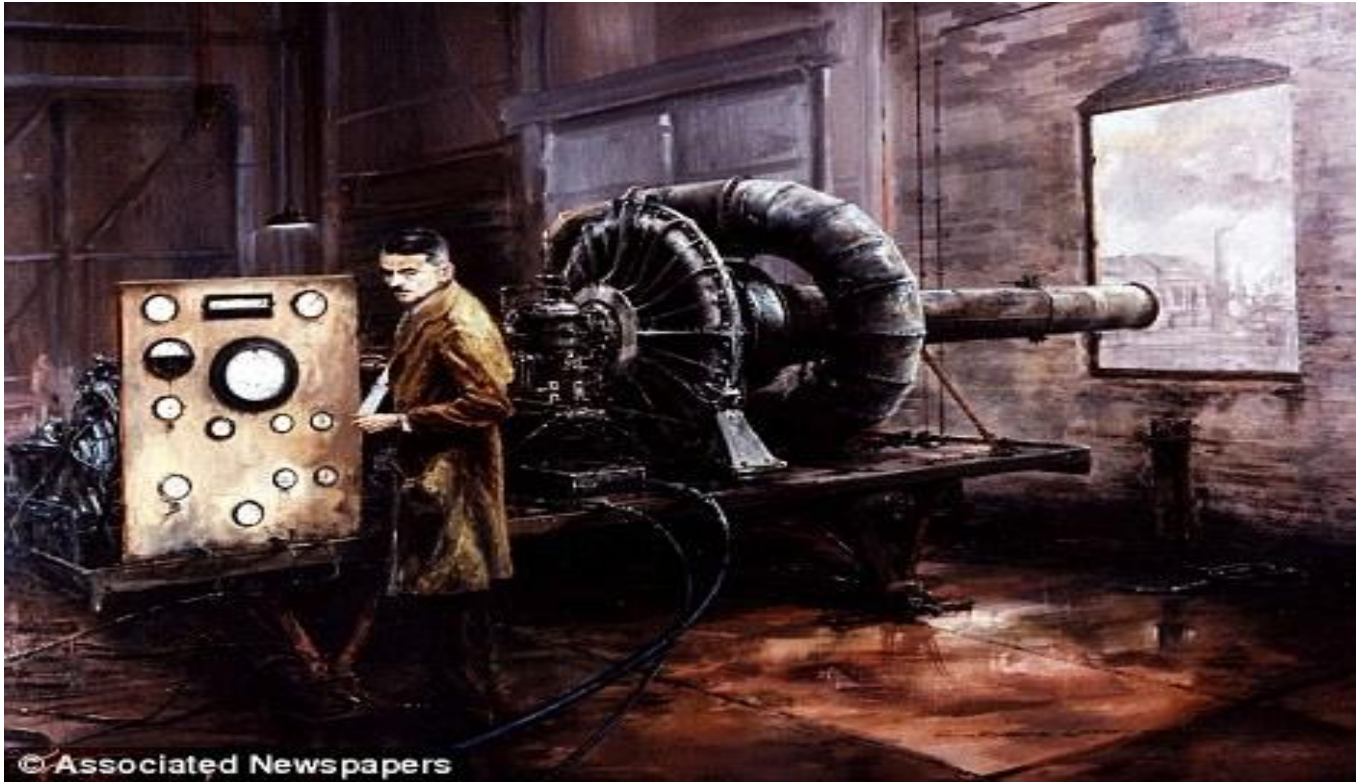
The Use of Predictive Intelligence to Optomize System Availability

NDIA Conference
October 31, 2013



Innovation….A Backbone for Continued Success

The Challenge

- Modern way of life is driven by Manufactured products that transport us, allow to produce goods and produce energy that supports the process.
- Model is limited unless we can:
  - Preserve energy
  - Extend the life cycle of equipment
  - Use equipment constantly at peak performance

Solution……Technology to the Rescue!

- Extended – Product Life Cycle Management (PLM)
  - Beyond design of products and processes
  - Present visibility into the complete lifecycle of a product
  - “Product-in-Life” model – History of maintenance ops, part repairs, part breakdown occurrences.

