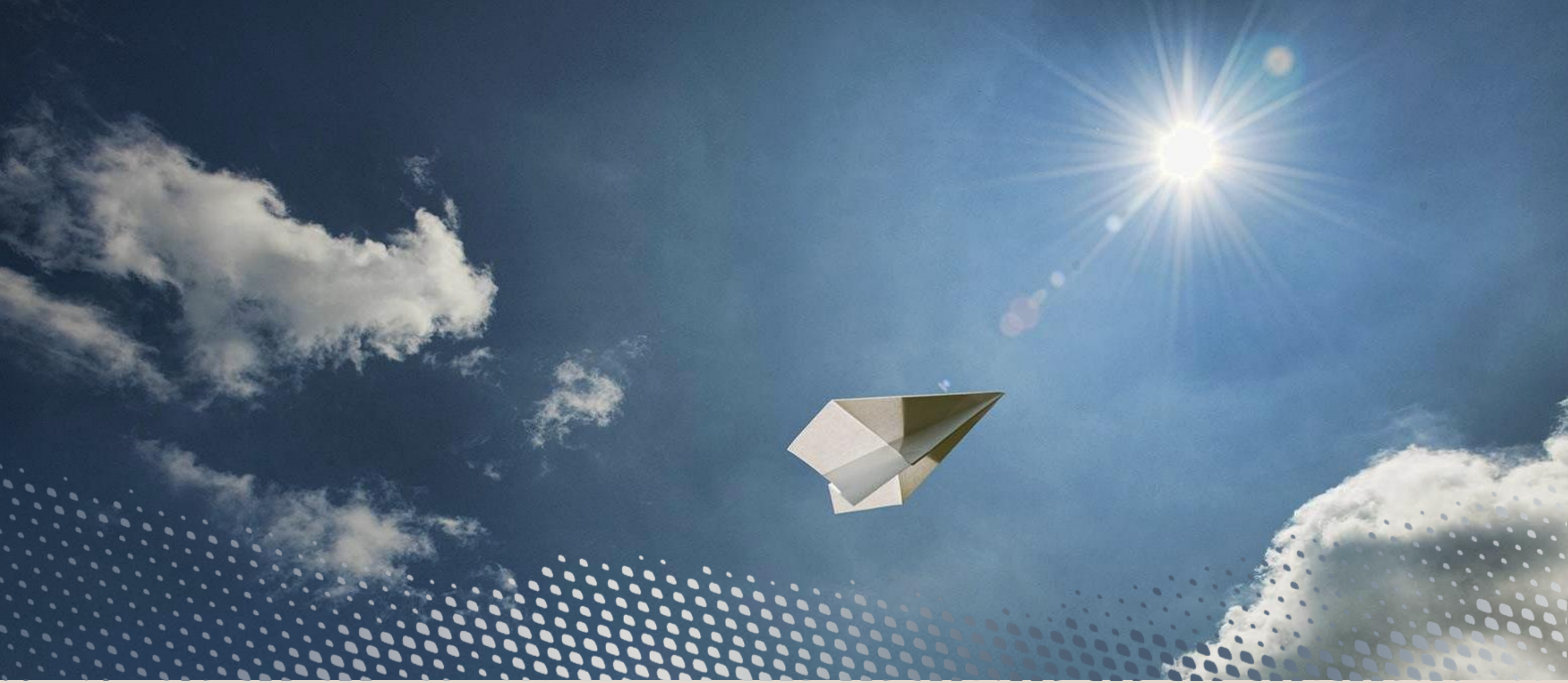

Analysis of Control Strategies for A/C Production Ramp-Up

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This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 314056.

Introduction

Airbus Group Innovations

Airbus Group Innovations is the central research function within Airbus Group with more than 700 researchers located in labs around the world.

Main mission

To support the technology strategy of the Airbus Group and to guarantee the technical innovation potential for TRL 1-6.

Competencies

- Composite and metallic technologies, surface engineering
- Structure engineering
- Sensors, electronics & system integration
- IT, security services & simulation
- Energy & propulsion
- Creative design & mobility

