WORLD MANUFACTURING FOUNDATION

BACK TO THE FUTURE

MANUFACTURING BEYOND COVID-19

INDUSTRIAL SMART WORKING

Fostering organisational resilience through smart working practices

Group Leader
Raffaella Cagliano
Professor of People Management and Organisation
at School of Management, Politecnico di Milano

CONTRIBUTORS

Ricardo Cevada
Co-founder of Skills.For.Industry;
Member, Young Manufacturing Leaders

Anna de Carolis
Post-Doc Researcher and Industry 4.0 Advisor and Trainer, School of Management, Politecnico di Milano

Jochen Deuse
Professor and Head Institute of Production Systems, TU Dortmund University
Professor and Director Centre for Advanced Manufacturing, University of Technology Sydney

Åsa Fast-Berglund
Professor of Production Systems, Chalmers University of Technology Project manager for Stena Industry Innovation Lab

Rositsa Georgieva
Programme Officer EU Policies, European Commission

Brian Jeong
Shop Supervisor, Autodesk Technology Centers;
Member, Young Manufacturing Leaders

Désirée Laubengaier
PhD Candidate, School of Management, Politecnico di Milano

Luca Manuelli
Chief Digital Officer, Ansaldo Energia and President Cluster Fabbrica Intelligente

Torbjørn Netland
Head of Chair of Production and Operations Management, ETH Zurich

Yves Paindaveine
Head of Sector Digitalisation of Industry, European Commission

Sharon K. Parker
Centre for Transformative Work Design, Future of Work Institute, Curtin University, Perth, Western Australia

Luciano Pero
Adjunct Professor, School of Management, Politecnico di Milano Consultant, META Goverance & Innovation

Daryl Powell
Research Manager, SINTEF Manufacturing Adjunct Professor, Norwegian University of Science and Technology (NTNU)

David Romero
Professor of Advanced Manufacturing, Tecnológico de Monterrey

Marco Spaltini
Research Fellow, School of Management, Politecnico di Milano;
Member, Young Manufacturing Leaders

Johan Wollin
Head of Operational Excellence, Absolent Group AB

INTRODUCTION

The COVID-19 pandemic caused many disruptive, unexpected and unprecedented changes that affected the global economy and industrial world across many sectors. Among those mostly impacted stands the manufacturing industry.
In light of these new circumstances, the corporate and institutional world is facing a crucial question:

How is work being performed and organised?

In many countries companies belonging to different industrial sectors that are not directly connected to the manufacturing of essential goods have been forced to shut down their physical operations for an uncertain duration and alter their operational activities to remote modes when possible. In all cases, even when physical presence was allowed or needed, several constraints forced companies to radically rethink the physical workplace and the organisation of work and to rapidly take action to ramp-up operations and create safe workplaces for the *new normal*.
Even after the COVID-19 emergency is over, companies still need (and will need to continue for quite some time) to rethink the workplace organisation in the following main directions:

- Enable workplaces that foresee a hybrid mix of physical and virtual and/or remote activities.
- Design workplaces complying with governmental regulations, local authorities' standards and recommendations such as social distancing measures or agreements with social parties.
- Develop a culture of responsibility and self-awareness on work health and safety and employee protection.
- Establish resilient workplaces which are able to deal with an uncertain environment and with short- and long-term worker shortages or unavailability.

Advanced digital technologies have been pointed out as one of the main enablers that differentiated successful responses to these challenges. However, as already anticipated by existing literature on digitalised workplaces, technological changes in the way work is being performed and organised require also a significant change in the organisational culture and leadership models. Importantly, the introduction of new technologies should be coupled with the redesign of work in terms of roles and responsibilities to yield success[1].
In this white paper, we will explore the main challenges and responses by industrial companies that arose from the COVID-19 pandemic, concerning work and workplace design and organisation. In particular, we will focus on those practices that can be considered substantially new in industrial settings, compared to the "normal" evolution that we were witnessing before the pandemic in terms of technological and organisational progress. Moreover, we spotlight practices that are expected to be maintained for a substantial time, even after the pandemic may find its end. We capture this nascent set of practices introducing the concept of *Industrial Smart Working (ISW)*.
In doing so, emphasis lies on work design and workplace organisation, defined as a socio-technical system, that is a system that is designed and managed considering both the technical aspects (i.e. enabling technologies, and business processes) and the social aspects (i.e. work organisation, management, leadership, and culture).
Specific attention is paid to human-centred production systems where the role of human work is paramount to their performance and success, and where new technologies support humans with an augmentation perspective, and, not vice versa. These contexts are expected to have a higher complexity in the transition towards smart working paradigms.
Although the need for new skills and competencies on the one hand, and the need to reconsider the role of industrial relations and new participation models on the other hand will be acknowledged, these aspects will not be central to our discussion (for further deepening see Back to the Future white paper *New Industrial Relations: How manufacturing will change in a post-Covid world)*
The rest of the paper is organised as follows: In the upcoming section, the context is described and challenges that emerged during the COVID-19 pandemic and companies' responses to overcome these challenges are outlined. Based on this, the concept of Industrial

Smart Working is introduced and its characteristics are discussed. Then, the opportunities of ISW scenarios are described for the post-COVID era. Also, recommendations concerning the main challenges of adopting ISW in future workplaces are derived. The final section concludes reporting the key findings and lessons learned to stimulate future action.

