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Predictive Cognitive Maintenance Decision Support System

Workshop on Predictive Maintenance

Predictive Cognitive Maintenance Decision Support System (PreCoM)

PreCoM Presentation | Netherlands

23/01/2019 | Prof. Dr. Basim Al-Najjar, on behalf of PreCoM consortium

Linnæus University

HORIZON 2020

Project Details

PRECOMM
Predictive Cognitive Maintenance Decision Support System

Administrative Details

- Predictive Cognitive Maintenance Decision Support System (PreCoM)
- Horizon 2020-FOF09, Nov. 2017- Oct. 2020
- Novel design and predictive maintenance technologies for increased operating life of production systems (IA)
- Budget:
  - Project costs: 7,263,332 Euros
  - Max. EU funding: 6,146,402 Euros

Project Details

Consortium

Linnæus University

eMaintenance

PARAGON S.A.

SAVVY

VERTECH GROUP

Rexroth Bosch Group

SORALUCE

SAKANA

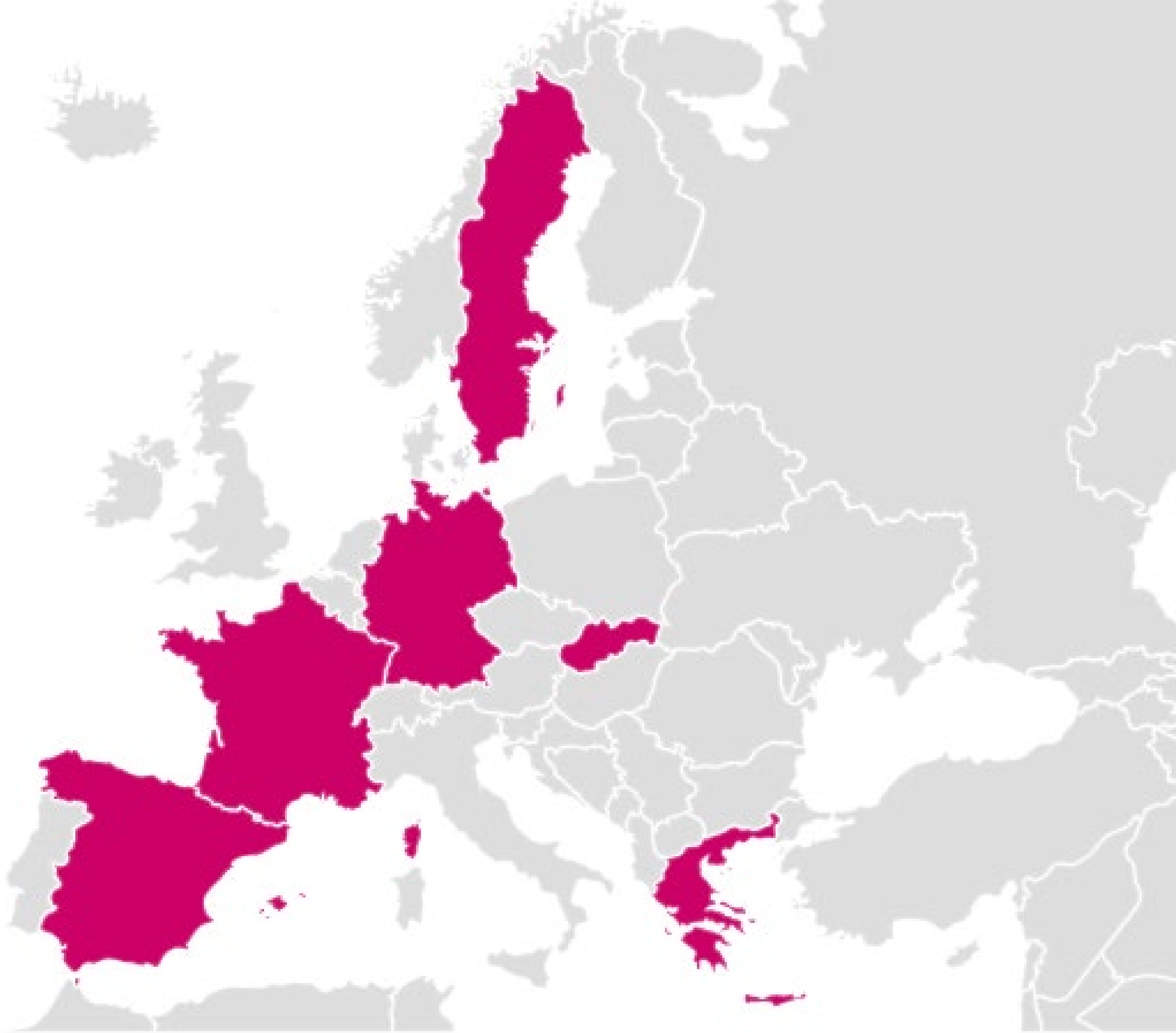
DANOBAT OVERBECK

SPINEA

GC GOMA-CAMPS

lantier®

IK4 IDEKO Research Alliance



FROM RESEARCH TO INDUSTRY cea

ITMATI

TUM

TECHNISCHE UNIVERSITÄT CHEMNITZ

Organisation

The consortium includes 17 partners:

- **3 end-user factories**

Sakana, Spinea, Goma-Camps

- **3 machine-tool suppliers**

Soraluce, Overbeck, Lantier

- **1 leading component supplier**

Bosch-Rexroth

- **4 innovative SMEs**

eMaintenance, Paragon, Savvy, Vertech

- **3 research organizations**

Ideko, CEA, ITMATI

- **3 academic institutions**

Linnaeus University, Technical University of Munich, Technical University of Chemnitz

