

REVOLUTIONARY ROOT CAUSE ANALYSIS WITH SAP HANA

A confidential summary by Warwick Analytical Software Ltd



Business case – Cost of Poor Quality (COPQ)

Cost of Poor Quality (COPQ) is one of the largest cost items for manufacturing, estimated at 15% to 30% of revenue *

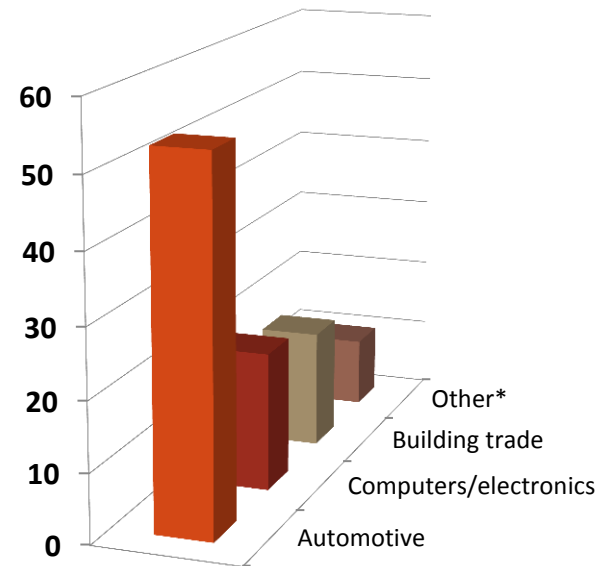
- \$72Bn pa warranty-related (c. 4% revenue)
- Internal costs (right first time and yields) \$950Bn lowest estimate**
- Excludes non-warranty service e.g. maintenance and PLM costs

* International Journal of Engineering Dec-12 average was 20%, Wang, Bhotte, Juran and Crosby cite up to 40% in some cases
 ** Warranty costs apply to certain industries, internal costs apply to all manufacturing industries, globally \$6.8 Trillion market

Manufacturing Priorities

- Improve quality/right first time
- Warranty cost reduction
- Avoid recalls/protect brand

Warranty Related Spending



Manufacturing Challenges

- Increasing complexity of products and processes
- Fault-finding as a manual hypothetical process
- Data issues – both overload and quality

* Mostly aerospace. Note that this excludes service costs post-warranty

Background

Warwick Analytics' disruptive patented technology stems from over a decade of academic research in the US and UK originating from six-sigma failures in complex manufacturing.

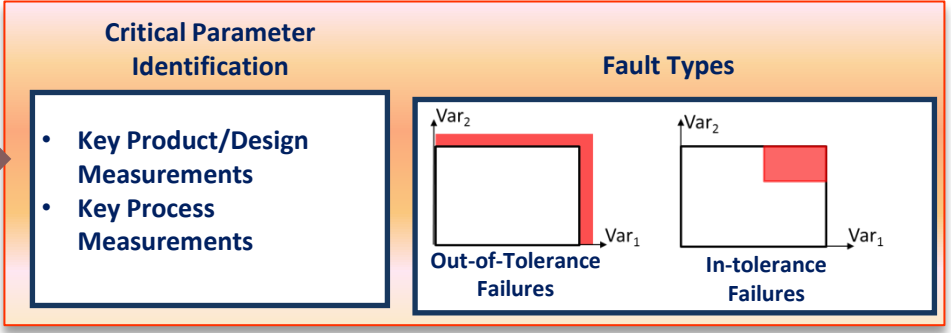
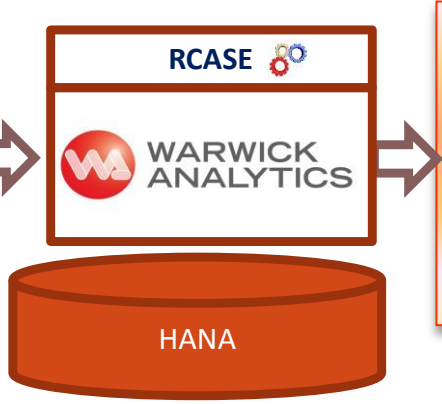
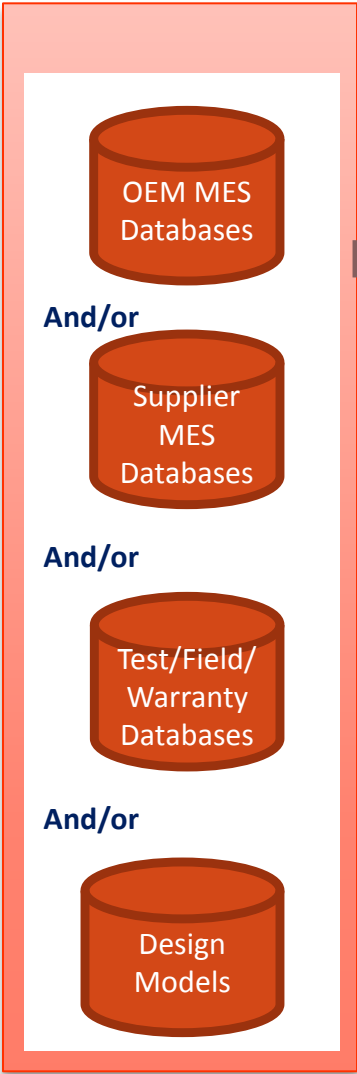
Initial deployments in electronics, the automotive sector and aerospace. However it has also been applied to the provision of healthcare services, utilities and other services.

