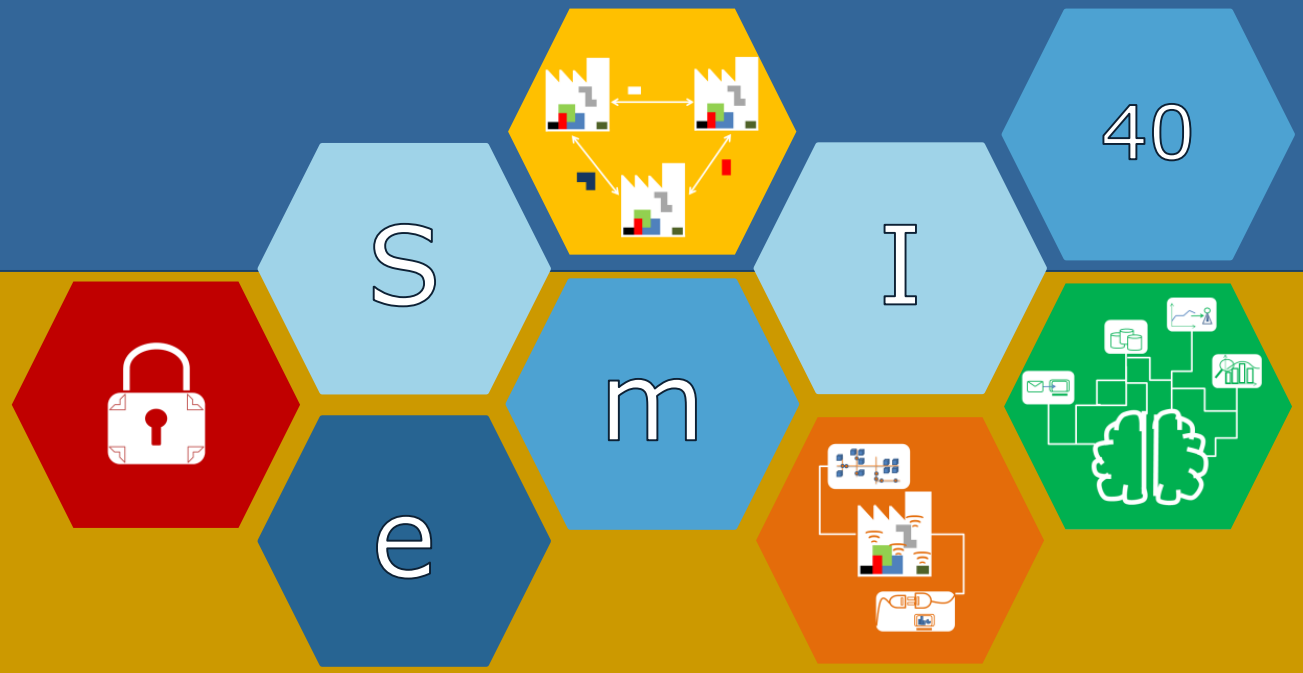
Transfer of Run-to-Run-Control to Production Control Level in Semiconductor Front-End



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Villach (AT), April 9 2019

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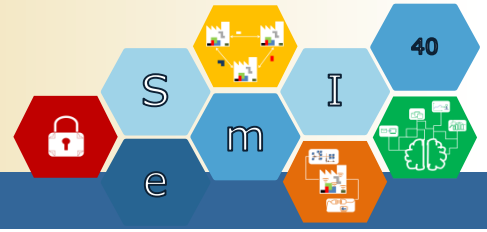
Villach, AUSTRIA • April 08 – 10, 2019

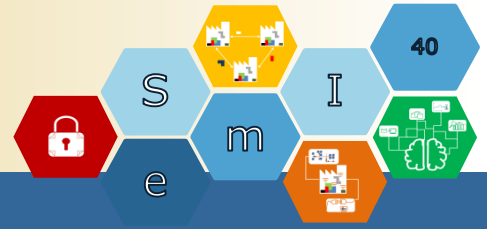
The project SemI40 is co-funded by grants from Austria, Germany, Italy, France, Portugal and the ECSEL Joint Undertaking and is coordinated by Infineon Technologies Austria AG

Agenda



1. Motivation
2. Concept
3. System architecture
4. Validation
5. Application Example
6. Findings and next steps

Motivation - Introduction



1. **Reduce the impact of unpredictable events on the supply chain‘s performance**

2. **Higher level of flexibility for demand changes**

- **Hypothesis: approach inspired by run-to-run-control to link supply chain to production control**

