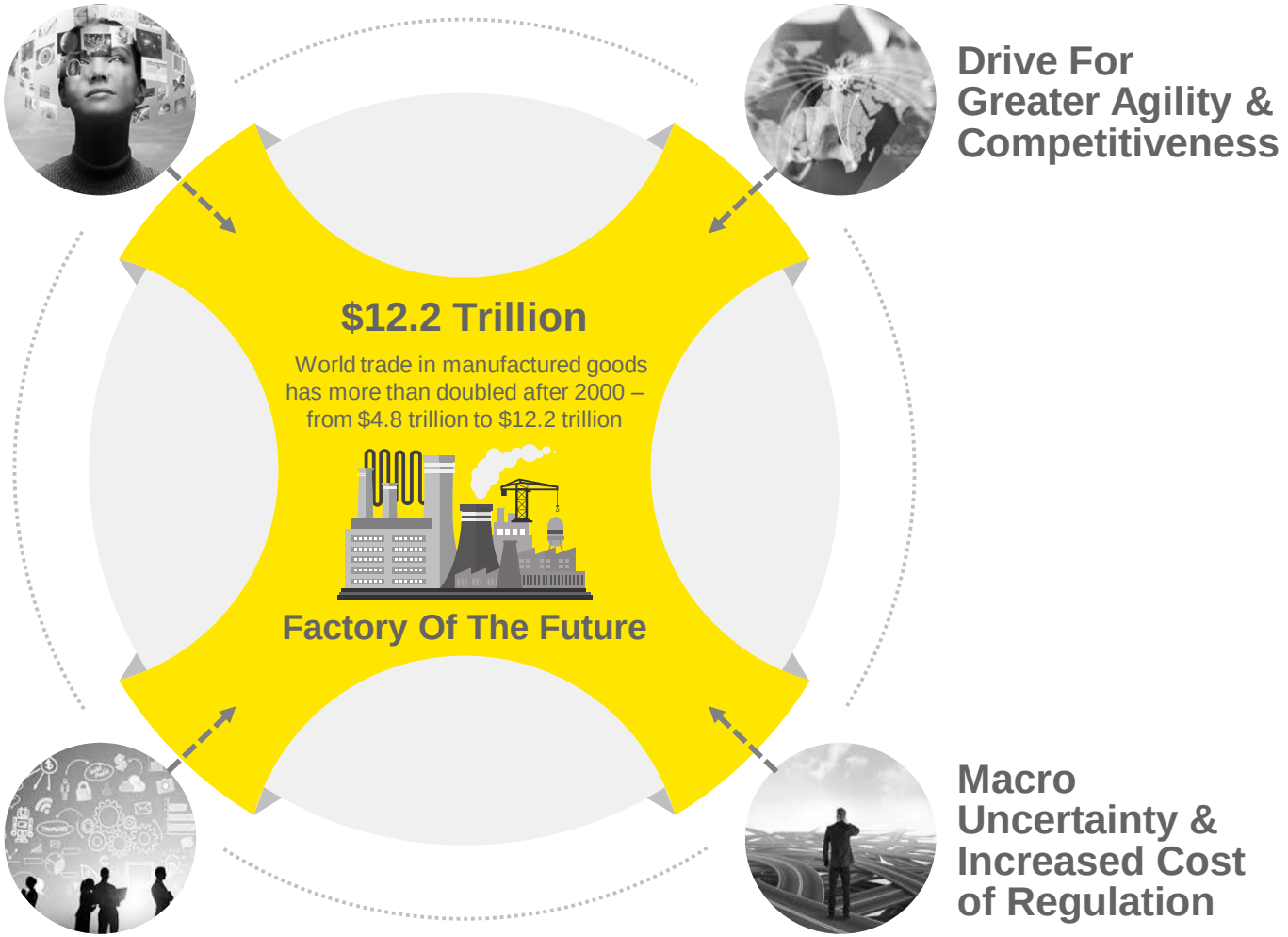
Unlocking The Full Potential Of Manufacturing Performance Through EY Smart Factory

June 2017

Building a better working world

External forces are shaping the direction of the factory of the future



We are the start of the 4th industrial revolution – both a threat and an opportunity for manufacturing …

1700's

First Industrial Revolution

Mechanical

Technology was steam and water powering the first factories

1800's

Second Industrial Revolution

Electrical

Electricity made possible the division of labour and mass production

1900's

Third Industrial Revolution

Automated

IT enabled programmable work and an end to reliance on manual labour

Today

Fourth Industrial Revolution

Connected

Cyber-physical systems, powered by IoT and fuelled by data, create a fully interconnected society

Unprecedented pace

35 days

For a new technology to reach a critical mass of 50m users

Extreme experiences

87%

Percentage of customers looking for a more seamless experience

Connected chaos

50bn

Internet connected "things" by 2020** including sensors, RFID chips etc.

Digital natives

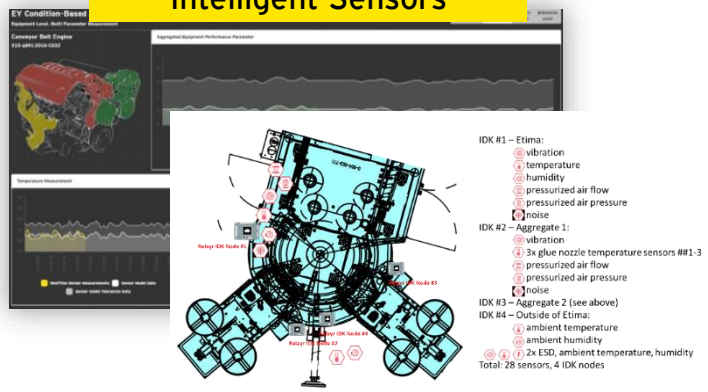
75%

By 2025, the makeup of the workforce is projected to be majority digital native

Technology is bringing significant opportunities.....

Real Time Monitoring & Advanced Loss Analysis

Smart Maintenance & Intelligent Sensors



Smart Products & Equipment & AI

Autonomous Vehicles & Robotics

Additive Manufacturing

Mobility & Skills Augmentation Through VR / AR

.....but the challenge for Manufacturers is where to start

Emerging / Disruptive Technology

Slow Momentum

- Will it create business value for the company?
- Where and how does it fit?
- How do I get started?

MES / MOM

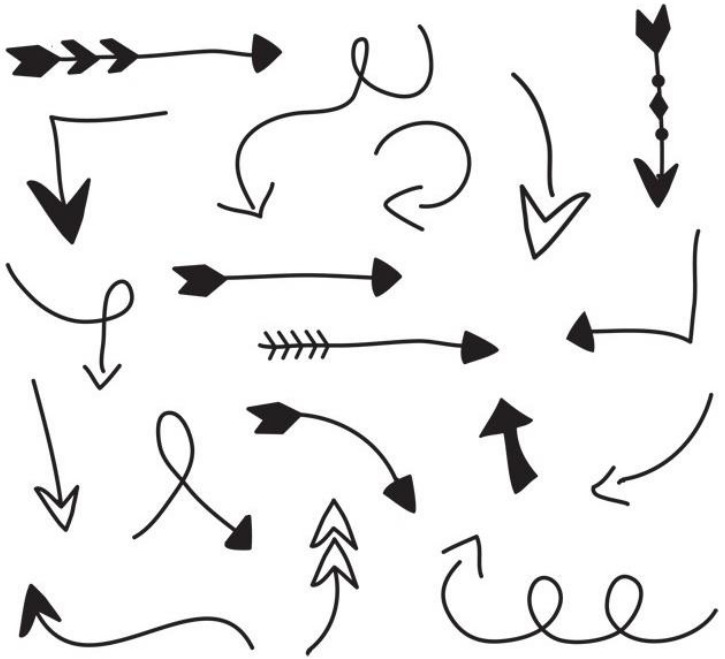
Resurgence

- OTS replacing custom home-grown solutions
- Building beyond SCADA
- Laying a good foundation

Big Data & Analytics

Struggling

- Normalizing data is an effort
- Tons of data – no clear paths of value
- Organizational silos



IoT - IIoT

Dabbling

- Proof of concepts
- Fear of putting data in the cloud – am I vulnerable?
- Lack of infrastructure to support IoT

Digital Strategy & Roadmap

Focus

- Leverage what I have
- Fill the gaps & meet opportunities
- "Living Strategy" – flexible; recognizing that technology is changing rapidly

Beyond the Shopfloor

Extending

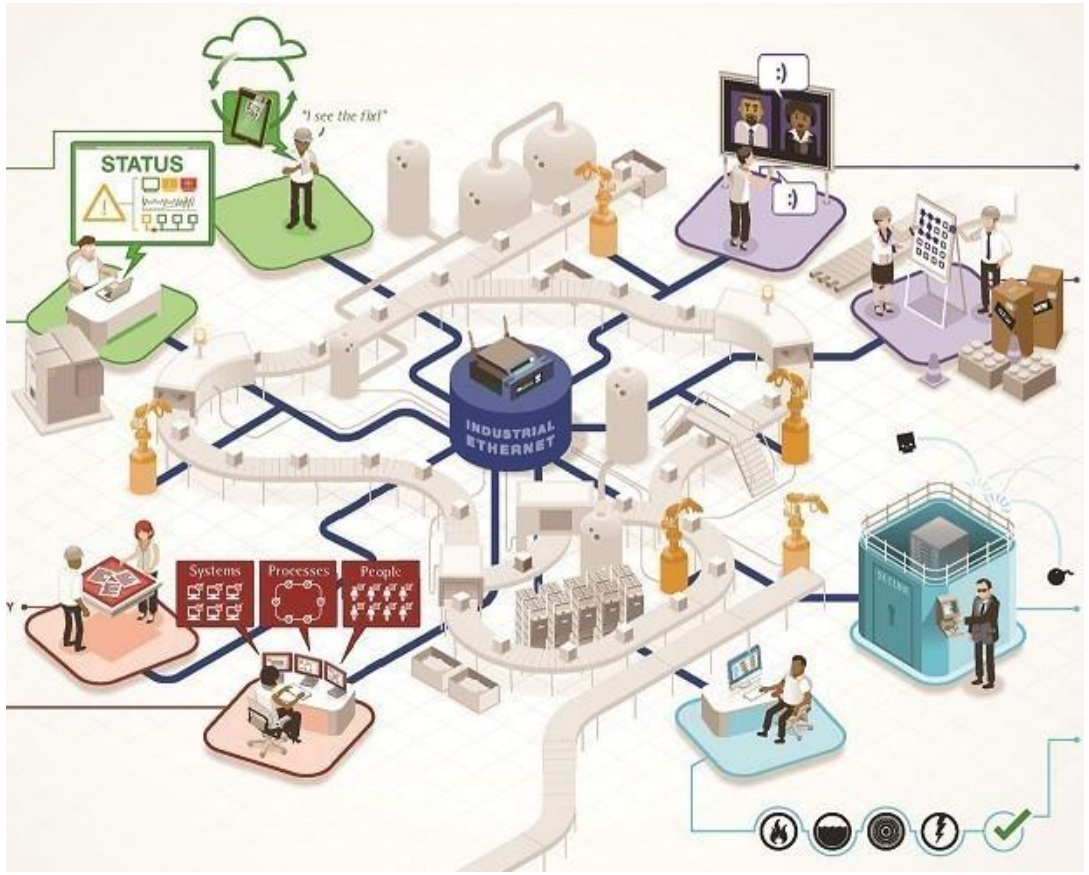
- Supply chain visibility
- Enabling field service
- Selling data

