

ASSISTANT SE Case Study

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Constraint Based Production Scheduling

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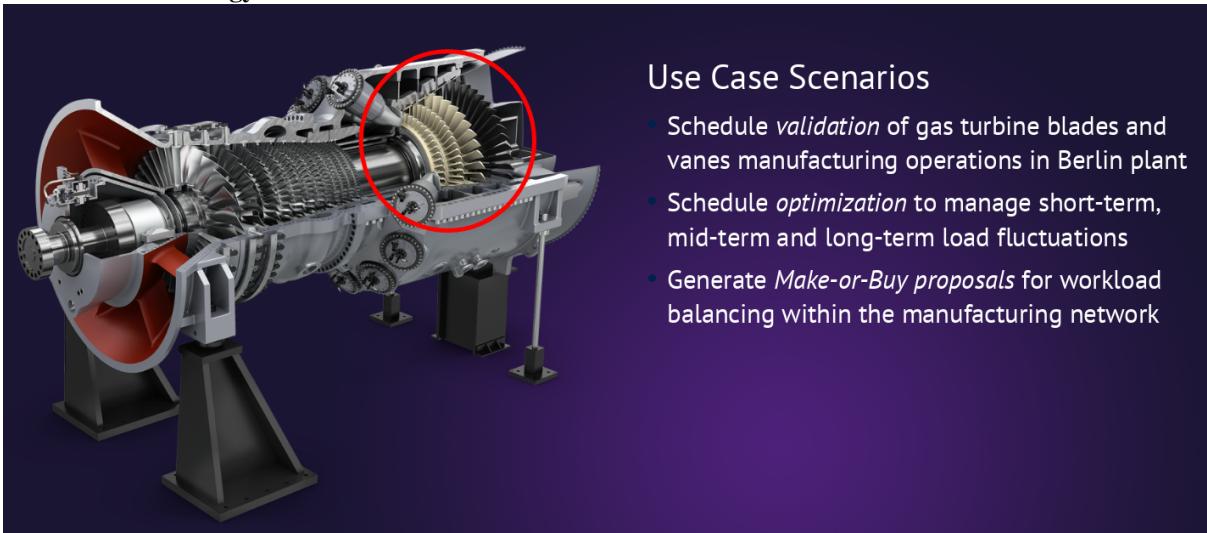
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Key Points

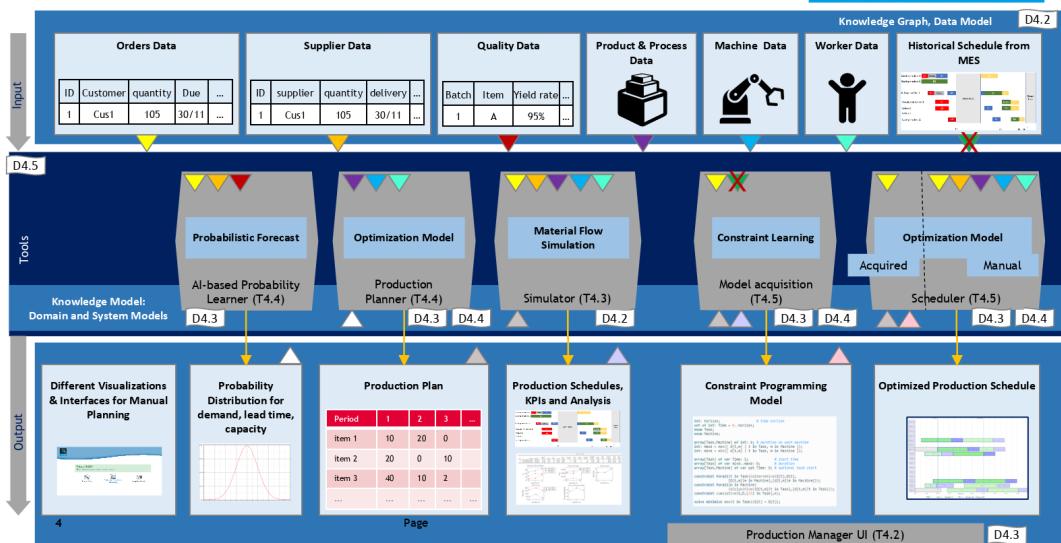
- Scheduling/Planning tool for manufacturing industry
 - Developed as part of European ASSISTANT project
 - Focused on key make-or-buy decisions
 - Complex manufacturing process with alternative process paths
 - Outperforms both current in-house tool and commercial simulator
 - Key Technology: Optimization and Constraint Programming