The Technology

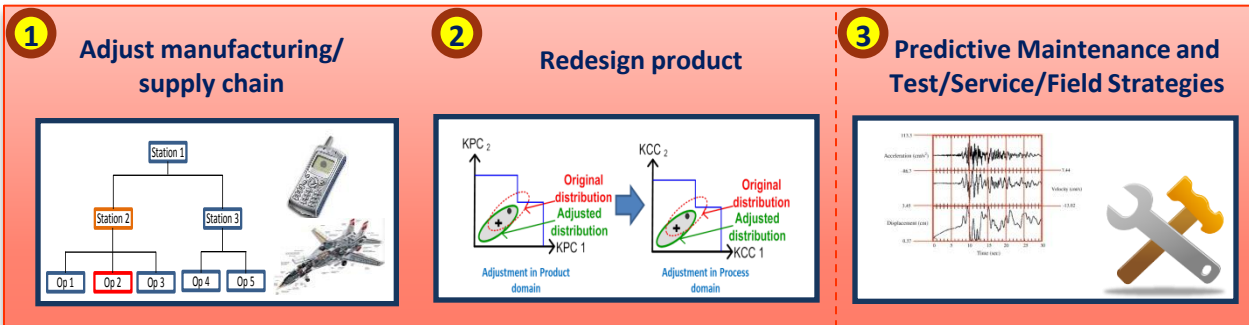


Core technology is rapid root cause analysis (RCA) for product faults and process bottlenecks:

- Zeros in on fault cause regions without knowing what the fault is
- Detects fault region in either the manufacturing process or the design even where No Fault Found (NFF)
- Non statistical, non-hypothesis – can deal with dirty and/or incomplete data



Corrective action dependent on ROI and Value Chain



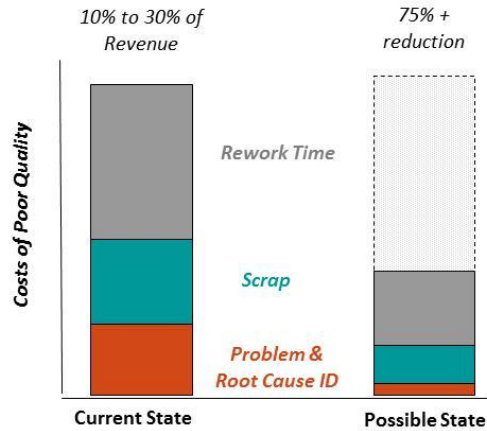
OEM / Supply Chain

MRO

Increased Yield and Reduced Cost of Manufacture

- Increase yield of specific/multiple product lines
- Reduce scrap, wastage and increase profitability
- Free up resources

