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Graphical Analysis for Epidemiology, Manufacturing and Marketing Applications

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TIBCO Data Science

TIBCO Analytics

Agenda

Graphical Analysis for Epidemiology, Manufacturing and Marketing

- Epidemiology - meta analysis, with:
  - Forest Plots
  - Double-dot Plots
  - Funnel Plots
- Manufacturing
  - Control Charts
  - Root Cause Analysis
  - Operator, Supervisor Dashboards, predicting equipment failure
- Sales and Marketing
  - Infographics
  - Trend Analysis
  - Field-force Optimisation

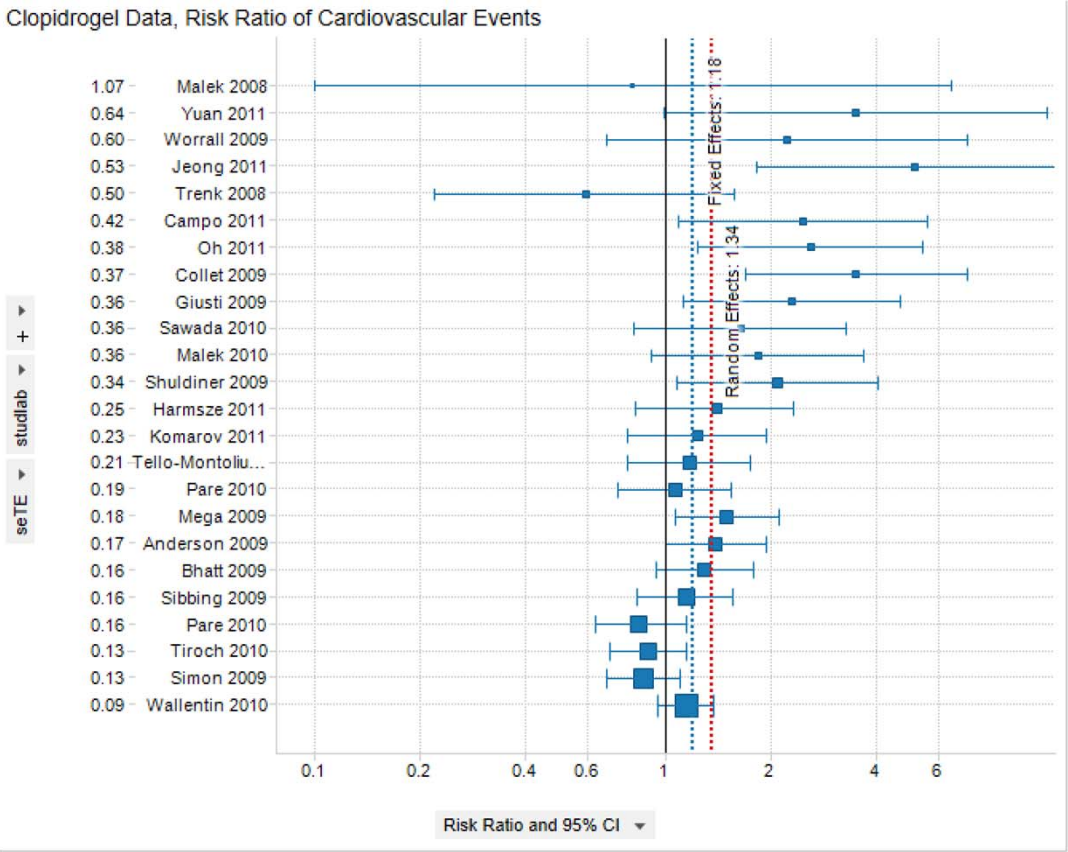
Forest Plot

- Most common graphical display for presenting results from meta-analyses
- Effect estimates displayed with their confidence intervals
- Area of symbol proportional to weight of estimate
  - Larger symbol draws attention to studies with larger weight
  - i.e. with smaller confidence intervals
- Any type of effect estimate can be used:
  - Odds ratios, risk ratios, hazard ratios, mean differences, etc.

TIBCO Spotfire® | Epidemiology – Forest Plot

- Example showing meta-analysis of Risk Ratio of cardiovascular events
- Comparing:
  - Individuals having one or more copies of any CYP2C19 genetic variant associated with reduced enzyme function
  - With individuals having none of these
- Higher risk ratio corresponds to higher chance of cardiovascular events
- Ordered by the weight that they have in the meta-analysis

TIBCO Spotfire® | Epidemiology – Forest Plot



Clopidrogel Data, Risk Ratio of Cardiovascular Events

studlab	TE	seTE	rr	lo95	hi95
Malek 2008	-0.22	1.07	0.80	0.10	6.49
Worrall 2009	0.80	0.60	2.22	0.68	7.23
Jeong 2011	1.64	0.53	5.14	1.82	14.54
Yuan 2011	1.25	0.64	3.48	0.99	12.19
Campo 2011	0.90	0.42	2.46	1.09	5.57
Trenk 2008	-0.53	0.50	0.59	0.22	1.57
Sawada 2010	0.49	0.36	1.63	0.81	3.28
Collet 2009	1.24	0.37	3.47	1.68	7.21
Giusti 2009	0.82	0.36	2.28	1.12	4.64
Shuldiner 2009	0.74	0.34	2.09	1.08	4.04
Malek 2010	0.60	0.36	1.83	0.91	3.68
Oh 2011	0.95	0.38	2.58	1.23	5.40
Harmsze 2011	0.34	0.25	1.40	0.82	2.30
Komarov 2011	0.21	0.23	1.23	0.78	1.94
Tello-Montoliu...	0.16	0.21	1.17	0.78	1.75
Pare 2010	0.06	0.19	1.06	0.73	1.54
Mega 2009	0.40	0.18	1.49	1.06	2.10
Anderson 2009	0.33	0.17	1.39	1.00	1.93
Bhatt 2009	0.25	0.16	1.29	0.94	1.77
Sibbing 2009	0.13	0.16	1.14	0.83	1.56
Pare 2010	-0.17	0.16	0.84	0.63	1.14
Tiroch 2010	-0.12	0.13	0.89	0.69	1.15
Simon 2009	-0.15	0.13	0.86	0.68	1.10
Wallentin 2010	0.13	0.09	1.14	0.95	1.37

