INDUSTRY 4.0

IK4 TEKNIKER
Research Alliance

ULMA
Carretillas Elevadoras

COLLABORATORS

Orkestra
INSTITUTO VASCO
DE COMPETITIVIDAD

B-I
strategy

Advanced maintenance solutions methodology & impact

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El Mantenimiento en IK4-TEKNIKER

- **Misión**: Apoyar a la industria a mejorar en la Detección, Diagnóstico y Pronóstico de mal-funcionamientos (sistemas mecatrónicos).

- **Objetivos mantenimiento**:
  1. Aumentar disponibilidad y fiabilidad de máquinas
  2. Extender la vida
  3. Reducir costes directos e indirectos

- **Visión**: Aunar **tecnologías y experiencia** para maximizar el retorno del mantenimiento.
  - Especial enfoque en el potencial (y limitaciones) de las tecnologías predictivas (sensores, CbM embebido, gestión ‘parques’…)

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I+D

R&D Groups

- **Sistemas de Información**
- Electrónica y comunicaciones
- Control
- Mecánica
- Tribología
- Fisica/Química Superficies

lubrication management
IK4-TEKNIKER

SERVICES

a2 atten2
advanced monitoring technologies

PRODUCTS

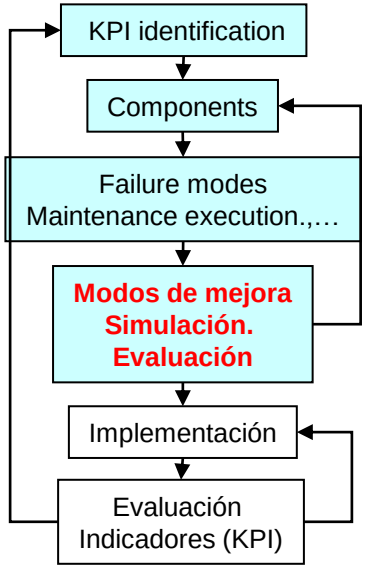
COLABORATION

WEAR CHECK INTERNATIONAL

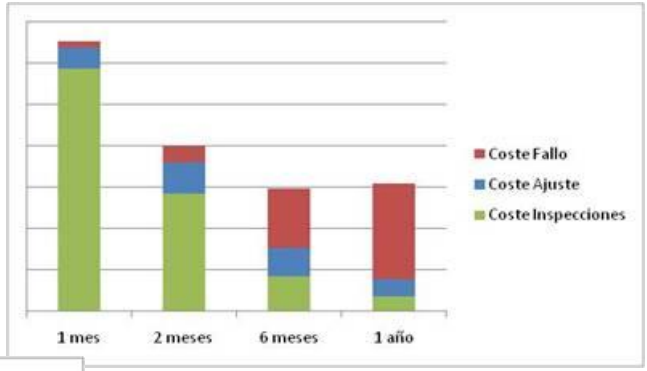
eIMS
CENTER FOR INTELLIGENT MAINTENANCE SYSTEMS

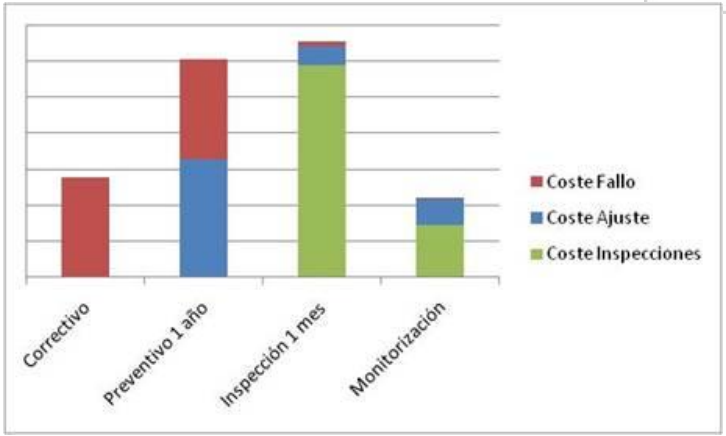
NORIA
"Lubrication-Enabled Reliability"

