ACE Factories: humAn CEntred **Factories Cluster -** Enjoy reading our second newsletter!

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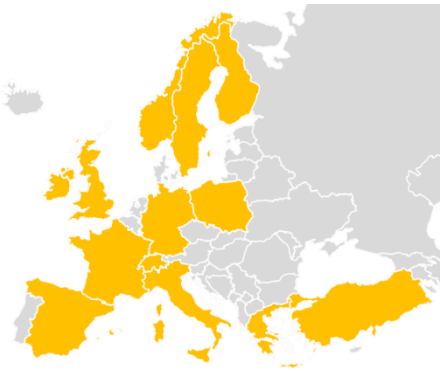
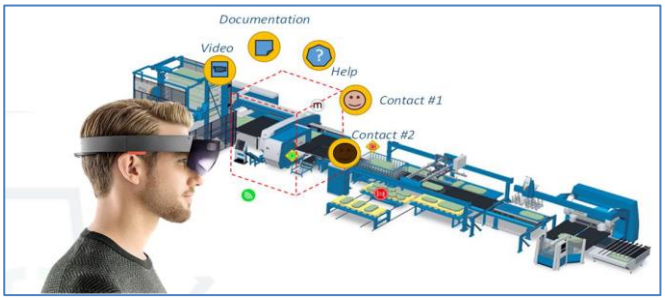
ACE Factories: humAn CEntred **Factories Cluster** is a networking Cluster of five FoF-4 projects funded under the European Union's Horizon 2020 research and innovation programme - A4BLUE, Factory2Fit, HUMAN, INCLUSIVE, and MANUWORK. Based on the common goals they are working towards, the cluster is a forum for sharing projects' knowledge, progress, and results. Those projects are developing solutions for manufacturing work environments that adapt to each individual worker. By combining their efforts, the projects hope to achieve greater impact and wider adoption of these new developments in advanced manufacturing systems.



Countries covered by the projects' cluster

Our vision and mission



Smart and connected technologies are not only transforming how parts and products are designed, produced, used, and maintained, but also workplaces and workers, transforming organisations themselves in human-centred factories. Consequently, now, by introducing new technologies, industrial work is increasingly mediated; i.e. the work is not related to the physical objects but to their counterparts in the virtual world. But people remain central to operations. In the past, people were expected to adapt to machine requirements. Now, automation systems are being developed that can recognise the users, remember their capabilities, skills and preferences, and adapt accordingly. Humans and automation are therefore taking advantage of each other's strengths, having a symbiotic relationship for enhancing capabilities, skills and quality of their work. Workers get encouraging feedback of their wellbeing and competence development, taking responsibility of their own competence development with adaptive on the-job learning tools. Adaptation can also make work organisation more flexible so that individual preferences are taken into account in task distribution. In short, new automation approaches, with workers at the centre, will complement people's capabilities and ensure higher performance, adaptability and quality. The result is more flexible, inclusive and safe workplaces, as well as better work conditions and increased productivity and improved quality. But, above all, this means increased worker satisfaction and work well-being, more empowered and engaged workers and increased interest towards factory work as a career, attracting young talented people.

ACE Factories cluster webinar on evaluation methods

On the 14th of November 2018, the hum**A**n **CE**ntred **Factories Cluster** organized an internal online workshop on the **work satisfaction evaluation methods**. Each cluster project was represented by one partner, who presented an evaluation method used in the context of the project to evaluate the satisfaction of the operators in the Factories of the Future.

Each project presented its approach for the evaluation, based on the unique requirements of the use cases and the approach through which they plan to measure work satisfaction in the context of the project. Also, the implementation and application of each Evaluation Framework in the corresponding use cases was presented, opening a discussion regarding the metrics and tools such as evaluation questionnaires. After each presentation, an open discussion between the participants took place, aiming to exchange ideas and propose additional features based on their expertise, while also detecting key points how each presented approach could be generalized after the completion of each project and be utilized by the industry. User evaluation needs to be planned carefully in the organization, such as the GDPR.

This workshop will serve as an initial example, on which fruitful discussion may be based not only in the context of the participating projects but also to organizations and unions (e.g. worker unions) that will drive forward their implementation in the current practice of the industry. Additionally, the success of this internal workshop dictates the necessity for collaboration in the cluster in other common interests, supporting the meaningful exchange of opinions and technical knowledge.

