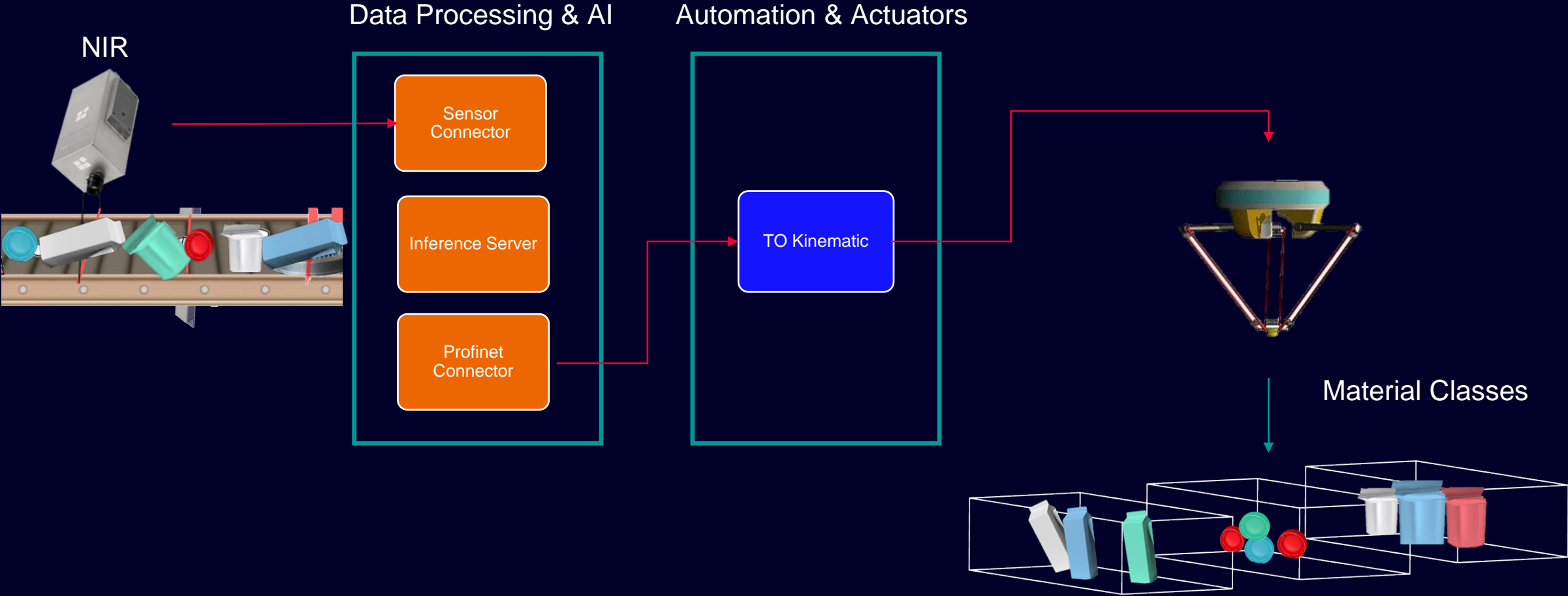
How VEP interacts with the Industrial AI portfolio



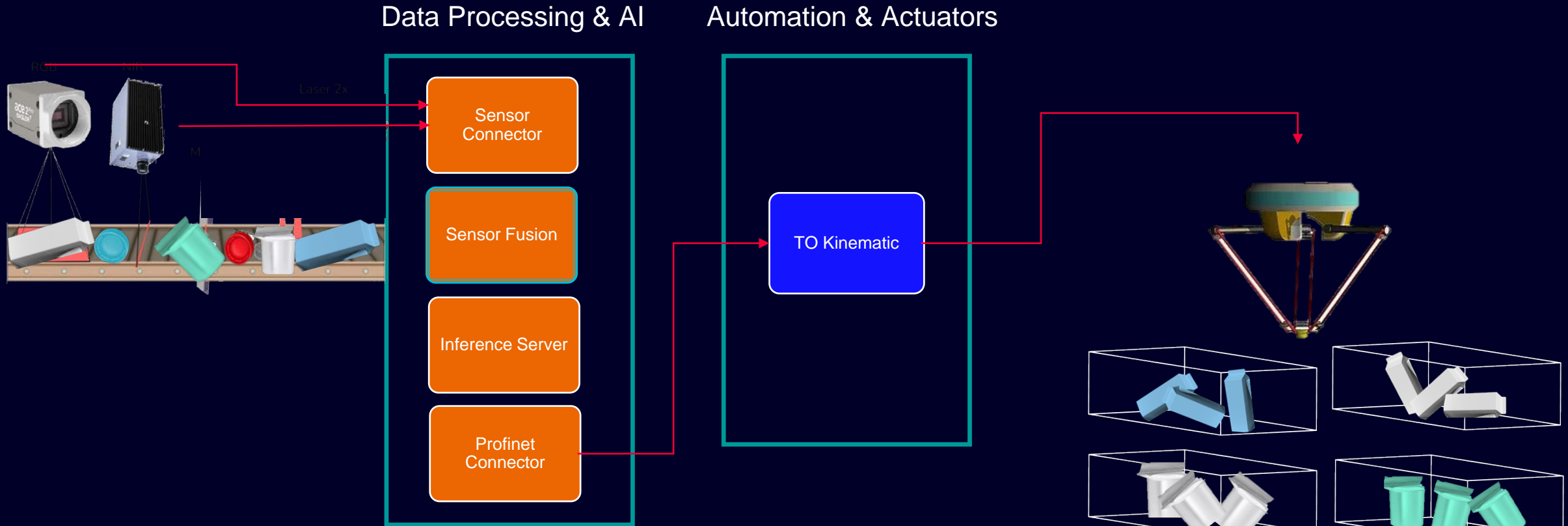
Sensors enable different Use Cases – RGB



