Tackling the challenges of technological convergence for governance and regulation

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Safeguarding future generations through forward-looking tech governance

From interdisciplinarity to convergence

- **Interdisciplinarity** = **integration of knowledge**, methods, and perspectives from multiple disciplines to address complex issues or create new understanding
- **Scope**: Focuses on **people** and their expertise, often combining fields like biology, engineering, and social sciences to solve problems or generate insights that a single discipline cannot address alone

- **Technology convergence** = **blending or integration of different technologies** to create new functionalities, applications, or solutions
- **Scope**: Focuses on **technologies** and their integration, often involving the merging of fields like information technology, biotechnology, and nanotechnology to create novel systems or products

Systems and technology integration is not new.

Its scale is.

- As a driving force for technological progress, technological change has been widely understood as a **process of combination and recombination** (Fleming and Sorenson, 2001; Schumpeter, 1934), where different new and already existing technologies are integrated resulting in a technological novelty.
- Innovation in the coming decades will be driven by **combining different technology** elements in new ways.
- **The potential impact** of billions of connected people, new quantum and biotechnology as well as increasingly powerful networked and AI driven devices, all with access to breakthroughs in emerging technologies, **is hard to conceive**.
- The combined effect delivered by multiple emerging and disruptive technologies is **multiplicative**.

Convergence is becoming the base scenario

- **Next stage: new multimodal solutions** to thoroughly augment care in brain healthcare
- Products with **AI tools linked back** to highly reliable data bases
- Once convergence starts, **it is unlikely to stop**

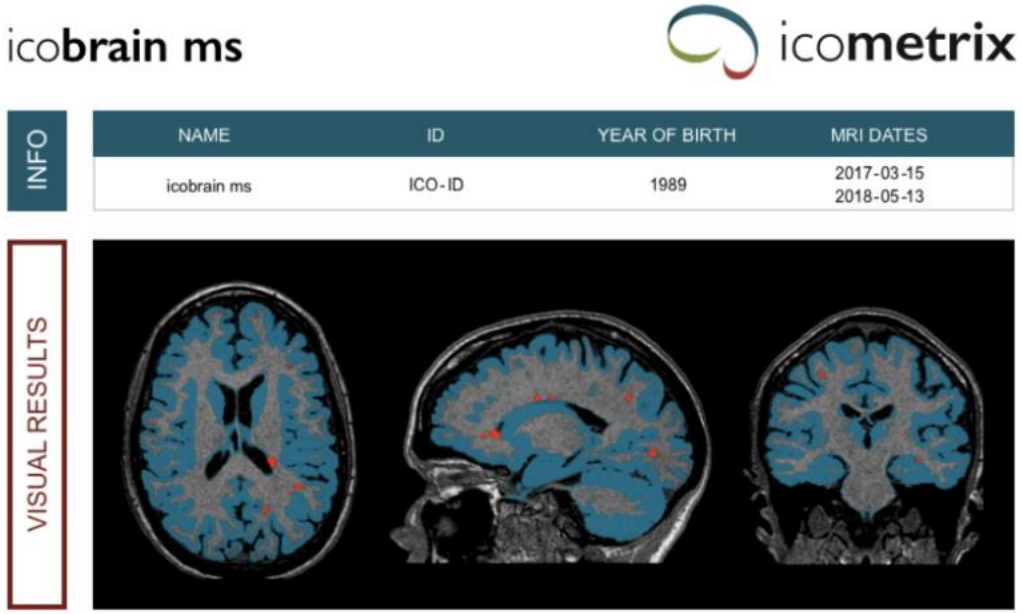
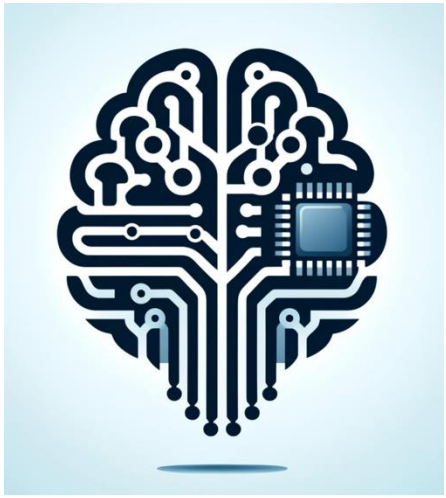


