Book of Abstract

VIII PhD On The Go "Marco Garetti"

Doctoral Workshop 2021

Industrial System Engineering and Operation Management
SSD ING-IND/17

University of Sannio
24-25 June 2021

PROGRAM

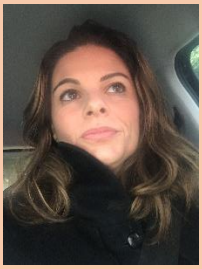
JUNE 24th2021

Time	Event	Virtual Room
10:00 - 10:30	**Welcome Meeting**	1
	Introduction Prof. Matteo M. Savino University of Sannio, Organizing Chair **Official Welcome and Greetings** Prof. Nicola Fontana Director of Engineering Department, University of Sannio **Official start of the Meeting** Prof. Emilio Ferrari – AIDI President Alma Mater Studiorum Università di Bologna	
10:30 - 12:30	TRACK 1 Design and Management of Production System Chair Prof. Giada La Scalia	1
	TRACK 2 Service Engineering Chair Prof. Marco Macchi	2
	BREAK	
14:00 - 16:00	TRACK 3 Production and Logistics within Industry 4.0 era Chair Prof. Riccardo Accorsi	1
	TRACK 4 Workplace Safety and Health Chair Prof. Marco Bortolini	2

JUNE 25th 2021

Time	Event	Virtual Room
9:45 – 10:00	***Greetings*** **Prof. Gerardo Canfora** Rector of University of Sannio	1
10:00– 12:00	**Keynote Speech** ***Occupational Safety in Confined Spaces and in Ergonomics: Tools and actions for Prevention*** **Professor Cristina Mora** Alma Mater Studiorum University of Bologna Department of Industrial Engineering Seminar Available on Youtube Channel of University of Sannio	1
12:00 – 12:15	Working Groups set up	1
12:15 - 13:15	Group Working	1 - 2
	BREAK	
14:30 - 16:00	Group Working	1 - 2
16:00	Workshop Closing	1

TRACK 1 - Design and Management of Production System Chair Prof. Giada La Scalia				
Time	**Name**	**University**	**Level**	**Project Title**
10:30 10:45	Maria Concetta Carissimi 	LIUC Università Cattaneo	First	Combining resilience and sustainability in supply chain management through the sharing economy
10:45 11:00	Luca Adelfio 	Palermo	First	Development of an industrial production system of geopolymer mortars with waste reuse of paper industry: energetic and environmental optimization by means LCA approach.
11:00 11:15	Mahsa Mahdavisharif 	Torino	Advanced	Supply Chain innovation: a bridge between Lean and Digital evolution
11:15 11:30	Luca Toneatti	Trieste	Advanced	Innovative waste management on board
11:30 11:45	Alesssandra Cantini 	Firenze	Advanced	Configuring spare parts distribution network: centralization and decentralization
11:45 12:00	Abror Hoshimov	Politecnico di Torino	Advanced	A framework development for integration Lean Manufacturing tools and level of automation in warehouse design and management

				
12:00 12:15	Valeria Fois 	Cagliari	Advanced	Implications of SDGS on LCA – based sustainable design of milk powder's dairy farm
12:15 12:30	Lorenzo Donati 	Roma	First	Modelling and improving resilience of industrial systems

Combining resilience and sustainability in supply chain management through the sharing economy

MARIA CONCETTA CARISSIMI
LIUC, Università CATTANEO

Context and main scientific issues under investigation

Nowadays resilience and sustainability are two important characteristics of supply chains. The spread of Coronavirus has shown how companies are unprepared to operate in a complex, vulnerable and uncertain environment (van Hoek, 2020). Concurrently, they are receiving pressures from external stakeholders to engage in a more sustainable development and achieve sustainability goals within the next years (e.g. SDGs, UE Green Deal). Although many researches in literature aimed to study resilience and sustainable supply chains, the relationship between these concepts is not clear. Both resilience and sustainability focus on the ability of a system to survive over time. However, in the medium-short term there are potential conflicts due to their sometimes-contrasting objectives, also making sustainable and resilient efforts working in a misaligned way in companies and organizations (Marchese et al., 2018). In fact, increasing resilience through traditional approaches such as investing in extra capacity is not always sustainable with respect to the declining availability of resources. Sharing economy can represent a lever to combine resilience and sustainability. By preventing excessive production and reducing wastes, sharing promotes a more efficient use of resources; at the same time, it offers redundancy and flexibility of options, laying the foundations of more resilient supply chains.

Research questions addressed

The research aims at addressing the following research questions:

- How have supply chain resilience and supply chain sustainability been addressed in the existing body of knowledge?

Analysing the main research themes and future research trajectories of SC sustainability and SC resilience, the study aims to provide insights on their joint implementation in supply chain management.

- How can sharing economy be a lever to combine sustainability and resilience within supply chains? The research aims to contribute to the current literature, by investigating strategies, barriers and enablers of sharing economy solutions for better sustainable-resilient supply chain.
- How can the institutional theory explain the implementation of sharing economy solutions as enabler of sustainable and resilient supply chains?

The research aims to provide insights on how the institutional theory can be a valuable theoretical lens to interpret the adoption of sharing economy for sustainable and resilient supply chains.

Research Objectives and Research Methodology

The aim of the research is to provide insights on how companies can improve their sustainable and resilient performances in supply chains. The first objective is to investigate what the main research paths within SC sustainability and SC resilience are, to seek conceptual clarity on their relationship, analysing their according and contrasting objectives with respect to the spatial and temporal scale of application. In this direction, a SLNA (Systematic Literature Network Analysis), combining the traditional literature review techniques with bibliometric network analyses, can be the best methodology to carry out the analysis. As a further step, sharing economy can be studied as a lever to combine sustainability and resilience objectives in the medium-short term. The role of sharing economy in sustainable-resilient SC can be examined by conducting case study research. Strategies, barriers, and enablers can be investigated through the study of real application cases with a focus on the industrial sectors in which these solutions are widespread. The adoption of a theoretical framework, such as the institutional theory, can offer an interpretive lens to originally explain the antecedents and constituents of the sharing economy as enabler of sustainable and resilient supply chains.

Development of an industrial production system of geopolymer mortars with waste reuse of paper industry: energetic and environmental optimization by means LCA approach.

LUCA ADELFIO
Università degli Studi di Palermo

Context and main scientific issues under investigation

The 21th century most important industrial challenge is, of course, the development of more efficient manufacturing systems from both energetic and environmental point of view. Actually, such issue is common to all the industrial sectors; more specifically the manufacturing production needs to be continuously improved in order to achieve the high environmental standards required by the present sustainable development policies. For this purpose, the construction industry has been recently investigated as it is extremely energy-intensive and it is one of the main sources of environmental pollution worldwide.

In particular, many studies were devoted to the development of novel construction materials as sustainable substitution to Ordinary Portland Cement (OPC) in concrete applications. Among these new materials, geopolymeric mortars raised increased interest especially for the possibility of reusing industrial waste in their production. The manufacturing technology of waste-based geopolymer is quite mature at the laboratory scale, but it cannot be said the same at the industrial scale.

Research questions addressed

This study aims to develop an industrial production system of geopolymer mortars that reuse wastes deriving from the paper industry. Every single process will be analyzed with the scope of identify the best plant solution. The design criteria will be inspired by the principles of energy efficiency and sustainable production. Fortunately, these two goals always coincide - so making efforts to achieve one means achieving both.

The research questions addressed are energetic optimization of a new industrial system and environmental optimization of every single process. These two main goals will be achieve trough a life cycle assessment approach of the production system proposed.

Research Objectives and Research Methodology

The LCA methodology is based on the evaluation of the environmental impact of a product (or production system), analyzing every single step of the life cycle product. Such approach allows to identify the hot spots of a life cycle and to improve the sustainability. Thanks to this capillary methodology, it will be possible to study thoroughly every process and choose the best plant solution based on energy requirement.

At the end of the study, it is expected to achieve all the proposed goals: the design of the industrial system, by selecting the most appropriate plant solutions based on the production volume; and the system environmental optimization, by means of the LCA approach. In addition, once the production system will have been defined, there will be the opportunity to change some processes to take into account the possibility to reuse other wastes. Finally, it will be possible to evaluate the setting of a cogeneration plant in order to satisfy the energy needs of the production system. In this way there will be a further opportunity to improve the energy efficiency.

Supply Chain innovation : a bridge between Lean and Digital evolution

MAHSA MAHDAVISHARIF
Politecnico di Torino

Context and main scientific issues under investigation

The research addresses the combined application of Lean Management and digital technologies to Supply Chain Management (SCM).
The study has first identified the digital technologies most related to SCM and has investigated the current literature on the implementation of such technologies and Lean principles in logistics and SCM, in order to understand the actual research needs. In this regard, particular attention has been given to the applications of digital technologies and Lean for improving SC structure and behavior.
In the next step, based on the identified gaps (see Section 2) and the Supply Chain Operations Reference (SCOR) Model, a framework will be developed to study how Lean and digital technologies change main warehouse activities and their performance. Procurement and delivery processes will be also considered since they have close links with warehouse activities. A simulation model will be proposed to predict digital warehouse performance and compare them with traditional warehouse ones.