Sensors enable different Use Cases – NIR



Sensors enable different Use Cases – Sensor Fusion

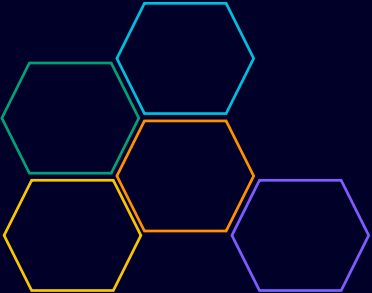


Objekterkennung				Materialinfos										Geometrie-Infos (lt. 3DLT)				RGB Infos												
Unique ID	Timestamp	Box Pos	Box with	Box height	Area	Feret diame	PET absolute	PE absolute	PP absolute	PPK absolute	Metal absolute	Paper absolute	Other absolute	Wood absolute	Metallinfo ja/nein	Objektvo lumen	projizierte Fläche	er Feret-Durchm	projizierte Fläche (lt. RGB)	Red	Orange	Yellow	Light-Green	Dark-Green	Turquoise	Light-Blue	Dark-Blue	Purple	Inner	
246	08:56:28.504	238	56	35	1960	56	1274	1	46	1	327400	10	6	0,00%	327400	10	6	0	0	0	0	0	0	0	0	0	0	0	0	0
247	08:56:33.763	216	48	53	2544	53	1291	36	1	6	19469536	624	6	0,00%	19469536	624	6	2544	21	1	1	2	0	0	0	1	5	11	2468	
248	08:56:33.692	41	42	26	1092	42	533	28	64	3	3377	2	1	0,00%	3377	2	1	1092	7	0	0	0	0	0	0	0	14	7	1057	
249	08:56:33.667	161	70	70	4900	70	1715	52	58	3	6,94%	3344	34	3	4900	34	3	4900	211	1	2	6	0	2	9	63	25	4516		
250	08:56:33.657	101	59	93	5487	93	2534	35	78	6	35,57%	1968347	240	12	5487	240	12	5487	51	0	0	0	0	0	1	48	19	5296		
251	08:56:33.562	63	50	82	4100	82	1904	34	24	4	0,12%	2256	23	8	4100	23	8	4100	31	0	0	0	0	0	0	0	21	4	4030	

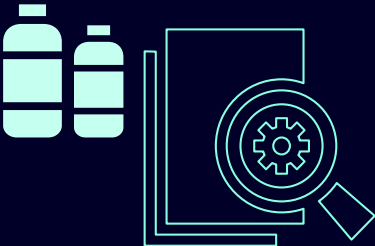


Current challenges on plastic sorting plants

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Integration Challenges



Emerging industry
Lack of Standardization



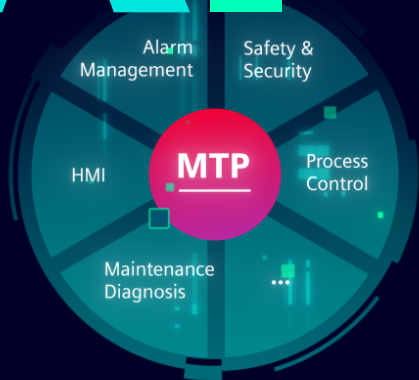
Operational rigidity
Demand for adaptability