Motivation - Expected Benefits

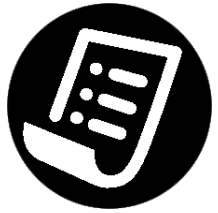
1. Faster reaction

2. Reduced false alarm rate

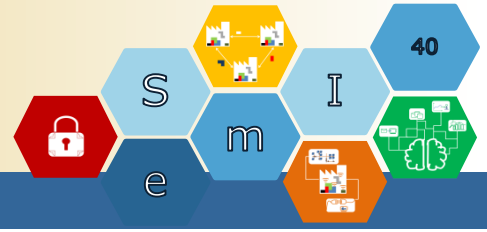
3. Reduced cycle time spread

4. Increased on-time delivery

5. Reduced inventory levels



Motivation - Run-to-Run-Control



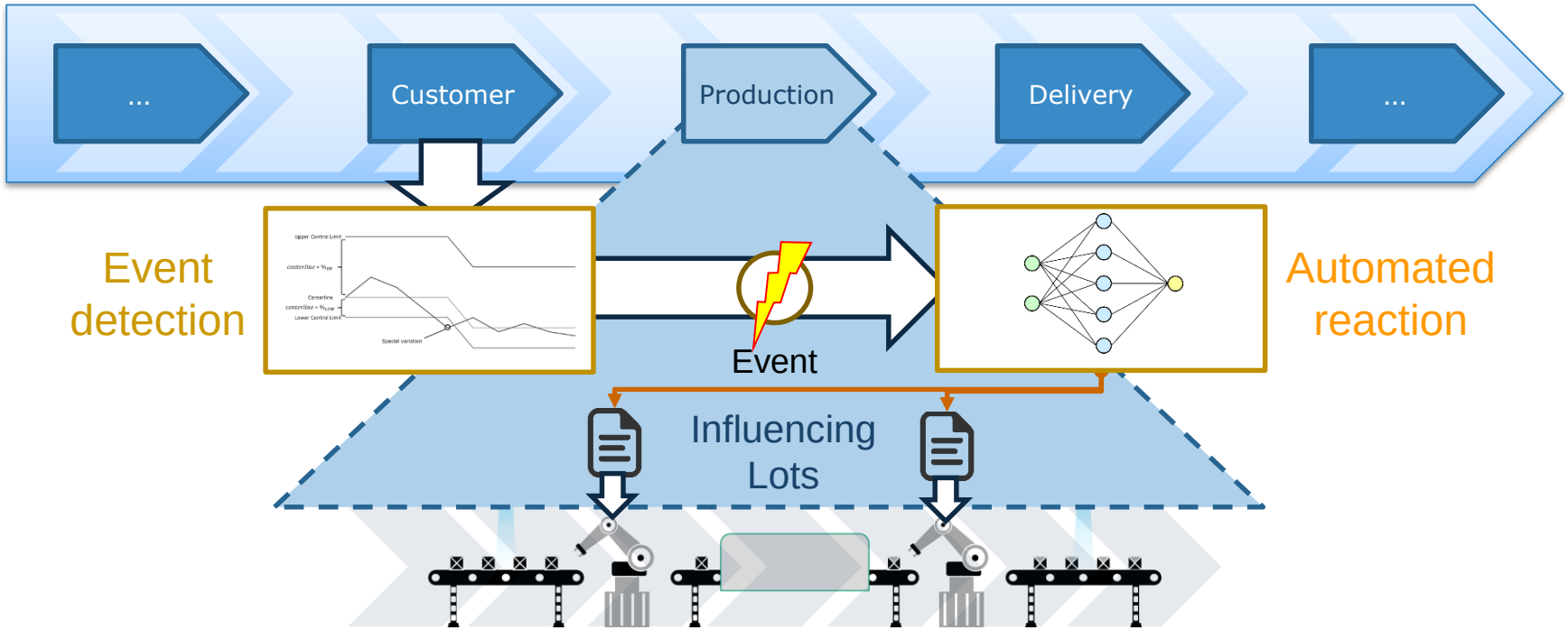
- **Run-to-Run-Control (R2R) has been applied to manufacturing processes in the last years with great success [1]**
- **minimize process drift, shift and variability [2]**
- **event-driven by measures before or after the process and the requirement that the process must be executed [2]**

➢ **has not yet been used to link supply chains and production control more closely**

[1] Moyne, James, 2015.Run-to-Run Control in Semiconductor Manufacturing. In: Baillieul, John; Samad, Tariq (Eds.): Encyclopedia of Systems and Control. London: Springer. ISBN 978-1-4471-5102-9
[2] Moyne, James; del Castillo, Enrique; Hurwitz, Arnon Max (Eds.), 2001. Run-to-run control in semiconductor manufacturing. Boca Raton: CRC Press. ISBN 978-0-8493-1178-9

