



The Next Step in Production: Using AI to Achieve Better Results

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Coatings Trends & Technology Summit, Lombard 9/6/2024

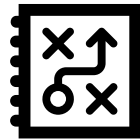
HEMMELRATH
TECHNOLOGIES

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Introduction

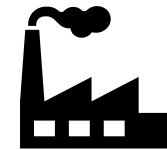
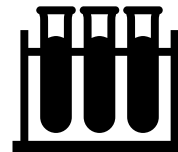
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Modular Factory



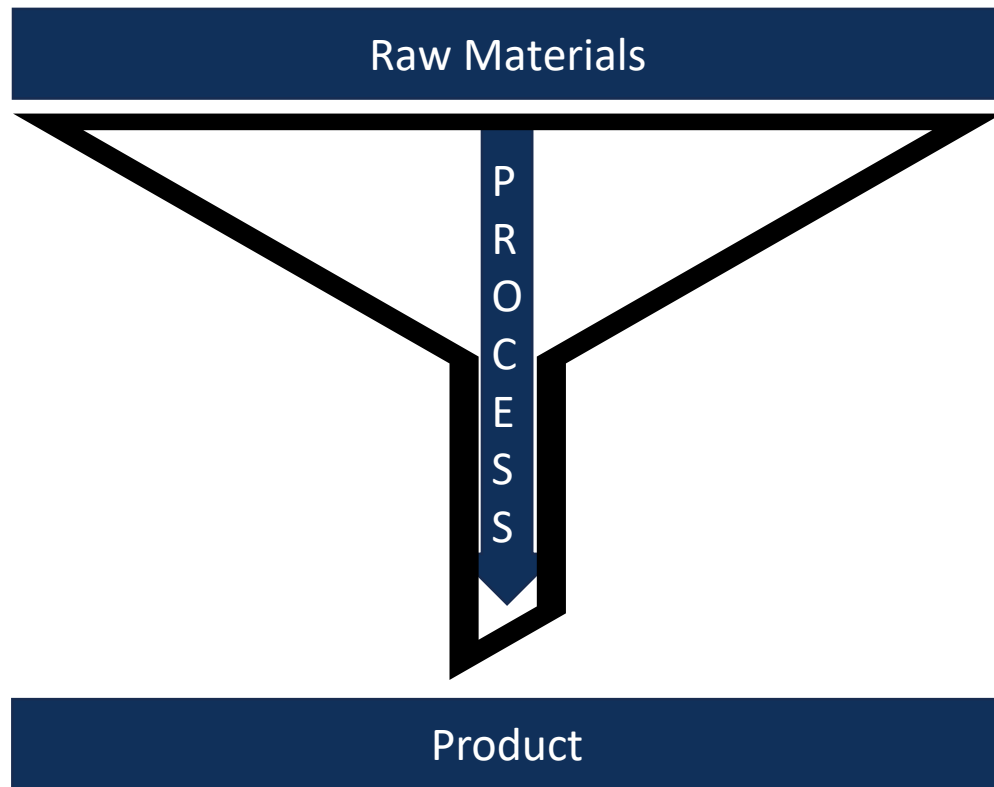
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Sales and Business Development

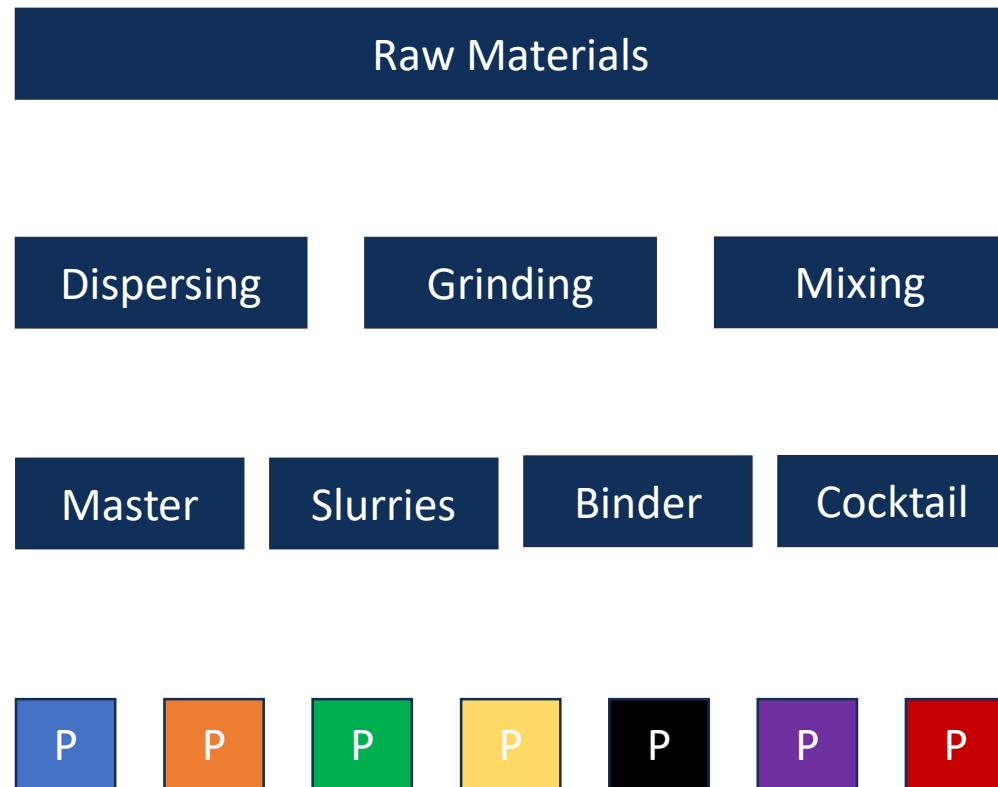


What is Modular Factory (MoFa)?

Traditional Manufacturing



Modular Manufacturing

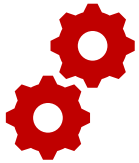


MoFa as a basis for production data



- Recipe Modularization
 - Compact Setup
 - Dispersion and Mixing
 - PLC Controlled
 - Sensors and interfaces
 - AI Enabled
- Benefits in production efficiency, stability and sustainability

Where are we and where do we want to go to?



