



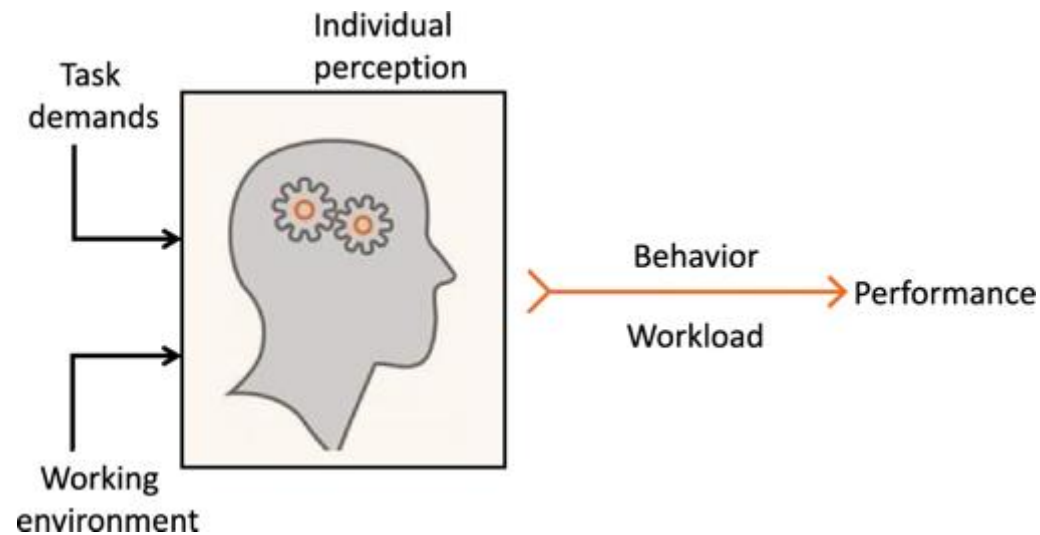
DEcision Support system for the Diagnosis and Evaluation of the Maintenance Operations Activities

DESDEMONA

Analytical model development (WP3)

