Geometric Process Control

Process and Product Improvement through Visual Data Mining

Affordable Real-Time Optimisation from Bakeries to Oil Refineries

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www.curvaceous.com

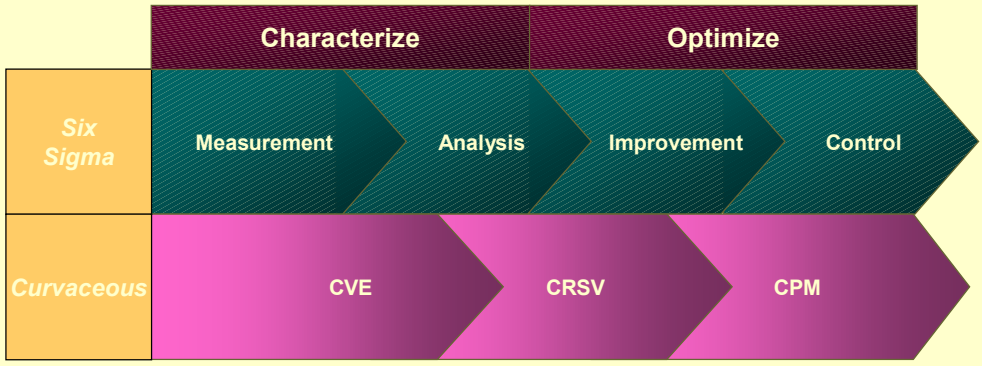
Curvaceous Software

- Founded in 1998 to research and develop applications of n-dimensional geometry for the process industries.
- A 25-year goal to find a practical way to analyse process history data…hundreds of variables in ONE graph. Unification of Process Control, Quality Control AND Alarm Management. First method of calculating values for Alarm Limits
- Several new discoveries including one patent granted and several more in progress
- 60+ Customers, mostly in UK
- Claims proven in two Field Trials at large UK chemicals sites
- Winners of the EPSC 2003 Award for the Biggest Single Contribution to Increasing Plant Safety

Some Curvaceous Clients

ICI	Conoco	Nestle
BNFL	Genzyme	Nova Chemicals
Mallinckrodt	INCO	Heinz
Carnaud Metal Box	Dow Corning	Ineos Chlor
Texaco	GlaxoSmithKline	BAE Eurofighter
Infineon	Philips Petroleum	Marathon Oil
LaFarge Cement	Ethyl Petroleum	DSM
Advanced Elastomers	PCS Potash	Cabot Carbon
BAE Rockets	James Robinson Ltd.	Pilkington Glass
Aughinish Alumina		

Curvaceous 6 Sigma Mapping



Key 'Six Sigma' Activities:

- Select key product
- Define performance variables
- Create process map
- Select performance variables
- Benchmark
- Identify success factors
- Define goal
- Propose causal variables
- Confirm causal variables
- Establish operating limits
- Verify performance
- Define control system
- Validate control system
- Implement control system
- Monitor performance metrics

Improving the 6 Sigma Process

How does it work ?