Maintenance strategies analysis

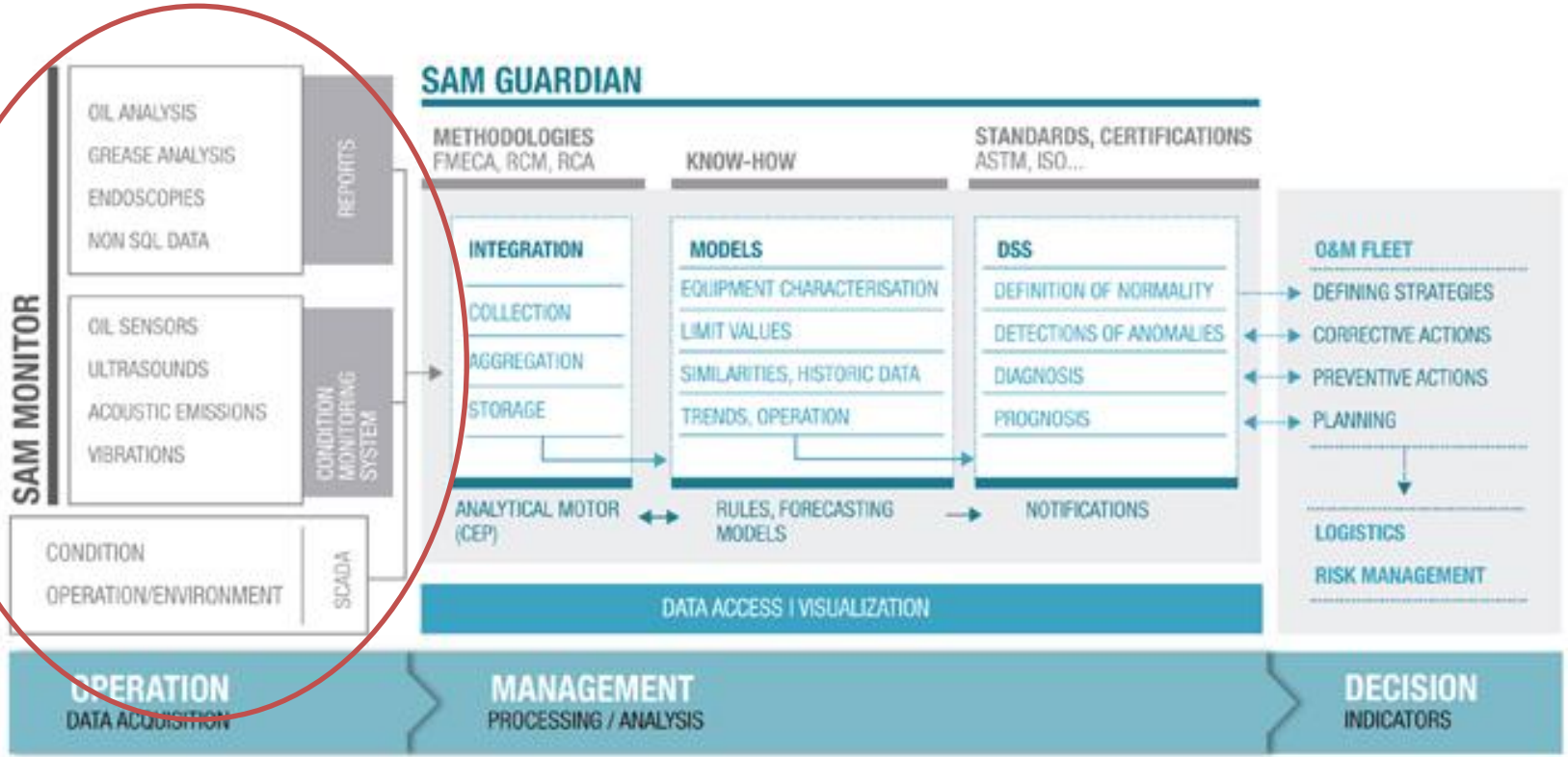


Impact of different inspection frequencies





Impact of different maintenance strategies in the maintenance costs of a component (in €/month)