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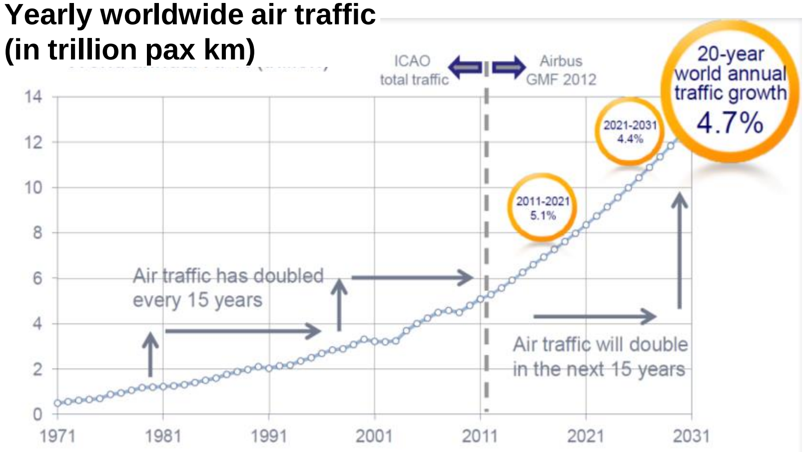
Introduction

Successes and Challenges

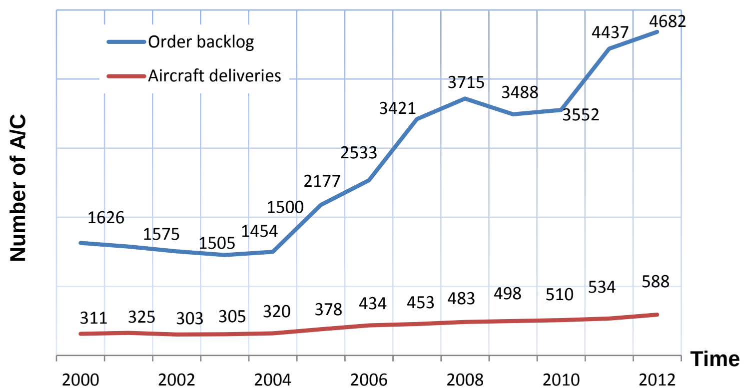
Airbus success story

- >5000 A320 delivered, >7000 overall A/C delivered
- New products delivered or in the pipeline: A380, A400M, A320NEO, A350 etc.
- Full order books for next decade
  ➔ >11.000 A/C market needs

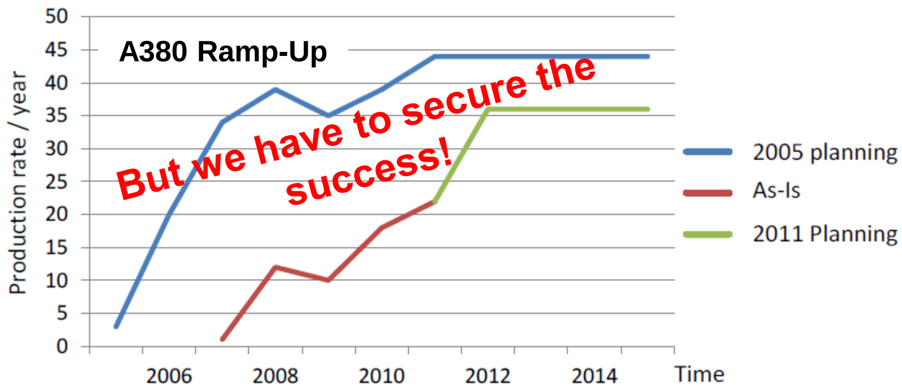
Yearly worldwide air traffic (in trillion pax km)



Increase of aircraft orders & deliveries



Production ramp-up delay



In a growing aerospace market (5% per year) the Airbus challenge is to deliver in time and to master the production ramp-up for the new aircrafts to come.

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Introduction

Research Project - Adaptive Production Management (ARUM)

Industrial Challenges

- Increasing risk for product immaturity and production disruptions due to shorter product lifecycle and thus frequent ramp-ups
- Complex and highly customized products for small series production with many ramp-ups
- High number of sources create changes at product and processes causing high number of correction processes influencing overall a/c lead time dramatically

ARUM solution

- Risk mitigation and management strategies for integrated control and optimization
- ICT systems implementing knowledge processing multi-agent-systems for pre-planning and production control and optimization within a scalable architecture
- Intelligent and knowledge-based Tools supporting the control and dynamic optimization of factory assets

EU 7th Framework Program project ARUM develops novel planning & control solutions for risk reduction in production ramp-up for new products.