Process Data Mining

The Root Problem

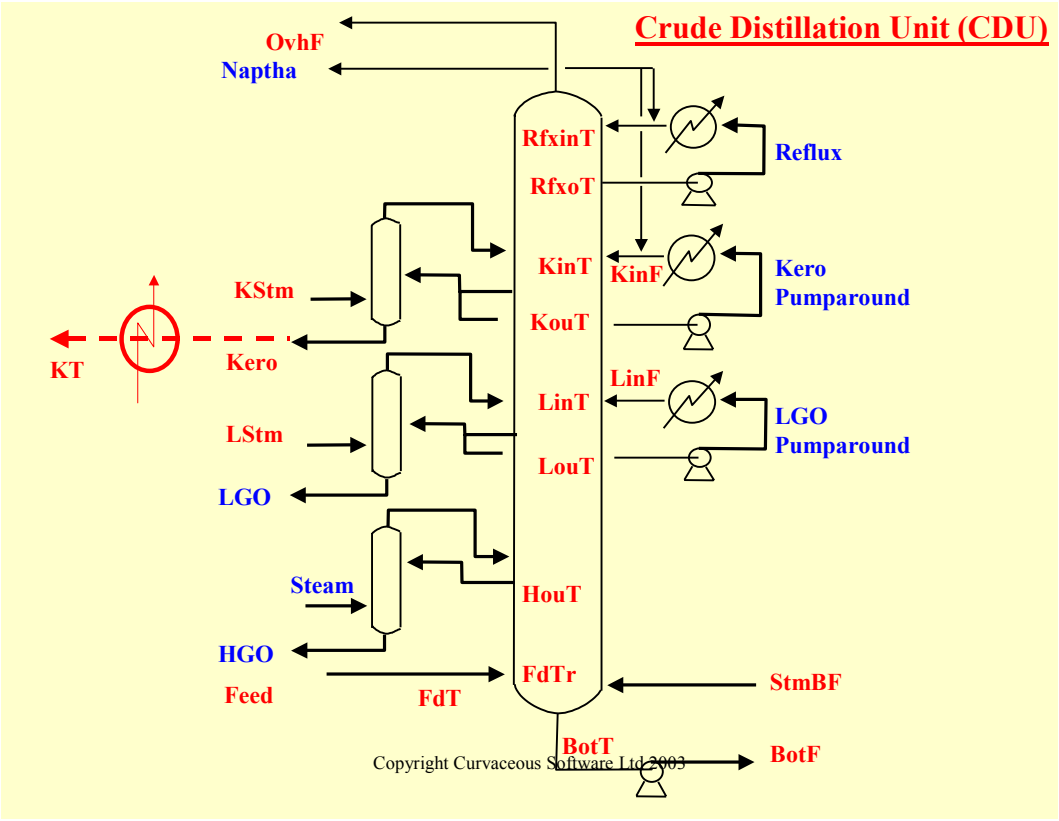
Human brains are visually oriented

Data Visualisation and Data Mining are intertwined

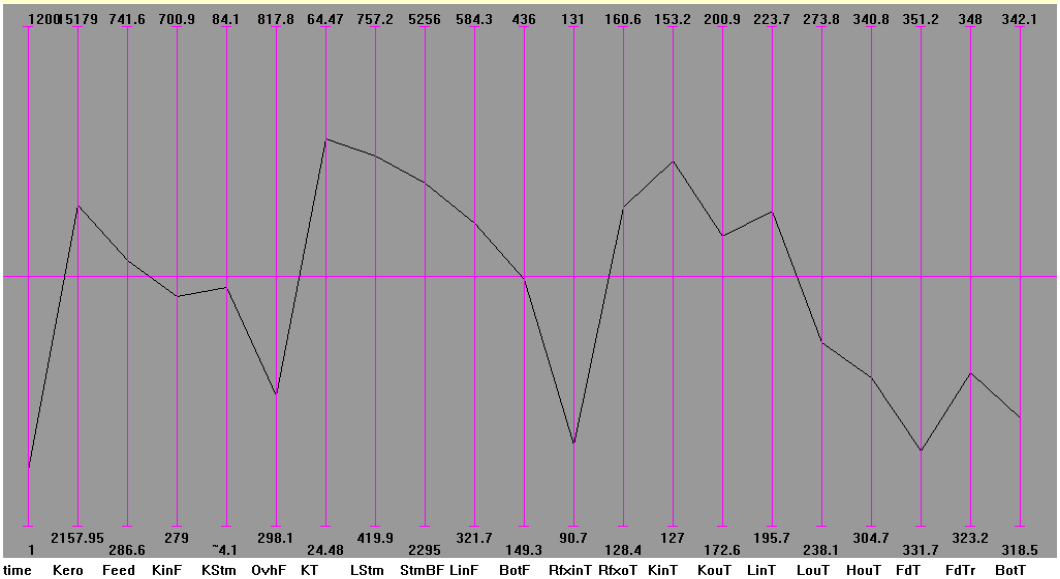
A picture is worth 1000 words

But…we can only draw a graph of 2 or 3 variables…..

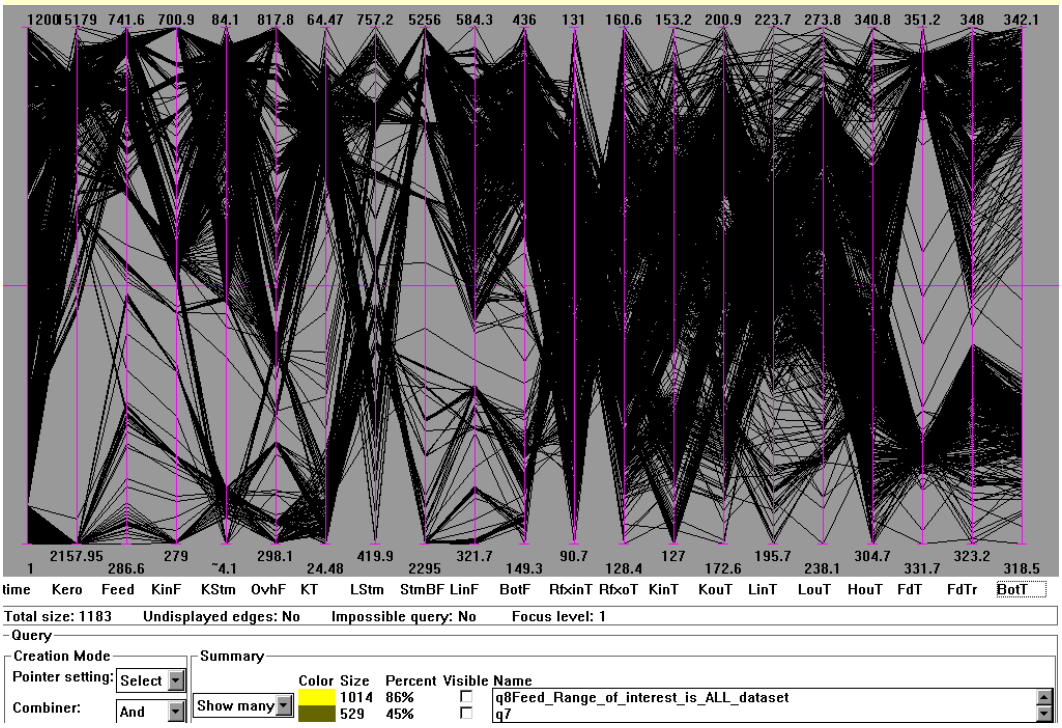
How many graphs would you need to show all the interactions between 30 variables?



