

# Production Planning Case Study

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Constraint Based Production Scheduling

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## Key Points

- Case study from industry
- Production planning and detailed scheduling
- Based on project with medical devices company in Cork
  - Real problem
  - Realistic data
- Solved in two stages
  - Production planning based on run-out days and safety stock levels
  - Scheduling using our generic scheduling tool

## Problem

This is a case study from industry, combining production planning and detailed scheduling. It is based on a project that some of my colleagues were working on for a local medical devices company.

The overall problem is to decide which products to make in which quantities over the planning horizon, so that we have enough stock to satisfy any customer demand, and make sure that we have some safety margin if the demand suddenly increases. At the same time we do not want to create inventory in products that we will not sell in the near future, as this increases our inventory carrying cost.

The company uses two main concepts for production planning: The run-out days for each product state how long the current stock will last, given a projected customer demand profile. We try to achieve the same run-out days value for all products, this works well for fast and slow moving products.

The safety stock values says how much stock we should have for each product. This gives us more control over the stock levels, this works better if the demand cannot be predicted as accurately as we would like, but it is more difficult to compare the stock levels for different products.

The production planning part of the application decides how much to produce for which product, but this is based on an estimate of the production capacity for the planning period. We use the detailed scheduling part of the application to validate the plan generated, and make sure that we can really produce the required capacities in the given planning period.

## Product List

Name	ShortName	Nr	DailySales	InventoryAtStart	CalcDaysCover	LotSize	CycleTime	LotDuration	Machine	ProductType	SafetyStock	SafetyAlert
P1	P1	1	3.20	877	274.06	163	1.33	217	8	pt1	66	253.44
P2	P2	2	11.40	1,011	88.68	240	1.20	288	8	pt2	774	20.79
P3	P3	3	796.20	26,204	32.91	420	2.10	882	5,7,9,10,13,14,16	pt3	12,108	17.70
P4	P4	4	233.80	7,877	33.69	420	2.00	840	5,7,9,10,13,14,16	pt4	3,358	19.33
P5	P5	5	267.30	7,152	26.76	350	2.30	805	5,7,9,10,13,14,16	pt5	3,906	12.14
P6	P6	6	606.20	18,654	30.77	350	2.30	805	5,7,9,10,13,14,16	pt6	9,293	15.44
P7	P7	7	137.30	4,939	35.97	420	2.00	840	5,7,9,10,13,14,16	pt7	1,979	21.56
P8	P8	8	88.30	3,152	35.70	350	2.30	805	5,7,9,10,13,14,16	pt8	1,342	20.50
P9	P9	9	77.20	2,688	34.82	420	2.10	882	5,7,9,10,13,14,16	pt9	1,082	20.80
P10	P10	10	165.60	5,971	36.06	420	2.10	882	5,7,9,10,13,14,16	pt10	2,649	20.06
P11	P11	11	60.70	2,310	38.06	420	2.10	882	5,7,9,10,13,14,16	pt11	877	23.61
P12	P12	12	51.80	1,928	37.22	350	2.30	805	5,7,9,10,13,14,16	pt12	883	20.17
P13	P13	13	79.00	2,231	28.24	320	2.30	736	5,7,9,10,13,14,16	pt13	1,193	13.14
P14	P14	14	271.20	8,951	33.01	432	2.10	908	5,7,9,10,13,14,16	pt14	3,732	19.24
P15	P15	15	86.60	3,244	37.46	336	2.00	672	5,7,9,10,13,14,16	pt15	1,454	20.67
P16	P16	16	42.40	2,110	49.76	420	2.10	882	5,7,9,10,13,14,16	pt16	875	29.13
P17	P17	17	17.60	681	38.69	420	2.00	840	5,7,9,10,13,14,16	pt17	290	22.22
P18	P18	18	217.50	5,710	26.25	336	2.00	672	5,7,9,10,13,14,16	pt18	2,814	13.31
P19	P19	19	56.30	2,450	43.52	420	2.00	840	5,7,9,10,13,14,16	pt19	804	29.24
P20	P20	20	13.60	506	37.21	480	2.00	960	5,7,9,10,13,14,16	pt20	272	17.21
P21	P21	21	10.80	977	90.46	360	2.10	756	5,7,9,10,13,14,16	pt21	293	63.33
P22	P22	22	21.80	1,538	70.55	420	2.00	840	5,7,9,10,13,14,16	pt22	349	54.54
P23	P23	23	189.10	5,195	27.47	360	2.30	828	5,7,9,10,13,14,16	pt23	2,941	11.92
P24	P24	24	9.50	886	93.26	350	2.30	805	5,7,9,10,13,14,16	pt24	191	73.16
P25	P25	25	7.50	326	43.47	120	2.30	276	5,7,9,10,13,14,16	pt25	210	15.47
P26	P26	26	11.60	418	36.03	360	2.10	756	5,7,9,10,13,14,16	pt26	187	19.91
P27	P27	27	16.50	1,388	84.12	480	2.10	1,008	5,7,9,10,13,14,16	pt27	218	70.91

