Best practices with MES in a new Industry 4.0 smart factory

Qi Kirsten
2 Mar 2017

BEAR
Back-End Automation Roadmap

FACTORY INTEGRATION

Infineon

Agenda

1. Introduction of Infineon
2. Semiconductor – an ERA and complicated manufacturing
3. Answer to all MFG performance issue – MFG theory
4. How does semiconductor manage the complexity
5. MES based Smart Manufacturing Implementation
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FACTORY INTEGRATION

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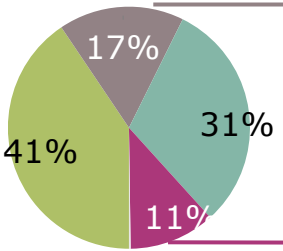
Back-End Automation Roadmap

Infineon at a glance

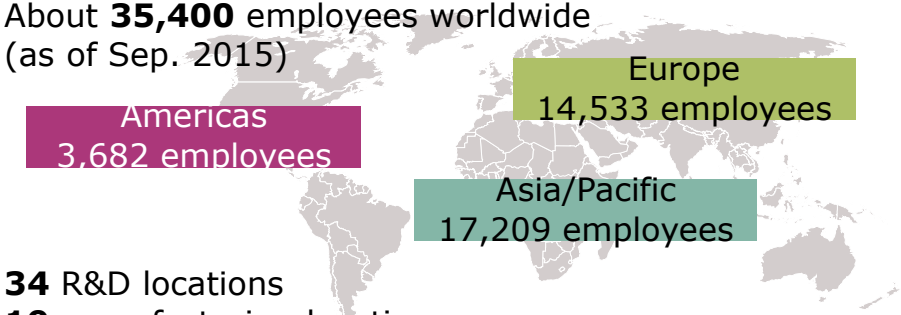
Business Segments



Revenue FY 2015

Employees

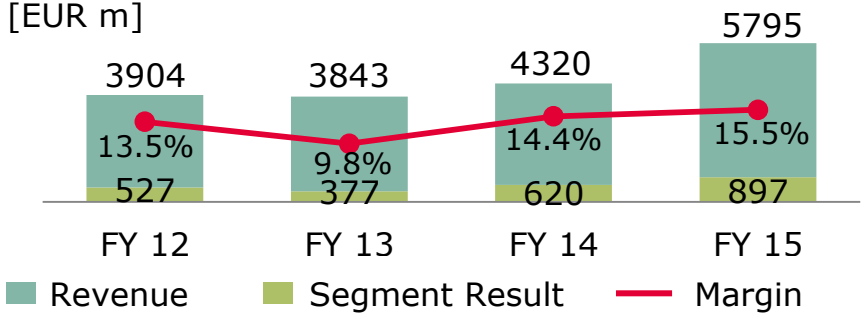
About **35,400** employees worldwide (as of Sep. 2015)



34 R&D locations
19 manufacturing locations

Financials

[EUR m]

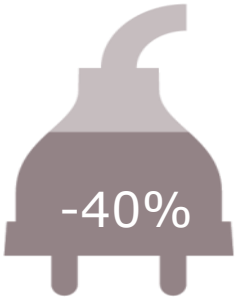


Market Position*

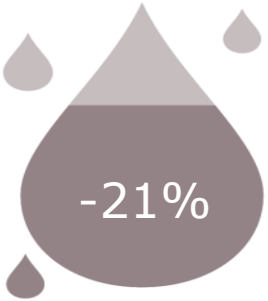
Automotive	Power	Smart card ICs
		
# 2	**# 1**	**# 2**
Strategy Analytics, April 2016	IHS Markit, July 2016	IHS Markit, July 2016

Corporate Social Responsibility
We are excellent in Resources Efficiency

At Infineon, less is more



About **40% less** electricity consumed per square centimeter produced wafer than the global average



About **21% less** water consumed per square centimeter produced wafer than the global average

About **50% less** waste generated per square centimeter produced wafer than the global average

We use resources much more efficient in our production processes than the global average of the semiconductor industry.

Basis for the calculations are the square centimeters processed wafer area in the front-end production and consumptions according to WSC definition.

The information and data given in this document apply to the Infineon Technologies group, except for International Rectifier companies.

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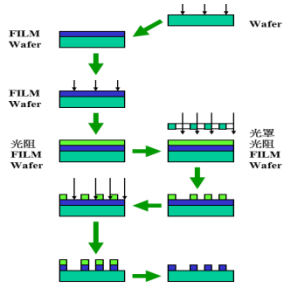
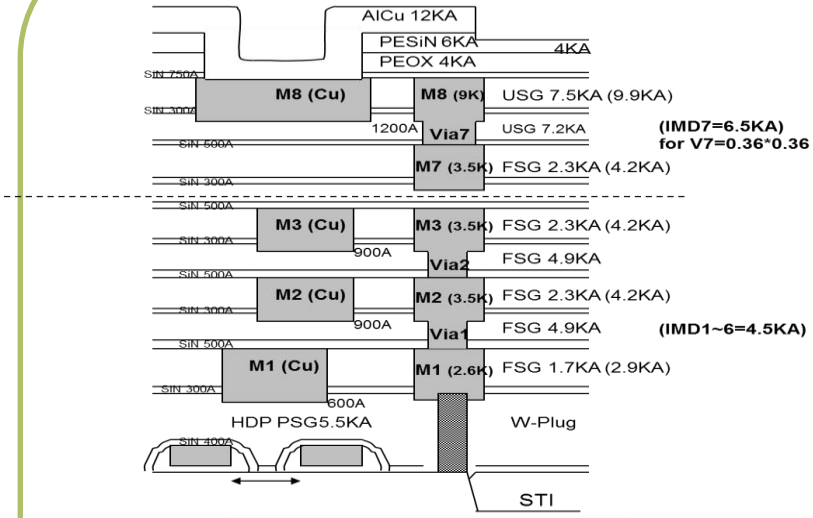
Wafer Fabrication Process