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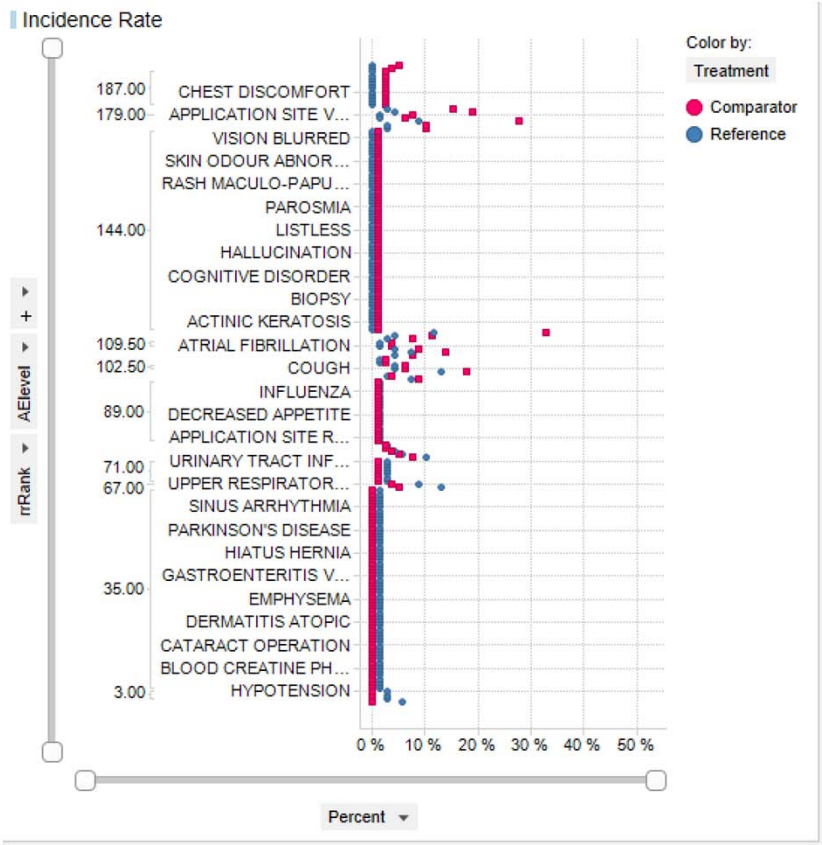
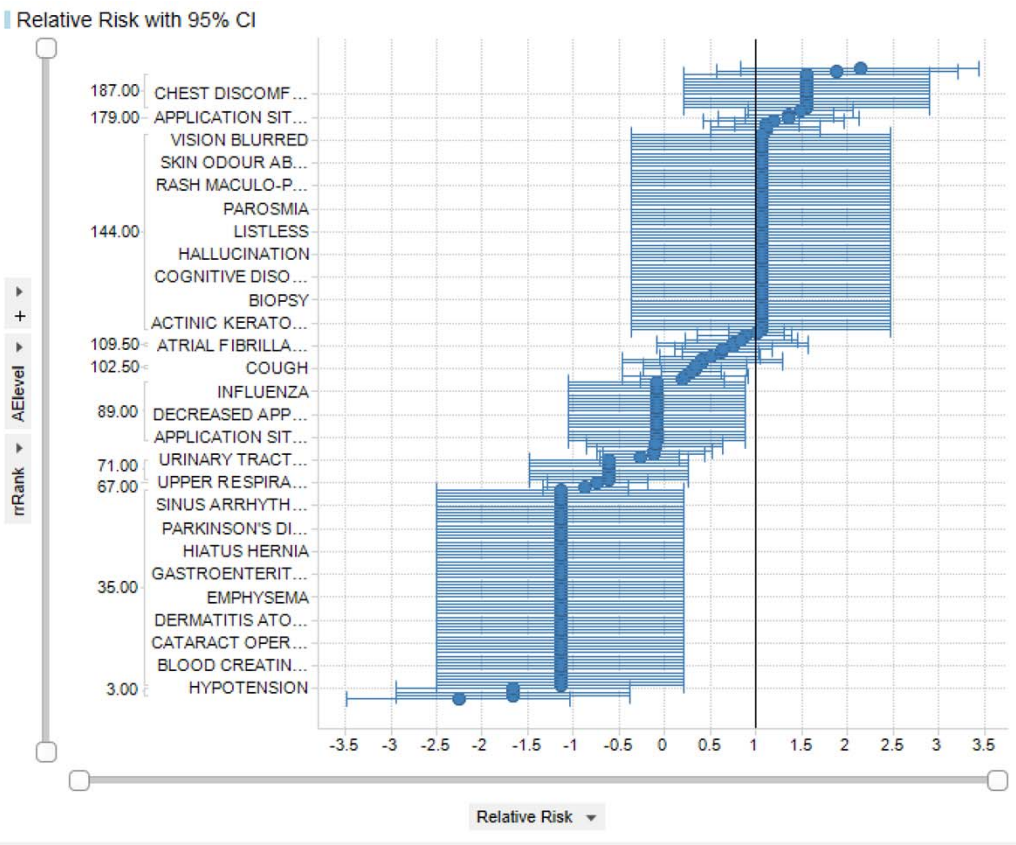
Forest Plot vs Double Dot Plot

- Forest Plot
  - No interpretation of result on natural scale of risk
- Double Dot Plot adds raw risks in each study to Forest Plot in an additional panel

TIBCO Spotfire® | Epidemiology – Double Dot Plot (AE Example)





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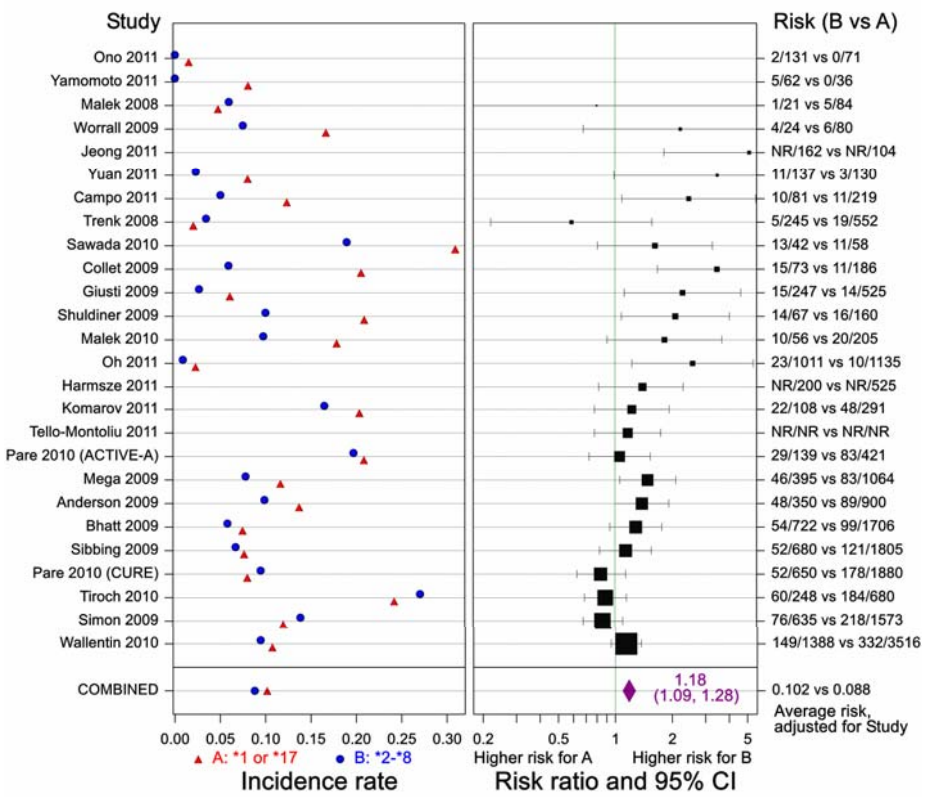
TIBCO Spotfire® | Epidemiology – Double Dot Plot (R Graphic)



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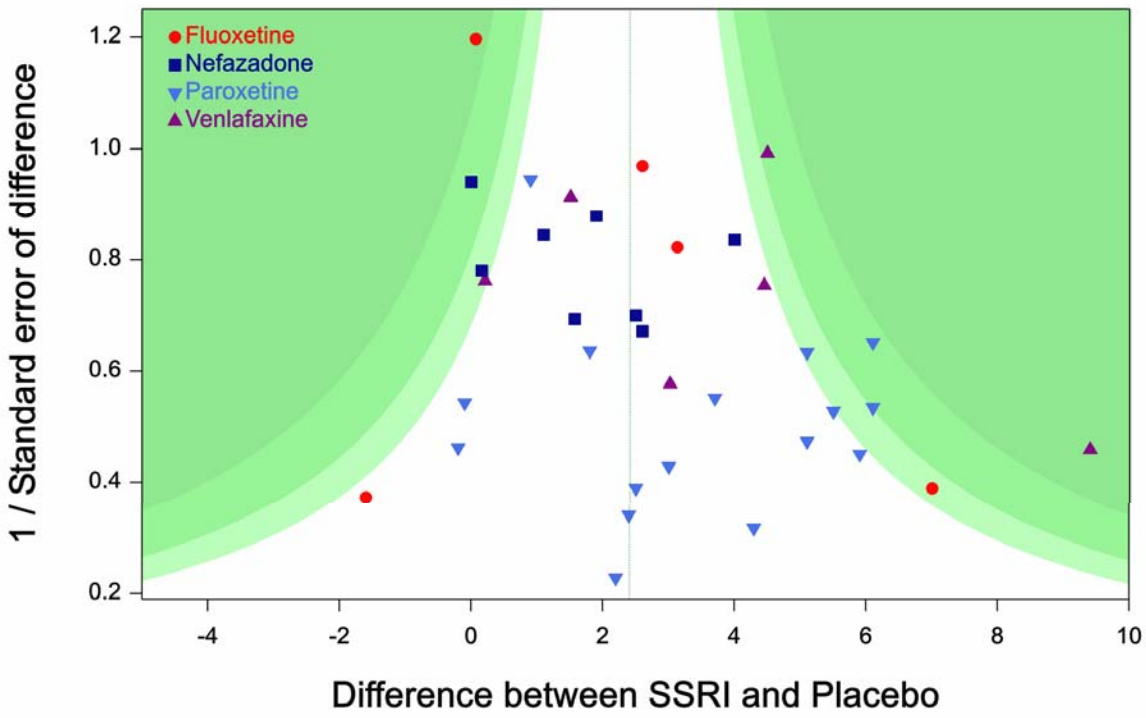
Funnel Plots

