

# Production Optimization of Automotive Body Shop

think 2018

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# Please note

General Motors has declined to participate in the presentation. It was too late to change the title. The content of this presentation does not reflect General Motors case study but experience of various automotive clients with the solution

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# Contents

## Production Optimization Overview

### OEE Losses and Plant Performance Analytics

- Automotive Body Shop Throughput Optimization

### Programing and Deploying Use Cases



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# Production Optimization Overview

# \$5 Trillion

As Per McKinsey Industry-wide  
Manufacturing Losses / Waste estimated to  
be \$5 Trillion Per Annum



# Get Plant Performance Insights And Advice For Best Action

## Production Optimization

Achieve Throughput to Potential

Eliminate Waste

## Productivity Losses

Equipment Related

- Machine Availability Loss
- Quality Loss
- Performance Loss

Process Related

- Energy Loss
- Yield Loss

Management Related

- Labor Loss
- Material Availability Loss

Predict, Pinpoint, Prescribe

# Process Manufacturing

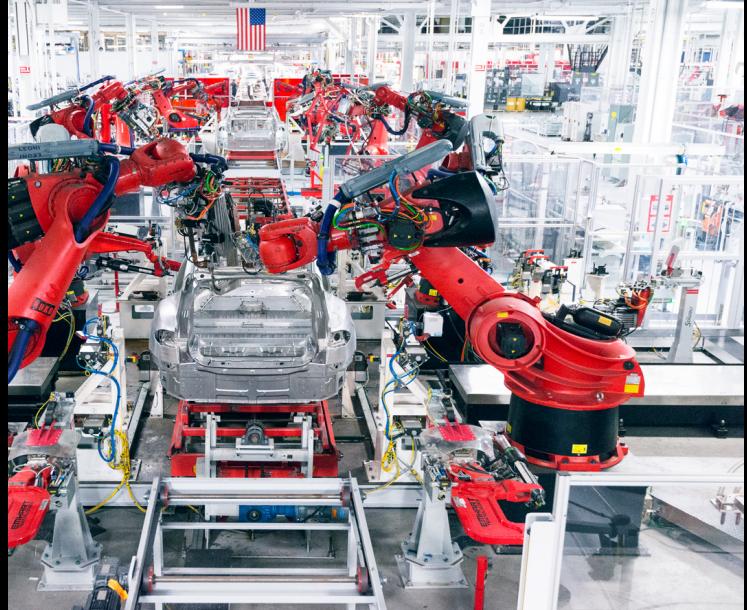


Throughput Optimization Use Case

with

**IBM Plant Advisor**

# Discrete Manufacturing

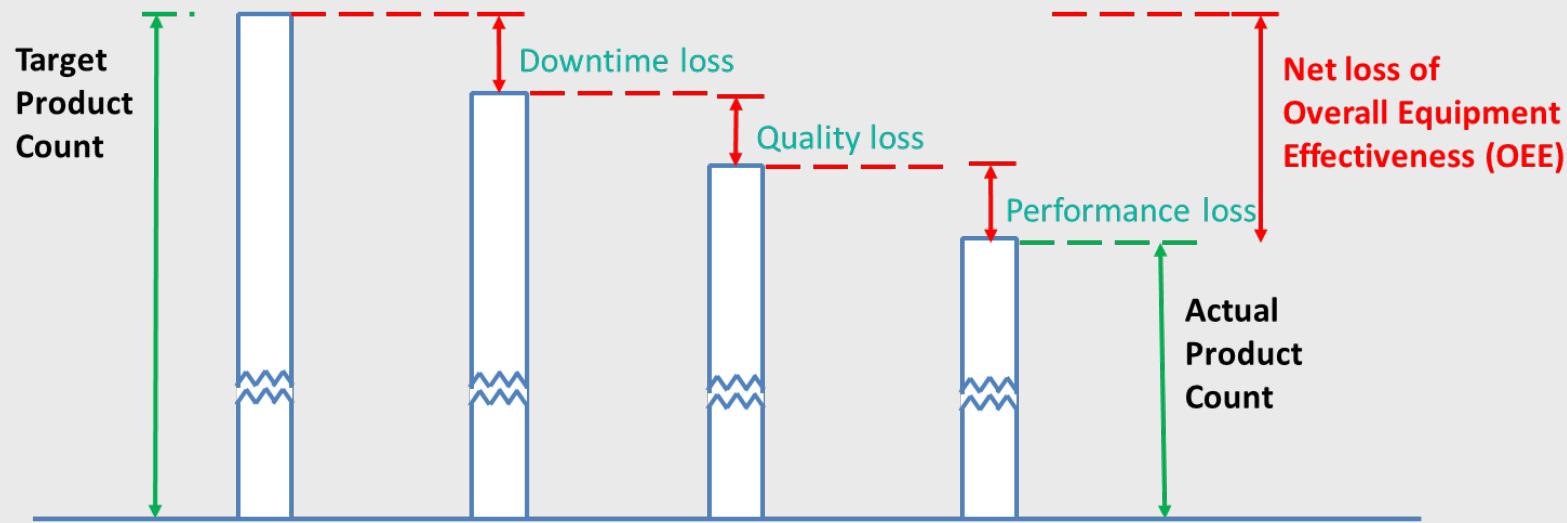


OEE Maximization Use Case

with

**IBM Plant Performance Analytics**

# What if we could predict & pinpoint potential OEE losses at machine level and prescribe optimized remedy?



Availability, Quality and Performance Constraints Contribute to OEE loss resulting in lower Throughput

# IBM Plant Performance Analytics



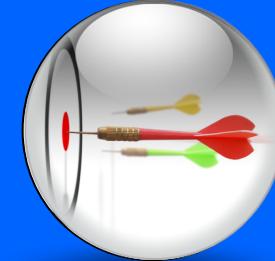
## Predict and Localize potential constraints to productivity

Turn plant floor data into actionable insights for plant management. Predict availability, performance and quality losses at individual device and station level. Calculate potential OEE impact of the losses.