Research questions addressed

This research aims to answer the following questions:
RQ1: What are the digital technologies most related to SC, and the processes less studied by digital technologies?
RQ2: Which SCM organizational issues need to be more investigated in the field of Digital SC?
RQ3: What are the combined effects of Lean and digital technologies on SC and how they change SC activities and performance
Questions RQ1 and RQ2 have been already partially answered during the Systematic Literature Review (SLR) phase. In particular, the results of SLR for the digital technologies most related to SCM (cloud computing, Blockchain, Big data Analytics, Internet of Things, Additive Manufacturing) are finalized.
In response to RQ1, the literature review revealed a lack of studies on applying digital technologies to warehousing, procurement, and inventory management processes. The search for answers to the RQ2 indicated that the SC structure and performance when digital technologies are applied scarcely investigated.

Research Objectives and Research Methodology

The final aim of the research is to develop a framework to predict and explain the change of SC structure, relationships, and performance when digital SCM technologies and Lean principles are introduced in specific processes. This objective will be achieved by applying the following steps:
1)Identifying Industry 4.0 technologies most related to in the SCM.
2)Conducting an SLR to reveal the gaps and needs in digital SCM and Lean principles.
3)Building a theoretical framework based on the SCOR model for assessing the structure and behavior of warehouse processes, as well as procurement and delivery, when digital technologies and Lean are applied.
4)Determining the most critical Key Performance Indicators (KPI)s to measure the performance of Lean-digital warehouse.
5)Comparing traditional and new framework performance based on a simulation model.
6)Validating the framework by case studies performed in collaboration with companies and Lean Management Associations.

Innovative waste management on board

LUCA TONEATTI
Università di Trieste

Context and main scientific issues under investigation

Waste management is a crucial aspect of nowadays world, due to its high environmental and economic impact. From collecting to final disposal, many different solutions are used on the mainland, but what about the maritime world and more precisely the cruise ships sector? They are small floating cities, which navigate repetitively in a small area and produce a great amount of solid waste. Furthermore, the rules and the norms of the sector are few, mainly the Annex 5 of MARPOL, and only in recent years has the attention been focused on their environmental impact.

An integrated and innovative approach is needed to reduce on the one hand waste production on board and, on the other, to exploit the energy available after the final disposal. Different procedure and technique can be studied, some of which can be applied immediately, while others involve some important changes in the overall design of the ship, which must foresee the design of new integrated plants.

The research investigated the current waste management on board, to propose a new innovative approach, highlighting the economic and environmental effects and showing new possible solutions.

Research questions addressed

1) How to reduce the environmental impact of the cruise sector?

By focusing on solid waste management, the environmental impact of cruise ships can be reduced by using new technologies and by lowering waste production (mainly paper) and by implementing new plants to exploit the energy deriving from their disposal.

2) Which are new solutions for waste disposal onboard?

Since the new marine engines can be powered by oil and gas (dual-fuel), the exploitation of solid waste for the production of combustible gas can solve the problem of on-board waste management with an ecological approach.

Research Objectives and Research Methodology

The main research objective is to design a new waste management system onboard, from collecting to final disposal, evaluating the economic and environmental effects together with the feasibility.

Starting with the subdivision of solid waste produced onboard, the evaluation of different power demands of different plants bring to a possible integration with waste disposal, whose feasibility and efficiency are investigated.

Configuring spare parts distribution network: centralization and decentralization

ALESSANDRA CANTINI
Università di Firenze

Context and main scientific issues under investigation

Efficient spare parts management increases the competitive advantage of after-sales organizations. Therefore, a dynamic asset deployment (DAD) strategy should be used to determine what spare parts allocate throughout the geographical hierarchy of company service support locations. That strategy should define whether to centralize or decentralize the items management, aligning spare parts storage and distribution chain closely with the equipment users' operations. A common challenge in DAD problems is to reduce inventory costs while ensuring high service levels and flexibility against demand fluctuations. After identifying existing methodologies for configuring spare parts distribution networks, this project aims at developing two novel DAD approaches. The first is based on ABC bi-criteria analysis, using individual item criticalities to guide rule-based distribution decisions. The second compares the costs of different scenarios, considering the possibility of producing parts with additive manufacturing and performing drone transportations. Two case studies are used to test and validate the proposed approaches. For the ABC approach, the case study of an Italian trucking company is presented. Instead, for the model comparing additive and conventional manufacturing, we show the case of two Norwegian companies, one skilled in using additive printers, and one needing spare parts to perform maintenance actions on oil platforms.

Research questions addressed

The main objective of this research project is to review and extend the current knowledge on spare parts distribution network configuration and dynamic asset deployment. It is intended to develop approaches and tools for spare parts management that can be applied and tested on real case studies, providing results on their performance and indications on their advantages and disadvantages.

From this point of view, the research questions of the present project can be summarized as follows:

RQ1) What methods exist to solve DAD problems? Are there strategies based on ABC analysis? Are there methods considering parts produced by additive manufacturing?

RQ2) How is it possible to use multi-criteria ABC classification as DAD approach?

RQ3) Is it possible to compare different scenarios of network centralization or decentralization with parts produced with additive or conventional manufacturing?

Research Objectives and Research Methodology

In this project, three objectives are set to answer the research questions.

O1) First, a literature review is conducted to gain an overall understanding of methodologies for facing DAD problems, thus configuring spare parts distribution network. Here, methodologies are also sought based on ABC analysis and able to compare scenarios of centralization and decentralization of parts produced with Additive Manufacturing.

O2) Then, existing ABC DAD approaches are investigated and analysed, and a novel ABC DAD approach is proposed, being tested on a case study. Here the differences in operation and performance of the proposed model are highlighted compared to existing methodologies.

O3) Finally, an analytical approach to compare costs and benefits of DAD scenarios of items produced with additive or conventional manufacturing is provided. The methodology is tested on a case study and the impacts on the supply chain of aspects including conducting different qualification tests or using different transportation vehicles are observed.

Overall, a case-base action research is implemented. Hence, generic knowledge consisting of the developed DAD approaches is provided to support managers in common decision-making situations. However, the application of such knowledge remains case-specific.

A framework development for integration Lean Manufacturing tools and level of automation in warehouse design and management

ABROR HOSHIMOV
Politecnico di Torino

Context and main scientific issues under investigation

The main focus of this research is to develop an integrated approach based on Lean Manufacturing (LM) tools and automation to improve warehouse operations.

The research will address the application of LM principles and techniques with different level of automation (LoA) in warehouse design and management.

To this end, the study will first investigate the current state of the art of literature on the application of LM tools and automation to internal logistics and warehouse operational management, in order to understand the actual research needs and gaps. In the next step, the study will enlarge this perspective by investigating the integration of LM practices and Lean Automation in warehouses design.

This research work contributes to enhance knowledge about the interconnections between LM, Automation and its recent Industry 4.0 advances, with particular attention to warehouse processes. In fact, the literature on these topics is still scarce. Moreover, previous contributions determined that LM tools require certain level of automation to have a successful implementation [1]. On the contrary, Industry 4.0 needs some fundamental LM tools to be implemented before applying new digital technologies[2]. Therefore, there is a general need for frameworks that guide the actual implementation of the associated principles.

Research questions addressed

Many researchers have focused on the application of LM techniques in different industry types and sizes ([1], [3]–[8]). However, there is a need to investigate the impacts of different automation and digitalization levels on the implementation of LM tools. Particularly, the combined application of various LM techniques and automated material handling and storage equipment in warehouse design and management should be addressed. This research aims to answer the following questions:

RQ1: What is role of Lean Tools and automation/digitalization in changing traditional warehouse management into Warehouse 4.0?

RQ2: Is there any combined framework of Lean tools and Levels of Automation in warehouse design and management?

RQ3: How warehouse performance changes when integrating the LM tools and automation elements (Warehouse 4.0)?

Research Objectives and Research Methodology

The final aim of the research project is developing a framework to integrate LM with different LoA. Such a framework will pay particular attention to the combination of automated material handling and Lean principles for efficient warehouse management.

Research methodology refers to System Development approach[9] which includes three correlated stages. The first stage follows theory building as a framework for predicting warehouse performance under different LoAs and combination of Lean tools. A Systematic Literature Review is currently underway in order to catch the actual needs and trends about these topics and better shape the detailed goals of the framework and tools for its development.