Image source: icometrix

Technological challenges to be addressed: the case of neurotechnology

- Improvements in **wireless data and power transfer** to enable the operation of high resolution and high precision devices
- Methods to **package technology in the body**, to ensure the longevity of devices and to avoid unwanted tissue responses
- Developments in the area of **micro-electrode technologies**, which would allow for the implantation of 100s to 1000s of electrodes in a small volume of brain tissue, able to stimulate with high spatial selectivity.
- **Better understanding of the immunological and non-immunological responses of the neural tissue**, permitting the development of next generation electrodes with enhanced life-time and efficacy
- Developments of new forms of actuation, such as **magnetoelectric nanoparticles, photobiomodulation** and **integrated optics and ultrasound for** opto- and sonogenetics, in a clinically relevant form
- Further development and clinical translation of **closed-loop control technologies**, which integrate brain recordings, computational methodologies and AI for effective brain stimulation.

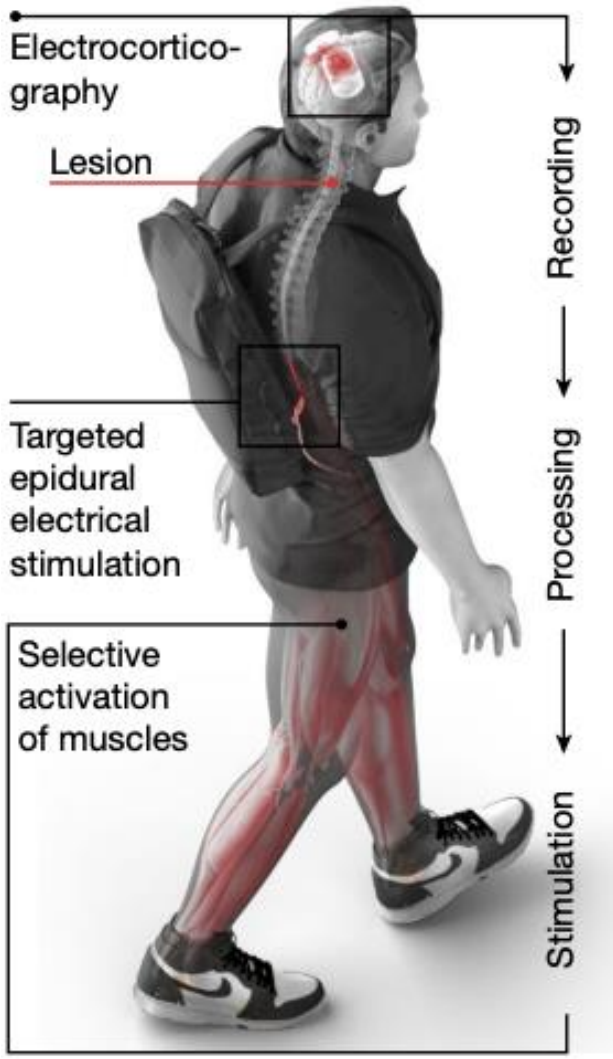


Decoding of motor intentions

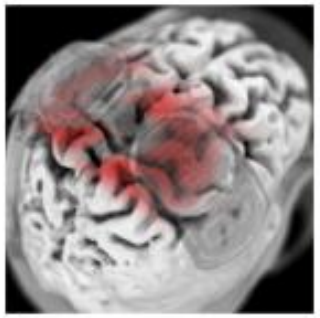
Spinal cord stimulation: paraplegia and tetraplegia

Digital bridge between the brain and spinal cord that enabled an individual with chronic tetraplegia to stand and walk naturally in community settings.

