

# ASSISTANT SE Case Study

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## Constraint Based Production Scheduling

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# Acknowledgments



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# Key Points



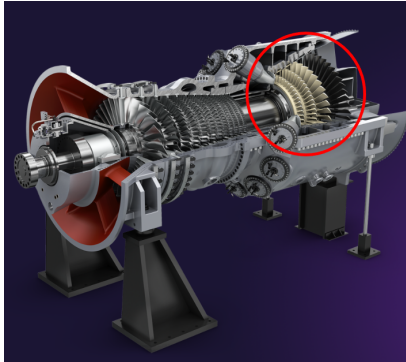
- Scheduling/Planning tool for manufacturing industry
- Developed as part of European ASSISTANT project
- Focused on key make-or-buy decisions
- Complex manufacturing process with alternative process paths
- Outperforms both current in-house tool and commercial simulator
- Key Technology: Optimization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

# Insight is one of the largest data research and innovation centres in Europe...



<b>4</b> Co-Lead Universities 9 partner institutions	Built on <b>20</b> years of research in Data Analytics and AI
<b>450+</b> Academics, Postdocs, PhDs, RAs	<b>3400+</b> Scientific conference and journal papers
<b>175+</b> Funded collaborations with industry partners	<b>350+</b> Research Awards
<b>16</b> Spin out companies 72 license agreements	<b>135+</b> H2020 consortia, 500+ collaborations, 40+ countries
<b>1,137+</b> school visits, 28,000 students	<b>276</b> PhDs graduated

# Assistant Siemens Energy Use Case



## Use Case Scenarios

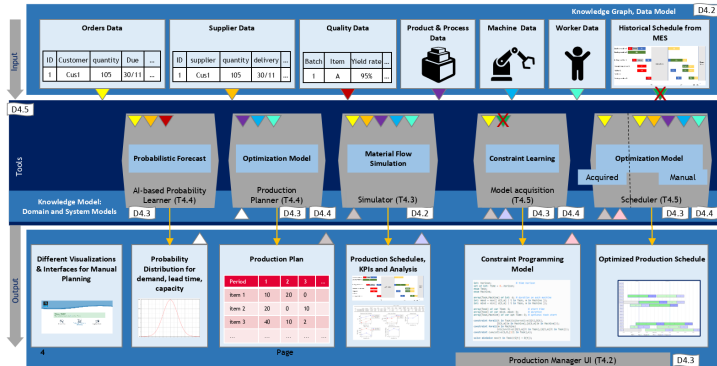
- Schedule *validation* of gas turbine blades and vanes manufacturing operations in Berlin plant
- Schedule *optimization* to manage short-term, mid-term and long-term load fluctuations
- Generate *Make-or-Buy proposals* for workload balancing within the manufacturing network

# ASSISTANT Project Overview

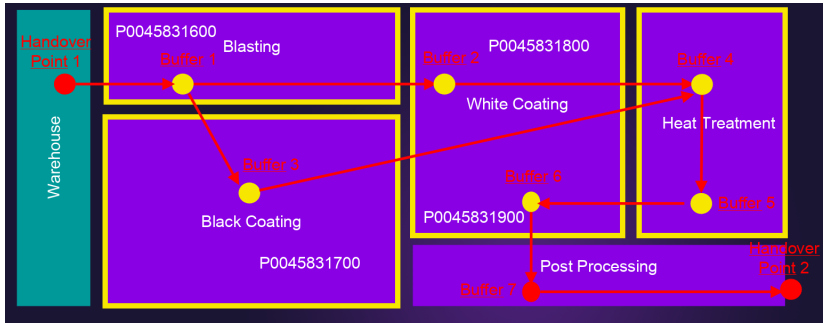


## Intelligent digital twin for process planning and scheduling

ASSISTANT



# SE Product Routing



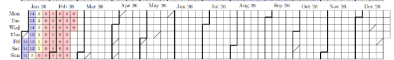
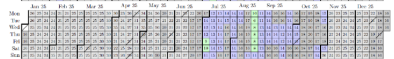
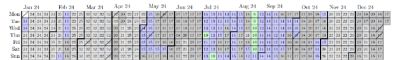
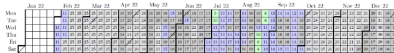
## Full Scale Datasets

