edited by
Gianluca Salviotti - Severino Meregalli

GENERAL REPORT
THIRD EDITION

HIGH IMPACT TECHNOLOGIES
RADAR

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The DEVO Lab HIT Radar is a support tool for the digital transformation of business. The Radar identifies emerging digital technologies through a methodology based on three questions: Which is, and could be, the impact of this technology on companies? How far is this technology from a "must adopt" decision? How quickly is this technology moving towards a full adoptability?

This Third Edition of the General Report sums up the result of an intensive scouting performed in collaboration with the MIT Design Lab on the technology clusters *Artificial Intelligence, Human Augmentation, Digital Infrastructure, IoT, Materials Printing, Advanced Robotics*, grouping 16 technologies.

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HIGH IMPACT TECHNOLOGIES RADAR

GENERAL REPORT - THIRD EDITION

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SDA Bocconi School of Management | DEVO Lab Digital Enterprise Value and Organization

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Contents

Introduction 5
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CHAPTER **ONE**
HIT Radar, 3rd General Report: An Overview 8

CHAPTER **TWO**
Artificial Intelligence 16

- Intelligent Vision 16
- Machine Learning 19
- Natural Language Processing 23

CHAPTER **THREE**
Human Augmentation 26

- Virtual Reality 26
- Augmented Reality 31

CHAPTER **FOUR**
Digital Infrastructure 37

- DNA Data Storage 37
- Big Data Technologies 42
- Blockchain 49

- Quantum Computing 54
- Edge Computing 57

CHAPTER **FIVE**

Internet of Things 62

- Long-Range IoT 62
- Short-Range IoT 68
- 5G 74

CHAPTER **SIX**

Materials Printing 80

- Enterprise 3D Printing 80

CHAPTER **SEVEN**

Advanced Robotics 85

- Collaborative Robotics 85
- Drone Robotics 89

APPENDIX

High Impact Technologies Radar Methodology 94

Further Readings 98

The Authors 105

SDA Bocconi School of Management DEVO Lab 107

DEVO Lab Members 108

Introduction

by *Gianluigi Castelli** and *Severino Meregalli***

With this 3rd General Report, the HIT Radar returns to its classic format, shifting the focus back from applications to technologies. From the scouting, what immediately stands out in this edition is the increased number of identified technological objects. On the one hand, this is due to the higher number of sources consulted during the realization of this work, a measure undertaken both to improve our analysis and to avoid the phenomenon of self-referencing. On the other hand, the new version of the MIT Disruptive Technologies and Clusters report has allowed us to focus even more in detail on some technologies such as Blockchain and 3D Printing, and to tackle a previously unexplored theme, that of bio-digital: the tendency to design digital systems that emulate biological ones that have already been perfected over thousands of years of evolution.

This is how an innovative and potentially disruptive technology such as DNA Data Storage ended up for the first time in the radar. But for a new technology that arrives, there are three that leave: Cloud Computing technologies and In-Memory Computing, that in the previous edition moved in the Adopt ring of the radar; and Digital Biometrics, now considered as a tech building block rather than a technology per se.

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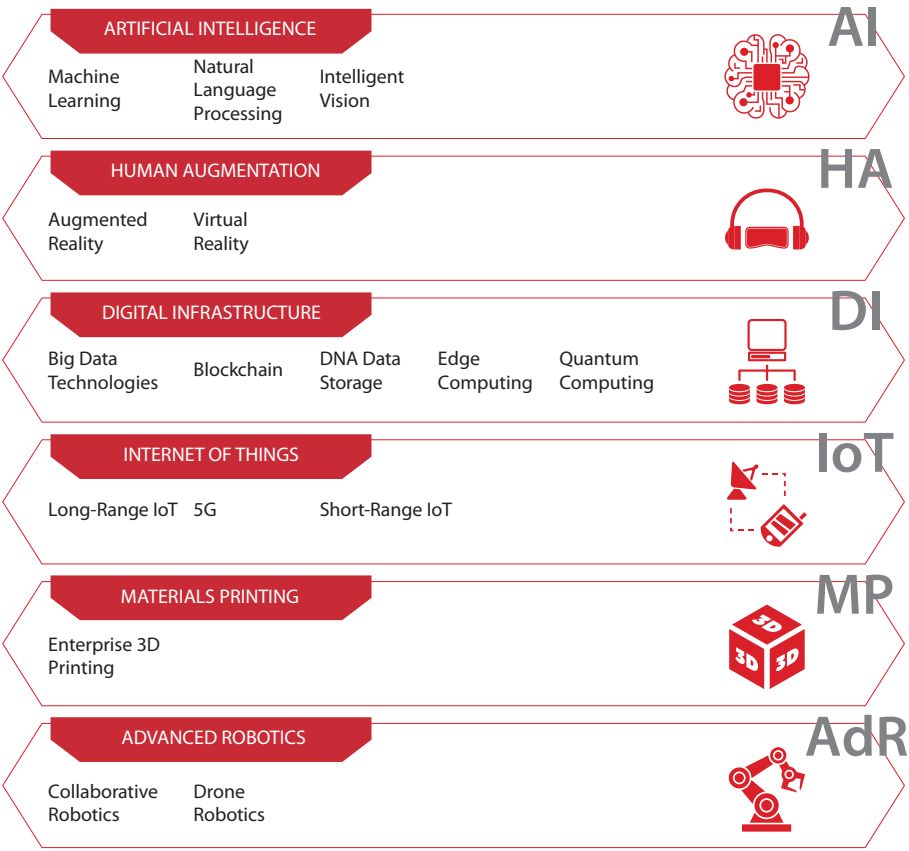
FIGURE 1 **HIT Radar 3rd General Report – Clusters and technologies**



Despite these variations, the basic structure of the radar remains the same, reflecting the soundness of the methodology applied until now in its realization, with the subdivision of technologies within the six classic clusters: Artificial Intelligence, Human Augmentation, Digital Infrastructure, Internet of Things, Materials Printing and Advanced Robotics.

The identified technologies have been therefore evaluated and placed on the Radar, following the classical HIT framework. The final result is described in Chapter One.

As for the last versions, the team made a particular effort to provide detailed evaluations as concrete and reusable as possible, in line with our mission to cut through the curve of disillusionment that often surrounds the most innovative technologies.

In order to support the reader in understanding our methodology, in Chapter 1 Gianluca Salviotti will provide a brief "How to read", together with an overview of the main highlights from our tech evaluation. After that, we will explore each tech cluster to deeply understand the state of the art of the related high impact technologies. Specifically:

- In Chapter 2 (by Gianluca Salviotti), we analyse the fast-growing cluster of Artificial Intelligence;
- In Chapter 3 (by Aakanksha Gaur and Ferdinando Pennarola), we focus on the core technologies for Human Augmentation;
- In Chapter 4 (by Leonardo M. De Rossi), we point to some new foundational technologies in the cluster of Digital Infrastructure;
- In Chapter 6 (by Nico Abbatemarco), we address one of the hottest digital topics going through the Internet of Things cluster;
- In Chapter 6 (by Leonardo M. De Rossi and Severino Meregalli), we try to understand the state of the art of Enterprise 3D Printing, within the Materials Printing cluster;
- In Chapter 7 (by Gianluigi Castelli and Lorenzo Diaferia), we move to the cluster of Robotics.

Through the tangible examples and use cases collected in the course of our research, we hope to have made easier for the reader to grasp the insights and operational advices related to all technologies presented in the course of this work.

HIT Radar, 3rd General Report An Overview

The HIT Radar is a tool to evaluate the impact, ecosystem and dynamics of digital technology solutions for mid- to large-size enterprises and should thus be considered by top executives in the company's decision-making processes. Its center represents the attention span of a Board of directors. Digital technology solutions are represented as icons in differentiated positions, shape and color based on their importance to the very same Board.

This is a quick guide for reading the visual output of the HIT Radar. Please refer to the methodology section for further details on the dimensions underlying each of the elements described below and the assessment process that brought to the assigned scores of this release.

The distance of the icon from the center of the radar (i.e. the Board) quantifies the existing gap between the emergence of a technology solution per se and the feasibility of its implementation given the current economic, regulatory and business context. The four resulting clusters of distance (i.e. the four rings of the radar), ranging from outer to inner, are:

- Out of Range: the Board should not take care of the technology (the gap is too wide);
- Watch: the Board should not take direct care of the technology, yet awareness of its characteristics and its progresses in the business context is required (the gap is wide, but implementation is taking shape as an actual option);

- Consider: the Board should consider the potential strategic relevance of the technology for the company and thoroughly evaluate its integration in the company's business model (the gap is narrow and there is concrete chance for implementation);
- Adopt: the Board must directly manage the technology's strategic role for competitive advantage generation (the gap is none or minimal and implementation has already consolidated in the industry).

The size of the icon represents the impact, in both economic and social (i.e. human capital) terms of the business implementation of the technology solution. There are 5 levels of impact:

Low Impact

Mid-low Impact

Mid Impact

Mid-high Impact

High Impact

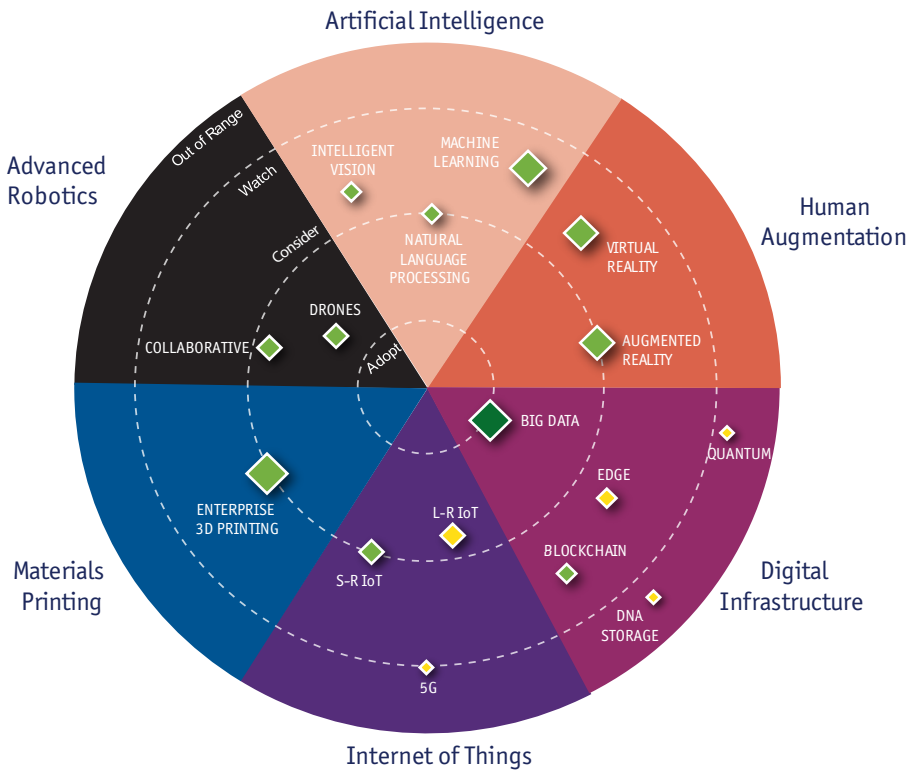
Finally, the color of the icon represents the speed of a given technology in approaching (or receding from) the center of the HIT radar (i.e. the importance for the Board) moving across the rings. In other words, it expresses the amount of change that surrounds a given technology solution, both in quantitative (e.g. amount of VC investments) and qualitative (e.g. pending regulatory reforms) terms, which may widen or shrink the aforementioned distance gap in the coming years, leading to a different positioning in the following editions of the HIT radar. The spectrum of such dynamic dimension varies as follows:

- Steady (red): we do not expect any advancement of this technology in the short term;

- Take-Off (yellow): there is movement supporting the advancement of this technology into an inner circle of the radar, yet we do not expect significant shifts in the coming year;
- Accelerating (light green): this technology is strongly supported and is likely to noticeably shift towards the center in the coming year;
- Swoop (deep green): this technology is strongly supported and is likely to noticeably shift towards the center in the coming 6 months.

After providing this brief "How to read", we can refer to Figure 2 to focus on the main findings of our evaluation.

FIGURE 2 **HIT Radar 3rd General Report – Applications Positioning**



Here, it is worth highlighting some of the most profound changes occurring within them:

- AI: despite the remarkable technical progress made over the last year, the technologies of this cluster lie slightly behind in the radar if compared to the previous edition. This is mainly due to the adoption of GDPR, that created a considerable uncertainty about the regulation concerning the data necessary to "feed" these technologies. However, in the long-run their growth trend remains more than positive;
- HA: with the devices needed to deploy Augmented and Virtual Reality becoming (even if slowly) more and more powerful, and the main problems related to their use as motion sickness being solved, we are beginning to realize what the true potential of these technologies can be. The more widespread adoption of use cases helps showing how VR and AR can be the foundations of a completely new mean of communication: hence the increased impact of both;
- DI: Digital Infrastructure sees another of its technologies entering the adopt sector, after Cloud Computing technologies and In-Memory Computing last year; we are speaking about Big Data technologies. Despite some objective limits (lack of "true" data scientists in the market and regulatory issues in the first place), companies now have to start exploiting Big Data in order to avoid the formation of heavy gaps towards their more advanced competitors. Blockchain and Edge Computing remain stable both in terms of dynamism and distance, limited in their advancement not by their technological maturity but by the lack of concrete business models. Finally, as already announced, DNA Data Storage makes its debut in the radar, but together with Quantum Computing is placed in the Out-of-Range sector, being a technology with a very high potential but currently impossible to implement into a company and far from being a commercial reality;

- IoT: on the one hand, long and short range IoT have made small steps forward, and they are now widely recognized as the best architectural options to realize applications ranging from smart homes to smart workplaces, from smart metering to smart parking. But even more relevant is the 5G advancement, with the technology now on the frontier between the Out-of-Range and the Watch rings;
- MP: 3D enterprise printing is becoming an increasingly refined system, whose deployment in companies, if properly carried out, can lead to significant savings: hence the increase in terms of economic impact. Together with Big Data technologies, 3D Printing is now the most important object of the radar in this regard;
- AdR: Collaborative and Drone Robotics have made great progresses over this last year. Both are increasingly becoming concrete realities, especially in the field of manufacturing and in general in all those companies that require an intense inventory management activity. In particular, drones turned out to be very mature from a technical point of view and are limited mainly from a regulatory point of view, due to their potential in collecting private, sensitive data.