Management structure

Governance

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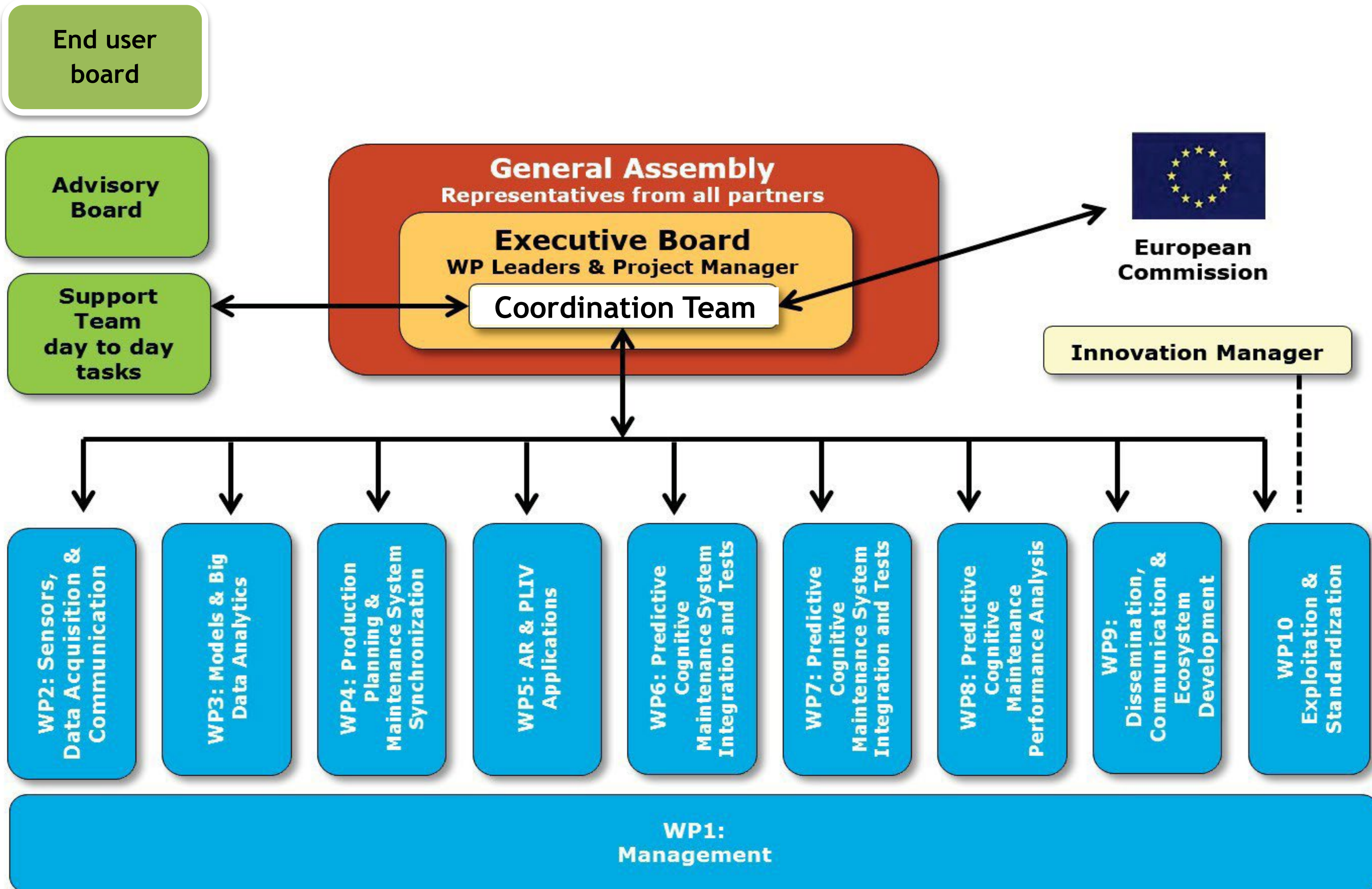
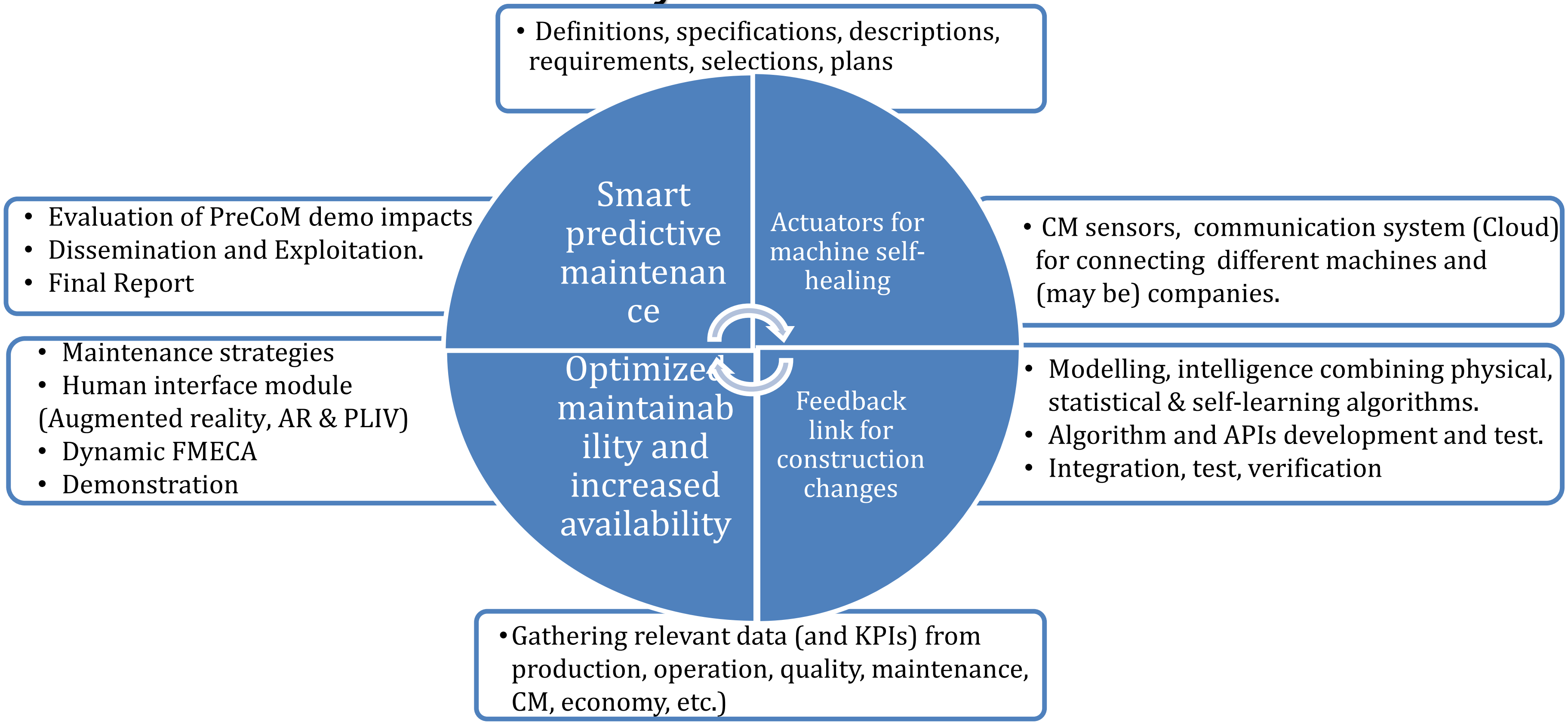


