produce more, consume less

Testing results: Changeover Testing

Date: 28/11/2025

TECHNICAL TESTING RESULTS

Durning the final testing stages of EvoAPS, it was important to validate the results using different data models that replicated the different scheduling environments typically seen.

These included:

- Single-operation process
- Finite resource calendar patterns
- Multiple-operation processes (Operation 10, 20, 30 etc.)
- Secondary constraints
- Sequence-dependent changeovers
- Internal and external material dependencies
- Operational dependencies through a presented BoM (Bill of Materials)
- Resources that could process multiple operations at the same time (such as cooking or curing ovens and heat machines)

During the testing, rather than test each element independently, models were constructed that could reflect combinations of these points, so that real examples could be tested.

The same data models were constructed with varying numbers of operations so that the speed of achieving a result could also be tested.

Different strategies were tested in all models to see how different strategies affected the results and could be used to create a schedule.

Model tests were compared against Siemens Opcenter APS to give a benchmark. This was partly so we were able to validate the results easily, but mainly because Opcenter APS has a long history of creating very good scheduling results, making it an ideal benchmarking tool. We also have over 30 years of implementation experience with Opcenter APS and are able to utilise advanced scheduling logic to build what is referred to as a 'trained model'. A 'trained model' is where an implementor configures Opcenter APS scheduling during an implementation to achieve a specific desired result. This could be built up using multiple scheduling rules, but the logic would always be heuristic-based, and so no other result would be considered.

Models were tested against both due date order scheduling and advanced scheduling logic.

MODEL 1 – SEQUENCE DEPENDENT CHANGEOVERS

Demo model used for showing potential customers examples of how scheduling issues can be overcome.

Operation Count	Multiple Operation	Secondary Constraints	Sequence dependant changeovers	BoM dependencies	Material dependencies	Ovens
78	No	Yes	Yes	No	Yes	No

The model is designed to replicate scheduling at a fictitious factory. Orders are represented by single operations, and have a BoM attached but the material requirement doesn't impact the result as there is enough material to satisfy all the orders.

The model is setup as follows:

- 10 resources
- Secondary constrain maximum value of 45 people at any one time
- 16 hours working day, 5 days a week
- 29 different Part Codes
- Multiple routing options for each operation
- Variable labour per each operation
- Sequence dependent changeovers based on product attribute
- All orders have the same due date

The model is designed that there is no way that everything can be done without something being late if the secondary constrain isn't broken by both Opcenter and Evo.

RESULTS COMMENTS

Several distinct heuristic scheduling methods were applied to the data, drawing on established solutions for this type of challenge. Additionally, various internal strategies within EvoAPS were tested to identify the most effective approach for solving the problem. EvoAPS delivered exceptionally strong results, surpassing all heuristic-based methods.

After analysing the outcomes, it seems improbable that a conventional heuristic scheduling technique could have been devised to organise operations in such a way and achieve this level of success.

RESULTS FROM BASE LINE TEST - SCHEDULE BY DUE DATE

	Baseline test	EvoAPS		
Schedule Creation method	Due Date	All Factors	Difference	Improvement
Schedule Start	31/03/2025 06:00	31/03/2025 06:00	-	-
Schedule End	07/04/2025 17:49	07/04/2025 10:53	6 h 54 mins	Yes
Make Span	7 days 11 h 49 mins	7 days 4 h 53 mins	6 h 54 mins	Yes
Total Operations	78	78	-	-
Late Operations	11	5	-6	No
Late Orders	11	5	-6	Yes
Total Setup Time	1 day 3 h 30 mins	7 h 0 mins	20 h 00 Mins	Yes

