RETE ALTA TECNOLOGIA
EMILIA-ROMAGNA
HIGH TECHNOLOGY NETWORK

TECNOPOLO PIACENZA

MAMUT

Sistema integrato per la manutenzione delle macchine automatiche di nuova generazione

Paolo Albertelli

POR FESR EMILIA-ROMAGNA 2014/2020

UNIONE EUROPEA
Fondo europeo di sviluppo regionale

RegioneEmilia-Romagna

ASTER
innovazione attiva

Richiedente

MIST E-R Laboratorio di **Mi**cro e **S**ubmicro **T**ecnologie dell'**E**milia-**R**omagna

Proponenti

MUSP, Redox, Fondazione Rei

Imprese

Sacmi Imola SC, Capellini srl, Mandelli Sistemi SpA, Global Technical Service

RETE ALTA TECNOLOGIA EMILIA-ROMAGNA HIGH TECHNOLOGY NETWORK
TECNOLOPO PIACENZA

Mamut

low cost smart and configurable IOT sensor solutions

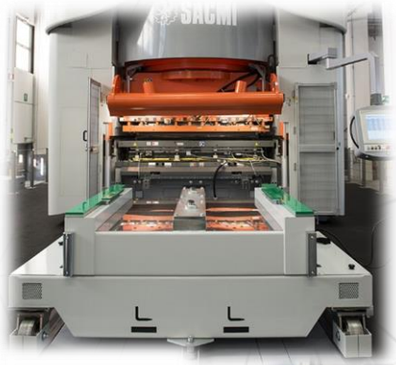
prognostics

maintenance

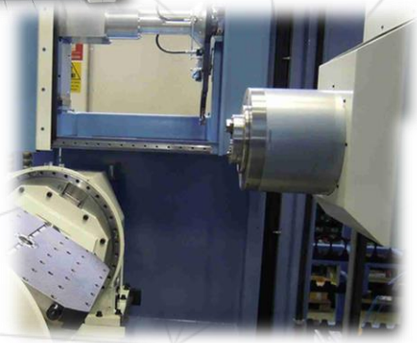
system level

manufacturing system

machinery level



Mandelli, Sacmi, Capellini, GTS, …

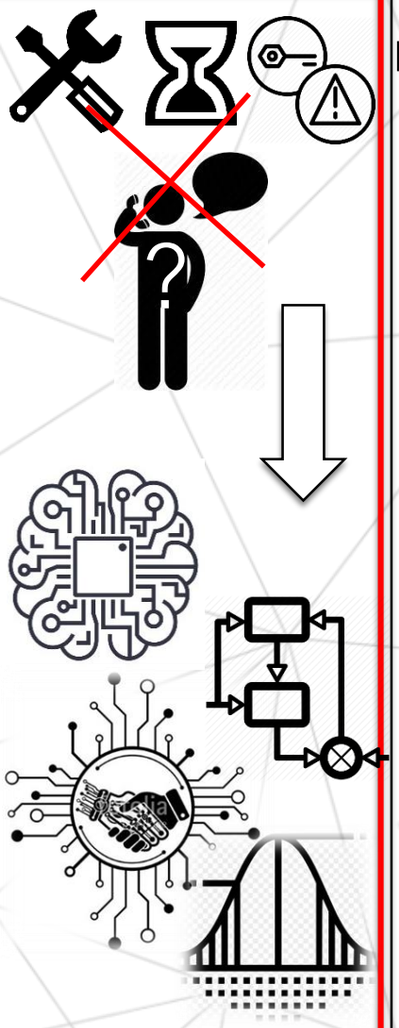


SENSOR

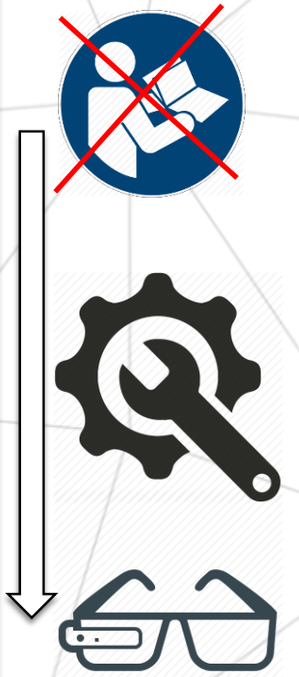
SENSOR

sub-component level

prognostics



maintenance



MISTER

MUSP

REDOX

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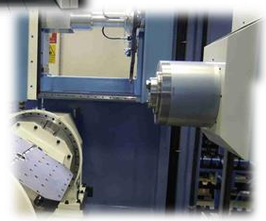
RETE ALTA TECNOLOGIA EMILIA-ROMAGNA HIGH TECHNOLOGY NETWORK
TECNOLOPO PIACENZA

MAMUT

smart and configurable
cheap IOT sensor solutions

machinery level

Mandelli, Sacmi,
Capellini, GTS, …



SENSOR

SENSOR

sub-component
level

prognostics

maintenance

prognostics

maintenance

Fondazione REI
(technological transfer)