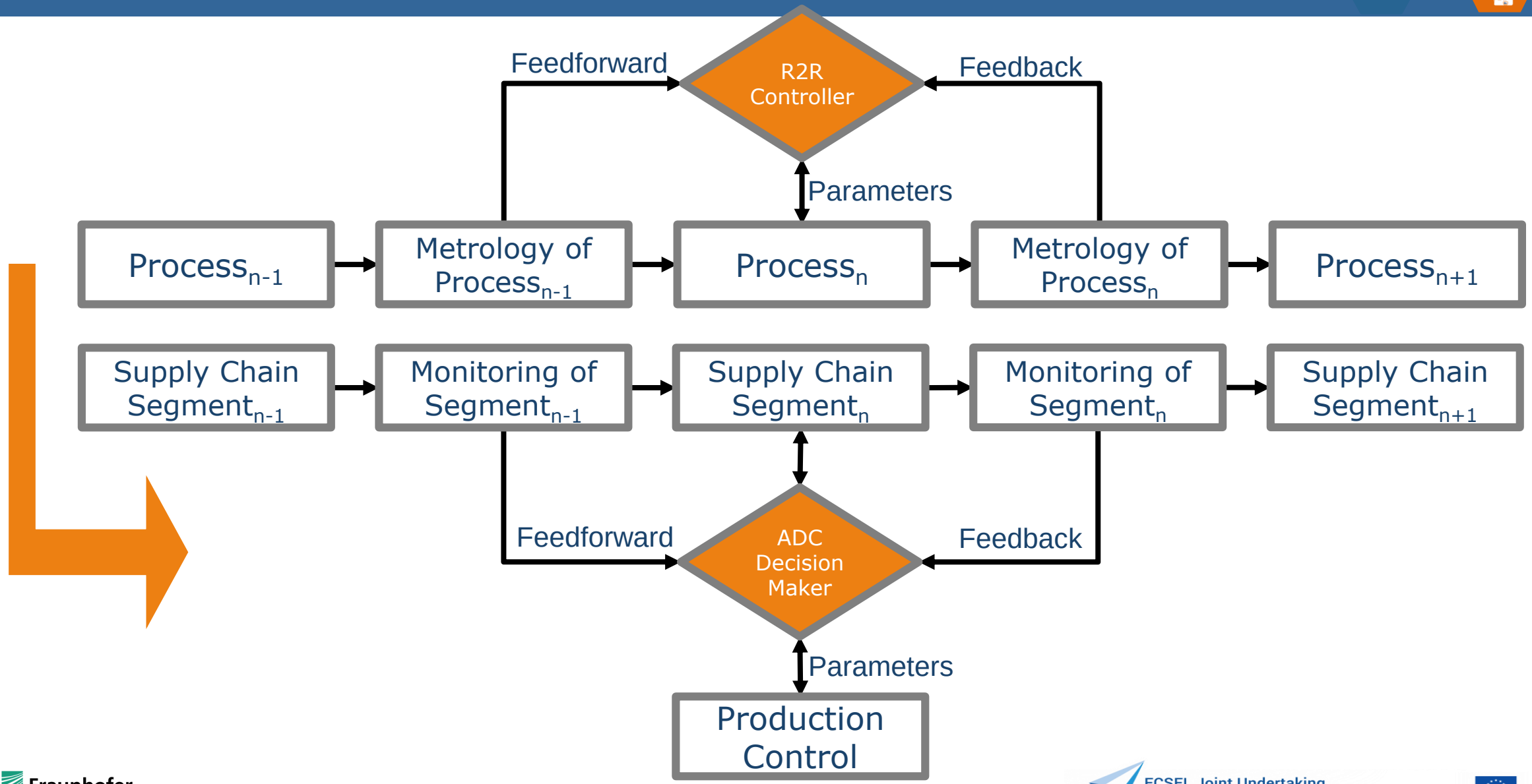
Concept of Advanced Dispatch Control

React on unexpected changes in Supply Chain **automatically**

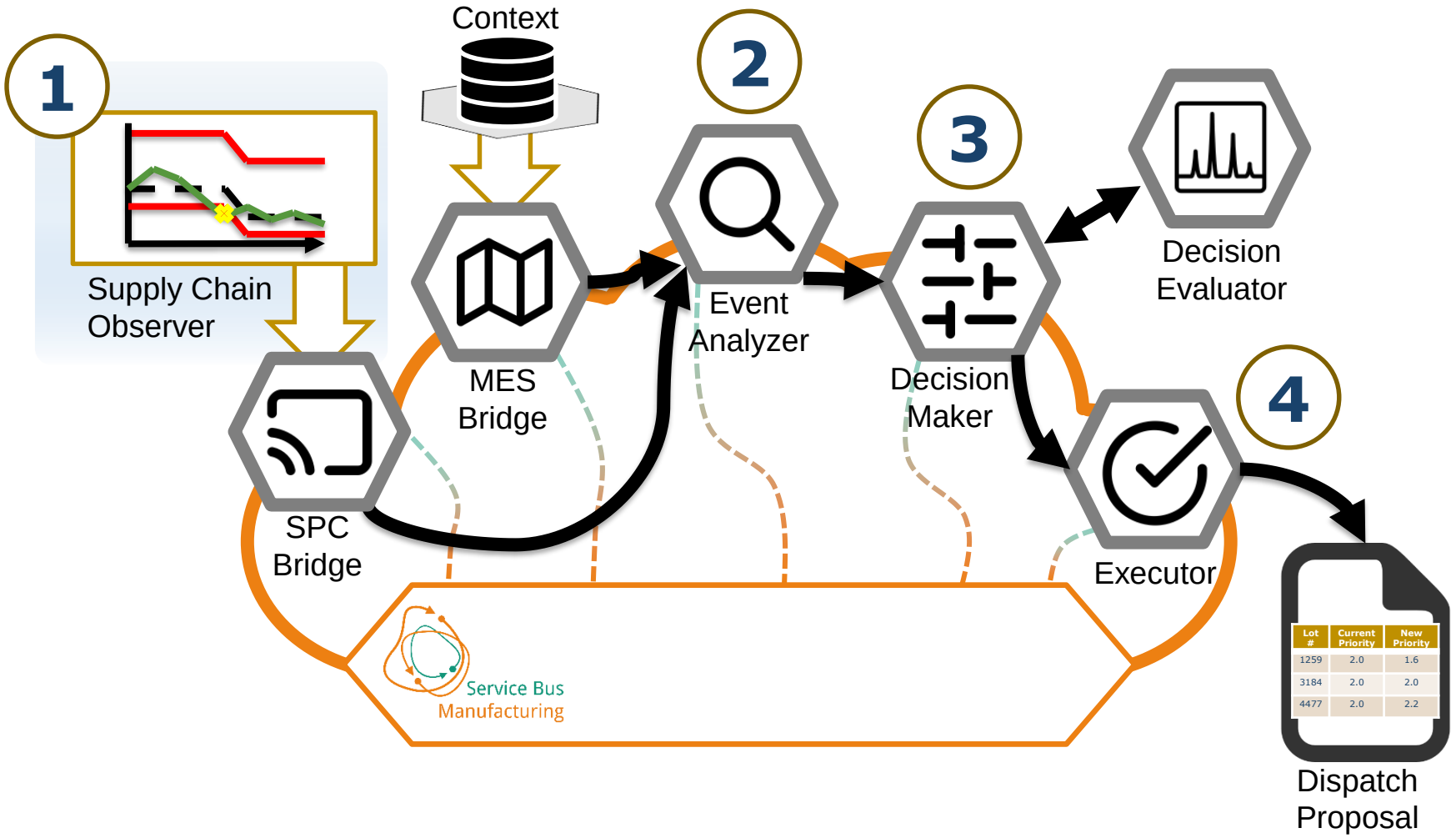


Bauer, Maier, Bauernhansl, Waschneck, Ponsignon, Gürster, Oberegger, Felsberger, Reiner. „Concept and possible application of an automated framework to influence production dispatch based on supply chain events", International Conference on Industrial Engineering and Systems Management (IESM), Saarbrücken, Germany, Oktober 11 – 13, 2017

Concept – Inspired by R2R