Instable processes complex formulations

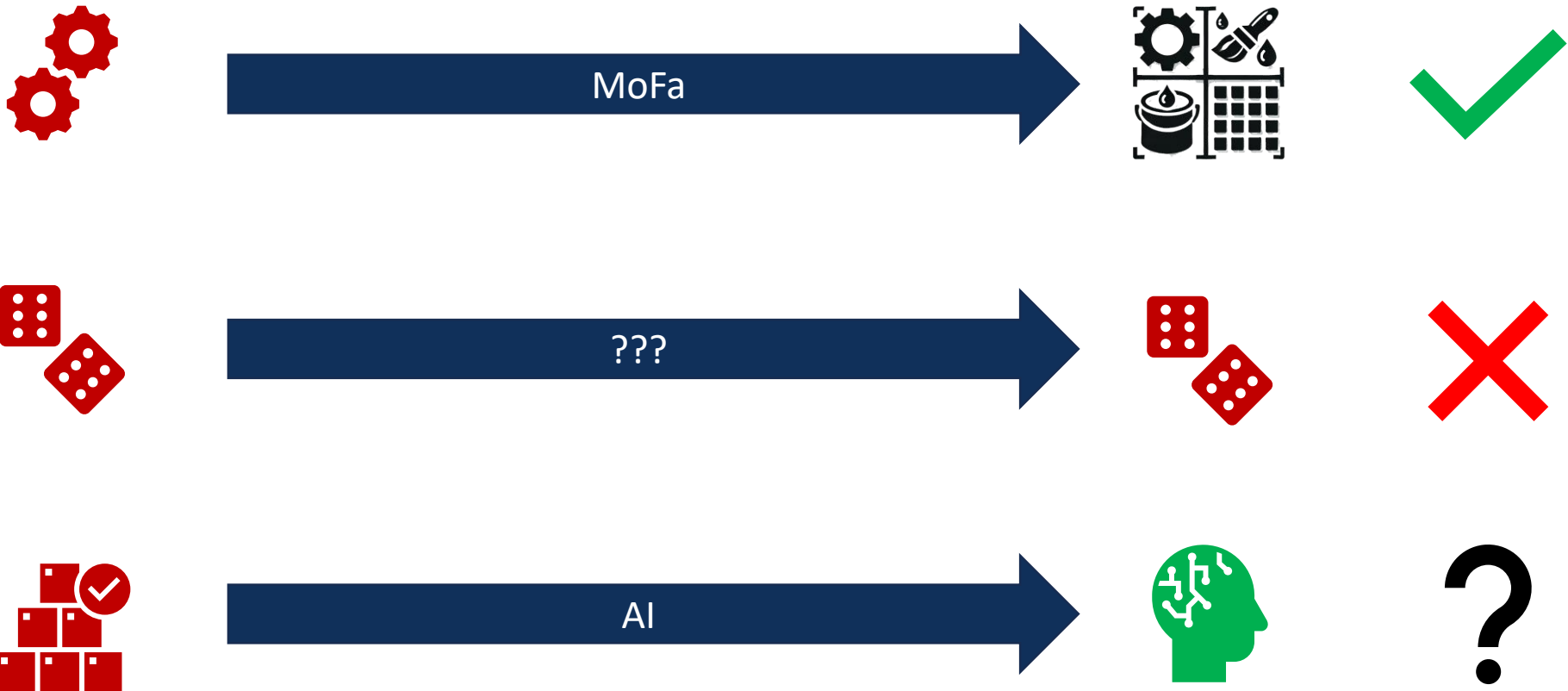


Raw material variation → final product



Difficult prediction of product quality

Where are we and where do we want to go to?

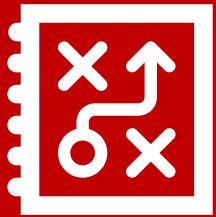


Case Study at a Paint Factory

Problem to solve:

- Heterogeneous recipe structures adapted to the customer
- Low production frequencies
- Difficult continuous data collection
- Raw material and recipe information is not sufficient as a basis for a quality prediction

→ **Is an AI implementation possible at all?**



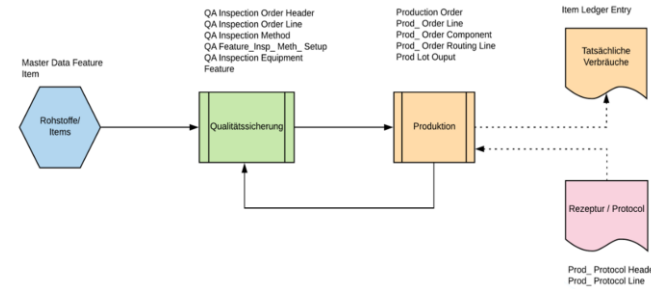
Phase 1: Status Analysis



Internal Analysis: Screening Data

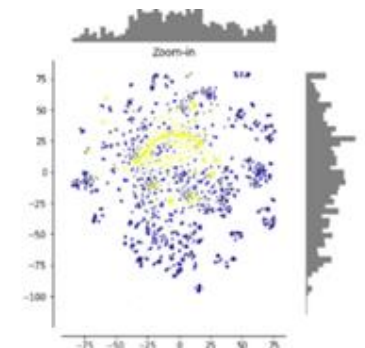
- Get to know the data
- Data collection
- Data Bundling

