industriAll
EUROPEAN TRADE UNION

Policy Brief 2015-07
Digitalisation of manufacturing

Digitalising manufacturing whilst ensuring equality, participation and cooperation

A Discussion Paper by industriAll European Trade Union

Digital technologies are increasingly present in our daily lives and our working lives. Digitally-enabled objects are present in our pockets (e.g. mobile telephones or credit cards), in our homes (domestic appliances), in our cars, in our trains, on our bicycles and in our work places in industry. They enable people and objects to communicate anywhere and at any time in a global and interactive network. They have transformed the way in which we work, have dramatically changed whole industries and will continue to do so in the future. They present challenges to the way in which we can protect personal data and privacy. The European Union considers digitalisation through its Digital Single Market and the digital transformation of European industry (announced by the Council of May 2015) as being its second highest priority for the legislative period from 2014 to 2019. It has engaged in ambitious Research, Development and Innovation (R&D&I) programmes on advanced manufacturing (e.g. Factories of the Future, SPIRE), as have many EU Member States. A complete map of these initiatives can be found here.

For all these reasons, industriAll European Trade Union has decided to engage in a reflection on the digitalisation of manufacturing through this discussion paper. It intends to provide background information, to identify issues and to propose policies and actions addressing these issues in the interests of industrial workers and of society at large.

***IMPORTANT DISCLAIMER:* This document is meant for discussion only. It is *not* an official position of industriAll European Trade Union.**

All member organisations of industriAll Europe and all interested stakeholders are invited to take part in the debate and to contribute input and comments to this document, which will be periodically updated and improved. IndustriAll Europe will use this discussion paper to generate official position papers on specific issues related to the digital transformation of manufacturing in due time.

Executive Summary

Digitalisation refers to the **connection made between** any object and any person at any time and in any place. It is based on hardware technologies (specifically: micro- and nano-electronics), but also on software and on institutions (specifically: interoperability standards with which machines can automatically understand and interact with one another).

In industry, it leads to the **digital integration** of all processes: design, manufacturing (the 'Industry 4.0' concept) and administration, and thus to massive gains in productivity, reliability, adaptation to customer needs and speed. It can significantly improve the comparative advantages of European manufacturing, and protect or even bring jobs that have been moved to countries outside the European Union back to the European Union.

As a whole, the consequences that digitalisation will have on **jobs** are potentially vast. Digitalisation is estimated to have an impact on around 40% of all jobs, including white-collar jobs. All the existing tools need to be fully mobilised to cope with such a large-scale shift: anticipation of change, reskilling and upskilling workers, a renewal of social dialogue and potentially a reflection on working time.

Beyond productivity, digitalisation also has specific effects:

- It **concentrates** power and wealth along the value chain in the digital marketplace platform or the owner of the communication standard, thereby depriving all other companies of the capacity to invest, to innovate and to provide good wages and working conditions.
- It challenges the foundations of the (permanent, full-time) **employment relationship**, because all functions of this relationship (including the control of the task) can be performed remotely. Consequently, workers are placed in a worldwide competition on price, and the amount of **precarious work** is exploding (e.g. numbers of freelancers, bogus self-employment work situations, crowdsourcing, etc.).
- It opens up new possibilities for **control** over workers but also for **cooperation** between them.

IndustriAll Europe proposes the following **actions** to seize the opportunities provided by digitalisation and to alleviate its threats. All these actions share the same objective: boosting the potential of digitalisation to develop **cooperative**, **integrative**, **democratic** and **egalitarian** workplaces and societies for all workers and citizens.

List of Policy Proposals

For each of these proposals, the following code is used to describe the institutions who are called on to take action:

- [EU] European Union and EU Member States
- [Emp] Employers' and industry associations
- [iAllE] industriAll Europe and its affiliates.

Social management of productivity gains			
• Fully mobilise the anticipation of change toolbox	[EU]	[Emp]	[iAllE]
• Step up social dialogue at all levels		[Emp]	[iAllE]
• Negotiate new rights for education and training in the digital age		[Emp]	[iAllE]
• Reflect on working time	[EU]	[Emp]	[iAllE]
Digitalisation for a socially, economically and environmentally responsible innovation			
• Aim at a capital-intensive industrial model for discrete manufacturing	[EU]	[Emp]	
• Develop human-machine interfaces adapted to manual workers	[EU]	[Emp]	
• Design ergonomic workplaces with virtual reality tools	[EU]	[Emp]	[iAllE]
• Create jobs and reduce waste with automated disassembly factories	[EU]	[Emp]	
• Bring jobs back to the EU with the mass customisation of industrial manufacturing, specifically for garments and footwear	[EU]	[Emp]	

• Digitally track and monitor the social and environmental conditions in the manufacturing sector	[EU]	[Emp]	[iAllE]
• Design innovative incentives for low-carbon consumption patterns	[EU]		
• Switch to IPv6 Protocol to ensure a fair allocation of addresses in the Internet of Things and to support European manufacturers	[EU]	[Emp]	
• Keep a leading industrial position in electronic components and systems	[EU]	[Emp]	
• Develop open and collaborative 'cloud' platforms	[EU]	[Emp]	
Regulate how value added is shared along digital supply chains			
• Set up open standards for digital communication in the manufacturing sector	[EU]	[Emp]	
• Define the rights attached to industrial data	[EU]		
• Regulate monopolistic digital platforms	[EU]		
• Provide a solid legal environment for Free, Libre and Open Source (FLOS) software and hardware development	[EU]		
• Limit the legal protection of software	[EU]		
• Regulate and tax value creation according to the rules of the country where work is physically performed	[EU]		
Strengthen the bargaining power of trade unions			
• Set up international digital coordination platforms for trade unions and workers			[iAllE]
• Negotiate a dedicated space for workers' representatives and trade unions in corporate Intranets		[Emp]	[iAllE]
• Negotiate the right for (European) Works Councils to extract custom-made indicators from the corporate management data repository		[Emp]	[iAllE]
• Monitor the physical parameters of working conditions		[Emp]	[iAllE]
Address the specific risks of the digital workplace			
• Define clear rules for liability in case of accidents in a digitally connected and automated working environment	[EU]	[Emp]	[iAllE]
• Obtain the right to disconnect from the digital work environment	[EU]	[Emp]	[iAllE]
• Obtain the right to privacy at work	[EU]	[Emp]	[iAllE]

Table of contents

The document is organised as follows:

- Part 1 describes the many and varied **phenomena** that are covered by the concept of "digitalisation", and attempts to give a synthetic, stylised view of the main developments
- Part 2 *(to be completed)* gives concrete examples of digitalisation of industrial processes
- Part 3 describes the potential **impacts** of digitalisation on (1) employment and skills, (2) industrial supply chains, (3) labour and employment relations, (4) working conditions, and (5) trade union work
- Part 4 **recommends** actions and policies to seize the opportunities and minimise the threats of digitalisation on industrial work.

Part 1. What is "Digitalisation of manufacturing"?

In each chapter of this Part 1, a short box contains the "main political message". The interested reader can then enter the more detailed, full text.

Digitalisation is a broad, complex phenomenon. In order to help understand it, this Part 1 presents successively, in a synthetic, stylised view of the main developments:

- the technical and institutional **enablers** of the digitalisation of manufacturing (§1)
- the **generic functions** that this technical and institutional infrastructure enables (§2)
- the **processes** that are **integrated** by digitalisation (§3)
- the current **legislation** governing the protection of personal data in the EU (§4).

1 Technical and institutional enablers of the digitalisation of manufacturing

Main political message

Digitalisation is not the result of one single innovation. It is the synergetic outcome of a great number of convergent, and partially independent, innovations in very diverse technical fields, whose performance and cost reach simultaneously levels with which they can be combined into complete, industrially operational **systems**. Each of these innovations is thus one "enabler" of the overall contemporary digital revolution.

While it is true that each of these components has been developed for some time, often for decades, it is a fact that these components coalesce into very large connected systems that is the distinctive feature of the 2010s.

This part distinguishes between three categories of enablers: hardware-based (§1.1), mathematics-based (§1.2), software-based (§1.3) and institutional (§1.4).

1.1 Hardware-based enablers

Main political message

The digital revolution is presented as the reign of "virtual" reality. It is, however, based upon a broad range of innovations and improvements of very concrete, equipment and devices. All of these devices can be patented.

These hardware devices enabling the digital revolution are:

1. low-cost **sensors** of physical phenomena (e.g. temperature, pressure, acceleration, rotation, etc.) but also low-cost cameras and microphones
2. low-cost tools for the **conversion** between **analogue** and **digital** signals: samplers, analogue-to-digital and digital-to-analogue converters, amplifiers
3. digitally-piloted, high-precision **actuators** (stepper electric motors, piezo-electric motors)
4. low-cost **radio communication** components (filters to select the right frequency, amplifiers to raise the low-intensity received signal to levels where it can be processed, antennas), at all ranges, from a few centimetres using technologies (called Near-Field Communication) in which the energy of one party in the communication can be provided remotely by the other, to tens of kilometres (or even thousands when the communication is made with a satellite)
5. drastic increase in **processing power** of semiconductor-based microprocessors (Moore's "law": a doubling of capacity every 2 years, observed since 1975) and in **storage capacity** of semi-conductor components (RAM memories), magnetic (e.g. hard disks) or optical media (e.g.

DVDs) at constant or decreasing prices and at constant or decreasing power consumption

6. low-cost, lightweight, flat **displays** (typically: LCD displays, OLED displays)
7. **robust** electronics, able to withstand the harsh radio-electric environments, the heat, shocks and vibrations to be found in typical industrial settings
8. very **low-power electronics**, able to operate for long periods of time with no connection to the main electricity grid
9. low-cost **electric energy storage** for portable devices, e.g. with batteries (specifically: Li-ion batteries) or large capacitors, and with solar photovoltaic chargers
10. high-capacity and high-transparency **optical fibre**, able to transport signal over long distances, and **optical components** (filters to select the right wavelength, multiplexers to combine several wavelengths on the same fibre, diodes to transform optical signals into electric signals, lasers to transform electric signals into optical signals, amplifiers to boost the optical signal after it was attenuated after having travelled long distances over the fibre)
11. low-power **atomic clocks**, able to operate on satellites, and to provide timing signals with nano-second accuracy.

1.2 Mathematics-based enablers

Software is the "intelligence" that brings the hardware to life, and that makes industrial products and processes capable of acquiring, communicating, and processing information.

Main political message

Applicative software, such as the one appearing on a desktop computer, or in a smartphone, appears to be infinitely diverse. However, this surface is based upon layers of a more limited number of underlying technical software categories, based on applied mathematics, which are the building blocks of digitalisation in manufacturing. These technical layers are as important and scientifically as sophisticated as the hardware component. Because they are based on mathematical principles, they are difficult to protect and to patent.

The main categories of software supporting the digitalisation of manufacturing may be described as follows.