SME industries
growth

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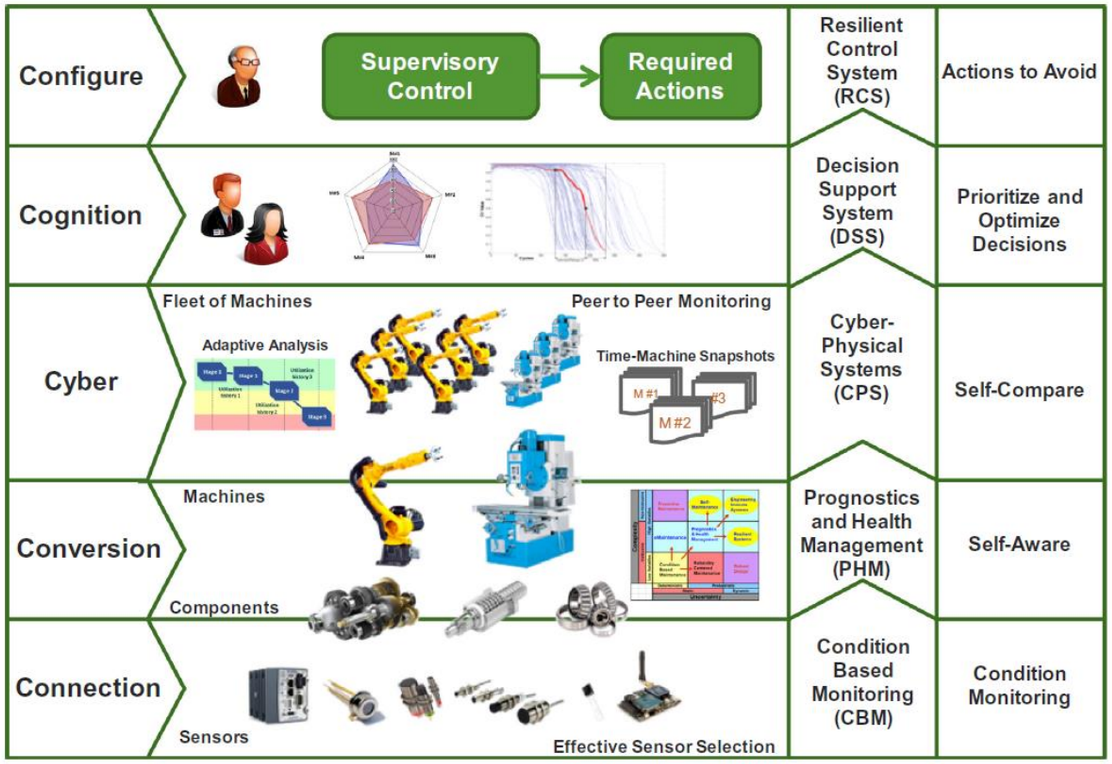
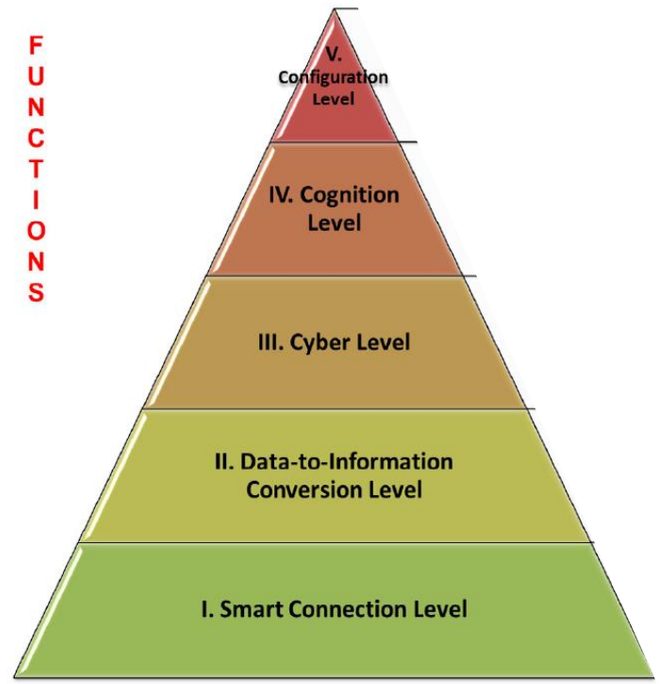
MACHINERY PROGNOSTICS IN INDUSTRY 4.0 ERA





Machinery prognostics and health management has gained an increasing attention in the Industry 4.0 thanks to some enabling technologies:

- Connectivity and ICT
- Data analytics
- Simulations capabilities

MAINTENANCE STRATEGIES IN MANUFACTURING

maintenance approaches and companies that deals with manufacturing

manufacturers

Machine tools and machinery producers

What is the current status of manufactures for what concern the maintenance policies?