→ Creation of a database structure



→ Based on this, further analysis

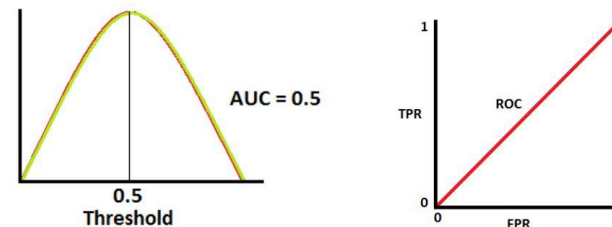
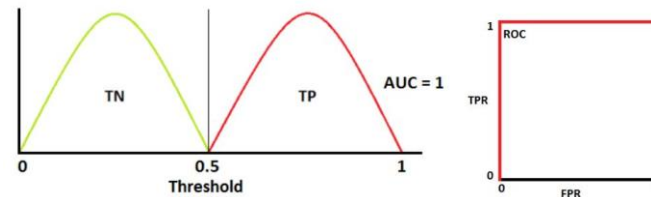
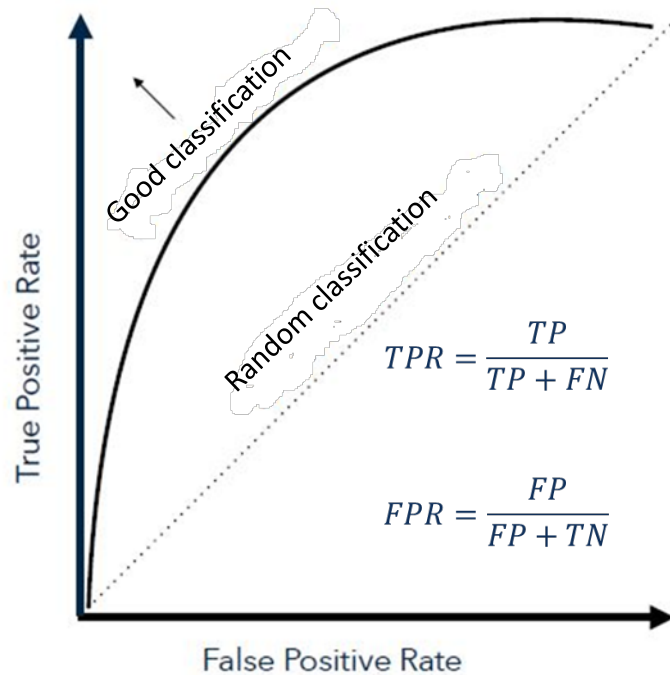
- AI-based data analysis on a defined product group
- Evaluation of correlations and patterns from the database
- Mathematical modelling to validate solutions for **O.K.** and **not O.K.** products





Internal Analysis: AUC Evaluation

Area under Curve (AUC)



Ideal classifier

- 100% TPR and 0% FPR
- Prediction is consistent with the observed results
- Clear distinction between TN and TP

Random Classifier

- 50% TPR and 50% FPR
- It is not possible to distinguish between TN and TP
- Predictive model is inappropriate
Insufficient data basis

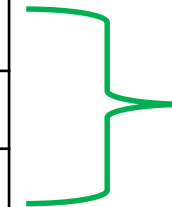


Internal Analysis: Check Models

Area under Curve (AUC)



AUC Value	Quality
0.9 – 1.0	Excellent
0.8 – 0.9	Very Good
0.7 – 0.8	Good
0.6 – 0.7	Fair
0.5 – 0.6	Bad



Integration of sensors to increase the data basis



AI possible, data basis O.K.

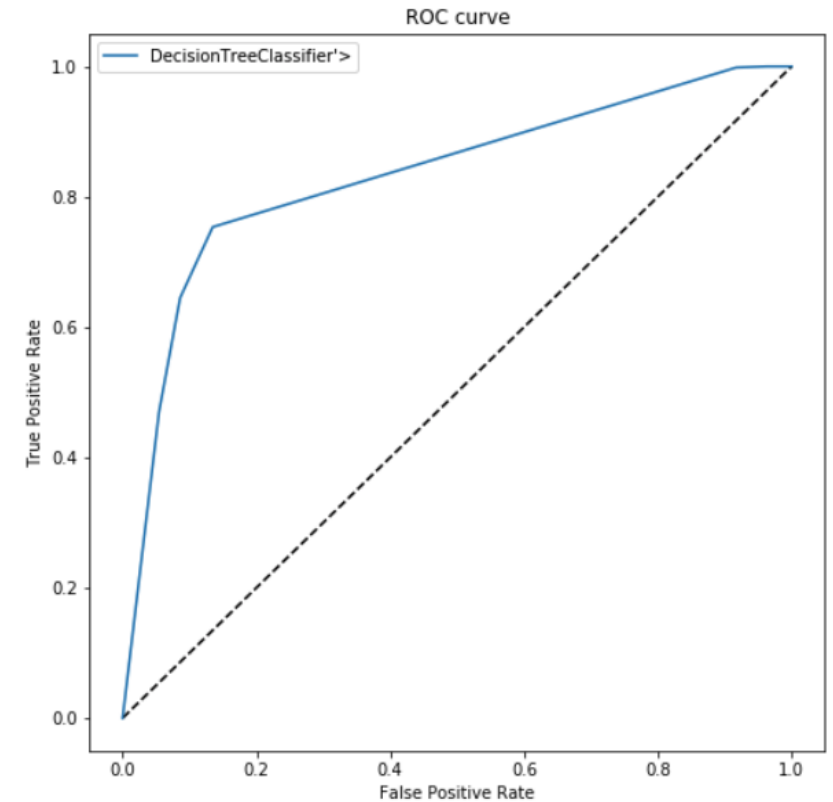


AI impossible, data basis not O.K.



Internal Analysis: Result

- As-is analysis successfully completed → $AUC \geq 70\%$
- Problems can be solved by classification
- Clear significance for practical use
- Potential for data diversity and quality
- **Basis for the development of AI is in place**

