

IFPAC 2015

Pharmaceutical Production Optimization

Rob Richards, Ph.D.

Stottler Henke Associates, Inc.

QbD

Quality by Design

IFPAC

Process Analytical Technology

QbD

Quality by Design

...first name in PAT

...the essential place for PAT

IFPAC® Annual Meeting, Jan. 25 - Jan. 28, 2015, Arlington, VA (Washington DC), U.S.A

Stottler Henke

Smarter Software Solutions

Intelligent Scheduling Application to Production / Packaging Optimization



Goals

- Maximize Throughput (primary)
- Minimize Changeover (secondary)
- Establish even production from cycle to cycle



Input & Output

Input data

Data per SKU

Minimum order frequency
Forecast next 12 months
Blister per pack
Demand last 12 months
Product value
Capsules per blister
Carrying costs
Dosage

Data per machine

Man-hours per changeover
Machines types
Downtime per changeover
Throughput
Capacity
Ramp-up loss

General data

Min Max Order Frequency
Demand Forecast Mix
Cost per manhour



Output

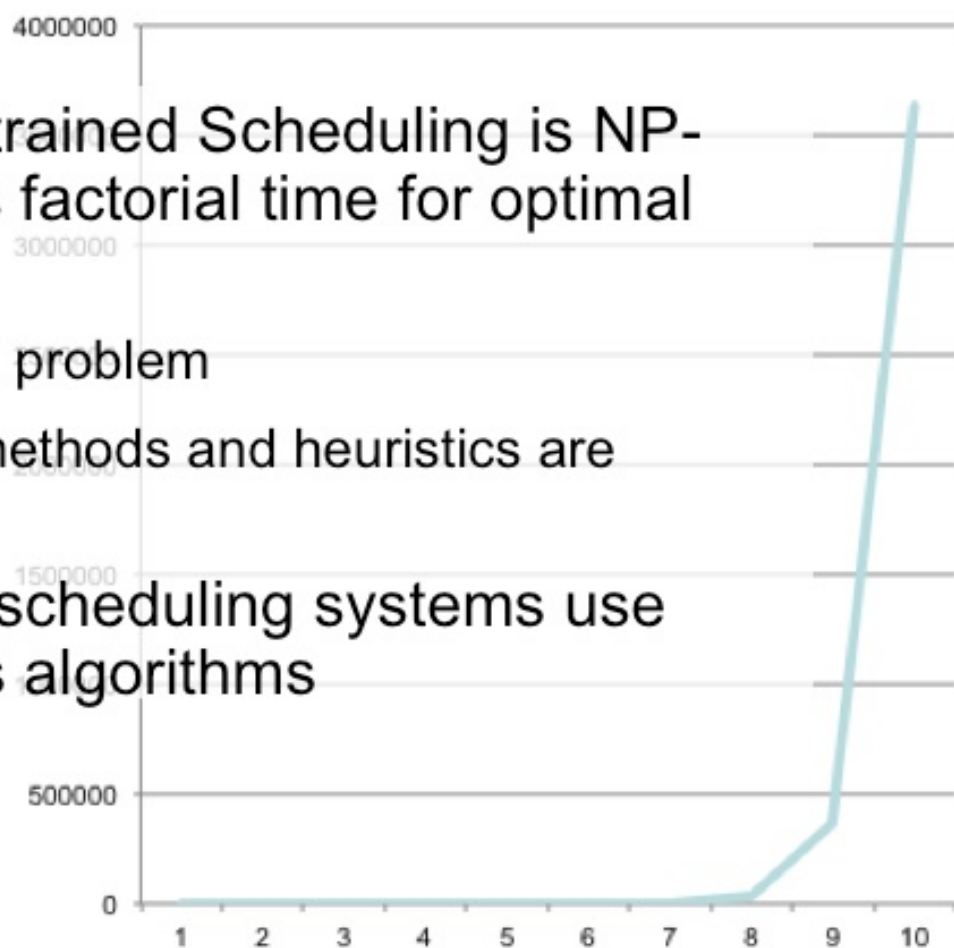
Optimal schedule

- 12 month schedule including all orders and all machines
- Output per line
- Overall Equipment Effectiveness per line
- Changeover times per line

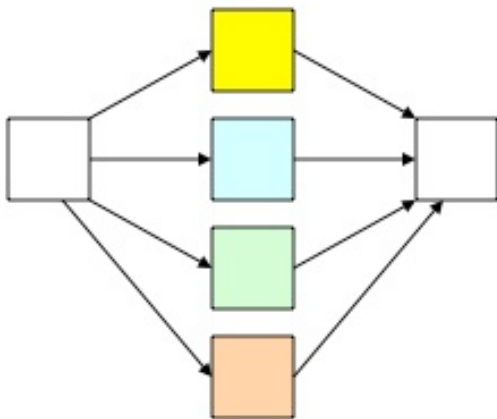
Background: Scheduling is Difficult

1	1
2	2
3	6
4	24
5	120
6	720
7	5040
8	40320
9	362880
10	3628800

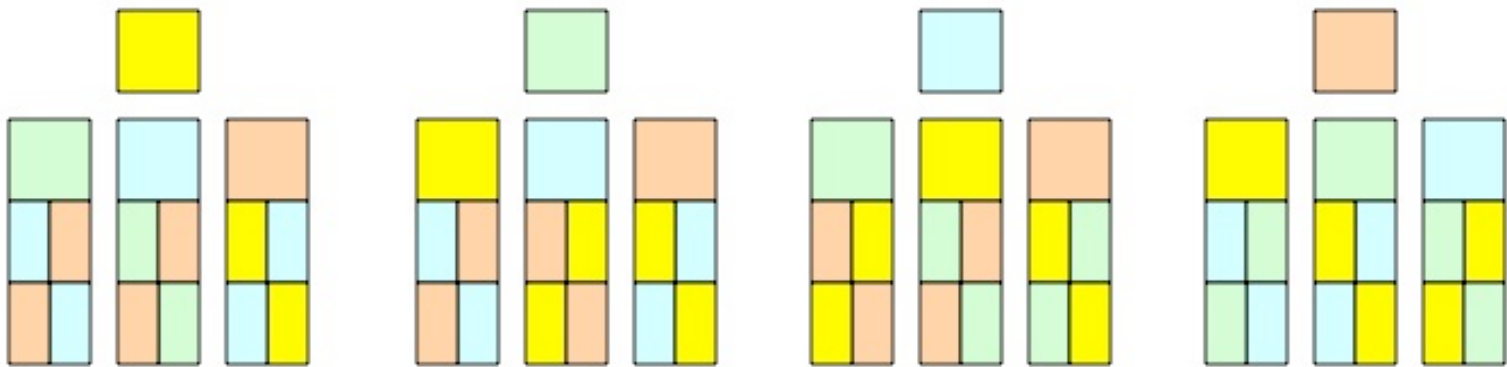
- Resource-Constrained Scheduling is NP-Complete, takes factorial time for optimal solution
 - I.e., it is a hard problem
 - Approximate methods and heuristics are needed
- Most automatic scheduling systems use simple one-pass algorithms



Four tasks that can occur in any order (one at a time)



results in twenty-four options

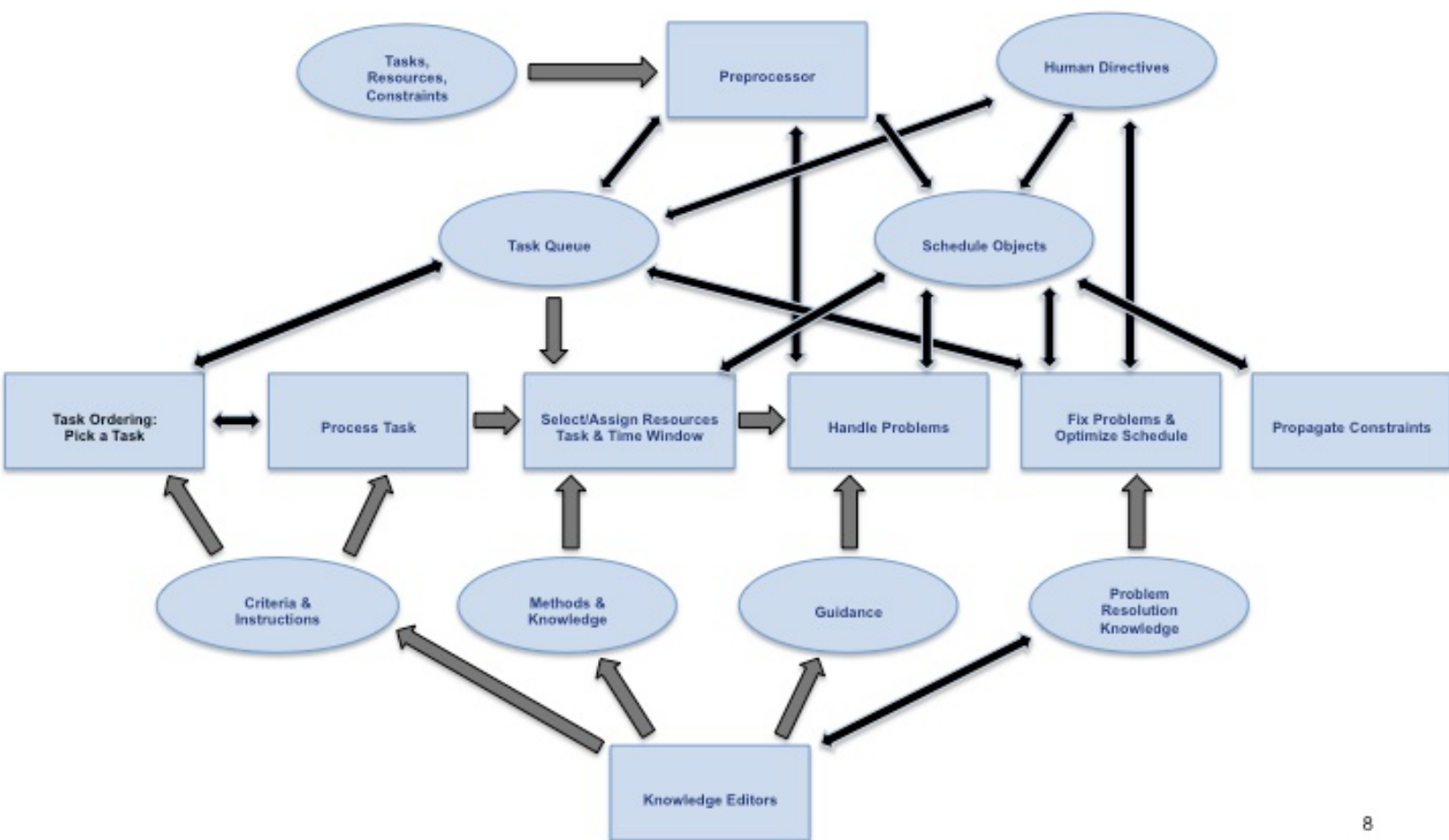


Analogy: Chess

- Chess mathematically is similar to resource scheduling.
 - Easy: Create basic rules to play
 - Hard: Be a good or great player
- Scheduling in most software is analogous to 'Easy' chess solution
- Each move analogous to execution mode update, challenge continues throughout game/execution of schedule