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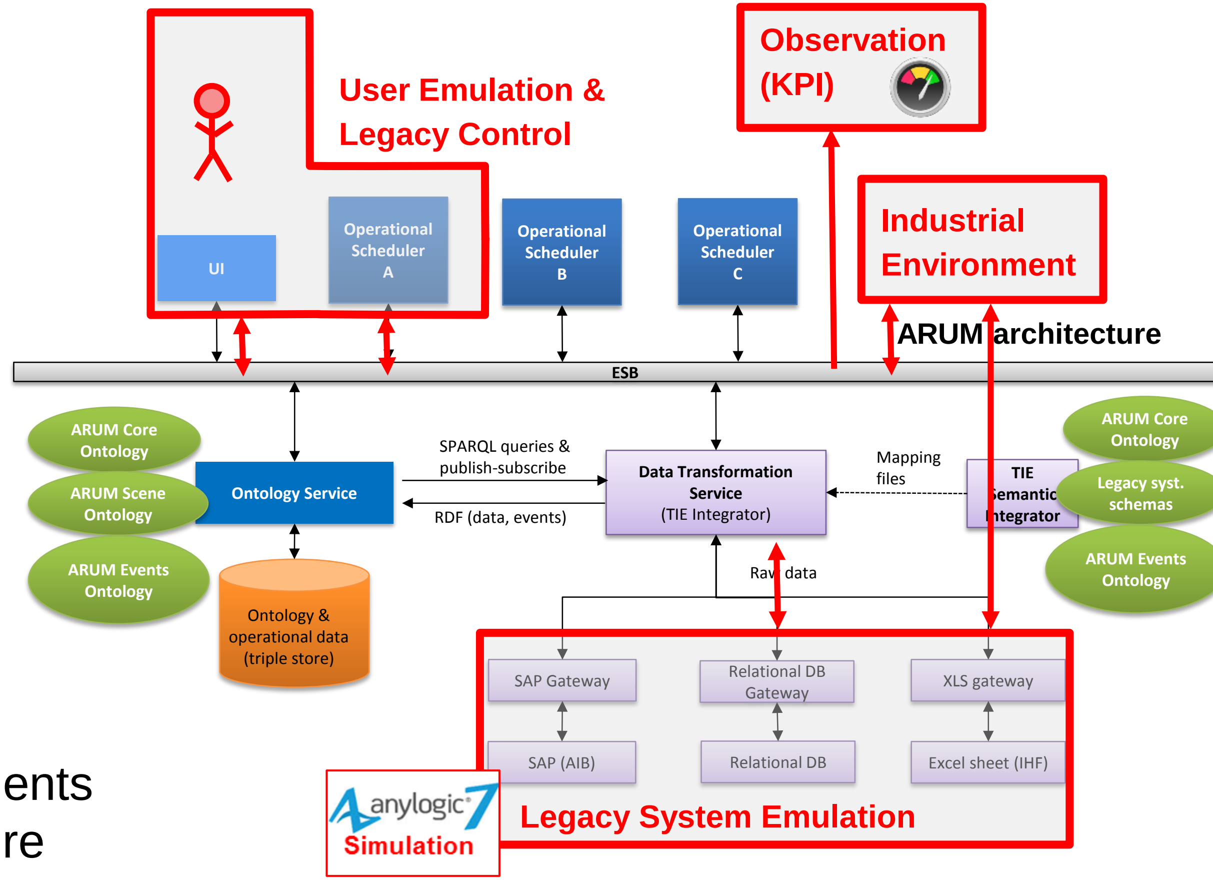
Introduction

Research Project - Adaptive Production Management (ARUM)

ARUM solution validation

- Validation of the ARUM results in a real industrial environment and benchmark against today’s solutions is mandatory
- Industrial use cases will be simulated with real industrial data and ARUM planning, scheduling and dispatch solutions
- Performance validation against classical planning, scheduling and dispatch approaches at Airbus

Living Lab for post-ARUM research
➔ simulation of artificial industrial environments fully integrated into the ARUM architecture



Validation of the ARUM developed control strategies against current industrial practices by simulation of the Airbus A350 production ramp-up.

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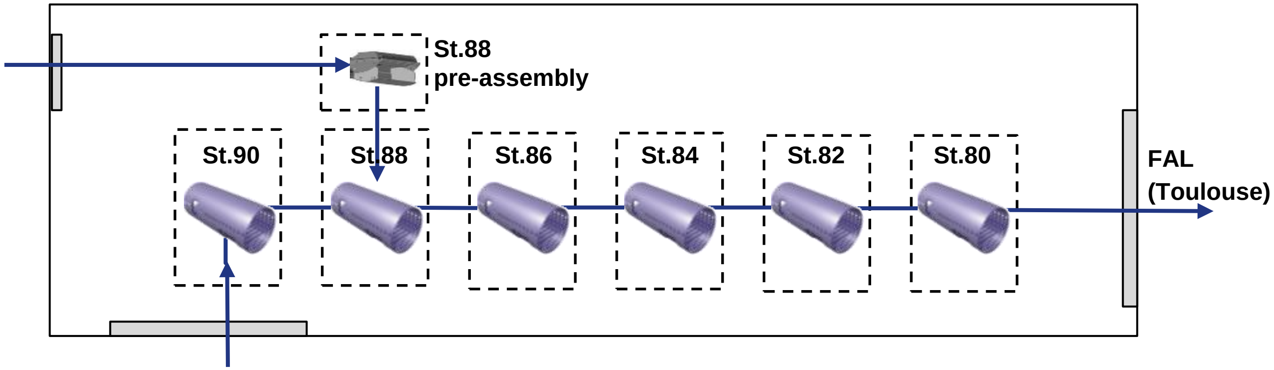
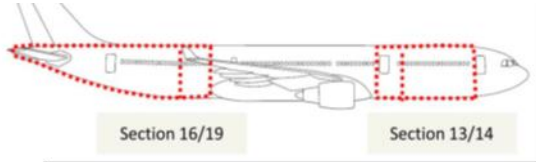
Use Case Details