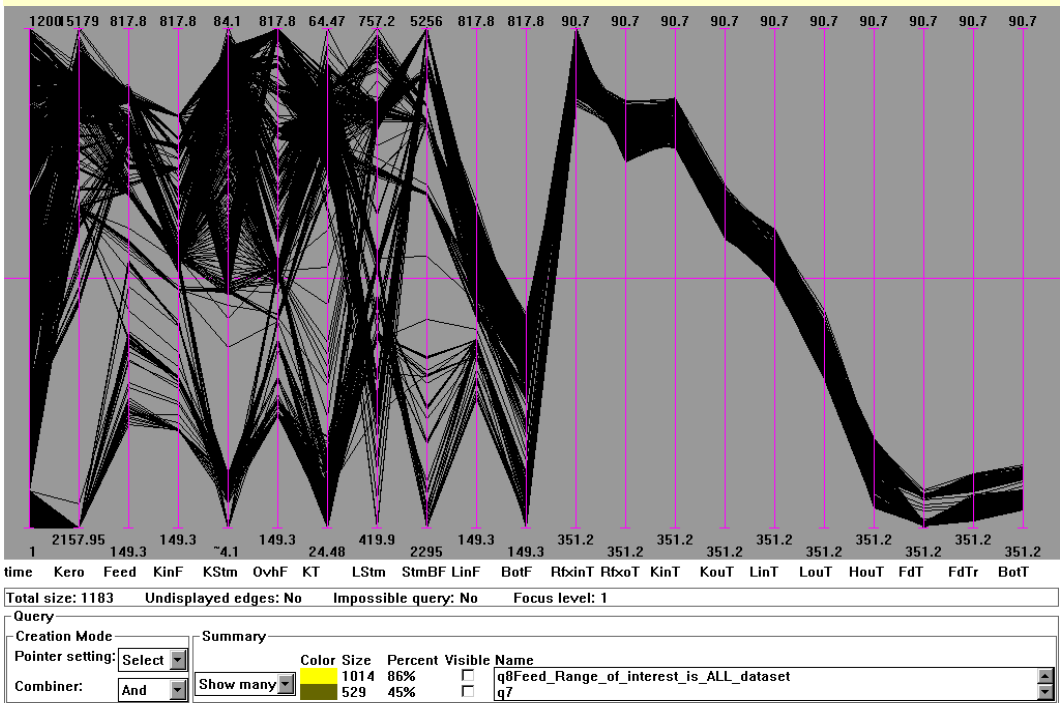
One Operating Point



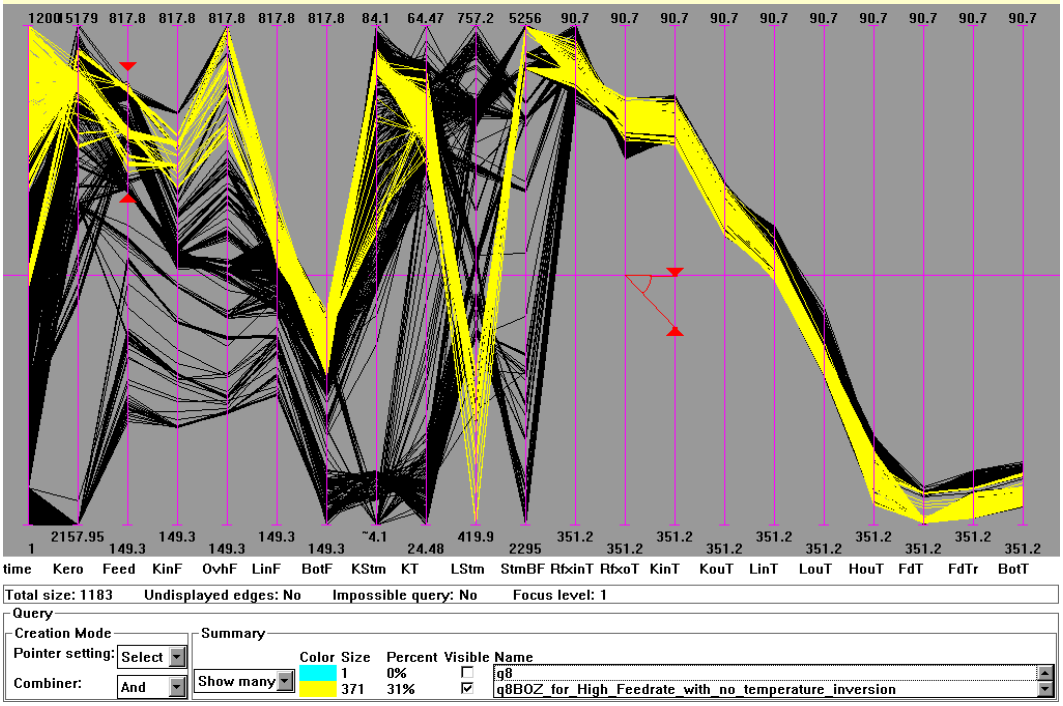
3 Months of Hourly Data



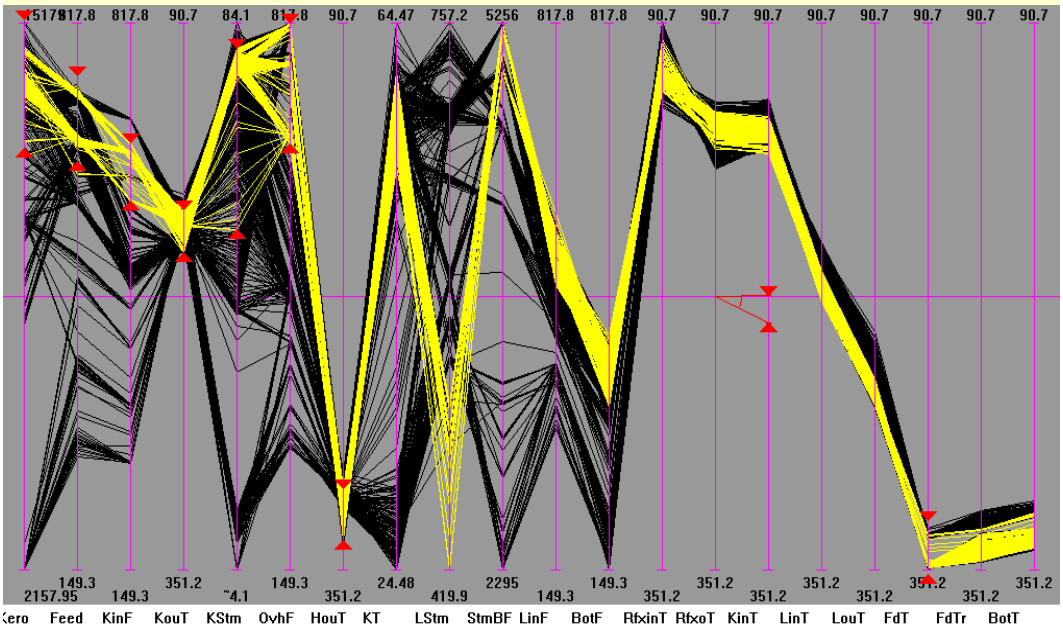
Temperature Profile



High Feed Without Inversion



Variables most affecting Inversion



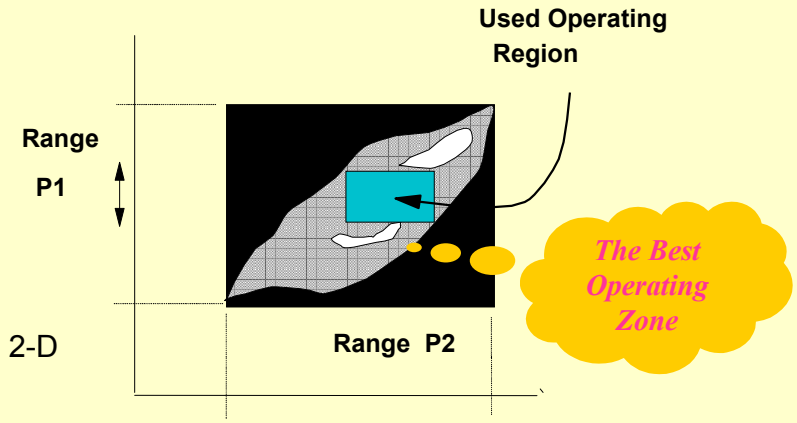
How does it work ?

