# Caterpillar: Transforming the Business with a Live Factory

Marty Groover, Operational Technology Leader

Who is Caterpillar?

- A Fortune 50 global enterprise
- 2016 sales and revenues of ~$40B
- Global team of more than 100,000
- Nearly 500 locations in 50 countries (manufacturing, marketing, logistics, service, R&D and dealer locations)
- Dealers Network and Products at work in more than 190 countries around the world
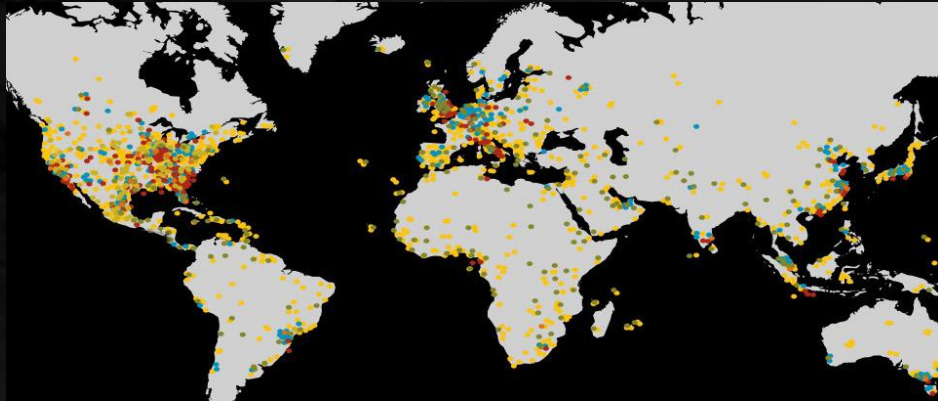
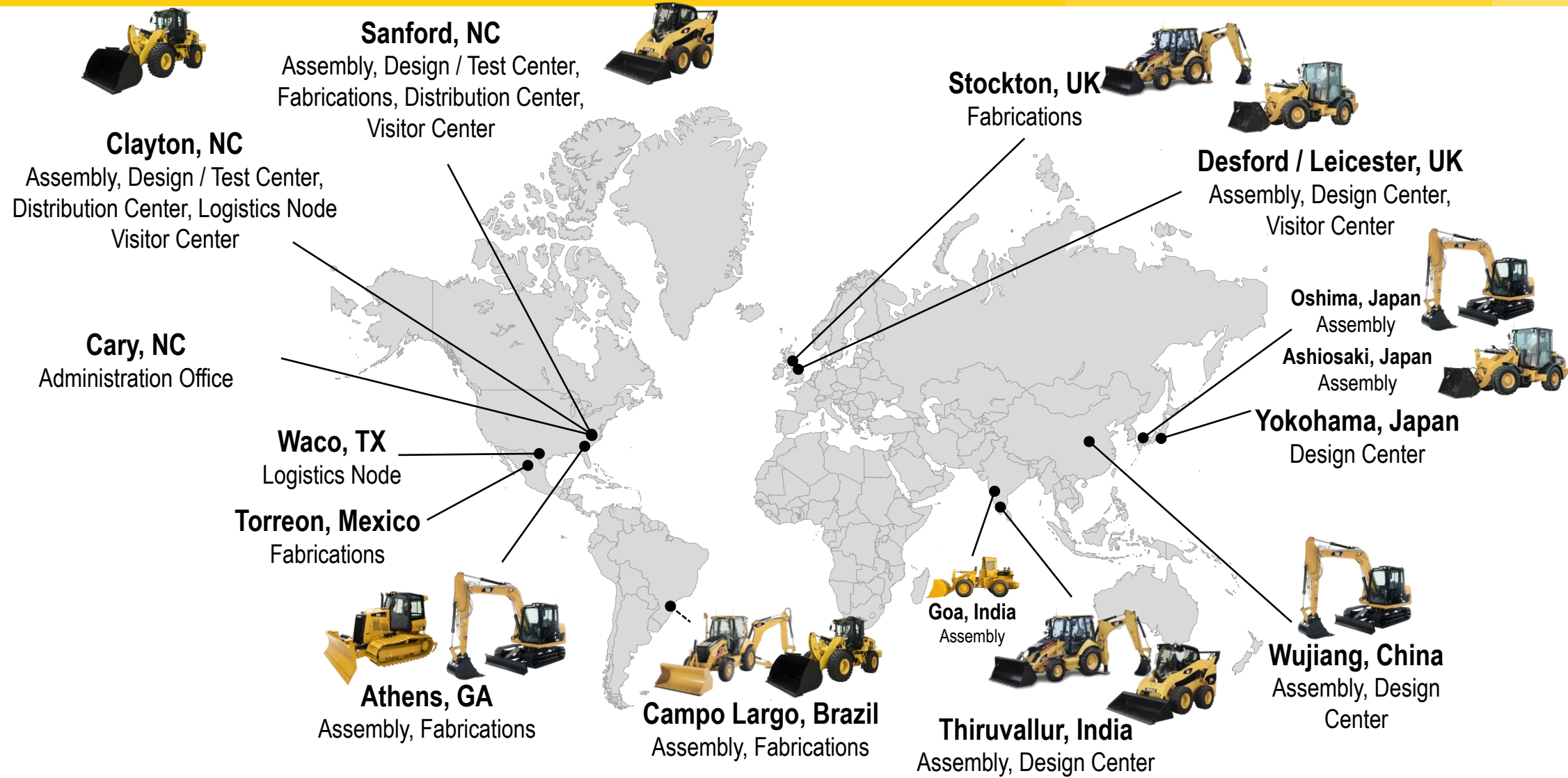Construction Mining Equipment Diesel & Natural Gas Engines Industrial Gas Turbines Diesel-Electric Locomotive

PRODUCT LINE

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BCP GLOBAL FOOTPRINT

Digitized in 80's

Sanford, NC
Assembly, Design / Test Center, Fabrications, Distribution Center, Visitor Center

Clayton, NC
Assembly, Design / Test Center, Distribution Center, Logistics Node Visitor Center

Cary, NC
Administration Office

Waco, TX
Logistics Node

Torreon, Mexico
Fabrications

Athens, GA
Assembly, Fabrications

Campo Largo, Brazil
Assembly, Fabrications

Stockton, UK
Fabrications

Desford / Leicester, UK
Assembly, Design Center, Visitor Center

Oshima, Japan
Assembly

Ashiosaki, Japan
Assembly

Yokohama, Japan
Design Center

Goa, India
Assembly

Thiruvallur, India
Assembly, Design Center

Wujiang, China
Assembly, Design Center

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Speed of Change

COMPETITION

55 competitors in China
35 in the U.S.

PHYSICAL CHANNEL

Outnumbered in physical
channels 8 to 1

LOYALTY

Customer loyalty
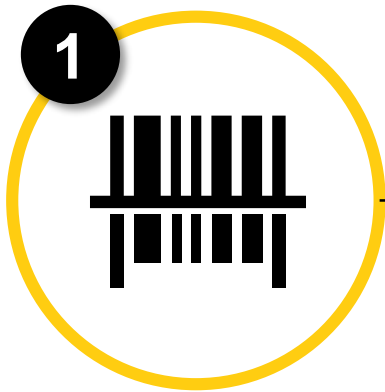is Unacceptable

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Manufacturers Must Adapt to Retail Speed

Employees will manage and take action for their part of the business in real time.
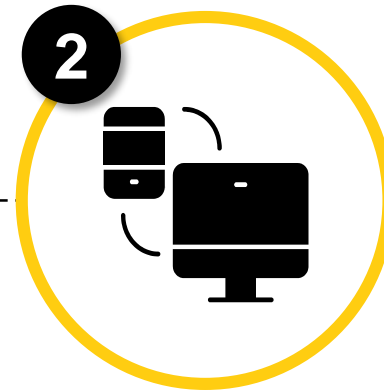
Managers will see business results in real time, and perform what if scenarios to better manage business.
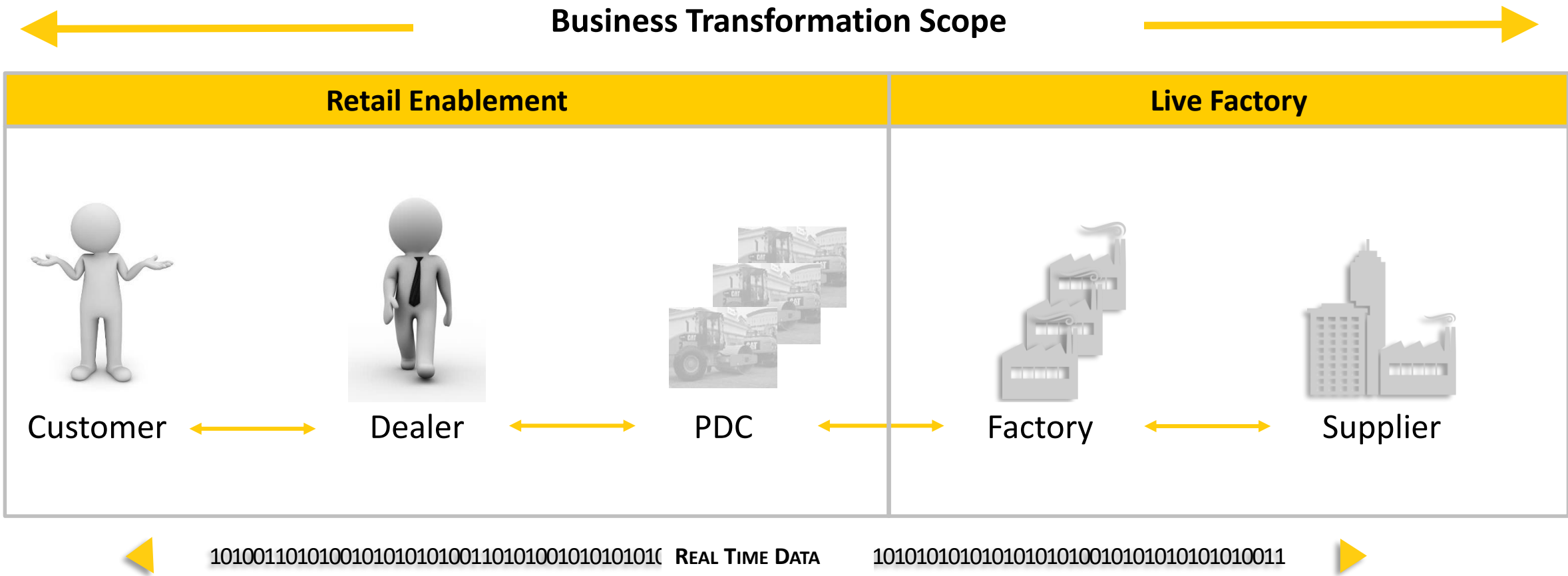
Physical Channel First… Then Digital Channels