- Measure of precision of each study against estimated effect from the study
- Mainly used to assess publication bias
  - Pattern indicates a deficiency of studies with low precision and non-significant results
  - Arises with many collections of published trials because of tendency not to publish results of trials showing no significance
- R package: meta – useful for doing meta-analysis and for producing funnel plots of the results

TIBCO Spotfire® | Epidemiology – Funnel Plot Example



Significance levels of <0.01, <0.05 and <0.1

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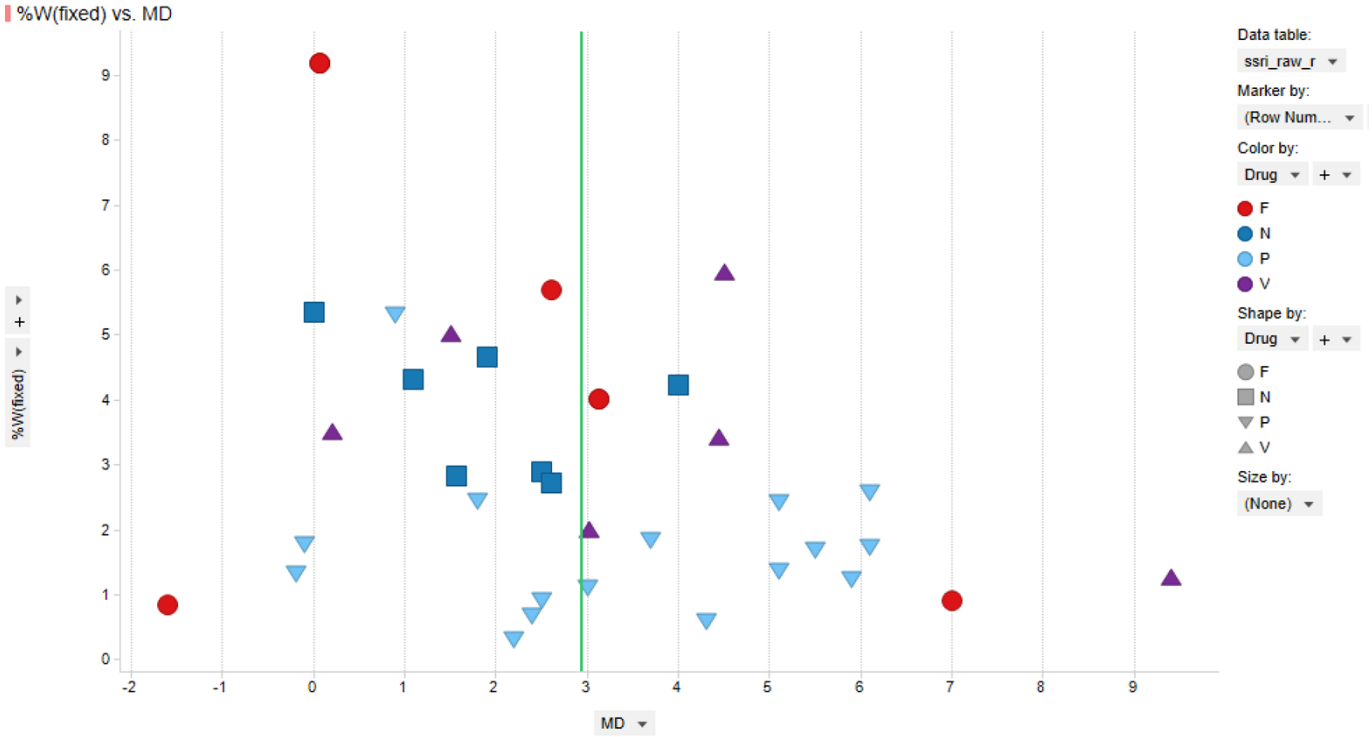
TIBCO Spotfire® | Epidemiology – Funnel Plot Example



The same plot in Spotfire. Calculations performed in R – todo: calculate and add the limit lines!

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TIBCO Spotfire® | Manufacturing Operations

- Problem
  - Control Product Quality
  - Obtain max value from expensive, complex automated equipment
- Value
  - Lowest cycle times
  - Most effective resource utilization
  - Quality Product
  - Minimize manufacturing costs
- Use Cases
  - Real-time Operations Monitoring
  - Optimize Maintenance
  - Factory Productivity
  - Process Capability & Control
  - Root Cause w/ Sensors

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TIBCO Spotfire® | Manufacturing – Control Charts

- Monitoring control charts:
  - Detect changes as soon as they occur
  - Predictor: Classic: time only; Advanced: time & any other market or product characteristics
  - Response: Any KPI
- Classic: all types of Shewhart control charts with Western Electric, Nelson rules
  - continuous, attribute or count data
- Uses CRAN qcc package
- For Advanced: multivariate, custom nonparametric models deployed

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TIBCO Spotfire® | Manufacturing – Root Cause Analysis

- Problem
  - Product quality problems difficult to accurately diagnose for complex manufacturing processes
  - Big Data problem – millions of units, hundreds / thousands of predictors
  - Response: Product Fail Bin or measurement
  - Predictors: in-process sensor / product measurements and equipment factors
- Value
  - Being used by customers to find previously undetected yield problems. Reduces time-to-market and increases profit.
- Method
  - GBM analysis template to identify significant predictors, interactions and nonlinearities
  - For large datasets, hybrid data access used to perform variable reduction step in-DB
  - Simple interface – easy for business analyst to run and interpret results

Gradient Boosted Modelling (Machine Learning)

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Manufacturing – Different Perspectives

Operator: Line Status

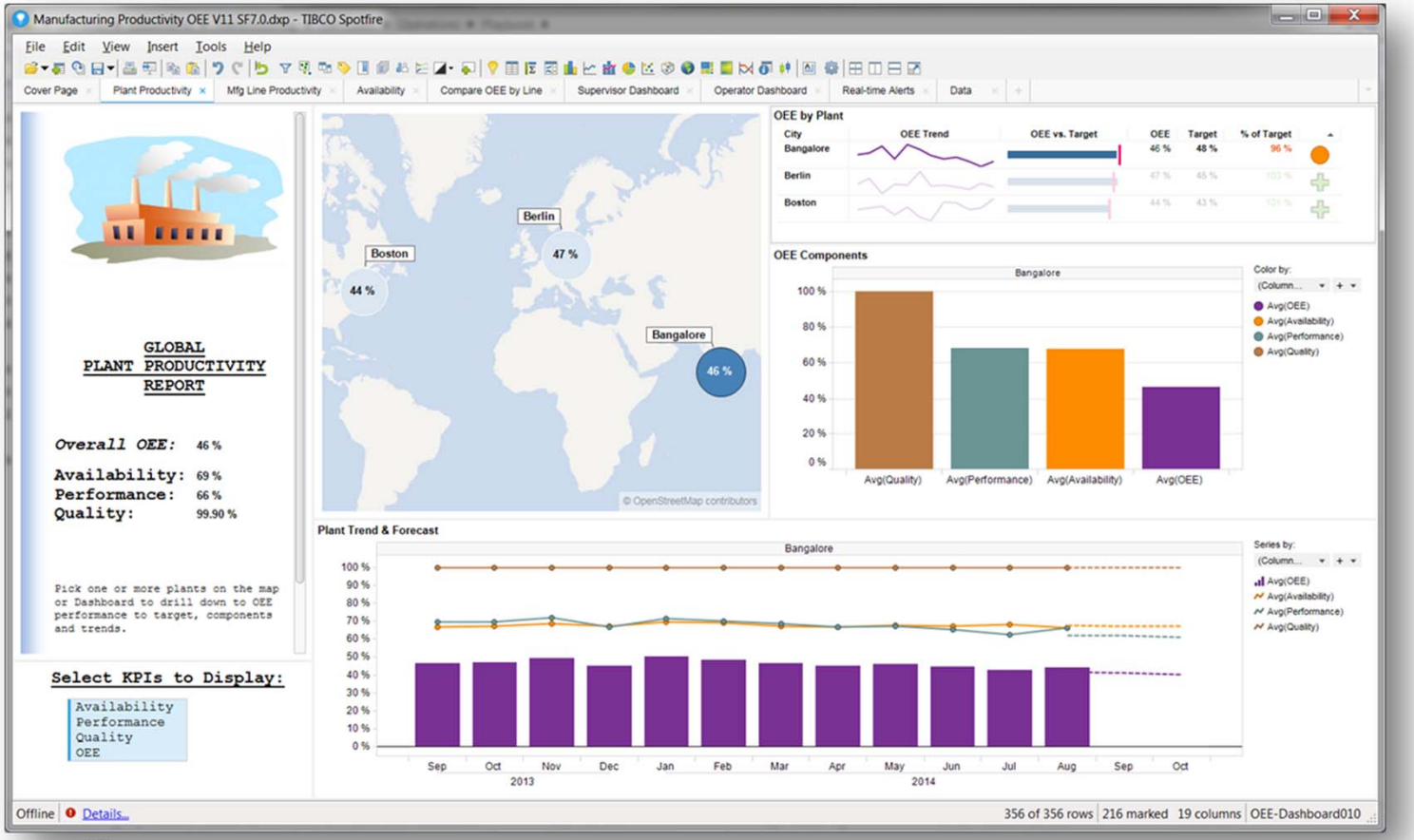
- Are the machines all operating normally?
- Are sensor readings normal?
- Is there an alert of a predictor of a failure

