



SOCIO-CYBER-PHYSICAL SYSTEMS (SCPS): ASSESSING THE FOURTH INDUSTRIAL REVOLUTION

Conceptual briefing

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- What is a system?
- SCPS as a research model
- Key terms: activity, domain, entity, interaction, relation, system

INTRODUCTION

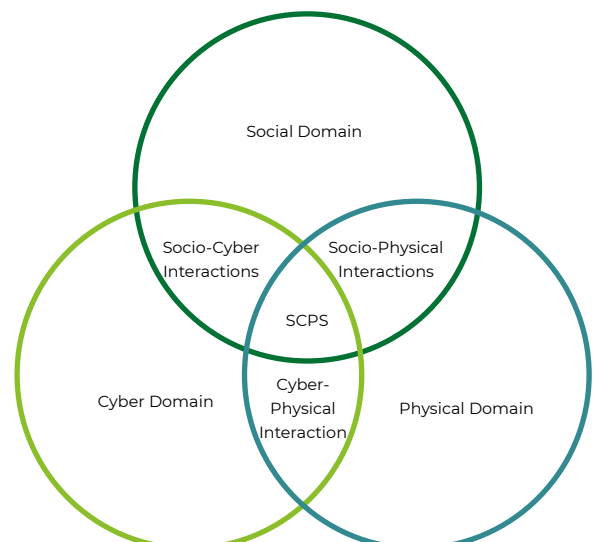
The **concept of Socio-Cyber-Physical Systems (SCPSs)** is introduced and used in DESIRA to approach the specific challenges associated with the fourth industrial revolution. This revolution is characterised by the entangling of digital, physical and social worlds through a multiplicity of technologies.

1. WHAT IS A SYSTEM?

People live and work in a world that is social, physical and, increasingly, cyber (requiring a digital entity to use the internet). To understand these three **domains** of analysis requires a transdisciplinary and participatory approach, because the social, physical and cyber domains are entangled and interacting in what is called a system. This interaction produces both expected and unexpected outcomes that can have ripple effects through the system. A **system** can be defined as a mental representation of given domains of reality for analysis and control purposes.

Actors within a system are called **entities**. **Relations** between entities allow for **activity and interaction** that in turn creates new entities, activities and interactions. **Activities** in any one part of a system, can have a ripple effect on the remaining parts of a system.

Figure 1. The socio-cyber-physical system with related interactions based on the three domains (social, cyber and physical)



Source: DESIRA, 2020



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2. THE SOCIO-CYBER-PHYSICAL SYSTEM AS A RESEARCH MODEL

Because these entities are intertwined and constantly creating new interactions among domains, it is difficult, in the real world, to isolate interactions between entities belonging to a single

domain. Our social interaction is profoundly influenced by our physical world, and even when machines interact only amongst themselves, they have been designed by actors that can switch them off at any time. However, for analytical purposes, it is useful to make distinctions, as described in Table 1.

Table 1. Entities and domains of the SCPS

| | Entities | Domain |
|----------|---|--|
| Social | Social entities are markets; institutional elements defining formal and informal rules, regulations and values; independent actors who make free choices; so and the resulting groups, communities or organisations and their particular behaviours. | Relations between entities in the social domain are regulated by social rules, such as laws, conventions, routines, ethical norms, and informal behaviour. |
| Cyber | Cyber entities are composed of: a) digital reproductions of the physical sphere, and b) original digital constructs. In the first case, digital entities are created by digitisation processes that transform analogue entities into digital entities. In the second case, for example using software, or data mining and analysis, digital entities are created through the interaction of other digital entities. | The relations between entities in the cyber domain are regulated by cyber-rules. For example, communication between devices is regulated by specific protocols (e.g. WiFi, Bluetooth, 5G). Digital technologies can communicate with other technologies. Digital entities interacting with other digital entities can perform operations independently of humans. |
| Physical | Physical entities can be natural or artificial, according to the degree of manipulation by human activities. They include living organisms and natural resources and physical things that support living and working in the (natural) environment (e.g. analogue technology, infrastructure, finances). | Relations between entities in the physical domain are regulated by natural rules and by technical rules. For example, wild animals select entities in the environment favourable to their survival. Water cycles are regulated by natural processes, such as evaporation and precipitation, but also by technical processes, such as water extraction and distribution in pipelines. |