EY's Smart Factory Solution

Building a better working world

Our vision of the Smart Factory

Our Definition:
In the Smart Factory, a virtual copy of the physical world is created via the integrated industrial network; machines and humans communicate and cooperate with each other in real time, enabling fast, decentralized, better decision making.



Smart Factory Capabilities

- Real-time, on demand info & visibility across the production chain
- Information & technologies to optimize physical process control
- Advanced analytics, to refine processes and master production
- Enables flexible, adaptive, and proactive production
- Facilitates end-to-end integration with suppliers and customers
- Smart Factory guides operators and assists in worker safety

EY's Smart Factory solution *uniquely* brings together Operational Excellence leading practice with Manufacturing 4.0 disruptive technologies

Operational Excellence

- TPM
- Lean
- Six Sigma
- TQM
- JIT
- Kaizen
- Theory of Constraints
- Kanban
- Reliability Engineering
- Synchronization

- Improved service levels
- Labour savings
- Maintenance savings
- Energy savings
- Yield loss savings
- Re-work cost savings
- Warranty cost savings
- Overheads cost savings
- Working capital savings

Disruptive Technologies

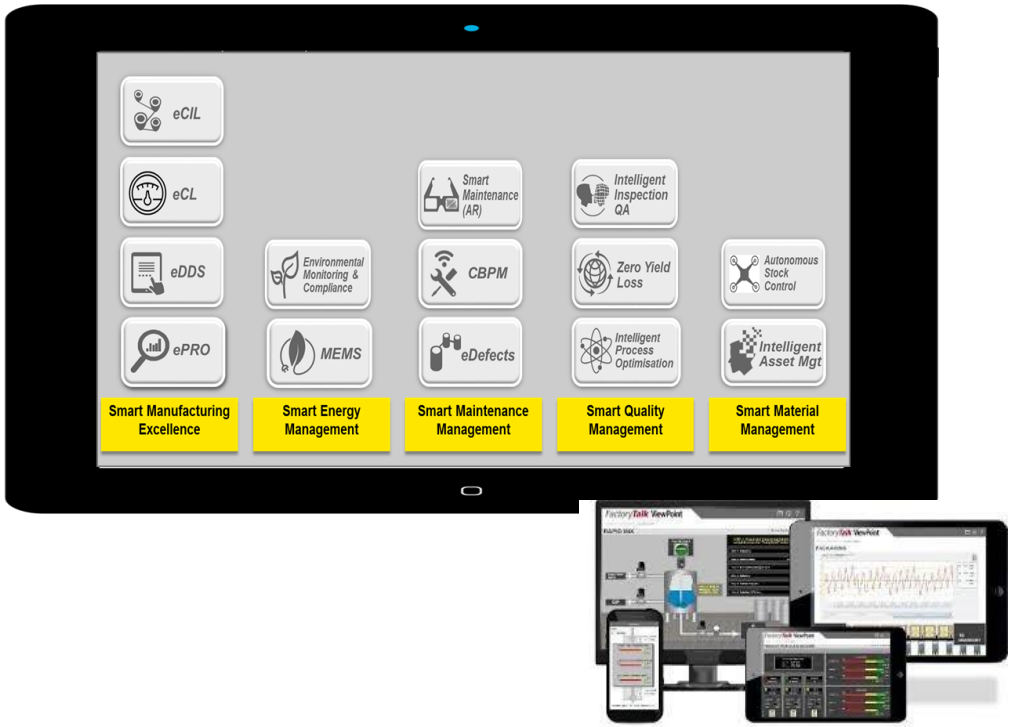
- RPA
- IoT and AI
- Robotics / Smart Machines
- Affordable sensors / smart equipment
- 3D Printing
- Cloud / Integrated Platforms
- Big data analytics
- Blockchain
- Cyber security

EY Smart Factory solution – "Catalyst"
Integrating manufacturing excellence capabilities & smart technologies

EY Smart Factory Solution

Digital Manufacturing Excellence Platform

Digital Shop Floor Execution Applications



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EY Smart Factory Solution

Digital Manufacturing Excellence Platform

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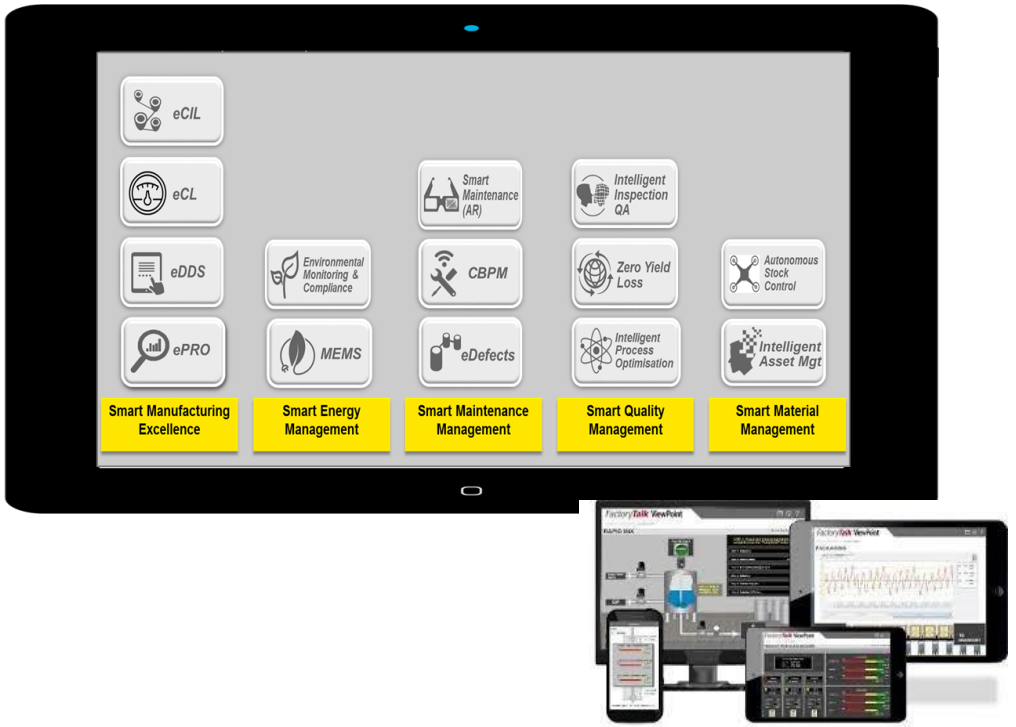
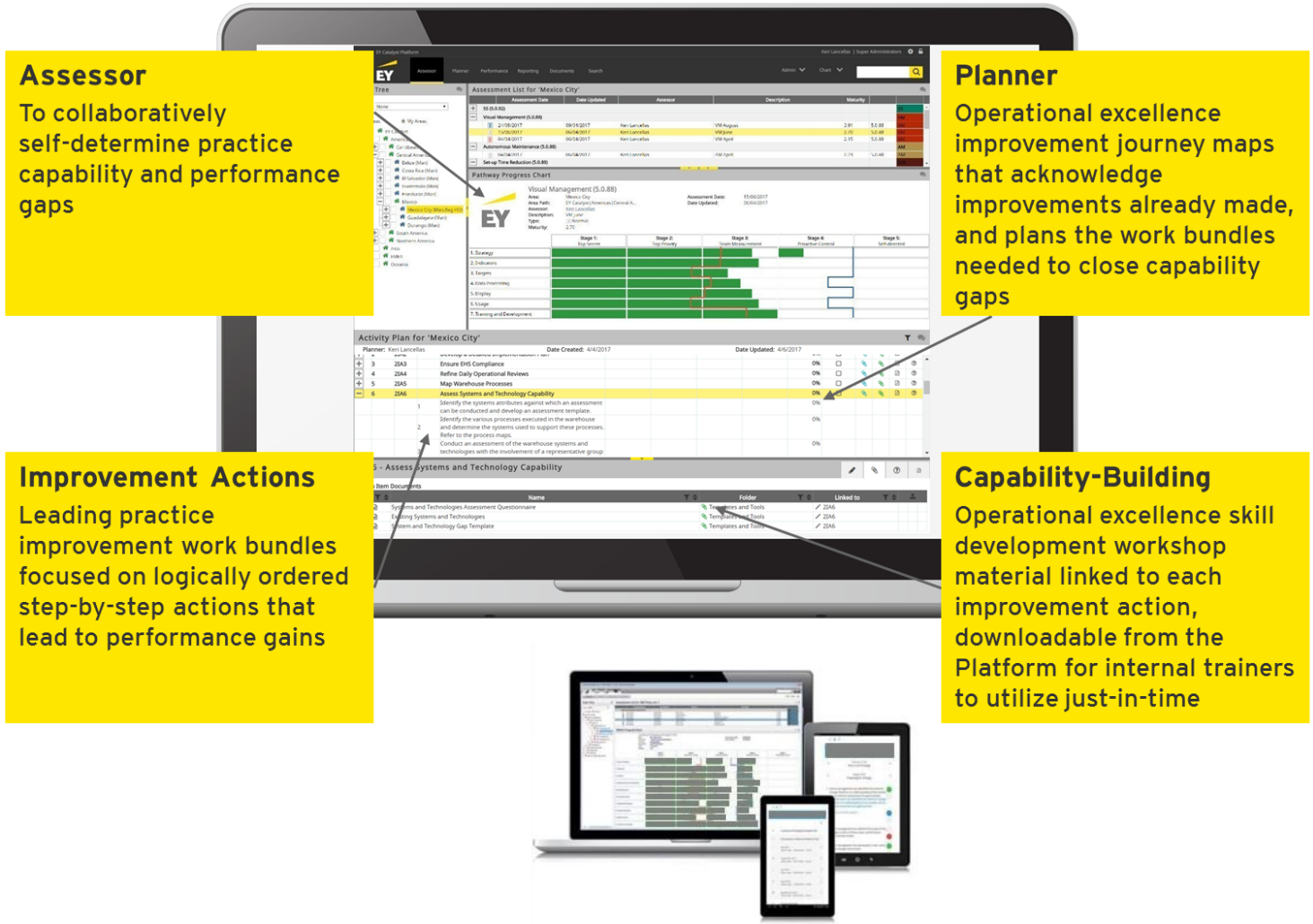