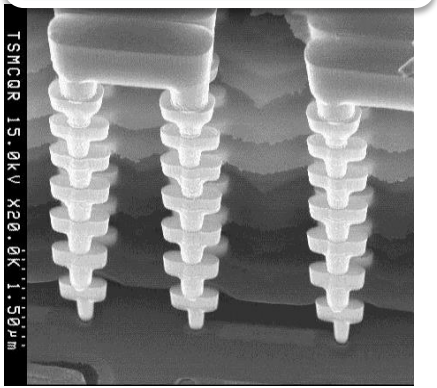


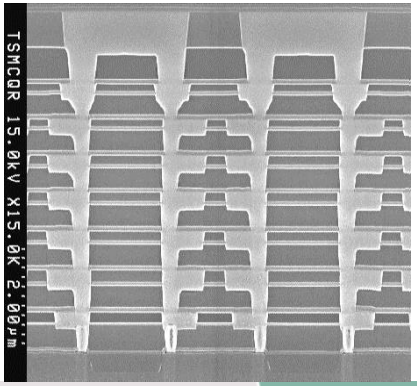
One layer



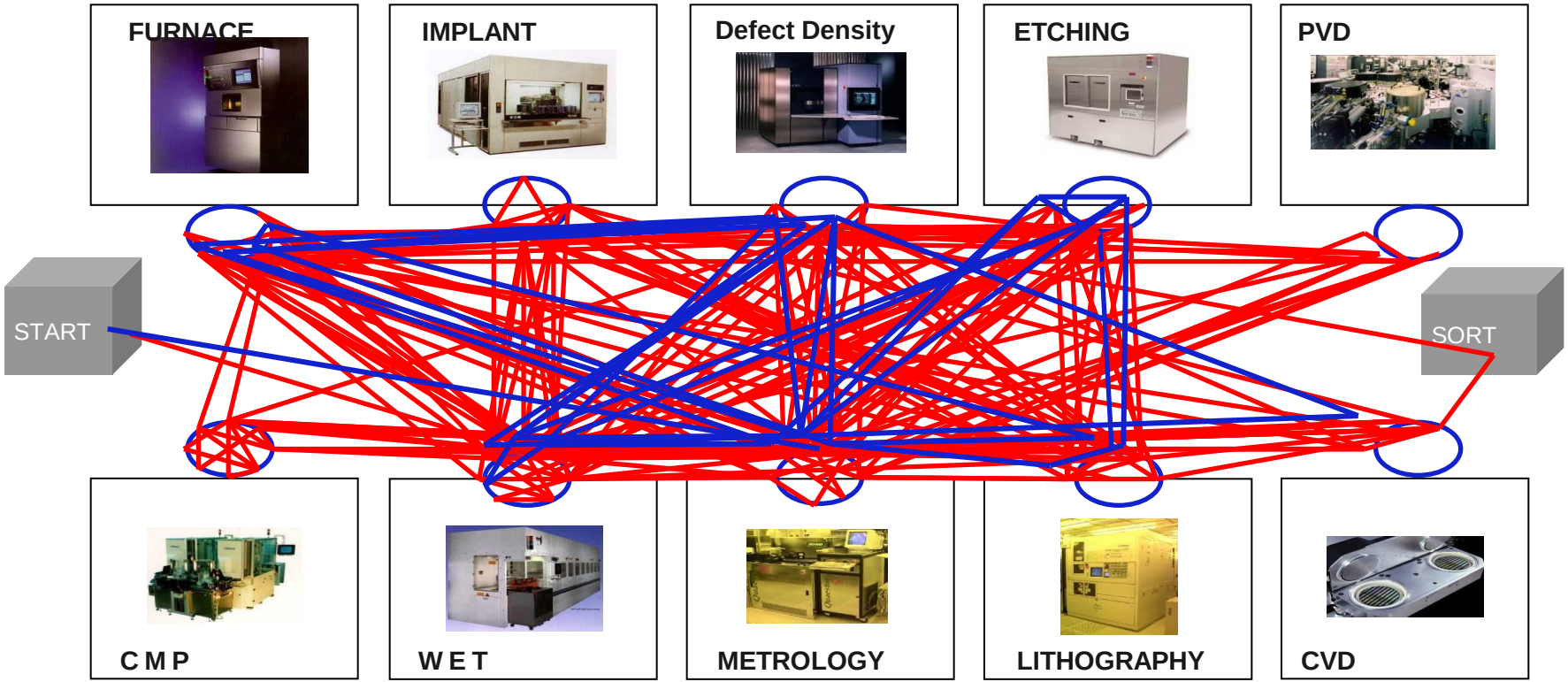
Overall Layers

Overall Layers



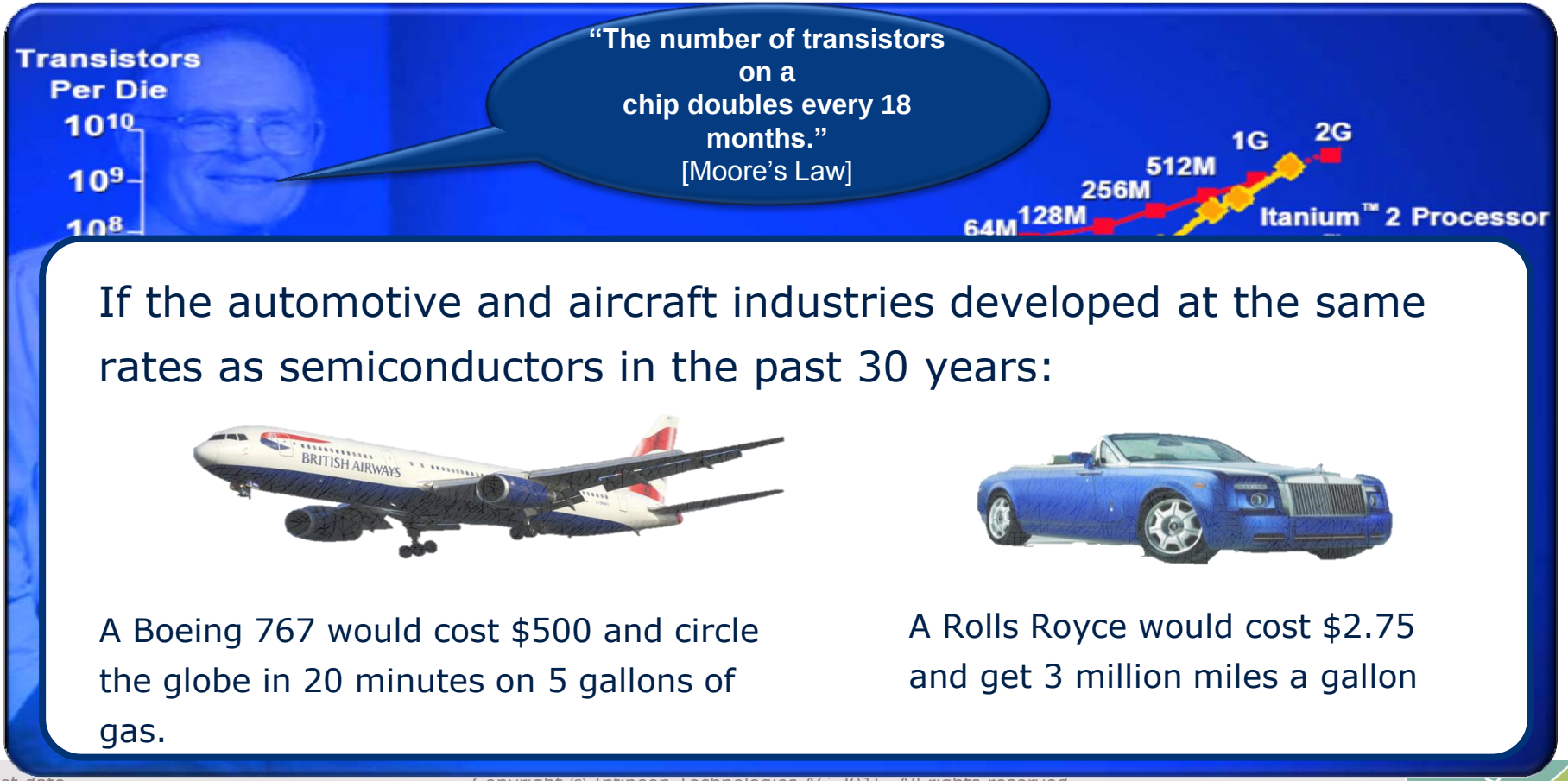


Complicated route for one wafer ..



Manufacturing steps & path of a lot throug a single FrontEnd Factory!

Enormous development of semiconductors – costs per function decline 30% each year



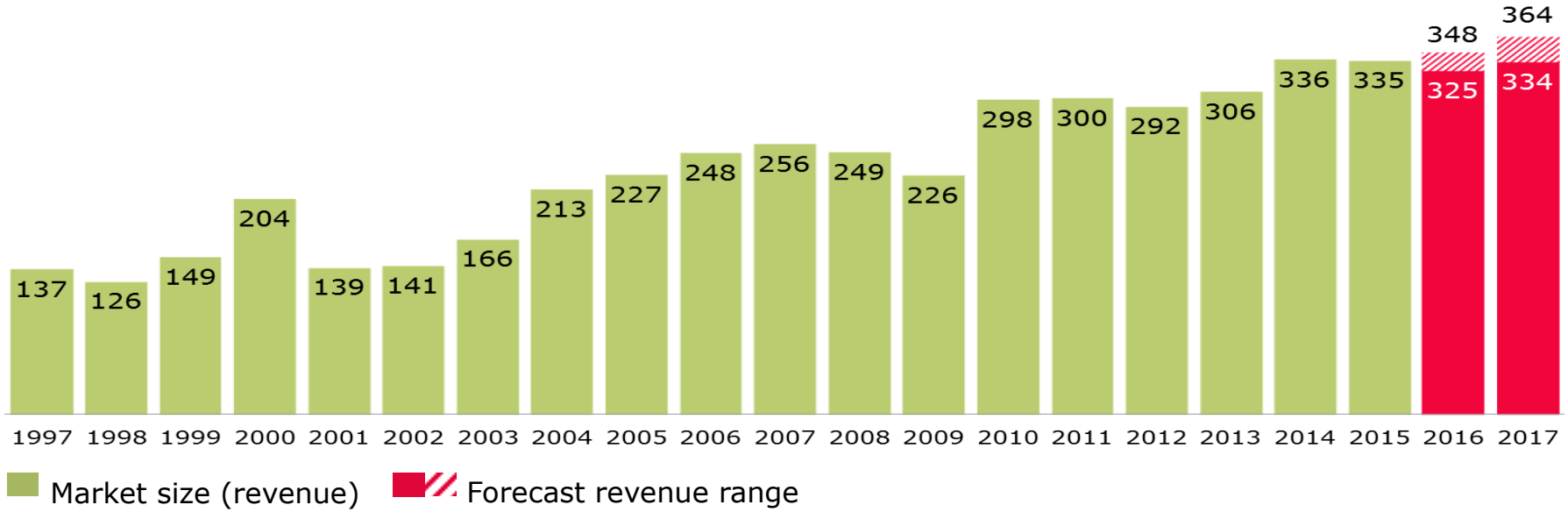
If the automotive and aircraft industries developed at the same rates as semiconductors in the past 30 years:

A Boeing 767 would cost $500 and circle the globe in 20 minutes on 5 gallons of gas.

A Rolls Royce would cost $2.75 and get 3 million miles a gallon

The outlook for the global semiconductor market is cautious

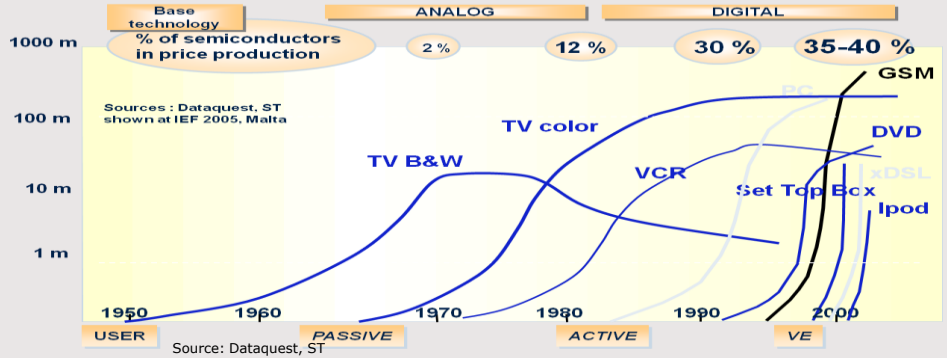
Global semiconductor market
in billion $



Source: WSTS for historical data. Forecast: ∅ of WSTS, IHS, Gartner, IC Insights; last update 28 April 2016

Semiconductor Industry is challenged by steep Ramps, short Product Life Cycles and long Cycle Times

Fast changing demands vs. fixed boundaries



Source: Dataquest, ST shown at IEF 2005, Malta

- **Steep Product Ramps**
- **Short Lifecycle**

- **Long Cycle Time**
- **Early in Value Chain**

Performance Gap Caused by Complexity

- Total 600-900 steps to complete a wafer fabrication process. (average one wafer stay in factory for 45-60 days , and there are 120K wafers in one FAB ..), to make a good MFG performance, need to :
  - Right time for best CT / OEE / CLIP
  - Right machine for best CT / OEE / CLIP / Quality
  - Right recipes for best Quality / Yield / OEE
  - Right lots for best CT / OEE / CLIP

- Without MES in Smart Manufacturing
  - Every step is based on paper traveler and human availability
- 40% CT gap + 20% OEE Gap + 8-15% yield difference + 6% CLIP difference

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Back-End Automation Roadmap

Basic Manufacturing Physics (speed of control – deviation)