## Prescribe remedies to mitigate productivity risks

Use machine learning to recommend best course actions based on data collected from plant floor. Optimization algorithms that prioritize maintenance tasks and recommends best time to repair machines.



## Achieve Throughput to Potential w/ Industry Content

Reduce unplanned downtime, slow downs. Avoid costly reworks and recalls. Achieve OEE improvement while reducing operations costs due overtime, material waste, spare parts and emergency maintenance

# Predictive and Prescriptive Capabilities that Maximizes OEE

## Predictive Insights

A

Availability  
(↓ Downtime Loss)

- Downtime Loss Prediction
- Probability of Failure
- Predicted Time to Failure
- Probable Cause
- Predicted Time to repair

## Prescriptive Decision Support

- Maintenance Plan Optimization
- Best time to repair
- What if analysis / OE impact analysis
- Maintenance Tasks / Advisor

## Production Objective

Maximize Throughput to Potential

P

Performance  
(↓ Speed Loss)

- Performance Prediction
- Slowdowns
- Cycle time – Ideal vs. actual
- Drill down to task / m/c level

- Production Plan Optimization
- Detailed Sequencing
- Resource allocation
- What if analysis

X

Q

Quality  
(↓ Quality Loss)

- Quality Loss Prediction
- Probability of Quality Issue
- Predicted Time to Issue
- Root Cause

- Quality Optimization
- Process/Recipe set points/limits
- What if analysis

# OEE Losses in Automotive Body Shop

# Automotive Body Shop Processes & Equipment

## Processes

Weld

    Spot weld

    Stud Weld

    Laser Weld

Sealing

Riveting

    Self Piercing Rivets

## Equipment

Robots – 200 to 500

    Weld guns – 100 to 400

    Clamps – 100 to 500

    Fixtures – 200 to 500

Pallets



# Issues

## Process Faults / Failures – Weld Quality

Spot Weld - C-Factor, High / Low Current

Sealants - High / Low Volume dispensing

Stud Weld – High / Low Pressure

## Machine Failure – Downtime

Robots – Servo, Gearbox

Inverter failure

## Slowdowns

Clamps, Fixtures – leaks, seals

We typically design body-in-white assembly lines for 20% over capacity. If the target OEE is 60 frames an hours, we design for 72 frames. But the cost of higher capacity is exponentially higher.