Creates new challenges

- Lack of Data Collection strategies
- Disparate systems
- "Big data" is difficult to leverage w/o proper data analysis tools
- Classical SPC is limited
- Machine learning introduced:
  - Neural Networks and Vector Support Machines= Predictive views
  - Decision Trees and Rules inference = Explanatory

From simple processes to highly sensitive multivariate processes

Linear

Spreadsheet

Complex

Specialized Learning Algorithms

Highly Sensitive

Real-time Dynamic Process Control

Unpredictability increases with complexity

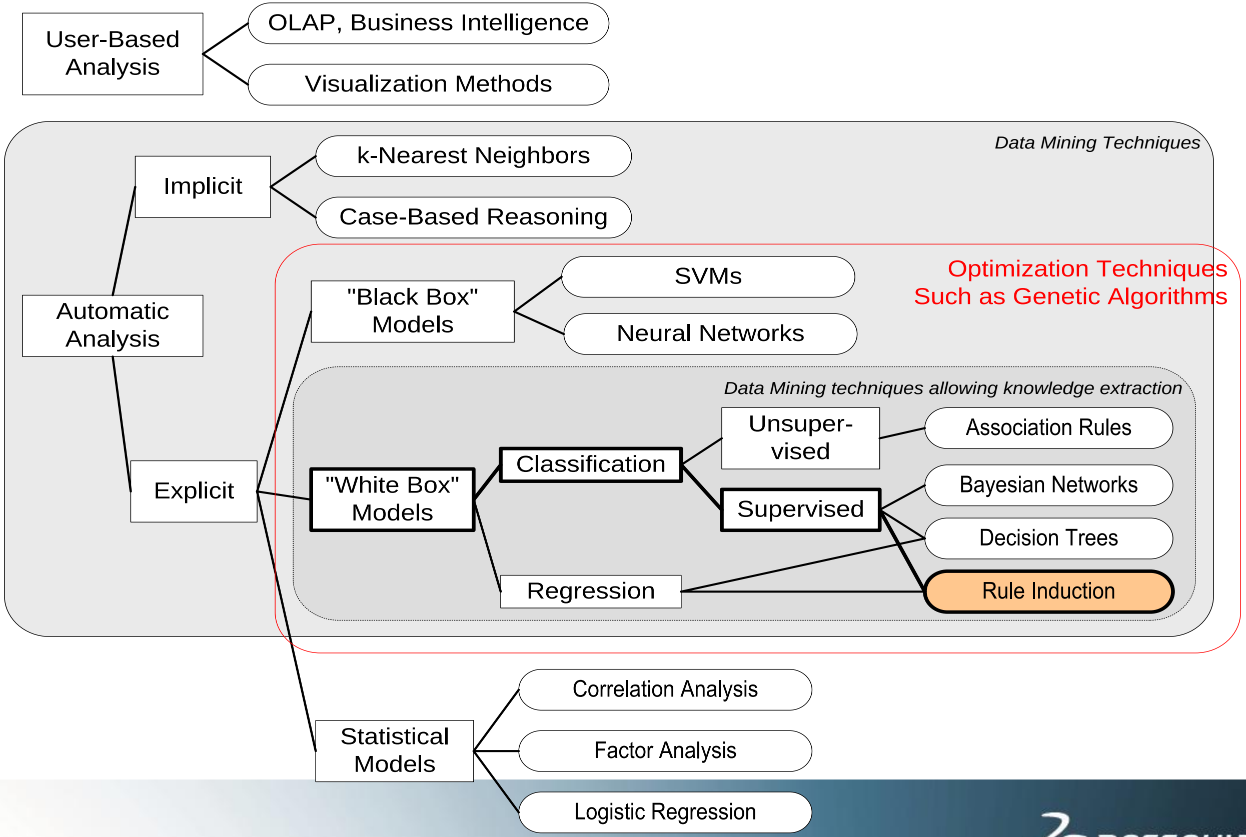
- Potentially dozens or hundreds of functional steps, each with multiple parameters
- High influence of the disparate characteristics (physical properties, formulation, composition, expiration, storage times and conditions)
- High influence of the operating conditions (product or process specifications) and the environment (humidity, temperature, etc.)
- Chemical reactions are highly non-linear, non-reversible phenomea and very difficult to predict
- Because of the highly multivariate and non-linear nature of the events, Theoretical Models and Statistical Process control are not effective to predict and eliminate failures.