1

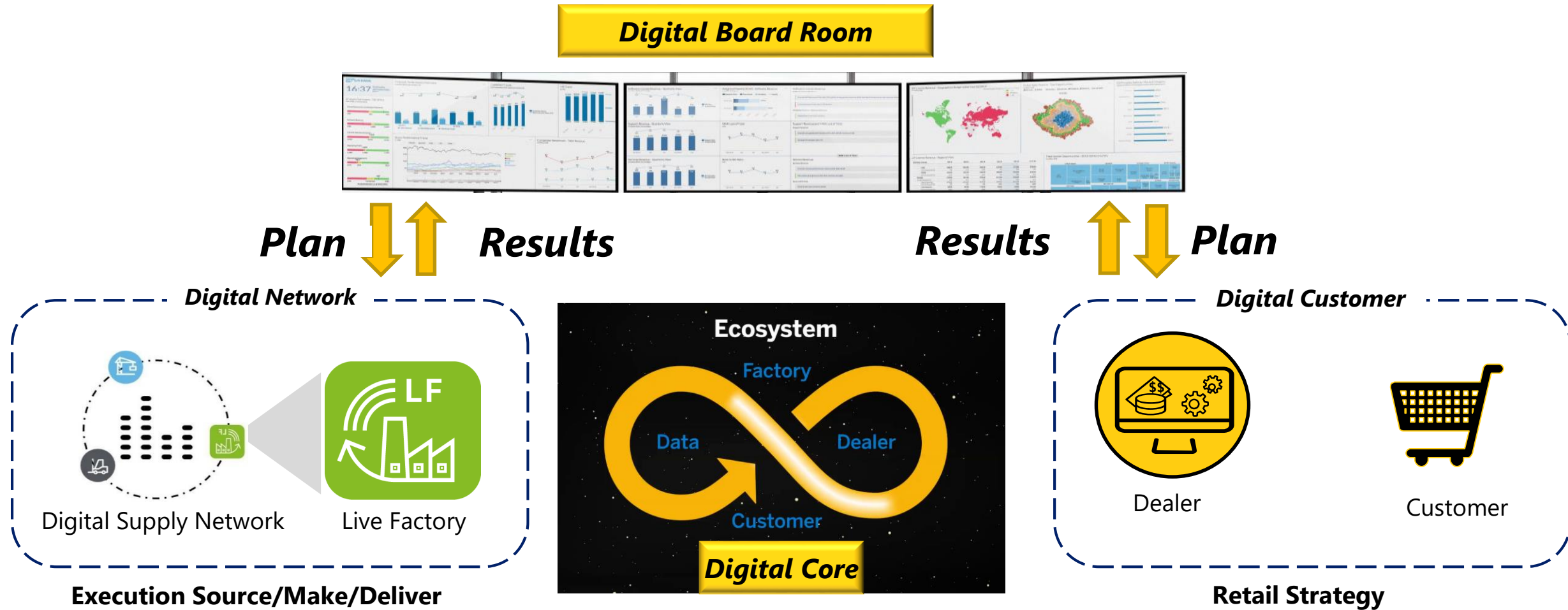Using new digital capabilities to transform the physical channel

2

Physical and digital channels will be aligned with business process and tools, so customers can go in and out of the different channels seamlessly

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Business Transformation

Business Transformation Scope

Retail Enablement	Live Factory

Customer ⟷ Dealer ⟷ PDC ⟷ Factory ⟷ Supplier

1010011010100101010100110101001010101010 REAL TIME DATA 1010101010101010100101010101010011

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Business Leaders Must Have Live

Digital Board Room

Plan ⬇⬆ **Results**   **Results** ⬆⬇ **Plan**

Digital Network

Digital Supply Network   Live Factory

Execution Source/Make/Deliver

Ecosystem

Factory

Data   Dealer

Customer

Digital Core

Digital Customer

Dealer   Customer

Retail Strategy

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Business Leaders Must Own Transformation

IT Solution

- Long Development and Deployment Cycle

- About the Technology and Software

- Development Focused
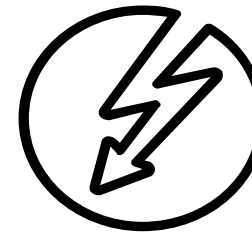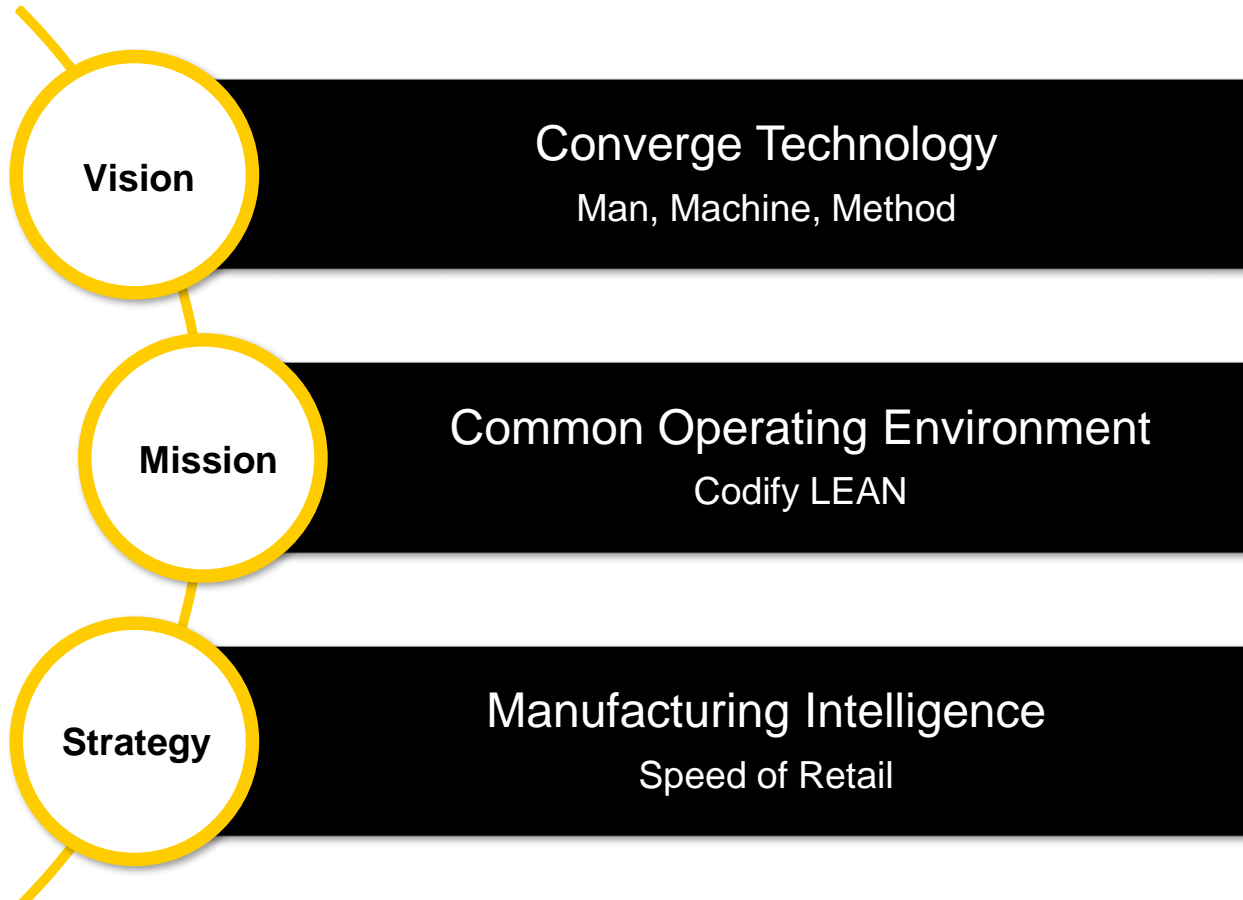
- Perfection vs Progress

