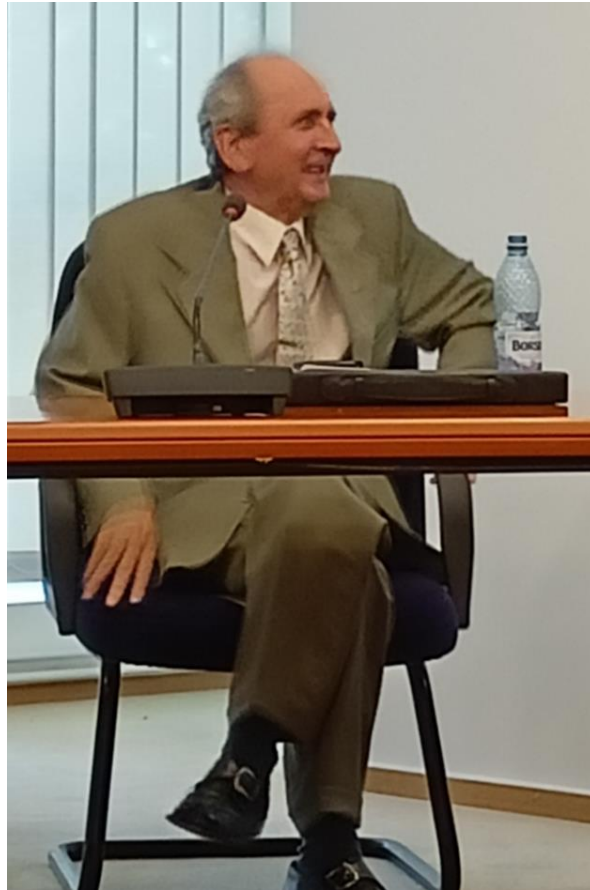


Developing information and communications technology to provide more intelligence and leverage more wisdom for a dramatically changing World
-Part 3-



Prof. Eng. Ph.D. Victor GREU

Abstract

The paper analyses the dynamic context of the dramatic World changes, where Information and Communications Technology (ICT) has to adapt its services, products and applications in order to support Information Society (IS) on the way towards the Knowledge Based Society (KBS), even if we see and face emergent crisis by crisis, or even the spectrum of poli-crises.

*The practical question, beyond any philosophy, is if we have to try to deeply understand the information we receive, or just wait the facts which usually confirm (later!) the trend or the crisis. There are a lot of approaches, between these extreme points of view, but **the right way is to refine the knowledge**, which is by far something more than **understanding the information we receive**. This means to continue to responsibly think and analyse the (ICT) World context, even by changing the paradigm in many domains, including, if necessary, ICT areas.*

As a starting point, it is a clear necessity to carefully analyse the unprecedentedly World changes/crises, even if we will continue to keep close only with the ICT context, but not ignoring the complex and crucial ways this is linked with the IS/KBS and generally with Earth ecosystem and humankind evolution. From Ukraine to USA and China, the World is dramatically changing, by events having the potential to completely change not only our habits and lives, but the whole Earth ecosystem and even humankind chances of sustainable evolution.

The ICT sustainable progress is crucial, but we have to also consider the changing context, where the ICT advances, like artificial intelligence (AI), Cloud, Internet of things (IoT) or Big Data must be further developed properly, while the new directions could appear. The basic support of all these areas is strongly

depending on innovations which have to answer to the inherent challenges and crises (semiconductor crisis is just one of the relevant examples, but energy and food could be also soon prominent, along with climate changes consequences).

The difficulty of any analysis is given by the fact that all these challenges are connected (not independent) processes, in the already very dynamic context of ICT/IS/KBS.

In addition, the most challenging features of the actual dramatical World changes could come from the deep levels of the turbulence in most of domains, which sometimes make not applicable the previous approaches. A simple recall of the crucial approach of the green ICT, we also analysed [11], seems to be not sufficient/suitable for the emerging new normality, but this aspect could be extended, without doubt, to the green deal strategy, where the situation is more complicated and not only at the EU level of decision. Another challenging feature of the analysed ICT context is fundamental as it arises from the unprecedented high level of performance, complexity and pace of ICT we are looking for expected improvements and progress [14].

As we also presented [3], many of the ICT achievements, but sometimes even ones of the challenges, are “copied” or lent to other domains due to the proliferation and crucial role of ICT in IS/KBS. This way we could observe the similarity of the challenges, coming from the high level of the World development and humankind wellbeing, which began to trouble the incumbents and people when facing the emergent restrictions and savings that the energy crisis could ask.

Consequently, the paper reveals, by analysing relevant examples, some of these processes and pointing how the knowledge is generated and eventually how, generally, it should be refined, considering the complicate mechanisms by which the exponential pace of ICT influences all the Earth ecosystem. As the best start of such analyses, communications remained the basic point, being the reliable bridge for all new approaches, leveraging the knowledge refining and, again generally for Earth ecosystem, the expected **unity of efforts against crises turbulences**. Approaching innovation and optimization should consider the communications reliability and quality/performances as the necessary media (Internet being only the most relevant example). This observation will be more and more relevant as the World crises will generally require more connectivity, solidarity and mutual understanding, but technically speaking this will be in fact the need for quick response and awareness in all domains, including critical infrastructures and decision centres.

On this way, the paper analysed the case of the 4 prestige high-tech companies which joined efforts to realize a new 170 GHz / 220 GHz Broadband Vector Network Analysis. The analysis revealed some important features/issues, which are relevant for the actual ICT context. The concretization of the idea of unity of efforts, for facing unprecedented difficulties, is here translated in the technology language and industry politics, as it also confirms the specific challenges which are inherently induced by the high level of performances involved. The high level of expertise/prestige for each component/partner, along with the unique selection involved in order to reach this new frontier of ICT, are proving the importance of collaboration/solidarity for facing the actual challenges (in all critical domains of Earth ecosystem). Using higher and higher frequencies is not a goal itself, as, for wireless communications, increasing the carrier frequency the useful bandwidth will also increase, which is one of the main objectives in the future broadband mobile communications systems 5G and 6G, in order to respond to the unprecedented needs of data transmission flows (i.e., broader bandwidth).