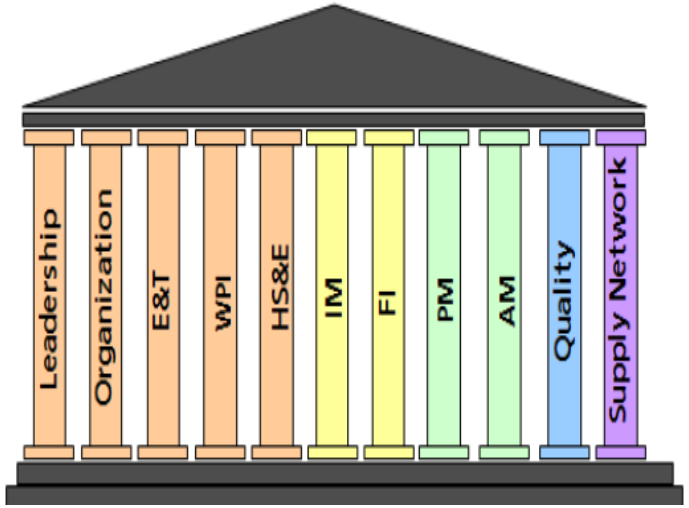
EY's Manufacturing Excellence platform automates the manufacturing excellence journey

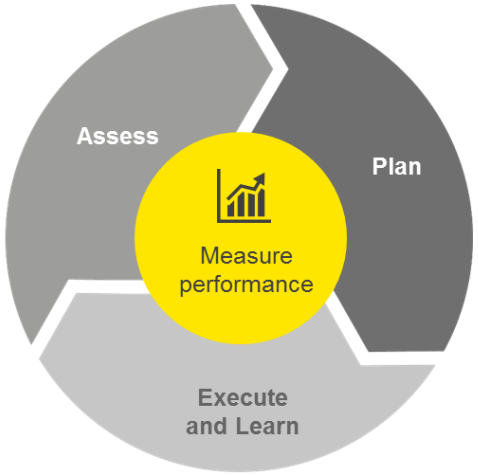
- World's leading Manufacturing Excellence Technology platform
- It holds IWS Manufacturing Excellence leading practices in a 5 Stage Maturity structure
- It is a digital, cloud based, on-line system which all sites log onto and execute there operational excellence journeys
- It has all self assessment and audits, it automatically creates the detailed project plan by line, site, department, and tracks compliance by each team as they execute their operational excellence journey.
- Content and upgrades can be maintained centrally with instant access at Plants
- All content is available on IOS and Android mobile devices



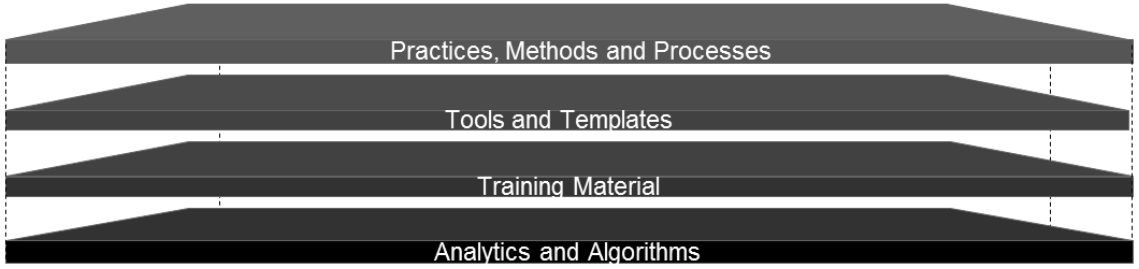
Digital Manufacturing Excellence platform provides both leading practices & operational excellence journey plans customised down to line level

Manufacturing Excellence Leading Practices

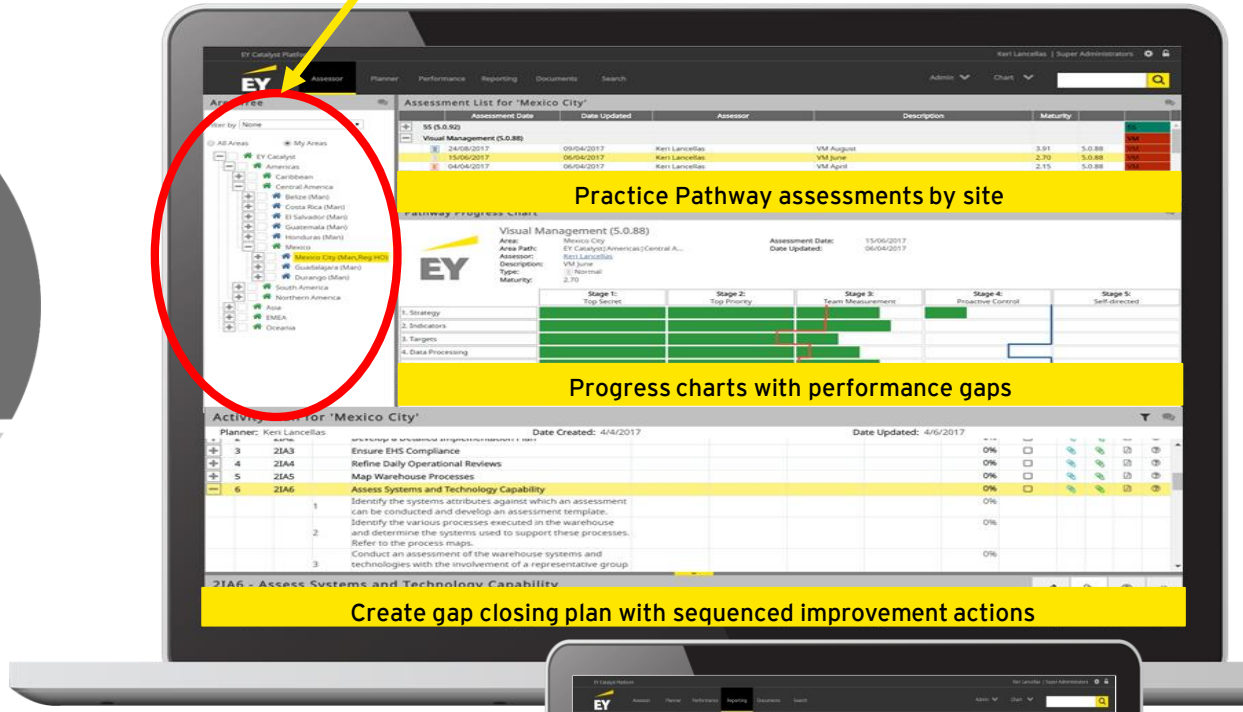


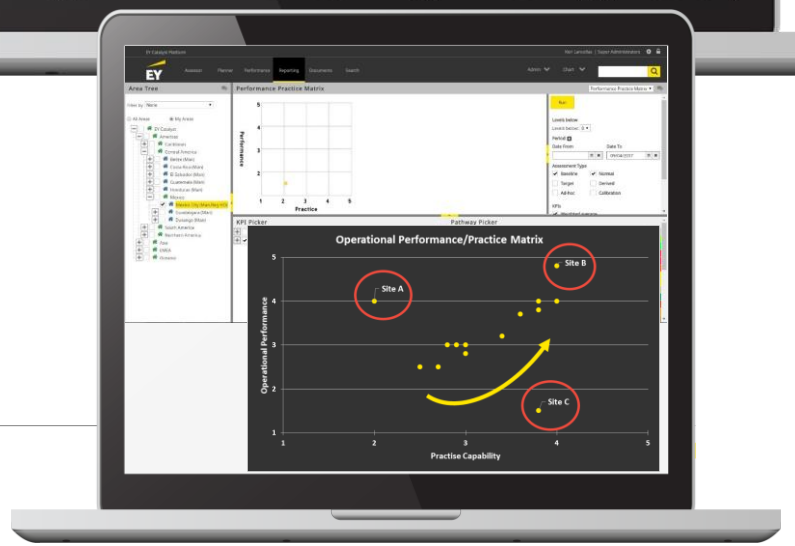


Phase 0	Phase 1	Phase 2	Phase 3	Phase 4
Leadership Preparation & Learning	Achieve and Maintain Base Condition	Extend Time Between Failures and Dramatically Increase Skill	Deliver Stable, Capable and Productive Supply Chains	Deliver Predictive, Flexible, Responsive and Cost Efficient Supply Chains



Replicate your organization's site structure





Digital Manufacturing Excellence Platform
One Global Digital Operational Excellence Platform

Catalyst Platform and Mobile Assessor — a secure web-based application to assess, plan, access sequenced improvement work packages, track and manage improvements

Catalyst Training — workshop materials, downloadable from the platform, designed to be customized and delivered by internal trainers

Catalyst Reader — a tablet and Windows PC application for mobile access to sequenced improvement work packages "How To" knowledge content

Catalyst Community — an online forum to see leading practice examples, and interact with others on the improvement journey