The second stage is an experimentation through lab experiments and computer simulations. Experimentation and simulation will provide broader representation of the impacts of LM and automation integration to throughput rate, order picking and storing time as operational performances to assess the warehouse management. A variety of modelling and simulation techniques are currently explored, such as (but not limited to) Agent Based and System Dynamics. Additionally, the possible integrated use of simulation and optimization techniques will be addressed. The third stage conducts the validation of proposed framework by performing case studies and field analysis. in Uzbek SMEs.

Implications of SDGS on LCA – based sustainable design of milk powder's dairy farm

VALERIA FOIS
Università di Cagliari

Context and main scientific issues under investigation
It is the elaboration of a method for the construction of processes related to the Infant formula that can be considered sustainable following some of the SDGs goals of the 2030 agenda. The goal is to obtain quantifiable indicators that can not only evaluate but also give indications for the sustainable design not only in the environmental field but also in the economic and social field. One of the tools addressed at this time is LCA which, however, finds little development in the literature in issues other than environmental ones.

Research questions addressed
1) What are the only indicators that need to be followed to guide the decision-making project of the design of a dairy farm does Infant formulate why it is sustainable and how can I quantify them?
In the literature there is no discussion of indicators that can be used to broadly analyze a project according to an understanding that is no longer just environmental, linked only to energy saving, but new initiatives must have an impact on workers and on the territory. The innovations of new projects are also linked to the competitiveness of a company.
2) How can industry 5.0 characterize this project design?
In the literature we talk about industry 4.0 and its tools, we know what the structural limits are and why not all companies are able to reach this goal. How digital twins and data processing and subsequent processing still have limits. Many identified precisely in the workers and in the creation of new figures in the industrial market.
3) How can the LCA methodology take a leap and become a decision-making tool in unexplored fields such as the social one?
This aspect is completely absent in the literature and in the legislation as quantifiable indicators have not been defined but we always talk about qualitative and arbitrary indicators.

Research Objectives and Research Methodology
The goal is to create a tool that does not remain only in the literature but is actually applied in a real decision-making process. The research is carried out at the same time as a real case of design and construction of an Infant Formula plant in Sardinia whose end user is China. Therefore the research makes use of all those problems that arise in this design process. A network algorithm is being sought that can help qualitative information transform into quantitative.

Modelling and improving resilience of industrial systems

LORENZO DONATI
Università degli Studi Roma Tre

Context and main scientific issues under investigation

Over the past decade, much scientific attention has focused on the issue of industrial resilience. Resilience represents the ability of a system to resist a disruptive event and quickly restore operations, recovering the initial capacity. The added value of the study of resilience compared to the classic vulnerability analysis lies in analysing not only the ability of the system to resist the impacts caused by disruptive events but also to actively reduce the negative consequences of the event on the functionality of the system, and on the recovery capacity, which refers to the system's ability to quickly restore its original functionality.

Academic attention on this topic is also the consequence of some disastrous events, such as the NaTech events or the current Covid-19 pandemic, which highlighted the vulnerability of industrial production systems.

The scientific literature on resilience has reached a certain maturity as regards civil infrastructures, or large utility networks, but is still lacking in the fields of industry and supply chains. In fact, an established and agreed resilience estimation method does not exist. Therefore, a need arises to develop new modelling and analysing tools allowing to assess and improve resilience of industrial systems.

Research questions addressed

1. To understand what the preferred conceptual approach is to model resilient industrial system
2. How to estimate the time trend of capacity recovery of industrial system following a disruptive event credibly and accurately?

The two above points arise from the multiplicity of suggested approaches to estimate resilience which are not specifically aimed at supply chains and industrial plants, and do not address all the specific issues involved in resilience estimation (namely: Disruptive event characterization, Damage states assessment, Scenarios generation, Initial capacity loss estimation, Time trend of capacity recovery, Economic loss analysis, Resilience quantification).

3. How to increase the resilience of existing industrial systems, and design new resilient systems?

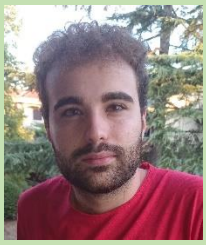
In case the analysis of given industrial system shows that resilience behaviour is not satisfactory, question arises on how to improve resilience, in the most cost-effective manner. This implies the criticality assessment of system components and the optimal allocation of resilience and resources to each component to maximize the resilience for a given budget or minimized total cost for achieving a resilience target.

Research Objectives and Research Methodology

Based on a critical review of the current literature on resilience modelling and quantification, in the definition and improvement of resilience in the industrial sector, at first a specific modelling paradigm for resilience estimation of both industrial plants and supply chains will be select.

Adopting the above paradigm, a methodology and a related software tool will be developed to compute the time trend of capacity recovery, together with associated economic losses, given a disruptive event scenario. This will allow to compute any desired resilience index for the system under analysis. A methodology for automatically generated damage scenarios in a probabilistic manner will be also developed.

From the design point of view, a method to assess the criticality of each system component will be developed together with the identification of possible strategies useful for improving system resilience. Finally, an optimization method will be developed to maximize the resilience of the investigated system. The above modelling approach will allow to operate on existing industrial systems and to design new ones, optimizing the activities to increase resilience, in an analytical and quantitative way.

TRACK 2 - Service Engineering Chair Prof. Marco Macchi				
Time	**Name**	**University**	**Level**	**Project Title**
10:30 10:45	Abbas El Toufaili	Trieste	First	Developing a new approach for an integrated solid waste management system in developing countries
10:45 11:00	Anita Salsano 	Sannio	First	Use of augmented reality in maintenance activities: benefits in terms of performance and process improvement
11:00 11:15	Leonardo Leoni 	Pisa	Advanced	Risk and reliability analysis of hazardous plant adopting a Smart Industry Approach
11:15 11:30	Beatrice Colombo 	Bergamo	Advanced	Development of innovative textile architectures based on recycled carbon fibre for the composite material industry
11:30 11:45	Carlo Riccio 	Padova	Advanced	Machine Learning for Preventive Maintenance: study of predictive model based on product performances

Developing a new approach for an integrated solid waste management system in developing countries

ABBAS EL TOUFAILI
Università di Trieste

Context and main scientific issues under investigation

The generation of waste has rapidly increased worldwide owing to the fast-economic development and urbanization. Hence, the current situation urgently requires improvement in waste prevention and treatment. In 2011, 2 billion tons of municipal solid waste were produced globally and this is expected to reach 9.5 billion per year by 2050. Municipal solid waste generation is highly linked with factors like economic growth and industrial development. In developing countries, other factors such as urban expansion, population growth, and technological development are contribute to increasing MSW generation. Environmental Management (EM) represents the management of various activities, including environmental action plan, conservation of resources, environmental status evaluation, environmental legislation and administration.

Research questions addressed

Can we find reliable data about waste quality and quantity in developing countries?
Do the methods and tools that we are going to use for the analysis and simulation of the waste management systems will give us reliable results?
Does the new approach that we are going to develop will be applicable in the reality?

Research Objectives and Research Methodology

This study sets out to analyze the waste management systems from waste collection till the treatment in developed and developing countries, and to identify the common aspects of waste management in developing countries. The analysis of environmental management system is a complex decision and it involves many factors, such as waste quality and quantity, climatic, social, environmental, technological legal and economic concerns. Applying Analytical Hierarchy Process (AHP) method will lead us in evaluating all the parameters of interest in the environmental management systems, and in selecting the best approaches for the entire solid waste management and treatment. Using Life Cycle Assessment (LCA) for developing of a methodology in the aim to identify the best approach for the new solid waste management system in developing countries, by definition of input parameters, key performance indicators, decision-making process, and highlighting the advantages of this new approach compared to one normally used. Utilizing Aspen Plus simulator for the solid waste management system optimization.

Use of augmented reality in maintenance activities: benefits in terms of performance and process improvement

ANITA SALSANO
Università degli Studi del Sannio

Context and main scientific issues under investigation

Thanks to the potential of 5G and of the key role in the Industry 4.0, Augmented Reality appears to be fundamental for innovation.

Solutions based on smart glasses, viewers and tablets equipped with AR software allow operators also to leave their hands free. These devices can guarantee effective support in carrying out activities, with a special regard to complex ones, suggesting the right actions to do step by step. In this way it is possible to reduce errors and increase operator productivity, while reducing time and costs, without ever needing an high level of experience of the operators.

In maintenance activities, AR allows to contact the experts remotely for help on troubleshooting, or simply consult "augmented" documentation while carrying out activities. Furthermore, AR can facilitate the training phase by correctly and quickly teaching operators how to carry out a certain activity.

This project aims to explore how AR may improve business performance in terms of Quality Safety and Environment, within an electromechanical production company, with a focus on maintenance activities.