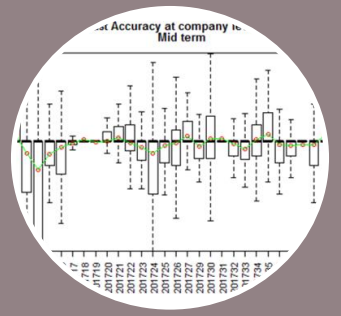


System Architecture - Overview



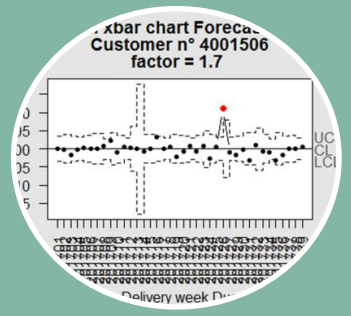
System Architecture – Step 1

1 Detect drift, shift and variability in supply chain and trigger event



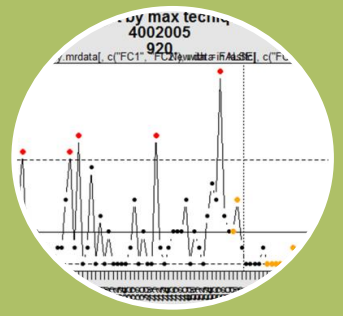
Company-level Chart

- Used to monitor overall fluctuations of the market



Customer-level Chart

- Used to monitor changes in customer behaviors & large deviations



Product-level Chart

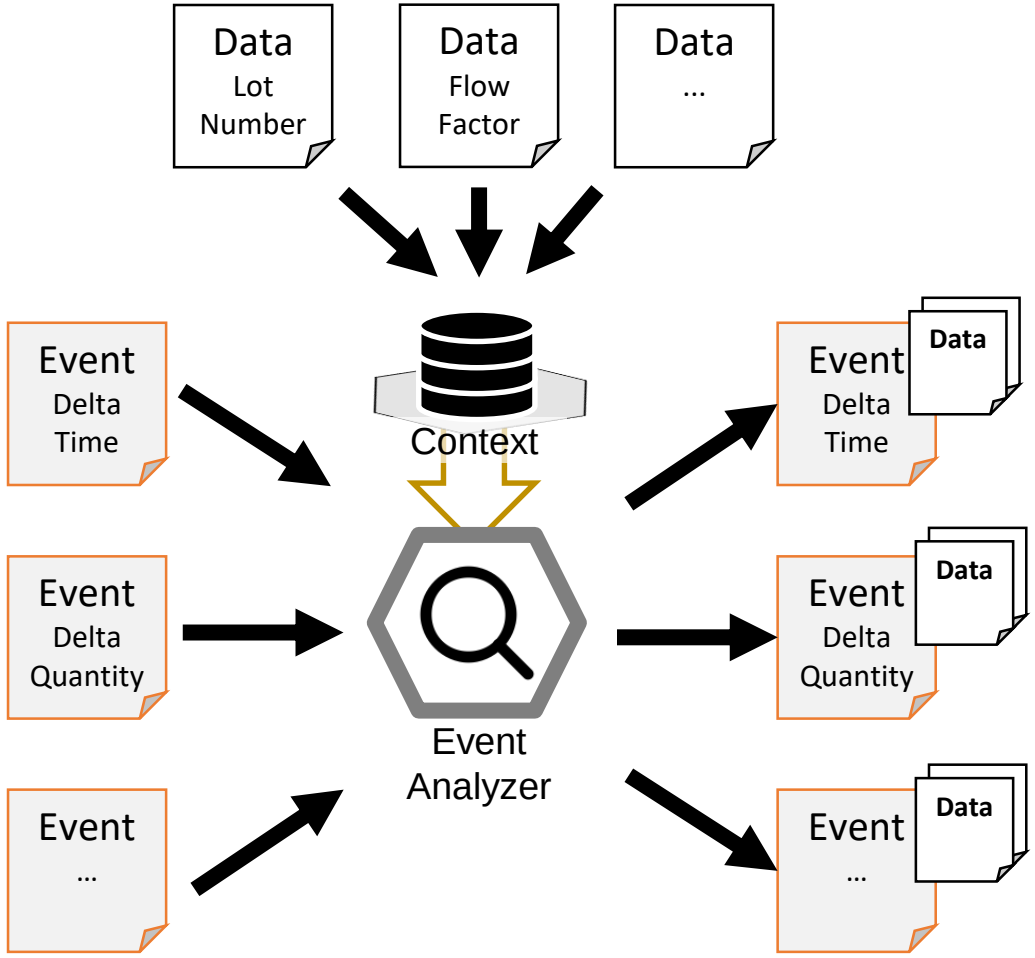
- Used to detect abnormal deviations for combinations of customer/product/wish date