- Perpetuity

Business Transformation

- Short Projects – Solve Specific Business Goal

- About the Customer

- Out of the Box Solution
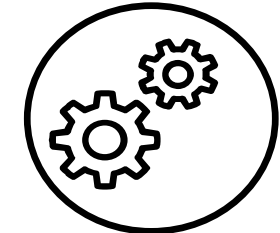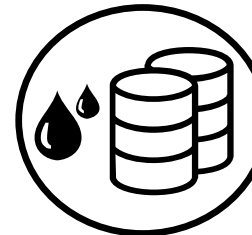
- Results Focused

- Productivity

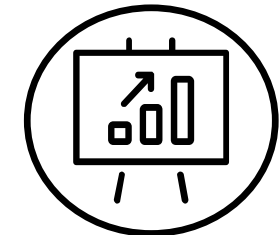# LIVE FACTORY

Live Factory: Empowered Employees

Vision — Converge Technology
Man, Machine, Method

Mission — Common Operating Environment
Codify LEAN

Strategy — Manufacturing Intelligence
Speed of Retail
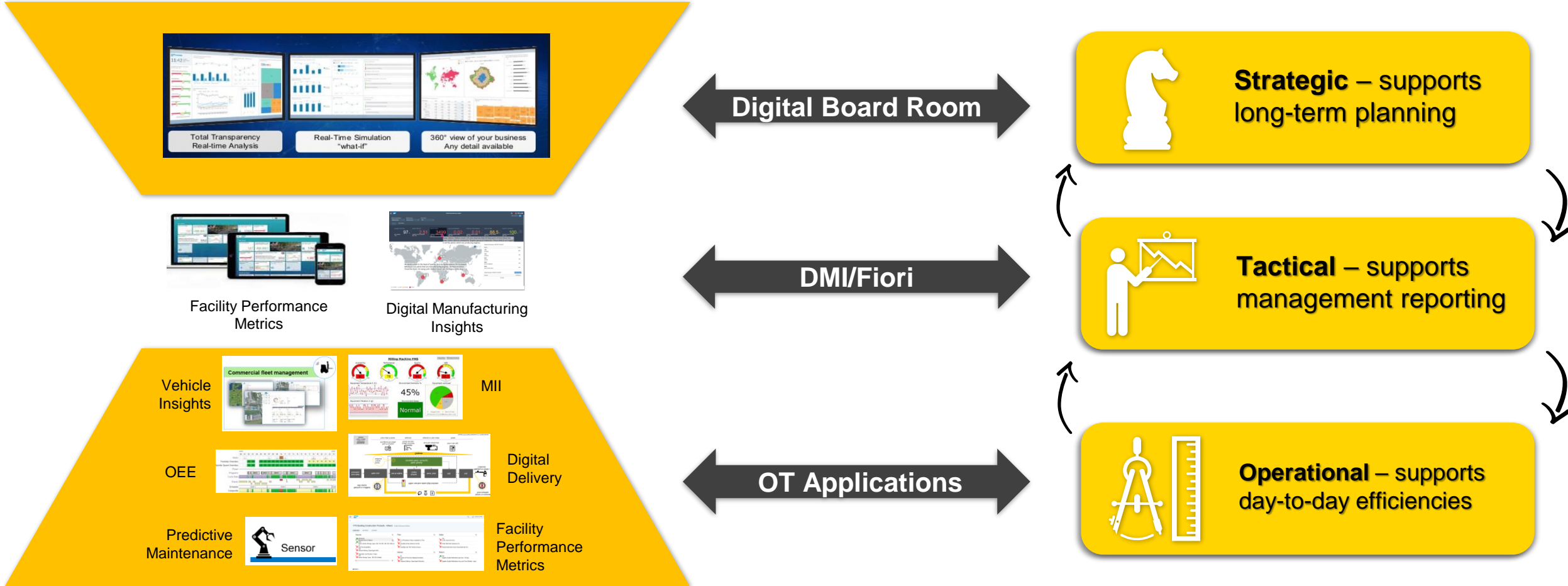
Energy Optimization

Machine Performance

Consumable Optimization

Process Standardization

Live Factory Enables the Retail Strategy Digital Thread

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Live Factory: Productivity

Total Transparency Real-time Analysis | Real-Time Simulation "what-if" | 360° view of your business Any detail available

Facility Performance Metrics

Digital Manufacturing Insights

Vehicle Insights

MII

OEE

Digital Delivery

Predictive Maintenance

Sensor

Facility Performance Metrics

Digital Board Room

DMI/Fiori

OT Applications

Strategic – supports long-term planning

Tactical – supports management reporting

Operational – supports day-to-day efficiencies

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Live Factory: SAP Leonardo Tools

Energy Optimization

Power Quality Monitor
Water Management
Climate Control Savings

Consumable Optimization

Vehicle Insights - IoT
Dock to Storage - IoT
Critical Parts Tracker
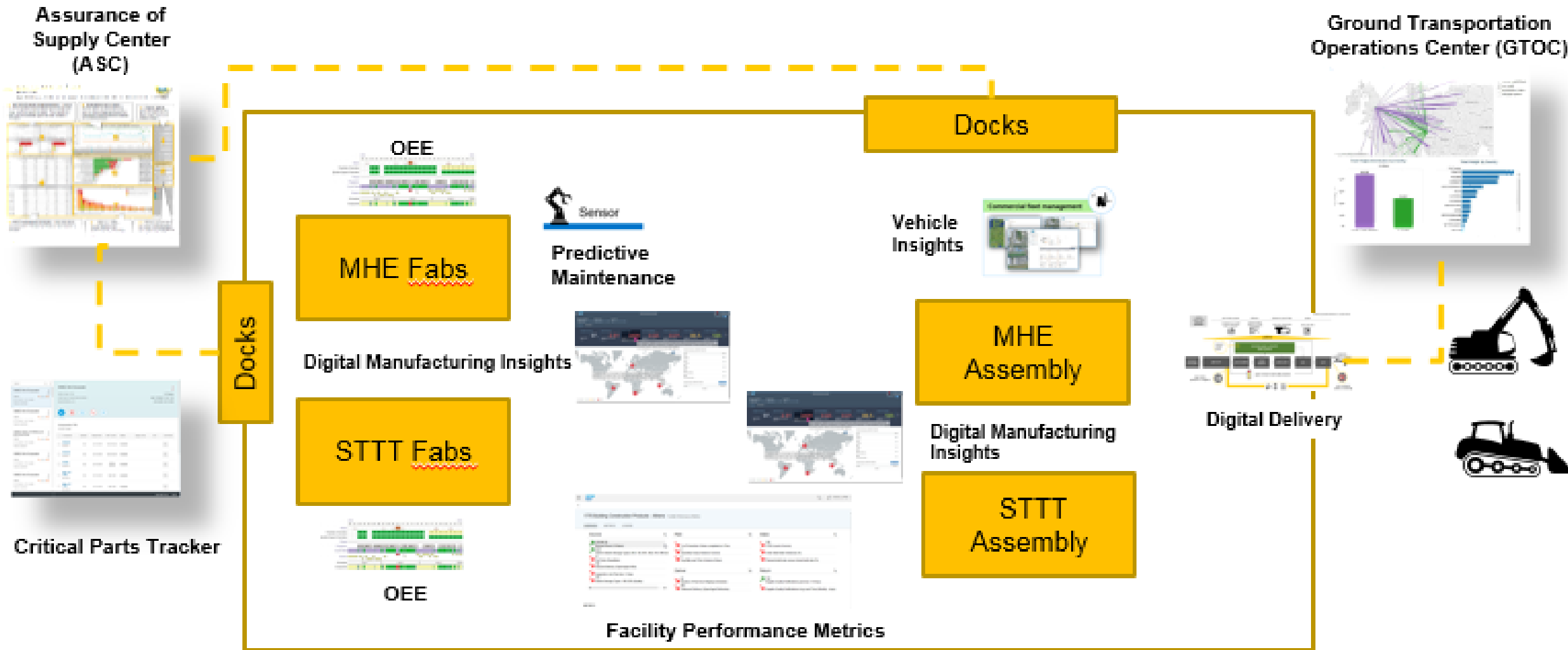**OPACC Digital Board Room**

Machine Performance

Predictive Maintenance - IoT
Machine Data - OEE
Facility Equipment Monitor

Process Standardization

Digital Delivery - IoT
Digital Manufacturing Insights
Facility Performance Metrics

SAP Leonardo
Phase I

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Connecting the Digital Supply Network

Assurance of Supply Center (ASC)

Ground Transportation Operations Center (GTOC)