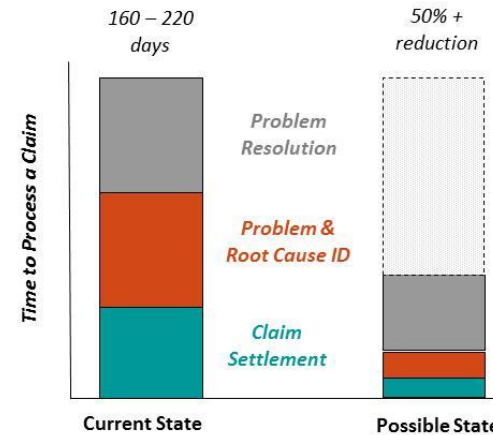
**Internal Cost of Poor Quality
(excluding warranty)**



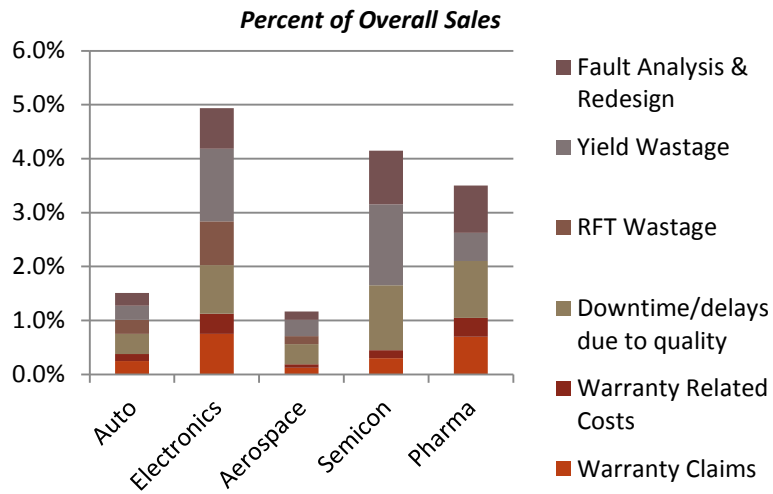
Reduced Maintenance/Service Costs

- Reduce time to resolve problems
- Validate genuine warranty costs
- Prevent warranty costs and recalls with predictive maintenance