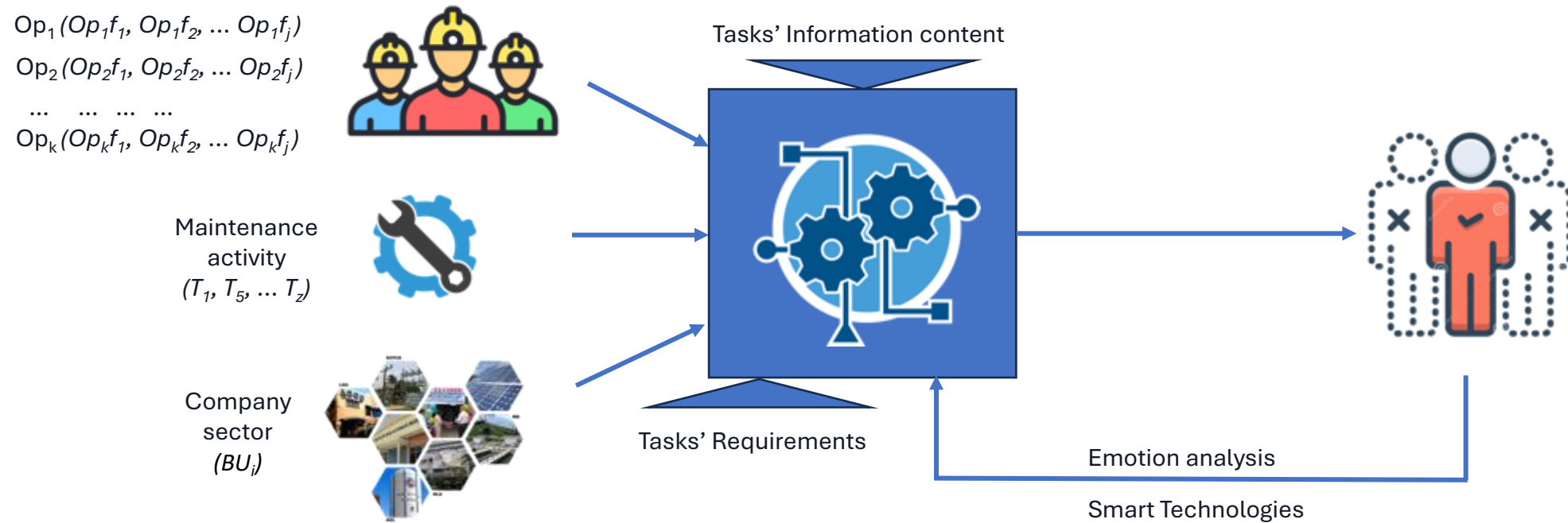
WP leader POLIBA

Update July 2024



Das Chakraborty, D., Roy, P. P. Cognitive workload estimation using physiological measures: a review. Cogn Neurodyn (2023). <https://doi.org/10.1007/s11571-023-10051-3>

Cognitive Analytical model



Road-map



Work package 3

WP3 Analytical Model Development (WP leader POLIBA, participant all) [30/01/2024-30/07/2025]

+ T3.1 Identification of maintenance tasks: identify a list of (at least) 20 maintenance tasks with cognitive needs to be assessed. The role of the associated companies (i.e., Bosch, Cestaro Rossi, and AIMAN) will be crucial in assisting the academic partners in identifying the most critical tasks (*1st August 2024*).

1. **Twenty tasks (T_2) will be identified** by literature review and industry experts, the task is defined as a single operation belonging to a complex maintenance activity (e.g. inspection of a hydraulic circuit, checking a fluid level in a tank, filter replacement, etc.).
2. **The tasks will be shared with associated companies** to assess their consistency with more common maintenance practices.

	BIM1	BIM2	BIM3	BIM4
WP3 - ANALYTICAL MODEL DEVELOPEMENT (WPL: POLIBA)				
T3.1 Identification of maintenance tasks				

Actual end
10/04/2024

Planned end
30/07/2024

Work package 3

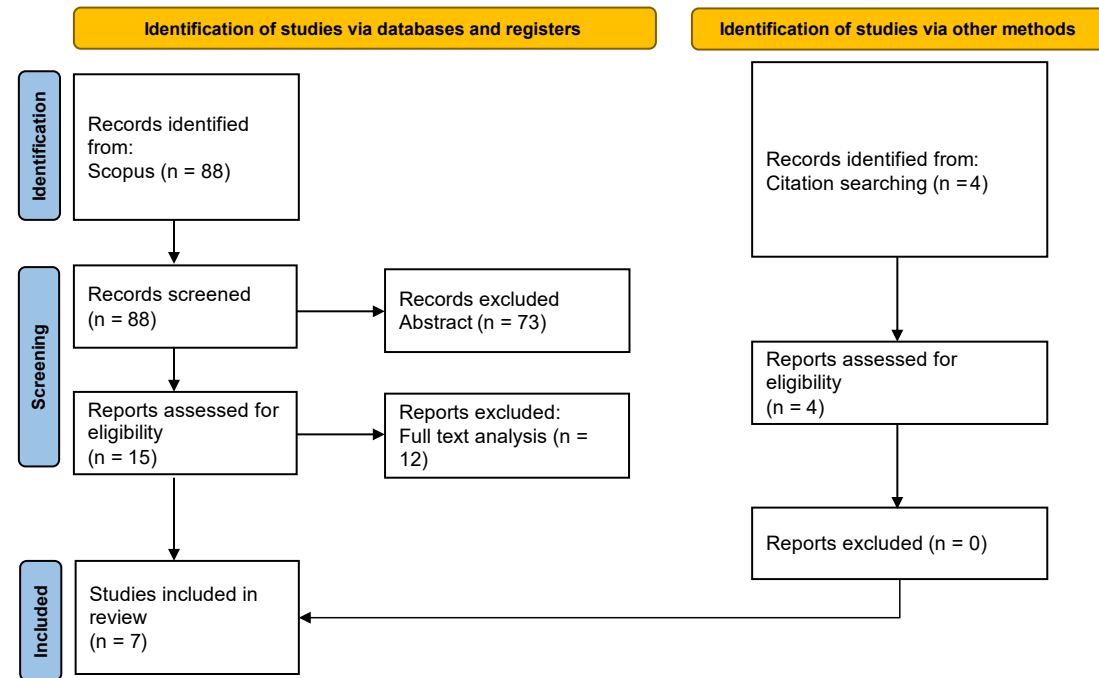
T3.1 Identification of maintenance tasks [30/01/2024-30/07/2024]