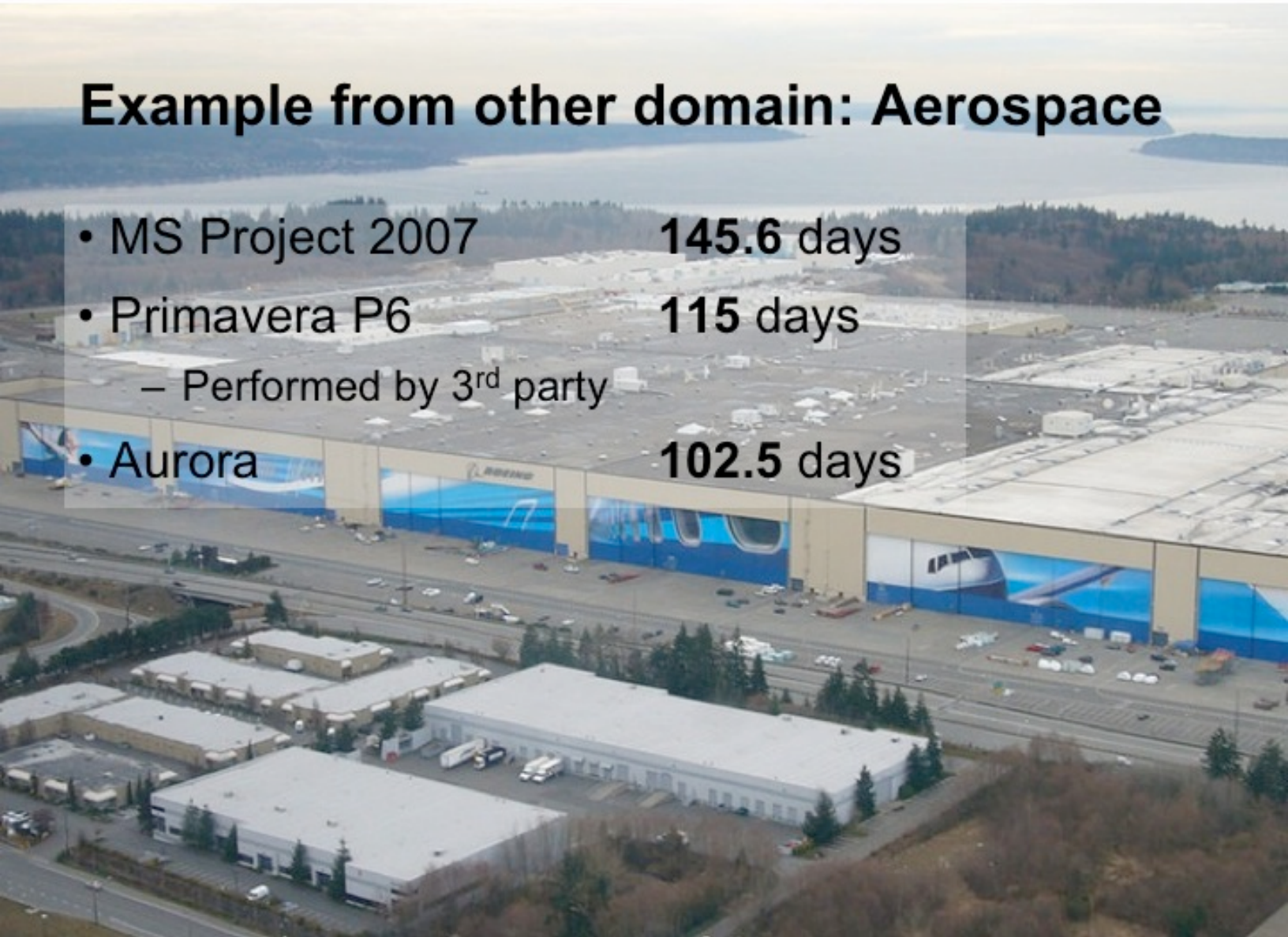


Architecture for Intelligent Scheduling

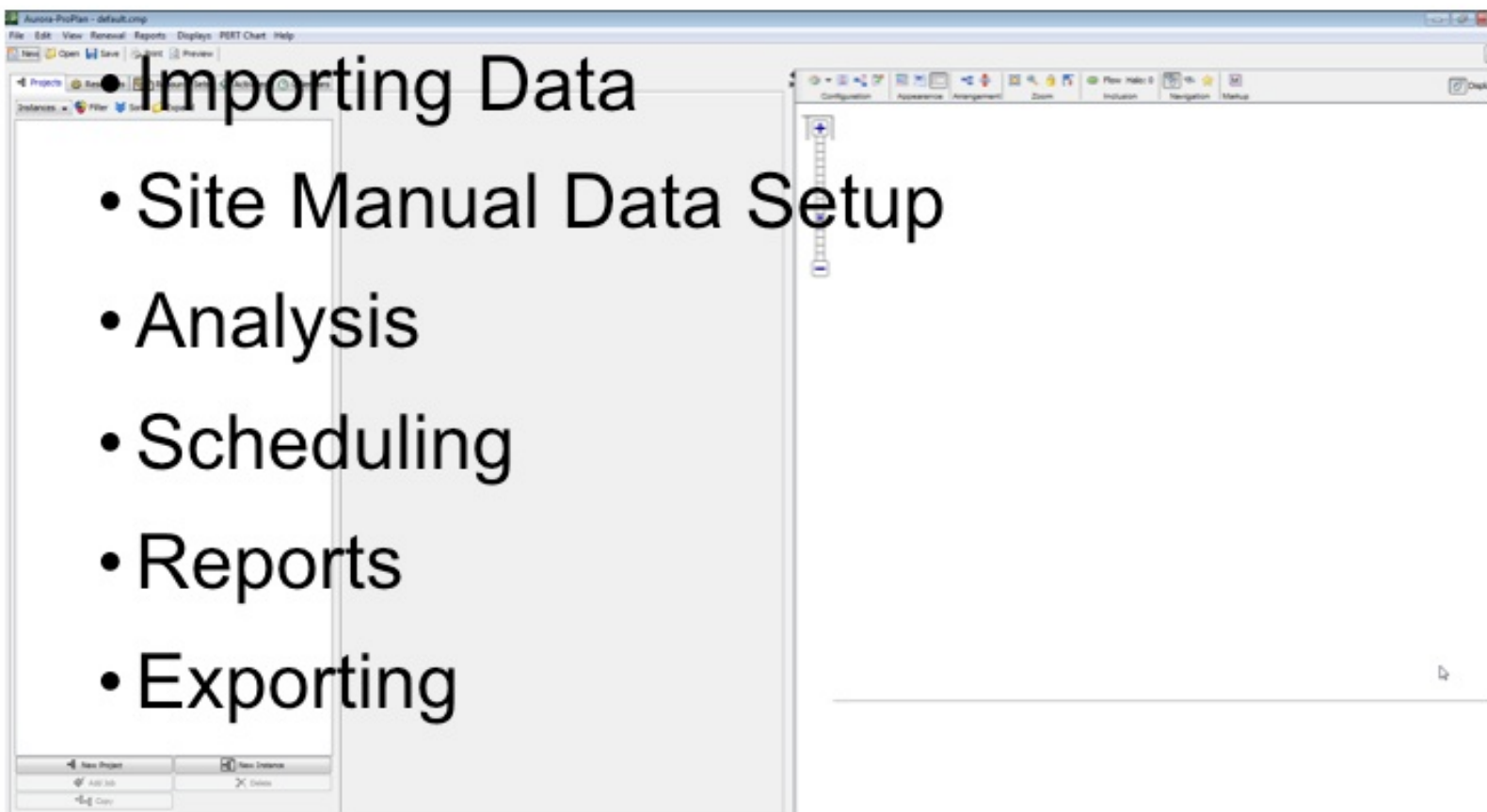


Example from other domain: Aerospace

- MS Project 2007 **145.6 days**
- Primavera P6 **115 days**
 - Performed by 3rd party
- Aurora **102.5 days**



Run-Through of Example



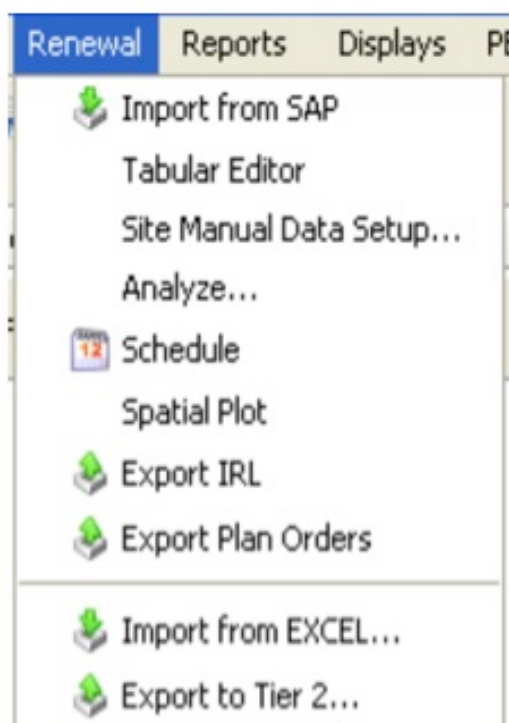
The screenshot shows the Auto-Plan software interface. The title bar reads "Auto-Plan - default.cmp". The menu bar includes "File", "Edit", "View", "Renewal", "Reports", "Displays", "PERT Chart", and "Help". The toolbar contains icons for "New", "Open", "Save", "Print", and "Preview". The main window is divided into a left sidebar with "Projects" and "Instances" sections, and a main workspace. A list of features is overlaid on the left sidebar:

- Importing Data
 - Site Manual Data Setup
 - Analysis
 - Scheduling
 - Reports
 - Exporting

The bottom of the interface has a status bar with buttons for "New Project", "New Instance", "Add Job", "Delete", and "Copy".