Manual
sorting processes

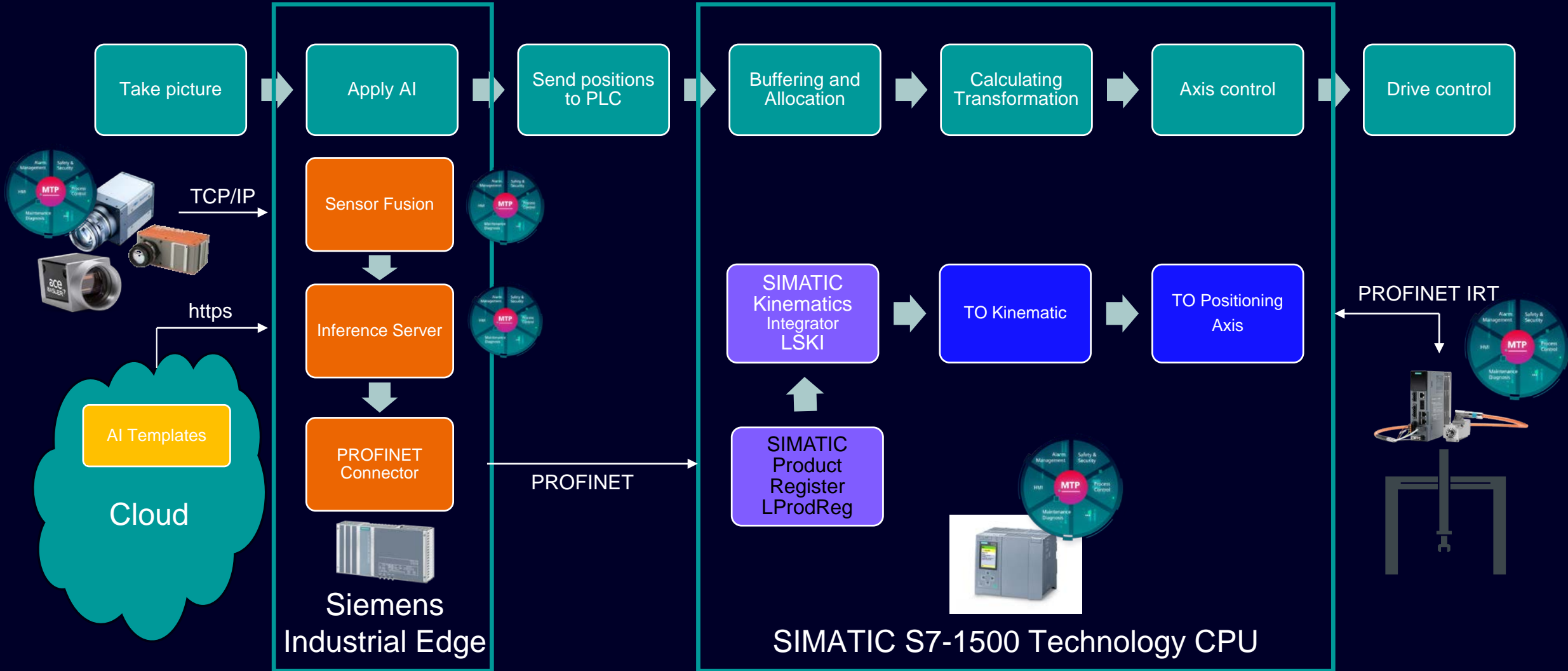


Ai

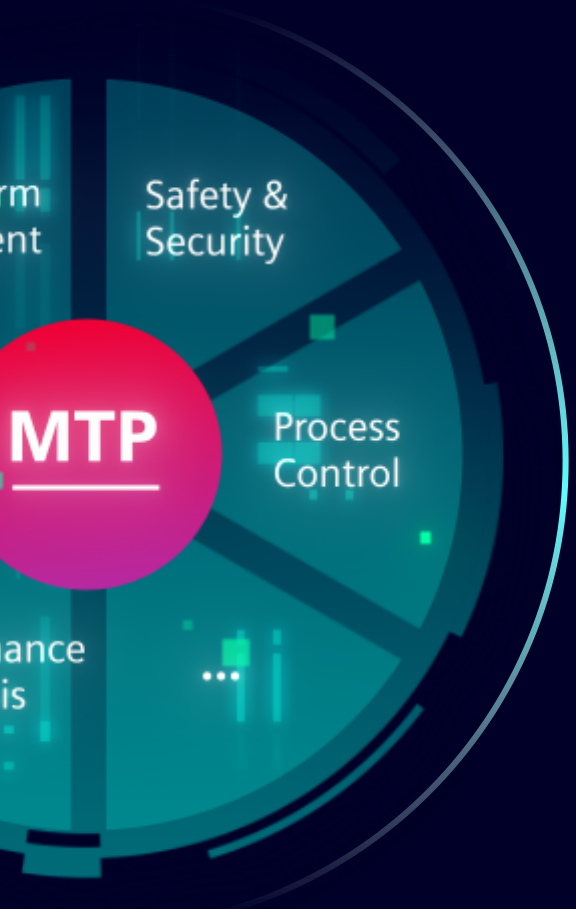


Blueprint @ AI and MTP

OUTLOOK

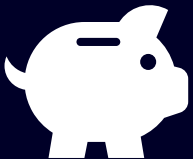


**Module Type Package (MTP):
Paradigm shift → Plug & Produce**



50%

faster time
to market*



70%

reduction in
engineering
effort*

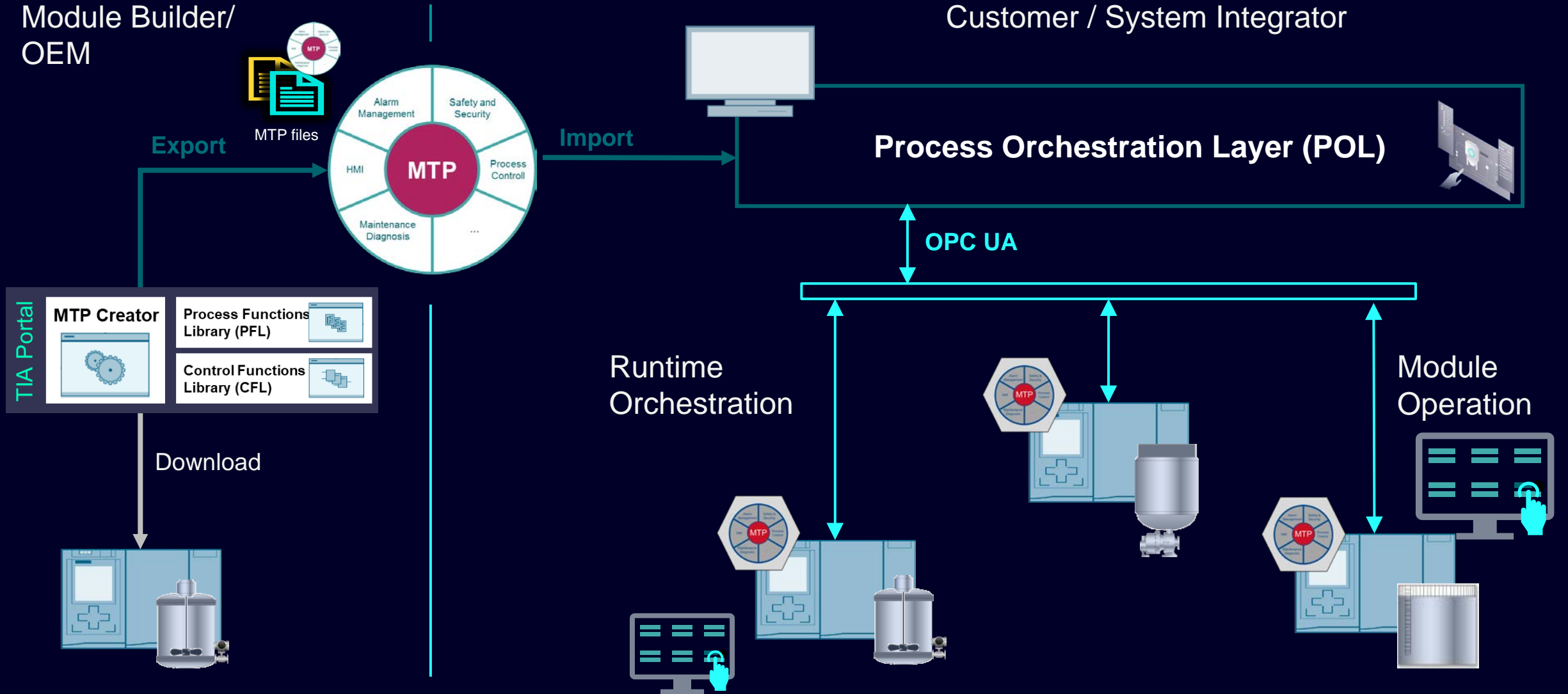


Limitless

flexibility

* Source: 2021-11_ZVEI_NAMUR_Status Report MTP NOAR

Module Type Package: how does it work?