**Body Shop Line Builder.**

# Data for Machine Learning

Event Log Data

    Warnings, Faults, Stops from Controllers

    Downtime Logs

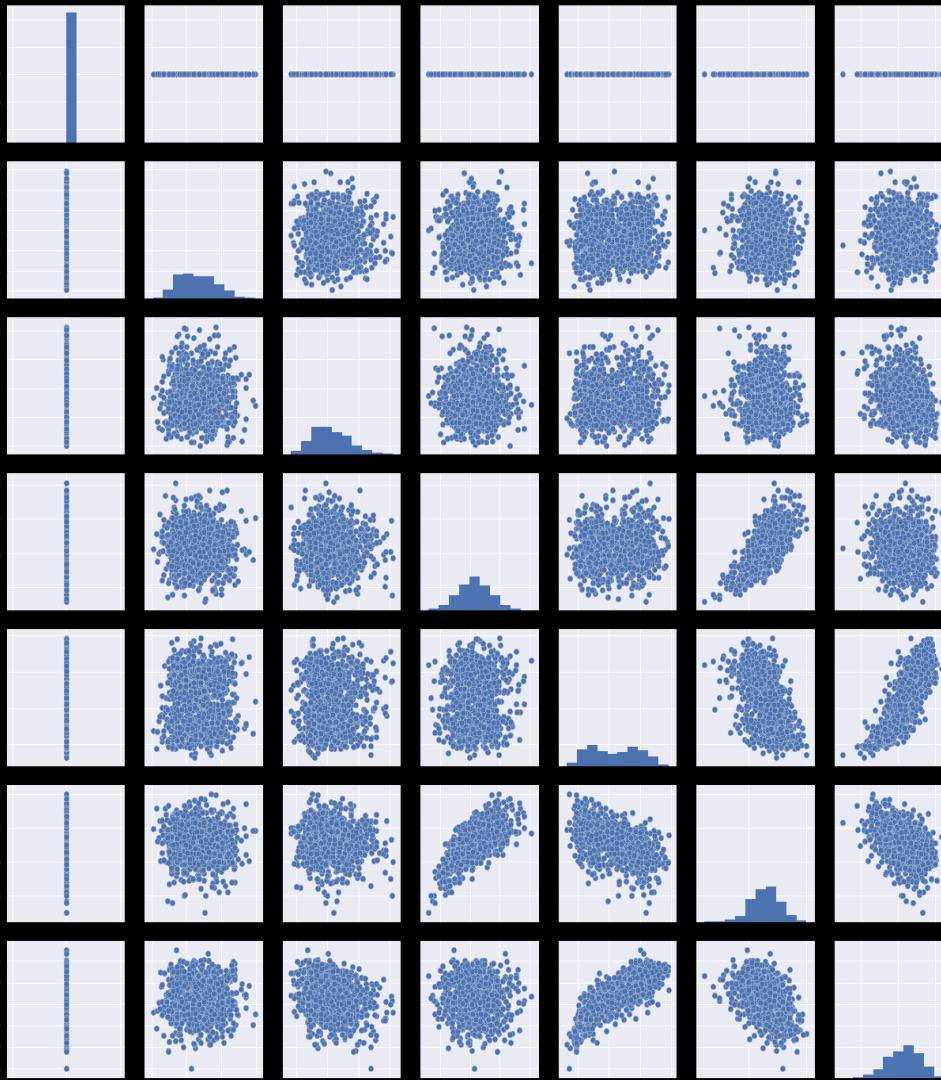
Time Series data Parameters

    Per Operation / Program Run

Cycle Time

    Hierarchical tasks adding up to takt time

    Task-wise cycle time, design max, min



# Industrial Machine Learning Pipelines for Model Selection

Event Data
Control System Event Log
Downtime Log
Maintenance Log

Parameters
Machine / Program ID
Timestamp
Parameter Values
Max / Min Design Values

Cycle-time Data
Machine / Program ID
Timestamp
Task ID, Cycle-time

Auto Classification Pipeline		
Feature Selection	Data Preprocessing	Classification
4 algorithms	3 algorithms	7 algorithms
84 pipelines evaluated with automatic hyper-parameter tuning		