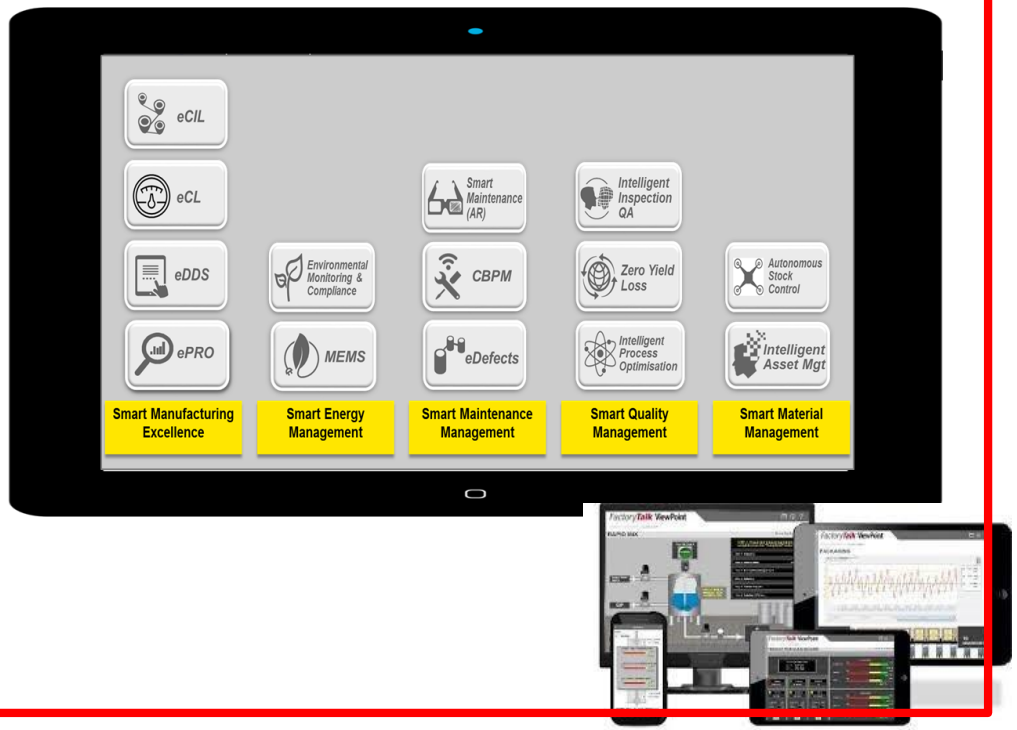
Catalyst eLearning — online learning modules for just-in-time knowledge acquisition

EY Smart Factory solution – "Catalyst"
Integrating manufacturing excellence capabilities & smart technologies

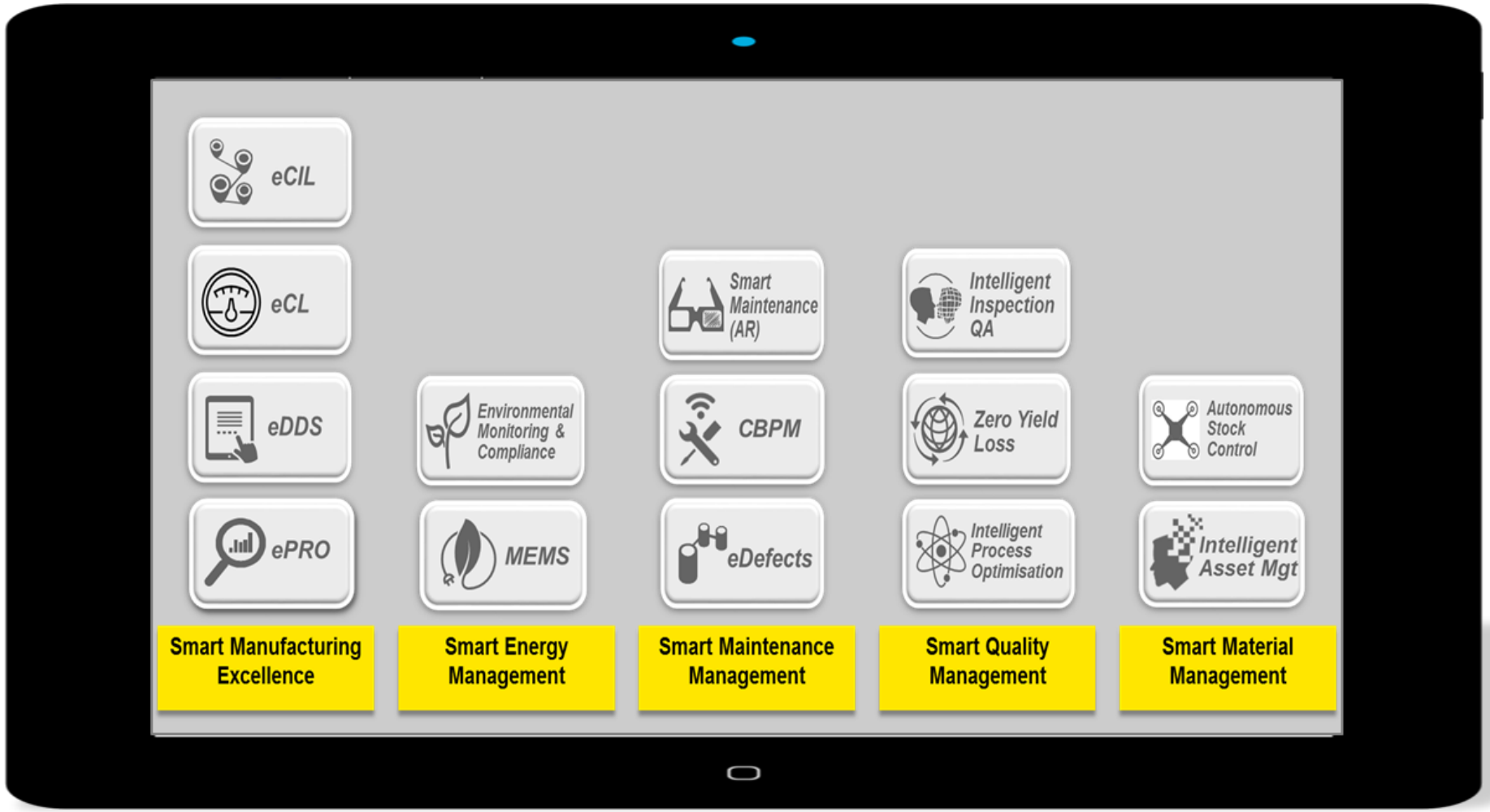
EY Smart Factory Solution

Digital Manufacturing Excellence Platform

Digital Shop Floor Execution Applications



EY's Digital Shop Floor execution applications; Manufacturing "App Store" aimed at zero losses



EY's Digital Shop Floor execution applications are linked directly to operational excellence capabilities that drive zero loss

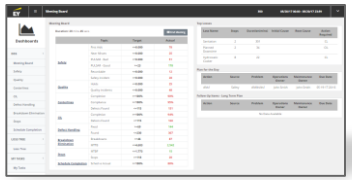
EY Smart Factory shop floor execution applications;
eDDS and eDMS applications improve OpEx quality of execution

eDDS and eDMS applications information flows – "closing the loop" - driving better analytics & quality of execution

ePRO

- Automatic updating of line performance metrics
- Automatic updating of advanced loss analysis using reliability engineering

eDDS

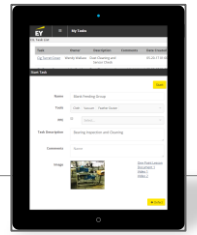


- CIL completion & quality automatically updated
- CIL quality Vs losses Vs Defects tracked & trends identified

- CL completion & quality automatically updated
- CL quality Vs losses Vs Defects tracked & trends identified

- Defects list auto updated
- Defects action tracking – check if CIL or CL updated
- Defects list Vs losses trends analysis

eCIL



- Record Defects immediately found

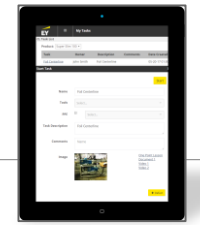
eDefects

SAP PM

- Automatic updating of Defects

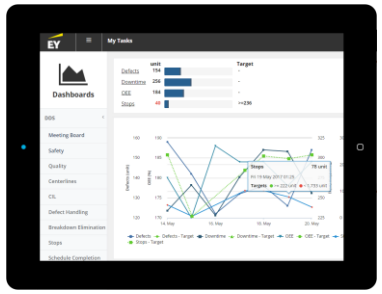
- Record Defects immediately found

eCL

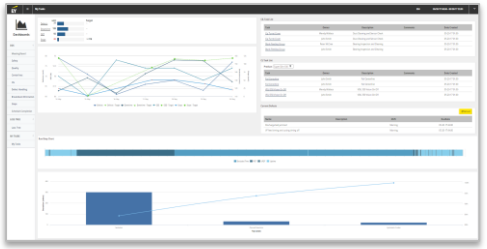


1 EY Smart Factory shop floor execution applications; *ePRO (Performance & Reliability Optimisation)*

Smart Shop Floor iPad (Mobility)

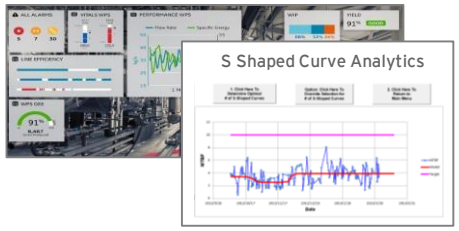


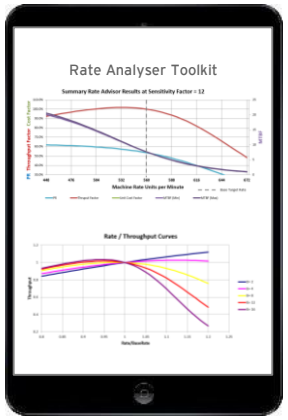
Performance reports (PMAC)