TIBCO Spotfire® | Manufacturing – Different Perspectives

Supervisor

- Monitoring dashboard
  - Looking at overall production line
  - Predicting failure
  - Optimising production

TIBCO Spotfire® | Manufacturing Productivity - OEE



OEE is calculated by multiplying Availability, Performance and Quality percentages together

Theory of Constraints suggests that it is most effectively used to increase productivity of synchronized lines or bottleneck equipment.

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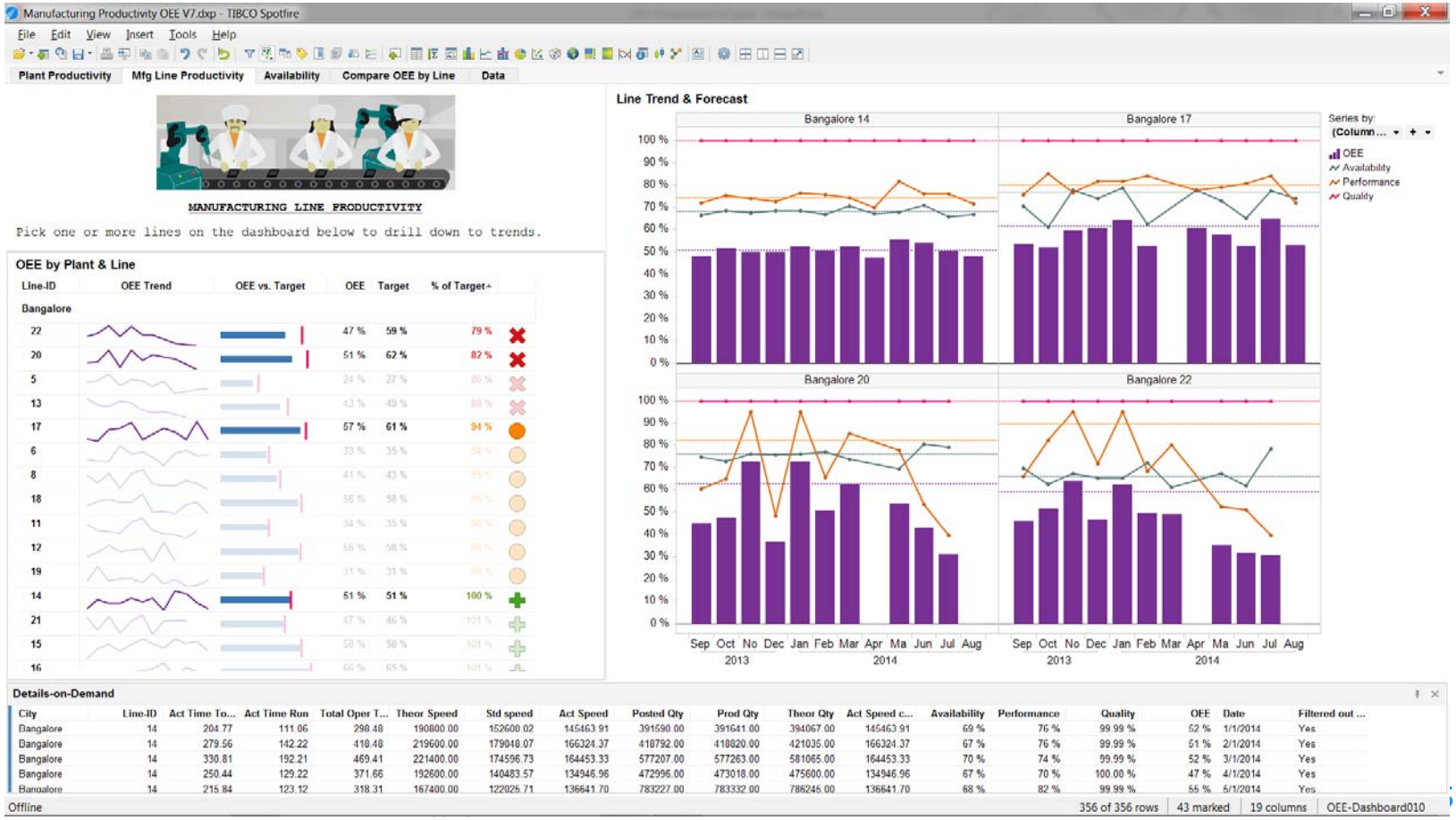
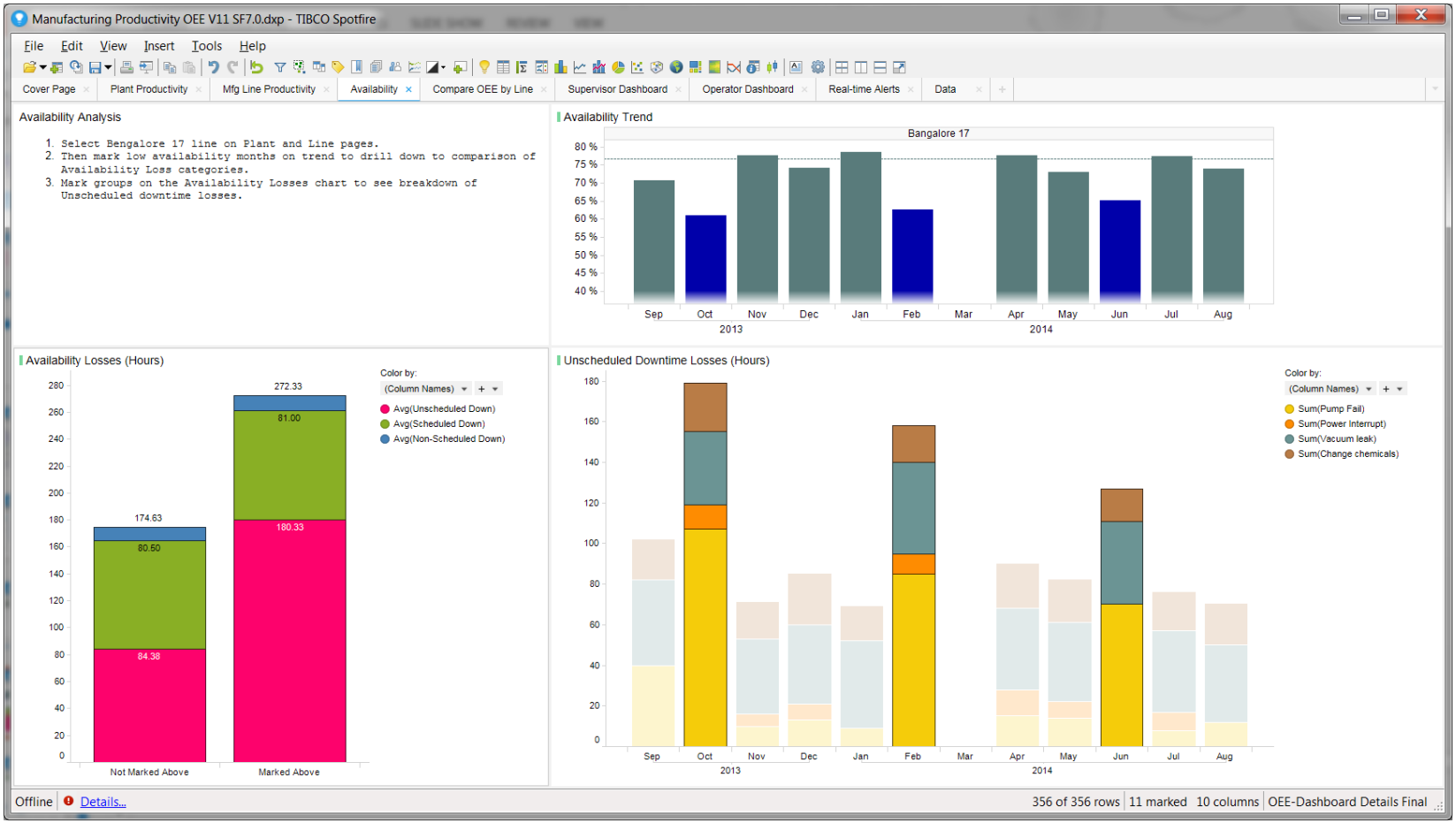
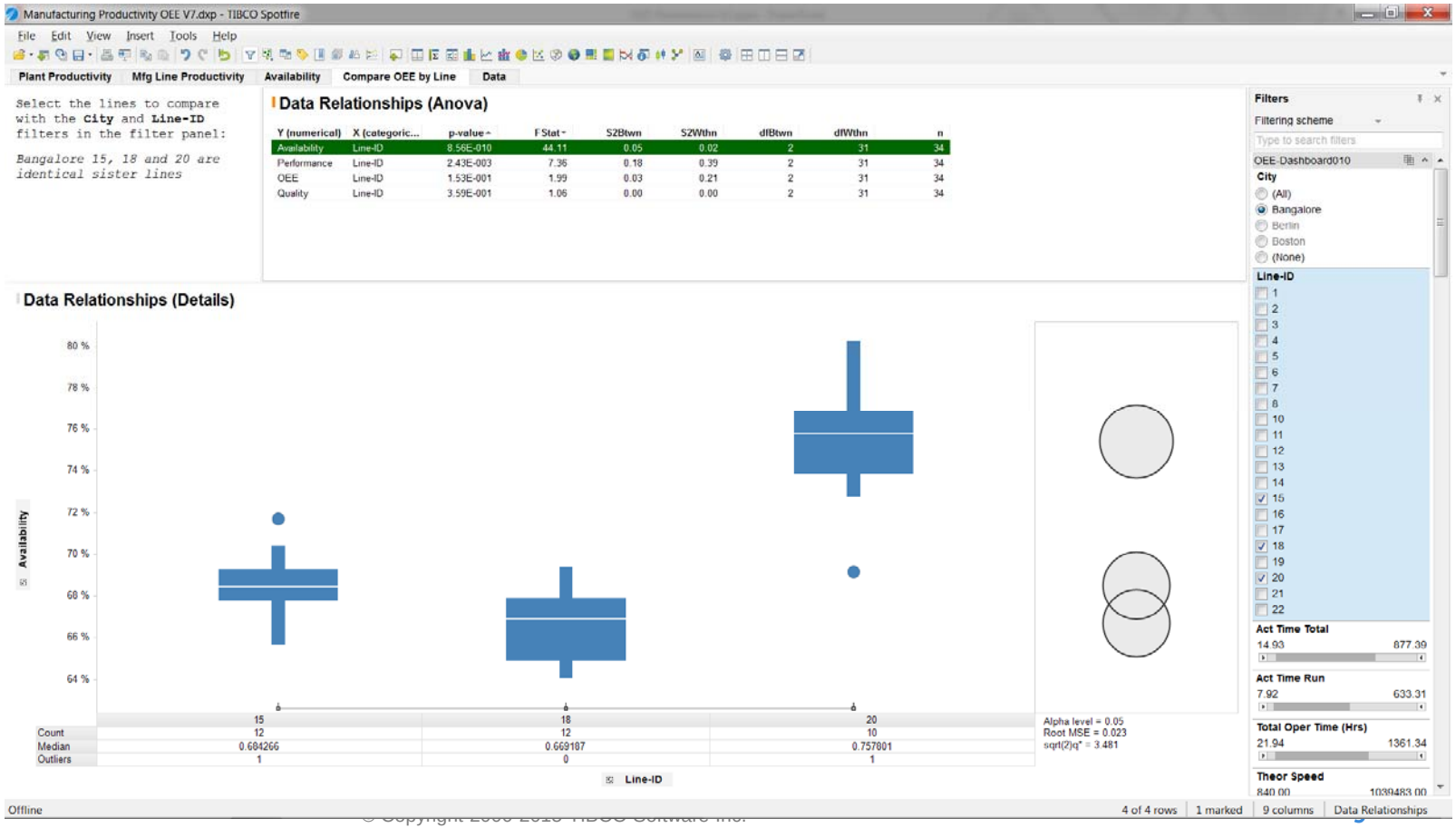
TIBCO Spotfire® | Manufacturing: Line Productivity