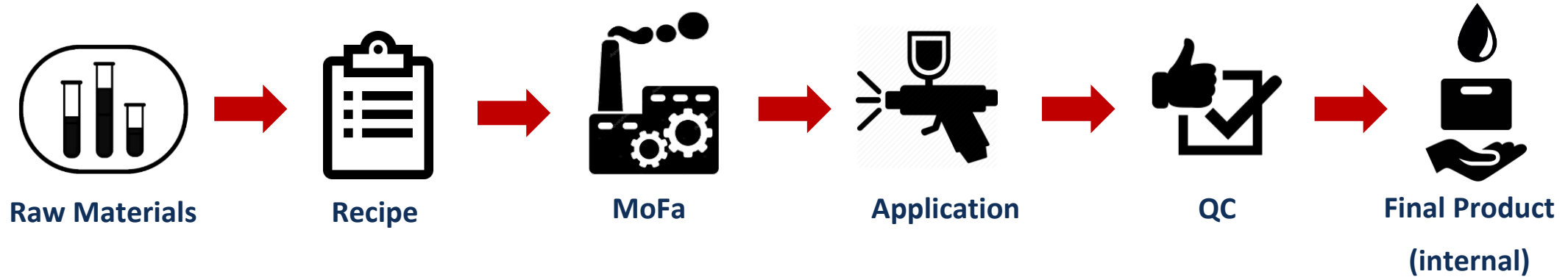




Phase 2: AI Development



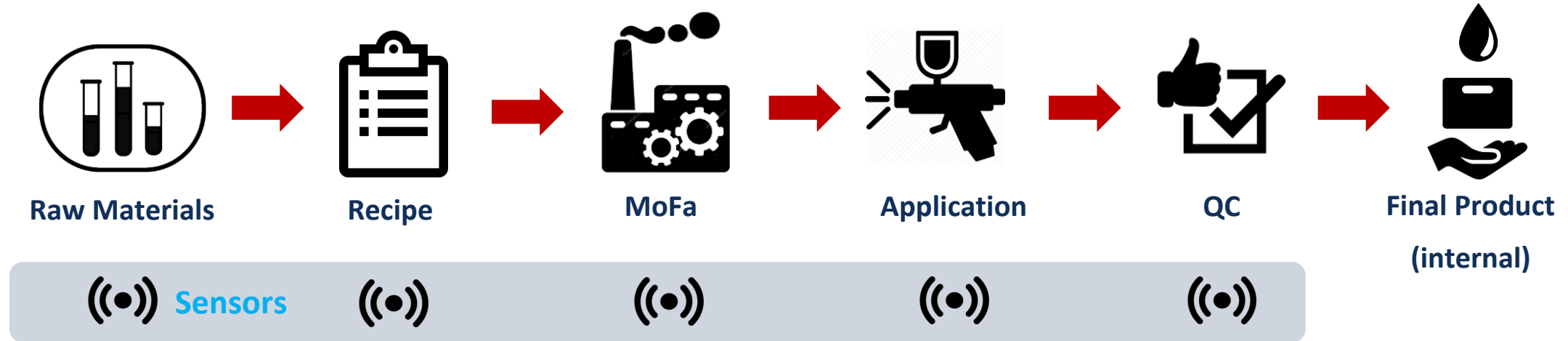
Process Analysis (Value Chain)



- Data chaos
- No connected value chain
- No prediction of product quality possible
- Rework, Returns and Disposal



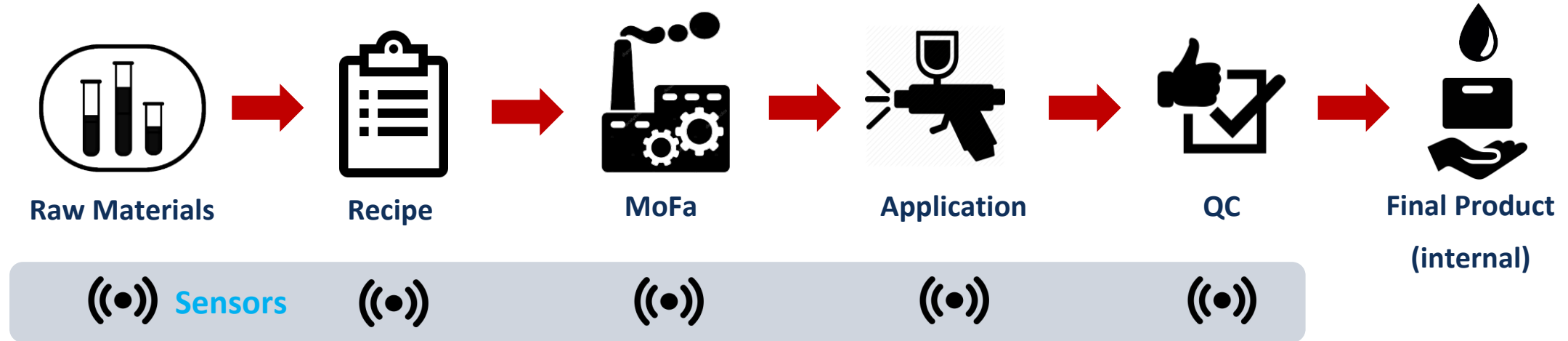
Data Caption Analysis



- What happens at which point?
- Where are sensors located?
- What data do the sensors provide?
- How are the sensors digitally stored and stored in the database?



