The Digital-Physical Transformation Imperative for the Public Sector

By

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Executive Summary

We live in a digital world founded on data generated by **humans** creating text, pictures, audio, and videos using digital tools and by, **cyberspace** applications and automated systems. Digital has invaded private enterprise and is the way of living and working through public big-platform social media and business services and offerings. Consequently, we are in the midst of massive digital transformation creating new digital and human processes which are changing our human behaviour, societal characteristics, and economy – compelling new digital governance and policies to amplify digitalization benefits and mitigate risks.

But wait - the **physical world** is also undergoing rapid digitalization – sensors, actuators, everyday objects, intelligent devices, and more. The resulting **digital-physical transformation** also has tangible impacts on individuals, businesses, and organizations that manifest in broader, higher-level **economic and societal transformation**. And yet, digital-physical transformation significantly lags the public policy and digital governance attention compared to digital transformation in the enterprise and big-platform contexts noted above.

At its core, **Digital-Physical Transformation** is the endowment of **digital personas** to **physical things** through embedded computing and Internet connectivity, or Internet of Things (IoT). What used to be inanimate objects (doors, cars, trees, etc.) are undergoing **physical animation,** transforming into smart and autonomous things that are seemingly coming to life. And, what used to be spaces where our only intelligent interactions were with other humans are now transforming into spaces that include interconnected intelligent digital-physical personas, creating human-aware **ambient intelligence** around us with which we can have "intelligent" interaction.

The mingling of humans and ambient intelligence in cyberspace blurs the boundary between our interactions with humans and the physical environment, creating a new and ambiguous model of our world. With that, we can no longer accept the physical world as being somehow separate from the digital world, so it's imperative that digital-physical transformation is brought under the overall digital transformation big-tent – including related digital governance and policy innovation.

To achieve the above, the public service must elevate their **digital literacy** around physical digitalization and its societal and economic impacts. That means knowing the essential concepts and terminology, understanding their inter-relationships, and applying it to **user-centered** governance and policy innovation, and government services.

Consequently, we must have an effective way for policymakers to acquire that technological intuition. To that end, Design Thinking is an invaluable tool to elevate digital literacy, help innovate digital-physical solutions and governance, and ultimately bring Digital-Physical Transformation into the fold under the Digital Transformation big-tent.

> ***Digital-Physical Transformation is real. It is not separate from the overall Digital Transformation efforts, including the Digital Governance innovation it compels.***

> ***Ignoring Digital-Physical Transformation and IoT means stalling economic transformation and accepting a less competitive economy and nation.***

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1 Introduction

We are in the midst of accelerating digital transformation, and with it, we have evermore technology and data, driving automation and greater efficiencies. The pandemic has further spurred digital transformation due to physical distancing requirements, reducing human workplace activity and interaction, and compelling even more automation to mitigate pandemic risks and effects.

Digital Transformation is the adoption of digital technologies and processes to make our work and lives easier. It has, so far, been a convergence of humans and cyberspace in the enterprise and social (big-platform) contexts involving co-production and co-consumption of data by humans and cyberspace. That convergence includes using digital technologies to take on mundane or repetitive tasks or to gain better insights through data analysis to achieve higher operational efficiencies and service quality (to name a few).

Human and enterprise-systems-generated data and communications have dominated digital transformation efforts for over two decades. Human-generated data comes from digital technologies that humans interact with – such as text documents, pictures, videos, emails, forms, tweets, etc. Enterprise-systems-generated data comes from digital computing applications and background processes in the enterprise cyberspace, such as gathering and managing data (e.g., inventory, billing), performing analytics, bots of various sorts, and more.

But wait - the physical world is also undergoing rapid digitalization – sensors, actuators, everyday objects, intelligent devices, and more. The resulting digital-physical transformation also has profound and consequential impacts on individual humans, businesses, the economy, and society. And yet, digital-physical transformation significantly lags the public policy and digital governance attention compared to digital transformation in the enterprise and social contexts above. The **physical is becoming digital**, and the corresponding digital-physical transformation must be brought under the big Digital Transformation tent to systemically and systematically address the full **human-cyberspace-physical convergence**. And that starts with

Digital vs. Cyberspace

Digital

"Digital" nominally means the encoding of data and information using electronic digits or binary bits, its aggregation, and storage. However, "digital" is also broadly used as a catchall term extending the definition to additionally encompass an entire realm of electronic or human processes that manipulate and use digital data.