MFG performance depend on how fast to control deviation
(queuing theory)

$$Queue\ WIP = \frac{\rho^{\sqrt{2(m+1)}}\left(C_s^2 + C_a^2\right)}{2(1-\rho)}$$

$$and \quad C_s^2 = \frac{[C_d^2 - (1-\rho^2)(C_a^2 - 1) - 1]\sqrt{m}}{\rho^2} + 1$$

due that C_s data is not available in MES

where

ρ = Utilization of the tool group

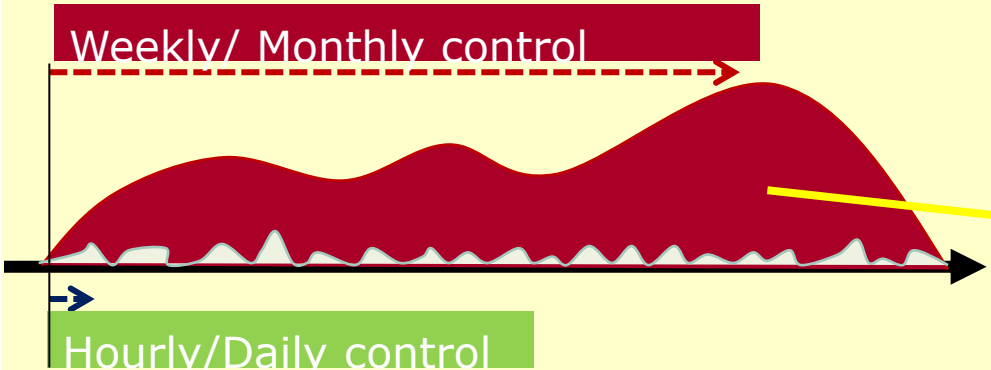
m = Tool number of the tool group

C_s = CV (Dev / Mean) of effective service time

(Lot Run time + Lot Wait time for an idle or unavailable tool)

C_a = CV of inter-arrival (move_in) time

C_d = CV of inter-departure (move_out) time

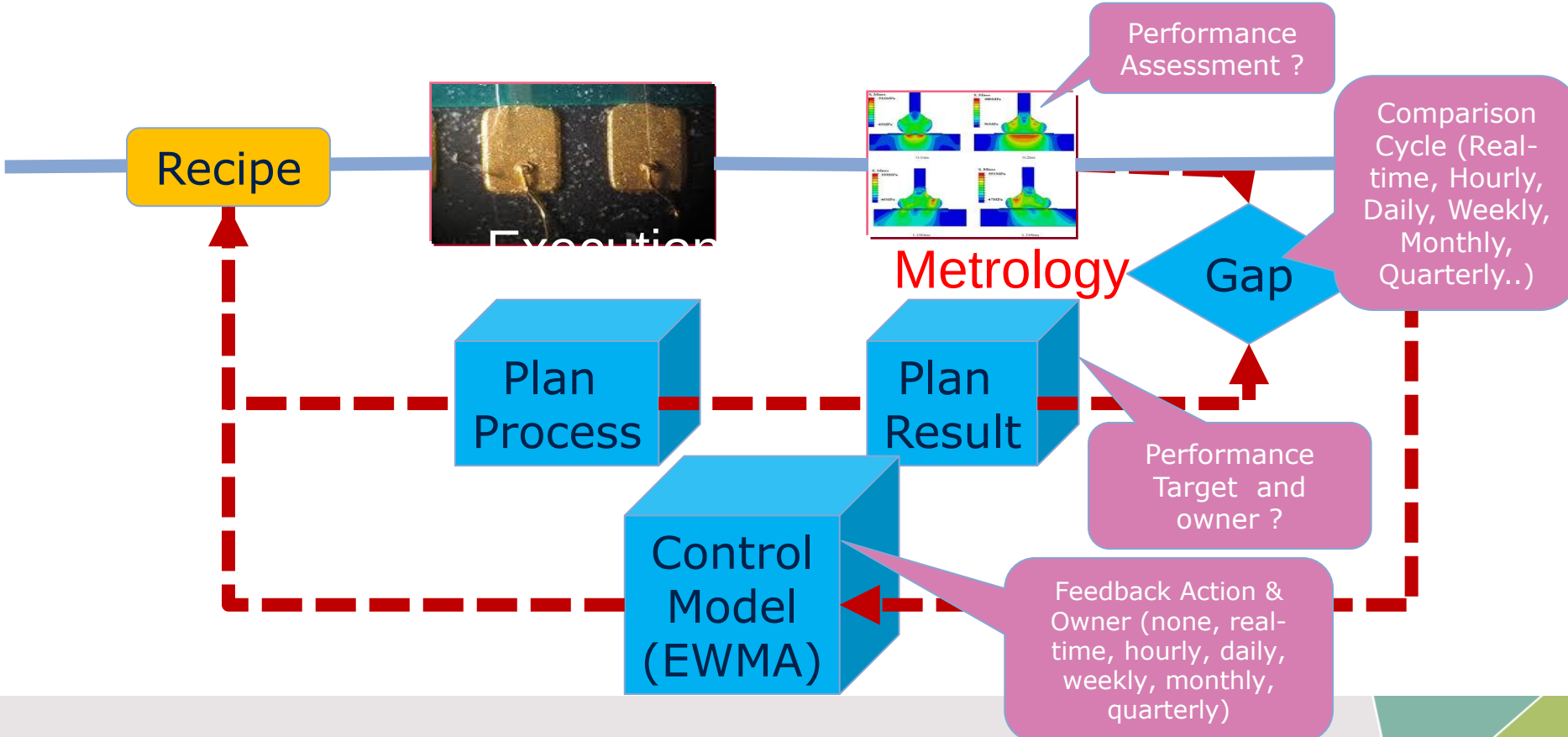


Cost competency

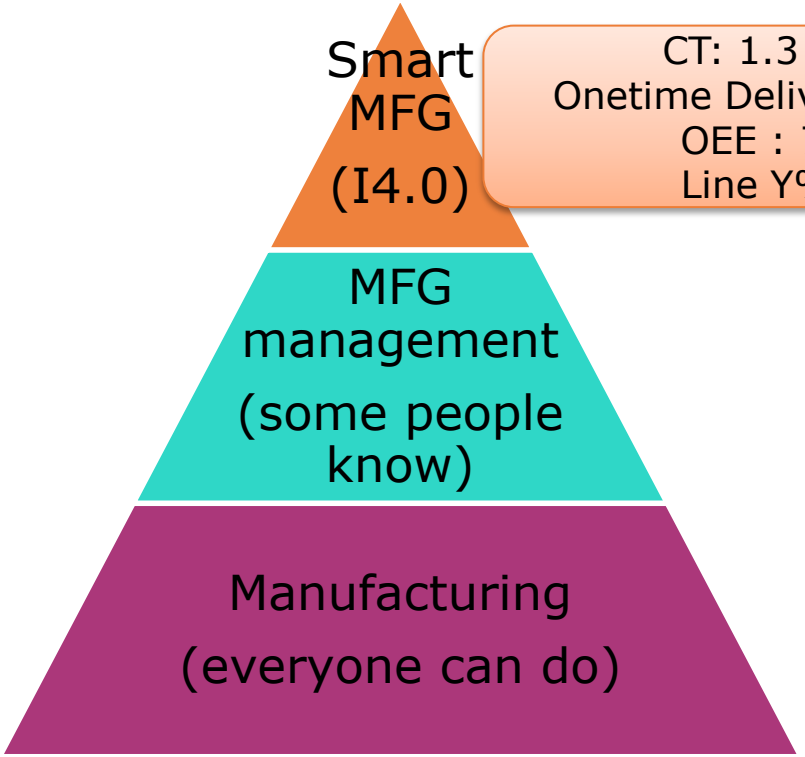
- CLIP performance gap
- Hold Lot performance gap (CT)
- Productivity performance gap (OEE)
- Quality control (SPC-Cpk)

Control Theory (1960)

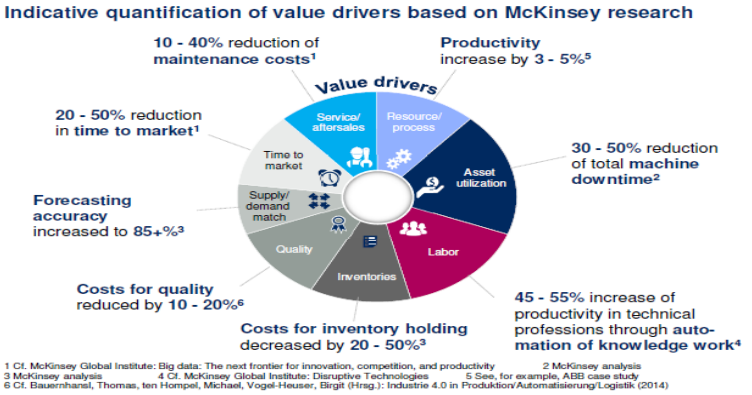
› Control theory have been widely applied in semiconductor industry for cycle time, CLIP, productivity, Quality .