The communications/ICT development picture is much larger, as proved by another case, a performant system of analysis and simulation of ICT circuits and systems, which is focusing on the concrete implications of processing the new signals of high-speed digital standards, used at ICT advances as 5G, AI, IoT, virtual reality or autonomous vehicles. The degradation of high-speed signals should be considered as a new challenge, as its level of complexity has unprecedentedly increased, being one of the sides we have mentioned as being given by the high level of starting/reference performances, which already are approaching the physical limits of technology. The optimal solution is a new and very performant system of analysis and simulation, i.e., the proper instrument needed by the actual and future very complex ICT equipments. It is important to recall also here that the main area of communications is no more separable of the digital processing, as the last decades confirmed the inseparable convergence of communication and IT issues inside of the new ICT products, equipments and systems, but things are far more complex as the cost and time implications will have dramatical effects in the actual race for adapting to crises and urgences, along with the increasing need for reliability and trust in operation.

All these, mainly technological issues, in the dramatical actual context, could lead clearly to the appropriate and extended system approaches, based again on knowledge refining and new criteria consideration, at Earth ecosystem scale.

For the **holistic understanding of the knowledge refining**, in the actual dramatic context of World changes/crises, we propose to also consider the implications of the new normality, which is the term more and more used to suggest the implications of the World emergent dramatical changes. We agree, from the beginning, that the new normality is just a generic term, far from being defined or concrete, considering the dramatical changes of the World and the necessity to refine the knowledge in order to find a new balance, in most of activity domains, aiming a sustainable development or at least a surviving approach of Earth ecosystem. The word normality could have special resonance in the

dramatical changes of the World context and we think it was not a simple coincidence that this word was found the most appropriate, from the beginning, to express the actual phase of uncertainties and turbulences the humankind has to face, as it also suggests the urgent necessity of crucial but appropriate changes of our rules and behaviour, everywhere.

Considering the huge theatre where all this context is changing and the subsequent approach, we should imagine to be next changed, it is clear that systemic approach and refined knowledge will be key features of appropriate solutions we have to imagine and apply. It is obvious that generally applicable principles, methods or solutions will not be found, although the idea of optimization will be followed everywhere and every time. This way, the systemic approach will lead us to consider the most affected/influent domains of the dramatical changes we face and inherently the energy is prominent, as the physical support of any process/action.

Although we already presented the impressive weight of ICT carbon footprint [11], confirmed also at the Paris Agreement on climate changes (2015), there are domains which still have higher contributions to greenhouse-gas emissions, as the shipping industry, which was largely analysed by a relevant example (ammonia, [2]). Starting from this case, we also revealed some relevant elements to be considered at holistic approach and knowledge refining for facing the actual crises and dramatic changes of the World. First of all, the energy crisis implications should be considered at planetary scale and notice that they started before the pandemic-war context, being linked with Earth resource fading and the unsustainable development in the last decades, as we also presented [11][18]. Then, we should analyse with priority the activity domains where the consumption and carbon footprint are prominent for Earth ecosystem and here ICT is also visible and perhaps more important due to its exponential pace – which must also to be among refined knowledge, while the time to react at planetary scale could be critical as the implied processes are more and more complex and interdependent. Among many other elements, the social, technical, operational and security/geopolitical issues have to be analysed in a holistic approach when searching the solutions for the new normality everywhere. In the ammonia case also, we observed that humankind/community joint efforts (generally including countries, industries, companies or scientific groups) are important, as the implications are global, but also the difficulties are higher and higher and need solidarity/unity and complementary/interdisciplinary contributions.

Returning to ICT development's global role and context, another relevant example (software testing) could reveal the diversity of the new challenges and point new criteria for refining knowledge. In fact, ICT sustainable development is one of the most complex problems and to optimize it is a very difficult aim, which is now even more complicated by the dramatical changes/crises, which induce uncertainties and unreliable data for decision processes, even when using the advances of AI. On the other side, it is not a new observation that software is a crucial resource for ICT sustainable development, but, naturally, new challenges come to reconsider it and again to refine knowledge, including the area of intelligent automation. AI is a prominent ICT advance, but, as it is penetrating everywhere, its design and optimization for software testing need to be carefully conceived, because of the systemic critical consequences of software reliability in the actual and future ICT complex systems. When designing new software for complex systems, rigor and imagination are mandatory for covering any possible and relevant scenario/case of use in operation and user's experience, but now open design and holistic approaches have to be added features for ICT sustainable development. This way, the perpetual competition between AI and human intelligence (HI) become crucial when imagination is pointed to cover all challenges. For reaching such high performances, AI must include new techniques and algorithms, which also have to be designed by a holistic approach and include refined knowledge to reflect updates for a diversity of criteria. Beyond other limits of the AI performances, it is worth to observe that, while the AI algorithm learns, for improvements it has to use **new data, i.e., updates reflecting the refined data which inherently must contain the way the incumbents and people think over the dynamic and dramatic World changes, meaning, in fact, refined knowledge**. This way, the whole complexity and difficulty of **holistic understanding of the knowledge refining in the new normality** could be, at least, suggested along with some elements for orienting the appropriate directions to search the needed solutions/actions among the diversity of options which the democracy, the market economy and the (relative) liberty could generate in time steps.

As a main conclusion, **for a systemic and holistic approach of knowledge refining in the new dramatic change's context, around the World, the role of ICT is essential, first as the link between all processes, having the connectivity features which proved salutary in pandemic, but beyond these, having the potential to speed and optimize the sustainable development of all activity domains of IS/KBS, with its advances like AI, Cloud, IoT, Big Data etc.**

Keywords: World crises, new normality, knowledge-based society, knowledge refining, greenhouse-gas emissions, intelligent automation, broadband vector network analysis, degradation of high-speed signals, decarbonizing cargo ships, ammonia-fuelled shipping

JEL Classification: L63; L86; M15; O31; O33

“The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom.”