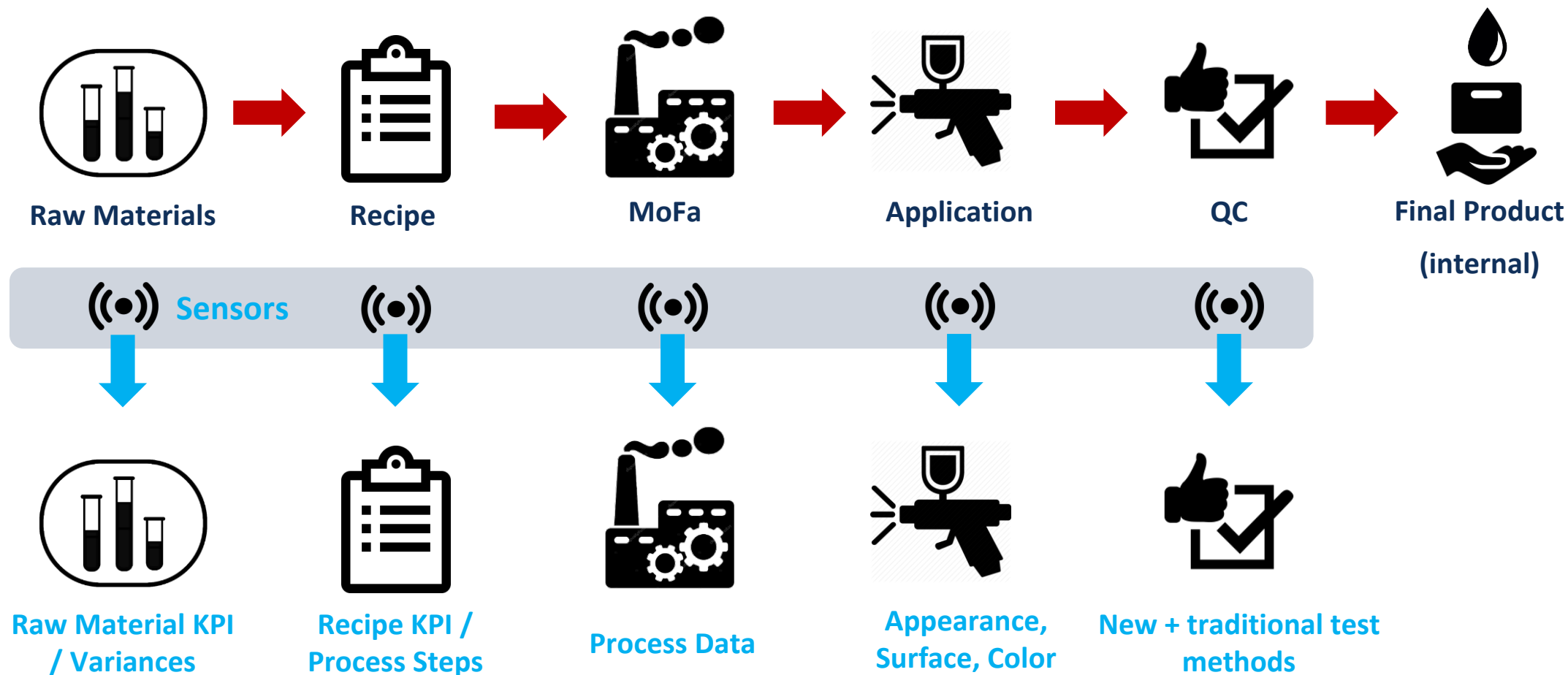
Connect Data Caption and Process



- Integration of sensor technology and analytical measurement methods for the collection of raw data
- Networking of the entire process chain
- Building a Centralized Database Infrastructure