1. **digital signal processing** of the digitally converted output of sensors (sound, radio or optical signals) and of cameras. The algorithms compress and de-compress data, protect it against corruption during transmission, recover it after degradation during transmission, recognise patterns in image or sound, etc.
2. management of large **databases**, to store and recover the exact data needed for an application, at high speed
3. **optimisation** algorithms, for design engineers to find what combination of parameters will achieve the best performance of the product
4. **simulation** algorithms, for design engineers to anticipate the physical behaviour of the product, in a computer-based test, with no need to take the time to build a prototype and perform a (costly) physical test
5. **3D modelling** of objects, with which design engineers and designers represent the product on a computer directly in volume, to visualise it, and also to feed digital manufacturing devices, such as a Computer Numerical Control (CNC) machine or a 3D printer (see below)
6. statistical predictive analytics algorithms on large data sets, also known as "**big data**", with which engineers and marketers attempt to anticipate random events, such as failures in a technical system, or customer behaviour
7. high-security digital **encryption** of sensitive information, such as PIN numbers of credit cards, so that only the authorised recipient can access the information (e.g. public-key algorithms), digital **signature**, which ensures that a message was indeed written by the person claiming it (authentication), that it was not altered in between (integrity), and that the sender cannot deny having sent it (non-repudiation)
8. **3D image synthesis**, with which the digital representation of a virtual object in a computer is displayed in a very realistic manner, for design engineers or to support its on-line sale

1.3 Software enablers

Main political message

Technical capacities are not sufficient *per se* to enable an effective digitalisation. For objects to communicate with one another, for them to exchange information and to be able to "understand" and process it, they need a common "language" - just as humans do. This common "language" does not appear spontaneously though. It needs to be defined by humans, as any convention.

How these conventions are defined is a strategically **critical** issue. The definition of conventions for mutual understanding in digital communications can take two contrasted forms:

- either in a cooperative way, along a structured and formalised procedure where all stakeholders have their chance to participate in the definition of the convention. This is the path of (official, *de jure*) **standardisation** (e.g. the GSM mobile telephony standard)
- or in a brutal, un-cooperative way, whereby a single company imposes its **proprietary** conventions[1], and attempts to capture the whole value added by extracting a toll from all other users (e.g. Microsoft Windows operating system).

These conventions are protected by a specific form of Intellectual Property Rights: an adapted version of literary copyright protection.

The main areas in which these conventions have been defined in the last decades are described in greater detail below.

1.3.1 Unification of telecommunication protocols

Telecommunication protocols are the rules to establish, maintain and break a communication link between two distant entities, before any meaningful content has been transmitted. Just like the rules of politeness between humans, they define how to identify oneself, who speaks first, what answer is expected to express readiness to engage in a conversation or that one is busy, how to resume in case of interruption, how to end the conversation, etc.

The patient work of standardisation bodies has led to the set-up and adoption of some essential data communication protocols, and specifically:

- the **Internet Protocol** **(IP)** is *the* foundation of the world-wide Internet network. It is essentially an **addressing** system, whereby each object connected to the Internet has one address (an "IP address"), from which and to which information "packets" are sent - just like letters would through a postage network. One important issue is to ensure that all persons and objects needing an IP address actually get one. The current version of the Internet Protocol, called IPv4, only provides ca. 4.3 billion addresses, an insufficient number for the "Internet of Things", and is unevenly shared (more on this below, Part 4)
- the other Internet protocols provide additional functions such as: the reliable transmission of data, with detection and re-emission of missing or faulty packets (TCP protocol); mutual information between infrastructure elements about their operational status (ICMP protocol); fast but less reliable broadcasting of data (UDP protocol); the transfer of complete, large files (FTP protocol)
- **mobile telephony protocols** have increasingly included data transmission features in addition to voice service, to allow long-distance, mobile Internet connectivity. Examples with increasing data rates are GPRS (1997), Edge (2003), UMTS (1999) and LTE-4G (2013)
- dedicated data radio protocols ensure **short-range** data transmission between two objects that do not move once they are connected. Examples are: WiFi, Bluetooth
- **Machine-to-Machine** (M2M) communication protocols are being developed (e.g. by ETSI), to address the specific needs of automated data transmission in industrial environments.

1.3.2 Unification of the data formats and semantics

Once the information is properly received, it must be automatically processed by the destination computer, with no need for human intervention.

[1] This form is sometimes misleadingly referred to as "*de facto*" standards.

Everyday experience with office productivity suites (e.g. proprietary Microsoft Office, open-source LibreOffice) or versions thereof (e.g. between .doc and .docx) illustrates this issue.

In order for this to happen, a first condition is that the data must be in a **format** that is known by the recipient. In the example above of text processors, this means that the internal code to describe characters (e.g. UTF-8, ASCII, Microsoft West European) must be known: if not, as an illustration, the French word "ambiguïté" in UTF-8 format is transformed into "ï»¿ambiguÃ¯tÃ©" in Windows Western European. The second condition is that the meaning or "**semantics**" of each data item in the file be known. In the same example, the way **broad** characters are represented, or a page break, must also be defined.

In the industrial world, the nature of data to be exchanged is much more structured than text files: it may be compared to the electronic version of paper forms, with a set of boxes in which only the specific information requested may be introduced, for it to be properly interpreted by the receiving computer. This is the purpose of Electronic Data Interchange (EDI) standards, which define messages for usual interactions between firms. Examples of such standards are:

- the Extended Markup Language (XML) standard that provides a generic syntax to describe the meaning of each segment of a message or document, making it both readable by humans and easy to be processed by machines
- the United Nations Edifact that standardises more than 190 different message types (from "Arrival notice" to "Worker's insurance history")
- the Odette standard for the exchange along the European car manufacturing industry value chain.

A specific, and more complex, field of data representation is that of Computer Aided Design (CAD) of mechanical and electrical hardware objects. The data incorporated in the file must be sufficient to represent all aspects of the system being designed: its shape and materials, the electric and electronic circuits, etc. This is the purpose of the standard called ISO 10303 "Industrial automation systems and integration -- Product data representation and exchange", which is used in the aeronautics industry.

The functional behaviour of software must also be described using a high-level description language, while yet remaining accurate and unambiguous enough for developers to swiftly implement it. This is the purpose of the Unified Modeling Language (UML) standard, maintained by the Object Management Group (OMG).

Despite these efforts, much remains to be done in the definition of standards, and in their implementation. Indeed, many players attempt to capture or to fragment the market by implementing their own, proprietary formats and semantics.

1.3.3 Individual identification of each industrial item or batch

The international GS1 standardisation association started with the bar code in 1974. It has since developed a full range of *unique* identification codes for industrial products, so that each *individual* item or batch being manufactured or transported can be identified and traced.

1.3.4 Interoperable software development tools

Application Programming Interfaces (APIs), such as the Apple OSX Frameworks, Microsoft's DirectX, and the Open Computing Language (OpenCL), are the tools with which a software developer can easily access and use full libraries of functions and procedures already written by others, and thus coordinate with their work, build upon it, and thus save very significant time and effort by concentrating his/her work on the specifically new features that s/he develops.

Integrated Development Environments (IDE), such as the free software Eclipse, NetBeans by Oracle, or XCode by Apple, are the everyday productivity tool of the software developer. They include a source code editor, automated compilation and build tools to generate the executable software from the programming code and a debugger.

1.4 Institutional tools

Main political message

The legal system has adapted to the digital age, and has introduced important institutional innovations:

- **fast** standardisation bodies

- the recognition of the **legal validity** of electronic, de-materialised documents
- a legal framework to **share** software tools: the Free, *Libre* and Open Source Paradigm.

1.4.1 Fast, Internet-based standardisation bodies

The process of standardisation has existed informally since the 19th century, and formally in national dedicated bodies (e.g. DIN, BSI, Afnor, Ansi) since 1918. International standards are established in dedicated institutions (ITU for telecommunications and radio since 1865, ISO for other issues since 1947). European standards are defined in the ETSI (telecommunications) since 1988 (following the CEPT founded in 1959), in the Cenelec (electrical engineering) since 1973, and in the CEN (all other matters) since 1961.

With the exception of ETSI, all other international and European standardisation bodies are in fact a federation of national bodies, in a two-tiered process: on each issue, national discussions are held, and the national standardisation body then represents this common position in the international or European circle, where the final decision is taken. This process is fair, but slow.

The technical capacities brought by the Internet of direct and fast interaction also impacted standard-making practices. The very first organisations that used Internet-based communication for their daily work were those defining the Internet standards themselves: the Internet Engineering Task Force (IETF), the World Wide Web Consortium (W3C). In these standardisation bodies, speed is privileged over fairness. Anybody can join, no control is placed on mandates nor on Intellectual Property Rights, and the rules are explicitly "informal". Following these early examples, international standard-setting processes have been accelerated by using Internet technologies and streamlined, taking up some or all of the informality of the original Internet community.

1.4.2 Recognition of the legal validity of de-materialised documents

In order for de-materialised, Internet-based interactions (e.g. a purchase order) to be followed by concrete action on either side (in the example: the start of manufacturing), and for the speed in information flow to be fully complemented by *automatic* processing, they must be considered as legally binding. If not, no action is undertaken until a formal confirmation is received - and much of the benefit of the data transmission speed is lost.

This is why legislation has evolved, so that electronic signatures now have full legal validity. In Europe, this was the purpose of the 1999 Community Framework for Electronic Signature. However, this is not sufficient: more is needed to ensure that the person signing the document is indeed the one s/he claims to be. It is the purpose of a proposed "Regulation on electronic identification and trust services" of 2012, still under discussion.

1.4.3 Free, Libre *and Open-Source legal framework*

Starting in 1984, some software developers have taken the option to deliberately *share* their software code, in order for all users to freely use, modify and distribute the modified version of their software, thereby setting up the Free, *Libre* and Open Source movement. By taking this radical position, they avoided the conflicts arising from Intellectual Property Rights disputes, and were able to collaborate effectively and fast to develop software. The most successful software project developed this way is the GNU/Linux operating system that runs on most Web servers.

Underpinning this effort, the GNU community developed a set of legal licensing documents, which ensure that these principles of freedom can be legally upheld.

2 Generic functions made possible by this infrastructure

Main political message

The technical and institutional building blocks described above (§1) can be **assembled**, to automatically and remotely perform complete **functions** that are present in many industrial processes.

These generic industrial functions where the effects of digitalisation are felt with the greatest acuity are listed hereafter:

- The Internet: long-distance, secure data transmission (§2.1)

- RFID tags: Automated identification and trace of each item or batch (§2.2)
- Robots and 3D-printers: flexible, programmable machines (§2.3)
- "Industrie 4.0": Ultimate customisation of manufacturing operations to customer requirements (§2.4)
- The "Cloud": high-performance, quasi real-time long-distance remote processing of information (§2.5)
- Remote payments (§2.6)
- Tele-working: remote employment relations (§2.7)
- Collaboration on shared documents (§2.8)
- Mobile communication (§2.9)
- "Big Data" (§2.10)
- Satellite-based geolocation and inertial navigation (§2.11)
- Augmented reality (§2.12).

2.1 The Internet: long-distance, secure data transmission

The fast reading and processing of IP addresses (§1.3.1) by microprocessors (§1.1 5°) embedded in routers connected to one another over long distance via optical fibres (§1.1 10°) enables the world-wide, reliable transmission of data from one point to the other of a single, unified network: the Internet.

