
To get there, together
REALDOLMEN
sas
THE POWER TO KNOW.

RIMSES
master in maintenance

sas

Bussines Development Manager Rimses

Pre-Sales consultant Analytics SAS

Sr. Pre-Sales Consultant Rimses

PREDICTIVE MAINTENANCE

ADRIAAN VAN HORENBEEK

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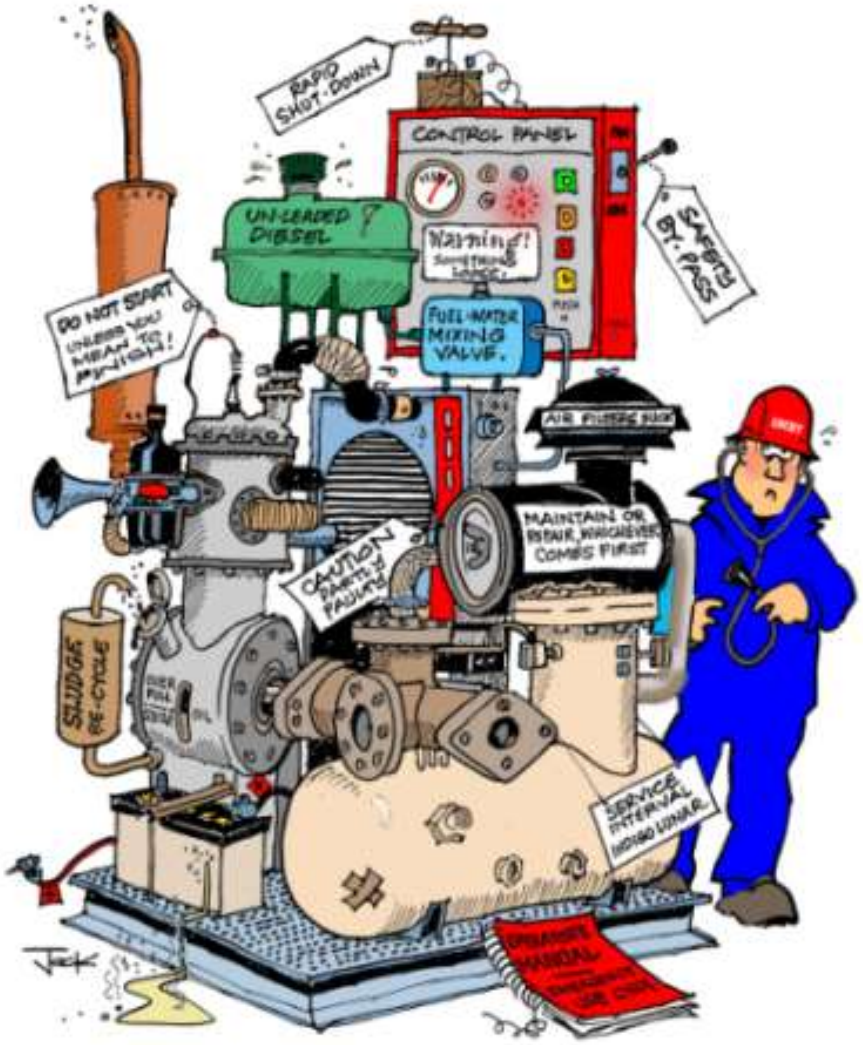
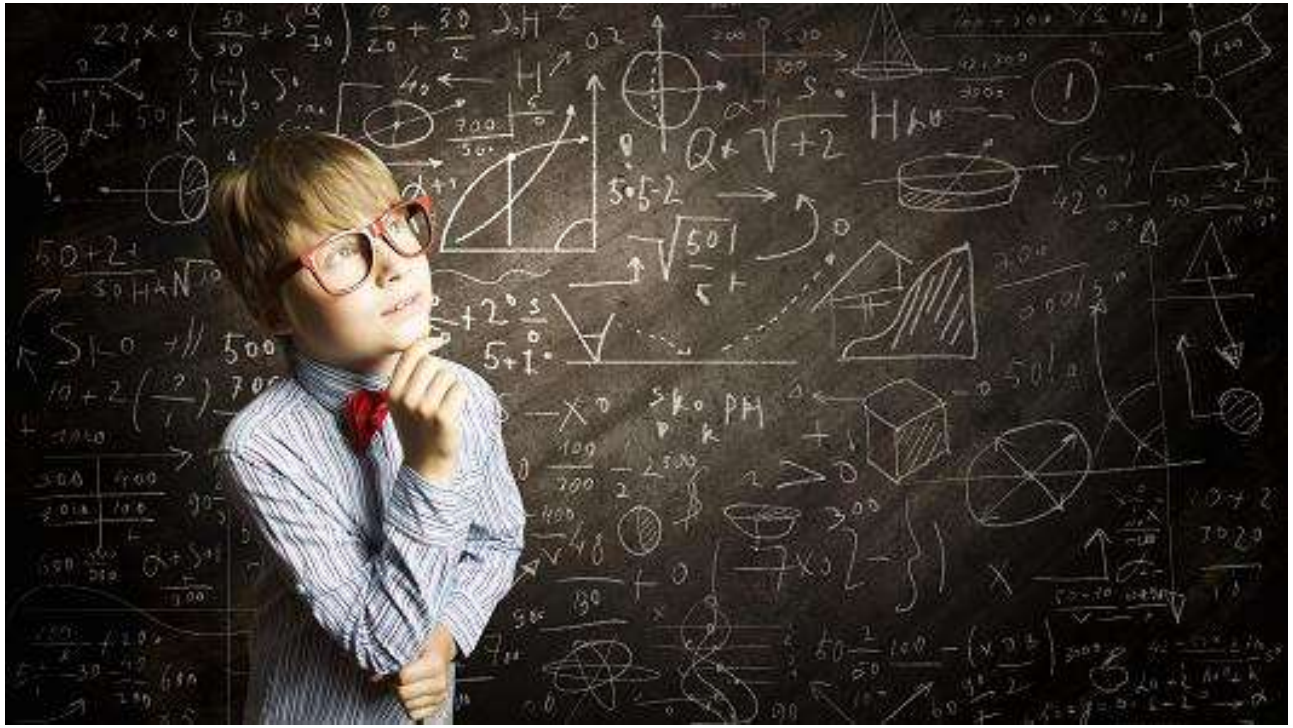
PREDICTIVE MAINTENANCE VS. PREDICTIVE MAINTENANCE





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AGENDA

- Introduction
- What is analytics?
- Why analytics for predictive maintenance?
- Roadmap to success
- Case studies
- Conclusion and Q&A

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INTRODUCTION...

MECHANICAL ENGINEER

ASSET MANAGEMENT CONSULTANT

PRE-SALES ANALYTICS IN MANUFACTURING

PhD IN MECHANICAL ENGINEERING

RESEARCH ON PREDICTIVE MAINTENANCE

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sas

40
Years of BUSINESS ANALYTICS

#1
World's LARGEST privately held software company

96%
Annual customer retention rate

14,021
SAS employees worldwide

Analyst Validation

FORRESTER
OVUM
Gartner
IDC
Analyze the Future

140
Employees in Belgium and Luxembourg

91
of the top 100 companies on the FORTUNE GLOBAL 500 LIST

25%
Annual reinvestment in R&D

80,000+
Customer sites in 146 countries

1,500+ In Belgium and Luxemburg

AGENDA

- Introduction
- What is analytics?
- Why analytics for predictive maintenance?
- Roadmap to success
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- Conclusion and Q&A

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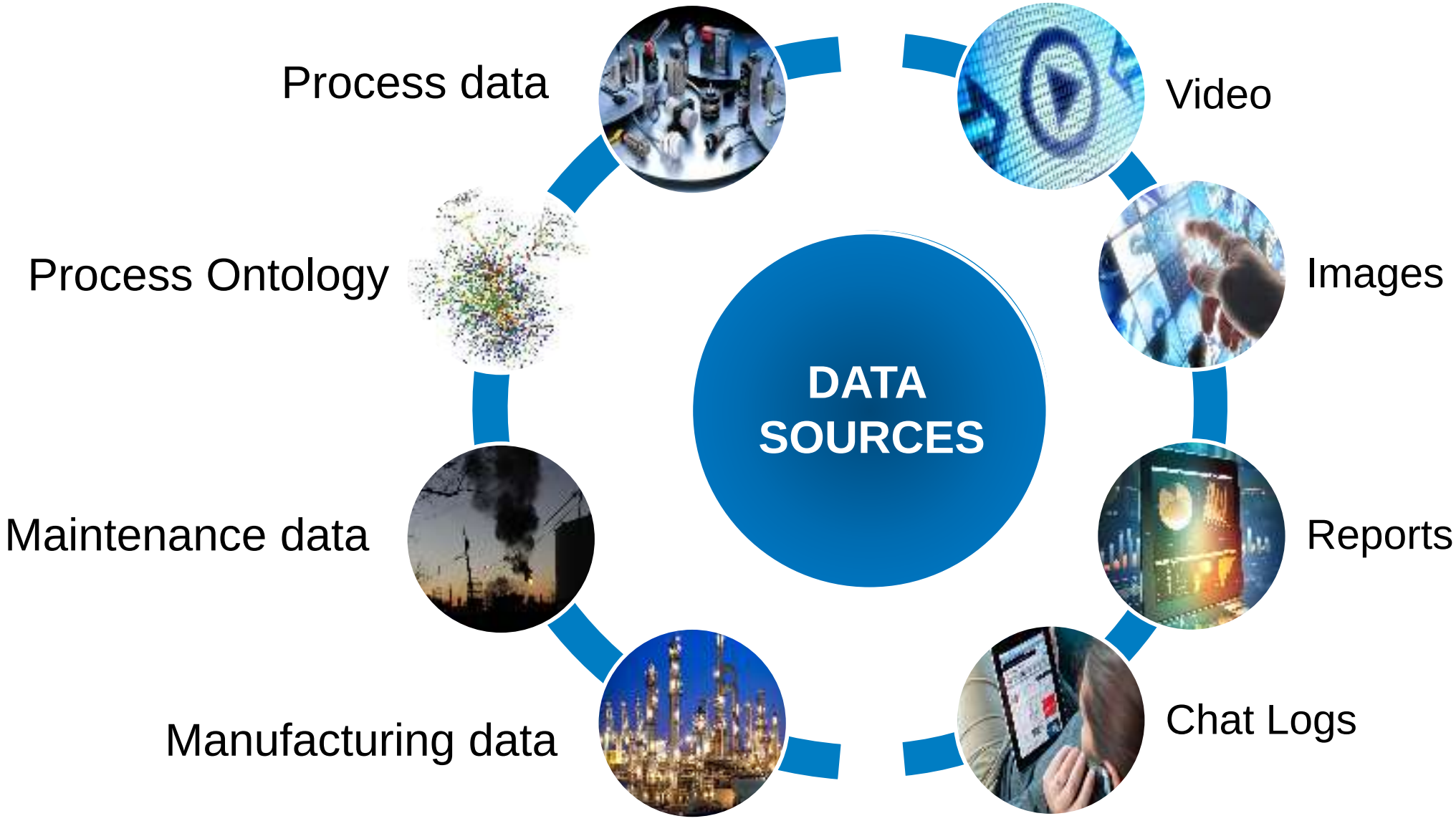
Discovery
Deployment
Data

DATA IS THE FOUNDATION



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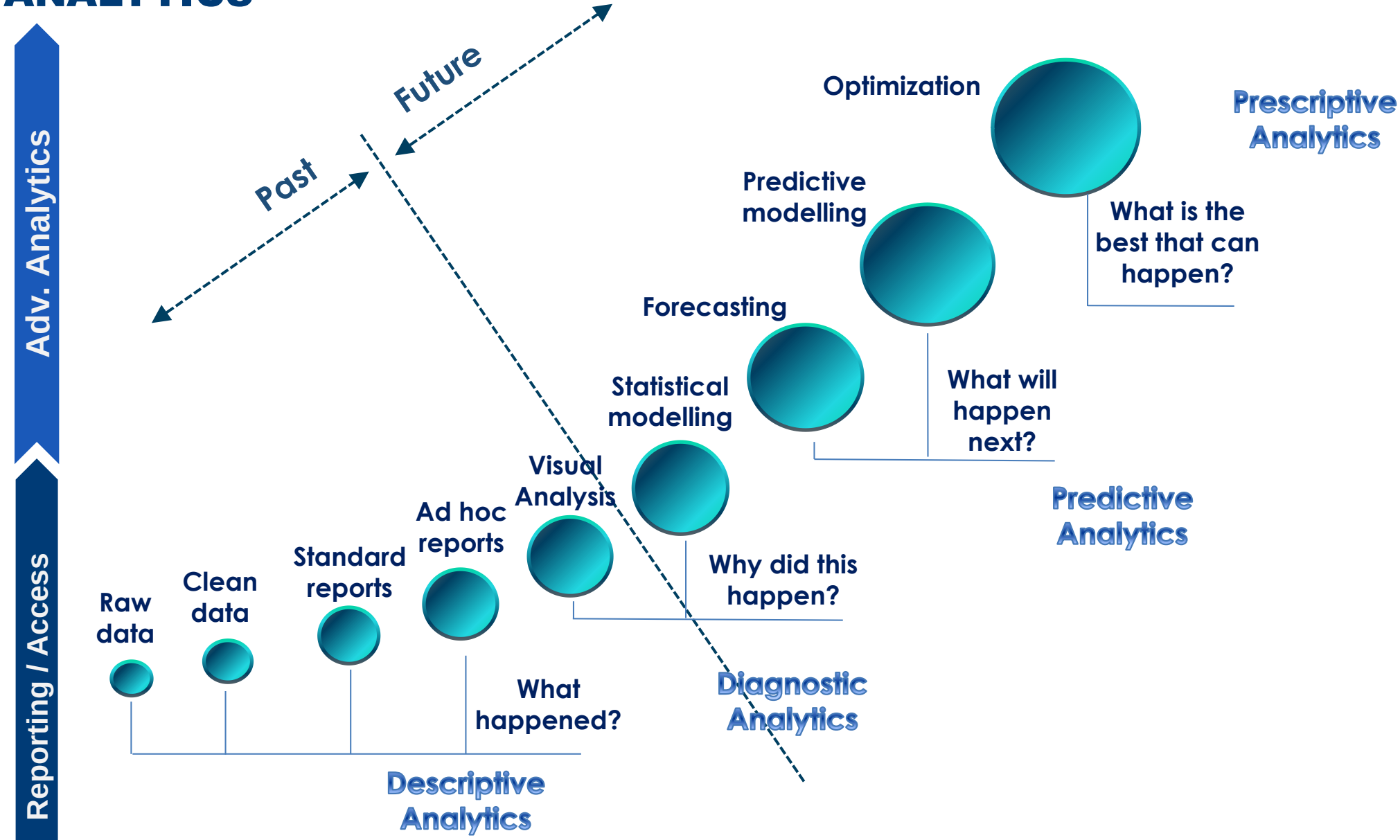
ANALYTICS



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Analytics Deployment

Edge Analytics

At device/sensor level

Smart sensors - Monitor equipment on the platform, and take action.