Dashboarding of Data – full drill down and roll up capability

Plant Performance Analytics





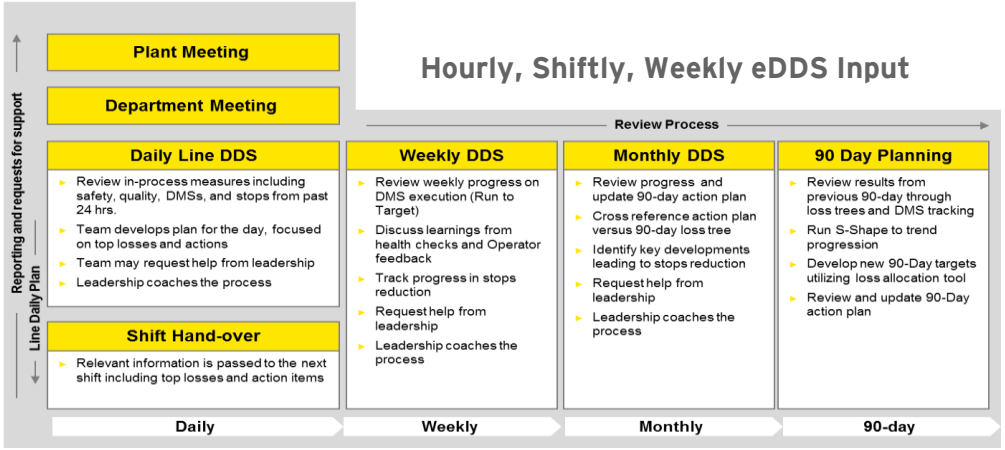
ePRO (Performance & Reliability Optimisation)

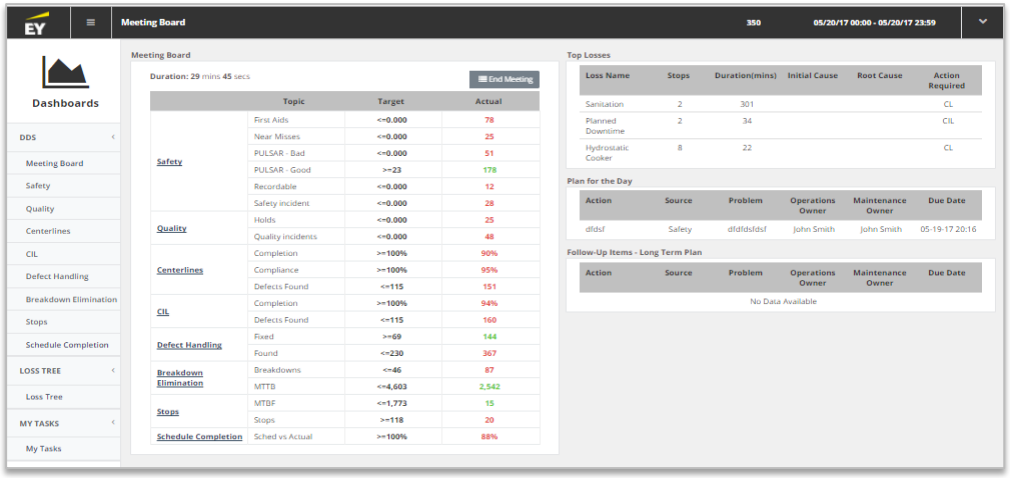
- Deep production line performance visualisation – KPI's, trends, correlations, stops, losses
- Advanced loss analysis – RE analytics, loss allocation tools, advanced problem solving
- Integrates disparate systems and normalizes the data
- Mobile handheld displays provide real time manufacturing data & alerts to Operators and Mechanics
- Directs Operators to key performance issues and losses to more effectively focus corrective actions
- Enables Operators to record line info, RTT settings, etc. directly into the system, supports line shift handovers
- Enables Line Leaders and Operators to drive faster, more standardized analysis and problem solving
- Allows simulation of potential future state performance

2 EY Smart Factory shop floor execution applications; *eDDS (Daily Direction Setting)*

eDDS

eDDS cycle



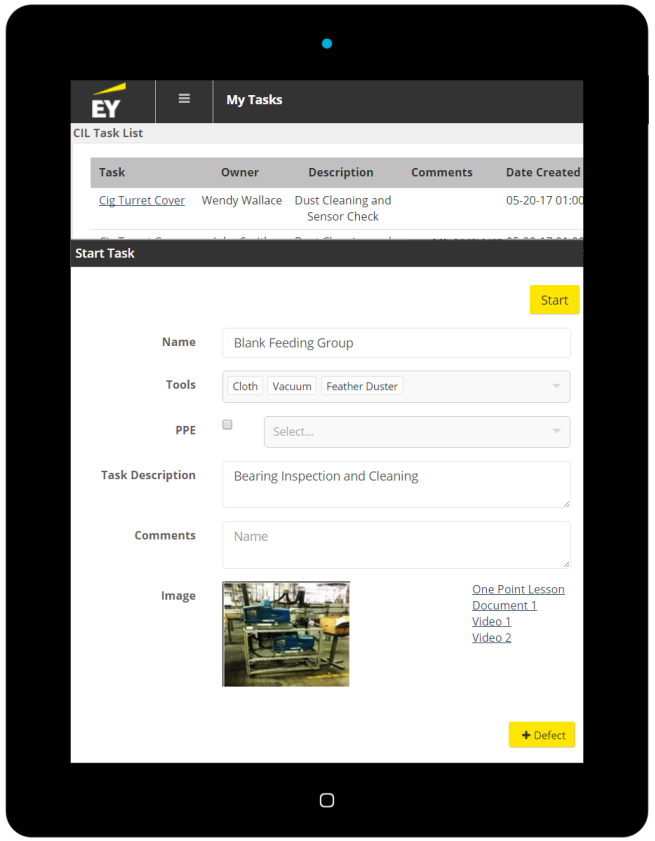


eDDS (Daily Direction Setting)

- Automated workflows to support Shift Handover, Line DDS and roll up into Department and Plant level Daily and Weekly Direction Setting
- Automated updates of line performance, in-process measures, loss analysis, defects & maintenance scheduling
- Ability to run meetings on-line, record agreed DDS actions and track completion of these actions
- DDS analytics - history of DDS actions, patterns of issues, effectiveness of problem solving actions, suggested actions
- Correlate specific CIL, DH, CL impact on loss reduction
- Weekly & Monthly In process & Out Process measure regression to flag ineffective DMSs
- Institutionalizes the DDS algorithm in the shiftly, daily and weekly rhythm by requesting specific DMS actions for each of the top losses

3 EY Smart Factory shop floor execution applications;
eCIL (Clean, Inspect, Lubricate)

eCIL Guidance and Tracking

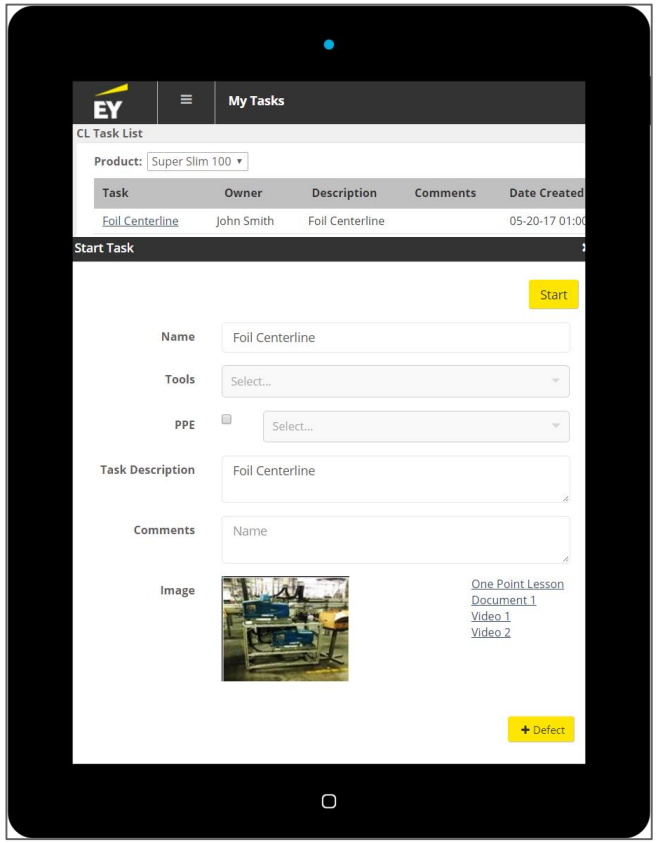


eCIL (Clean Inspect Lubricate)

- Automates workflow - improves efficiency, compliance & quality of execution
- Ability to track effectiveness of CIL's;
  - Number of Defects found & frequency of findings
  - Reoccurring losses and stops on specific machine vs. CIL's available
  - Time taken to complete CIL – efficiency, completeness
  - User name associated with Shift & CIL when issues arise
- Automatic check when Defects closed – is a CIL updated (drives closed loop DMS)
- Immediate access to supporting material e.g. photographs of equipment, eLearning material, coaching tips
- Ability to identify correct frequency of specific CIL checks vs defects found – daily vs weekly, etc.
- Supports workload balancing
- Correlate CIL tasks executed with loss reduction