From coarse to detailed

Figure by Thomas Ponsignon (Infineon Technologies AG), Idea described in Bauer, Maier, Bauernhansl, Waschneck, Ponsignon, Gürster, Oberegger, Felsberger, Reiner. „Concept and possible application of an automated framework to influence production dispatch based on supply chain events", International Conference on Industrial Engineering and Systems Management (IESM), Saarbrücken, Germany, Oktober 11 – 13, 2017

System Architecture – Step 2

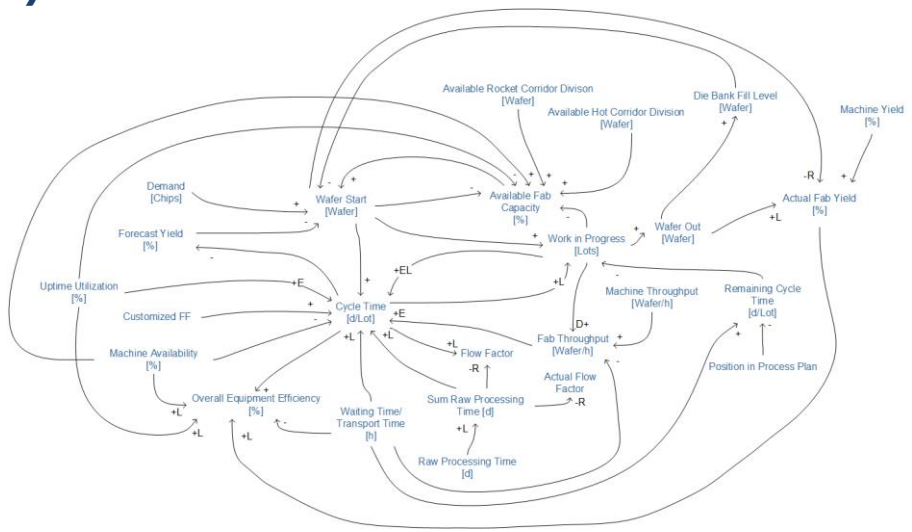
2 Enhance event with context information



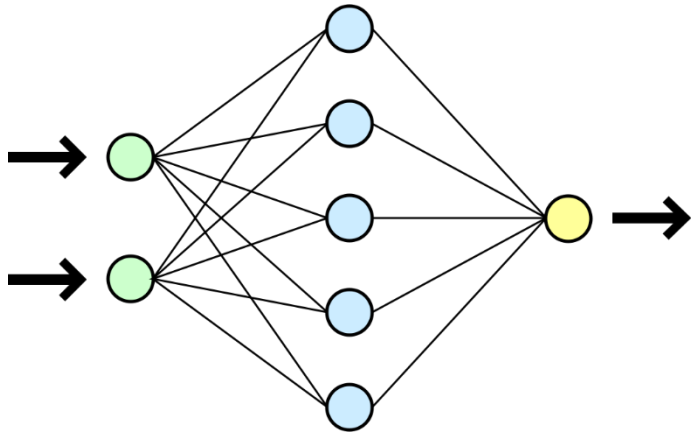
System Architecture – Step 3

3 Decide for corrective actions

a)



b)