- To reach the research objective, i.e., identifying the main maintenance tasks carried out in an I4.0 (5.0) context, a **Systematic Literature Review** was conducted following the **PRISMA** methodology (Moher et al., 2009).

Identification: TIT-AB-SKEY (“maintenance" AND "task" OR "activity" AND "Industry 4.0" OR "Industry 5.0" AND "description" OR "classification" OR "taxonomy" OR "type”)

Screening: The documents have been screened by analysing their titles and abstracts and have been selected for full-text reading if they met one eligibility criterion., i.e., if they mentioned the description of maintenance procedures, routines, activities or tasks.








Included: 12 papers have been excluded, resulting in a sample of 3 papers. Moreover, 4 papers identified through the snowballing approach have been added to the final sample of documents. Finally, 7 studies have been included



Work package 3

T3.1 Identification of maintenance tasks [30/01/2024-30/07/2024]

The identified papers have been analysed according to different dimensions:

- 
+ Maintenance tasks identified.
- 
+ Reference maintenance activity.
- 
+ Industry in which the maintenance activity is carried out.
- 
+ Maintenance policy (i.e., Predictive, Preventive, Corrective).
- 
+ Physical/Cognitive nature of the identified maintenance task.
- 
+ I4.0 supporting technologies mentioned.
- 
+ Classification of the identified maintenance task according to the EN 13306:2017 taxonomy.

Work package 3

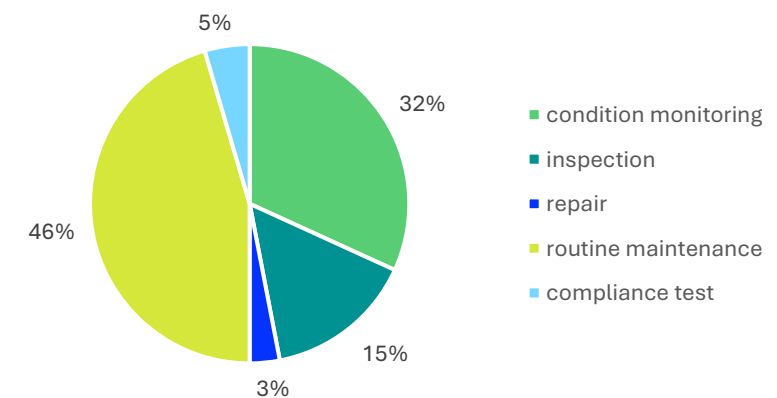
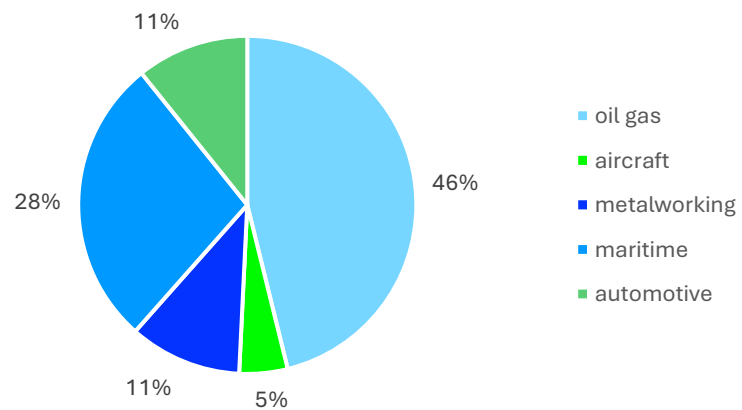
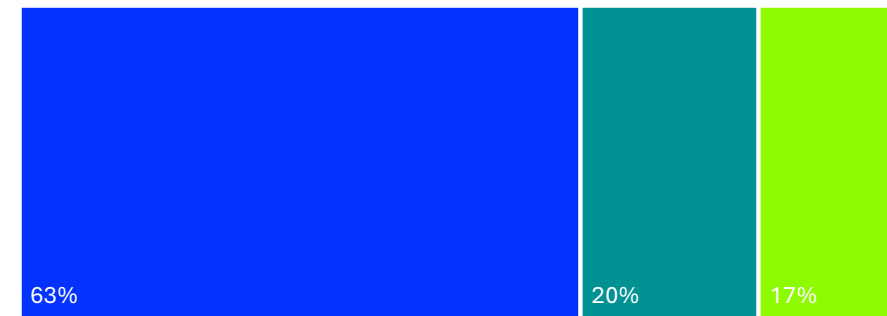
T3.1 Identification of maintenance tasks [30/01/2024-30/07/2024]