→ Best pipeline

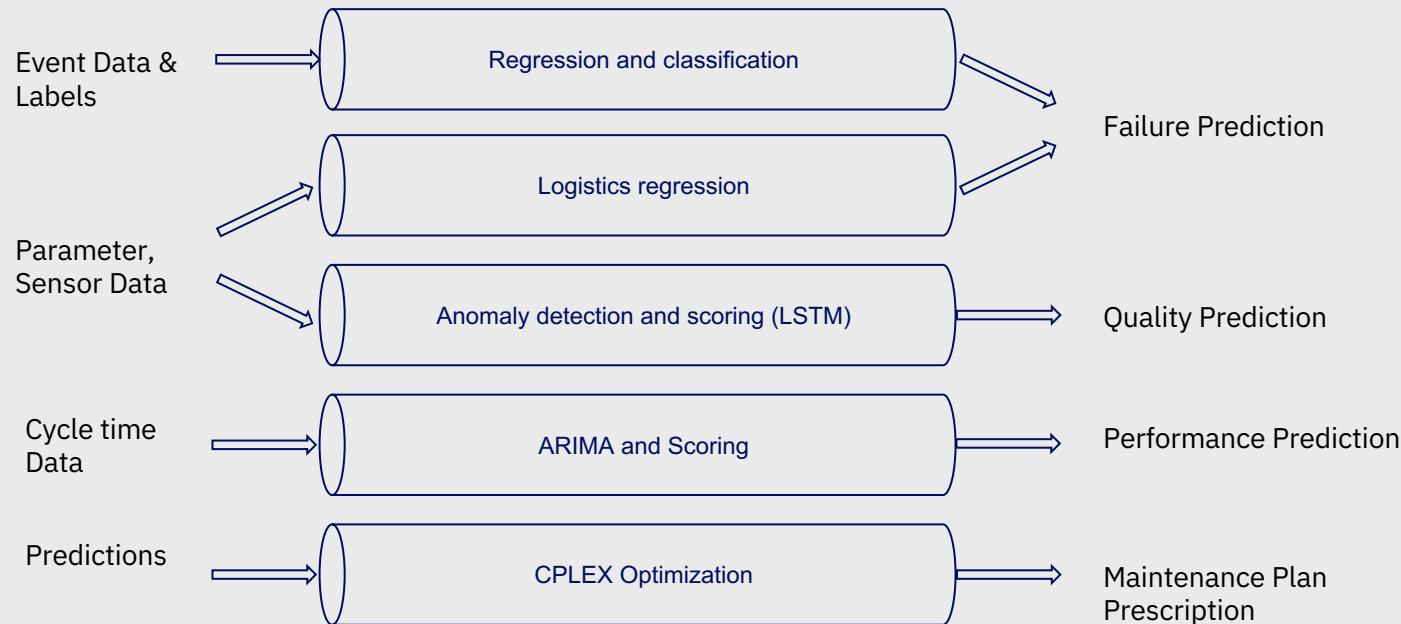
Anomaly Detection Pipeline	
Feature Selection	Anomaly Detection
4 algorithms	15 techniques
60 pipelines evaluated with 5 different parameter configurations	

→ Best pipeline

Survival Analysis Pipeline	
from srom.survival_analysis.kaplan_meier import KaplanMeier	
from srom.survival_analysis.cox_regression import CoxRegression	
from srom.survival_analysis.aalen_additive_regression import AalenAdditiveRegression	
from srom.survival_analysis.nelson_aalen import analyze	

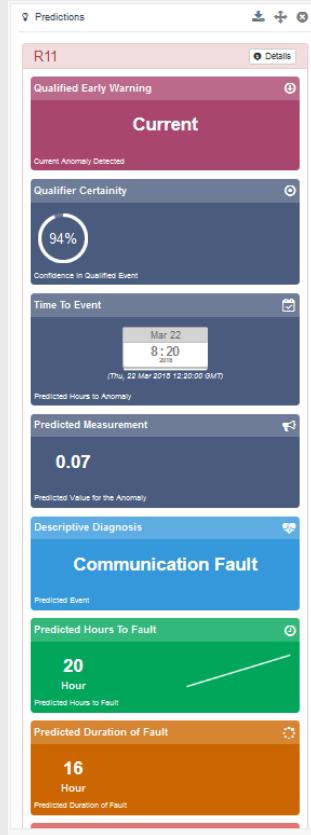
→ Best pipeline

# Flexibly Deploy Analytical Models in Cloud or Edge



Deliver Analytical Model Templates that predicts OEE losses for specific processes

# Issue Predictions and Alerts



Configurable Threshold

**Alerts** **Hierarchy** **Severity** **Filter**

**R16** **Critical** **Accept**

Emergency! Maintenance work for Fault Code 13 expected in 20.0 hours

Last modified by: Alex Joseph Last modified on: 2017-04-19 07:26:48 View Complete History

**Maintenance Recommendation**

Jun 16 11:55 2017 Jun 16 11:55 2017

**R19** **Critical** **Late**

Emergency! Maintenance work for Fault Code 17 expected in 28.0 hours

Last modified by: Alex Joseph Last modified on: 2017-04-19 07:26:30 View Complete History

**Maintenance Recommendation**

undefined NaN undefined NaN

**R14** **Moderate** **Open**

Stay Alert! Maintenance work for faultcode 17 expected in 48.0 hours

Last modified by: Joe Black Last modified on: 2017-06-21 02:13:08 View Complete History

**Maintenance Recommendation**

Jun 18 7:55 2017 Jun 18 8:55 2017

**R23** **Moderate** **Open**

Emergency! Maintenance work for Fault Code 9 expected in 14.0 hours

Last modified by: System Last modified on: 2017-06-08 06:25:10 View Complete History