Berlin06: 96 orders, 9 months horizon, previous review

Berlin07: 450 orders, 4 years horizon

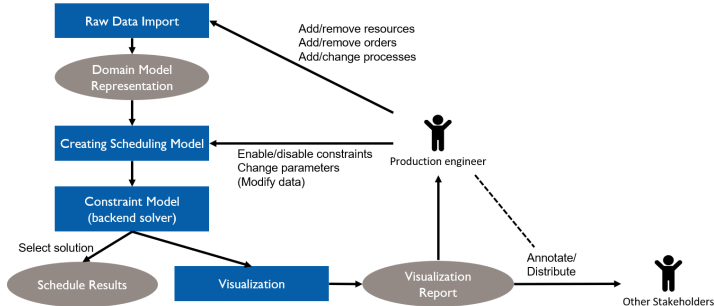
Berlin08: 559 orders, Christmas gap added

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

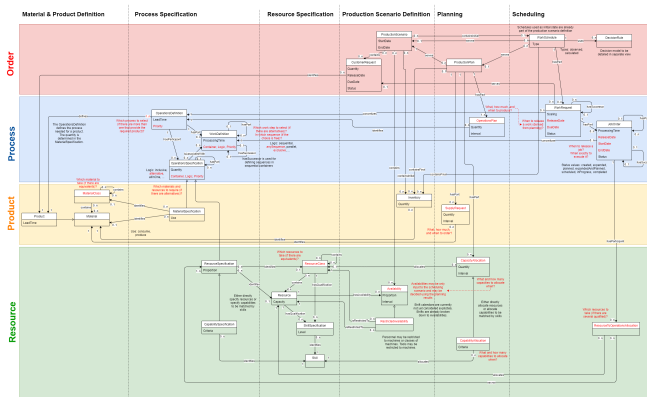


- Raw data come from spreadsheet
  - 20 tabs
- Excel is a particularly bad input data format
- Realistic, not real data
- Created by hand/automatically from existing test scenarios
- Series of files Berlin01 - Berlin05 were too inconsistent to run
- Berlin06 still contains some errors
- Optimizer explains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

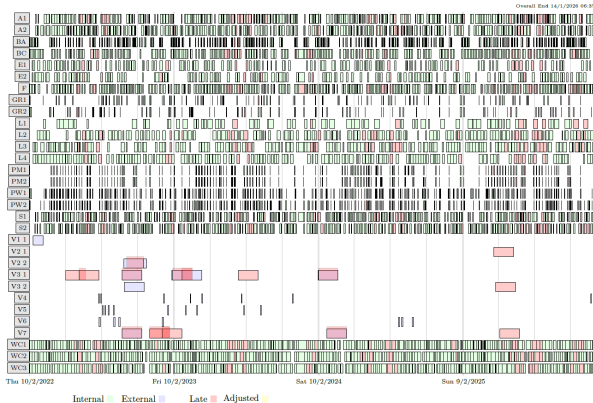
ASCCANT Project Services Energy Use Case - Insight SH Centre for Data Analytics