Assistant Siemens Energy Use Case

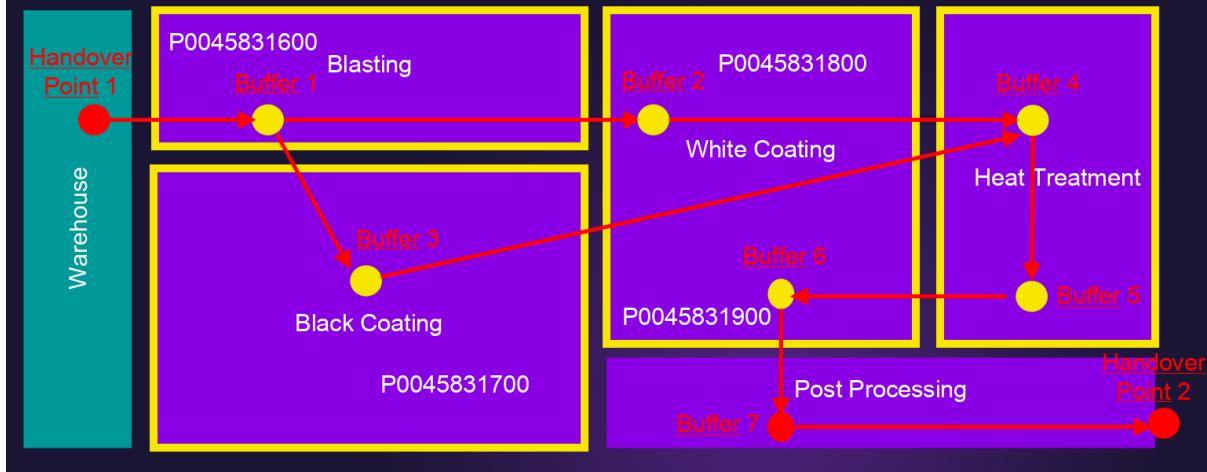


ASSISTANT Project Overview

Intelligent digital twin for process planning and scheduling



SE Product Routing



Test Datasets

Full Scale Datasets

Berlin06: 96 orders, 9 months horizon, previous review



Berlin07: 450 orders, 4 years horizon



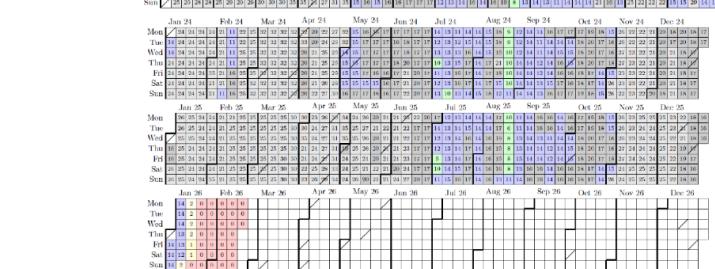
Berlin08: 559 orders, Christmas gap added



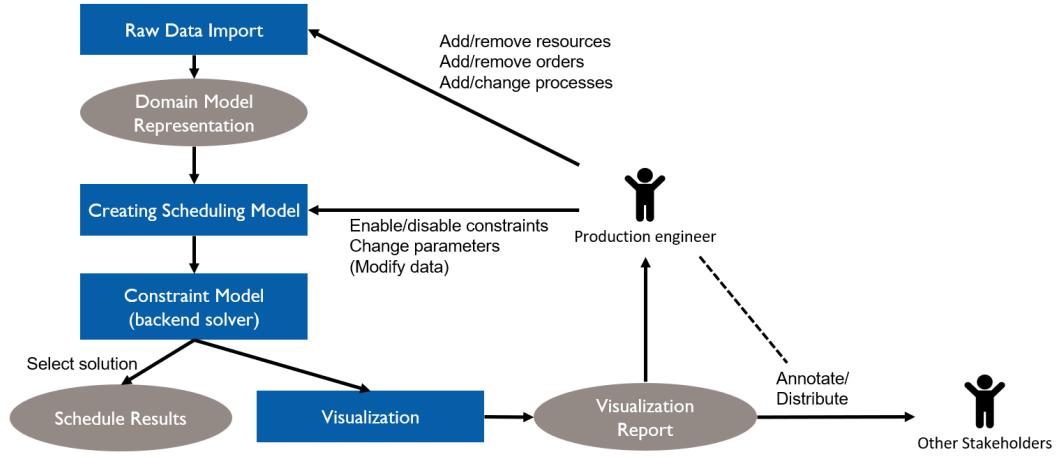
Berlin08a: 670 orders, filling gaps



Value in cell indicates active orders
Yellow and red colors indicate low order volume