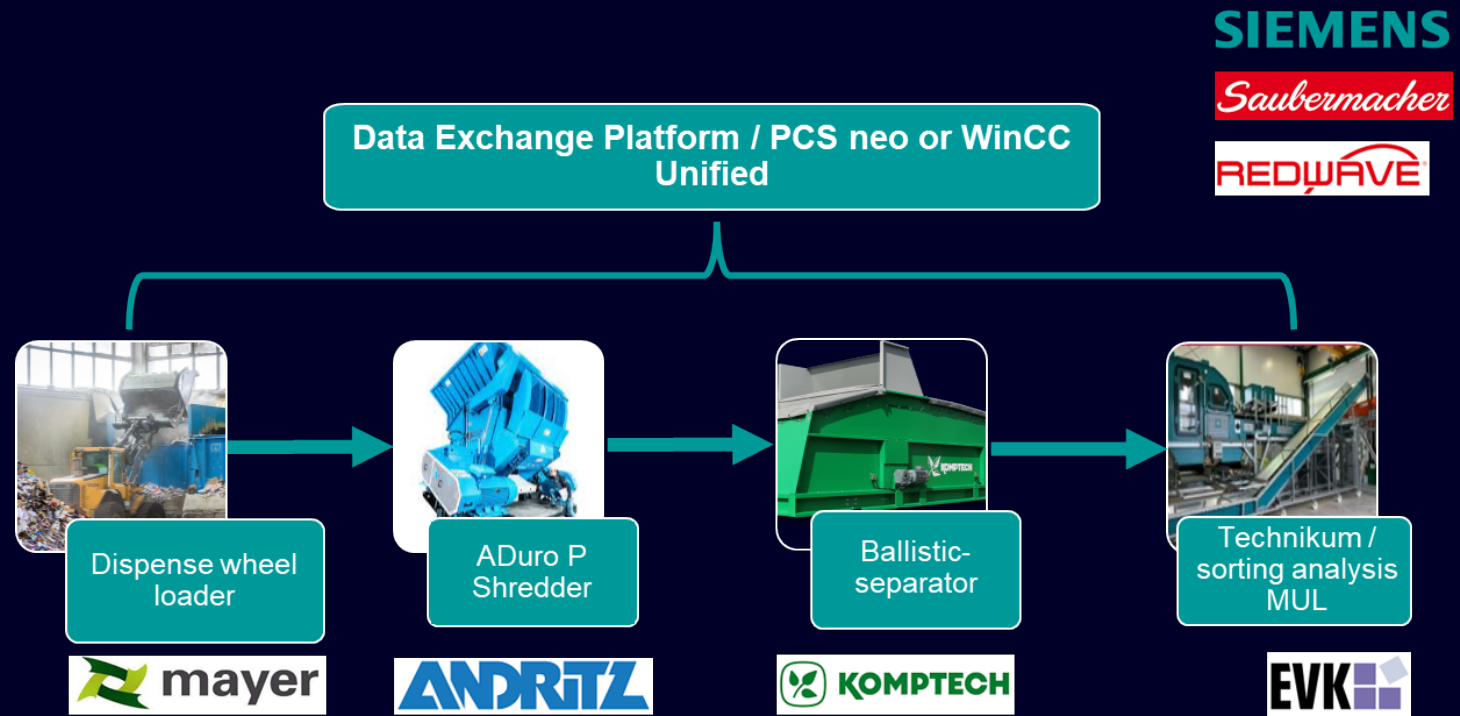
Digital Waste Research Lab

First plastic recycling plant based on Module Type Package

Collaborative creation of an **MTP demo case** facility with the ReWaste F consortium

Harnessing the power of MTP for achieving an **adaptive plant**

Digital Data Platform for Sensor and Process Data Processing/Exchange & Monitoring



Aduro P Shredder from Andritz



Shredder

MTP Implementation

Preferred solution:

MTP Native Implementation:

- Siemens products: Process Function Library (PFL) or Control Function Library (CFL) and SIMATIC MTP Creator

Alternative:

MTP Upgrade Implementation:

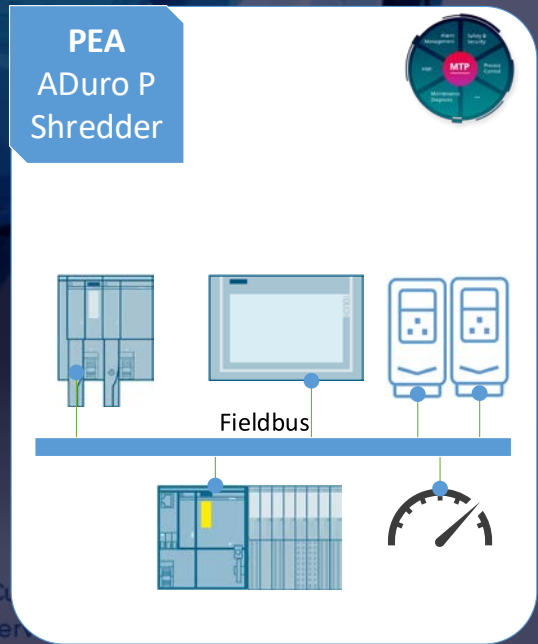
- Siemens products: Machine Proxy App for Ind. Edge

Consultancy and implementation support by
Siemens Graz

ANDRITZ

Typical applications

- Household/industrial waste
 - Bulky waste
- Pulp and paper rejects
 - Plastics
 - Textiles
 - Wood
 - Paper





Ballistic Separator

MTP Implementation

MTP Upgrade Implementation:

- Siemens products: Machine Proxy App for Ind. Edge

The Ballistor separates out usable fractions from waste and potential recyclables. By combining ballistic separation with screening, in just one pass-through the material stream is separated to the criteria 3/2-dimensional, rolling-cubic-rigid/ flat-soft-narrow, and particle size.

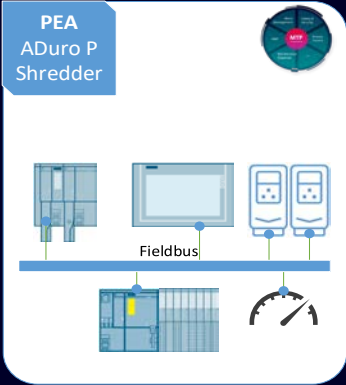


SIMATIC MTP Integrator for WinCC Unified

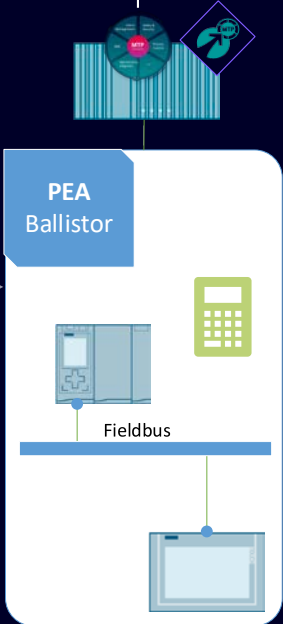
First Siemens SCADA enhanced with MTP capabilities



MTP Integrator for WinCC Unified



Conveyor belt



SIEMENS

Summary and Outlook

AI enables **automated sorting**

AI & Automation together boost up effectiveness and efficiency to gain higher recycling rates