WHEN TO APPLY OPERATIONS INTELLIGENCE:

WHERE COST OF FAILURE IN PRODUCTION (REWORK, SCRAP) OR OPERATIONS IS HIGH (FIELD FAILURE)

1. High Engineering Content
2. Small Batch runs or unique end items
3. Highly variable process
4. Complex Configuration Management

DELMIA OI within Data Mining / Analytics Landscape



Temporary adjustments to controllable parameters

Release constraints when context allows it

LEARNING by EXPERIENCE

Resin Rate	Temperature	Vacuum	Autoclave #	*RESULT*
			1	OK
			2	NOT OK
			1	OK
			1	NOT OK

FINDING PATTERNS

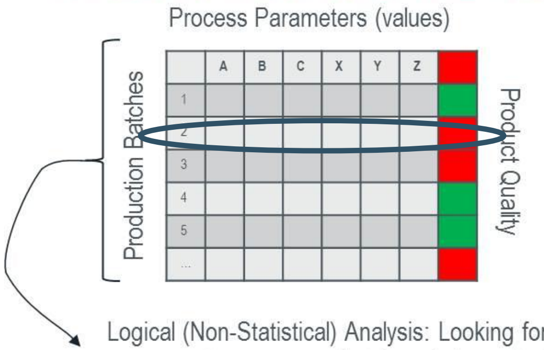
NO STATISTICS, NO EQUATIONS, NO MATHS

JUST LOGIC

A complement to Statistics for the most complex situations

OI Learning Engine

ANALYZING THE LINES OF THE TABLE

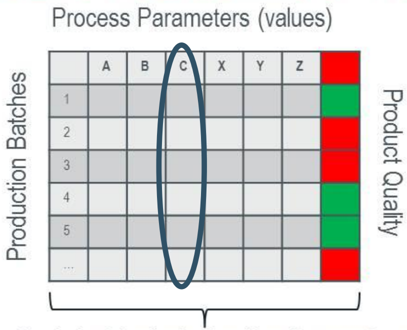


Logical (Non-Statistical) Analysis: Looking for common patterns among batches, independently of number of variables

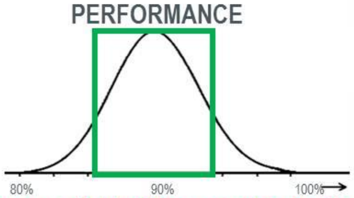
Learning from the end tails

Statistical Tools

ANALYZING THE COLUMNS OF THE TABLE

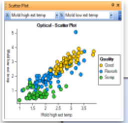


Statistical Analysis: Looking for trends and correlations among parameters, independently of number of samples



Creating a model for the normal behavior

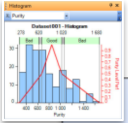
Overview of the Operations Intelligence Algorithms



Data Preparation

- Experiment Plans
- Correlations
- Curve pre-processing
- Histograms (number of bars), graduations

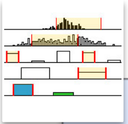
Process Rules Discovery



Study Preparation

- Discretization
- Multi-objective output definition
- Explanatory potential
- Determination of the most influent variables

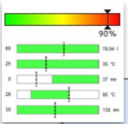
Process Rules Discovery



Rule Discovery

- Learning
- Rule indicators
- Build new rule from samples
- Rule optimization
- Operations on rules and conditions