Optimizer High Level Structure



Raw Data - Manual Data Entry Causes Problems

- Raw data come from spreadsheet
 - 20 tabs
- Excel is a particularly bad input data format
- Realistic, not real data
- Created by hand/automatically from existing test scenarios
- Series of files Berlin01 - Berlin05 were too inconsistent to run
- Berlin06 still contains some errors
- Optimizer explains all issues that it finds

ASSISTANT Project Siemens Energy Use Case - Insight SFI Centre for Data Analytics

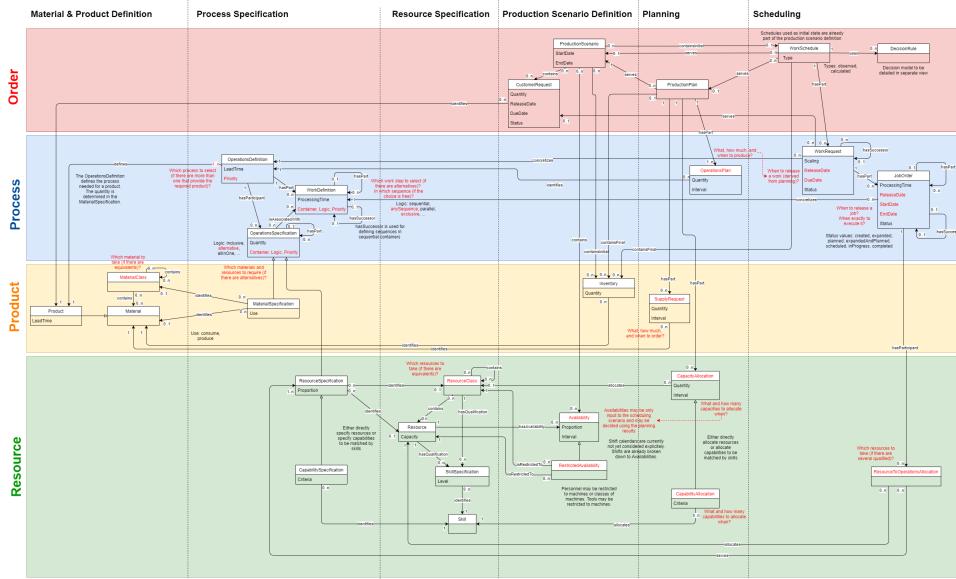
File Edit Scenario View Window Help

RawIssue X

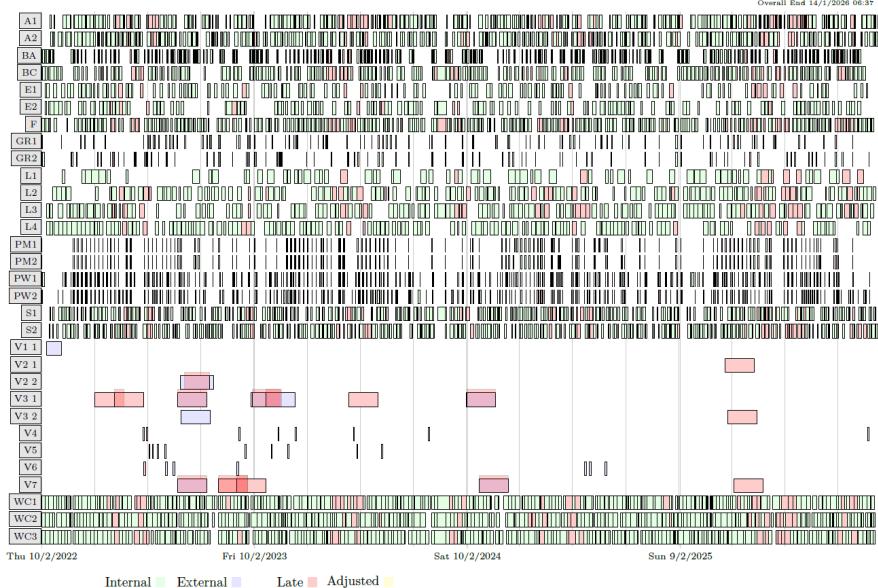
| Name | Severity | Sheet | RowNr | ColNr | Description |
|---------|----------|--------------------|-------|-------|---|
| Issue1 | Major | t_Load | 129 | 11 | DateTime not formatted correctly, found 2022-02-2800:00:00 format yyyy-MM-dd'T'HH:mm:ss |
| Issue2 | Minor | t_Products | 1 | 15 | Extra Empty Header |
| Issue3 | Minor | t_Availabilities | 1 | 8 | Extra Empty Header |
| Issue4 | Minor | t_Unavailabilities | 1 | 8 | Extra Empty Header |
| Issue5 | Minor | t_Shift_Segments | 1 | 6 | Extra Empty Header |
| Issue6 | Major | t_Shift_Segments | 1 | 1 | TimeOnly not formatted correctly, found 0.250000, format H:mm:ss |
| Issue7 | Major | t_Shift_Segments | 1 | 2 | TimeOnly not formatted correctly, found 0.583333, format H:mm:ss |
| Issue8 | Major | t_Shift_Segments | 2 | 1 | TimeOnly not formatted correctly, found 0.291667, format H:mm:ss |
| Issue9 | Major | t_Shift_Segments | 2 | 2 | TimeOnly not formatted correctly, found 0.302083, format H:mm:ss |
| Issue10 | Major | t_Shift_Segments | 3 | 1 | TimeOnly not formatted correctly, found 0.458333, format H:mm:ss |
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| Issue20 | Major | t_Shift_Segments | 8 | 1 | TimeOnly not formatted correctly, found 0.000000, format H:mm:ss |
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| Issue32 | Minor | t_Shift_Segments | 18 | 0 | First Column Empty |
| Issue33 | Minor | t_Shift_Patterns | 1 | 9 | Extra Empty Header |
| Issue34 | Minor | t_Shift_Patterns | 7 | 0 | First Column Empty |
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▶ Filter