Import from Data Source

- Support for various formats including
 - SAP
 - Excel



Site Manual Data Setup

The screenshot displays a software window titled "Site Manual Data Setup" with three main input sections: "Site Manual Input", "Resource Manual Input", and "Product Manual Input". Each section contains various data entry fields and buttons.

Site Manual Input

- Plant Code: Guayama AN
- Inventory Carrying Cost Rate: 0.05
- Cost Per Man Hour (USD): \$29.13
- Period 1 Sales: 02/2013
- Period 1 Forecast: 02/2014
- Buttons: "Apply To Site", "2 Table", "Change Over Matrix"

Resource Manual Input

- Target Utilization: 100%
- Mean Man-Hours to Perform a Changeover: 20
- Forced Cleaning Allowance: 0%
- Button: "Apply To All Machines"

Product Manual Input

- EPEC Volume Threshold 24 Month Average in Pads: 75,000
- EPEC Volatility Threshold 24 Month Deviation in Percent: 0.35
- Shipment Prep Time: 1
- Service Level: 99%
- Cycle Time Buffer: 1
- Quality Time: 1
- MMQ Time: 7
- Minimum Order Frequency: 1
- Maximum Order Frequency: 12
- Button: "Apply To All Products"

A "Done" button is located at the bottom center of the window.

Change Over Setup

 Change Over Editor

Has At Least On Blan...	Has No Duplicate Patterns	Estimated Distribution adds to 1.0	
			
NAME	DISTRIBUTION	dimension1	dimension2
A	0.75	☒	☐
B/D	0.25	☒	☒

Analyzing – Product Segmentation

Product Segmentation																		
Color Coding Legend																		
Forecast Data																		
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Analyze



Generated Values

Volume	Volatility	previously EPEC	EPEC allowed	is EPEC
260838	1.03	false	no	false
192604	0.62	false	no	false
141201	0.89	false	no	false
37915	0.76	false	no	false
149281	0.9	false	no	false
78431	0.93	false	no	false
724865	0.17	false	must be epec	true
379070	0.27	false	must be epec	true
321322	0.3	false	must be epec	true

Analyzing – EOQ / EOF Analysis

EOQ/EOF Analysis

Inventory Carrying Cost Rate5%Cost per Man Hour USD\$29.13

90Instance Elements

Configuration

Navigation

Control

Uncategorized

Missing data

Incorrect format

Abnormal value

Production Data Replaced by Forecast

Changes From Previous EPEC

SPEC Outcome Affected by "SPEC Allowed"

Color Coding Legend

Material Number	Material Description	Forecast 1	Forecast 2	Forecast 3	Forecast 4	Forecast 5	Forecast 6	Forecast 7	Forecast 8	Forecast 9	Forecast 10	Forecast 11	Forecast 12	Forecast Summation	value per 1000 packs
3330	ADVIS, FILM COATED TABLETS 20	160900	228900	215178	199379	213755	223957	246586	228266	162958	186712	183027	188197	2437794	708.5877
3340	ADVIS, FILM COATED TABLETS 40	133917	167343	169341	158490	189269	158331	159234	202901	166903	173140	156883	150447	1986139	1244.3362
3380	ADVIS, FILM COATED TABLETS 80	55000	122800	143971	118248	172394	86091	99158	166588	112720	107546	100917	93018	1378451	2309.7508
3389	ADVIS, FILM COATED TABLETS 160CT	0	0	0	0	0	75000	102679	25545	25545	25545	25545	25545	265403	4619.42
3400	ADVIS, FILM COATED CAPLETS 20CT	80360	113601	130034	124527	142115	120511	122206	143169	121538	116405	108185	101719	1422370	708.5877

Analyze



Generated Values

Wilson EOF	Wilson EOQ	Batch EOF	Batch EOQ	EPEC EOF	EPEC EOQ	EOF	replenishment time	EOQ
12	203147	0	0	0	0	12	31.33333	203147
12	165514	0	0	0	0	12	31.33333	165514
12	114871	0	0	0	0	12	31.33333	114871
11	24128	0	0	0	0	11	34	24128
10	142237	0	0	0	0	10	37.3	142237
12	59286	0	0	0	0	12	31.33333	59286

Analyzing – IRL Analysis

Analyze...

IRL Analysis

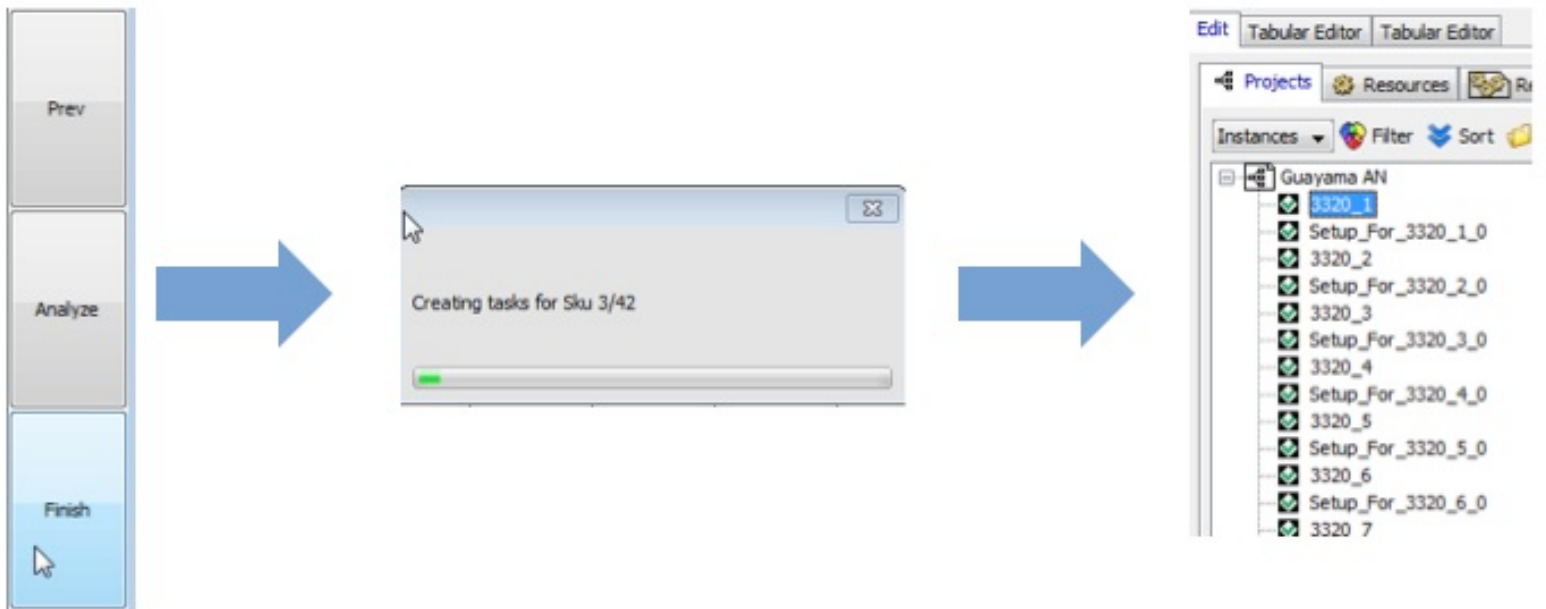
Missing data Incorrect format Abnormal value Production Data Replaced by Forecast Changes from Previous PPEC BPEC Outcome Affected by "BPEC Allowed"