Docks

OEE

Vehicle Insights

MHE Fabs

Predictive Maintenance

Docks

MHE Assembly

Digital Manufacturing Insights

Digital Delivery

Critical Parts Tracker

STTT Fabs

Digital Manufacturing Insights

OEE

STTT Assembly

Facility Performance Metrics

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Digital Board Room

Shop Floor to Top Floor Live Connection

Total Transparency
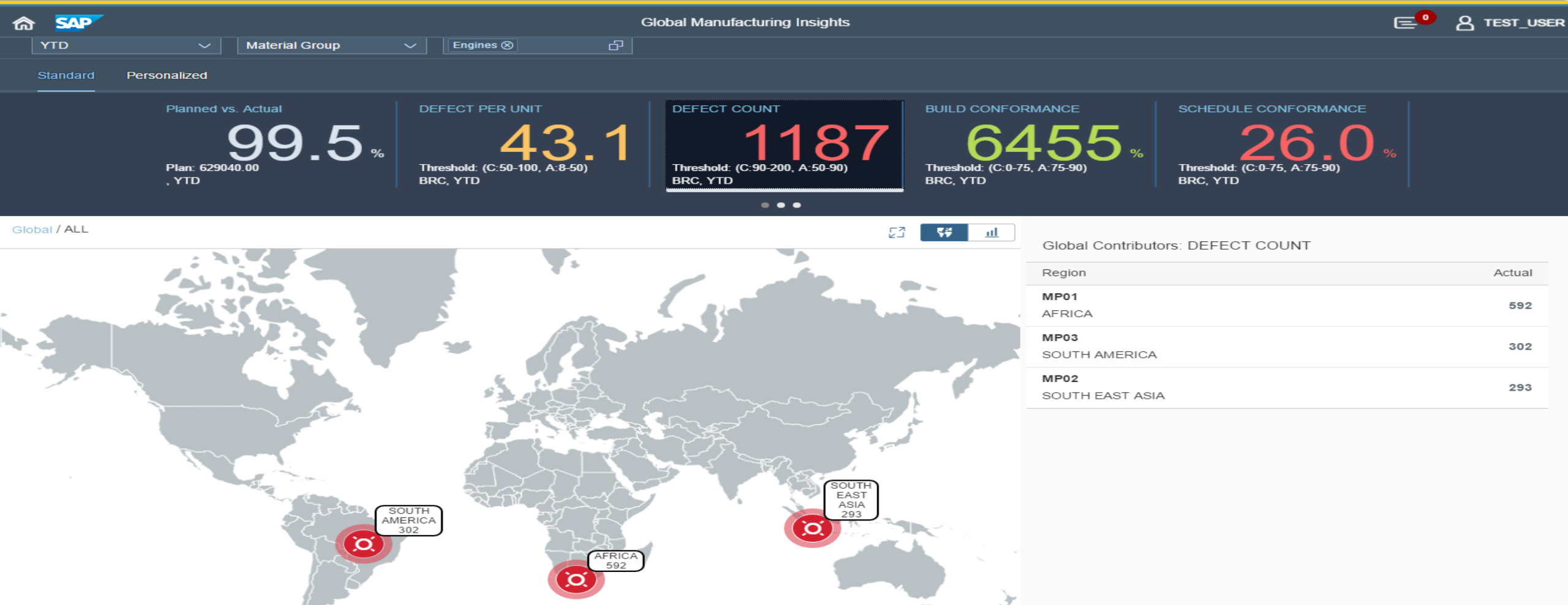Real-time Analysis
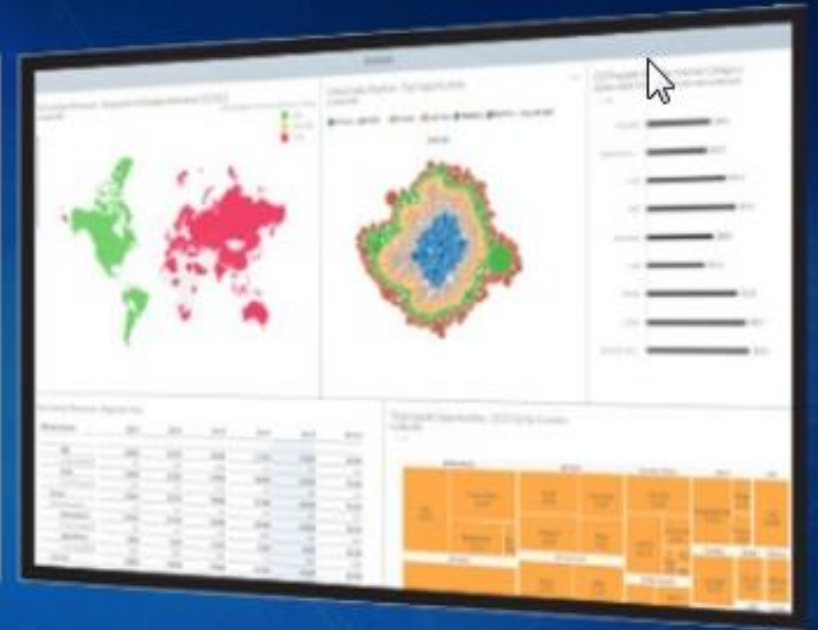
Real-Time Simulation
"what-if"

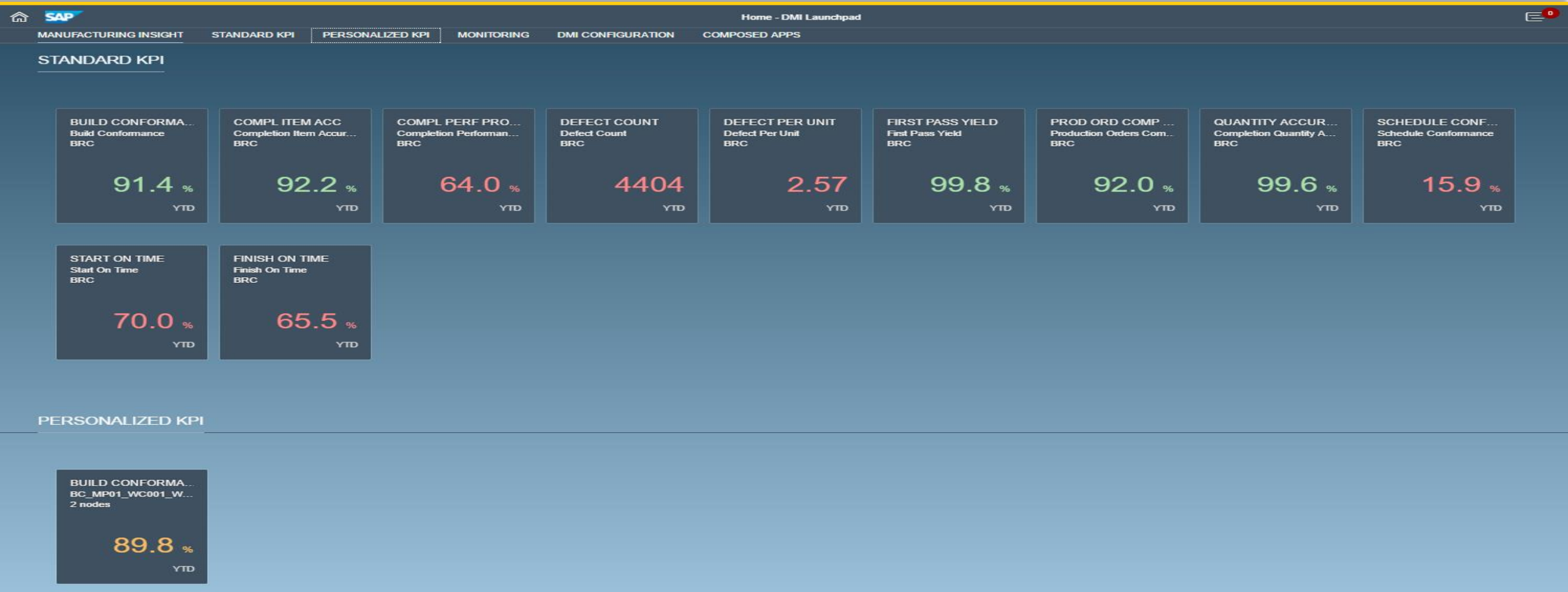360° view of your business
Any detail available

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Digital Manufacturing Insights - Beta