In the next Chapters we will discuss the six tech clusters in deep.

DISTANCE KEY

Technology Maturity

- experimental/BETA
- early availability
- general availability
- consolidating
- mature

Infrastructure Coherence

- hostile
- unfavourable
- neutral
- enabling
- perfect fit

Business Model Coherence

- hostile
- unfavourable
- neutral
- enabling
- perfect fit

Regulation

- no reference
- incomplete
- “by analogy”
- well-defined

Skills and Knowledge

- none
- basics
- practitioner
- professional
- master

Legal Fit

- hostile
- unfavourable
- neutral
- enabling
- perfect fit

IMPACT KEY

Adoption

innovators
early adoption
early majority
diffusely adopted
mainstream

Workforce

none
marginal
moderate
high
radical

Economic Impact

none
marginal
moderate
high
radical

Competitiveness

none
marginal
moderate
high
radical

DYNAMISM KEY

Adoption Growth Rate

- none
- next within 5 years
- next within 3 years
- next within 1 year
- next within 6 months

Upstream Value Chain Support

- divestment
- maintenance
- incremental
- sustained

Changing Regulation

- no change
- thoughts
- debate
- ongoing reform

Accessible Knowledge

- none
- non-formalized
- good practices
- formalized
- diffused

Infrastructure Trends

- no change
- debate
- limited
- sustained

Business Model Knowledge

- none
- non-formalized
- good practices
- formalized
- diffused

CHAPTER TWO

Artificial Intelligence

INTELLIGENT VISION

Algorithm-based technology allowing machines to learn how to recognize and classify images and classify their content at human-like or superior standards, as well as to improve their accuracy over time, without the need for exhaustive rule-based programming.

Technology Maturity		early availability
Infrastructure Coherence		neutral
Business Model Coherence		neutral
Regulation		no reference
Skills and Knowledge		practitioner
Legal Fit		unfavorable

DISTANCE As for all AI technologies, 2017 has been a year of growing ecosystem, which is set to start stabilizing throughout 2018. Intelligent Vision capabilities are provided either through incumbent platforms and their APIs, as well as by focused vendors (e.g. recognition capabilities for automotive or ID authentication) and open-source platforms. All are set to improve and evolve in the coming months and years, so lock-in to individual vendors and inflexible integrations are not advisable. The biggest change from the last edition comes in the regulatory field, due to the GDPR, which imposes strict duties in terms of personal data processing, storage and algorithm transparency. While not problematic for back-office capabilities like OCR/ ICR, it poses significant challenges in dealing

with images that involve customers: the way intelligent vision data should be handled is not clear and has stopped many experimentations.

In fact, Intelligent vision requires taking into account the legal issues related to the processing of personal data. Particularly, data protection issues may arise in case of processing of images and photographs, which fall within the scope of personal data. The relevant activities are thus subject to the principles on data protection set forth by the General Data Protection Regulation. Also, the storage of these data must be carried out in accordance with the relevant EU law provisions.

Another common issue affecting technologies that rely on AI capabilities lies with liability in case of mistakes. Wrong associations may result from intelligent vision processes and lead to various consequences (including damages) depending on the type of machine.

Adoption		innovators
Workforce		marginal
Economic Impact		marginal
Competitiveness		marginal

IMPACT While OCR/ICR has surely started diffusing thanks to the rising adoption of RPA and IPA technologies, and some automotive players are experimenting with IV (still, it is a minority, as current L2 autonomous driving applications mostly rely on radars rather than on cameras), advanced image recognition capabilities are not widespread. Applications to retail analytics, real-time sentiment analysis, facial authentication and visual intelligence are being explored, yet are still at an experimental state and have suffered an alt after the enforcement of the GDPR. The Manufacturing and Media industry are the one, which are more likely to keep some momentum for quality inspection and content classification applications of IV. As a result, overall impact assessment of Intelligent Vision remains low.

Adoption Growth Rate		next within 1 year
Upstream Value Chain Support		sustained development
Changing Regulation		no change
Accessible Knowledge		good practices
Infrastructure Trends		sustained advancement
Business Model Knowledge		non formalized

DYNAMISM At a global level, Intelligent Vision benefits from the advancements in deep learning and the overall AI ecosystem. Outside Europe, many use cases are being explored and developed, so that by the time the GDPR is understood more clearly, a greater corpus of knowledge will also be available in terms of technical and business good practices to deploy Intelligent Vision at scale across industries.

ADVICE TO THE BOARD

Thoroughly assess the application of intelligent vision to your internal operations, as far as it does not involve sensible employee or customer data (e.g. ICR, reconciliation, image classification, etc.) to set up actual implementations. At the same time, establish a consistent conversation with your legal team to shed some light on how image data should be dealt with in compliance with GDPR on other, more sensible applications. If opportunities are identified, further engage the business in first reflections on how intelligent vision could be deployed within the next 12-18 months.

MACHINE LEARNING

Algorithm-based technology enabling the advanced mathematical- statistical elaboration of numeric data and the autonomous improvement of accuracy over time without the need for exhaustive rule-based programming.

Technology Maturity		early availability
Infrastructure Coherence		unfavourable
Business Model Coherence		enabling
Regulation		no reference
Skills and Knowledge		practitioner
Legal Fit		unfavorable

DISTANCE The Machine Learning (ML) ecosystem has been growing significantly throughout 2017 and use cases are starting to consolidate. Yet, the integration of ML at enterprise level implies:

- Challenges of data sourcing and cleaning;
- Integration of external cloud applications leveraging on proprietary company data;
- Requirement for dedicated, high-performing hardware;
- A fast-paced, ever-changing arena of open-source platforms and tools.

On the one side, modular IT architecture leveraging on APIs and open-source platforms seem to be the best answer, yet good practices to evolve legacy systems and integrate scalable ML solutions still have to be experimented. From a regulatory standpoint, the GDPR has brought the topic of data management regulation forward, yet it also

creates many headaches, as Machine Learning architectures often rely on cloud and API services, which make it highly complex to ensure full control over the data lifecycle. As a result, the legal fit remains unfavourable.

On 25 April 2018 the EU Commission released the communication "AI for Europe", aiming to facilitate a coordinated approach among Member States in: maximizing the impact of investments in AI; exchanging best practices to prepare the EU for the AI transformation; to address the legal and ethical challenges raised by AI. Also, the European AI Alliance has recently been set up to create a forum for stakeholders in the AI industry.

Adoption		early adoption
Workforce		moderate
Economic Impact		moderate
Competitiveness		marginal

IMPACT From Machine Learning platforms, to data science automation tools, to predictive and prescriptive applications, a lot of use cases have emerged and are starting to be explored by innovators. Prediction and optimization capabilities have a broad application scope, which virtually touches all functional areas. Early experiences worldwide provide significant results, both in terms of revenue increase (e.g. content personalization and advertisement targeting) and cost management (e.g. reduced downtimes through predictive maintenance). Yet, the majority of use cases are still at experimentation or PoC level: they still have to be truly scaled and to prove their actual contribution to long-term competitive advantage.

DYNAMISM The sustained advancements in algorithm development, open-source platforms and ecosystem consolidation would move ML to the "Consider" ring within 6 months. Nevertheless, the GDPR poses critical regulatory issues that still have to be fully understood, so that we estimate that ML will remain in the "Watch" ring for another year. Still, many education initiatives are emerging, either online and offline, which provide a good understanding of the ecosystem and the business opportunities supported by Machine Learning. We forecast that the next year will see a significant increase in market awareness and use case development, enabling the definition of good management practices for ML implementation.

Two main legal issues are being discussed pertaining ML and AI in general: (i) allocating liability among the relevant parties (programmers, distributors, users) for possible malfunctioning or damages; and (ii) ensuring that decisions adopted on the basis of ML are fair and non-discriminatory. With respect to first issue, EU policymakers are exploring different options including either (a) relying on existing rules on product liability or (b) introducing vicarious liability based on a strict/negligence-based regime. On the contrary a preliminary regulatory response has been given to the second issue highlighted above in the General Data Protection Regulation ("GDPR"), which introduces two principles: data sanitization and algorithm transparency. The first princi-

ple requires the removal of special categories from datasets used in automated decision making (Articles 9 and 22).

The second principle is enshrined to Articles 13 and 14, which grant data subjects the right to obtain "meaningful information about the logic involved, as well as the significance and the envisaged consequences when automated decision-making or profiling takes place".

Invest in education from top-notch institutions to develop a sound understanding of the opportunities and challenges presented by ML and develop aware decision- making framework to assess potential use cases on our business. Engage your IT in reflections about your current infrastructure, reasoning about the structuring of adequate data streams and the scaling of ML architectures by avoiding lock-in on individual vendors and opening up to the open-source ecosystem.

ADVICE TO THE BOARD

Invest in education from top-notch institutions to develop a sound understanding of the opportunities and challenges presented by ML and develop aware decision-making framework to assess potential use cases on our business. Engage your IT in reflections about your current infrastructure, reasoning about the structuring of adequate data streams and the scaling of ML architectures by avoiding lock-in on individual vendors and opening up to the open-source ecosystem.

NATURAL LANGUAGE PROCESSING

Algorithm-based technology allowing the parsing, thus the understanding of natural language provided by users through text of voice (NLU), as well as the generation of natural language (NLG), based on autonomous learning that does not require exhaustive rule-based programming.

Technology Maturity		general availability
Infrastructure Coherence		enabling
Business Model Coherence		enabling
Regulation		no reference
Skills and Knowledge		practitioner
Legal Fit		unfavorable

DISTANCE There is a broad offering of NLP platforms providing advanced NLU capabilities to support conversational interfaces both on the front- (e.g. chatbots) and back-end (employee virtual assistants) side of the business. Their integration is relatively easy, while their training requires a consistent effort in structuring and classifying an exhaustive knowledge corpus and Q&A library. The showcase of Google Duplex and IBM Project Debater demonstrate that significant advancements are also being made in how sophisticated conversations can get. Yet, beware that NLG remains the most challenging NLP field and research is still exploring how to make machine understand the fundamentals of language structuring to enable proper generation, and the transferability of such experimentations is still highly limited. From a regulatory standpoint, in spite of the enforcement of the GDPR, a clear reference for conversational data is still missing.

Adoption		early availability
Workforce		marginal
Economic Impact		marginal
Competitiveness		marginal

IMPACT Voice recognition and NLU have reached 95% accuracy through 2017, enabling increased effectiveness of conversational solutions and content classification engines. Their application scope is extremely broad, from virtual assistants retrieving BI data, to classification engines screening the web to provide analysts with tagged knowledge corpuses, to chatbots that effectively understand context to uphold increasingly sophisticated conversations with users. Several analysts forecast the rise of conversational commerce within the next one to two years, as conversational interfaces are projected to become the preferred medium to place orders. However, specifically in Italy and Europe, most advanced NLP applications are still at pilot stage and conversational devices like Google Home, Amazon Alexa and Apple HomePod are significantly less diffused than in the US. Therefore, we assess current impacts of NLP to be only marginal on business results and competitiveness.

DYNAMISM Being in the "Consider" ring, we do not expect conversational solutions to be a candidate for the "Adoption" imperative before 3 years from now. Still, all major incumbents, as well as major research institutes and open-source communities are heavily investing and developing the NLP ecosystem, which is set to keep evolving and sophisticating in the coming months and years. Further, NLU is a well-explored field, with many reputable sources of education to either train resources or draw from to inspire new business applications. Yet, relying on AI

Adoption Growth Rate		next within 3 years
Upstream Value Chain Support		sustained development
Changing Regulation		thoughts
Accessible Knowledge		good practices
Infrastructure Trends		sustained advancement
Business Model Knowledge		good practices

systems, NLP is not immune from the legal issues which impact other technologies, such as ML. In particular, the most critical point lies with the consequences in terms of liability of malfunctioning or damages generated by the use of this technology.

ADVICE TO THE BOARD

Assess your business for opportunities that could benefit from conversational, retrieval and automated content classification capabilities. Couple with an external technology partner, as expertise in this field is increasingly sound, yet avoid lock-in to specific solutions, as the ecosystem is set to evolve significantly in the short- to mid-term. Do not forget to establish a thorough conversation with your legal team to ensure compliance with the GDPR, in case your candidate solutions involve sensible employee or customer interactions and data.

CHAPTER THREE

Human Augmentation

VIRTUAL REALITY

A computer technology that generates realistic images, sounds and other sensations that simulate a user's physical presence in a virtual three-dimensional environment. This environment can be explored and interacted with by a person through a range of systems such as headsets, omni-directional treadmills, special gloves and controllers.

Technology Maturity		general availability
Infrastructure Coherence		neutral
Business Model Coherence		neutral
Regulation		no reference
Skills and Knowledge		basics
Legal Fit		unfavorable

DISTANCE Virtual and augmented reality (VR and AR) are extensions of current mediums. They both add new features and functions which can be successfully exploited depending on the target and objective. In comparison to augmented reality VR isolates the user's vision completely from the real world and immerses the user into a virtual world. Therefore, VR is excellent for storytelling, simulating environments and capture the full attention of the user.

The main obstacle is still motion sickness from disorientation. The main solution is using teleportation when moving around, as this limits the movements within the virtual space. Latency and graphic also play a certain but minor role in VR fruition, as they can be limited through streaming speed and hardware upgrades. Especially the much higher speed from 5G networks can be a gamechanger for smartphones displaying VR content. More technical aspects that still need improvements are related to the design of the head mounted displays (HMDs), given the still recent introduction of untethered models. Despite HMDs being still big and clumsy, the removal of cables is a major improvement.

At the same time, prices have heavily fallen. Still, hardware is the smallest cost. For private use, the price for good content like games is quickly topping the price of the hardware, while in professional contexts the cost for creating content is very high due to the need for a professional specialized team using licensed software. Nonetheless, the infrastructure coherence has moved from being unfavourable to neutral as VR to a larger extend fits the context infrastructures in which it is utilized. Moreover, many companies, such as Danfoss Drives and Olivetti, are entering a new experimental phase of developing VR training systems.

From a legal point of view, there is no specific legal or regulatory framework applicable per se to Virtual Reality. However, the implementation of these technologies has raised a number of legal issues.

VR technologies may, first of all, create legal concerns regarding protection of intellectual property rights. Uncertainty from a legal standpoint regards (i) both the status of existing IP rights in the real world and (ii) the protection of "virtual" intellectual property that does not correspond to existing rights in the real world.