Modelling
Quality Management
Alarm Management

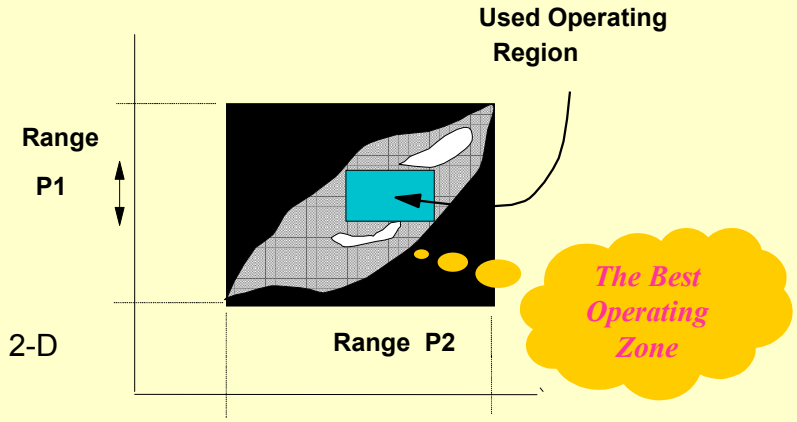
The Problems

- Operations need values of process variables that will deliver the desired quality values
- Qualities are variables that can only be measured after the product has been made, for instance product qualities, yields, efficiencies, KPI's

The Used Operating Region

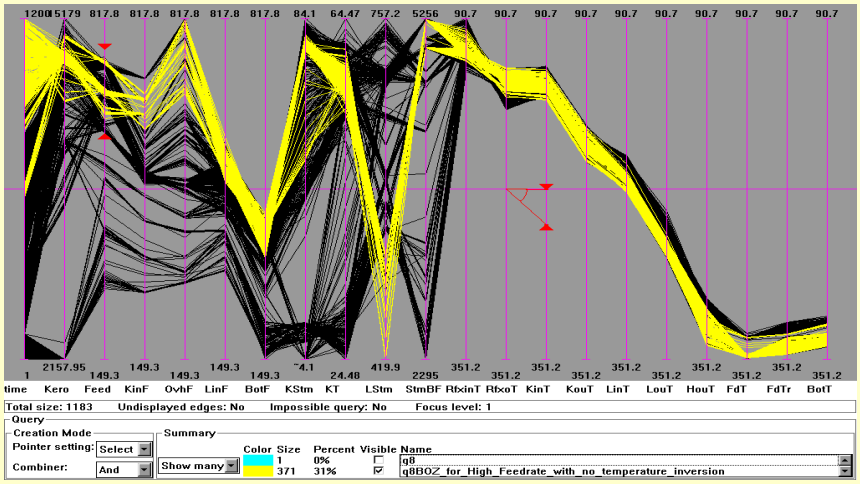


The Best Operating Zone Concept



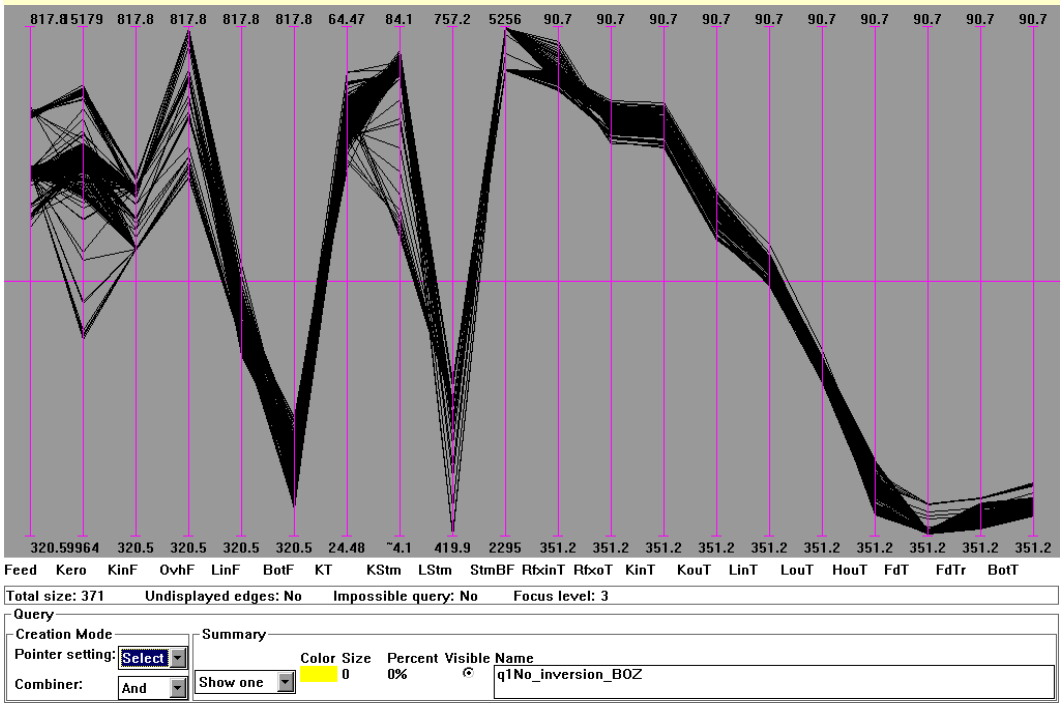
What would a 20-variable BOZ look like?