Manufacturing Competency
- Smart Manufacturing improve MFG performance



CT: 1.3 D/L (FE)
Onetime Delivery (d): 99%,
OEE : 78-85%
Line Y%: 99%



Courtesy of Mckinsey

10%-20% cost gap
Faster time to market

CT: 1.8 D/L (FE)
Online delivery (w) : 90%,
OEE : 60-75%
Line Y%: 95%

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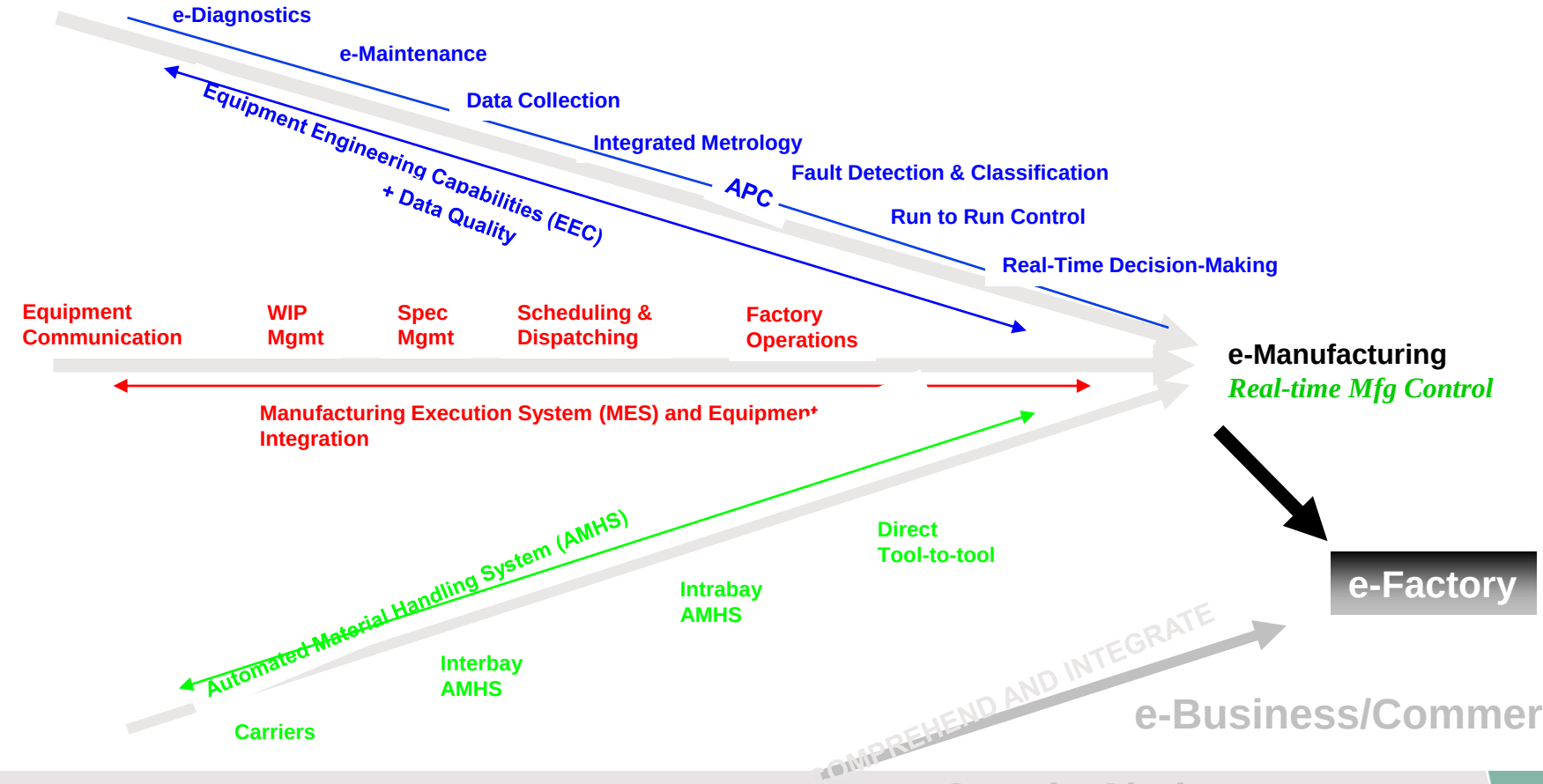
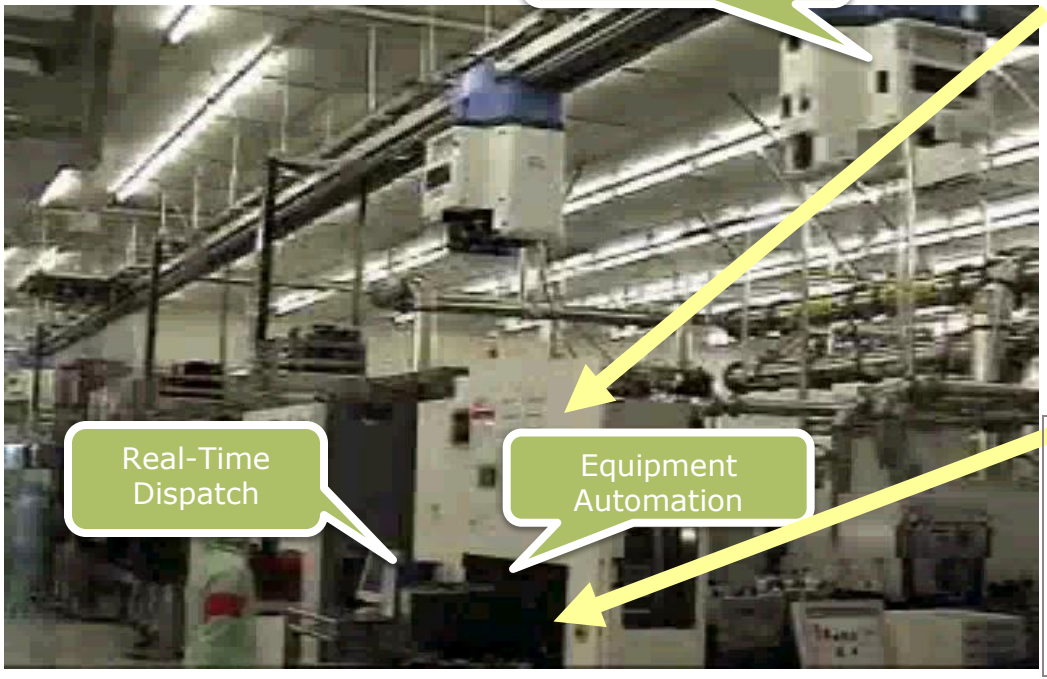
Industry Path to e-Manufacturing



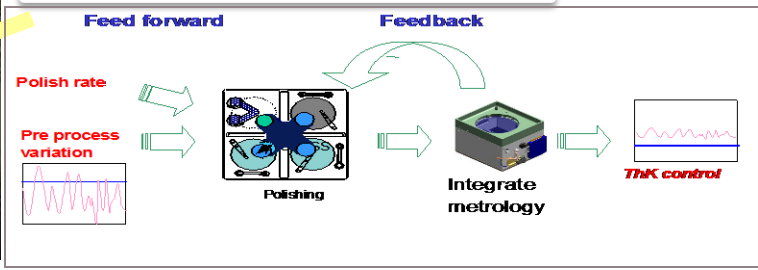
Source : ISMT – TSMC 2003 roadshow

Full-Auto in 300mm Semiconductor Industry



Advanced Equipment Control

Advanced Process Control

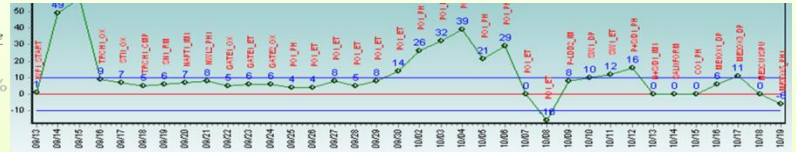


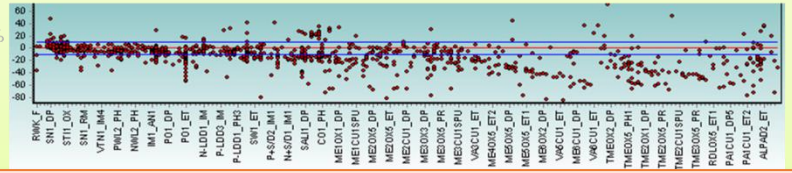
ITRS Matrices :

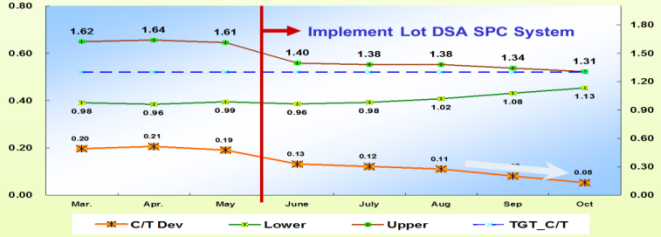
Reduced Cycle Time (0.33 for HSR)
Improve Equipment Utilization (90%)
Reduce Losses from High Mix
Ramp up time (4 month)

NPW reduction (<16%)
Improvement Throughput (5000/w 193 scanner wafer out)
Reduce Average delivery time (8 min)

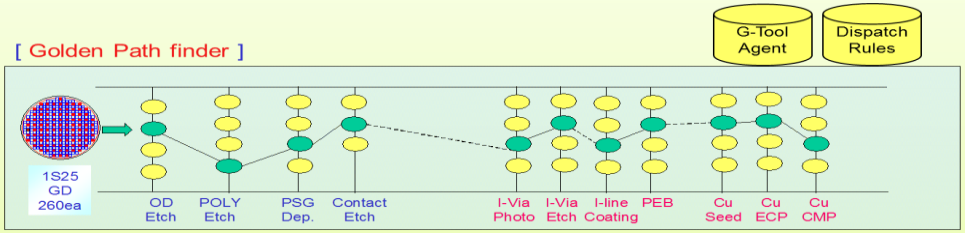
Full-Auto (Smart MFG) enable advanced MFG management – this is called Smart Manufacturing

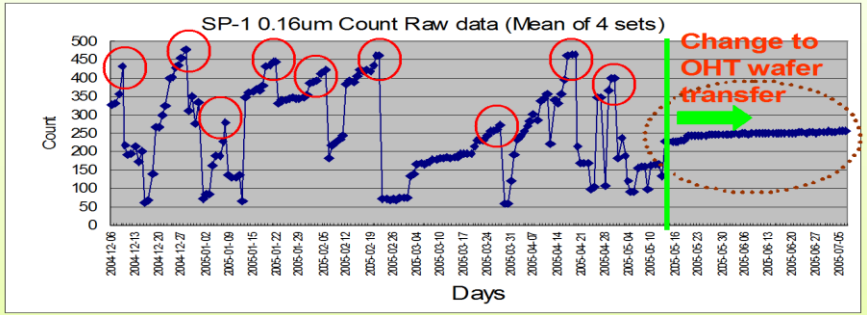






Real-time SPC control integration into dispatching for CT deviation control





Defect SPC data integration into dispatching for yield improvement

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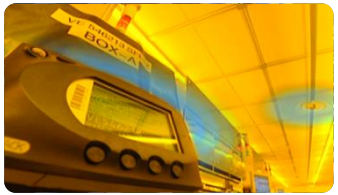
Back-End Automation Roadmap

Infineon has already implemented various Industry4.0 elements in our factories

Manufacturing Information in Real time



Paperless Manufacturing

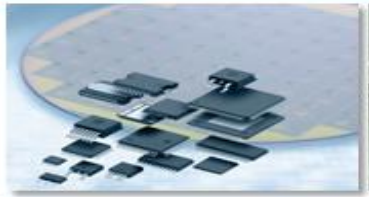
Material Clearly Identified and Tracked

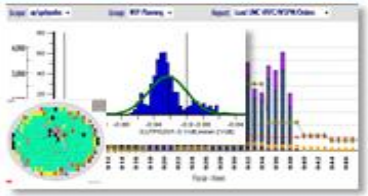
Collaborative Human-Machine Interaction

German chancellor Dr. Angela Merkel visiting the Infineon Dresden factory, hosted by Infineon CEO Dr. Ploss