Color Coding Legend

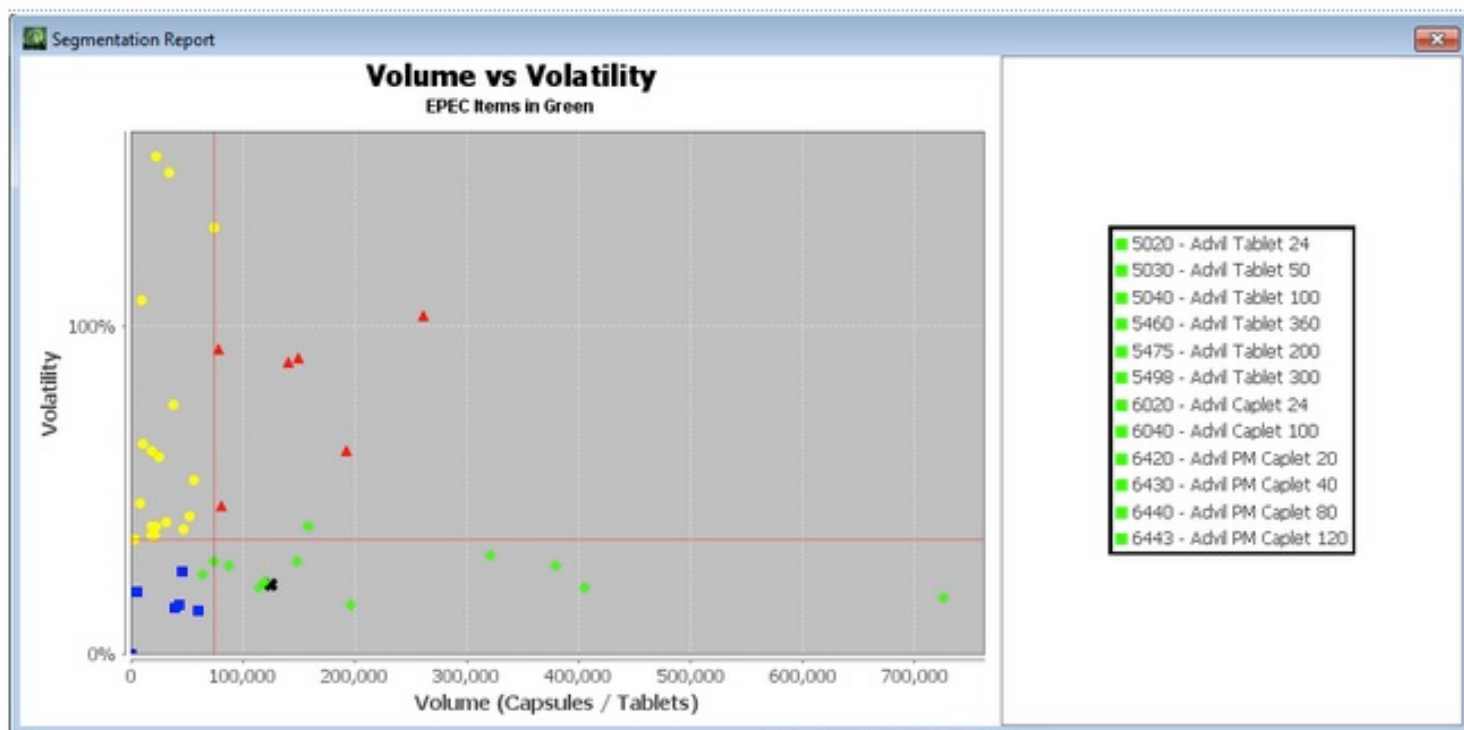
Material Number	Material Description	rythm time demand	safety stock demand	safety stock supply	other cycle time demand	mean daily demand	replenishment time	square root replenishment time	standard deviation of demand	standard deviation of sales
3320	ADVL FILM COATED TABLETS 20	201302.10011	4850844.96184	83791.68566	109217.09687	6424.53511	31.33333	5.59762	371927.39977	371927.39977
3340	ADVL FILM COATED TABLETS 40	129305.18892	2464740.61347	53823.0756	70154.93262	4126.76074	31.33333	5.59762	188976.32742	188976.32742
3380	ADVL FILM COATED TABLETS 80	102518.41454	2297708.04964	42673.13022	55671.69276	3271.86428	31.33333	5.59762	176171.4891	176171.4891



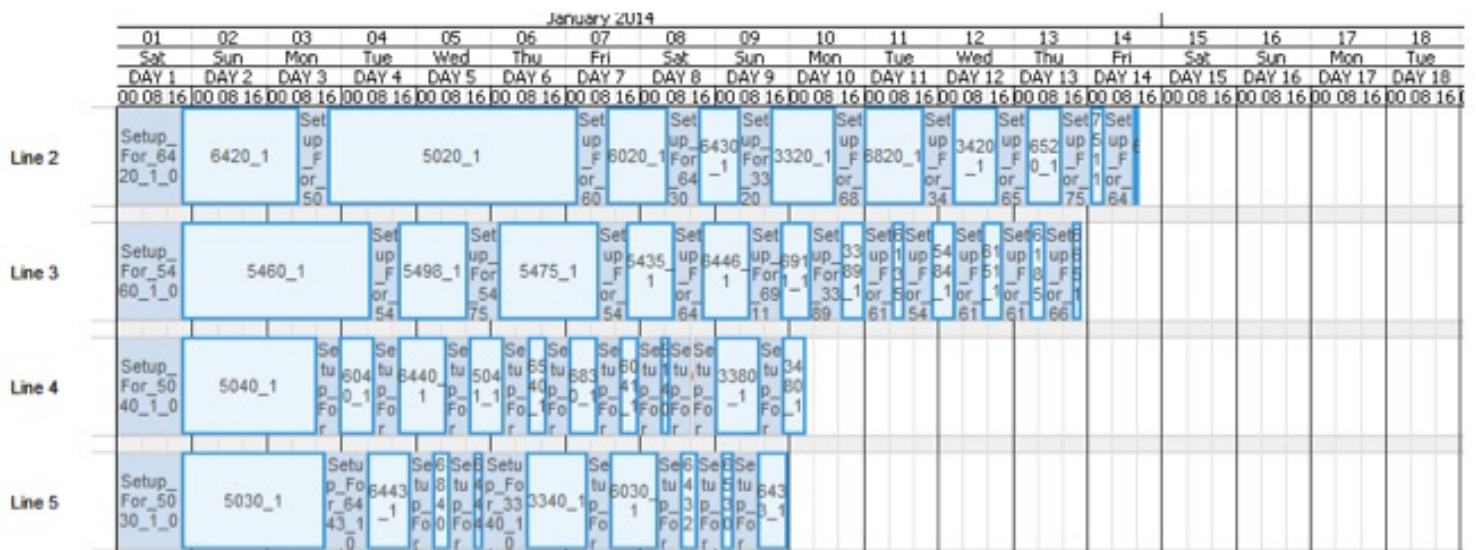
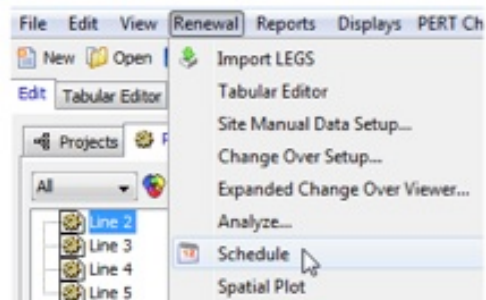
Create Tasks



Reviewing Results Graphically



Scheduling

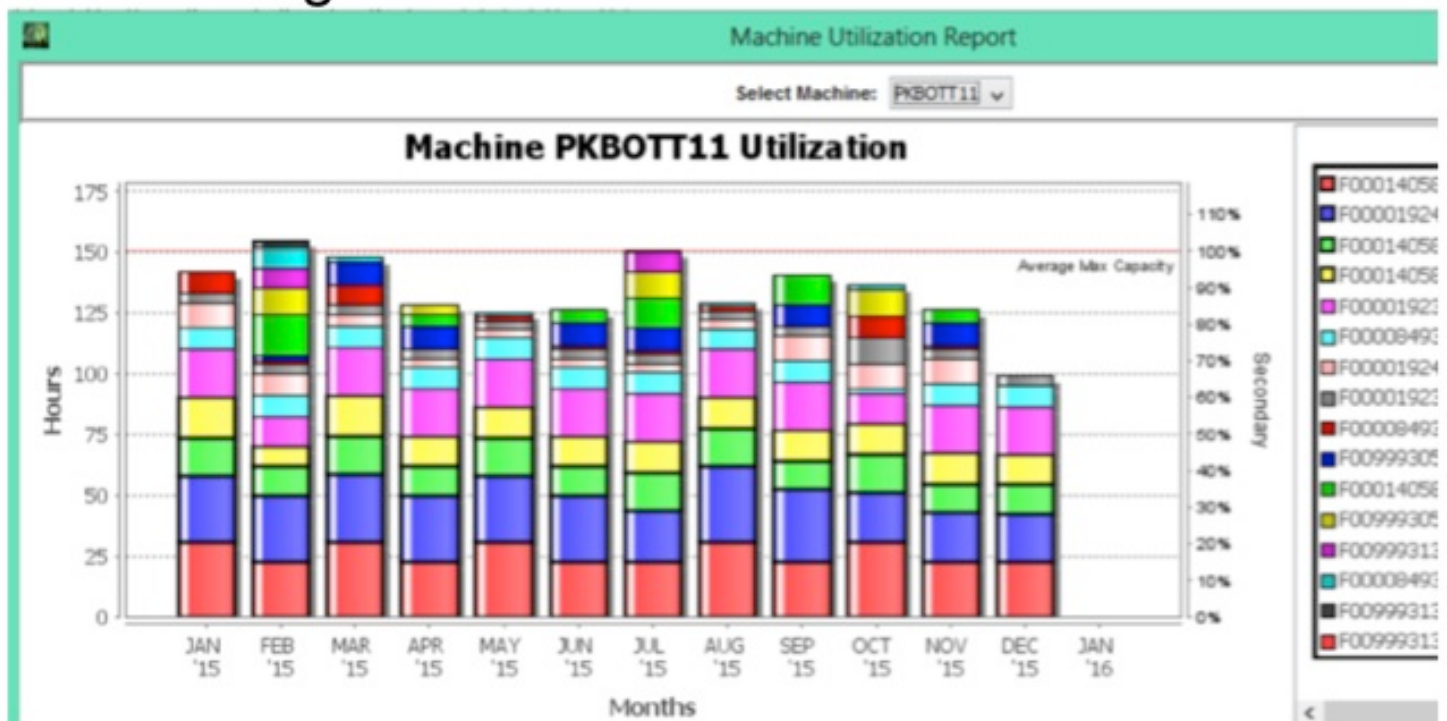


Summary Report

Summary Report	
Number of EPEC SKUs	12
EPEC share (percent of SKUs)	29%
EPEC share (percent of packs)	66%
Number Of Orders Per Year	310
Number Of Products	42
Number of EPEC packs per year	34,937,878
Number of packs per year	52,568,980
Average Changeover Downtime (h)	8.748
Total Changeover-Time (h)	2,712
Total Production-Time (h)	7,496
Total Time (h)	10,208

Machine Utilization Report

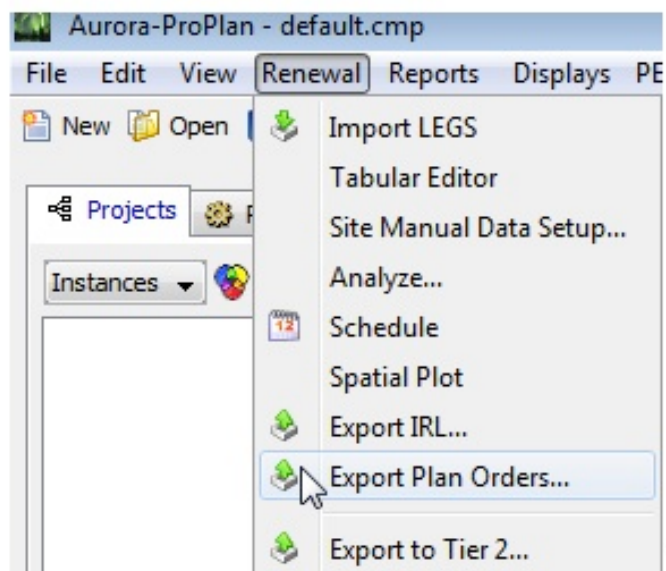
- Shows overall utilization of products by line
- Allows planners to see overall allocation and line balancing