CONTEXT

Challenges and responses

The global disruption caused by the COVID-19 pandemic has forced people, organisations, processes, operations, and the use of technologies to adapt and rethink themselves in unprecedented ways to prevent drops in productivity, output and employment. Some industrial companies are proving their resilience in face of the pandemic, while others are either undergoing major disruptions, or are forced to shut down all operations entirely.

At the core of companies' ability to cope with the challenges posed by the pandemic are new approaches in work organisation, workplace, work time, and work tools supported by innovative technologies and appropriate cultural and leadership models. Overall, these modifications were aimed at building a resilient organisation that is able to cope with change and rebound from the pandemic's far-reaching impact.

In this regard, companies enacted several measures, depending on their industry, type of activity, severity of the impacts by the pandemic in their country/region, but also depending on their technological and organisational readiness, as well as their resilience capability. In fact, many of the responses have been made possible by previous (significant) investments in advanced digital technologies, but also in workplace organisation and culture inducive of flexibility, participation, and continuous innovation.

The changes that we are observing can be traced back to three main aspects:

- Introduction of remote or virtual work practices.
- Increased attention and awareness of work safety and employee protection measures, including psychological safety and mental health and well-being.
- Flexible work time.

Most of these changes were already on their way before the COVID-19 outbreak. However, they were mainly introduced as pilot projects or isolated implementations with certain, but limited organisations on the forefront of implementing new and innovative models. Remarkably, most of the changes have been significantly accelerated, amplified or adapted as a consequence of the challenges faced by companies to (re-)organise the work of their employees during the COVID-19 pandemic. We therefore focus on those changes that are considered as a more specific answer to the needs and restrictions imposed by the pandemic. Besides the specific needs for resilience, social distancing, and safety linked to the pandemic, we emphasise those changes that are highly promising in the *new normal*. Specifically, we focus on those changes that are expected to deliver significant advantages especially when implemented in a less radical way once the constraints and regulations will be eased or suspended.

We summarize these changes in the concept of **Industrial Smart Working (ISW)**, which we define as *the set of new working practices in a socio-technical system – comprised of people, work-organisation, technologies, and business processes – that are oriented at making operations more flexible, resilient and safe while keeping organisational and workers' performance high.*

The concept traces back to smart/flexible working models that were already in existence in clerical work and service industries, even before the Coronavirus health emergency[2]. However, when implemented in industrial settings and applied to manufacturing activities, additional – often severe – challenges arise. In particular, among others:

- More limited transferability of physical activities to a remote or virtual mode.
- Importance of a whole experience, including "all senses", when monitoring production facilities.
- Need for synchronous work of workers along a pro-

duction line or within a manufacturing cell.
- More command and control culture in industrial settings.
- Traditional habit of problem-solving at the physical location.
- Emphasis on stability, reliability, and routines in the everyday operations in contrast to adaptability and flexibility.

As a consequence, specific considerations and recommendations for decision-makers should be developed to introduce ISW practices successfully. Particular attention should be paid to the actual performance of current ISW experimentations since evidence shows conflicting results: in many cases companies are experiencing increases in productivity, safety, quality of work, and worker engagement and satisfaction, but in other conditions, productivity losses, reduction of coordination and management effectiveness, workers' disconnection, work stress increase and excessive demands, among others.

In what follows, we describe the main responses to work organisation challenges in the pandemic and the main enablers that emerged.

Remote or virtual work practices

The most evident consequence of the COVID-19 outbreak on how work is performed, has been the need to relocate on-site physical presence to a remote or virtual manner as much as possible. Companies that have already been well-experienced regarding smart and flexible work in clerical activities and that had invested in the past into the digitalisation of the shopfloor were able to transfer also some (or most of the) white-collar activities to the virtual space. In particular, jobs that were more often transformed into remote work are the ones connected to management and control of operations activities. Execution activities in an operations setting are the ones that are much more difficult to be successfully transferred. Examples are: maintenance, quality control, testing and commissioning, audits, among others. As in the case of clerical smart/flexible work, the key enablers to successfully apply virtual/remote work are technology, organisation and management, as well as culture and leadership styles.