Descriptive analysis

■ predictive
 ■ preventive
 ■ corrective



■ cognitive
 ■ physical
 ■ cog/phys



Work package 3

T3.1 Identification of maintenance tasks [30/01/2024-30/07/2024]

- + To categorize and group the 65 identified maintenance tasks in 20 maintenance tasks, the Sort, Label, Integrate and Prioritize (SLIP) methodology has been applied (Maeda, 2006).
- + The final list of 20 maintenance tasks is:



- | | |
|--|---|
| 1. Interpretation Of Data Trend | 11. System Disassembly |
| 2. Visual Inspection Based On Image Comparison | 12. (Preventive) Replacement Of Macro-Components |
| 3. Visual Inspection Based On The Physical Component | 13. System Reassembly |
| 4. Repair Of Mechanical Failures | 14. Lock Out/Tag Out |
| 5. Repair Of An Electrical Fault | 15. Mechanical Isolation |
| 6. Control Using Technical Instrumentation | 16. Electrical Isolation |
| 7. Monitoring Of Single Values | 17. Mechanical Reconnection |
| 8. Precision Cleaning | 18. Electrical Reconnection |
| 9. General Cleaning | 19. Test Performance |
| 10. (Preventive) Replacement Of Micro-Components | 20. Certification Of Maintenance Activities Performed |

Work package 3

WP3 Analytical Model Development (WP leader POLIBA, participant all) [30/01/2024-30/07/2025]

- + T3.2 Clustering of the key maintenance operators' features: A set of key maintenance operators' features (e.g., competencies, training level, role, age, ergonomics requirements, etc.) will be collected using a survey on a sample of employments of (at least) 8 companies. Thus, cluster analysis will identify the features most impactful to human performance in maintenance operations (*30th September 2024*).
1. A preliminary survey with eight companies (i.e., C_A, C_B, \dots, C_H) of different business areas will be conducted **to identify the most impactful operator's feature needed to accomplish the specific task** (i.e. training level, role, age, etc.).
 2. **(at least) One respondent for each company will be identified** as an 'expert/s'.
 3. **A questionnaire will be developed** to assess the impact of each "operator's feature" related to the single task.

Work package 3

WP3 Analytical Model Development (WP leader POLIBA, participant all) [30/01/2024-30/07/2025]

- + T3.2 Clustering of the key maintenance operators' features: A set of key maintenance operators' features (e.g., competencies, training level, role, age, ergonomics requirements, etc.) will be collected using a survey on a sample of employments of (at least) 8 companies. Thus, cluster analysis will identify the features most impactful to human performance in maintenance operations (*1st October 2024*).
4. The questionnaire will be structured with “MS Forms[®]”, and all replies will be organized according to the **Likert-scale** approach; It will be shared with each company's expert. Each expert will provide a value in the range of 1 (low important)-5 (high important) **to assess the importance of each “operator’s feature” needed to accomplish the task** (e.g., how important is the training level of the operator for this task? ... the role? .. the age? etc.).
 5. The results of the questionnaire will be collected, analyzed and elaborated in **twenty matrices** (one per task).