Various Other Reports

Audit Viewer							
Time	User Name	Action	Initiator	ID	Property Name	Old Value	New Value
12/21/2014 09:59:00	Administrator	Edit	User	9016	optimal order frequency maximum	1000	12
12/21/2014 09:59:00	Administrator	Edit	User	9017	shipment prep time	23	1
12/21/2014 09:59:00	Administrator	Edit	User	9017	cycle time buffer	5	1
12/21/2014 09:59:00	Administrator	Edit	User	9017	optimal order frequency minimum	2	1
12/21/2014 09:59:00	Administrator	Edit	User	9017	optimal order frequency maximum	1000	12
12/21/2014 09:59:00	Administrator	Edit	User	9018	shipment prep time	23	1
12/21/2014 09:59:00	Administrator	Edit	User	9018	cycle time buffer	5	1
12/21/2014 09:59:00	Administrator	Edit	User	9018	optimal order frequency minimum	2	1
12/21/2014 09:59:00	Administrator	Edit	User	9018	optimal order frequency maximum	1000	12
12/21/2014 09:59:00	Administrator	Edit	User	9019	shipment prep time	23	1
12/21/2014 09:59:00	Administrator	Edit	User	9019	cycle time buffer	5	1
12/21/2014 09:59:00	Administrator	Edit	User	9019	optimal order frequency minimum	2	1
12/21/2014 09:59:00	Administrator	Edit	User	9019	optimal order frequency maximum	1000	12
12/21/2014 09:59:00	Administrator	Edit	User	9020	shipment prep time	23	1
12/21/2014 09:59:00	Administrator	Edit	User	9020	cycle time buffer	5	1
12/21/2014 09:59:00	Administrator	Edit	User	9020	optimal order frequency minimum	2	1
12/21/2014 09:59:00	Administrator	Edit	User	9020	optimal order frequency maximum	1000	12
12/21/2014 09:59:00	Administrator	Edit	User	9021	shipment prep time	23	1
12/21/2014 09:59:00	Administrator	Edit	User	9021	cycle time buffer	5	1
12/21/2014 09:59:00	Administrator	Edit	User	9021	optimal order frequency minimum	2	1
12/21/2014 09:59:00	Administrator	Edit	User	9021	optimal order frequency maximum	1000	12
12/21/2014 09:59:00	Administrator	Edit	User	9022	shipment prep time	23	1
12/21/2014 09:59:00	Administrator	Edit	User	9022	cycle time buffer	5	1
12/21/2014 09:59:00	Administrator	Edit	User	9022	optimal order frequency minimum	2	1
12/21/2014 09:59:00	Administrator	Edit	User	9022	optimal order frequency maximum	1000	12
12/21/2014 09:59:00	Administrator	Edit	User	9023	shipment prep time	23	1
12/21/2014 09:59:00	Administrator	Edit	User	9023	cycle time buffer	5	1
12/21/2014 09:59:00	Administrator	Edit	User	9023	optimal order frequency minimum	2	1

Export Plan Orders



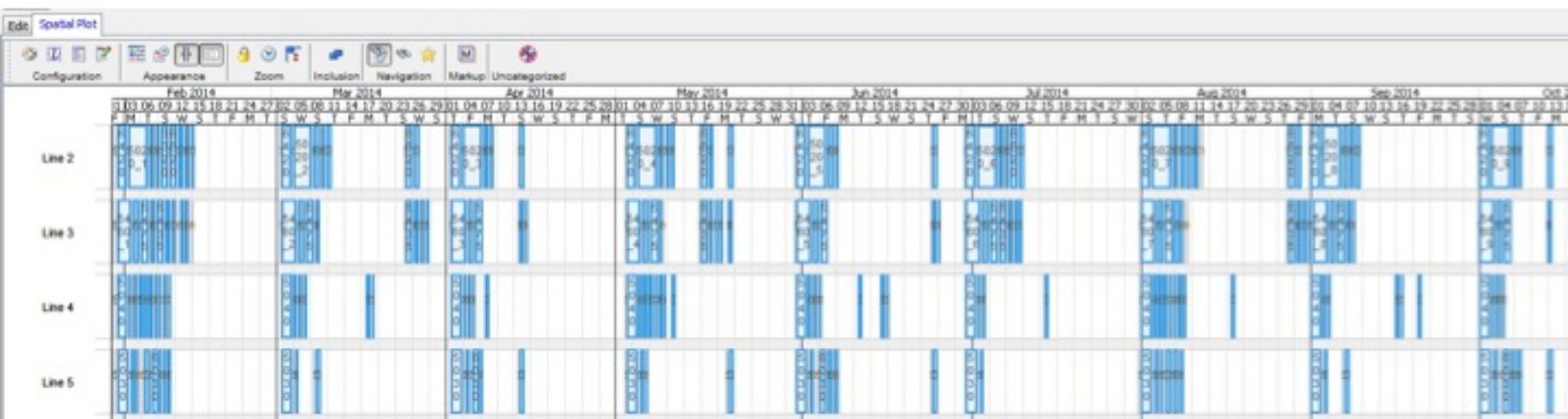
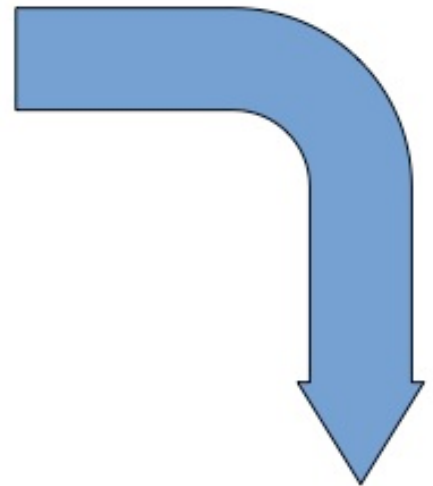
Summary: Intelligent Scheduling Application to Production / Packaging Optimization