— Isaac Asimov

1. Developing ICT new solutions in the new crises' context

Looking every day for news is for many of us a way for trying to keep the pace with World changes, in order to orientate our thinking and actions, although, obviously, this is not a general philosophy of the most people, which will rather continue to do what they usually do and think on a traditionally basis.

Without intending to enter philosophy issues, behind such dilemmas we could observe that, anyway, the World changes, reflected apparently by **the information we receive**, have to be considered, especially when they become dramatic, like we see and face today, as emergent crisis by crisis.

The practical important question/issue, beyond any philosophy, is if we have to try to deeply understand the information we receive, or just wait the facts which usually confirm (later!) the trend or the crisis.

We think that, obviously there are a lot of approaches, between these extreme points of view, **the right way is to refine the knowledge**, which is by far something more than **understanding the information we receive**, as we already presented [13][18].

It is sure that this is just a starting point for the actual clear necessity to carefully analyse the unprecedentedly World changes/crises, even if we will continue to keep close only with the Information and Communications Technology (ICT) context, but not ignoring the complex and crucial ways this is linked with the Information Society (IS) and the Knowledge Based Society (KBS) and further, generally, with Earth ecosystem and humankind evolution.

From Ukraine to USA and China, the World is dramatically changing, by events/crises having the potential to completely change not only our habits and lives, but the whole Earth ecosystem and even humankind chances of sustainable progress.

It is already known that, facing such dramatically World changes, the most important is to not panic, but to continue to responsibly think and analyse, even by changing the paradigm in many domains, including, if necessary, ICT areas.

This way we understand that ICT sustainable progress is crucial, but we have to also consider the changing context, where the ICT advances, like artificial intelligence (AI), Cloud, Internet of things (IoT) or Big Data must be further developed properly, while the new directions could appear. The basic support of all these areas is strongly depending on innovations which have to answer to the inherent challenges and crises (semiconductor crisis is just one of the relevant examples, but energy and food could be also soon prominent, along with climate changes consequences).

The difficulty of any analysis is given by the fact that all these challenges are connected (not independent) processes, in the already very dynamic context of ICT/IS/KBS [3].

Perhaps the most challenging features of the actual dramatical World changes come from the deep levels of the turbulence in most of domains, which sometimes make not applicable the previous approaches.

A simple recall of the crucial approach of the green ICT, we also analysed [11], seems to be not sufficient/suitable for the emerging new *normality*, but this aspect could be extended, without doubt, to the *green deal strategy*, where the situation is more complicated and not only at the EU level of decision.

Another challenging feature of the analysed ICT context is fundamental as it arises from the unprecedented high level of performance, complexity and pace of ICT we are looking from for expected improvements and progress [14].

As we also presented [3][14], many of the ICT achievements, but sometimes even ones of the challenges, are “copied” or lent to other domains due to the proliferation and crucial role of ICT in IS/KBS.

Here we actually could observe the similarity of the challenges, coming from the high level of the World development and humankind wellbeing, which began to trouble the incumbents and people when facing the emergent restrictions and savings that the energy crisis could ask.

Consequently, we could only continue to try to reveal, by relevant examples, some of these processes and understand how the knowledge is generated and eventually how, generally, it should be refined, considering the complicate mechanisms by which the exponential pace of ICT influences all the Earth ecosystem.

When searching for the best start of such analyses, communications remain the basic point, as the reliable bridge for all new approaches, leveraging the knowledge refining and, again generally for Earth ecosystem, the expected **unity of efforts against crises turbulences**.

With other words, any approach of innovation and optimization should consider the communications reliability and quality/performances as the necessary media (Internet being only the most relevant example) [7][15][8][10].

Obviously, this observation will be more and more relevant as the World crises will generally require more connectivity, solidarity and mutual understanding, but technically speaking this will be in fact the need for quick response and awareness in all domains, including critical infrastructures and decision centres.

Under such generic observations, ICT and IS/KBS provide and will continue to provide a high diversity of complex products, systems and services, which, of course, now have to be fast adapted to the World dramatic changes.

With these premises, the complex role of 5G systems could appear even more important and of course more difficult to implement and improve, as it is also presented by [1]:

“Keysight Technologies, Inc. (NYSE: KEYS), a leading technology company that delivers advanced design and validation solutions to help accelerate innovation to connect and secure the world, FormFactor, Inc. (NASDAQ: FORM), a leading provider of essential test and measurement technologies along the full IC life cycle; DMPI Inc., a leading developer of millimeter wave and terahertz probe technology; and Virginia Diodes, Inc. (VDI), who designs and produces millimeter wave and terahertz devices, components and systems, have joined forces to deliver a new 170 GHz / 220 GHz Broadband Vector Network Analysis (VNA) Solution that shortens design and verification cycles for 5G and emerging 6G applications”

Before other details, we have to observe the concretization of the mentioned idea of **unity of efforts**, here translated in the technology language and industry politics millimetre, as

it also confirms the specific challenges which are inherently induced by the high level of performances involved:

“Keysight, FormFactor, DMPI and VDI have jointly developed this new VNA solution to provide on-wafer millimeter-wave component characterization under various conditions. It offers an advanced dynamic range, high output power and maximum stability. As a result, designers can efficiently characterize on-wafer devices and circuits, enabling the creation of highly accurate process design kits (PDKs) used to design integrated circuit models that shorten the design and verification cycle. Additionally, it enables rapid deployment of devices for the emerging 5G and 6G monolithic microwave integrated circuits (MMICs), a type of integrated circuit (IC) device that operates at microwave frequencies. The joint solution, Keysight's new 220 GHz Broadband Network Analyzer, enables customers to address the needs of 5G and future 6G technologies that will have a significant impact on communications through the internet of things and ubiquitous wireless connections.”