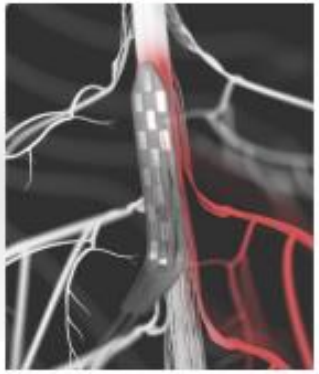
Source: Henri Lorach et al., Walking naturally after spinal cord injury using a brain-spine interface, Nature, 24 May 2023

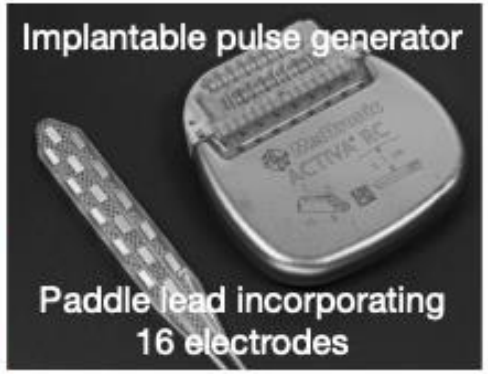


Cortical implants incorporating 2 × 64 channels



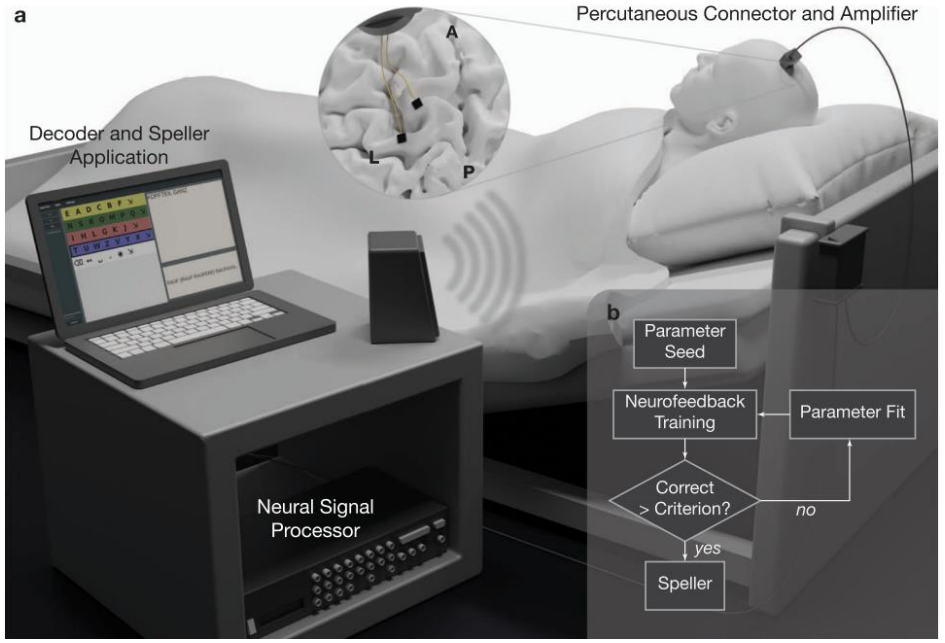
Wearable processing unit
Receive neural data
Extract spatial, temporal and spectral features to predict motor intentions
Send updated stimulation commands