Use case - A350 System Installation Flow Line

The use case #1 to be modeled and simulated in AnyLogic 7 is the production ramp-up of the Airbus A350 System Installation Flow Line in Hamburg.

A350 System Installation Flow Line





- Mixture of section 13 & 16 ➔ various complexity (>30% workload deviation)
- Up to 300 work orders / station, workload 8k – 25k IM / station
- Station wise allocation of 30-35 workers (mech., electr., QS)

Production Ramp-Up Characteristics

- Production output increase (0,5-3 a/c per month ➔ 10-13 a/c per month)
- Decreasing cycle time (1,5 weeks down to 1 day)
- Learning curve for work order duration / number of disturbances

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Use Case Details

Use case - A350 System Installation Flow Line

Disturbances

- Unbalanced workload & resource allocation (mixed-products, learning curve)
- Missing material / incompatibilities due to late changes
- Non-conformities / design changes

Control Strategies

- Line balancing: Cycle time adjustment / optimization
- Resource issues: Fix and variable assignment of workforce to stations
- Open work: “Stop-and-Fix” and “Traveling Work (flow line / beyond)”

Performance KPI

- Achieving the lead time / tardiness of deliveries to FAL
- Amount of traveling work (inside / out of the flow line)
- Resource utilization / balance across the flow line (labor, stations)

The use case shall validate the improved performance of control strategies and ARUM schedulers in relation to todays expert driven decision support.

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Modelling Approach

Requirements

Simulation shall allow experimentations with the new ARUM schedulers in place of the industrial environment at work order/task and station level.

Modelling & simulation

- Modelling the Airbus A350 Flow Line and the execution of the work plan down to task level including resource utilization (station, labor, material)
- Modelling the todays expert based control approach (work order-queue based) and different control strategies for disruptions (events)
- Model has to be readable for externals / easy to reuse without extensive documentation

Integration into ARUM architecture & test bed

- Support the integration of the simulation model into the ARUM architecture / test bed
  - update the scene (events from / response to legacy systems)
  - trigger the schedulers and receive updated work plans
- Visualization of the Flow Line simulation and of KPIs