Manufacturing Common Operating Environment

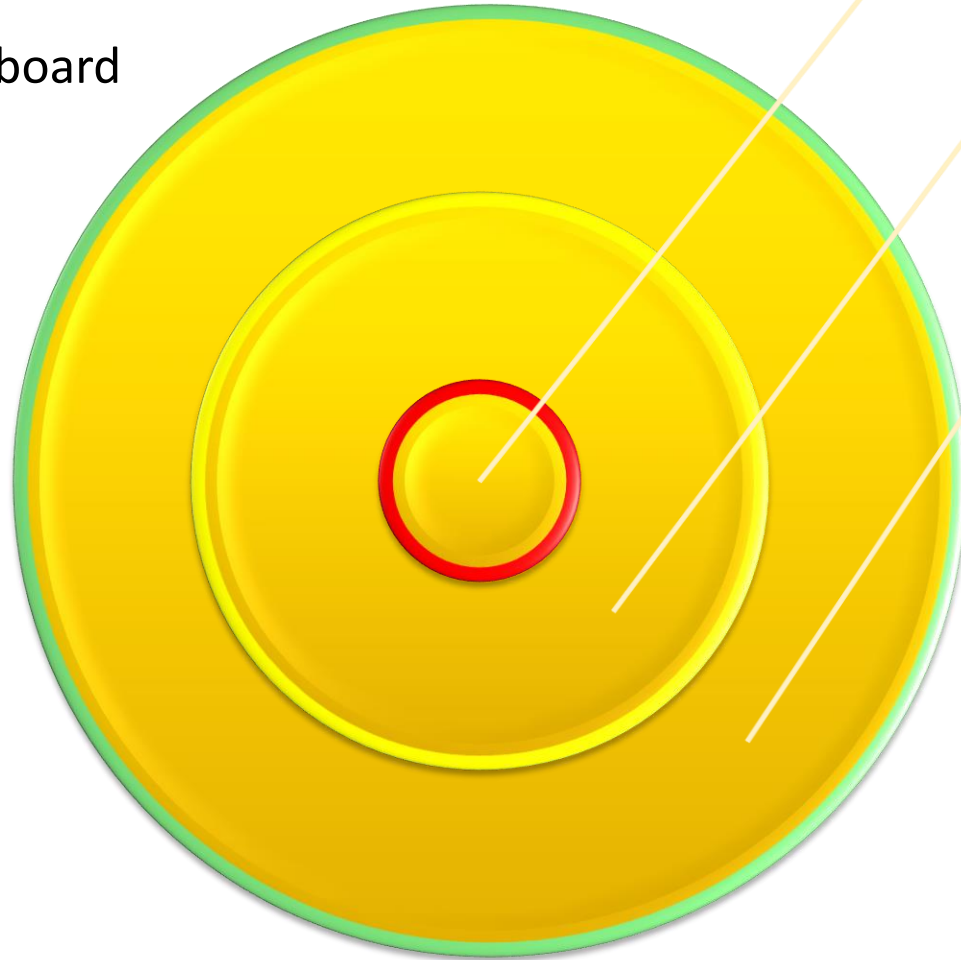# Digital Manufacturing Insights - Beta

Manufacturing Common Operating Environment

CPT – Critical Parts Tracker

MRP Zones of Defense

- Build Sequence Short Part Dashboard
- Line Checker Dashboard
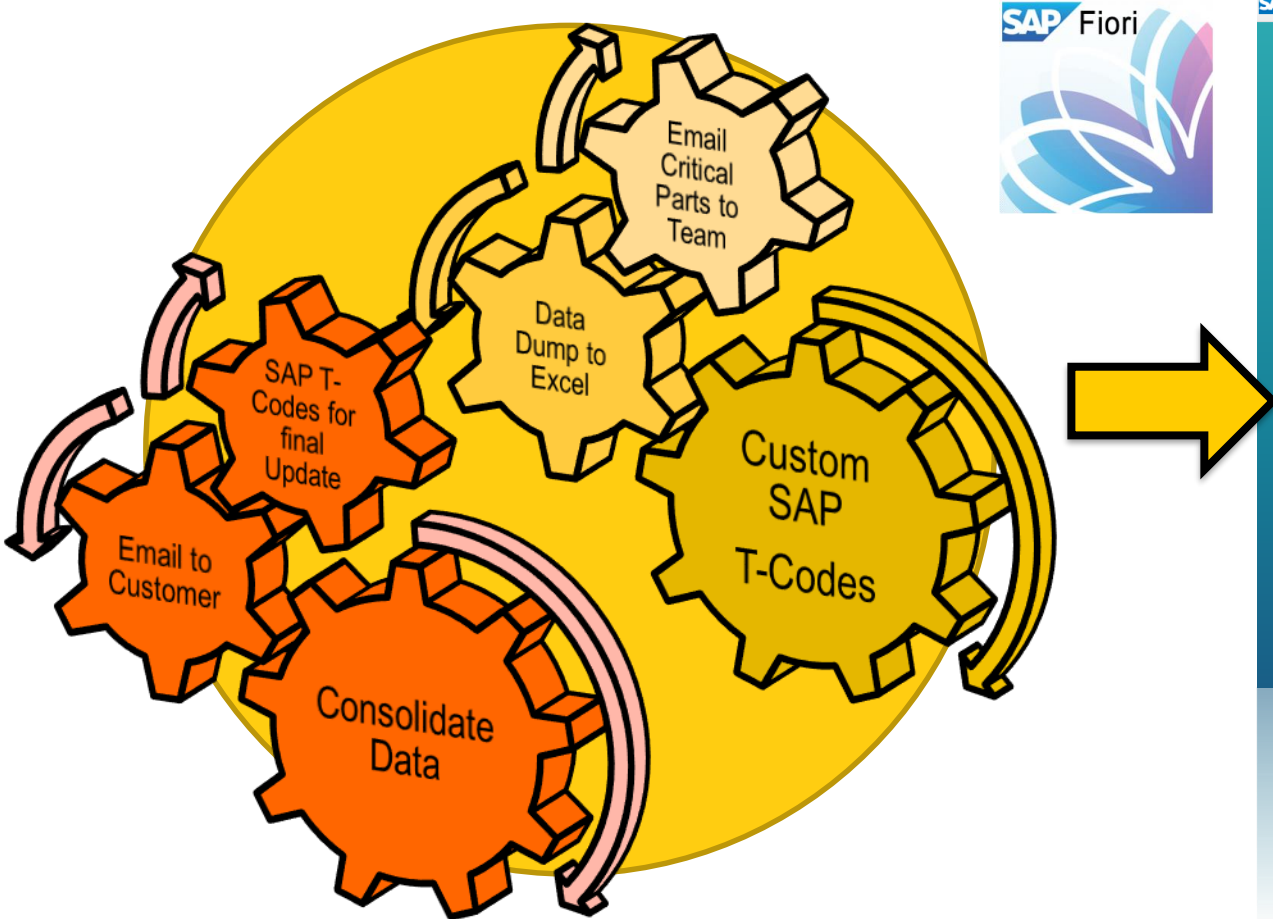- Vehicle Insights

Missing Part Affecting Takt

Hot Part In Factory not in POU

Short Part Not in Factory

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CPT – Critical Parts Tracker – Short Parts Dashboard

FROM: Static, Manual Intensive Data Mining Process

TO: Real Time, Constantly Updating Process

ONE VERSION OF THE TRUTH IN REAL TIME!

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CPT – Critical Parts Tracker – Short Parts Dashboard

- **Customizable Dynamic Groups & Tiles**
  - Days of Coverage Customizable by Supplier Location
    - i.e. North America, Overseas or VMI

- **Create Multiple Material Coverage Groups**
  - MRP Controllers by Direct Supervisor
    - Top 10 Past Due Suppliers

Dynamic Tiles with AUTOMATIC REAL TIME UPDATES

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CPT – Critical Parts Tracker – Line Checker Dashboard

Enough inventory line side to cover 5 Day's Build

Enough inventory line side to cover Today and Tomorrow's build

Status	Supply Area	Storage Bin	Material	Description	Requirement date	Requirement time	Day1	Day2	Day3	Day4	Day5	Available Qty	VC Qty	BUn	Putaway Qty	Pick Qt	Whse Avail	On Order	In Transit	On Hold	Backorder
●	JQWEIV03	E2JQR3600	2609174	ADAPTER AS-STR	03/29/2017	08:47:12	33	69	105	132	132	79	79	EA	0	0	450	0	325	0	0
●	JQWEFT01	E1JQR3720	2977886	SENSOR-FUEL LVL	03/27/2017	16:36:34	10	22	35	44	44	6	6	EA	27	0	108	0	0	35	0
●	JQWEFT01		3769487	PUMP AS-FUEL	03/29/2017	16:08:45	1	4	13	21	21	8	8	EA	0	0	44	0	0	0	0
⚠	JQWEFT01		3792008	VALVE AS-FOOT	03/29/2017	18:00:01	1	4	13	21	21	9	9	EA	30	0	0	0	0	0	0
■	JQWEFT01		1360344	GROMMET		00:00:00	10	22	35	44	44	115	115	EA	0	0	100	0	0	0	0
■	JQWEFT01		1G7206	FILTER-FUEL		00:00:00	10	22	35	44	44	56	56	EA	120	0	0	120	120	7	
■	JQWEFT01		3790525	HOSE		00:00:00	1	4	13	21	21	45	45	EA	0	0	0	0	0	30	0
■	JQWEFT01		3790526	HOSE	03/30/2017	08:15:52	1	4	13	21	21	13	13	EA	0	0	0	0	10	30	0
■	JQWEFT01		3790728	BRACKET AS		00:00:00	1	4	13	21	21	42	42	EA	0	0	17	0	0	17	0
■	JQWEFT01		3826351	FILM-SHPG NOTICE	04/03/2017	05:56:47	10	22	35	44	44	45	45	EA	0	0	0	0	500	500	25
■	JQWEHT01		3790820	SWITCH AS-ROCKER		00:00:00	2	5	14	21	21	32	32	EA	0	0	0	0	34	68	0
■	JQWEHT01		3790821	SWITCH AS-ROCKER		00:00:00	2	5	14	21	21	31	31	EA	0	0	0	0	34	170	12
■	JQWEHT01	E1JQF3821	3790715	BOX AS-REFUEL	03/30/2017	17:56:31	2	5	14	21	21	18	18	EA	0	0	48	0	0	0	0
●	JQWEIV03	A2JQR0510	4257816	TUBE AS	03/29/2017	08:47:12	2	5	14	22	22	7	7	EA	0	0	0	0	40	49	0
⚠	JQWEIV03		4257817	TUBE AS	03/28/2017	05:04:40	8	16	19	19	19	8	8	EA	40	0	0	0	0	20	0
●	JQWEIV01	A2JQR0030	3491812	SWITCH AS	03/27/2017	05:34:15	41	75	106	140	140	11	11	EA	0	0	0	0	160	0	238
●	JQWEIV01		4I9533	BAND-HOSE	03/23/2017	20:24:22	142	210	272	340	340	25	25	EA	0	0	0	0	2,400	0	1,682

Not enough inventory line side for today's build: potential stock out

Capability of viewing warehouse inventory

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CPT – Critical Parts Tracker – Line Checker Dashboard