Closing of questionnaire

30/08/2024

	BIM1	BIM2	BIM3	BIM4	BIM5	
WP3 - ANALYTICAL MODEL DEVELOPEMENT (WPL: POLIBA)						Planned and 30/09/2024
T3.1 Identification of maintenance tasks						
T3.2 Clusterization of the key maintenance operators' features						

Work package 3

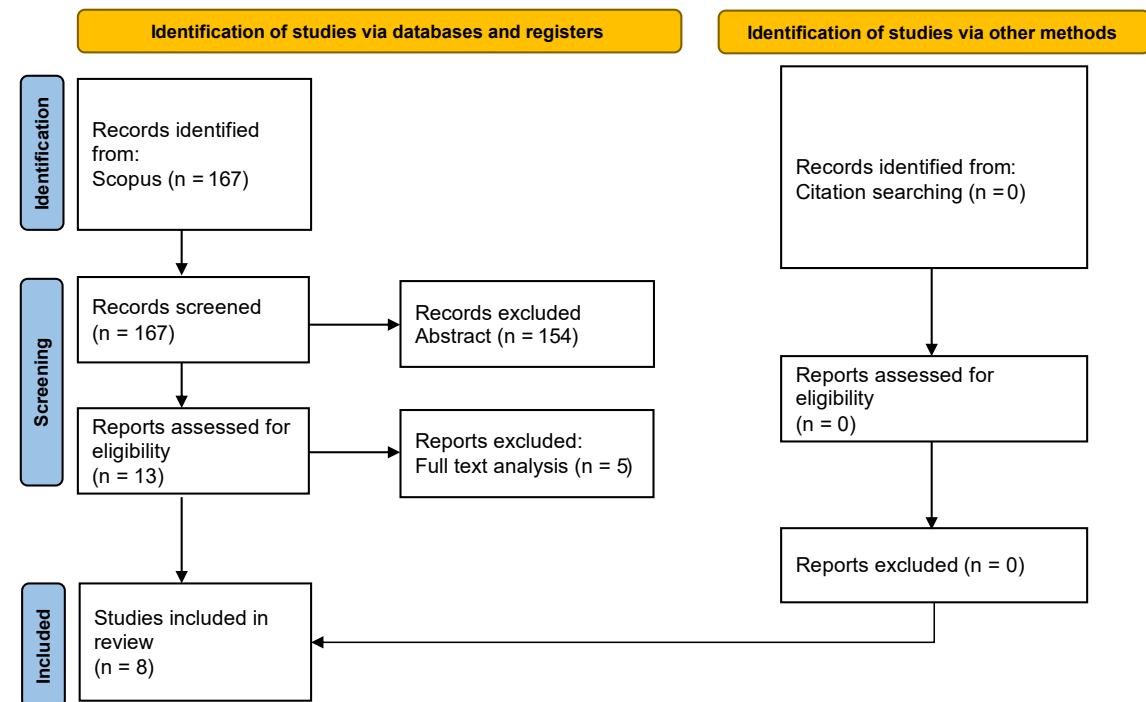
T3.2 Clustering of the key maintenance operators' features [30/03/2024-30/09/2024]

- To reach the research objective, i.e., identifying features most impactful to human performance in maintenance operations , a **Systematic Literature Review** was conducted following the **PRISMA** methodology (Moher et al., 2009).

Identification: TIT-AB-SKEY ("operator" AND "featur*" OR "characteristic*" OR "skill*" AND "task" OR "activity" AND "accomplishment" OR "error" AND "manufacturing" OR "production" OR "maintenance")

Screening: The documents have been screened by analysing their titles and abstracts and have been selected for full-text reading if they met one eligibility criterion., i.e., if they mentioned the operator's skills/features needed to accomplish tasks.





Included: 5 papers have been excluded, resulting in a sample of 8 papers.