For an accurate image of such technological achievement and effort, we have to recall that only in the last decades the large use of the frequencies above 60 GHz became practical and the 200GHz frequency were still a target.

A more comprehensive dimension of such remarkable projects is further detailed by their main components and with the corroborated efforts, as:

<<The fully integrated solution is comprised of:

Keysight's N5291A 125 GHz broadband VNA – a single-sweep solution with compact frequency extenders, that delivers accurate leveled power.

DMPI / FormFactor T-Wave GSG Dual band probes – which provide wafer-level electrical measurement on FormFactor wafer probing solutions of millimeter wave (mmW) devices and materials up to 1.1 terahertz (THz).

VDI's specially designed sub-THz frequency extenders – which allows for high accuracy measurement of on-wafer device under tests from 900 Hz to 170 GHz or 220 GHz in a single frequency sweep.

"We worked closely with Dominion MicroProbes on the probe design and our solution partners, VDI and FormFactor, to deliver the highest performance 170 and 220 GHz single-sweep solution for testing on-wafer devices and circuits," said Joe Rickert, vice president and general manager of Research and Development at Keysight. "Keysight's new solution will enable customers to shorten design and verification cycles for 5G and emerging 6G applications and allow them to deliver new solutions to market faster."

"We've designed sub-THz extenders that allow users to leverage their existing N5291A systems to support a single sweep to 170 or 220 GHz," said Jeffrey Hesler, chief technology officer at Virginia Diodes.>>

More than these combined technological arrangements, we can observe the high level of expertise/prestige for each component/partner along with the unique selection involved in order to reach this new frontier of ICT, proving the importance of collaboration/solidarity for facing the actual challenges (in all critical domains of Earth ecosystem):

<<Equally critical to the new capability are a new line of broadband micromachined T-Wave® dual band probes developed by Dominion Microprobes Inc. and marketed by FormFactor. Each partner in this new broadband solution brings a unique set of technology and talent to solve these measurement challenges," said Jens Klattenhoff, vice president and

general manager of the Systems Business Unit at FormFactor. "Through close collaboration, we can now provide customers an integrated solution that allows continuous broadband sweeps up to 220 GHz.>>

For our further analysis it is important to observe also here that the main area of communications is no more separable of the digital processing, as the last decades confirmed IT&C crucial convergence, but in this case the novelty is given by the processing of signals at unprecedented high frequencies (*it enables rapid deployment of devices for the emerging 5G and 6G monolithic microwave integrated circuits*), which is one of the featured performances of the future broadband mobile communications systems 5G and 6G.

It is also worth to notice that using higher and higher frequencies is not a goal itself, as, for wireless communications, increasing the carrier frequency the useful bandwidth will also increase, which is one of the main objectives in 5G and 6G, in order to respond to the unprecedented needs of data transmission flows (i.e., broader bandwidth) [16][17][15].

As a relevant expression of the mentioned convergence of IT&C, considered in the actual context of ICT development, another example is given by [4]:

"High-speed digital standards are quickly evolving to keep pace with the data demand from emerging technologies such as 5G, the Internet of Things, artificial intelligence, virtual reality, and autonomous vehicles. Each generational change of high-speed computing standards provides new signaling features, faster data transfer rates, and smaller design margins. Faster speeds create new design challenges that require higher-accuracy simulation, new software tools, and more efficient workflows. As a hardware engineer, your job is to design, verify, build, and test electronic products. Fail to adopt new design methodologies and you risk product failure caused by degradation of high-speed signals in your printed circuit board (PCB). You also risk project delays, a skyrocketing budget, or jeopardizing your stellar reputation. Avoiding this dilemma requires new design tools and a holistic design methodology that connects the workflows of multiple disciplines. With this approach, you can design for the myriad interface standards, without increasing design and verification time."

In fact, here we find one of the complex challenges in developing ICT advances, although it could seem a natural technology/industry usual problem. The optimal solution is a performant system of analysis and simulation of ICT circuits and systems, i.e., the proper instrument needed by the actual and future very complex ICT equipments.

Still, the *degradation of high-speed signals* should be considered as a new challenge, as its level of complexity has unprecedentedly increased, being one of the sides we have mentioned as being given by the high level of starting/reference performances, which already are approaching the physical limits of technology:

"Signal integrity (the quality of an electrical signal) is all around us. In a digital communication channel, signal integrity analysis is the study of electrical signals as they traverse PCB traces, vias, connectors, and other components. Signal integrity problems can cause havoc for digital designs, including performance issues, lower yield, and possible failures in the field. These are costly problems as they often go undetected until late in the design and test cycle. The best time to simulate a PCB for signal integrity is after layout and before fabrication. Taking the time to simulate becomes more important as speeds increase."

Beyond other technical intimate details, we have to observe the inseparable convergence of communication and IT issues inside of the new ICT products, equipments and systems, but things are far more complex as the cost and time implications will have dramatical effects in the actual race for adapting to crises and urgences, along with the increasing need for reliability and trust in operation.

All these, mainly technological issues, in the dramatical actual context, could lead clearly to the appropriate and extended system approaches, based again on knowledge refining and new criteria consideration, at Earth ecosystem scale.

2. Holistic understanding of the knowledge refining in the new normality of the World

We have to agree, from the beginning, that the *new normality* is just a generic term, far from being defined or concrete, considering the dramatical changes of the World and the necessity to refine the knowledge in order to find a new balance, in most of activity domains, aiming a sustainable development or at least a surviving approach of Earth ecosystem.

The word *normality* could have special resonance in the dramatical changes of the World context and we think it was not a simple coincidence that this word was found the most appropriate, from the beginning, to express the actual phase of incertitudes and turbulences the humankind has to face, as it also suggests the urgent necessity of crucial but appropriate changes of our rules and behaviour, everywhere.