Also, data protection ranks among the sensitive legal issues relating to VR technologies. Accordingly, organizations implementing VR have to comply with the appropriate measures to prevent or reduce data breaches and are subject to the relevant obligations set forth by

the GDPR, where applicable. Privacy of individuals/ users may be affected in different ways, most notably to the extent attitudes or sensitive data of users can be derived from the actual use of VR technologies.

Likewise, data protection can be impaired when data relating to users' navigation experience are shared.

Finally, liability for damages, injuries or losses arising out of the use of VR constitutes another critical issue. In this context, it is debated whether VR technologies might be charged with a type of vicarious liability in connection to any illegal act or conduct committed by users (the same point has been speculated by commentators with respect to AI entities).

Adoption		*Early adoption*
Workforce		moderate
Economic Impact		marginal
Competitiveness		high

IMPACT The economic impact for companies utilizing VR is marginal, as VR per se often does not generate revenues. Businesses selling VR experiences, like WeArena which is realizing a digital theme park in Italy, are an exception to the general case.

Outside the entertainment sector, the value of VR is mostly justified qualitatively as it adds intangible value as a stronger, better and more suitable medium for its various purposes. Moreover, VR is entering many businesses as a professional tool, carrying a certain value as a medium in itself. As the famous philosopher and professor Herbert Marshall McLuhan once stated "The medium is the message." The experience for many first-time users of VR can be so strong, exciting and overwhelming that focus disappears from the original intention that VR was standing for.

An example worth mentioning is Volvo, who utilizes an interactive VR presentation of its cars in the Volvo studio in Milan. Curious potential customers can sit inside or stand right in front of a real size Volvo car and change several of its features to find their perfect fit. Another example is Focus Magazine, that takes advantage of VR by enriching and completing the magazine with more engaging experiences and more information through an interactive user experience. However, VR does not only serve as a better tool but can also provide important data regarding the user's habits. If appropriately applied, VR can provide high competitiveness advantages due to the benefits it provides to the targets and the extra data it produces for the messenger.

Adoption Growth Rate		next within 3 year
Upstream Value Chain Support		sustained development
Changing Regulation		debate
Accessible Knowledge		good practices
Infrastructure Trends		sustained advancement
Business Model Knowledge		good practices

DYNAMISM Unlike augmented reality, the adoption of VR will require a more radical change in consumer behaviour, given the compulsory need for HMDs and their relative technological immaturity. Despite the big improvements realized over 2018, it is probable that it will take at least another three years to take a further step towards a greater adoption of VR.

However, the level of investments on this technology remains very high. VR will be used in an unlimited number of fields and industries, and there are various application domains in which it has already been successfully implemented, such as are education, training, rehabili-

tation, visualization, commerce, and pure entertainment (in form of games, live sports channels and news). However, it is when the unique features of VR exceed the ones of other mediums that the value of VR is fully justified. Along with a wider utilization of the technology, VR companies are striving to provide more industry-specific VR solutions and platforms or to work directly with clients as custom VR development companies.

ADVICE TO THE BOARD

Because VR is a limitless medium when it comes to the content it can immerse its user into, it is important to consider what the overall purpose of utilizing VR is. VR holds unique features but is only a beneficial technology in the right context. Therefore, it is advisable to first do a throughout analysis of what goal is to be achieved for which target. Thereafter list the pros and cons of using VR and hold this list up against a trade-off as well as a cost-benefit-analysis. Once convinced that VR can be a beneficial solution, go to a professional VR company that not only offers the service of creating the content but also consultancy, to reassure that the installation of VR will create value as the opposite might as well become the case.

AUGMENTED REALITY

Augmented reality (AR) is a live view of a physical, real-world environment whose elements are augmented by computer-generated sensory inputs such as sound, video, graphics or GPS data.

Technology Maturity		general availability
Infrastructure Coherence		neutral
Business Model Coherence		enabling
Regulation		no reference
Skills and Knowledge		practitioner
Legal Fit		unfavourable

DISTANCE Augmented reality can be divided into different fields based on how it is employed. Mobile AR, deployed through tablets and smartphones, comes in handy for the private sector, while heads-up displays allows to extend the range of AR use cases in the enterprise. Next to these, there are other devices such as projectors, holograms, transparent screens and digital mirrors.

Mobile AR is considered the most mature of AR fields. Many applications have been already developed for this environment, such as the once so popular app Pokémon Go, or the still much relevant Google Translate. Other examples are the IKEA Place app, that allows people to place furniture in their own homes, and the BMW i-Visualizer app, that is able to display BMW vehicles in full size right in front of people. On top of that, some of the major smartphone providers like Samsung, Apple and Asus have started to implement two back cameras in their newest released phones to allow for further expansion and exploration of AR and to add the possibility to take higher advantage of what this technology can offer.

As for heads-up displays, they can further be divided into two classes depending on their size. Bigger displays like the Microsoft HoloLens, Meta 2 and the long- awaited Magic Leap are designed to display digital content through transparent glasses. In this case, information that are otherwise invisible or not available to the user can be easily visualized. Conversely, smart eyeglasses like the Vaunt by Intel do not make use of transparent displays, exploiting instead a low-powered laser (VCSEL) to beam directly the information onto the retina of the user (retinal projection). The number of information that can be provided in this case is lower, following the philosophy that "less is more". However, this design allows smart eyeglasses to shrimp down to the regular size of a normal pair of glasses. The rest of the AR devices comes in many shapes and can serve a myriad of purposes. After all, augmented reality is any sort of computer-based system that overlays data on top of the current view of the world, whilst the world is still visible. Therefore, even a GPS app that speaks directions is technically an AR app. Other examples of AR devices are:

- Sephora's virtual mirror, which allows people to see digital layers of make-up upon their face. This makes it easier to decide which product to choose;
- Samsung's mirror, that allows to digitally try clothes;
- the project "Le Petit Chef", that flashes projections of a tiny cartoon chef on restaurant tables to show how the real chef is cooking dishes.

All in all, AR comes in many shapes from simple to complex applications. Which AR solution best suits one's needs depends on each specific situation and goal.

Complex AR is highly depending on Computer Vision using cameras, sensors (IoT), artificial intelligence and mobile connectivity, needed to

provide the software with the ability to see and understand one's surroundings and interact with the physical world. AR bridges information from the digital world to the physical; Therefore, the overall maturity of this technology depends on many different components coming together and their individual advancements. AR is a medium per se and could be a critical enabler for the full value of IoT as the visualization in real time of data extracted from IoT platforms can be crucial in many types of application, for example to service technicians with tools to monitor, control, optimize, maintain and solve problems in a quicker and easier way while minimizing the risk of fatal errors. Accordingly, the adequacy of AR today is to some extent more limited by the current software capabilities than the hardware ones, and simple AR applications like some smartphone apps can be considered much more complete compared to more complex solutions like heads-up displays, where the interplay between hardware and software in many cases is still novel.

Adoption		early adoption
Workforce		moderate
Economic Impact		moderate
Competitiveness		moderate

IMPACT Like Virtual Reality, Augmented Reality is a medium extending current human capabilities, but in many cases not completely providing a totally different dimension. Instead, it often combines functionalities which were previously provided by several different devices into one. For example, Mitsubishi Electric is working to provide AR for its maintenance workers in manufacturing environments. Previous training methods involved reading static paper maintenance manuals, a time-consuming and wearisome task for the workers. On the contrary, heads-up displays provide workers with updated documents and more

visuals info, which relieves them from reading and at the same time helps them to better understand how to carry out their tasks. AR can improve workplace performance by optimizing processes and creating more efficiency by providing more relevant data and better resources, offering real-time compliance, and reducing time and errors. The keywords are information/knowledge flows: where AR can function at its best is as a strong tool for communication. Telepresence is an example: a worker using a "see what I see" video streaming feature could be connected to a faraway expert, which would see exactly what the service worker sees while having the capabilities of both aurally and visually guiding him in solving a complex task.

Many other companies have started to implement AR heads-up displays: Thyssenkrupp announced that over 20.000 of its technicians would begin using Microsoft's HoloLens technology as a tool in service operations. Thyssenkrupp says the introduction of HoloLens will allow their engineers to work in a better, more efficient way, increasing the productivity and making their job safer and funnier.

The economic impact of AR is still set as moderate and has not been moved to a higher level, even though several examples demonstrate that with a correct integration of AR some companies are optimizing their processes and ensuring consistent savings. Such savings are already sufficient to justify the implementation of AR as a technology, not to mention the improved competitiveness; Airbus has reported that Mixed Reality Application (MiRA) reduced the time required to inspect the 60,000-80,000 brackets in the A380 fuselage from 3 weeks to 3 days. "MiRA links a real object with its digital genome, transforming reality into an interactive world in which information about the object can be directly accessed," said Nicolas Chevassus, head of industrial processes at Airbus Innovations.

However, high economic impacts only apply to those who have found the right space for AR. Many companies are still in an experimental

phase when it comes to explore how AR can benefit them. Olivetti is investigating how AR can improve their complicated 3D printers installation process, Volvo is experimenting with Microsoft's HoloLens on its assembly lines, and Danfoss Drive is considering AR as a better solution for training in comparison to Virtual Reality. Furthermore, the obstacles following AR are still considerably limiting its capability in some environments. Microphones show problems in loud environments when it comes to picking up speak commands, light needs to be substantial for the AI to recognize objects, the devices' battery life is still limited and their prices high, and mobile connectivity is often crucial.

DYNAMISM Accessible knowledge has gone back one step due to the advancement of AR applications. The simpler the AR application solution demanded the more accessible is the knowledge needed to build and consolidate the skills needed to master the solution. However, for complex AR applications there is a bigger need for more skilled developers, additional powerful and complex tools and a better knowledge of how to incorporate data from IoT-systems into existing assets. In this perspective, the field of accessible knowledge available for complete AR solutions has diminished. This is mostly due to the positive realization of what AR can do. In response, more educational programmes are being offered. Moreover, large corporations

such as Intel and Siemens have started to integrate Human Augmentation technologies into Centres of Excellence to further develop knowledge on the topic.

The number of companies and consumers adopting AR solutions is expected to considerably grow within the next 3 years, with large investment still flowing in the value chain. Magic Leap alone has received $1.887.500.000 in funding, with Google being responsible for almost 1/4th of the amount. The heavy bets on AR can be justified by the incremental improvements that this technology can provide in many fields. However, some industries seem to be able to benefit more from AR than others. Key attributes to these industries are that they are dealing with physical world objects, large workforces, global markets, the need to reduce risks on the workplace.

ADVICE TO THE BOARD

Because AR often does not provide any direct return on investment it is important to evaluate how beneficial AR can be as a tool to optimize processes while creating more efficiency along safer and funnier work environments. Improving efficiency and productivity is generally easier in fields that are dealing with lots of data where information and workflows are of a crucial importance. When implementing AR, it is advisable not to roll it out too quickly; Instead, make sure AR is beneficial on a manageable level and focus on building a positive culture around it with a few employees involved in AR projects before the majority. The odds for a successful acceptance and usage of AR noticeably rise when workers realize the many benefits this technology can provide.

CHAPTER FOUR

Digital Infrastructure

DNA DATA STORAGE

DNA Data Storage refers to any process to encode and decode digital data in the base sequence of DNA, using commercially available oligonucleotide synthesis machines for storage and DNA sequencing machines for retrieval.

Technology Maturity		Experimental/BETA
Infrastructure Coherence		hostile
Business Model Coherence		neutral
Regulation		no reference
Skills and Knowledge		practitioner
Legal Fit		neutral

DISTANCE In recent years, the growth rate of data generated by electronic devices has risen dramatically. Everything suggests that with the advent of the IoT such growth is destined to remain, if not furtherly increase: according to a recent study by IDC, by the end of 2020 every person on the planet will generate an average of 5,000 GB per year. The storage of such a large number of information cannot take place on the current available, silicon-based devices.

For this reason, many scientists are looking for an alternative method of data storage. One of the most promising technology seems to be the data storage on DNA strands.

DNA shows many potential advantages compared to current hardware, with two in particular that stand above the others:

- Incomparably longer shelf life (5-10 vs. 500-10,000 years);
- Outstandingly higher capacity (200 Petabytes[1] per gram of DNA).

Despite seeming more an argument for science fiction than for business science, DNA storage is actually a technology already in its experimental phase, although at the very beginning. In 2017, Microsoft claimed to have stored 200MB of data on synthetic DNA strands; in 2018, researchers Yaniv Erlich and Dina Zielinski reported successfully using DNA to store and retrieve the operating system KolibriOS, an old French film, a $50 Amazon gift card, a computer virus, a Pioneer plaque, and the 1948 study "A Mathematical Theory of Communication" by Bell Lab information theorist Claude Shannon.

Obviously, the knowledge of DNA Data Storage is still extremely limited, especially to groups of scientific researchers. Despite the interest shown by IT companies (especially those offering cloud services) during the last year, the focus of research seems destined to remain more in the scientific field than in the economics one, at least for the next few years.

Therefore, it makes little sense to speak about Business Model and Infrastructure Coherence: on one side, it does not make sense to talk about business models given the distance that separates this technology from maturity and the potential changes that may occur in the meantime; on the other, before becoming a viable technology compatibility should at least be achieved with existing applications and hardware (suffice it to say that information are currently stored as a series of 1 and 0, while with DNA storage requires them to be transformed in four base nucleotides: adenine, guanine, cytosine and thymine).

1 A petabyte is equivalent to 1 million gigabytes.

DIGITAL INFRASTRUCTURE

Adoption		none
Workforce		none
Economic Impact		none
Competitiveness		none

IMPACT Given the immaturity of technology, it is not possible to speak of impact up to date. However, it is worth pointing out some of the potential that DNA presents as a storage method compared to traditional silicon-based systems. Should big giants like Amazon, Microsoft or Google find a way to actually deploy this technology, they would obtain a considerable advantage in terms of storage capacity and longevity; moreover, a plummeting in tech costs would therefore lead to an increased commercial usage of the technology, with user interfaces becoming both critical and wildly profitable. But it is also possible to speculate that data centers will become useless, with every company able to manage an incomparable amount of data compared to today and with heightened cybersecurity parameters.

Others come to hypothesize scenarios in which DNA storage has an even more disruptive impact on the human society as a whole. For example, Peter Diamandis, founder of Singularity University, points out how DNA Data Storage could be one of the enablers of space colonization, making it possible to transfer large amounts of information over very long distances.