2.2 RFID tags: Automated identification and trace of each item or batch

The unique identification number of an industrially manufactured item or batch, defined by the GS1 standard (§1.3.3), can be reliably stored in a permanent semiconductor memory (§1.1 5°), using cryptographic authentication algorithms (§1.2 7°) to prevent spoofing. The information can be exchanged at short range by radio (§1.1 1° and §1.3.1), with power requirements that are so low (§1.1 8°) that they can be provided by the radio link itself. The resulting system is called a "RFID tag". It can be read remotely, with no need for a human operator to specifically place the item in front of the reader (as is the case for bar codes and optical scanners).

The information contained in the RFID tag, or to which the RFID gives access in a database (§1.2 2°) being remotely accessed to via the Internet (§2.1), can **trace** the steps of the industrial process that was applied to the item to which the RFID tag is attached.

2.3 Robots and 3D-printers: flexible, programmable machines

Robots combine sensors and cameras (§1.1 1°), image recognition software (§1.2 1°), micrometric positioning of tools (§1.1 3°), and the capacity to engage in complex actions that are stored in digital programmes, executed locally despite the hostile electromagnetic environment (§1.1 7°) caused by high-power electric engines, and that are downloaded via factory-wide Local Area Networks (§1.3.1).

A specific, recent example of robots is the **3D-printer**. This device builds complex objects by "additive manufacturing", placing layer after layer of matter (initially: plastics, but increasingly other materials such as metals or ceramics), exactly where needed. It is a low-cost complement to existing manufacturing technologies such as moulding, forging or machining, and is considered by many (but not by all) as a technological revolution.

In the textiles & clothing sector, a similar revolution is experienced with the **2D-printing of textiles**.

2.4 "*Industrie 4.0*": Ultimate customisation of manufacturing operations to customer requirements ("one-unit batch")

The RFID tag (§2.2) associated to an item or batch (that jointly build a "cyber-physical system") can engage in direct radio communication and interaction with a software-enabled mechanical or electro-technical processing or measuring equipment. Specifically, it can trigger the download of the programme to be used. Thus, the process is entirely automated, personalised to the individual customer's needs, and decentralised.

2.5 The "*Cloud*": high-performance, quasi real-time long-distance remote processing of information

The fast, reliable, long-distance transport of massive amounts of data over the optically-enabled Internet (§2.1), their secure remote storage (§1.2. 7°), and standardised interfaces between software components from different sources (§1.3.2) re-opened the possibility of centralised data processing architecture (which prevailed in informatics until the emergence of the IBM PC in the 1980s). The perspectives are a simplification of software upgrades and of informatics administration in general, and a better controlled security. It also allows organisations of all sizes to access massive storage capacities, and sophisticated software, on a "pay-per-use" basis, with no need to purchase the whole infrastructure and the full software licence.

2.6 Remote payments

Electronic payment means of our daily life embedded in a "smart card" are the consequence of the joint development of low-power electronics (§1.1 8°), and of cryptographic algorithms (§1.2 7°).

2.7 Tele-working: remote employment relations

All elements of the **employment relation** and of the labour market can be made **remotely**, with no need for face to face interaction:

- match the competence of the worker with the requirements of each task, with data-bases that are accessible on-line (§1.2 2° and §1.3.1)
- draft and sign contracts (§1.3.5)
- specify and allocate tasks
- control work with sensors (§1.1 1°) and image or signal-processing algorithms (§1.2 1°)
- perform payments (§2.6).

Thereby, the employer can, with limited costs and risks, engage workers remotely. This means from home and during travel (e.g. in airports, trains, ferries), in "**tele-working**" arrangements, in "co-working" spaces, but also from "**near-shore**" (e.g. lower-wage Member States of the EU, or of the Euro-Mediterranean area) or "**off-shore**" locations (e.g. in India, Ethiopia, China, Indonesia, the Philippines).

2.8 Collaboration on shared documents

Information workers, such as accountants, administrative staff, design engineers and technicians work simultaneously without damage on different parts of a single document, because it is stored in a database (§1.2 2°), accessible through a "Cloud" infrastructure (§2.5). The document is standardised enough in its format and semantics (§1.3.2) for it to be processed cooperatively by several persons working from different computers at different locations, with the modifications brought by one worker being exploited seamlessly by the other.

This enables on-line, remote, asynchronous, round-the-clock cooperation of teams geographically dispersed across time zones.

2.9 Mobile communication

Digital radio communication components (§1.1 4° and §1.1 2°) exchange digital signals using radio waves. These signals are decoded using digital signal processing algorithms (§1.2 1°), so that the fixed base stations, on the one hand, and the mobile part (e.g. mobile telephone, RFID tag), on the other hand, establish and maintain a communication link according to a common protocol (§1.3.1). The most sophisticated mobile communication protocols (specifically: mobile telephony) have provisions for the "*handover*" of the mobile part from one base station to the next - thereby allowing long-range mobility (because the mobile part is not bound to remain within the radio range of the base station with which it connected initially).

Thereby, the collection, processing and communication of information, increasingly overcome the physical limitations of the transmission of data over radio channels.

This communication is performed on low-power, robust, portable **mobile terminals** (§1.1 6°, 7°, 8°), with high computing power (§1.1 5°) and long-lasting batteries (§1.1 9°).

2.10 "Big Data"

Data is collected *en masse* using sensors (§1.1 1°), the signals of which can be pre-treated on the fly by digital signal processing algorithms (§1.2 1°) so as to retain only the most significant events. Once transmitted over the Internet (§2.1) and stored remotely in "Cloud" infrastructure (§2.5), it can be processed using "Predictive analytics" statistical algorithms (§1.2 6°), to predict random events (e.g. failures of industrial equipment, customer orders and preferences) or to monitor processes (by early detection and correction of anomalies).

2.11 Satellite-based geolocation and inertial navigation

The nano-second timing information generated on satellites by atomic clocks (§1.1 11°) is transmitted by radio and received (§1.1 4°), decoded (§1.2 1°) and converted into a geographic location, in **satellite-based navigation systems** such as the Global Positioning System (GPS) or the future European Galileo.

By adequately combining sensors for acceleration, rotation and external sources (such as satellite navigation, beacon-based short range location systems, the measurement of distance travelled on a road, or digital maps), systems can be built that provide the 3D position and orientation of a device in space (e.g. the information whether it is looking up or down, towards North or South, etc.). Such systems are called (hybrid) **inertial navigation systems**, and can be found in cars, aircrafts, and any moving object in general.

2.12 Augmented reality

Lightweight, semi-transparent displays (§1.1 6°) can be worn as glasses, and their electric energy can be supplied by batteries (§1.1 9°). Their location and orientation in space can be supplied via inertial navigation systems (§2.11), so that they superimpose digitally-generated information on top of the image seen through the glasses. This is called **augmented reality**, and was made popular by devices such as Google Glass prototype (discontinued on 15th January 2015).

3 Digital integration of processes

Main political message

In manufacturing, these digitally-enabled functions lead to a capacity to fully **integrate** processes, from end to end. The processes being digitally integrated are:

- the short-term industrial **production** process, including recycling
- the longer-term **product design** process
- the **usage** process of the product itself
- the **maintenance** process.

All of these processes permanently integrate **external actors**, and specifically:

- **customers**, before sales (for the specification of needs, e.g. using product configurators to choose their preferred options) and after sales (for complaints, quality feedback, requests for improvements)
- **suppliers** of complete modules
- **sub-contractors**, **agency** and **self-employed** workers, specifically because of the possibility to conduct the whole employment relation remotely (§2.7)
- **academic institutions** and research organisations.

3.1 Digital integration of the industrial production and sales processes

The digitally-integrated industrial production and recycling process is a double loop of information and matter, between the customer and the industrial plant. It is generally performed with Enterprise Resource Planning (ERP) software (the best-known of which being SAP), and includes:

- (on-line) **sales**, where the customer chooses the product s/he wants using database searches (§1.2 2°), and sees the product displayed to him/her using 3D image rendering algorithms (§1.2 8°)
- **customer order**, in which the contract is signed (§1.3.6) and paid for (§2.6) remotely. These two functions are often referred to as **e-commerce**
- automated purchasing from **suppliers** or from subcontractors, based on EDI (§1.3.2), triggered by the newly sold product
- automated **order planning** in the manufacturing plant, based on actual sales
- automated, customised **manufacturing operations**, using digital command & control, automation, flexible programmable machines (§2.3) and direct communication between item or batch being manufactured and the machines (§2.4)
- automated intra- and inter-site **logistics**, and final **delivery** to the customer, keeping

permanent connection using mobile networks (§2.9), RFID tags (§2.2), optimised route planning (§1.2 3°) and road navigation systems (§2.11)
- remote supervision, monitoring via sensors (§1.1 1°) and **maintenance** of the sold product at the customer's premises
- collection of the used or failed product from the customer, and **reverse logistics** to the **dis-assembly** or **recycling** plant.

3.2 Digital integration of the product design process

The digitally-enabled product design process is a single loop of information between the Marketing, the R&D&I and the Operations departments. It includes:

- the definition of **customer needs** by Marketing
- the **functional specification** of the product using high-level behaviour description languages such as UML (§1.3.2)
- **Research & Development** and **Computer-Aided product Design**, with a capacity to identify the optimal technical compromise (§1.2 3°), with high-quality 3D rendering (§1.2 8°), shared in a "Cloud" infrastructure (§2.5) and collaboratively worked upon with customers and suppliers using common data formats and semantics (§2.8)
- embedded **software programming**, using Integrated Development Environments (§1.2 10°) and Application Programming Interfaces (§1.2 9°)
- product **simulation** and **testing** (§1.2 4° and 5°)
- the programming of **processing machines**, and specifically of robots and 3D printers (§2.3)
- **process design** using again simulation (§1.2 4°) and visualisation tools (§1.2 8°)
- statistical analysis of **customer feedback** and of **maintenance data**, using "big data" methods (§2.10).

3.3 Digital integration of the product usage process

The digitally-enabled product can be **used** in a connected network providing additional **functionalities** and **performance**, such as access to dynamic content, remote sensing and action. They are the source of **added value** to the customer, and of **positive differentiation** on the marketplace. These enhanced functionalities are enabled by:

- mobile communication modules (§2.9)
- powerful data processing capabilities provided by the fixed Cloud infrastructure (§2.5).

3.4 Digital integration of the maintenance process

A digitally-enhanced **maintenance** process of an equipment includes:

- the remote **detection** of failures and defaults using sensors (§1.1 1°) embedded in the product, which are connected via RFID tags (§2.2) or mobile communication devices (§2.9)
- the **prediction** of failures, based on real-time data being transmitted from the device, processed with “big data” algorithms (§2.10)
- optimised **route-planning** (§1.2 3°) of interventions
- reliable **navigation** to the intervention with road navigation (§2.11)
- compact, easily accessible and up-to-date **technical documentation** stored in handheld mobile terminals (§2.9)
- **diagnostic** supported by the “big data” exploitation (§2.10) of the local information logs
- the location of the action to be performed on the equipment displayed on augmented reality devices (§2.12).

4 Data protection legislation in the EU

The right to protect personal data is stated in the EU Charter of Fundamental Rights. The EU Commission estimates that the value of the personal data of European citizens has the potential to grow to nearly 1 trillion Euro annually by 2020. This makes a huge potential for growth. But this potential depends on the trust among the European citizens. Only 22 % of the Europeans have full trust in the collection of data by search machines, social networking sites and e-mail services, and 92 % are concerned about mobile apps collecting personal data without their consent. The EU Data Protection Reform, which is to be concluded in 2015, addresses these concerns by among others things suggesting “Privacy by De-sign”, one continent – one law and a level playing field for companies in and outside Europe.