Project Theme

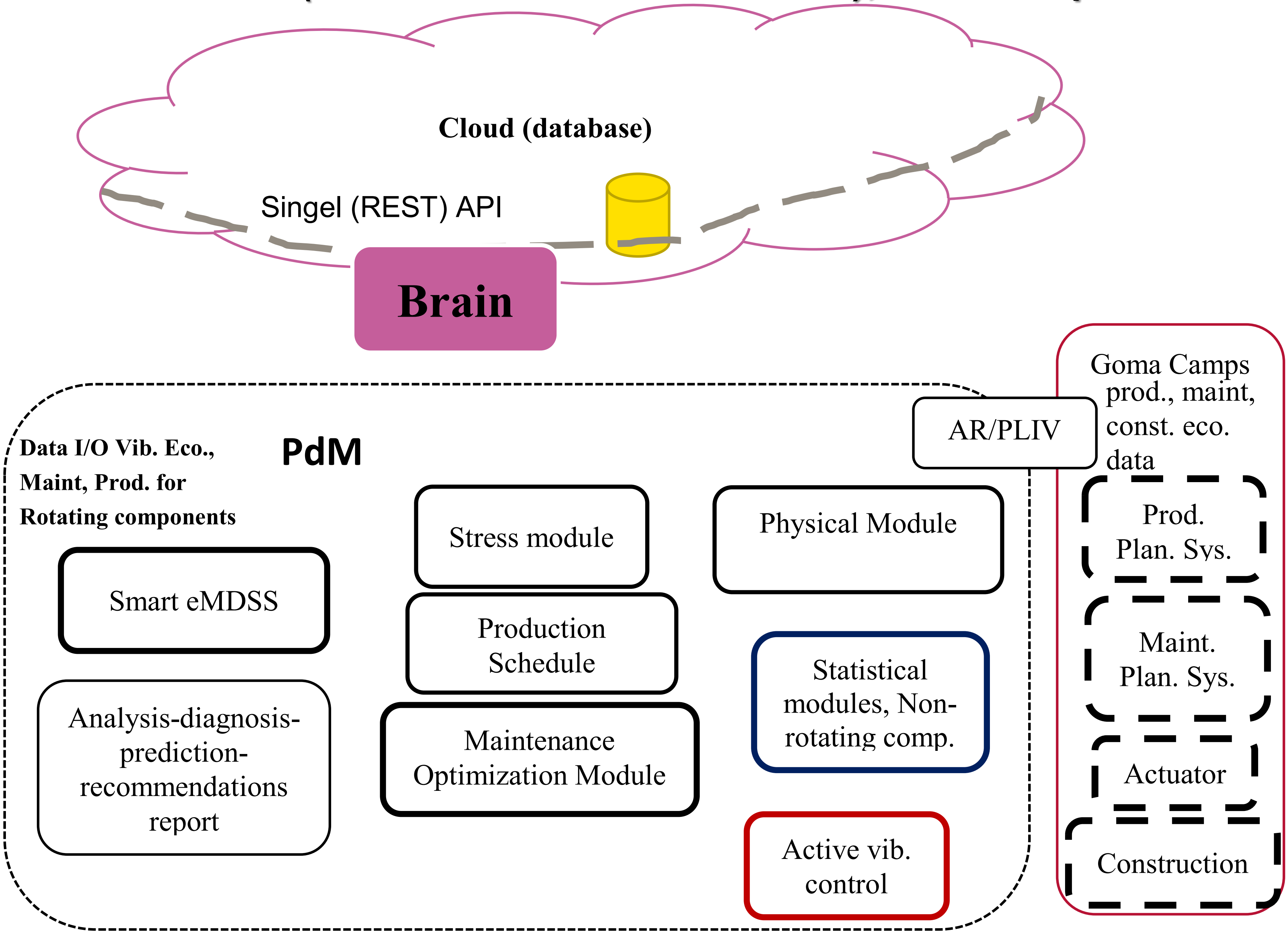


Project Details

Expected impacts

- **EFFICIENCY:** +10% increased in-service efficiency
- **MAINTENANCE:** Reaching 30% of time spent on predictive maintenance activities (from 15%)
- **WORKER SAFETY:** Reduction of failure-related safety accidents by 30%
- **ENERGY:** Energy usage reduction (range: -6 to -10%)
- **RESOUCES:** Raw material usage reduction (range: -7 to -15%)
- **STANDARDS**: Contribution to standards in development (PREN 17007 CEN, PREN 16991 CEN)

Communications (I/O data and recommendations), GomaCamps



WP2: Multi-sensor platform

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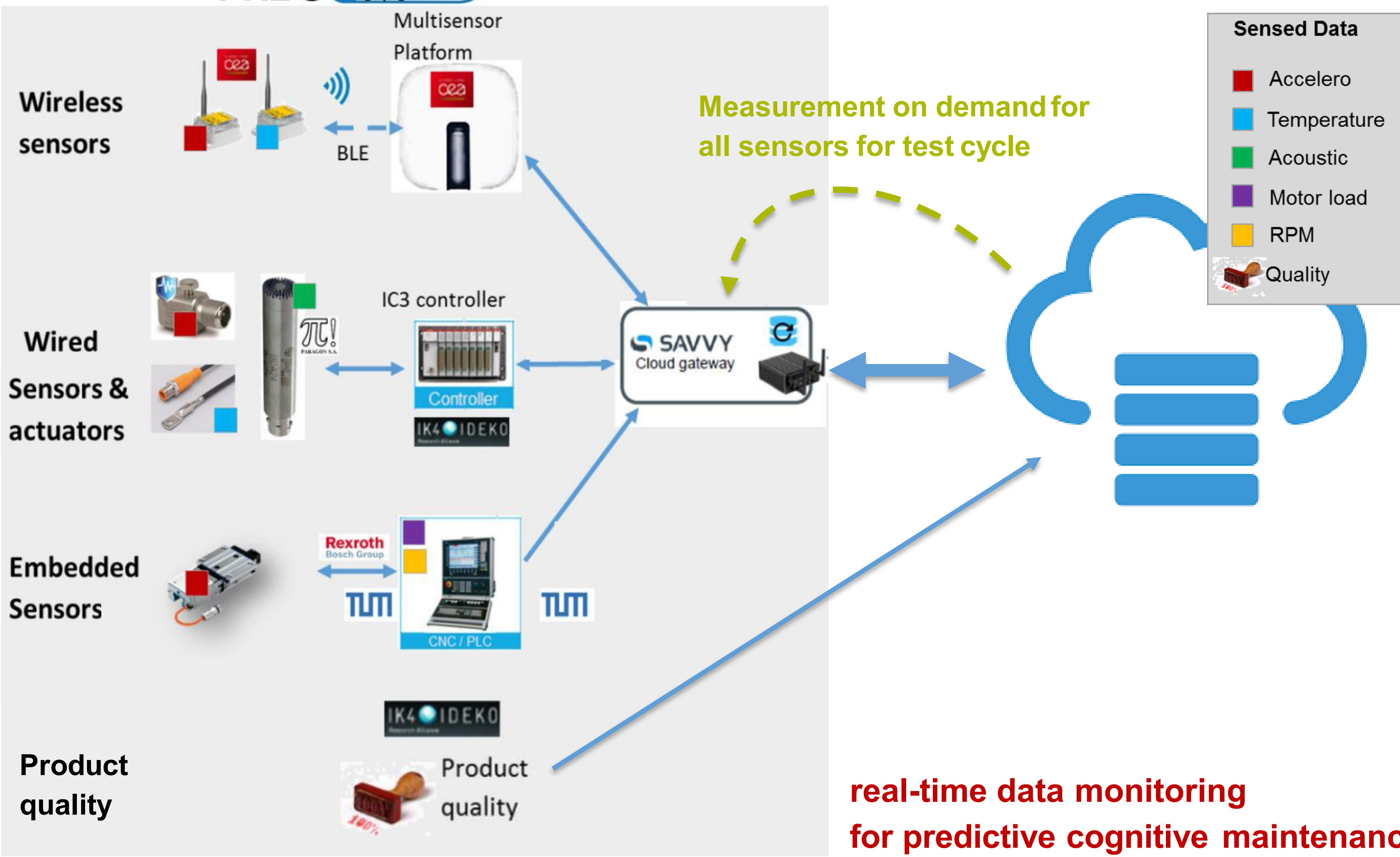
Vision of PRECOMM - Sense solution