A4BLUE: Methodology for the Development of a Measure of Worker Satisfaction

A4BLUE aims to develop and evaluate a new generation of sustainable, adaptive workplaces dealing with evolving requirements of manufacturing processes through the integration of flexible automation mechanisms. A4BLUE presented their approach for measuring operator satisfaction in the project's use cases. The focus of this approach is to support the user- centred design, combining the high functionality with psychological satisfaction of the user. Traditional approaches that tackled this issue was studied in order to determine the best approach to tackle the issue in the A4Blue Use cases, also considering the new technologies that will be used, such as Augmented and Virtual Reality, which may also affect the satisfaction of the users. Moreover, it is important to create a framework for continuous assessment of the satisfaction, connected with the adaptation of the workplace. In close collaboration with the research laboratories and the industrial experts, this methodology is being formalized. The A4BLUE solution is being tested and validated in real industrial scenarios (AIRBUS and CESA) and in laboratory scenarios (IK4-TEKNIKER and RWTH Aachen). In this period, the selected survey for evaluation is tested in the shopfloor by the operators, evaluating their satisfaction, and as new tasks come forth, the process will be repeated so as to evaluate the long term impact. This effort will also lead to a model of satisfaction and a Satisfaction Measurement Tool. For more information, the presentation is available in ACE Factories website. Furthermore, the project gave several presentations in international events in the last 2 years, as well as made scientific publications illustrating the results achieved that are available for consultation at the following link.

Factory2Fit: Design and Evaluation Framework for Solutions that Support Work Well-being

Factory2Fit design and evaluation framework includes immediate implications on user experience, user acceptance, usability, safety and ethics. The framework further includes impacts on work well-being and company benefits. The approach aims to extend beyond the satisfaction of the operators and study their overall well-being at work. The work well-being includes i) job satisfaction, ii) work engagement and iii) work motivation. The Framework has supported both design and evaluation activities. The project started by co-creating the common vision, and further defining concepts of empowering the worker and engaging the work community. The solutions have been designed with an iterative human-centred design process, where the solutions have been regularly evaluated with future users, and the evaluation results have guided the design. Piloting will take place in three countries and several factories and the developed solutions will be evaluated by different research organisations/people, each having their own scientific preferences and a different background, either academic or industrial. A common questionnaire template has been developed, to be complemented with pilot specific questions for the various solutions to be evaluated in the project. The common questionnaire ensures that the results of the pilots can be compared. The proposed framework includes both quantitative and qualitative elements and it studies both immediate implications and impacts on work well-being and productivity. The challenges identified during the first implementations were discussed, as they are common between various cases in the ACE Factories cluster.

For more information, the presentation is available in ACE Factories website, and the work well-being framework is described in an open access publication:

Eija Kaasinen, Marja Liinasuo, Franziska Schmalfuß, Hanna Koskinen, Susanna Aromaa, Päivi Heikkilä, Anita Honka, Sebastian Mach and Timo Malm. 2019. A Worker-Centric Design and Evaluation Framework for Operator 4.0 Solutions that Support Work Well-Being. In: Barricelli B. et al. (eds) Human Work Interaction Design. Designing Engaging Automation. HWID 2018. IFIP Advances in Information and Communication Technology, vol 544. Springer, Cham. DOI https://doi.org/10.1007/978-3-030-05297-3_18

INCLUSIVE: Employee satisfaction with the adaptive HMI and working conditions questionnaire

The aims of the project is to create smart and adaptive interfaces for Inclusive work environment by adapting the behaviour and communication of the automated systems to human capabilities, including inexperienced users, elderly operators or people with disabilities. The developed framework should ensure worker satisfaction with work in general and with Human Machine Interface (HMI) in particular. Thus, the proposed model considers three basic pillars: i) the satisfaction with the HMI, ii) the physical workplace and working condition and iii) the Psychosocial working conditions& Ethical aspects. Considering the existing literature an discussing the unique requirements with the involved industrial experts has led to the creation of a questionnaire, which will be translated and used in the project pilot cases. On the Psychosocial aspects infamous questionnaires, such as the Copenhagen Psychosocial Questionnaire II, have been considered and partially included in the proposed methodology, resulting in a 28 item questionnaire with a 5-point Likert scale response. For the evaluation of the operator satisfaction with the adaptive HMI and its modules, a separate questionnaire has been developed, that tackles issues such as safety, design, efficiency and module- linked evaluation.

For more information, the presentation is available in ACE Factories website.