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T-REX METHODOLOGY & WORKBENCH FOR FAST DEPLOYMENT OF ADVANCED MAINTENANCE SOLUTIONS

METHODOLOGY

- Maintenance is gaining importance in business
- Impacting lifecycle value

The IoT will lead to a **25 %** reduction in **asset maintenance costs** and **35 %** reduction in **downtime**

U.S Department of Energy

PdM

- Can reduce the **Cost of planned repairs** by **12%**,
- Cut **maintenance costs** by almost **30%** and
- Reduce **unscheduled downtime** by **70%.**

World Economic Forum and Accenture

Where to start from???

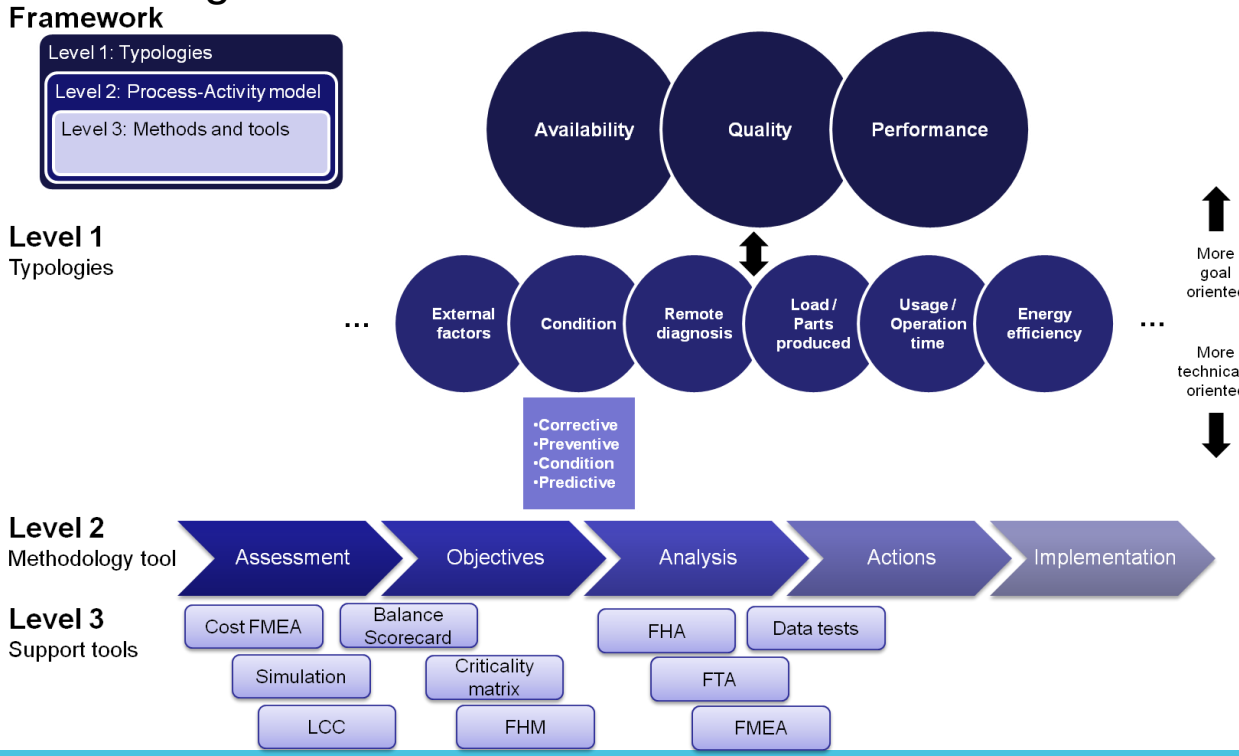
Motivation

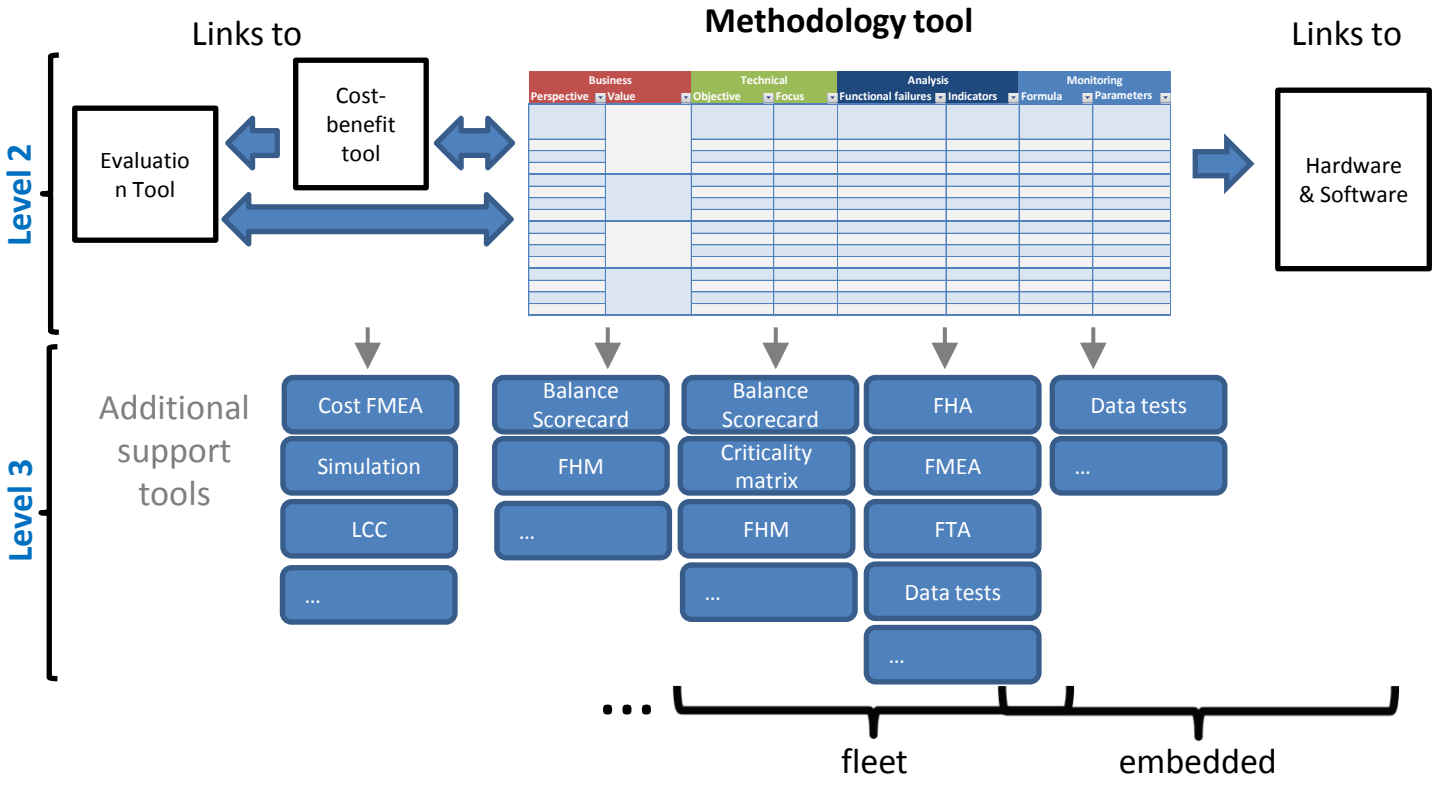
- The methodology is a guideline for facilitating a roadmap for newcomers
- Assess and clarify needs, limit challenges, and in doing so, to favour fast development
  - It helps to develop effective PdM solutions by aligning condition monitoring features and details with business needs
  - A solution specific condition monitoring workbench can be made available for visual data inspection, plus including the application of generic algorithms for event and condition detection and alarm triggering
- It contributes to
  - Facilitate linking business goals and technologies
  - Provide inputs on architecture, indicators, algorithms, hardware

- A framework for a methodological design and deployment of continuous monitoring and predictive technologies

- Methodology develops from strategic business perspective to implementation of monitoring technology.

