Governance Principles for a Society Based on Cyber-Physical Systems

These Principles were developed by a voluntary group of experts from the G7 member nations, with the intention of contributing to the discussion on governance innovation at the G7 Digital and Technology Ministers' Meeting. This document is not legally binding.

Principles

Section 1: Basic Principles for Governing Cyber-Physical Systems

1. Exploration of Possibilities of CPS
   • To realize a human-centered, sustainable, and resilient society by solving social problems such as climate change, pandemics, and the effects of aging populations, and to boost the economy through improving productivity, it is necessary for G7 countries to fully explore the potential of Cyber-Physical Systems (hereinafter, “CPS”), which are emerging as a society-wide “system of systems.”
   • In governing a society that includes widespread adoption of various CPS, we should carefully consider the ancillary risks of CPS, such as the creation of enormous architectural power and increasing uncontrollability, as well as the fact that people will find it practically impossible to avoid the influence of CPS.

1.2 Application of the Principles of Rule of Law to CPS
   • Powers derived from CPS, either public or private, should be subject to the principles of the rule of law.
   • The possibility of a more agile and distributed governance system, which aims to address the risks generated by the complex and dynamic nature of CPS, should be explored in a way that is consistent with the principles of the rule of law.

1.3 Agile and Multi-Stakeholder Process as Due Process for Governing CPS
   • Actors that play an active role in CPS, either public or private, including organizations and individuals that develop, deploy or operate CPS (hereinafter, “CPS actors”), should act according to fair procedures based on the notion of due process. Accordingly, they should proactively self-evaluate the consequences of the behavior of CPS and, in accordance with feedback from their stakeholders and generated data, keep the architecture and operation of CPS updated.
   • The principles of the rule of law for CPS should be materialized through fair procedures based on the notion of due process, under which laws, standards, codes, algorithms, and physical features which control the behavior of CPS should be designed, operated, and updated based upon reasonable, meaningful,
and inclusive involvement of appropriate stakeholders.

- The fair procedures for governing CPS should be interwoven into the whole structure of the democratic governance system, which, if necessary, may require appropriate modifications or improvements.

1.4 National policies and international co-operation

- Given the borderless nature of cyberspace, it is necessary to consider national policies and international cooperation that can engender an interoperable framework of CPS, in a way that is consistent with shared core values among G7 countries, such as respect for the rule of law, democracy, and human rights principles.

Section 2: Integrated Governance Framework for Cyber-Physical Systems

2.1 Integrated Approach for Governance Framework

- In order to put the basic principles described in the former section into practice, an integrated governance framework should be pursued, which includes proactive governance by CPS actors, expert involvement and utilization of digital tools, agile regulatory governance, reliable certification mechanisms, effective sanction systems appropriately tailored liability systems, and legal remedial measures to ensure an agile, meaningful, reasonable, and inclusive multistakeholder process.

2.2 Proactive and Voluntary Governance by CPS Actors

- CPS actors should be encouraged to, in good faith, to implement proactively implement and comply with the agile and multi-stakeholder governance process designed for grounding the codes, algorithms, and physical features that control behaviors of CPS on legitimate reason consistent with human rights principles and the fair procedures based on the rule of law.

2.3 Expert Involvement and Utilization of Digital Tools

- Given the difficulties faced by citizens in understanding the nature of CPS or in accessing relevant multi-stakeholder procedures, an adequate expert involvement and effective utilization of digital tools should be considered as a measure to make the multi-stakeholder approach reasonable, meaningful, and inclusive.

2.4 Agile Regulatory Governance

- Governance and regulatory approaches should be adaptive, iterative, flexible, responsive, and anticipatory, in accordance with the OECD Recommendation for Agile Regulatory Governance to Harness Innovation.

- Governments should appropriately seize the opportunities offered by CPS to
improve the design and means of regulations.

2.5 A reliable Assurance Framework for Enhancing Trust in CPS

- A framework for assurance mechanisms for the constituents of CPS, including for each constituent system, in relation to the processes underlying the system or the management of the organization that controls the system, should be employed to ensure trust among CPS actors.
- Assurance mechanisms in relation to the interactions between constituents of CPS should also be discussed to improve trust in the CPS.

2.6 Effective Sanction System and Appropriately Tailored Liability System for Elaborated Incentive Structure

- Governments should explore effective sanction system and appropriately tailored liability systems to ensure compliance with responsible development and deployment of CPS, which consider the incentives for CPS actors as well as the degree of unpredictability and uncontrollability of CPS so that they promote innovation while ensuring the implementation of agile and multi-stakeholder procedures and respect for fundamental principles including the rule of law, democracy, and human rights principles.