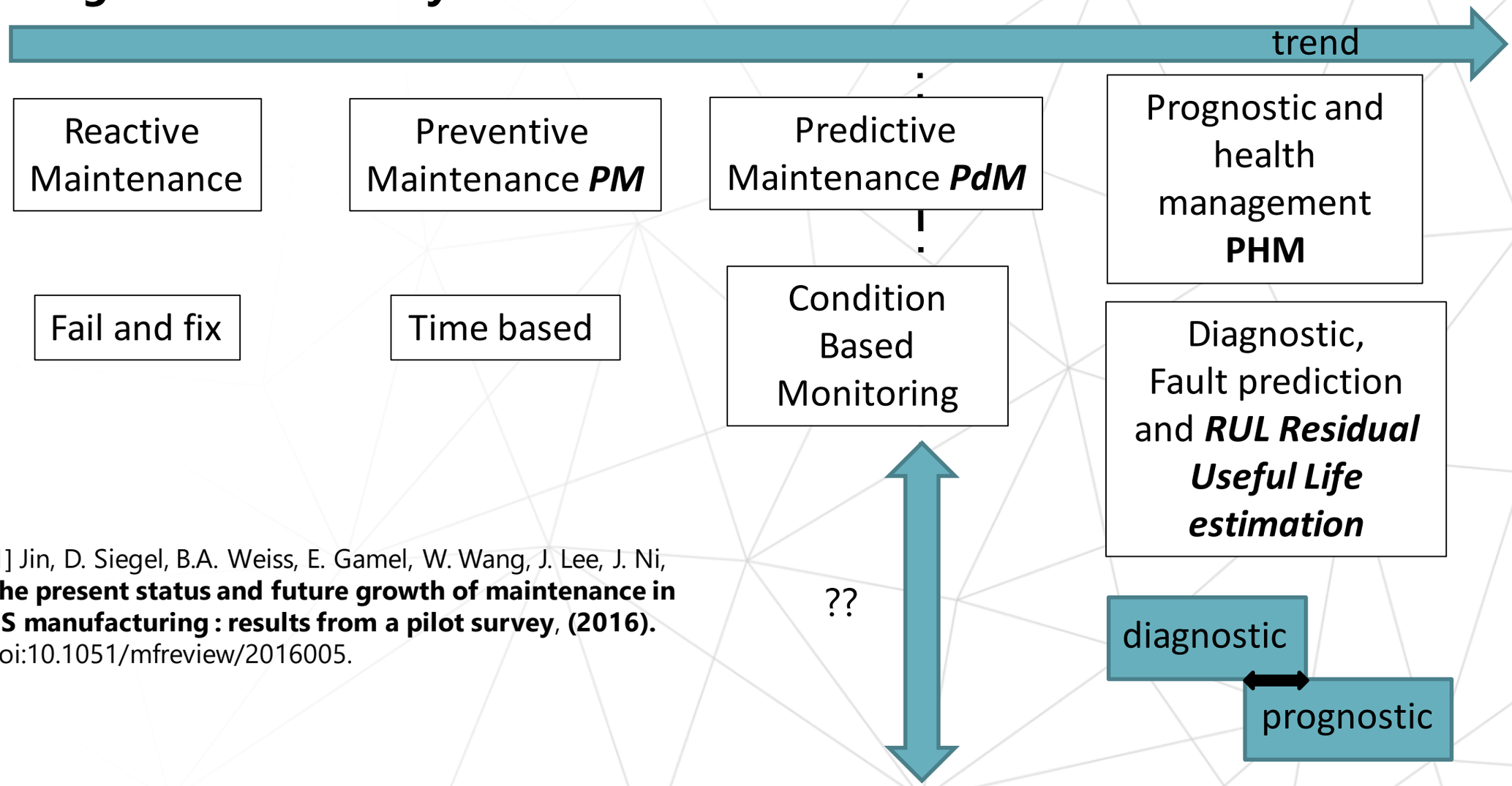
Limitations and roadmaps

Research activities on Prognostic

Limitations and challenges

MACHINERY MAINTENANCE POLICIES

Paradigms in machinery maintenance



[1] Jin, D. Siegel, B.A. Weiss, E. Gamel, W. Wang, J. Lee, J. Ni, **The present status and future growth of maintenance in US manufacturing : results from a pilot survey**, **(2016).** doi:10.1051/mfreview/2016005.

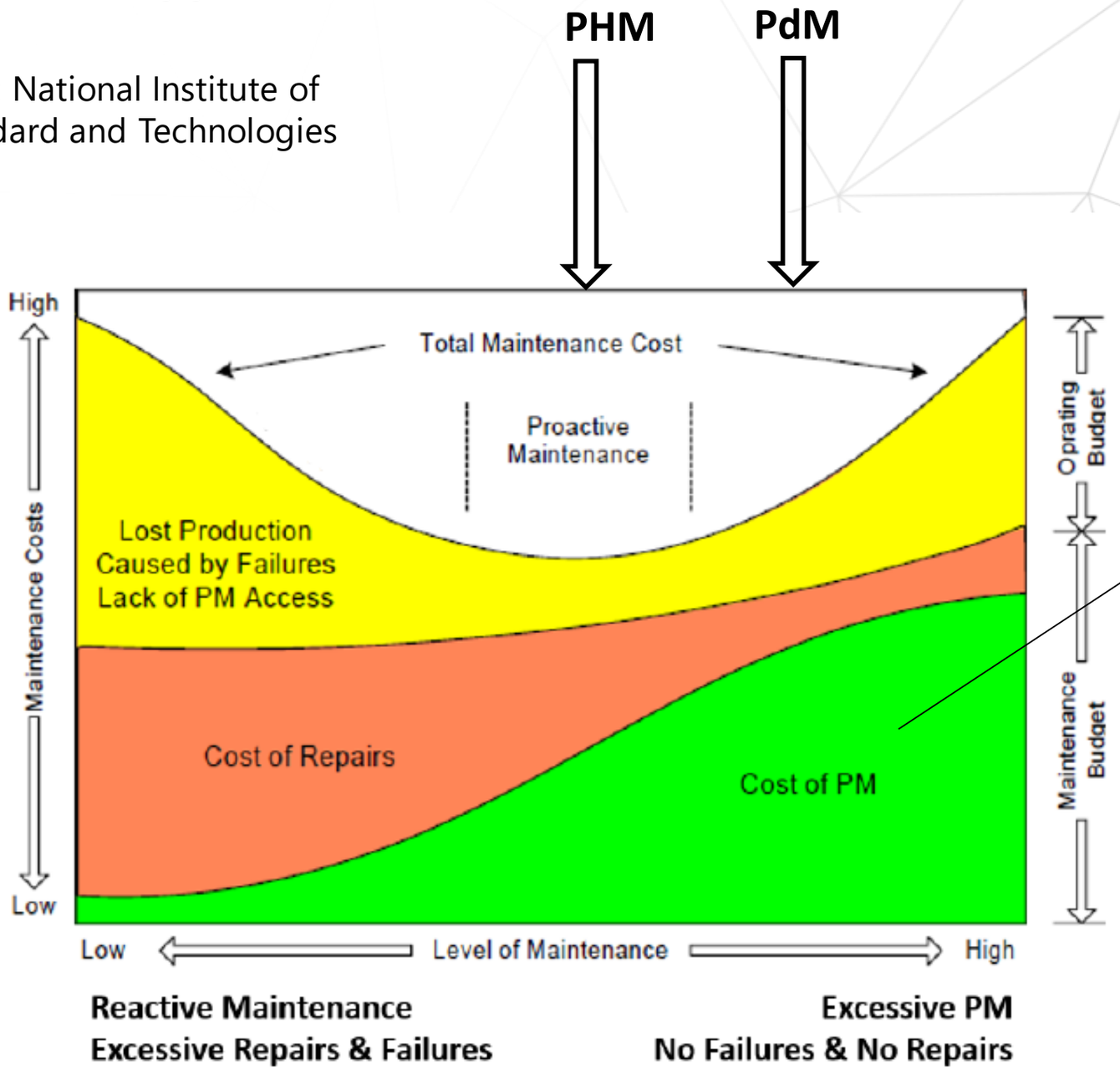
Despite their greater adoption of maintenance practices and technologies, **large manufacturing organizations** have had only ***modest success with respect to diagnostics and prognostics and preventive maintenance projects [1]***.

