

**PRIN: PROGETTI DI RICERCA DI RILEVANTE
INTERESSE NAZIONALE – BANDO 2022 PNRR
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**DEcision Support system for the
Diagnosis and Evaluation of the
Maintenance OperatioNs Activities
(DESDEMONA)**

**SUMMARY REPORT
RELEASE OF THE STATE-OF-THE-ART
DOCUMENT**



Summary Report:

The Fifth Industrial Revolution, known as Industry 5.0, aims for an innovative, resilient, competitive, and society-centered industry. This approach promotes increased human-machine interaction, allowing people to express themselves through personalized products and services. The growing need for flexibility and adaptability in smart factories requires greater cognitive efforts for new industrial tasks, particularly maintenance tasks, which are crucial for the flexibility of production systems. Although emerging technologies (such as Augmented Reality and Artificial Intelligence) can support operators, the complexity of tasks and the use of innovative technologies can overload them, reducing workplace well-being. To address these challenges, the DESDEMONA project aims to develop a Decision Support System (DSS) that provides real-time suggestions on the most suitable operators for maintenance tasks with high cognitive loads.

The WP2 report offers a thorough analysis of the state of the art regarding the cognitive load of operators interacting with machines and the existing human-centered digital solutions. The objective is to provide the Research Team of the DESDEMONA project with the main information needed to bridge the gap between the current state-of-the-art DSS and the main goals they aim to achieve.

To achieve this goal, a Systematic Literature Review (SLR) was conducted (Denyer & Tranfield, 2009). On February 21, 2024, using the tools of the Scopus Database (one of the largest databases of peer-reviewed scientific literature, see Fig. 1), scientific manuscripts most related to the topic of the state of the art were filtered by defining inclusion and exclusion criteria. As a result, 730 papers were initially filtered, and 51 articles were retained for the next review phase using the SLIP methodology (Maeda, 2007)

The screenshot shows the 'Export 730 documents to CSV' interface. At the top, it says 'Export 730 documents to CSV' with a help icon and a close button. Below this, there are radio buttons for 'All documents on this page' and 'Documents' (selected). The 'Documents' section shows a range from 1 to 730. Under 'What information do you want to export?', there are five main categories with checkboxes: Citation information, Bibliographical information, Abstract & keywords, Funding details, and Other information. Under 'Citation information', 'Author(s)', 'Document title', 'Year', 'EID', 'Source title', 'Volume, issues, pages', 'Citation count', 'Source & document type', 'Publication stage', 'DOI', and 'Open access' are all checked. Under 'Bibliographical information', 'Affiliations', 'PubMed ID', 'Publisher', 'Editor(s)', 'Language of original document', 'Correspondence address', and 'Abbreviated source title' are checked. Under 'Abstract & keywords', 'Abstract', 'Author keywords', and 'Indexed keywords' are checked. Under 'Funding details', 'Number', 'Acronym', 'Sponsor', and 'Funding text' are checked. Under 'Other information', 'Tradenames & manufacturers', 'Accession numbers & chemicals', 'Conference information', and 'Include references' are checked. At the bottom, there is a 'Select all information' link, a 'Truncate to optimize for Excel' toggle (checked), a 'Save as preference' checkbox, and an 'Export' button.

Fig. 1: Downloaded data of the identified documents

Quantitative Analysis

- The United States has the highest number of publications with 15 articles, followed by Italy with 6, and Germany with 4.
- Seven countries have 2 publications each, and 12 countries have 1 publication each.
- The papers are grouped into journal articles (61%), conference proceedings (33%), and books or book series (6%).
- The most frequent type of research is Theoretical Assessment with 19 publications, followed by Analytical Assessment with 14 publications. This prevalence is likely due to the topic's complexity, making it challenging to implement on an application scale by industrial stakeholders. Consequently, research on case studies and development applications is less frequent, as shown by the numbers: Case Study 5, Survey 4, Technology Development 4, Application Case 4, and Action Research/Application Case 1.

It was observed that in the United States, despite having the most publications and being technologically advanced, there is a high concentration of research on theoretical and analytical assessments. However, the U.S. also has more case studies and applications compared to other countries. Notably, Italy, the second country with the most publications, focuses particularly on Analytical Assessment.

Qualitative Analysis

The qualitative analysis of the examined papers revealed a diversity of approaches and topics related to decision support systems, cognitive load management, and maintenance. Although each article offers significant contributions within its specific scope, none fully addresses the DESDEMONA project's objective of developing a real-time DSS for optimally assigning the most suitable operators to maintenance tasks with high cognitive loads. Several articles focus on cognitive load assessment and ergonomics, discussing techniques like eye tracking for performance analysis. Other studies explore virtual reality and robotics for maintenance training, emphasizing reducing mental load through immersive technologies and haptic feedback. Additionally, some research addresses person-organization fit and psychosocial factors. There are also studies on decision support systems for top management and the impact of emerging industrial paradigms on the workforce, providing valuable insights.

Identified Gaps

- **Real-time task assignment:** Many articles focus on technologies and methodologies to assess cognitive load, person-organization fit, and performance improvement (21), but they do not provide a real-time decision support system for task assignment. Additionally, only 4 articles focus on the field of maintenance, and only 3 are centred on Industry 4.0 and Smart Manufacturing.
- **Maintenance with high cognitive load:** Although some articles address maintenance and training (such as those on virtual reality and robotics), they do not specifically focus on managing tasks with high cognitive loads. Furthermore, the sectors or tasks analyzed are very limited, such as railway maintenance, the automotive industry, and mechanical parts production. Some papers report laboratory experiences or completely lack application aspects.

- **Decision Support Systems (DSS):** Several articles discuss decision support systems (such as executive information systems and cognitive support systems), but none focus on a DSS designed to assign maintenance tasks in real-time based on the cognitive load of operators.
- **Human factors and cognitive ergonomics:** Many articles analyze human factors and cognitive ergonomics but do not integrate them into a system that suggests in real-time the most suitable operators for specific maintenance tasks. It should also be noted that no article addresses the emotional state of the operator and how it might affect performance.

In summary, while the selected articles offer a theoretical basis and useful tools in related areas, none fully meet the objective of the DESDEMONA project. This suggests a significant gap in the literature that the DESDEMONA project could fill.

Bibliography

Denyer, D., & Tranfield, D. (2009). Producing a Systematic Review. In *The SAGE Handbook of Organizational Research Methods*.

Maeda, J. (2007). The Laws of Simplicity: Design, Technology, Business, Life. In *Visible Language* (Vol. 41, Issue 1).