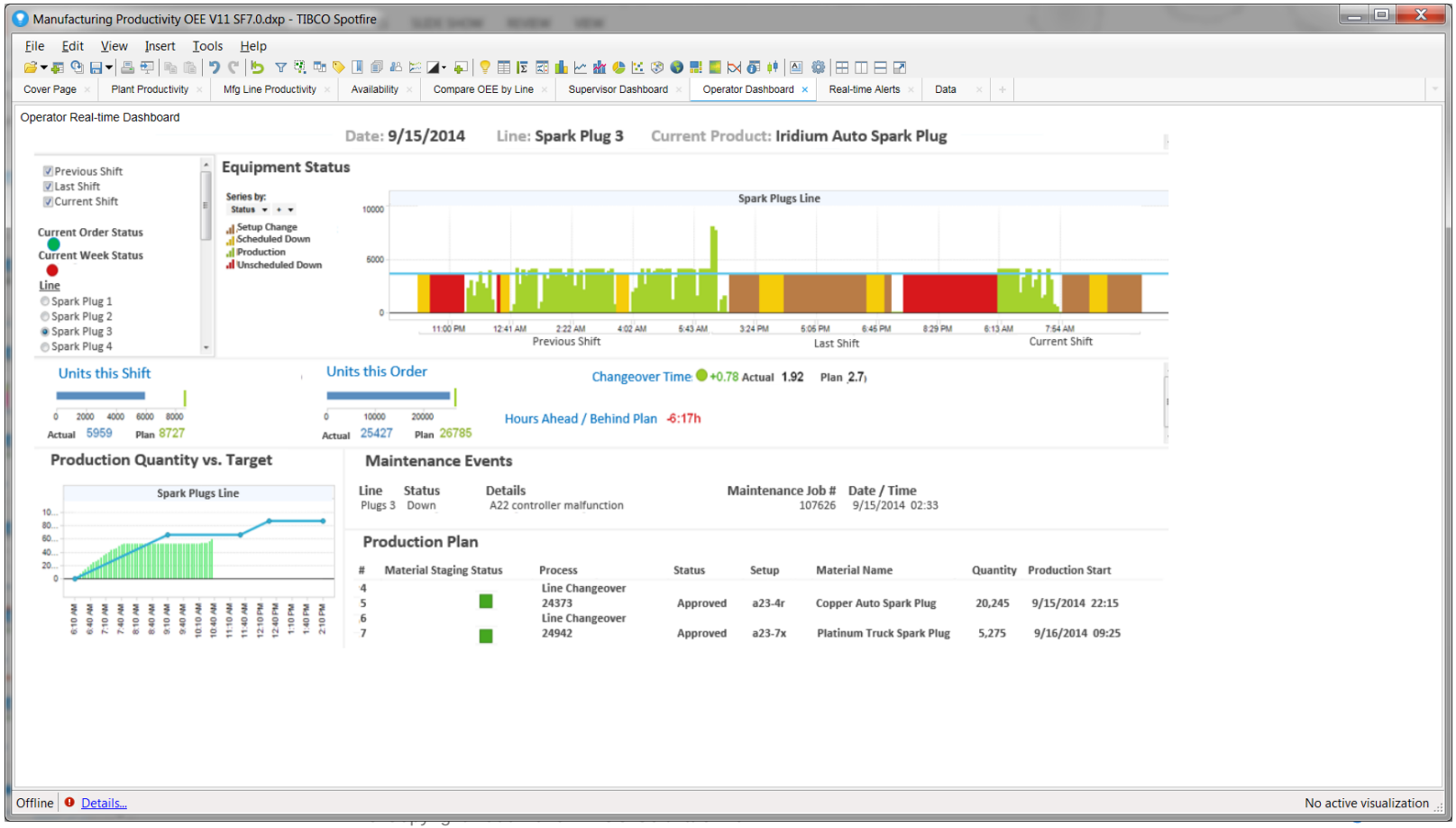
TIBCO Spotfire® | Manufacturing: Availability