MAINTENANCE COSTS

Different approaches to maintenance - costs

NIST: National Institute of Standard and Technologies

B.A. Weiss, J. Pellegrino, M. Justiniano, A. Raghunathan, NIST ADVANCED MANUFACTURING SERIES 100-2 Measurement Science Roadmap for Prognostics and Health Management for Smart Manufacturing Systems, (2016).

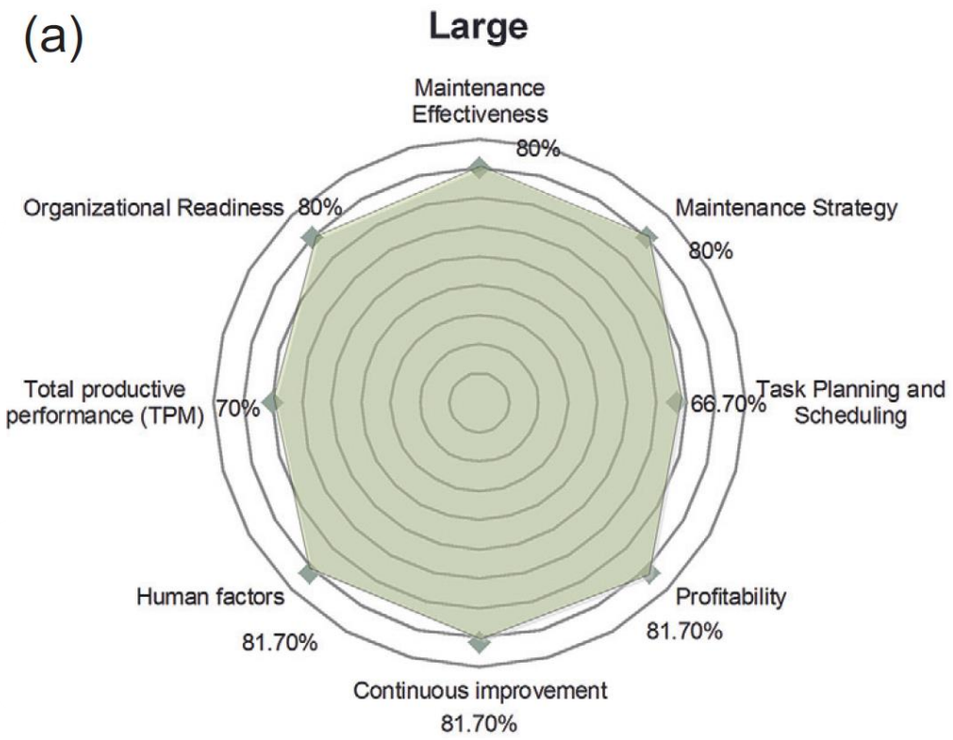


PM preventive maintenance

INDUSTRIAL STATE OF THE ART – BARRIERS

Key factors and maintenance performance (SME vs Large)

(a)

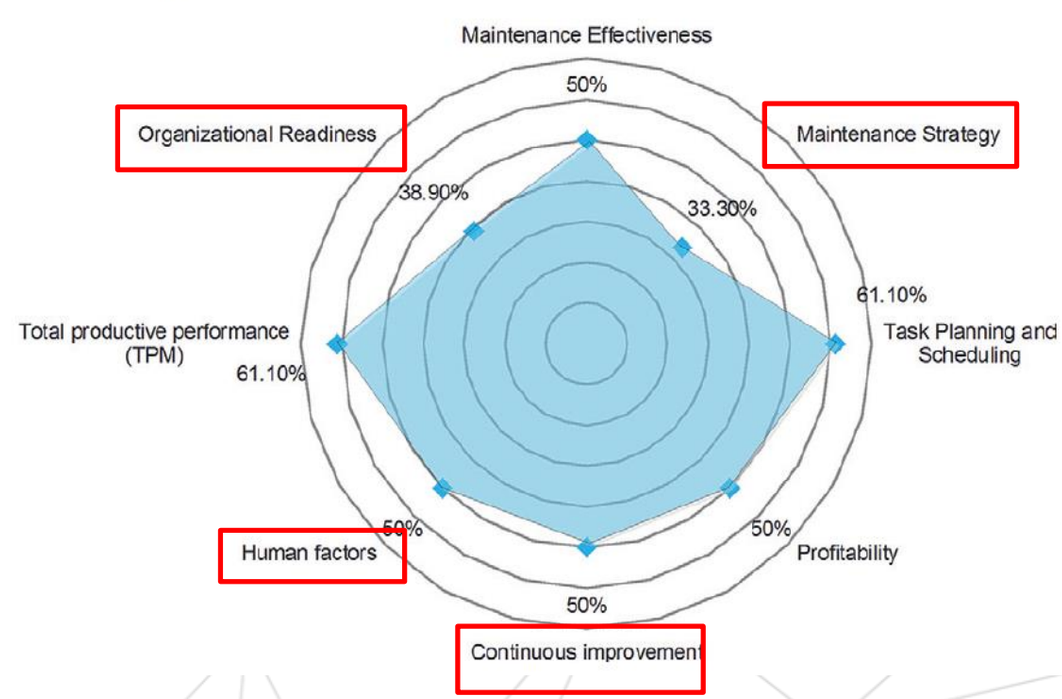


Weak factor (SME vs Large)

- Maintenance Strategy
- Organization Readiness
- Continuous improvement
- Human factors