Cyberspace

"Cyberspace" is a concept that envelops connected computing, the [digital] data it processes and communicates, virtualized on connected systems. The scope of "cyberspace" is discussion context dependent – it could mean localized enterprise connected computing, or the entire Internet, or subset of connected private networks and cloud.

vs.

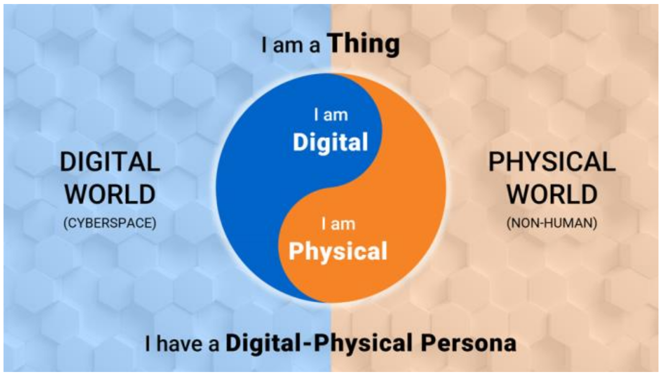
"Digital" only exists as underpinned by connected computing of digital data in cyberspace, and "cyberspace" only exists in a digital context. They are intimately intertwined, and consequently they are often, rightly or wrongly, used synonymously.

literacy in digital-physical transformation to create the digital-physical solutions and governance that our new world compels. Without it, we give up on economic growth and a smart, safe, and inclusive society.

2 Enter Digital-Physical Transformation

At its core, **Digital-Physical Transformation** is the endowment of **digital personas** to **physical things** and their consequential transformative impact through interaction with other physical and digital entities – and humans.

2.1 The Basics



By "**physical things**", we mean, literally, the material objects and spaces we interact with and occupy. Everyday things like doors, cars, rooms, sidewalks, thermostats, trees, gardens, cows, drones, and robots – the list is endless. These are things that we humans can sense and feel through our touch, vision, smell, and other human senses and **can physically manipulate** directly with our body or the mechanical (dumb) tools we use.

A persona[1], typically referring to humans, is a role or behaviour that is externally or publicly observable. That means it has a set of characteristics and states that are communicated (or perceived) outwardly. A **digital persona** is a role or behaviour whose attributes are digitally encoded and communicated. It can represent different types of entities, including applications in cyberspace, humans, or physical things.

So - how do physical things acquire digital personas? That's accomplished by embedding computing and communications microelectronics into physical things. Computing that can range from simple and minute eight-bit microcontrollers to sophisticated high-end processors and even specialized AI-purposed processors – depending on the role and complexity of the thing. And digital communication can be of various feeds and speeds, and protocols. This hyperconnectivity includes wireless technologies ranging from Bluetooth to 5G, fiberoptics, and wired connectivity, such as Power over Ethernet (POE).

2.2 The Transformation Begins

The acquisition of digital personas by physical things, call them **digital-physical personas**, gives rise to two fundamental and critical transformational characteristics:

- **Smart things** - The exponentially advancing computing is enabling more complex thing functionality with greater awareness of its environment and interaction capability - resulting in "smart" things.

[1] Persona, Wikipedia, https://en.wikipedia.org/wiki/Persona

- **Internet communication** - Despite the advancements in various communication speeds and feeds technologies, the Internet Protocol (or the IP layer) is ultimately the standard layer where the thing or thing-related communication occurs.

In effect, the digital-physical personas are smart things that communicate over an internet, and that is the basis of the **Internet of Things (IoT)** – a collection of connected communicating digital-physical personas.