BEAR: Advancing Quality @ BE

BE Manufacturing Excellence





Paperless Manufacturing

- Elimination of manual data handling
- Automated Data Acquisition
- Automated validation of material & tool set-up

Traceability

- Chip and Module
- Material and tools
- Closed-loop Industrial Engineering Analysis Capabilities

Line Control & Capacity Mgt

- Improved OEE & IE Capabilities
- Scheduling & Dispatching Capabilities

Engineering Data Analysis

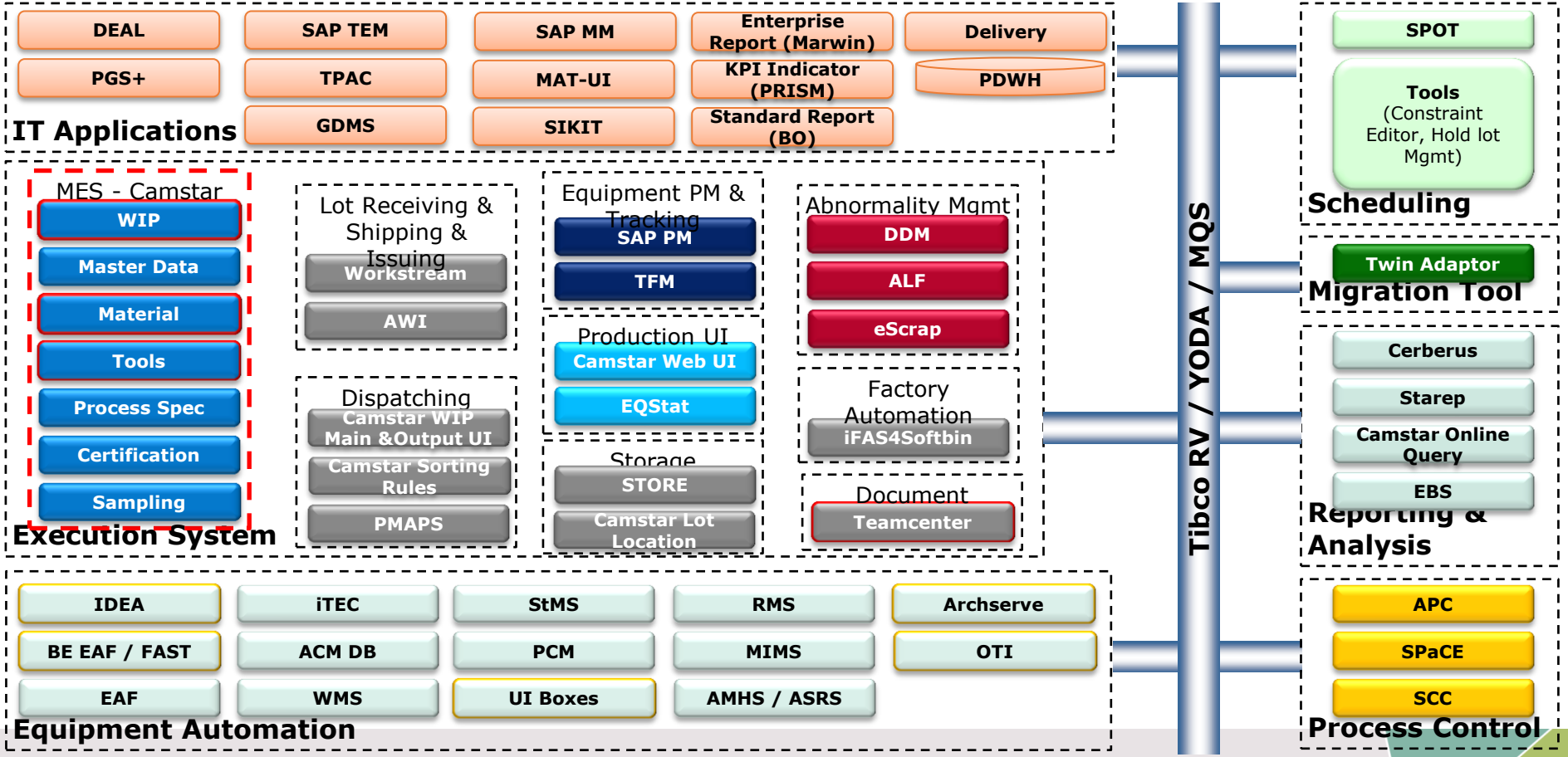
- Advanced Process Control Capabilities
- Life span management of sockets, tools & fixtures

Seamless Product & Material Identification and Tracking

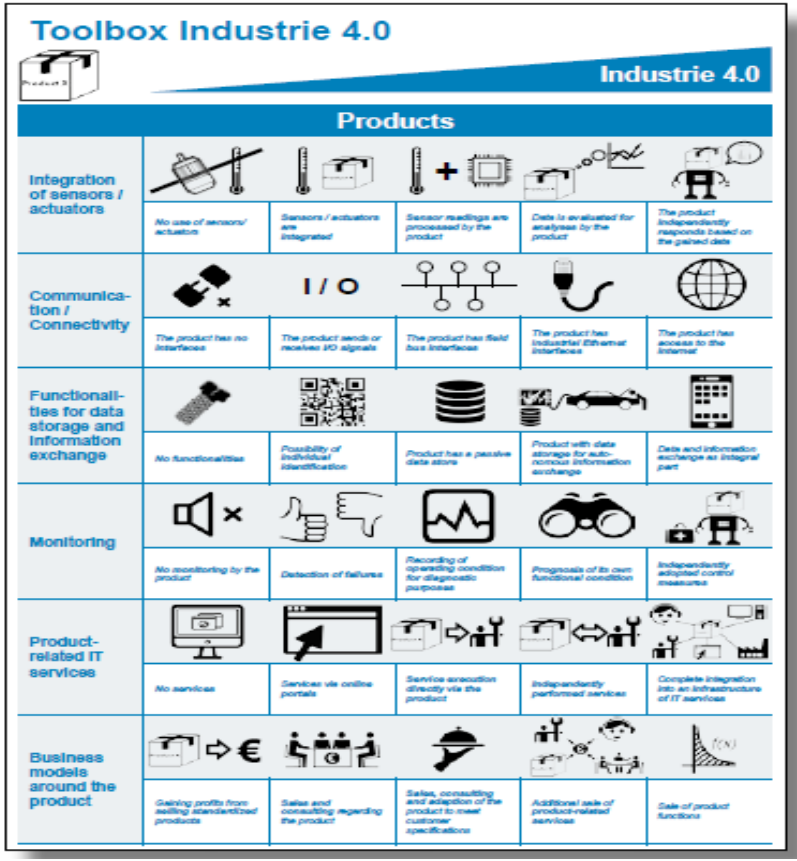
Paperless / electronic Equipment & Key Process Data Acquisition

