

# ASSISTANT SE Case Study

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## Constraint Based Production Scheduling



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# Acknowledgments



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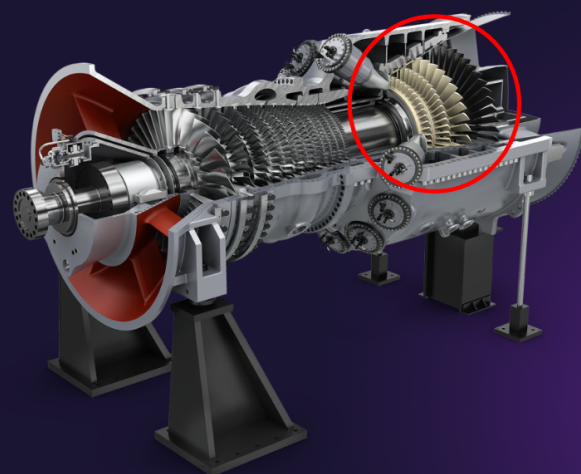
## Key Points



- 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

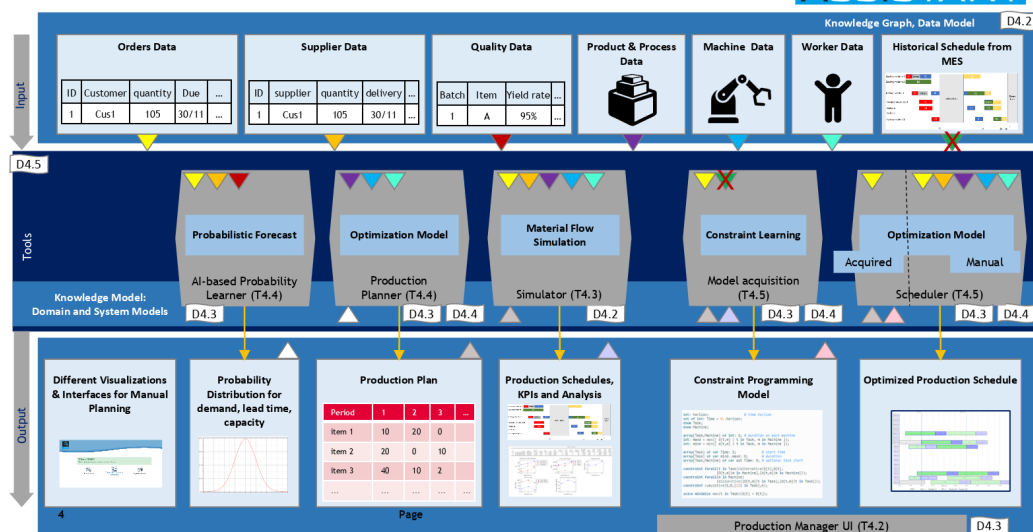
- Schedule *validation* of gas turbine blades and vanes manufacturing operations in Berlin plant
- Schedule *optimization* to manage short-term, mid-term and long-term load fluctuations
- Generate *Make-or-Buy proposals* for workload balancing within the manufacturing network