4 EY Smart Factory shop floor execution applications; *eCL (Centrelines)*

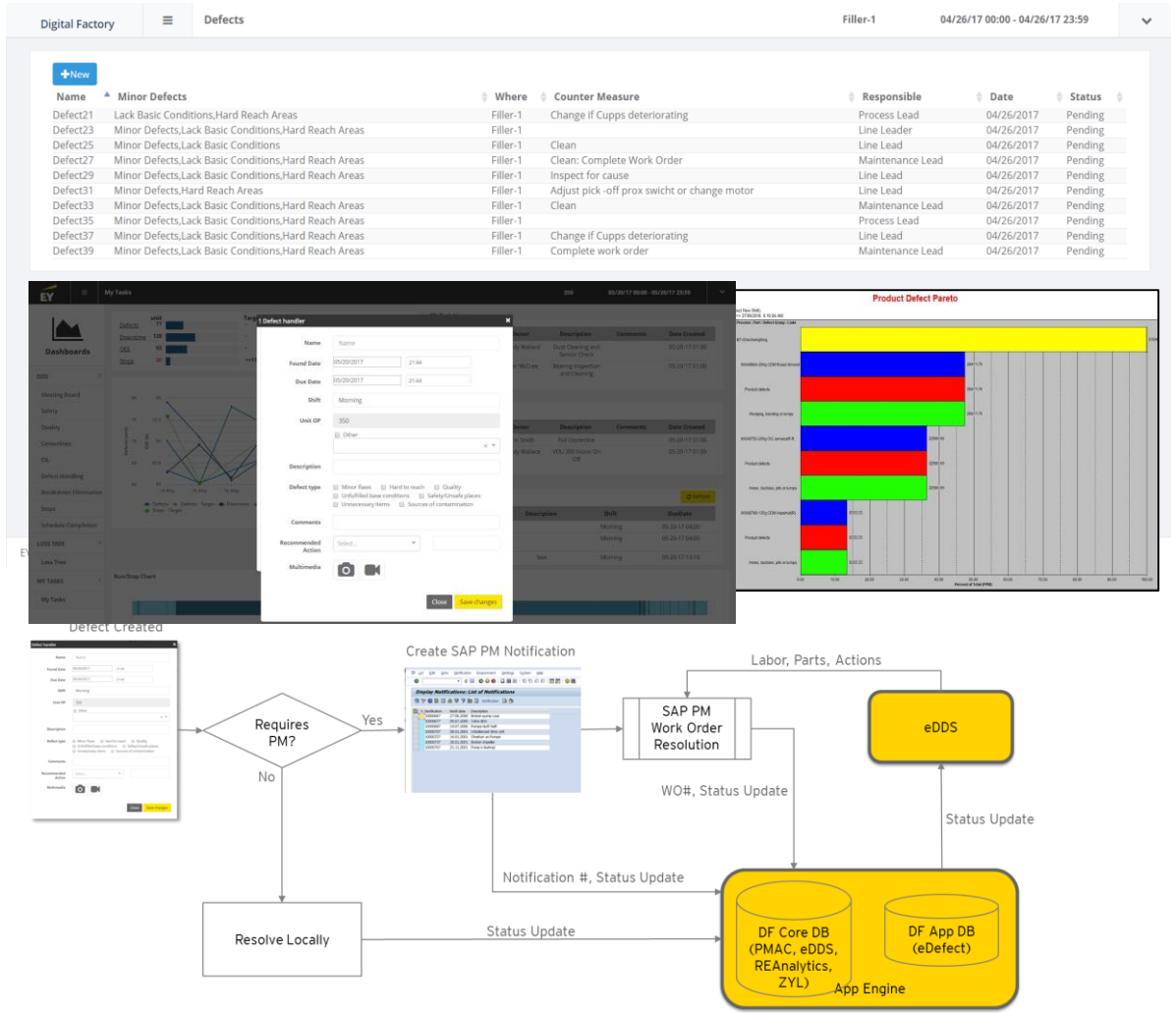
eCL Guidance and Tracking



eCL (Centrelines)

- Automates workflow - improves efficiency, compliance & quality of execution
- Provides real time alerts to Operators & Mechanics on CL issues – where equipment is trending outside CL's
- Ability to track effectiveness of CL's;
  - Loss trends and analysis vs CL's
  - Number of Defects found & frequency of findings
  - Reoccurring losses vs CL's
  - User name associated with Shift & CL when issues arise
- Automatic check when Defects closed – is a CL updated (drives closed loop DMS)
- Immediate access to supporting material e.g. photographs of equipment, eLearning material, coaching tips
- Prompt Equipment Owners for immediate CL check following changeovers and preventive maintenance

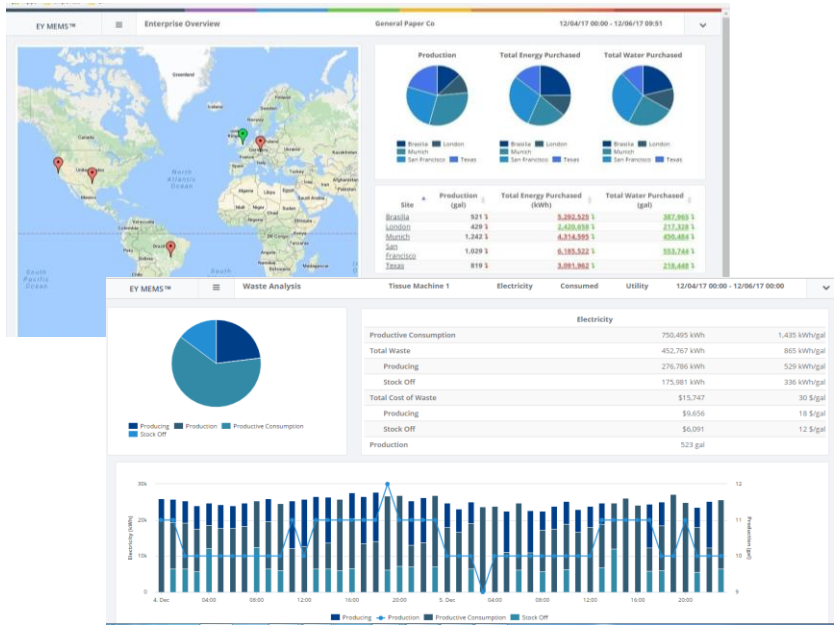
5 EY Smart Factory shop floor execution applications; *eDefects*

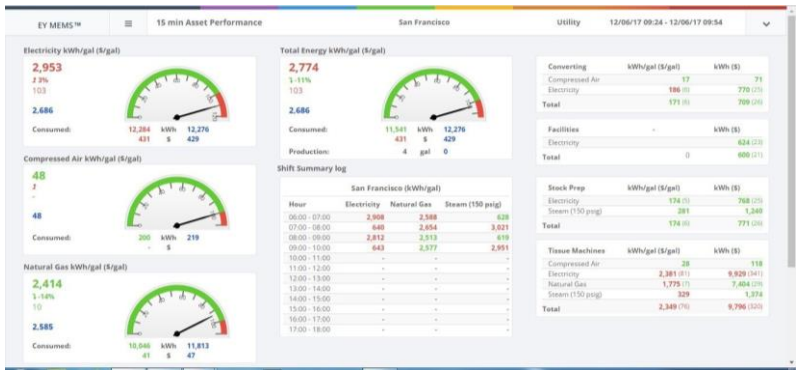


eDefects

- Enables more accurate recording of defects immediately they are found – during CIL, line stop, PM, etc.
- Empowers Operators to drive Defect identification – immediate access to support material to improve accuracy of recording, improves training
- Automates workflow - improves efficiency, accuracy, compliance & quality of execution on Defects
- Automatic integration with SAP PM maintenance & scheduling
- Ability to run analytics across defects found to improve capability build & predictive maintenance – defect trends on specific equipment
- Forces DMS update confirmation before closing – CIL, CL, etc updated
- Correlate Defect Fixing with loss trend observed

6 EY Smart Factory shop floor execution applications; *MEMS™ Energy in the context of production*

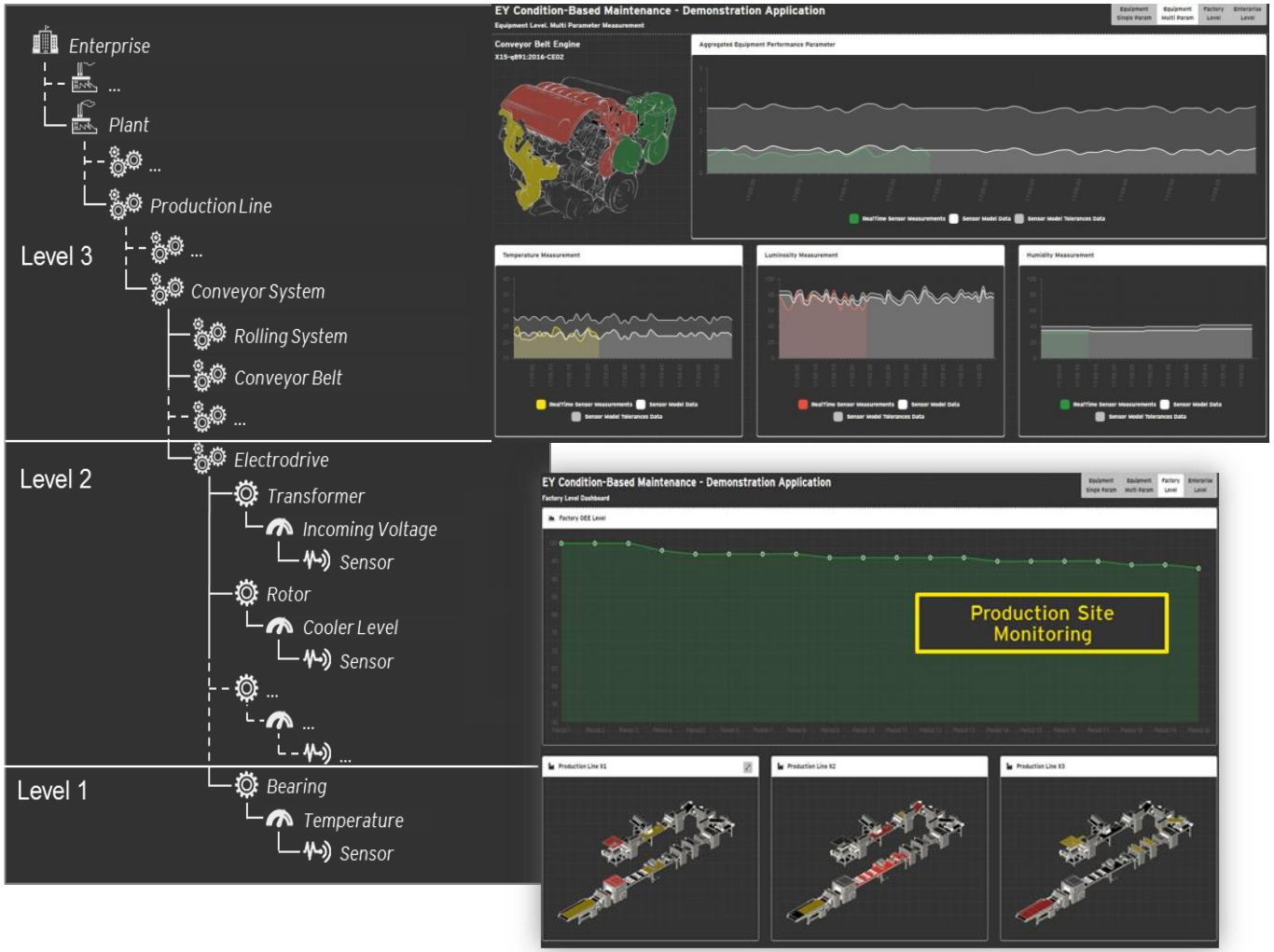




MEMS (Manufacturing Energy Management System)