Among the most important enabling technologies for remote or virtual work practices in industrial activities are: process digitization or real-time data collection, virtual and augmented reality, digital twins and advanced simulations, virtual collaboration technologies, artificial intelligence and machine learning, cobots and robots. A technological consideration that appears to be specifically relevant in the context of ISW is cybersecurity.

At the same time, remote or virtual work requires an organisational and managerial culture supportive of trust, autonomy, openness and goal-orientation instead of procedural and execution control, monitoring, hierarchical, or silo thinking and in-presence control and supervision.

In this light, existing working environments oriented towards lean principles and continuous improvement, with a focus on employees' autonomy and contribution accompanied by a team mind-set, have shown a higher readiness compared to other companies

Work safety and employee protection measures

The central role of employees' health and safety in industrial workplaces is clearly not new. Yet, a renewed emphasis and a higher awareness of the individual and company-level responsibility on employees and social system health is certainly an integral part of the current pandemic.

Safety measures and guidelines have been defined by governments and relevant bodies and authorities, and companies developed specific practices and solutions to implement them. As in the other ISW practices, both technology and organisational culture have demonstrated to be key enablers.

On the one hand, several digital technologies promise to support in a very effective way the need to trace employees' health and to monitor their health conditions. On the other hand, digital technologies can be used to calculate and warn about possible infection risks, to facilitate social distancing measures, etc. These applications of digital technologies recall the model of the "healthy operator"[3], i.e. a smart and skilled operator who performs work using new technologies, such as smart wearable solutions including data analytics and hu-

man-machine interaction technologies, as well as new work-methods to deal with risks that are prevalent in manufacturing environments. If these technologies are integrated with workforce management systems, they also allow for a higher resilience of the overall organisation on account of a better ability to deal with short- or long-term absence or leaves. Some key challenges related to the use of these technologies are significant risks related to privacy issues, increased work intensity and harmed mental health. Due to that, the level of acceptance of monitoring technologies by employees is generally low.

From a technological perspective, it is also important to recognise safety risks which emerge from greater interdependencies between technology and humans and between complex technological systems, combined with increasingly autonomous machines. New health and safety standards and improved systems of occupational health and safety management need to keep up to date with these emerging risks. Crucially, psycho-social risks are increasingly taken into account, and will need to be understood and effectively managed alongside physical risks.

With respect to organisational factors, employee compliance with safety measures is a pivotal part of the equation. Compliance in turn depends on effective leadership, work design, and culture, such as having a strong safety climate in which operators trust that managers genuinely value and prioritise safety[4].

As a response to the pandemic, centrality has been put on the awareness and individual responsibility of oneself and others' health at work, as well as the social responsibility and ownership of companies for the protection and safety of their workers.

Flexible worktime

Flexible work time has been one of the responses put in place by companies to restart their operations during the health emergency to guarantee social distancing during entrance and exit times, breaks, shift changes, etc. Flexible work time refers to the definition of flexible time slots for the start, end, and break time at work. Two main challenges have emerged to enable this practice, i.e. the existence of appropriate planning systems to manage this flexibility – in most cases new software, or functionalities integrated into the Workforce Management Systems, and the organisation of team or interdependent activities. In particular, specific criticalities emerge in clock-face production lines or cells where activities of different workers are highly interdependent, since their presence should be synchronized, thus limiting the flexibility space. Sometimes, the consequence of social distancing and flexibility measures is a higher amount of individual (instead of team) work. Also, key enablers of these solutions have been proven to be a culture of flexibility among workers, and organisational models that give space to autonomy and trust since work time flexibility might imply the absence for some time of supervisors and managers. Also, collaborative and positive industrial relations have been proven to be critical to support the development of appropriate agreements between the company and the employees. While these practices started as a response to a specific need arisen from COVID-19 outbreaks, in most cases they brought significant advantages in terms of reduced absenteeism and higher workers' satisfaction, due to a better work-life balance/integration and, consequently, a higher social sustainability of work systems. Companies that provide ISW settings can be expected to be considered as an "employer of choice" and can benefit from the ability to attract and retain workers. Moreover, if coupled with virtual or remote work, work time flexibility could open up an important opportunity to hire/employ specialized workforce from different time zones during night shifts, to overcome the typical shortage of skilled workers in inconvenient time schedules.

Resilient culture and organisational models

Resilience has been largely cited as the core capability for companies to react effectively to the crisis and challenges posed by COVID-19. Firstly, a resilient working environment and organisation is predominantly one that is able to quickly adapt and respond to the new context, challenges, and working conditions. Secondly, it is an organisation that is able to operate and cope with continuous uncertainty without losing its effectiveness. In particular, the ability to deal with short- and long-term workers shortages, or unavailability has shown to

be of primary importance in the context of a pandemic this scale. Finally, it is a system that is able to reconfigure itself according to new requirements. During the times of deepest COVID-19 crisis, there evolved many examples of companies that quickly rebounded and adapted to the new constraints, regulations, and working conditions to restart their operations in the smoothest and most effective way possible. In addition, notably, a number of companies completely reconfigured their operations during the emergency with the intent to produce and compensate for the increased demands in essential goods such as masks, gowns, medical devices, sanitisation goods, and even ventilators, etc.