**Warranty Resolution Lead Time
(typical automotive)**

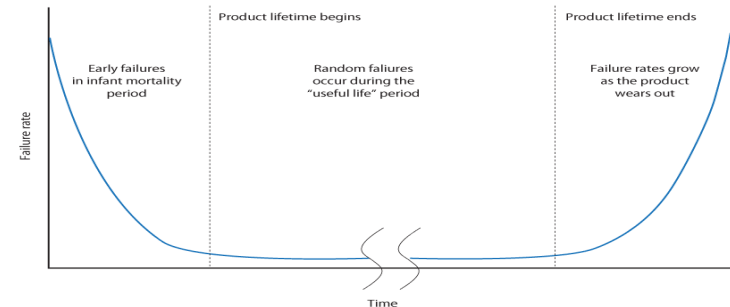


Indicative Savings - EWAP



Better Lifecycle: Quicker Launch, Costs, Safety & Environment

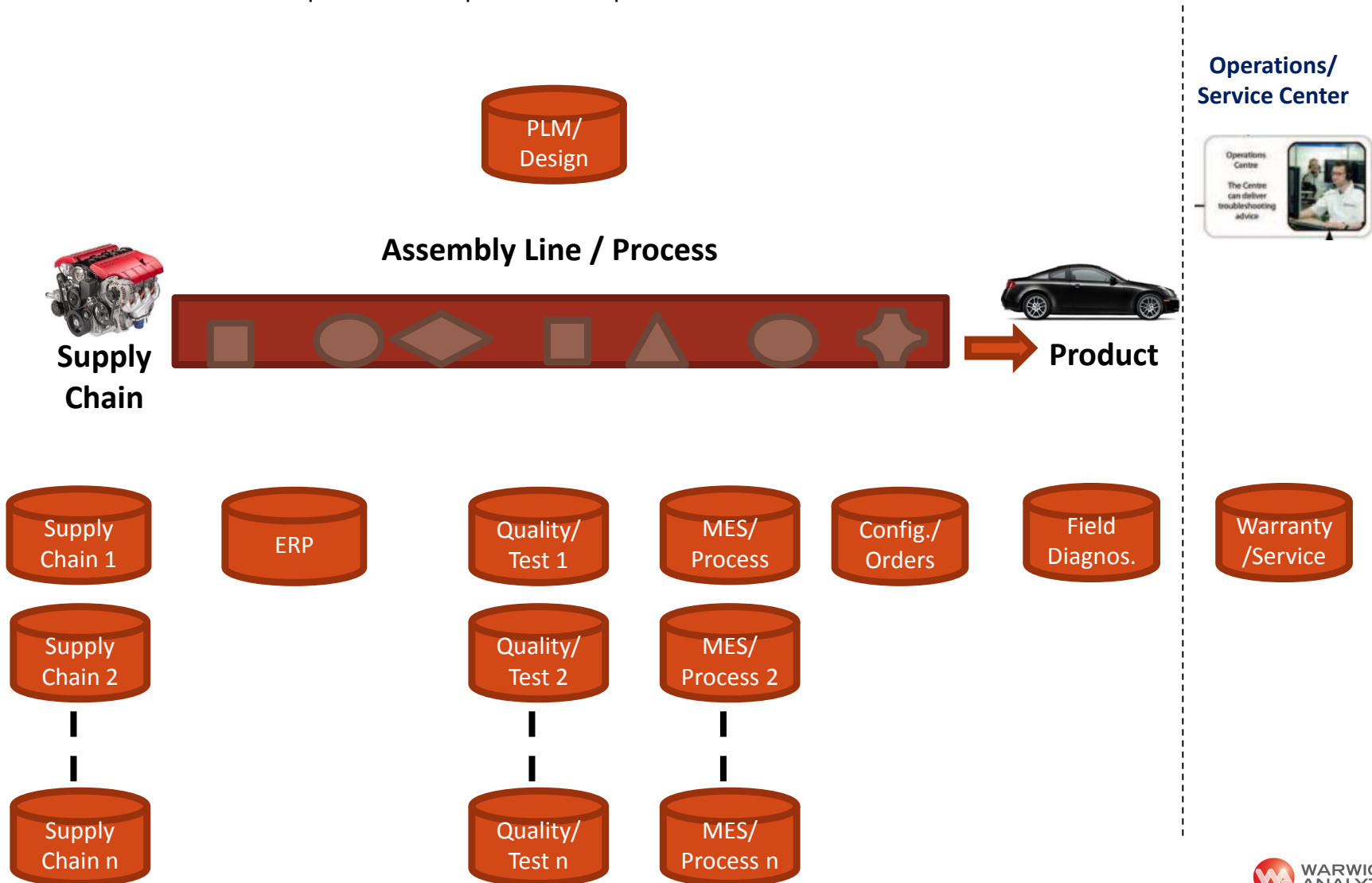
The "Bathtub Curve"