**Maintenance Recommendation**

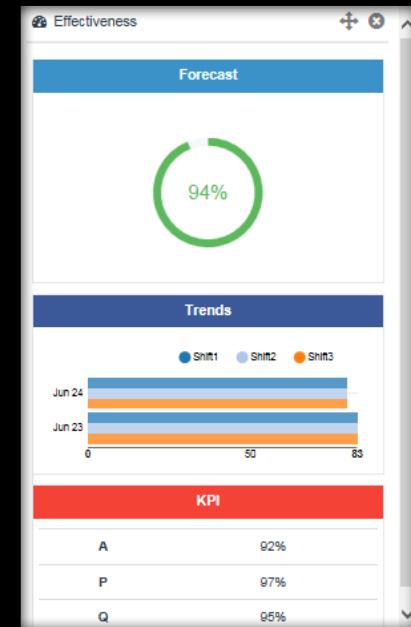
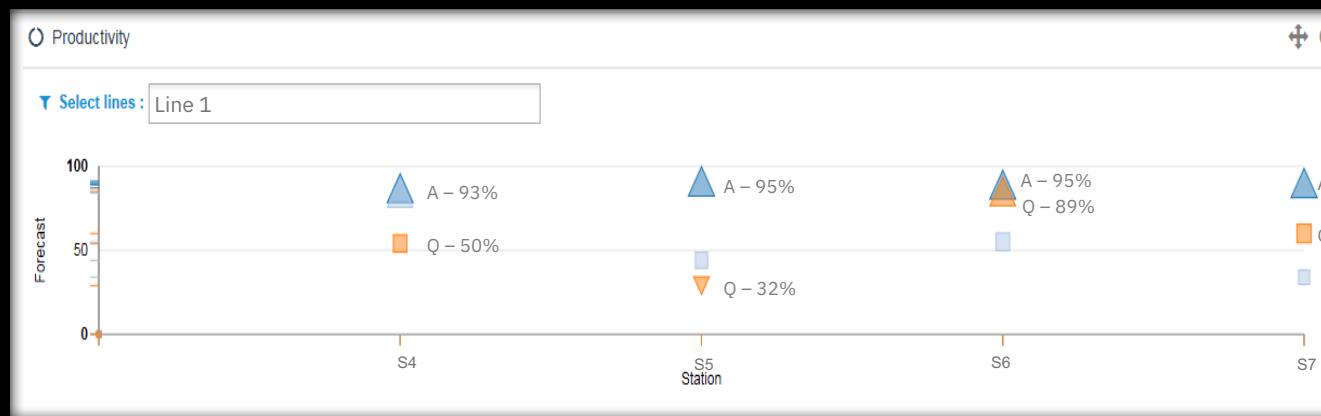
undefined NaN undefined NaN