The Directive 95/46/EC on "the protection of individuals with regard to the processing of personal data and on the free movement of such data" set and harmonised the minimal set of rules to be secured across the whole Union.

The principles of this Directive are, as of May 2015:

- Data must be processed fairly and lawfully and must be collected for explicit and legitimate purposes and used accordingly.
- Data must be relevant and not excessive in relation to the purpose for which they are processed.
- Data must be accurate and where necessary, kept up to date.
- Data controllers are required to provide reasonable measures for data subjects to rectify, erase or block incorrect data about them.
- Data that identify individuals must not be kept longer than necessary.

The collection of industrial data, i.e. the data collected from machines in the workplace, is however not regulated at European level. Whereas the consumer and the citizen are explicitly protected, the worker is not.

Part 2: Concrete examples of digitalisation of manufacturing

(to be completed)

IndustriAll Europe has identified some flagship initiatives that illustrate the transformational potential of digital technologies for industry, in all sectors, and in all processes:

- Digital integration of the **design** process: Full digital design and testing of the Falcon 7x airplane (Dassault Aviation)
- Digital integration of **manufacturing** process: multi-product assembly line for hydroelectric valves (Bosch Rexroth), real-time factory network connecting machine tools (Maschinenfabrik Rheinhausen), real-time management of workers' time shifts using mobile phones (BorgWarner Ludwigsburg GmbH)
- Digital remote **maintenance** of machine tools (Trumpf AG)
- Digital integration of **logistics**: RFID tracking of garments in warehouses and retail stores (Inditex – Zara brand)

Part 3: Potential impacts of digitalisation on manufacturing

Digitalisation is a major driver and enabler of **productivity improvements** in many sectors. The average value added per worked hour is clearly higher in firms with extensive use of ICT than in other enterprises. Enterprises who efficiently exploit the competitive advantages of digitalisation may provide better conditions for growth in activity and employment. A study by PwC anticipates 140 Bn€ of investment in Europe until 2020 with 18% productivity increase expected. It should be noted that the most advanced countries in terms of robot penetration are the leaders of European industry (Germany, Northern Europe, Italy...). Like any technology that increases productivity, it will have an impact on employment, on skills requirements, and on the sharing of this increased value added within industrial firms (§1).

Digitalisation, however, has impacts beyond the standards effects of productivity increases, and actually impacts the whole industrial activity:

- supply chains and the sharing of value added *between* firms(§2)
- labour and employment relations (§3)
- working conditions (§4)
- not forgetting trade union activity (§5).

1 Quantitative and qualitative impacts on employment in Europe

The assembly line has been the massively dominant manufacturing model since the beginning of the 20th century. Its days are not numbered yet: there are still, specifically in Asia, massive plants employing hundreds of thousands of workers. However, the pace of robotisation and digital automation is drastically increasing worldwide, with a massive impact on employment.

1.1 A massive impact on employment, for all workers (blue-collar and white-collar)

A study by Boston Consulting Group released in February 2015 anticipates that “new generation robots, connected and able to solve complex problems could handle 25% of automatable tasks instead of 10% as of now”. In 2013, the department of engineering at Oxford University published a research paper on “How susceptible are jobs to computerisation”. They estimated the probability of computerisation for 702 detailed occupations and examined expected impacts of future computerisation on US labour market outcomes. According to their estimates, about 47 percent of total US employment is potentially impacted by this development. The Bruegel think-tank provides first anticipations, using the same methodology, for the European Union, and concludes that "54% of EU jobs at risk of computerisation", with figures ranging between 47% for Sweden and 62% for Romania.

Roland Berger published a study along the same methodology for France in 2014, according to which 42% of all jobs could be impacted by digitalisation, and 3 million jobs, *including white-collar jobs*, could be destroyed before 2025 if nothing is done.

1.2 Improvement in quality and performance

Digital technology has the potential to strongly improve raw materials and energy efficiency, flexibility, reliability, productivity, accuracy and adaptation to customer needs. This is highly documented in national programmes like the “*Industrie 4.0*” in Germany or “*Usines du Futur*” in France. This is key to European industrial excellence.

This remarkable **increase** in **quality** and **productivity** could improve the position of European industrial firms on the market, reduce costs in Europe below those in Asia, and thus have the positive potential of **re-shoring industrial jobs back to Europe**.

IndustriAll Europe supports developments in which investment in technology and processes improves the quality, the reliability and the productivity of human work, and the efficient usage of resources (energy and raw materials). This is the **quality-based differentiation** on industrial markets that industriAll Europe supports.

These improvements, however, must be managed in a socially responsible way, specifically when taking into account the following phenomena, which are a major concern to workers in industry.

1.3 Specific threat on employment in skilled manual work

The last decades of the 20th century saw off-shoring of lowly qualified jobs to low-cost countries and sweatshops. In the 21st century, high-precision sensors and actuators, combined with real-time automated control, start to compete against the human dexterity and experience. The manual workers elite come under direct threat by more and more intelligent and accurate robots.

1.4 Specific threat on routine tasks, a specificity of manufacturing

Digital technologies enable the complex programming of tasks: the software is written once, takes into account a large number of pre-defined cases, and is then executed according to the real-time input from the outside world. It is specifically well-suited for **routine** tasks, in which similar actions are performed repeatedly in well-controlled environments – such as industrial factories.

Such routine tasks are numerous in manufacturing: in mass production, of course, but also in clerical administrative work, in the test phase of design, and even in the "High-Throughput Screening" of pharmaceutical research. These routine tasks are performed by the middle-skilled backbone of the manufacturing work-force.

1.5 Polarisation of the work-force

If middle-skilled routine jobs disappear, those remaining are at both extremities of the labour market: "abstract" jobs that require conceptual capabilities, and non-routine manual jobs taking place in non-controlled environments (such as cleaning, construction, agriculture & forestry, inter-site logistics, health care). This leads to a **polarisation** of the work-force and of society, with a risk of it being split between a rich, dominant minority of abstract workers and a poor, subordinate majority of unskilled labourers. Such a divided, unequal society is a **risk** for **democracy** and for the pursuit of the **sustainability** agenda.

This polarisation phenomenon is already taking place: over the 2005 – 2013 period, in the EU-15, middle-skilled "Routine" jobs sank by 10%, whereas "Abstract" and "Manual" jobs increased by 4% and 8% respectively.

2 Impacts on industrial supply chains

The digital revolution can be summarised by 3 s. “sensors, software and services”.

2.1 On industrial demand = on the material and immaterial goods being sold

2.1.1 Service-based economy

The first impact concerns the industrial demand in itself. Internet is changing the way consumers approach the ownership of goods. What is called the economy of functionality or the service-based economy is penetrating all fields. Consumers don’t need a specific good, just the service it renders.

- I don’t need a washing machine, I just need clean clothes and I’ll wash them at the launderette next door.
- I don’t need to buy a CD / DVD: I’ll just stream or download the song or the movie.
- I don’t need my own car. I can travel using carpooling through dedicated websites (e.g. Car2Go by Daimler).

ADEME, the French agency in charge of energy and raw materials, has suggested the number of cars in France might be 1/3 lower in 2050 than today. This illustrates how deeply industrial production could be affected. This is not necessarily bad news: shared products should be more durable and with a reduced impact on the environment. But this means massive job transfers.

2.1.2 Permanent connection of the product

We are quickly moving towards the Internet of Things where all objects will be connected with one another and with a common infrastructure. This is for example the case of cars with the highly advertised work by Google or Apple: a car will soon be nothing more than a computer on wheels. But the Internet of Things also reaches home equipment, domestic appliances, leisure, health products, even clothing and food. Connection to a central information processing site brings added information-based services and features to the customer such as location-based information or autonomous driving.

The inclusion of new features and services, based on the digital networking of industrial products, is a source of **positive differentiation** on the market, and improves the competitive position of the firms that master it. This is the reason why traditional industrial companies increasingly acquire software-intensive firms (e.g. the acquisition in May 2015 of the Finnish Elektrobit Oy software firm’s automotive division by equipment manufacturer Continental AG).

2.1.3 Economic value shifts towards immaterial goods

This evolution also means a shift of the perceived value and of the willingness to pay from the material good to the digital-based service. The economic added value shifts from the industrial manufacturer of the material good towards the supplier of the connected immaterial service. European industrial companies and their workers must ready themselves to provide this immaterial added value, based on connectedness.

2.1.4 The economy leans towards a fixed-cost economic model with "natural" monopolies and arbitrary salary levels

As the value of products is more and more embedded in its immaterial component, the production conditions of this immaterial component tend to prevail in the competition dynamics of industrial sectors.

Immaterial, digital components of a product, such as the embedded software, its design, the media content of the related on-line service, the digital geographic map, etc. are very costly to design and produce for the first unit, but the reproduction cost of all other units is zero (or close to zero). In economic terms, the "fixed" costs, incurred at the start of the process to obtain the first unit, dominate, while the "marginal" costs of the other units are zero (or close to zero).

In traditional manufacturing of material goods, the situation is more balanced. Fixed costs can be high (e.g. the investment in the plant, the R&D), but the marginal costs remain significant: each additional unit requires costly raw materials, energy and human labour.

In a world with increased digital, immaterial content for industrial goods, the fixed costs will dominate, and the marginal costs will lose significance. This situation was widely publicised by Jeremy Rifkin in his book "The zero marginal cost society".

This "zero marginal costs economy" or "fixed costs economy", however, has two very negative consequences:

- it leads to **natural monopolies**, because the biggest player in each industry is the one having the largest customer base between which to share its fixed costs. It displays therefore the lowest price, and thereby reinforces its dominance, in a self-reinforcing loop.

- it gives **no rule** to legitimately determine the **remuneration for labour**. The whole economic system of classical textbooks is based on the hypothesis of decreasing marginal yields (and thus of increasing marginal costs), so that the "socially optimal salary" in each labour market is determined by the marginal yield of the last worker being hired by the firm, which equals the marginal cost (and the selling price) of the last produced unit. When this marginal cost is zero, there is no means to legitimately determine the salary of the worker.

2.1.5 Blurred liability in case of multiple input to the product

In the Internet of Things, the "Thing" incorporates external software, communication services and data. Suppose a driverless car breaks down on the highway. Where does the problem come from: the engine? the radio base station which transmits data from the car to a central traffic data base? the data base which controls the car?

2.1.6 Long-term maintenance & repair

RFID tags make it possible to get individual wear data on objects and piece parts. This significantly improves the forecast of breakdown and boosts preventive maintenance and consequently **increases the lifetime of products** (on top of the fact that shared products must be durable as mentioned above). Better-maintained, longer-life will lead to a more efficient use of natural resources.

It will be possible to set-up "one unit batches" for the missing spare parts, thereby increasing the lifetime of products even further.

2.2 Manufacturing processes:

2.2.1 Reliability using predictive maintenance based on the exploitation of "big data"

Big data analysis gives statistical results on machine and component life cycle. Parts most likely to fail are identified leading to an improvement of the component performances and/or the manufacturing process. All working positions along the line provide automatic error reports, which means important savings in the time necessary for quality control and its accuracy (+ feeding of the reliability database).