As such, resilience is both part of the ISW paradigm, as well as a key enabler to it. Resilience is a core capability enabling a shift towards the new practices of ISW, that require completely new mind-sets, routines, and organisational practices, starting from the operational sphere up to the managerial level. Nevertheless, resilience is also the result of being able to implement ISW in an effective way and, thus, being able to recover from the implications caused by the pandemic.

In the case of resilience, technology has a partial role as an enabler, while organisational culture plays a key role. Specifically, continuous learning attitude, openness, responsiveness, adaptability, and a substantial human-centred perspective evolved to be crucial in this respect. Participatory organisational models, in which workers' involvement in continuous improvement and innovation activities is core, proved to be an essential component of resilience and reconfigurability. In these contexts, employees and workers were fully involved and contributed to finding the appropriate redesign and reconfiguration to suit the new needs and constraints (e.g. redesign of workplace layout and spaces for safety measures).

OPPORTUNITIES AND RECOMMENDATIONS

Opportunities

Moving forward from the initial experiences of companies forced by the shutdowns, or constraints and regulations to guarantee worker safety and social distancing, we envision a future scenario of ISW. The future of ISW specifically implies the conversion of practices that companies were experimenting with and that proved to be beneficial into industry best practices helping to improve organisational performance and the quality of work, equally.

The ISW paradigm in the *new normal* is described in terms of key characteristics, enablers, and outcomes in line with Figure 1.

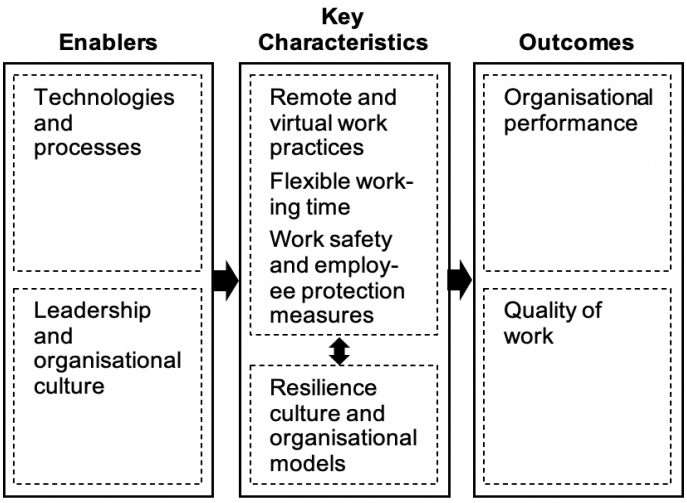


Figure 1.

The future ISW production system is sketched by a manufacturing cell or line that operates fulltime, where workers are only physically present at planned slots and in the case of unplanned disruptions, or emergencies. A digital twin of the manufacturing cell allows the team to have full transparency of all operations in real-time.

The manufacturing cell is IoT-enabled and "smart." Smart means that the cell is learning from experience and using AI to suggest adjustments or improvements, approved by the responsible worker. The cell is automated, yet flexible. Cobots are used where human judgment and flexibility is appropriate and the material flow

is semi-automated.

The team operates in an open mode by sharing data on a cloud-based platform that enables internal and external actors to improve the team's internal processes. The operators' work time is almost evenly divided between direct and indirect work. The team also works flexibly from home with further education and work tasks.

At the same time, in the ISW production system, most of the management, control, continuous improvement, and collaboration activities are performed in a hybrid virtual and physical mode with the support of digital technologies. Advanced digital technologies support the transition of shopfloor management and Kaizen activities, such as shift change meetings, or Gemba walks, in a virtual setting.

Also, shopfloor management approaches and methods evolve to face the need to manage and supervise a mix of physical and virtual workers and activities.

Moreover, ISW is characterized by blurred boundaries between blue and white collars. The new worker – the "Operator 4.0"[5] – is responsible and accountable for performance, problem-solving, and interaction with technical functions. At the same time, Industry 4.0 technologies take away from workers the more routine and less value-added activities and allow to assign workers more cognitive activities and roles. Thus, the ISW scenario includes also the emergence of the so-called "grey collar" roles.

Virtual shopfloor management is expected to result in increased productivity and effectiveness, higher speed of feedback, and easier problem escalation. Besides this, real-time data availability enables an improved ability for workers to act on problems and to provide improvement suggestions which ultimately leads to higher motivation and engagement of the workforce.