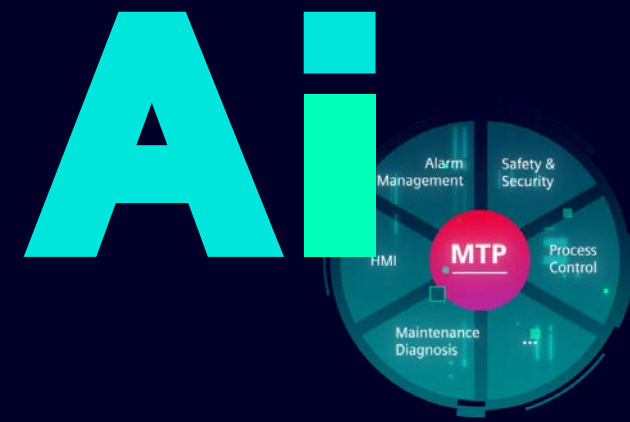
Module Type Package as a **standard** helps to overcome proprietary solutions

Blueprints as a framework help to work in **ecosystems** and allow **flexible solutions**

Use Case determines the choice of **sensors** and the **AI model**



Bild: Steinert



Too good to be true?

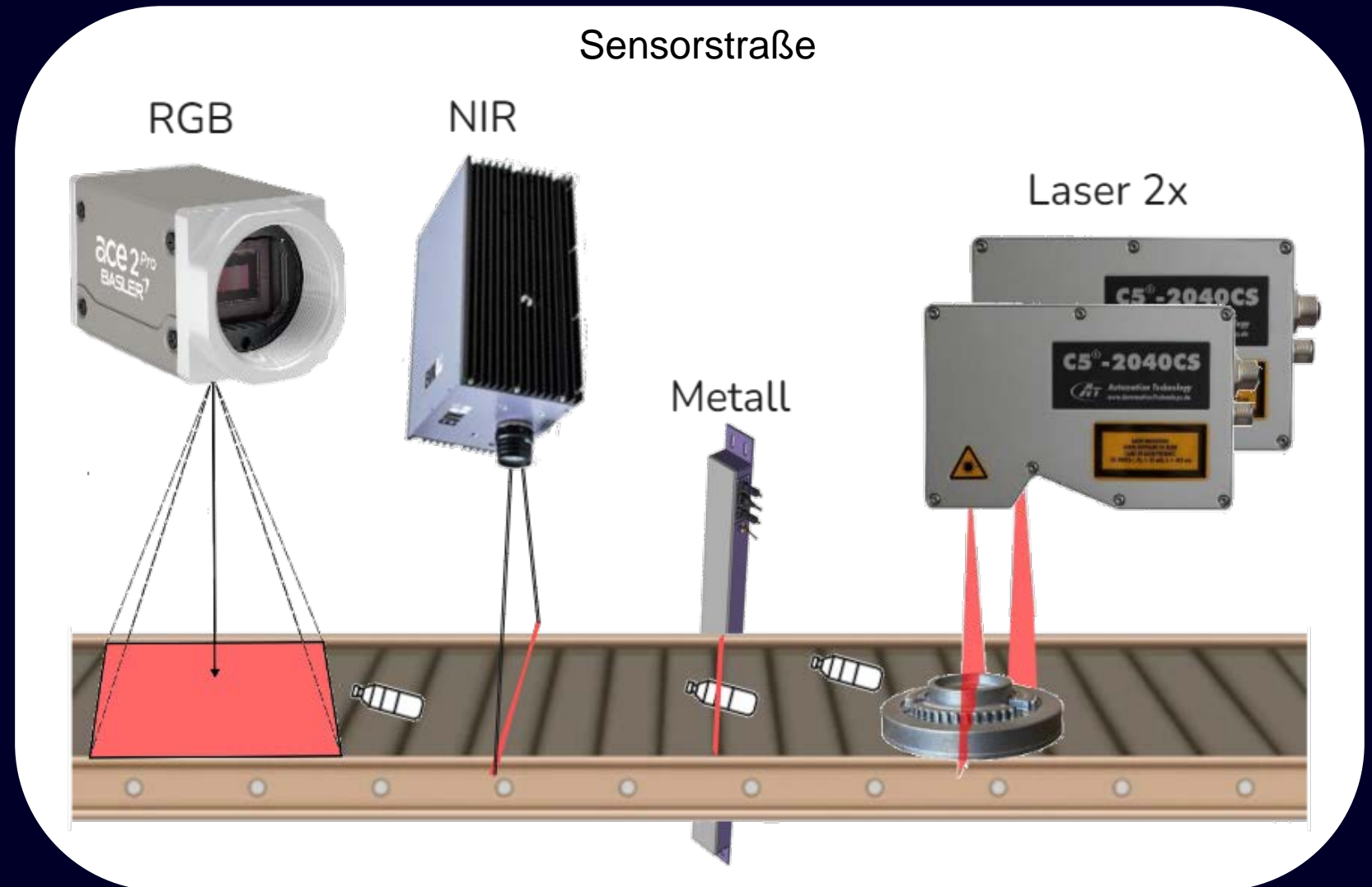
Stay tuned!

Thank you for
your attention.

Any questions?

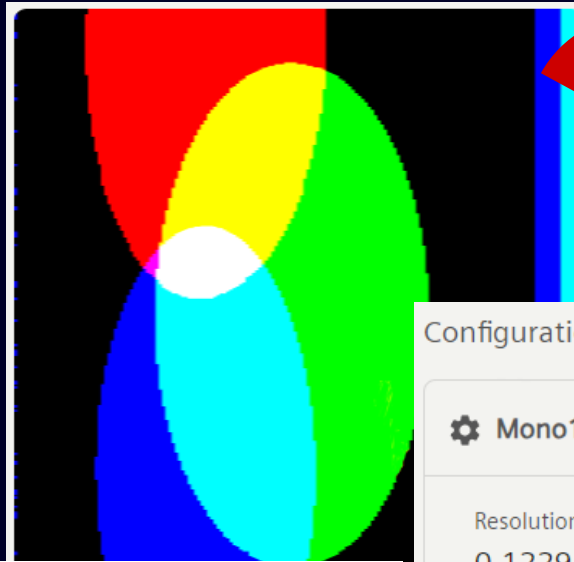
Sensorfusion - Problem

- Erkennung mit RGB nicht ausreichend (geschreddert / Flakes)
- Wie erreicht man höhere Klassifizierungsraten?
- Einzelne Sensoren – einzelne Datenströme
- Wie Synchronisieren?