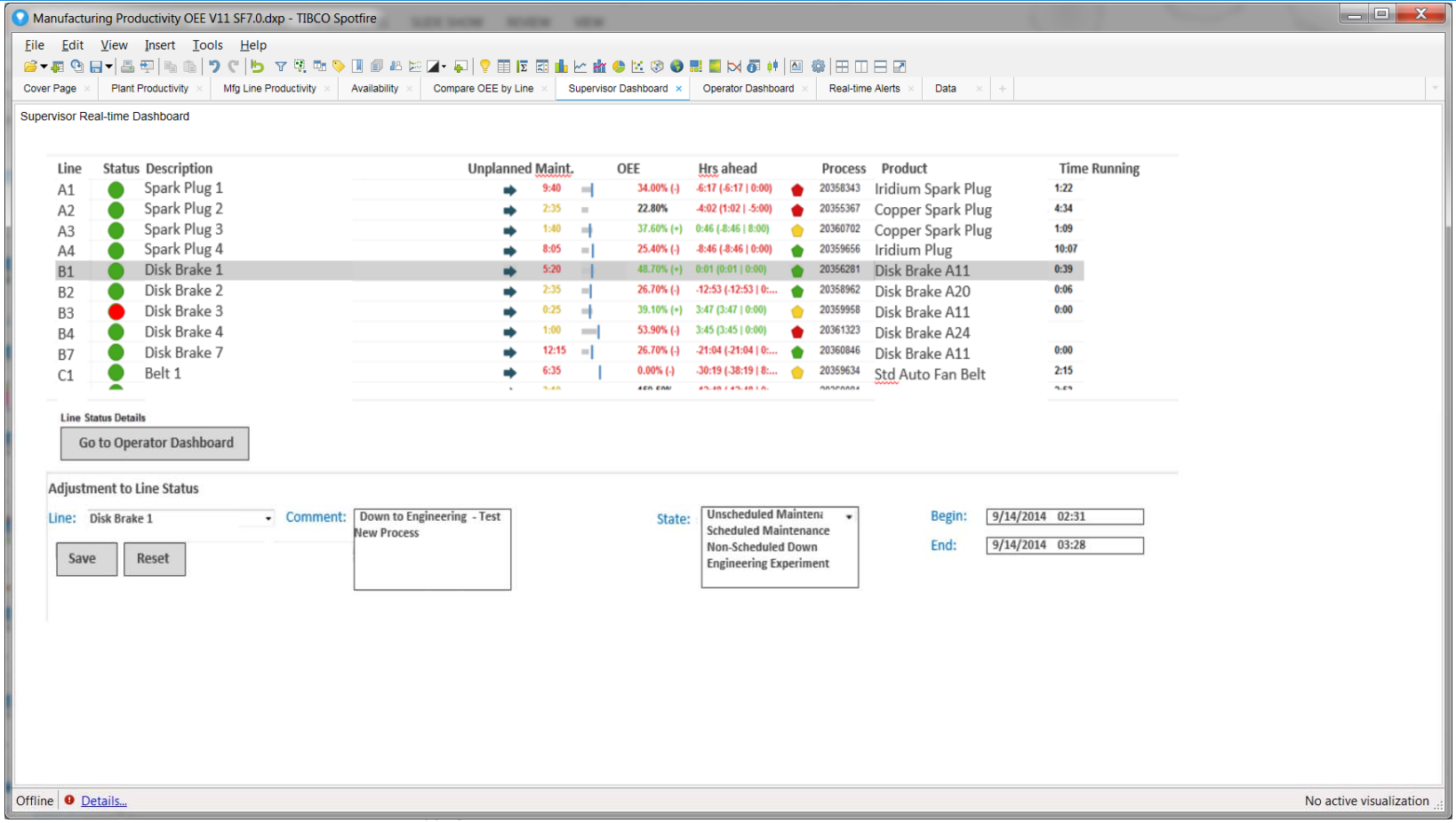
TIBCO Spotfire® | Manufacturing: Comparison of Lines



TIBCO Spotfire® | Manufacturing: Real-Time Operator Dashboard



TIBCO Spotfire® | Manufacturing: Real-Time Supervisor Dashboard



Line	Status	Description	Unplanned Maint.	OEE	Hrs ahead	Process	Product	Time Running
A1		Spark Plug 1	9:40	34.00% (-)	-6:17 (-6:17 | 0:00)	20358343	Iridium Spark Plug	1:22
A2		Spark Plug 2	2:35	22.80%	-4:02 (1:02 | -5:00)	20355367	Copper Spark Plug	4:34
A3		Spark Plug 3	1:40	37.60% (+)	0:46 (-8:46 | 8:00)	20360702	Copper Spark Plug	1:09
A4		Spark Plug 4	8:05	25.40% (-)	-8:46 (-8:46 | 0:00)	20359656	Iridium Plug	10:07
B1		Disk Brake 1	5:20	48.70% (+)	0:01 (0:01 | 0:00)	20356281	Disk Brake A11	0:39
B2		Disk Brake 2	2:35	26.70% (-)	-12:53 (-12:53 | 0:...	20358962	Disk Brake A20	0:06
B3		Disk Brake 3	0:25	39.10% (+)	3:47 (3:47 | 0:00)	20359958	Disk Brake A11	0:00
B4		Disk Brake 4	1:00	53.90% (-)	3:45 (3:45 | 0:00)	20361323	Disk Brake A24	
B7		Disk Brake 7	12:15	26.70% (-)	-21:04 (-21:04 | 0:...	20360846	Disk Brake A11	0:00
C1		Belt 1	6:35	0.00% (-)	-30:19 (-38:19 | 8:...	20359634	Std Auto Fan Belt	2:15