Production Data

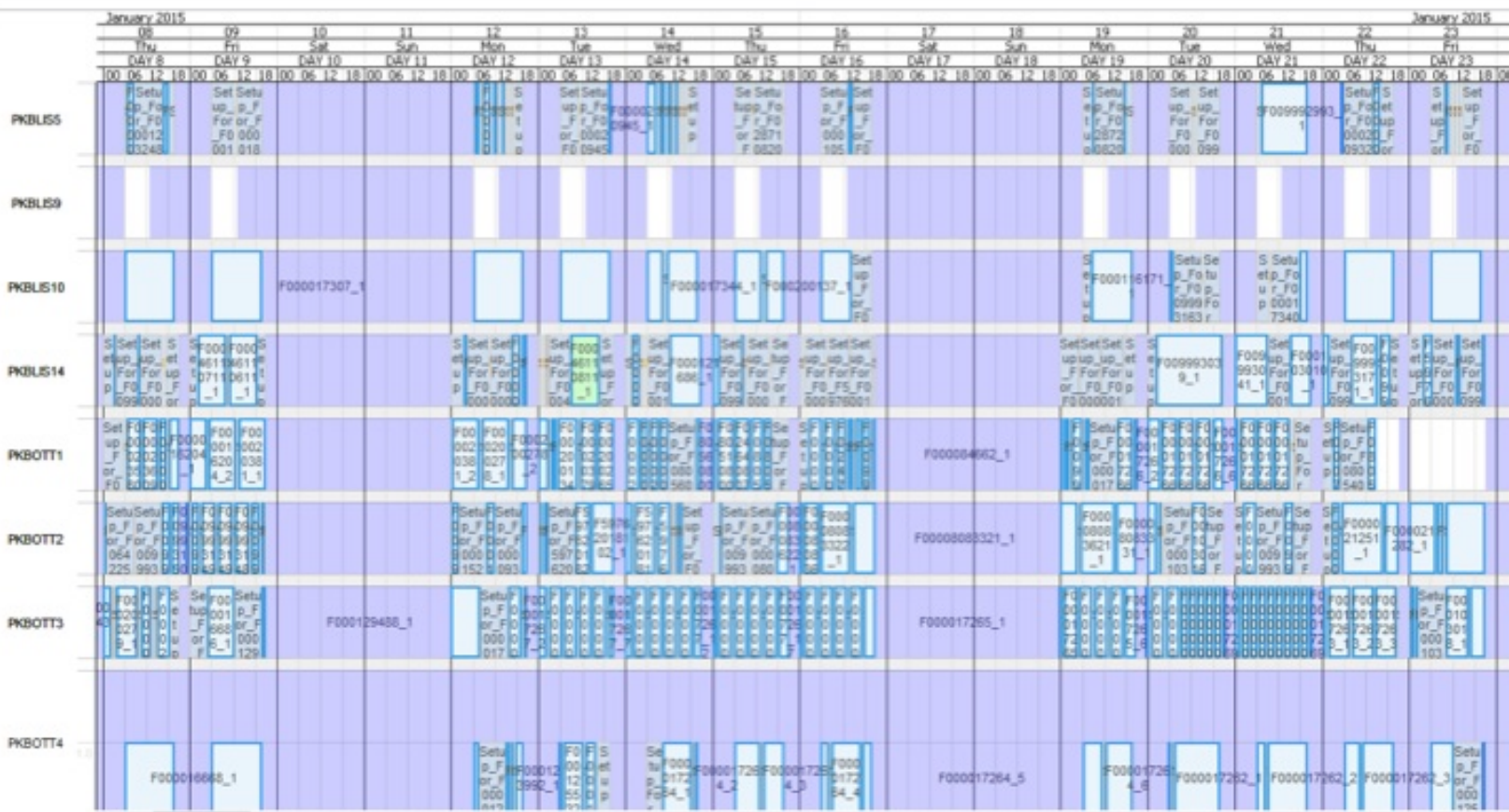
→ Aurora-ProPlan

→ Production Schedule

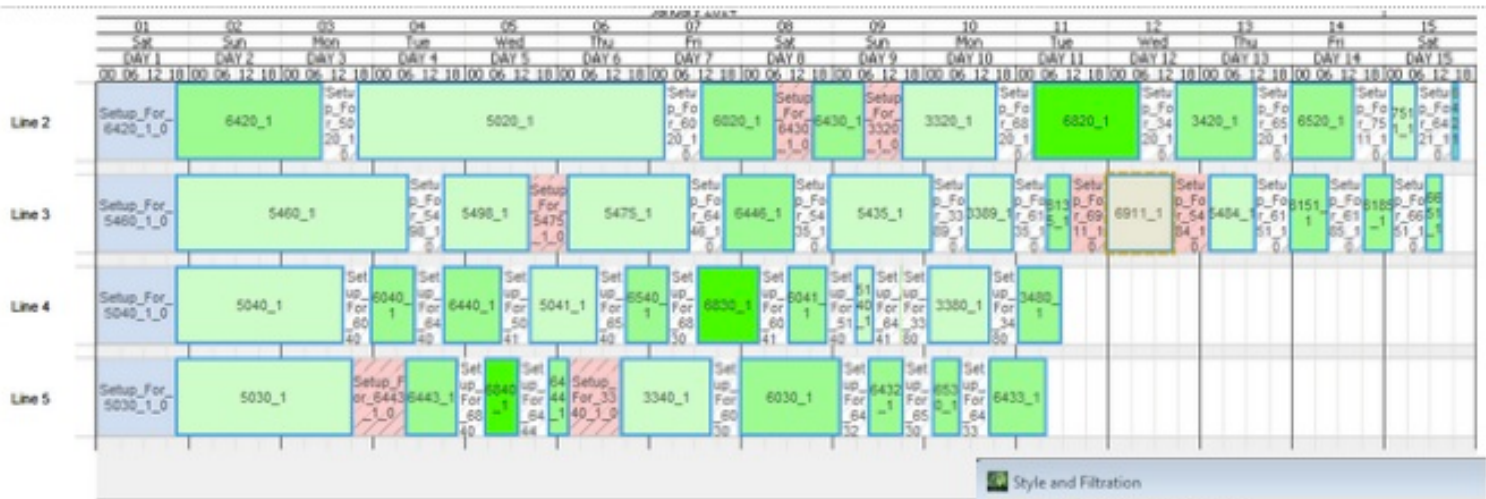
→ Export



Graphical Differences: Setup vs Production vs Downtime



Style & Filtration: Options to enhance visualization



Style and Filtration

Rule Set: Pfizer_Spatial

Combined ☐ Include/Exclude ☐ Fill ☐ Tags ☐ Border ☐ Font

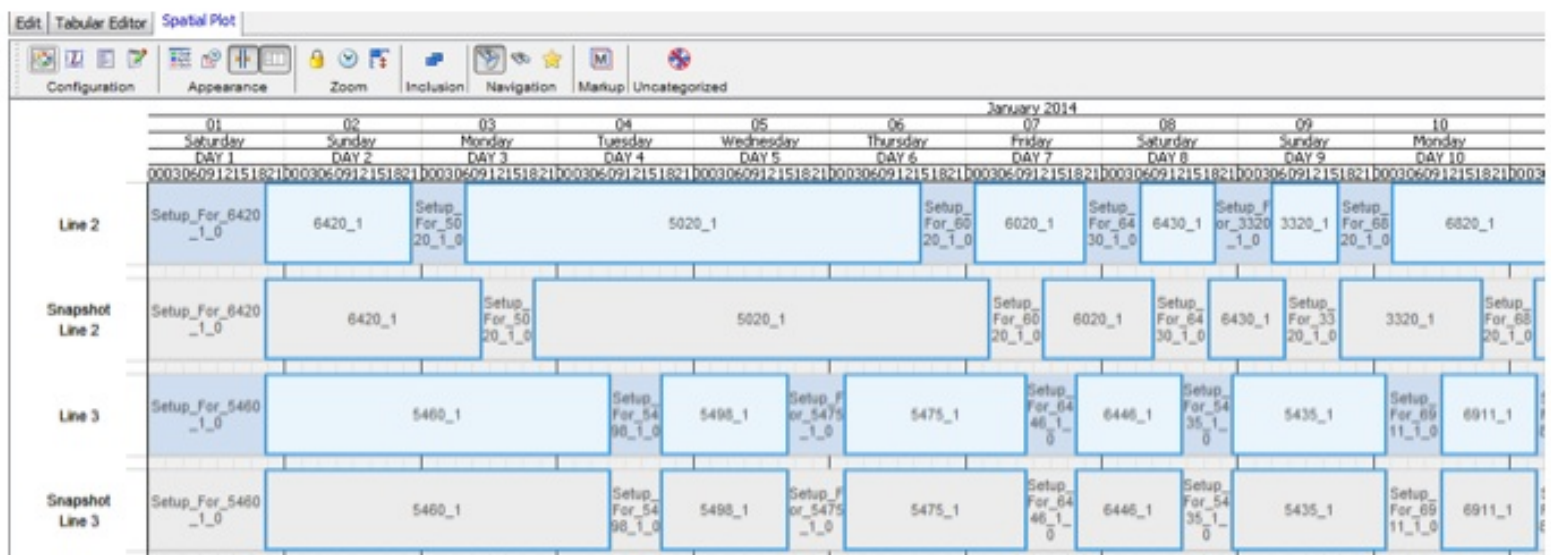
- 25 MG Task**
fill color, border width, border color matches=0
- 50 MG Task**
fill color, border width, border color matches=0
- 75 MG Task**
fill color, border width, border color matches=0
- 100 MG Task**
fill color, border width, border color matches=0
- 150 MG Task**
fill color, border width, border color matches=0
- 200 MG Task**
fill color, border width, border color matches=0
- 300 MG Task**
fill color, border width, border color matches=0

Turned End Date: 02/01/2015 00:00

- Change the demand for different SKUs
 - Due to inventory & expiration dates
- Change the working time of machines
- Change changeover properties
- Make changes in external data or in ProPlan
- Update production schedule after changes in a matter of minutes

What-If Capabilities

- The user can manually add/remove machines or change calendars to see the effect on the schedule.



Complete Calendar Support

Projects Resources Resource Sets Activities **Calendars**

day baseline: 00:00 (HH:MM)

Define Filter Sort

3 shift default
Calendar 2

Name: 3 shift default

Description:

Daily Schedule Simple Detail

Shift N...	Start Ti...	End Time	Duration	Work T...
+ shift 1	00:00	07:00	07:00	07:00
+ shift 2	08:00	15:00	07:00	07:00
+ shift 3	16:00	23:00	07:00	07:00

Add Shift Add Break
Remove

Work Days

☒ Monday ☒ Friday
☒ Tuesday ☒ Saturday
☒ Wednesday ☒ Sunday
☒ Thursday

Holiday Set

Select Edit Clear

3 shift default

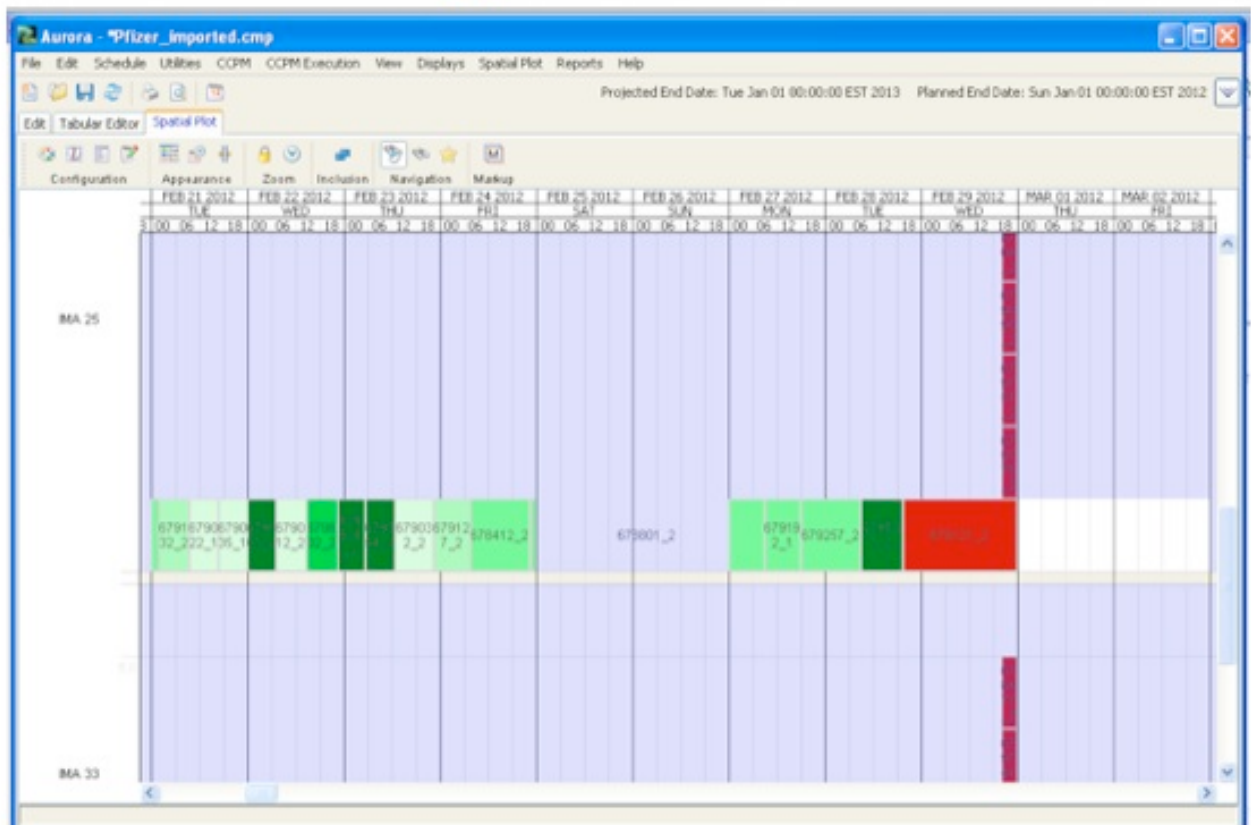
Sunday	Monday
3 6a 12p 6p	4 6a 12p 6p
10 6a 12p 6p	11 6a 12p 6p
17 6a 12p 6p	18 6a 12p 6p
24 6a 12p 6p	25 6a 12p 6p
31 6a 12p 6p	

