

ASSISTANT SE Case Study

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Constraint Based Production Scheduling

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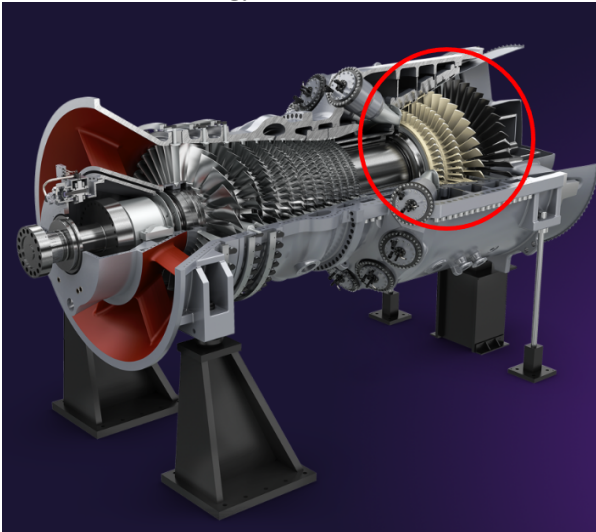
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Key Points

- 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

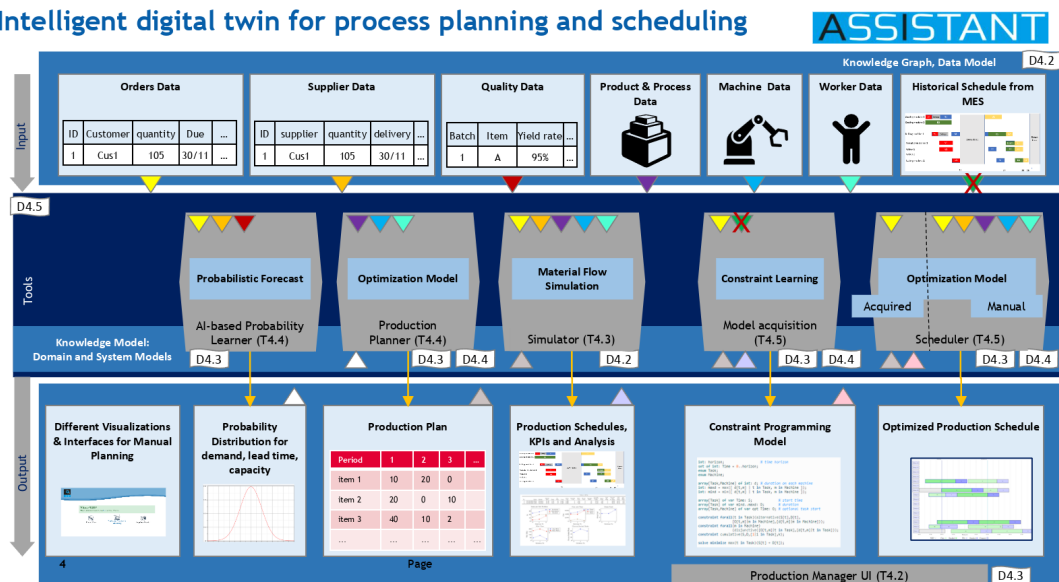


Use Case Scenarios

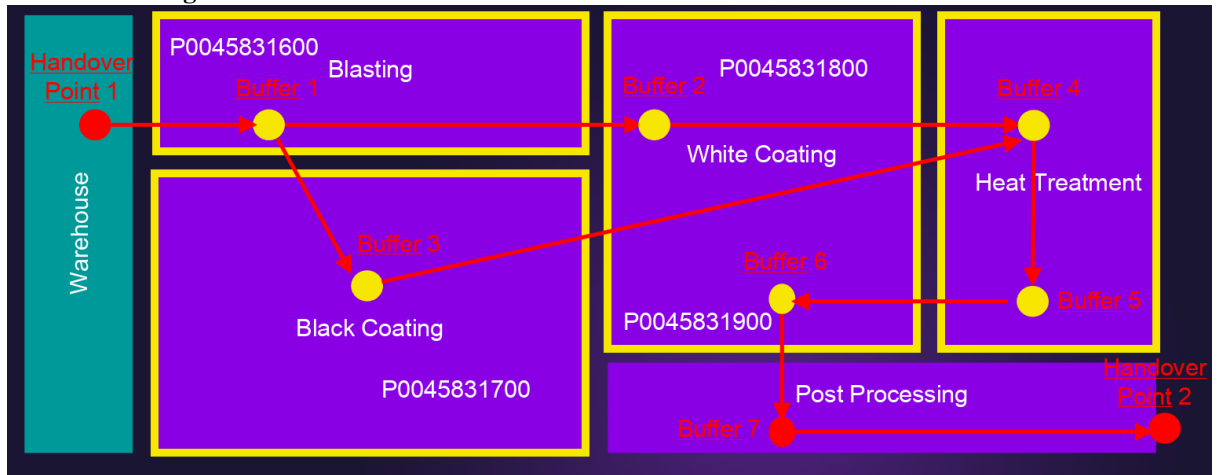
- Schedule *validation* of gas turbine blades and vanes manufacturing operations in Berlin plant
- Schedule *optimization* to manage short-term, mid-term and long-term load fluctuations
- Generate *Make-or-Buy proposals* for workload balancing within the manufacturing network