Considering the huge theatre where all this context is changing and the subsequent approach we should imagine to be next changed, it is clear that systemic approach and refined knowledge will be key features of appropriate solutions we have to imagine and apply.

Anyway, it is obvious that generally applicable principles, methods or solutions will not be found, although the idea of optimization will be fallowed everywhere and every time.

This way, the systemic approach will lead us to consider the most affected/influent domains of the dramatical changes we face and inherently the energy is prominent, as the physical support of any process/action.

Although we already presented the impressive weight of ICT carbon footprint [11], confirmed also at the Paris Agreement on climate changes (2015), there are domains which still have higher contributions to *greenhouse-gas emissions*, as *the shipping industry* is largely approached by the next relevant example [2]:

<< *"For most people, the shipping industry is out of sight, out of mind," Gallucci notes. "But it's a significant contributor to greenhouse-gas emissions. I wanted to look at what kinds of tech will be needed to decarbonize the industry." She's spent the last three years doing exactly that. She's written about ships that run on hydrogen fuel cells and batteries and maritime biofuels. And in this issue, she reports on one of the most promising efforts: engines and fuel cells that run on ammonia, which has low environmental impact when produced using renewable energy.*

"I first heard about ammonia at the conference in Bonn," Gallucci recalls. "It almost seemed like an aside at the time, so I was surprised to see the industry starting to coalesce around ammonia." Among other big developments, the International Maritime Organization has set a goal of halving shipping's greenhouse-gas emissions by midcentury.

"That's the reason ammonia is getting all this attention," Gallucci says. "Before it was just a few companies trying different initiatives. Now there's a real sense of urgency.">>

From the beginning, we should notice the subliminal excellent observation that our World arrived in the actual difficult situation also because of the fact that there are processes and factors/contributions that (for long time) seem to be *out of sight, out of mind*.

Before analysing ammonia importance, it is also worth to notice the confirmation of the crucial feature of the context/crises we are in for the last few years, as *now there's a real sense of urgency*, i.e., leading to the necessity of appropriate changes of our rules and behaviour, we have above mentioned.

In fact, for such complex and complicate processes, the expected solutions will come naturally from some evolution phases (*Before it was just a few companies trying different initiatives*), but surely they will be leveraged by the last dramatical evolutions of the World context, as in this case is further detailed:

<<Maritime shipping contributes nearly 3 percent of annual carbon-dioxide emissions, according to the International Maritime Organization (IMO), the United Nations body that regulates the industry. In 2018, delegates agreed to reduce emissions by 50 percent from 2008 levels by 2050. Meeting that target will require swift and widespread development of diesel-fuel alternatives and new designs for freighters, tankers, and container ships.

Shipowners and industry analysts say they expect ammonia to play a pivotal role in decarbonizing cargo ships. But there's a crucial caveat: No vessels of any size today are equipped to use the fuel. Even if they were, the supply of renewable, or "green," ammonia produced using carbon-neutral methods is virtually nonexistent. Most ammonia is the product of a highly carbon-intensive process and is primarily used to make fertilizers and chemicals.>>

Now it is clear that ICT is only more visible, but not higher carbon contributor (estimated with around 2%) than maritime shipping (having around 3%) and this way the IMO agreement in 2018 has built good premises for combating the actual urgency.

Unfortunately, if a problem/crisis is an obvious urgency, it does not mean the solution is simple or fast applicable, as in this case is proved:

<<...Finland's Wärtsilä plans to begin testing ammonia in a marine combustion engine in Stord, Norway, by late March. Germany's MAN Energy Solutions and Korean shipbuilder Samsung Heavy Industries are part of an initiative to develop the first ammonia-fueled oil tanker by 2024.

The supply vessel Viking Energy is being retrofitted with a 2-megawatt ammonia fuel-cell system. Ammonia has only half the energy density of traditional fuel, so storing it on board requires much more space.

Also by 2024, the Viking Energy is poised to become the first vessel propelled by ammonia fuel cells. The Norwegian energy company Equinor (formerly Statoil) charters this offshore supply vessel, which currently runs on liquefied natural gas. Chemical giant Yara will provide the green ammonia, which it plans to produce at a plant in southern Norway.

The initiative "will open up a completely new option for zero-emission shipping," says Henriette Undrum, Equinor's vice president of renewable and low-carbon technology. "We are not just solving one small problem for one ship. It's part of the bigger picture. It will be a starting point to build up the market for zero-carbon fuels.>>

More than these, the financial costs for such huge projects should be considered, even the advantages are also obvious:

<<Still, industry experts say that revamping the global shipping fleet will be extraordinarily expensive. Researchers estimate that up to US \$1.4 trillion will be needed to achieve the IMO's emissions-reduction target. And fully eliminating emissions will require an additional \$500 billion, according to a January 2020 study by a panel of maritime experts.

A number of climate-friendly technologies are being considered to reach that goal, including fuel cells, hydrogen-storage systems, and large battery packs. Spinning metal cylinders, towing kites, and other propulsion methods are already helping to curb diesel fuel consumption by harnessing the wind. But ammonia will likely dominate among ocean-crossing vessels, which sail for days or weeks between refueling and rely on common infrastructure worldwide. For such ships, "ammonia is the lowest-cost zero-emission fuel that we could find," says Tristan Smith, a researcher at University College London's Energy Institute, which evaluated more than 30 different shipping fuels.>>

The relevance of this example, for our analysis, is also given by the planetary scale of the project, along with the global consumptions and the technical, operational and security implications:

<<For ammonia-fueled shipping to become a reality, though, several things need to go right. Manufacturers and engineers must overcome key technical hurdles and safety issues in the design of ammonia engines and fuel cells. Port operators and fuel suppliers must build vast "bunkering" infrastructure so ships can fill ammonia tanks wherever they dock. And energy companies and governments will need to invest heavily in solar, wind, and other renewable-energy capacity to produce enough green ammonia for thousands of ships. Globally, ships consume an estimated 300 million tons of marine fuels every year. Given that ammonia's energy density is half that of diesel, ammonia producers would need to provide twice as much liquid ammonia, and ships will need to accommodate larger storage tanks, potentially eating into cargo space.>>

If things appear complicated, perhaps the further details would show the real picture size and difficulty of producing green ammonia:

<<To make ammonia, hydrogen and nitrogen are reacted with a catalyst at high temperature (about 500 °C) and high pressure (20 to 40 megapascals) via an industrial process developed by the German chemists Fritz Haber and Carl Bosch more than a century ago. To be stored in large quantities, ammonia can be liquefied by putting it under pressure (about 1 MPa at 25 °C) or refrigerating it (to –33 °C). All told, the Haber-Bosch process accounts for 1.8 percent, or half a billion metric tons, of human-caused global CO₂ emissions each year.