DYNAMISM As for what regards the actual adoption of technology, guesses are that DNA storage will become a commercial reality in about five years from now. In 2016, Nick Goldman, group leader at the European Bioinformatics Institute calculated the need for a "100,000-fold improvements to make the technology sing [...] While past performance is no guarantee, there are new reading technologies coming on-

Adoption Growth Rate		next within 5 year
Upstream Value Chain Support		maintenance
Changing Regulation		thoughts
Accessible Knowledge		none
Infrastructure Trends		debate
Business Model Knowledge		non formalized

stream every year or two. Six orders of magnitude are no big deal in genomics. You just wait a bit."

Doug Carmean, a partner architect at Microsoft Research, said the company hopes to create a "proto-commercial system in three years storing some amount of data on DNA in one of our data centers, for at least a boutique application."

A recent research by Markets and Markets estimates the next-generation data storage market to be valued at around 150 billion dollars by 2022. DNA Storage, as one of the most promising among these new technologies, is projected to rapidly outpace in growth terms most of the others.

Of course, the lack of widespread knowledge is currently slowing down the growth of this technology. There are very few start-ups that are dealing with DNA storage, and very few able to systematically address its development Two of these are Catalog and Twist Bioscience. In particular, Catalog Technologies, a young start-up based at the Harvard Life Lab, claims to have developed a process that addresses the two most important issues of DNA storage today: the slowness and costliness both of encoding data in manufactured DNA.

Business Model Knowledge must be considered not formalized, because, as already stated, it is not possible to determine what the impact of DNA Data Storage will be compared to traditional storage systems. On the contrary, the infrastructure trend is absolutely positive, with more and more researchers already investigating the potential of molecular com-

puting. And with general improvements in the infrastructure happening (in particular in terms of biochemical technologies), accessing data encoded in DNA should become almost automatically even cheaper and faster.

Based on the current state of the art, it is hardly predictable whether DNA storage will trigger any particular legal issue. DNA is supposed to replace storage capabilities and traditional data centers. Assuming this *fictio juris*, the implementation of DNA storage would require considering the implementation of the same security measures applicable to currently available devices and trigger the application of the relevant data protection framework, to the extent personal data are concerned. In addition to that, the use of DNA for storage of personal data should be implemented and designed in a way compatible with the different kind of processing of data on request of the data subject or any third party (e.g. data portability, right to erasure, etc.).

ADVICE TO THE BOARD

DNA Data Storage is definitely not yet a mature technology, and it will take some time to consider it a reality and not a purely scientific experiment. However, the ever-increasing amount of digitally generated data will inevitably alter the current paradigm of data storage within the next decade. CxOs, in particular those of companies operating in the field of cloud storage, should monitor the shift from silicon-based to biologic-based computing and promote, at least in the context of long-term R&D, projects that work in this direction. Should it be realized in a short-to-medium range of time, DNA Data Storage could prove to be one of the most disruptive technologies of the 21st century.

BIG DATA TECHNOLOGIES

Wide set of digital assets processing great volumes of highly-diversified data to provide fast and valuable insights to enable timelier and more effective decision-making processes.

Technology Maturity		consolidating
Infrastructure Coherence		enabling
Business Model Coherence		perfect fit
Regulation		incomplete
Skills and Knowledge		practitioner
Legal Fit		neutral

DISTANCE From a business perspective, Big Data is a Janus Bifrons. It is both a consolidating trend and, at the same time, a vintage digital buzzword. During the past years both the business and the academic communities started to add "Vs" in order to describe data sets that are so complex to be collected, stored, processed and analyzed with traditional data management platforms and tools. Attributes such as veracity, variability and value have been added to the traditional 3 Vs referred to volume, variety and velocity (Gandomi and Haider, 2015). As companies increased their digitization journeys embracing cloud computing, IoT and connected products, social media, web channels, as well as transactional business apps, it is now very hard to find a data set in an organization that is not characterized by one or more of the above-mentioned features. As a result, the word "Big" is now disappearing both from market analysts' reports and from tech vendors' brochures. This is why, according to our previous analysis, we state that there is now a perfect fit between Big Data and Business Models.

Big Data technologies show a very high level of fit with both current and emerging business models in many industries. The industry focus of the HIT Radar (DEVO Lab, 2017) has highlighted a perfect fit in Retail & Distribution, Financial Services and Telco & Media industries, where Big Data could play a central role for data- monetization-based business models. We also found an "enabling" level in Energy & Utilities and Manufacturing companies. Considering the recent focus of manufacturing companies on Industry 4.0 and Digital Manufacturing practices, as well as the renewed attention of utilities towards tech streams such as IoT and smart metering-based-business initiatives, we can now see a perfect fit in all our reference industries.

From a technical perspective, Big Data technologies are following the same trend. Tech maturity is consolidating, driven by the convergence of Big Data and other technologies, especially in the field of Artificial Intelligence (Machine Learning Analytics, Image Vision and NLP). Big Data management capabilities are now a must-have feature for both advanced analytics & business intelligence platforms and for data science platforms (Gartner, 2018a, 2018b).

Moreover, the large availability of open source frameworks and cloud implementation options are enabling organizations of different sizes and complexities to exploit Big Data without investing in complex infrastructures. This is pushing our infrastructure coherence evaluation from "neutral" to "enabling". The increasing availability of Big Data tools and functionalities in the cloud is largely recognized as the key trend of the last year by several experts in the field (KDnuggets, 2017). According to Matei Zaharia, Chief Technology Officer at Databriks, "2017 saw continued growth and rapid evolution of Big Data tools in the cloud. Through offerings from many vendors, we see that Big Data in the cloud is not just a matter of "forklift" deployment of on-premise systems, but instead means new systems that take advantage of the scale, elasticity and management capabilities."

Unfortunately, such an advancement in terms of both technology maturity and infrastructure coherence is not aligned with the current availability of people able to deal with Big Data technologies. According to Glassdoor, data scientist has been the number one profession in America for 2017, with an estimated shortage of 190,000 specialists in the US only. This shortage is due to the multifaceted nature of this job. The data scientist has to master statistical techniques; he needs to be a proficient user of the most advanced tech tools; he has a sound understanding of the business domain and, eventually, he is a natural born data storyteller and owns a C-level's mix of soft skills. In a recent study, 365datascience has surveyed more than 1.000 LinkedIn profiles, highlighting that the "average" data scientist is "a male, who speaks at least one foreign language, and has a second-cycle academic degree (Master's or PhD). He has been in the workforce for 4.5 years, after taking him 2 years to land the title. R and Python are the preferred coding languages, followed by SQL."

The most mature companies, such as Pirelli and Ferrovie dello Stato, have started to realize that to fully exploit their large and complex data sets, they need to rely on Data Science teams rather than on hard-to-find individuals with this sophisticated profile. Again, one of the key capabilities is still related to the ability to provide meaningful business context to data analytics.

Considering the mix of competencies and skills needed, our evaluation points to a medium level labeled as "practitioner".

The processing of Big Data may give rise to a series of legal issues, despite the absence of a specific legal notion and framework relating to it. Data protection and competition law rank among the branches of law that more impact Big Data. From the antitrust perspective, competition authorities are paying an increasing attention to Big Data, as witnessed by the existing (though limited and somewhat incoherent) case law. In May 2016, the French Competition Authority and German Federal

Cartel Office released a joint report on Big Data, focusing on the main issues to consider while assessing the interplay among Big Data, market power and competition law. The latter include potential data concentration and foreclosure of competitors in related markets resulting from a transaction and potential contractual foreclosure or marginalization of competitors active in markets where the data is used. Some important decisions involving Big Data have been handed down by the European Commission and competition authorities, focusing on three possible clusters: i) anti-competitive agreements involving Big Data; ii) abuse of a dominant position; iii) merger control.

The other side of the coin lies with data protection. Companies whose business is based on the exploitation of Big Data are now bound by some relevant provisions established by the General Data Protection Regulation. Article 22 of the GDPR provides that "the data subject shall have the right not to be subject to a decision based solely on automated processing, including profiling, which produces legal effects concerning him or her or similarly significantly affects him or her".

Furthermore, the GDPR provides that companies shall necessarily comply with certain requirements (otherwise non-binding) in case they deal with Big Data. First, under Article 30 of the GDPR controllers are required to maintain a record of processing activities under their responsibility. This obligation does not apply to organizations employing less than 250 persons, unless the processing is not occasional. In the latter scenario, as the case of processing of Big Data may be, this obligation applies regardless of the number of employees of the organization. Furthermore, pursuant to Article 35 of the GDPR, a data protection impact assessment must be carried out in case of processing on a large scale of special categories of data or data relating to criminal convictions and offences, or in case of systematic monitoring of a publicly accessible area on a large scale. Additionally, the designation of a data protection officer is mandatory, under Article 37 of the GDPR, when

"the core activities of the controller or the processor consist of processing operations which, by virtue of their nature, their scope and/or their purposes, require regular and systematic monitoring of data subjects on a large scale" or "the core activities of the controller or the processor consist of processing on a large scale of special categories of data" or "data relating to criminal convictions and offences".

Among the measures that companies may adopt to reduce the risks to personal data, the GDPR introduces the "pseudonymization", i.e. "the processing of personal data in such a manner that the personal data can no longer be attributed to a specific data subject without the use of additional information, provided that such additional information is kept separately and is subject to technical and organizational measures to ensure that the personal data are not attributed to an identified or identifiable natural person". Pseudonymization, then, ranks among the measures to implement the principle of data minimization.

IMPACT On average, In Italy, Big Data technologies are still a matter for "early adopters". Of course, there are significant differences across industries and firm dimensions. Banks and financial institutions are driving the adoption. Energy and utilities companies – such as Enel and A2A – are exploiting Big Data technologies as one of the key enablers of their digital initiatives (DEVO Lab, 2018). Large mobility operators – such as Ferrovie dello Stato – are leveraging on their newly constituted data teams to address business issues related to traffic control and predictive maintenance. Moreover, large industrial manufac-

turer – such as Pirelli – are broadening use cases moving from their initial pilots on smart factory and plants, cyber fleet management and supply chain optimization. Telco operators, such as Vodafone, are relying on Big Data technologies to explore data monetization opportunities with fair operators (Vodafone, 2018) and other enterprise customers. Apart from these examples related to large groups that are experiencing interesting results in terms of competitiveness, the overall state of the art in terms of impact is similar to our last analysis, with a moderate influence on both the workforce and the economics (DEVO Lab, 2017). Despite the increasing adoption of Big Data technologies by Italian companies, the predominant nature of the implemented initiatives is still experimental. Thus, we still do not see a significant impact in terms of economic value.

DYNAMISM The overall Italian market of Big Data is expected to hit 1.1 Billion euro by the end of this year, according to recent studies (Politecnico di Milano, 2017). The adoption growth rate is more than 20% higher compared to 2016.

The international outlook on value chain support is also promising. According to IDC (2017) "worldwide revenues for Big Data and business analytics are likely to grow from $150.8 billion in 2017 to $210 billion in 2020. That's a compound annual growth rate of 11.9 percent."

The positive path is driven by the advancements in data-related fields such as Artificial Intelligence and IoT, but Cloud computing seems to be the real infrastructure trend affecting further adoption of Big Data. According to Forrester Research (2017), "the shift to the cloud for Big Data is on. In fact, global spending on Big Data solutions via cloud subscriptions will grow almost 7.5 times faster than on-premise subscriptions."

ADVICE TO THE BOARD

As the hype around digital technologies is quickly moving to cooler objects such as Machine Learning and Blockchain, it's time for companies to either start or continue working on Big Data. Although volume remains the key dimension of the 4Vs of Big Data, variety is getting hit, as the technologies able to deal with these features are maturing. Regardless to industry and organizational dimensions, companies operating in data intensive environments should start building a data strategy aimed at exploiting the value of both traditional and Big Data set. Data quality and the capability to create a context before moving into analytics are still the starting points in this data journey. The assessment of relevant regulations related to the exploitation of Big Data, coupled with a comprehensive data protection strategy, should be a relevant part of the game.

BLOCKCHAIN

A Blockchain is a sequence of blocks, each one containing a certain amount of information distributed through a chain (i.e. a ledger) over a network.

It represents a new way of transferring information, even sensitive ones, between two users, without necessarily having to go through a central body that certifies their validity.

Technology Maturity		general availability
Infrastructure Coherence		enabling
Business Model Coherence		unfavourable
Regulation		no reference
Skills and Knowledge		basics
Legal Fit		unfavourable

DISTANCE Blockchain has been the 2018 buzzword, especially after the crypto market boom of January 2018. Today it is possible to count more than 1600 different Blockchain protocols[2]. But, is this abundance a synonym for maturity? Perhaps, it is not. From a purely technical perspective, Blockchain has not reached maturity yet. Without doubts, there are still many technical problems, such as scalability, privacy and efficiency, but the main constraints for a general adoption resides at a cultural and legal level.

The ecosystems which can be developed with a Blockchain infrastructure are very far from today's business realities. In fact, a Blockchain solution comes along with some drastic changes of some core business

2 Source: coinmarketcap.com

aspects (such as governance, accountability and trust); which have been hardly accepted by companies. Thus, the actual constraint to overcome is not purely technical nor infrastructural, but it's rather about finding a coherency between today's business models and the Blockchain-enabled ones.

Lawmakers and regulators of several countries are paying more and more attention to the rise of Blockchain and distributed ledger technology in general and for specific applications in given sectors. Recently, most of the Member States of the EU signed a Declaration on the establishment of a European Blockchain Partnership, meant to be "a vehicle for cooperation amongst Member States to exchange experience and expertise in technical and regulatory fields and prepare for the launch of EU-wide Blockchain applications across the Digital Single Market for the benefits of the public and private sectors". On parallel, the European Commission launched the EU Blockchain Observatory and Forum.

From a legal standpoint, on March 2017 the Commission focused on Blockchain and the applications of DLTs in the context of a public consultation on FinTech. In the consultation document, the Commission highlighted the main areas of possible regulatory actions in the field. The main legal issues over Blockchain and DLTs are related to: 1) the applicable law and related jurisdiction issues; 2) the legal recognition that Blockchain and DLTs' data are true, correct and have legal value. Furthermore, scholars are considering other issues, including: the legal status of smart contracts; privacy issues regarding digital health and personal care; data protection and cybersecurity; protection of copyright and intellectual property rights.

Adoption		innovators
Workforce		none
Economic Impact		marginal
Competitiveness		marginal

IMPACT The Blockchain adoption is still extremely limited. The main reason behind this current Blockchain "failure" has been previously mentioned and is strictly related to some crucial business aspects which would require a total change. The answer to such constraints has been until recently the development of closed Blockchain ecosystems[3], but we do not believe that this is the right path to foster Blockchain adoption. What is lacking is a deep understanding of what Blockchain can bring at the enterprise level, which is simply a new transparent, ungoverned, censorship resistant, distributed ecosystem to store and transfer digital value.