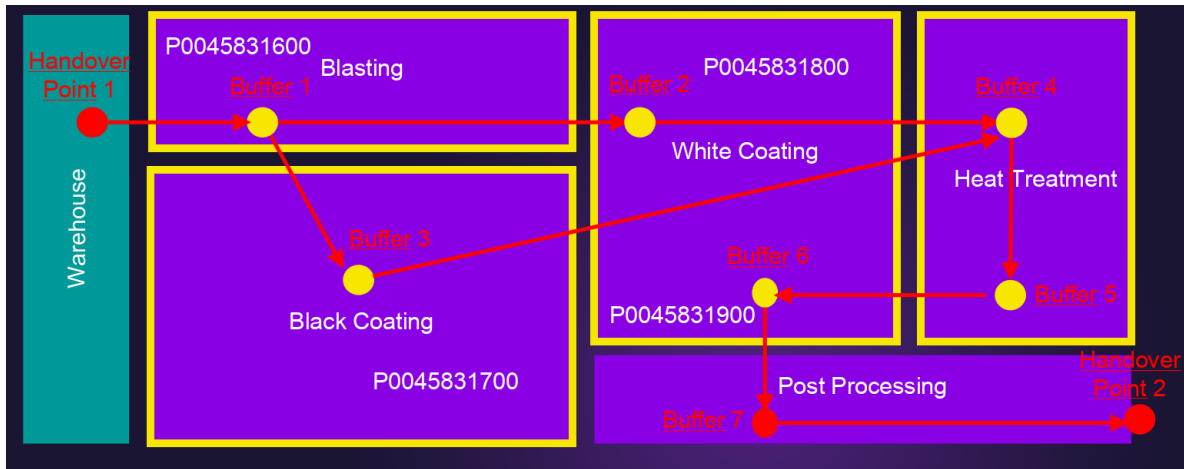
# ASSISTANT Project Overview



Intelligent digital twin for process planning and scheduling

**ASSISTANT**





## Test Datasets

### Full Scale Datasets

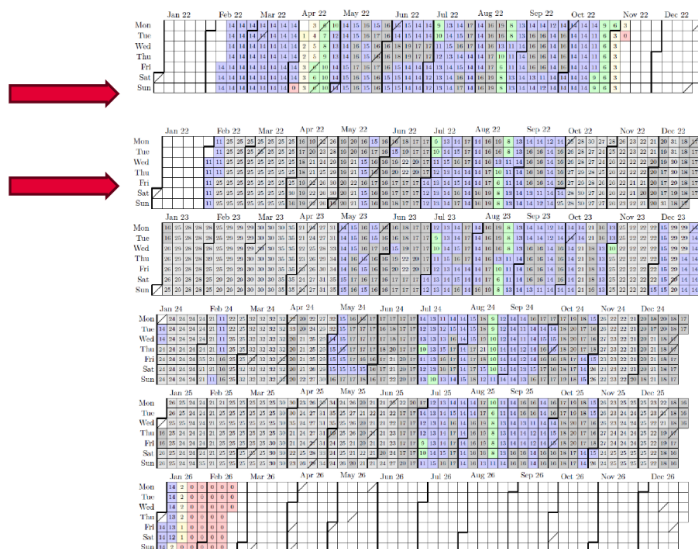
Berlin06: 96 orders, 9 months horizon, previous review

Berlin07: 450 orders, 4 years horizon

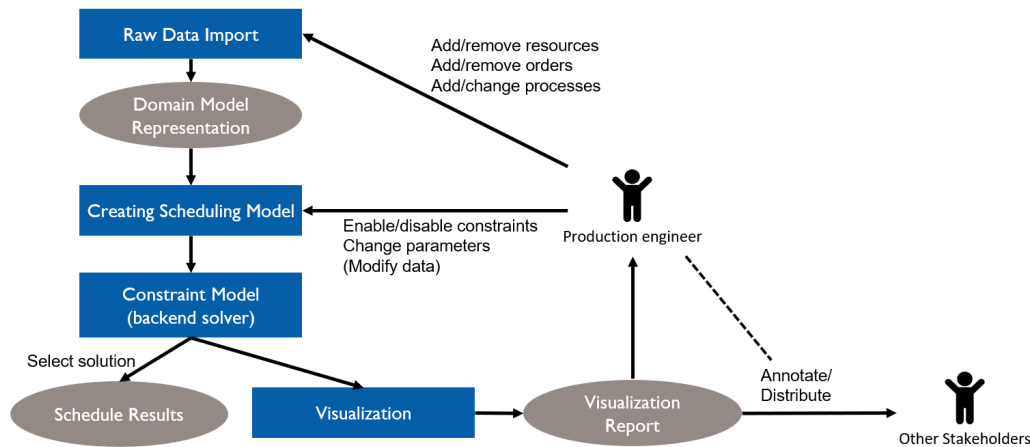
Berlin08: 559 orders, Christmas gap added

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

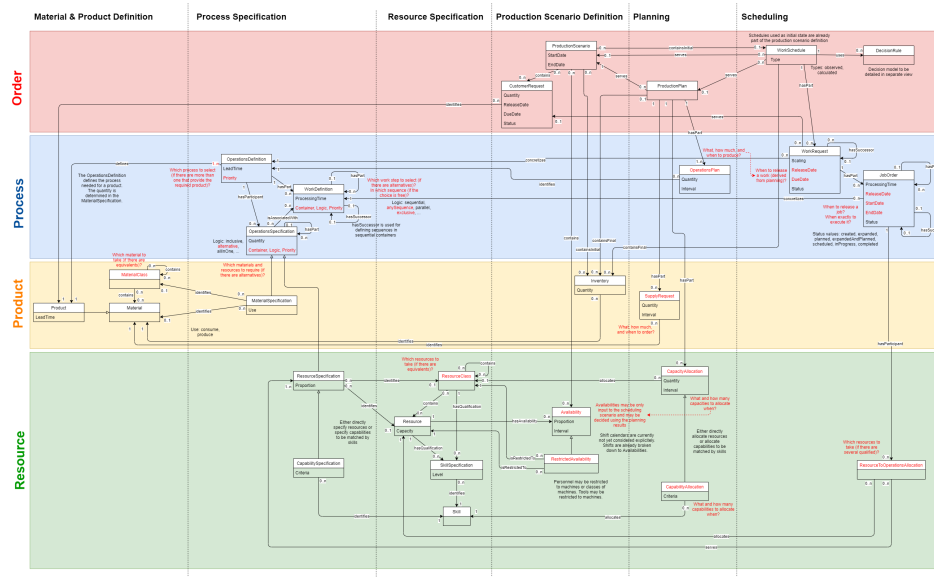


- Raw data come from spreadsheet
  - 20 tabs
- Excel is a particularly bad input data format
- Realistic, not real data
- Created by hand/automatically from existing test scenarios
- Series of files Berlin01 - Berlin05 were too inconsistent to run
- Berlin06 still contains some errors
- Optimizer explains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

The screenshot shows a software window titled 'ASBESTANT Project Siemens Energy Use Case - Insight SPI Centre for Data Analytics'. It displays a table of issues with columns for Name, Severity, Sheet, RowNo, ColNo, and Description. The table lists various issues, many of which are related to 'TimeOnly not formatted correctly' and 'First Column Empty'.