real-time data monitoring
for predictive cognitive maintenance

WP2: Multi-sensor platform

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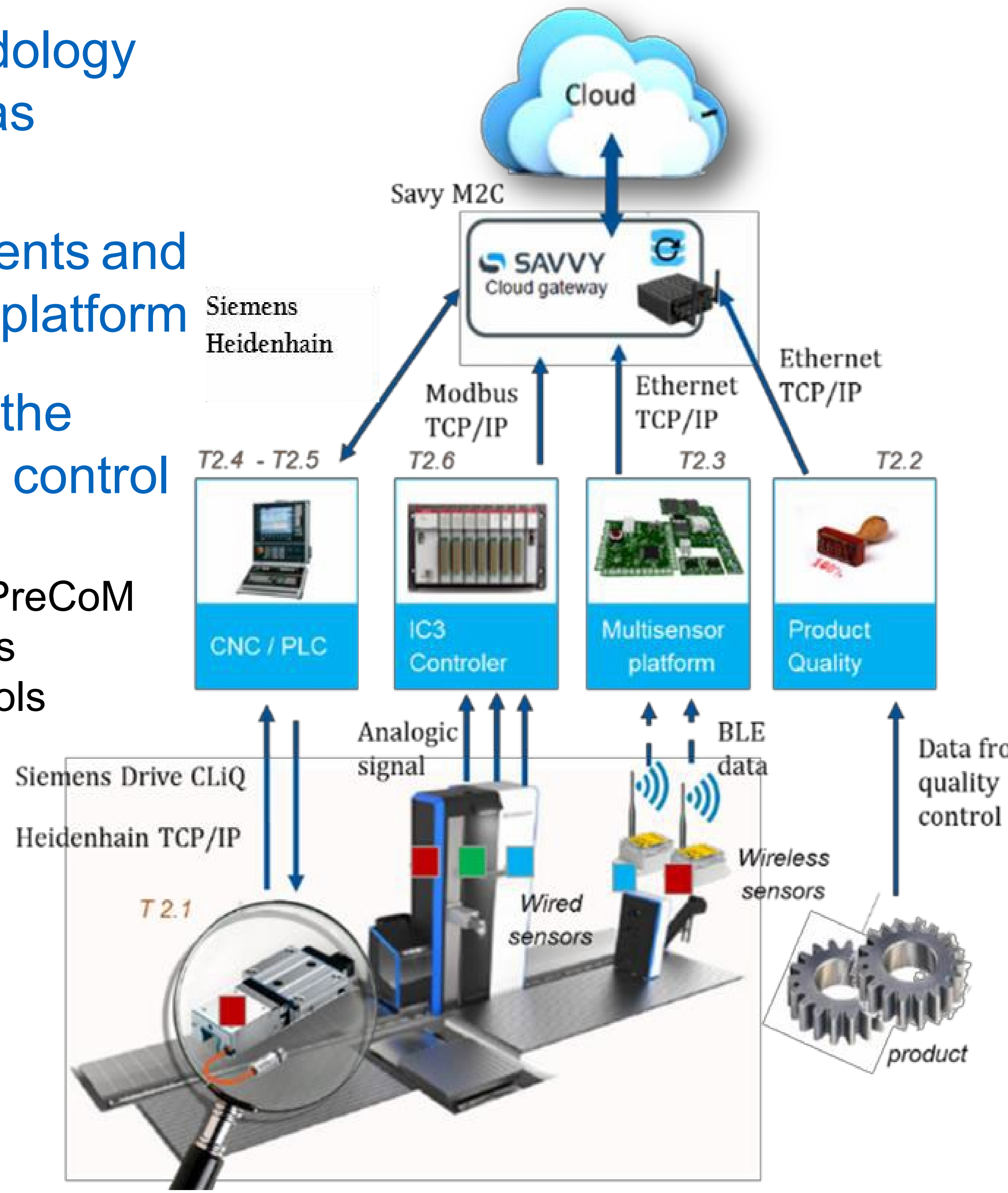
Task 2.2 Development of a methodology for evaluating the product quality as sensor signal

Task 2.3 Definition of the requirements and interfaces for the external sensing platform

Task 2.4 Communication between the sensor platform and the numerical control system

Integration of machine tool controls in the PreCoM sense platform. Integration of both Siemens (Overbeck) and Heidenhain (Spinea) controls