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

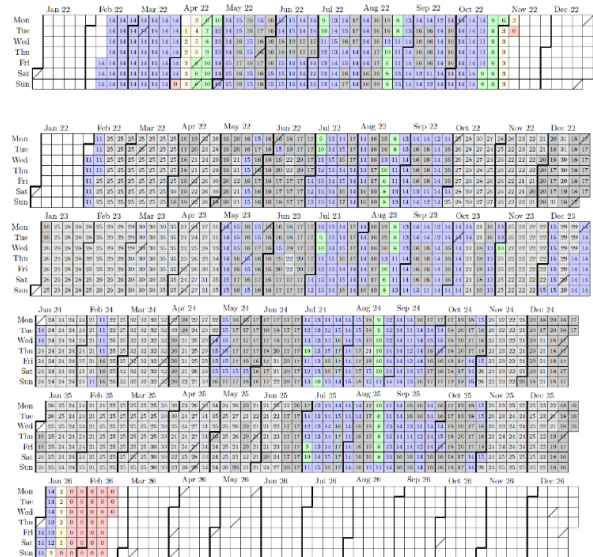
Berlin07: 450 orders, 4 years horizon

Berlin08: 559 orders, Christmas gap added

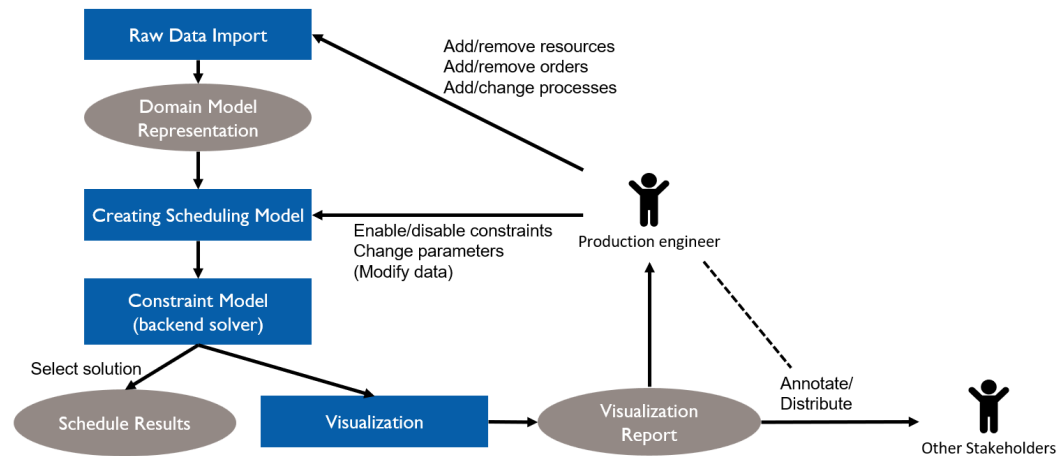
Berlin08a: 670 orders, filling gaps



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



Optimizer High Level Structure

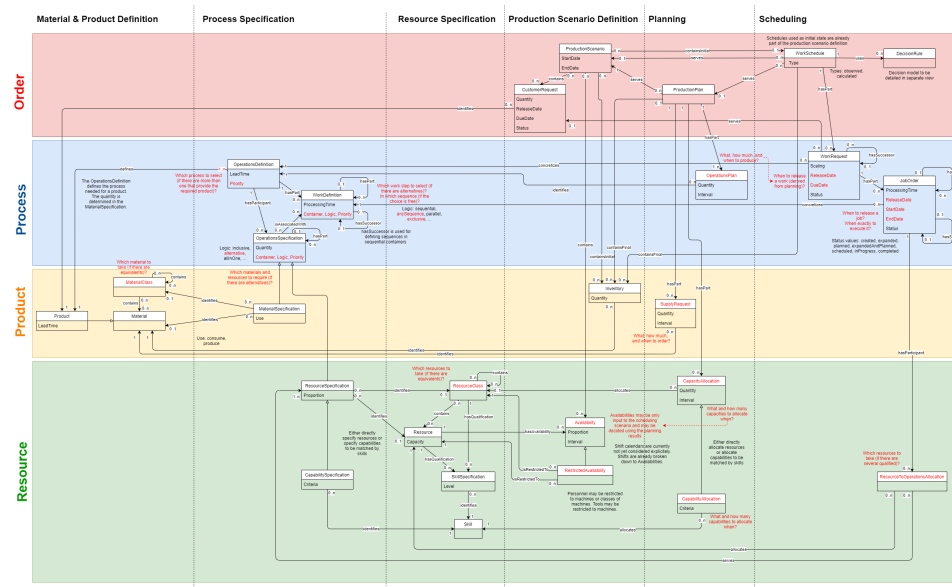


Raw Data - Manual Data Entry Causes Problems

- 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			
Issue11	Major	t_Shift_Segments	3	2	TimeOnly not formatted correctly, found 0.479167, format H:mm:ss			
Issue12	Major	t_Shift_Segments	4	1	TimeOnly not formatted correctly, found 0.583333, format H:mm:ss			
Issue13	Major	t_Shift_Segments	4	2	TimeOnly not formatted correctly, found 0.916667, format H:mm:ss			
Issue14	Major	t_Shift_Segments	5	1	TimeOnly not formatted correctly, found 0.666667, format H:mm:ss			
Issue15	Major	t_Shift_Segments	5	2	TimeOnly not formatted correctly, found 0.677083, format H:mm:ss			
Issue16	Major	t_Shift_Segments	6	1	TimeOnly not formatted correctly, found 0.770833, format H:mm:ss			
Issue17	Major	t_Shift_Segments	6	2	TimeOnly not formatted correctly, found 0.791667, format H:mm:ss			
Issue18	Major	t_Shift_Segments	7	1	TimeOnly not formatted correctly, found 0.916667, format H:mm:ss			