The smart things or digital-physical personas that comprise the **Internet of Things generate and consume a lot of data**. The data they transmit represents the physical world around them or their internal state – e.g., temperature, humidity, location, orientation, human presence, battery level, etc. The data they receive constitutes information from other physical-digital personas or applications in cyberspace that they need to act out their role - e.g., control commands, state of other personas, etc.

That data must be managed, communicated, secured, stored, and analyzed over the Internet, in the cloud or locally, to extract value from it.

Why is the Internet of Things so transformative? IoT drives digital transformation at several layers, including the higher economic and societal layers (covered later), but they are all grounded in the following fundamental transformations.

- **Physical Animation** - What used to be inanimate objects (physical things like doors, cars, trees) are now transformed into intelligent and often autonomous things. They seemingly come to life due to their animated interaction with each other and humans – physically and digitally.
- **Ambient Intelligence** – What used to be spaces where our only intelligent interactions were with other humans are now transformed into spaces that include intelligent digital-physical personas. They collectively create a human-aware ambiance with which we can now have "intelligent" interaction (e.g., human-aware sidewalk robots, mall kiosks, smart speakers, factory cobots, etc.).

2.3 A Unified Digital Realm - same-old but new?

Once we endow physical things with digital personas, making them smart and communicating over an internet, **how do we combine them into solutions and derive value** from them? Do we build a separate infrastructure for the Internet of Things – a separate internet, dedicated cloud, or IoT-specific connectivity? Do we use/create commercial and public infrastructure or build private enterprise structures?

Fortunately, the **same-old Internet/Web** we've been using in enterprise and social IT contexts is both a model and an available infrastructure to support IoT. That's because **there are significant needs and characteristics overlaps between the digital-physical personas and the digital personas in the enterprise and social IT contexts**. All of these personas

- rely on the Internet,
- store, manage, and analyze via cloud services,
- use access technologies like Wi-Fi, Ethernet, cellular, optical, other, and
- can build solutions on public or private networks and clouds

What's new? Compared to human-generated or enterprise-systems-generated data, physical devices produce real-time data that require deterministic, resilient, and low-delay communication. Also, the device density (devices per unit area) can far exceed most enterprise or public device situations – e.g., hundreds of thousands per square kilometer. In addition, IoT devices, unlike enterprise computers and terminals, are often deployed in very remote locations without access to electrical power, requiring battery operation.

The solutions to such IoT requirements are new **add-ons to the existing Internet/Web paradigm**, primarily in the form of new communication technologies. For example, 5G was designed to address super-high device density (up to one million per square kilometer), low latency, and low-power communication requirements. Other communication technologies, like LoRa, offer super-remote access for very low-power devices. In addition, cloud extensions add real-time data services to align with the IoT device data qualities and volumes.

But - what's really new? The really new and most transformational aspect of Digital-Physical Transformation, with IoT at its core, is the situation we now have where humans, enterprises, applications in cyberspace, and smart physical things cohabitate on the same Internet/Web - creating a new **Unified Digital Realm**. In addition, the number of devices, or digital-physical personas, will far exceed, by many multiples, the number of humans in it. The expected 75 billion IoT devices will dominate Internet activity in the next few years compared to the eight billion humans.

What will it mean to have so many smart physical devices digitally mingling with humans? What tremendous benefits will industry and humanity enjoy? And, if we thought we were already stressed about dealing with the insidious aspects of the existing Internet, how will we cope when 75 or 100 billion smart (often autonomous) devices join in? In addition to addressing the issues like privacy and cybersecurity at a much larger scale, we'll now also face **physical risks** that Digital-Physical Transformation introduces.