To ensure higher flexibility, ISW comprises advanced workforce management systems to accommodate work time flexibility, required by the production system, or by the employees. Work time flexibility extends beyond the choice of entrance and exist times, to include also shifts types and rotation, permits and holidays. These systems match workers with the required activities, in both remote and physical modes, on the basis of the skills required and available, but also taking into account the physical conditions, or limitations of the workers. This flexibility in work time and workers' allocation allows for productivity increases, as well as higher resilience in the face of recurring workforce absence, or shortages. At the same time it brings also higher health, safety, and well-being, resulting in a higher social sustainability of the work system.

Additionally, ISW includes an advanced health and management system that refers to both the new, but also more traditional physical health risks, as well as to mental health considerations. This system is enabled by digital technologies and is supported by appropriate leadership, work design, and cultural models that drive a strong safety climate and foster a high awareness of individual and company level responsibility. This renewed attention and awareness on employee health and safety should help to design better and higher-performing workplaces.

The ISW production system is resilient, both because it uses work practices that allow for flexibility in the workplace, time, and tools and because it develops a culture of openness and adaptability, a continuous learning attitude, as well as a high responsiveness of individuals. The human-centred and participatory approaches to changes and adaptations are at the core of the ISW paradigm.

In this context, the "smart" label also takes a different meaning. Smart work design describes work that is, for the individual employee, experienced as stimulating (e.g., uses and develops skills), enables mastery (e.g., provides feedback and clarity), supports human agency (e.g., allows worker autonomy and influence), is relational (e.g., has team spirit, social support), and has tolerable demands (e.g., reasonable workloads, shifts, etc.)[6]. Overall, this suggests a high quality of work of ISW production systems.

Organisational performance is also improved. In a well-implemented ISW production system the company experiences an increase in productivity, especially in monitoring and coordination activities, but also in execution activities that require expert support, such as maintenance or audits. Benefits are also achieved on effectiveness, flexibility, time-reliability, safety, and ability to guarantee business continuity.

As much as ISW promises to be "good for the system and good for people", a number of challenges are still to be faced. Some of them are:

- The need to find the right balance and best integration between the physical and digital worlds towards cyber-physical systems.
- Solutions to overcome the lack of "all senses" experience coming from the use of industrial applications of augmented reality.
- The risk of reduced collaboration, creativity, and communication across an organisation.
- Effective, new planning and control systems, including new performance measures for the production system and advanced workforce planning capacity.
- The ability to manage workers' autonomy.
- The situational adoption and adaptation of management through "presence and control" versus management based on "trust, cooperation, flexibility, and delegation".
- The implementation of supportive leadership styles and the limitation of authoritarian and hierarchical behaviours. Managers need to shift from a techno-centric mind-set to a human-centred one.
- The alignment of organisational and human resource management systems to the new working models, such as changes to recruitment and selection, training and development, appraisal and promotion.

Recommendations

The analysis of the current experimentations and the proposed ISW scenario for the post-COVID-19 era allows drawing some recommendations about the opportunities and challenges of adopting an ISW paradigm in future workplaces.

ISW is a new, viable opportunity and not just a temporary solution to face the emergency.

ISW proves to be an opportunity to improve both organisational performance and the quality of work. If correctly designed and implemented, ISW can be "good for the system and good for people".

ISW is a new organisational model that includes a set of interdependent work practices.

While remote work is the more evident aspect associated with the concept of ISW, a more complete implementation of this paradigm includes an increased flexibility in the time of work and a better quality of the workplace with specific reference to its healthiness and safety. All of these aspects combined result in a higher resilience of the work organisation.

ISW requires to find the right balance to make the most out of it.

A radical implementation of ISW aspects presents a high risk of drawbacks counteracting the advantages experienced. A balanced implementation of the different aspects is expected to guarantee the best outcomes. In particular, a balance should be found in the following areas:

- Physical vs. remote work
- Individual vs. teamwork
- Autonomy vs. supervision
- Self-management vs. guidelines/ instructions
- Corporate goals vs. individual goals

ISW should be designed as a socio-technical system.

The introduction of new technologies, when not done properly, has the potential to undermine smart work designs and lead to low-quality workplaces. This calls for a socio-technically-oriented approach in which the work design of operators is proactively considered alongside the implementation of technologies. ISW design would also benefit from a trial-and-error approach for joint optimisation of technology and organization and a culture of experimentation. However, an understanding of socio-technical systems approaches is generally lacking amongst many CEOs, managers, and technology designers. Consequently, the transformation will require significant investments in upskilling, training, and building awareness about the value of said approaches.

Quality work should drive ISW design choices together with productivity and organisational performance.

When work is designed to be smart, not just from a technological perspective, but also from a psychological one, it supports employee mental health and well-being, job satisfaction, employee commitment, and safety. Engendering such outcomes is critical, especially at a time when mental health concerns are a growing challenge.