Issue19	Major	t_Shift_Segments	7	2	TimeOnly not formatted correctly, found 0.250000, format H:mm:ss			
Issue20	Major	t_Shift_Segments	8	1	TimeOnly not formatted correctly, found 0.000000, format H:mm:ss			
Issue21	Major	t_Shift_Segments	8	2	TimeOnly not formatted correctly, found 0.010417, format H:mm:ss			
Issue22	Major	t_Shift_Segments	9	1	TimeOnly not formatted correctly, found 0.083333, format H:mm:ss			
Issue23	Major	t_Shift_Segments	9	2	TimeOnly not formatted correctly, found 0.104167, format H:mm:ss			
Issue24	Minor	t_Shift_Segments	10	0	First Column Empty			
Issue25	Minor	t_Shift_Segments	11	0	First Column Empty			
Issue26	Minor	t_Shift_Segments	12	0	First Column Empty			
Issue27	Minor	t_Shift_Segments	13	0	First Column Empty			
Issue28	Minor	t_Shift_Segments	14	0	First Column Empty			
Issue29	Minor	t_Shift_Segments	15	0	First Column Empty			
Issue30	Minor	t_Shift_Segments	16	0	First Column Empty			
Issue31	Minor	t_Shift_Segments	17	0	First Column Empty			
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			
Issue35	Minor	t_Shift_Patterns	8	0	First Column Empty			
Filter								

Domain Model - Knowledge Graph



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



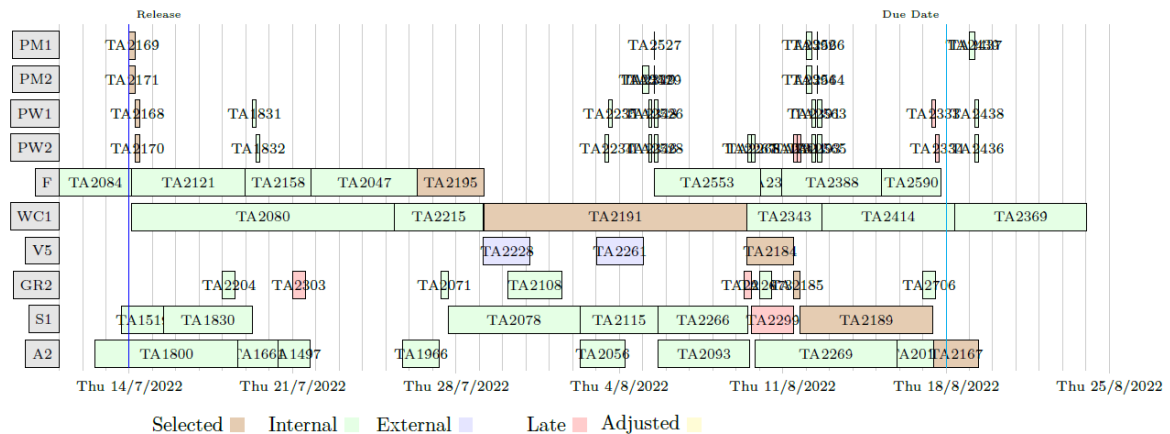
Implementation

- 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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