- Connected to service oriented business model development tools





Business perspective

States the focus and the impact expected from the technologies in terms of the value introduced with respect to the business model or business plan. Thus, it makes a explicit link to business model. (e.g. expectations in maint. Costs, performance, unavailability, lifecycle extension, re-use,…)

Technical objectives

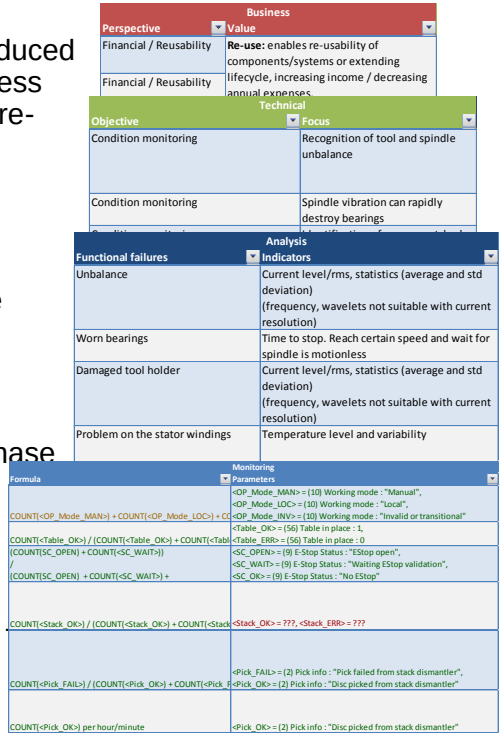
Focus on the technical approach to be pursued. It is the highest technical level and the responsible for assessing the degree to which technical objectives have to be met (remote diagnostics, usage monit., condition monitoring, …)

Technical analysis

States the critical functional aspects and the means to pinpoint them. This is a technical phase that leads to the identification of adequate monitoring scenario (indicators, frequencies, thresholds, …)

Data monitoring

States the parameters and processing leading to the extraction of the expected indicators. stage is the closest to the implementation level.



Business	
Perspective	Value
Financial / Reusability	**Re-use:** enables re-usability of components/systems or extending lifecycle, increasing income / decreasing
Financial / Reusability	annual expenses

Technical	
Objective	Focus
Condition monitoring	Recognition of tool and spindle unbalance
Condition monitoring	Spindle vibration can rapidly destroy bearings

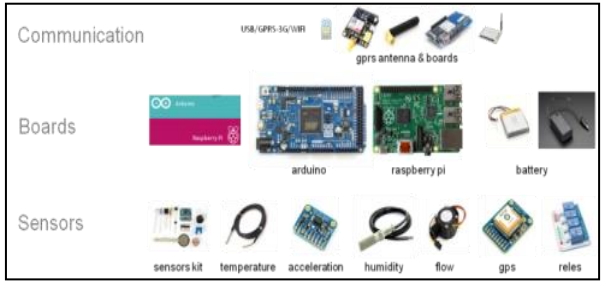
Analysis	
Functional failures	Indicators
Unbalance	Current level/rms, statistics (average and std deviation) (frequency, wavelets not suitable with current resolution)
Worn bearings	Time to stop. Reach certain speed and wait for spindle is motionless
Damaged tool holder	Current level/rms, statistics (average and std deviation) (frequency, wavelets not suitable with current resolution)
Problem on the stator windings	Temperature level and variability