**R23** **Moderate** **Open**

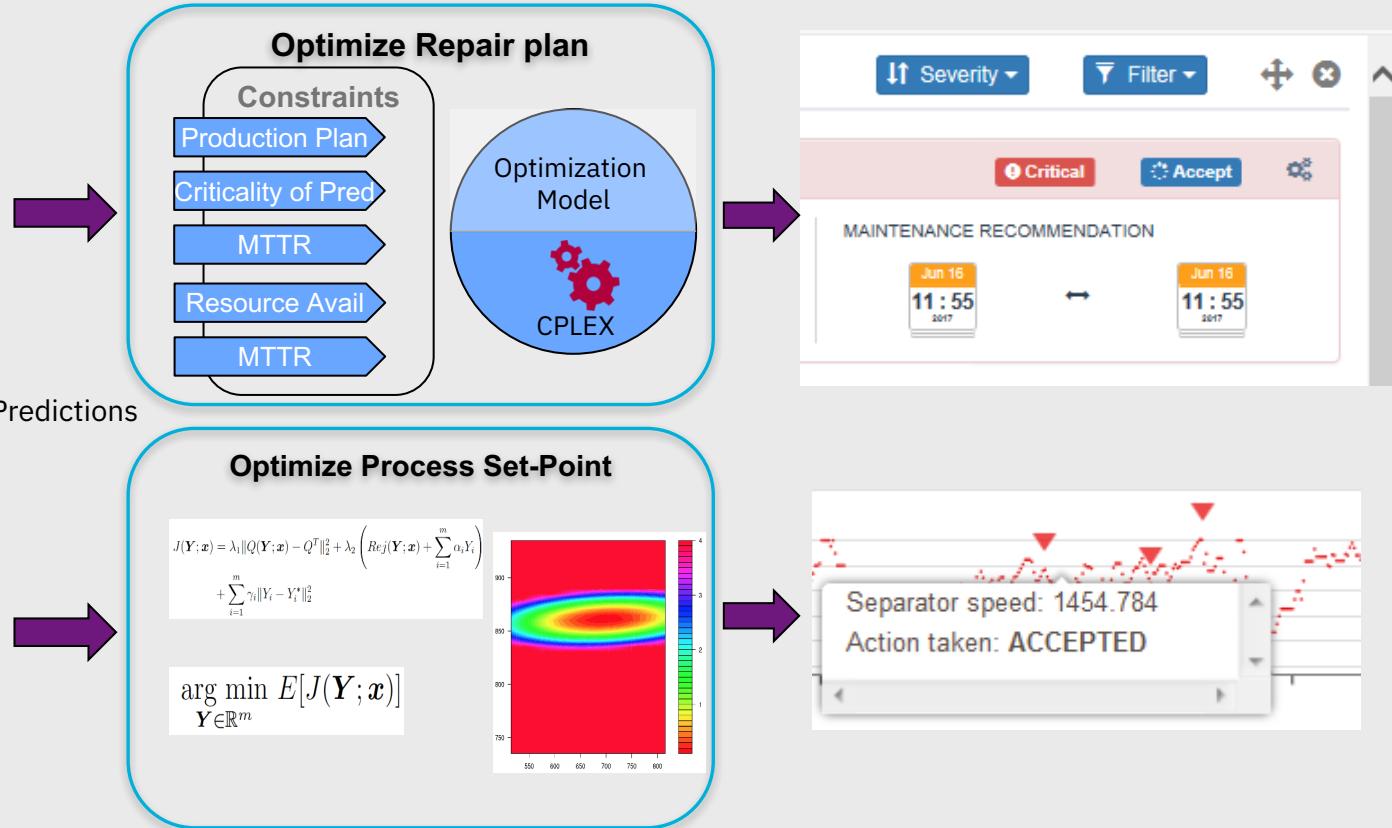
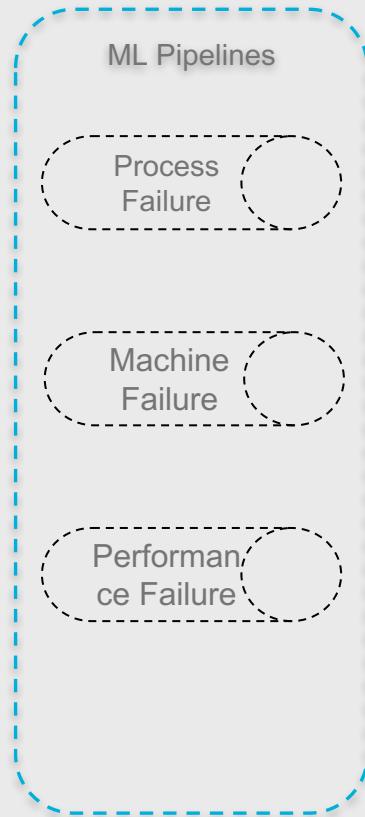
Stay Alert! Maintenance work for faultcode 17 expected in 48.0 hours