What-If: Same Demand 3 vs 2 Lines

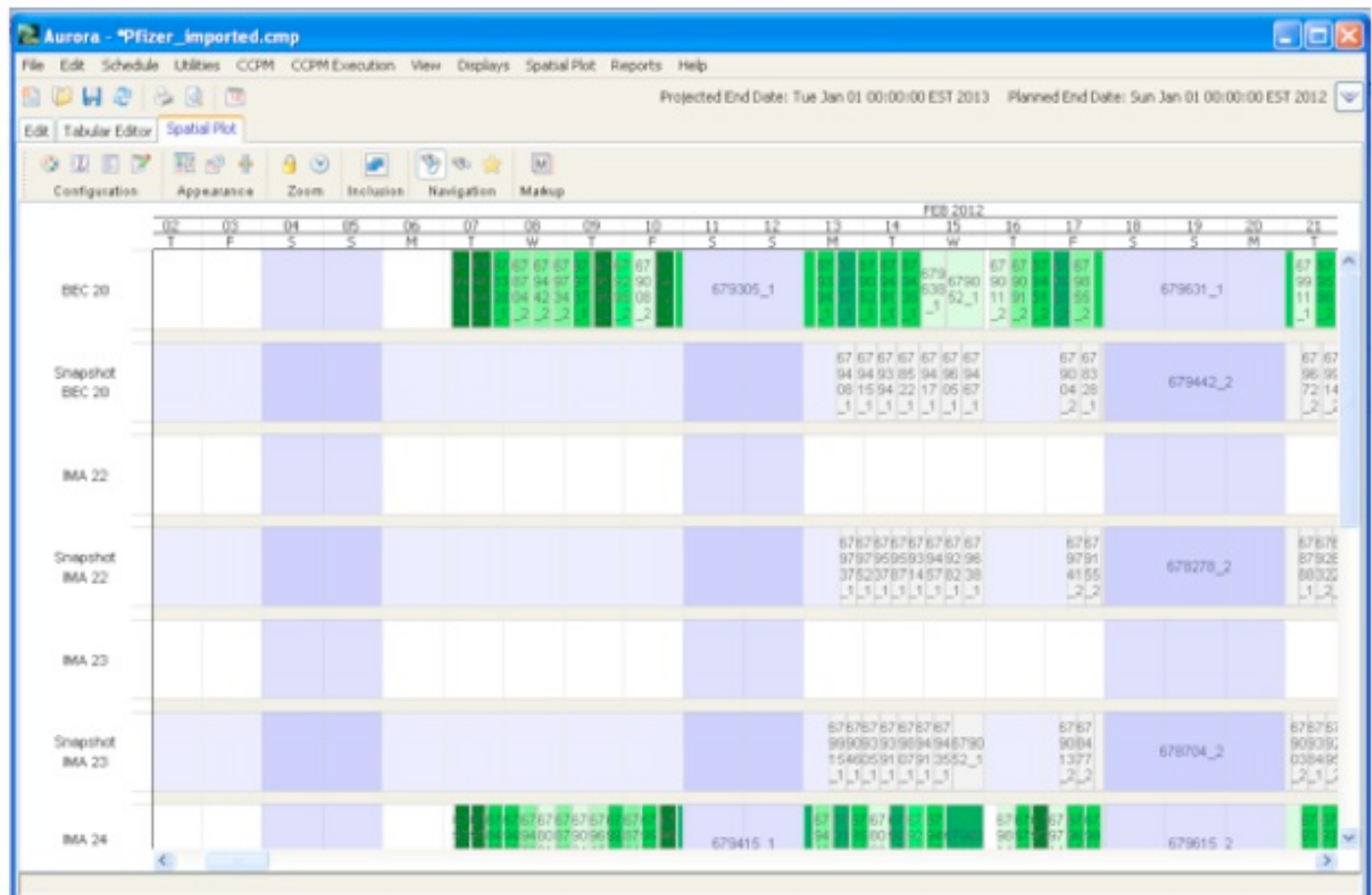


Conflicts

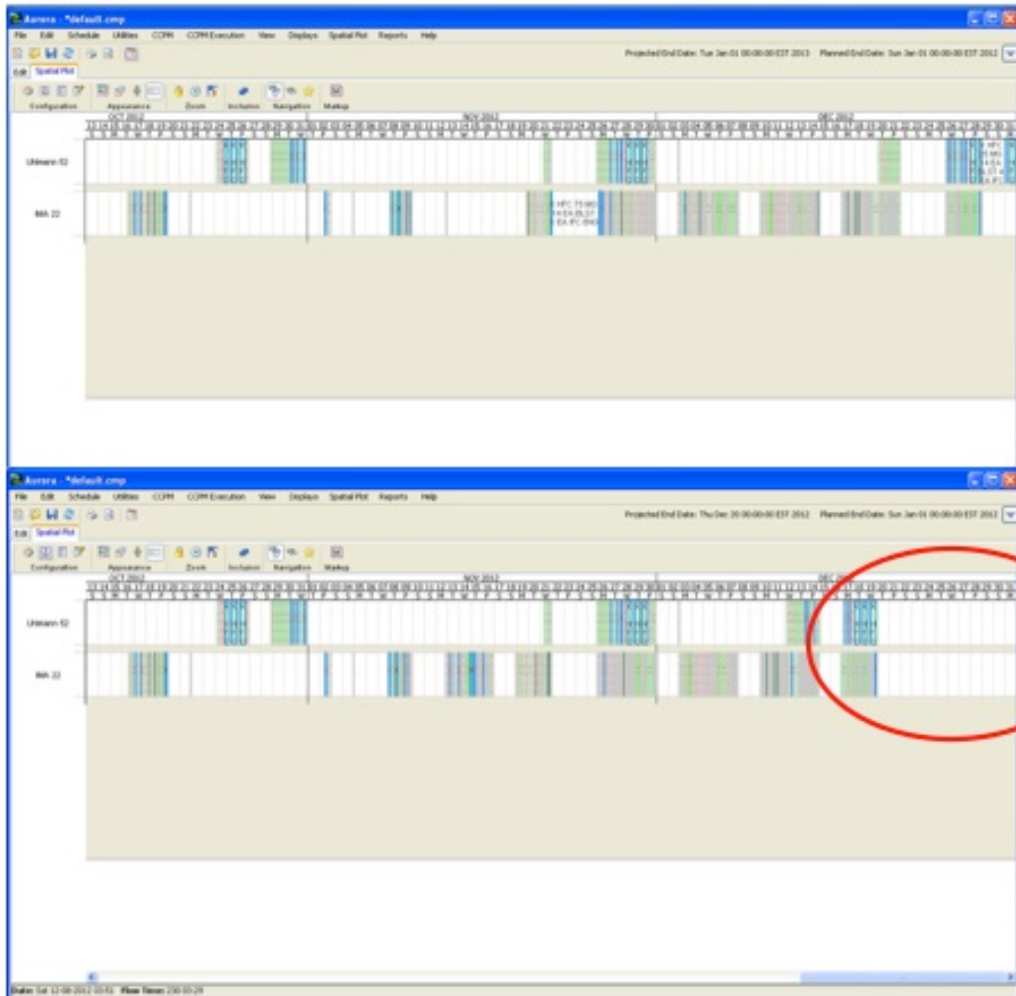
- Conflicts will occur if there are not enough lines / machines
 - Conflicts shown in red