In-Motion Analytics

Between sensor, machine or human interface

M2M communication to optimize operational process

At-Rest Analytics

Strategic Data Integration

Intelligently integrate quality /maintenance data with real-time streaming data

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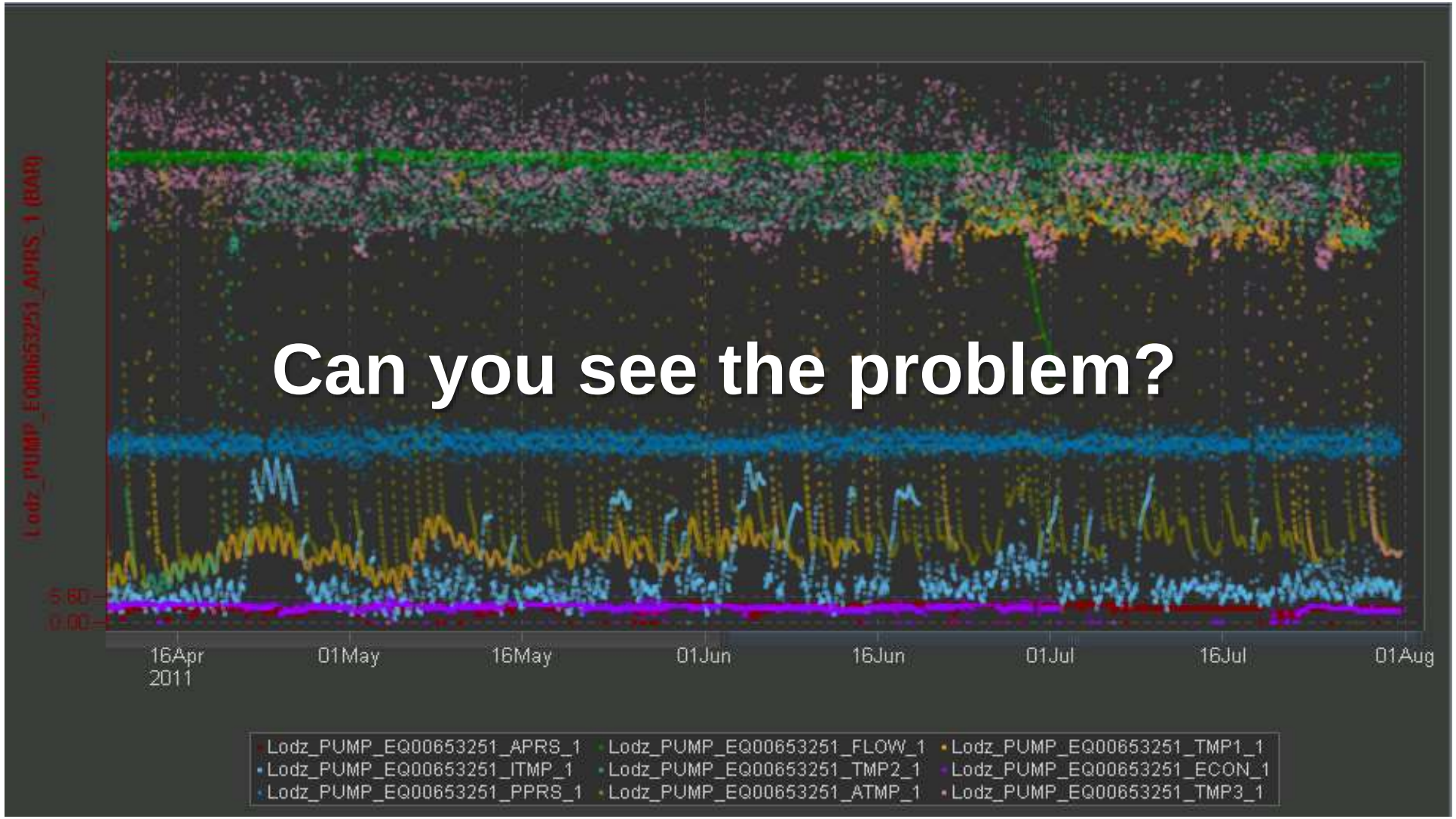
MANY ORGANIZATIONS TODAY



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DATA-DRIVEN ASSET MANAGEMENT

H **Optimized Asset Management**  **Optimization** — What's the best that can happen?

G **Asset Performance Management**  **Predictive modeling** — What will happen next?

F **Living reliability centered maintenance**  **Trend analysis** — What if these trends continue?

E **Preventive Maintenance Optimization**  **Statistical analysis** — Why is this happening?

D **Condition based Maintenance**  **Alerts** — What actions are needed?

C **Usage based Maintenance**  **Query drilldown** — Where exactly is the problem?

B **Preventive maintenance**  **Ad hoc reports** — How many, how often, where?

A **Work initiation & prioritizing**  **Std. reports** — What happened?

Maturity & Business Value

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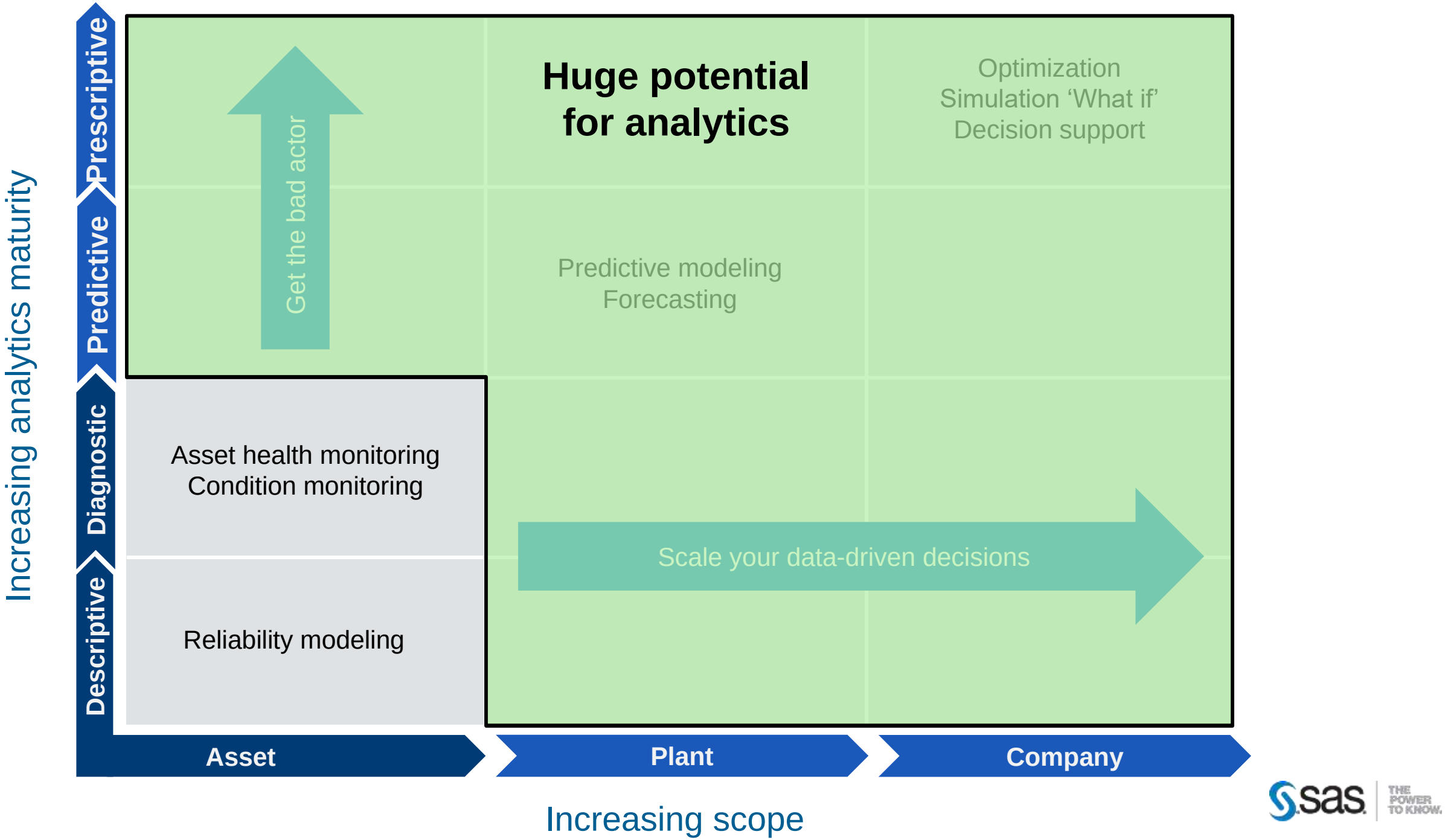

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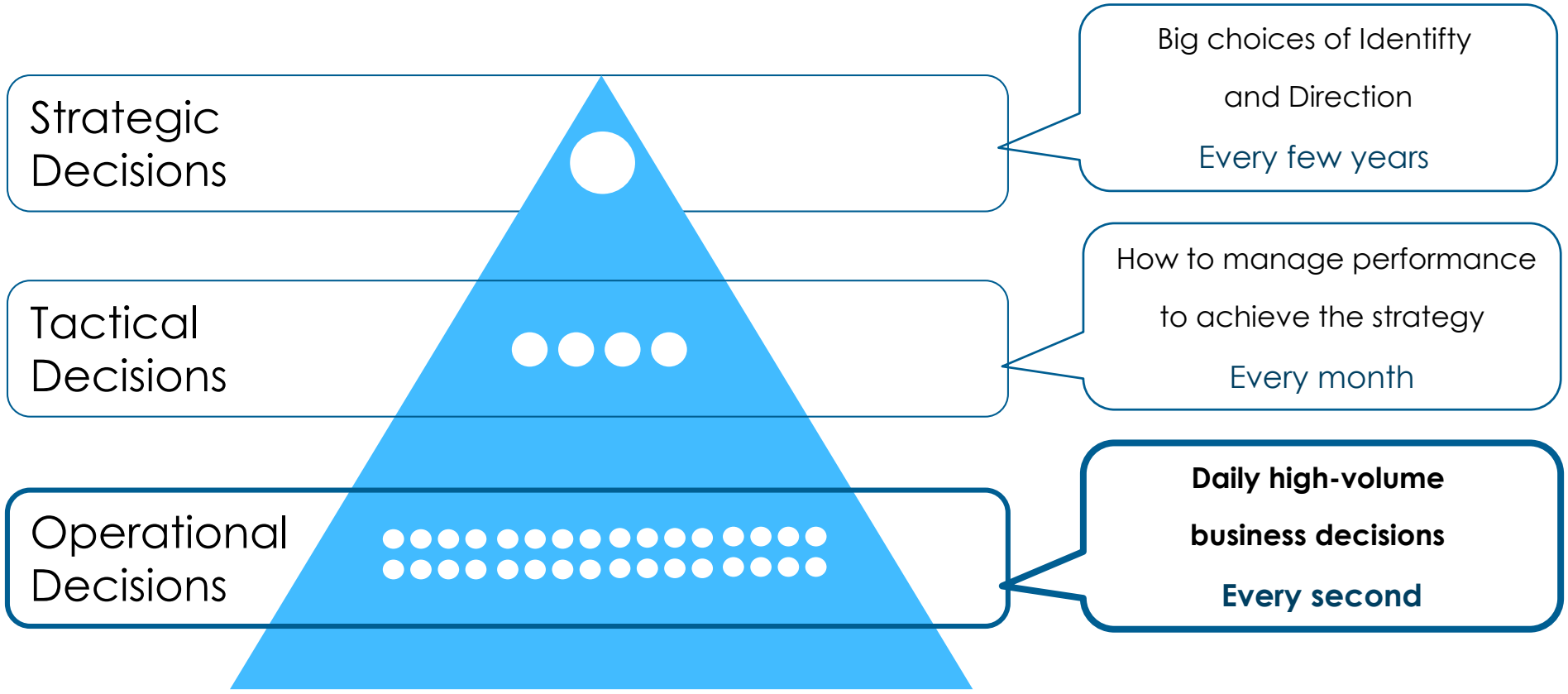
ANALYTICS IMPROVES DECISIONS



VALUE = NUMBER OF DECISIONS x VALUE IMPROVEMENT PER DECISION

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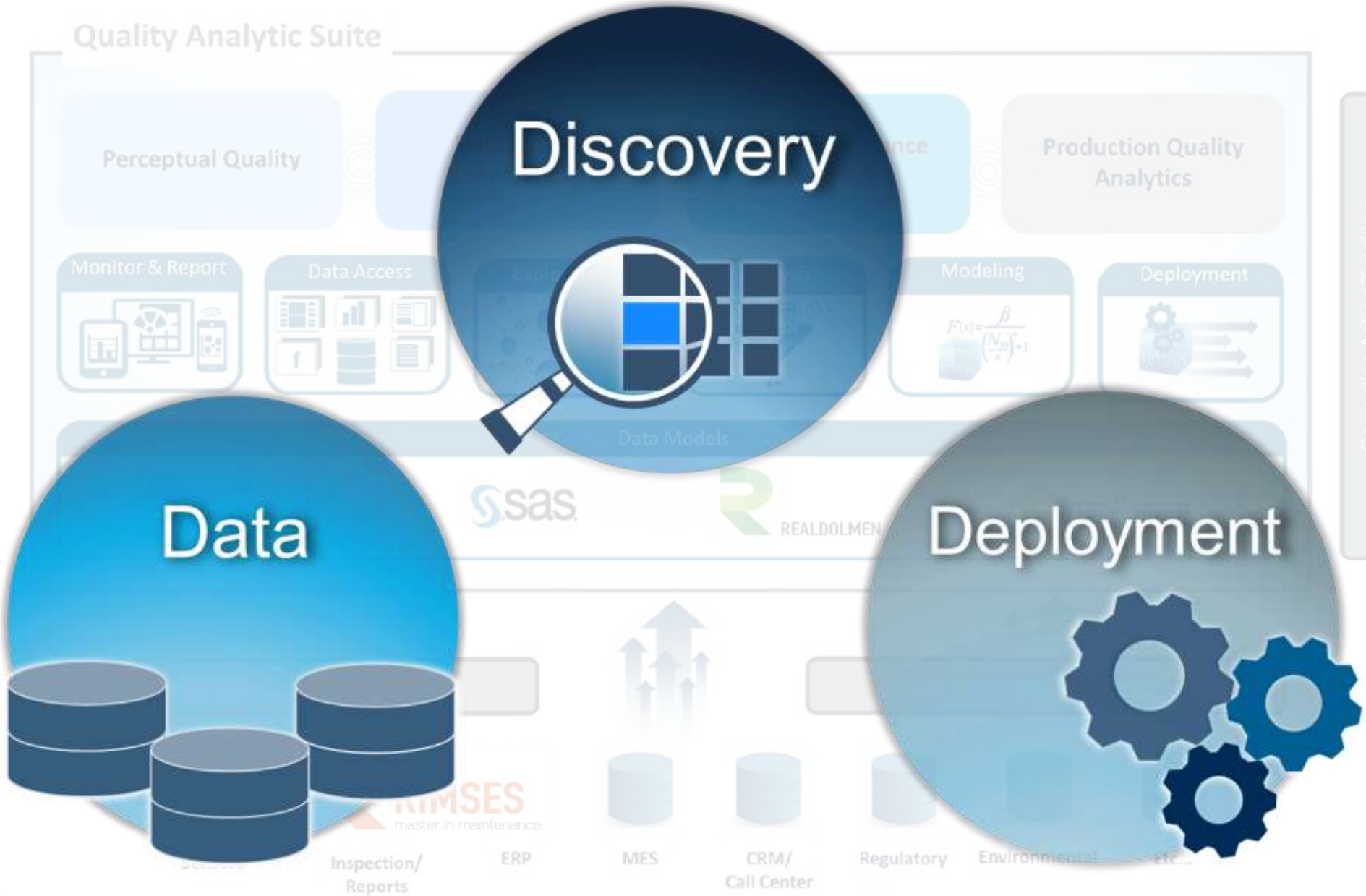
ASSET PERFORMANCE ANALYTICS



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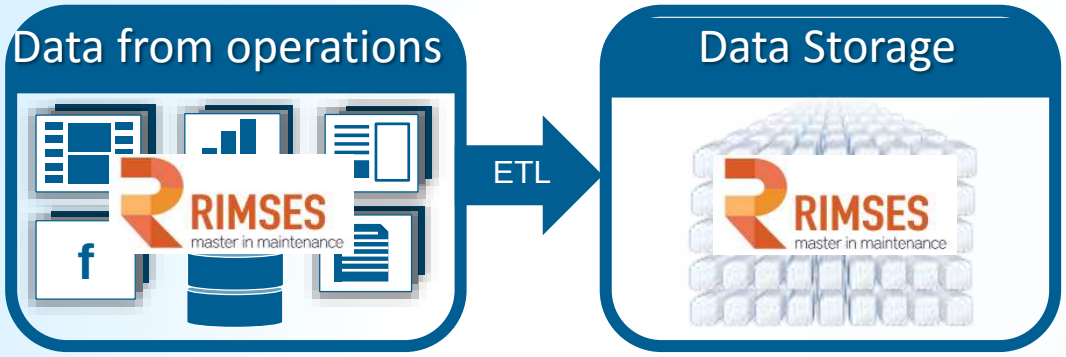
ASSET PERFORMANCE ANALYTICS

A ROADMAP TO SUCCESS

SENSE – UNDERSTAND - ACT



- We need data to perform analytics
- Data quality is crucial (GIGO)

- Typically 80% of the time data preparation and only 20% analysis
- Make sure your data is structured, of good quality and readily accessible

- Determine business case

- Think about deployment!

