Collaborative Embedded Systems
CrESt

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

SIEMENS
Ingenuity for life

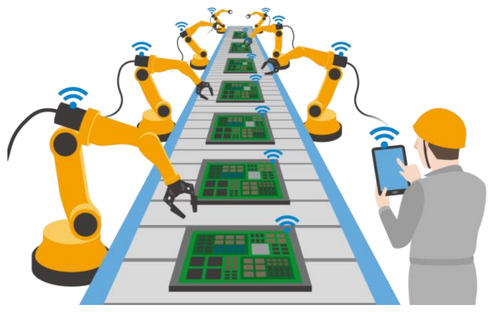
Model-based Process Failure Mode and Effects Analysis

Quality Assurance for Flexible Production Systems

Trends and Challenges for Flexible Production

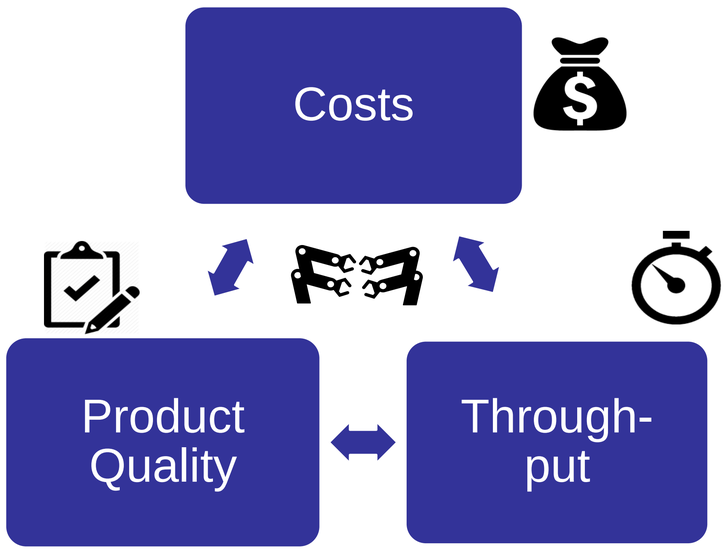
Envisioned e. g. by *Industrie 4.0*

- **Individualization** up to lot-size-1
- **Order-controlled** production at runtime
- **Dynamic integration** of machinery and skills
- **Reconfigurable** production systems



Challenges

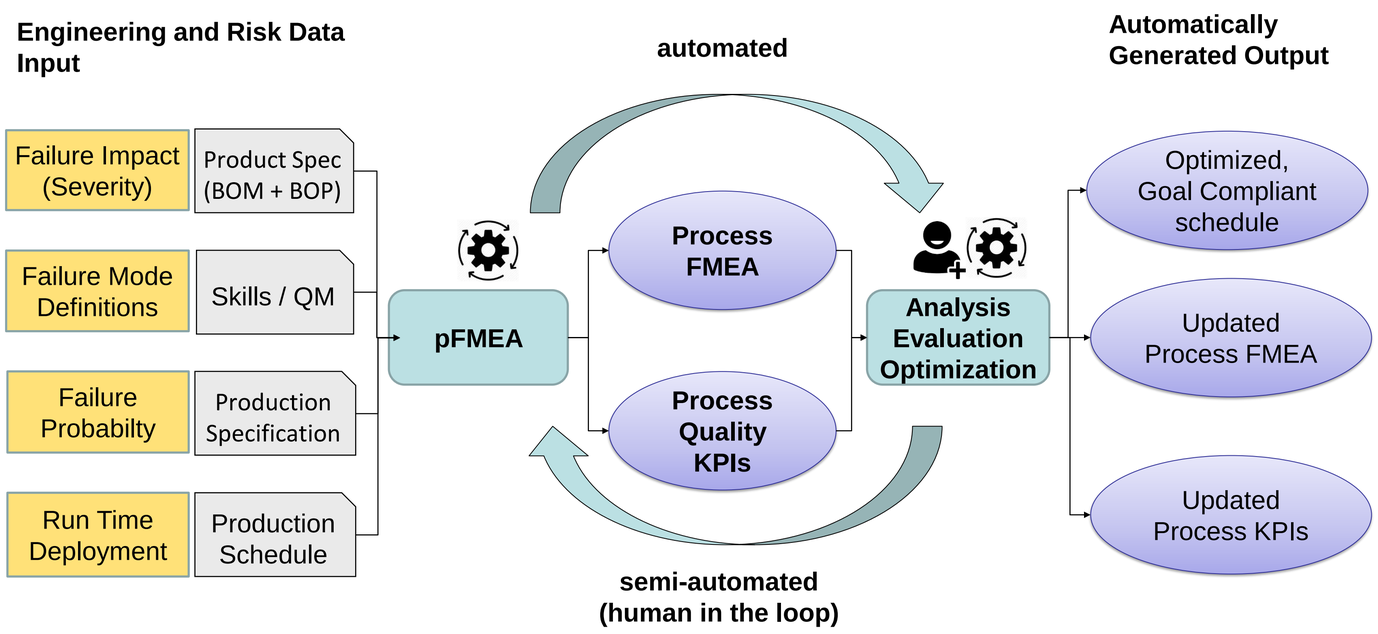
- **Ensure quality** for changing production schedules
- Process FMEAs need to be performed **rapidly and frequently**
- Find **optimal balance** regarding **quality, cost and production time**