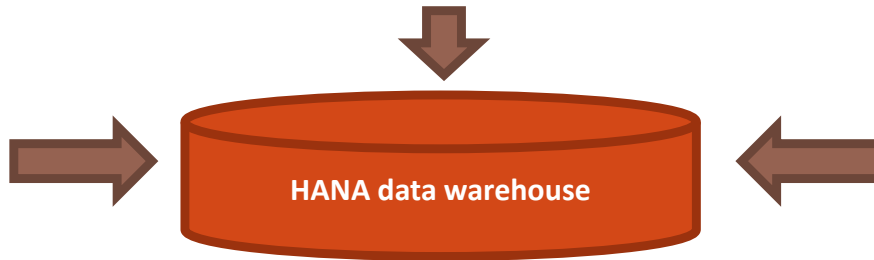
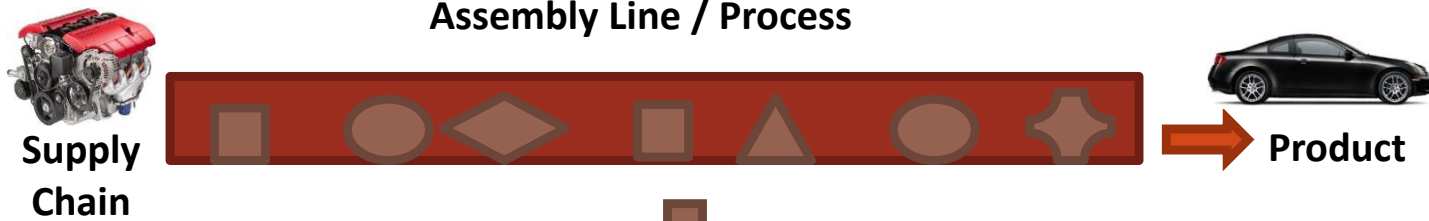
USE CASES



- Data silos; disparate and unstructured
- Systems not all online
- Cannot resolve problems or optimize each part in isolation



- HANA data warehouse = 'real-time knowledge repository'
- Use case benefits in own right
- Further use case benefits from global problem solving and optimization Apps
- Not just cost savings: Further revenue opportunities
 - extended warranty
 - Quicker product launch/innovation
 - Quicker customer fulfilment, even with customization



Apps:



Early Warning & Prevention



Operations/
Service Center



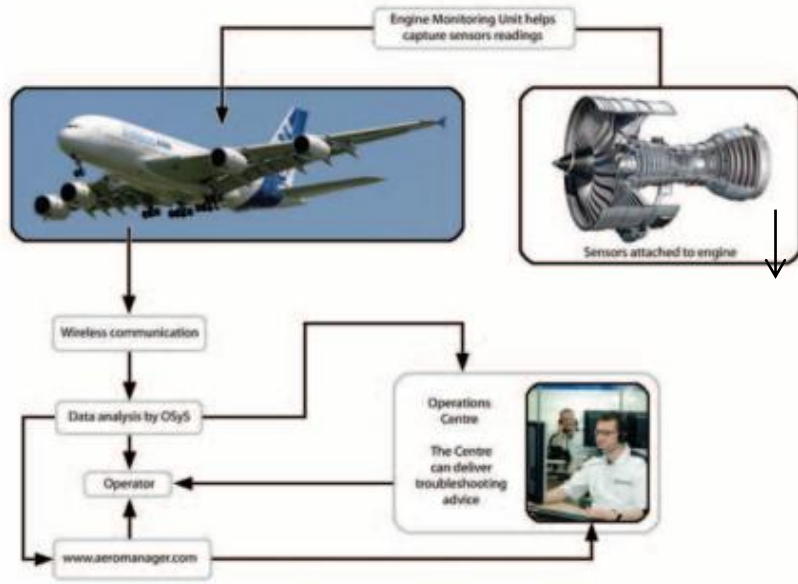
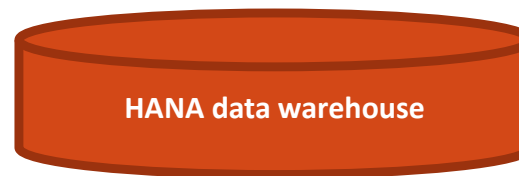
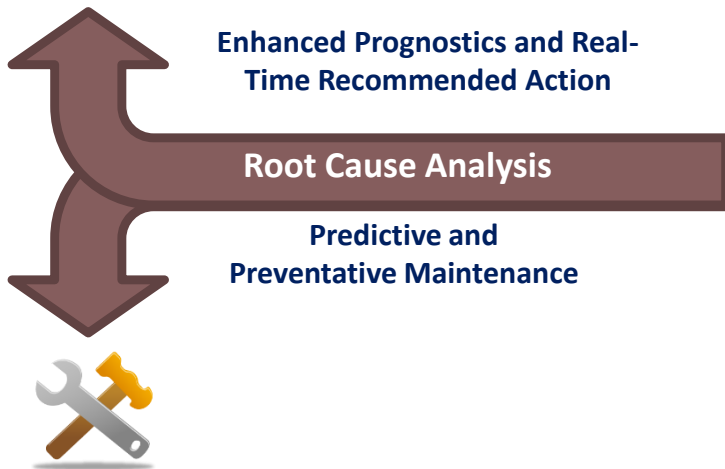