Research questions addressed

The main purpose of this research is to verify if: I) Can AR increase efficiency and productivity? II) What kind of benefits can we have from using AR on sustainability and improvement in QSE levels? III) Does the use of these devices actually correspond to a simplification for operators or is it seen internally as an increase in the work? IV) Can AR be used for the optimization of predictive maintenance plan and the improvement of the associated operating instructions ?

Research Objectives and Research Methodology

The objective of this research project is to investigate the application of emerging AR technology for business process improvement, through a case study in an electromechanical manufacturing industry.

Using IT tools, some work cycles relating to maintenance activities will be digitalized and virtualized. The digitalized scene will be scanned to identify its content; objects to be made interactive will be identified and the appropriate virtual information will be added to the scene, in real time. This process will then be appropriately investigated in order to verify: I) the improvement of the overall performance obtained in the company using QSE Management system indicators. II) the optimization in predictive maintenance activities. III) the degree of acceptance of these new technologies from the users, through a specific questionnaires that will be prepared; IV) the improvement in term of ergonomic evaluation of the postures held by users.

Risk and reliability analysis of hazardous plant adopting a Smart Industry Approach

LEONARDO LEONI
Università di Pisa

Context and main scientific issues under investigation

Risk analysis has established itself as a pivotal tool for improving the safety of industrial operations. Losses of containment of hazardous substances can indeed lead to disastrous consequences for human beings and environment. The objective of this research is to develop a novel methodology capable of mitigating the risk arising from failures by identifying the most critical devices and scheduling maintenance. In the industrial sector, one of the major challenges is determining the frequencies of dangerous events since few data are available. To perform this task Hierarchical Bayesian Modelling (HBM) and machine learning can be adopted. HBM has several advantages with respect to traditional frameworks, indeed it allows to include prior information and it can be updated as soon as new observations become available. The second part of a risk analysis is evaluating the severity of the consequences, which will be conducted through software able to simulate failure scenarios. Finally, techniques for monitoring the critical devices will be proposed to predict and prevent future failures. The major pros of the present PhD proposal are first overcoming the limitations arising from lack of data and second developing updatable tools that rely on tracking the operational parameters to guide maintenance and inspection.

Research questions addressed

Optimizing maintenance policies is crucial to reduce risks and costs, while maintaining performance. This will improve the safety of the operations as long with an increase of productivity. To fulfil the research objectives the study is divided into four research questions:

- How to estimate the probabilities of hazardous events for an industrial plant in case few data are available?
- How to improve the current adopted techniques for assessing the severity of the hazardous events?
- How to develop a risk-based maintenance strategy able to reduce the risk arising from operations of an industrial plant?
- How to develop a methodology capable of guiding the prognostic maintenance actions based on relevant parameters of a certain device?

Research Objectives and Research Methodology

The main objective of this PhD project is improving the safety of industrial operations through the application of a methodology capable of quantifying and reducing the risk arising from failures. The following sub-objectives are required to reach the main one:

- Developing a methodology for calculating accurate probabilities of hazardous events in case of lack of data. The methodology must be updatable when new information or observations are gathered (Hierarchical Bayesian Modelling, Machine Learning)
- Developing a methodology for assessing the severity of the hazardous events through a simulation software (Safeti by DNV-GL).
- Defining a maintenance and inspection plan based on the estimated risk. For this step an allowable risk level and the monitored parameters for planning the inspection are determined.
- Developing a methodology that allows to perform prognostic actions based on the monitored parameters (Hierarchical Bayesian Modelling, Machine Learning).

Development of innovative textile architectures based on recycled carbon fibre for the composite material industry

BEATRICE COLOMBO
Università di Bergamo

Context and main scientific issues under investigation

Thanks to their outstanding mechanical properties, low weight and good fatigue behaviour, Carbon Fibre-Reinforced Plastic (CFRP) composite materials are increasingly being employed in many industrial applications [1]. Their extensive use has resulted in an increase of generated waste, including end-of-life products and manufacturing scraps. Nevertheless, their heterogeneous nature does not allow for a suitable recovery of produced waste [2], as the existing recycling technologies are unable to obtain a material of equivalent quality to the original [3]. This involves the necessity to landfill the produced waste, causing environmental problems and economic losses [4]. Moreover, regardless of its origin, recycled Carbon Fiber (CF) does not possess the technical characteristics appropriate for a traditional spinning process to be employed in structural applications [5]. Therefore, researching and developing new spinning processes emerges as essential to obtain good-quality yarns [6]. In such a context, this Ph.D. project aims to develop a spinning process to produce a yarn made of recycled CF suitable for weaving textile substrates for the production of good-quality CFRP. The contribution of this project is twofold. First, it provides a strong practical enrichment to composite material industry. Second, it supports theoretical knowledge improvement about the relationship between composite materials and CE.

Research questions addressed

Currently, there are several types of CF waste sources: manufacturing scraps (I), out-of-date prepregs (II), and end-of-life CFRPs (III) [6, 7]. (I) CF has properties similar to the virgin CF, while (II) and (III) have to be recovered through specific recycling processes (mechanical, thermal, or chemical), resulting in low property material. RQ1:

• Which type of CF waste source has the best properties to be spun and which recycling process provides recycled fibres with the best properties?

So far, recovered fibres have only been used for the production of second-quality materials, including short fibres random mats [8], and injection moulded composites [7]. Therefore, a new spinning process is required to produce CFRP for structural applications. RQ2 and RQ3:

• How can the traditional spinning process be adapted and how can the new spinning process be turned into an industrial process?

• What is the economic-environmental impact of the newly developed spinning process?

Research Objectives and Research Methodology

This project is structured in 6 main stages. An appropriate methodological approach will be adopted for each stage:

1. An extensive literature review about CFRP recycling processes will be carried out to understand the existing recycling processes, as well as to determine the mechanical properties of the recycled CF from each process.
2. A detailed patent search about CFRP recycling processes and analysis of the patent pool retrieval will be developed to gather all the necessary data required for the development of comprehensive assessment on maturity of CF recycling technologies.
3. An analysis of technology maturity and further development will be provided. Proper statistical methods will be adopted to analyze collected data.
4. A survey and secondary data analysis will be carried out to gather primary data about the recycled CF to be used in the new spinning process (quantity, type and so on).
5. A development of a new spinning process through experimental tests in lab will be carried out. Then, the laboratory process will be transported on an industrial scale.
6. A validation of the identified spinning process will be introduced to verify the repeatability of the work cycles and to perform an economic and environmental evaluation of the process.

Machine Learning for Preventive Maintenance: study of predictive model based on product performances

CARLO RICCIO
Università degli Studi di Padova

Context and main scientific issues under investigation

Maintenance has a key role in the Industry 4.0; the amount of data that modern industrial machinery can generate, are allowing a constant evolution of the Predictive Maintenance strategies (PdM).
Through the processing of historical data and the control of parameters measured in real time, PdM allows to anticipate possible machine failures. The prediction of failures, and the elaboration of a maintenance strategy, can be achieved by models based on Artificial Intelligence (IA) techniques. PdM strategies must guarantee not only the continuity of production, but also the quality of the product. In fact, the quality parameters of the product are related to the machine's operating parameters, whose trends determine the development of the correct maintenance strategy. Therefore, the qualitative characteristics represent an input that an IA model must consider in the optimization of the maintenance, together with availability and costs. In fact, different levels of desired quality of the product (while still maintaining conformity to specifications), can determine different predictive maintenance strategies.
In addition to quality level, a product is characterized by a degree of performance, related to machine control parameters. This work explores how a model based on IA techniques can determine the optimal PdM strategy based on the required level of quality and performance of the product.

Research questions addressed

This study attempts to answer some basic questions regarding the connection between maintenance strategy and product performance.
RQ1: How is it possible to consider the product performance within the problem of maintenance scheduling?
The first research question aims to address the feasibility of a model considering quality and product performance parameters as variables in the failure prediction; the idea is to relate the big data from machines to predictive maintenance indicators and product features (expressed as performance and quality).
RQ2: May we optimize the maintenance intervals when the desired level of product performance changes?
The second research question aims to investigate the impact of the maintenance strategy according to a given level of product performance; this need investigating the model's ability to "learn" and suggest the optimal maintenance actions.

Research Objectives and Research Methodology

The main goal of this research path is to build a model that, through Machine Learning techniques, elaborates the machine parameters and the predictive maintenance indicators, to give the best maintenance strategy in order to achieve the desired level of quality and performances of the product.
The Research Methodology has been elaborated to obtain a flexible approach to study predictive maintenance strategy in connection with quality and product performance, according to 3 steps:
1. In the first step a set of parameters, related with the machine working, the predictive maintenance and the product performance, are defined.
2. The second step has the goal to relate the maintenance scheduling with the production performance; in this step we use the Artificial Intelligence techniques to build a model able to learn the behaviour of the system and detect the relation between the status of the machine and the performance levels of the product.
3. The last step should allow us to select the maintenance strategy according to the desired level of product performance. A production line for current transformers assembly has been chosen as case study to validate the model.