DYNAMISM Even if the Blockchain adoption has been very sluggish, the investments in this technology rise every day[4]. The main reason behind this phenomenon is twofold. On one side, everyone is trying to create the new Bitcoin - especially through ICOs[5]. On the other side,

3 In addition to public-permissionless Blockchain – such as Bitcoin – there are other types called "permissioned Blockchain" which are closed ecosystem where one (or more) authorities are actually controlling the content stored within it.

4 A Research and Markets report indicates that the overarching global Blockchain market will grow from $411.5 million in 2017 to a staggering $7.68 billion by 2022, increasing at a compound annual growth rate (CAGR) of 79.6 percent during that time.

5 ICO stands as an abbreviation for Initial Coin Offering: an innovative, vastly unregulated fundraising mechanism in which new public Blockchain projects sell their underlying digital tokens in exchange for other already circulating cryptocurrencies (mostly bitcoins and ethers) or fiat money. The ICO acronym

Adoption Growth Rate		next within 3 year
Upstream Value Chain Support		sustained development
Changing Regulation		debate
Accessible Knowledge		non formalized
Infrastructure Trends		sustained advancement
Business Model Knowledge		non formalized

technology incumbents are trying to develop creative Blockchain solutions to foster its adoption at the enterprise level. Considering that the vast majority of Blockchain applications serve no purpose right now, it is evident that a big change will happen in the next few years. The most likely scenario could be:

- A huge collapse. No real use-cases will be developed, and Blockchain technology will fundamentally fail;
- A massive transfer of funds to a limited sample of valuable projects, which will have actual purpose for consumers and companies.

While in the EU the regulatory debate on Blockchain and DLTs is still at its early stages, in the US some states are already discussing the issuance of specific regulations allowing the use of Blockchain-based solutions for particular purposes. For instance, the Delaware Corporate Council of the Corporation Law Section of the Delaware State Bar Association recently released a draft legislation proposing to amend several sections of the Delaware General Corporation Law to clarify the application of existing laws and facilitate the use of Blockchain technology for various corporate purposes.

is an explicit reference to Initial Public Offerings (IPO) in which investors purchase shares of a company (even though the two operations cannot be defined exactly coincident).

At the time being, at least at EU level it is not likely that imminent regulatory innovations on Blockchain and distributed ledger technology would be implemented. Nonetheless, the debate amongst regulators is ongoing and most likely the regulatory initiatives in the coming years would be essentially aimed at allowing the use of those new technologies in specific areas (including financial services, intellectual property, e-democracy) recognizing legal value to the data embedded in the registries.

ADVICE TO THE BOARD

Despite the humongous hype around Blockchain, the real value of this technology is still unclear due to the lack of mainstream services and real business cases. Bitcoin has been the first technology able to create valuable scarcity in the digital world and it has the potential to make a significant impact at the enterprise level. Executives should be prepared to explore the potential of this technology, first by clearly understanding its actual nature and then developing some valuable use cases. At the same time, it is likely that within the next few years the market will be drastically different and that only few valuable projects will cannibalize the entire market.

QUANTUM COMPUTING

Computing technology leveraging on qubits, entanglement and quantum algorithms to enable a new form of parallel, rather than sequential computation.

Technology Maturity		experimental
Infrastructure Coherence		unfavourable
Business Model Coherence		neutral
Regulation		no reference
Skills and Knowledge		no knowledge
Legal Fit		unfavourable

DISTANCE All major tech companies are active in the development and experimentation of quantum technology. IBM Q already provides a QaaS (Quantum-as-a-Service) access to its technology. In addition, Microsoft, Google and Intel are working on increasingly advanced hardware and software solutions to build their quantum capabilities further. At the same time, there is increasingly greater clarity on the tasks a Quantum Computing can target, specifically factorization (Sohr's algorithm), search (Grover's algorithm) and optimization problems (Adiabatic algorithms). Yet, this knowledge is limited to research and experimental domains and held by few experts.

Quantum Computing technologies are subject to the same legal and regulatory framework applicable to technologies working on binary code. Commentators have highlighted some concerns regarding the consequences that the implementation on large scale of these technologies might raise in the long run, including the creation of potential for breaking or circumventing existing security measures implemented in encrypted networks, systems based on the Blockchain technology and

military applications. It is of utmost importance to consider that security measures are generally designed on the assumption that resources to be employed for breaking them are subject to limits.

Security of networks and information systems may also be affected, most notably to the extent that these technologies are used in the context of essential services (in sectors such as energy, transport, banking, financial market infrastructures, health, digital infrastructure) and digital services (including online marketplaces, online search engines and cloud computing services), in accordance with the NIS Directive.

Adoption		none
Workforce		none
Economic Impact		none
Competitiveness		none

IMPACT New companies have joined Quantum Computing initiatives at global level, one of the latest being Volkswagen Group. However, these represent research projects aimed at exploring and experimenting the potential for quantum applications within specific industries. There are no consolidated use cases yet, therefore there are no current impacts across any of the different areas of analysis. In perspective, the biggest impacts can be predicted on industries such as pharma and material engineering (molecule modelling), transportation planning (optimization), cybersecurity and telecommunication (factorization).

DYNAMISM As major digital companies progress their quantum programs, many specialized start-ups and labs have also emerged. Some of them propose different approaches to trapped ions and superconductors. While these are currently the most likely to become commercial applications, the quantum landscape has far to reach a consolidated

Adoption Growth Rate		next within 5 year
Upstream Value Chain Support		sustained development
Changing Regulation		thoughts
Accessible Knowledge		non formalized
Infrastructure Trends		debate
Business Model Knowledge		non formalized

state, both in terms of technology and players. Nevertheless, the trend is certain and positive, and significant resources are being invested into its development. As a matter of general policy, it is unlikely that lawmakers and regulators will restrict or prohibit the implementation of these technologies as such, in accordance with a technologically neutral approach. However, the prescribed security requirements could be tightened by amending the relevant data protection and data security framework. Indeed, it is clear that once Quantum Computing becomes a reality, significant IT migrations will be needed, as quantum computation will make traditional encryption methods obsolete and ineffective (thanks to its factorization capabilities).

ADVICE TO THE BOARD

Though there is an increasing awareness of the kind of problems quantum may help to solve, significant developments in both hardware and software are needed before it becomes an available technology. You can start experimenting with could-accessible quantum processors or directly engage with a quantum tech partner to research on potential application. Yet, do not expect practical deployments within the next 5 years.

EDGE COMPUTING

Edge Computing is a horizontal IT architecture that delivers computing capabilities to the logical extremes of a network in order to improve the performance, operating cost and reliability of applications and services. By shortening the distance between devices and the cloud resources that serve them, Edge Computing mitigates the latency and bandwidth constraints of Internet, ushering in new classes of applications.

Technology Maturity		general availability
Infrastructure Coherence		enabling
Business Model Coherence		neutral
Regulation		no reference
Skills and Knowledge		practitioner
Legal Fit		unfavourable

DISTANCE During the last year, the edge market has registered some major changes. Nowadays, it is possible to find affordable and sophisticated examples of edge hardware along with advanced analytics software platforms. For example, Google has recently launched the Edge TPU: a tiny accelerator which can carry out Machine Learning jobs directly on IoT devices. This Google "edge kit" seems to have numerous advantages, such as advanced security, minimum latency and data integrity, to name a few. Google is not the only company designing chips for this sort of on-device AI tasks; ARM, Qualcomm, Mediatek and many others all make their own edge accelerator as well.

From the architectural perspective, it is possible to configure an edge network from scratches simply by:

- Installing some specific edge devices with the required computation and storage capabilities; and
- Implementing an edge software platform on top of the company IT architecture (e.g. a cloud architecture) to instantly analyse the gathered data.

Therefore, we do not see any infrastructural constraint actually limiting edge's adoption.

Decentralizing computing intelligence within an IoT network may require taking appropriate steps and measures for protecting physical assets. At a data protection level, the more a network is distributed, the more likely the possibility that it will incur in risks such as alteration, corruption or data losses. It is worth noting that in Europe the General Data Protection Regulation encapsulates a risk-based approach in accordance to which it is up to data controllers to determine and take the appropriate measures to prevent data breaches, if necessary upon prior consultation of the competent data protection authority and on the basis of a prior data protection impact assessment. Likewise, very detailed provisions regulate data breaches, requiring data controllers to take some steps in case breaches may affect individuals' rights and freedoms. Security of networks and information systems may also be affected, most notably to the extent that these technologies are used in the context of essential services (in sectors such as energy, transport, banking, financial market infrastructures, health, digital infrastructure and digital services (including online marketplaces, online search engines and cloud computing services), in accordance with the NIS Directive.

The implementation of Edge Computing does require considering the increase of risks against the protection of data, including personal information and the security of networks as well as information systems. In case of geographical delocalization, furthermore, jurisdiction issues concerning the scope of application may come into play.

Adoption		innovators
Workforce		marginal
Economic Impact		marginal
Competitiveness		marginal

IMPACT Currently, the adoption level of Edge Computing by companies based in Italy is still unclear. Nevertheless, cloud computing is widely adopted both by enterprises and consumers. It is likely to see a rise of Edge Computing as time-critical applications – such as self-driving cars, smart homes applications, robotic technologies powering smart manufacturing – consolidate and diffuse furtherly.

Even if it is not possible to find any Italian company actually using Edge Computing in their core business, there are some multinational company which are starting to use it, such as:

- Dropbox: this leading file storage company has recently adopted some edge technologies. According to Dropbox, as a result of its shift to Edge Computing, "Some users have increased their sync speeds by as much as 300 percent, and performance has improved across the board." The company attests that Edge Computing has increased median download and upload speeds throughout Asia and Europe. Customers have also experienced 5x improvements in terms of latency reduction;
- Nest: the famous IoT home automation company has started to implement Edge Computing directly into some of their homemade devices (thermostats, cameras, security systems, etc.). On-device processing creates efficiencies in making intelligent and automated security decisions, especially those systems powered by AI. The Nest Cam IQ indoor security camera, for example, uses image and video recognition capabilities. All the processing is made directly within

the camera enabling an immediate analysis without delay, ensuring increased safety for families. Edge Computing features within these devices also allow for an increase in terms of data security, in addition to home security, as data are processed and encrypted before being sent to the cloud;

- General Electric: GE has recently added to its Predix IoT platform some edge- to-cloud services. It will support large number of edge devices (up to 200,000) connected from a single console and it will enable faster and more efficient processing at a low latency, making data and analytics more powerful.

Adoption Growth Rate		next within 1 year
Upstream Value Chain Support		incremental development
Changing Regulation		thoughts
Accessible Knowledge		non formalized
Infrastructure Trends		limited advancements
Business Model Knowledge		good practices

DYNAMISM Edge Computing is one of the hottest tech trends in the wireless industry. As we have seen in the previous paragraph, big players are already starting to use it. The noise behind Edge Computing is not necessarily a surprise; the technology is being pushed by three interrelated trends:

- Data processing processes closer to the end user – to reduce latencies;
- Network densification – more and more necessary for telco operators due to the development of 5G;
- Virtualization of network elements - to reduce costs and encourage the realization shared infrastructures.

"To get to the 5G performance goals of low latency, [...] you need to push content and apps as close to the radio as you can" said analyst Iain Gillott, president of consulting firm iGR. "The idea is that to send data all the way back to radio and backhaul packet to a cloud processor somewhere takes too long. It's as simple as that."

In addition, big tech players are highly investing in this field. One of the most famous examples is Hewlett Packard Enterprise, which recently said it will invest $4 billion over the next four years to develop what it calls intelligent edge devices.

ADVICE TO THE BOARD

In the last year, Edge Computing has quickly shaped into a more mature technological paradigm. Most of tech providers have started to offer both edge devices and edge network services in order to create secure zero-latency IoT networks. But this technology is not for everyone and most of IoT applications don't need an Edge Computing layer to work properly. If the quick data management and advance data protection are critical factors for you, then you should seriously consider this technology. In all other cases, you should keep relying on traditional IoT and Cloud networks.

Internet of Things

LONG-RANGE IOT

Long-range communication among connected objects is a procedure enabled thanks to a series of wireless wide area networks working at a low bit rate, also known by the name of LPWAN (Low Power Wide Area Networks). LPWAN-connected objects are characterized by a long battery life, a wide-area connectivity (ranging from 2 to 1,000km), limited data throughput capacity and low power consumption and network usage.

Technology Maturity		consolidating
Infrastructure Coherence		neutral
Business Model Coherence		enabling
Regulation		no reference
Skills and Knowledge		basics
Legal Fit		neutral

DISTANCE LPWAN have been designed to enable long range machine-to-machine (M2M) communication, solving some of the most relevant issues that previously limited its diffusion. In fact, until not so long ago long-distance M2M communication could take place only through 3G/GPRS cellular networks, but such process involved considerable costs: expensive equipment, high energy consumption, large footprints, submission fees.

The main difference between LPWAN is the frequency on which they operate: licensed or unlicensed. The first LPWAN to be developed were solutions operating on unlicensed spectrums, such as SigFox and LoRa. However, after realizing the potential of LPWAN, the main telco operators decided to propose their own long-range solutions based on licensed cellular networks: the two most famous examples of standards recognized by the 3GPP, the standardization body of the GSM, are narrowband IoT (NB-IoT) and LTE-M (also known as Cat-M1).

Today, both LoRa and NB-IoT have become quite widespread standard, representing nuances of a technology that already shows real and concrete impacts. In Italy, as we have already written in the last edition of the radar, A2A began to implement LoRa for the realization of its smart city project based in Milan and Brescia. In 2018, for example, A2A managed to install in Brescia a series of digital panels based on e-paper technology for managing urban bus stops.

These displays are the first in the world able to show information on the transport network through the LoRaWan network, showing real-time information on arrivals, waiting times, and emergency communications.

The already tangible use of the technology, combined with the continuous coverage expansion and the realization of new standards, led us to confirm that Long-range IoT has passed the general availability maturity phase and is proceeding in its consolidation process.

As for what regards the level of infrastructure coherence, this is heavily influenced by the type of LPWAN considered. In general, devices using unlicensed spectrums are characterized by a higher latency, a lower data rate and cost per unit and a longer battery life compared to those exploit cellular networks. However, the former needs a specific gateway to connect to the network, while the latter does not.