Sensorfusion - Kalibrierung

- Probleme:
 - Linien/Flächenkameras
 - Unterschiedliche Framerate
 - Unterschiedliche Auflösung
 - Zeitlicher Offset
 - Vertikaler Offset



Configuration

⚙ Mono16 File

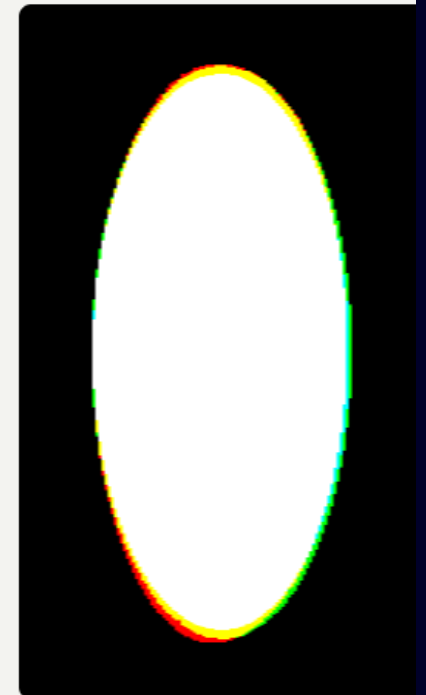
Resolution Factor
0,12295502

Left Offset
224

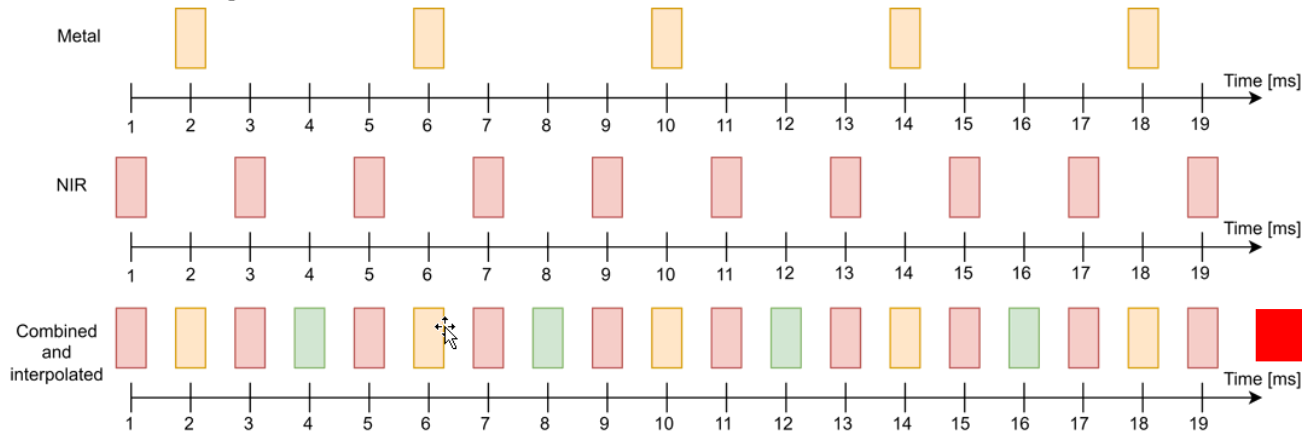
Right Offset
0

Spatial Offset
-475

Flipped

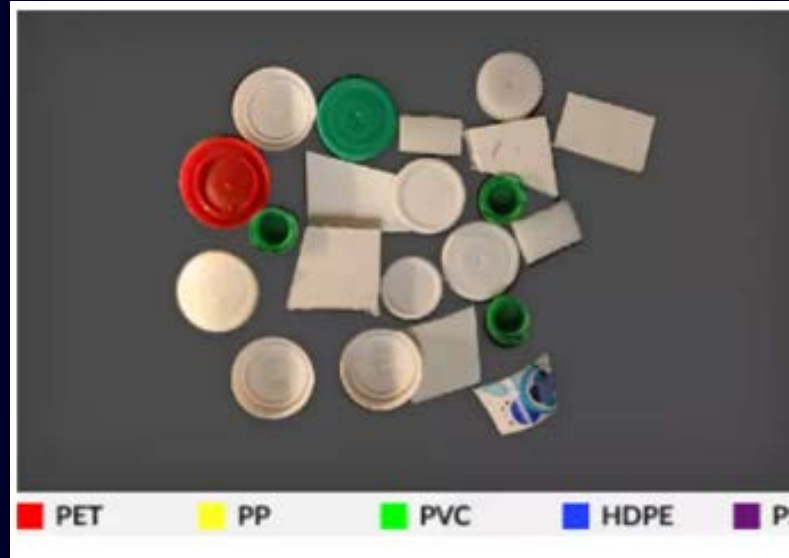


Interpolation

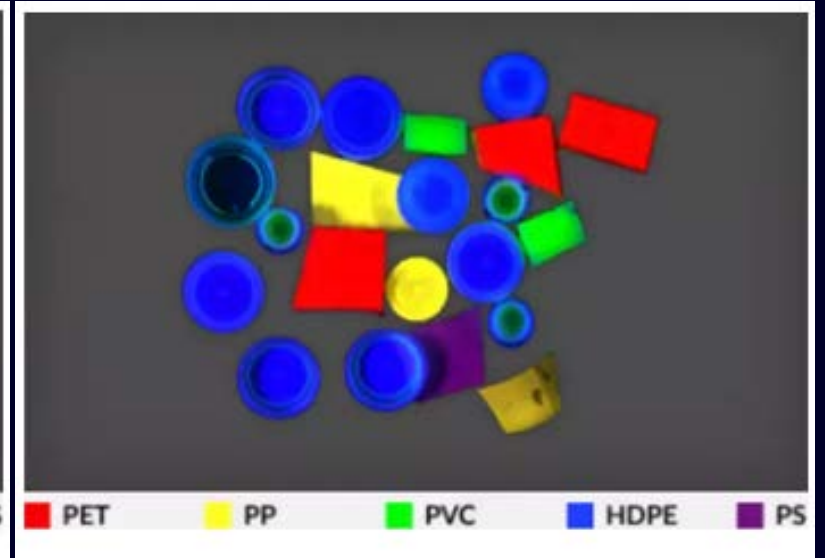


Sensorfusion - Ergebnis

- Analyseplattform - Fusionierte Datenströme
- VQI Tool - AI Modell Trainieren / Managen
- Inference Server – AI Objekterkennung + Klassifizierung
- Objektdaten (Pickinformationen) - über Profinet and PLC