2.2.2 "Mass customisation" for tailor-made products or spare parts.

The customer can interact in real time with the company's ERP (Enterprise Resource Planning) software, and order by Internet a fully customised product (e.g. a car with a given colour and specific options). The supply chain can react immediately, mobilising highly flexible digitally-enabled manufacturing tools, and produce one single unit, at a cost comparable to the one achieved with mass manufacturing techniques.

It should be noted that the same "mass customisation" processes and tools can be also used for spare parts of obsolete products (thereby increasing their life time). On the more negative side, so-called "industrial hackers" can more easily manufacture counterfeit or illegal products (specifically weapons).

2.2.3 Monitoring of social & environmental conditions of manufacturing

Many Corporate Social Responsibility (CSR) commitments by transnational companies lack efficiency due to scattered supply chain and manufacturing locations. RFID tags and Global Standard (GS1) supply chain coding with item-level identification make it possible to trace product origin and (social or environmental) processing conditions even in distant, developing countries. These technologies are a step in the direction to full transparency and effective CSR. The monitoring of the physical parameters of working conditions can be supported by sensors networks.

The same applies when trying to accurately calculate the carbon contents of manufactured goods along the value chain. The worldwide journey of each component can be made accessible through a data base.

2.2.4 Flexible automation of dis-assembly

Most current products are based on a "cradle to grave" cycle where:

- At best raw materials are recycled through energy consuming and little efficient industrial processes like recovering a small percentage of rare earth or precious metals from tons of electronic waste.
- At worst incinerated or stored in a landfill with high toxicity risks.

Digital identification procedures provide a much better possibility to **recover the complete, operational modules** which are often in excellent working condition. The product is identified with its tag, so that the automated dis-assembly line knows what operations should be performed in what order to recover each and every module. These can then be reused in a much more resource-efficient "cradle to cradle" production cycle.

2.3 Product and process design

Digital technologies contribute to revisit the role of R&D department. Parts of a product or process design can be outsourced on the Internet either at cost or even for free. This is even easier when calling for support by an open source community. R&D department will benefit from skills beyond company own resources.

The customer itself is called to contribute to product design. Not only as usual by requesting given technical specifications, but also because he can be part of the design team through collaborative tools.

R&D department itself is not limited to one or a few locations, but extends worldwide within all company sites. High-speed asynchronous data interchange give immediate access anytime, anywhere to specifications, drawings, lists of components and piece parts, etc. New simulation tools and augmented reality provide the R&D staff with the capability to model any working position in any factory worldwide and to get a virtual replica of the product under design.

The design process itself is changing; new "AGILE" methods question the traditional back and forth communication between the design department and the assembly line. The product / process design work is made quicker, more creative and more reliable. The availability of design results and diagrams through one click at any working position including at subcontractors' site maximise the manufacturing flexibility.

2.4 Business models

The way to make business and to strike a commercial deal is also deeply modified. Online sales progressively replace the old salesman and impact the organisation of the sales departments. The buyer may set up a web (reverse) auction which shoves the traditional buyer / seller relationship.

But the change also questions the ownership of product and added value. Does the car added value come from its engine or from the web infrastructure providing traffic and routing information? New digital actors obviously claim an even bigger slice of the cake with several consequences:

- Risk of **capture of the added value** added by the (predominantly US-based) owners of **proprietary standards**, if they were to dominate the market for the digital integration of design, manufacturing, usage, maintenance or disposal of industrial products – with negative consequences on wages, working conditions, investment and innovation in the European manufacturing sector.
- Concentration of the added value in the **monopolistic digital platforms**, the virtual marketplaces that connect the manufacturer of

the industrial product with the customer, the product with on-line service provisioning, or the workers with the tasks to be performed

- Increased capacity to **avoid taxation**, because the value is concentrated in immaterial rights (trademarks, software licenses, patents), for which no market price can be defined: their value is arbitrary and can be set at any level that suits the tax avoider's interests; it also can be shifted at will across continents to the place where they are least taxed or not taxed at all using opaque transfer prices.

3 Impacts on labour and employment relations

Automation first destroys jobs, before it creates new ones, elsewhere in the economy. This has been true since steam-powered looms started to replace weavers two centuries ago. As mentioned in §1.1 above, more than one half of European jobs are under threat due to digitalisation in the coming 20 years. Such estimates do *not* include jobs *created* by automation. But created jobs will replace destroyed jobs neither in terms of required skills, nor in terms of geographic location or position along the value chain.

Even for remaining jobs, the work perimeter undergoes significant changes. Digital technologies scramble time, geographic and functional barriers. Work is no longer defined in a given location, time slot or activity. It goes beyond traditional frames and enlarges the professional activity. At a time when firms shift the allocation of tasks world-wide at limited costs, employees are more and more at risk of becoming isolated individuals in front of more and more globalised employers. If nothing is done, social inequalities risk exploding in a dual society made of few stressed managers and crowds of low-cost workforce providers.

Workers and their unions must anticipate this massive "creative destruction". They must find means to ensure that this transformation is fairly managed, that threats are avoided, and opportunities seized. This is the purpose of Part 4 of this Policy Brief.

3.1 The negotiation power of workers is severely weakened.

Workers can be substituted by others in different locations easily, fast and at low cost and risk for management, because all elements of the employment relation can be performed remotely. World-wide competition between workers results in a permanent threat of out-sourcing work to lower-cost / less regulated jurisdictions. Consequences are well known: pressure to accept worse wages and working conditions in working hours, occupational health & safety risks, regressions in data protection, in the right of association, and in the right to strike.

3.2 More precarious labour relations,

"New forms of employment", many of which appear primarily in the digital sector, illustrate that the business risk (but not the business surplus!) can be shifted to the workers for the sake of flexibility:

- "crowdsourcing" and bogus self-employment transform the labour contract into a commercial contract. A vulnerable underclass develops, dependent on this crowdsourcing as its main source of income.
- lottery-type remuneration schemes appear (85% of "apps" being developed remain un-used and provide zero income to their developers, while 85% of "apps" revenues are concentrated in the hands of 3% of developers)
- 0 hour contracts or 1 hour contracts, where the worker should be 24/7 at the disposal of its employer in the unconfirmed expectation that s/he might work.

Despite their advanced underlying technologies, many platforms that connect marginal offerings of work (e.g. car transport like Uber), of second-hand products or services (e.g. eBay, AirBnB, etc.) with demand, are little more than the digital guise of the "informal sector" of lesser-developed economies. They industrialise and globalise economic activity where no rule, no social protection, exist, and where the weaker members of society are under permanent threat by rogue employers or even organised crime. They have the potential of a terrible regression into lawlessness, out of which only decades of workers' struggle managed to come out.

3.3 Skills and qualifications

3.3.1 Fast changes de-qualifying workers

Multiplication and rapid sequences of new working methods and tools mean permanent de-learning and re-learning by workers which prove to be exhausting and destabilising. Mastering digital technologies is a key asset to keeping one's job and competency level. But workers find it harder and harder to cope with the pace of change. Older people are often forgotten or even dropped in the change projects, because they are perceived as not adjustable to new technologies. Their long experience and practical knowledge just becomes useless, while they could contribute to the design of the processes. They know "why" and can thus help on "how".

3.3.2 Reduced investment in education or training

With workforce globalisation and the rapid changes in technologies, employers have less interest in training groups of workers who might soon become redundant. Employees often complain of the lack of training. Or training often comes too early or too late compared to the implementation of the technology. It may be poorly adapted to the worker's needs because it is too far from his daily activity or from its professional practices. One size seldom fits all.

3.3.3 Increased attractiveness of industry for young people

The digitalisation of manufacturing gives a new, clean, modern and connected image to industry. It also brings industrial work closer to office work, dominated by computer screens and abstract representations of reality. It has therefore a potential to make industrial careers more attractive for young people - thereby alleviating the shortage of technical skills that starts becoming a handicap for some sectors in Europe.

4 Impacts on the working conditions of the "core" workers in the company

This part has been enriched by the Eurocadres document "Judicious use of ICT".

Digital technologies invade the working life. But they also invade the non-working life where they are willingly and happily used by the same people at home like at work. Many workers see them as a progress towards more autonomy and more efficiency. The possibility to tele-work or to temporarily perform private activities at the office is massively approved. The sword is, however, double edged.

4.1 Loss of work significance

Many workers, whether on the assembly line or in front of their laptop, lose control of their activity. Their tasks are dictated by machines. They can simply obey and at best monitor what happens. But often the system works because the human being is capable of intelligence and can ignore the official process taking personal initiatives. The "real" job is not the "prescribed" job. This criticism has been regularly made to the "lean" model when implemented in a top-down approach.

4.2 Easy, massive, automated and low-cost surveillance of workers

By means of cameras, microphones, image and sound processing, textual analysis of e-mails and web traffic plus all kinds of indicators, etc., firms are able to measure very precisely what each individual does and produces: who is doing what, with whom, at which point in time and how quickly (pace of work and responsiveness). Workers are not always informed of the presence of these tools for monitoring their work, or on how they have been designed. What is even more problematic is that these systems do not give an accurate indication of the real work that gets done: what was actually achieved and what the objective was, but also all the preparation work, the trial and error, all of which are needed to complete a task.

4.3 Blurred separation between professional and private life

Highly volatile customer demands and sometimes poor organisation in the firm require the worker to be always connected. This may be made worse when managers are workaholic or themselves under stress. The employee can (and consequently can be requested to) be reached 24/7. His freedom to organise himself is at the cost of overwork, unpaid working hours, intrusive e-mails or phone calls, permanent presence of job concerns in his private and family life. The question has been publicised enough not to require further emphasis. The right to disconnect has become a major issue. It is at times mentioned in some company charters, although their relevance and efficiency is still to be evaluated. The developing trend of BYOD (Bring Your Own Device) is another example where more flexibility is paid by more constraints.

4.4 Modified hierarchical relations

In the digital globalised firm, an employee's direct manager (n+1) can be located elsewhere in the country and n+2 anywhere else in the world. The guidance, support, and ordering relationship is replaced by management through quantitative indicators, with no capacity to discuss them, and no access to those who actually take decisions. And the manager's role is more and more to fill reporting spreadsheets which replace human beings.

The autonomy, competence and expertise of employees in their work is increasingly challenged and weakened, with the consequent shift towards a type of omnipresent and omnipotent technological regulatory authority. These mechanisms (such as ERP, workflow, reporting systems, etc.) apply throughout the work process. They determine the sequences of actions to take, check information that is logged, prioritise and schedule tasks, request data updates and ultimately give employees the impression that they are serving these technologies and not vice versa.

4.5 Infobesity

The worker is bombed by hundreds of petty e-mails (3 million e-mails are sent every second in the world), permanent interrupts, load trucks of links to websites, if not spam cargos or permanent information news channels. Too much information kills information.

Information overload occurs when the amount of input to a system or to a human being exceeds its processing capacity. Decision makers who must consider too many data will probably make wrong choices … if they manage to make any choice!

Digital technologies may allow performing one task much more quickly or taking into consideration more parameters. But it may lead to permanent petty modifications or lack of clarity with no real productivity improvement.

4.6 Lower quality education and training

The aim of training should be to improve professional skills; but it risks being limited to simply learning how to use the new digital tools. This may lock workers in proprietary software technologies with increased dependency towards employers, reduced opportunities of chosen professional mobility and of bargaining.