A BOZ from 20 Variables

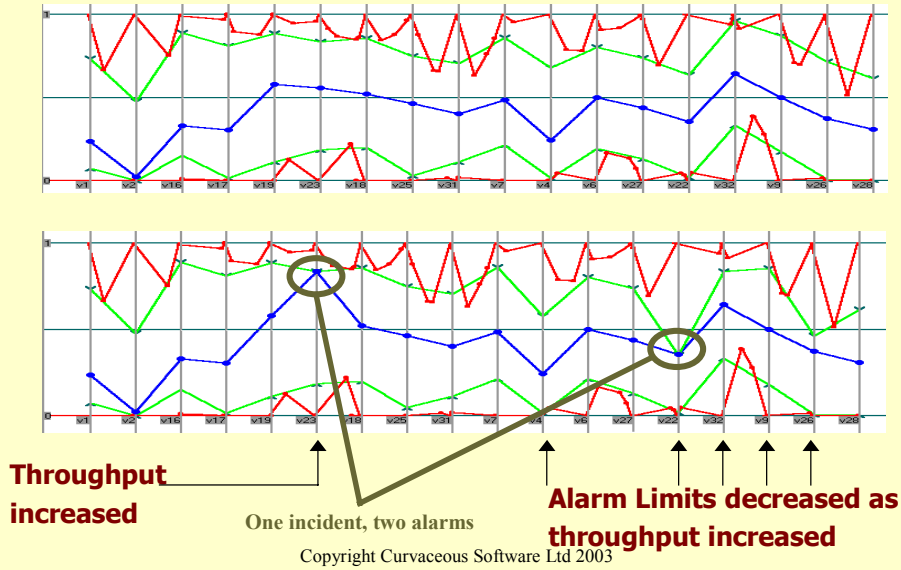


The yellow region is a 20-dimensional BOZ chosen by the specifications on feed and upper temperature inversion.

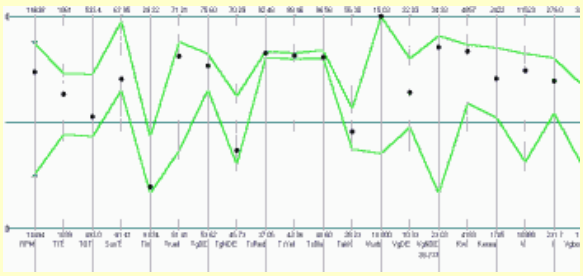
The Chosen BOZ



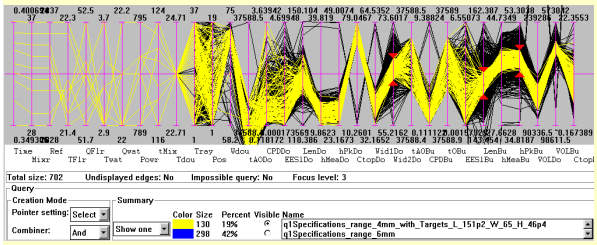
Alarms and Operating Points



Large-Scale Process Behaviour

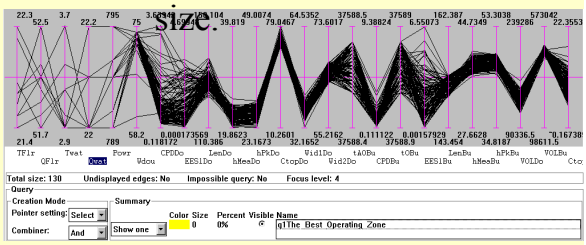


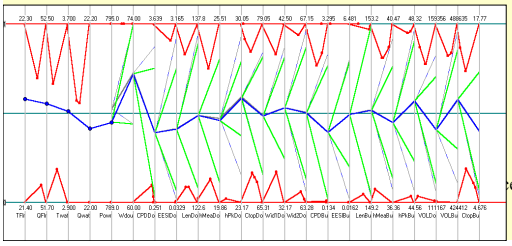
Building a CPM Model



1. Decide where to operate by applying KPI criteria as a query. The yellow area is the KPI for Buns within ±2mm of revised target size.

