The world has experienced three industrial revolutions with a fourth in progress and a fifth on the horizon. These transformations have brought major shifts to the way we work and live and major changes to the way industry functions. These changes have challenged not only industry, but also the quality infrastructure (QI) to respond and adapt in a manner that will ensure the benefits of the current transformation are realized. Quality and quality management are innovating in response to the challenges of digitalization and Industry 4.0.

At the same time, there is recognition that the Earth cannot sustain the current level of production indefinitely unless something changes. The world needs a new model of industrialization and infrastructure development that can sustain the Earth for future generations and hence the sustainability imperative was born. Recently, social responsibility-driven considerations around inclusiveness, representation, accessibility, and decent work, inter alia, have gained momentum in the discussion of the effects and uses of the digital transformation and associated technologies and innovations.

Today, industry is at a turning point with phenomenal forces transforming the sector to one driven by digitalization, new patterns of globalization, rapidly changing markets, consumer preferences and the social and environmental sustainability imperative. It is therefore timely to engage in a discussion on:

▪ How digital transformation is reshaping QI into what we now call “Smart QI” and “Smart Quality”;
▪ How QI is unleashing the fourth industrial revolution and how it supports and ensures adherence to the social and environmental sustainability paradigm.

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The new UNIDO publication, “Smart Quality Infrastructure: Shaping a sustainable future”, was officially launched at the virtual panel session. In order to set the scene for a deeper dive on the topic by QI expert panelists and participants who were free to ask questions, the panel session’s keynote address outlined the following technical aspects of the publication.

The publication provides a broad overview of how standardization has accompanied industrialization processes starting from mechanization, electrification and automation, through to digitalization and Society 5.0 (which builds on the fourth industrial revolution, cyber-physical systems, the merging of new technologies, and what is coming next, quantum computing). It is important that the digital transformation, particularly in relation to QI, has a strong emphasis on sustainability.

The analysis undertaken for the publication follows UNIDO’s systemic approach to QI, and addresses how the advent of advanced digital technologies opened new opportunities for QI and its organizations. Likewise, QI needs in this new digital era are redefining the notion of “quality”. This drives QI to transform itself to a more flexible “Smart Quality Infrastructure”.

Quality is also responding to the challenges of new technologies—including “automatic” decision-making processes; real-time monitoring and measurement and instantaneous feedback loops; pre-programmed collective actions; machine learning, predictive analytic and artificial intelligence (AI); advanced robotics and sensors; Internet of Things; and the Internet of Everything—and as such, has taken the designation “Smart Quality”.

The publication dives into the issue of the supply chain, now that we are witnessing its digitalization. The smart value chain encompasses digitalization, faster response to customers and improved communication throughout the chain. In the progression from mass production to mass customization, we must ensure that we are following a sustainable approach to the supply chain that takes into account environmental and inclusiveness issues, including human rights and decent jobs. Many skills will be needed in order to cope with this change in QI, and in quality itself, and we will see that the role of quality professionals will require a shift to support the digital transformation; the design and redesign of systems and processes; translating big data into real value in terms of preventing failures and complex problems; and continuous skills development and capacity building.

Understanding what the future holds is difficult because the speed of change will likely increase more rapidly as technology adapts and develops. Despite this, we can identify that future trends will include:

- Product manufacturing and services will converge based on market demand.
- Manufacturers will redefine their process around the new technologies.
- Hybrid human-machine processes will be on the rise.
- Manufacturing will incorporate more automated intelligence.
- Manufacturing culture will embrace digital.

These trends will bring new challenges—for the overarching issue of sustainability and for more operational issues such as cybersecurity—as well as numerous opportunities.
The discussion explored the impact of digital transformation on QI as well as elaborated on the evolution of QI in view of anticipating and meeting future needs, including how “Smart QI” can contribute to shaping a sustainable future. To that end, the session brought together experts to share perspectives, experiences, and concrete ideas on:

- What challenges does QI encounter on the way to becoming “Smart QI”?
- Where are the opportunities (for developing countries) in applying new technologies in QI? How can this contribute to sustainable industrial development?
- What are the risks of digital transformation in QI for people, planet and prosperity?
- Looking to the future, how can we ensure that the digital transformation of QI serves a bigger cause, thereby contributing to the sustainability paradigm?