E-learning, including Massive On-line Open Courses (MOOC), offers a wider range of training capabilities with reduced constraints on schedule and possible savings on travel & accommodation costs. But it is also a low-cost solution which shifts skills acquisition totally on the worker's side, while depriving him of the possibility to fully dedicate himself to training (without the background noise of ongoing tasks) and to have rich and supportive contacts with the trainer and fellow trainees.

4.7 Vulnerability and dependency on networks and tools

In many cases, it is simply impossible to work if the digital environment is out of service. The worker may be victim of hardware failure, faulty or obsolete software, corrupted data, network breakdown, not to mention hacking, spying or virus attacks. He is often left isolated or dependent on an outsourced / off-shored help desk (or simply on stupid answering machines).

The risk of cyberattacks, intellectual property theft or malware must be seriously addressed. There are reported examples of hackers totally stopping a factory or stealing technological secrets.

4.8 Blurred employer liability

In a digitally connected, automated environment, the accident can be caused by the machine, the software, the external data received or the lack of security of the network provided by an external operator, etc. Workers can be held responsible and blamed for poor performance due to issues totally out of their control. Worse still, they can be left with no capacity to obtain redress and compensation in case of accident, because each contributor to the digital factory (the factory owner, the machine manufacturer, the software developer, the data provider, the network operator) blames the next and refuses liability.

4.9 Health and safety risks

Long hours of isolated work on a screen is definitely recommended neither for brains nor for bodies. Moreover, the workplace / working time are no longer clearly defined: how to determine if an accident in the worker's living room is a work accident?

Isolation is detrimental to human interaction and relationship which is part of a normal work environment. Machines are more and more communicating, but what about workers? The coffee break may be good for workers' mental health and a company's productivity.

In an automated environment, machines can start operating spontaneously, without warning. Their software must contain means to protect the workers nearby, and to allow a human-machine interaction that is harmless to workers.

4.10 Job market

Digitalisation has also modified the job market. The Internet is the main media to learn about job vacancies and to submit applications. Social networks like LinkedIn are a must, and in some countries E-bay collects more job offers than official employment agencies.

5 Impact on trade union work

A trade-unionist is a worker who lives in the same digital world as any other worker. No wonder that trade union activity is deeply impacted in this new era.

5.1 Dispersion

Workers are geographically dispersed, with (hyper-) short-term contracts, and yet the technology enables them to work collectively for the company. Geographic dispersion, lack of face-to-face interaction, short-term working relationship with one another limit workers' capacity to coordinate. This threatens the very possibility for them to organise collectively. It is more and more difficult to physically meet a union officer, or for unionists to report information and discussions with management. On-line communication poorly replaces direct talks with the people in charge.

5.2 On-line activism

Activism is more and more on-line. This is true as well on labour issues at international scale, specifically for the "digital natives" generation (e.g. "Glass door" in the United States). On-line activism is both a complement and a potential competition to traditional trade union work.

On-line campaigning and petitioning has proven efficient in the case of workers' rights violations. Workers' groups know how to use the Internet to spread information or to reach the public opinion. They also know that firms are very sensitive to their e-reputation. Firms find it increasingly counter-productive not to adhere to commitments taken in their Corporate Social Responsibility.

Crowdfunding is helpful to support workers during a conflict or to support a longer term fight for workers' rights.

The current issue for workers' organisations is to get some durable web recognition and to build their own web reputation. But this question of reaching the media was the same before the age of Internet.

5.3 Collective bargaining

Collective bargaining is the safest way to protect workers' rights and to set up stable and mutually profitable relations between employers and employees. Collective agreements are today discussed almost 100% at a geographical level: national, regional or local.

This does not apply only to usual topics (salaries, working time, health and safety, skills...), but to components of the welfare state which indirectly depends on the work environment: social security, pension systems, employment of disabled workers...

Firms have become international thanks to digitalisation, and so has the competition between workers because:

- Transnational firms apply a single world-wide policy on work relation regardless of the nation.
- National states hope they can get a competitive advantage by lowering work regulations. In Europe, and especially in Southern Europe, the proportion of workers covered by collective agreements has drastically decreased since the 2008 economic crisis.

A ray of hope is given at the European level with more than 1000 European Works Council (60% of them in the scope of IndustriAll Europe) and by a few tens of transnational frame agreements (Europe or world).

Part 4: Recommendations. Digital technologies must be a tool for democratic coordination in manufacturing

This Part 4 explores the concrete means to seize the opportunities and to minimise the threats of digitalisation on manufacturing. The perspective for industriAll Europe is to **shape the changes** brought by digitalisation, in the long-term interest of workers and of society at large, to positively accompany this transformation.

As was seen in Part 3 above, the potential impacts of digitalisation are extremely diverse, and cover a large variety of phenomena. However, despite the variety, two unifying concepts, **coordination** and **control**, may be used to describe and assess these impacts in a more simple way. This is the purpose of §1. Based on these concepts, industriAll Europe recommends actions for the **social management of productivity gains** (§2), in the fields of **Industrial Policy** (§3) and of **Collective Bargaining and Company Policy** (§4).

1. Coordination and control: two unifying concepts to describe and assess the impacts of digitalisation

Digitalisation provides a capacity for information to be collected, transmitted and processed anywhere, anytime, remotely and in real-time.

By using this capacity, two or more entities (people, machines, objects, workshops, factories, companies) can **coordinate** to achieve their common task with greater effectiveness and efficiency. In a "coordination" process, all parties emit and request information, process it in parallel, and act according to the outcome of this information processing, taking into account the objectives and goals of the other parties. E.g. automotive suppliers contribute to the design of, and provide just in time on the assembly line, the exact component that fits (colours, size, equipment level...) with the individual car being worked upon; engineers work jointly on the digital model of the new product being developed. Coordination is a **symmetric, horizontal, multilateral** process, where all parties involved participate jointly to the design and the execution of the task, share the risks and the rewards.

The capacity provided by digitalisation can also be used in an **asymmetric, vertical** and **unilateral** process, which can be called **control**. In a control mode, one entity (person, machine, institution, company) is active. It collects information on the other entities (persons, machines, objects to be processed, companies) using sensors, processes the information unilaterally, and acts upon these entities, using actuators, to achieve its own goals. These entities on which information is obtained, and upon which action is exerted, are passive. Examples of such asymmetric control are: the action of a machine on a non-digital object to be manufactured; the extreme fragmentation of tasks in "crowdsourcing" platforms such as Amazon Mechanical Turk, where micro-tasks (lasting a few seconds to a few minutes) are allocated to "click-workers" for a few cents.

In the "control" mode, higher efficiency is also achieved because the work of the passive entity fits very exactly with the requirements of the active one, but at a double cost:

1. all the intelligence and capacity to provide knowledge and competence input of the passive, controlled entity is lost
2. the passive, controlled entity is deprived of any form of autonomy. It is, literally, alienated.

"Coordination" and "Control" may be considered as two opposite extremes of a continuum. In real life, no situation is a complete "control", nor a complete "coordination" as described here. Even in the strictest "control" situation of slavery, the slave attempts to reach (and sometimes achieves) a form of (very limited) autonomy. Even in the most democratic "coordination" processes, some players have greater capacities or are in a stronger position to obtain what they need than others. However, as a stylised way to consider a more complex reality, the distinction between "coordination" and "control" is useful to assess the effects of digitalisation on manufacturing.

"Coordination" and "Control" differ by the **political status** of the entities involved. In "coordination" mode, *all* entities are considered as active, autonomous subjects, on an **equal** footing. In "control" mode, entities are **unequal**, with one (or a limited group) being active, and using the others as passive instruments to achieve its (or their) narrow goals.

This means that there is **no technological determinism** regarding the consequences of digitalisation. The outcomes of digitalisation will be the result of a *political* decision, regarding the status of the participants in the network.

Based on this analysis, on its democratic values and on the trade unions' perspective of work as a tool for human emancipation, industriAll Europe has a clear view on the direction in which the digitalisation process should be steered.

Digitalisation must be a tool to foster the efficient and democratic coordination of all players involved in manufacturing processes.

All companies, along the whole value chain, all workers, whatever their contractual relation to the companies, must be promoted as actors of their own life, with their own, legitimate goals. Digital tools must be used to enhance the expression of each player's goals and constraints, and to support their cooperative coordination to define common perspectives, to share and assign tasks, risks and rewards.

The other side of the coin is that digitalisation should not be used as a means of unilateral control, of concentration of power or wealth.

2 Manage productivity gains

The improvements brought by digital technologies to the efficiency, productivity and reliability of industrial processes will have quantitative and qualitative impacts on employment.

This phenomenon is well-known, and has occurred before, in several sectors and regions, with the changes in technologies and in the availability of (natural and other) resources. A specificity of the digital transformation of industry is that it impacts many sectors simultaneously. However, it is not new *per se.* Many tools already exist and were developed over time to cope with the social consequences of productivity gains.

IndustriAll Europe demands that these tools be fully mobilised for the social management of the productivity gains induced by digitalisation: **anticipation of change** (§2.1), **social dialogue** (§2.2), **Education & Training** (§2.3) and a reflection on **working time** (§2.4).

2.1 Fully mobilise the toolbox of anticipation of change

N.B. industriAll Europe's detailed policy on Anticipation of change will be the purpose of an additional, specific Policy Brief.

Tools exist to cope with industrial change. They must be used.

Workers in all industrial firms must be informed, well in advance, of transformations incurred by digitalisation. They must be given sufficient information, and time and the opportunity to react constructively. This is the very purpose of workers' **information and consultation rights**. The digital transformation of industry must be a new opportunity to develop and enrich them.

2.2 Reinforce social dialogue at all levels

As stated above (§1), industriAll Europe believes that digitalisation must foster the democratic, multi-lateral, egalitarian *coordination* of workers, where they are considered as responsible, active, conscious and autonomous subjects. Digitalisation must not be a tool to *control* and alienate them as objects.

The European social model has historically developed an institutional framework that was specifically set up for workers to be treated as subjects: **social dialogue**. Social dialogue is *the* institution of choice for workers to express their views, and to be involved in shaping the strategic objectives, the material and moral conditions, and the metrics of assessment of their work.

industriAll Europe demands that the transformation brought to manufacturing by digitalisation be seized as an **opportunity** to open new and productive fields for social dialogue at all levels (company, sector, Member State, EU), to ensure that the changes brought by digitalisation are made with and for the workers, specifically in terms of Occupational Health & Safety, employment and qualifications.

2.3 Negotiate new rights for Education & Training in the digital age

N.B. industriAll Europe's detailed policy on Education & Training will be the purpose of an additional, specific Policy Brief.

industriAll Europe would recommend to:

1. Integrate the new digital **qualifications**, tasks and work categories in the negotiations with employers
2. Negotiate the **permanent up-** and **re-skilling** of the existing workforce, to adapt to the fast pace of technical change in the digital world
3. Support the usage of **standards** as tools to increase **vendor-neutral training** and **certification**
4. Negotiate **e-learning** conditions that are favourable to workers, i.e. with effective, measurable and certified outcomes, at affordable prices and a fair sharing of costs (in time and money) and benefits.

Such reflections are already under way in the European e-skills policy, such as the common, technology-neutral e-Competence Framework, and the "Grand coalition for digital jobs".