Accessibility

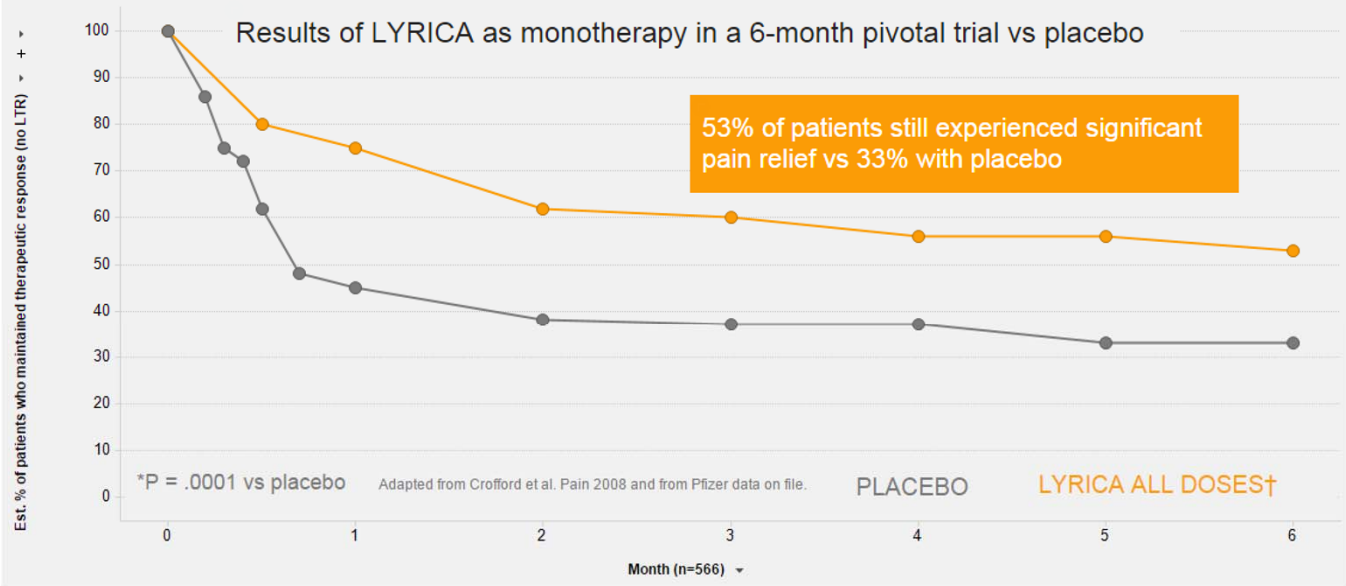
- Graphics for sales and marketing should be simple
- Accessible to senior managers or general public
- Don’t require background in statistics!
- Limit to simple charts like line charts, bar charts, etc.

TIBCO Spotfire | Sales and Marketing: LYRICA Example

LYRICA.dxp - TIBCO Spotfire

File Edit View Insert Tools Help

LYRICA Infographic



- Patients randomized to treatment in the double-blind 6-month phase and treated with LYRICA reported feeling better (as measured by PGIC) for a longer period of time than did placebo-treated patients (P=.0001).

†Includes studied 600 mg/day dosage; 450 mg/day is the maximum recommended dose for FM patients. LTR=loss of therapeutic response; PGIC=Patient Global Impression of Change.

Statistically significant results despite a challenging patient population

- Patients had a history of FM and moderate to severe pain at baseline
- No dose adjustments were allowed during the 6-month double-blind phase
- LTR was difficult to maintain, based on 3 stringent criteria
- Study Description

IMPORTANT SAFETY INFORMATION & INDICATIONS

LYRICA is contraindicated in patients with known hypersensitivity to pregabalin or any of its other components. Angioedema and hypersensitivity reactions have occurred in patients receiving pregabalin therapy.

There have been postmarketing reports of hypersensitivity in patients shortly after initiation of treatment with LYRICA. Adverse reactions included skin redness, blisters, hives, rash, dyspnea, and wheezing. Discontinue LYRICA immediately in patients with these symptoms.

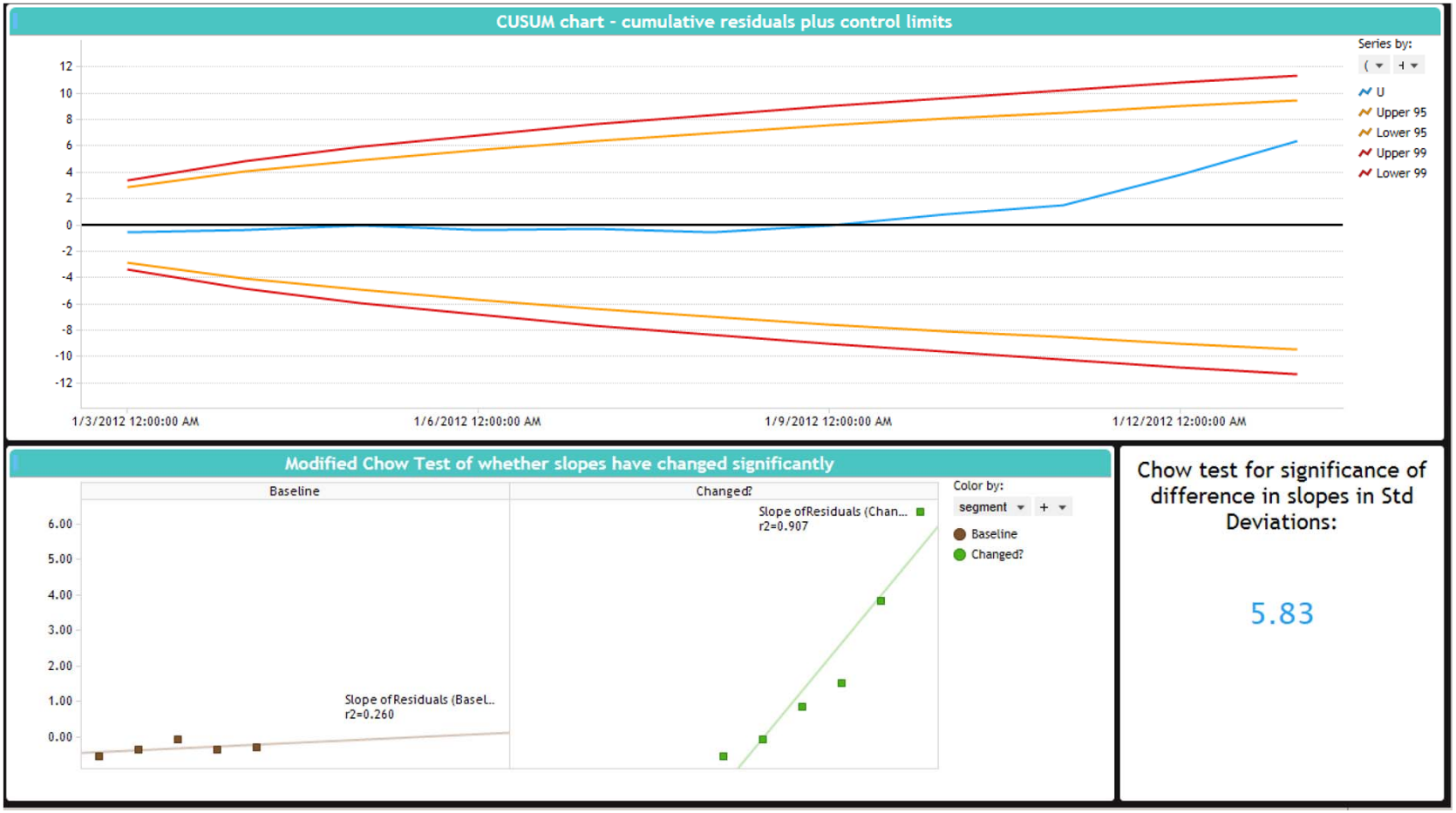
Trend breaks of a certain metric – widely sought information

- Identify effect of sales promotions, economy, bad publicity, loss of exclusivity, etc.
  - Positive effects
  - Negative effects
- Typically look at NRx (new Rx scripts prescribers write), Total Rx, NRx Market Share and TRx Market Share
- Looking at the raw metrics, it can be difficult to identify if the trend is positive or negative
- Use CUSUM control chart

CUSUM Control Chart in combination with statistical test – e.g. Chow Test

- The Cumulative Sum plot shows the trend…
  - … but the trend may not cross the confidence bounds
  - So the CUSUM can be too slow in detecting trend breaks
  - ... Therefore good idea to use Chow test and present the results simultaneously
- We often divide the chart into two equal halves, estimate the slope in each half
- Then apply a t-test to conclude whether the change in slopes is statistically significant