Erkennung RGB

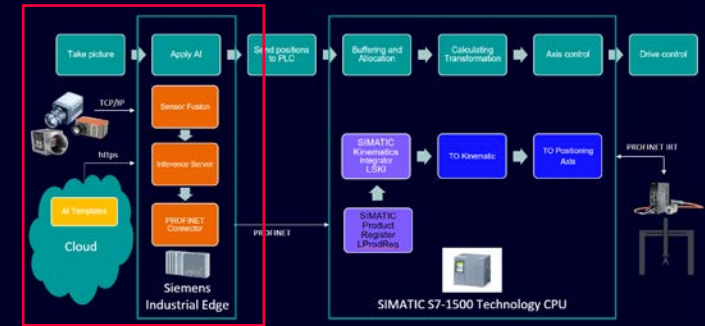
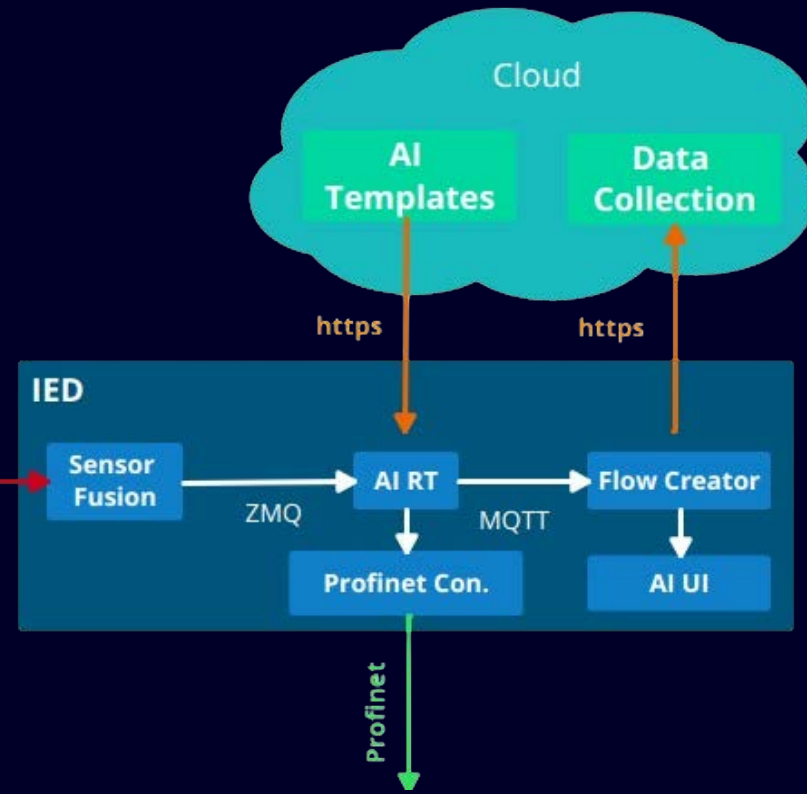


Erkennung Fusion

Objekterkennung							Materialinfos							Geometrie-Infos (lt. 3DLT)			RGB Infos												
Unique ID	Timestamp	Pos	Box with	Box height	Area	Ferret diame	PET	PE	PP	PPK	Metal	Paper	Other	Wood	Metallinfo ja/nein	scheinbar	projizierte	er Feret-	projizierte Fläche (lt. RGB)	Red	Orange	Yellow	Light-Green	Dark-Green	Turquoise	Light-Blue	Dark-Blue	Purple	Inner
							absolute px	absolute px	absolute px	absolute px	absolute px	absolute px	absolute px	absolute px		absolute px	absolute px	Fläche		Durchmesser	Red	Orange	Yellow	Light-Green	Dark-Green	Turquoise	Light-Blue	Dark-Blue	
246	08:56:28.504	238	56	35	1960	56	1274	1	46					1	0,00%	327400	10	6	0	0	0	0	0	0	0	0	0	0	0
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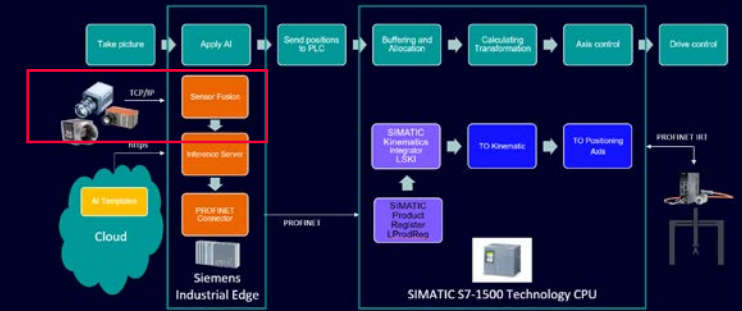
Sensorfusion – combined sensor streams

- Sensors (camera, NIR, ...) are periodically triggered
- Sensor streams are combined using sensor fusion
- AI processes sensor streams
- Real-world coordinates of objects are computed
- Send object data to PLC via Profinet
- Easily manage AI Templates on Edge
- Perform automatic data collection



Sensorfusion – retrieving more information

- Analysis using sensor fusion is performed in two steps:
 - Data Aggregation
 - Multi-modal Inference
- Sensors (camera, NIR, ...) are periodically triggered
- Sensor fusion component (VCA + SiWaste) aggregates data of multiple sensor streams
- Synchronized data is sent to AI RT using ZeroMQ
- Analyse products on the conveyor using state-of-the-art multi-modal AI