The kind of spectrum used also influences the type of business models enabled by the devices: due to their independence from 4G coverage, LoRa and Sigfox work in remote areas as well as in motion, while NB-IoT and LTE-M performs better in indoor applications and dense urban areas. Moreover, licensed frequencies can guarantee a better quality of service and a lower latency when transmitting messages. Therefore, LoRa and Sigfox seem to be the optimal choice for applications such as smart metering and supply chain tracking, while NB-IoT and LTE-M for the high-data throughput ones such as predictive manufacturing and retail transactions.

As already stated in the last version of the radar, the effective deployment of IoT applications will require a wide set of developer skills and competencies, such as hardware management, infrastructure networking, UI design and development, security engineering and data analytics. In a recent global CIO survey conducted by consultancy Business Performance Innovation (BPI), a relevant percentage (31%) of the respondents answered that their organizations face a major skills gap in their IoT readiness, while the same proportion suggested the talent gap was large but improving.

Even if implemented in a variety of fields, technologies enabling Internet of Things (IoT), whether Short-range or Long-range, are not subject to a clear and specific framework. As far as Long-range IoT is concerned, the effective implementation of these devices and systems requires appropriate infrastructures. The rise of public Low-Power Wide-Area Network (including, e.g., LoRa and SigFox) does constitute a key development in this respect, even though a specific regulation in this specific field is still lacking, apart from the application of gas smart metering introduced in Italy by Resolution of 22 October 2008 of the Italian Regulatory Authority for Electricity Gas and Water. Most likely, the development on a larger scale of long- range IoT applications would trigger more specific regulatory initiatives. It is

worth noting that the Italian Communications Authority launched a fact-finding survey concerning Machine-to-Machine communication services that resulted in the publication of a final report (Annex A to Resolution no. 120/15/CONS).

Adoption		early adoption
Workforce		marginal
Economic Impact		moderate
Competitiveness		marginal

IMPACT The development of Long-Range IoT systems in Italy is advancing smoothly. At the end of January, Telecom Italia successfully deployed a new wireless network for the Internet of Things, making available nationwide both the LTE-M and NB-IoT standards. Sigfox, which in Italy is offered exclusively by the network operator Nettrotter, is now covering over 80% of the country. Moreover, more and more companies have started deploying their own Long-Range solutions; for example, Telemar is one of the first telecommunication company in Italy to offer a wide range of IoT services on a platform designed to work on the LoRa network.

However, the number of companies who really decided to implement a Long- Range IoT solution in their field is still limited. The most famous application case remains that of the already mentioned A2A Smart City initiative, operative in the municipalities of Milan and Brescia, that is exploiting the LoRa network for many different use cases. Vodafone too is working on projects related to the concept of smart city, in particular developing a complete suite (based on narrowband IoT) capable of providing services such as Smart Metering, Smart Waste Management, Smart Parking and Smart Air Monitoring.

DYNAMISM LPWANs are currently one of the few successful working applications in the world of IoT. In a recent research, Markets and markets affirmed also that the value of LR-IoT technologies is vastly underestimated and could rise by more than 90% by 2021. In terms of market penetration, according to a recent report by Machina Research, in the same timeframe long range systems are expected to represent approximately 30% to 40% of all the IoT platforms (in figures, about 7.6 billion devices).

Still, there are many doubts regarding which of the LR-IoT standards will become the most diffused one. The LoRa network has furtherly increased its number of members from 428 to 527, a 23% increase compared to 2017. Despite a faster initial growth phase, cellular networks seem now to be growing slower in terms of adoption compared to non-cellular, unlicensed ones.

However, this trend may be reversed soon: IDC recently stated that until now the use of unlicensed spectrum and lack of Quality of Service agreements caused companies to focus their LR-IoT projects only on non-critical applications. Cellular networks, which on the contrary rely on licensed spectrums and can easily provide QoS terms, may help shifting this paradigm.

Moreover, there is no 100% certainty that only one standard will survive: given the wide number of possible use cases and the variability of

some factors (geographic conformation, different legislations, etc.) it is possible that in the field of LR-IoT there will be room for the development of more than one solution.

Regarding business model knowledge, it is still not possible to define which are the good practices, even though the path is well defined. As we said in the last version of the Radar, the main players from the supply side already provide a somewhat well-defined business model to their customers (Sigfox requires customers to route all the traffic through its cloud platform, while in the case of LoRa users can source modules and gateways from hardware vendors, then deploy their own networks and manage them privately). Moreover, the presence of open networks like "The Open Things" are favouring the spread of culture related to LR-IoT systems.

ADVICE TO THE BOARD

LPWAN are increasingly proving themselves as an established reality and seem destined to become the reference technology for applications in the scope of smart cities, smart agriculture and rural areas monitoring. Companies interested in working in these sectors should immediately begin to deepen the LR-IoT topic, if they have not already done so. An essential element to consider before entering the field is to evaluate which type of LPWAN will better comply with the company's necessities (in a simplified way, unlicensed but open networks vs. closed ones with guaranteed QoS).

SHORT-RANGE IOT

Short range IoT refers to the network family characterized by short-range coverage (maximum 1km), low-power consumption, low-rate and low-cost communication, deployed to be used within a room or a building.

Technology Maturity		general availability
Infrastructure Coherence		neutral
Business Model Coherence		neutral
Regulation		no reference
Skills and Knowledge		practitioner
Legal Fit		neutral

DISTANCE The Short Range IoT sector has been steadily consolidating over the last year. The market is fragmented among a series of more or less diffused protocols, such as Zigbee, Z-Wave and Thread (based on the IEEE 802.15.4 standard) plus others that can be already be considered mainstream, such as wireless and various implementations of the Bluetooth technology. Nonetheless, a universally recognized standard is still lacking.

Wireless, which today represents the most widespread system able to connect objects in a short range, is in fact too energy-consuming to really enable the establishment of a Short Range IoT ecosystem. However, Bluetooth, in particular declined in its latest version, Bluetooth Smart (or Bluetooth Low Energy) seems increasingly destined to become the reference standard in this field, thanks to its already wide adoption, reduced power consumption and implementation of mesh networking (i.e. the possibility of connecting a very large number of de-

vices). Just like what happened in the first years of deployment of classic Bluetooth, the growth of devices natively designed to support a well-identified standard will likely bring the prices down. Therefore, the advancement in the infrastructure (which should be considered still neutral as of today) will play a key role in influencing the development of all the protocols mentioned above.

From a business point of view, it seems that Z-Wave and Zigbee are becoming more and more the standard for connecting beacons inside smart buildings (although with some substantial differences, such as for example the need to install gateways in the case of Zigbee) and in general in low power, closed ecosystems. Bluetooth, on the other hand, holds and will probably keep holding a little monopoly over the interconnection of personal items such as laptops, smartphones and tablets. Cloud services providers are increasingly embedding IoT solutions within their platforms - thus making the adoption smoother and less invasive. Some relevant examples are Microsoft, which offers IoT services within its Azure suite, and SAP, which provides an IoT solution inside its Hana platform. As for LR-IoT, analytics efficiency and data-driven culture are two necessary prerequisites to an effective adoption of a SR-IoT network.

Exactly as in the case of LR-IoT, also the development of the SR-IoT solutions necessitates a notable series of skills, the most important of which is the ability of establishing a safe and sound network around connected objects. However, being SR-IoT solutions more focused on the end user than on industrial processes, the process of structuring network results more homogeneous, requiring a lower level of skills and knowledge compared to technologies that each time need a customized installation like LoRa or SigFox (see LR-IoT for more details).

The most critical legal issues regarding Short-range IoT systems are related to data protection and data security. In September 2016 the Global Privacy Enforcement Network, a body which gathers the nation-

al regulatory authorities of each Member State, focused on Internet of Things in its annual "privacy sweep".

The report released by the GPEN showed that most of the devices, including, among others, smart electricity meters and internet-connected thermostats, did not grant data an adequate level of protection. Particularly, data protection issues were reported in connection to failure to inform customers on how IoT devices process and store personal data and how they delete the same. Other critical points were reported with respect to the requirement of consent and data breaches.

Additionally, a new piece of legislation will be relevant for IOT devices and technologies in the next future. The European Commission proposal for a Regulation on Privacy and Electronic Communications is in effect expected to replace Directive 2009/136/EC and will likely apply to IoT devices and systems, as "the transmission of machine-to-machine communications involves the conveyance of signals over a network and, hence, usually constitutes an electronic communications service".

Adoption		early adoption
Workforce		marginal
Economic Impact		moderate
Competitiveness		moderate

IMPACT The potential impact of the SR-IoT is higher than that of LR-IoT. This is because the number of devices that could potentially be connected in the so-called "last 100 meters" range is extremely vast. However, network operators should move beyond the idea of simply providing IoT access if IoT is to become a significant revenue contributor and start offering complete packages of value-added services such as IoT application enablement, systems integration, hosting or security.

As already stated last year, many companies are installing IoT devices within their workspace, but few of them are really deploying this technology through a specific IT architecture. However, the number of real, well-structured use cases is increasing day by day; for example, Sapio Group, a company operating in the technical and medical gas sector, has begun to deploy IoT sensors into its cylinders, in order to constantly monitor the gas level and enable predictive maintenance of the cylinders in real time.

At workforce level, the impact of the SR-IoT seems to be quite marginal. However, in specific sectors such as logistics management, SR-IoT could play a key role in optimizing processes without negatively affecting quality: through real time analysis of data such as traffic, weather, type of customer and his/her preferences, it would be possible to both reduce the costs and improve the general level of performances.

Regarding competitiveness, the real battle is currently being fought at the level of standards and services. However, SR-IoT is a revolution that will bring together most of the electronic objects that are in our home today, and therefore whoever plans to release such objects should design the new models to be able to exploit natively the potential of the SR-IoT.

DYNAMISM The number of devices using short range sensors is expected to grow exponentially by 2021 up to about 3.5 billion connected devices, almost twice the number forecasted a year ago. In particular, the adoption of SR-IoT is currently being pushed by the competition with other IoT technologies, such as 5G and Narrowband IoT. Although not designed specifically for usage in the short range, these technologies could work as an alternative to traditional SR-IoT standards at least in some types of applications (for example in the field of smart vehicles management).

Adoption Growth Rate		next within 3 year
Upstream Value Chain Support		maintenance
Changing Regulation		debate
Accessible Knowledge		good practices
Infrastructure Trends		limited advancements
Business Model Knowledge		good practices

In fact, given the relevance, in any type of IoT network, of the ecosystem factor, it is likely that the first mover will accumulate a significant advantage over other competitors.

In general, the market is growing at constant positive rates, and most analysts estimate the growth rate of the sector to be in a range between 15 and 25% from now until 2022, with the geographical area considered playing a fundamental role in its development.

As underlined in the last version of the radar, the market for short-range connectivity - including Bluetooth, Wi-Fi and 802.15.4 standards - should continue to evolve and expand its use cases in order to meet the new market requirements.

In terms of accessible knowledge, good practices are quite widespread, and they are becoming more and more formalized: as of today, all the short- range technologies have already been available for some time, from the more mainstream ones such as Bluetooth to the more specific ones such as Zigbee and Z-Wave. Moreover, changes in the surrounding infrastructure are fostering the diffusion and development of these technologies, which are gradually achieving at an increasingly higher level of interoperability and integration with many different connected objects. By 2019 Bluetooth Smart, by far the most used of the SR-IoT standards, should be supported on most of the commercially available smartphones.

A more critical element is instead represented by the knowledge of the business models enabled by SR-IoT. Some use cases are now well established (e.g., wearables, beacons installed within smart homes and smart building in general), while others are competing from a technological point of view with alternative IoT standards (e.g. in smart traffic management and smart parking). In any case, a company interested in developing an IoT business model IoT should first think about how to exploit the information collected by "things" – to understand customer behaviour, to deliver services, to improve products, and to identify and intercept business.

ADVICE TO THE BOARD

From a technical point of view, CxOs should have very clear that SR-IoT encompasses a wide range of technologies, each with an optimal application target: standards like Zigbee and Z-Wave are currently better when it is necessary to deploy WAN gateways or beacons, while Bluetooth Smart seems to be the best option for devices such as wearables and smartphones.
As for all types of IoT technologies, before deciding to implement the ideal technology and start developing an IoT network, companies should investigate if they have the right kind of data-driven and analytics-oriented mindset, fundamental to create stream of revenues from the data collected from the connected devices.

5G

5G is the coming fifth-generation wireless broadband technology based on the IEEE 802.11ac standard.

Although no official technical requirement has been confirmed yet, different initiatives and companies have defined a general perimeter of the criteria that this technology should meet:

- 1 to 10Gbps connections to end points in the field
- 1 millisecond end-to-end round-trip delay
- 1000x bandwidth per unit area (compared to 4G)
- 10 to 100x number of connected devices (compared to 4G)
- (Perception of) 99.999% availability
- (Perception of) 100% coverage
- 90% reduction in network energy usage
- Up to 10-year battery life for low power, machine-type devices

Technology Maturity	●○○○○	experimental/BETA
Infrastructure Coherence	●●○○○	unfavourable
Business Model Coherence	●●●○○	neutral
Regulation	●○○○	no reference
Skills and Knowledge	●●○○○	basics
Legal Fit	●●○○○	unfavourable

DISTANCE Compared to last year, 5G is the IoT-enabling technology that has progressed most of all. While in 2017 it was possible to talk about 5G in terms of an almost abstract concept, indicating what would have been its plausible features, today the technology is more and more tangible, although still available only in experimental projects.

Thanks to its faster speed, lower latency, and greater capacity, 5G is expected to improve a wide range of existing broadband services, such as mobile ultra-high-definition video, video conferencing or Virtual Reality, and to enable a set of business models currently only conceivable in theory, such as the management of connected devices in time-critical contexts such as healthcare, transportation, and utilities.

Obviously, the fact that many projects are already experimenting with 5G does not imply that the technology is ready for large-scale deployment, which is expected to happen in the early 2020s. There are indeed a huge number of issues to be solved in order to proceed with a capillary release of 5G. 5G will need huge investments to be deployed: in a 2018 market research, McKinsey predicted that telecommunications companies will have to increase their network- related capital expenditures by 60 percent from 2020 through 2025.

No less significant, the level of skills and knowledge is still scarce. As Jonathan Adelstein, president of the WIA (Wireless Infrastructure Association) stated in a recent interview: "The wireless industry is experiencing a major shortage and a skills gap. Wireless jobs are changing, and they are changing incredibly fast. We have a hard time filling positions with applicants that have the skills they need."