Digital readiness is fundamental for the ISW transition.

The digitalisation of the production system and the implementation of a number of advanced production technologies are essential enablers of ISW. At the same time, cybersecurity becomes a key challenge and point of attention in an increased virtual productions system.

Cultural and leadership models are key enablers of ISW.

The successful adoption of ISW largely depends on organisational cultural factors and leadership styles. Implementing new technologies needs to be complemented by cultural changes that facilitate the new work approaches. Openness, transparency, and collaboration are core cultural traits. Similarly, supportive leadership styles are essential to enable ISW by empowering employees. Cultural and leadership models need to be centred on participation, flexibility, and autonomy.

ISW requires new digital and soft skills.

The introduction of digital technologies in the production system leads to new digital skills to be developed among workers. Similarly, the new organisational models, the required higher level of autonomy and accountability, the greater rate of individual work, as well as the increased awareness of personal and others health protection necessitate a number of new skills among production workers. These new skills range from adaptability, openness, and complex problem-solving to communication and collaboration.

New industrial relations approaches.

Having a strong employee representation can help to ensure organisational decision-makers pay attention to human and social issues, alongside technological ones. Also important for fostering a good balance between social and technical systems are supportive national employment policies, active labour market policies, and appropriate health and safety legislation. A specific attention of industrial relations is expected on the emerging category of home or distance workers, that require reconsideration of established industrial relations tenets.

Support policies at industry, national, and regional level are needed besides the single company effort.

Wide-ranging implementation of ISW requires support actions and policies that extend beyond the organisational level. As such, policies that establish conducive frameworks for bringing ISW to the forefront need to be developed. At the industry, but also at the national, and regional level, incentives and support mechanisms are vitally important.

CONCLUSIONS

Among the many challenges posed by the COVID-19 pandemic on industrial companies, a central part is played by the need to rethink work, workplace design and organisation. This White Paper focuses on the responses enacted by companies to tackle these challenges, summarized under the concept of Industrial Smart Working. The overarching question was: *How is work being performed and organised?*

A first key insight of this paper is that the challenges that accrued in the pandemic up to now can be transformed into significant opportunities for the future. In fact, ISW does not represent a temporary solution, but marks a long-lasting change to the work environment that will undoubtedly remain on companies' agendas, as it might offer major advantages, also in the long-term.

Resilience represents a fundamental trait of ISW. First-

ly, resilience is a constitutive element in the ISW paradigm and, secondly, resilience acts as a key enabler of ISW. As a consequence, both a resilient culture and organisational models are pivotal for successfully establishing ISW practices.

In order to achieve resilience, ISW redesigns the workplace and how work is being performed and organised using a set of interrelated practices that are conceived taking a socio-technical perspective which comprises a joint approach to technical aspects (i.e. enabling technologies, business processes, etc.) and social aspects (i.e. work organisation, management, leadership, and culture). Companies must adopt such a joint consideration of technology and organisation to break from traditional work designs approaches taking into account possible impacts of implemented technologies.

Likewise, preserving and reinforcing ISW goes well beyond the implementation of technology. Organisation and managerial culture, as well as leadership models are equally important enablers. Thus, organisations must carefully consider the complementarities and interdependencies, in order to reap positive effects of ISW.

An essential implication of ISW is its hybrid nature. This means that ISW characterizes a workplace that encompasses different working modes (e.g. physical-remote, individual-team work, etc.). Hence, ISW predominantly comes into being by mixing different modes, which inevitably result in the need for finding the right balance between them. As a consequence, the configuration of the new normal in respect to work and workplace organisation is a complex endeavour.

Ultimately, a number of open challenges are associated with ISW, which must be carefully addressed to be able to redesign industrial workplaces in a way that allows to benefit from the various possible advantages that ISW offers. In this light, ISW requires systemic support actions and policies that extend beyond the organisation level.

As future steps for the spreading of ISW as a best practice for the new normal, we also foresee the development of specific tools and methodologies that might support companies in defining their own adaptation of the ISW paradigm and in measuring their progress towards it.

ANNEXES

The Maritime Case : The Digitalisation of Shop Floor Management Beyond COVID-19

Headquartered in Norway, the firm produces technological products for the maritime industry and has been implementing lean management principles since 2015. The lean management principles are primarily in use within shop floor teams but also in middle- and senior management teams. In 2018, the company transitioned its analogue Kaizen system (with whiteboards and suggestion cards) to a digital online solution based on Microsoft® Teams and Planner. A detailed analysis of this transition highlighted that multiple areas which have been tackled since then improved as a result of the digitalisation of the Kaizen system.