	Material Count	Negative Bins	Day 1		Day 2		Day 3		Percentage Green		
		Excluding Kits	🔴	🟢	🔴	🟢	🔴	🟢	Day 1	Day 2	Day 3
Implement Valve	202	0	49	153	49	153	94	108	76%	76%	53%
Swing Frame	215	12	45	170	45	170	72	143	79%	79%	67%
Radiator, Firewall, Counterweight, Cab	231	28	53	178	53	178	80	151	77%	77%	65%
Boom & Stick	245	28	75	170	75	170	93	152	69%	69%	62%
VAB, Work Tools, EOL	73	14	22	51	22	51	27	46	70%	70%	63%
Op Group, Engine, Joystick, Adapter	294	23	91	203	91	203	125	169	69%	69%	57%
Angle Blade, Base Frame, Swivel Joint, Swing Motor, ML 1-9	163	20	42	121	42	121	63	100	74%	74%	61%
ML 10-22	132	24	53	79	53	79	60	72	60%	60%	55%
MHE Summary	**1,555**	**149**	**430**	**1,125**	**430**	**1,125**	**614**	**941**	**72%**	**72%**	**61%**

> Reduced Line Side Grief by **75%**

> Improved From **72%** to **98%** Day 1 Coverage

	Material Count	Negative Bins	Day 1		Day 2		Day 3		Line Check Coverage		
			🔴	🟢					Day 1	Day 2	Day 3
Implement Valve, Swivel Joint, Swing Motor		0	0	240					100%	92%	79%
Swing Frame		0	0	205	4	201	26	179	100%	98%	87%
Radiator, Firewall, Counterweight, Cab	223	10	10	213	19	204	39	184	96%	91%	83%
Boom & Stick	195	3	3	192	8	187	26	169	98%	96%	87%
VAB, Work Tools, EOL	76	3	3	73	7	69	12	64	96%	91%	84%
Op Group, Engine, Joystick, Adapter	305	9	9	296	21	284	60	245	97%	93%	80%
Base Frame, ML 1-9, Angle Blade	144	5	5	139	10	134	31	113	97%	93%	78%
ML 10-22	133	7	7	126	17	116	28	105	95%	87%	79%
MHE Summary	**1,521**	**37**	**37**	**1,484**	**106**	**1,415**	**272**	**1,249**	**98%**	**93%**	**82%**

Merging Physical Assets with Transactional Results
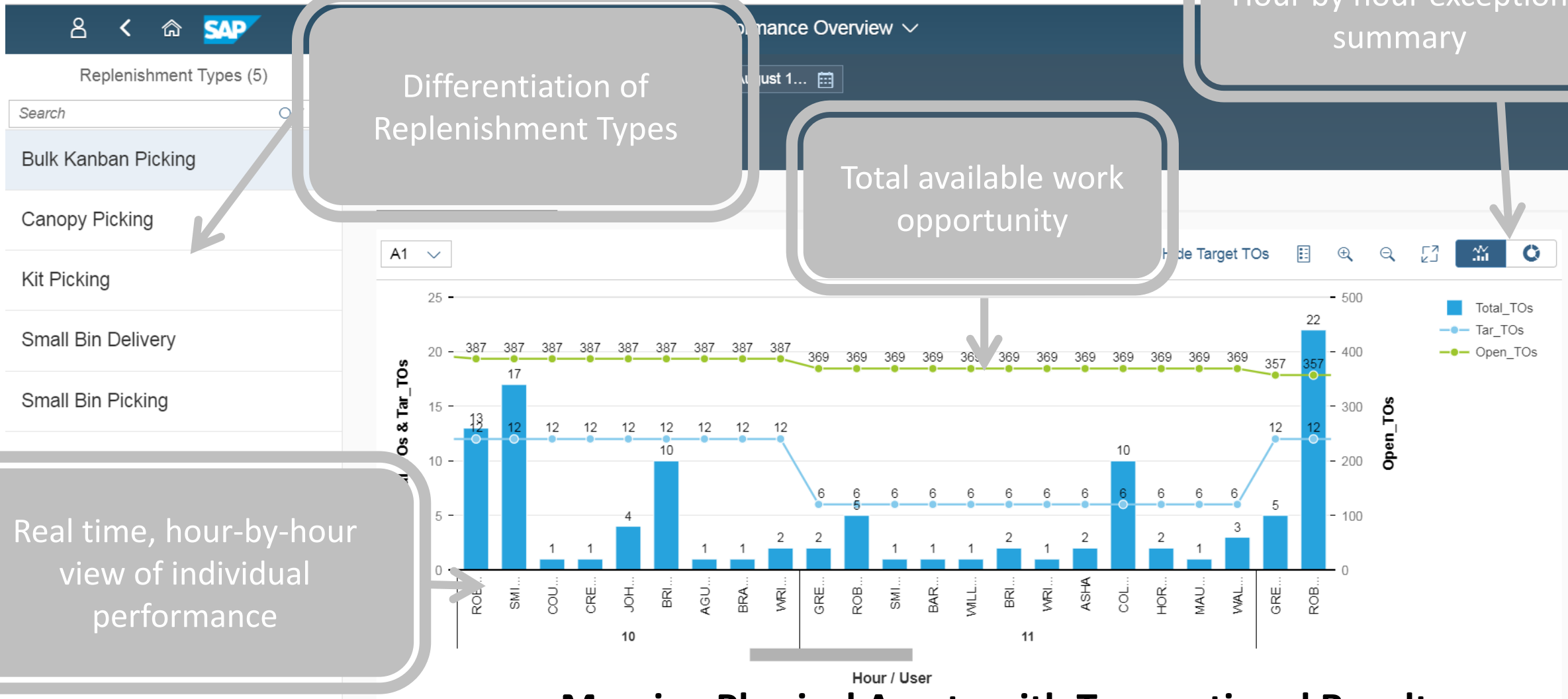
SAP Vehicle Insights Integrating:

- SAP ERP Transactional Data

- Material Handling Equipment Performance Data – Powerfleet

- Logistics Replenishment Material Flow Rate and Routing Plans

SAP Vehicle Insights – Intra Logistics Fleet Management

I.D. Systems®
Transforming Mobile
Asset Management

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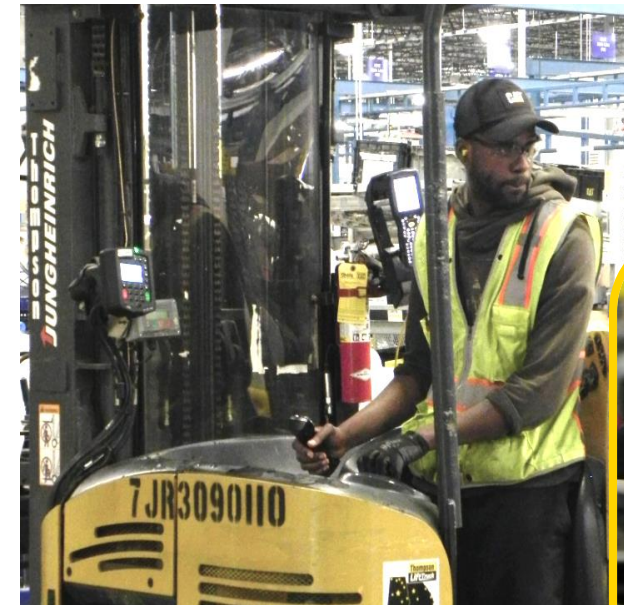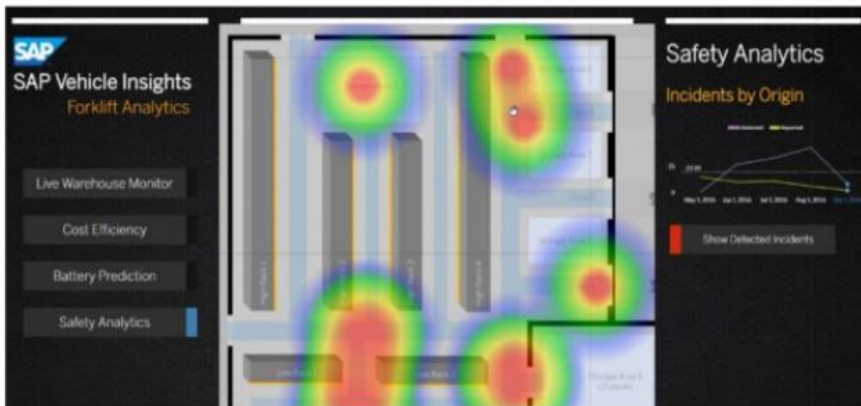
Vehicle Insights

Differentiation of Replenishment Types

Total available work opportunity

Hour by hour exception summary

Real time, hour-by-hour view of individual performance

Merging Physical Assets with Transactional Results

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Vehicle Insights

CURRENT DEPLOYMENT: MHE Assembly Stock To POU

IMPROVES:
- People (Impact monitoring, forklift safety checklist)
- Velocity (Standard vs Actual performance)
- Cost (Asset utilization)

NEAR TERM MGPP:
- Improved Access Point Traceability (5GHz ID Systems Units)
- Load Sensor Calculation
- Expand to Full Facility

LONG TERM MGPP:
- GPS Like Location Tracking
- Automatic Material Confirmations Based On Location