There is no specific legal and regulatory framework applicable to 5G technologies. However, European institutions have paid significant attention recently to the developments concerning 5G. The Security Working Group of the EU Public Private Partnership on 5G (so called "5G PPP") published a white paper in July 2017 which highlighted the need to revisit current network security approaches in light of the emergence of 5G. Also, in its report delivered in March 2018 the ENISA (European Network and Information Security Agency) pointed out that early generations of mobile networks rely on a set of protocols designed decades ago and several threats and attacks are likely to occur in light of that and in the absence of appropriate

safeguards. Organizations wishing to implement 5G-based technologies have therefore to take data security and data protection seriously from a legal standpoint, e.g. by adopting the necessary organization and technical measures.

Adoption		none
Workforce		none
Economic Impact		none
Competitiveness		marginal

IMPACT As already mentioned, 5G's impact will probably be considerably high, as the technology is going to hit a wide range of industrial sectors such as energy and utilities, manufacturing, public safety, healthcare, public transport, media and entertainment, automotive, financial services, retail, and agriculture. However, with the technology being still in its experimental phase it would be wrong to already give high scores in terms of adoption, economic impact and workforce. Nevertheless, it is interesting to check some predictions on how big the impact of the 5G will be in the next ten years.

A recent market research by IHS Markit and Berkeley Research Group states that by 2035 5G will create 22 million new jobs globally, generate $ 3.5 trillion in direct economic activity and fuel sustainable long-term growth to global real GDP, with a real contribution equivalent to an economy the size of India.

Moreover, 5G should be seen as a strategic technology at national level, with China, the United States and the European Union all extremely interested in the topic and with high ambitions for its rollout.

In particular in Europe, according to a report prepared by Trinity College Dublin Major investments, the wireless advisory firm real wireless, the mobile technology research firm InterDigital and the research

consultancy tech4i2, major investments will lead to the generation of € 141.8 billion in new revenues and the creation of 2.39 million jobs.

As for competitiveness, especially in the telco sector investments in the field of 5G development are already significant and the race for who will be the first to develop and commercialize a working 5G solution (both at the consumer and at the enterprise level) has already started.

Adoption Growth Rate		next within 3 year
Upstream Value Chain Support		sustained development
Changing Regulation		thoughts
Accessible Knowledge		non formalized
Infrastructure Trends		limited advancements
Business Model Knowledge		non formalized

DYNAMISM The release of 5G will not happen overnight; despite the large number of pilot projects, large-scale deployment is unlikely to take place until the early 2020s. Still, many of these experiments are worth mentioning. For example, in February 2018 Nokia and Vodafone inaugurated the first 5G experimental station for traffic, emergency services and tourism management at Milano Cadorna station. In the same month, other two trials took place: firstly, in Bonn, Deutsche Telekom, Intel and Huawei tried the world's first 5G interoperability and development testing (IODT) environment based on the 3GPP R15 Standard; secondly, Ericsson and Fastweb presented a test of 5G linked to experiential Virtual Reality at the Biblioteca Fabrizio Giovenale in Rome. Virtual Reality through 5G had already been explored by Ericcson, TIM and the Politecnico of Torino in December 2017, when this cooperation led to the creation of a digital avatar able to guide people through the city of Turin with minimum latency levels.

The level of knowledge of business models related to 5G cannot yet be defined as formalized, but the potential fields of use of this new technology are becoming more and more clear. Some of the solutions that will be possible to realize with 5G are:

- To provide gigabit broadband to residential homes and act as an effective last- mile complement to fiber or cable networks;
- To deliver a next-generation mobile driven by Virtual Reality, tactile internet, etc.;
- To deliver highly reliable, low latency connectivity and solutions to enterprises;
- To develop digital industrial ecosystems with machine-to-machine (M2M) connectivity;
- To deliver next-generation infrastructure-as-a-service for entire countries.

Yet, as of today, the ability to monetize these use cases so to justify a nationwide rollout of 5G in any country remain unclear.

In fact, delivering the performances promised by 5G will require a fundamentally different architecture with much denser networks compared to current LTE networks. In particular, while in rural and suburban areas, as well as along roadways, operators could handle increased traffic simply by densifying existing networks, in many highly populated urban areas it will be necessary to establish proper small-cell solutions for two reasons: a higher concentration of traffic and the use of higher spectrum bands (greater than 3 gigahertz). As a result, 5G will be probably initially deployed in micro-areas such as few big cities, while nationwide networks are unlikely to materialize in the short to medium term.

Moreover, the release of 5G will require more qualified and skilled technicians. As said by Dr. Rikin Thakker, chairman of the Workforce Development Working Group at WIA's Innovation & Technology Coun-

cil: "It is crucial that the wireless industry take steps now to provide the technical training needed for 5G to its existing workforce and prepares to train and educate new workers as the industry continues to expand and mobile broadband reaches a greater base of users."

ADVICE TO THE BOARD

CxOs should start considering how 5G could improve some of their companies' already existing offerings and enable new services, limited until today by broadband speed, latency, and capacity. 5G will represent one of the key element of the next major wave of innovation across many industries (from healthcare to automotive, from manufacturing to retail), so enterprises should be ready with their solutions before 2020, when the average consumer will likely begin experiencing the technology.
On the contrary, telco companies need to start preparing for 5G now, in particular by undertaking a series of crucial moves such as the realization of the required infrastructure (also considering the possibility of sharing costs with other companies), the acquisition of the license for the frequencies, and a close collaboration with regulatory authorities.

CHAPTER SIX

Materials Printing

ENTERPRISE 3D PRINTING

Materials printing, also known as 3D printing (3DP) or addictive manufacturing (AM) refers to the various processes used in the manufacture of products realized by depositing or fusing materials layer by layer.

Technology Maturity		general availability
Infrastructure Coherence		neutral
Business Model Coherence		neutral
Regulation		"by analogy"
Skills and Knowledge		practitioner
Legal Fit		unfavourable

DISTANCE 3D printing is evolving to its fullest potential: printers are becoming faster, their price lower, and they can now make use of different types of materials, like metal and ceramic. This is leading to a larger utilization of 3D printing, with a 21% overall industry growth in 2017 (Wohlers Report 2018). Technical improvements are following along, giving life, for example, to sophisticated biomedical printers already capable of printing cells, proteins and organs. The maturity of this technology has moved from a stage of early availability to one of general availability; according to a report by Wohlers Associates, revenues from the industry exceeded $7.3 billion in 2017, while the Inter-

national Data Corporation (IDC) estimates that the global spending on 3D printing in 2018 will be $12.0 billion including hardware, software, materials and related services. Still, this represent a little step back from their last year estimate of $13.2 billion.

One of the main reasons behind the reduced distance between businesses and 3D printing is the increased number of options available to decentralize the manufacturing of products. The benefits can be time and costs savings, improved responsiveness and flexibility and reduction in required inventory. Skills and knowledge needed to properly manage 3D printing solutions can be wide-ranging, as the technology allows for producing complex geometries, integrated assembly, engineering redesign and mass customization.

3D printing has become so sophisticated that is important to notice, from a legal point of view, that its advent has raised various issues. For example, with the possibilities of printing guns and other dangerous products the same restrictions and existing prohibitions which are applicable when creating these items by traditional manners should be applied to 3D printing.

Another critical point concerns the allocation of liability for any type of injuries deriving from the use of or in any way connected to the items. Determining the party which bears liability for damages may turn out to be difficult when it comes to 3D printing, because of the number of potential actors involved in the manufacturing process (including, but not limited to, the owner of the printer, the manufacturer, the seller). Last, 3D printing may impact data protection to the extent the relevant operations may either require or involve the processing of personal data (e.g. pictures). As there is no precedent in point, regulations are today not well-defined and instead act upon reasoning by analogies. This involves referring to cases that concern unrelated subject matters but are governed by the same general principles and applying those principles to the cases at hand. Thus, questions remain of when two cases are the

"same" or "similar", and why should the case of 3D printing be affected by decisions made previously.

Adoption		early adoption
Workforce		moderate
Economic Impact		moderate
Competitiveness		high

IMPACT While more businesses from several different fields are taking advantage of this technology, the majority of companies have yet not adopted materials printing due to lack of information about the technology and in-house expertise to establish the processes driven by 3D printing. However, for the ones who have integrated 3D printing in professional settings, 55% of the usage is dedicated to creating prototypes faster, which makes of this feature the primary application of 3D printing. Realization of proof-of-concepts takes the second place with 29%, and production of effectively working products the third with 24%. Such digits are useful to illustrate the competitive and economic impacts 3D printing can have when correctly installed.

At the same time, many concerns have emerged in the field of intellectual property rights protection. It is worth reporting that under current legislation both end- users, sellers and manufacturers may be responsible for infringements committed in terms of copyright infringement. A different allocation of liability with specific regard to 3D printing may definitely have an impact on the development of this technology and the relevant industry.

DYNAMISM For production purposes, 3D printing can be particularly cost-effective when it comes to low to medium-volumes, as it saves

Adoption Growth Rate		next within 3 year
Upstream Value Chain Support		incremental development
Changing Regulation		debate
Accessible Knowledge		good practices
Infrastructure Trends		limited advancement
Business Model Knowledge		good practices

higher initial investment for tooling and setup. The overall workflow can be optimized with fewer production steps and lower expenses, while generating less scrap and reducing iterative process as well as assembly processes. 3D printing has proven ideal for automotive, aerospace, consumer goods and medical industrial products, which are the industries currently leading the adoption of this technology. A good example is BMW, that makes use of 3D-printed water pump wheel for its race cars. As race cars only account for a limited share of BMW's total production, 3D printing is the most cost- effective and fastest solution to this demand-oriented production.

Despite the many advantages of this technology, there is still room for many improvements. Mass manufacturing cannot yet be replaced by 3D printers, as this technology does not have any advantage over traditional mass manufacturing. Besides, full automation of 3D-printed products is still virtually impossible, as many printed parts still need a traditional finishing touch which limits payoff in lead time and production flexibility.

Moreover, several product engineers lack the required in-house expertise to establish the processes driven by 3D printing. Many consulting agencies are collaborating with 3D printing providers to help companies learn how to individuate cost-benefit trade-offs and where and when 3D printing makes sense compared with conventional manufac-

turing technologies. Deloitte and HP, for example, have recently entered a partnership to help large enterprises accessing knowledge and hardware to compete more effectively in this field.

ADVICE TO THE BOARD

Before getting your claws into 3D printers, get your "feet wet" by looking for "as-a-service" opportunities. This ensures you to receive a more complete understanding of which assets to invest in while assuring all your needs are fulfilled at the time being. Whilst the implantation of 3D printers can be beneficial in many ways it is equally important to provide your team of e.g. developers, engineers, or R&D Managers with enough knowledge form e.g. consulting agencies to understand which new levels of design freedom and performance enhancements this new method can bring. If correctly introduced, 3D printing can allow for a shift to focus less on manufacturability and more on functionality, inspiring your team to think differently for higher efficiency.

Advanced Robotics

COLLABORATIVE ROBOTICS

Integrated system of coordinated robots that operate in the same environment of, or even interact with, other human operators, without the need of physical separation.

Technology Maturity		general availability
Infrastructure Coherence		enabling
Business Model Coherence		neutral
Regulation		incomplete
Skills and Knowledge		practitioner
Legal Fit		unfavourable

DISTANCE The state of collaborative robots (cobots) technology has not shifted significantly over the last 12 months. Nevertheless, increasing awareness of Collaborative Robotics has driven a broadening in the scope of their potential applications: the functionalities of humanoid cobots such as Softbank's Nao and Pepper, as well as of non-humanoid cobots such as Savioke's Relay, enable customer-facing use cases and an increased variety in how Collaborative Robotics can be integrated within the operations of an enterprise. Indeed, a growing number of corporations are starting to recognize a strategic role to collaborative roots to reshape their strategies. Some examples include

Nike and Adidas, which are thinking about a cobot-enabled re-shoring strategy to overcome increasing labor costs, as well as logistic inefficiencies in the regions they currently concentrate their productions. Others are starting to rethink their operations by leveraging on cobots to operate in the same context of their customers and to even interact with them. For example, Residence Inn, a Marriott company, is using Savioke's Relay robots to provide in- room delivery service to its guests.

Yet, all these cases highlight the need to thoroughly revise one's operating model to ensure such technologies can effectively integrate within the organization. From a regulatory standpoint, the debate on robotics and its legal implications has been fueled in recent times by the communication issued by the EU on AI for Europe. In 2017, the European Parliament passed a resolution asking the Commission to work out rules on robotics and AI, which will permit players in various industries to fully exploit their economic potential, while guaranteeing a high level of safety and security.

Adoption		innovators
Workforce		moderate
Economic Impact		marginal
Competitiveness		marginal

IMPACT Innovative use cases as those mentioned above aside, we are far from having Collaborative Robotics diffused across a broad range of organizations. Yet, this does not reduce the impact they could realize today if adopted. At the light of the broader and increasingly diversified set of uses cases, the impact confirms to be up to moderate on workforce. On the one side, there is increasing potential for automation across a greater number of tasks, within either manufacturing, lo-

gistics, warehousing, but also customer management applications in healthcare, hospitality and retail. On the other, all experts highlight that cobots are not going to substitute human operators, rather to augment their capabilities. Current impacts on competitiveness are not more than marginal, as robotic-enabled strategic re- designs of enterprise should not be doable before 3 to 5 years from now.

Adoption Growth Rate		next within 3 year
Upstream Value Chain Support		sustained development
Changing Regulation		ongoing reform
Accessible Knowledge		good practices
Infrastructure Trends		sustained advancement
Business Model Knowledge		good practices

DYNAMISM The development of different uses cases is set to trigger more experimentation and adoption in the coming years, while growing investments in the technology are set to make it increasingly reliable and usable. Indeed, spending in robotic technology has more than tripled in the last few years.

From a regulatory standpoint, the EU Parliament is focusing its attention on the following key aspects of a possible future regulation:

- evaluate the opportunity to recognize a specific legal status (or even legal subjectivity) to robots taking into account the relevant ethical considerations;
- ensure standardization, safety and security common standards;
- evaluate which model of liability best fits the characteristics of robots;
- assess the impact of the development of robots and the relevant social measures to be adopted.

With specific reference to liability rules the EU bodies are exploring different options. EU institutions are considering the application of existing rules on products liability in connection with damages caused by defects of the robots. In the absence of case law on this matter, the scenario is quite uncertain.