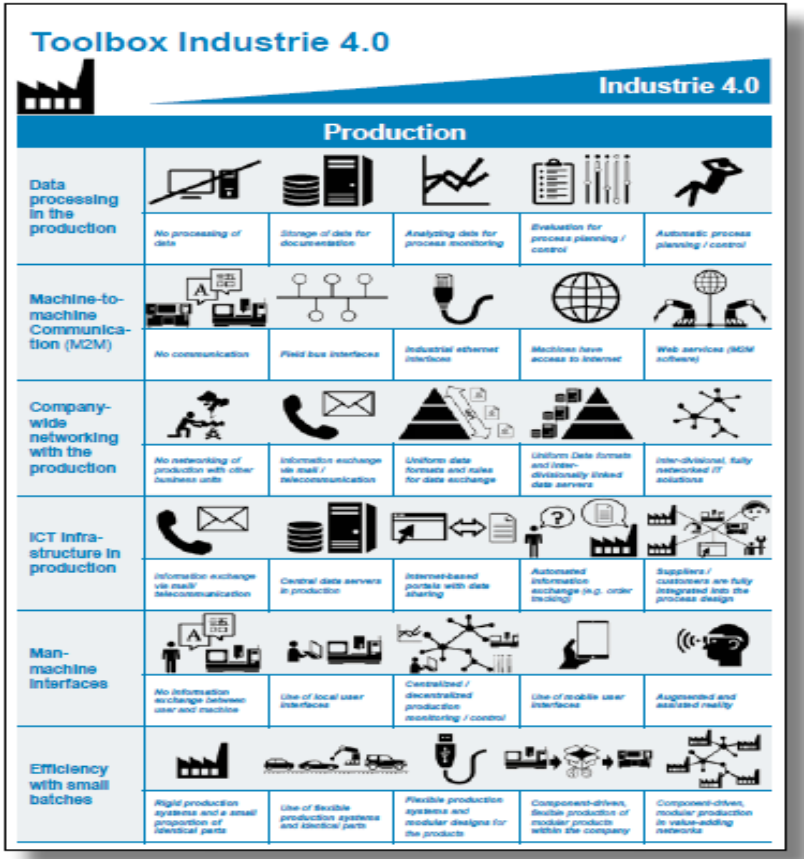
BE FI Application Landscape

- Camstar and it's integrated applications

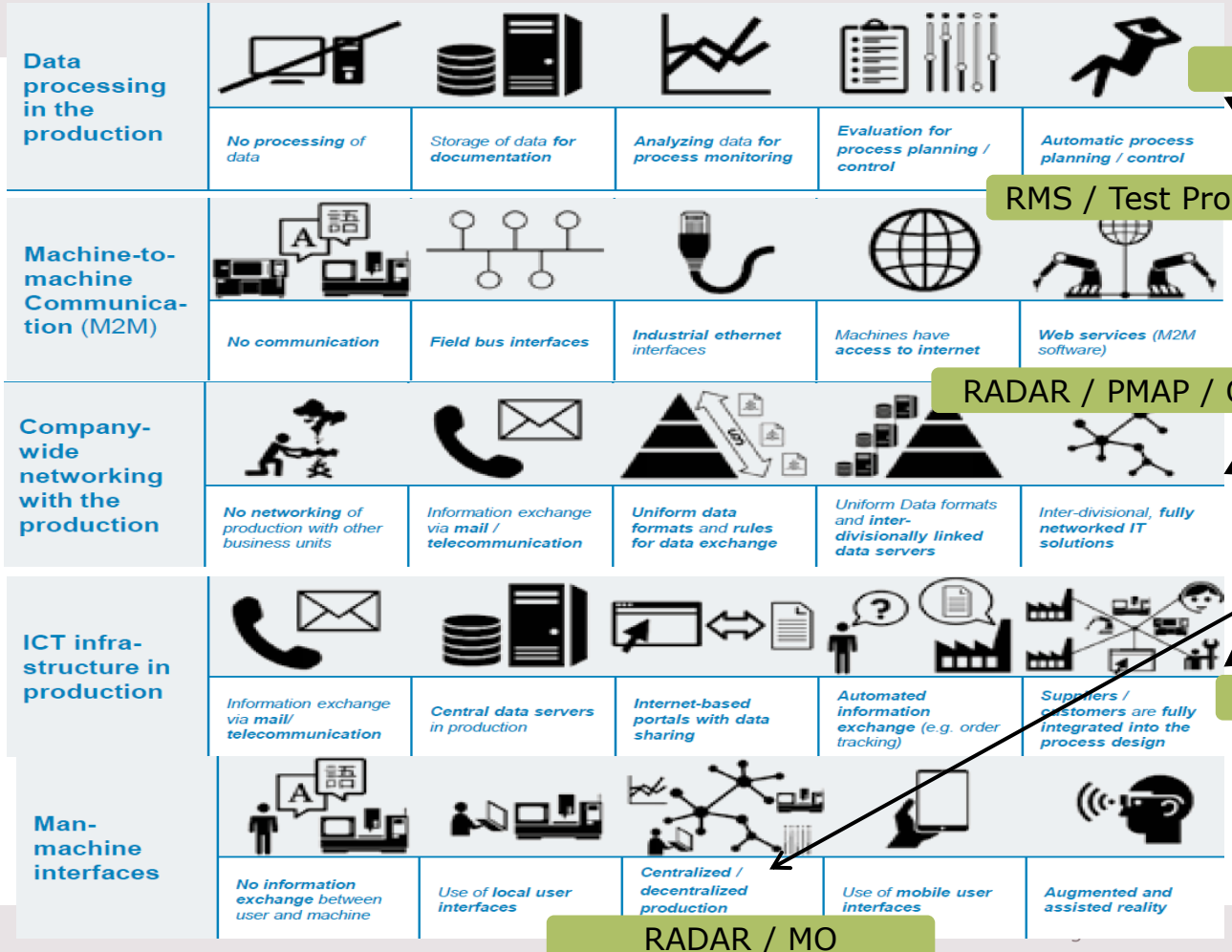


Industry 4.0 –VDMA, German Engineering Federation – Assessment of I4.0 readiness





Basic Assessment of BEAR with VDMA



SPC/APC

RMS / Test Program

RADAR / PMAP / OEE

Master DB / Due Date

RADAR / MO

BEAR
Back-End Automation Roadmap

We are in I4.0. Are we smart ?

Smart Factory (enabled with BEAR toward I4.0)

Today Factory (industry 3.0)

Mainly human decision without information or limited information (dispatching, scheduling …), also could not see the decision quality.

- 300-500 human decision (dispatching/ material validation/ lot searching/ test summary check…) for all operation steps for one lot.
- 400-800 human-decision for devices level execution (strip location, device level traceability..)

Human Execution (move / load)

- Inconsistent Quality gating (product mix)
- Inconsistent Execution performance (dispatching)
- Huge communication effort by human

Smart Factory (industry 4.0)

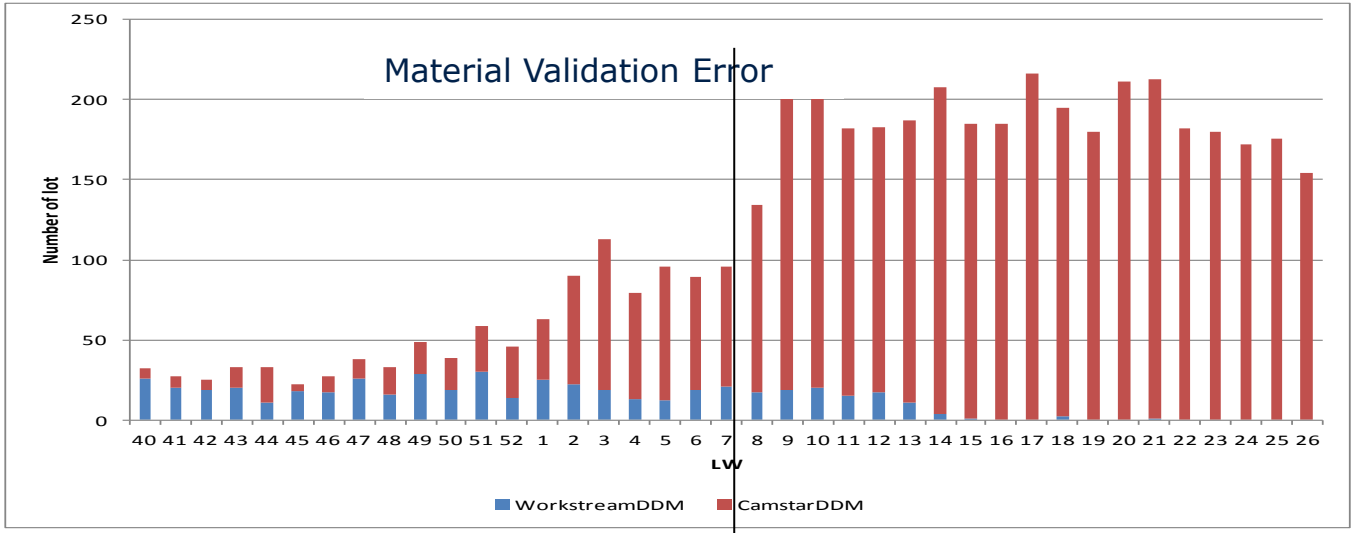
Create factory intelligence to replace human decision .

- Dispatching / Material validation / Material searching / deviation response / Strip validation / auto data collection.
- Image recognition automation.

Human Execution (move / load) -> AGV

- Consistent Quality (test summary check)
- Consistent Execution performance (dispatching compliance/ tracking error)
- Minimum human communication

Example: comprehensive real-time quality control For next level of Zero Defect (NLoZD)



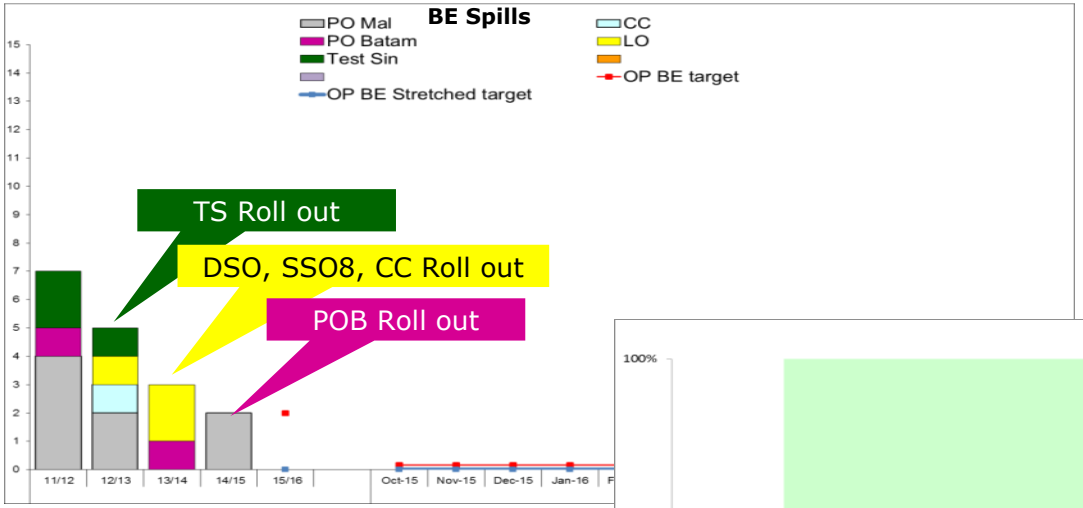
There is guidance for material validation, but never trigger error without automation.

100% material going through CAMSTAR material validation instead of human guidance