TRACK 3 - Production and Logistics within Industry 4.0 era Chair Prof. Riccardo Accorsi				
Time	**Name**	**University**	**Level**	**Project Title**
14:00 14:15	Marco Spaltini 	Politecnico di Milano	First	Development of an Industry 4.0-oriented tool supporting Sustainable Manufacturing
14:15 14:30	Lorenzo Ragazzini 	Politecnico di Milano	First	Digital Twins for advanced manufacturing operations
14:30 14:45	Serena Ilari 	Politecnica delle Marche	First	Development of circular economy models based on Industry 4.0 technologies
14:45 15:00	Nicolò Saporiti 	LIUC Università Cattaneo	Advanced	Digital Twin in Manufacturing: Adoption Framework and Benefits

15:00 15:15	Leonardo Maretto 	Padova	First	A Decision Support and Control System for An Efficient Digital Technology Implementation in Manufacturing Systems
15:15 15:30	Federico Angelo Maffezzoli 	Brescia	First	Development of a Data Integration Framework in the "Agriculture 4.0" application field

Development of an Industry 4.0-oriented tool supporting Sustainable Manufacturing

MARCO SPALTINI
Plitecnico di Milano

Context and main scientific issues under investigation

The call for overcoming the current take-make-dispose paradigm has now become a global imperative for governments, business and academia.

Among the paths investigated in literature to achieve an environmental sustainability, Circular Economy (CE) appears as a promising solution.

According to Ellen MacArthur Foundation, the purposes of CE are three: preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows, optimize resource yields by circulating products, components and materials in use at the highest utility and foster system effectiveness by revealing and designing out negative externalities.

In addition to CE, another relevant trend for academia and practitioners is represented by Industry 4.0. The interest toward these 2 topics has dramatically increased over the last decade.

Due to the entity of the topics, manufacturing firms will be the unit of analysis, with regards to processes taking place within factory's boundaries

Hence, the scope of the research project is to investigate the role that Industry 4.0 play in achieving CE principles within the manufacturing context.

In particular, the aim is to develop a tool able to support manufacturers in exploiting advanced technologies to reach specific objectives designed to reduce their environmental footprint and shift toward Circular Business Models.

Research questions addressed

RQ1: Does a relationship between Circular Economy and Industry 4.0 exists?

RQ1 aims at understanding whether Industry 4.0 could impact CE and if these two concepts are synergically applicable.

RQ2: What are the barriers that impede Circular Economy practices and Industry 4.0 to be implemented by practitioners in manufacturing Industry?

RQ2 aims to investigate the challenges that manufactures face in adopting Industry 4.0 technologies and CE practices. It is worth identifying the barriers present in both the areas to define the strategies to propose to achieve higher circularity levels.

RQ3: Which instruments do practitioners in manufacturing Industry need in order to establish a digital transformation process to enable Circular Economy practices?

RQ3 is designed to understand how modalities digital technologies could support manufacturers in achieving circularity. From this interpolation the goal is to develop a framework able to support manufacturers in undertaking a digital transformation oriented to achieve environmental sustainability.

Research Objectives and Research Methodology

The objective of the research is the development of a tool able to support manufacturers in defining a Circular Business Model enabled by Industry 4.0.

For RQ1, the methodology selected is based on academic literature. Since the objective is to understand the existence of a link between Industry 4.0 and CE, the systematic literature review (SLR) will be adopted to minimize the risk of missing existing contributions. Bibliometric analysis techniques will be implemented. The search process will also be supported by snowballed documents identified along the systematic search process. The main unit of analysis will be the factory. No experimental nor other empirical methods are planned to be implemented.

For RQ2, it is deemed appropriate to rely on SLR. The boundaries of analysis will be the single manufacturing firm. No a given sector has been delimited since, at present, there are not enough elements to declare or confute the presence of commonalities. Also grey literature will be analyzed to find real cases. Finally, empirical methods will be used to validate the analysis of the barriers.

For RQ3, the design of the tool able will be based on literature and empirical methodologies and subsequently validated through workshops and interviews to manufacturers.

Digital Twins for advanced manufacturing operations

LORENZO RAGAZZINI
Politecnico di Milano

Context and main scientific issues under investigation

The area of investigation is Production Planning and Control as a branch of Operations Management in manufacturing. This sector is undergoing deep transformations following the Industry 4.0 wave. To exploit the benefits of digital technologies production planning and control functions shall be revamped: many new data-driven control-oriented methods based on Industrial Internet of Things have been proposed. Despite not being one of its main enabling technologies, simulation models, traditionally applied to solve complex problems, have experienced a renewed interest in the context of Industry 4.0. Lately, the idea of Digital Twin (DT) as the new paradigm for modeling and simulation is emerging, gathering great interest from the academy and the industry. In the manufacturing sector, key features are simulation models and the integration level, as bilateral communication with the physical system is necessary. Despite DT is an attractive topic for scholars with diverse backgrounds, its potential impacts should be furtherly investigated. They include improvements enabled by real-time monitoring functions generating insights in real-time, production control applications, and optimizations based on predictive models of production resources. From a managerial perspective, DTs may support decisions at tactical and operational levels, and be used to analyze the performances being integrated within business intelligence.

Research questions addressed

The overarching question driving the research project is:

• RQ1: How may Digital Twins support manufacturing operations, and in particular production planning and control?

This question is threefold. Firstly, seeks to discuss the models on which DTs are built. Firstly, different modeling techniques, the level of detail, and the level of integration must be analyzed. Secondly, this question addresses the decisions that DTs are supporting. Thirdly, the functionalities of DTs which may support decisions and allow improvement in manufacturing systems are studied.

Two additional questions will be discussed in this research project:

• RQ2: What is the impact of DT on manufacturing operations?

This question would investigate how DTs may support new developments in production management research in terms of autonomy, responsiveness, and management of variability?

• RQ3: which optimization models can be based on DTs?

Considering DT as the new paradigm for modeling and simulation, frameworks and methods for DT-based optimization shall be studied.

Research Objectives and Research Methodology

The research objective of this project can be formulated as:

• RO: to define a comprehensive model for integrating a DT supporting different functions of a manufacturing company

Some sub-objectives are prosed to better address the stated research objective:

• RO1: to understand which are the gaps in the literature related to DT in manufacturing operations;

• RO2: to define the requirements in terms of models, functions, and connections of a DT for supporting manufacturing operations;

• RO3: to propose a reference methodology for developing and implementing a DT in manufacturing companies. Possible methodologies that will be adopted in the research project include a literature review, specifically designed to address the first research question (RQ1) and the first research sub-objective (RO1). Then, proposed DT-based methods will be subject to analysis and implementation in a laboratory, to test the proposed framework in a reduced-scale environment. Finally, a case study shall be developed too, also challenging the results of previous developments in a real industrial context could provide insightful results.

Development of circular economy models based on Industry 4.0 technologies

SERENA ILARI
Università Politecnica delle Marche

Context and main scientific issues under investigation

The core topic of the research project is the use of Industry 4.0 technologies to develop circular economy models. The topics related to Industry 4.0 and sustainability play an extremely important role within the world scene and, in particular, in the industrial scenario will constitute the innovations and challenges of the near future thanks to the possibilities offered by their simultaneous implementation. Manufacturing is currently transforming from a linear economy to a circular economy, and it is precisely in this direction that Industry 4.0 plays a decisive role. With its intelligent solutions, Industry 4.0 provides transparent access to product data and in this way allows for optimization of their life cycle, more efficient utilization of resources, leading to the reduction of energy consumption and minimizing waste as much as possible. We are therefore increasingly moving towards the idea of a Sustainable Smart Factory understood as an efficient, sustainable and safe reality in which the benefits of digitalization obtained, thanks to industry 4.0 and circular economy technologies, can be merged.

Research questions addressed

-How to evaluate the sustainability of production system adaptation solutions?
Through the research activity, frameworks will be created in order to evaluate the sustainability of machine tool adaptation solutions.

-Which Industry 4.0 technologies are most conducive to the creation of circular economies?
By Combining research activities and case study analysis, Industry 4.0 technologies that allow for the creation of new business models capable of creating circular economies are outlined. This is extremely useful to create Sustainable Smart Factories.

-How can the machine tools end of life of machine be managed sustainably?
By combining research and innovation, it is possible to study specific solutions to manage the end of life of a machine tool such as retrofitting, that, thanks to the collection and processing of data of machinery or the entire production process, allows extending the useful life of the machines making them perhaps Industry 4.0 ready through a smart retrofitting.