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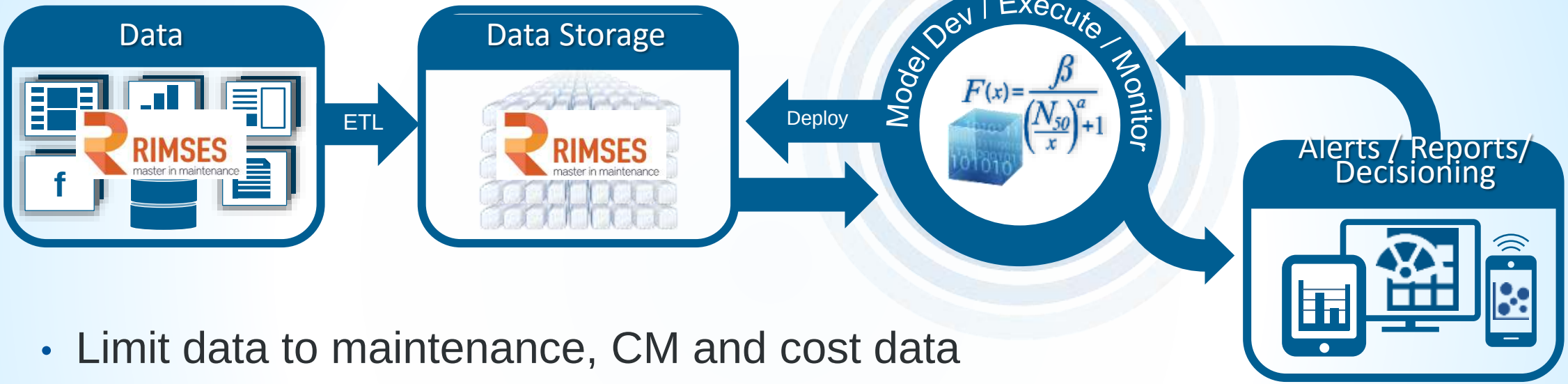
ASSET PERFORMANCE ANALYTICS

A ROADMAP TO SUCCESS

SENSE – UNDERSTAND - ACT



- Limit data to maintenance, CM and cost data
- Perform reliability analysis on event data
- Set alerts on condition monitoring data
- Visualize and explore data

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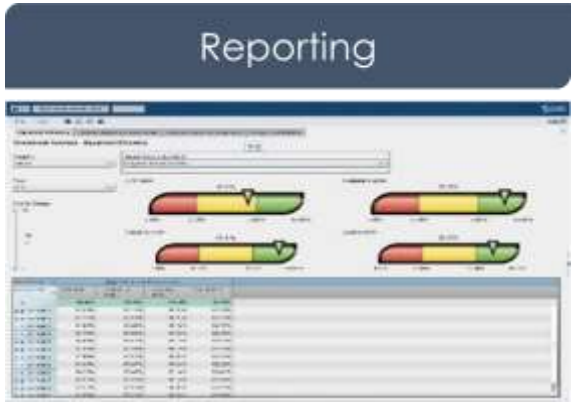
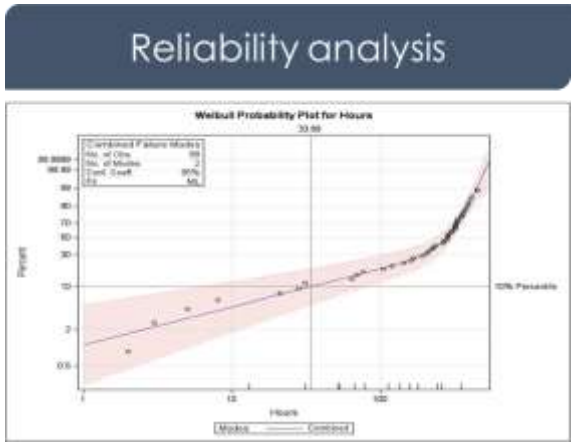
ASSET PERFORMANCE ANALYTICS

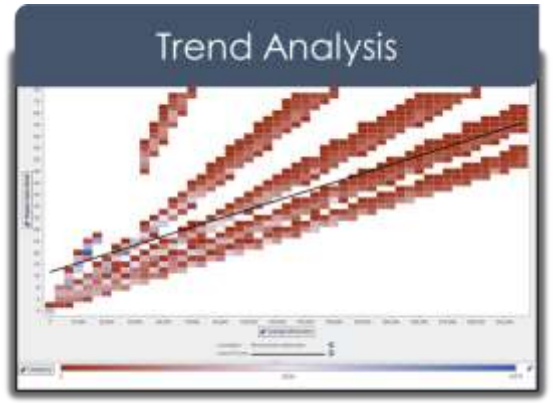
A ROADMAP TO SUCCESS

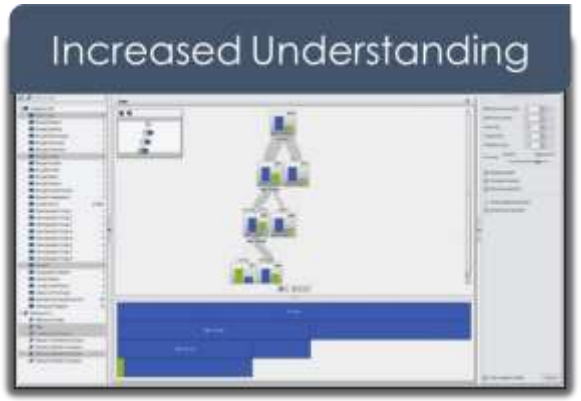
SENSE – UNDERSTAND - ACT

- KPI’s and Dashboards
- Reporting on costs, MTTF, downtimes…
- Reliability modeling
- Reliability block diagrams
- Cost modeling
- Data-driven RCM
- Bad actor analysis
- Criticality assessment
- …









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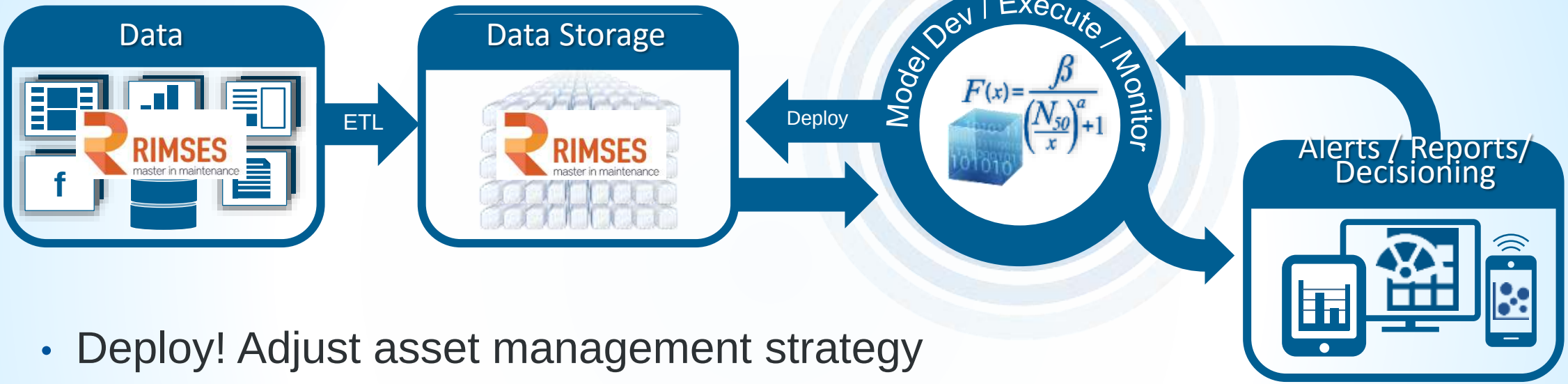
ASSET PERFORMANCE ANALYTICS

A ROADMAP TO SUCCESS

SENSE – UNDERSTAND - ACT



- Deploy! Adjust asset management strategy
- Continuous improvement

- Add additional data sources (e.g. quality, MES)

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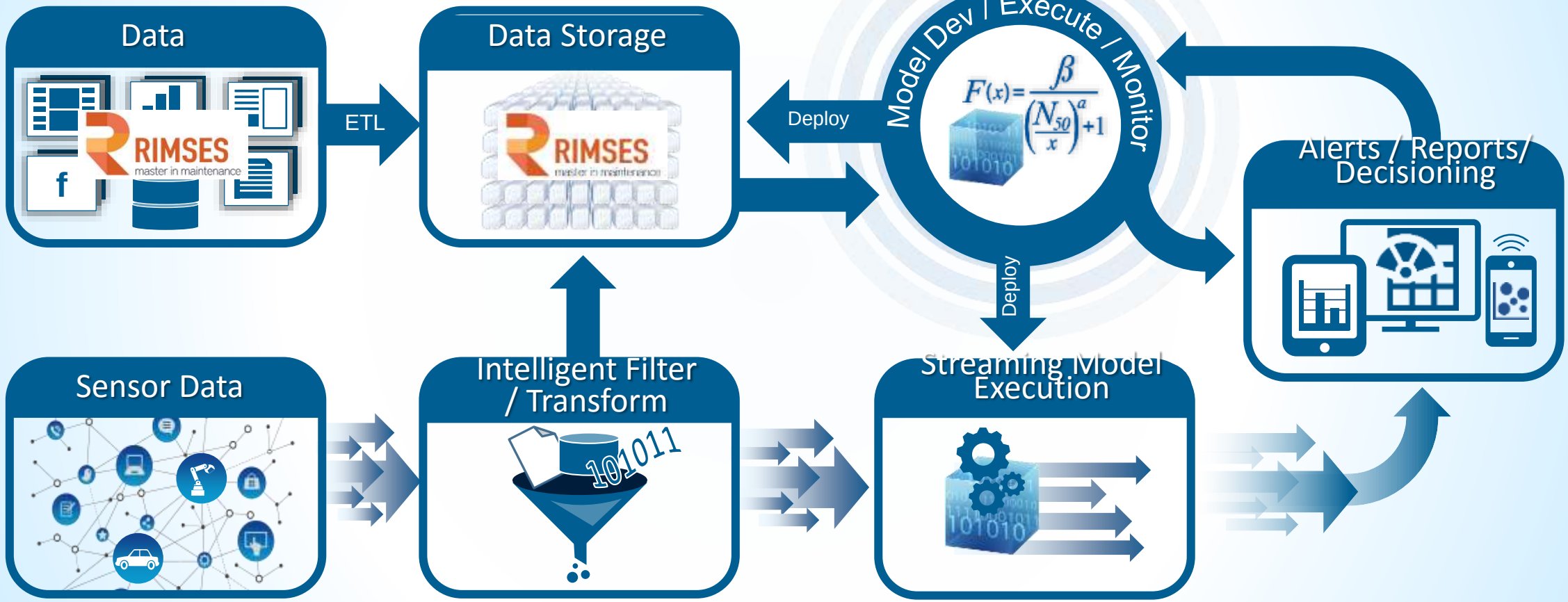
ASSET PERFORMANCE ANALYTICS

A ROADMAP TO SUCCESS

SENSE – UNDERSTAND - ACT



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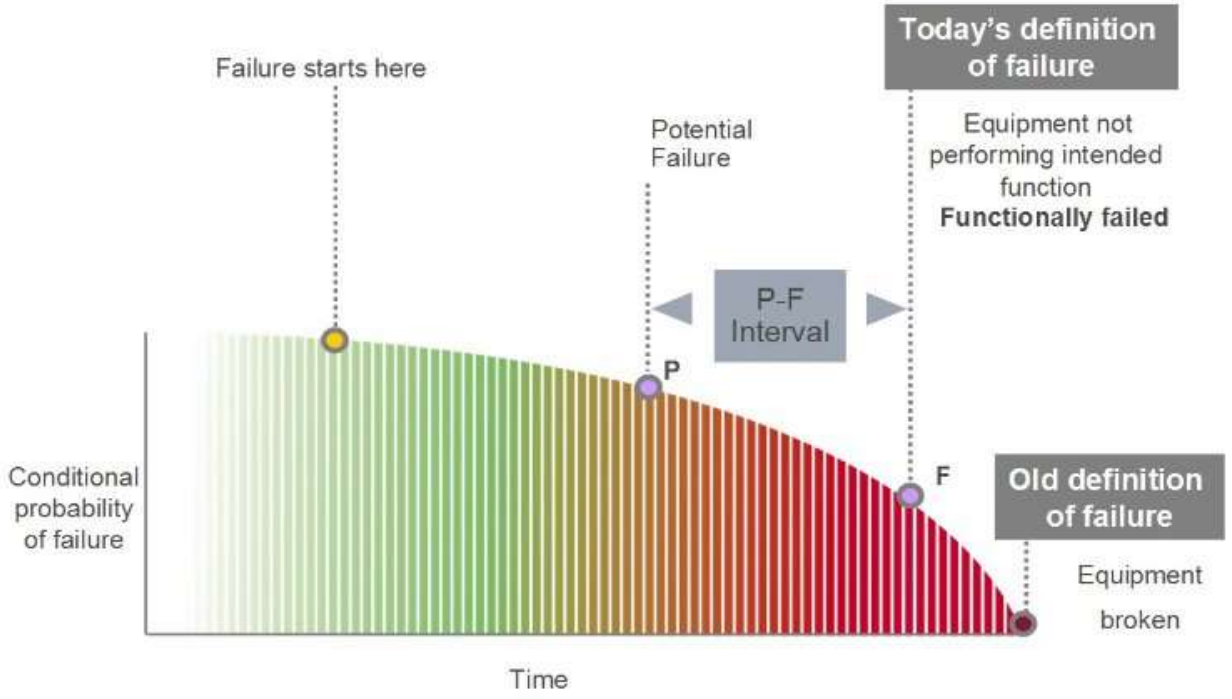
ASSET PERFORMANCE ANALYTICS

A ROADMAP TO SUCCESS

SENSE – UNDERSTAND - ACT

- Root cause analysis for failures
- Root cause analysis for product quality deviations
- Process optimization
- Predictive maintenance
- …