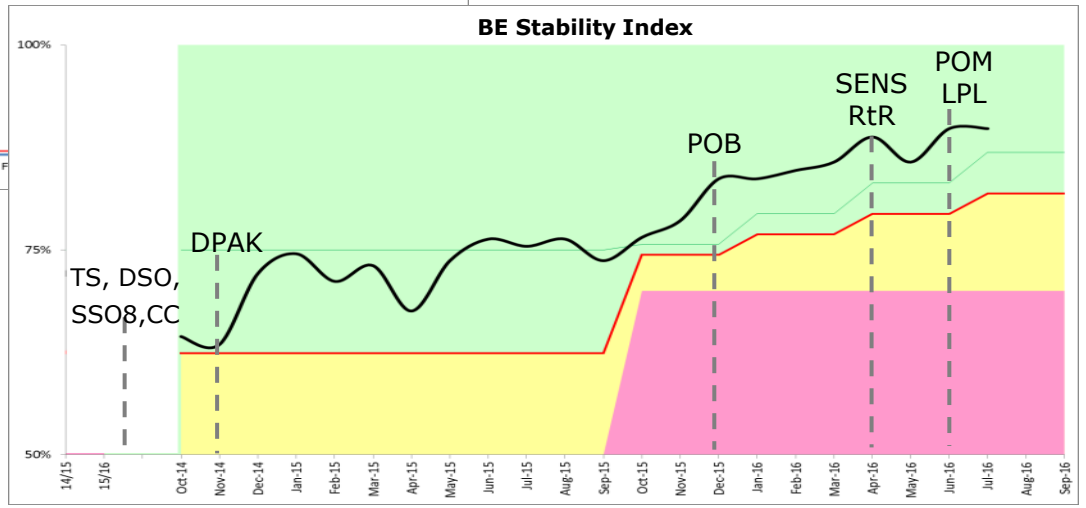
Back-End Automation Roadmap

BEAR – Camstar as an Enabler of Stable Manufacturing

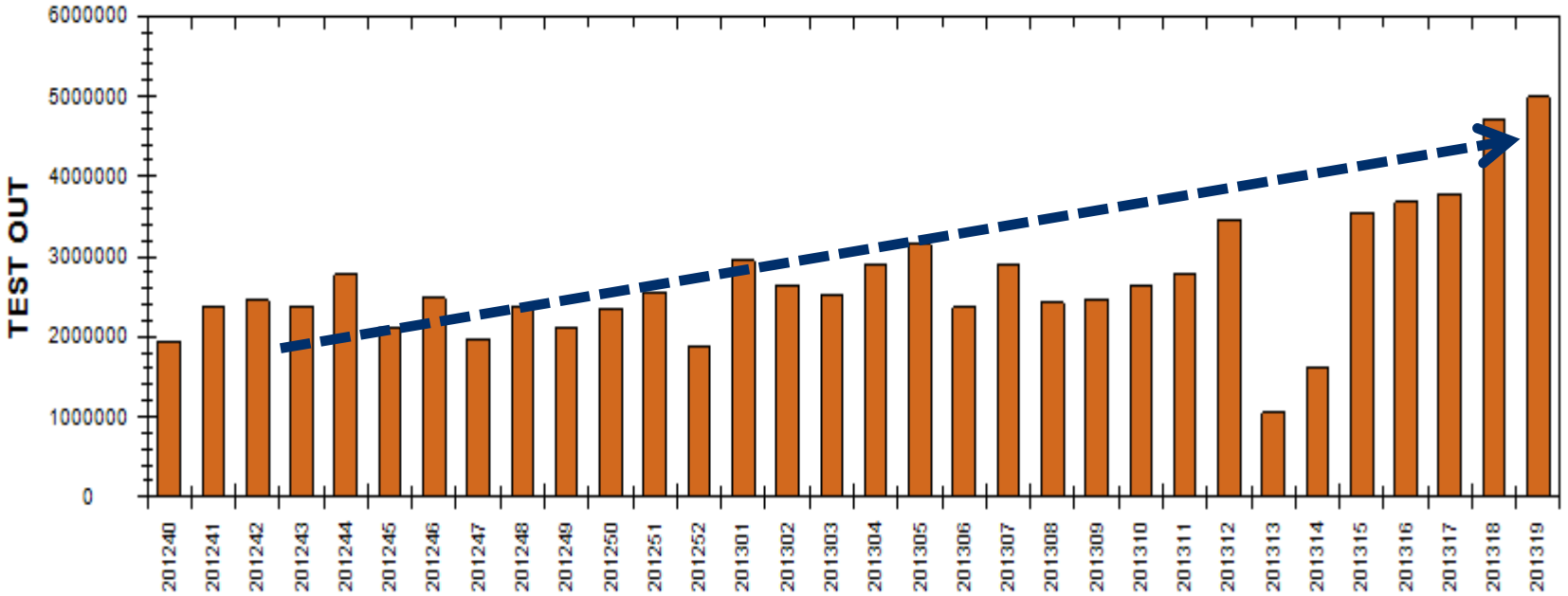
BE Spill



BE S.I



Example Chip Test: 25% Productivity gain through Automation enabled closed loop control



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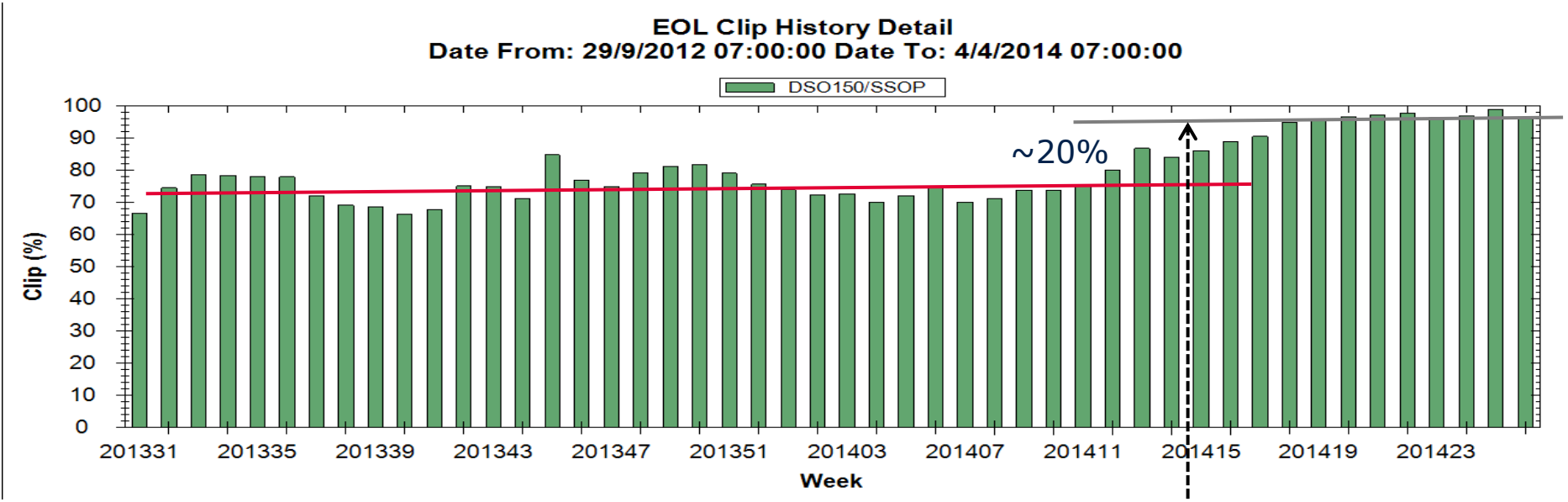
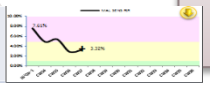
Example in On-time delivery: Improve CLIP to 98% through integrated, consistent demand/WIP dispatching

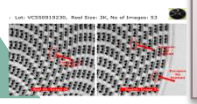


Completed 100% WIP migration into CAMSTAR

(I4.0) Automation Based Manufacturing
Full coverage of Automation – Function view

KPI	System	MFG Capability
› No human communication › **Fast response**	SCM integration	› End-to-end supply chain (Customer, RD , Time to market..)
› No human communication › **Fast response**	MFG intelligence (new MFG)	› Performance Deviation detection and response action assignment (Scheduling / dispatching / central alarm / mobile phone)
› No human decision › **Fast response** › **Good quality w/o human deviation**	MES (control all 4M to follow defined operation without human decision) BigData IoT	› Precise operation (do what defined) – MES / APC / SPC … with compliance check
› No human operation › **Good quality w/o human deviation**	Physical Operation Automation (auto inspection, recipe download, auto data collection..)	› Automation Operation with consistent operation performance



Human Decision in Manufacturing
- Are we smart manufacturing : operation view.

Continuous improvement control in unknown area (I4.0)
(OEE improvement, Yield Improvement, CT improvement, CLIP improvement, Cost improvement)

~1K/m

- Improving cost
- Improving quality
- CSR

Deviation Management
(DDM, ALF, Machine Alarm, Material Alarm, Man Alarm, SPC alarm..)

~100k/m

- Dispositioning
- Screenings

Standard Operation
(Lot selection, machine selection, PM planning, data collection, ..)

~4m/m

- Employee data updates
- System updating
- Reporting
- Legal procedures and filing

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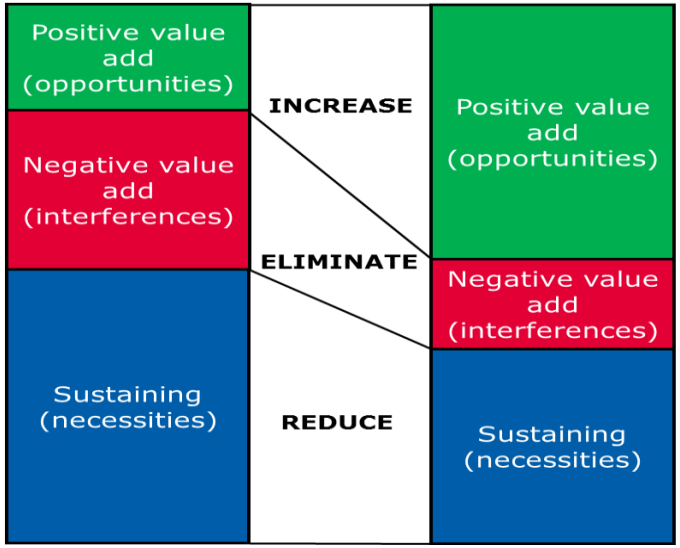
Back-End Automation Roadmap



Courtesy of Soo Hee

Early detection ??

Fast time to Market

Benefits
- Same or less human resources
- Job satisfaction
- Less materials cost
- Less capital cost
- Less risk of quality
- Faster time to market
- More people potential

Auto Inspection

Less quality issue (test summary check, RMS..)

Less data collection

Less human decision

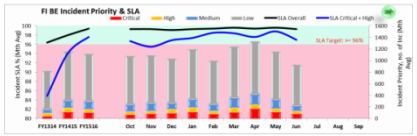
Standard Practice

Auto Inspection

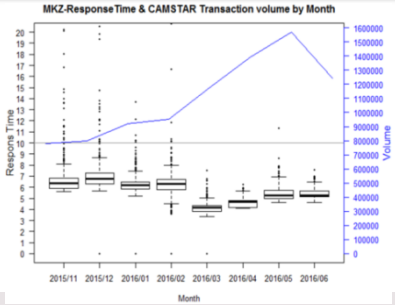
Success factor for a global MES implementation

- Project Management Setup (professional project manager)
- Clear end in mind (Smart Manufacturing but Automation)
- Competency in MES development (CAMSTAR, SPC, APC, EA, ..)
- Competency in MES Operation (production dependence)

Incident SLA with FaQ



MES Performance monitoring (E2E)



FI/BEAR have brought below new MFG & Benefit to OP BE, including MES/EA/SPC/DDM/Reporting..