Process Rules Discovery

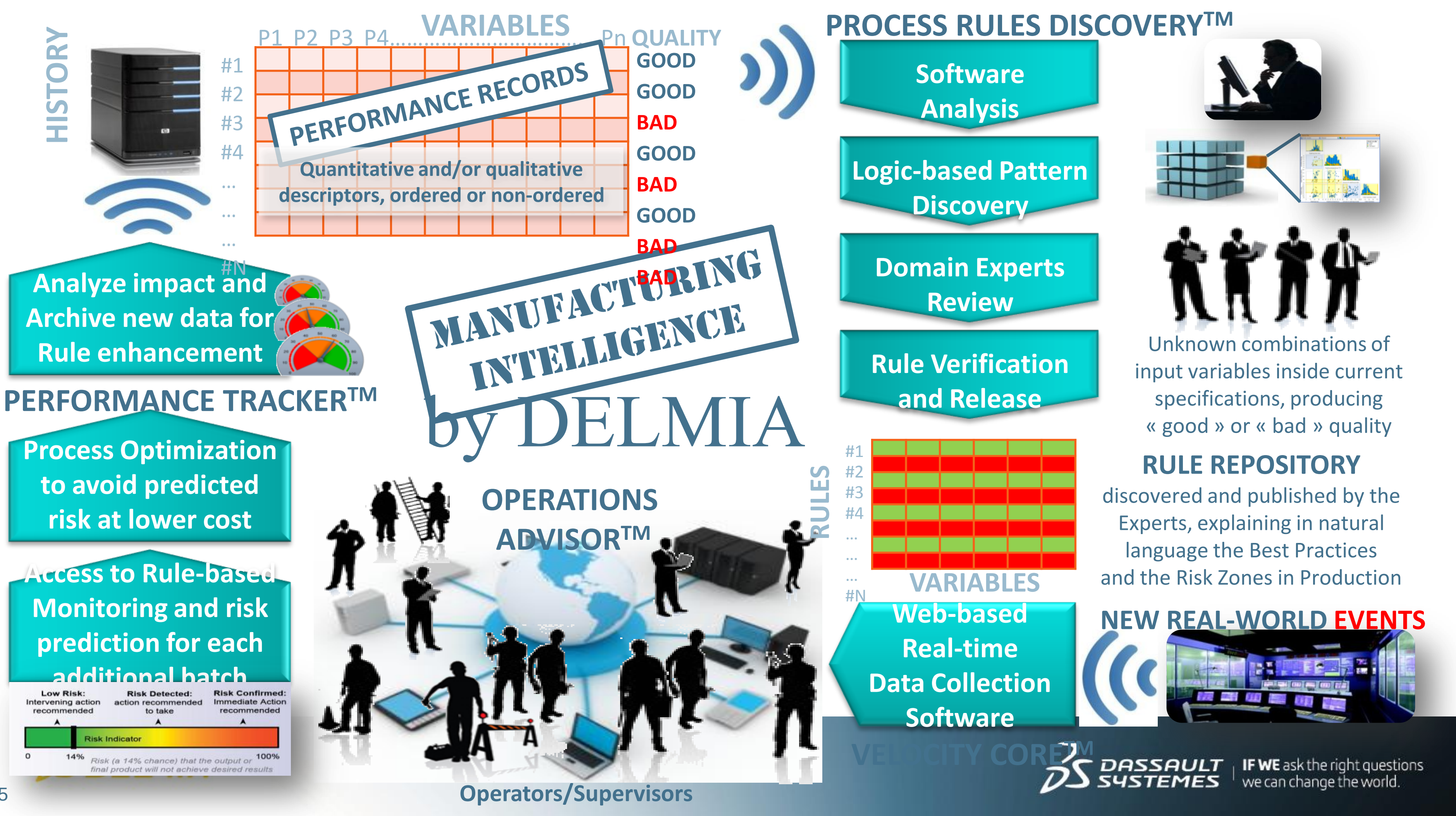


Rule Compliance

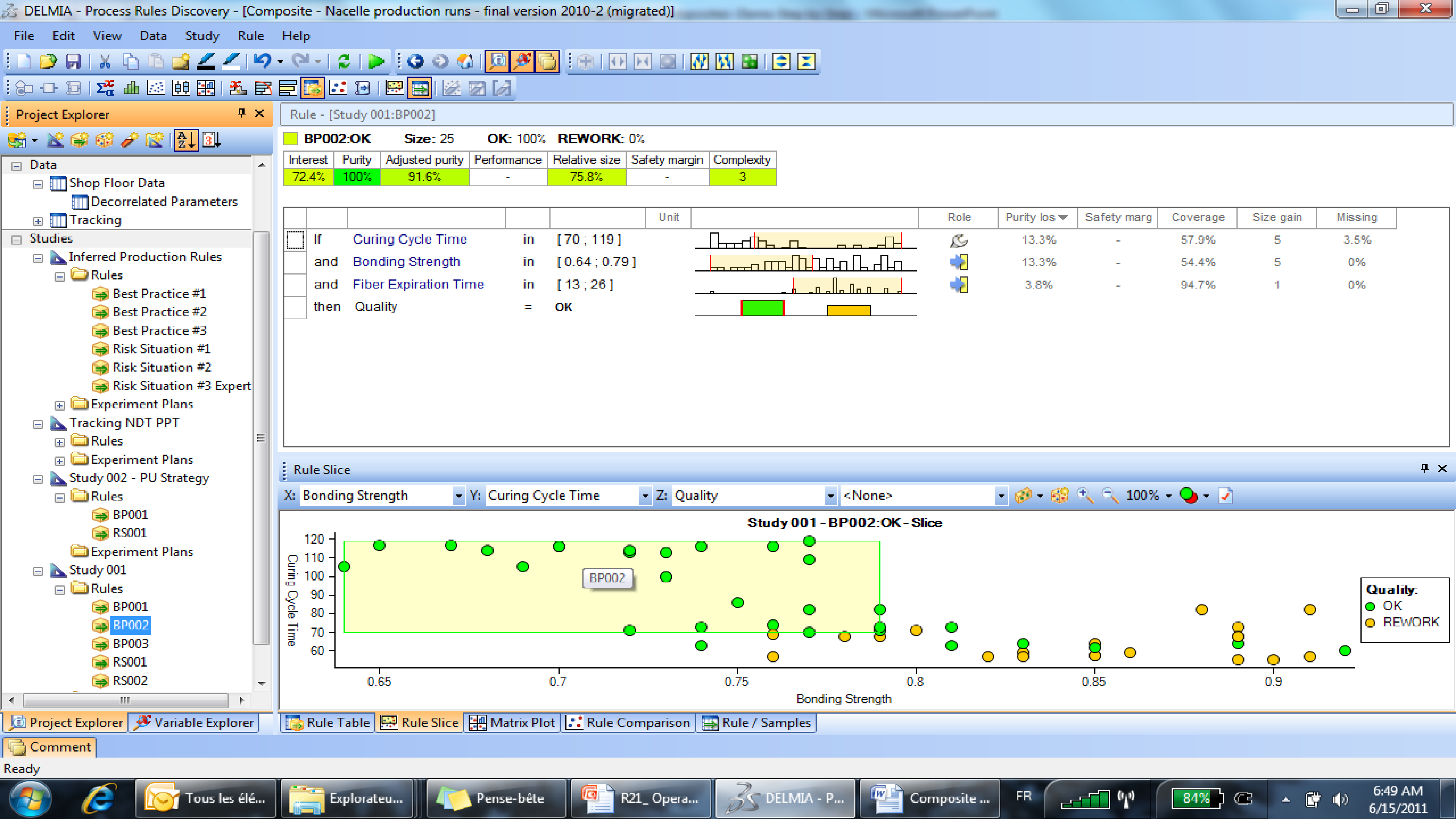
- Risk calculation
- Recommended setting ranges

Operations Advisor

Patented



HISTORY
VARIABLES
P1 P2 P3 P4…………………………………… Pn QUALITY
#1 #2 #3 #4 … … … #N
GOOD
GOOD
BAD
GOOD
BAD
GOOD
BAD
BAD
PERFORMANCE RECORDS
Quantitative and/or qualitative descriptors, ordered or non-ordered
PROCESS RULES DISCOVERY™
Software Analysis
Logic-based Pattern Discovery
Domain Experts Review
Rule Verification and Release
Unknown combinations of input variables inside current specifications, producing « good » or « bad » quality
Analyze impact and Archive new data for Rule enhancement
PERFORMANCE TRACKER™
MANUFACTURING INTELLIGENCE
by DELMIA
Process Optimization to avoid predicted risk at lower cost
Access to Rule-based Monitoring and risk prediction for each additional batch
Low Risk: Intervening action recommended
Risk Detected: action recommended to take
Risk Confirmed: Immediate Action recommended
Risk Indicator
0
14%
100%
Risk (a 14% chance) that the output or final product will not achieve desired results
OPERATIONS ADVISOR™
Operators/Supervisors
RULES
#1 #2 #3 #4 … … … #N
VARIABLES
RULE REPOSITORY
discovered and published by the Experts, explaining in natural language the Best Practices and the Risk Zones in Production
NEW REAL-WORLD EVENTS
Web-based Real-time Data Collection Software
VELOCITY CORE™
DASSAULT SYSTEMES
IF WE ask the right questions we can change the world.