Figure 1 - Engine Health Management system flow diagram drawn by Simon Roulstone

Operations/Service Center



Asset Maintenance

- Provides additional profitable revenue streams as well as cost-saving
 - e.g. customer premise predictive and preventative maintenance
 - Maintenance strategies and real-time tactical responses
 - Doesn't wait for 'statistical significance'
- Longer-term optimisation of design of assets and parts



Grid Management

- Quasi real-time, data driven root cause analysis for faults and issues
- Optimisation and capacity planning
- Energy trading – looking for the causes of prices/demand-supply inequalities



Insight Beyond Other Techniques in Complex Issues

- Statistical techniques are limited
- Warwick Analytics technology (RCASE) benefits:
 - doesn't require hypotheses or setting up multivariate statistics
 - Works with incomplete/dirty data
 - Will always narrow down searchspace (i.e. always provide a result)

Asset Maintenance

- Predictive and preventative maintenance
 - Prognostics + root cause to assess what needs fixing and when
 - Maintenance strategies and real-time tactical responses
 - Doesn't wait for 'statistical significance'
- Longer-term optimisation of design of assets and parts

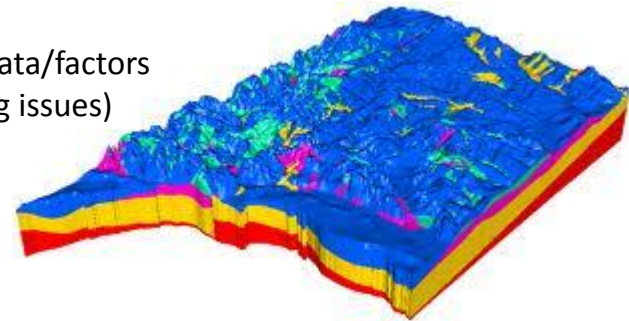


Resource Prospecting

- Complements the many sophisticated software packages and specialist companies
 - The more complex the problem, the greater utility and synergy with these
- Looking for causes/signals of resource assets and potential issues
 - Assist location of resources by root cause of contributing data/factors
 - Ditto in terms of issue identification (e.g. fracking or drilling issues)

Additionally: Insight Beyond Other Techniques in Complex Issues

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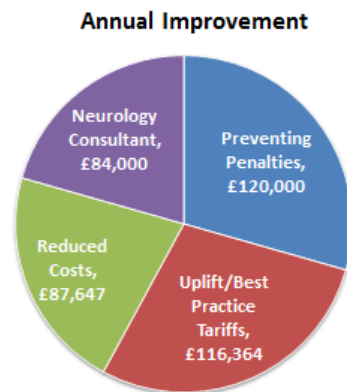
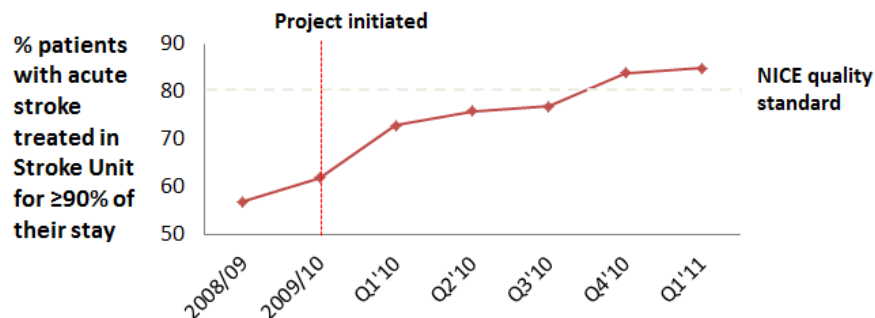
Improve Quality