If ammonia is to play a part in reducing maritime emissions, the fuel must be made in a cleaner way. For example, the hydrogen can be made through electrolysis, splitting water into hydrogen and oxygen using electricity from a renewable source such as wind or solar power. Renewable energy can also be used to separate nitrogen from air.

A trial plant at the Fukushima Renewable Energy Institute in Japan [top] uses solar power to produce up to 50 kilograms of green ammonia a day. A demonstration system [bottom] at the Rutherford Appleton Laboratory in England is powered by a wind turbine and makes up to 30 kg of green ammonia daily>>

Now, counting the example implications and details, we could observe relevant elements to be considered at holistic approach and knowledge refining for facing the actual crises and dramatic changes of the World.

First of all, the energy crisis implications should be considered at planetary scale and notice that they started before the pandemic-war context, being linked with Earth resource fading and the unsustainable development in the last decades.

Then, we should analyse with priority the activity domains where the consumption and carbon footprint are prominent for Earth ecosystem and here ICT is also visible and perhaps more important due to its exponential pace – which must also to be among refined knowledge, when the time to react at planetary scale could be critical as the implied processes are more and more complex and interdependent [10][12].

Among many other elements, the social, technical, operational and security/geopolitical issues have to be analysed in a holistic approach when searching the solutions for the *new normality* everywhere.

Here, the presented humankind/community joint efforts (generally including countries, industries, companies or scientific groups) are important, as the implications are global, but also the difficulties are higher and higher and need solidarity/unity and complementary/interdisciplinary contributions.

Returning to ICT development's global role and context, another relevant example could reveal the diversity of the new challenges and point new criteria for refining knowledge.

In fact, ICT sustainable development is one of the most complex problems and to optimize it is a very difficult aim, which is now even more complicated by the dramatical changes/crises, which induce incertitudes and unreliable data for decision processes, even when using the advances of AI.

On the other side, it is not a new observation that software is a crucial resource for ICT sustainable development, but, naturally, new challenges come to reconsider it and again to refine knowledge, including the area of *intelligent automation*, as it presented by [5]:

“Organisations are increasingly embracing intelligent automation to deliver efficiencies and free up resources. These solutions are applied to various tasks across industries, with artificial intelligence (AI) providing vital brainpower.

Automation aims to create processes that think, learn and adapt independently, and the technology replaces humans carrying out repetitive tasks with intelligent software robots.

AI-assisted automation will deliver tangible business benefits, and in a digital-first world, the need and demand will continue to grow. By 2024, Gartner estimates organisations will lower operational costs by 30 percent by combining advanced hyper-automation technologies with redesigned operational processes. One area that intelligent automation is transforming is software testing...”

It is not a surprise that, in the new context, AI is a prominent ICT advance, but, as it is penetrating everywhere, its design and optimization for *software testing* need to be carefully conceived, because of the systemic critical consequences of software reliability in the actual and future ICT complex systems [17][12][6][9].

<<Intelligent automation applies innovative technologies like AI, machine learning (ML), and robotic process automation (RPA) to scale and streamline decision-making and

processes to deliver operational efficiencies. The AI assists in the automation of processes to deliver better and faster results...

Intelligent automation uses technologies like AI to evaluate systems and auto-generate previously resource-intensive assets (such as scripts), analyse the results to predict bugs, and adjust the automation logic to improve test coverage and overall quality. This is a profound change from the testing environment of a couple of years ago.

Then, software testing was perceived as a box-ticking activity to ensure that a product or system passed pre-defined and largely static tests.

Manual testing provides the "intelligence" but is too slow for modern systems and isn't comprehensive, making it obsolete – and there are more effective ways to use your workforce. Similarly, legacy test automation didn't incorporate intelligent technologies and relied on running the same script every time software was released.>>

In fact, as we also expressed, when designing new software for complex systems, rigor and imagination are mandatory for covering any possible and relevant scenario/case of use in operation and user's experience, but now open design and holistic approaches have to be added features for ICT sustainable development [12][15][6][9][8].

This way, the perpetual competition between AI and human intelligence (HI) become crucial when imagination is pointed to cover all challenges, as it is further detailed by [5]:

“These approaches fail to spot new bugs, do not proactively find weak points in a system, and lack the brains to identify what is critical to test from a user's perspective.

In a digitally dependent world, it's no longer sufficient to rely only on verifying that a system meets the requirements. Instead, organisations must also be able to validate that their solutions meet users' needs; it's essential to understand and gauge the digital user experience. This requires continuously testing real user journeys across all touchpoints, browsers, devices, and systems. And the only way to do this is by integrating intelligent technologies that automate testing from the user perspective and garnering insights to optimise the experience.

Intelligent automation is like unleashing an army of AI-powered bots onto applications, websites, and processes that behave like real users and explore (and experience) the workflows (or user journeys) as real users would. The automation needs to encompass more than functional testing and blend in performance and usability aspects. This accelerates the release of high-quality software because you find meaningful problems and defects in those real-world flows. The result is a smarter, more cost-effective way of continuously testing software and apps.”