Domain Model - Knowledge Graph



Solution for Berlin 08a - Shows Only 20% of Tasks in Model



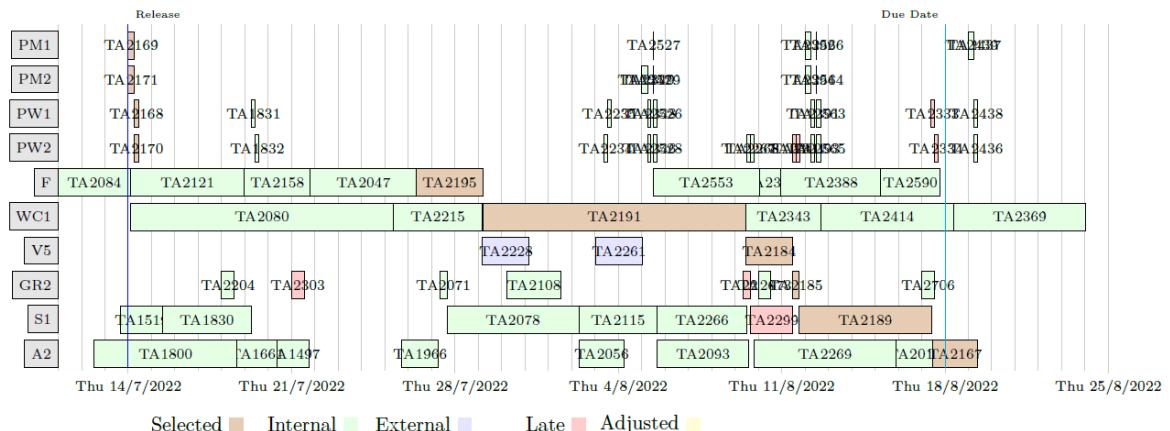
Implementation

- Requirement capture done inside project
- Data checking/cleaning most time consuming aspect
- Some specified functionality was rejected by Betriebsrat
- Built in Java
- Uses IBM's CPOptimizer back-end
- 120k LoC, 110k generated, 3k solver
- Outperforms both
 - Current in-house tool

- Simulation based tool based on commercial simulator
- System installed at SE site, but not in daily use

Explaining Late Delivery

- Explain why some orders are delivered late
- Find root-cause, show schedule in context



Evaluation - KPIs

| KPI | Baseline | Optimizer |
|--------------------------------|----------|-----------|
| OTD | > 80 % | 92 % |
| Bottleneck machine utilization | 99.5 % | 100 % |
| Manufacturing defects | 10-15 % | < 10 % |
| Scenarios in 8 hours | 15-20 | > 100,000 |

Conclusion by Siemens Energy

"Within less than eight hours the ASSISTANT tools provided us thousands of manufacturing scenarios including different make-or-buy recommendations for making deliberate decisions on the way to proceed for strategic planning."

from ASSISTANT final project review: Siemens Energy assessment

Summary

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- Key Technology: Optimization and Constraint Programming