Research Objectives and Research Methodology

The main objective of the research project is to develop circular economy models thanks to the use of Industry 4.0 technologies in order to create Sustainable Smart Factories (Smart Green Factories). To do this, the different technologies of Industry 4.0 and the concepts of circular economy and the sustainability triad are studied and their links are analyzed also thanks to the use of Co-occurrence bibliometric maps.
There will be an evaluation of processes to extend machine shelf-life through different retrofitting options using IoT solutions in a sustainable development perspective. Furthermore, Big Data Analytics algorithms will be developed to improve the efficiency, competitiveness, and environmental impact of companies.

Digital Twin in Manufacturing: Adoption Framework and Benefits

NICOLÒ SAPORITI
LIUC - Università Carlo Cattaneo

Context and main scientific issues under investigation

The core of the research is the study of an emerging but rarely discussed in literature Industry 4.0 tool: the Digital Twin (DT). DTs belongs to the simulation pillar of Industry 4.0 and can be defined as integrated simulation and emulation systems, which aim at mirroring in an accurate way a single machine or complex environments, in order to provide insights and forecasts about the corresponding physical twin. Together with the powerful tools of Industry 4.0 related to data collection, data storage and data processing, a DT could be enabled to simulate and emulate its twin with real-time exchange of data

Research questions addressed

The research questions addressed in the study are related both to a managerial as well as technical point of view. Indeed, the first RQs concern the challenges and countermeasures of DT adoption and implementation. On the other hand, the technical side of the research is related to the analysis of the use of a Digital Twin in an Assembly Line Balancing Problem, with a particular attention to human-intensive assembly lines. Therefore, the following research questions will be addressed:

- What are the challenges for the implementation of DT within industrial contexts?
- How should these challenges be overcome?
- What is the impact of a DT in an ALBP?
- What are the advantages of a DT in a human-intensive assembly line?

Research Objectives and Research Methodology

The main objective of the research addresses the topic of the adoption and implementation of a DT, underlying the main challenges to overcome and key success factors or countermeasures to be adopted to achieve a successful application of a DT. This thematic will be treated especially in from managerial point of view, but technical issues will be taken into consideration as well.

In order to answer the managerial research questions, firstly a systematic review of the extant literature on barriers and enablers to DTs implementation has been conducted. Secondly, a Delphi Study on challenges and countermeasures for DT adoption is ongoing. In this way, the research aims at developing an adoption framework of DT in industrial contexts. Thirdly, the impact of a DT in a human-intensive ALBP is being addressed through a case study on the assembly line of i-FAB, the learning factory of LIUC.

A Decision Support and Control System for An Efficient Digital Technology Implementation in Manufacturing Systems

LEONARDO MARETTO
Università Degli Studi di Padova

Context and main scientific issues under investigation
Digital technologies and their interconnection are at the basis of the Fourth Industrial Revolution, also known as Industry 4.0. My research aims at sharing light on this interconnection, with a special focus on the interconnection between different levels of the industrial layout: it will start from the application of vision systems to the workstation level up until their integration with a decision support system that operates at a strategic and managerial level. Academics will find relevance in the analysis of a technology such as vision systems, which is being used more and more often within industrial plants, and its introduction in a closed loop system that connects all the levels of an industrial plant: therefore, the research will also fall within the thematic umbrella of digital twins. Academics and practitioners will also benefit from the analysis of the productive and economic impact that the introductions of these technologies have, due to the existing lack of clarity on the topic, especially for the latter.

Research questions addressed
RQ 1) What is the potential of vision systems in the manufacturing sector? The study will try to understand how they can be used, for which tasks and what will be the productive advantage of their implementation.

RQ 2) How to effectively develop a decision and support control system of an industrial plant? The research will target how to effectively retrieve data from the plant and how to use them to support the decision process of plant and production managers.

RQ 3) What is the economic benefit of the introduction of digital technologies? The Fourth Industrial Revolution and the adoption of the associated digital technologies is a wide-known phenomenon but a wide cost-benefit analysis, with dedicated models, is an aspect that has not been addressed enough in the literature yet.

Research Objectives and Research Methodology
The objectives of the research are the following:

- Develop a vision system application for an assembly workstation (either manual or with the presence of a collaborative robot)
- Develop a decision support and control system that aids managers and leaders of an industrial plant to understand data and make decisions.
- Develop models to measure the impact of the introduction of digital technologies and their validity in economic terms, with the aim of generalising the results.

With regards to the methodology, the research will start with a thorough review of the existing literature concerning digital technologies and where they are applied within an industrial plant. Secondarily, laboratory activities will be performed, using depth cameras and skeleton-tracking software to monitor the movements of an operator. At the same time, the development of the control and support system will be conducted. Finally, the two systems will be implemented and tested, and their results will be compared to other real-life case studies of similar industrial applications. Finally, and in parallel with the two previous activities, a model to evaluate the economic impact of digitalisation will be developed.

Development of a Data Integration Framework in the "Agriculture 4.0" application field

FEDERICO ANGELO MAFFEZZOLI
Università di Brescia

Context and main scientific issues under investigation

My research focuses on a specific branch of the industry 4.0 paradigm: Agriculture 4.0

Although the existing literature is starting to demonstrate the applicability of the Industry 4.0 paradigm in the agricultural environment and indicates how it can bring advantages to both farmers and customers, there are still many opportunities which firms are not taking so far.

My proposal aims to develop a Data Integration Framework, investigating the managerial implications of a shared platform and how to integrate (which) data from different sources (e.g. tractors, sensors, weather stations, drones, robots, etc...) in order to meet the most relevant needs of farms, trying to overcome the obstacles related to the lack of interoperability among these different sources. Focusing from the point of view of an integrated platform, capable of going beyond the logic of vertical silos, typical of the various applications currently on the market.

The outcomes of this project can be used to define practical guidelines in order to support companies that wish to understand how to change their business towards the paradigm of the fourth industrial revolution; on the other hand, the results obtained in the project will also be useful for directing scientific research in this area.

Research questions addressed

To describe the areas of inquiry that I am going to work on during my path, they can be divided into two separated research questions:

RQ1: What are the specific peculiarities of Agriculture 4.0 paradigm with respect to Industry 4.0?

With first RQ the purpose is to understand how the paradigm can be described and especially get into the merits in terms of enabling technologies, benefits, constraints and application domains.

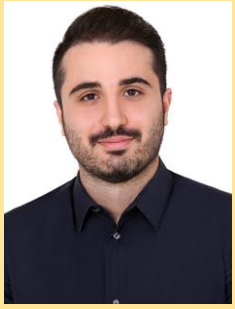
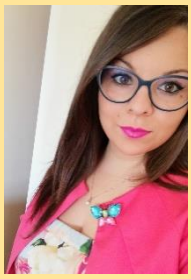
RQ2: What are the main features and managerial implications of the designed data integration framework?

The second RQ aims to understand which are the characteristics of data integration in the agricultural context and identify the gaps that this involves from the management point of view in the operations of a farm. Doing so by starting from what are the needs of companies and how this drives 4.0 innovation in agriculture.

Research Objectives and Research Methodology

The main aim of the project will be to design an innovative framework that goes in the direction of a true 'Data Federation' among different actors, sources and technology that are involved in the A4.0 ecosystem. Afterward, investigate the operational and managerial implication of a truly digitalized farm, identifying the main gaps with current situation. The concepts of data integration and interoperability will have to be taken up, in order to build a framework for mapping and categorizing data that are useful for the needs of farms. The aim is to help (Italian) farms to evolve their traditional business model.

The methods that are likely to be used are many. First, a careful analysis of the scientific literature will be carried out to better understand the gaps just mentioned above. Then, some surveys are needed to understand the A4.0 phenomenon within real companies. Surveys are going to be used in a longitudinal study, (repeated observations of the same variables over short or long periods of time). Then, case studies will be carried out, to extend experience or strengthen what is already known from previous research as well as modelling techniques to shape the data integration framework and its managerial implications.

TRACK 4 – Worplace Safety and Health Chair Prof. Marco Bortolini				
Time	**Name**	**University**	**Level**	**Project Title**
14:00 14:15	Gaia Vitrano 	Politecnico di Milano	First	A holistic approach for occupational safety and health management: designing and maintaining a dynamic ecosystem
14:15 14:30	Ali Keshvarparast 	Padova	First	Modeling and optimization of manufacturing systems considering human-machine interoperability and the active aging workforce
14:30 14:45	Alice Caporale 	Bologna	First	Design of industrial environments and plants, workstations and industrial products according to predictive models of ergonomic risk assessment, microclimate and confined environments
14:45 15:00	Marialuisa Menanno 	Sannio	Advanced	Study of Artificial Intelligence Techniques for the Improvement of Production Ergonomics and Development of Production Activities
15:00 15:15	Antonio Javer Nakhal Akel 	La Sapienza, Roma	First	Resilience analysis for the evolution of industrial sociotechnical systems in critical or highly complex contexts

15:15 15:30	Silvia Colabianchi 	La Sapienza, Roma	First	Resilience of cyber socio-technical systems: pursuing the shift from cybersecurity to cyber-resilience
15:30 15:45	Alessandro Federici 	Aquila	First	Design of industrial equipment and systems under uncertainty and variable operating conditions.