Enable future production scenarios requires to ensure production quality efficiently

Model-based Process FMEA

Automatic Generation of Process FMEA Ensures Production Quality efficiently

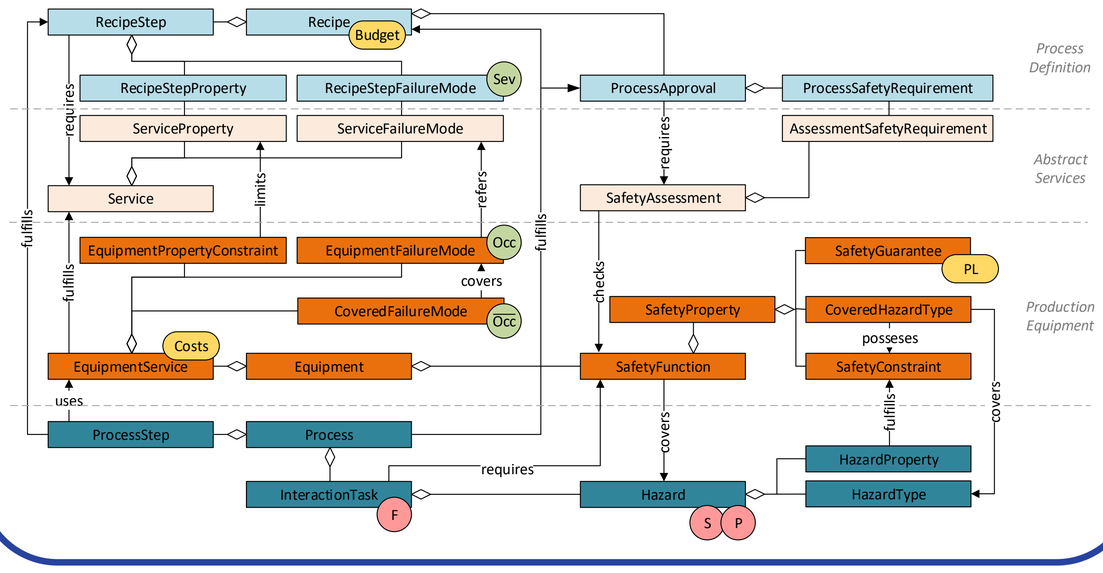


- **Model-based** and **modular** approach supports development process (agile, iterative and incremental development)
- **Decouple** independent **stakeholders** via defined interfaces
- **Reuse** existing **solutions** and **knowledge** from **risk analysis** for production services, product definition (BOM/BOP)
- **Automated** (re-) **generation** of artifacts
- **Semi-automatic** assistance for analysis, **evaluation** and **optimization**