For reaching such high performances, AI must include new techniques and algorithms, which also have to be designed by a holistic approach and include refined knowledge to reflect updates for a diversity of criteria:

“AI enables testing to move beyond simple rule-based automation. It utilises algorithms to efficiently train systems using large data sets (and there is a lot of data available in the testing world). It can mimic human behaviour through the application of reasoning and problem-solving and works by executing automated test routines that reflect the actions of real human users. The AI hunts for user interface errors, bugs, and performance glitches and then auto-fixes issues before they can impact the user experience.

The automation increases coverage by considering every potential user journey and predicting and identifying any bottlenecks that may affect performance. As the AI algorithm

learns, it continuously improves the quality and performance of systems and software, providing a competitive advantage.”

Beyond other limits of the AI performances, it is worth to observe that, while the AI algorithm learns, for improvements it has to use **new data**, i.e., **updates reflecting the refined data which inherently must contain the way the incumbents and people think over the dynamic and dramatic World changes, meaning, in fact, refined knowledge.**

This way, the whole complexity and difficulty of **holistic understanding of the knowledge refining in the new normality** could be, at least, suggested along with some elements for orienting the appropriate directions to search the needed solutions/actions among the diversity of options which the democracy, the market economy and the (relative) liberty could generate in time steps.

In addition, we have to notice that, **for a systemic and holistic approach of knowledge refining in the new dramatic changes context, around the World, the role of ICT is essential, first as the link between all processes, having the connectivity features which proved salutary in pandemic, but beyond these, having the potential to speed and optimize the sustainable development of all activity domains of IS/KBS, with its advances like AI, Cloud, IoT, Big Data etc.**

3. Conclusions

We consider that **this analysis could and need to be further continued/detailed**, but some conclusions should count the most important ideas of the above presented issues.

Between ignoring and panic about the World changes, reflected apparently by **the information we receive**, we think these have to be carefully considered and analysed, especially when they become dramatic, like we see and face today, as emergent crisis by crisis, or even as *poli-crises*. The practical question, beyond any philosophy, is if we have to try to deeply understand the information we receive, or just wait the facts which usually confirm (later!) the trend or the crisis.

Obviously, there are a lot of approaches, between these extreme points of view, but **the right way is to refine the knowledge**, which is by far something more than **understanding the information we receive**, as we already presented [13][18]. This means to continue to responsibly think and analyse the (ICT) World context, even by changing the paradigm in many domains, including, if necessary, ICT areas.

As a starting point, it is a clear necessity to carefully analyse the unprecedentedly World changes/crises, even if we will continue to keep close only with the ICT context, but not ignoring the complex and crucial ways this is linked with the IS/KBS and generally with Earth ecosystem and humankind evolution. From Ukraine to USA and China, the World is dramatically changing, by events having the potential to completely change not only our habits and lives, but the whole Earth ecosystem and even humankind chances of sustainable evolution.

That is why the ICT sustainable progress is crucial, but we have to also consider the changing context, where the ICT advances, like artificial intelligence (AI), Cloud, Internet of things (IoT) or Big Data must be further developed properly, while the new directions could appear. The basic support of all these areas is strongly depending on innovations which have to answer to the inherent challenges and crises (semiconductor crisis is just one of the relevant

examples, but energy and food could be also soon prominent, along with climate changes consequences).

The difficulty of any analysis is given by the fact that all these challenges are connected (not independent) processes, in the already very dynamic context of ICT/IS/KBS.

In addition, the most challenging features of the actual dramatical World changes could come from the deep levels of the turbulence in most of domains, which sometimes make not applicable the previous approaches. A simple recall of the crucial approach of the green ICT, we also analysed [11], seems to be not sufficient/suitable for the emerging new *normality*, but this aspect could be extended, without doubt, to the *green deal strategy*, where the situation is more complicated and not only at the EU level of decision.

Another challenging feature of the analysed ICT context is fundamental as it arises from the unprecedented high level of performance, complexity and pace of ICT we are looking from for expected improvements and progress [14].

As we also presented [3], many of the ICT achievements, but sometimes even ones of the challenges, are “copied” or lent to other domains due to the proliferation and crucial role of ICT in IS/KBS.

This way we could observe the similarity of the challenges, coming from the high level of the World development and humankind wellbeing, which began to trouble the incumbents and people when facing the emergent restrictions and savings that the energy crisis could ask.

Consequently, we could only continue to try to reveal, by relevant examples, some of these processes and understand how the knowledge is generated and eventually how, generally, it should be refined, considering the complicate mechanisms by which the exponential pace of ICT influences all the Earth ecosystem.

As the best start of such analyses, communications remain the basic point, being the reliable bridge for all new approaches, leveraging the knowledge refining and, again generally for Earth ecosystem, the expected **unity of efforts against crises turbulences**.

With other words, approaching innovation and optimization should consider the communications reliability and quality/performances as the necessary media (Internet being only the most relevant example). This observation will be more and more relevant as the World crises will generally require more connectivity, solidarity and mutual understanding, but technically speaking this will be in fact the need for quick response and awareness in all domains, including critical infrastructures and decision centres.

Under such generic observations, ICT and IS/KBS provide and will continue to provide a high diversity of complex products, systems and services, which, of course, now have to be fast adapted to the World dramatic changes.

On this way, the paper analysed the case of the 4 prestige high-tech companies which joined efforts to realize *a new 170 GHz / 220 GHz Broadband Vector Network Analysis*.

Starting from this remarkable case, the analysis revealed some important features/issues, which are relevant for the actual ICT context.

The concretization of the idea of **unity of efforts**, for facing unprecedented difficulties, is here translated in the technology language and industry politics, as it also confirms the specific challenges which are inherently induced by the high level of performances involved.

The high level of expertise/prestige for each component/partner, along with the unique selection involved in order to reach this new frontier of ICT, are proving the importance of

collaboration/solidarity for facing the actual challenges (in all critical domains of Earth ecosystem).