ON YOUR PHONE

EST: $700K ANNUAL SAVINGS

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Predictive Maintenance

Preventing Impacting Machine Failures

Predictive Maintenance – Freedom eLog OEE

Weld Robot Operator Home Screen

Team Lead Dashboard

Section Manager Top Level Dashboards

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Live Factory – Freedom eLog

MHE Fabrications
Variable Labor Efficiency

35% Reduction

Freedom 4.0 Rollout

2015	2.60
2016	2.04
Jan-17	1.48
Feb-17	1.41
Mar-17	1.44
Apr-17	1.37
May-17	1.29
Jun-17	1.34
Jul-17	1.33
Aug-17	1.32

Labor Efficiency — Target
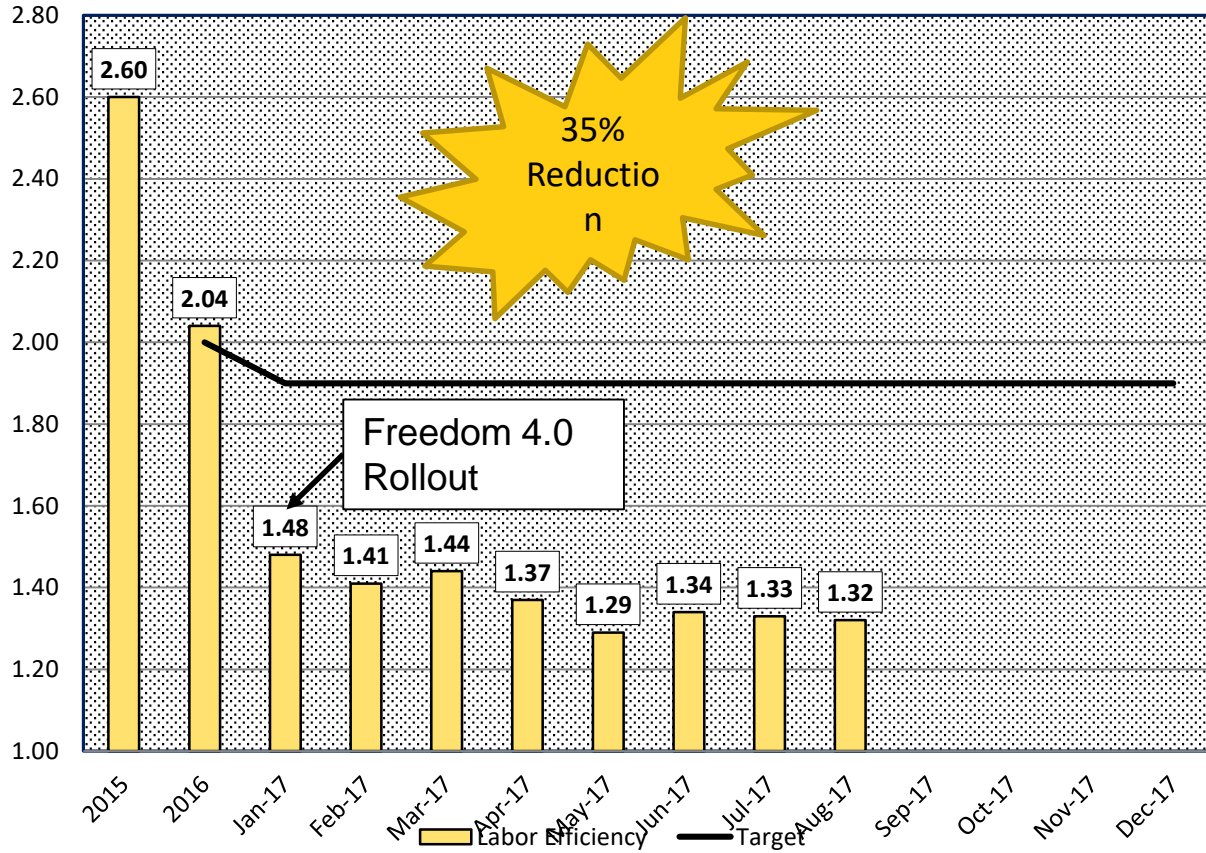
MHE Fabrications
Variable Labor Cost/Structure

Freedom 4.0 Rollout

20% Reduction

2015	$327.00
2016	$296.00
Jan-17	$300.00
Feb-17	$276.00
Mar-17	$258.00
Apr-17	$274.00
May-17	$259.00
Jun-17	$256.00
Jul-17	$255.00
Aug-17	$237.00

Cost Per Structure — ATS

Caterpillar: Confidential Green

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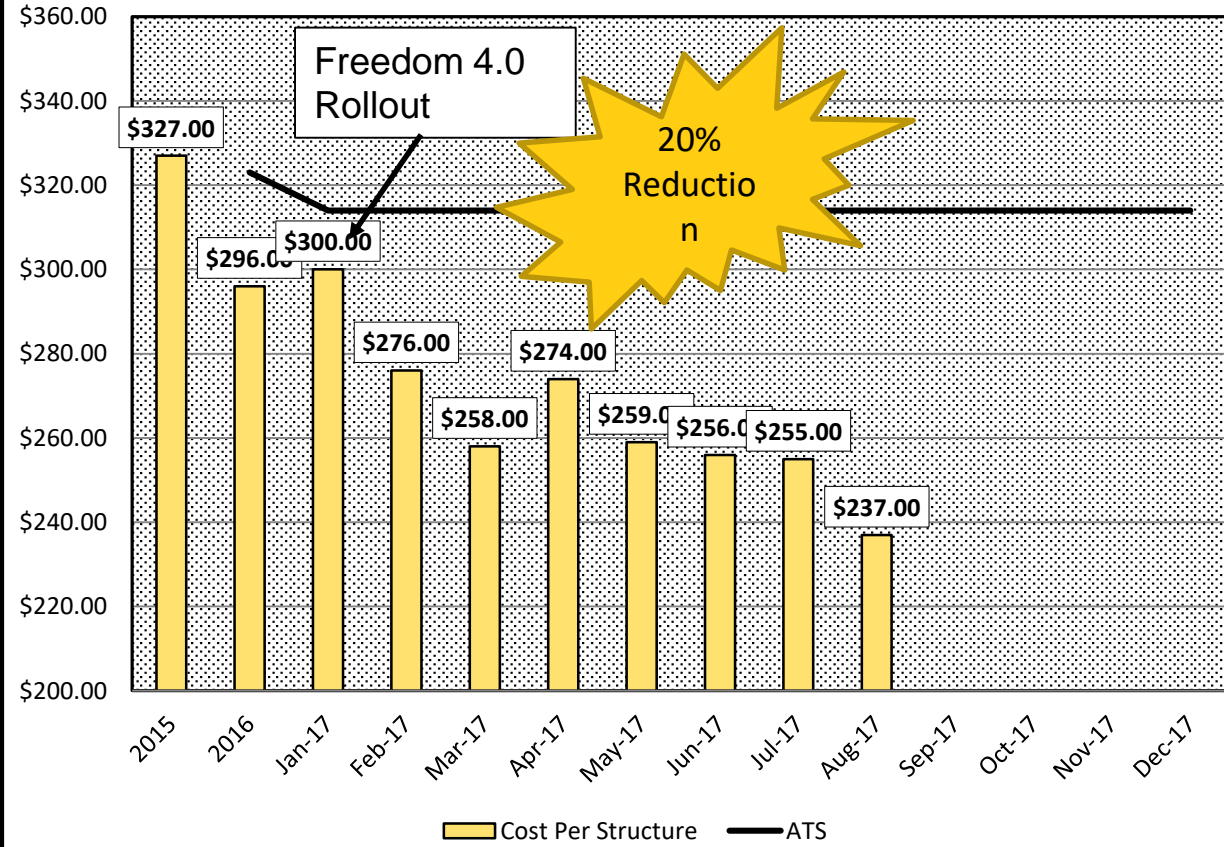
Previous State:

Reactive/preventative maintenance

No trending of machine data
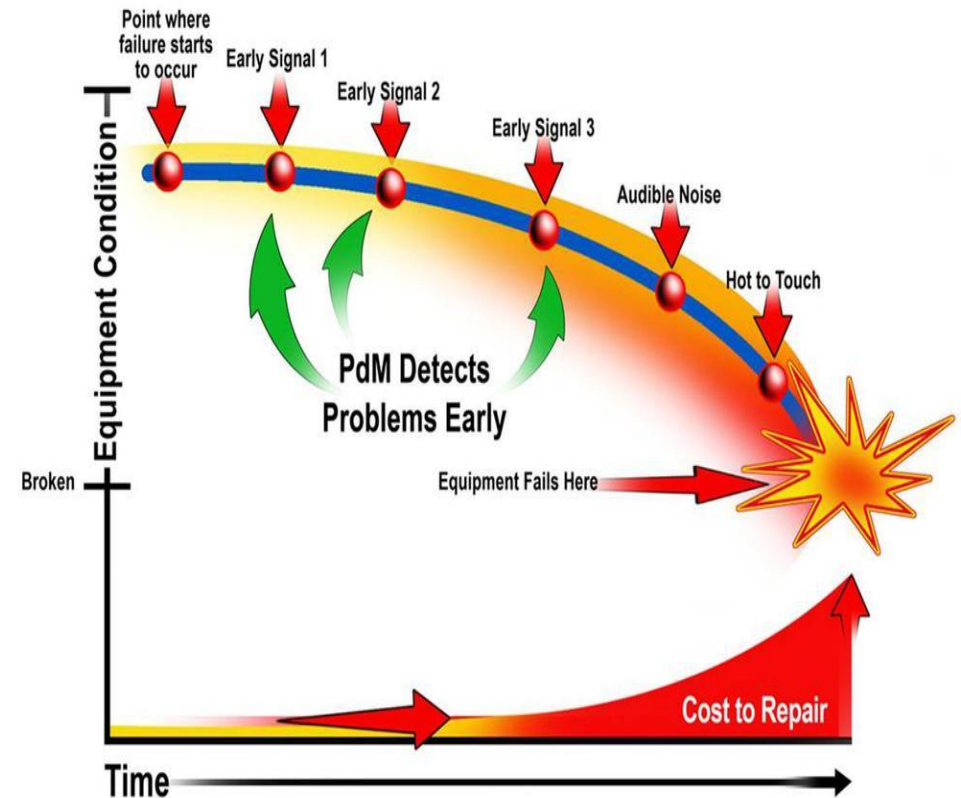
Limited awareness of machine conditions