	Traditional Operation		New Manufacturing		Performance Gap
Daily Production Planning	Manual data consolidation, Long discussion and inconsistent decision (PM, Setup..) without consistence and closed loop check.		Optimized scheduling/ Material star planning / Dispatching by automation as well compliance check and improvement.		OEE + People Productivity + 3-5m per year.
OP1 : Follow defined process	Manual validation of material/machine/recipe/map, Manual machine control for PM/Recipe/map (from paper/experience)		Auto material/machine validation. Auto recipe / test program /wafermap download.		OEE+, People Productivity+, Quality+. 4-5m / pa.
OP2 : material/machine data collection	Manual data collection of material / …chine / quality data		Auto data collection of material history, machine sensor, quality data which human co… never do it		Without FI, impossible for OEE / Quality rating (APC)
OP3 : Deviation monitoring / recovery	Manually deviation monitoring / recovery for Material / Machine / Human		Auto deviation detection and recovery action assignment and monitoring (SPC/APC/CAMSTAR/DDM/RADAR)		OEE+, People … Quality+. 20-50m/
OP4 : Physical Operation	Human Visual Operation / Material transportation / PM activity / Recipe Tuning		Auto Inspection, Auto Recipe download, Auto Machine Tuning, Auto Transportation		OEE+, People Productivity+, Quality+. 4-5-30m / pa
OP5 : Offline Analysis	Long and ineffective analysis for performance issue (CLIP/ Quality / OEE) based on paper and human.		Standard analysis method based on consistent data collection / quality.		OEE+, People Productivity+, Quality+. 3-5m / pa.

Old MFG without automation

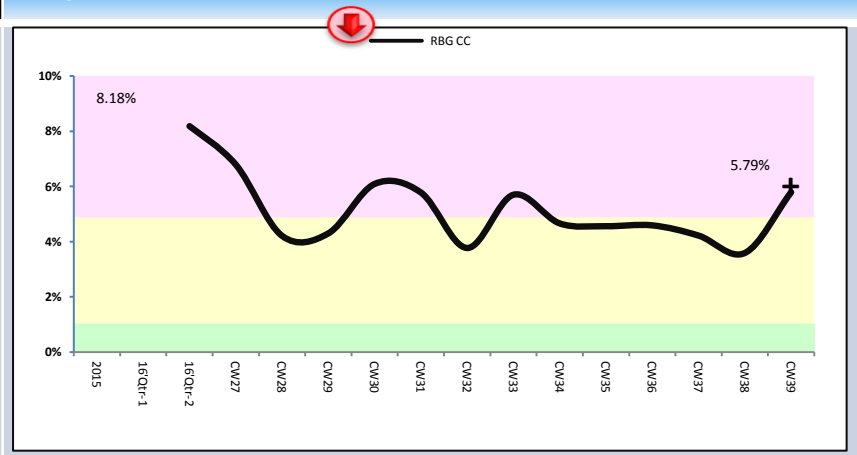
New behavior with automation

More than 5% of performance gap

FACTORY INTEGRATION

Manufacturing Competency (Scheduling, New MFG design, MFG performance analysis) + Service Delivery Competency (ITIL, IPMA, AM, BA) + System Competency (CAMSTAR, SPC, APC, EA, Reporting, Oracle.)

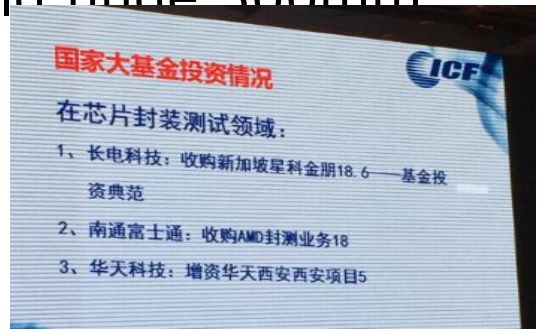
MFG Capability Cockpit view – review CAMSTAR maturity in factory

Site / Segment	Track-IN Transaction Error
RGB CC	

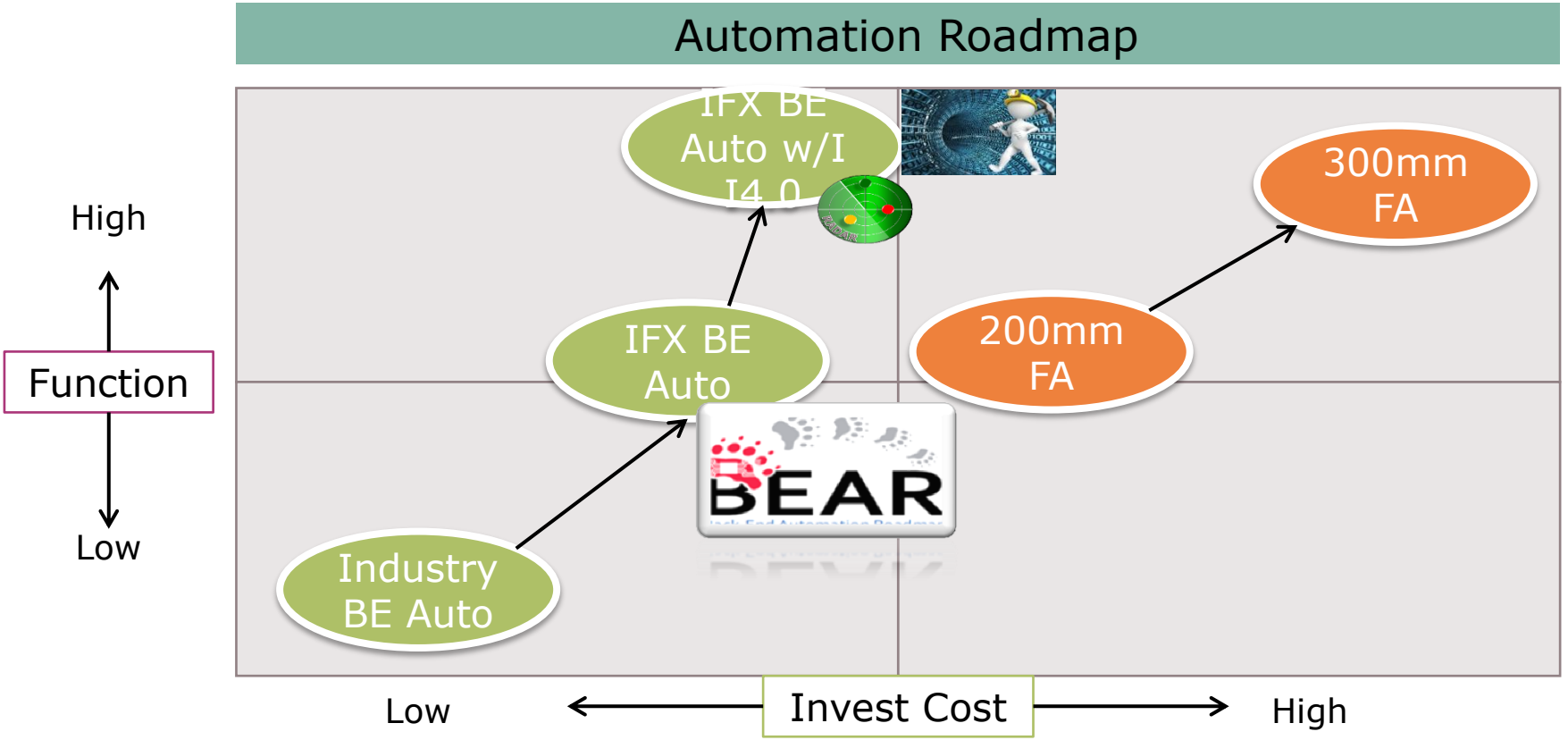
Improving No Changes Deteriorate

Takeaway from 2016 China Semiconductor Packing/Test annual conference in Nantong

- Huge investment power (billions) from government funding to support China semiconductor to acquire global semiconductor companies (Statschipack. AMD, ..), also build huge 300mm capacity (600K/m @ 28nm).

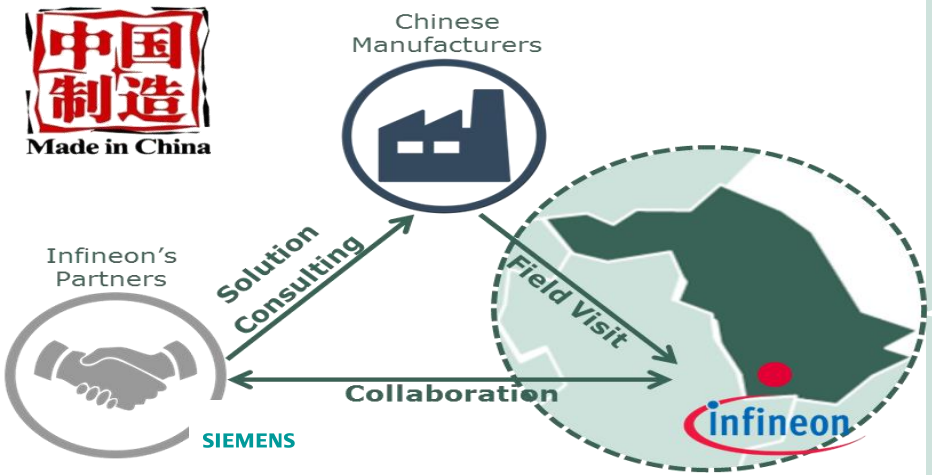


Our Opportunity



Infineon Spearheads “Made in China 2025” with Expertise in Industry 4.0

Infineon Powers "Made in China 2025"



Win-with China	❑ Infineon focus on Chinese market and localization, contribute to the development of china
Our perception	❑ Infineon deeply understood the different reality and challenges of German Industy4.0 and Chinese strategy “Made in China 2025”

Automatic 4M Control Leads IFWU to Success

Men
equipped with proper training & sufficient certification

Machines
featuring monitored status & parameters

Materials
thoroughly traced & efficiently utilized

Methods
comprising of auto. downloaded programs & parameters

Wuxi’s Top 10 Internet of Things Demo Projects 2015

On Sept. 24, 2015, Infineon’s security chip assembly & test smart factory in Wuxi was listed into “Wuxi’s Top 10 Internet of Things Demo Projects 2015”, Dr. Su Hua, President and Managing Director of Infineon Technologies China received the award from Wuxi municipal government.

Summary

- Semiconductor is one of most complicated manufacturing. And semiconductor has demonstrated smart manufacturing in last 2 decades.
- Using smart manufacturing from semiconductor could improve MFG performance to improve production competency.
- MES play core of Smart Manufacturing including MFG know-how, Reliable system and System scalability.
- PLM_MES integration could significantly improve time to market .
- CISMA (China Infineon Smart Manufacturing) build the synergy to help China Manufacturer toward Industry 4.0 to become smart manufacturing.

Part of your life. Part of tomorrow.

infineon