2.7 Remedial Measures for Reasonable and Meaningful Multi-Stakeholder Process

- When relevant persons and entities are excluded from the multi-stakeholder process regarding the design of the codes, algorithms, and physical features that control the behavior of CPS which have a significant impact on them, the right and access to legal remedies should be granted to them.
Background Information

This Background Information is an explanatory memorandum prepared by the [secretariat of the Task Force] to help readers understand the backgrounds of the Principles. This is a referral document and not subject to the agreement of the Task Force members.

1. The Potential of Cyber-Physical Systems

Digital technologies are changing the world by accelerating the integration of cyberspace and physical space. Their remarkable development means that, in the not-too-distant future, society will consist of Cyber-Physical Systems (CPS)—networks of independent yet integrated systems that collect process and analyze data in real time using algorithms, and applying the output to physical space. This emerging “system of systems” will underpin smart cities, homes and medical care, autonomous driving and automated government services among other applications.

Cyber-Physical Systems also have the potential to help humans address social problems such as climate change, pandemics, and the effects of aging populations, and to boost the economy through improvements in productivity. Furthermore, Cyber-Physical Systems can also contribute to making government more efficient, effective, fair and inclusive.

We recognize that the potential of Cyber-Physical Systems needs to be explored and maximized in order to create a more human-centered, sustainable, and resilient society.
<Examples of CPS constituted by private and public systems>
1. Smart city system developed for better preparedness for disasters

Imagine a smart city system where a network of sensors and devices installed throughout the city improves disaster preparedness by collecting and transmitting data in real-time on weather conditions, traffic patterns, infrastructure conditions and other variables. The data are analyzed and used to identify potential risks and help take appropriate responses. When an earthquake or heavy storm is detected, the system automatically reroutes public and private transportation, keeping people away from danger zones such as underpasses or riversides; helps emergency services to reach affected locations; and alerts residents using a warning system. Rescue robots connected to this system could save lives, and overall system could dramatically improve the resilience of the city. If connected to automated driving systems, this system could contribute to a sustainable society by supporting the development of lower-congestion, energy-efficient transportation networks. This smart city system would make society more human-centered, sustainable, and resilient.

2. Smart medical service system

Imagine a smart medical-service system in which people in isolated areas can receive medical examinations through real-time remote sensors. This system would enable all people to receive appropriate treatment in the early stages of disease. Advanced robots could even allow for remote surgical procedures. This smart medical service system would reduce disparities in medical care among different regions and make our society more human-centered, sustainable, and resilient.

2. Risks Ancillary to CPS

With the aim of achieving the above-mentioned objectives, several risks shall be considered in developing CPS.

First, CPS may create enormous “architectural power”, i.e. power exercised through various forms of architecture in physical space, cyberspace, or both. While CPS may have a significant impact on people's daily lives and well-being, there is a risk that architectural power may not be executed in a way that is consistent with the fundamental values shared by G7 countries, such as the rule of law, democracy, and human rights. Mitigating this risk requires a global dialogue about the human-centered principles that should underlie digital systems, such as well-being, fairness, transparency, robustness, and accountability. It is especially important to note that avoiding CPS will not be an option for most people – before the emergence of CPS, people could choose not to be connected to cyberspace, but such a choice will no longer exist after the entire social system is connected to cyberspace.
<Examples of risks of creating enormous architectural power>

1. CPS controlled by public sector organizations

CPS could be used by governments to monitor the behavior of citizens and control individuals and groups by severely restricting their activities both in cyberspace and in physical space. The concern is most acute in authoritarian states that may use CPS to suppress rights and freedoms and effect political control.

2. CPS controlled by private sector organizations

CPS could be used by private sector organizations, such as corporations, to pursue private interests at the expense of individual and social welfare.

Second, the dynamic and complex nature of CPS makes it hard to analyze system-wide risks in advance. Therefore, a more agile and distributed governance system is required. The risks of agile and distributed governance are that some of the constituent systems of CPS may work in ways that are at odds with the fundamental values shared by G7 countries, or that they may work inconsistently, which will lead to system-wide dysfunction.

<Example of risks of increasing uncontrollability>

The above-mentioned smart city system for disaster prevention consists of several independent systems—including sensor systems that acquire data, a communication network, and a system that calculates emergency vehicle routes—that are operated or managed by different service providers. Furthermore, AI systems that are part of CPS are dynamically learning from the outside environment. In this situation, it is hard to predict at the time of design how systems that are added later will interact with the original system, how an update in a certain system will affect the behavior of other systems, or what security vulnerabilities will emerge.

3. Rule of Law and Due Process for CPS

In order to maximize the positive impact brought by CPS in a way that harmonizes with the fundamental values shared by G7 countries, we believe due attention must be paid to the emerging CPS-driven society and its governance system.

In particular, from the perspective of controlling architectural power, an important question is how to apply the principle of the rule of law which plays an important role in the control of power in our current society and its governance system.