More generally, an effort to modernise universities and colleges through a broad and general digital competence of the staff is needed, and targeted efforts to develop and implement good digital solutions at the institutions. This will in turn contribute to increased digital competence in business and thereby contribute to increased value creation.

2.4 Reflect on working time

Digitalisation brings with it remarkable **productivity gains**: the work time needed to perform many value-adding tasks (including highly qualified tasks in R&D&I and product design) will be dramatically reduced. Tele-working enabled by digitalisation specifically has a remarkable potential for saving time, infrastructure capacity and energy for daily commuting between home and work-place.

In the views of industriAll Europe, the allocation and distribution within society of these gains should be broadly discussed. The solution whereby the work time remaining from the digitalisation process should be concentrated in fewer and fewer hands deserves being thoroughly weighted against alternative options.

3 Recommendations in Industrial policy

3.1 Leverage digitalisation for socially, economically and environmentally responsible innovation

3.1.1. Aim at a capital-intensive industrial model for discrete manufacturing

Discrete manufacturing covers all those processes that are applied to independent, solid objects. They are mainly present in the metalworking (in the broad sense: metal fabricated products, mechanical and electrical engineering, transport equipment, NACE codes C.25 to C.30) and the Textile, Clothing, Leather & Footwear (TLCF, NACE codes C.13 to C.15) sectors. Discrete manufacturing distinguishes itself from continuous manufacturing, which operates on fluid-like materials (gases, liquids, powders, pastes) and is found in the chemical industry, in paper, steel and power plants, in oil refineries and in food processing.

Discrete manufacturing has traditionally been the domain of labour-intensive processes, where human skills were directly mobilised to shape or assemble hard matter (metal, glass or fibre), in work assignments that could be highly repetitive. The promise - or the threat - of digitalisation in discrete manufacturing factories is to have intelligent machines, sensors, and integrated digital automation systems being able to fully or partially replace the skilled hand of the worker in its interaction with hard matter (e.g. with interactive robots that have the capacity to operate in the same space as humans). The promise is to relieve manual workers from repetitive and sometimes dangerous tasks, and to prevent musculoskeletal disorders, specifically in circumstances where manual workers will be required by demographic changes to work until a much older age. The threat is on the number and quality of the jobs remaining after this transformation.

industriAll Europe proposes, in discrete manufacturing plants, to aim at a highly **capital-intensive** model, in which machines tend to automatically manage the permanent, or "steady", state of the factory (including short-term random events), while humans take care of the transitional states (maintenance, repair, improvements, innovation) and concentrate on the high-level tasks of planning, control and supervision. Under this cooperative division of labour between humans and machines, humans specialise on their specific creative, innovative and strategic capacities, and are being *assisted* by digitally-enabled machines, robots or computers.

This capital-intensive model already successfully exists in continuous manufacturing, and workers in these sectors enjoy good wages and working conditions.

Achieving this model will not happen overnight, though. Three conditions *must* be met for this transition of discrete manufacturing (and of those continuous processes that are not yet fully digitalised) to a capital-intensive model to succeed:

1. The massive, idle European savings should be funnelled towards **massive investment** in the necessary digital industrial machinery and software.
2. Worker representatives and trade unions must be directly involved in the **design** of these capital-intensive plants, in a fruitful and concrete **social dialogue** with employers. This social dialogue must ensure that the autonomy, creativity and strategic capacities of workers are appropriately mobilised in the new digitally integrated factory design, under the model of "coordination" described above (§1).
3. Workers in discrete industries must be provided with the **re-skilling** and **up-skilling** resources necessary for them to perform the higher-level tasks assigned to humans in this revised division of labour (as seen above §2.3).

3.1.2 Develop Human-Machine Interfaces adapted to manual workers

Manual workers tend to have a specific, concrete mode of interaction with the outside world. They understand and learn by examples, by accumulating concrete observations and experience, by connection to the real life and to real things. This mode of interaction with the world must be respected and valued.

The virtual cyber-world being generated by digitalisation is just the opposite. It is a world created by theorists, composed of abstract entities, which interact according to highly formalised procedures, and are represented by mathematical models.

This structural inadequacy must be addressed. Manual workers should not be discriminated against in the digital world.

industriAll Europe demands that public research develops **Human-Machine Interfaces** of the machines present in digitally-enabled factories, so that they be adapted to the **specific skills** of **manual workers**, and to their concrete mode of interaction with the outside world. Thereby, manual workers will have the concrete means to enjoy their full rights as active members in the digital environment.

3.1.3. Design ergonomic work-places with virtual reality tools

Virtual reality design tools have a remarkable potential to design a complete work-place *ex ante*.

Their use must be generalised and made systematic, specifically to address the needs of an ageing work-force.

3.1.4. Create jobs and reduce waste with automated dis-assembly factories

(This proposal mirrors the one made in industriAll Europe's [Discussion Paper "Innovation by all and for all"](), Part II, §9.i)

Flexible, digital assembly technologies could be used in a reverse flow to efficiently **dis-assemble** products having reached their end of life. Provided the product contains (e.g. in a removable RFID tag) the information relative to its assembly operations, a flexible dis-assembly line could use this information to dismantle the product, and recover re-usable components and strategic raw materials, thereby reducing waste generation and pollution, in a high-performance re-use, re-manufacturing and recycling process.

Such technical developments could have a strong, positive impact on industrial employment, and on raw material and energy efficiency, thereby reconciling environmental and employment concerns.

industriAll Europe recommends that the technologies, standards and institutions be developed to equip such "dis-assembly" factories: reverse logistic flows, sensors, automated testing systems, data semantics to describe (dis-)assembly operations.

3.1.5. Re-shore jobs with the mass customisation of industrial manufacturing, specifically for garments and footwear

(This proposal mirrors the one made in industriAll Europe's [Discussion Paper "Innovation by all and for all"](), Part II, §9.f)

Garments and footwear are among the industries in which the diversity of needs is extreme. The dimensions of the human body, their relative proportions vary from one person to the next (so much so that these measurements were used until recently for criminal identification purposes in France), and so do the colours, tastes, social status, season, fashion (and sensitivity to fashion). Garments and footwear are thus among the products for which customisation can reach the highest level of detail and variety.

industriAll Europe proposes to invest in the development of **fully integrated supply chains for the mass customisation of garments and footwear**. The process would seamlessly intertwine retail with manufacturing: the measurement of the person's dimensions and colours, the trial of items on a digital avatar, the manufacturing and the delivery. Such mass-customised garments and footwear would need to be manufactured in locations geographically close enough for delivery times to be acceptable – thereby re-shoring the jobs that currently are massively in Asia. In the process, the highest working standards for all those involved in sales and in production must be assured.

3.1.6. Digitally trace and monitor social and environmental conditions of manufacturing

Corporate Social Responsibility commitments by EU-based companies is made difficult by their reliance on long and complex supply chains in the global South. Deliberately or not, they are not in a position to know what are precisely the social and environmental conditions of manufacturing at their suppliers' facilities.

industriAll Europe demands that a technical and institutional infrastructure be set up to ensure the reliable **tracing** and **monitoring** of **environmental & social** manufacturing conditions along complex, international value chains. In order to provide reliable information at the source, the institutional infrastructure should involve the only organisations that are independent from management and permanently inside the company: the **trade unions**, in the EU and in the global South. Once reliably collected, this information should be inscribed into an individual RFID tag attached to the item, with appropriate authentication so as to prevent later tampering. Thereby, Corporate Social Responsibility policies could be reliably implemented, and international competition made fairer.

3.1.7. Design innovative incentives for low-carbon consumption patterns

The possibilities of digital technologies to trace and monitor industrial processes, and to implement sophisticated accounting systems, lead the way to accurately measure the **carbon content** of each individual industrial product. In the views of industriAll Europe, this information should be collected, transmitted along the value chain in adapted accounting systems, and displayed to the customer to influence his/her choice. It should also be used to devise innovative economic incentives to support low-carbon consumption patterns.

3.1.8. Switch to IPv6 protocol to ensure a fair allocation of addresses in the Internet of Things, and to support European manufacturers

The current Internet Protocol, called IPv4, contains only 4.3 billion addresses. This could be sufficient for the Internet of People, but is definitely not enough for the anticipated 50 billion addresses needed for the future Internet of Things supporting the digital integration of manufacturing. The situation is made even worse by the highly unfair allocation of IPv4 addresses: 43% (111 blocks among 256 available) are concentrated in North America (with block n° 018 allocated to the MIT alone!), so that other regions (Asia Pacific, Europe, Latin America) have already exhausted their IP addresses allocation since 2011. In the IPv4 world, the market for the infrastructure equipment (called "core routers") is massively dominated by US player Cisco.

The next version of the Internet Protocol is **IPv6**. It provides an address space that is vastly sufficient to meet current needs and those of the foreseeable future, and its allocation of resources is geographically much fairer. The transition to IPv6 is a major discontinuity in the market of network equipment.

industriAll Europe demands that the EU engage in a **massive transition to IPv6**, potentially in coordination with the other economic powers that have the greatest interest in this transition, specifically in Asia. The EU (and the other interested parties) would mandate that all equipment in networks located in their jurisdiction must be compatible with IPv6 Protocol, by a given date (e.g. end of 2022). Such an organised transition already took place in Europe, e.g. for terrestrial television broadcasting, from analogue to digital.

This strong political move would loosen the bottleneck currently being experienced in IPv4 addresses, which risks bridling the development of the Internet of Things being needed by digitally integrated manufacturing. Like any discontinuity in a market, this transition also opens a window of opportunity for new entrants, or for minor players to increase their market share. Strategically, Europe must be a front-runner in this revolution, so as to give its industrial equipment manufacturers the lead in this new market.

3.1.9 Keep a leading industrial position in Electronic Components and Systems

(This proposal mirrors the one made in industriAll Europe's Discussion Paper "Innovation by all and for all", Part II, §9.b)

3.1.10 Develop open, collaborative "cloud" platforms

(This proposal mirrors the one made in industriAll Europe's Discussion Paper "Innovation by all and for all", Part II, §9.e)

3.2 Regulate the sharing of value added along digital supply chains

Companies can only provide decent working conditions and wages to their workers, invest and innovate for their future, if they generate a sufficient economic value added. If this value added is captured by a dominant player along the value chain, and specifically by a digital platform, no other company has the capacity to be a decent and sustainable employer. The distribution of value added along the value chain is thus an essential topic, to be treated in parallel to the more usual issues of the sharing of the company's value added between labour, investment and the remuneration of capital.

3.2.1. Set-up open standards for the digital integration of manufacturing

This is the purpose of a detailed existing Policy Brief by industriAll Europe, aiming at distributing the economic value of the digital integration of manufacturing along the whole supply chain, and at preventing its capture by the owner of a proprietary standard.

3.2.2 Define the rights attached to industrial data

The legal landscape regarding the collection and processing of data in general, and of "big data" in particular, is that of almost absolute wilderness, where the rich, the powerful, the bold and the violent grab whatever the naive, the poor, the weak or the honest player gives them access to. The only field in which some form of regulation exists at European level is that of personal data (cf. Part 1, §4). In the area of industrial data, i.e. of the data being generated by machines on other machines, on items being processed or on workers, no EU-wide regulation exists.