MAMUT

(b)



NEEDED APPROACH…

Scientific Literature

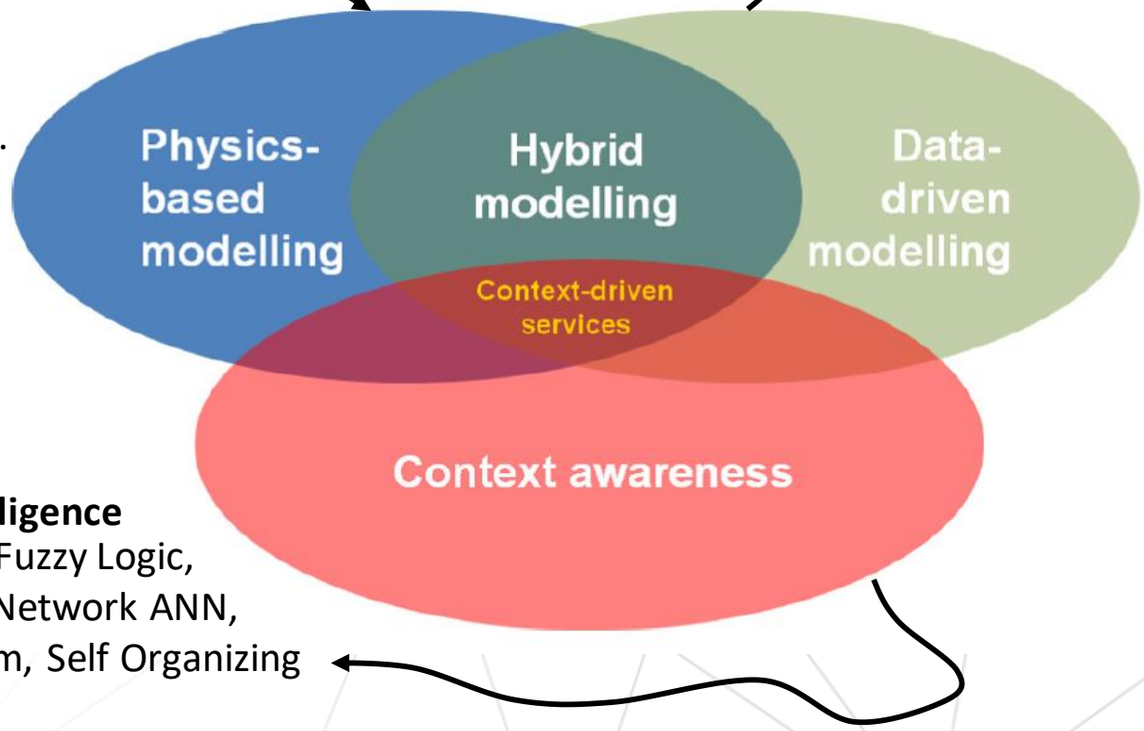
hybrid approaches seem the PHM frontier

Defect propagation models
Kalman Filter
System identification,
mechanistic model etc.

sensor data

data processing
FFT, Wavelet based,
Synchronous Averaging
SA, PCA (principal
component analysis),
ARMA

event and conditioning
monitoring data



Modelling and decision support
Regressive Models, Bayesian network, Hidden Markov Model HMM, Proportional Hazard Models PHM, Proportional Intensity Models PIM, etc.
Support Vector Machine

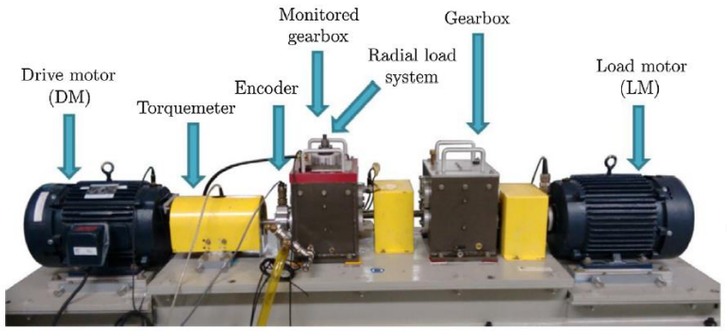
AI Artificial Intelligence
Expert Systems, Fuzzy Logic,
Artificial Neural Network ANN,
Genetic Algorithm, Self Organizing
Maps etc.