Data Caption System



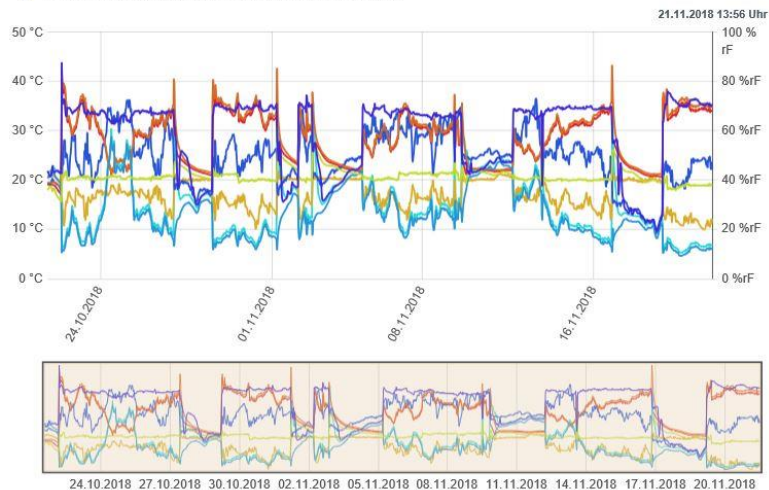


Example: Lab Spray Application

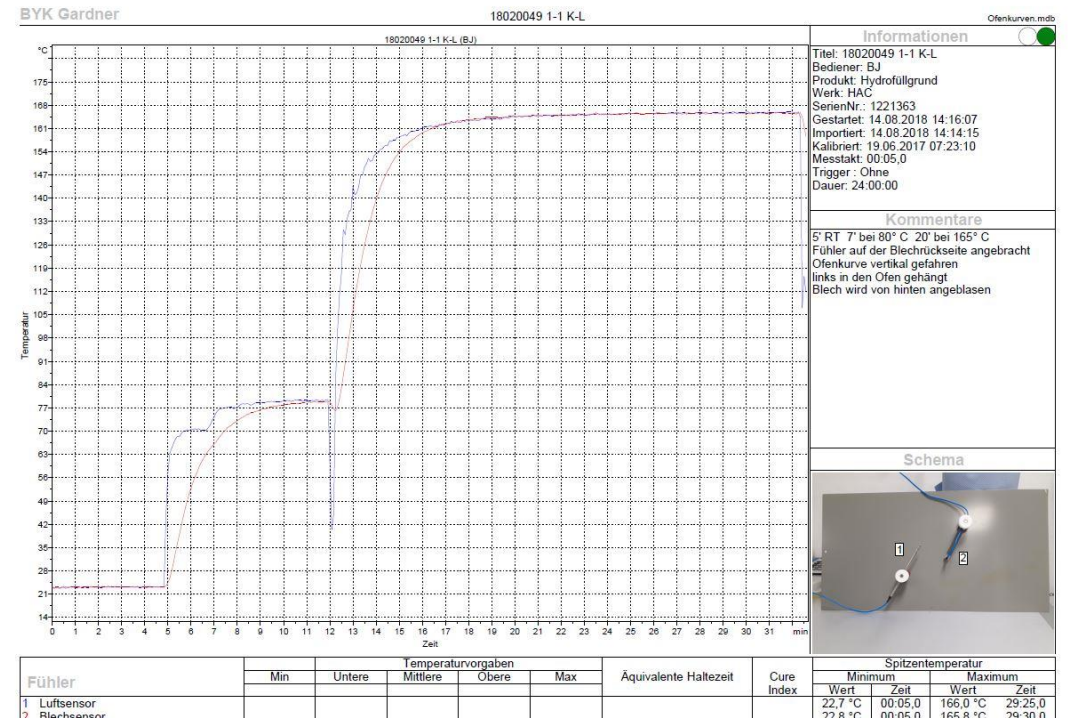


Air Data Paint Booth
Temperature / Humidity

- 2. Nach Kühler 22-138 [°C] = 32.0 @ 22.10.2018 12:26 Uhr
- 2. Nach Kühler 22-138 [%rF] = 20.1 @ 22.10.2018 12:26 Uhr
- 1. Aussenluft 22-140 [°C] = 15.5 @ 22.10.2018 12:26 Uhr
- 1. Aussenluft 22-140 [%rF] = 49.1 @ 22.10.2018 12:26 Uhr
- 3. Nach Erhitzer 22-139 [°C] = 32.6 @ 22.10.2018 12:26 Uhr
- 3. Nach Erhitzer 22-139 [%rF] = 18.4 @ 22.10.2018 12:26 Uhr
- 6. Zuluft LabPainter 22-143 [°C] = 20.1 @ 22.10.2018 12:26 Uhr
- 6. Zuluft LabPainter 22-143 [%rF] = 69.2 @ 22.10.2018 12:26 Uhr