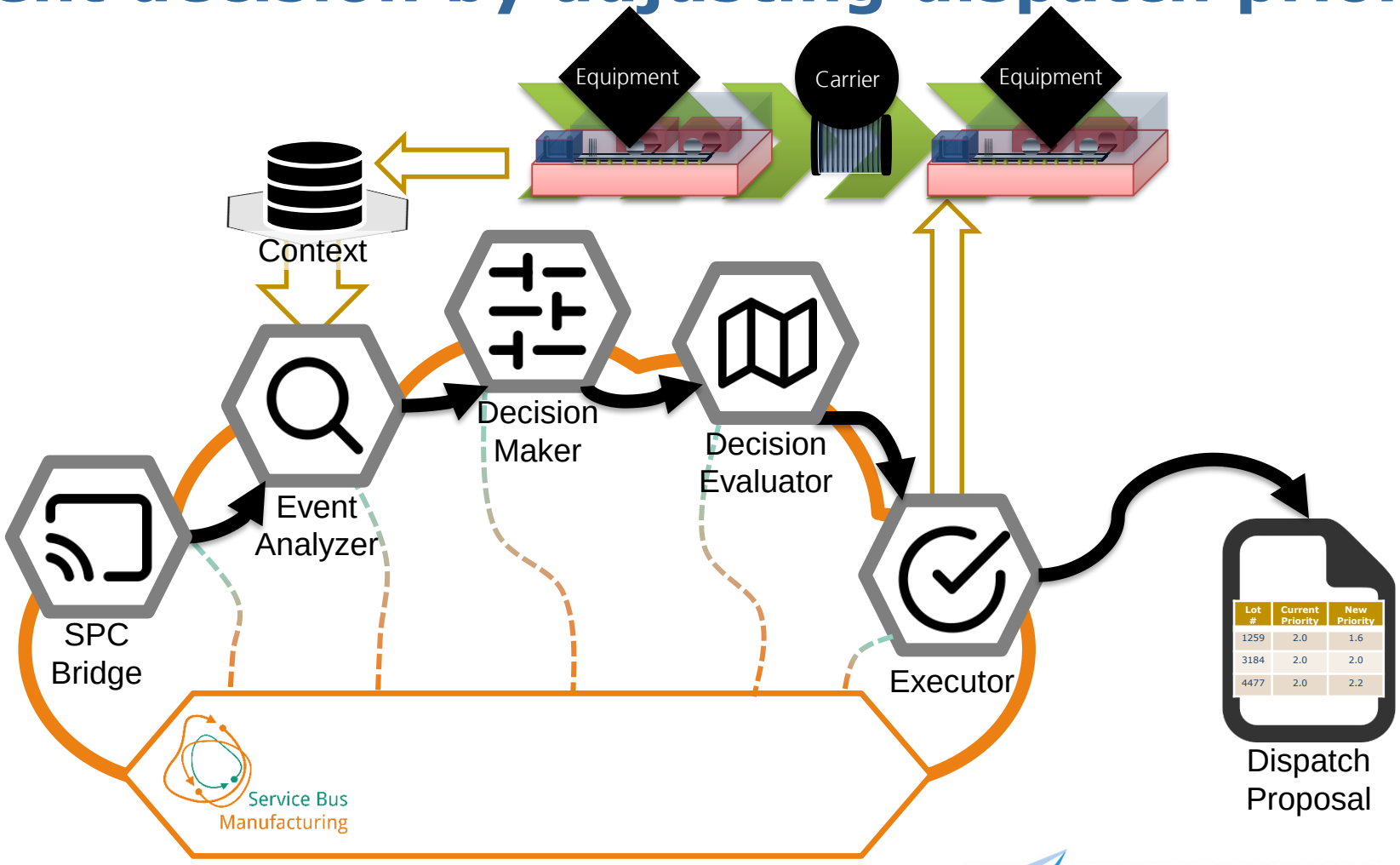


c)

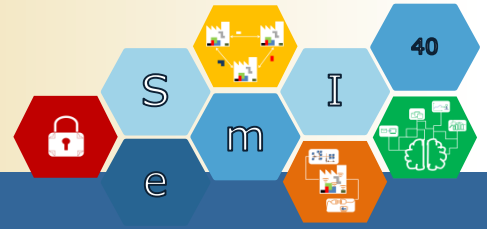
- Do nothing
- Increase/ Decrease planned FF
- Start lot(s)
- …