Work package 3

T3.2 Clustering of the key maintenance operators' features [30/03/2024-30/09/2024]

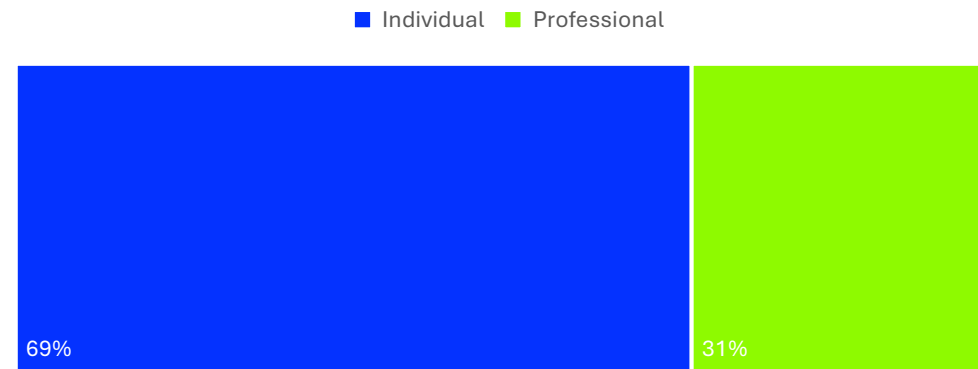
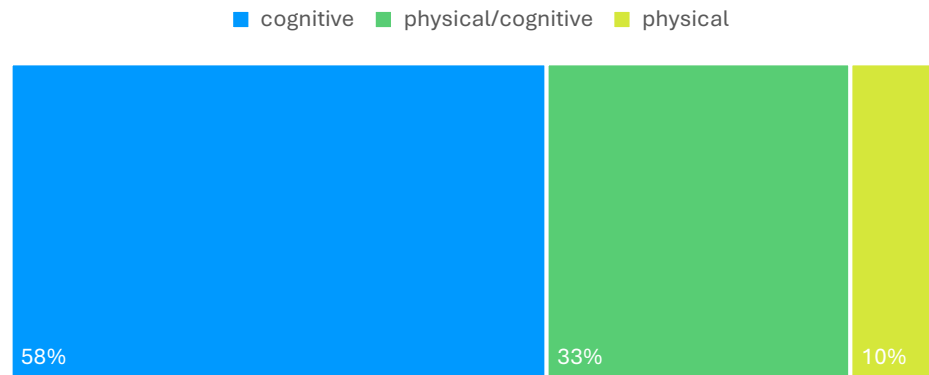
The identified papers have been analysed according to different dimensions:

-  + Reference maintenance activity.
-  + Industry in which the maintenance activity is carried out.
-  + Physical/Cognitive nature of the identified feature.
-  + Individual/Professional nature of the identified task.

Work package 3

T3.2 Clustering of the key maintenance operators' features [30/03/2024-30/09/2024]

Descriptive analysis



Work package 3

T3.2 Clustering of the key maintenance operators' features [30/03/2024-30/09/2024]

- + To categorize and group the 52 identified features, the Sort, Label, Integrate and Prioritize (SLIP) methodology has been applied (Maeda, 2006).
- + The final list of the 9 identified features is:



1. Memory
2. Level of professional training
3. Level of education
4. Ability to work under pressure/stress
5. Ability to organize assigned work
6. Soft skills (teamwork, communication skills, etc.)
7. Ability to take decisions autonomously
8. Observance of technical and safety regulations
9. Manual dexterity

Work package 3

T3.2 Clustering of the key maintenance operators' features [30/03/2024-30/09/2024]

- + A questionnaire has been developed (using *freeonlinesurveys.com*) both in English and Italian to evaluate the relative importance of each of the identified features on the correct accomplishment of the identified tasks.



The aim of project DESDEMONA (DEcision Support system for the Diagnosis and Evaluation of the Maintenance OperatiONs Activities), promoted by the Italian Ministry for Universities and Research (MUR) funded by the European Union – NextGenerationEU, component M4C2, investment 1.1, consist of assessment the cognitive workload related to maintenance tasks, at the scope of dynamically assigning the maintenance tasks ensuing workers well-being and reliability of the assigned task.

Consistent with this end, a survey including 20 answers requiring time to fill in twenty minutes was developed to identify the most important skills to accomplish the most common maintenance tasks. The questionnaire is anonymus, it was designed consistent with art. 14 of Regolamento (UE) 679/2016 (Regolamento generale sulla protezione dei dati, di seguito "GDPR"), the data will be processd for scientific scope according to current regulation.