From an organizational standpoint, the development of an operative model that is able to harmonize people alongside collaborative machines will require a great managerial effort. In order to prepare for this shift, it is important to start igniting awareness and confidence towards the technology: Collaborative Robotics are going to become a part of the workplace across different organizational domains along with human employees and professionals.

ADVICE TO THE BOARD

Collaborative robots are mature for applications across manufacturing and logistics and are emerging as a doable application also for some customer-facing domains. Yet, consolidated success stories still have to develop. You should actively keep an eye on the technology while assessing potential applications within your business, while engaging your organization on a conscious reflection on the role cobots will have in the future of its workplace.

DRONE ROBOTICS

Unmanned vehicles, which can be remotely controlled by a user or can autonomously work based on pre-programmed plans or more complex dynamic automation systems. Drones are usually built with stabilization sensors, advanced software systems and other equipment (e.g. GPS, cameras, First Person Viewing,...).

Technology Maturity		consolidating
Infrastructure Coherence		neutral
Business Model Coherence		neutral
Regulation		well-defined
Skills and Knowledge		practitioner
Legal Fit		enabling

DISTANCE Unmanned Aerial Vehicles (UAVs) have reached an extremely advanced level of technology maturity and are now consolidating into an even more advanced and valuable technology; in the last year, most of the effort has been spent to improve drones' energy autonomy. Two of the most relevant technical trends refers to the development of (i) nano drones (ii) perpetual drones.

- Nano drones: Enhancing new customized micro-chips, these drones both are extremely energy efficient[1] and can offer advanced features, such as processing real-time camera images, auto-stabilization, remote control, etc.;
- Perpetual drones: The purpose of this new family of drones is to stay in air for several days, or even several weeks, without interrup-

1 This chip consumes only 24 milliwatts which is about 1 one-thousandth the energy required to power a lightbulb.

tion. Generally, these drones are either solar or wind powered. The main challenges to solve rely on the performance of their energy storage and conversion systems as well as the intelligence in energy management and the mechanical design of the drone.

As for 2017, Italian physical infrastructures and business models are neutrally affecting drones' adoption. For physical infrastructures, we mean (i) the field – intended as the surface where the drone operates – and (ii) the network for transmitting/receiving data – intended as the networks which drones exploit to be radio-piloted and to transmit data. In both cases, we do not observe any relevant limitations that could affect drones' adoption.

According to the Remotely Piloted Aviation Systems (RPAS) "drones" include "any type of aircraft that is automated and operates without a pilot on board". Two types of drones fall within this definition: (i) Remotely Piloted Aviation Systems (RPAS), where the aircraft is controlled by a human pilot from a distant location; (ii) Unmanned drones, which are automatically programmed to work without being piloted (even remotely). Based on EU law, only the use of Remotely Piloted Aviation Systems can be authorized.

At the EU level recent developments can be reported with respect to drones. On 26 June 2018, the Council adopted a regulation which contains a set of rules aimed at fostering competition and growth in the aviation sector. The regulation defines proportionate and risk-based rules concerning drones, with the purpose of pursuing objectives such as safety, security, privacy, data and environmental protection. Under the regulation, operators must be registered if their drones are capable of transferring more than 80 Joules of kinetic energy upon impact with a person. It is worth noting that the regulation defines "unmanned aircraft" as any aircraft operating or designed to operate autonomously or to be piloted remotely without a pilot on board.

Also, under Regulation no. 216/2008 only remotely piloted aircrafts with a mass above 150 kg were subject to EU law, while those with a mass of or under 150 kg fell outside the scope of application of EU law and had therefore to comply with the requirements posed by Member States domestic legislation. However, in the view of the European institutions such fragmentation of the legal and regulatory framework undermined the development of a single EU market for unmanned aircrafts and cross-border operations. As a consequence of that, the recently-passed regulation has extended the competence of the EU to regulate all unmanned aircrafts and is applicable regardless of their maximum take-off mass.

More detailed provisions regarding drones will be approved by the Commission in cooperation with the EASA, in accordance with the principles set forth in the regulation.

Adoption		general adoption
Workforce		moderate
Economic Impact		marginal
Competitiveness		marginal

IMPACT Italian companies have started to adopt drones within their companies. Drones are rapidly entering both in private and public entities, such as:

- Italian Police Force: The Italian Police Force is already using drones as a "third eye" in multiple occasions - such as concerts, international meetings, sports events – especially as a support for anti-terrorism controls;
- Enel: Enel recently inaugurated at its Torrevaldaliga Nord power plant an innovative system that uses drones to support the oper-

ation, maintenance and protection of the plant, through solutions developed by Convexum and Percepto;

- Italian Red Cross (IRC): The "SAPR Project" by the Italian Red Cross is the first major national program for the use of drones in critical areas. These radio- controlled aircrafts will be used by the Italian Red Cross in SAR activities in case of major emergencies in Italy and during missions abroad.

From an economic and workforce perspective, we do not see any relevant changes from last year.

Adoption Growth Rate		next within 3 year
Upstream Value Chain Support		incremental development
Changing Regulation		ongoing reform
Accessible Knowledge		good practices
Infrastructure Trends		limited advancement
Business Model Knowledge		formalized

DYNAMISM The investments on drones in Italy are extremely high. Recently, the Italy's Economy Ministry (MEF) has proposed to the parliament a draft ministerial decree for the "approval of a multi-year programme for the acquisition of Medium Altitude Long Endurance remotely piloted aircrafts". The MEF has proposed a multi-year defence plan which included an investment of €766 million. According to a report by a national newspaper, the document contains expenditure details for the P2HH drones that the Air Force is likely to purchase from Piaggio Aerospace.

With specific regard to Drone Robotics, it is also worth noting that on 6th March 2015 European Commission representatives, Directors General of Civil Aviation of the EU Member States, data protection au-

thorities and leaders of manufacturing industry and service providers entered into the Riga Declaration "Framing the future of aviation" relating to remotely piloted aircrafts.

Italy ranks among the Member States that have introduced an ad-hoc regulation in this respect. Most notably, ENAC (the Italian Civil Aviation Authority) has recently released a new version of the regulation on unmanned remotely piloted aircrafts.

ADVICE TO THE BOARD

Drones are quickly becoming a "must-have technology" thanks to the continuous advancements they are making. From quick and secure field inspections to advanced data analytics, drones are becoming a real game changer in some specific activities - such as agriculture, construction, infrastructure and inventory management. If you are engaged in such activities, then you should start to seriously consider this technology as a first-class analytic tool for your business.

High Impact Technologies Radar Methodology

The HIT Radar is a tool to evaluate the impact, ecosystem and dynamics of digital technology solutions for mid- to large-size enterprises and should thus be considered by top executives in the company's decision-making processes. Its center represents the attention span of a Board of directors. Digital technology solutions are represented as icons in different positions, sizes and colours based on their importance to the very same Board. The HIT Radar is the final output of a 4-phase methodological process structured to ensure:

- Full awareness of the state of the art of emerging technologies and technology trends mapped by specialized business analysts and tech/ICT operators;
- Updated view of all emerging technologies across all industries, both close to and far from actual business exploitation;
- Clear definition and classification of all terms and concepts provided in the DEVO Lab materials;
- Objective and scientific approach to technology assessment.

The scouting for the 3rd edition of the HIT Radar General Report focused on trends and technologies highlighted by the major technology

analysts, both those already considered in our previous works (Gartner, Forrester, Ovum, IDC and Everest Group) and new ones (KD Nuggets, Tractica, McKinsey & Company, Boston Consulting Group), along with academic technology think tanks (MIT Technology Review and Harvard Business Review), the World Economic Forum and technology-focused press (Business Insider, TechCrunch, Forbes).

The review of these sources resulted in the identification of 134 objects, distributed among the different layers of our DEVO Lab taxonomy as follows:

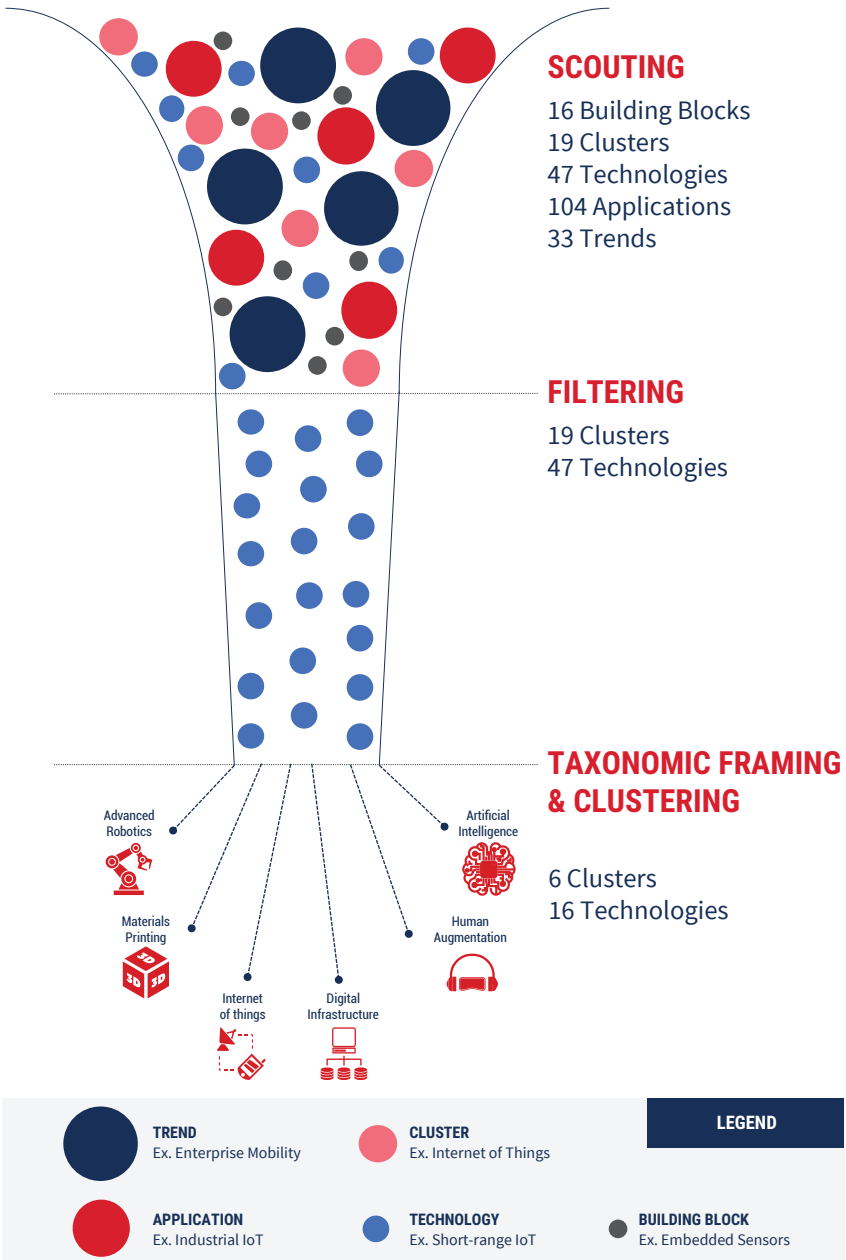
- 16 building blocks (7.3%);
- 47 technologies (21.4%);
- 104 applications (47.5%);
- 19 clusters (8.7%);
- 33 technology trends or business models (15.1%).

Our partner team at MIT Design Lab provided the DEVO Lab with an updated version of their Disruptive Technologies and Clusters report, in particular offering an in-depth analysis about recently developed technologies and applications such as Autonomous Mobility, Blockchain Computation, Enterprise Augmented Reality, Genomic Emulation and Biofabrication, thus giving a further significant contribution to our scouting.

After having gathered all the objects in our taxonomic framework, we clearly separated them among layers, cleaned overlaps and clustered similar elements. Once we filtered only by those technologies which were worth of managerial considerations within the next 5 years, we eventually identified 16 technologies. A new technology was eventually added: DNA Data Storage, in the Digital Infrastructure cluster.

As a result, the present edition of the HIT Radar provides the following distribution of technologies among the six DEVO Lab clusters:

FIGURE A.1 **Scouting Funneling to Select Key Technologies**



- Artificial Intelligence: Machine Learning, Natural Language Processing, Computer Vision;
- Human Augmentation: Virtual Reality, Augmented Reality;
- Digital Infrastructure: Big Data Technologies, Edge Computing Technologies, Blockchain, Quantum Computing, DNA Data Storage;
- Internet of Things: Long-range IoT, Short-range IoT, 5G;
- Materials Printing: Enterprise 3D Printing;
- Advanced Robotics: Collaborative Robotics, Drone Robotics.

As for last year, the technologies were then assessed based on the three-pillar HIT Radar model, comprising 16 assessment dimensions to analytically score:

- Distance (rings): the existing gap between the emergence of a technology solution per se and the feasibility of its implementation given the current economic, regulatory and business contexts;
- Impact (icon size): the potential impact, both in economic and social (i.e. on human capital) terms of the business implementation of a given technology solution;
- Dynamism (icon colour): the amount of change that surrounds a given technology solution, both in quantitative (e.g. amount of VC investments) and qualitative (e.g. pending regulatory reforms) terms, which may widen or shrink the aforementioned distance gap in the coming years.

Details of all assessment dimensions, their meaning and coding is provided at the end of Chapter 1.

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SDA Bocconi School of Management DEVO Lab

The aim of DEVO Lab is to bring together diversified perspectives, experiences and backgrounds to consistently assess the business implications of digital technologies and the value generation they can enable. The Lab's activities rely on a Digital Manifesto based on 5 principles:

1. Respect technologies;
2. Acknowledge that technological competences are rare and expensive;
3. Remember the fundamental economic rules;
4. Be a savvy adopter;
5. Diffuse an innovative attitude throughout the whole organization.

DEVO Lab merges the ideas and insights coming from applied researches and field projects, carried out in collaboration with a broad and multidisciplinary community of professionals that take part in the DEVO Lab's Think Tank.

DEVO Lab Members

DEVO Lab's research program and initiatives are supported by "Member" organizations.
Each Member is a company with a long-term commitment to the DEVO Lab that is entitled to have a representative in the DEVO LAB's Think Tank. The Think Tank is a permanent organizational body that actively contributes to the Lab's a by

- proposing and voting yearly researches;
- taking part in working sessions;
- challenging and validating the research outputs with a solid field perspective.

The Think Tank community entails technical experts, innovation specialists, digital enablers, CIOs, CTOs, Digital Officers, experienced tech consultants and practitioners from both the demand side and the supply side of the digital market.

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