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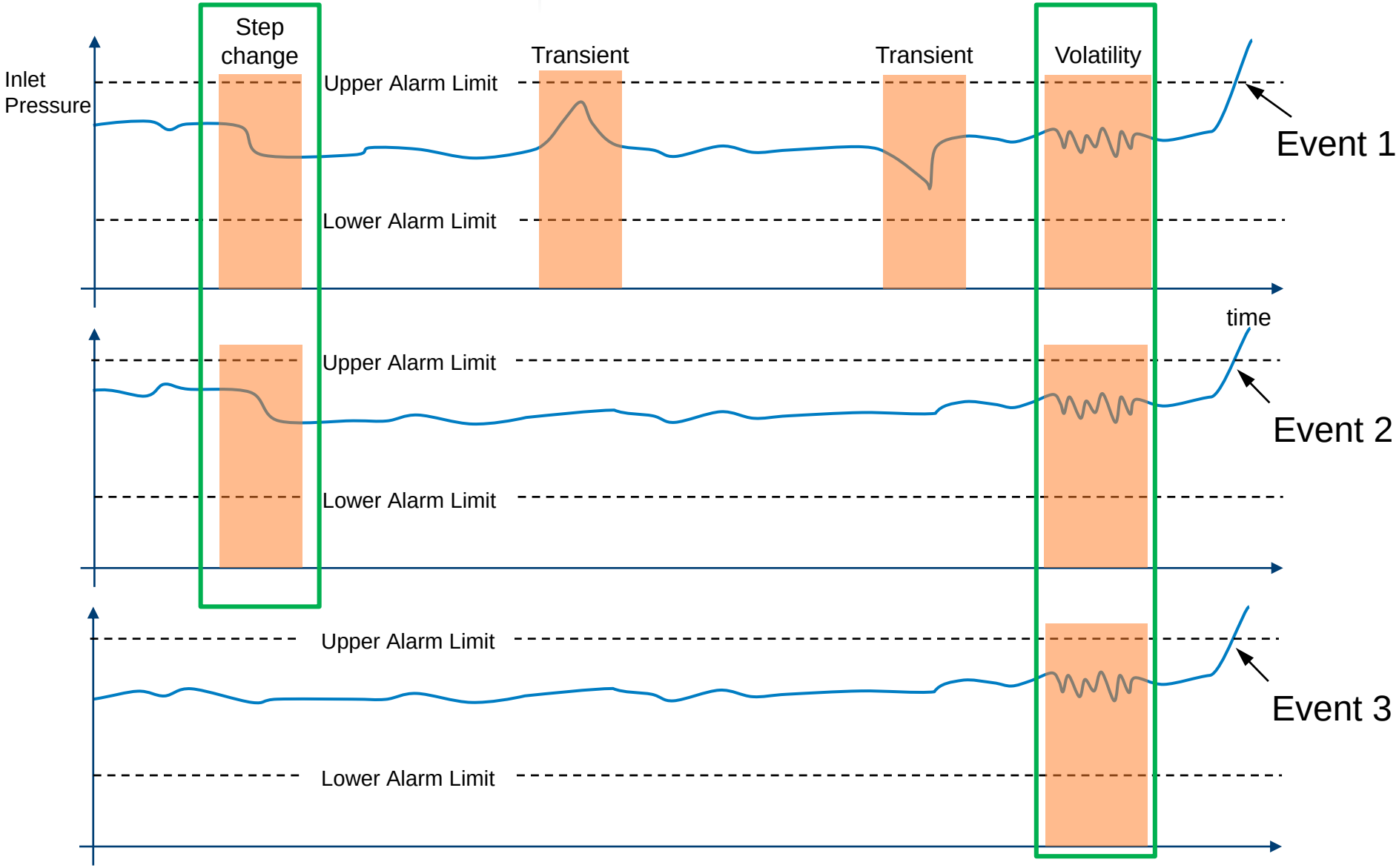
ASSET PERFORMANCE ANALYTICS

A ROADMAP TO SUCCESS

SENSE – UNDERSTAND - ACT

Root cause analysis



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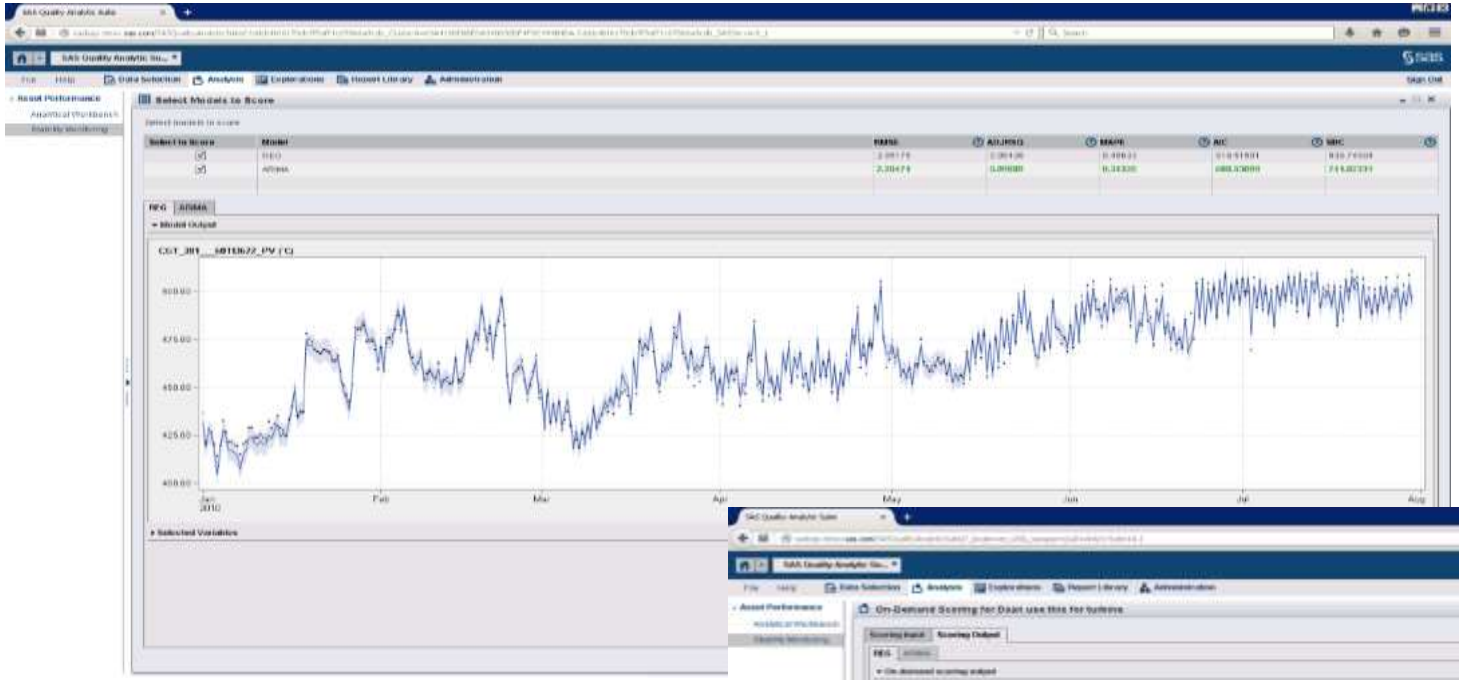
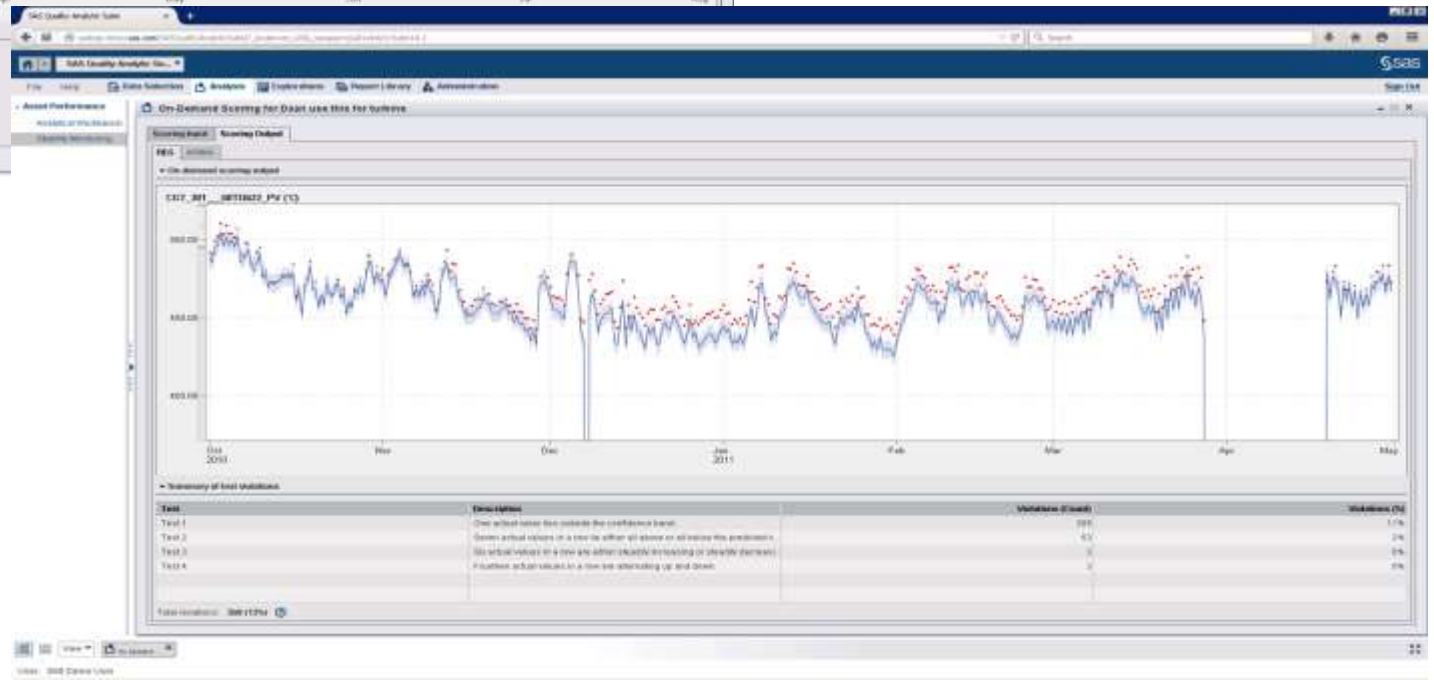
ASSET PERFORMANCE ANALYTICS

A ROADMAP TO SUCCESS

SENSE – UNDERSTAND - ACT

Stability monitoring





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sas THE POWER TO KNOW.

ASSET PERFORMANCE ANALYTICS

A ROADMAP TO SUCCESS

SENSE – UNDERSTAND - ACT

Predictive maintenance

- For predictive maintenance you both need (multiple) maintenance events and sensor data
  - Business Challenge
    - 20 production locations with a total of 296 wells
    - Active Magnetic Bearing (AMB) sensors of compressors
    - Sensor data is only used as a diagnostic aid during reactive maintenance
    - Analysis of data depends upon an engineers' knowledge
  - Results
    - Alarms are generated with a 10 weeks notice, a reduction of MTTR from 38 days to 10 days

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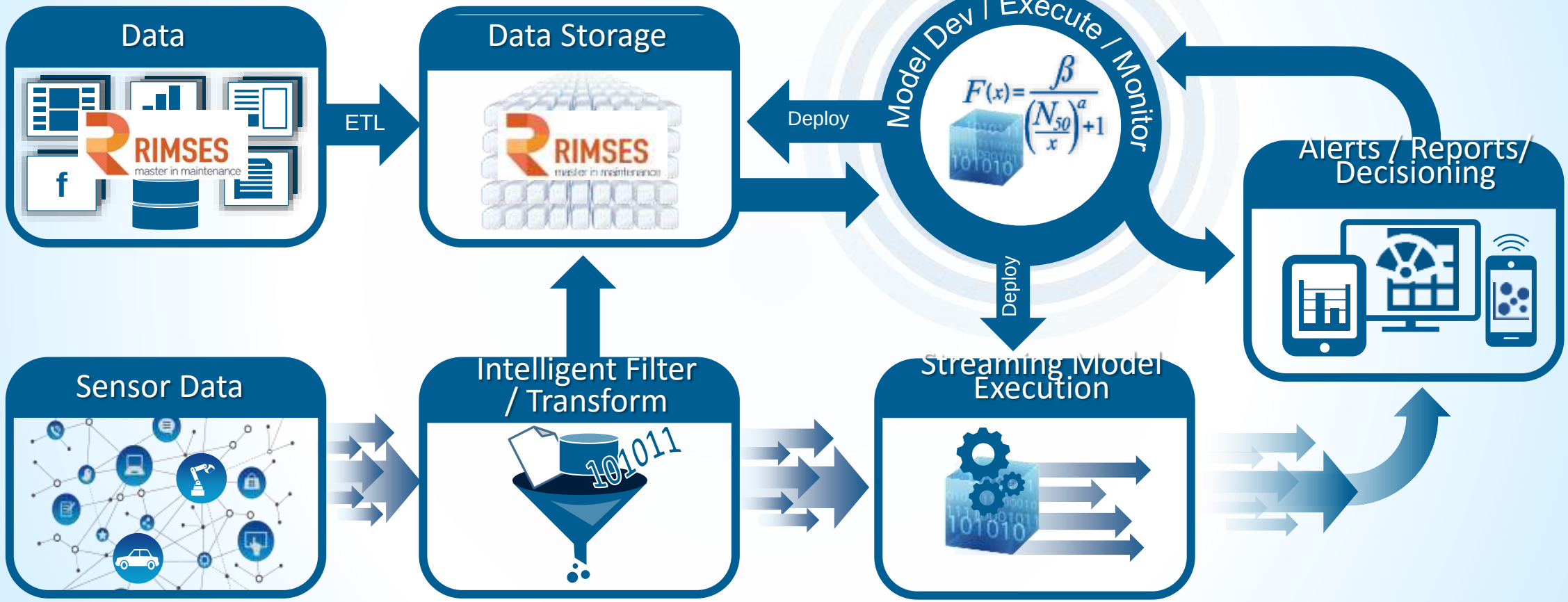
ASSET PERFORMANCE ANALYTICS

A ROADMAP TO SUCCESS

SENSE – UNDERSTAND - ACT



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TRUCK FLEET

ASSET PERFORMANCE ANALYTICS

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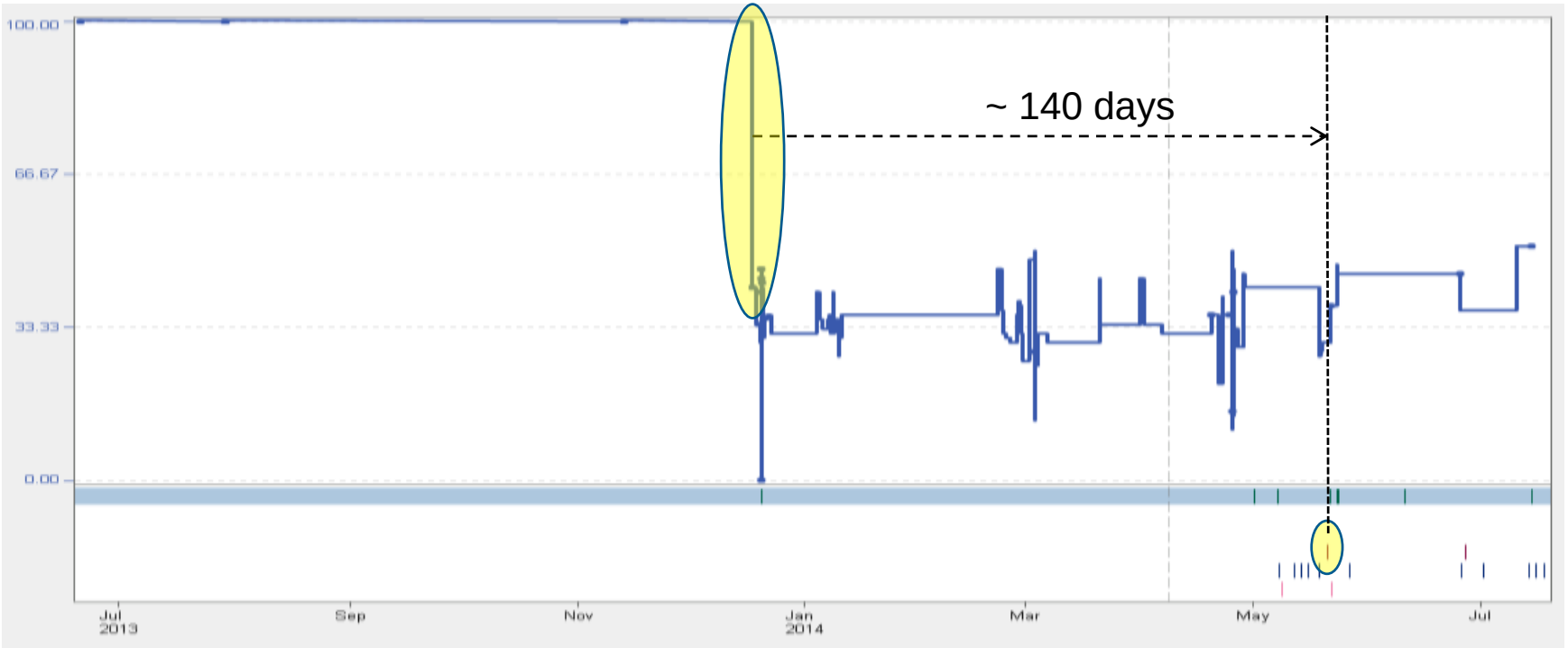
EXPLORATION HIGHLIGHTING FAILURE DUE TO NON-ACTION

Truck Fleet

- Correlate fault data to breakdowns and failures
- Predict breakdowns and component failures
- Perform reliability analysis on major parts

Engine Coolant Level compared to various Maintenance Events



ANALYTICAL FINDING: Exploration of engine coolant level and various maintenance events highlight failure to react to a drop in coolant level resulted in several **unplanned maintenance activities including an engine breakdown 140 days later**.