More information is available at <https://www.uniba.it/italiano/ricerca/progetti/2023/09/01/2023-09-01-desdemona>

- + English version

<https://freeonlinesurveys.com/s/btPbJvMf>

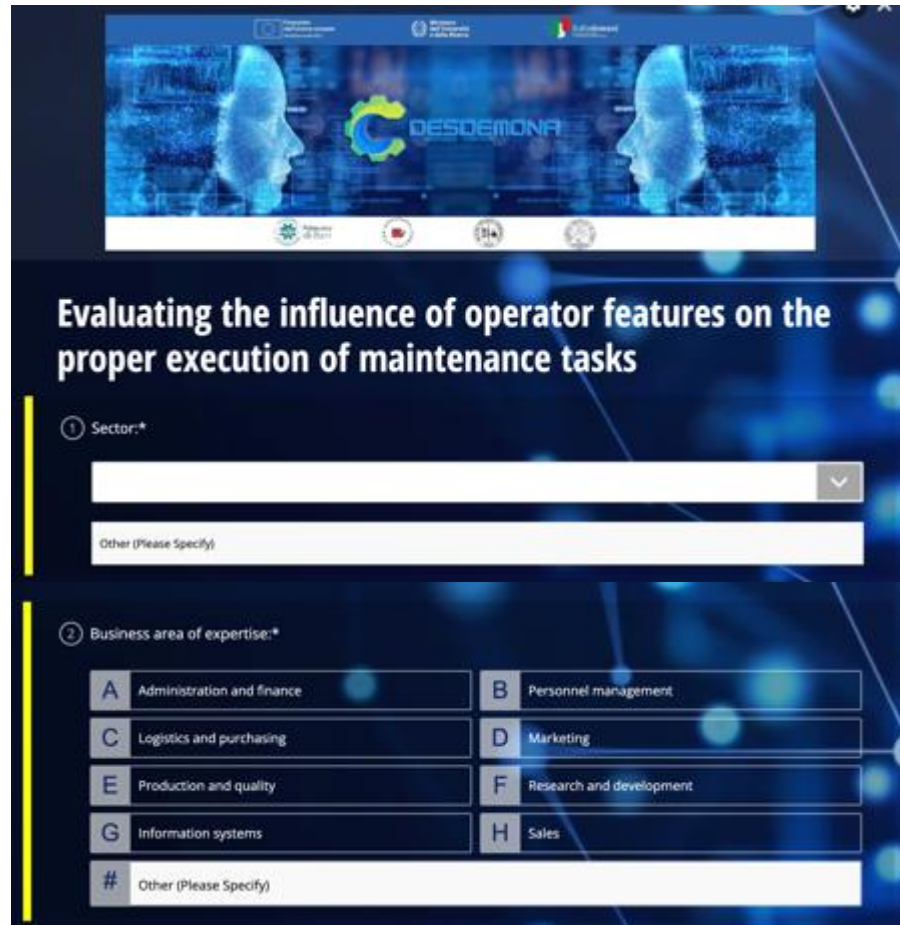
- + Italian version

<https://freeonlinesurveys.com/s/xYixYmrG>

PLEASE
SHARE

Work package 3

T3.2 Clustering of the key maintenance operators' features [30/03/2024-30/09/2024]



Evaluating the influence of operator features on the proper execution of maintenance tasks

1 Sector:*

2 Business area of expertise:*

A Administration and finance	B Personnel management
C Logistics and purchasing	D Marketing
E Production and quality	F Research and development
G Information systems	H Sales
# Other (Please Specify)	



3 Company role:*

A Maintainer	B Technician	C Manager
D Executive	E Director	F CEO
# Other (Please Specify)		

4 Work experience:*

A Less than 3 years	B Between 3 and 5 years
C Between 5 and 10 years	D More than 10 years

5 Age range:

A Less than 30	B Between 30 and 40
C Between 40 and 50	D Over 50

6 Geographical area of the company:*

A EU	B Extra-EU
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Work package 3

T3.2 Clustering of the key maintenance operators' features [30/03/2024-30/09/2024]

Example of a single task in the questionnaire

Task-features matrix

Task

Task explanation

Examples

Supporting pictures

Question 1

Please rate the relevance that each of the workers' features listed below has on the maintenance tasks' proper accomplishment, giving it a value on a scale of 1 (very low relevance) to 10 (very high relevance).