Living Lab

- Run time version / executable for Living Lab

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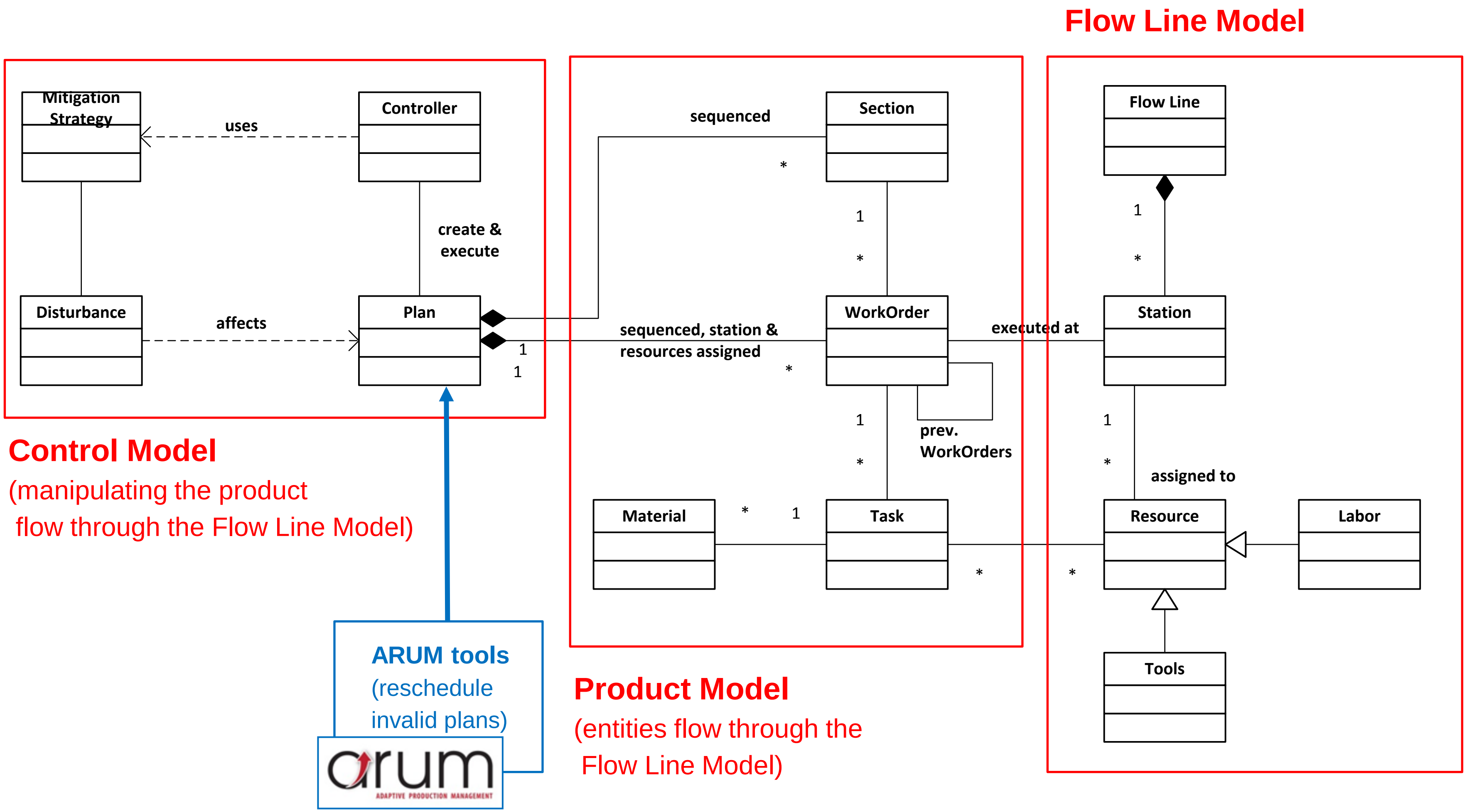
Modelling Approach

Model Elements

Domain model (simplified)



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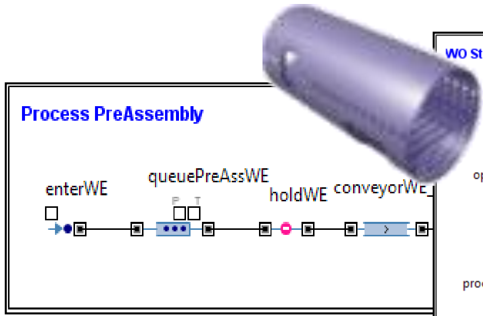
Modelling Approach

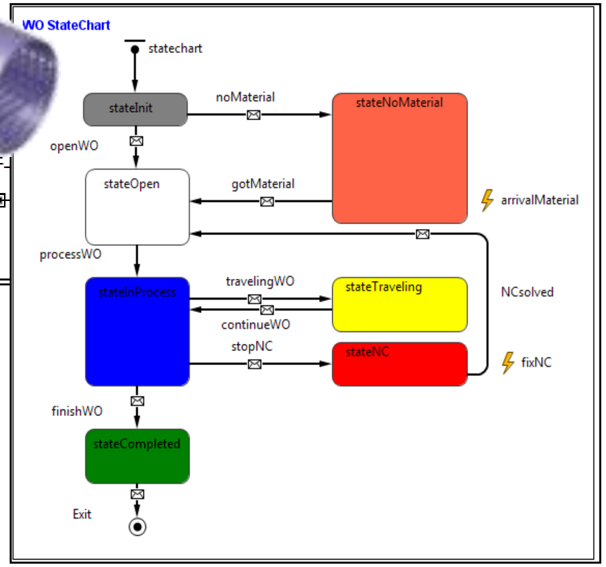
Model Elements & Dynamics

The section is compiled from work orders. The section is modelled as *Entity* flowing along the stations, were then the work orders & tasks are executed.