diagnostic ⟷ prognostic

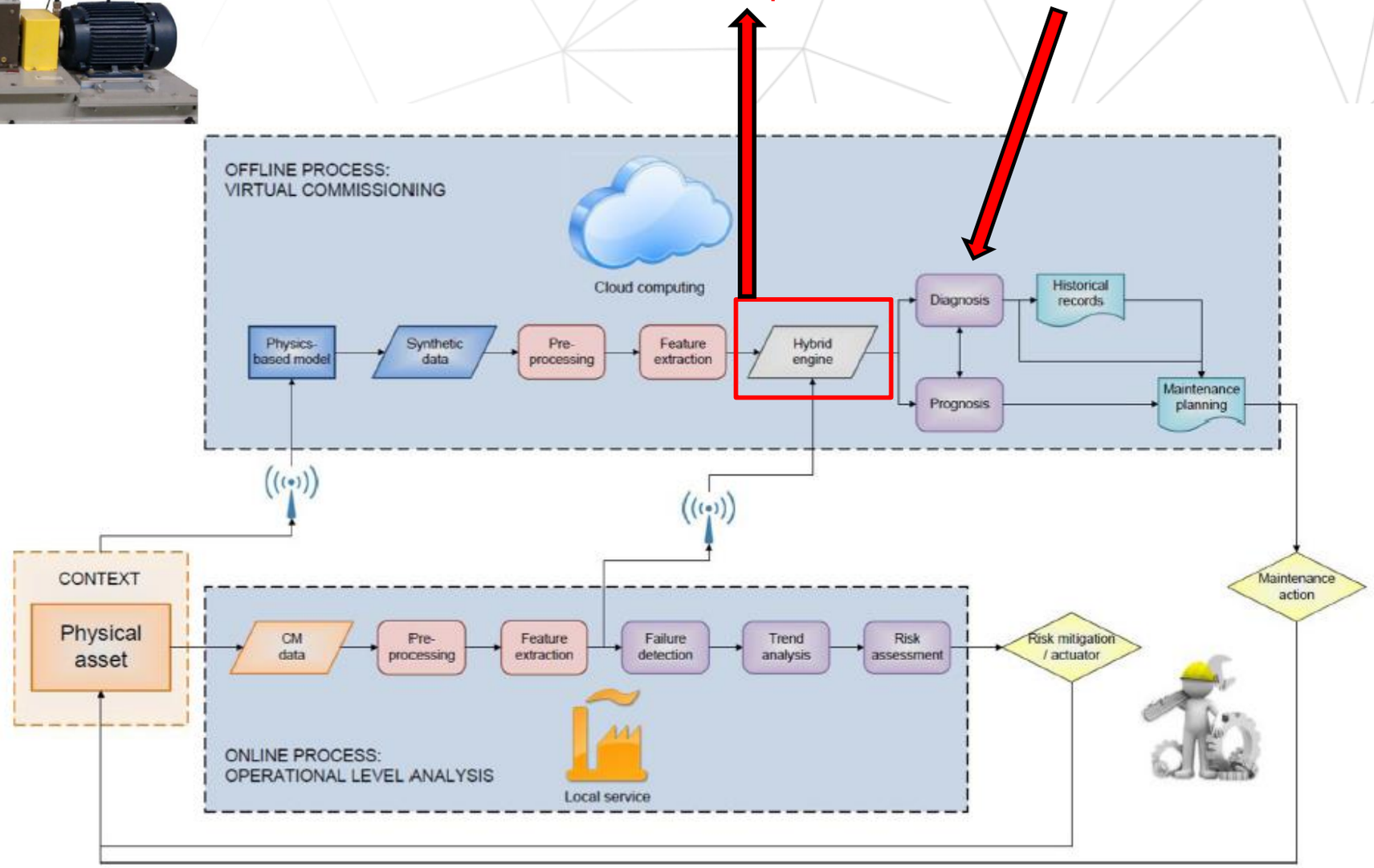
- the design of a combined prognostic algorithm with its hardware and software platform is not treated in the literature, where only the prognostics of a single component has been extensively analyzed
- Include the maintenance policies in the prognostic
- the literature lacks of a systematic analysis of the state of the art of prognostics approaches applied to machine tool systems

AN EXAMPLE FROM LITERATURE

Hybrid approaches: mechanical transmission and rolling bearing



cyber physical system (CPS) vs real system comparison → residuals



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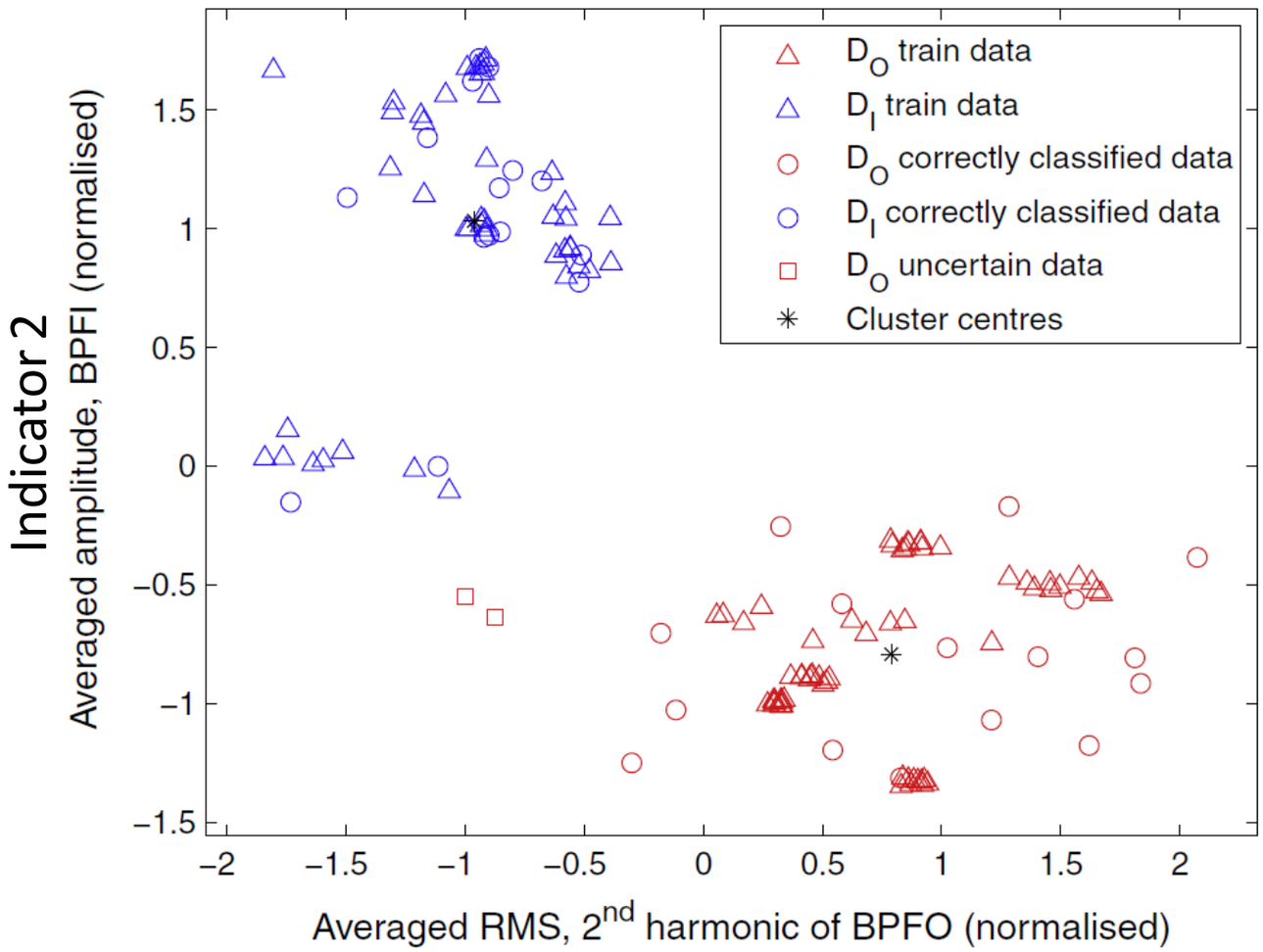