Name	Severity	Sheet	RowNo	ColNo	Description
Issue1	Major	t_Load	129	11	DateTime not formatted correctly, found 2022-02-2800:00:00 format yyyy-MM-ddTHH:mm:ss
Issue2	Minor	t_Products	1	15	Extra Empty Header
Issue3	Minor	t_Availability	1	8	Extra Empty Header
Issue4	Minor	t_Unavailability	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 HH:mm:ss
Issue7	Major	t_Shift_Segments	1	2	TimeOnly not formatted correctly, found 0.550332, format HH:mm:ss
Issue8	Major	t_Shift_Segments	2	1	TimeOnly not formatted correctly, found 0.291667, format HH:mm:ss
Issue9	Major	t_Shift_Segments	2	2	TimeOnly not formatted correctly, found 0.302083, format HH:mm:ss
Issue10	Major	t_Shift_Segments	3	1	TimeOnly not formatted correctly, found 0.458333, format HH:mm:ss
Issue11	Major	t_Shift_Segments	3	2	TimeOnly not formatted correctly, found 0.479167, format HH:mm:ss
Issue12	Major	t_Shift_Segments	4	1	TimeOnly not formatted correctly, found 0.563333, format HH:mm:ss
Issue13	Major	t_Shift_Segments	4	2	TimeOnly not formatted correctly, found 0.916667, format HH:mm:ss
Issue14	Major	t_Shift_Segments	5	1	TimeOnly not formatted correctly, found 0.866667, format HH:mm:ss
Issue15	Major	t_Shift_Segments	5	2	TimeOnly not formatted correctly, found 0.677083, format HH:mm:ss
Issue16	Major	t_Shift_Segments	6	1	TimeOnly not formatted correctly, found 0.770833, format HH:mm:ss
Issue17	Major	t_Shift_Segments	6	2	TimeOnly not formatted correctly, found 0.791667, format HH:mm:ss
Issue18	Major	t_Shift_Segments	7	1	TimeOnly not formatted correctly, found 0.916667, format HH:mm:ss
Issue19	Major	t_Shift_Segments	7	2	TimeOnly not formatted correctly, found 0.250000, format HH:mm:ss
Issue20	Major	t_Shift_Segments	8	1	TimeOnly not formatted correctly, found 0.000000, format HH:mm:ss
Issue21	Major	t_Shift_Segments	8	2	TimeOnly not formatted correctly, found 0.010417, format HH:mm:ss
Issue22	Major	t_Shift_Segments	9	1	TimeOnly not formatted correctly, found 0.083333, format HH:mm:ss
Issue23	Major	t_Shift_Segments	9	2	TimeOnly not formatted correctly, found 0.104167, format HH: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

# Domain Model - Knowledge Graph



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

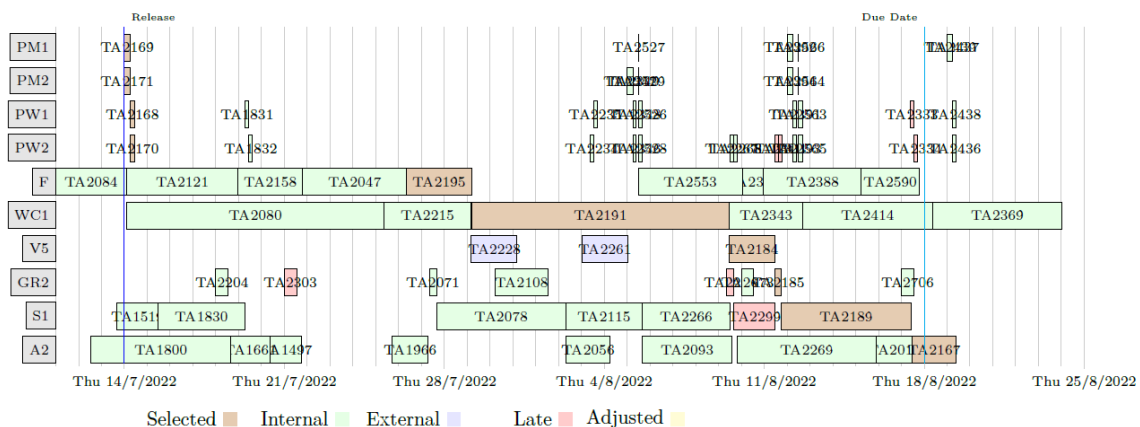


- Requirement capture done inside project
- Data checking/cleaning most time consuming aspect
- Some specified functionality was rejected by Betriebsrat
- Built in Java
- Uses IBM's CPOptimizer back-end
- 120k LoC, 110k generated, 3k solver
- Outperforms both
  - Current in-house tool
  - Simulation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





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





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