- Connects all utility consumption and costs through IoT with production and provides a detailed view of consumption by site, crew, shift, equipment, product.
- MEMS treats energy, air and water as a part of the production bill of materials.
- Respond to energy waste in real-time and identify energy waste from poor production practices or equipment defects
- Enables utility usage standards to be established by SKU and continuous tracking during DDS meetings
- Compare & contrast sites, lines, equipment, shifts & crew by product
- Enables site level investigation of utility cost saving opportunities through supply renegotiation or alternative energy approaches
- Enables accurate budgeting & forecasting of utility use & cost and enables energy bills validation
- Enables energy demand planning based on peak rates

7 EY Smart Factory shop floor execution applications; CBPM (*Condition Based Predictive Maintenance)*

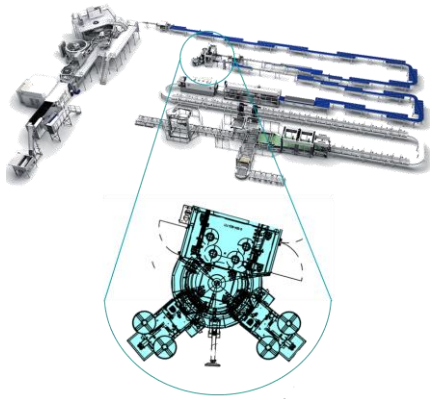


CBPM (Condition Based Predictive Maintenance)

- **Monitors** in real-time the equipment's performance against critical parameters
- **Machine learning (AI)** algorithms determine behavior of the equipment under different external & internal conditions; learns optimal running parameters.
- **Automatically alerts** Operators and Maintenance when equipment runs outside desired targets to enable early intervention
- **Predicts failure** by recalculating failure times based on how the equipment is being run and its current condition.
- **Better scheduling** of Planned Maintenance based on actual equipment condition; extending Planned Maintenance periods

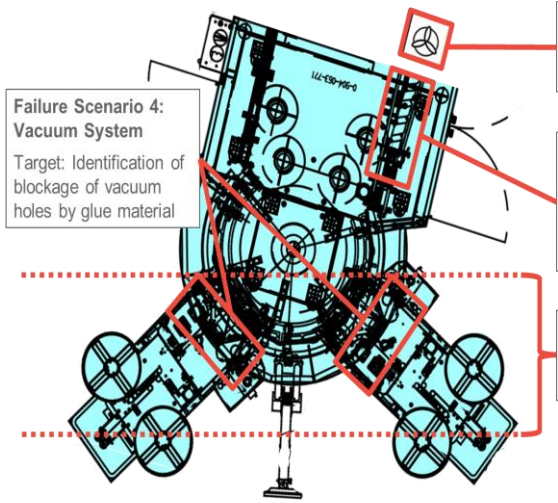
8 EY Smart Factory shop floor execution applications; *Condition Based Predictive Maintenance (CBPM) – Case Study*

CBPM



Case Study Example

1 We identified failure points on the equipment & reasons for failure



Failure Scenario 4: Vacuum System
Target: Identification of blockage of vacuum holes by glue material

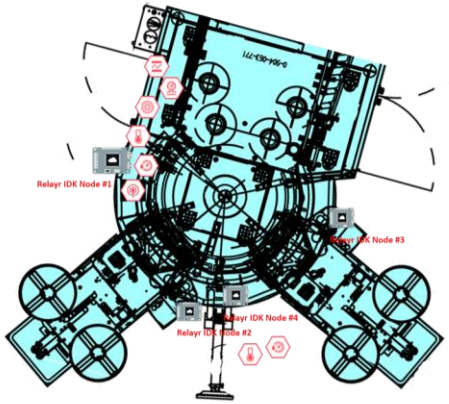
Failure Scenario 2: Hot Air System/Dryer
Target: Identification of closed dryer flap using additional sensors

Failure Scenario 1: Infeed Worm
Target: Identification of misalignments of the infedd worm, avoidance of vibrations and resulting quality problems, reduction of machine wear

Failure Scenario 3: Air Pressure System
Target: Identification of air pressure leakages, avoidance of energy waste

2 Based on likely failure reasons, we defined additional sensors to be added to the equipment

IDK and Sensor architecture of a labeling machine (28 additional sensors, 4 IDK nodes)



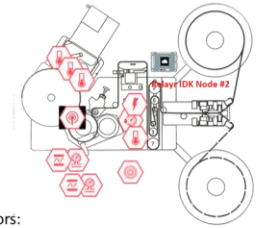
IDK #1 – Etima:
- vibration
- temperature
- humidity
- pressurized air flow
- pressurized air pressure
- noise

IDK #2 – Aggregate 1:
- vibration
- 3x glue nozzle temperature sensors ##1-3
- pressurized air flow
- pressurized air pressure
- noise

IDK #3 – Aggregate 2 (see above)

IDK #4 – Outside of Etima:
- ambient temperature
- ambient humidity
- 2x ESD, ambient temperature, humidity

Total: 28 sensors, 4 IDK nodes



Sensors:
- vibration
- ambient temperature
- ambient humidity
- glue nozzle temperature sensors ##1-3
- electrostatic discharge (ESD)
- pressurized air flow x2
- pressurized air pressure x2
- noise

Note: 3 sensors (ESD, ambient temperature, ambient humidity) are part of one reading head Keyence SK-050 and share the same communication unit connected to IDK #4 for both aggregate #1 and #2.

3
- We used EY's Condition Based, Predictive analytics application linked to these new sensors
- We added Augmented Reality to direct Operator intervention when required

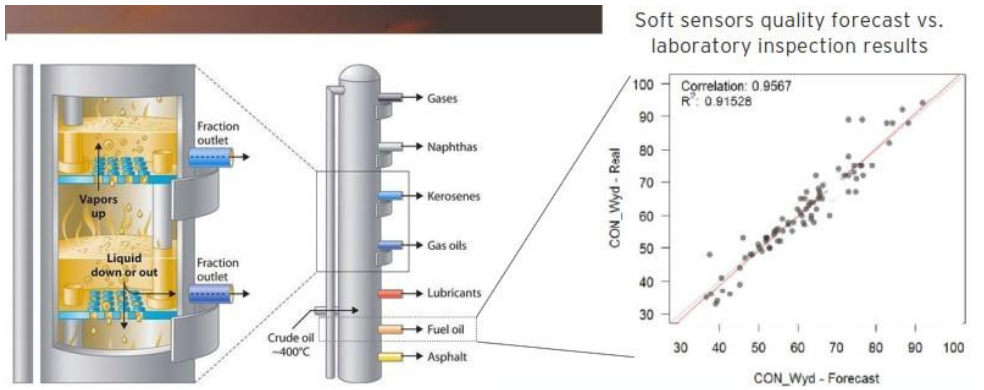
8 EY Smart Factory shop floor execution applications; *Intelligent Process Optimisation*

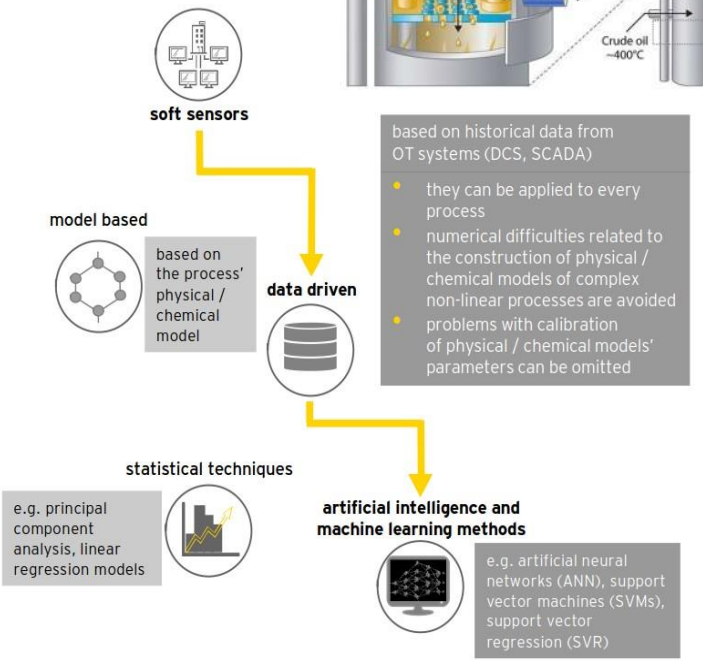
Intelligent Process Optimisation

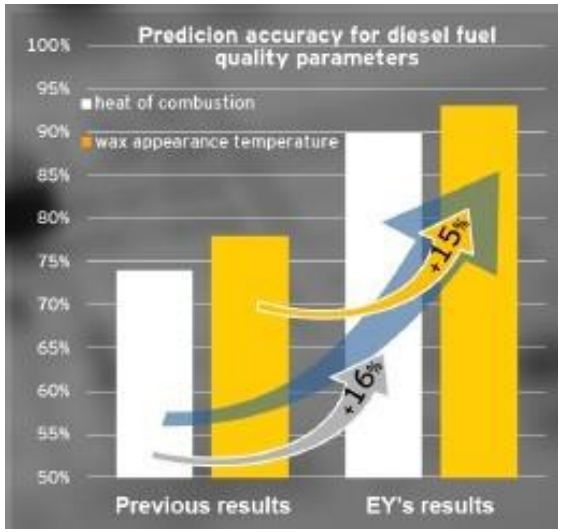
Objective — to improve yields in chemical processing in industries such as Food, Pharma, Home & Personal Care, and Chemicals

- Application uses historical data & machine learning (AI neural networks) to understand yield outcomes
- During production the application takes material data, hard sensor information, soft sensors, shift information, etc.
- Soft sensors are used where real sensors are missing and use simulation techniques
- Based on machine learning algorithms, the application predicts quality issues & corrective actions needed before processing completes
- Actions automatically executed during processing to improve yield