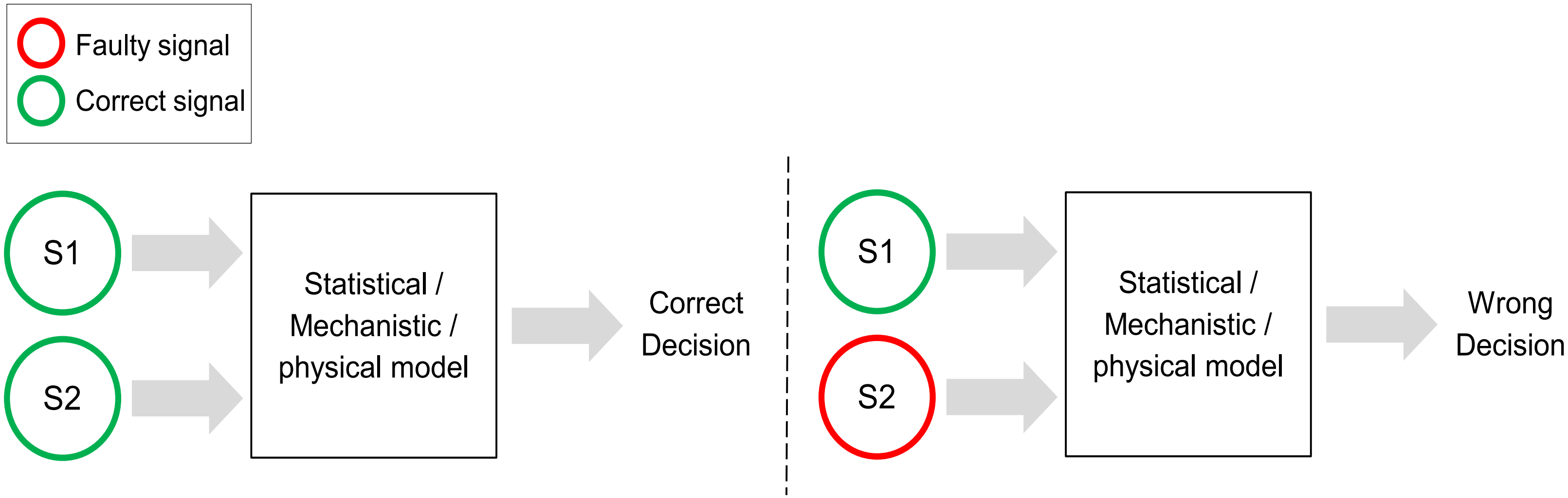


WP3: Models & Analytics
D3.2 Physical Model

A) Virtual Sensors

1. All PreCoM-AI modules rely on correct sensor signals
2. In case of faulty sensor signals the modules potentially produce wrong decisions
3. A system for monitoring the sensors‘ condition is needed

➢ Virtual sensors can assess the condition of the installed sensors by exploiting the sensor redundancy



WP3: Models & Analytics

D3.3 Statistical Model

Predictive Cognitive Maintenance Decision Support System

A) Statistical Models for prediction the condition of **rotating components**

Statistical tools for predicting vibration level and machine probability of failure

mechanistic model for predicting the vibration-level

(Smart eMDSS) PreVib Software

Total-Time-on-Test (TTT) Plots for Assessing Probability of Failure and Residual Time

(Smart eMDSS) ProLife Software

PreVib including the mechanistic model: It aims to detect damages in components at an early stage and predict its development in the near future in order to keep the probability of failure low and plan maintenance action with enough lead time.

$$Y_{i+1} = X_i + a * Exp(b_i * T_{i+1} * Z_i^{c_i}) + E_i$$

TTT Plots (ProLife): It is a probabilistic approach aims to assess the probability of failure and residual life of a machine/component.

$$T_i = \sum_{j=1}^{i} (n - j + 1)(t_j - t_{j-1})$$

WP3: Models & Analytics
D3.3 Statistical Model

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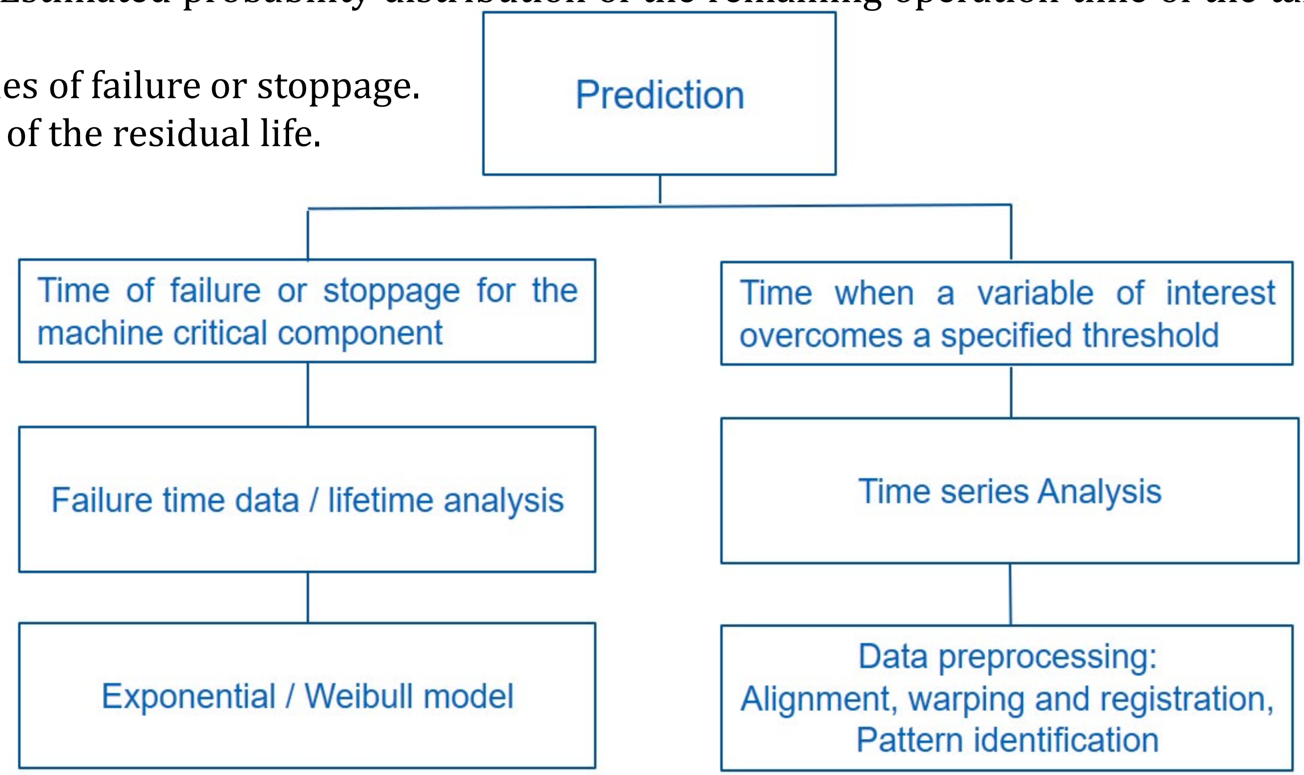
B) Statistical Models for prediction the condition of **non-rotating components**

- Time Series Analysis (TSA):
  1. Point and interval prediction of the variable of interest.
  2. The probability and the time that the predicted values overcomes a specific threshold at the time $t + h$
- Life Time Analysis (LTA):
  1. Mean
  2. residual lifetime. Estimated probability distribution of the remaining operation time of the targeted component.
  3. Future probabilities of failure or stoppage.
  4. Specific quantiles of the residual life.