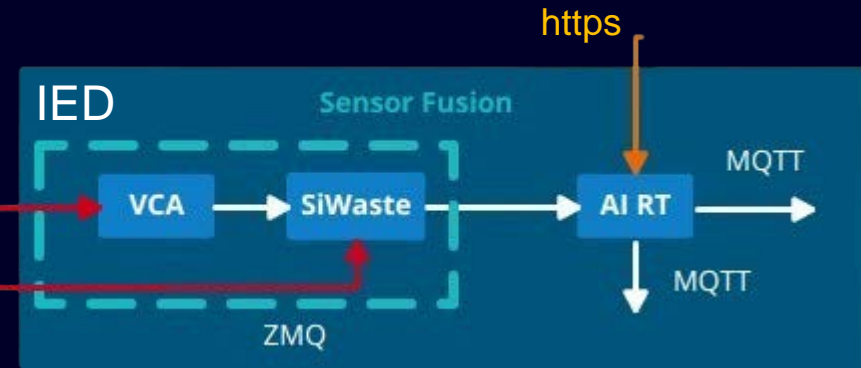
RGB camera



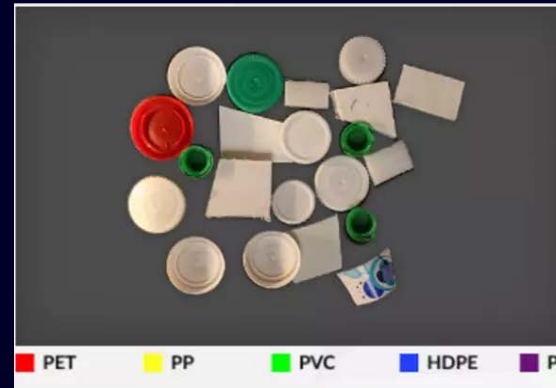
GigE



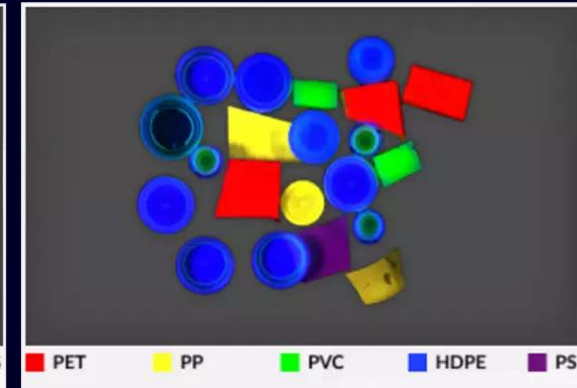
NIR camera



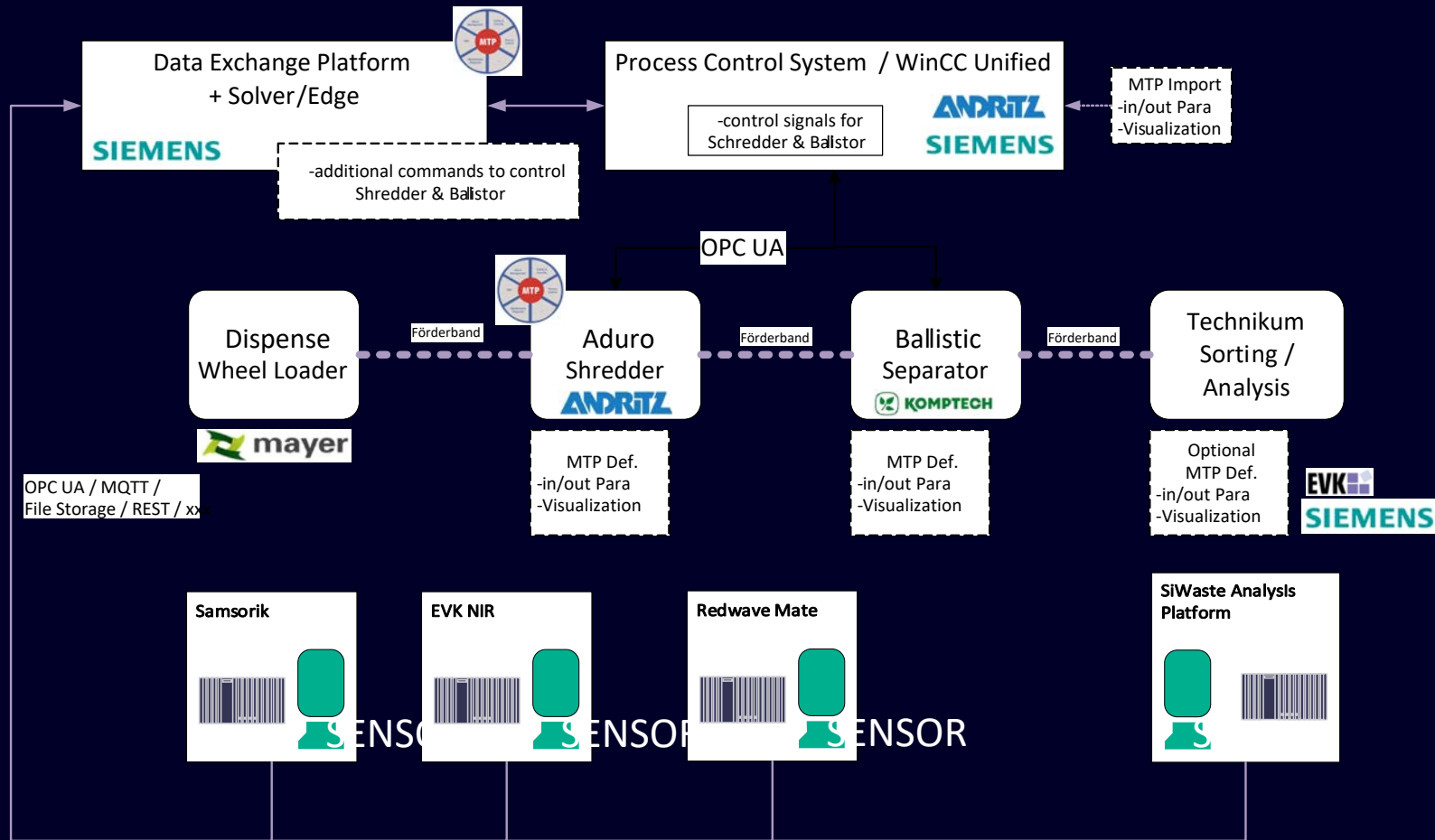
RGB Camera



Hyperspectral Imaging



Digital Waste Research Lab – MTP Prototype



Standardization

For seamless integration of cross-vendor machines – faster time to market

Dynamic adaptation of machine parameters

Quantify the value of the sorting system outputs to define Ballistor and Shredder parameters

Plug & Recycle: Operational continuity

Reduced downtime by machine replacement on failure