TIBCO Spotfire® | CUSUM With Chow Test



Optimise the number of visits for the best benefit

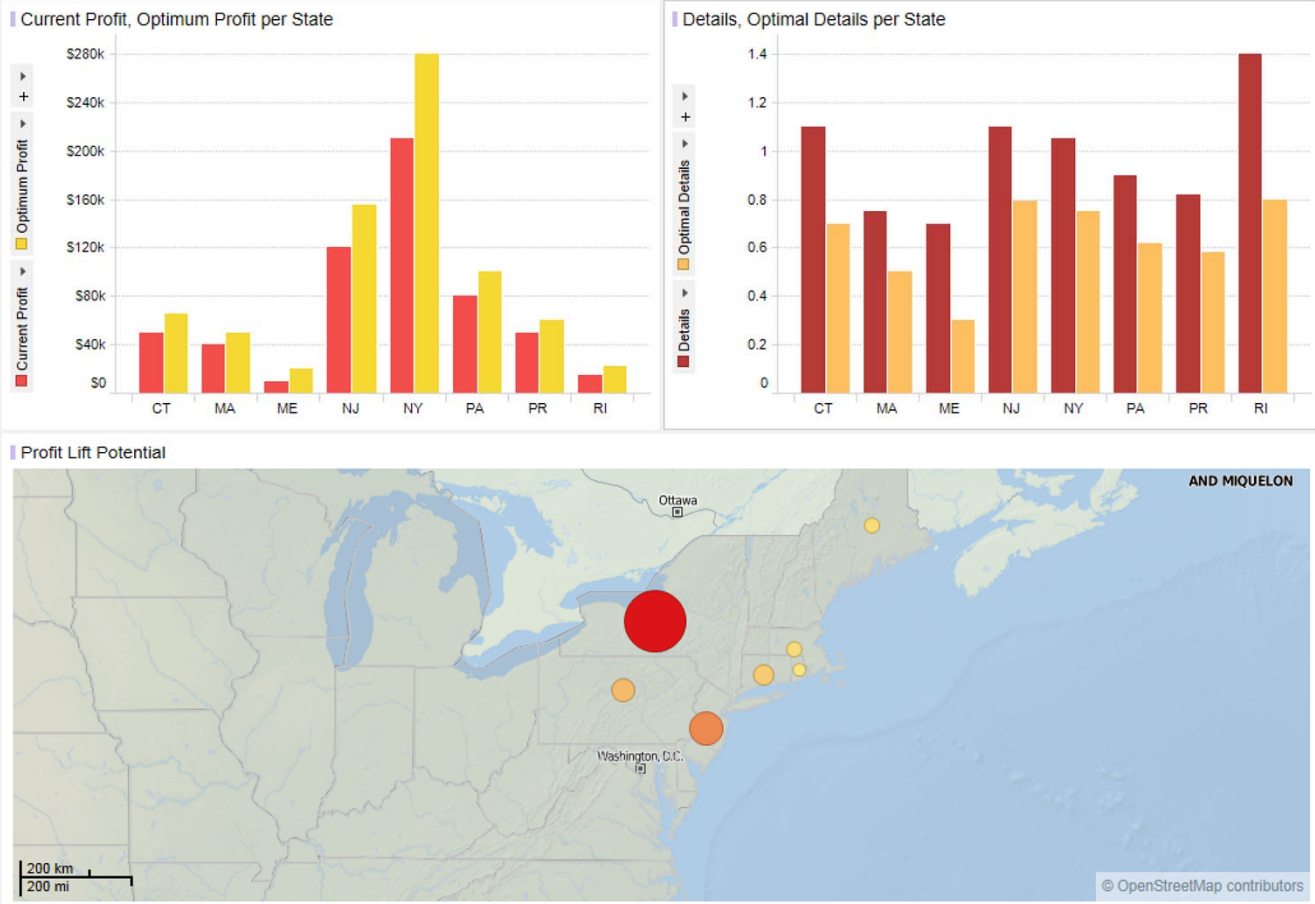
- Too frequently could have negative impacts
  - Cannibalisation of sales (reduction of sales of one product due to introduction of a new product)
- Too infrequently
  - Could result in new patients starting on competing brands
- Detailing (number of times a field representative visits a doctor's office) at a level close to optimum is important

Field Force Optimisation

Optimise the number of visits for the best benefit

- Doctor response to detailing estimated by using marketing mix models
  - Control all drivers for prescribing behaviour
  - While estimating the response parameter of interest

TIBCO Spotfire® | Field Force Optimisation



Three graphs in unison allow user to immediately identify where the most benefit is to be had (complex are hidden)

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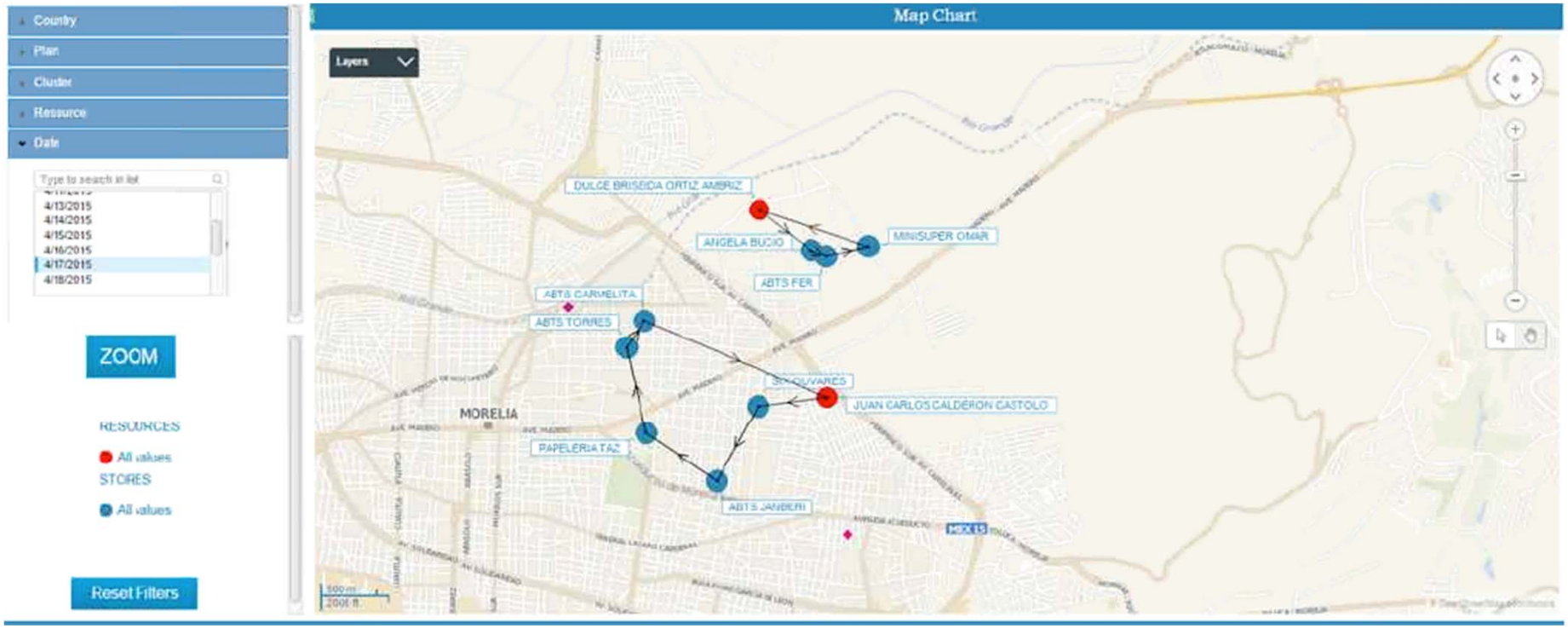
Optimise driving routes and schedules

- With multiple sales representatives visiting multiple doctors, the problem of optimising routes and schedules is complicated!
- Many variables, many possible solutions to the problem
- Genetic algorithms in combination with geo-analytics
  - Each part solution to the problem has a “fitness” based on several KPIs
  - Evolve generations of the solutions based on the previous best solutions, combining “genes” and performing random mutations

TIBCO Spotfire® | Field Force Optimisation – Optimise Driving Routes

Optimise driving routes and schedules



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  - Infographics
  - Trend Analysis
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TIBCO Spotfire® | Useful reading/references

Forest Plots

- Thomas Lumley

Double-dot Plots

- Amit O.
- Heiberger R
- Peter Lane

Funnel Plots

- Peter Lane

Sales and Marketing

- Sam Weerahandi
- Birol Emir
- Ed Whalen

A Picture is Worth a Thousand Tables, O'Connell, Krause, et al.

Chapters:
15: Graphics for Meta-Analysis
20: Post-approval Uses of Clinical Data, Phase IV Data and Sales and Marketing Data

Thank You and Contact Details

Thank you!

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