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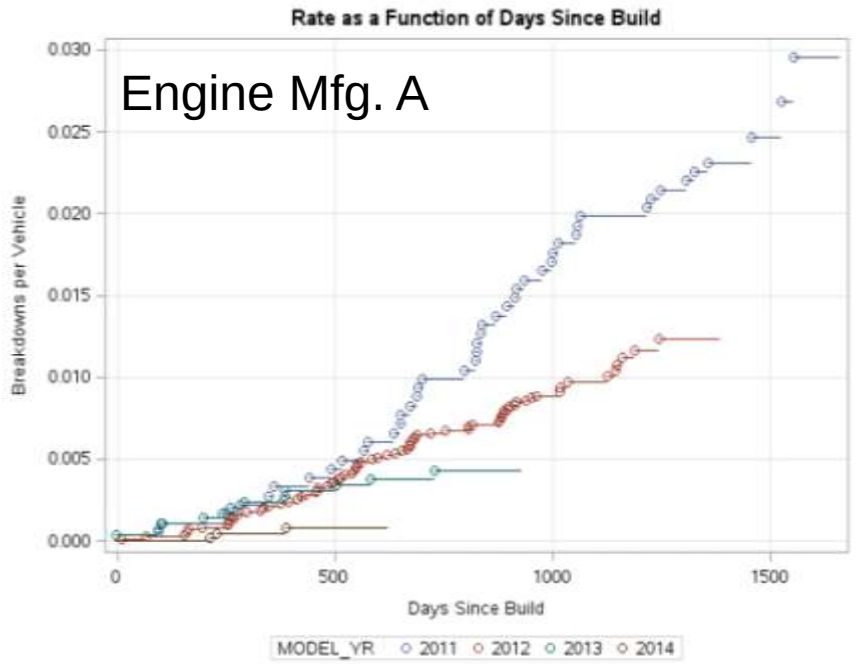
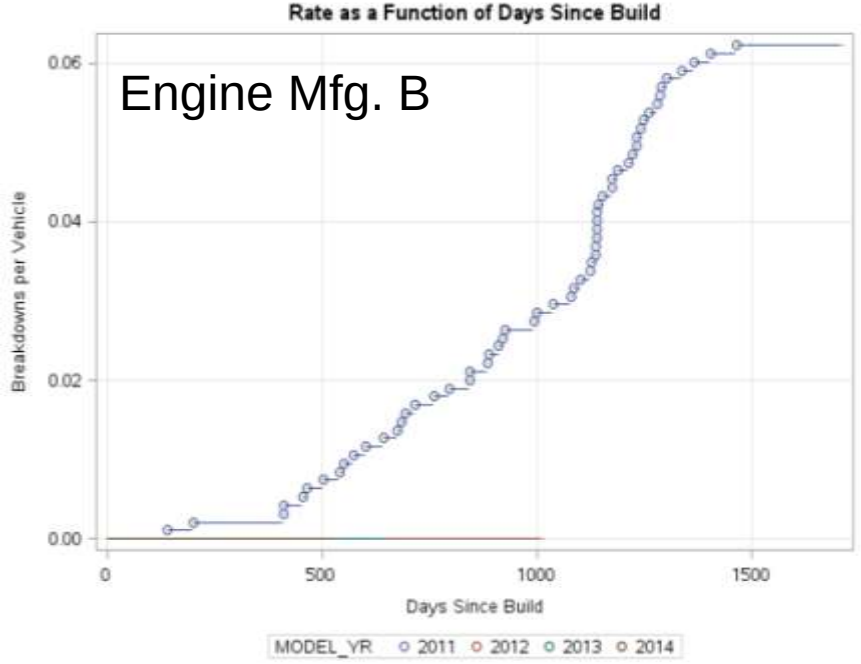
MONITORING / REPORTING OF KPIS

Truck Fleet

- Correlate fault data to breakdowns and failures
- Predict breakdowns and component failures
- Perform reliability analysis on major parts

Emerging Issues: Breakdown Systems for 6 subsystems





ANALYTICAL FINDING: Reliability analysis demonstrated Engine Mfg. B greatly improved after Model Year 2011 breakdown issues. **Engine Mfg. A** is improving but demonstrates **higher breakdown rates than Engine Mfg. B (Model Years 2012 – 2014)**

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YARA

ASSET PERFORMANCE ANALYTICS

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USE CASE EXAMPLE

- IN SEARCH FOR AN INNOVATIVE DATA ANALYTICS TOOLBOX FOR:
  - MAKING BETTER USE OF EXISTING PROCESS INFORMATION
  - PREVENTIVE MAINTENANCE – ABLE TO DETECT PROCESS DRIFTS IN AN EARLY STAGE, TURNAROUND SCOPE ANTICIPATION
  - PERFORMANCE EVALUATION OF EQUIPMENT
  - FAST AND EFFECTIVE PROCESS FOLLOW-UP
  - CONTINUOUS IMPROVEMENTS – PROCESS INCIDENT ROOT CAUSE ANALYSIS AND FAILURE PATTERN IDENTIFICATION
  - POSSIBLE GLOBAL IMPLEMENTATION

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Use case example

- Ammonia plant
- 2 use cases defined:
  - Waste heat boiler leakage
  - Gas turbine nozzle failure
- Determine relevant data – scope
  - Gas turbine components
  - Air compressors
  - Gas exhaust
  - Furnace
  - Convection section

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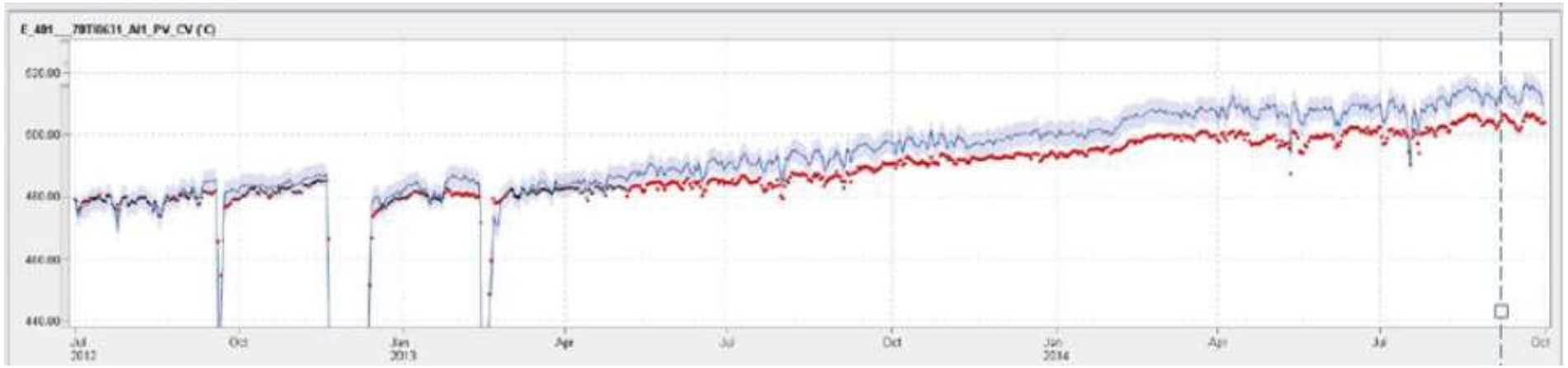
USE CASE EXAMPLE

- WASTE HEAT BOILER LEAKAGE
  - DISCOVERED (OCTOBER 2014) DURING INSPECTION AT THE TURNAROUND, NOT ANTICIPATED BY MONITORING
  - COULD HAVE RESULTED IN MAJOR TURNAROUND DELAY, BUT SPARE WAS AVAILABLE

  - DRIFT OBSERVED IN APRIL 2013



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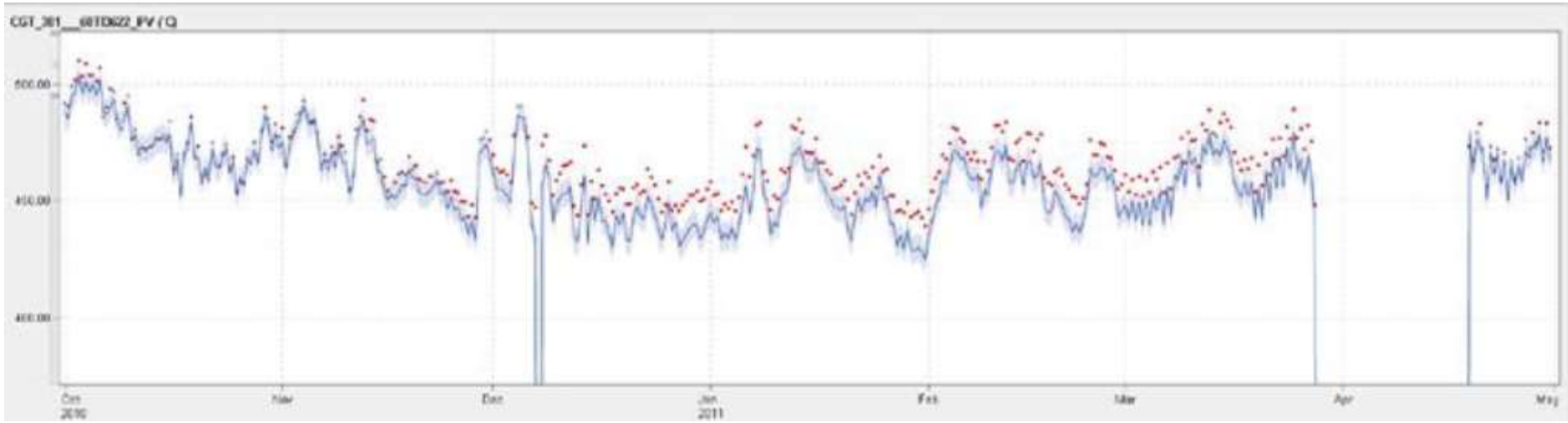
USE CASE EXAMPLE

- GAS TURBINE NOZZLE FAILURE
  - FIRST TRIP ON 7 DECEMBER 2010 AND STOP IN MARCH 2011 (DAMAGE OBSERVED)
  - CURRENT MONITORING RESULTED IN LATE DETECTION

  - DRIFT OBSERVED IN NOVEMBER 2010



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TIRE MANUFACTURER

PRODUCTION QUALITY ANALYTICS

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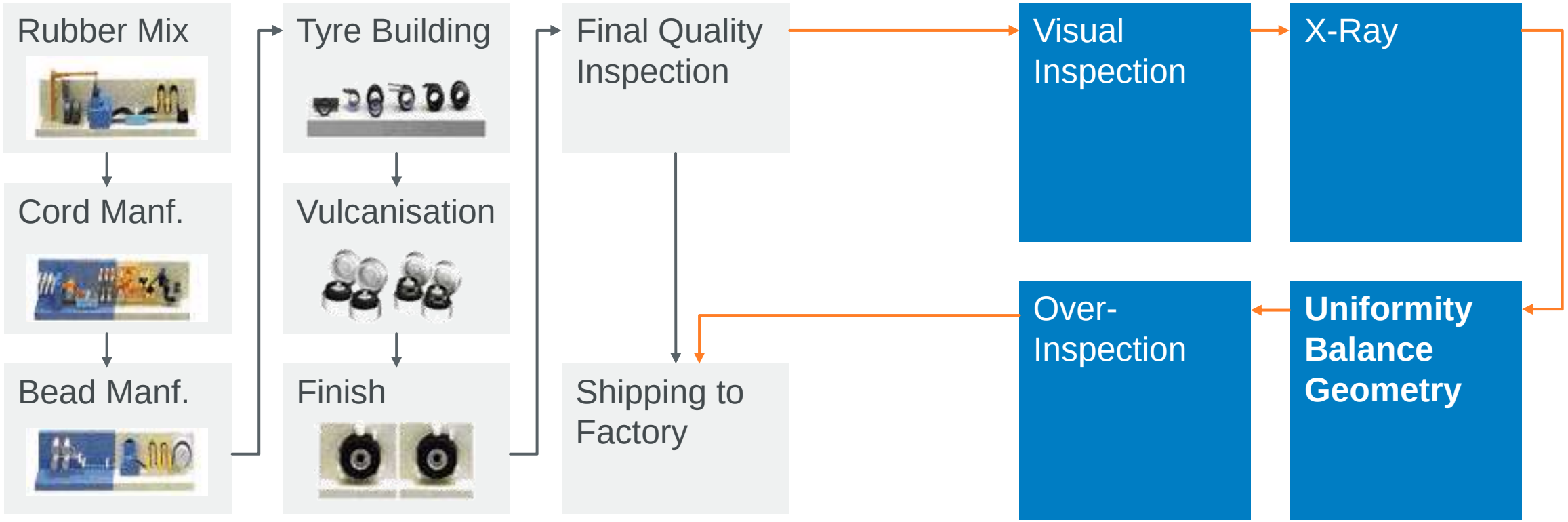
TIRE MANUFACTURING - PRODUCTION QUALITY ANALYTICS

Support Tire Production end-to-end: Mixing, Preparation, Building, Curing, Final Finish…



Target is to enable Engineers to drive sustainable Quality and Productivity Improvements