WP4: Production Scheduling

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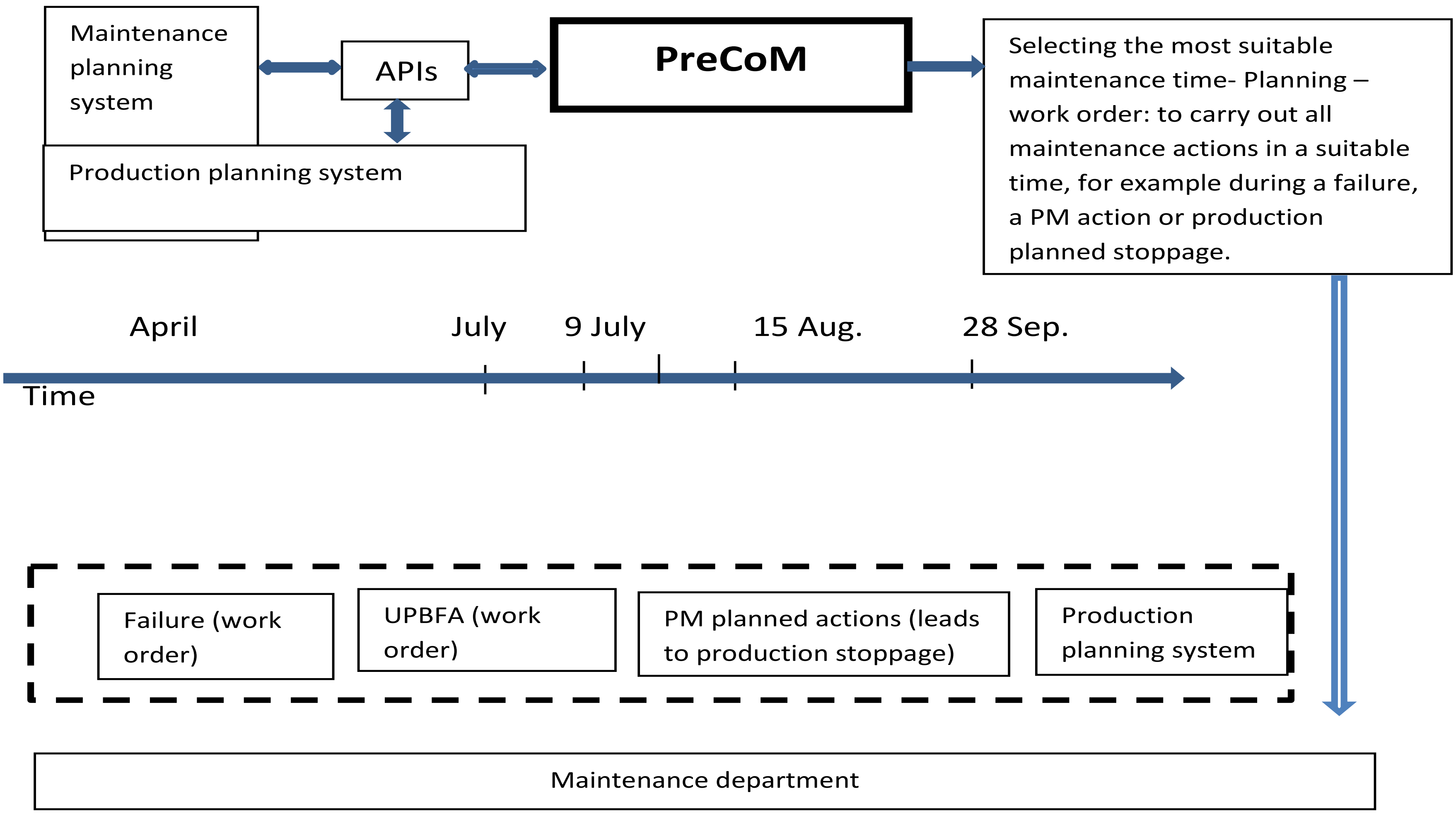
Black Box View

Work Package Overview

Input Information	WP4	Output Information
PdM Information Vibration and temperature measurements	Dynamic production scheduling depends on machine condition	• Optimal time for maintenance actions when different maintenance strategies are used, e.g. PM, BD, CBM and PreCoM recommendations • Production Schedule which respects machine condition • Synchronisation of maintenance and production planning to reduce no. of stoppages.

WP4: Production Scheduling

Main results

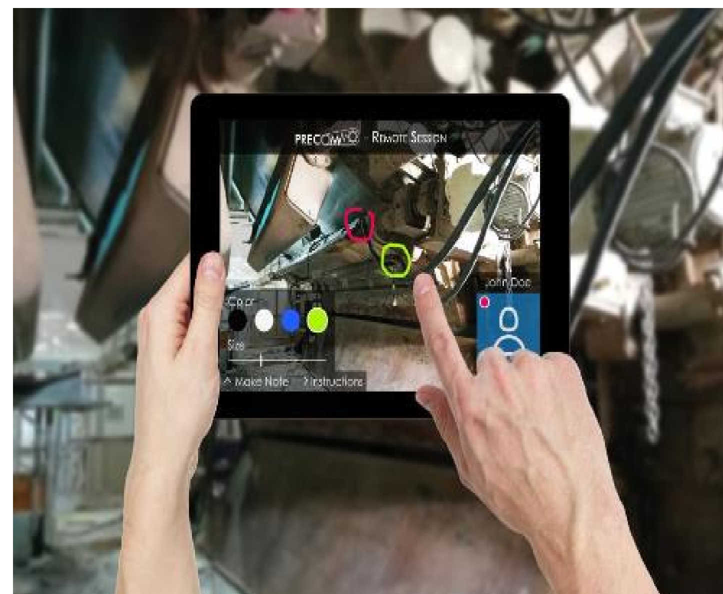


WP5: AR & PLIV Applications

Predictive Cognitive Maintenance Decision Support System

We are connecting the users to the system!