- Healthcare organisations are under increasing pressure to increase quality targets and service delivery whilst at the same time saving costs.
- **PathwayClear** from Warwick Analytics is software that identifies and fixes operational bottlenecks in care pathways from care data.
 - Derived from manufacturing R&D at Warwick University Digital Healthcare Lab
 - Proven in Stroke, ED (A&E), theatre and other care pathways at hospitals and elsewhere



Case Study

- University Hospitals Coventry & Warwickshire (UHCW) failing on stroke target
 - Less than a year later was above standard
- As well as achieving targets and improving outcomes, financial benefit:
 - £408,011 per annum
 - Savings across A&E, Stroke Unit and Direct Care
 - Trust very happy
 - One of largest improvements for single project
 - Looking to extend to other areas A&E and other acute



Many situations looking for analytical edge

- Trading: quicker identification of indicators/events
- Investing: better insight/understanding of fundamentals
- Infrastructure: greater efficiency



- Key is looking for **causality** while **using dirty and incomplete data** – Information Theory not just statistics
- Provide prediction of shocks/events/step-changes not just trends

Methods	Problem data structure			
	Non-normal distribution, Different covariance structure	Multiple and disjoint fault regions	Interpretation of result	Uncertainty and error in data classification
Regression using GLM (logit, probit)	✗	✗	✗	✗
Discriminant analysis (Linear and quadratic)	✗	✗	✗	✗
Support vector machine (SVM)	✓	✗	✗	✗
Neural network	✓	✓	✗	✗
Root cause analysis (Warwick Analytics)	✓	✓	✓	✓

Retail

- Analytical edge for understanding and predicting consumer behavior beyond statistical modeling – complimentary
 - What products are bought together and influencing behavioral factors
 - Customer segmentation/cluster analysis without hypotheses
 - Optimize store, web, supply chain, marketing
 - Fraud detection and prevention by cause



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Security and Policing

- Identifying parameters of behaviour
 - criminology – real time analysis for prevention and tactical monitoring
 - External factors causality – economy, weather etc.
- Linking together disparate sources – web/comms/profile

Citizen Behaviour

- Citizen segmentation – policy making
- Reducing risk/fraud by cause identification

Insight Beyond Other Techniques in Complex Issues

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Cybercrime



Espionage



Terrorism



Psycopaths

- **WA solution is computationally intensive as well as big data**
 - **Quasi-real-time with HANA**
 - **Algorithms optimised for HANA**
 - **Use case from 36 hours to 35 seconds!**
 - **Reduces load times**
- **Roadmap based on HANA capabilities**
 - **Native algorithm (further speed/performance)**
 - **R integration (statistical reporting on our non-statistical rules)**
 - **Other features on roadmap – streaming and parallelism/
distributed architecture**
- **Cloud deployment pathway (HANA One) moving to on-premise**
- **Enhanced ‘data warehouse’ – Early Warning and Prevention System**