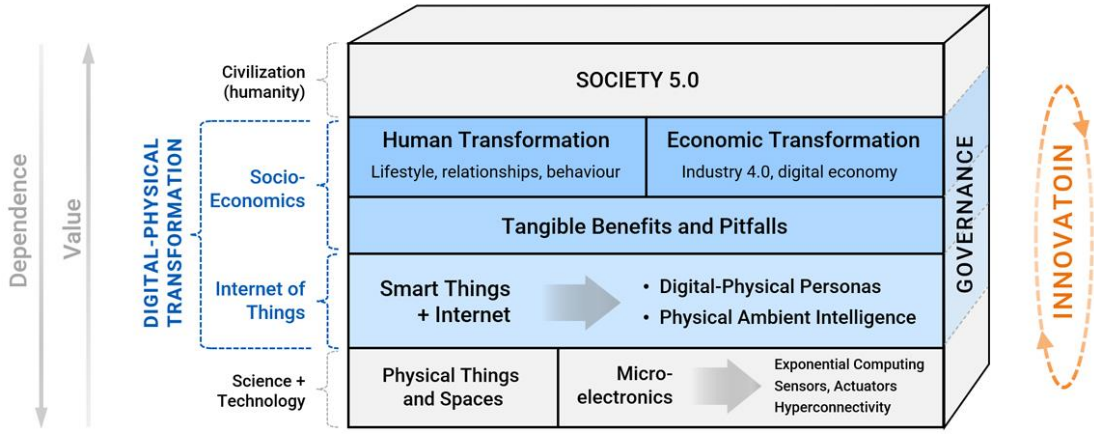
> *Digital-Physical Transformation is real. It is not separate from the overall Digital Transformation efforts, including the Digital Governance innovation it compels.*

3 So What?

We can no longer afford to treat the IoT-based physical digitalization and the resulting Digital-Physical Transformation separately from the broader Digital Transformation discussions and efforts. After all, the Internet of Things space or paradigm has made its way into every corner of the global economy, substantially impacting our work, lives, and society.

It's everywhere, including **vertical digital solutions** such as connected transportation, smart buildings, smart cities, wearables, connected health and others. Its **architectural components,** such as 5G and other types of networks, cloud installations and data centers, and user applications, are also the bits and pieces involved in enterprise and social digital transformation. And the enabling and impacted **disciplines and domains** like AI, semiconductors, cybersecurity, numerous digital algorithms, and business models and processes are at the **forefront of digital innovation and transformation**.

The above result in tremendous impacts and, therefore, reasons why we should care about IoT and its transformational forte, as expressed in this "[Internet of Things – why should you care]" video brief.



The reasons and impacts why care about IoT can be divided into several broad categories, including

- tangible material benefits,
- tangible material pitfalls,
- economic transformational impacts,
- human and societal transformational impacts, and
- governance transformation

The above constitutes a layered framing of impacts where the immediate tangible IoT benefits and pitfalls at one layer drive the higher-layer economic and societal impacts and transformation. Both layers and the IoT layer compel systemic human-centered governance transformation.

3.1 Tangible Benefits

There are many recipients of tangible benefits from IoT and the Digital-Physical Transformation it drives.

For **individuals**, IoT means better health and fitness based on biometric and activity data from wearables, for example. Or more convenient, safer, and energy-efficient homes from smart thermostats and security systems.

In **business**, IoT underpins automation, which increases product and service quality, and lowers operating costs through reduced human involvement. It enables faster and more reliable supply chains, reduces equipment and facility costs, and makes work safer.

The **economic** benefits, for example, include safer, faster, and more efficient movement of people and goods through connected and autonomous transportation, more reliable energy distribution such as through electrical smart-grids, and more.

Communities and **society**, in general, get benefits such as better quality of life through Smart Cities founded on IoT, with efficient mobility, greater safety and security, reliable infrastructure, and more. IoT also elevates **public health effectiveness** - including earlier infection detection and pandemic mitigation through touchless automated interaction and connected medical devices for diagnosis, treatment, and care.

All levels of **government** benefit from improved service delivery, operational efficiencies, and reduced cost and risk through asset management, regulation compliance monitoring, automation and other operations areas.

In addition, Digital-Physical Transformation is essential for executing the climate plan, which, among other initiatives, must include the Circular Economy.

> ***Remaining unaware of Digital-Physical Transformation and IoT means hindering the tangible benefits for constituencies ranging from individuals to society, businesses to the economy, and government.***

3.2 Tangible Pitfalls

As with any disruption or transformation, Digital-Physical Transformation comes loaded with pitfalls or negative impacts, including the two very tangible and ever-present cybersecurity and privacy risks.