- Development of an Augmented Reality (AR) application to support the maintenance worker on-site for case companies
- Development of a Production Line Information Visualization (PLIV) application to support the maintenance and production managers

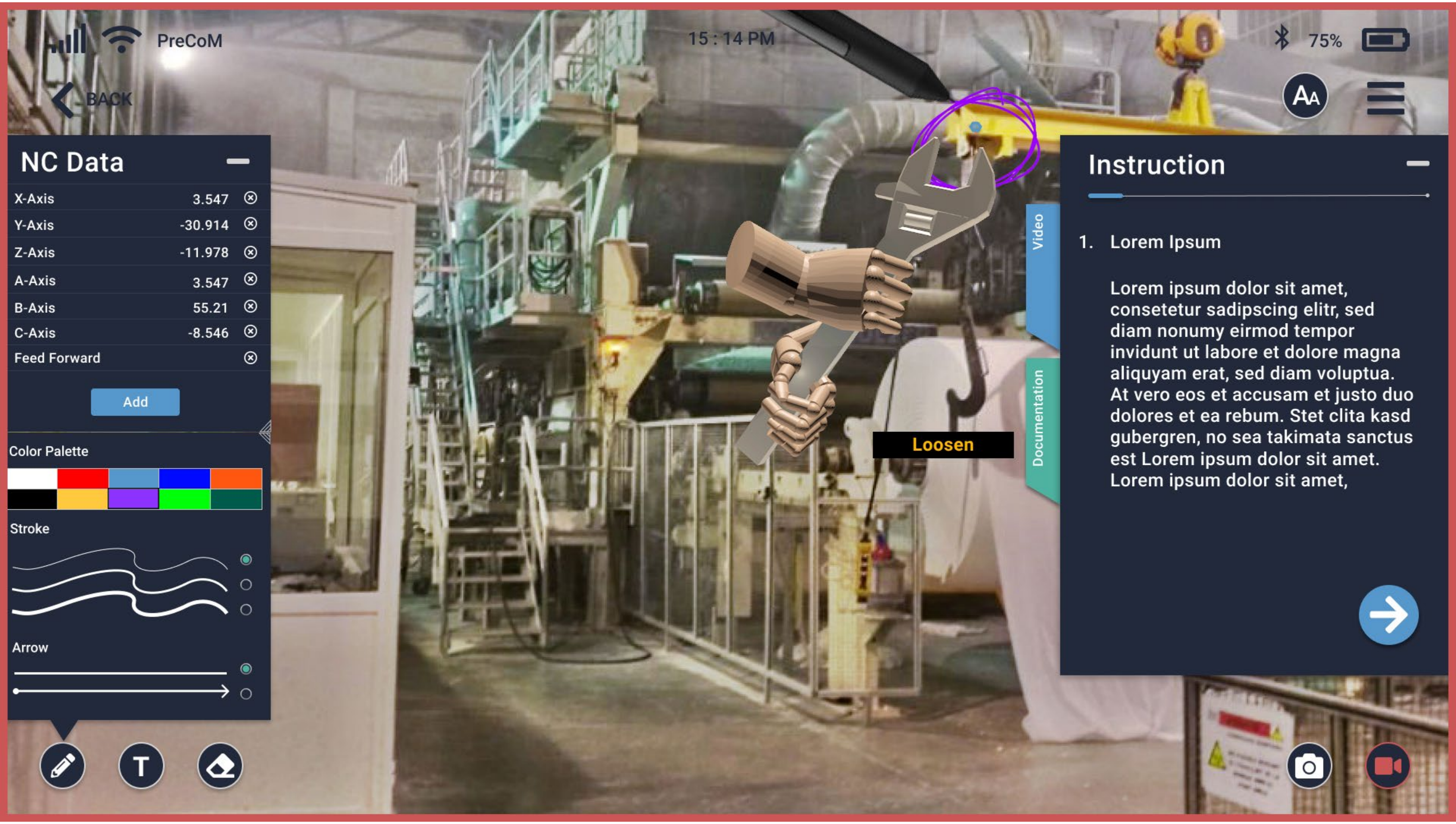


Reduce Maintenance execution time

WP5: AR & PLIV Applications

Predictive Cognitive Maintenance Decision Support System

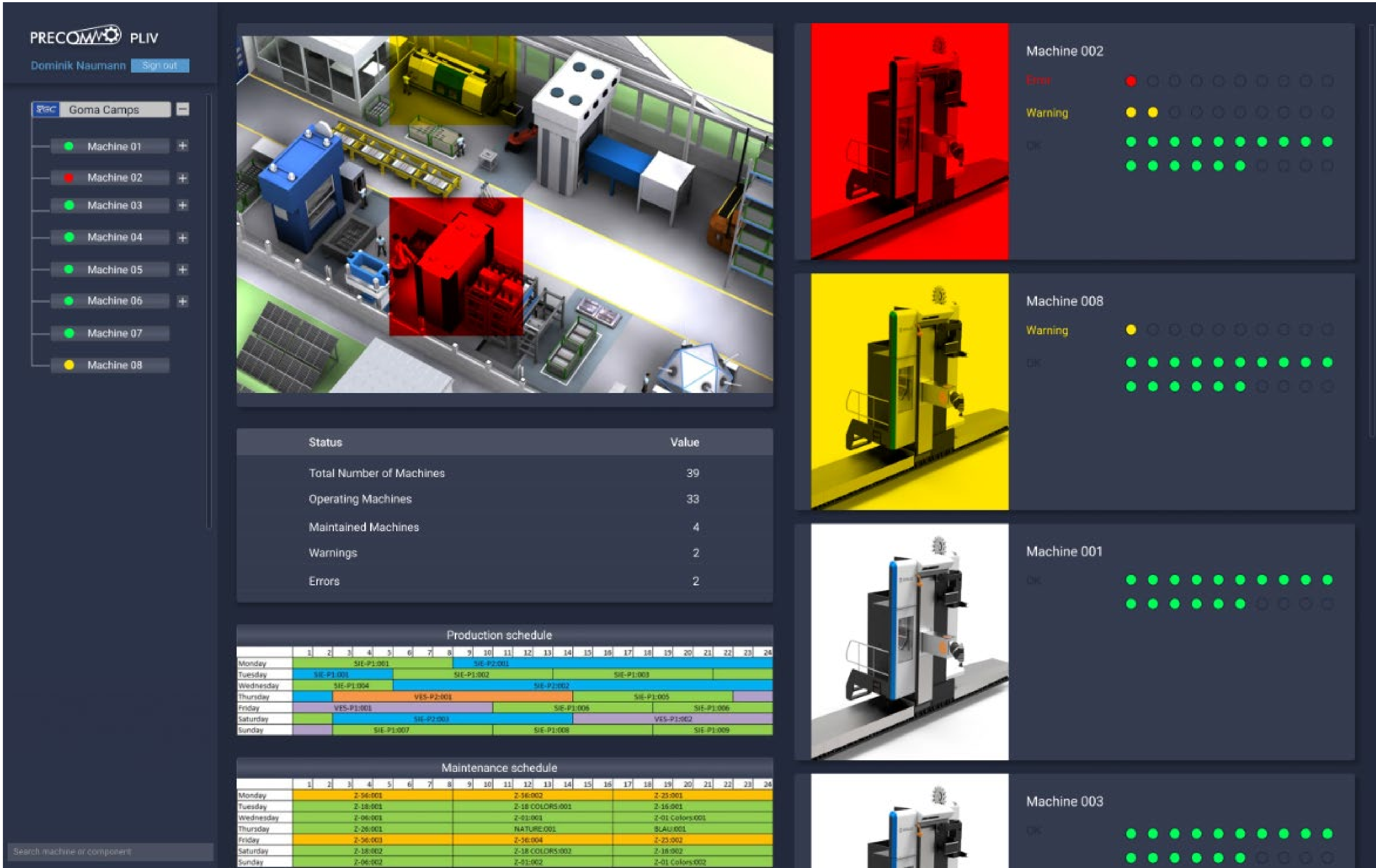
ARGS



WP5: AR & PLIV Applications

PLIV

Predictive Cognitive Maintenance Decision Support System



WP6: Integration of Modules

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Software Modules and hardware to be Integrated	Number
1. Statistical model	2
2. PreVib	1
3. MainSave	1
4. Prolife	1
5. Physical model	1
6. Stress model	1
7. Production scheduling	1
8. Maintenance optimisation	1
9. ARGS	1
10. ARRS	1
11. PLIV	1
12. Active vibration control system	0
13. Actuators	0
14. PreCoM Brain	1
15. Modal Tracking for SHM	1
16. Integration with databases of: Production; Maintenance; economic API/ID	9
Total	**23**
Hardware Modules	
I. IC3 Wired sensor Platform	0
II. Wireless multi-sensor Platform	0
III. Raw Data	1
Other	
Total	**24**

WP6: Integration of Modules

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D6.1
Integration of the 13 modules:
These modules will communicate and share data through a single REST API to manage the import and export of data in the PreCom database from all modules and data sources (production, maintenance, etc.).

- One single line of communication – with the REST API administrator which will structure uniform communication
- Development, adjustments or changes are easily catered for
- future development and ease of maintenance
- Module owner is responsible for data security/integrity of its module, and within its module.

WP6: Integration of Modules

D6.2: Development of secure data interfaces with production systems

D6.3: Development of secure data interfaces with maintenance systems

D6.4: Development of secure data interfaces with other systems

- Design the database used for storing/sharing data between the modules.
- Start implementing triggers and rules for actions, how and when to derive information and timeliness for the actions within PreCoM (Emaint)

WP7: Demonstrators

Workflow organization during demonstration

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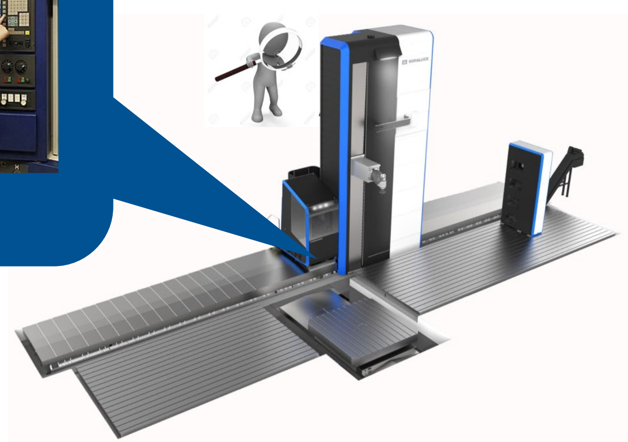
Test cycle (diagnostic measurement)

Operator launches cycle in the machine → Spindle starts rotating → Sensing platform acquisition starts → PreCoM module run → Recommend ation



Data (Hz, rpm…)

End users will support PreCoM Brain in order to validate PreCoM output.

WP8: Performance Analysis

LCA and LCC: tools to assess how PreCoM system contributes to improve the environmental as well as the profitability and competitiveness of the company.