**TOPICS OF DISCUSSION**

**TECHNICAL SPEAKERS**

- Roberta Gerasymchuk, Programme Manager, Strategy & PMO, International Organization for Standardization (ISO)
- Brahim Houla, Accreditation Service Director, GCC, Accreditation Center GAC/Communications and Marketing Committee Chair, International Accreditation Forum (IAF)
- Stefano Sedola, Chief Technical Advisor for MARKUP Kenya and QUALITAN, UNIDO
- Aparna Dhawan, Executive Director, TIC Council

**MODERATOR**

- Bernardo Calzadilla-Sarmiento, Director, Fair Production, Sustainability Standards and Trade, UNIDO
Panel Discussion

The digital transformation is altering all spheres of life. This calls for adequate standards in many areas that ensure the classical role of standards, interoperability and safety. How are standards evolving to meet the digital needs of the future? What role will standards play in the digital transformation process, and what is ISO doing in this regard?

Roberta Gerasymchuk shared that ISO sees digitalization as a tool to bring new efficiencies in delivering value to a variety of stakeholders (e.g., users, manufacturers, consumers), and, according to ISO’s vision, making lives easier, safer and better, which reflects its people-centric and value-driven approach.

- It is along these lines that ISO, in collaboration with the International Electrotechnical Commission (IEC), is structuring its current programme—IEC/ISO SMART (Standards Machine Applicable Readable Transferable)—to identify the necessary tools and processes to support this digital transformation and new deliverables.
- The programme will be built along the lines of the need from end-users and stakeholders to move from seeing standards as a document to standards as actionable content or as a service. Joint groups are working on collecting the use cases, analyzing the business models, conformity assessment implications and aspects, and, aligning on the technology side, approaching digital transformation through planning to grow digital capabilities of standards developing organizations (SDOs) and how to approach members in this regard.
- ISO wants to identify digital needs and deliver real value for people to make their lives easier, safer and better.

In this regard, we are seeing much more digital dominance and digital elements in the development and the preparation of the standards. Do you think that one day, standards may be only developed by AI?

Roberta Gerasymchuk responded that this question was tested on the recently released ChatGPT by Open AI:

Question posed to ChatGPT: “Are standards going to be developed by AI?”

ChatGPT response: “It is possible that AI will play a role in the development of standards in the future but it is unlikely that standards will be developed entirely by AI. Standards are often developed through a collaborative process involving experts in a particular field and it is difficult to imagine a scenario in which AI could replace the knowledge and expertise of these individuals. Additionally, the development of standards is often influenced by social and cultural factors that are difficult for AI to take into account.”

Moving from standards onto other areas. Accreditation is an area where, especially in COVID times, we have seen digital transformation has happened. COVID has brought about a new push to digital transformation and we have seen assessment techniques evolving. What are the most important technological advancements in accreditation, and how is it going to change how quality assurance is working?

Brahim Houla stated that the accreditation community recognizes that the digital transformation is going to change the way we work.

- Perhaps the pandemic accelerated this, but since then, there have been three types of challenges related to:
  » Customers, clients, conformity assessment bodies and industry
  » The way we do accreditation and assessment
  » The way in which we do capacity building

- We have seen a number of waves of digital transformation. The first wave included the use of information and communications technology (ICT), smart glasses, virtual reality (VR) and telepresence, and in conformity assessment activities, we saw inspection with drones and satellite navigation. It is really the second wave that is affecting the way we are working with the use of AI and data analytics, which is creating the challenge of having to adapt to it. In conformity assessment, there is a lot of data that is not used after the certificate.

- A future opportunity though is that AI and data analytics could predict the issues that could happen in systems even before going to audit, i.e., seeing how a company may work or a product may have failures in the future, before making the approval and the design.

- With regards to new techniques of auditing and assessing, the real question is not if it will be onsite or remote, but rather if it is going to be performed by humans or AI or both, or if it is going to be at a real organization or a digital twin of the organization. This is an example for certification but can see the same for automated testing, touchless calibration, digital simulations and inspections, and AI-led processes, all of which are forcing the accreditation community to adapt in order to stay relevant.

- In terms of delivery of capacity-building and training activities, the first wave, we moved to webinars and online training, and now we are also moving in the direction of VR and metaverses therefore a physical laboratory is not required to train assessors.

- Most importantly, it is not about the technology itself but about the skills and knowledge development in that field so that quality professionals can embrace the technology and adapt.
From the private sector perspective, where do you see the risk with these new technological advancements, and how can we prepare so that these processes are smooth and maintain people at the center?

Aparna Dhawan stated that the conformity assessment sector is a wide sector (e.g., food and agriproducts, health, heavy industries, environment) with quite a lot of diversification, and when we talk about digitalization of processes, there are a lot of activities that have to be considered (e.g., internal processes, communication, business activities).