Monitoring	
Formula	Parameters
COUNT(<OP_Mode_MAN>) + COUNT(<OP_Mode_LOC>) + C	<OP_Mode_MAN> = (10) Working mode : "Manual", <OP_Mode_LOC> = (10) Working mode : "Local", <OP_Mode_INV> = (10) Working mode : "Invalid or transitional"
COUNT(<Table_OK>) / (COUNT(<Table_OK>) + COUNT(<Tabl	<Table_OK> = (56) Table in place : 1, <Table_ERR> = (56) Table in place : 0
(COUNT(SC_OPEN) + COUNT(<SC_WAIT>)) / (COUNT(SC_OPEN) + COUNT(<SC_WAIT>) +	<SC_OPEN> = (9) E-Stop Status : "EStop open", <SC_WAIT> = (9) E-Stop Status : "Waiting EStop validation", <SC_OK> = (9) E-Stop Status : "No EStop"
COUNT(<Stack_OK>) / (COUNT(<Stack_OK>) + COUNT(<Stack	<Stack_OK> = ???, <Stack_ERR> = ???
COUNT(<Pick_FAIL>) / (COUNT(<Pick_OK>) + COUNT(<Pick_F	<Pick_FAIL> = (2) Pick info : "Pick failed from stack dismantler", <Pick_OK> = (2) Pick info : "Disc picked from stack dismantler"
COUNT(<Pick_OK>) per hour/minute	<Pick_OK> = (2) Pick info : "Disc picked from stack dismantler"

Implementation

- Final implementation is company specific – depends on the machinery existing electronics & communications capabilities
- A pragmatic typology has been identified (embedded, PC embedded, virtual PC)
- Therefore,
  - ☑ defined as needed based on the options identified (embedded, PC embedded, virtual PC) and use case constraints
  - ☑ it is further feedback to take into account within methodology (viability, costs)

Embedded



PC embedded

Virtual PC

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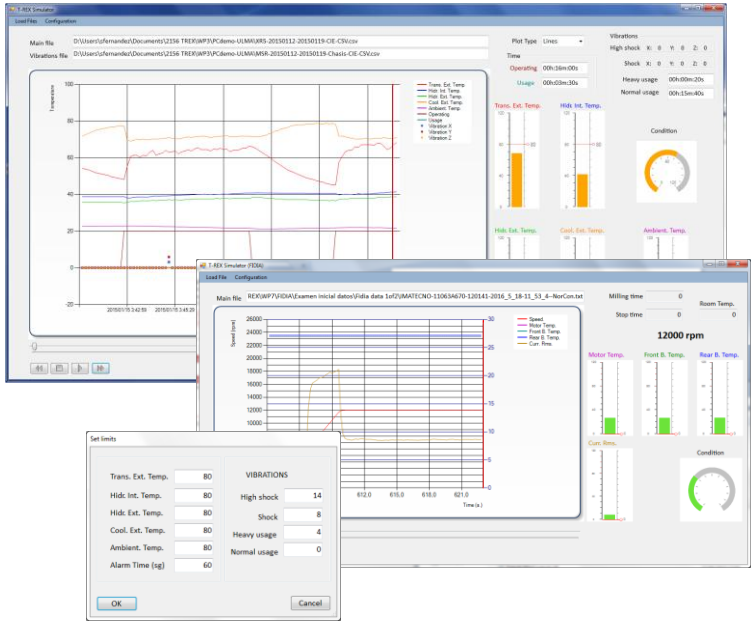
Workbench for - first data - embedded simulation

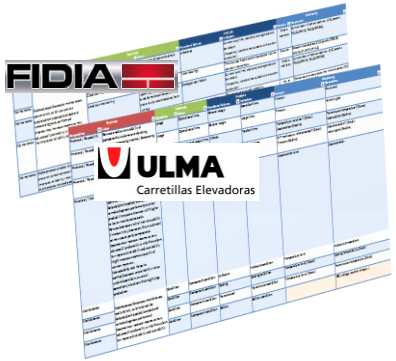
- Counters
- Event detection
- Anomaly detection
- Alarm triggering