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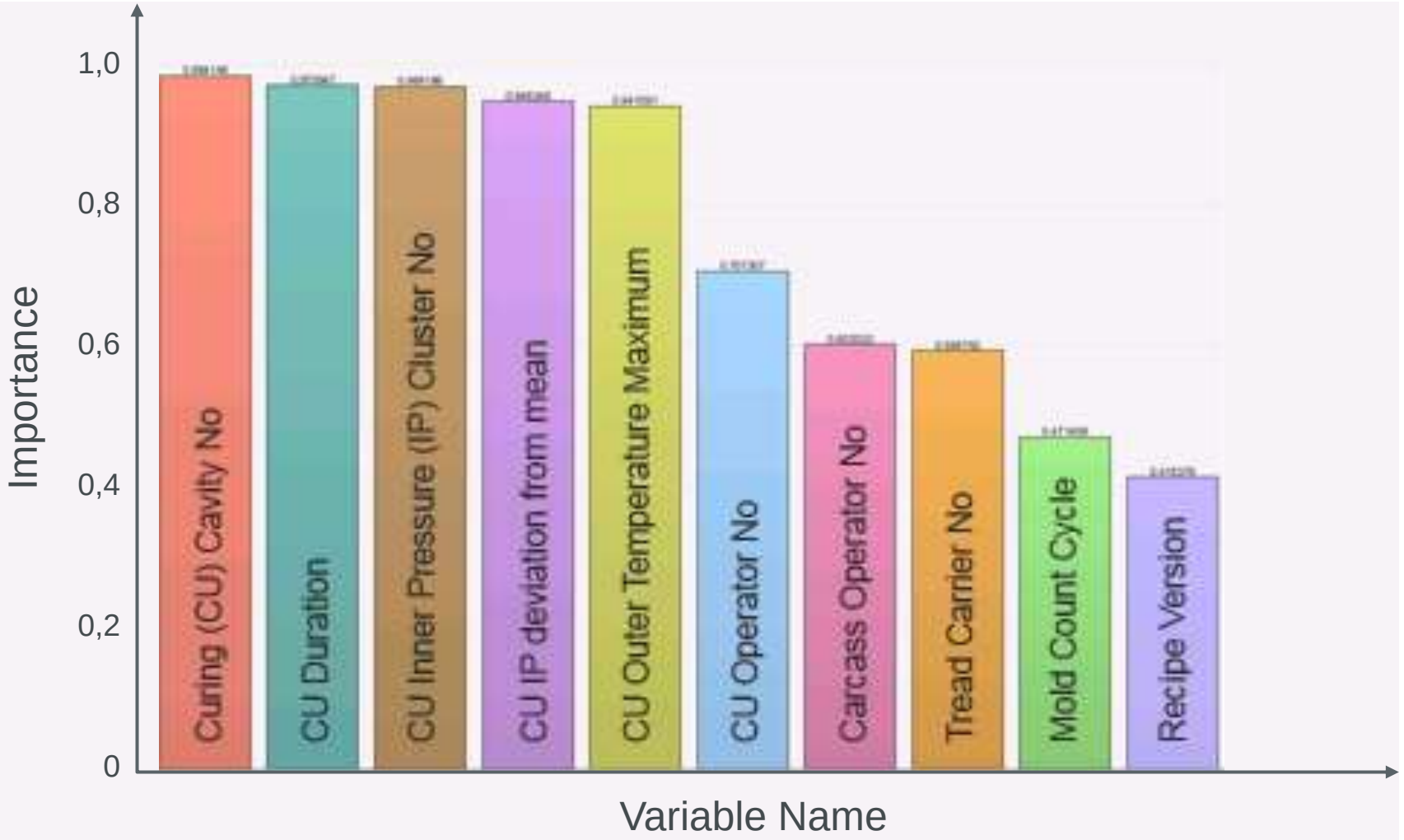
ROOT CAUSE ANALYSIS - PRODUCTION QUALITY ANALYTICS

The How's :

- Data Integration into analytical production centric data model
- Reporting
- Dimension reduction Analysis
- Root Cause Analysis
- Incident Management



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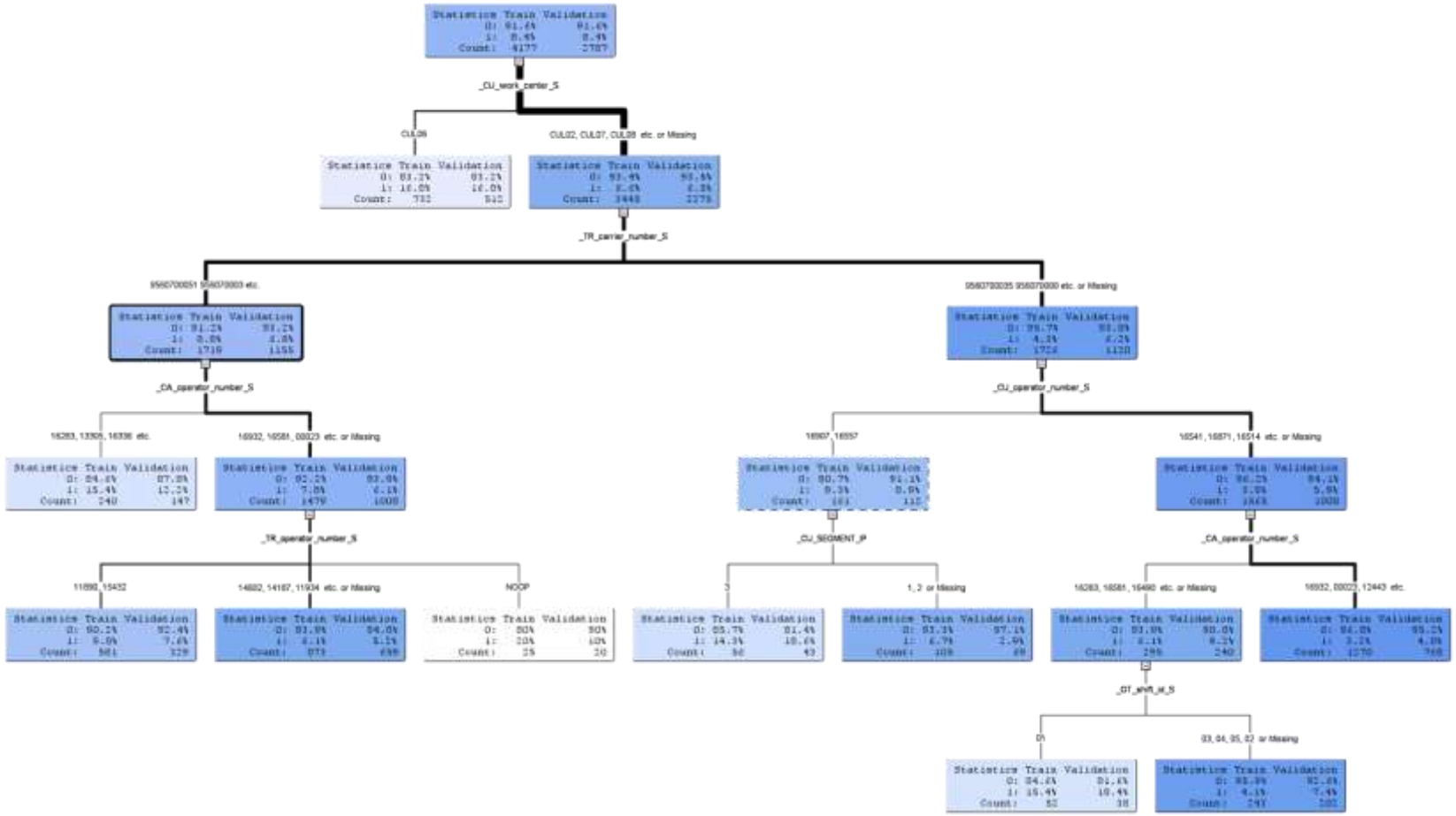
ROOT CAUSE ANALYSIS - PRODUCTION QUALITY ANALYTICS



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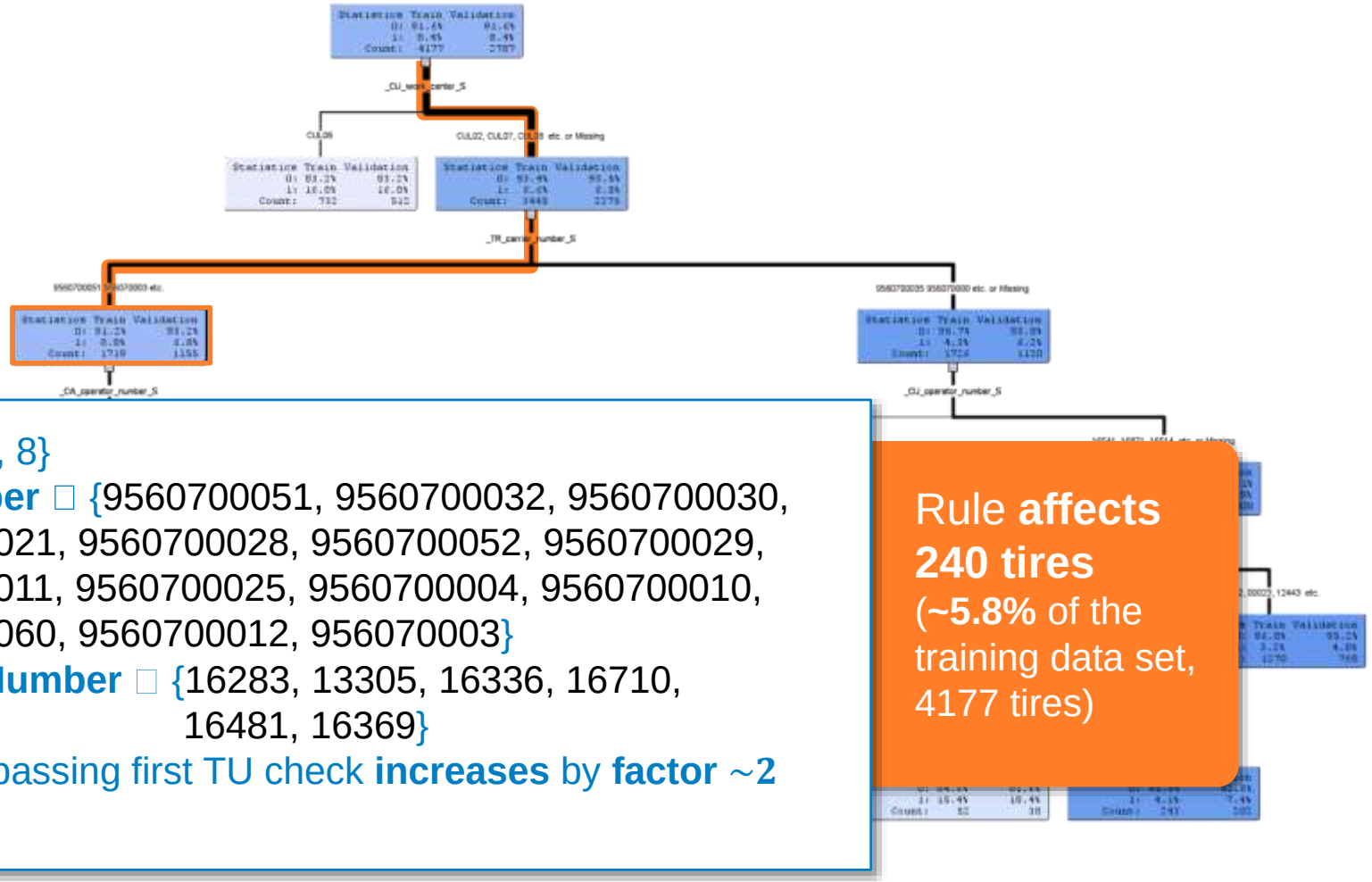
ROOT CAUSE ANALYSIS - PRODUCTION QUALITY ANALYTICS



Example Rule 1

If **Curing Cavity** □ {2, 5, 7, 8}
AND **Tread Carrier Number** □ {9560700051, 9560700032, 9560700030, 9560700021, 9560700028, 9560700052, 9560700029, 9560700011, 9560700025, 9560700004, 9560700010, 9560700060, 9560700012, 956070003}
AND **Carcass Operator Number** □ {16283, 13305, 16336, 16710, 16481, 16369}
THEN Probability of NOT passing first TU check **increases** by **factor ~2**

Rule **affects 240 tires** (**~5.8%** of the training data set, 4177 tires)

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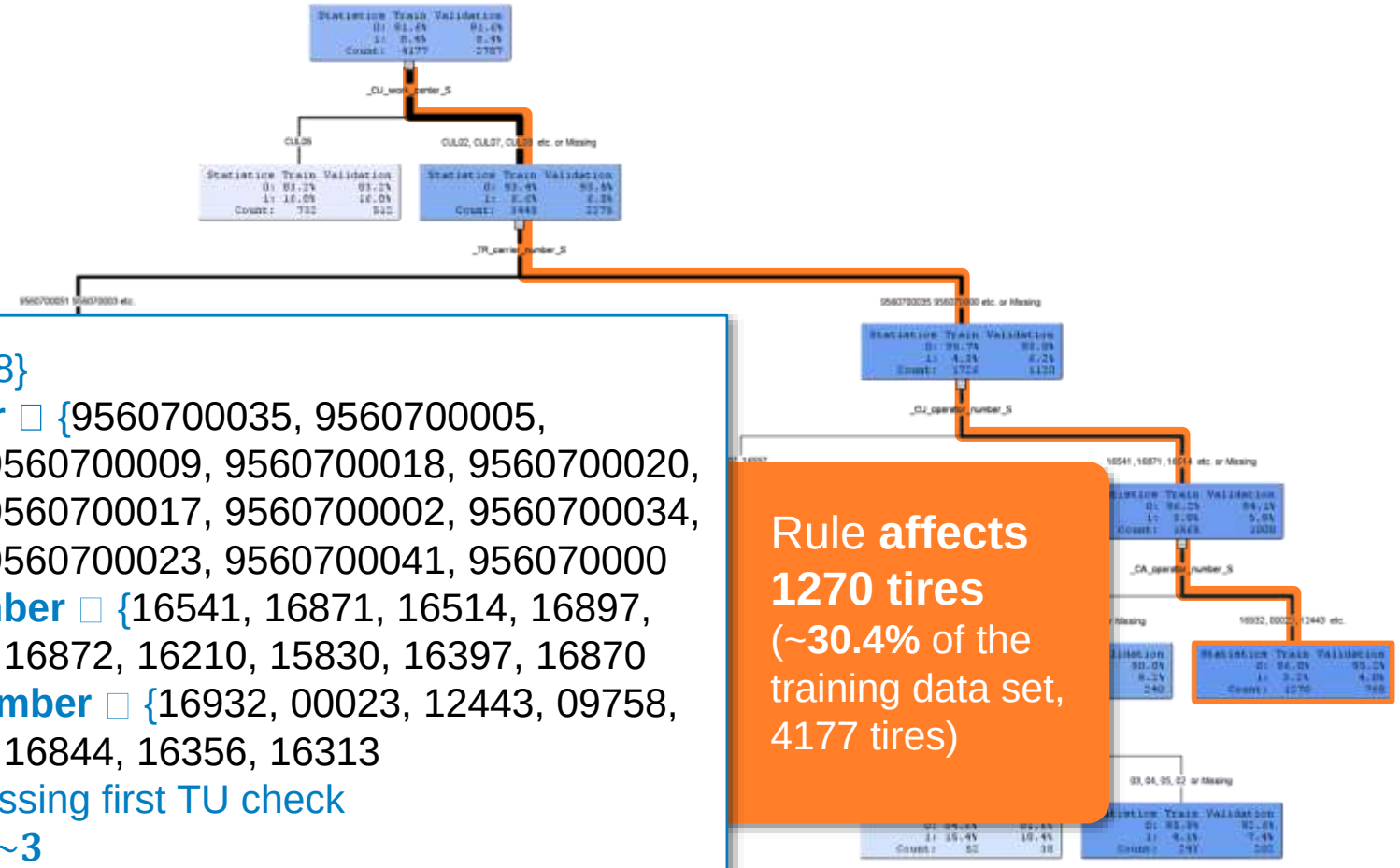
ROOT CAUSE ANALYSIS - PRODUCTION QUALITY ANALYTICS



Example Rule 2

If **Curing Cavity** □ {2, 5, 7, 8}
AND **Tread Carrier Number** □ {9560700035, 9560700005, 9560700040, 9560700009, 9560700018, 9560700020, 9560700001, 9560700017, 9560700002, 9560700034, 9560700022, 9560700023, 9560700041, 956070000
AND **Curing Operator Number** □ {16541, 16871, 16514, 16897, 16559, 12482, 16872, 16210, 15830, 16397, 16870
AND **Carcass Operator Number** □ {16932, 00023, 12443, 09758, 16336, 15836, 16844, 16356, 16313
THEN Probability of NOT passing first TU check **decreases** by **factor ~3**

Rule **affects 1270 tires** (~**30.4%** of the training data set, 4177 tires)

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PRODUCTION QUALITY ANALYTICS

Learning & Benefits

- Use Root Cause Analysis to find whether systematic influences on quality exist
- 4 rules identifying better / 6 rules identifying worse than average quality
- Use process optimization potential by analyzing rules
- Used data mining technologies can additionally be used for Root Cause Analysis for Semi-Finished Products

By fixing 50% of the discovered issues, virgin yield improved by 3%.