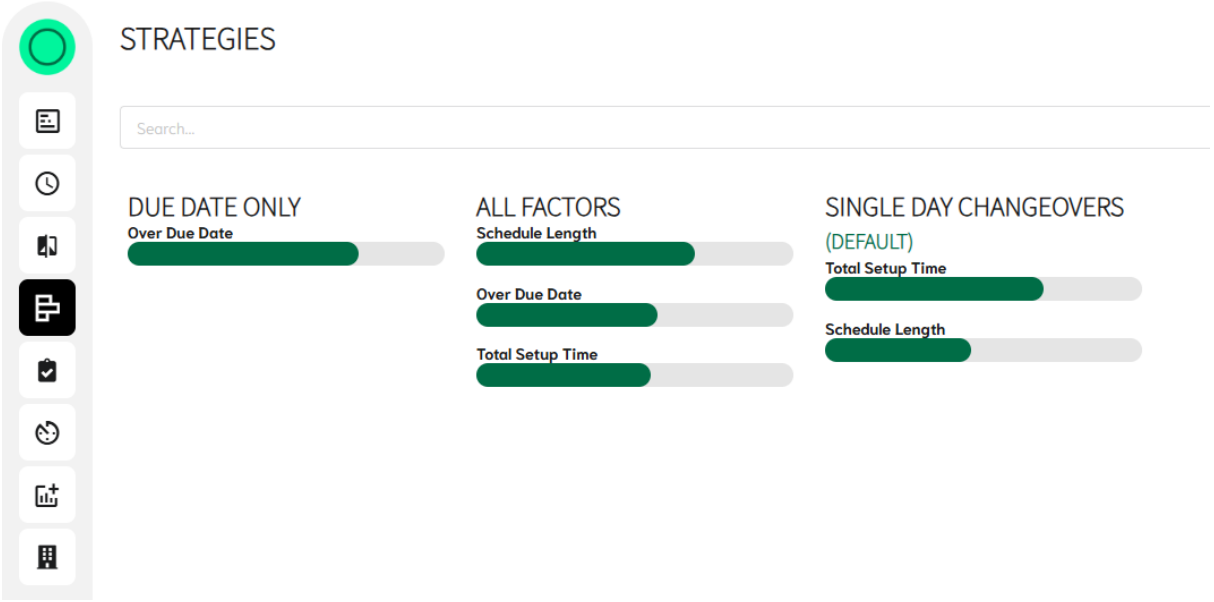
RESULTS FROM THE ADVANCE SCHEDULING LOGIC

	Opcenter APS	EvoAPS		
Schedule Creation method	Advanced logic	All Factors	Difference	Improvement
Schedule Start	31/03/2025 06:00	31/03/2025 06:00	-	-
Schedule End	08/04/2025 12:09	07/04/2025 10:53	1 day 1 h 16 mins	Yes
Make Span	8 days 6 h 9 mins	7 days 4 h 53 mins	1 day 1 h 16 mins	Yes
Total Operations	78	78	-	-
Late Operations	14	5	-9	Yes
Late Orders	14	5	-9	Yes
Total Setup Time	10 h 45 mins	7 h 0 mins	3 h 45 mins	Yes

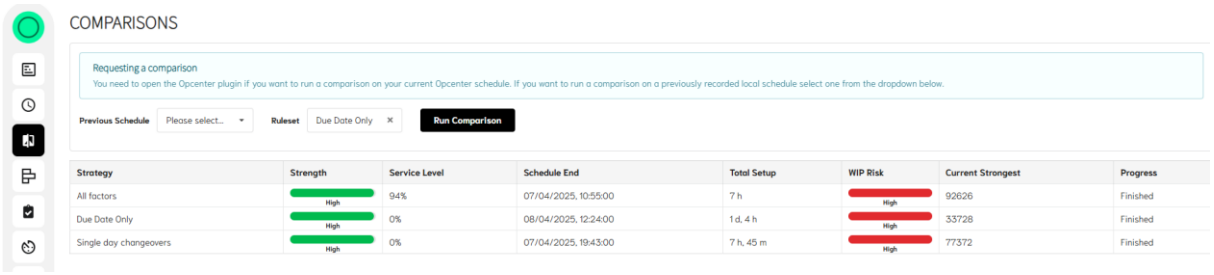
As we can see improvements were made against both the baseline test and the advance scheduling logic in all aspects. It is also worth noting that the advance logic was only specified to reduce the setup time and the impact of doing this is that more orders were late even though the setup time was reduced,

TESTING PROCESS

The process of testing in EvoAPS is simply done by building a strategy and running a set of data against this. In this case a few different approaches were used.



Two additional strategies were created, Due Date Only and All factors. The strategies were both only run once (100,000 generations each). These can be run concurrently to keep testing time to a minimum.



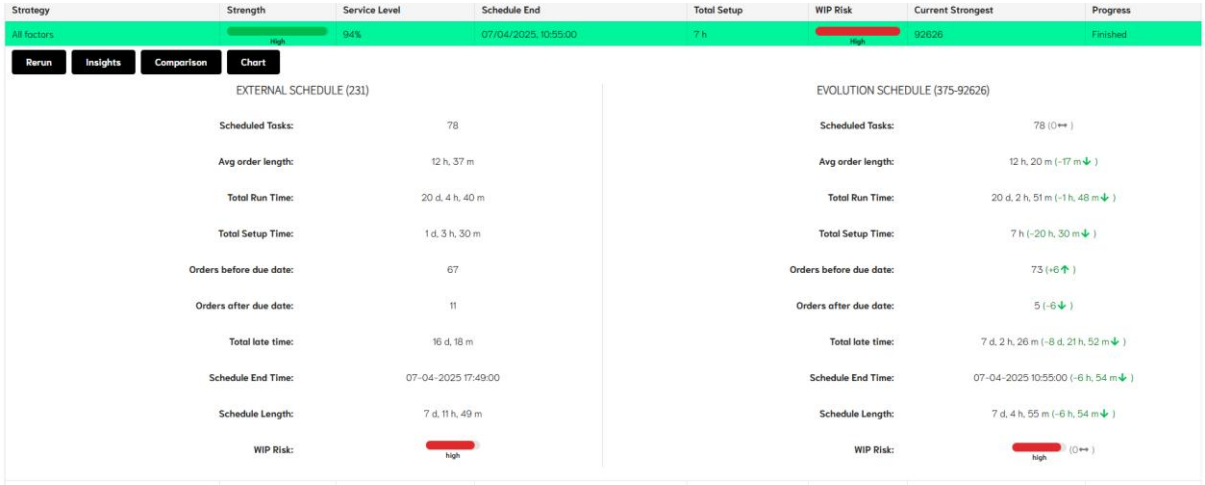
The 2 strategies above took on average around 34 minutes run. Each strategy ran for 100,000 generations creating an average of 2,900 different schedules per minute.