System Architecture – Step 4

4 Implement decision by adjusting dispatch priorities

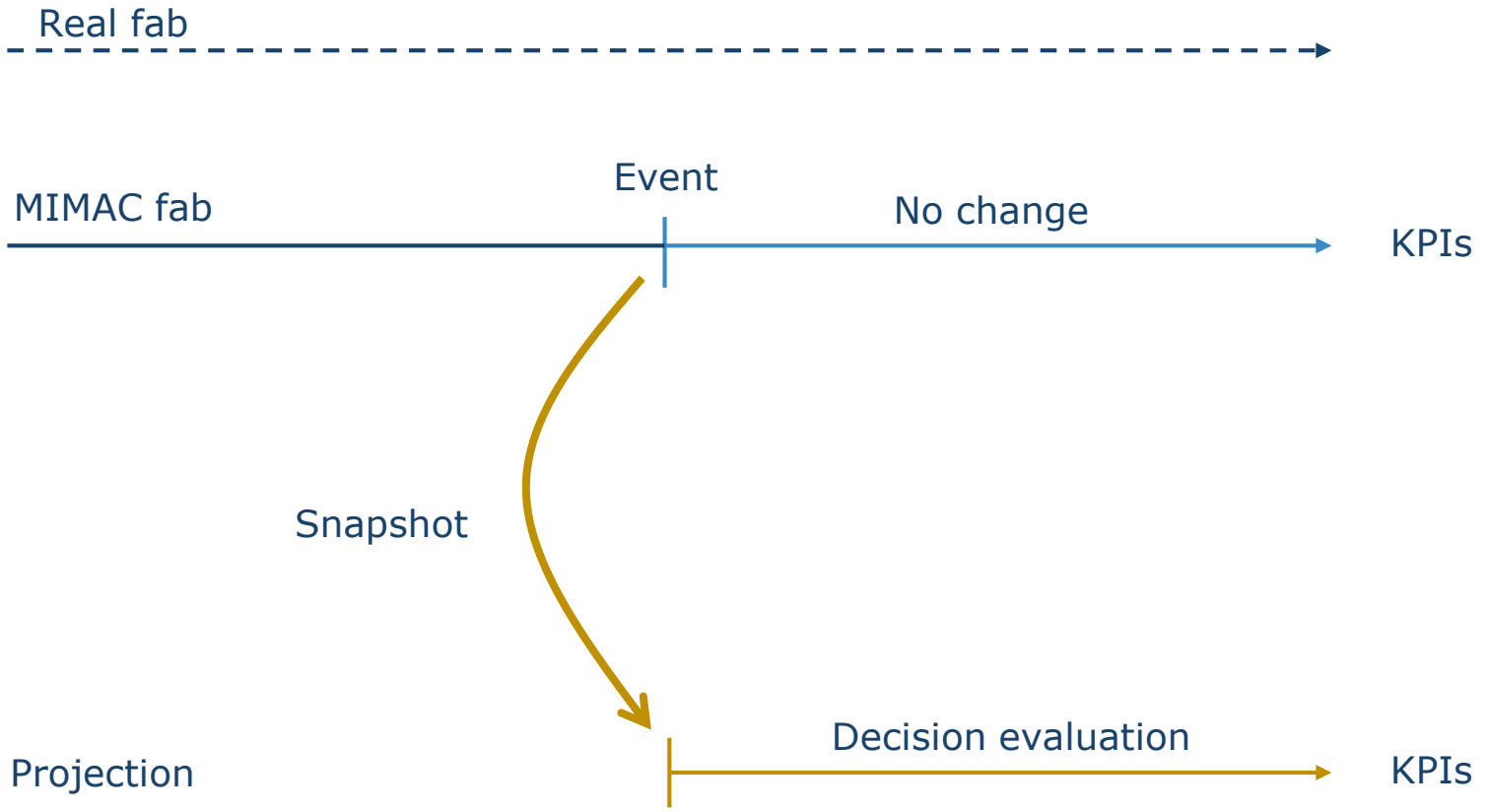


System Architecture – Why R2R?



	Run-to-Run-Control	Advanced Dispatch Control
Concept	Minimize variability, drift and shift by adjusting the process to counteract process upset	
Process adjustment	Semi-automated to automated	
Modes	Feedback Feedforward	Feedback – e.g. demand change Feedforward – e.g. supply disruption
Measurement	(Virtual) Metrology	Supply Chain Monitoring
Controller	R2R controller	Decision Maker
Parameters	Process parameters, e.g. flow rate, speed etc.	Production control parameters, e.g. dispatch priority

Validation



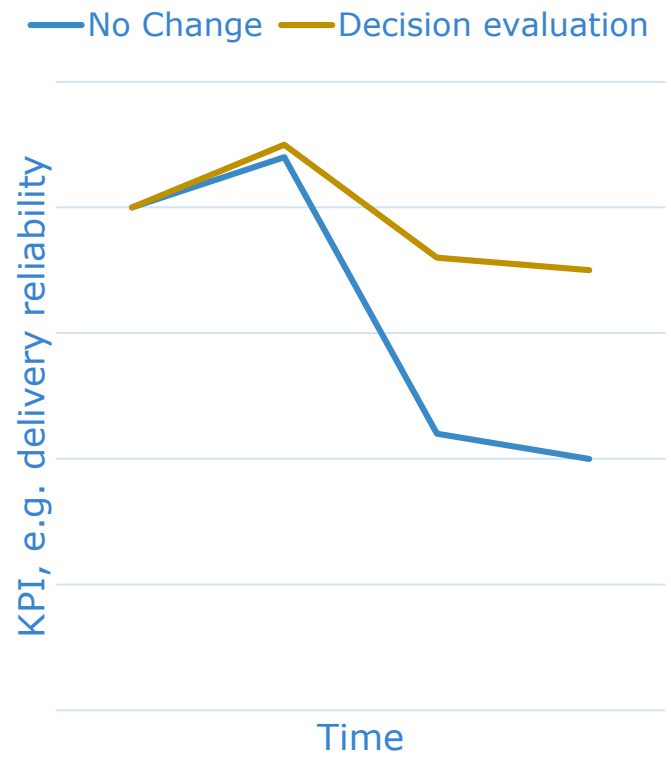
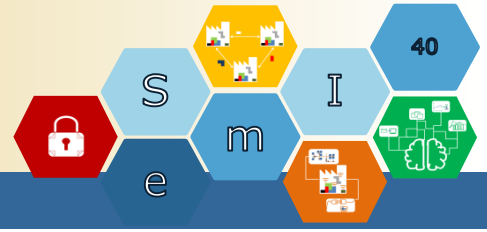


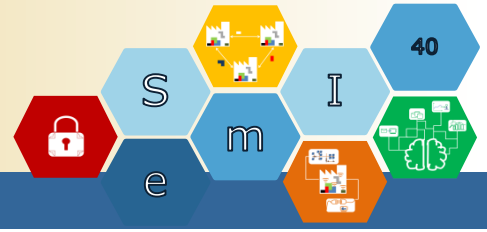
Figure by Thomas Ponsignon (Infineon Technologies AG), adapted for this presentation