Breakdowns occur without warning

Phase 1 Current State:

Added predictive maintenance tool

Automated statistical analysis of spindle load, spindle temperature, and Z-axis load

Improved awareness of machine conditions

Preventing Impacting Machine Failures

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Predictive Maintenance - PdMS
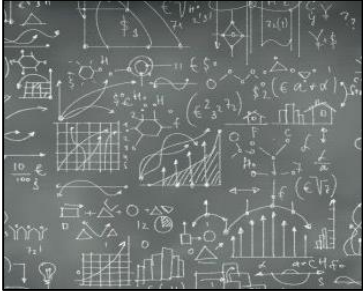
Mazak V100 Machining Center Example

MACHINE SENSOR DATA

- Spindle Load
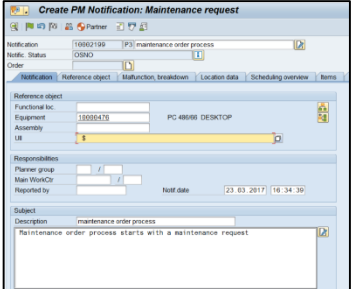- Spindle Temperature
- Z-Axis Load

DATA COLLECTION & NORMALIZATION

- FreedomE
- SAP PdMS

STATISTICAL ANALYSIS

- SAP PdMS
- Data Trending
- Data Relationships
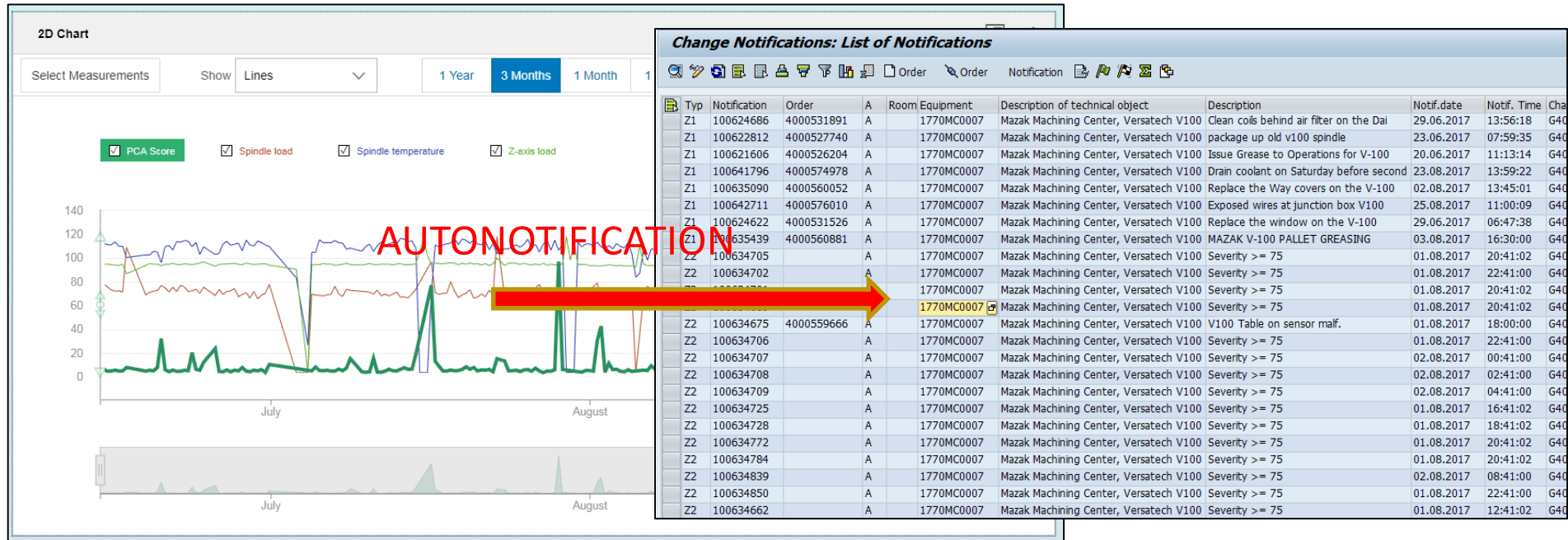
AUTOMATED NOTIFICATION

- Maintenance Work Request

System Predicts Machine Failures

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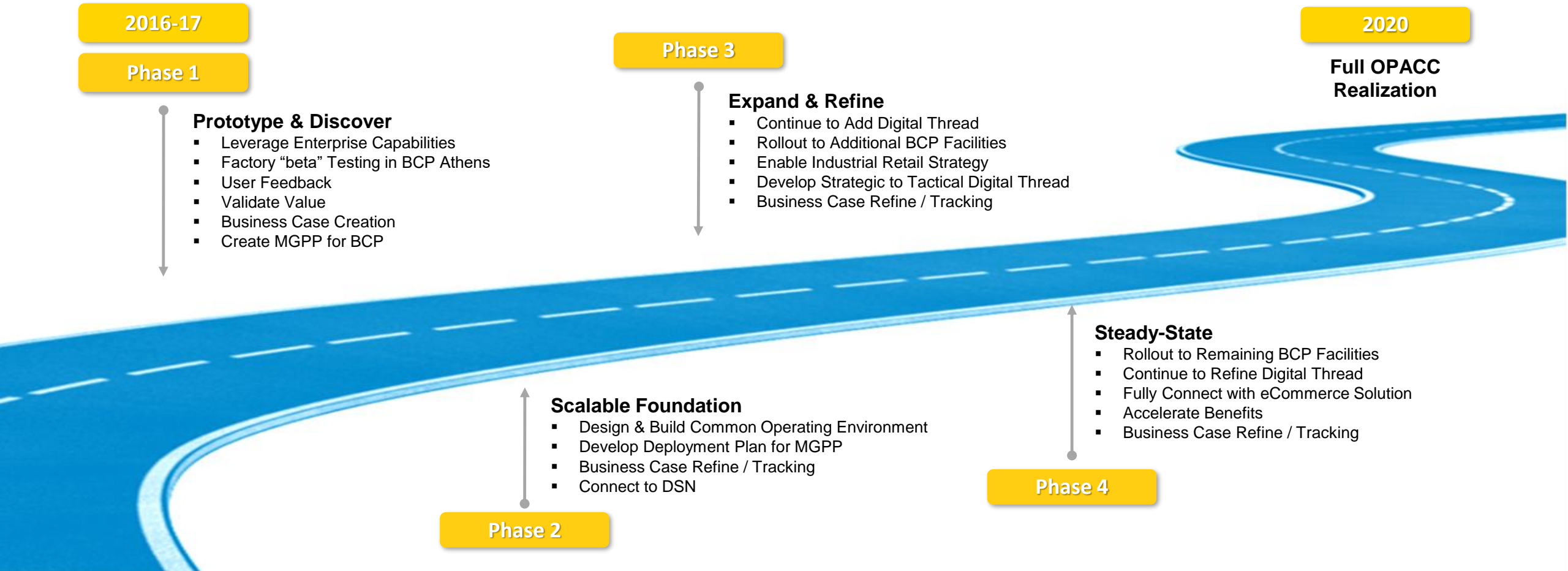# SAP Workflow Integration and Next Steps

PdMS Screen Shot

Next Steps
- Increase number of sensors on machine to identify where risk is occurring
- Add additional machining centers (Phase II)
- Continue to streamline information flow to build real-time dashboards

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We Can't "Eat The Elephant" With One Bite…

We must start small, get real world reactions, adjust, and generate value along the way

2016-17

Phase 1

Prototype & Discover
- Leverage Enterprise Capabilities
- Factory "beta" Testing in BCP Athens
- User Feedback
- Validate Value
- Business Case Creation
- Create MGPP for BCP

Phase 3

Expand & Refine
- Continue to Add Digital Thread
- Rollout to Additional BCP Facilities
- Enable Industrial Retail Strategy
- Develop Strategic to Tactical Digital Thread
- Business Case Refine / Tracking

2020

Full OPACC Realization

Steady-State
- Rollout to Remaining BCP Facilities
- Continue to Refine Digital Thread
- Fully Connect with eCommerce Solution
- Accelerate Benefits
- Business Case Refine / Tracking

Phase 4

Scalable Foundation
- Design & Build Common Operating Environment
- Develop Deployment Plan for MGPP
- Business Case Refine / Tracking
- Connect to DSN

Phase 2

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Thank You

Marty Groover, Operational Technology Leader, BCP