The stakes, however, are significant. Companies can perform predictive maintenance of durable consumer goods (e.g. cars), or of investment goods (e.g. factory machinery), based on the information received and collected from the specific object and from comparable ones (e.g. from the whole fleet of cars of the same model, or driven by the same type of driver), by using "big data" predictive analytics (cf. Part 1, §1.2).

Thereby, the company changes the business model from that of a hardware supplier to that of a service provider, with permanent connection to the customer, for enhanced value. Who, among the potentially interested industrial stakeholders (the owner of the digital system, the system integrator, the equipment manufacturers, the maintainer, the user...) should have access to this data? This is an unanswered question to date.

There are other vast economic possibilities offered by this capacity to process large amounts of industrial data e.g. by insurance companies, or for the sake of consumer marketing (as the shopper on sites such as Amazon can experience). The potential is that the firm having access to this industrial data can shift value added away from the firm manufacturing the product, and thereby deprive it from a capacity to invest, to innovate, and to provide good wages or working conditions.

In the views of industriAll Europe, the **democratic debate** on the **legal rights attached to industrial data**, and on the **economic conditions** attached to these rights, must take place, in order to define the **fair** means to attach rights to industrial data. The rights to consider include (but are probably not limited to):

- to access,
- to duplicate,
- to store, and then: for how long,
- to modify,
- to erase,
- to transfer – where, to whom, under which conditions (specifically: with a transfer or not of the original rights),
- to aggregate – i.e. to analyse jointly with the same nature of data collected on other machines / persons / items,
- to correlate – i.e. to analyse jointly with different nature of data collected on the same machines / persons / items,
- to exploit, commercially or not, in anonymised form or not, where, when.

One simple regime could be the “Big data is open data” principle (cf. §3.2.3 below).

This discussion on rights attached to data should not be mistaken with data "ownership". The concept of "ownership" is not neutral: it conveys the idea that, once the data is "sold", the seller loses any further right on the way it is used (as is the case with any material object: once it is sold, the former owner loses any right to it). In the views of industriAll Europe, the democratic discussion to take place on the rights attached to industrial data should leave the option open of **maintaining a legal connection** between the **originator** of the data (and potentially of others), to the **data** itself, across its whole life.

In the views of industriAll Europe, a specific debate should additionally be engaged regarding data related to workers, and should apply a strong regime of "privacy at work" (cf. §4.2.3 below).

3.2.3 Regulate monopolistic digital platforms

This is the purpose of a detailed existing Policy Brief by industriAll Europe. The objective is to reduce the concentration of wealth and power in the hands of monopolistic digital platforms, to the detriment of their suppliers, specifically with four measures:

1. the "big data is open data" principle,
2. the obligation to introduce "fair" search algorithms,

3. the breaking up of cross-subsidisation structures, and
4. the prevention of Unfair Trade Practices.

3.2.4 Provide a solid legal environment for Free, Libre *and Open Source (FLOS) software and hardware development*

(This recommendation mirrors the one made in industriAll Europe's Discussion Paper "Innovation by all and for all", Part II, §5.d.)

3.2.5 Limit the legal protection of software

industriAll Europe demands that this protection be conditioned by the immediate publication of the source code, and that its duration be limited to 20 years after the registration of the software code. *(This recommendation mirrors the one made in industriAll Europe's Discussion Paper "Innovation by all and for all", Part II, §5.b.)*

3.2.6 Regulate and tax value creation along the rules of where work is physically performed

Digital-based companies have the technical possibility to legally settle anywhere - and specifically in jurisdictions where labour laws and taxation are low, or even non-existent (aka "tax havens" or "tax and legal black holes"). From there, they organise the work of their employees remotely, but are subject only to the legal and taxation obligations of their legal place of establishment. This can be the source of dramatic races to the bottom in terms of wages and working conditions for employees, and of tax revenues for EU Member States.

industriAll Europe believes that such developments must be prevented. We recommend the following rules:

- the **labour law** applicable to a given employee must be that of his/her **physical place of effective work**, i.e. also his/her home if s/he works remotely from there
- the **tax regime** applicable to the company's profits should be determined according to the Member States where its employees physically work.

On the second point, industriAll Europe recommends to apply the principles of a *mandatory* **Common Consolidated Corporate Tax Base** to *all* firms having employees that physically work in more than one Member State of the EU:

- the profit is consolidated at EU level, according to common rules
- this consolidated profit is split between Member States according to a rule accounting for the *real* activity of the firm: turnover and number of employees, i.e. according to the physical location of customer delivery for turnover, and to the physical place of work for the number of employees
- each Member State is then allocated a share of the profit being allocated to it according to this rule, and taxes it according to its own tax rates.

4 Recommendations in Collective Bargaining and Company Policy

Digitalisation will entail massive impacts on all aspects of manufacturing, and specifically on employment. Trade unions cannot remain passive in front of such structural transformations. They should:

- strengthen their own bargaining power (§4.1)
- address the specific risks of the digital work-place (§4.2).

4.1 Strengthen the bargaining power of trade unions

4.1.1 Set up international digital coordination platforms for trade unions and workers

Company management coordinates world-wide, and exploits this unity of decision-making to "divide and conquer" workers, and to play them against each other internationally. This central command is made more efficient by digital means.

In order to combat this central power in corporations, employees have traditionally built coordination networks - which are the core of trade unionism. Most of these networks, however, are based on physical means, and do not yet fully exploit the resources that digital technologies could supply to support the workers' movement.

industriAll Europe believes that, in the digital age, trade unions should make full use of the resources of digital technologies. They should build up **digital platforms** and **networks** dedicated to Europe- and world-wide **democratic coordination of their action**, in parallel to existing or future "physical" networks, in order to:

1. **disseminate** and **share information** about working conditions and wages, company- or sector-specific events and mobilisations,
2. collectively and democratically **define common demands** and policies vis-à-vis company management, national and European authorities.

Digital coordination platforms should also be set up by trade unions for the use by people in precarious, untypical working situations borne by digitalisation, such as (sometimes bogus) self-employed and free-lancers, or crowd-workers (e.g. the FairCrowdWork platform set up by IG Metall in Germany).

industriAll Europe supports the development of (preferably open-source) dedicated software to support this international, cross-lingual democratic coordination of workers.

4.1.2 Negotiate a dedicated space for workers' representatives and trade unions in corporate Intranets

In the physical world, workers' representatives and trade unions have the right to be allocated a dedicated, private space in the company's premises for them to hold their meetings and to organise. In the views of industriAll Europe, the equivalent right must be given to workers in the digital workplace.

IndustriAll Europe demands that workers' representatives and representative trade unions in a company be given a private, specific space on the corporate Intranet, with the capacity to install whatever software or data they consider fit, under the protection of an adequate firewall.

4.1.3 Negotiate the right for (European) Works Councils to extract custom-made indicators from the corporate management data repository (ERP)

Corporate management has access to hoards of management data, obtained via multiple physical sensors and pervasive reporting procedures. However, the information made available to workers is often extremely limited in scope and precision.

If workers had the right to access the corporate management data repository (generally managed by the Enterprise Resource Planning software, cf. Part I, §3.1), they could devise and obtain **their own indicators** and **analytic accounting data**. Thereby, they would be in a much better position to assess the *real* situation of the company and of each individual site or business unit, according to metrics that matter to workers. They would thus be in a much better position to objectively discuss management's claims regarding the relative "profitability" of industrial sites - which often are at the root of restructuring decisions.

industriAll Europe demands that workers' representatives, and specifically (European) Works Councils, have the right to access the corporate management data repository (ERP), in order to design custom-made indicators and analytic accountancy tools tailored to their needs, and to obtain the resulting charts and dashboards on a periodic basis. If necessary, they should be entitled to access the assistance of qualified consultants and auditors to perform these tasks, under the standard conditions for workers-appointed experts.

4.1.4 Have trade unions monitor the physical parameters of working conditions

Low-cost sensors can measure and transmit the physical parameters of the work environment: temperature, noise, moisture, vibrations, mechanical strength or torque applied in specific parts of the body. This physical data can then be stored and used for a **permanent monitoring of working conditions**, at collective or even individual level.

This concrete, objective monitoring could be used by trade unions to discuss improvements in Health & Safety at work with management.

4.2 Address the specific risks of the digital work-place

Improving the working conditions in the digital age is not only an issue of social rights. In the view of industriAll Europe, it is a positive contribution to the long-term innovativeness of the firm, and is thus a profitable investment.

4.2.1. Define clear rules for the liability in case of accidents in a digitally connected, automated working environment

industriAll Europe favours simple and clear rules, which place the liability where the competence, the knowledge and the power lie. It thus proposes that the company for the exclusive (or quasi-exclusive) benefit of which an industrial facility is run should bear full liability for all accidents happening in this facility, whatever the legal relationship between the worker and the company, and whatever the complexity of the digital-based technology being operated.

4.2.2. Obtain the right to disconnect from digital work environment

Digital technologies must contribute to social progress and human emancipation - and not place the employee in a position of being permanently at the disposal (and under the hierarchical power) of its employer. In the views of industriAll Europe, this is an issue of **human rights** and of basic freedom. The employment contractual relationship is an exchange between security for the employee against *part-time* subordination to the employer (and the appropriation of the surplus by the employer). If this subordination were to become *permanent*, the very nature of the relation would change - from employment to slavery (whatever the attached salary).

industriAll Europe supports the institution of technical procedures that **force the disconnection** of workers from their digital work environment, between the end of working hours in the evening to the start of working hours the following working day in the morning, and on holidays. Examples of such measures are:

- the shut-down of access to e-mail servers, according to the local time zone, and with exceptions for those workers who are on alert duty
- the automatic re-direction of mobile telephony calls to a voicemail server.

4.2.3. Obtain the right to privacy at work

Employers have the right to ensure that their employees actually perform the work that they are paid for, and that they respect safety and security rules. A form of surveillance of workers by their employer is thus legitimate. However, the technical means made available by digital technologies enable a level, a permanence and a frequency of surveillance that is beyond anything experienced so far.

This excessive surveillance is resented by workers. It is also an issue for employers – because it leads to de-motivation and passive-aggressive behaviours. industriAll Europe advocates a right to **privacy at work**. The exact limits of legitimate surveillance, adapted to each work-place situation, should be the purpose of explicit social dialogue.

Reference documents

National initiatives supporting the digitalisation of manufacturing:

- "*Produktion der Zukunft*" and "*IKT der Zukunft*" in Austria
- "Made different" in Belgium
- "*Platforma pro internetovou ekonomiku* (Platform for Internet Economy)" in the Czech Republic
- "Manufacturing Academy of Denmark" in Denmark
- the "E-Estonia council" in Estonia
- "Industrial Internet Business Revolution" and "Finnish Metals and Engineering Competence Cluster" in Finland

- "*Usines du futur*" in France
- "*Industrie 4.0*" in Germany
- "*Fabbrica Intelligente*" in Italy
- "*Digital Lëtzebuerg*" in Luxemburg
- "Smart industry" in the Netherlands
- "Innolot" in Poland
- "Produtech" in Portugal
- the "*Agenda para el fortalecimiento del sector industrial en España* (Agenda for the promotion of the industrial sector)" in Spain
- "*Produktion 2030*" in Sweden
- "High Value Manufacturing Catapult" and "Digital Catapult" in the United Kingdom.

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