## Product List (Sorted by Daily Sales)

Product X												
Name	ShortName	Nr	DailySales*	InventoryAtStart	CalcDaysCover	LotSize	CycleTime	LotDuration	Machine	ProductType	SafetyStock	SafetyAlert
P3	P3	3	796.20	26,204	32.91	420	2.10	882	5,7,9,10,13,14,16	pt3	12,108	17.70
P6	P6	6	606.20	18,654	30.77	350	2.30	805	5,7,9,10,13,14,16	pt6	9,293	15.44
P14	P14	14	271.20	8,951	33.01	432	2.10	908	5,7,9,10,13,14,16	pt14	3,732	19.24
P53	P53	53	267.70	8,264	30.87	504	1.20	605	1,2,3,8	pt2	3,734	16.92
P5	P5	5	267.30	7,152	26.76	350	2.30	805	5,7,9,10,13,14,16	pt5	3,906	12.14
P124	P124	124	242.70	16,503	68.00	240	5.00	1,200	15,18,19	pt65	3,595	53.19
P4	P4	4	233.80	7,877	33.69	420	2.00	840	5,7,9,10,13,14,16	pt4	3,358	19.33
P123	P123	123	223.40	7,600	34.02	490	2.33	1,142	1,2,3,8	pt51	3,738	17.29
P18	P18	18	217.50	5,710	26.25	336	2.00	672	5,7,9,10,13,14,16	pt18	2,814	13.31
P23	P23	23	189.10	5,195	27.47	360	2.30	828	5,7,9,10,13,14,16	pt23	2,941	11.92
P56	P56	56	168.20	4,824	28.68	504	1.20	605	1,2,3,8	pt2	2,660	12.87
P10	P10	10	165.60	5,971	36.06	420	2.10	882	5,7,9,10,13,14,16	pt10	2,649	20.06
P59	P59	59	152.80	5,666	37.08	420	1.33	559	1,2,3,8	pt51	3,095	16.83
P7	P7	7	137.30	4,939	35.97	420	2.00	840	5,7,9,10,13,14,16	pt7	1,979	21.56
P57	P57	57	134.80	5,358	39.75	588	1.10	647	1,2,3,8	pt53	2,294	22.73
P36	P36	36	133.50	3,895	29.18	336	2.00	672	5,7,9,10,13,14,16	pt36	2,057	13.77
P54	P54	54	122.40	5,059	41.33	480	1.33	639	1,2,3,8	pt51	1,965	25.28
P121	P121	121	98.10	4,334	44.18	588	1.10	647	1,2,3,8	pt53	1,524	28.64
P8	P8	8	88.30	3,152	35.70	350	2.30	805	5,7,9,10,13,14,16	pt8	1,342	20.50
P125	P125	125	86.90	8,593	98.88	240	5.00	1,200	15,18,19	pt65	1,022	87.12
P15	P15	15	86.60	3,244	37.46	336	2.00	672	5,7,9,10,13,14,16	pt15	1,454	20.67
P100	P100	100	85.20	2,665	31.28	420	1.33	559	1,2,3,8	pt56	1,115	18.19
P55	P55	55	79.50	2,876	36.18	441	2.33	1,028	1,2,3,8	pt52	1,367	18.98
P13	P13	13	79.00	2,231	28.24	320	2.30	736	5,7,9,10,13,14,16	pt13	1,193	13.14
P9	P9	9	77.20	2,688	34.82	420	2.10	882	5,7,9,10,13,14,16	pt9	1,082	20.80
P47	P47	47	74.60	5,391	72.27	160	6.84	1,095	2,11	pt47	1,132	57.09
P11	P11	11	60.70	2,310	38.06	420	2.10	882	5,7,9,10,13,14,16	pt11	877	23.61
P61	P61	61	60.30	2,758	45.74	490	1.33	652	1,2,3,8	pt56	1,073	27.94
P78	P78	78	57.60	2,234	38.78	588	1.10	647	1,2,3,8	pt59	824	24.48
P19	P19	19	56.30	2,450	43.52	420	2.00	840	5,7,9,10,13,14,16	pt19	804	29.24