Over the coming months, INCLUSIVE will be presented by project partners University of Modena and Reggio Emilia (UNIMORE), Aachen University (RWTH), Central Institute for Labour Protection - National Research Institute (CIOP-PIB) and Technical University of Munich (TUM) at the following conferences:

- TUM presenting at the IEEE International Conference on Industrial Informatics, INDIN'19, Industrial Applications of Artificial Intelligence, 23-25 July 2019, Helsinki-Espoo, Finland: "Adapting Virtual Training Systems for Industrial Procedures to the Needs of Older People" (still to be confirmed)
- CIOP-PIB, UNIMORE, RWTH submitted an abstract to the 10th International Conference on the Prevention of Accidents at Work - The Future of Safety in a Digitalized World, September 23 – 26, Vienna: "Smart and Adaptive Human-Machine Interfaces for Safe and Inclusive Factories: the EU INCLUSIVE Project"

HuMan Manufacturing: Evaluation methodologies of two use case services- Exoskeleton Service and Workplace Optimization Service

During the ACE Factories Cluster online workshop which focused on evaluation methods, HUMAN presented evaluation methodologies for two of the HUMAN services; the Exoskeleton Service and the Workplace Optimization Service.

Exoskeleton is a short-term service aiming to deliver physical assistance to the operator during repetitive/continuous tasks, providing support to the most critical joints. The two exoskeletons that developed within HUMAN are enhanced with wearables for physiological monitoring of workers. Exoskeleton Service is evaluated in two different use cases; Airbus use case with the aim to assist the upper extremities of the workers and the ROYO use case with the aim to assist the low back of the operators. Two separate evaluations can be carried out: Laboratory experiments under controlled experimental conditions in order to test the exoskeleton devices, and experimentation with real workers in a scenario closer to an ecological one to test the whole Exoskeleton Service. Laboratory experiments ensure the effectiveness of the robotic devices in terms of assistance and easy to wear. Laboratory experiments are currently ongoing, but results cannot be published yet as they are still confidential. Preliminary test has been carried out at Airbus premises where real workers tested the Exoskeleton Service. Workers filled in questionnaires in order to evaluate the subjective perception both for the exoskeletons as well as the Exoskeleton Service. Questionnaires were separated in standard questionnaires to evaluate the perceived effort and the usability of the system and to ad-hoc designed questionnaires to evaluate the Exoskeleton service in a more technical point of view.

The second service that was presented was the Workplace Optimization Service (WOS) which is a long-term service. WOS is a decision support tool that utilizes Virtual Reality (VR) and Augmented Reality (AR) in order to assess and improve a workplace in a human centered way in terms of ergonomics and efficiency. WOS provides to the engineer all the necessary tools to be able to simulate an assembly procedure, identify the bottlenecks, rearrange the workplace and repeat the simulation before making changes to the actual shopfloor. WOS service is evaluated in the COMAU use case. Initially, laboratory experiments were carried out in order to identify effectiveness of the tool in terms of usability and ergonomics. Preliminary tests at industrial environment involving real workers have been carried out at COMAU premises. 5 workers and 5 engineers participated in the tests. Verbal feedback in form of interviews received from the workers and the

engineers. Moreover, they filled in questionnaires that will be used to enhance the characteristics of the tool in order to improve the acceptance of the users, evaluating the subjective perception of both workers and engineers. A summarized evaluation will be conducted over the following months.

For more information, the presentation is available in ACE Factories website.

MANUWORK: Evaluation of job satisfaction- a psychological approach

One of the main parts of MANUWORK project is to create a framework for evaluation and promotion of the job satisfaction under the cases of the project which include, among others, operators with disabilities. After the definition of the job satisfaction and the analysis of the existing approaches, the main psychometric and socio-organizational factors have been detected. All and all, around 30 existing questionnaires were analyzed in order to determine criteria that are matching to the project use cases. Based on each pilot case of the project, the governing factors are detected and a separate questionnaire is developed. Thus, three approaches for evaluating job satisfaction are created: i) Job satisfaction defined by extrinsic motivational factors, ii) Job satisfaction defined by extrinsic motivational and hygienic factors and iii) job satisfaction partially defined by workload and isolation. Each one of these approaches is fitted to one of the use cases, following their unique requirements. As a result, the created job satisfaction accessing approaches generated by MANUWORK will be capable of covering multiple use cases beyond the project, by selecting the most suitable approach. Additionally, the questionnaires will be integrated in an Industrial Social Network (ISN) that is developed in the context of MANUWORK. The ISN will serve as an intriguing interface for the operators to provide their evaluations, and also a gathering point for the questionnaires that will enable quick adaptation of the workplace.

For more information, the presentation is available in ACE Factories website.

WANT TO KNOW MORE?

For further information about the ACE Factories cluster and five projects, visit www.ace-factories.eu.

To **subscribe to the ACE Factories newsletter**, click here: http://www.ace-factories.eu/subscribe/.

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