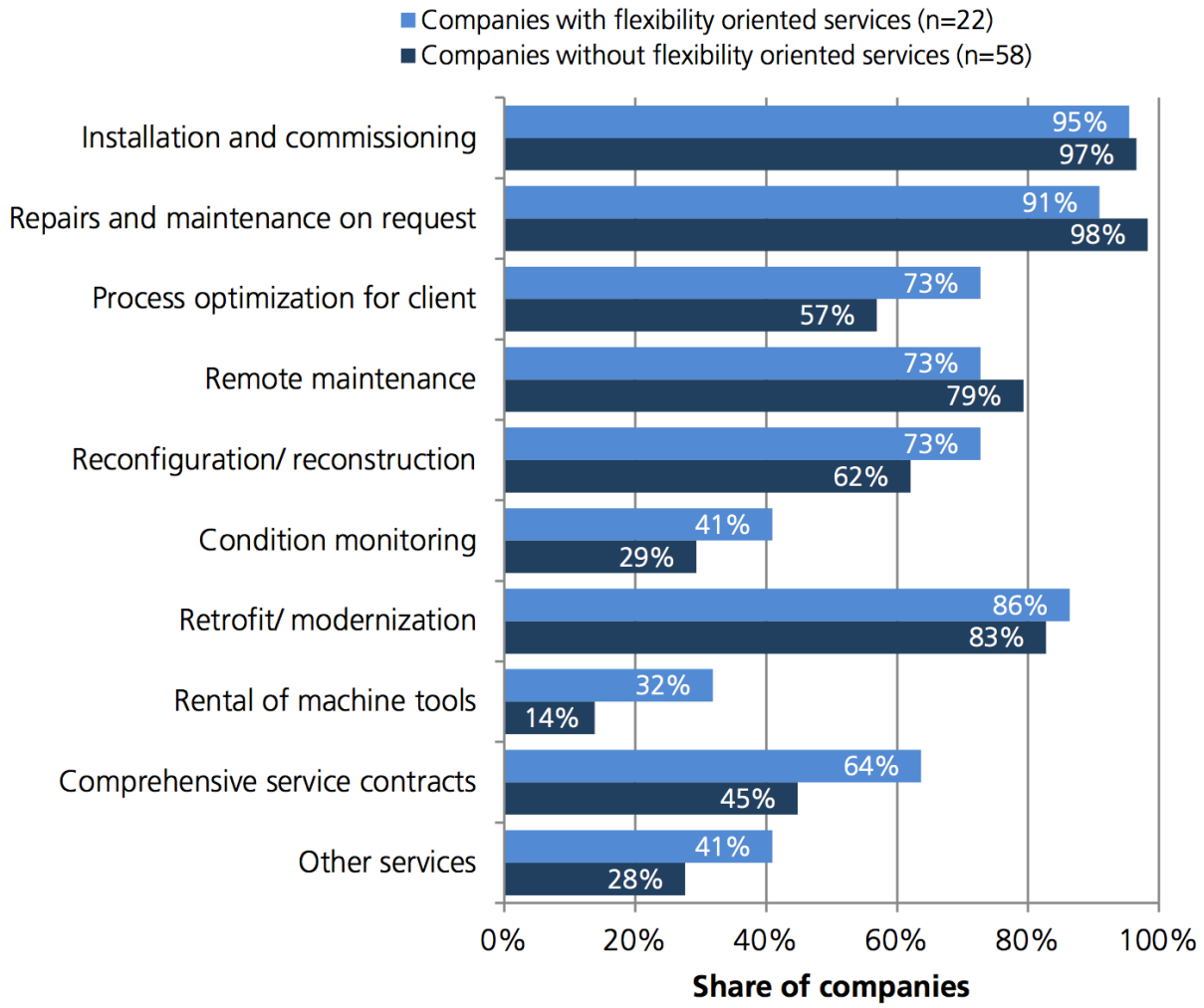

Stockholm, 4th December 2013
MANAGEMENT OF CRITICAL KNOWLEDGE TO SUPPORT MAINTENANCE DECISION MAKING
MONDRAGON
HUMANITY AT WORK
Finance
Industry
Distribution
Knowledge

“Maintenance is no longer a necessary evil that costs what it costs, but an important function that creates additional value in the business process”.