A holistic approach for occupational safety and health management: designing and maintaining a dynamic ecosystem

GAIA VITRANO

Politecnico di Milano

Context and main scientific issues under investigation

The continuously changing working environment (i.e., social, political, technological and economic changes) makes Occupational Safety and Health (OSH) management more complex over time and a constant challenge for any organisation.

Understanding successful strategies i.e., effective initiatives (efficiency plays a minor role in OSH) in organisations is a crucial priority for OSH management and workers' well-being that should be contextualized in the environment where they are implemented.

Among academics and practitioners, there is an increasing consensus that a connected network of OSH actors is a strong driver to improve the implementation and effective monitoring of initiatives. However, in the literature, it seems that – when developing OSH initiatives – just local improvements rather than the surrounding OSH system are considered.

The preliminary analyses (literature reviews and field interviews) have revealed that there is still a gap in OSH practices between what is theorised at the policy level and what is daily implemented at the operational level. Here arises the need to study existing OSH systems and to understand how they can effectively improve the development of new initiatives and the management of those already in place.

Research questions addressed

Overarching Question: How can an OSH ecosystem increase its effectiveness?

Assessing the value of the OSH ecosystem's items and connections is the foundation for effective OSH improvement.

RQ1: How do national (European) OSH systems currently work?

It is believed that OSH systems are already sufficiently developed and there are working practices across countries that reflect the current status (equilibrium) of general OSH systems by identifying stable items and connections.

RQ2: How can pivotal items enable an OSH ecosystem to better adapt to changing environment?

It is believed there are distinctive (local) items that, if properly managed, can make the system dynamic able to readily adapt, actually becoming an ecosystem.

RQ3: How can knowledge of the OSH ecosystem support local OSH initiatives?

It is believed that the knowledge of the OSH ecosystem (how it is made up) will help in improving current local OSH initiatives and developing new, more effective ones.

Research Objectives and Research Methodology

It has been deemed important to analyse how current OSH systems across countries operate (in equilibrium) by defining shared ("universal" and "local") items and connections that can influence the success of OSH initiatives.

This objective will be developed by a comprehensive analysis of national (European) OSH systems through the OSHwiki website, which is a very reliable source as edited by the most prominent national OSH organisations, and complemented by cross-checks in the respective national websites and literature papers on the topic. Then, a confirmatory survey with international experts (academics and institutional practitioners) will be performed.

Further analyses will be necessary to deepen pivotal items and connections by identifying the one most contributing to the continuous improvement of the ecosystem. To this end, a deductive study (i.e., a Delphi study) with international experts (mainly from academics) will be performed.

Thanks to the current collaboration with INAIL on a project for developing an OSH ecosystem to support the monitoring of near misses in industrial sectors, it will be possible to perform surveys involving partners at different levels to investigate the beneficial effects of the acquired knowledge about the OSH ecosystem on local OSH initiatives, in particular on implemented activities for near-miss monitoring.

Modeling and optimization of manufacturing systems considering human-machine interoperability and the active aging workforce

ALI KESHVARPARAST
Università degli Studi di Padova

Context and main scientific issues under investigation

Currently, the industry is going through a digital transformation that is being accelerated by new technologies that are evolving exponentially, such as robotics, autonomous systems, Artificial Intelligence, and so on. The accelerated pace in the digitization process with "Industry 4.0" has transformed the business content and contributed to an increasingly dynamic environment and market structure. My research concerns the development of an age-friendly manufacturing system through new models, based on the relation between digitalization and workforce performance and the application of specific assistive equipment. With the aim of this research, the impact of different assistive technology and digitalized equipment can be determined. As the result, designing a more productive and ergonomic production system will be reachable. Additionally, technology designers also can use the results of our research to design more suitable ethnology for the industry.

Research questions addressed

RQ 1) What is the correlation between digitalization & ageing workforce? This research will study the mutual impact of digitalization and ageing workforce, to identify the trade-offs and correlations, and to consider these trade-offs in global optimization.

RQ 2) How to model and design a digitalized production system concerning the active ageing workforce? This research will provide a conceptual and mathematical model for designing and optimizing a cyber-physical production system considering the workforce's identified features.

RQ 3) What are the impacts of different kind of digitalization tools on different category of workers? This research will study the impact of different kind of assistive equipment and digitalization tools in production system. In this way we can find out which technology can be used in different situation.

Research Objectives and Research Methodology

The objectives of the research are the following:

- Develop a new methodological framework for manufacturing systems in presence of assistive equipment inside a collaborative environment.
- Develop a new model for manufacturing system in presence of collaborative and assistive tools for designing an age-friendly workforce.
- Develop a new Decision-Making System to evaluate the use of different assistive equipment by considering the workforce characteristics.

With regards to the methodology, the research will start with a thorough review of the existing literature concerning digital technologies and digitalized production systems. With the aim of the literature, a first methodological framework for manufacturing systems in presence of assistive equipment inside a collaborative environment will be developed. As a next step, a new model for manufacturing system in presence of collaborative and assistive tools related to the workforce, especially aging workforces, will be performed and validated with a set of numerical instances derived from literature and Italian company cases. At the end, by analysing the results obtained from the developed model, a Decision-Making System will be presented to evaluate the use of different assistive equipment by considering the workforce characteristics in a manufacturing system.

Design of industrial environments and plants, workstations and industrial products according to predictive models of ergonomic risk assessment, microclimate and confined environments

ALICE CAPORALE

Università Degli Studi di Bologna

Context and main scientific issues under investigation

The health and safety of workers represent the most important challenge when designing environments and workstations. In this regard, appropriate design criteria and prevention tools for the reduction and elimination of risks are necessary. To date, the risk of biomechanical overload is being accompanied by previously underestimated criticalities in industrial environments. In this regard, this project intends to analyze the microclimatic conditions (e.g. temperature levels, relative humidity, air speed) that can lead to situations of physical and psychological discomfort for workers with consequent impacts on the business economy due to illness and days of absence. A particular focus will concern confined spaces in which the risk of microclimate (lack of oxygen, presence of toxic and / or flammable gases) is particularly dangerous for the health of operators. Since postural analyzes and the composition of the working environment are often not sufficient to determine all the potential elements of damage, it is also necessary to consider the personal characteristics of the operators (anthropometric measures, biological age, individual risk factors and lateral dominances) in relation to the interactions with the workspace (machinery and screens) and to the present microclimate.

Research questions addressed

1) What are the effects of factors that determine indoor air quality on the health and productivity of industrial workers?

Human exposure to microclimatic elements is regulated by national (art 180, title VIII, chapter I, of Legislative Decree 81/08) and international directives which indicate limit values for each factor. However, these ranges guarantee safe working conditions without implying the achievement of comfort conditions for the operators.

2) Which technological solutions can guarantee the health safety of workers who carry out activities in confined environments?

In many cases, operators who carry out activities in confined spaces are assisted by technologies that prevent worker access. However, where there are no no-entry technologies for risk prevention, it is necessary to intervene on improving the access conditions of operators and monitoring the internal atmosphere to ensure safe entry and activity.

Research Objectives and Research Methodology

This research project aims to define new models of risk assessment and user safety in the industrial environment. The primary interest concerns the identification of harmful activities and processes, not only through the analysis of the physical characteristics of the operators and their relationship with the context but also by evaluating the influence of microclimatic variations and perceived comfort on health and productivity of workers.

This project will integrate the Bank of Solutions, in place since 2014 at the Industrial Engineering Department (DIN) of the University of Bologna, with the collaboration of AUSL Bologna, INAIL, the Labor Inspectorate and the Fire Brigade. In particular, with the creation of a section dedicated to improving the microclimate of industrial plants, warehouses, storage areas, interports, through the inclusion of both technical and organizational solutions.

Study of Artificial Intelligence Techniques for the Improvement of Production Ergonomics and Development of Production Activities

MARIALUISA MENANNO
Università Degli Studi del Sannio

Context and main scientific issues under investigation

Despite the progress made by academic research, industrial activities are often affected by injuries that may be fatal for the operators. The goal of having a safe workplace may be featured by procedures and behaviours that may not pay attention to prevention. Under this point of view, a firm has to focus its efforts on prevention policies, that can be intended as a set of measures to be implemented in order to anticipate the potential development of injuries. This research may start with a careful assessment of the possible risks, to obtain a realistic plan designed to monitor, keep and improve over time the safety conditions inside a shop floor. My Ph.D. project aims to improve the safety of a working environment through a detailed analysis of processes and activities, with the final goal of reducing potential accidents. From the academic perspective, different studies on industrial safety have been addressed through artificial neural networks (ANN).