In a society where architectural power is increasing, not only laws or standards, but also codes, algorithms, and physical features that control the behavior of CPS must be
grounded in legitimate reason consistent with human rights principles, as they play a central role in governing CPS.

To examine whether a law is grounded in legitimate reason, stakeholders must be guaranteed the opportunity to make arguments in both law-making and remedial processes. The guarantee of due process in law-making and remediation is closely related to the principle of the rule of law. Due process seeks to make the law just by making the process of creating law fair.

Therefore, it is necessary for public and private actors that play an active role in CPS, including organizations and individuals that deploy or operate aspects of CPS (hereinafter, “CPS actors”), to implement fair procedures based on the notion of due process that ensures that codes, algorithms, and physical features are grounded in legitimate reason. Accordingly, they should proactively self-evaluate the consequences of the behavior of CPS and, in accordance with feedback from stakeholders and generated data, keep the architecture and operation of CPS updated.

Given that the fair procedures for governing CPS interact with legal rules at multiple levels, such as constitutional provisions, legislative acts, regulations, and standards, it is crucial to pursue their harmonization with the existing governance system in an integrated manner. The fair procedures for governing CPS should be interwoven into the whole structure of the democratic governance system, and, if necessary, may require appropriate modifications or improvement of the current governance system.

Given the borderless nature of cyberspace, it is also necessary to consider national policies and international cooperation for building an interoperable framework for CPS in a way that is consistent with core values shared by G7 countries, such as the rule of law, democracy, and human rights.

4. Need for an Integrated Governance Framework

One promising option for governing CPS consistently with shared core values such as the rule of law, democracy, and human rights principles, is the implementation of an agile yet multi-stakeholder approach for designing the codes, algorithms, and physical features used by CPS actors. Incorporating an appropriate multi-stakeholder approach into an agile design process will create the potential for codes, algorithms, and physical features to be democratically controlled and legitimate. It is also desirable for CPS actors to make the CPS more democratically legitimate and socially acceptable. Therefore, the potential of an agile and multi-stakeholder approach for designing or redesigning the codes, algorithms, and physical features should be explored.

To effectively implement the above-mentioned due process, we should establish an integrated governance framework. Such framework should include proactive governance by CPS actors, expert involvement and utilization of digital tools, agile regulatory governance, reliable certification mechanisms, effective enforcement systems and appropriately tailored liability systems, and legal remedial measures to ensure a meaningful, reasonable, and inclusive multi-stakeholder process.

First of all, CPS actors should be encouraged to, in good faith, proactively implement and comply with the agile and multi-stakeholder governance process designed for grounding the codes, algorithms, and physical features that control behaviors of CPS in legitimate reason consistent with human rights principles and the fair procedures based on the rule
of law.

Adequate procedures for expert involvement and effective utilization of digital tools should be considered as measures to make the multi-stakeholder approach reasonable, meaningful, and inclusive. It is often difficult for citizens to understand the meaning of codes, algorithms, and physical features that control the behaviors of CPS. Adequate expert involvement helps people to deepen their understanding of the technical aspects of CPS, which in turn makes the multi-stakeholder approach more meaningful in the sense of grounding the codes, algorithms, and physical features on legitimate reason.

Agile regulatory governance refers to a regulatory approach which is adaptive, iterative, flexible, responsive, and anticipatory, as stated in the OECD Recommendation for Agile Regulatory Governance to Harness Innovation.

A reliable assurance framework, not only for constituents of CPS, but for the interaction between constituents of CPS, should be designed to enhance trust among relevant stakeholders, which is a foundation of the reasonable and meaningful agile and multi-stakeholder approach.

An effective sanction and appropriately tailored liability system should be elaborated in addition to an incentive structure for stimulating innovation as well as meaningful implementation of and compliance with fair procedures based on the notion of due process. Possible and not exclusive options may include, well-designed strict civil liability or fault-based civil liability with shifting the burden of proof, which encourage elaborated cost-benefit analysis for CPS actors to internalize the external harm caused by the CPS; or a deferred prosecution agreement scheme, originally used in the context of corporate misconduct, to extract proactive implementation of the fair procedure for governing CPS and voluntary cooperation with the relevant authorities and entities from CPS actors, and so on.

Legal remedial measures are also important to keep agile and multi-stakeholder approach reasonable, meaningful, and inclusive. Especially when it is revealed that relevant stakeholders have been excluded from the multi-stakeholder process regarding the design of the codes, algorithms, and physical features that control the behavior of CPS which have a significant impact on them, the right and access to legal remedies should be granted to these stakeholders. Implementing a variety of online dispute resolution mechanisms depending on different types of disputes and stakeholder needs, such as complaint handling by CPS actors, or alternative dispute resolution (ADR) by neutral organizations, would help materialize the right and access to legal remedies.
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The Task Force members contributed to developing the Principles as individual experts, not as a representative of any organization she/he belongs to.