PreCoM as decision support system at maintenance level can influence:

- Availability and maintainability: It reduces failures and unnecessary stoppages, and shortening repair time: prolonged production time and increased production,
- Losses: It reduced wastes and costs for components replacements
- Organizational: Reduced need for specialized technicians (vs in-house technicians) and improve working environment.
- Environmental: Reduced emission for transportation and reduced costs for assistance
- Economic: It reduces losses in production time through reducing unnecessary stoppages
- Performance: Improved performances of the machines: increased productivity through maintaining cycle time needed to produce one item.
- Energy: It reduces losses in energy consumptions and environment impact
- Quality: Reduced defective items due to inefficient maintenance. reduced wastes and reduced costs

Environmental impacts **Company's profit**

WP8: Performance Analysis

Next steps (Tasks 8.3 and 8.4)

- **Life cycle inventory (LCI):** technical process of *data collection* (M13-M18 aprox).
  - Quantification of the inputs and outputs within the technosphere, as defined in the system boundaries. Sum of elementary flows entering the system and releasing into the environment.
  - Quantification of the costs, saving and revenues.

Final remarks

Strengths

- **Goal-oriented R&D work:** the complexity of the PreCoM system improved considerably, compared to the initial project proposal. Thanks to the joint collaboration between all partners, we designed a complex system which covers ideally all expected impacts and industry needs.
- **Innovation for end-users:** the interaction with demonstration companies and industry partners was highly beneficial for conducting real R&D work and adapting the PreCoM system design to their actual needs and improve the chances of success.
- **Support from European Commission:** we have been in continuous relations with the Project Officer and our Monitor, who always provided valuable feedback and recommendations for our work.

Final remarks

Challenges

- **Heterogeneity of consortium:** working with partners from very different backgrounds (e.g. applied sciences, theoretical sciences, industry), experience levels and actual interests (e.g. R&D, scientific research, manufacturing) needs a lot of work in coordination and harmonisation.
- **Interdependence of R&D activities:** each WP/task is strictly influencing and/or influenced by other WPs/tasks, thus pending issues in one activity impacts the overall project work.
- **Duration of demonstration:** although we are doing our best to respect the original work plan, the demonstration period seems a bit compressed (8-10 months max.), with consequent pressure for the final evaluation of the PreCoM system.

Thanks for your attention

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