Temperature Data Curing Oven
Control of Curing Process





Example: Lab Spray Application



Lab Painter: Application Setup

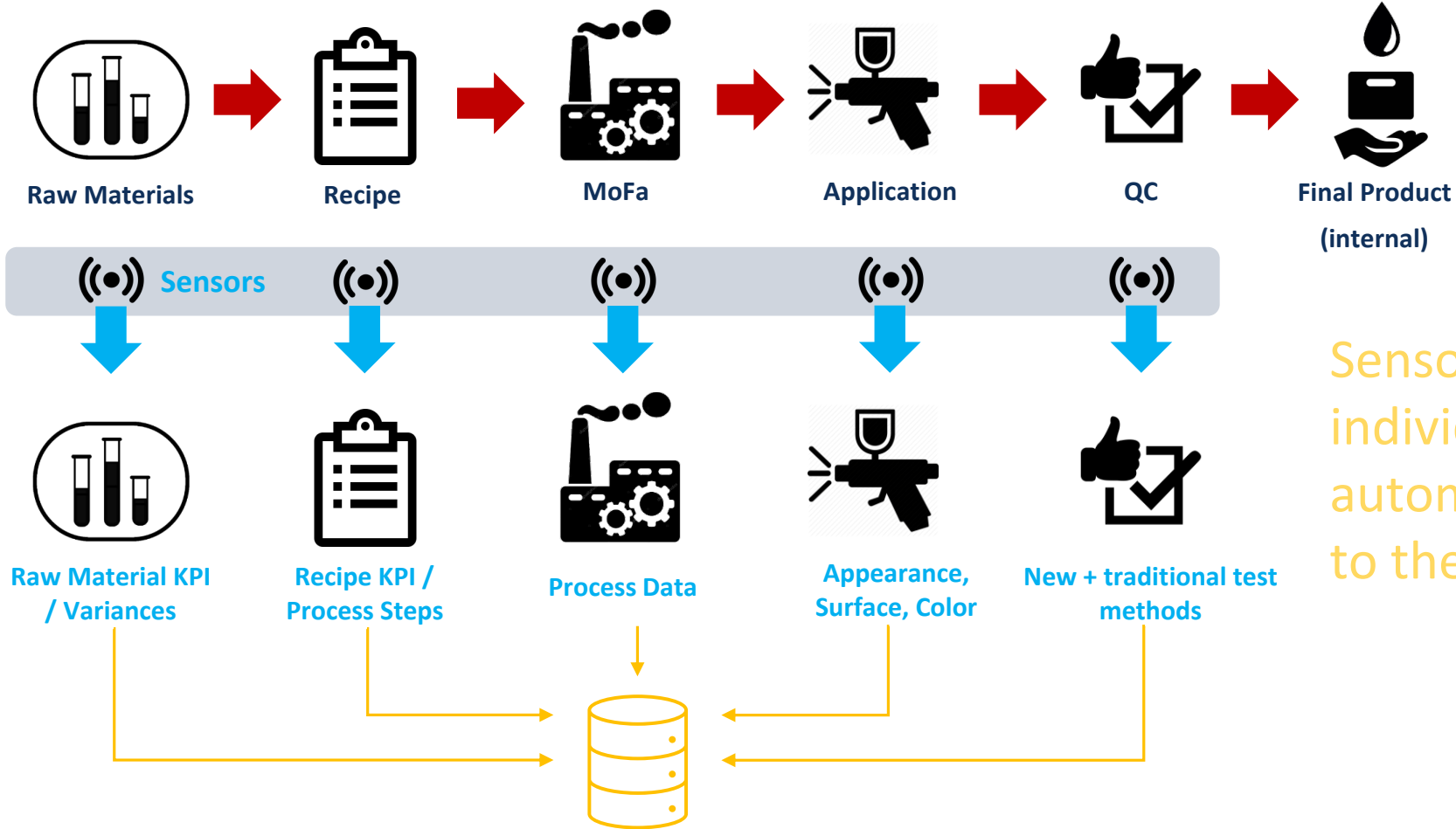


Automated Data Logging and Data Export

	SG1	SG2	SG3	SG4	SG5	SG6	SG7	SG8	SG9	SG
Freigabe										
Zerstäuber Name	EcoBell3									
Zerstäubertyp	Z-Platz 1									
Lackversorgung	LV 3									
Lackierart	Rechteck (R)									
Substratlage	waagrecht									
Punkt Y1 vertikal [mm]	500									
Punkt Y2 vertikal [mm]	-500									
Geschwindigkeit in Y1 vertikal [m/min]										
Geschwindigkeit in Y2 vertikal [m/min]										
Punkt X1 horizontal [mm]	650									
Punkt X2 horizontal [mm]	-650									
Geschwindigkeit in X1 horizontal [m/s]	1,5									
Geschwindigkeit in X2 horizontal [m/s]										
Verfahrenstrecke Linie [mm]										
Doppelhöhe [1/min]										
Raster [mm]	130									
Verfahrensgeschwindigkeit [m/s]										
RW Geschwindigkeit X-Achse horizontal [m/s]										
RW Geschwindigkeit Y-Achse vertikal [m/min]										
RW Pausenzeit [s]										
RW Bahnbreite [mm]										
RW Hübe [Stück]	8									
RW Beschleunigung X-Achse horizontal [m/s ²]										
RW Beschleunigung Y-Achse vertikal [m/s ²]										
Lenkluft 1 [N/min]	220									
Lenkluft 2 [N/min]	150									
Lenkluft 3 [N/min]	0									
Drehzahl [1000 U/min]	50									
Horizont [N/min]										
Zerstäubertyp [N/min]										
Lackmenge [ml/min]	250									
Hochspannung [U]	70									
Solvent Spannung [kV]	70									
Solvent Strom [µA]	0									
Abfüllzeit [s]	0									
Lackierabstand [mm]	200									
Tap-2K	--(-)									
Aktionen										
Mischungsverhältnis-STA44 [100/0]										
berechneter Verbrauch	53									



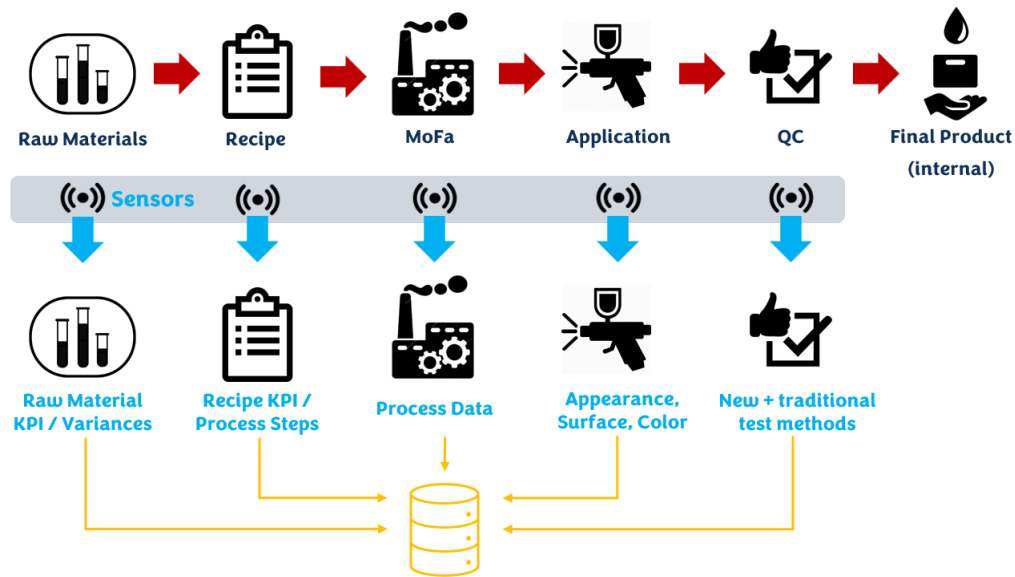
Organize Data Flow



Sensor data from the individual process steps is automatically transferred to the cloud database.



Database Structure



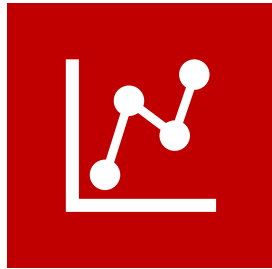
Data of the complete value chain is:

- Centralized
- Available
- Retrievable

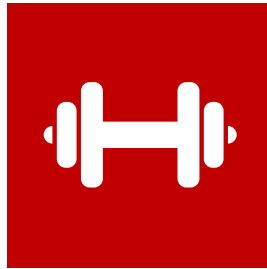
→ Basis for development of the Artificial Intelligence Application