- Set configuration parameters
- Visual data inspection
- Output log

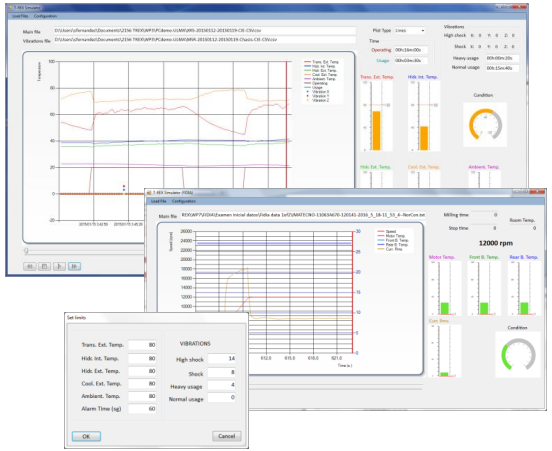
Workbench



Methodology Tool



Workbench



Implementation

FTA, FMEA

DATA TESTS

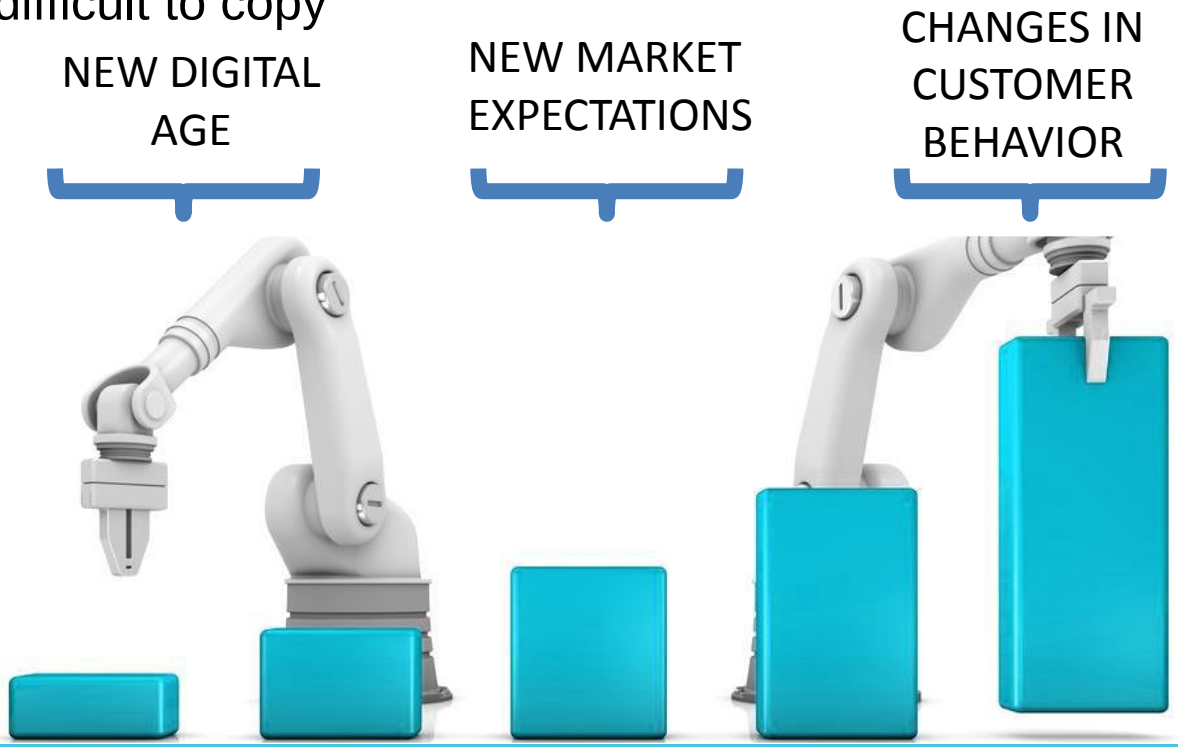
	Fixed speed				Transients		
Nominal condition	6000 RPM	12000 RPM	18000 RPM	24000 RPM	6000-12000 RPM	12000-18000 RPM	18000-24000 RPM
No X axis movement	X	X	X	X	X	X	X
No Y axis movement	X	X	X	X	X	X	X
No Z axis movement	X	X	X	X	X	X	X
Stop by inertia				X			
No. Repetitions	4						
Test length	1800s/step						
Transient set-value time	3s	*Keep all control variables equal for all runs					