At the time the company was faced with the challenges posed by the COVID-19 pandemic, the case company appeared to be somehow prepared for the need to further digitalise the Shoop Floor Management (SFM) system. The main element pushing to an increased digitalised SFM have been the restrictions on the physical presence. In response, the physical presence of both middle- and senior management on-site has been changed. In fact, in order to reduce the risk of transmitting infection, all administrative and support staff were instructed to work from home. This has resulted in the higher empowerment of front-line leaders to take responsibility for day-to-day operations.

Apart from this, a number of SFM aspects have been further transitioned to a virtual space. Firstly, as part of its lean leadership program, the company implemented Gemba walks in 2017. Rather than dropping these completely in light of COVID-19 restrictions, the production manager continues to walk the Gemba 2-3 evenings per week to maintain a connection with the physical operations. However, the site is otherwise empty and any observations or findings must be discussed virtually with the team leaders and operators, in retrospect.

Moreover, most of the other SFM activities are performed virtually by now. Describing the new way of working, the Vice President (VP) for Supply Chain states: “We operate the same as before, only we meet in (Mi-

crosoft) Teams". As such, it was clear that Teams and Planner had been further adopted as the platforms for coordinating and managing operations throughout the firm. "Teams provides a very simple means for sharing information and communicating with others – despite restrictions for physical meetings". In the meanwhile, all SFM occurs on Teams – from daily production status meetings, weekly Kaizen team meetings, department meetings, to management meetings. For example, together with the team leaders, the production manager participates in a weekly planning meeting every Monday, a status meeting on Tuesday, and a review meeting every Friday. Friday meetings are structured using Achievements, Benefits, Concerns and Do Nexts (ABCD) which is further communicated to the VP Supply Chain as input to the senior management meeting on Monday mornings. The production manager explains that: "In the beginning we met every single day, but now things have normalised".

"Teams has become the digital office" adds the VP Supply Chain. Another example of this development towards a more digitalised daily business, is the departmental meeting agenda structure which is created with Planner buckets for each production team. Moreover, Planner is used for Health, Safety and Environment (HSE), ABCD, strategic actions, new product introductions, and risk management. There is even a bucket for "good news" where employees can upload pictures and text to celebrate achievements and successes. In addition, there is a PowerBI app for performance management and Key Performance Indicators (KPIs). The work teams have also initiated the usage of a colour code system for managing the prioritisation and escalation of problems and improvements.

To conclude, digital collaboration technologies represent a very useful and beneficial platform for the digitalisation of SFM. Possibly, this could very well be complemented with new forms of Gemba walks which include combining virtual- and physical mobility to further discover challenges and opportunities for improvement[vii].

The Ansaldo Energia Case: Cyber security and Smart Maintenance to support business continuity

Ansaldo Energia is a leading international player in the power generation industry, to which it delivers an integrated model embracing turnkey power plants construction, power equipment, manufacturing and services and nuclear activities. In the last years, Ansaldo Energia has launched in an ambitious program of Digital Transformation (DT) covering all the processes along its value chain and keeping the human capital in the centre in order to increase its competitiveness facing the global challenges of the Energy market. In the realm of practical action, two main DT initiatives have been launched:

- The Byte2Energy project aimed to improve the integration of product and service into a servitisation model enabled by digital platforms;
- The empowerment of the manufacturing process as the Factory of Genoa has been selected as the first Lighthouse Plant of the Italian Industry 4.0 National Plan.

Both initiatives have generated significant impact on the process, organisation, mind-set, and skills of Ansaldo Energia.

Within this context, two specific projects resulted to be key enablers to manage the impact of COVID emergency and ensure the resilience of Ansaldo Energia operations.

IT/OT Cyber Security

During the COVID-19 crisis, continuity of the activities in alignment to the Government prescriptions could be guaranteed by the implementation of a remote/smart working platform enabling more than 2000 employees worldwide to manage all of those processes that are not strictly related to manufacturing and other physical activities. To achieve this shift in a very short time a powerful, integrated action plan has been launched on top of the implementation of new technology. Essentially, the action involved the revision of processes, organisation, as well as cultural aspects.

One key aspect that has shown to be central in such an approach is Cyber Security of both *IT and OT systems*.

For what concerns IT, the increase of digital transactions, both internal and external to the company, has drawn specific attention to limiting Cyber Security risks related to human behaviours. On the one hand, specific processes have been put in place to prevent information misuse and on the other hand, a cultural change aimed at pushing a stronger discipline by users to understand the value of the information – especially when this is strictly connected to the Corporate IP.
For what concerns OT, the high level of connection of equipment, machines, and systems both inside the factory and with the external partners increases the risk of cyber threats that potentially have a negative impact on operations continuity as well as on workers' safety.
Also in this case a change in the mind-set of people and a strict discipline have been developed to mitigate OT cyber threats. In addition, a Security Operation Centre devoted to risk monitoring and crisis management has been introduced.