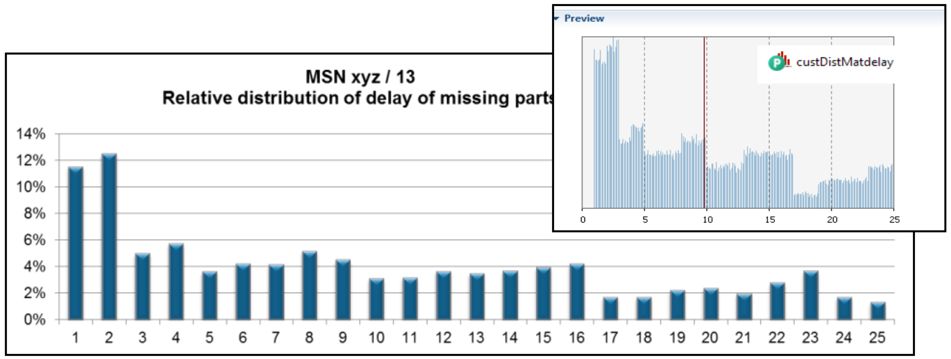
Product model

- Section, Work Orders and Tasks are modelled as agents (*aSection*, *aWorkOrder, aTask*)
  - ➔ State charts to describe the conditions
  - ➔ Recursive state model, the completion of the section is managed by completion of all work orders, etc.





- Processes like work order execution best to model via the Process Modelling Library
  - ➔ Sorted queues of entities (work order, tasks)
  - ➔ Delay / Service elements for resource allocation and time utilization (task duration)
  - ➔ Process parameters from statistical data (Material delay, NC delay, WO duration)



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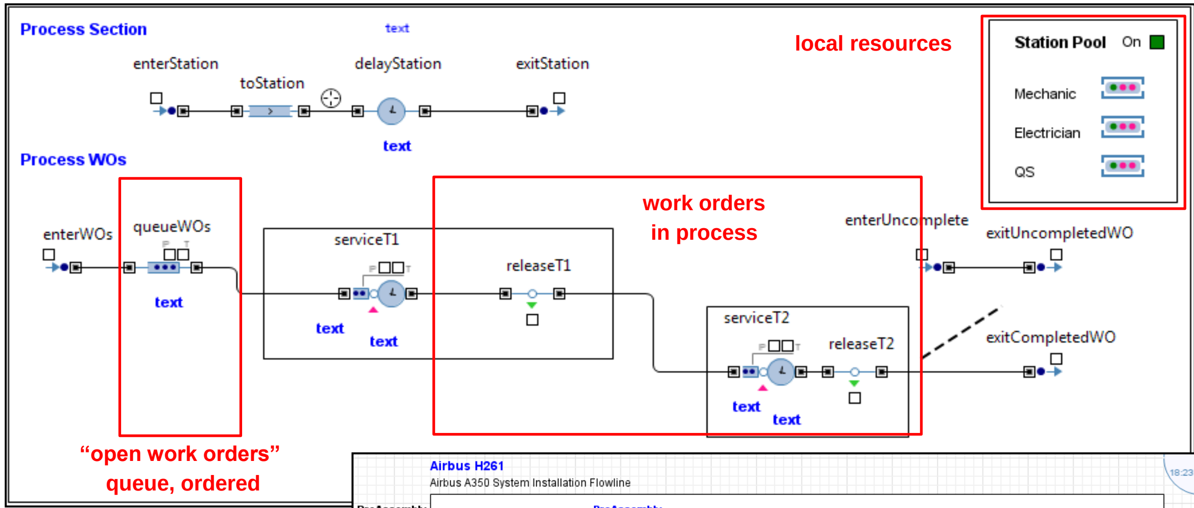
Modelling Approach

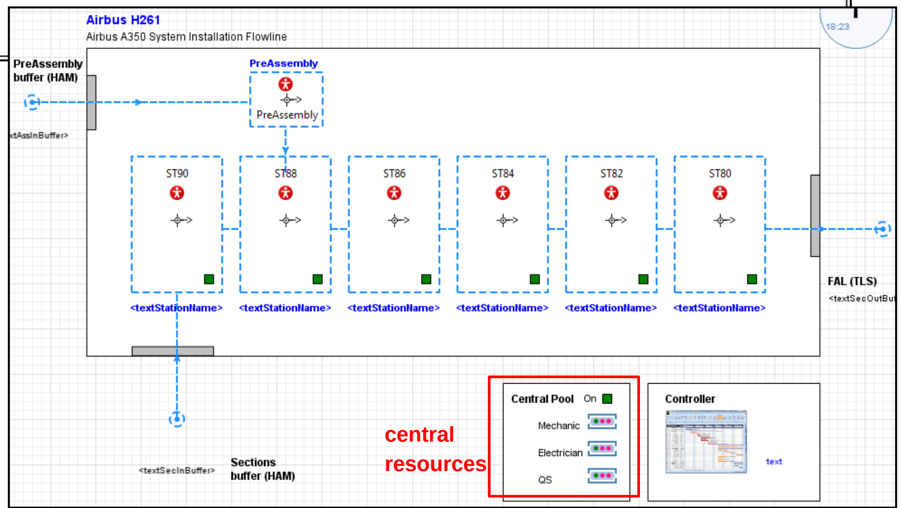
Model Elements & Dynamics

The flow line is built from stations, buffers and links. Central shop floor element is the station executing the work orders, providing resources, etc.