Indicator 1

Clustering techniques and AI: semi-supervised learning approach

The system is capable of correctly classify the defect

Limitations:

- Only rolling bearings and gearbox have been analysed
- Several data are necessary to train the system

MUSP ACTIVITIES

machinery level

SENSOR

SENSOR

sub-component level

fault statistics

Pareto Analysis

?

spindle systems

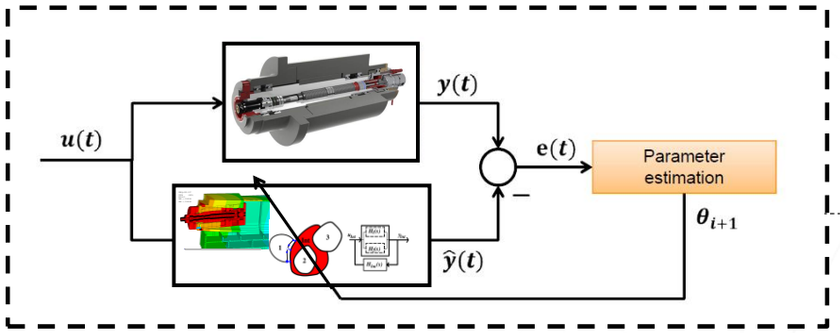
transmission axis system

hydraulic unit

....

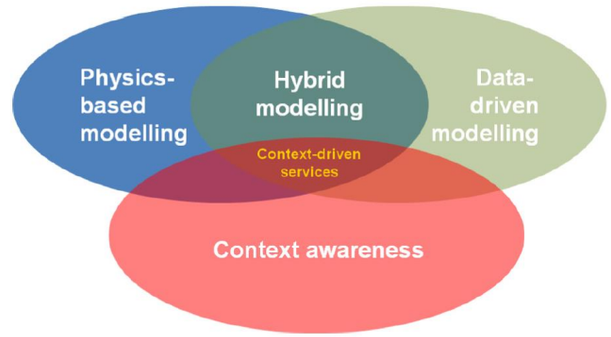
SPINDLE BEARING PROGNOSTICS

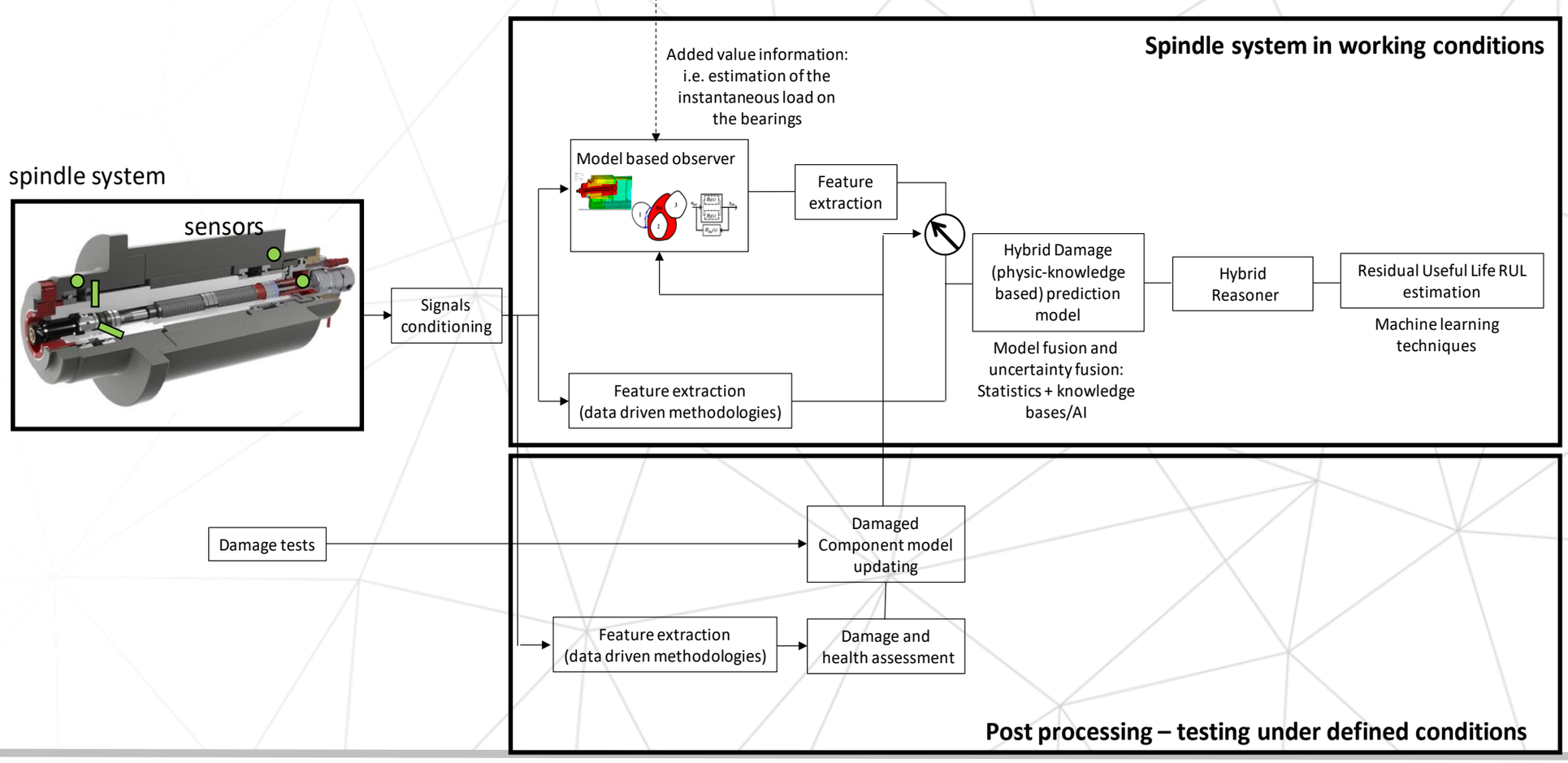
Initial system model identification procedure