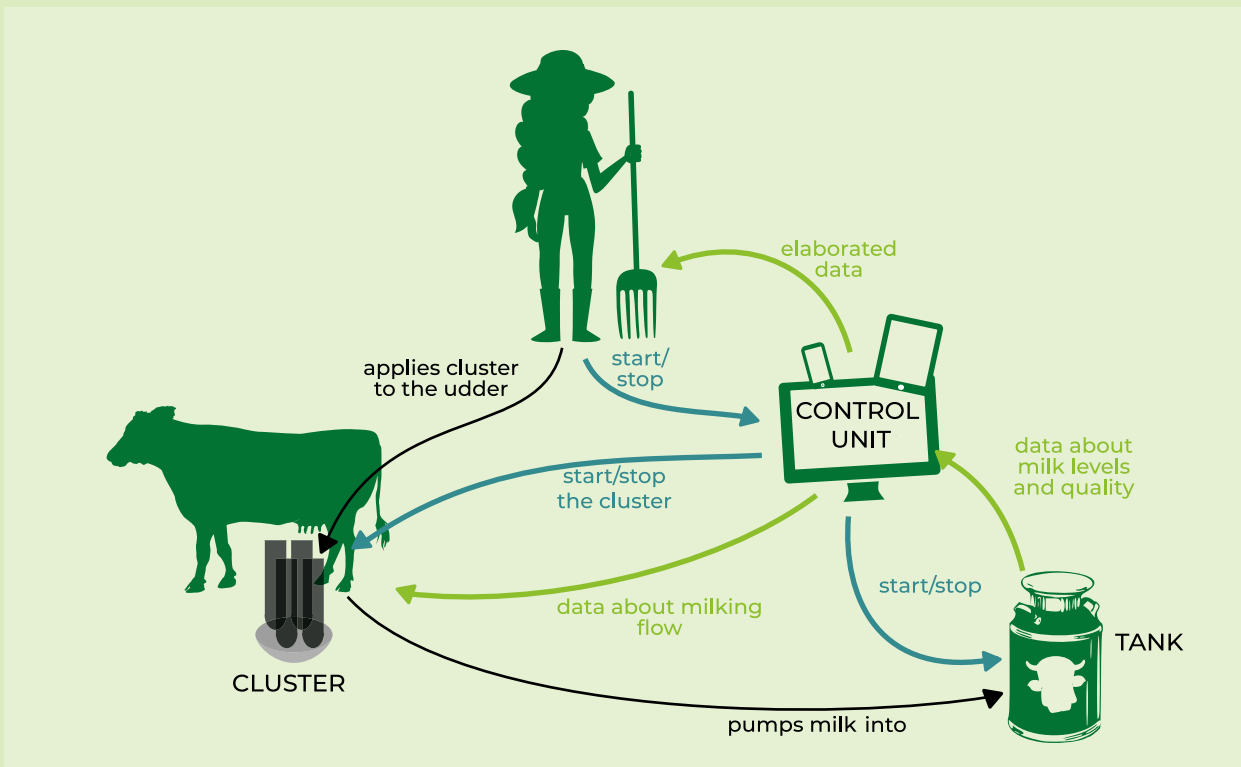


Example of Socio-Cyber-Physical Systems:

Milking system as a SCPS

If a robotic arm is introduced in a milking system, it can replace human activity in applying the cluster to the udder of the cow. However, access to the control unit; the ability to use it; the choice for a particular type of robotic arm; the regulation of the milking process; etc.; are set by social aspects. These social aspects can include organisational rules around the farming household or the developer of the robotic arm, skills of the farmer, regulations for using a robotic arm, and the social values of the farmer and the farming community.

Figure 3. Example of a SCPS



Source: DESIRA 2020

AirBnb as a SCPS

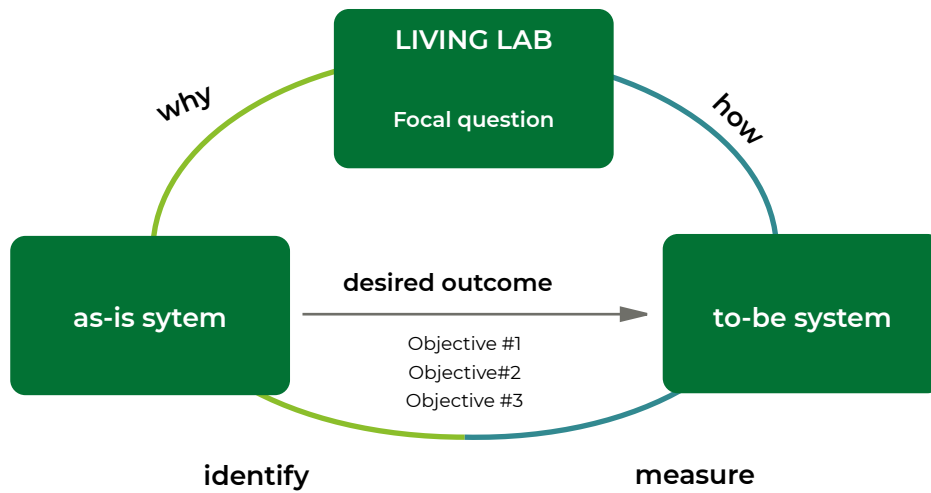
Airbnb is a digital technology that influences a socio-cyber-physical system which consists of people looking for travel experiences (social) through means of housing (physical), making use of the Airbnb platform (cyber). However, the interactions between those elements have multiple (positive or negative) consequences. They affect the tourism market for accommodation, the experiences as a tourist (accessibility, privacy, etc.), the city infrastructures, rules and regulations about sub-renting and ownership of housing, liveability in cities (busier city centres, increase number of tourism-oriented shops), and housing markets (price increase). Airbnb consequently needs to provide insight into their algorithms, and adapt them accordingly to meet local legal requirements. Moreover, data privacy of both owners and renters has become an issue, as well as the physical safety of owners, renters, and the surrounding neighbourhood.

3. IMPLICATIONS FOR ANALYSIS

One of the purposes of DESIRA is to analyse the potential of digital technologies to improve conditions in 20 European regions. Each region or Living Lab has an existing SCPS, which will be further explored and developed by means of a 'focal question'. This question, co-developed with the Living Lab participants, embodies local needs and expectations. Moreover, the focal question provides guidance to build the local SCPS and to set its boundaries.

Ultimately, the focal question will guide the Living Labs to analyse the current state of the SCPS in terms of the **outcomes** it generates and to explain why and how the process of digital transformation has affected this state. The analysis of the state of the SCPS (**as-is system**) allows Living Labs to identify the desired outcomes of the system, to set the targets to be achieved and to measure the distance to these targets. The Living Labs will then continue to analyse how the desired outcomes could be achieved through incorporation of digital game changers into the current SCPS (**to-be system**).

Figure 3. Process of analysis of SCPS within a Living Lab



Source: DESIRA 2020

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