**Maintenance Recommendation**

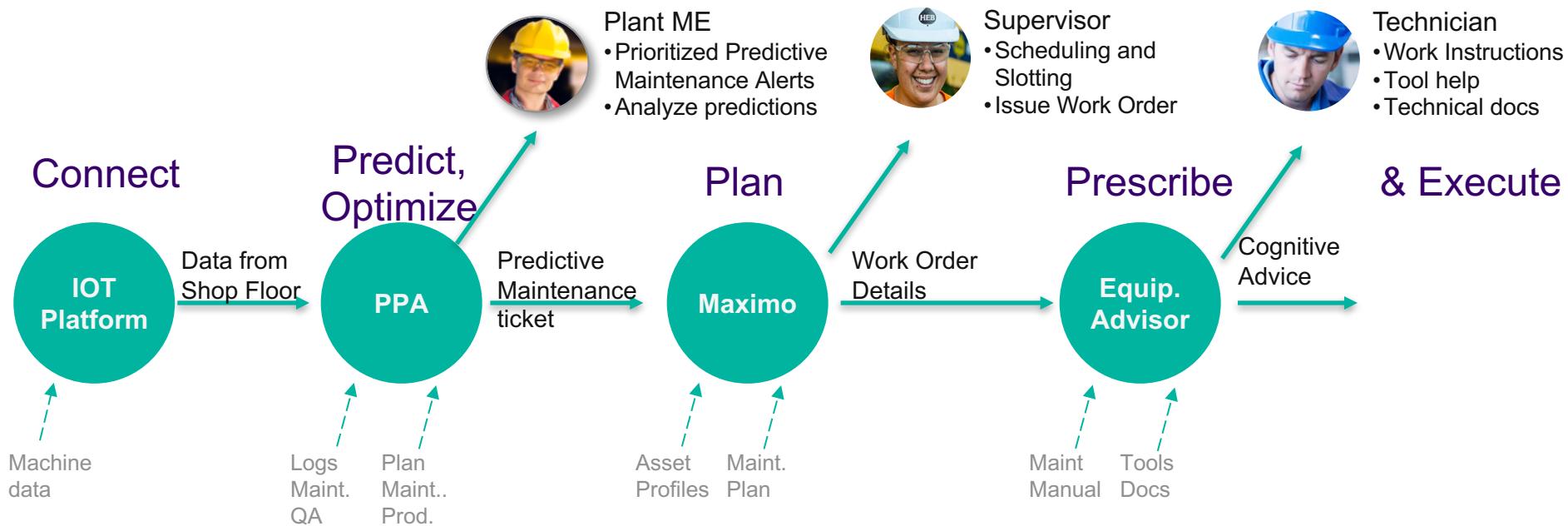
# KPI Consolidation



# Optimization Pipelines for Prescribing Remedy



# Prescriptions for Remedy



**Reduce Cost with Targeted Maintenance**  
**Digitally Retain Maintenance Skills**  
**Drive towards Zero Downtime**

# Prescriptions for Remedy

The screenshot shows a web browser window for the Watson Field Service Advisor. On the left, a purple sidebar displays a "Best Solution" for a "Low current limit fault" with a 37 min duration and 86% success rate, along with 87% solution probability. It also lists "Parts" (Secondary diodes in the welding transformer, Weldcaps) and "Tools" (Jumper cables, Insulation sealer, Primary cables). At the bottom are "Troubleshoot" and "Complete" buttons. The main content area shows a "Low current limit fault" details pop-up. The pop-up has a table with columns: FAULT NAME, DEFAULT VALUE, POSSIBLE CAUSE, and SOLUTION. The FAULT NAME is "HIGH CURRENT LIMIT FAULT". The POSSIBLE CAUSE section contains two items: "1 the weld processor detects that the current passed during the weld schedule exceeded the value programmed into HIGH CURRENT LIMIT WINDOW in the Setup Parameters" and "2 the weld processor detects that the current passed during the weld schedule exceeded the HI value programmed into function #76 (SEC. CURR LIMITS: HI=nnnn;LOW=nnnn) in the weld schedule.". The SOLUTION section provides three steps: 1. Ensure the percentage value programmed into HIGH CURRENT LIMIT WINDOW in the Setup Parameters is correct for the welding application. 2. Ensure the HI value programmed into function #76 (SEC. CURR LIMITS: HI=nnnn;LOW=nnnn) in the weld schedule is correct for the welding application. 3. Ensure the value programmed into TRANSFORMER TURNS RATIO in the Setup Parameters is correct for the welding application.

FAULT NAME	DEFAULT VALUE	POSSIBLE CAUSE	SOLUTION
HIGH CURRENT LIMIT FAULT		<p>Occurs when:</p> <ul style="list-style-type: none"><li>1 the weld processor detects that the current passed during the weld schedule exceeded the value programmed into HIGH CURRENT LIMIT WINDOW in the Setup Parameters</li><li>2 the weld processor detects that the current passed during the weld schedule exceeded the HI value programmed into function #76 (SEC. CURR LIMITS: HI=nnnn;LOW=nnnn) in the weld schedule.</li></ul>	<ol style="list-style-type: none"><li>1 Ensure the percentage value programmed into HIGH CURRENT LIMIT WINDOW in the Setup Parameters is correct for the welding application.</li><li>2 Ensure the HI value programmed into function #76 (SEC. CURR LIMITS: HI=nnnn;LOW=nnnn) in the weld schedule is correct for the welding application.</li><li>3 Ensure the value programmed into TRANSFORMER TURNS RATIO in the Setup Parameters is correct for the welding application.</li></ol>

**Low current limit fault**

CLOSE

# Business Value Assessment

## Business Need

- Average unplanned downtime 20 mins per day
- Overtime used to compensate the lost production time
- Average of 2-3 emergency maintenance incidents per station per month
- Total cost of overtime and maintenance \$2.5M per year due to downtime

## IBM Approach

- Train advanced analytical models in PPA with historical data from the plant to analyze the % of downtime that can be predicted minimum 2 hours in advance.