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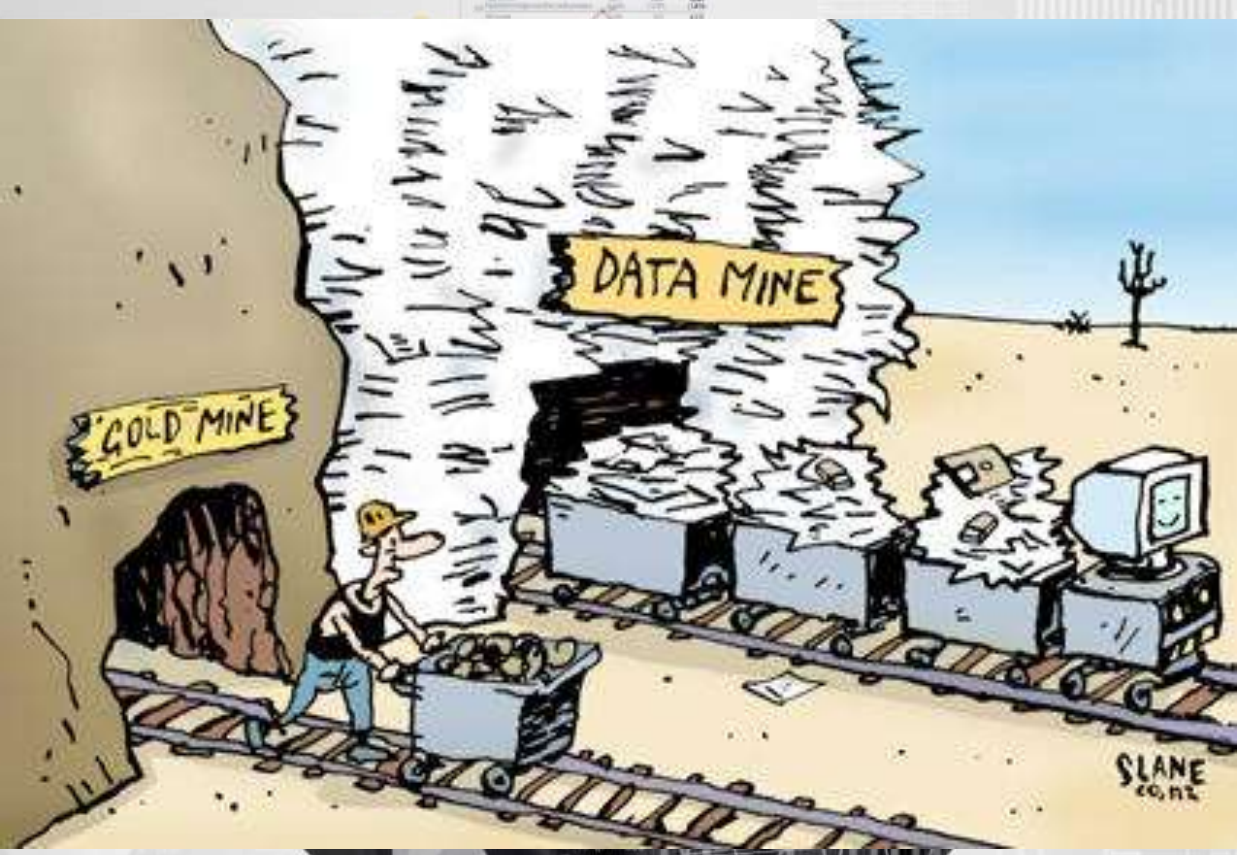

TAKEAWAYS

- If data is not *actionable*, it's likely not worth storing and analyzing
- Data needs *analytics* as lever to create value

- Align your asset management and analytics *maturity*

- Data – Discovery – Deploy

- Start small, find *value* and scale fast!

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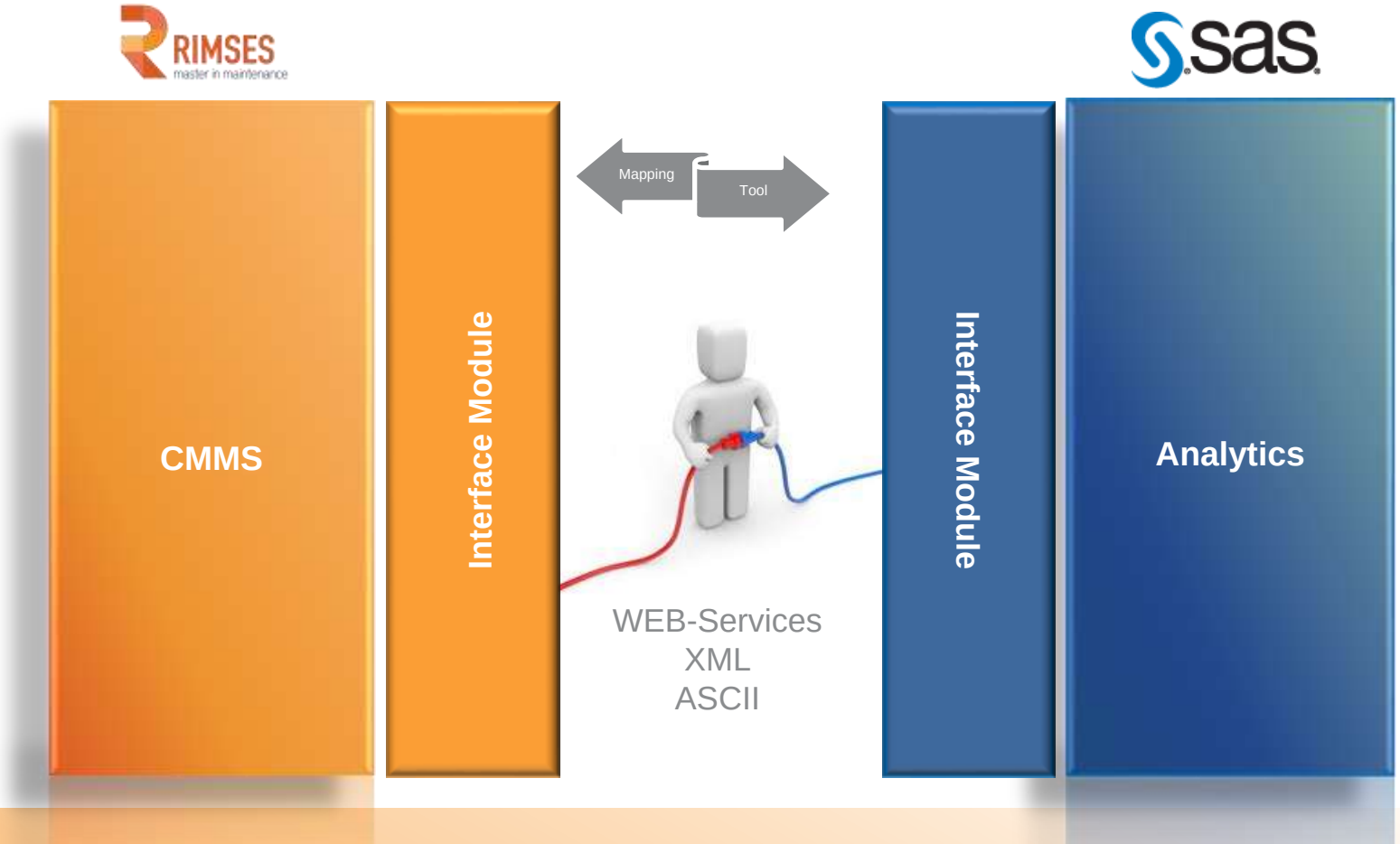
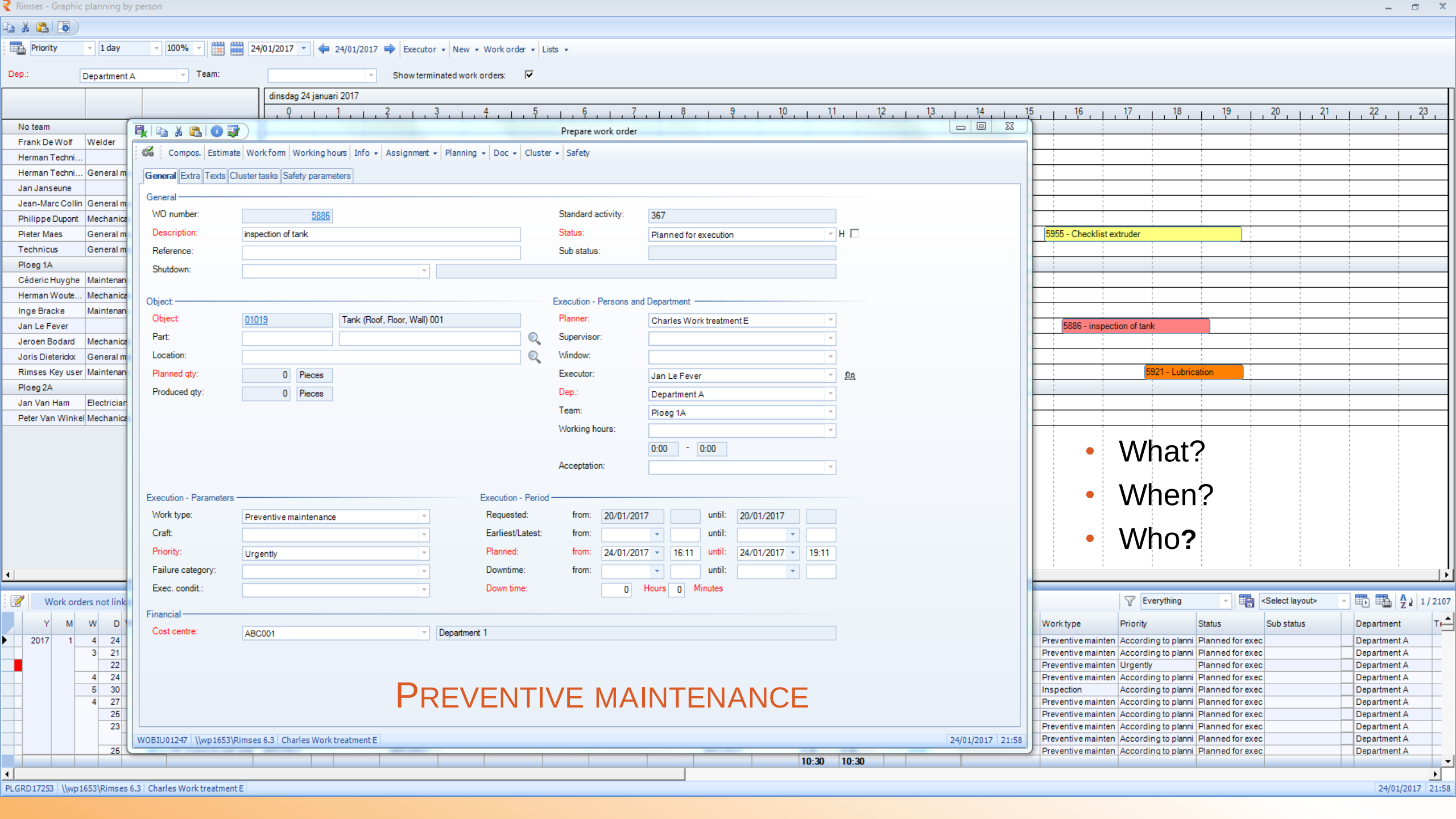
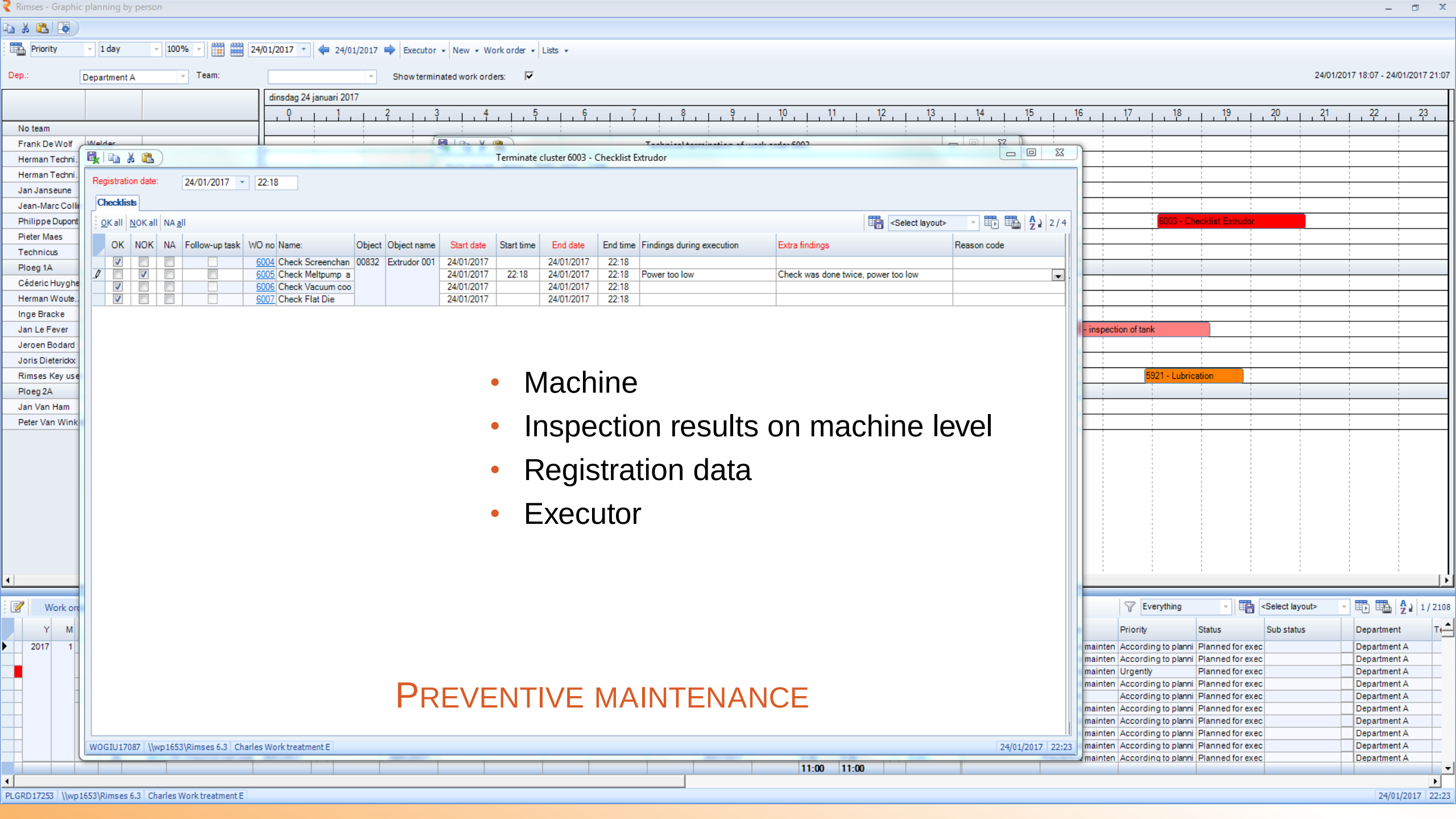
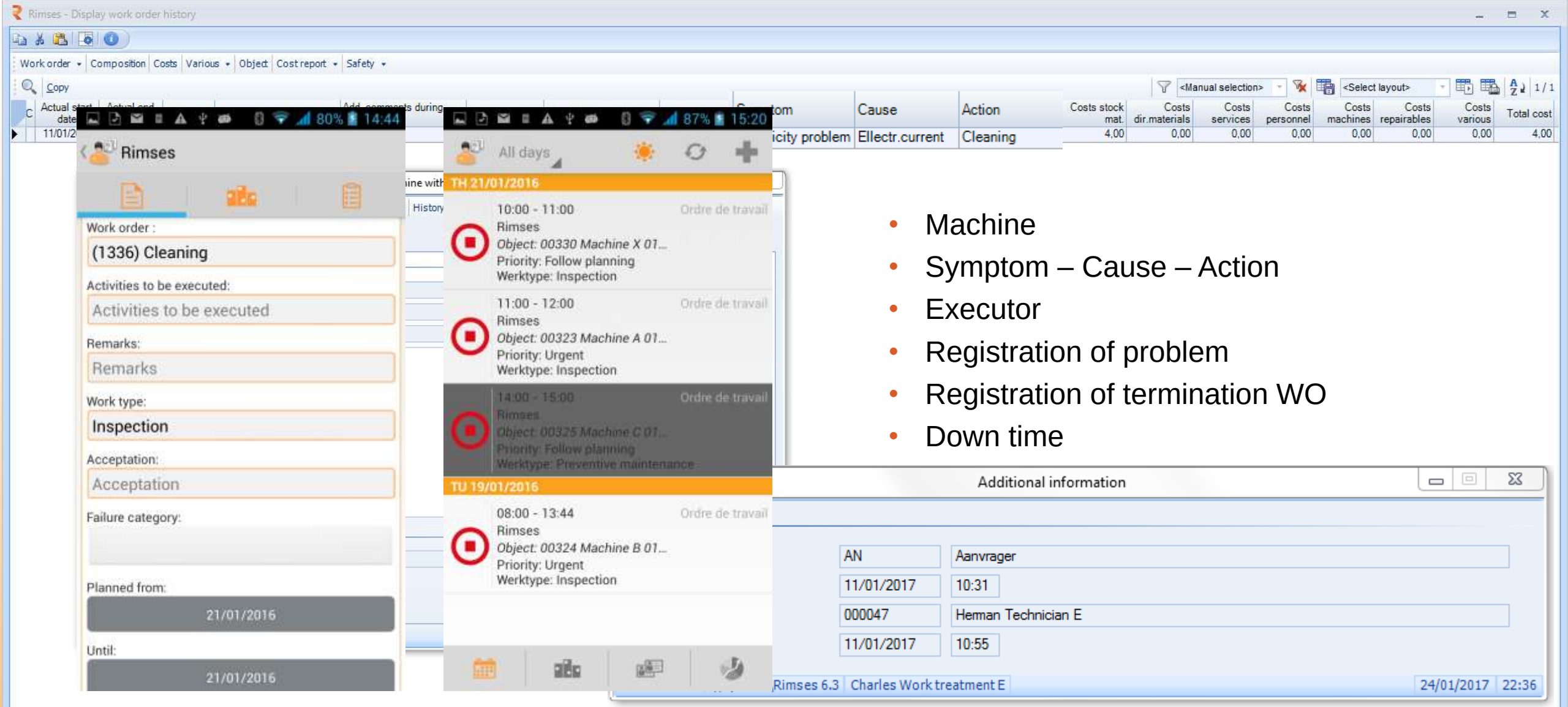
RIMSES DATA