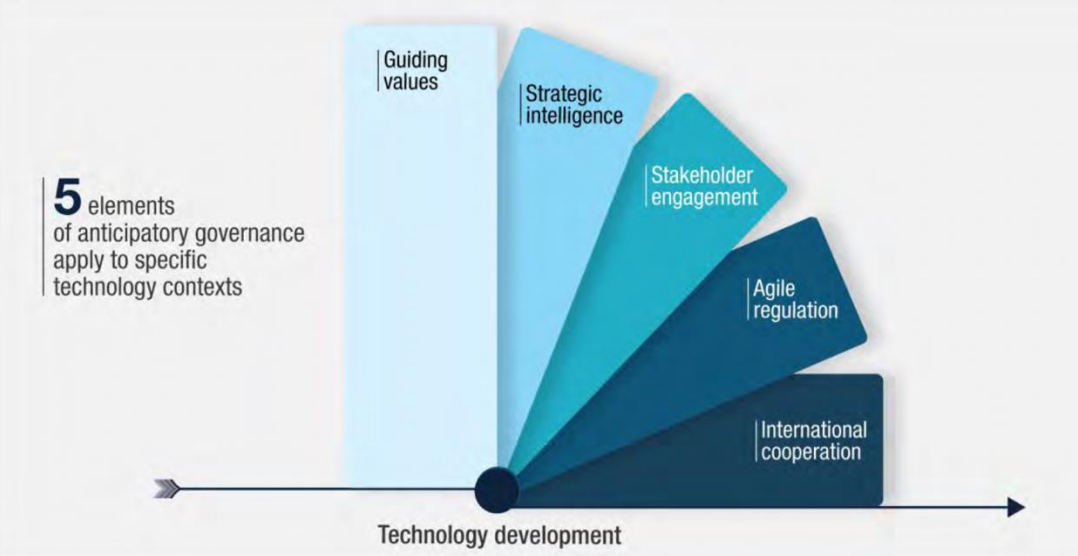
Decoding of thoughts: convergence adding to ethical challenges

- Support in some of the most devastating brain disorders: Locked-in Syndrome due to brainstem stroke or Amyotrophic Lateral Sclerosis
- Brain Computer Interfaces allow reading and decoding brain activity and transforming it into commands
- However, safety, authenticity, and mental privacy **needs are magnified by convergence with AI**: internal monologues get decoded that users may not intend to externalise



Source: Ujwal Chaudhary et al, Spelling interface using intracortical signals in a completely locked-in patient enabled via auditory neurofeedback training, Nature Communications (2022)13: 1236

Technology convergence and the OECD Framework



*"Convergence of technologies results in the **blurring of categories in prior frameworks**, making it more complex and harder to govern emerging technologies. Here, synthetic biology provides a case in point as it combines biotechnology with AI and other digital technologies to speed up the manufacture of novel and useful organisms; as a further example, brain-computer interfaces are bringing together neuroscience, digital tools, and new materials to restore or even enhance cognitive and motor function".*

Technology convergence and governance needs

Six dimensions for assessing governance needs are likely to point to:

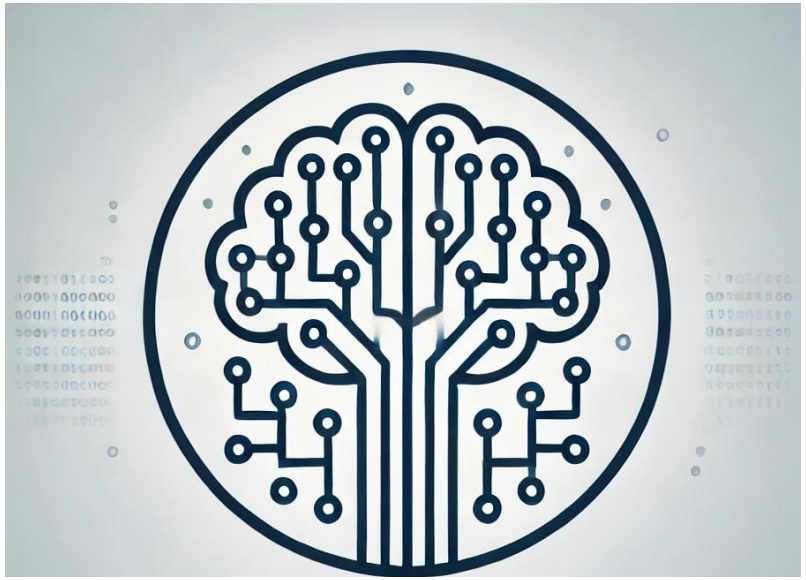
- a higher **degree of uncertainty** (necessitating more intelligence)
- greater importance of **analysing risk and scale of impact**
- potentially greater **level of public concern**
- similar levels of the **pace of technology emergence**
- potentially greater level of **strategic importance**
- likely greater **governance gaps**

Guiding values

- **Foundational values**: respect for human rights, safety and security, privacy, democratic values, sustainable development, equity and inclusion ⇒ scope subject to change given technology convergence