Flow Line model

- Station is modelled as an Agent (*aStation*)
- Execution of work orders of the section entered the station and the assignment of local resources are modelled using the process library
- Sequence of work is managed by queue order
- Flow Line is modelled as linked *aStation* instances, the entities (*aSection*) arriving at the IN-buffers will flow across the linked stations and will leave at the OUT-buffer to Toulouse, the *aController* instance is managing the execution the production plan





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arum ADAPTIVE PRODUCTION MANAGEMENT

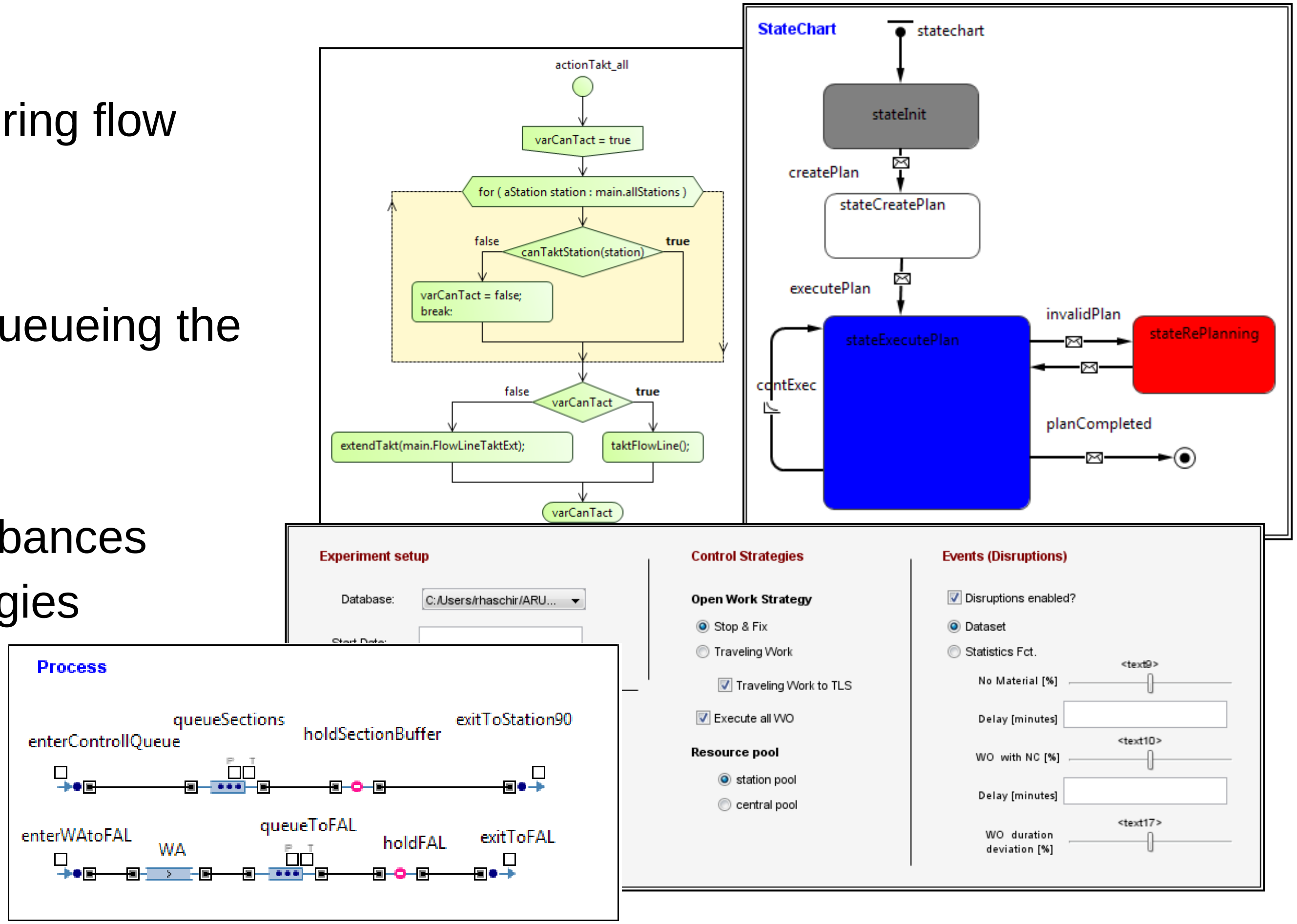
Modelling Approach

Model Elements & Dynamics

The control agent models the complex behavior of human controllers reacting on events with control strategies described in action charts.