- For example, from the collection of a sample to the time the report is released from the laboratory will have a lot of activities that will have to be taken up internally to ensure that it is foolproof, all digital methodologies are performed, and IoT and AI are being used at the maximum level possible. Human interface will always need to be there.
- Risks in this sector and across organizations relate to:
  - Complexity of processes: Investment needed to digitalize to make customer engagement easier, and an appropriate digital strategy needed for this undertaking to ensure resources used effectively.
  - Adequate skillset: Need for continuous upgrading of knowledge and skills of quality professionals in order to develop new processes, understand new technologies, and innovate, leading to maximum output.
  - Data protection & IT security management: With the explosion of consumer products with internet capability functionality, protection from cybercriminals will be essential therefore it is important to focus on good cloud management practices—adequate data protection tools will have to be applied so that there is a robust cybersecurity ecosystem that is set up, be it for accreditation, standards, or conformity assessment, to protect. Cyber security frameworks will need to be strengthened irrespective of developing or developed country or an organization’s size.
  - Weak public digital infrastructure: Related to Wi-Fi and connectivity issues.

- Mitigating factors include:
  - Need to develop uniform standards that can be globally practiced.
  - Digital strategy implemented by top management: Must look into an organization’s agility and options for collaboration.
  - Collaboration: Key as new technologies, terms and activities will be coming up.

What are the struggles of developing countries with these new technologies and with QI services? What is critical for industrial development?

Stefano Sedola described his first-hand experience of the struggles of new technology use within developing countries.

- At the macro level, struggles relate to infrastructure and power supply issues. There is a need to translate business and societal needs into the right technology solutions rather than pushing technology per se. From a developing country perspective, have to start from the problem.
- There is also typically a cost associated with new technology therefore need to find a way to lower this cost for a more sustainable digital transformation.
- Key message: data and data exchanges are also part of the digital transformation therefore need to explore ways of going beyond hardware. For example, additional data as part of smart farming allows farmers to implement timely and targeted strategies to prevent production losses and decrease costs.
- Three examples were provided related to data sharing helping smallholders:
  - Forecasting weather via smartphones (e.g., severe weather warnings), though not something many associate with smart farming, can have a profound effect on farmers’ decision making.
  - Smartphones can be used to warn farmers of biosecurity risks (e.g., goat farmers could receive notification of potential disease or outbreak in their area).
  - Technology and data can be used to enhance access to market/trade options for smallholders (e.g., smallholder can send notification of product to potential buyers).
- There is a need to give more relevance to how data is harvested and exchanged, and how data governance is addressed in developing countries.

Looking to the future, we want to see that efficiency gains of technology are not at the expense of other important things like the imperative of sustainability, social inclusion and existing environmental challenges. How can we balance this as industry will be looking at efficiency gains?

Aparna Dhawan agreed that it is important for efficiency gains not to happen at the cost of important causes.

- For example, in the conformity assessment framework, the audit system shifted from onsite to remote assessment during the pandemic year. This exercise brought challenges globally because effective time management was required, assessors needed to be trained, and effective tools had to be used.
- Solutions were found which include guidance documents from IAF and regional bodies, efficient ways of conducting remote assessments and a TIC white paper on remote assessment techniques. Can now say that a balance between remote and face-to-face methods is the best way to adapt to the technology.
- Likewise, when talking about digitalization practices, there is a need to have a digital strategy that considers the following factors:
  - Connectivity: Connect and share all information, merge it, link it with the data, collaborate with each other, and once connectivity happens effectively using digital technologies, there will be an integrated flow of high-quality data.
  - Improving connectivity: For example, the challenge of laboratory efforts being hindered by laboratory equipment and software can be addressed by using appropriate sensors, augmented reality, and appropriate methodology, and when connectivity is improved, have data that can be used to identify gaps to improve assets and improvise strategic activities such that there is maximized gain of current laboratory operation.
  - Implementing advanced analytics.
How can standards play a role to ensure sustainability is not left aside and remains the focus of our attention?

Roberta Gerasyzmchuk confirmed that net zero guidelines were introduced at COP27, a huge milestone in ISO’s sustainability commitment:

▪ All standards contribute to the Sustainable Development Goals (SDGs), and in this regard, smart/digital standards can help in understanding impact on SDGs/contribution to sustainability.

▪ Additionally important to understand that standards provide framework for the development and implementation of new technologies and practices, and they help ensure that these technologies and practices are developed in a way that is safe and efficient.

▪ By participating in SDOs, individuals can help shape future innovative technologies. Smart/digital standards will provide new opportunities for the feedback loop into standards development from end users, consumers, and everyone who is participating in the new digital standards creation process but also for the usage of it.

Looking to the future, how can we ensure that digital transformation of QI can serve a bigger cause, contributing to the sustainability paradigm, particularly from the perspective of developing countries?

Stefano Sedola stressed that sustainability is an imperative for all of UNIDO’s projects. Within UNIDO, there is a clear vision that low-tech delivery mechanism needs to be encouraged along with high-level technology, and that this will eventually support human capital development.