Example — Chemical Processing







9 EY Smart Factory shop floor execution applications; *Smart Maintenance (Digital Skill Augmentation using AR)*

Smart Maintenance (AR)

- **Operators use tablets / glasses to automatically identify the equipment & get the relevant technical info**
- **A combination of augmented reality and sensors on the equipment enable the Operator to visualise the breakdown of the equipment and refer to standards to understand equipment issues**
- **It also helps eliminate errors in workflows such as CILs, Centrelines, Maintenance tasks, etc.**

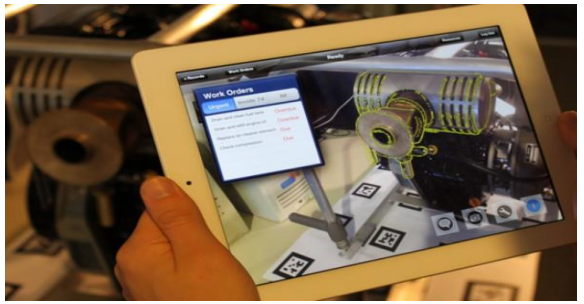
Virtual Manuals for service and repair functions

- Work instructions for service or maintenance virtually available on the wearable device
- Paperless, secure process enabling higher efficiency

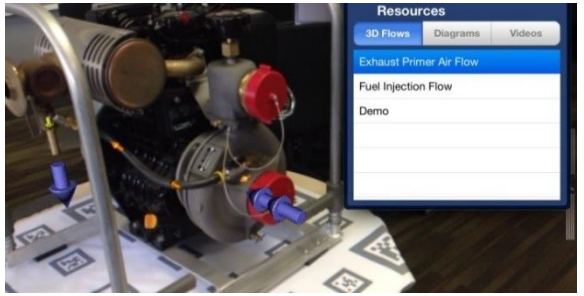
Visualization of asset conditions

- Deviations from target machine parameters are visualized on a tablet, smartphone, smartglasses or smartwatches
- Rapid identification of assets to be targeted to maintenance activity

Maintenance & Remote Service

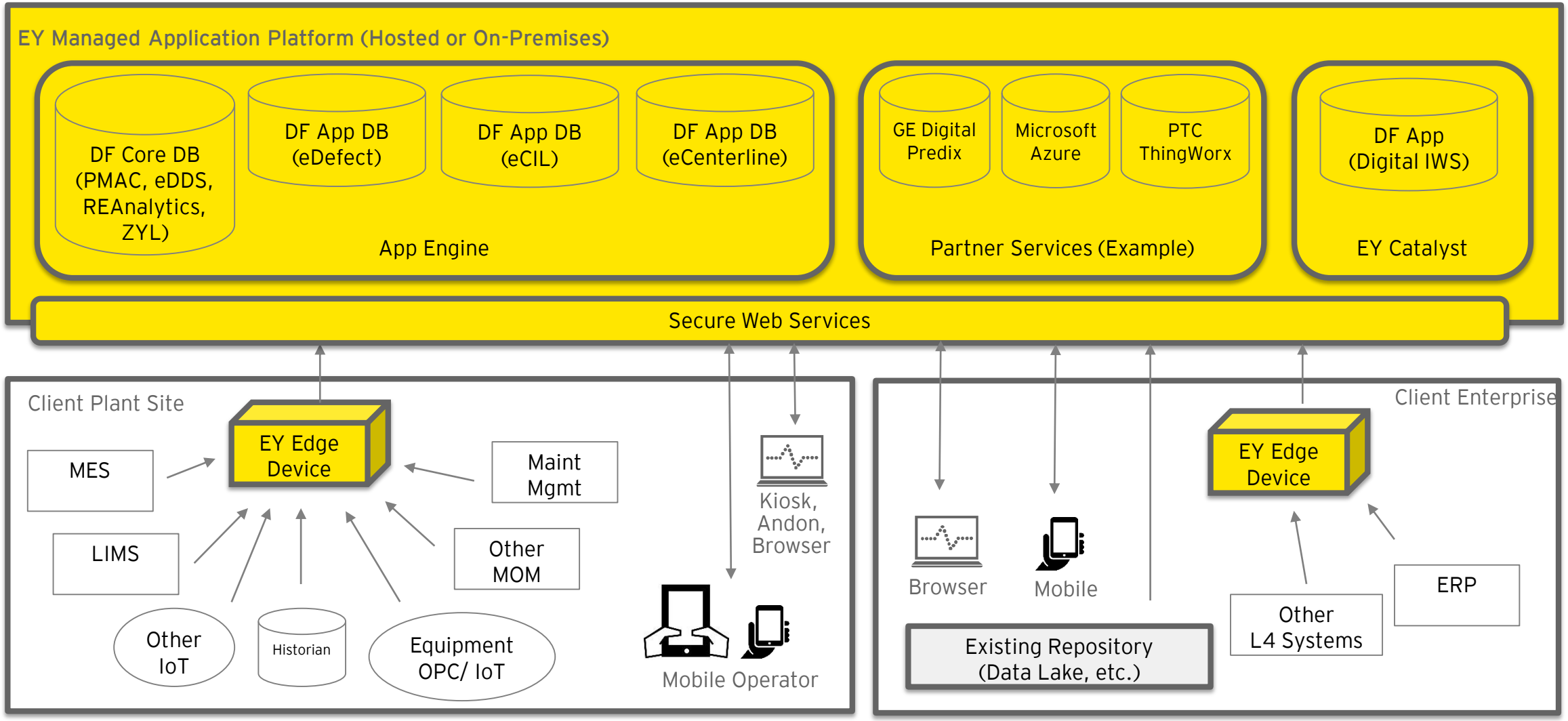


- Real-time capturing of maintenance order information
- Maintenance work is immediately registered after completion and confirmation by technician



- Spare part ordering
- Spare parts can be directly ordered locally at the machine by looking at the defective part

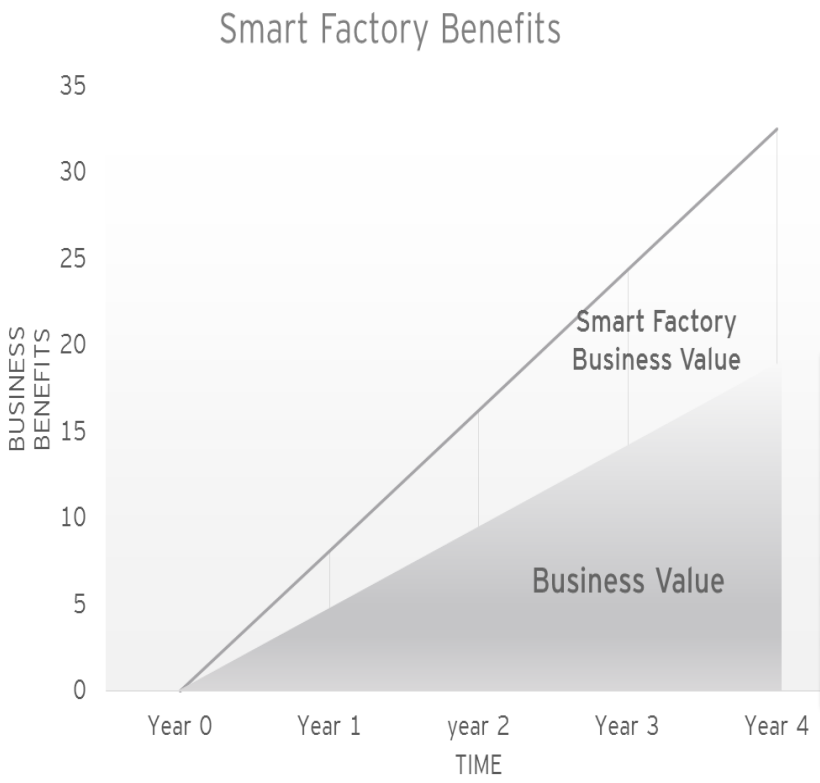
EY Smart Factory technical architecture



Case for Change and Implementation Considerations

Building a better working world

Integrating EY Smart Factory applications with manufacturing excellence capabilities can unlock significant additional benefits



Smart Factory - Example OGSM

- Additional cost competitiveness
- Accelerate and enhance results by optimizing IT enablement of Cell Teams, Pillars and Leadership
- Enhanced decision making to become more flexible and pro-actively avoid costs
- Become a great place to work

Example CBN

- +15% OEE Over Baseline
- Employee Engagement 75th percentile
- 40 MM conversion cost reduction
- +/-10% volume flexibility
- 5% year on year Capex Reduction
- 10%-20% Indirect Cost Savings
- TIR < 0.5

Smart Factory immediately addresses five operational performance challenges	Potential gains (≈>10% of cost price)
1. Improved monitoring and control of the industrial process	5 to 10 OEE points 30% reduction in NQ 10% reduction cost in energy
2. Manufacturing desensitization of mass production	Depending on applications
3. Enhanced maintenance performance	15 to 20% cost reduction
4. Improved planning to facilitate saturation and stability	1 to 3 OEE points 10% reduction in material losses
5. Reduced logistics costs	15 to 20% cost reduction

Opportunity	Technology	Waste	**Savings range
Labour cost	eDDS, eCIL, eDefect & eCenterline (Automation of knowledge work)	Document updates, Errors & Versioning, Meeting time	½ - 1 hr per shift per equipment owner
Yield Optimization	Analytics, Neural Network based AI on specific processes such as Calendaring	Tire rework	5% - 20% of current level
Maintenance cost (Labour & Parts)	Condition Based Maintenance	Breakdowns	10% - 25% reduction in breakdowns per week from baseline number
Energy	Manufacturing Energy Management Solution - MEMS	Process variable deviations, water conservation,	5% - 15% cost reduction

** These are savings estimates based on what has been seen at other manufacturers

In activating the Smart Factory agenda, there are 3 key areas of challenge to be considered

How to effectively adopt new disruptive technology alongside legacy systems complexity without excessive costs and disruption?

With increased levels of external connectivity across products and equipment, how to protect old Operational Technology against cyber threats?

With increasing "digitisation and "automation," how will the organisation, talent and skills need to evolve?

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