Removing Capacity Without Causing Conflicts



What-if: End of Year Shutdown



What-if: Demand Increase

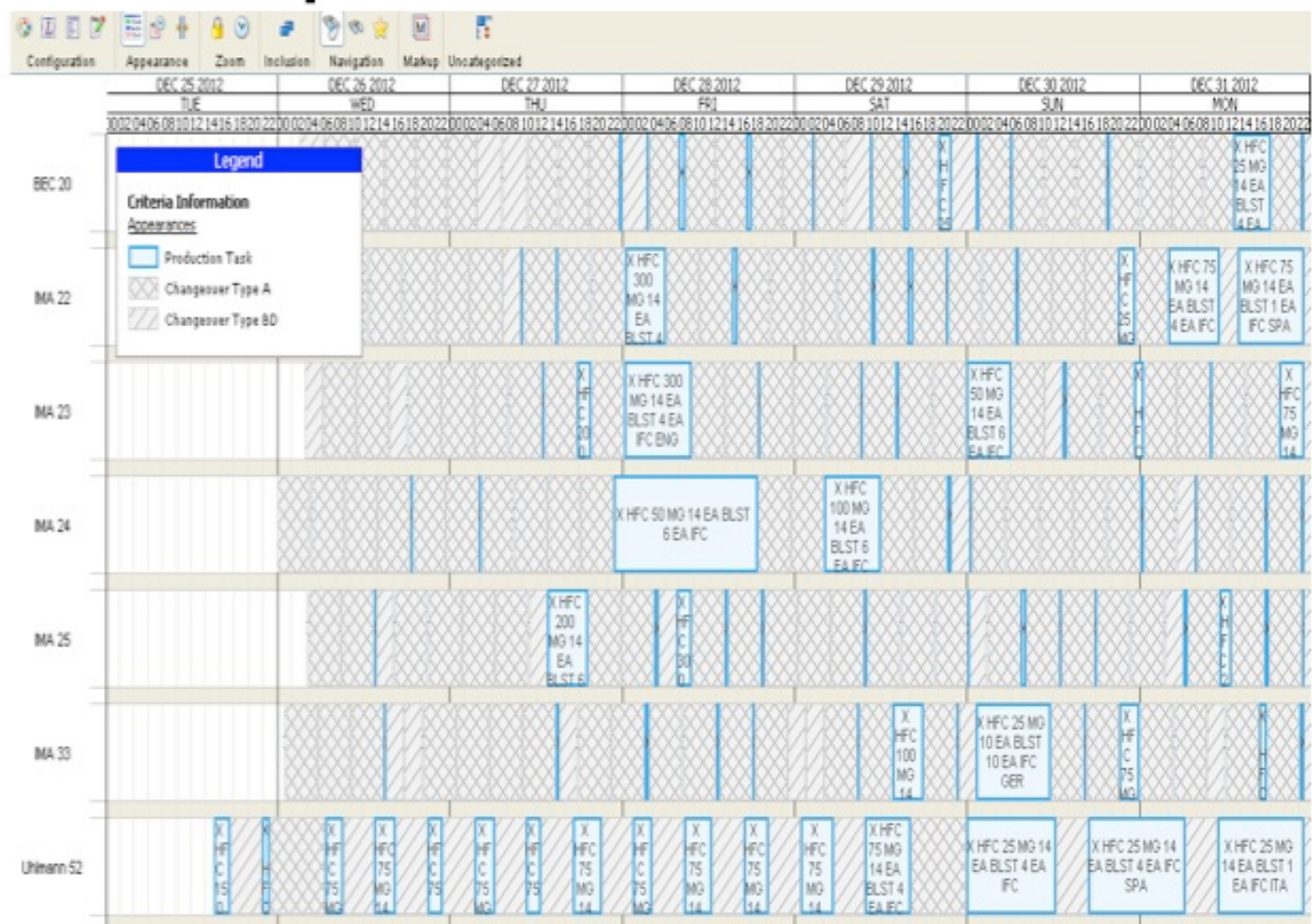


Optimizations

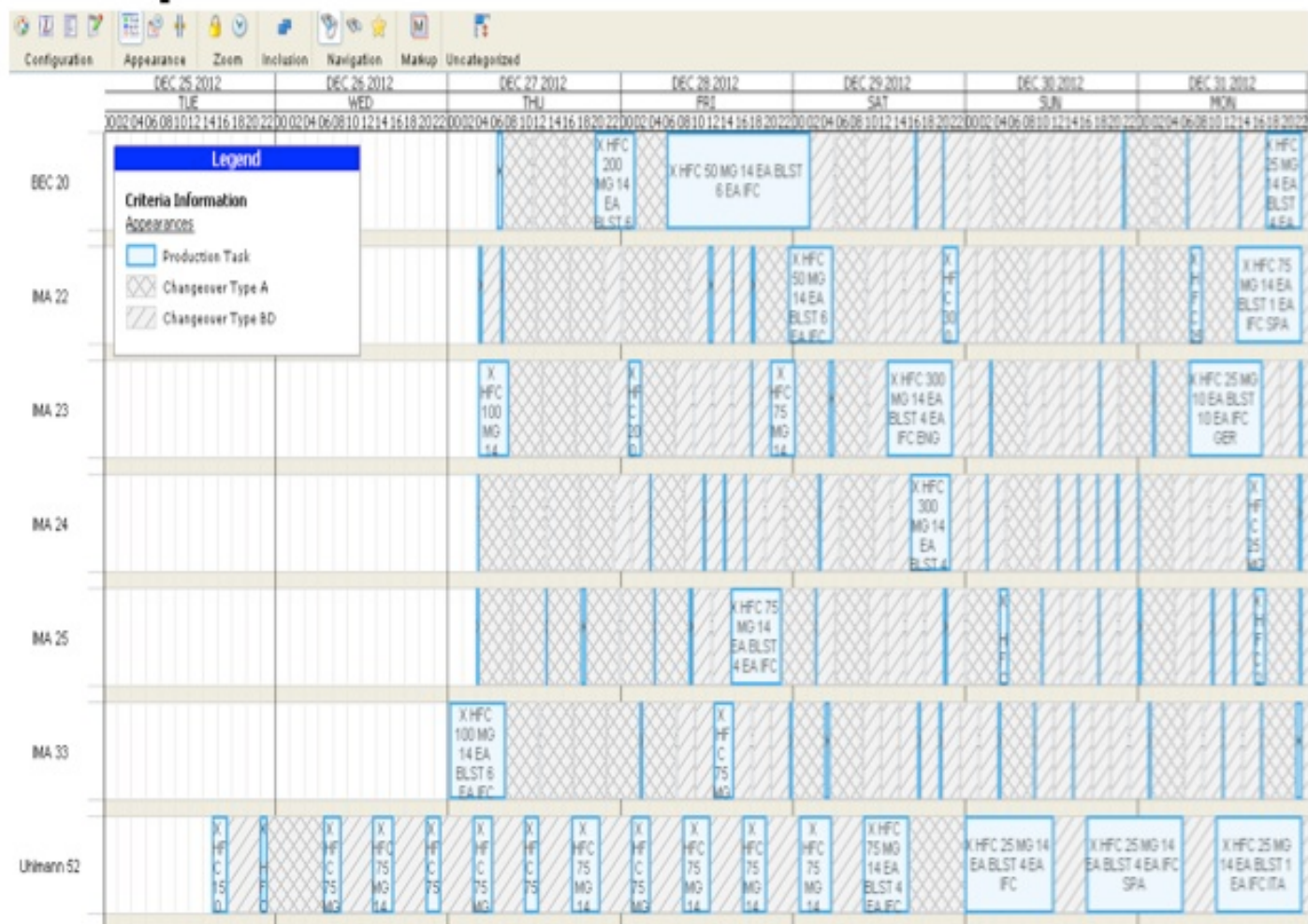
- Maximize Throughput
- Minimize the Changeover times



WithOUT Optimization

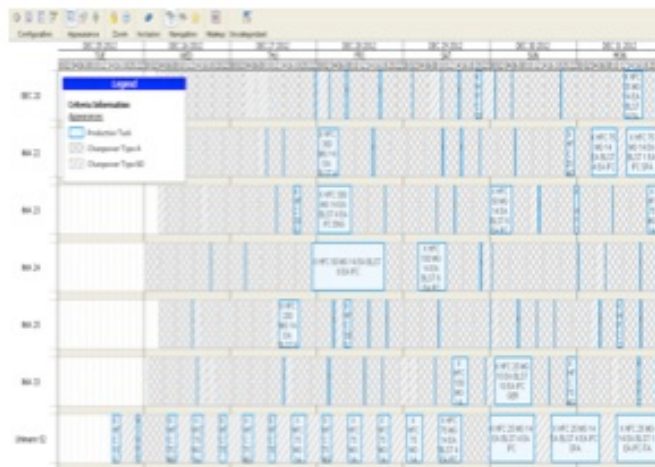


With Optimization

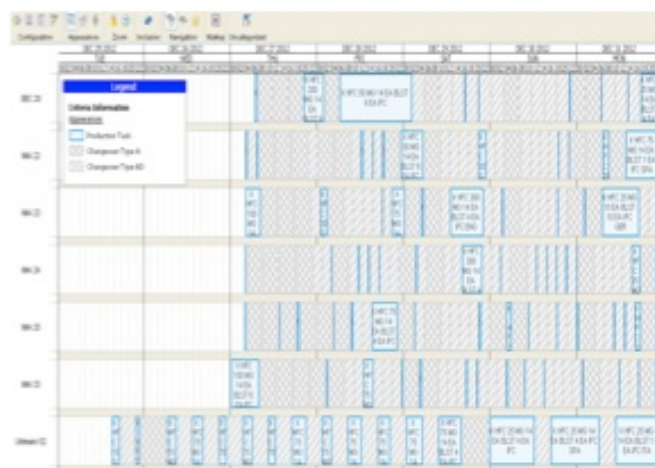


Production Optimization (changeover)

Previous
solution

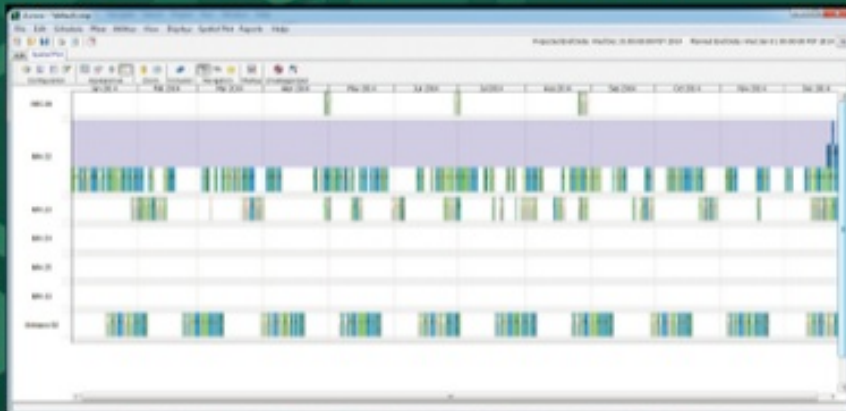


With
optimization



Non-optimal production scheduling

Changeovers: 263 (conflicts in schedule)

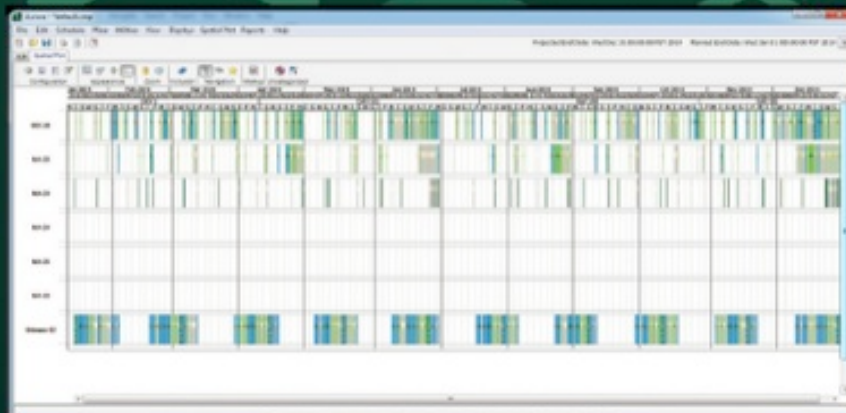


16%

improvement
in efficiency!

Optimal production scheduling with ProPlan™

Changeovers: 226 (No more conflicts in schedule)



IFPAC 2015

Rob Richards, Ph.D.

Stottler Henke Associates, Inc.

Richards@StottlerHenke.com