▪ Call to action to encourage, at the design level of a capacity building programme, low-tech delivery mechanism to be accelerated using new technologies that answer specific needs.

▪ An example was provided of low-tech delivery project in Tanzania focused on building capacity of an institution by using technology to accelerate the pace of capacity building and reduce the cost of compliance. In a laboratory management information system, such a solution enabled the reduction of cost of compliance, helping with a large volume of laboratory data, while adhering to strict standards and improving efficiency and turnaround time, enabling the automation of the relevant protocols within the laboratories. Simple digital applications can enable the reduction of cost of compliance.

Moving to action now, what will be needed and how can we contribute?

Brahim Houla pointed out that this is being discussed at different levels of accreditation.

▪ Most important is the need to apply digital transformation but still keep trust in what we do. Though not everything needs to be digitalized, a wisely planned strategy for capacity building and digitalization needs to exist, while having the trust of regulators and users (as remote is not as trusted as onsite) therefore our digital transformation focus must be on how to deliver that.

▪ An example was provided of the Arab Accreditation Cooperation’s digital transformation project that helped a number of accreditation bodies access software that digitalized different processes, saving the accreditation bodies time and money. IAF had its own digital transformation project in which it digitalized all of its procedures and processes and allowed developing countries access to information on how they digitalized their own processes.

▪ INetQI and regional QI networks are also discussing the importance of ensuring that technical support projects focus on digitalization in a wisely planned manner. The trade potential of developing economies is related to the trustfulness of the QI. Digital transformation adds to that trust because of quality fairness and data transparency, which adds to that infrastructure. This is a real focus of support projects that need to be developed for developing economies so that we can ensure a sustainable future for these economies.

Another example is the use of QR system for market surveillance and traceability that provides the users of this application the possibility of scanning a QR code on a product using a smartphone camera. The scan is communicated to the smartphone, the smartphone reads the QR code and sends to the cloud, matches with the database of products, and communicates the results to the operators. Data is tracked in real time, made available on the dashboard and able to verify the validity of quality of product on market—this can be used in any technical cooperation project.
Questions from the Audience

QI will drastically change in the future. What will be needed for quality management and professionals to keep up with technology intervening in QI?

Brahim Houla: At the IAF and ILAC level, a working group was created to help members follow what is happening around the world and to give guidance to members as well as to establish best practices in the field.

Stefano Sedola: The role of quality manager will evolve and increase in importance as there will be more and more technology embedded into the organization. The quality manager is someone who can translate the business needs and processes of the organization into the right technology system or application. One example is the AI Act that will be approved by the European Union Parliament and will enter into force, and there are conformity assessment procedures required for AI systems and conformity assessment rules that have to be followed, defined by the regulator. The quality manager will have the additional responsibility of ensuring this compliance to the AI Act. A technical file will embed requirements from the AI Act and therefore requirements about data quality, data harmonization, and ethical human-centric requirements. There is a great future for the quality manager who will invest in developing their digitalization skills.

Aparna Dhawan: Collaboration is key between the different organizations to produce a guide document.

Building upon Brahim Houla having said that IAF and ILAC are supporting developing countries with embracing this digitalization journey, are there any plans to further develop guidelines at the global level?

Brahim Houla: Part of the task of the working group at the conformity assessment and accreditation levels is to develop guidelines and documents for conformity assessment bodies, laboratories, inspection bodies, and for specific industries, but there is a need to collaborate with the different organizations at the InetQI level to have a harmonized message and information spread around the world.

Conclusion

The changes brought about by the ongoing digital transformation have challenged both industry and QI to adjust in ways that will ensure the benefits of the transformation are realized. In response, quality professionals need to upgrade their skills and the knowledge in order to embrace digital technologies and adapt. While there are a number of risks associated with the digital transformation for QI systems and organizations in general, they can be mitigated by developing uniform standards that can be globally practiced, implementing an appropriate digital strategy and collaborating.

From a developing country perspective, there is also a need to give more relevance to how data is harvested and exchanged as part of the digital transformation, and how data governance is addressed. In this regard, a low-tech delivery mechanism needs to be encouraged along with high-level technology to answer specific needs when designing capacity-building programmes. As the trade potential of developing economies relates to the trustfulness of the QI, and digital transformation adds to that trust, international and regional QI networks stress the importance of ensuring technical support projects focus on digitalization in a wisely planned manner in order to ensure sustainability. Along these lines, it is important to understand that standards serve to ensure that new technologies and practices are developed both safely and efficiently, and that a plethora of stakeholders can help shape future innovative technologies through participating in the standards development process.

Looking to the future, this all highlights the continued need for collaboration through partnerships in order to address the challenges and to reap the benefits for people, planet and prosperity.