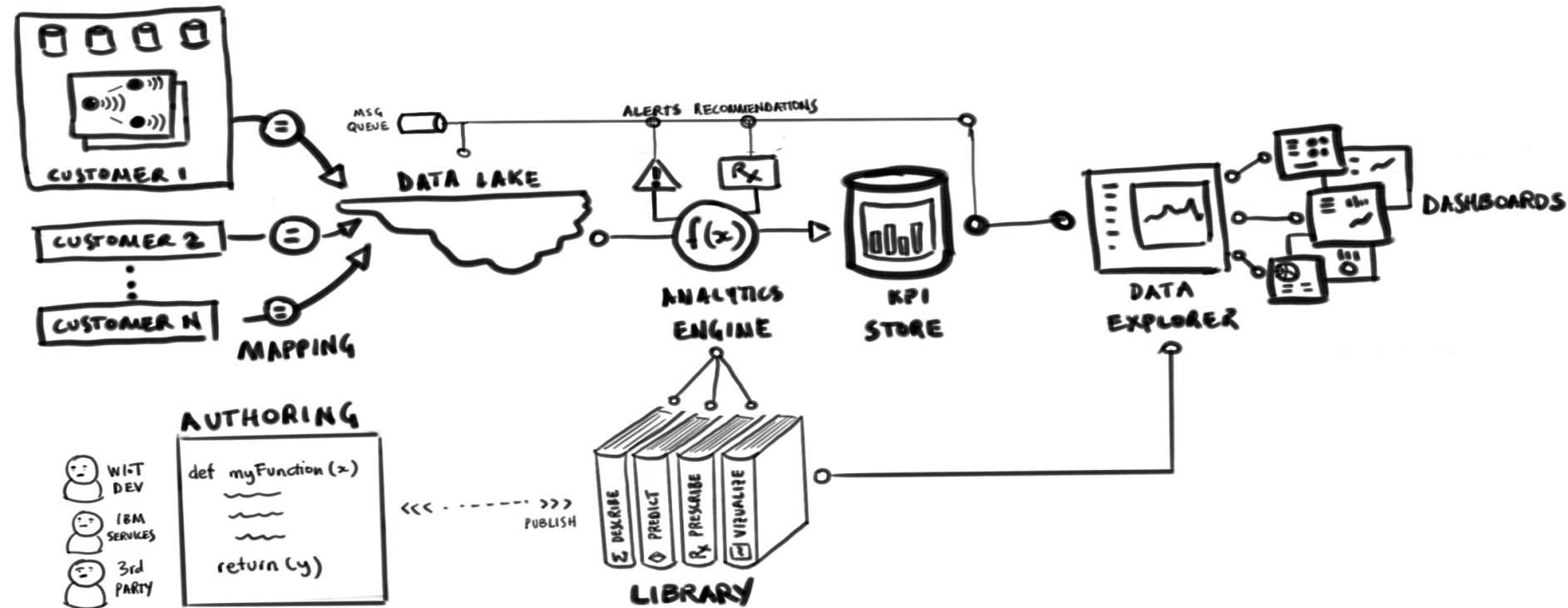
## Results Achieved

- 52% of downtime could be predicted at least 2 hours in advance
- Potential cost saving of \$1-2M per body shop including overtime reduction, scrap reduction and maintenance cost saving



# Programming and Deploying Use Cases

# Author your use cases with DSX and Our Industry Analytical Model Pipelines



# Industry Analytical Models for Manufacturing Processes

Processes that can be addressed with Industry Analytical Models

Stamping

Equipment failure,  
tooling failure

Paint Booth

Equipment, tool  
failure, process  
failures

Automotive Body Weld

Weld station failure, weld quality, line slowdown predictions

Paint Booth

Paint quality failure, equipment failure predictions and prescriptions

Casting

Process failures

Machining

Process failures

# Implementation Projects

## PoC Program

### Data Track

- ▶ Data Source Identification
- ▶ Data Acquisition Infrastructure
- ▶ Data Aggregation

Customer



### Application Track

- ▶ Data Onboarding (Batch, Manual)
- ▶ Model Tuning
- ▶ UI Configuration

SI

## Pilot Program

- ▶ Live Production Data
- ▶ Automated data ingest
- ▶ Implement on a critical line
- ▶ Business Value Assessment

6-8 weeks

10-12 weeks

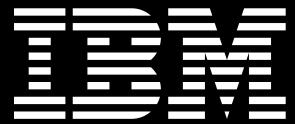
# Takeaways

- Machine Learning and Artificial Intelligence help achieve production “overdrive” over and above waste elimination
- Existing Control System Data can be a good starting point. Will require data gathering and consolidation infrastructure
- Incrementally build use cases that offers incremental value
- Build to roll-out.

# Thank you

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# Color palette



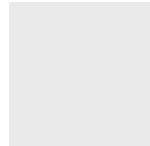
R-0  
G-0  
B-0



R-110  
G-23  
B-125



R-0  
G-15  
B-94



R-234  
G-234  
B-234



R-31  
G-179  
B-207



R-0  
G-59  
B-201



R-219  
G-38  
B-99



R-105  
G-166  
B-255



R-0  
G-100  
B-255



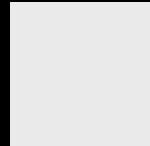
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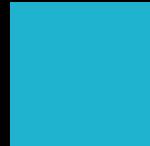
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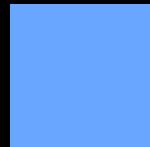
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