Cybersecurity risk is a top-ranking IoT concern stemming from Things, or the Digital-Physical personas, effectively being connected computers. Consequently, they are vulnerable to cyber-attacks and are hackable to become platforms for launching attacks. Cyberattacks disrupt the digital functioning of Things and cause physical faults that can cause serious bodily harm or death by, for example, releasing hazardous industrial gases, disrupting patients' I.V. drips, or disabling residential or business machinery (like cars, drones, and HVAC). And with the billions of Things deployed, they are ideally suited for supporting massive botnets.

Privacy is a big concern stemming from the IoT sensing and monitoring capabilities. For example, the wearables we sport can transmit our intimate bodily information and location. And the ambient intelligence around us, the various sensors in the space we move within, can track and analyze our behaviour, generating data about us that can be put to malicious or unwanted use.

Unfortunately, digital governance concerning IoT cybersecurity and privacy is in its infancy.

There are even more pitfalls from the higher-layer economic and societal transformation induced by Digital-Physical transformation, covered below.

Illiteracy in Digital-Physical Transformation and IoT means being unaware and accepting tangible pitfalls of cybersecurity and privacy risks and the physical and bodily harm that smart Things can impose.

3.3 Economic Transformation

Digital-Physical Transformation is a significant driver of economic transformation. IoT application in industry or IIoT (Industrial IoT) revolutionizes industrial activity through increased automation, connected manufacturing and supply chains. **Cyber-physical Systems**, or the coupling of massive data generated throughout these physical systems and ubiquitous connected computing, drive innovation in digital algorithms, analytics, and AI to create value. That digitalization of industry is one of the main pillars, the digital pillar, of the fourth industrial revolution, or **Industry 4.0** - a new competitive landscape for companies and nations.

Cyber-physical Systems are not just present in manufacturing. They are also applied in other economic sectors, including Smart Agriculture, Smart Mining, Oil and Gas, and more – all aiming to increase efficiency, product quality and quantity, and financial return to stakeholders.

While Cyber-physical Systems and Industry 4.0 drive demand for new types of higher-skill economic jobs, they also fundamentally shift demand and costs away from labour, blue-collar, and some white-collar work to more efficient smart machinery, robots, and AI.

> ***Ignoring Digital-Physical Transformation and IoT means stalling economic transformation and accepting a less competitive economy.***

3.4 Human and Societal Transformation and Impacts

Like the Internet, which has recently driven human and societal transformation, the Internet of Things is poised to amplify that transformation from the intensified physical digitalization. That transformation comes in the form of beneficial behavioural changes and better quality of life, but also the seemingly intangible, though genuine, concerns around the future of work, human agency, and cyber autonomy.

Human Behavioural Impacts

Physical digitalization brings with it human behavioural impacts – both intentional and unintentional. For example, that includes behaviours like greater motivation from wearables for healthy activity due to their motion and biometric sensing capabilities rather than friends and coaches. Or, taking cashless and payless shopping to the next level, like walking into a brick-and-mortar store, grabbing what you want, and just walking out without stopping to pay. That's made possible by IoT-based shelf inventory, customer tracking, and surveillance automation, with charging/billing in the background.

The above are just two of many consequential behavioural changes from Digital-Physical Transformation, which, at their core, have ever-diminishing interaction and dependence on other humans while increasing reliance on smart Digital-Physical personas. With that, we have to ask who is accountable for things we depend on and, therefore, where are the related transformational public policies and governance. For example, in a world where we can buy IoT things from anywhere globally through sites like Amazon that don't necessarily comply with product regulations, what protection do we have? What responsibilities do developers of physical products (IoT devices and applications) need to take on – in terms of human behavioural impacts and accountability to humans?

Also, as the physical transforms to digital (i.e., becoming virtual), it further reinforces the already prevalent virtualization of humans – i.e., somewhere in cyberspace without a physical location or even physical body association. For example, one of the authors recently talked on the phone with a new consultant in a different area code about working together. The image of the consultant being in cyberspace, not in any particular location, came naturally, especially due to the area code difference. As they spoke, they realized they were just two physical street blocks apart, immediately ascribing physical attributes to each other as humans and realizing that it could have been more productive and relationship-building to meet in person. Our physical vicinity still matters, and cyber-human-physical integration and physical awareness are vital, paradoxically, to leverage our physicality for good and to protect against physical privacy intrusion.