“New business models with a stronger service orientation are seen as an instrument to react to the upcoming competition and future challenges”.



Source: DEMAT survey on machine tool industry 2012.

"How can I optimize my maintenance plan?"

"How can I detect warranty issues sooner?"

"How can I perform in depth root cause failure analysis on my process and equipment?"

"How can I predict an impending equipment failure and the cause?"

"What is the life expectancy of an asset's component or part?"

"How can I reduce unscheduled maintenance and its high costs?"

"How do I achieve optimal equipment efficiency and availability?"

EMBEDDED SYSTEM TECHNOLOGY - RESEARCH

- **What's the usual**
  - Communication **network infrastructures** of factories are ten years behind of what it can be found elsewhere (offices, homes, buildings, malls, etc.)
  - Machine and systems have mostly used **hardwire connections** for sensing and control
    - Lack of standard, interoperable, reliable, secure and adaptable **wireless systems** for industrial environments
  - **Scarce gathering of process information** and even lower real use of available/ existing data

- **State of the Art**
  - **Condition based maintenance**
  - Gateway architecture for **heterogeneous networks** requiring high reliability and interoperability (cloud-enabled)
  - **Fault-tolerant** heterogeneous **real-time** and low-latency **control and sensor networks**
  - Methodology for developing **dependable embedded systems** (no failures - no maintenance concept)
  - **Advanced analytics**

ISSUES

- Lack of **visibility** into asset health
- **No accurate forecast** of asset downtime and costs
- Difficulty separating the "**signals**" from the "**noise**"
- Difficulty separating the "**information**" from the "noise"
- Need **interoperability** and **integrability**
- Need of **reliable** information and communications
- Need to back up decisions with **hard data**

EMBEDDED SOLUTIONS

- **New sensing CPS** to capture maintenance relevant/critical information
- **Virtual Plug & Play**
  - Easy to configure and deploy complex maintenance services
- **Secure wireless solutions**
  - Increasing the possibility to reach inaccessible places for a wired network.
- **Remote access** that facilitate access to new geographic markets
- **Distributed** (local) **decision making**
- Connection to the **Cloud** enabling new capabilities for data aggregation and complex computing
- **Distributed Big Data analysis** with focus on critical data sources

KNOWLEDGE MANAGEMENT

- For an enhanced **advanced analytics** methodology
  - Predictive asset/maintenance
  - Root cause failure analysis
  - Remaining useful life identification
  - Simulation, prediction and scenario tools

- **Information sources**
  - Asset maintenance history
  - Condition monitoring and historical meter readings
  - Inventory and purchasing transactions
  - Labor, craft, skills, certifications and calendars
  - Safety and regulatory requirements
  - ERP, sensors, CMMs, SCADA,…
  - New CPS will provide relevant/critical data/information

CONTEXT AWARENESS

- Serving the **right personnel** with the **right information** at the **right time**

- Providing **mobile** extensions to solutions they offer
  - Operators and technicians are just now getting mobilized, as opposed to being confined to a control room viewing the process-control dashboard on fixed-position screens

- Combined with **user-friendly**, industry dashboards

APPLICATION INNOVATION

- **Advanced maintenance,** without large investments, considering the effect of **product variability** and customization in the maintenance of production assets
  - **Prognostics** based on machinery status & expected process operation
- **Extending life of aged factories** and equipment
- Prediction of the **Remaining Useful Life** for **re-using assets** and components in lower quality demanding applications
- **Servizitating** maintenance operation for OEM manufacturers

USE CASES

- MONDRAGON Corporation
  - Fagor Ederlan (final user, automotive sector) uses Loramendi's (MTB) machine tools in its machining processes