- **Technology-specific values**: trustworthiness, responsibility, transparency, technology stewardship, innovation for public good, responsiveness ⇒ rendered significantly more complex by technology convergence

Convergence of neurotech and AI driving evolution of the meaning of data

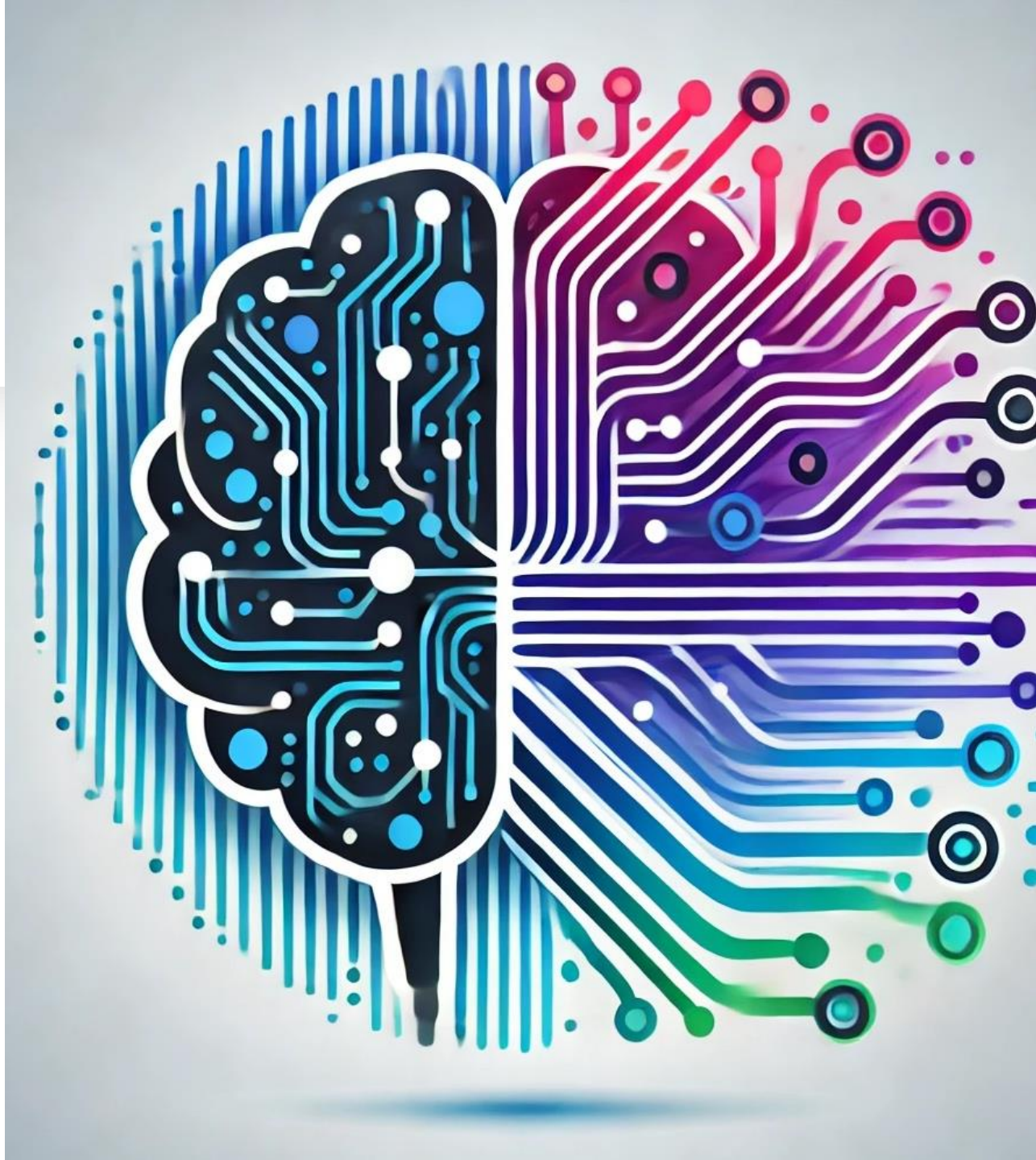


OECD Framework:

"*Values are subject to evolution, and technological change can reshape them*" (OECD Framework). "*An example here is privacy, where the adoption of new technologies may drive or reflect new attitudes with respect to the protection of personal data*".