CASE STUDIES



Process
Mobile phone assembly process



- Data**
- (i) Manufacturing Data
 - (ii) Service Data

Time	SN	FREQ_OFFSET_FX	FREQ_OFFSET_FY	WARP_RESOLUTION	AVG_PWR_NL_F5	RXBER_111_F1_0_OK	AUTOPWRSP_F1	AGC_TR_TUNING	...	
14	450	36.00	307.00	25.50	37.00	444.00	36.00	327.00	0.10	...
17	519	40.00	382.00	27.00	37.00	447.00	32.00	336.00	0.10	...
7	786	37.00	388.00	24.75	23.00	420.00	37.00	327.00	0.11	...
15	771	38.00	348.00	25.25	24.00	396.00	32.00	296.00	0.11	...
26	892	38.00	385.00	26.50	34.00	413.00	30.00	314.00	0.11	...
13	881	37.00	347.00	25.00	38.00	400.00	31.00	292.00	0.11	...
5	883	39.00	379.00	24.00	28.00	433.00	12.00	322.00	0.10	...
11	843	22.00	382.00	25.75	44.00	415.00	24.00	313.00	0.11	...
24	420	36.00	382.00	27.00	36.00	437.00	31.00	325.00	0.10	...
9	716	0.00	391.00	26.00	36.00	404.00	42.00	295.00	0.10	...
3	844	34.00	412.00	24.00	38.00	406.00	17.00	295.00	0.10	...
20	621	37.00	414.00	27.25	36.00	471.00	37.00	297.00	0.10	...
22	621	40.00	398.00	26.25	35.00	468.00	37.00	341.00	0.10	...
16	586	37.00	396.00	28.00	24.00	410.00	31.00	300.00	0.10	...
1	527	36.00	393.00	27.25	29.00	446.00	36.00	327.00	0.10	...
14	618	37.00	387.00	26.25	35.00	430.00	31.00	333.00	0.11	...
20	330	40.00	378.00	25.25	28.00	376.00	33.00	303.00	0.11	...
12	742	34.00	329.00	24.75	1.00	374.00	34.00	284.00	0.10	...
18	184	33.00	392.00	25.00	28.00	402.00	40.00	298.00	0.11	...
10	487	36.00	328.00	25.25	33.00	383.00	34.00	272.00	0.10	...
8	930	40.00	364.00	25.25	39.00	422.00	36.00	300.00	0.10	...
27	176	36.00	384.00	24.75	37.00	427.00	31.00	329.00	0.11	...
6	641	36.00	376.00	27.75	26.00	427.00	14.00	322.00	0.11	...
25	617	47.00	372.00	26.75	12.00	421.00	42.00	311.00	0.10	...
4	216	35.00	357.00	24.00	18.00	415.00	27.00	296.00	0.10	...
23	639	40.00	384.00	26.50	52.00	418.00	35.00	309.00	0.11	...
23	639	33.00	369.00	25.50	23.00	422.00	0.00	314.00	0.11	...

Variables measured

- FREQ_OFFSET_FX
- FREQ_OFFSET_FY
- WARP_RESOLUTION
- AVG_PWR_NL_F5
- RXBER_111_F1_0_OK
- ...
- AUTOPWRSP_F1
- AGC_TR_TUNING

170 parameters

Pareto Analysis
Illustration of Top-5 Warranty failure out of 23 reported failure

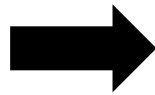


Data associated with NFF-battery failure

Critical parameter identification

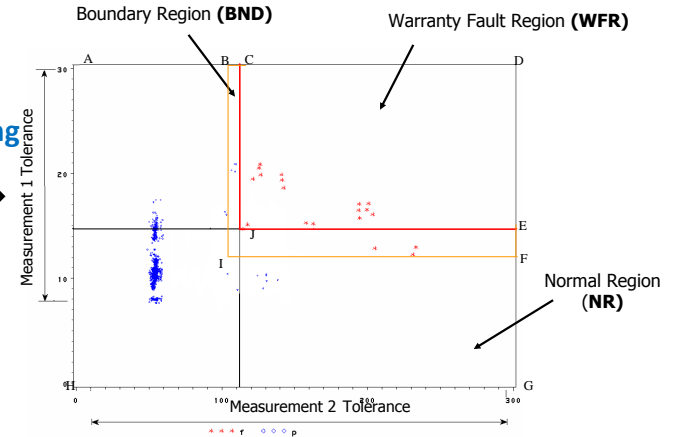
Fault Region

Identification



- FREQ_OFFSET_FX
- FREQ_OFFSET_FY
- WARP_RESOLUTION
- AVG_PWR_NL_F5**
- RXBER_111_F1_0_OK**
- .
- .
- AUTOPWRSP_F1**
- AGC_TR_TUNING

Reporting



Out of 170 Parameters
2 parameters which explains the NFF-battery problem are identified

Warranty Fault Region is Identified based on Data Mining Kernel

■ Identified Parameter

Design was rectified and SPC controlling process to eliminate failure

DEMO

