Evaluation of the Habilitation Thesis of Ruppert Tamás

Undersigned, Professor Eva-H. Dulf, as a Member of the Evaluation Committee, I hereby present my evaluation of the habilitation thesis of Ruppert Tamás, titled

„Human-centered systems in manufacturing”,

submitted to the Doctoral School of Information Science at the University of Pannonia.

The habilitation thesis addresses the modern challenges of Industry 5.0 by focusing on the integration of human factors into digitalized production environments. This research represents a highly relevant, multidisciplinary approach at the intersection of applied informatics, ergonomics, and lean management.

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1. General Assessment of the Work

The habilitation thesis addresses the critical transition toward Industry 5.0 by focusing on the integration of human factors into digitalized production environments. The work explores the evolution of human-machine collaboration through real-time data acquisition and digital twin technology. The significance of this research represents high added value in several key areas:

- Scientific Advancement: The dissertation contributes to the fundamental understanding of operator dynamics by developing new methodological systems for evaluating human-centered performance indicators.
- Technological Innovation: By integrating Real-Time Locating Systems (RTLS) and visual observation, the candidate has developed algorithms for real-time process improvement that bridge the gap between digital solutions and traditional Lean techniques.
- Social and Industrial Impact: The research directly addresses worker well-being by assessing spatial and temporal comfort levels (e.g., noise, temperature) and cognitive load, which is essential for improving quality of life in industrial settings.

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2. Evaluation of Scientific Results

The thesis formulates three distinct thesis groups, which the candidate has supported through

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experimental validation and scientific publications:

- Thesis Group I: Human-Centered Performance Evaluation

The candidate developed an algorithm package to evaluate human-centered performance indicators based on RTLS information and visual activity recognition. The novelty lies in combining supervised learning and motif-searching algorithms with real-time movement tracking to create a continuous and objective assessment system. The research proves that RTLS can be used not only for performance evaluation but also to assess worker comfort levels (noise, temperature) in real-life manufacturing scenarios. Traditional skeletal data-based analysis (MS Kinect) was successfully paired with Lean techniques to improve task allocation and work scheduling.

- Thesis Group II: Human-centered digital models

To manage real-time performance measurements, the candidate developed a Human-Asset Administration Shell (HAAS) model as a foundation for the human digital twin. The model manages perceived cognitive load based on real-time physiological metrics and task requirements (worker characteristics, routine vs. non-routine tasks). Extending the conventional Asset Administration Shell concept beyond interoperability between assets toward active manipulation of task parameters and environmental conditions enables human-centric optimization in Industry 5.0. A Human-Centric Knowledge Graph (HCKG) was developed to integrate various assets—robots, operators, and sensors—into a single production management system using standard ontologies.

- Thesis Group III: Human-centered indicators and physiological parameters

The research validates the applicability of wearable sensors to monitor physiological signals within manufacturing environments. Through dual-task experiments, a correlation was established between physiological data and perceived cognitive load/awareness levels. The work objectively measured the efficiency of different work instructions (code-based vs. visual) using both performance metrics and physiological measurements.

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3. Formal and Methodological Requirements

Structure and Content: The thesis is logically structured and meets the requirements for habilitation procedures.

Scientific Standard: The applied methodology—combining objective sensor data with subjective validation—is scientifically sound and confirms the candidate's ability to conduct independent research.

Publications: The scientific novelty is recognized by the international community and supported by a strong publication record. I mention the 37 peer-reviewed publications with impact factor and 15 Q1 ranked publications.

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4. Summary Declaration

Based on the presented scientific results, I consider the Applicant professionally suitable for the title of Habilitated Doctor.
I support the procedure moving to the public phase, and I consider the thesis suitable for public defense. Following a successful public phase, I recommend the awarding of the Habilitated Doctor title to the candidate.

Budapest, February 2, 2026

Dr. habil. Dulf Éva
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