VIEWING RESULTS IN EVOAPS

The differences between the two schedules can be viewed using the ‘Comparison’ feature.

The comparison shows a schedule that is currently in place in the system—displayed in the left-hand column (in this case, Opcenter APS)—alongside the results from EvoAPS in the column on the right.

The differences between the two schedules are shown in brackets, with green highlighting an improvement and red showing a negative change.

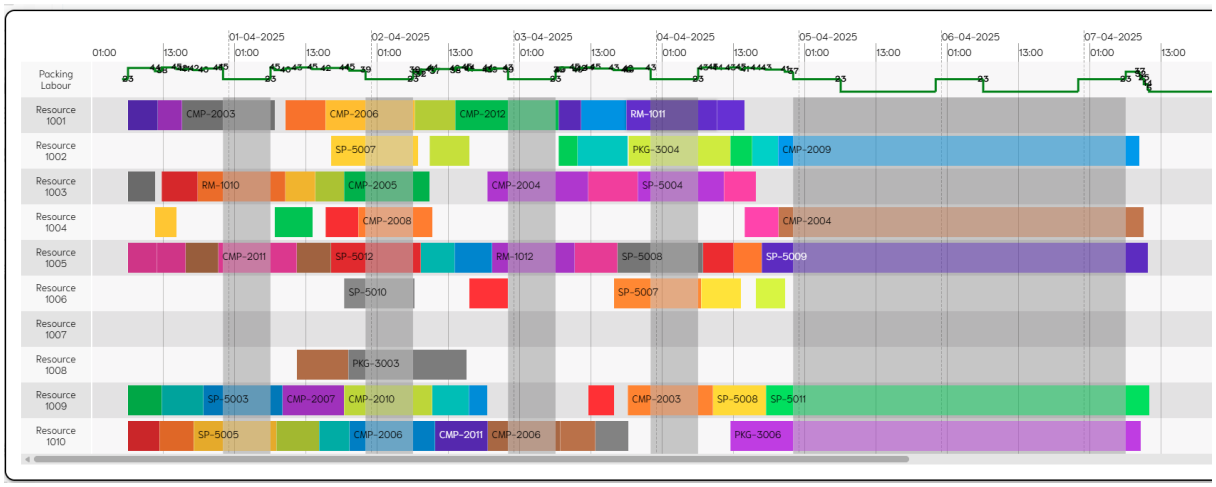


Strategy	Strength	Service Level	Schedule End	Total Setup	WIP Risk	Current Strongest	Progress
All factors	High	94%	07/04/2025, 10:55:00	7 h	High	92626	Finished

Rerun | Insights | Comparison | Chart

	EXTERNAL SCHEDULE (231)	EVOLUTION SCHEDULE (375-92626)
Scheduled Tasks:	78	78 (0↔)
Avg order length:	12 h, 37 m	12 h, 20 m (-17 m↓)
Total Run Time:	20 d, 4 h, 40 m	20 d, 2 h, 51 m (-1 h, 48 m↓)
Total Setup Time:	1 d, 3 h, 30 m	7 h (-20 h, 30 m↓)
Orders before due date:	67	73 (+6↑)
Orders after due date:	11	5 (-6↓)
Total late time:	16 d, 18 m	7 d, 2 h, 26 m (-8 d, 21 h, 52 m↓)
Schedule End Time:	07-04-2025 17:49:00	07-04-2025 10:55:00 (-6 h, 54 m↓)
Schedule Length:	7 d, 11 h, 49 m	7 d, 4 h, 55 m (-6 h, 54 m↓)
WIP Risk:	high	high (0↔)

A simple ‘read only’ Gantt chart is also available for viewing the final schedule.



The generation history showing when and how improvements in the overall schedule are achieved, can be viewed in EvoAPS. This allows any improvements found by the evolutionary algorithm can be viewed and the strategies and their impact on results to be more easily understood.

As the number of completed schedules increases, and the improvements made, these can be seen visually on the Generation History graph below. The graph shows each element of the strategy represented along the generation timeline and indicates when a change to that element occurs. Combined, these elements make up the overall fitness result of the schedule.

More detail on each generation is available in both a Gantt chart and tabular format by selecting the ‘Show Generation History’ button. The user can scroll between the generations and see the chart and the table update in line with each change.

Are you ready to re-think scheduling?