Task:
INTERPRETATION OF DATA TREND
 The task is based on observing and interpreting graphs showing the trend of specific machine/system characteristics over time to identify potential anomalies.

E.g., checking vibration signal trends, checking pressure levels over time, checking temperature level trends over time, etc.

	1 Not at all relevant	2 Not relevant	3 Insufficient	4 Relevant	5 Very relevant
Memory	1	2	3	4	5
Level of professional training	1	2	3	4	5
Level of education	1	2	3	4	5
Ability to work under pressure/stress	1	2	3	4	5
Ability to organize assigned work	1	2	3	4	5
Soft skills (teamwork, communication skills, etc.)	1	2	3	4	5
Ability to take decisions autonomously	1	2	3	4	5
Observance of technical and safety regulations	1	2	3	4	5
Manual dexterity	1	2	3	4	5

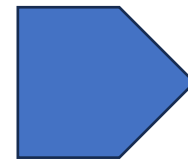
Work package 3

T3.2 Clustering of the key maintenance operators' features [30/03/2024-30/09/2024]

What's next

$C_{...}/BU_i$	T_1	T_2	...	T_z	
C_B/BU_1	T_1	T_2	...	T_z	
C_A/BU_1	T_1	T_2	...	T_z	
f_1	$Ev_{1,1,1}$	$Ev_{1,2,1}$	...	$Ev_{1,z,1}$	OB
f_2	$Ev_{2,1,1}$	$Ev_{2,1,1}$	...	$Ev_{2,z,1}$	OB
...	
f_j	$Ev_{j,1,1}$	$Ev_{j,2A}$	...	$Ev_{j,z,1}$	OB

One per company



T_z	Area	f_1	f_2	...	f_j
T_2	Area	f_1	f_2	...	f_j
T_1	Area	f_1	f_2	...	f_j
C_A	BU_1	$Ev_{1,1,1}$	$Ev_{2,1,1}$	...	$Ev_{j,1,1}$
C_B	BU_1	$Ev_{1,1,1}$	$Ev_{2,1,1}$	...	$Ev_{j,1,1}$
...
C_H	BU_i	$Ev_{1,1,i}$	$Ev_{2,1,i}$	...	$Ev_{j,j,1}$

One per task



For each task and business area, **one** evaluation score for each Operator feature, Task, Business Area ($Ev_{j,z,i}$) will be identified

Dissemination up to July 2024

- + **Exploring the cognitive workload assessment according to human-centric principles in Industry 5.0.** In APMS 2024 CONFERENCE Production Management Systems for Volatile, Uncertain, Complex and Ambiguous (VUCA) Environments. Under review
- + **An assignment model for high-cognitive-workload maintenance activities in Industry 5.0.** In 30th IJCIEOM – International Joint Conference on Industrial Engineering and Operations Management. Accepted
- + **Investigating maintenance operations in Industry 5.0: a cognitive-oriented tasks framework.** In XXIX SUMMER SCHOOL “Francesco Turco” – Industrial Systems Engineering. Under review
- + **Enhancing Maintenance Operations in Industry 5.0: A Conceptual User Interface Design for Task Assignment.** In ISM 2024 International Conference on Industry 4.0 and Smart Manufacturing. Manuscript preparation
- + **A Decision Support System tailored to the Maintenance Activities of Industry 5.0 Operators.** In 6th IFAC International Workshop on Advanced Maintenance Engineering, Services and Technology (AMEST2024)
- + **Digital twin supporting environmental performance evaluation according to ISO certification: an application case in the tire industry.** In Production & Manufacturing Research, 12(1). <https://doi.org/10.1080/21693277.2024.2351839>

Q&A