## Product List (Sorted by Days Cover)

Product X												
Name	ShortName	Nr	DailySales	InventoryAtStart	CalcDaysCover▲	LotSize	CycleTime	LotDuration	Machine	ProductType	SafetyStock	SafetyAlert
P35	P35	35	1.30	26	20.00	120	2.30	276	5,7,9,10,13,14,16	pt35	33	0.00
P18	P18	18	217.50	5,710	26.25	336	2.00	672	5,7,9,10,13,14,16	pt18	2,814	13.31
P5	P5	5	267.30	7,152	26.76	350	2.30	805	5,7,9,10,13,14,16	pt5	3,906	12.14
P23	P23	23	189.10	5,195	27.47	360	2.30	828	5,7,9,10,13,14,16	pt23	2,941	11.92
P13	P13	13	79.00	2,231	28.24	320	2.30	736	5,7,9,10,13,14,16	pt13	1,193	13.14
P56	P56	56	168.20	4,824	28.68	504	1.20	605	1,2,3,8	pt2	2,660	12.87
P58	P58	58	55.00	1,590	28.91	420	2.33	979	1,2,3,8	pt54	1,208	6.95
P36	P36	36	133.50	3,895	29.18	336	2.00	672	5,7,9,10,13,14,16	pt36	2,057	13.77
P6	P6	6	606.20	18,654	30.77	350	2.30	805	5,7,9,10,13,14,16	pt6	9,293	15.44
P53	P53	53	267.70	8,264	30.87	504	1.20	605	1,2,3,8	pt2	3,734	16.92
P100	P100	100	85.20	2,665	31.28	420	1.33	559	1,2,3,8	pt56	1,115	18.19
P122	P122	122	45.40	1,421	31.30	490	1.33	652	1,2,3,8	pt56	725	15.33
P3	P3	3	796.20	26,204	32.91	420	2.10	882	5,7,9,10,13,14,16	pt3	12,108	17.70
P14	P14	14	271.20	8,951	33.01	432	2.10	908	5,7,9,10,13,14,16	pt14	3,732	19.24
P4	P4	4	233.80	7,877	33.69	420	2.00	840	5,7,9,10,13,14,16	pt4	3,358	19.33
P123	P123	123	223.40	7,600	34.02	490	2.33	1,142	1,2,3,8	pt51	3,738	17.29
P77	P77	77	33.00	1,146	34.73	336	1.20	404	1,2,3,8	pt61	565	17.61
P9	P9	9	77.20	2,688	34.82	420	2.10	882	5,7,9,10,13,14,16	pt9	1,082	20.80
P8	P8	8	88.30	3,152	35.70	350	2.30	805	5,7,9,10,13,14,16	pt8	1,342	20.50
P7	P7	7	137.30	4,939	35.97	420	2.00	840	5,7,9,10,13,14,16	pt7	1,979	21.56
P26	P26	26	11.60	418	36.03	360	2.10	756	5,7,9,10,13,14,16	pt26	187	19.91
P10	P10	10	165.60	5,971	36.06	420	2.10	882	5,7,9,10,13,14,16	pt10	2,649	20.06
P55	P55	55	79.50	2,876	36.18	441	2.33	1,028	1,2,3,8	pt52	1,367	18.98
P63	P63	63	42.40	1,565	36.91	490	1.33	652	1,2,3,8	pt51	689	20.66
P59	P59	59	152.80	5,666	37.08	420	1.33	559	1,2,3,8	pt51	3,095	16.83
P20	P20	20	13.60	506	37.21	480	2.00	960	5,7,9,10,13,14,16	pt20	272	17.21
P12	P12	12	51.80	1,928	37.22	350	2.30	805	5,7,9,10,13,14,16	pt12	883	20.17
P44	P44	44	5.50	205	37.27	360	2.10	756	5,7,9,10,13,14,16	pt44	126	14.36
P15	P15	15	86.60	3,244	37.46	336	2.00	672	5,7,9,10,13,14,16	pt15	1,454	20.67