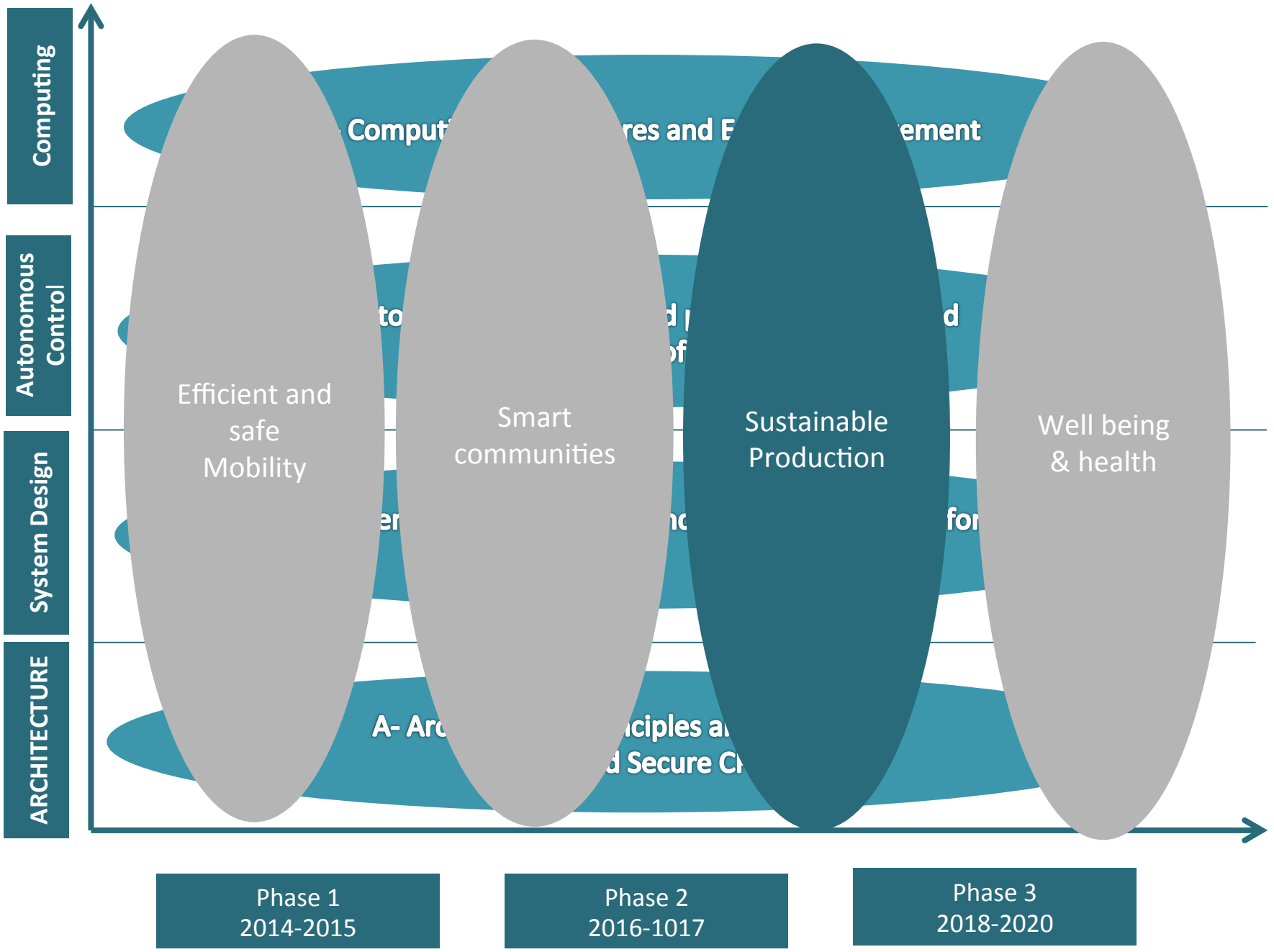
- ACCIONA Infrastructuras
  - Makes pultruded composite components for the road and rail infrastructures (such as bridges)