Remote and Predictive Maintenance

Ansaldo Energia has introduced advanced digital technologies to support the introduction of innovative maintenance models.
In particular, the development of IoT platforms supported by Advanced Sensors and Big Data has been deployed both toward the customers (through the Byte-2Energy approach) and to the suppliers (through the Lighthouse Plant project).
The possibility to extend the outage frequency based on the analysis of data coming from the field operations can generate benefits in terms of efficiency and effectiveness of both gas turbines working in the Customers' Power Plant and of Suppliers' Plant and Equipment working in the Genoa Lighthouse Plant, enabling innovative approach such as predictive diagnostics and maintenance. This approach benefits from setting up the right mix of experienced maintenance technicians and data scientists.
Another direction of technological innovation implemented by Ansaldo Energia is the Remote Maintenance enabled by VR/AR technologies.
During the COVID emergency these previous investments resulted in a further significant advantage as a consequence of the limitation of on-site inspections.
In particular, the application of VR/AR technologies has been fundamental to guarantee service operations continuity to the Customers Power Plants located in the critical red areas during the most difficult phases of the COVID-19 emergency. The pre-condition to extract the maximum value from these technologies is the ability to capitalise the consolidated knowledge and experiences of senior technicians that can be shared with the younger ones.
The use of AR/VR technologies to accelerate the training of such resources as well to simulate the digital twin of the physical operational framework is a further opportunity that can bring high value also in the new normal scenario.

ENDNOTES

[1]See e.g. Cagliano, R., Canterino, F., Longoni, A., & Bartezzaghi, E. (2019). The interplay between smart manufacturing technologies and work organization. *International Journal of Operations & Production Management*. and: Parker, S. K., & Grote, G. (2019). Automation, algorithms, and beyond: Why work design matters more than ever in a digital world. *Applied Psychology: An International Review*.

[2]Smart of flexible work i soften defined as an organisational model characterized by flexibility in the choice of workplace, working hours and working tool, supported by a culture of workers autonomy and accountability, a management based on trust, cooperation, flexibility and delegation and by the introduction of digital working tools and the redesign of physical workspaces (see e.g. Raguseo, E., Gastaldi, L., & Neirotti, P. (2016, January). Smart work: Supporting employees' flexibility through ICT, HR practices and office layout. In *Evidence-based HRM: A Global Forum for Empirical Scholarship* (Vol. 4, No. 3, pp. 240-256). Emerald Group Publishing.).

[3]Romero, D., Mattsson, S., Fast-Berglund, Å., Wuest, T., Gorecky, D., & Stahre, J. (2018, August). Digitalizing occupational health, safety and productivity for the operator 4.0. *In IFIP International Conference on Advances in Production Management Systems* (pp. 473-481). Springer, Cham.

[4]Neal, A., & Griffin, M. A. (2006). A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. *Journal ofAapplied psychology*, 91(4), 946.

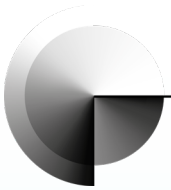
[5]Romero, D., Stahre, J., Wuest, T., Noran, O., Bernus, P., Fast-Berglund, Å., & Gorecky, D. (2016, October). Towards an operator 4.0 typology: a human-centric perspective on the fourth industrial revolution technologies. In *proceedings of the international conference on computers and industrial engineering (CIE46)*, Tianjin, China (pp. 29-31).

[6]Parker, S. K., Morgeson, F. P., & Johns, G. (2017). One hundred years of work design research: Looking back and looking forward. *Journal of applied psychology*, 102(3), 403

[vii]Romero, D., Gaiardelli, P., Powell, D., Wuest, T., and Thürer, M. (2020). New Forms of Gemba Walks and their Digital Tools in the Digital Lean Manufacturing World, Towards Smart and Digital Manufacturing, B. Lalic et al. (Eds.), in International Federation for Information Processing (IFIP), AICT 592, Part II, Springer, pp. 432-440, 2020, ISBN: 978-3-030-57996-8, DOI: 10.1007/978-3-030-57997-5_50. APMS'20 Conference Proceedings.

This white paper, published in November 2020, is part of the Back to the Future: Manufacturing Beyond Covid-19, an initiative by the World Manufacturing Foundation, aimed at analysing the impacts of the Covid-19 pandemic on the manufacturing sector and outlining key findings for a resilient manufacturing sector in the new normal.

For more information on the project and to read other topic-focused white papers that are part of the initiative, visit https://worldmanufacturing.org/report/whitepaper-back-to-the-future/



WORLD
MANUFACTURING
FOUNDATION

World Manufacturing Foundation
Via Pantano, 9 - 20122 Milano, Italy

info@worldmanufacturing.org
worldmanufacturing.org