Results

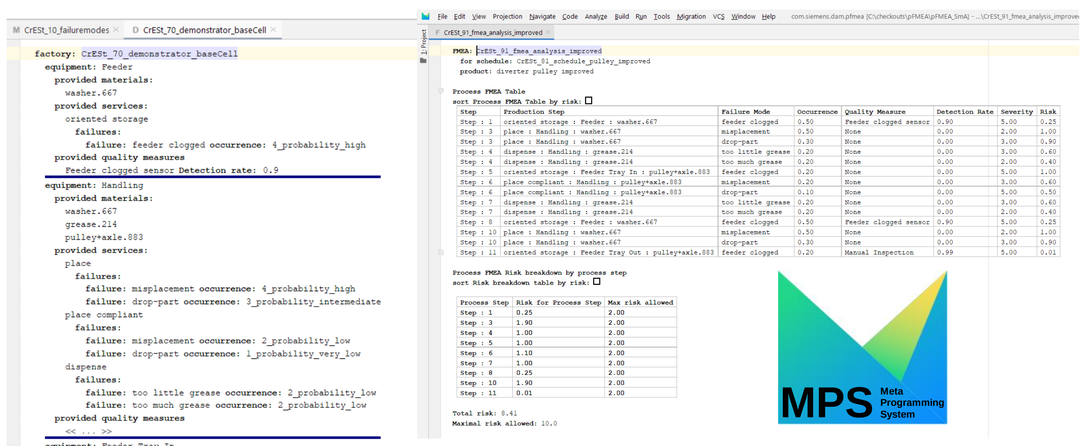
Meta Model for Safety and Quality

- **Decoupling** of stakeholders via defined interfaces
- **Information for automated risk assessment** with regard to safety and quality captured in one place



Method supported by Tooling

- Prototypical **implementation in MPS** to enable modeling by domain experts
- Integration in existing toolchains and production planning workflows is practicable



```
factory: CrESt_70_demonstrator_baseCell
  equipment: Feeder
    provided materials:
      washer.667
    provided services:
      oriented storage
        failures:
          failure: feeder clogged occurrence: 4_probability_high
    provided quality measures
      Feeder clogged sensor Detection rate: 0.9
  equipment: Handling
    provided materials:
      washer.667
      grease.214
      pulley+axle.883
    provided services:
      place
        failures:
          failure: misplacement occurrence: 4_probability_high
          failure: drop-part occurrence: 3_probability_intermediate
      place compliant
        failures:
          failure: misplacement occurrence: 2_probability_low
          failure: drop-part occurrence: 1_probability_very_low
      dispense
        failures:
          failure: too little grease occurrence: 2_probability_low
          failure: too much grease occurrence: 2_probability_low
    provided quality measures
      << ... >>
```

```
FMEA: CrESt_91_fmea_analysis_improved
  for schedule: CrESt_91_schedule_pulley_improved
  product: diverter pulley improved

Process FMEA Table
sort Process FMEA Table by risk:
```

Step	Production Step	Failure Mode	Occurrence	Quality Measure	Detection Rate	Severity	Risk
Step : 1	oriented storage : Feeder : washer.667	feeder clogged	0.50	Feeder clogged sensor	0.90	5.00	0.25
Step : 3	place : Handling : washer.667	misplacement	0.50	None	0.00	2.00	1.00
Step : 3	place : Handling : washer.667	drop-part	0.30	None	0.00	3.00	0.90
Step : 4	dispense : Handling : grease.214	too little grease	0.20	None	0.00	3.00	0.60
Step : 4	dispense : Handling : grease.214	too much grease	0.20	None	0.00	2.00	0.40
Step : 5	oriented storage : Feeder Tray In : pulley+axle.883	feeder clogged	0.20	None	0.00	5.00	1.00
Step : 6	place compliant : Handling : pulley+axle.883	misplacement	0.20	None	0.00	3.00	0.60
Step : 6	place compliant : Handling : pulley+axle.883	drop-part	0.10	None	0.00	5.00	0.50
Step : 7	dispense : Handling : grease.214	too little grease	0.20	None	0.00	3.00	0.60
Step : 7	dispense : Handling : grease.214	too much grease	0.20	None	0.00	2.00	0.40
Step : 8	oriented storage : Feeder : washer.667	feeder clogged	0.50	Feeder clogged sensor	0.90	5.00	0.25
Step : 10	place : Handling : washer.667	misplacement	0.50	None	0.00	2.00	1.00
Step : 10	place : Handling : washer.667	drop-part	0.30	None	0.00	3.00	0.90
Step : 11	oriented storage : Feeder Tray Out : pulley+axle.883	feeder clogged	0.20	Manual Inspection	0.99	5.00	0.01

```
Process FMEA Risk breakdown by process step
sort Risk breakdown table by risk:
```

Process Step	Risk for Process Step	Max risk allowed
Step : 1	0.25	2.00
Step : 3	1.90	2.00
Step : 4	1.00	2.00
Step : 5	1.00	2.00
Step : 6	1.10	2.00
Step : 7	1.00	2.00
Step : 8	0.25	2.00
Step : 10	1.90	2.00
Step : 11	0.01	2.00

```
Total risk: 8.41
Maximal risk allowed: 10.0
```

MPS Meta Programming System

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