## Product List (Sorted by Safety Alert)

Product X												
Name	ShortName	Nr	DailySales	InventoryAtStart	CalcDaysCover	LotSize	CycleTime	LotDuration	Machine	ProductType	SafetyStock	SafetyAL...
P35	P35	35	1.30	26	20.00	120	2.30	276	5,7,9,10,13,14,16	pt35	33	0.00
P51	P51	51	5.70	405	71.05	140	4.50	630	2	pt50	381	4.21
P58	P58	58	55.00	1,590	28.91	420	2.33	979	1,2,3,8	pt54	1,208	6.95
P82	P82	82	6.10	259	42.46	441	1.33	587	1,2,3,8	pt51	189	11.48
P23	P23	23	189.10	5,195	27.47	360	2.30	828	5,7,9,10,13,14,16	pt23	2,941	11.92
P5	P5	5	267.30	7,152	26.76	350	2.30	805	5,7,9,10,13,14,16	pt5	3,906	12.14
P56	P56	56	168.20	4,824	28.68	504	1.20	605	1,2,3,8	pt2	2,660	12.87
P13	P13	13	79.00	2,231	28.24	320	2.30	736	5,7,9,10,13,14,16	pt13	1,193	13.14
P18	P18	18	217.50	5,710	26.25	336	2.00	672	5,7,9,10,13,14,16	pt18	2,814	13.31
P36	P36	36	133.50	3,895	29.18	336	2.00	672	5,7,9,10,13,14,16	pt36	2,057	13.77
P44	P44	44	5.50	205	37.27	360	2.10	756	5,7,9,10,13,14,16	pt44	126	14.36
P122	P122	122	45.40	1,421	31.30	490	1.33	652	1,2,3,8	pt56	725	15.33
P6	P6	6	606.20	18,654	30.77	350	2.30	805	5,7,9,10,13,14,16	pt6	9,293	15.44
P25	P25	25	7.50	326	43.47	120	2.30	276	5,7,9,10,13,14,16	pt25	210	15.47
P59	P59	59	152.80	5,666	37.08	420	1.33	559	1,2,3,8	pt51	3,095	16.83
P53	P53	53	267.70	8,264	30.87	504	1.20	605	1,2,3,8	pt2	3,734	16.92
P112	P112	112	3.40	134	39.41	588	1.20	706	1,2,3,8	pt2	76	17.06
P20	P20	20	13.60	506	37.21	480	2.00	960	5,7,9,10,13,14,16	pt20	272	17.21
P32	P32	32	5.40	222	41.11	480	2.00	960	5,7,9,10,13,14,16	pt32	129	17.22
P123	P123	123	223.40	7,600	34.02	490	2.33	1,142	1,2,3,8	pt51	3,738	17.29
P99	P99	99	5.70	247	43.33	96	2.00	192	1,2,3,8	pt60	148	17.37
P77	P77	77	33.00	1,146	34.73	336	1.20	404	1,2,3,8	pt61	565	17.61
P3	P3	3	796.20	26,204	32.91	420	2.10	882	5,7,9,10,13,14,16	pt3	12,108	17.70
P100	P100	100	85.20	2,665	31.28	420	1.33	559	1,2,3,8	pt56	1,115	18.19
P55	P55	55	79.50	2,876	36.18	441	2.33	1,028	1,2,3,8	pt52	1,367	18.98
P14	P14	14	271.20	8,951	33.01	432	2.10	908	5,7,9,10,13,14,16	pt14	3,732	19.24
P80	P80	80	7.20	293	40.69	420	1.33	559	1,2,3,8	pt51	154	19.31
P4	P4	4	233.80	7,877	33.69	420	2.00	840	5,7,9,10,13,14,16	pt4	3,358	19.33
P49	P49	49	50.90	2,273	44.66	378	1.00	378	2	pt48	1,260	19.90

## Setup Matrix

[illegible]