- Transport domain: research on condition-based maintenance and fleet management as a lever for improved short-term rental service
- Machine-tool domain: research on new designs and on monitoring technologies as an enabler of condition-based maintenance services

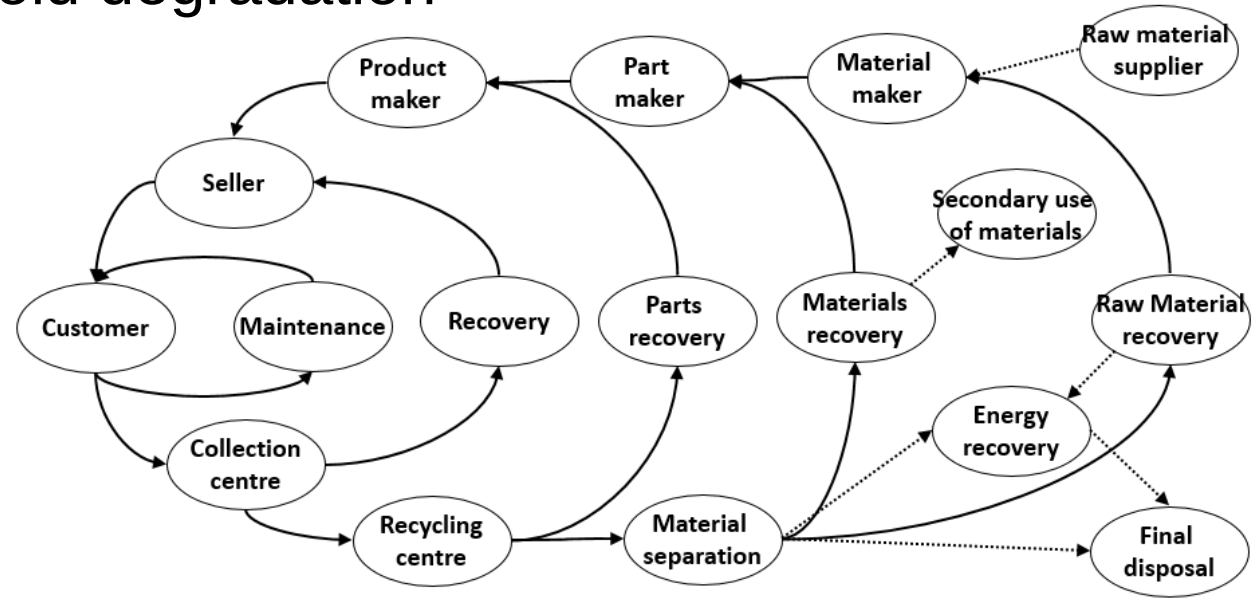
- Overall,
  - Potential impact identified in terms of maintenance costs reduction, lifecycle costs reduction, lifecycle extension and components/systems re-use increase
  - Identified condition indicators grouped into:
    - Usage: such as time of operation/use and anomalous usage
    - Condition and diagnosis: based on various physical sensor measurements
    - Performance: for instance associated to energy consumption, number of operations, among others
  - Tools such as FMEA applied in some cases for understanding/clarification. Data collection applied for algorithm identification, technology adjustment, among others
  - Main general algorithms identified were: counters, event detection and condition, along with some associated alarms/actions that could be triggered.

IMPACT

- A trend towards the convergence of digital virtual and physical systems
- Advanced maintenance strategies can be a factor of internal strength at manufacturer – difficult to copy



- Maintenance ➔ first line for re-XXX extension
- (Proactive) maintenance – beyond prediction – act oin order to avoid degradation



Conclusions

- A methodology has been introduced in order to help structuring a condition monitoring offer
  - from goals perspective to condition monitoring technologies
  - contribute to assess and clarify needs, limit challenges, and in doing so, to favour fast development.
- The methodology was applied to industrial use cases, for supporting industry in adopting new or alternative maintenance strategies
  - Commonalities have been already extracted from the analysis of use cases (hardware/software/condition typologies)

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