DELMIA - Process Rules Discovery - [Composite - Nacelle production runs - final version 2010-2 (migrated)]
File
Edit
View
Data
Study
Rule
Help
Project Explorer
Data
Shop Floor Data
Decorrelated Parameters
Tracking
Studies
Inferred Production Rules
Rules
Best Practice #1
Best Practice #2
Best Practice #3
Risk Situation #1
Risk Situation #2
Risk Situation #3 Expert
Experiment Plans
Tracking NDT PPT
Rules
Experiment Plans
Study 002 - PU Strategy
Rules
BP001
RS001
Experiment Plans
Study 001
Rules
BP001
BP002
BP003
RS001
RS002
Rule - [Study 001:BP002]
BP002:OK
Size: 25
OK: 100%
REWORK: 0%
Interest
Purity
Adjusted purity
Performance
Relative size
Safety margin
Complexity
72.4%
100%
91.6%
-
75.8%
-
3
Unit
Role
Purity los
Safety marg
Coverage
Size gain
Missing
If Curing Cycle Time in [70 ; 119] 13.3% - 57.9% 5 3.5%
and Bonding Strength in [0.64 ; 0.79] 13.3% - 54.4% 5 0%
and Fiber Expiration Time in [13 ; 26] 3.8% - 94.7% 1 0%
then Quality = OK
Rule Slice
X: Bonding Strength
Y: Curing Cycle Time
Z: Quality
<None>
100%
Study 001 - BP002:OK - Slice
BP002
Curing Cycle Time
120
110
100
90
80
70
60
0.65
0.7
0.75
0.8
0.85
0.9
Bonding Strength
Quality:
OK
REWORK
Project Explorer
Variable Explorer
Rule Table
Rule Slice
Matrix Plot
Rule Comparison
Rule / Samples
Comment
Ready
Tous les élé...
Explorateu...
Pense-bête
R21_ Opera...
DELMIA - P...
Composite ...
FR
84%
6:49 AM
6/15/2011

Air France Industries

Business Challenges

- Find new maintenance practices to guarantee higher levels of performance
- Reduce EGT margin variability without increasing costs
- Being able to beat industry standards and become more competitive
- Increase customer satisfaction and loyalty

Operations Intelligence

- Analyze past work scopes to identify good and bad practices
- Discover how engine modules actually interact for global performance
- Keep analysis 100% fact-based
- Produce results that can be shared with customers

17

Air France Industries

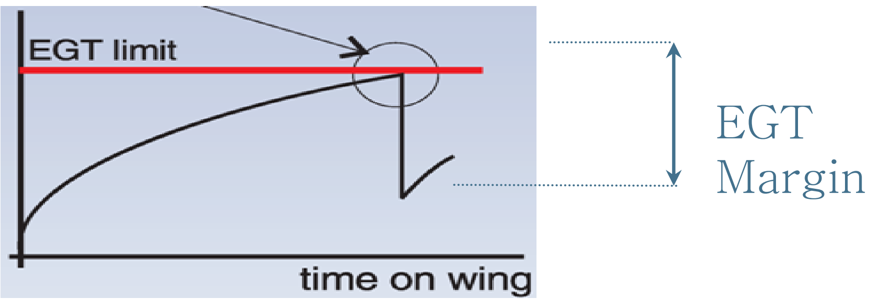
Key results

- New practices were discovered, using a mix of module parameters
- New inter-module coordination at shop level
- + 10° average on EGT margin levels on Airbus 340 and Boeing 747 fleet
- 1% savings on in-flight fuel flow

"Operations Intelligence has been extremely useful in identifying optimized combinations of maintenance parameters. Previously, we suspected the existence of such parameters. However, now we can identify and justify them in a very clear manner. We obtained tangible results that demonstrated a direct impact on the EGT margin. With Operations Intelligence, we are able to implement a program of continuous improvement which enables us to enrich our knowledge and to better address our customers' expectations"
– Emmanuel Desgrées du Loû, Engine Overhaul Director, Air France Industries.