Control model

- Dynamic control the manufacturing flow by the central *aControl* agent (takt sections, handle events)
- Sequencing the execution by queueing the work orders using priorities (e.g. “remaining time”)
- *aControl* agent to handle disturbances (events) using mitigation strategies modeled in action charts (e.g. takt station variants)



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First Results

Experimentation Results

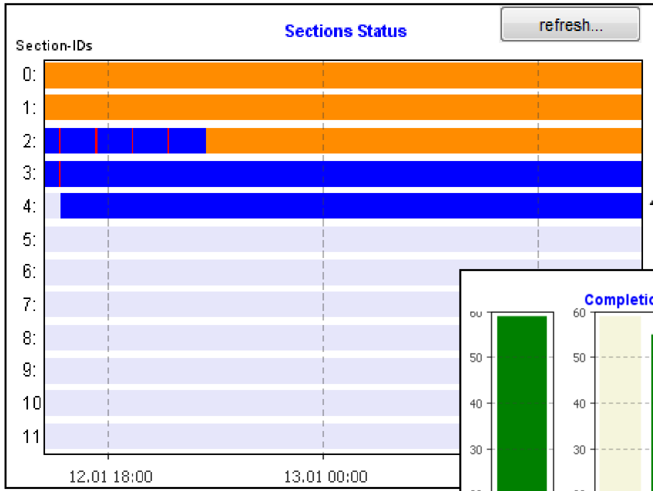
Actual model and experiments to study the suitability of AnyLogic 7 in modeling the Airbus legacy baseline behavior and impact for control strategies.

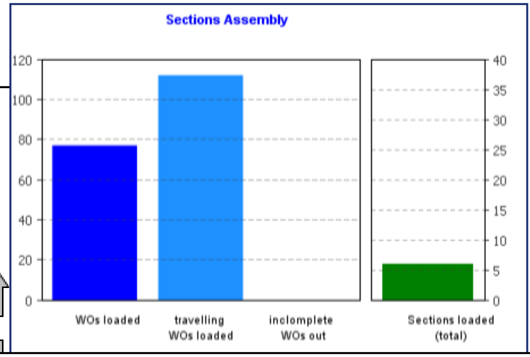
Experimentation

- Multiple scenarios along the ramp-up by different pre-planned data sets
- Multiple event sets of disturbances (based on previous programs, more extreme scenarios)
- Alternative strategies (“stop-and-fix”, “traveling work”)

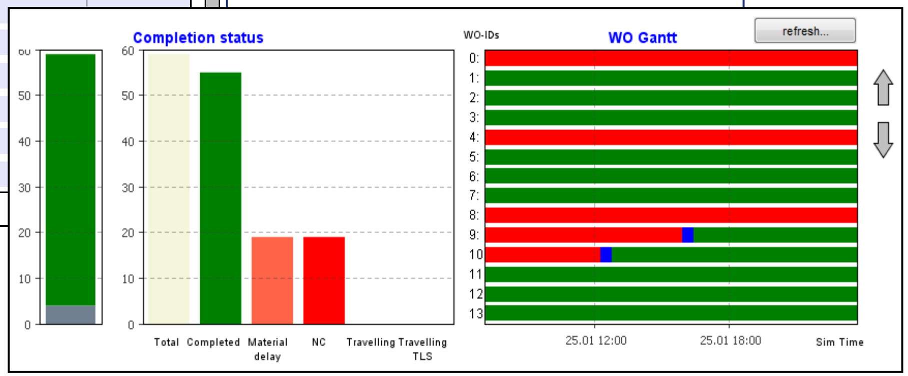
First Results

- Work order execution, amount of traveling work across the stations and to TLS, blocked cycles
- Station lead time deviation
- Resource utilization





Station Status



Section & work order completion

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Demonstration

ARUM UC#1 simulation model

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Conclusion

- Study has confirmed the suitability of AnyLogic 7 for the simulation based validation of the novel ARUM strategies
- AnyLogic 7 prime advantage is the multi-method approach allowing the combination of easy manufacturing process modelling and complex behavior modelling with agents
- Next steps are the integration of the simulation model with the ARUM test bed and with the ARUM schedulers
- The use of AnyLogic 7 as part of the Living Lab is under investigation

Combination of Agent based and Process based modelling and simulation and Java integration make AnyLogic 7 simulator to our favorite tool in ARUM.

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Thank you!

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