Societal Impacts

In addition to driving the transformation of human behaviour above, Digital-Physical Transformation presents some seemingly intangible, though real, higher-level negative societal impacts. IoT challenges the **future of work** with its fundamental role in automation – not only for labour but also for cognitive and decision-making functions. Consequently, our **human agency** will be challenged, diminishing the feelings of relevance and **societal inclusion.** That threatens to destabilize and fragment human and class relationships. It could further escalate the social and political turbulence we are already seeing if it's left unaddressed through missing transformational social policies.

Another potential danger lurking in Digital-Physical Transformation is the possible **erosion of cyber autonomy**. Given some of the benefits of wearables and ambient intelligence enabling continuous digital tracking of humans, will cyber-tracking become the norm, and will we become permanent residents of cyberspace, not allowed to be disconnected and losing our autonomy? That is not just a hypothetical but already a reality in less democratic jurisdictions.

To facilitate the positive human and societal impacts of the Digital-Physical transformation and mitigate the negative, we must ensure the survivability and resilience of the digital-physical space and personas. For example, it's essential to understand and deal with the implications of devices creating radio-frequency (RF) interference with other devices, unintentionally or maliciously rendering them inoperable or allowing security breaches into our home or workplace networks.

> ***Understanding Digital-Physical Transformation and IoT enhances the human experience and societal interest. It identifies the future-of-work, human-agency, and societal-inclusivity risks that lurk in digital-physical intensification that we must tackle.***

3.5 Digital Governance Transformation

As Digital-Physical Transformation with IoT delivers tangible benefits along with tangible risks, it also drives profound broader socioeconomic transformation. Those benefits, risks, and transformations stem from the IoT-created ambient intelligence, which shifts how we see and experience our lived environment and deal with the world.

Until this age of IoT, we had the human-to-human environment and its (intelligence-to-intelligence) interactions and the separate human-physical environment and its (intelligence-to-inanimate) interactions. As a result, our governance and policies dealt with human-human relationships, expectations and boundaries on behaviours, and separately with our rights and responsibilities for property and movement within the inanimate physical environment.

But things are different now. The mingling of humans and ambient intelligence comprised of digital-physical personas is increasingly blurring the boundary between our interactions with humans and the physical world, creating a new and ambiguous world model. **We are no longer concerned with just siloed human-human and human-physical (inanimate) interplay to drive our policies, but the wholistic realm converging humans, cyberspace, and the (intelligent animated) physical world.**

Additionally, new technologies have historically given diagonal (parallel but delayed) rise to new policies and often entire governance models. And for good reasons – accelerating and scaling adoption and mitigating adverse effects. It's not too different today. However, the digitalization of everything and the rise of exponential advancement of technologies surrounding digital-physical transformation is creating a gaping and ever-widening governance hole - not just in digital governance but also in broader socioeconomic policies. When governance policies are not developed, that's a de facto decision not to govern.

This situation compels a corresponding governance transformation. That certainly includes new policies to deal with the new digital-physical world and its socioeconomic impact. But it also compels transformation of the policy-making process to simultaneously ensure the creation of human-centered policies and innovate governance faster to close the widening digital-governance hole.

Unfortunately, many quarters in public and private organizations are unaware of Digital-Physical Transformation and IoT, resulting in missing or incomplete policies. That means missed opportunities for economic growth, national competitiveness, and societal good and protection. For businesses, this also means missing opportunities for revenue generation and efficiencies. One of the many benefits of Digital-Physical transformation is enabling more efficient and effective services and allowing for enhanced customization. Without this, organizations are susceptible to profit decline, liability and irrelevance.