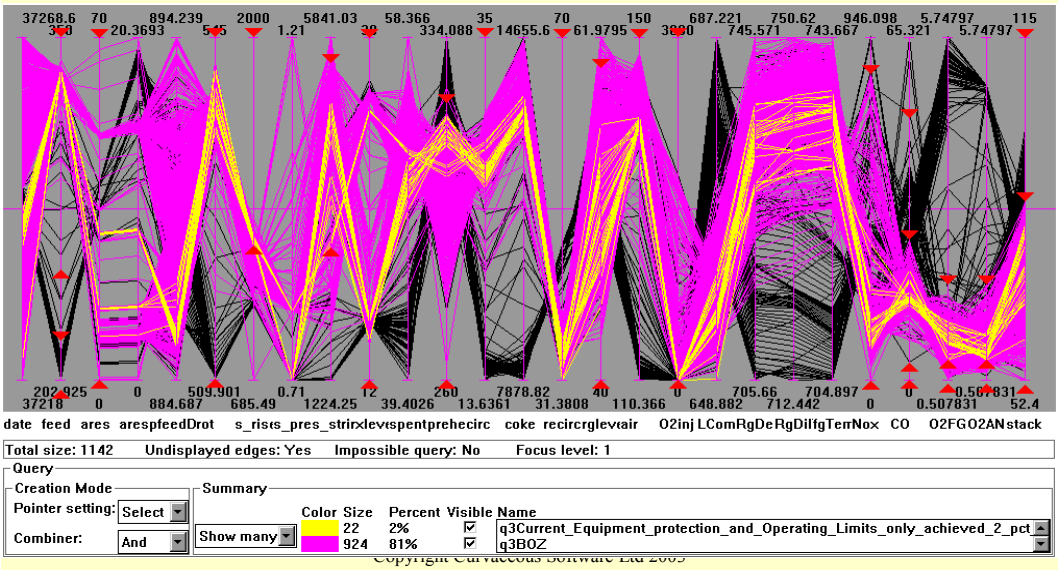
2. ‘Focus’ on the yellow points, remove unwanted variables and ‘save as’



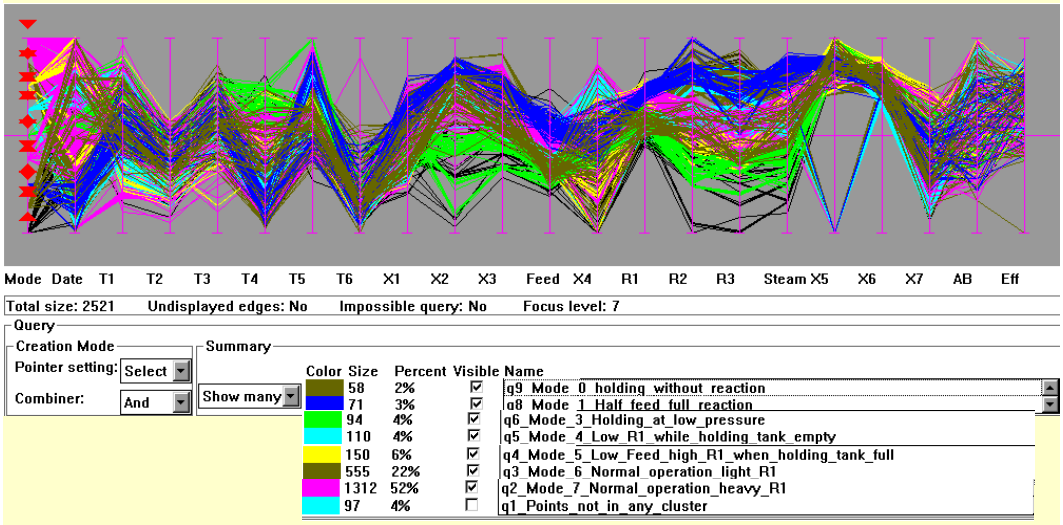


3. Open the file in CPM, create the red envelopes and start to use. Here it is being used in CRSV mode to understand variable interactions and ‘opportunity giveaway’