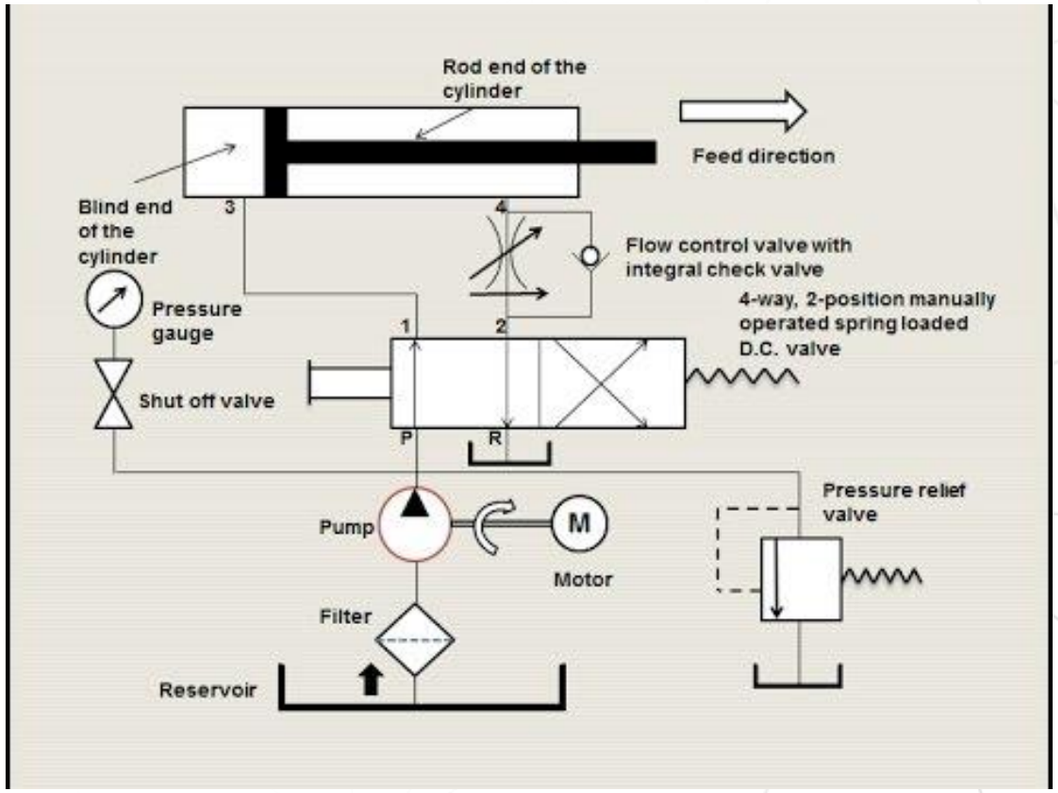
Hybrid modelling procedure:

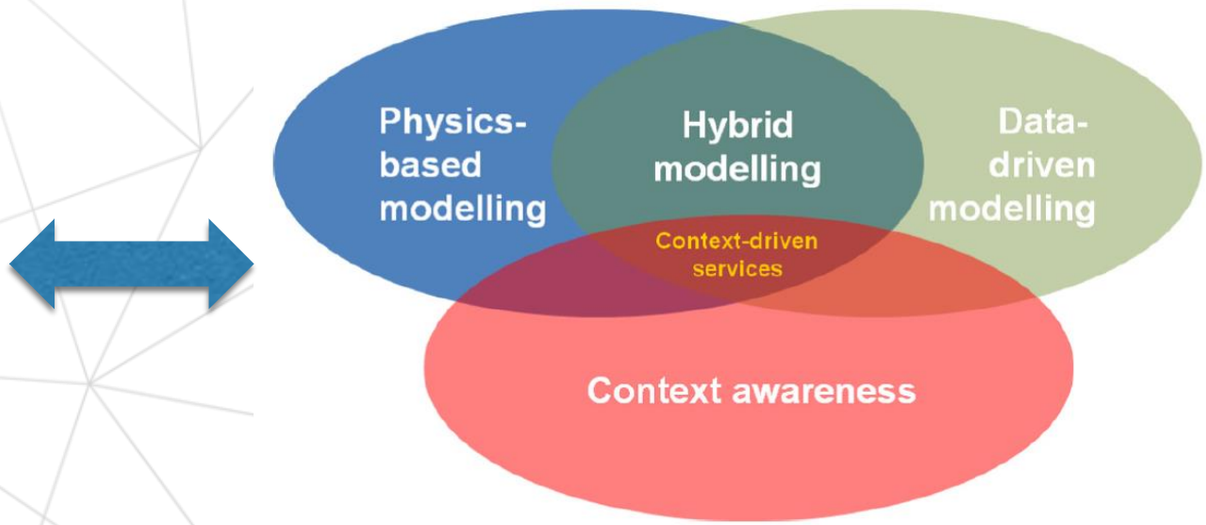
- experimental+analytica/FEM modelling
- substructuring





HYDRAULIC UNIT





THE WHOLE MACHINE