Digital transformation started in the digital enterprise converging humans and cyberspace, enabling the creation of better digital services for citizens and customers. **How can we now create better services for citizens by heeding Digital-Physical Transformation?** How do we include Digital-Physical transformation as an inextricable and necessary part of the overall Digital Transformation? That is, to bring intelligent physical objects and spaces into the fold – as part of the broader digital strategy and digital operations implementation, including monitoring

and maintenance. And what do we need to know, understand and be able to use for a systemic and systematic approach that involves all three digital-realm components – cyberspace, humans, and the physical?

Unaddressed, digital governance will remain incomplete, leaving to chance the impacts of IoT and ambient intelligence and where we ultimately end up as a civilization. As Ella Wheeler Wilcox put it, *"Tis the set of the sails and not the gales which decides the way to go"* – so we must set the sails in our quest for digital governance in a seascape that includes Digital-Physical Transformation and IoT.

> ***Physical things and IoT now compel digital-governance transformation as sure as screens, clicks, scrolls, swipes, and social media have, but with property integrity and human bodily well-being and risks at stake.***

4 What should we do about it

While it's critical to appreciate the above opportunities and challenges of Digital-Physical Transformation, what do we want to get out of it, and what is our way forward? That is, **ensuring that we reap the corresponding benefits and mitigate the risk deliberately** – rather than leaving ourselves, as a society and economy, exposed to where the wind may blow or letting the chips fall where they may.

Whatever we do, we must ensure to put humans as individuals and citizens of society at the center. But, we should do it in a way to maximize technological benefits for humans within an intelligent, just, and inclusive society.

That objective and its realization are aptly represented in the far-reaching aspirational model and a growing movement for Society 5.0. Initially devised as a blueprint for a "super-smart society" for Japan, Society 5.0 merges cyberspace and physical space with humanity. It's enabled and driven by digital-physical transformation, including cyber-physical systems, IoT, and related technologies and systems such as AI, robotics, hyperconnectivity, autonomous driving, and more. It's a human-centered model that balances economic progress with a just and inclusive society, where technology plays critical roles in both aspects

Society Evolution

	Society 1.0	Society 2.0	Society 3.0	Society 4.0	Society 5.0
Society	Hunter-gatherer	Agrarian	Industrial	Information	Super Smart
Productive approach	Capture/Gather	Manufacture	Mechanization	ICT	Merging of Cyberspace and physical space
Material	Stone, Soil	Metal	Plastic	Semiconductor	Material 5.0
Transport	Foot	Ox, horse	Motor car, boat, plane	Multimobility	Autonomous driving
Form of settlement	Nomadic, small settlement	Fortified city	Linear (industrial) city	Network city	Autonomous decentralized city
City ideals	Viability	Defensiveness	Functionality	Profitability	Humanity

Cyberspace Human Physical Convergence

Adapted from Society 5.0 A People-centric Super-smart Society

To realize the aspirations of Society 5.0, we must start from a position of strength in digital literacy around digital-physical transformation and IoT.

> ***We must have an effective way for policymakers to acquire technological intuition around IoT, to develop policies for IoT innovation and adoption and the related social and digital governance.***

4.1 Digital Literacy

We must elevate our literacy in IoT and Digital-Physical transformation to fill out our overall digital literacy and complete the whole digital transformation journey. That means **knowing** what is out there, **understanding** it, and **using** it to innovate solutions and governance around it, as we explain in our article on IoT and Digital-Physical literacy.

Knowing means having access to, and being able to take in information about, IoT and Digital-Physical mechanisms, their concepts, terminology, who's doing what, and knowing where to get it.

Understanding means finding patterns and associations between the concepts to critically analyze, interpret, gain insights and infer consequences and conclusions from the information.

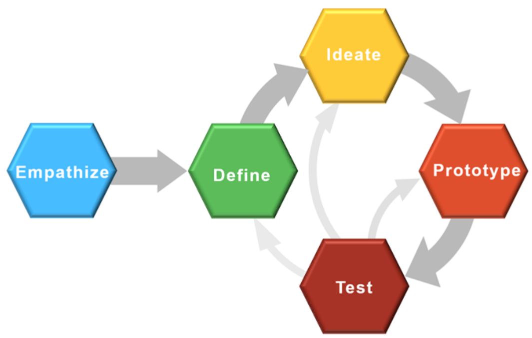
Using means applying the gained understanding of IoT and the physical-digital realm toward innovation of new solutions and related digital governance.