USE CASES

- LORAMENDI produces vertical moulding machines for foundry
- Technical challenges:
  - **Monitoring** of hydraulic and servo-mechanical actuators
  - **Root failure analysis**: process characterization in terms of voltage, intensity, energy consumptions, resin quantity...
  - **Maintenance of internal pipes** for reducing losses
  - Eco-labelled foundry machines (**minimum energy consumption**)
  - **Portable** solutions for maintenance and technical assistance (RUL, machine set up)

IMPACT TO ARTEMIS TARGETS

- Built with the Ambition and **Targets**
  - To exploit the **ubiquity** of the Embedded Systems/ Cyber-Physical Systems
  - To exploit the connectivity of networked ES/CPS: **the neural system of society**
  - To address the challenge of **Time to Market/time on Market**
  - To **master the complexity** while reducing the cost
  - To address the challenge of **energy and power consumption**


Computing
Autonomous Control
System Design
ARCHITECTURE
Efficient and safe Mobility
Smart communities
Sustainable Production
Well being & health
Phase 1
2014-2015
Phase 2
2016-1017
Phase 3
2018-2020

IMPACT TO ECSEL TARGETS

Manufacturing & Process Industries: "100% available factory".

- Reduce the **environmental impact** of manufacturing industries
- Maximising manufacturing **efficiency**
- Augment manufacturing **employment** in Europe
  - Assure jobs in the design, manufacturing, integration and servicing of the manufacturing equipment itself

- Embedded Systems will
  - Precisely control process parameters
  - Active reduction of pollutants
  - **Reduce** the total **cost and environmental impact** of manufacture

- **Competitive advantages**
  - Controllability, flexibility and condition monitoring
  - **Reduce** the need for **maintenance**, lowering cost still further

IMPACT TO ARTEMIS TARGETS

- Maintenance will benefit from advances in the three main areas of research of Artemis:
  - Reference designs and architectures: Security, composability, certification…
  - Seamless connectivity and interoperability: Ubiquitous connectivity, Perception techniques…
  - Design methods and tools: Early verification and early validation, product lines…
- Some of the identified technological challenges:
  - Communication
  - Sensors and actuators
  - Interoperability of sensor and actuator networks up to the exchange of data with applications
  - Sensor fusion and data fusion of data coming from multiple sensors
  - Data management and service provisioning
  - HMI
  - Distributed computing
  - Cloud computing
  - …

LINKS TO OTHER IDEAL CONCEPTS

- IC2: It will be necessary to increase the **transparency** between ERP and field devices

- IC3: New **intelligent sensing CPS** will be required to capture relevant/critical data for maintenance

- IC9: **Reliable and secure** information is key to keep maintenance businesses running

IMPACT ON SOCIETAL CHALLENGES

- **Energy** and **raw materials** losses and emissions reduced through optimum performance.
  - Reduction in spare part consumption thus, smaller stock of spares
- Lower **CO2 footprint**
  - Through full life cycle use and components re-use
- Optimum balance of **safety** and production capabilities
  - Improving Safety on mandatory checks and manual confirmation processes
- More friendly and **attractive working** environments
  - The work can be planned, giving the crew stable working hours, avoid extreme workload
- **Employment** sustainability and new job creation based on new business models and opportunities