Issue	Severity	Sheet	Row#	Col#	Description
Issue1	Major	_Load	129	11	Date/Time not formatted correctly, found 2022-02-28000000 format yyyy-MM-ddTHH:mm:ss
Issue2	Minor	_Products	1	15	Extra Empty Header
Issue3	Minor	_Capabilities	1	8	Extra Empty Header
Issue4	Minor	_Usability	1	8	Extra Empty Header
Issue5	Major	_SHR_Segments	1	1	TimeOnly not formatted correctly, found 0.250000, format %m/%d/%y
Issue6	Major	_SHR_Segments	1	2	TimeOnly not formatted correctly, found 0.581333, format %m/%d/%y
Issue7	Major	_SHR_Segments	2	1	TimeOnly not formatted correctly, found 0.320263, format %m/%d/%y
Issue8	Major	_SHR_Segments	2	2	TimeOnly not formatted correctly, found 0.320263, format %m/%d/%y
Issue9	Major	_SHR_Segments	3	1	TimeOnly not formatted correctly, found 0.456333, format %m/%d/%y
Issue10	Major	_SHR_Segments	3	2	TimeOnly not formatted correctly, found 0.456333, format %m/%d/%y
Issue11	Major	_SHR_Segments	4	1	TimeOnly not formatted correctly, found 0.581333, format %m/%d/%y
Issue12	Major	_SHR_Segments	4	2	TimeOnly not formatted correctly, found 0.581333, format %m/%d/%y
Issue13	Major	_SHR_Segments	5	1	TimeOnly not formatted correctly, found 0.686667, format %m/%d/%y
Issue14	Major	_SHR_Segments	5	2	TimeOnly not formatted correctly, found 0.686667, format %m/%d/%y
Issue15	Major	_SHR_Segments	6	1	TimeOnly not formatted correctly, found 0.791667, format %m/%d/%y
Issue16	Major	_SHR_Segments	6	2	TimeOnly not formatted correctly, found 0.791667, format %m/%d/%y
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Issue18	Major	_SHR_Segments	7	2	TimeOnly not formatted correctly, found 0.916667, format %m/%d/%y
Issue19	Major	_SHR_Segments	8	1	TimeOnly not formatted correctly, found 0.250000, format %m/%d/%y
Issue20	Major	_SHR_Segments	8	2	TimeOnly not formatted correctly, found 0.250000, format %m/%d/%y
Issue21	Major	_SHR_Segments	9	1	TimeOnly not formatted correctly, found 0.581333, format %m/%d/%y
Issue22	Major	_SHR_Segments	9	2	TimeOnly not formatted correctly, found 0.581333, format %m/%d/%y
Issue23	Major	_SHR_Segments	10	1	TimeOnly not formatted correctly, found 0.134167, format %m/%d/%y
Issue24	Minor	_SHR_Segments	11	0	First Column Empty
Issue25	Minor	_SHR_Segments	12	0	First Column Empty
Issue26	Minor	_SHR_Segments	13	0	First Column Empty
Issue27	Minor	_SHR_Segments	14	0	First Column Empty
Issue28	Minor	_SHR_Segments	15	0	First Column Empty
Issue29	Minor	_SHR_Segments	16	0	First Column Empty
Issue30	Minor	_SHR_Segments	17	0	First Column Empty
Issue31	Minor	_SHR_Segments	18	0	First Column Empty
Issue32	Minor	_SHR_Patterns	1	9	Extra Empty Header
Issue33	Minor	_SHR_Patterns	7	0	First Column Empty
Issue34	Minor	_SHR_Patterns	8	0	First Column Empty

# Domain Model - Knowledge Graph



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



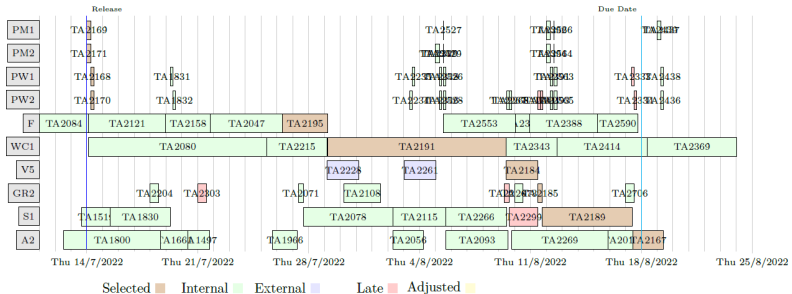


- Requirement capture done inside project
- Data checking/cleaning most time consuming aspect
- Some specified functionality was rejected by Betriebsrat
- Built in Java
- Uses IBM's CPOptimizer back-end
- 120k LoC, 110k generated, 3k solver
- Outperforms both
  - Current in-house tool
  - Simulation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



# 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



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