

## Lean 5.0 and beyond: designing Human-Centric Manufacturing systems in Industry 5.0

**INVITATION CODE: a5yhg**

In the ever-evolving landscape of manufacturing, Lean principles have traditionally served as the foundation for efficiency, waste reduction, and process optimization [1]. Lean and Industry 4.0 (I4.0) are two paradigms that guide the manufacturing industry in tackling the challenges presented by the growing complexity of the market [2]. Lean 4.0 has been studied by researchers and practitioners to understand how both approaches, when implemented together, can raise operational and financial performance levels to a different pattern [3]. However, Industry 5.0 (I5.0) paradigm is replacing the well-known I4.0, switching the industrial perspective towards a Human-Centric approach [4]. As defined by European Commission in 2021, I5.0 introduces a Human-Centric approach while emphasizing sustainability and resilience [5]. This session will explore the possibility of transitioning from traditional Lean methodologies to Lean 5.0 by integrating the core tenets of I5.0, including the human-machine collaboration introduced by the cyber-physical systems of I4.0, and the broader social and environmental priorities of I5.0. The focus will be on enhancing human roles, fostering sustainability, and building resilient manufacturing systems. Traditional Lean methodologies primarily target waste elimination and process optimization. By focusing on the needs and experiences of operators, Lean 5.0 enhances the traditional waste-reduction and process-optimization goals by aligning with a Human-Centric design approach. This shift empowers workers, fostering greater creativity and adaptability in the workplace, as they collaborate more effectively with advanced technologies like cyber-physical systems [6]. Moreover, Lean 5.0 extends its focus beyond operational efficiency to address broader environmental and societal goals. By integrating sustainability into waste-reduction strategies [7], and enabling organizations to better anticipate and respond to disruptions through digital twins, predictive maintenance, and other I4.0 technologies [8]. Lean 5.0 provides a transformative approach that will offer insights on how to design innovative, human-centered manufacturing systems for Industry 5.0 and beyond. Beyond Lean, other Human-Centric approaches enabling I5.0 paradigm could be addressed. For instance, the application of design thinking principles, which prioritize empathy, creativity, and iterative problem-solving in the design of manufacturing systems.

### Topics of the session may include, but are not limited to:

- Integrating Human-Centric design in Lean manufacturing systems
- Enhancing worker empowerment and creativity through technology
- Applying design thinking principles to manufacturing system innovation
- Aligning Lean efficiency with sustainability and circular economy goals
- Resilient Lean Systems through Industry 5.0
- Strategies for transitioning from Lean 4.0 to Lean 5.0
- Optimizing performance with Human-Centric Approaches
- Human-Centric Lean operations strategies
- Lean and Agile Supply Chain optimization under I5.0
- Enhancing Lean Value Stream Mapping with I5.0 technologies

#### Invited Session chairs and contact information:

- Torgeir Welo, Norwegian University of Science and Technology, Norway
- Monica Rossi, Politecnico di Milano, Italy
- Romeo Bandinelli, University of Florence, Italy
- Paolo Gaiardelli, University of Bergamo, Italy
- Erlend Alfnes, Norwegian University of Science and Technology, Norway
- Virginia Fani, University of Florence, Italy
- Ilaria Bucci, University of Florence, Italy – Politecnico di Milano, Italy

#### References:

- [1] R. Hardcopf, G. (Jason) Liu, e R. Shah, «Lean production and operational performance: The influence of organizational culture», *International Journal of Production Economics*, vol. 235, p. 108060, mag. 2021, doi: 10.1016/j.ijpe.2021.108060.
- [2] B. Kassem, M. Callupe, M. Rossi, M. Rossini, e A. Portioli-Staudacher, «Lean 4.0: a systematic literature review on the interaction between lean production and industry 4.0 pillars», *Journal of Manufacturing Technology Management*, vol. ahead-of-print, fasc. ahead-of-print, gen. 2024, doi: 10.1108/JMTM-04-2022-0144.
- [3] M. Rossini, F. Costa, G. L. Tortorella, e A. Portioli-Staudacher, «The interrelation between Industry 4.0 and lean production: an empirical study on European manufacturers», *International Journal of Advanced Manufacturing Technology*, vol. 102, fasc. 9–12, pp. 3963–3976, 2019, doi: 10.1007/s00170-019-03441-7.
- [4] M. Ghobakhloo, M. Iranmanesh, B. Foroughi, E. Babaei Tirkolaee, S. Asadi, e A. Amran, «Industry 5.0 implications for inclusive sustainable manufacturing: An evidence-knowledge-based strategic roadmap», *Journal of Cleaner Production*, vol. 417, pp. 138023–138023, set. 2023, doi: 10.1016/j.jclepro.2023.138023.
- [5] Directorate-General for Research and Innovation (European Commission), M. Breque, L. De Nul, e A. Petridis, *Industry 5.0: towards a sustainable, Human-Centric and resilient European industry*. LU: Publications Office of the European Union, 2021. Consultato: 8 novembre 2023. [Online]. Disponibile su: <https://data.europa.eu/doi/10.2777/308407>
- [6] V. Fani, I. Bucci, M. Rossi, e R. Bandinelli, «Lean and industry 4.0 principles toward industry 5.0: a conceptual framework and empirical insights from fashion industry», *Journal of Manufacturing Technology Management*, vol. 35, fasc. 9, pp. 122–141, 2024, doi: 10.1108/JMTM-11-2023-0509.
- [7] R. Rathi, M. S. Kaswan, J. A. Garza-Reyes, J. Antony, e J. Cross, «Green Lean Six Sigma for improving manufacturing sustainability: Framework development and validation», *Journal of Cleaner Production*, vol. 345, p. 131130, apr. 2022, doi: 10.1016/j.jclepro.2022.131130.
- [8] A. Abdullah, S. Saraswat, e F. Talib, «Impact of Smart, Green, Resilient, and Lean Manufacturing System on SMEs' Performance: A Data Envelopment Analysis (DEA) Approach», *Sustainability*, vol. 15, fasc. 2, Art. fasc. 2, gen. 2023, doi: 10.3390/su15021379.