## Running the Planning Solver

Planning Solver Parameters

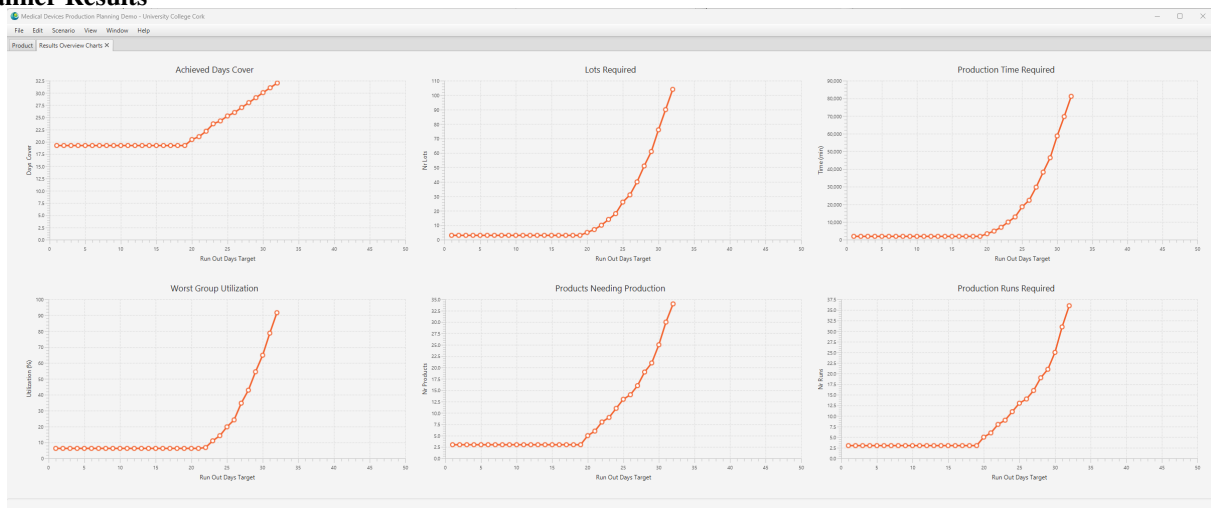
Label:

Horizon Days:

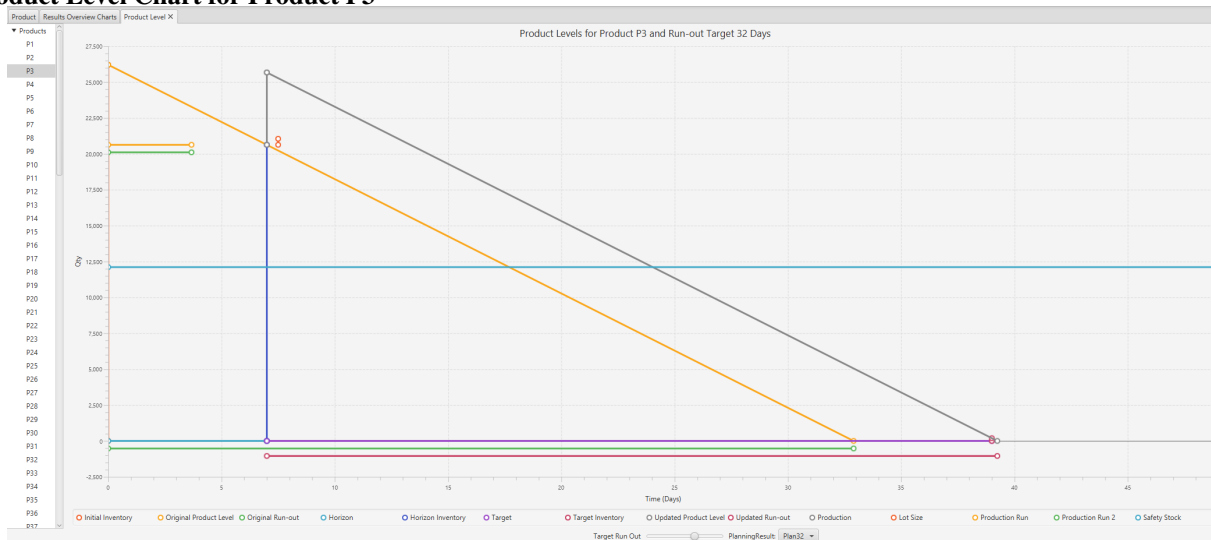
Target Max Days:

Balancing Strategy:

## Planner Results

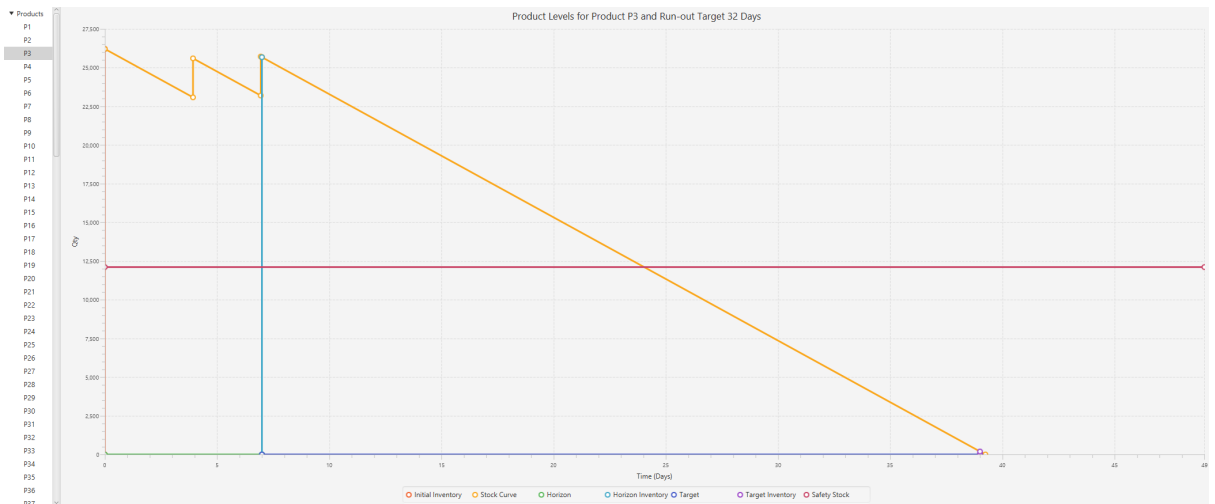


## Product Level Chart for Product P3

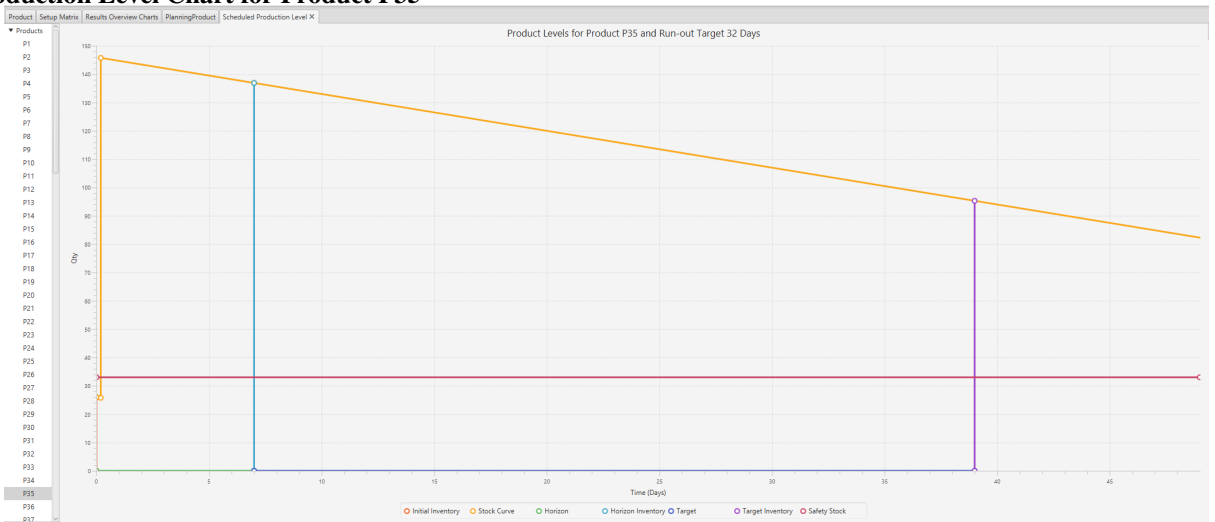


## Product Level Chart for Product P35

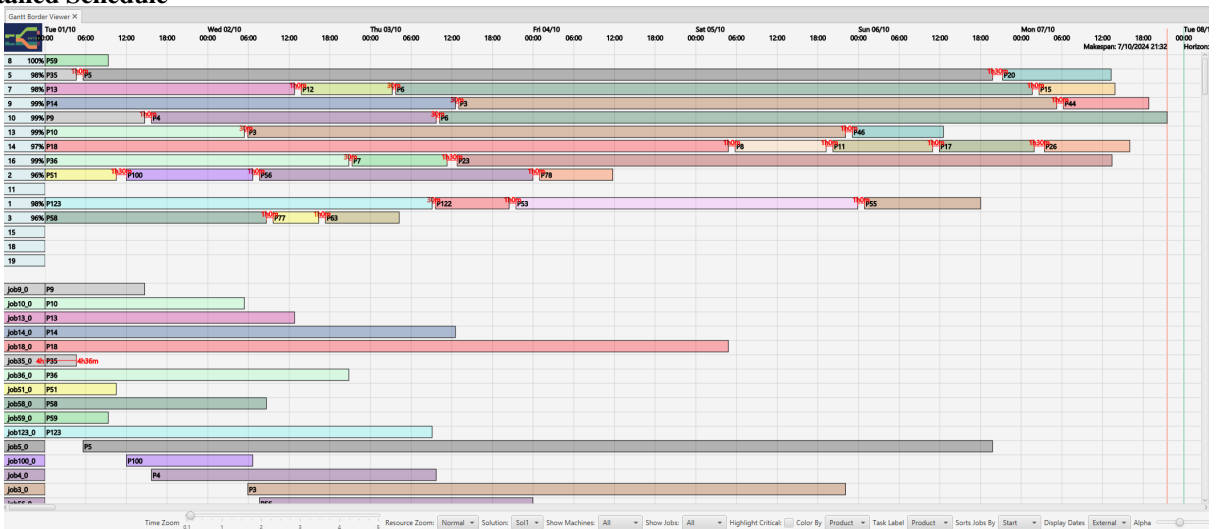




## Production Level Chart for Product P35

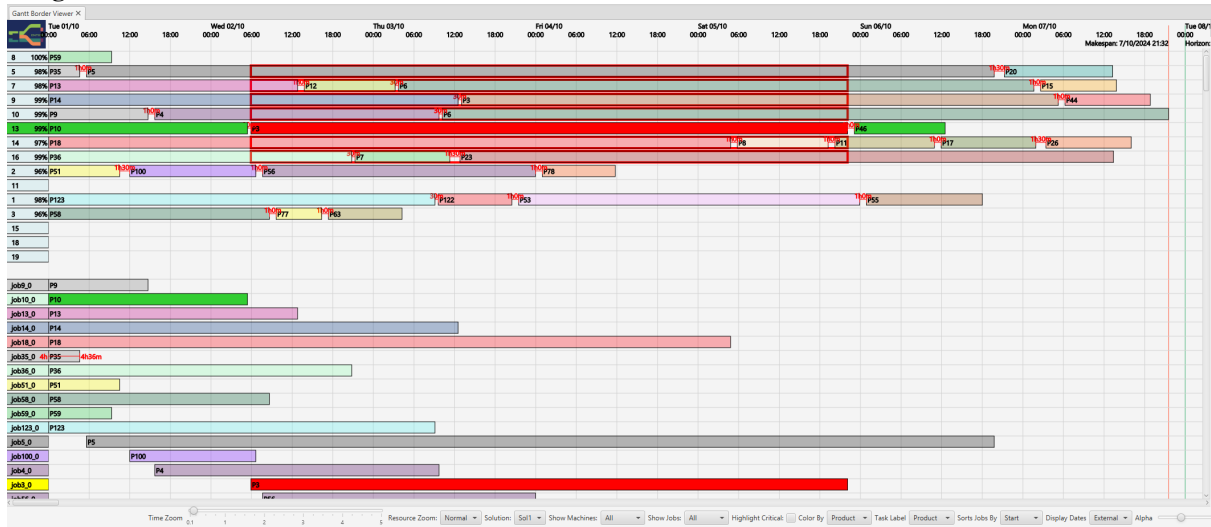


## Detailed Schedule





## Showing Alternative Machines in Gantt Chart



## Summary

- We demonstrated the use of our scheduling tool inside a production planning problem from industry
- Production planning decides which products to make in which quantity
  - Balance stock levels against projected demand
  - Allow for product specific safety stock levels
- Uses estimate of production capacity over planning horizon
- Use detailed scheduling to validate plan