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Toward a Socio-Cognitive Engineering Readiness Level (S-CERL) to estimate the maturity of a multi-agent's collaborative system

Cabour Garrick
Department of Mathematics and Industrial Engineering
École Polytechnique de Montréal
Montreal, QC H3T 1J4, Canada
garrick.cabour@polymtl.ca
Samuel Bassetto
Department of Mathematics and Industrial Engineering
École Polytechnique de Montréal
Montreal, QC H3T 1J4, Canada
samuel-jean.bassetto@polymtl.ca

Élise Ledoux
Department of Physical Activity Sciences
Université du Quebec a Montreal
Montreal, QC H2X 1Y4, Canada
ledoux.elise@uqam.ca

Abstract

Context: Technology Readiness Level (TRL) has been widely used in the management of aeronautical automation projects. However, it does nothing to take on board non-technological aspects such as human factors, organizational factors and human-machine interaction to name a few. It has been demonstrated that many projects failures are related to a lack of consideration to human & organizational issues. On the other hand, human factors specialists and systems/software engineers often find collaborative and communicative aspects difficult between them. With the upcoming 4th industrial revolution, new collaborative system emerges where human operators interact with automated system to achieve a goal. This statement led us to develop a 7 steps matrix that measures the maturity of a human-machine system and enable both human factors engineers and system/software engineers to collaborate in the design of efficient and safe systems. Furthermore, this scale can be used in conjunction with TRL.
Methodology: Literature review has been made on existing scales measuring human factors readiness level, manufacturing readiness level and system readiness level. This state of the art has made it possible to identify a gap among all these structural scales. They focus on one aspect that surrounds the system: either the technological maturity of the subsystems, the system's integration into an operating environment or the consideration of human factors. The following matrix takes a functional perspective by using and activity-centered approach and seeks to assess the maturity of a human-machine systems (or joint cognitive systems) to achieve its goals in a dynamic environment.
Relevant elements of those scales were codified according to the meaning they were making for collaborative system design. The first model underwent a validity test that resulted in modifications of the three first steps (S-CERL 1, 2 & 3). In this way, the model follows an incremental path. Indeed, it is confronted with a case study in the field of aircraft engine maintenance. Several elements have been added, deleted and/or modified following its confrontation with the case study. Thereby, further adjustments are expected.
Results: The matrix provides a framework for engineers to consider human and organizational issues surrounding the system. It makes it possible to assess the adequacy of the system with its environment during the design process. More precisely, it provides 1) a collective thinking on the future human-machine work situation with an activity-centered approach; 2) a communication support among stakeholders and a means of bringing together different work packages, especially human factors and design/software team; 3) it prepares the operational actors for change through the participatory methods it uses.

Keywords
System readiness level, human factors, cognitive engineering, human-machine interaction, organizational automation

Biography

Garrick Cabour is a Ph.D candidate in Industrial Engineering at the École Polytechnique of Montreal. He holds a Master of Science degree in Human Factors & Ergonomics from University of Quebec at Montreal. His research interests include activity-centered design in aerospace, cognitive engineering, cognitive work analysis and human-automation collaboration. Garrick is also a research intern at Rolls-Royce Canada and focuses on the application of ethnographic studies to understand work practices, elicit and model operational knowledge that informs the design of automated systems.

Samuel Bassetto, PhD is an Associate Professor in the Department of Mathematics and Industrial Engineering of Polytechnique Montréal, Creative, dynamic and passionate. Over the years, he has directed more than 150 graduate students, CIMAR-LAB to structure researches on continuous improvement and system engineering. He graduated from ParisTech in 2001, on mechanical engineering while in the meantime got his MSc from University of Nancy in the field of Artificial Intelligence. He earned his PhD in 2005, from ParisTech, in the field of Industrial Engineering and Systems Modeling, Pierre-Bezier and GDR MACS, ADRIQ and NSERC prices. His investigations are now focused on the integration of AI in system engineering and habit development

Élise Ledoux, PhD is a Full Professor of Human Factors & Ergonomics at UQAM since 2014. Author of the book *Ergonomic Intervention*, she teaches ergonomic intervention in the workplace and project management as part of the Professional Master's program and the DESS in ergonomics in the Department of Physical Activity Sciences. Her current research interests include OHS aspects of collaborative robotic systems (cobots) and youth occupational health and safety. Her investigations contributed to the development of a work-studies balance kit for young employed students aged 15 to 24. She is also director of the scientific journal *Perspectives interdisciplinaires sur le travail et la santé* (PISTES : https://pistes.revues.org/) and in charge of the research field Sustainable Prevention and Work Environment at the Institut de recherche Robert-Sauvé en santé et sécurité du travail.