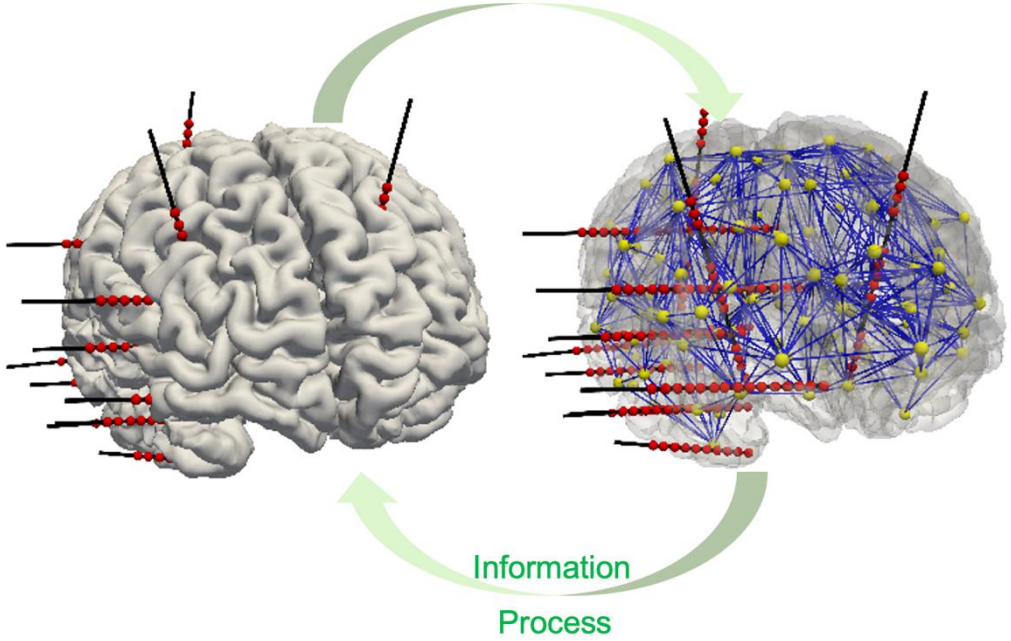
Future is here: inferences from brain data

- **Brain data is a special category of personal data** given its highly sensitive and intimate nature
- **Unique brain wave signatures** enable authentication systems and practice of profiling
- Neurotechnology = **massive amounts of data** = challenge for the proportionality principle
- **AI tools & neurotech ⇒ inferences from brain data**
- Can discern **observed or intended behaviour**
- Brain data **transcends** objectively identifiable tenets of information