It's apparent that digital literacy means more than just being able to use and operate the technology. It, more importantly, enables us to innovate products, policies and services in an informed and reasoned way, but with one crucial bias. A human-centred perspective is needed to understand the people, how they use IoT products, and what should be done for citizens or customers through policy. As part of digital transformation so far, we have only been looking at the cyber-human interplay aspects, but the physical aspect, more precisely the digital-physical aspect, has been overlooked.

Digital literacy in physical-digital transformation requires not just literacy of IoT or the digital-physical components and applications but must also include that human-centric focus. Consequently, we must use a human-centric methodology to innovate solutions and governance – and that's where design thinking comes in.

4.2 Design Thinking for Digital-Physical Innovation and Literacy

Design thinking is an invaluable method of ensuring the integration of cyberspace, human, and physical components in a way that serves humans and societies. Design thinking is about looking at challenges from a human and end-user perspective. We look to understand the end-users' challenges before identifying the problem we aim to solve. Creating technologies for the sake of creating technologies may be fun, but at the end of the day, the technology needs to solve a challenge for end-users – customers or citizens.



Design Thinking

Design thinking is so effective because time is taken to **empathize** with the end users to understand the end-users' real needs, achieving clarity before we **define** the real problem to be solved and its scope. Once the problem is clearer, it is easier to make decisions along the way, including the essential tasks of **ideating**, **prototyping,** and **testing** the solutions. It's a recursive process, ultimately converging onto one or more solutions.

Design thinking has been used widely for some time in the private sector by organizations like Procter & Gamble to understand their customer's needs better and create more innovative products. And the public sector has leveraged design thinking more recently to develop better services internally within the government and create better services for citizens. That is, analyzing and working with internal and external end clients to better understand their pain points and develop solutions with them to increase services' ease of use and effectiveness.

Businesses like Telus used design thinking to foster 5G adoption innovation among potential partners and customers. Design thinking was used to identify customer and partner challenges and how to support people to understand better that 5G is here to help solve their problems. The outcome was the Telus innovation hub strategy. They also use design thinking within the innovation hubs to issue challenges based on knowledge and understanding of end users. The solutions to challenges are then presented back to users (a city, a hospital, an enterprise, a mine, or an agriculture farm) for validation and eventual productization. That is a much faster and higher-quality go-to-market approach than traditional methods.

In the public sector, design thinking supports agile procurement of products and services, such as at Shared Services Canada, by first talking with end users to better understand them and their needs before articulating a better-defined challenge to vendors. Once conversations and a selection process are completed, fewer vendors can prototype and test their solutions and select the best solution for their end users.

Design thinking serves to innovate Digital-Transformation and IoT solutions and governance. It also aids literacy development by applying it to use cases that are part of a group-based human-centered interactive learning process.

> ***Design thinking is an invaluable tool to bring Digital-Physical Transformation into the fold under the big Digital Transformation tent.***

5 Conclusion

We are in the thick of Digital-Physical Transformation with the Internet of Things (IoT) at its core, where **everything and every Thing is connected**. Physical Things (with their Digital-Physical Personas) are digitally interconnected with cyberspace and humans, resulting in a new unified digital realm with powerful socioeconomic benefits and some significant pitfalls. Therefore, the technological innovation it drives must also be coupled or interconnected with digital-governance transformation to reap the benefits and avoid those pitfalls.

We can no longer afford to think, let alone accept, that the physical world is somehow separate from the digital world. As such, Digital-Physical Transformation is an inextricable part of overall Digital Transformation pursuit and innovation. To innovate IoT, its related technologies, and the required digital governance, a baseline level of digital literacy is needed for public servants - including technological intuition among public-sector executives and policymakers. Since governance is all about meeting citizens' needs, it's important to empathize with citizens and uncover their real and diverse problems and requirements. That's where Design thinking steps in – for human-centred and inclusive digital governance innovation and digital literacy elevation.

Everything and every Thing is digital.

Everything and every Thing is connected.

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