Research questions addressed

The objective of the study is to develop a system that automates ergonomic risk assessment based on 3D modelling with the support of user-friendly platform for rapid workplace design.

Thus, the first question RQ1 is: how it's possible evaluate the impact of the collaborative automation in terms of capacity, task time, ergonomics and safety within a single methodology?

The second RQ2 is: may we optimize the placement of the collaborative robots both along the whole production line and within the single task performed on specific workstation?

Most organizations use conventional ergonomic risk assessment methods, which are based on observations and self-reports, making them error-prone, time consuming, and labor-intensive (Lee et.al 2016)

More recently, researchers have started exploring alternative sensor-based automated assessment methods.

In spite of advances, these works do not provide a general-purpose framework to predict the ergonomic risks for any representative set of object manipulation tasks commonly performed in the industry.

Research Objectives and Research Methodology

Based on the REBA and RULA method, the model assigns scores to the human poses, on a frame-by-frame basis by accounting for the joints motions and angles, load conditions, and activity repetitions.

The scores assigned for each frame are then aggregated over all the actions and workers so that we have a constant risk score for every frame that corresponds to a particular action.

In this respect, the present study develops a comprehensive and automated ergonomic risk assessment framework with the support of 3D modelling in order to conduct workplace design changes efficiently for increased safety and productivity in modular construction tasks.

Resilience analysis for the evolution of industrial sociotechnical systems in critical or highly complex contexts

ANTONIO JAVER NAKHAL AKEL
Università di Roma, La Sapienza

Context and main scientific issues under investigation

My research topic focuses on issues related to safety management and risk analysis in socio-technical processes. The present techniques of risk analysis or safety management are focused on analyzing the interactions between the components of an industrial complex process trying to reduce the incidence of incidents/accidents arisen in the past. Over time industrial processes are becoming more complex due the increase of the interactions between system's components, demanding for updated safety models. On the other hand, there is a large extent of data related to industrial accidents/incidents, stored on databases whose potential is not fully exploited. Therefore, my research focuses on using Business Intelligence tools to obtain information from past industrial incidents/accident reports, and to contribute to current techniques on risk and safety management by adding new parameters/analysis to complement them. Business Intelligence will be complemented with dedicated Machine Learning algorithms.

Research questions addressed

The application of Business Intelligence on databases related to industrial safety reports entails the major research question of my PhD project: how can Business Intelligence tools provide useful information to learn from past accidents and allow the development of new quantitative and semi-quantitative analyses for the reduction of future criticalities?.
With the information obtained through the analysis using Business Intelligence, I seek to create a novel safety model that incorporates information from past accidents as a basis for the study of the interactions of system's components. The model is expected to be a support tool to reduce the incidence of accidents, and to manage more efficiently possible risks to ultimately promote a safer, sustainable and resilient work environment.

Research Objectives and Research Methodology

The main objective of safety/risk management is to reduce occurrence of the industrial incidents with operational and occupational impacts and improve the knowledge of the industrial processes to manage in smart way the risk existed in themself. Going into the details of my PhD project, the overall research question is translated incorporating Resilience Engineering theories to evolve towards proactive strategies that can deal with modern safety management issues .
Specifically, my research question can be translated into four different objectives: (i) to apply business intelligence tools to classify and describe past accident reports, in a way that remains understandable by all parties; (ii) to perform advanced analysis on past accident reports for the prevention and prediction of future accidents with the help of natural language processing; (iii) to apply machine learning algorithms to observe or determine new behaviors or potential hazards that have not been previously considered; (iv) to design a database structure needed for reporting data referred to modern Industry 4.0 industrial context, for which business intelligence and machine learning can be further applied.

Resilience of cyber socio-technical systems: pursuing the shift from cybersecurity to cyber-resilience

SILVIA COLABIANCHI
Università di Roma, La Sapienza

Context and main scientific issues under investigation

This research project focus on Cyber-Physical Systems resilience. The research has started with a systematic literature review focused on understanding how CPS resilience is measured and to which extent do CPSs contribute to the resilience of technical and socio-technical systems. The survey highlighted two main issues which are now under investigation.

First, the mapped evidence highlights the prevalence of research that investigates CPS's resilience at a technical level while new emerging domains require a joint technical and socio-technical research dimension integrating safety and security needs. Therefore, the study investigates an integrated approach to deal with safety, resilience, and security issues of CPS.

Second, the importance of building resilience in cybersecurity. The cyber defense mechanism is today dynamic and real-time. Threats and incidents become more sophisticated, and there is the need to keep pursuing the shift from cybersecurity to cyber-resilience understanding the nitty-gritty of these events in real operational settings, rather than simply fight them in small-world scenarios, managing variability rather than simply trying to reduce it. In keeping with the need for a dynamic approach to threat identification, this research investigates the Common Vulnerability Exposure database and the MITRE attack framework proposing an efficient, and time-saving way to prioritize CPSs vulnerabilities.

Research questions addressed

The extensive literature review conducted during the first year of this PhD has better clarified the research questions of this PhD project.

First, the objective is to identify a socio-technical system in which to research the concepts of cybersecurity to safety-critical systems. Recent studies demonstrate an increase of interest in safety performance and underline the fact that is no longer possible to separate cybersecurity from safety in critical infrastructure contexts. For this reason, the project will investigate an integrated approach for safety and security analysis for cyber-physical systems.

Second, another aspect to be investigated concerns the threats modern systems face. Cyber hazards are constantly changing, forcing a continuous reconsideration of strategies to ensure operational continuity. This PhD project aims to fill this gap by mapping the CVEs database to the MITRE ATT&CK framework to help security professionals prioritizing and patching vulnerabilities in their industrial systems.

Research Objectives and Research Methodology

This PhD journey started with a systematic literature review which provided insights into how the topic of CPSs resilience has been addressed in the literature and which methods are used to study and measure the resilience of these CPSs. Moreover, the literature review identified challenging gaps of research that are now under investigation. The first objective is to identify a socio-technical system in which to research the concepts of cybersecurity to safety-critical systems. Moreover, the review has shown that resilience metrics that consider both technical and socio-technical aspects are limitedly discussed in the literature. Therefore, the goal is to define a framework of flexible socio-technical metrics to evaluate the resilience of systems including CPSs.

The second objective is to connect two of the most widely used data sources in the cybersecurity field. To do this, the research will develop a Natural Language Processing data model that through NLP algorithms will map common vulnerabilities and exposures included in the CVE database with their potential impact and attack techniques included in the MITRE ATT&CK framework. This integration will help security analysts reduce the time spent on the mitigation phase by improving the operational continuity of critical infrastructures

Design of industrial equipment and systems under uncertainty and variable operating conditions.

ALESSANDRO FEDERICI
Università degli Studi dell'Aquila

Context and main scientific issues under investigation

Even though industrial equipment and systems often operate in variable conditions, and during their life cycle may also experience changing scenarios and requirements, they are designed resorting to nominal conditions. Additionally, their performance is affected by random events, as well as the uncertainty of their internal parameters. Moreover, there is an epistemic uncertainty of the underlying phenomena inducing imprecise design correlations. Some rules of thumbs may be used to manage variability but frequently it is simply neglected using nominal specifications based on average operating conditions, and assuming mathematical models, parameters, and physical properties as deterministic. Sometimes worst-case conditions are used for design purposes (leading to costly "overdesign"). Penalties for off-design performances are usually not included in the evaluation of economic/technical objective functions in case of design optimization.

Literature analyses the response of a system under uncertainty, for example using sensitivity analysis and uncertainty propagation, but it is very scarce in considering this uncertainty during design process. The proposed research deals with incorporate uncertainty in design for equipment and industrial systems believing that taking into account variability and uncertainty in the design phase leads to superior performances and better system design.

Research questions addressed

1. Is there an economic and/or technical revenue by considering uncertainty during equipment (or industrial plant) design?
2. Given a case study, does the variability of the input influence the design and how much?
3. How may the performance of the designed system be optimized considering both epistemic and aleatory uncertainty?

The answer at the first question could show if look for new design methodologies is consistent with the real behaviour of industrial systems and if the more designing efforts are aimed by economic and technical revenue. Control systems are implemented also to maintain the nominal condition during operating time, but they could be expansive or not useful in all cases, so the second and the third question try to identify what the problems in which new design process could be used and suggest when it helps to find a better solution than traditional methods.

Research Objectives and Research Methodology

A critical literature review of design methodologies under uncertainty and variable condition (for process and manufacturing plant) is on-going.

At the same time design methodologies considering variable operating condition is being applied to the case of a single equipment design. The chosen equipment, due to widespread diffusion end economic importance, are heat exchangers. Therefore for the same equipment uncertainty in design correlation will be considered and included in a technic and economic design model.

Further, the design approach will be applied to a system, in process industries yet. The last step will be the use of proposed methodology in manufacturing environment, characterized by many discrete quantities more difficult to manage.