18

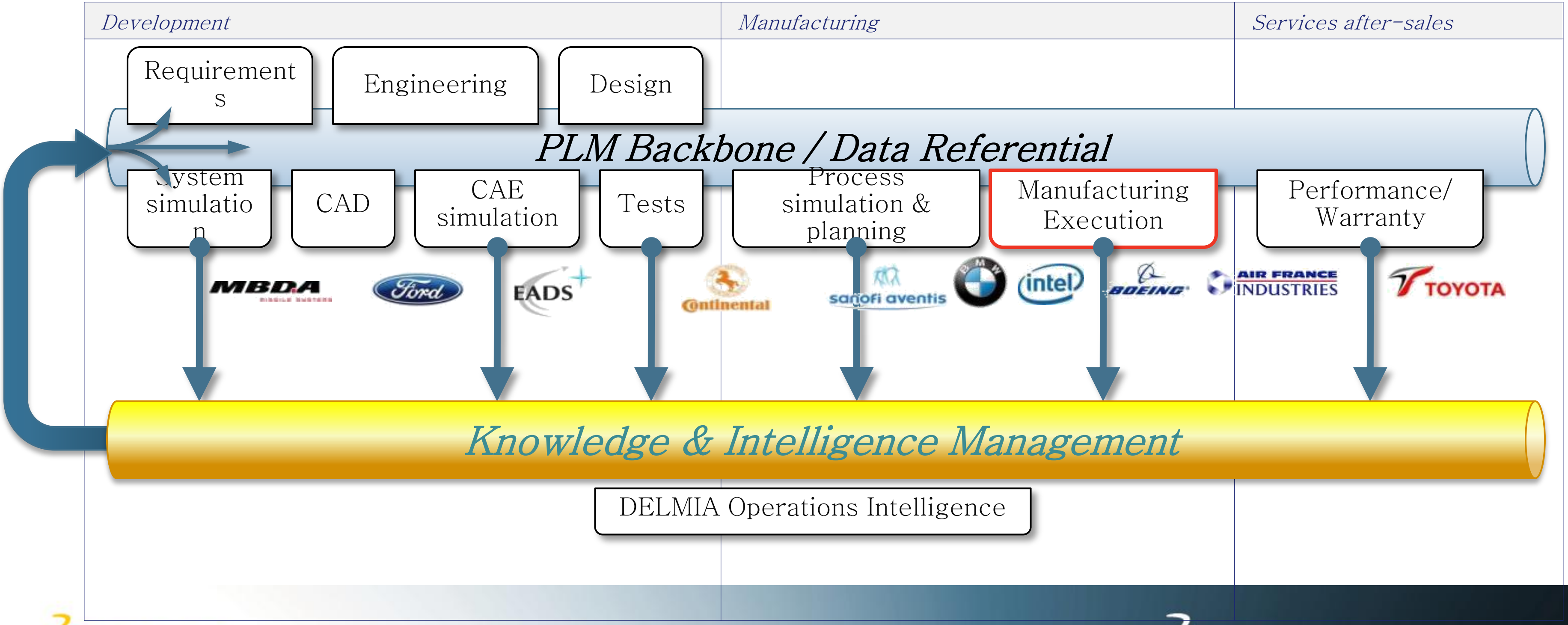
Optomized System Availability = RC



<u>Input Data:</u>

- Engine Overhaul cost = 100$ / EFH
- Average EGT increase = 3°/1000 EFH
- Average EGT penalty = 10,000 $ per ° below spec
- Average % of engine removal due to EGT limit : 60%
- +5° on EGT margin creates 160,000 $ per engine in cost savings for Airlines (equivalent to 1600 additional hours on wing)
- **<u>ROI for a fleet of 50 engines = 160,000 $ x 50 Engines x60% = 4,8 M$ / yr</u>**

Operations Intelligence *as a closed-loop mechanism*

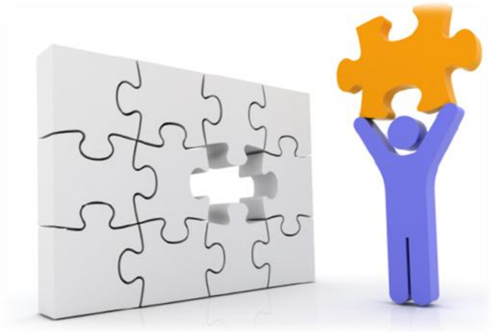


Changing times require new innovations

Contact Information

Chuck Buckley
Director – Aerospace and Defense Sales
DELMIA
Dassault Systemes

719-686-8976
Chuck.buckley@3ds.com



IF WE™