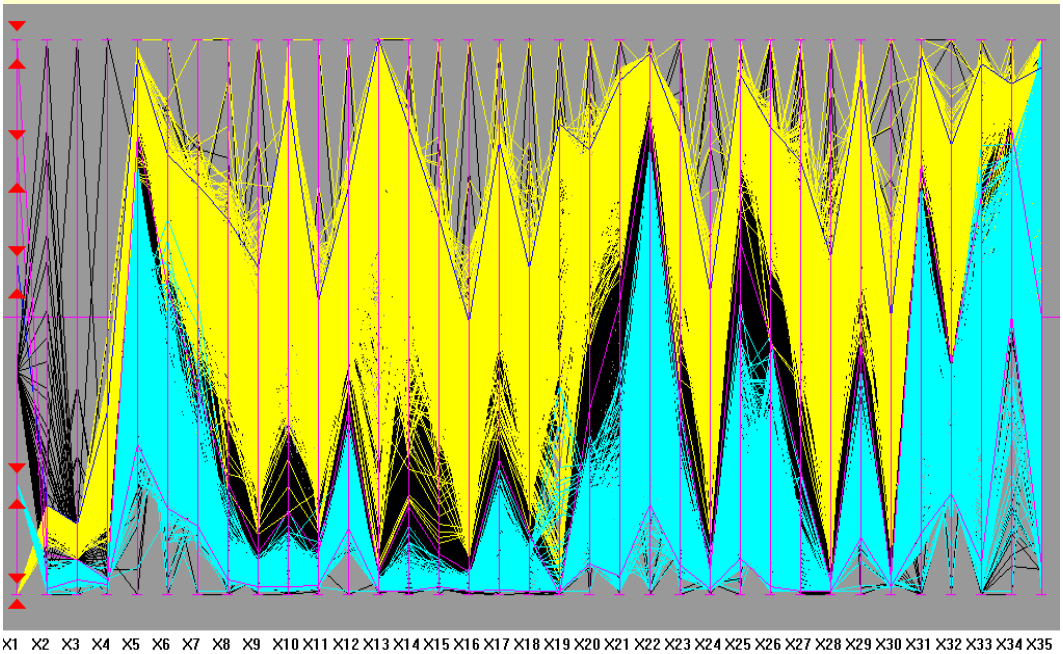
Alarms Today



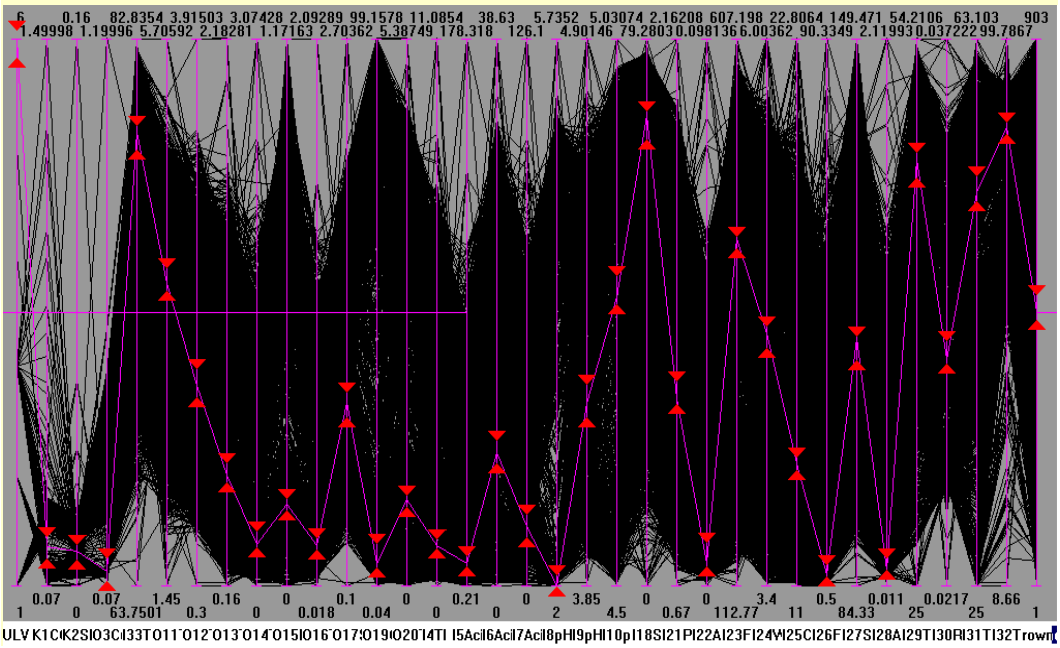
8 Modes of Operation found by Clustering on 5 main control variables



Region boundaries over 3 months of operation. Also 5th and 95th percentiles and median line



But the median is not an operating point.



Conclusions

- **Visual Analysis is much faster and much less mathematical and Communication of results to others greatly simplified – so more analysis will be done resulting in more discovery and improvements.**
- **GPC improves Six Sigma by offering multi-variate data analysis methods that anyone can use as an alternative to statistics.**
- **GPC Models are multi-variable, non-linear, cheap to implement and reduce dependence on laboratory results and online analysers**
- **Eliminate experiments in a DOE exercise.**
- **Unifying mathematics of GPC simultaneously improves product quality, process operations and process alarms and safety.**