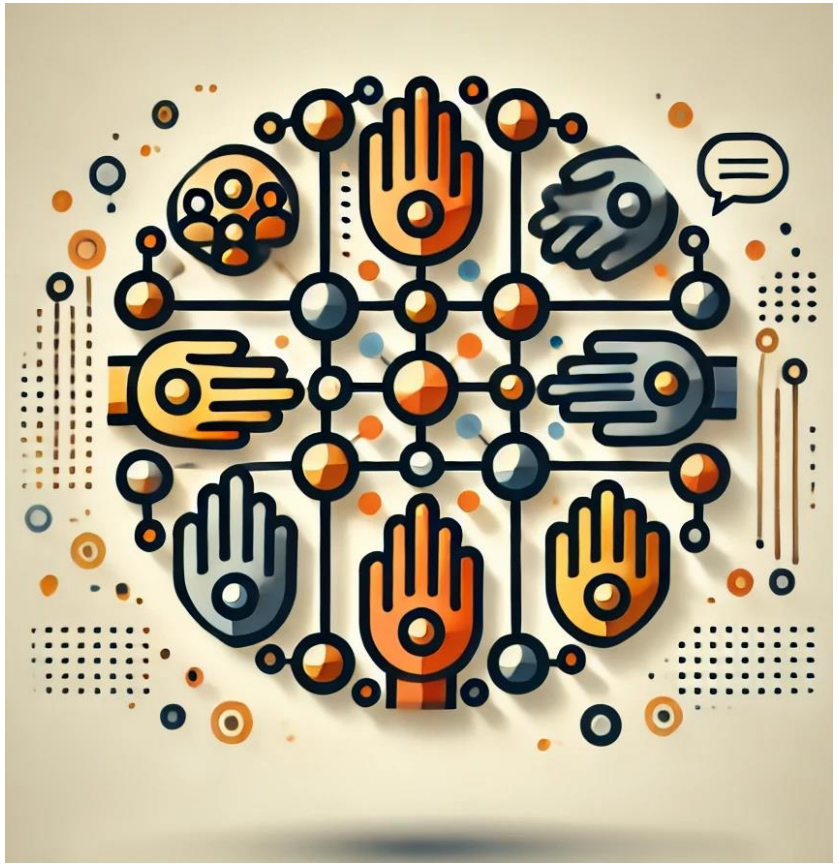
Virtual data needs to be protected when it enables inference

Virtual models designed to adequately represent an object or process that **is constrained by data** from its physical counterpart, and that **provides simulation data to guide choices and anticipate their consequences**.



Enabling deliberative processes

- Taking account of broader communities of stakeholders to be involved: **technology "observatories"** might need to be **deliberately devoted to issues of technology convergence**,
- **Active moderation techniques** may have to be deployed
- As part of capacity-building, policymakers, technologists, citizens and stakeholders will need to be **specifically informed about the implications of technology convergence**
- **Integrity of information** that is shares for these discussions **will need to be looked after**



Strategic intelligence

- Horizon scanning, as a form of preliminary analysis, **should encompass the likelihood of technology convergence**
- Tools need to be adapted to the requirements of technology convergence: **need to move towards more deep dives and extended appraisals**
- Technology Assessments and Emerging Risk Assessments **need to increasingly focus on technology convergence**

Stakeholder engagement

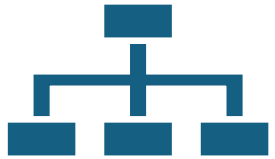
- Anticipatory engagement needs to be **more multifaceted**
- **Commitment must be made not to shield complexity** in public dialogue and scrutiny
- **All tools** (capacity-building, communication and consultation and cocreation) need to explicitly focus on technology convergence

Agile regulation

- Formal and informal kinds of governance mechanisms to be involved
- **In line with the "staircase approach",** tracking the stage of technology development, **strong role for informal tools at first**
- **More granular mapping necessary** to understand how features such as property right regimes, ethical standards, pre-market trials and industrial standards will affect the life cycle of innovation in the technology convergence areas
- **Tailor-made technical standard development** should be pursued whenever needed
- **Set up dedicated testing and experimentation facilities** for areas of technology convergence

International cooperation

- **Possibly more impactful than in individual technology areas**
- The OECD Global Forum on Technology should devote ample space to technology convergence
- Scope for building **shared understanding** about potential risks and benefits of convergence, with **agreed forms of evidence and evidence-making** regarding convergence, as well as **shared models of technology assessment**
- **Stronger cooperation in science and technology development** in line with common ethical practices, norms and understanding of good technology



Dynamic capabilities of technology governance to be enhanced

- **Dynamic capabilities** are necessary to adapt to the rapid pace of technology convergence
- They include **responsive regulatory frameworks** that are **principle-based rather than excessively prescriptive**, allowing for flexibility in application as new technologies emerge and existing ones converge
- Mechanisms for **regular review of the regulatory framework and rapid adaptation** are also necessary to ensure they remain relevant
- Establishing **dedicated entities to assess technology convergence** can help in timely understanding their implications
- Similarly, convergence-focused **regulatory sandboxes** are needed
- Convergence makes the case for **stakeholder engagement only stronger**