It is also worth to notice that using higher and higher frequencies is not a goal itself, as, for wireless communications, increasing the carrier frequency the useful bandwidth will also increase, which is one of the main objectives in the future broadband mobile communications systems 5G and 6G, in order to respond to the unprecedented needs of data transmission flows (i.e., broader bandwidth).

In reality, the communications/ICT development picture is much larger, as proved by another case, a performant system of analysis and simulation of ICT circuits and systems, which is focusing on the concrete implications of processing the new signals of *high-speed digital standards*, used at ICT advances as *5G, AI, IoT, virtual reality or autonomous vehicles*. The *degradation of high-speed signals* should be considered as a new challenge, as its level of complexity has unprecedentedly increased, being one of the sides we have mentioned as being given by the high level of starting/reference performances, which already are approaching the physical limits of technology. The optimal solution is a new and very performant system of analysis and simulation, i.e., the proper instrument needed by the actual and future very complex ICT equipments.

It is important to recall also here that the main area of communications is no more separable of the digital processing, as the last decades confirmed the inseparable convergence of communication and IT issues inside of the new ICT products, equipments and systems, but things are far more complex as the cost and time implications will have dramatical effects in the actual race for adapting to crises and urgences, along with the increasing need for reliability and trust in operation.

All these, mainly technological issues, in the dramatical actual context, could lead clearly to the appropriate and extended system approaches, based again on knowledge refining and new criteria consideration, at Earth ecosystem scale.

For the **holistic understanding of the knowledge refining**, in the actual dramatic context of World changes/crises, we proposed to also consider the implications of the *new normality*, which is the term more and more used to suggest the implications of the World emergent dramatical changes.

We agree, from the beginning, that the *new normality* is just a generic term, far from being defined or concrete, considering the dramatical changes of the World and the necessity to refine the knowledge in order to find a new balance, in most of activity domains, aiming a sustainable development or at least a surviving approach of Earth ecosystem.

The word *normality* could have special resonance in the dramatical changes of the World context and we think it was not a simple coincidence that this word was found the most appropriate, from the beginning, to express the actual phase of incertitudes and turbulences the humankind has to face, as it also suggests the urgent necessity of crucial but appropriate changes of our rules and behaviour, everywhere.

Considering the huge theatre where all this context is changing and the subsequent approach we should imagine to be next changed, it is clear that systemic approach and refined knowledge will be key features of appropriate solutions we have to imagine and apply.

Anyway, it is obvious that generally applicable principles, methods or solutions will not be found, although the idea of optimization will be fallowed everywhere and every time.

This way, the systemic approach will lead us to consider the most affected/influent domains of the dramatical changes we face and inherently the energy is prominent, as the physical support of any process/action.

Although we already presented the impressive weight of ICT carbon footprint [11], confirmed also at the Paris Agreement on climate changes (2015), there are domains which still have higher contributions to *greenhouse-gas emissions*, as *the shipping industry*, which was largely analysed by a relevant example (*ammonia*, [2]).

We should notice the subliminal excellent observation that our World arrived in the actual difficult situation also because of the fact that there are processes and factors/contributions that (for long time) seem to be less visible (*out of sight, out of mind*). It is also worth to observe the confirmation of the crucial feature of the context/crises we are in for the last few years, as *now there's a real sense of urgency*, i.e., leading to the necessity of appropriate changes of our rules and behaviour. For such complex and complicate processes, the expected solutions will come naturally after some evolution phases (*Before it was just a few companies trying different initiatives*), but surely they will be leveraged by the last dramatical evolutions of the World context. Starting from this case, we also revealed some relevant elements to be considered at holistic approach and knowledge refining for facing the actual crises and dramatic changes of the World.

First of all, the energy crisis implications should be considered at planetary scale and notice that they started before the pandemic-war context, being linked with Earth resource fading and the unsustainable development in the last decades, as we also presented [11][18].

Then, we should analyse with priority the activity domains where the consumption and carbon footprint are prominent for Earth ecosystem and here ICT is also visible and perhaps more important due to its exponential pace – which must also to be among refined knowledge, while the time to react at planetary scale could be critical as the implied processes are more and more complex and interdependent [10][12].

Among many other elements, the social, technical, operational and security/geopolitical issues have to be analysed in a holistic approach when searching the solutions for the *new normality* everywhere. In the *ammonia* case also, we observed that humankind/community joint efforts (generally including countries, industries, companies or scientific groups) are important, as the implications are global, but also the difficulties are higher and higher and need solidarity/unity and complementary/interdisciplinary contributions.

Returning to ICT development's global role and context, another relevant example (*software testing*) could reveal the diversity of the new challenges and point new criteria for refining knowledge. In fact, ICT sustainable development is one of the most complex problems and to optimize it is a very difficult aim, which is now even more complicated by the dramatical changes/crises, which induce incertitudes and unreliable data for decision processes, even when using the advances of AI. On the other side, it is not a new observation that software is a crucial resource for ICT sustainable development, but, naturally, new challenges come to reconsider it and again to refine knowledge, including the area of *intelligent automation*.

It is not a surprise that, in the new context, AI is a prominent ICT advance, but, as it is penetrating everywhere, its design and optimization for *software testing* need to be carefully conceived, because of the systemic critical consequences of software reliability in the actual and future ICT complex systems. When designing new software for complex systems, rigor an

imagination are mandatory for covering any possible and relevant scenario/case of use in operation and user's experience, but now open design and holistic approaches have to be added features for ICT sustainable development. This way, the perpetual competition between AI and human intelligence (HI) become crucial when imagination is pointed to cover all challenges. For reaching such high performances, AI must include new techniques and algorithms, which also have to be designed by a holistic approach and include refined knowledge to reflect updates for a diversity of criteria.

Beyond other limits of the AI performances, it is worth to observe that, while the AI algorithm learns, for improvements it has to use **new data**, i.e., **updates reflecting the refined data which inherently must contain the way the incumbents and people think over the dynamic and dramatic World changes, meaning, in fact, refined knowledge**.

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