Application example



- **Situation: Customer orders for an earlier date than forecasted**
- **Step-by-step procedure:**
  - SPC-based detection of abnormalities in supply chain segments
  - Defined information flow involving affected systems
  - Context enrichment with relevant production data
  - Data-driven decision making, e.g. priority change of orders
  - Implementation using existing production IT systems
- **System is designed for escalation management**

Application example

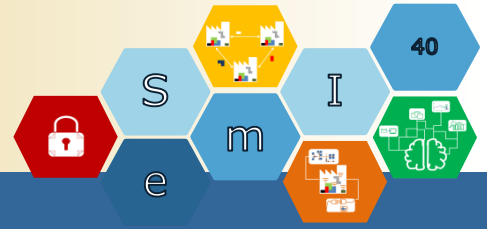


- **Situation: Customer orders for an earlier date than forecasted**
- **Evolvement compared to the state of the art:**
  - semi-automated process → mostly automated process
  - multiple people involved → mostly IT based
  - different communication methods → IT interfaces
  - gut decision → data-driven decision
- **Production control can focus on daily business rather than escalation management only**

Findings

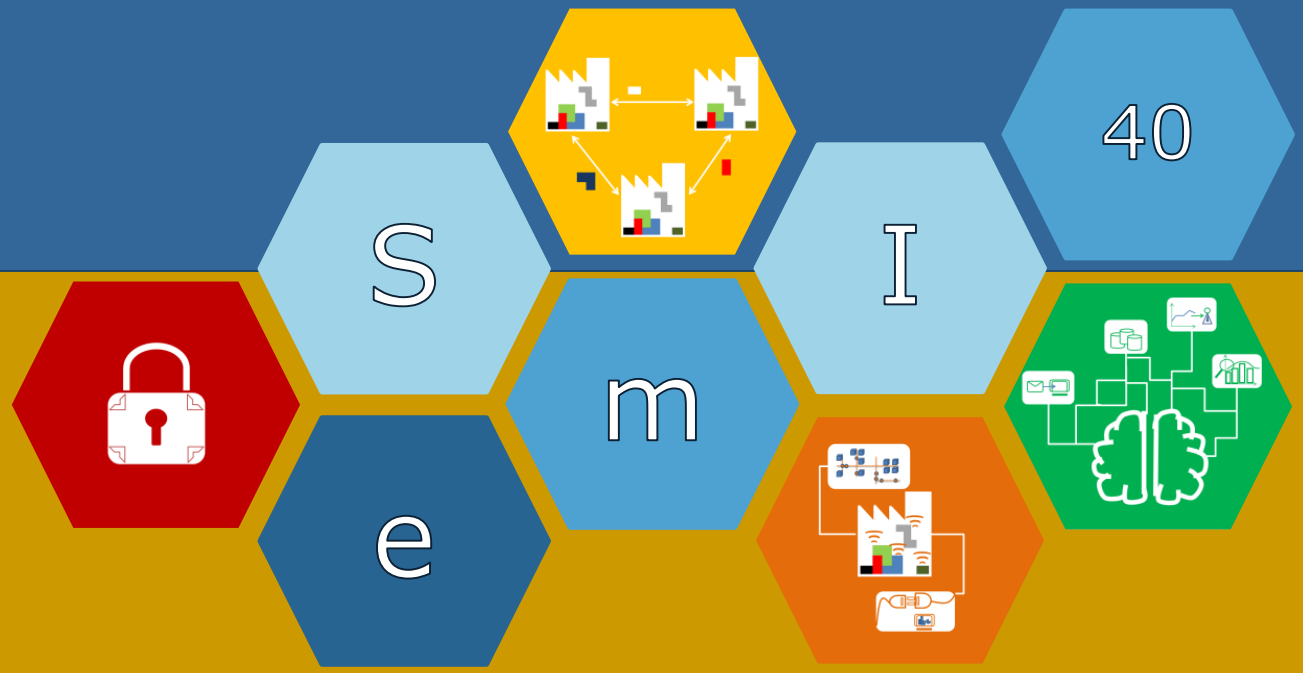
- Defined as is process for supply chain event handling and outlined its limitations
- Developed concept of Advanced Dispatch Control to overcome these limitations
  - → Defined target system and derived requirements
  - → Defined events and relevant context data
  - → Designed IT-architecture and components
  - → Replaced initial idea of static rules by adaptive machine learning based model
- Simulation development very complex to generate artificial data
  - → Reimplementation of MIMAC set 1, adapted by our needs (e.g. additional data)
  - → Many assumptions had to be made and discussed with experts
- Concept is basically working and promising, but further research has to be done in the field of decision evaluation
- Thanks a lot to our project partners from Infineon Technologies (Munich & Villach) for supporting this development with their expert knowledge

Next steps



- Further assessment of decision maker and its decisions by MIMAC-based simulation model
- Development of interfaces to existing production IT systems (e.g. Applied Materials Real-Time Dispatcher)
- Application to real production data, validation by fab simulation model
- Validation of decisions in production line

Thank you!



Questions?

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