BUSINESS IMPACT

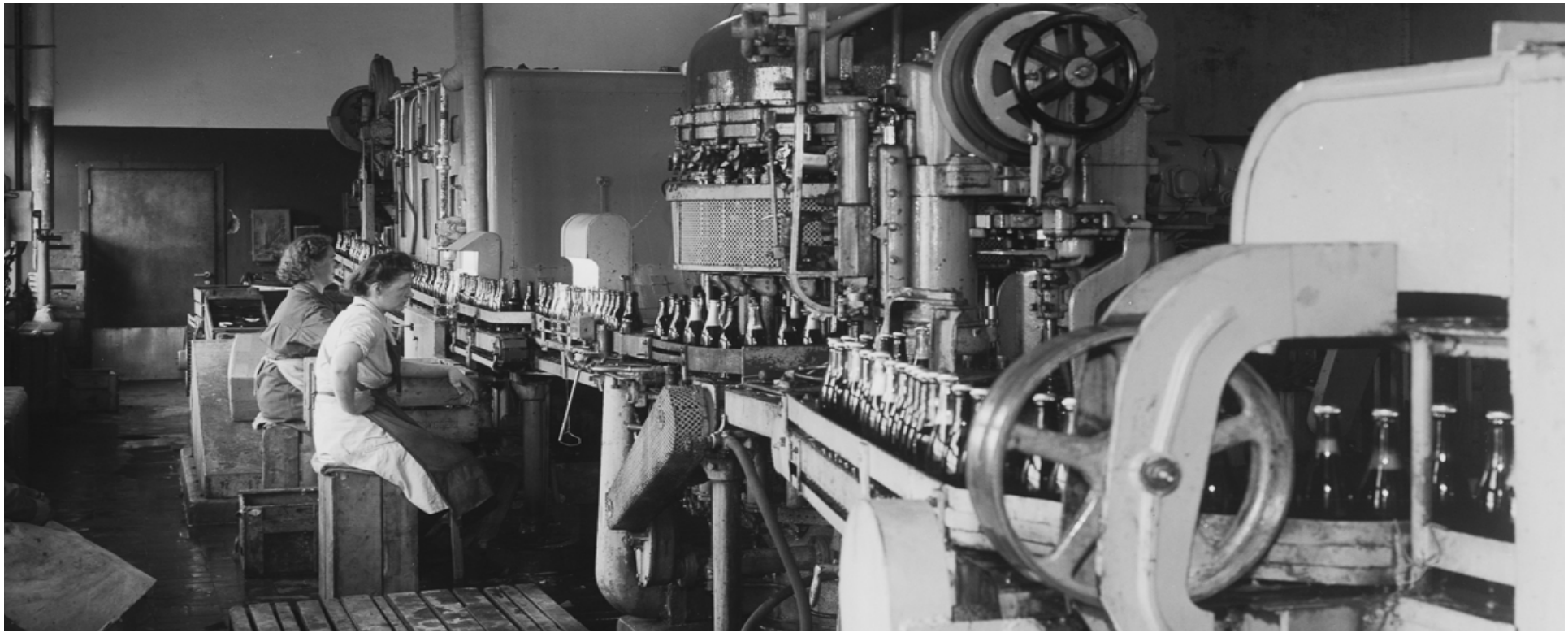
- **Optimization of maintenance**
  - Maintenance costs down
  - Unexpected failures down
  - Reduction of unscheduled maintenance and its high costs
  - Repair and overhaul time down
  - Spare part inventory down
  - Work orders down
  - Optimized maintenance windows to reduce operating expense
  - Improved reliability and uptime of assets
  - Higher availability
  - Improved competitiveness
  - Avoid unnecessary investments in redundancy
  - Efficient assignment of labor resources
  - Minimize parts inventory
  - Lower energy need

BUSINESS IMPACT

- New business models
  - **Servitization** of maintenance (added value and competitiveness)
  - **Ageing factories**: Competitive for longer time
  - Key **components re-use** (rental o second-hand asset market)
  - **New hardware, software and application** developers
  - **Internationalization** oportunities

REFERENCES

- “Improving Operational and Financial Results through Predictive Maintenance”, IBM
- “CECIMO Service-based business models in MTB industry”, DEMAT Project Survey Report
- “System Maintenance: Trends in Management and Technology”, Uday Kumar
- “European Roadmap for industrial Process Automation”, ProcessIT.eu
- “OEM trends and technology”, Rockwell Automation
- Creative Commons images from Flickr



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