- Analytics are as good as the availability and quality of the data
- Maintenance data becomes available for analytics using Rimses Interface




Rimses - Graphic planning by person
Prepare work order
General
Extra
Texts
Cluster tasks
Safety parameters
WO number: 5886
Description: inspection of tank
Reference:
Shutdown:
Standard activity: 367
Status: Planned for execution
Sub status:
Object:
Object: 01019 Tank (Roof, Floor, Wall) 001
Part:
Location:
Planned qty: 0 Pieces
Produced qty: 0 Pieces
Execution - Persons and Department
Planner: Charles Work treatment E
Supervisor:
Window:
Executor: Jan Le Fever
Dep.: Department A
Team: Ploeg 1A
Working hours:
0:00 - 0:00
Acceptation:
Execution - Parameters
Work type: Preventive maintenance
Craft:
Priority: Urgently
Failure category:
Exec. condit.:
Execution - Period
Requested: from: 20/01/2017 until: 20/01/2017
Earliest/Latest: from: until:
Planned: from: 24/01/2017 16:11 until: 24/01/2017 19:11
Downtime: from: until:
Down time: 0 Hours 0 Minutes
Financial
Cost centre: ABC001 Department 1
5955 - Checklist extruder
5886 - inspection of tank
5921 - Lubrication
What?
When?
Who?
PREVENTIVE MAINTENANCE

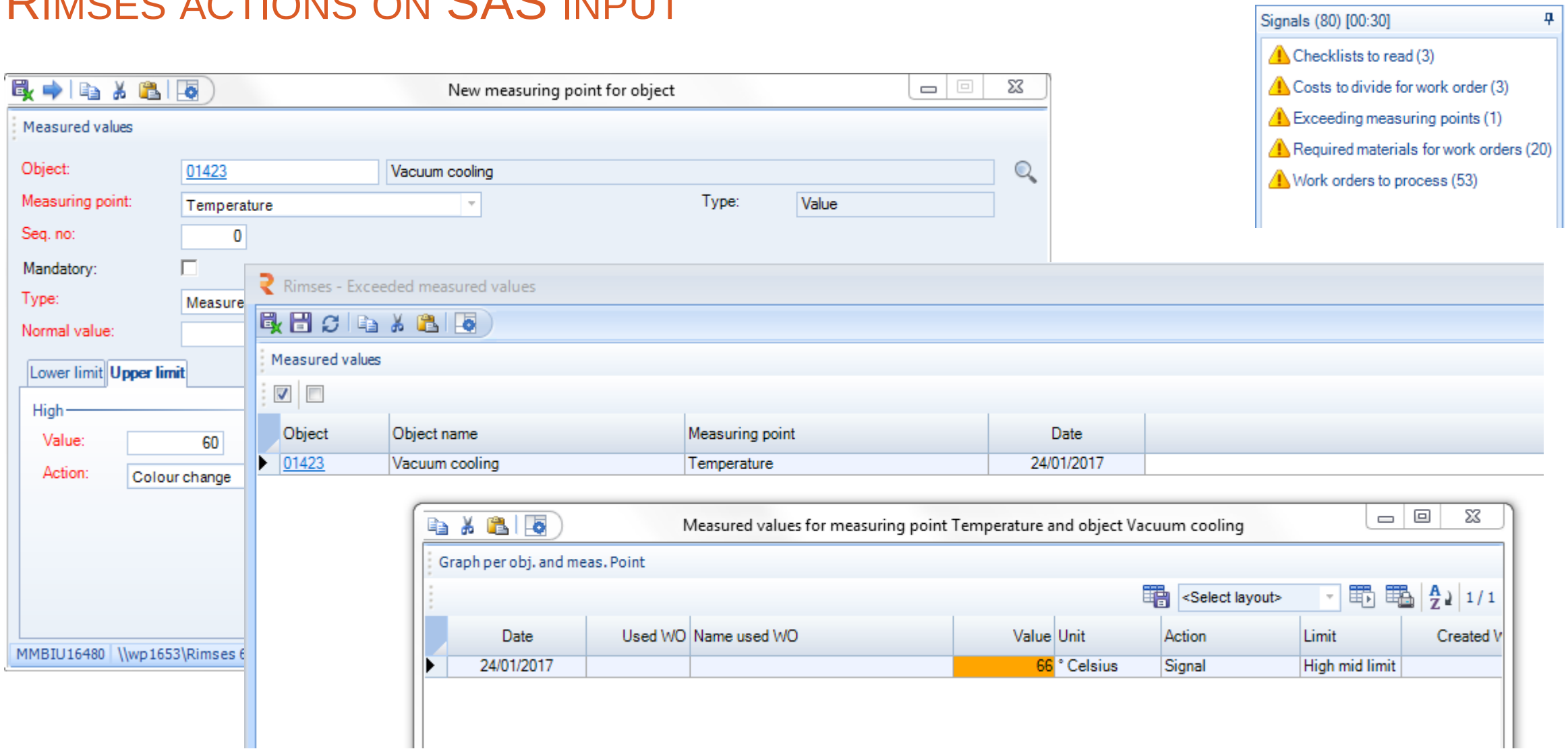

Terminate cluster 6003 - Checklist Extrudor
Registration date: 24/01/2017 22:18
Checklists
OK all NOK all NA all
OK NOK NA Follow-up task WO no Name: Object Object name Start date Start time End date End time Findings during execution Extra findings Reason code
6004 Check Screenchan 00832 Extrudor 001 24/01/2017 24/01/2017 22:18
6005 Check Meltpump a 24/01/2017 22:18 24/01/2017 22:18 Power too low Check was done twice, power too low
6006 Check Vacuum coo 24/01/2017 24/01/2017 22:18
6007 Check Flat Die 24/01/2017 24/01/2017 22:18
6003 - Checklist Extrudor
- inspection of tank
5921 - Lubrication
Machine
Inspection results on machine level
Registration data
Executor
PREVENTIVE MAINTENANCE



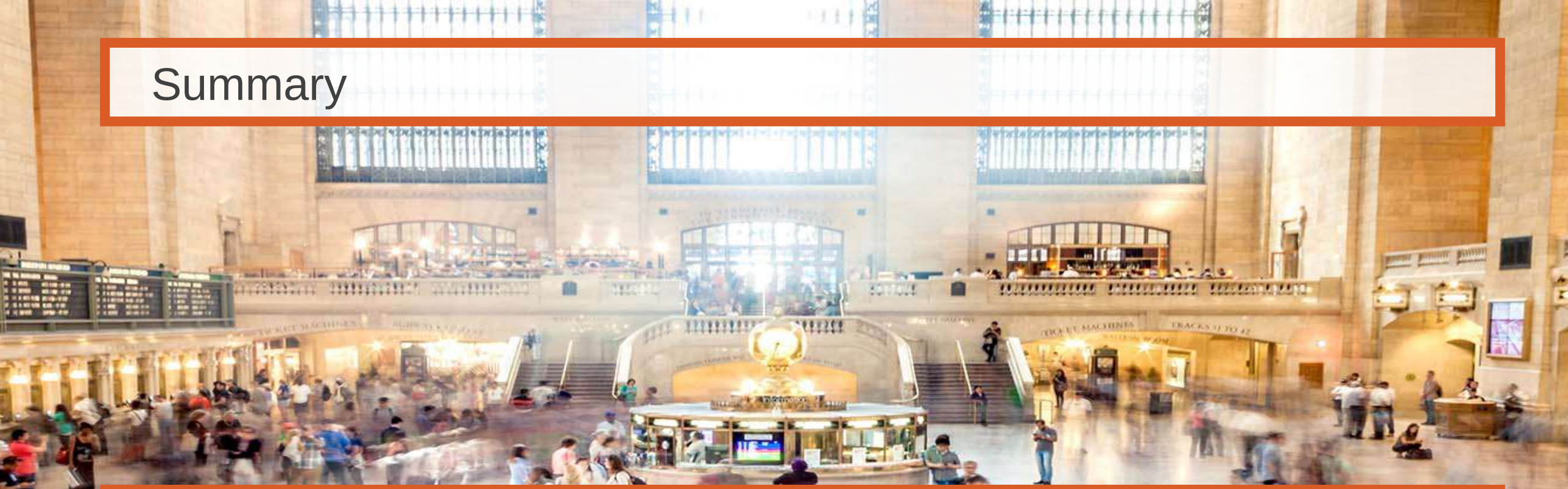
- Machine
- Symptom – Cause – Action
- Executor
- Registration of problem
- Registration of termination WO
- Down time

FAILURES AND WORK REQUESTS INFORMATION

RIMSES ACTIONS ON SAS INPUT

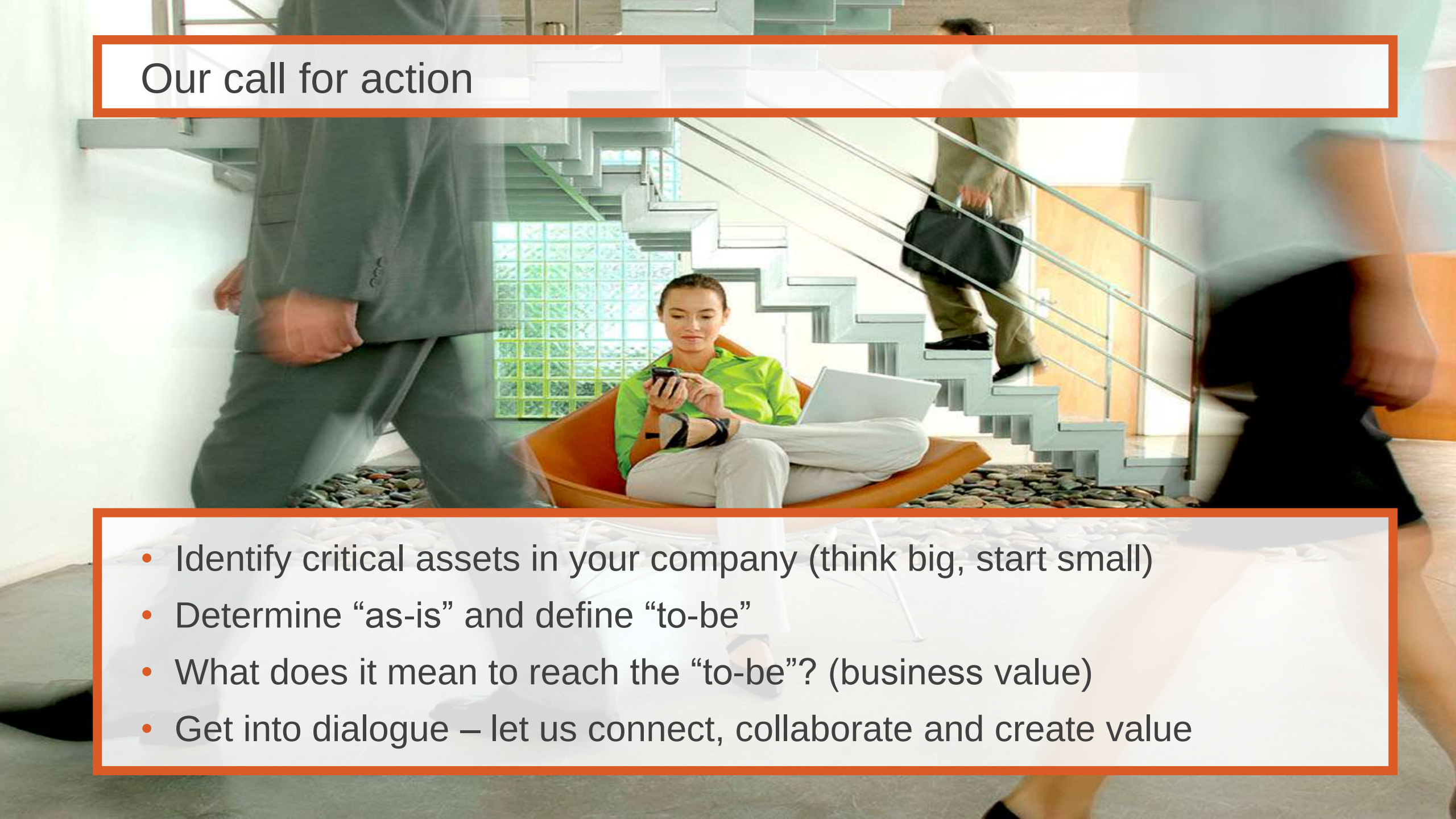


Summary



- Data is crucial (and the quality)
- Data can come from differtent sources (including CMMS)
- Analytics will lead to better decisions
- Rimses/SAS offer an integrated platform

Our call for action



- Identify critical assets in your company (think big, start small)
- Determine “as-is” and define “to-be”
- What does it mean to reach the “to-be”? (business value)
- Get into dialogue – let us connect, collaborate and create value

REALDOLMEN

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