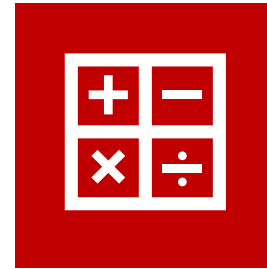
Roadmap for AI Implementation



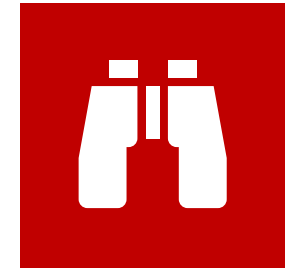
PROCESS ANALYSIS
TAKE II



FIX
WEAKNESSES



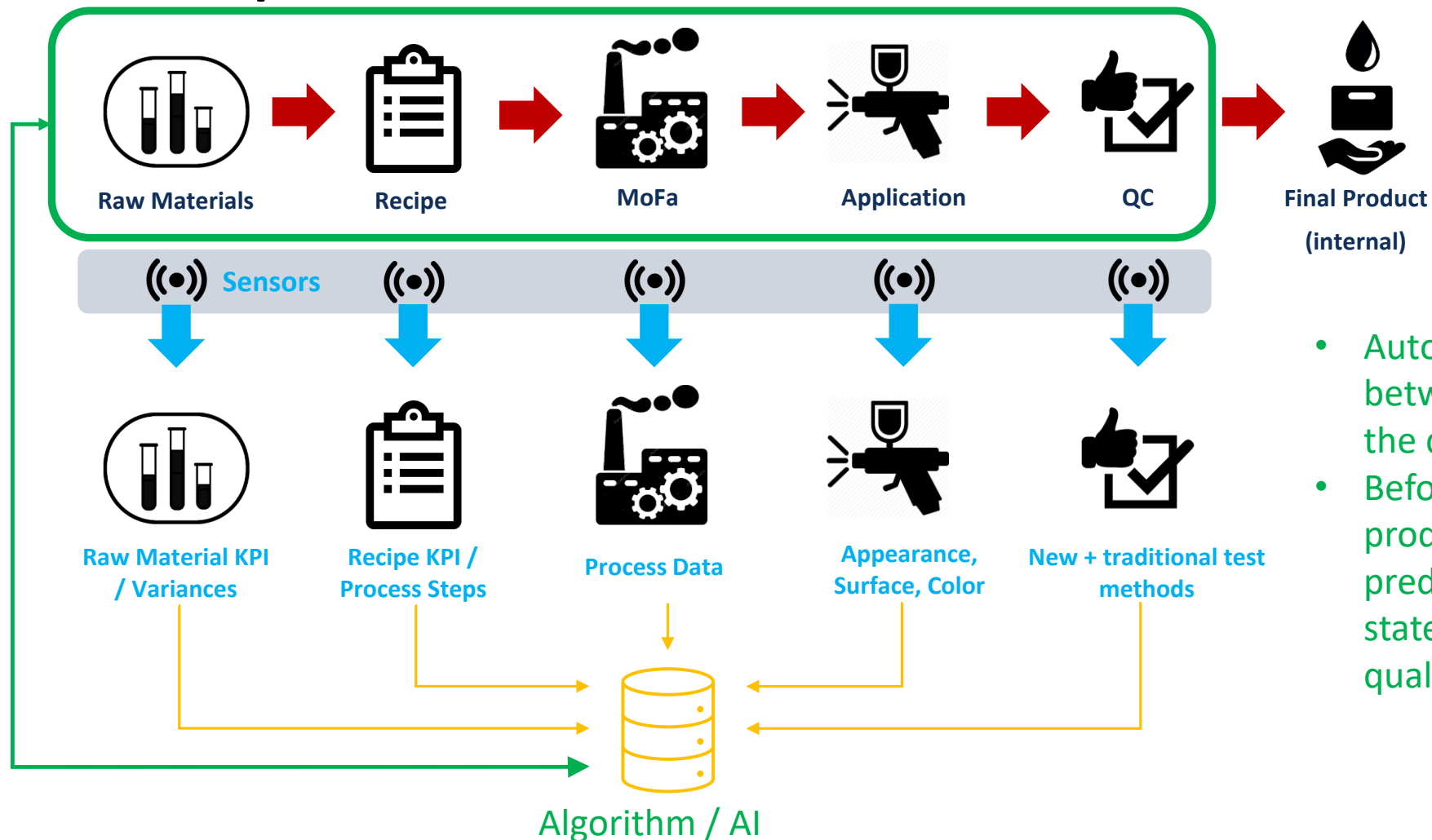
CHOOSE ML
ALGORITHM



AI PREDICTION SYSTEM -
AUC \geq 85%


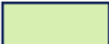
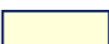




AI Optimization



- Automatic communication between the AI and the data in the database
- Before starting a new production, the AI quality prediction system makes a statement about the product quality

Software





	Solids (Scale, Oven)
	Semi Finished Alu Slurry
	Stapa IL, Hydrolan 2154 Aluminum / SD / coated
	Hydrolan PnB
	AEP Stapa Hydrolan 2154, 50% SD



Test Ergebnisse

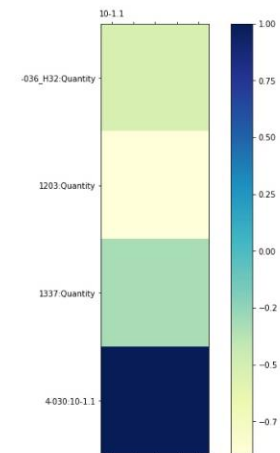
Suche nach einem Test

+ Neuer Test

Name	Anzahl der Rohstoffe	Anzahl der Versuche	Erstellungsdatum ↑	Ergebnis	Aktion
17060151	4	1	2017-06-01	IO	 
16110338	4	3	2017-03-02	NIO	  Andern

KORREKTUR 16110338

CORRELATION MATRIX



Zurück

AUSGEWÄHLTE ROHSTOFFE

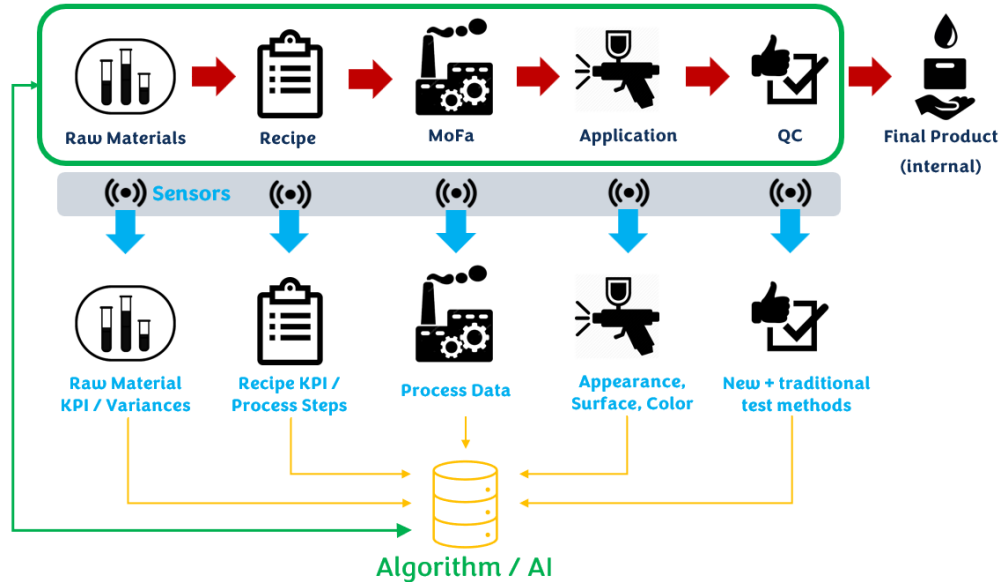
Suche nach Rohstoffe

- × 0-036 Halbfabrikat für Aluschlämmen. Menge 1180
- × 1203 Stapa IL Hydrolan 2154. Menge 59562
- × 1337 Dowanol PnB. Menge 1111
- × 4-303 AES Stapa Hydrolan 40

Automatische Korrektur

Test

Results



- Development of an AI quality prediction and decision support system successfully completed.
- Predictability for O.K. / not O.K. products is **89%**.
- Raw material quality has a major influence on the quality of the product, with a stable production process (MoFa).

Thank You!

Ralph J. Woerheide

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