# Physical Internet Principles: a Proposition

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In order to insure a coherent and effective development of the Physical Internet towards achieving its objectives, it is proposed that its conceptualization and its realization be provided guidelines through a set of thirteen principles: five founding principles and eight organization principles. The following sections present these principles.

## I. Founding principles

Five grand founding principles underlie the conceptualization and the realization of the Physical Internet. They have wide scope and great depth. They are beacons never to be out of sight.

1. *Instrumentality principle*
    - *a.* The physical Internet metaphor is not an end by itself. It is rather an instrument, a means, a catalyst, stimulating thought, design and innovation for transforming the way physical objects are transported, handled, stored, supplied, realized and used, with a aim to significantly and sustainably improve the joint economic, environmental and societal performance of such activities. It is thus not only the economic and environmental efficiencies that are at stakes, but also the service offered to society through the efficiency, reliability and resiliency of physical flows and their networks.
    - *b.* The Physical Internet metaphor should not become a constraining and closed intellectual ghetto. It must rather be inspiring, rallying, carrying. One should not hesitate to test and stretch its limits, to explore and to innovate.

2. *Responsibility principle*

    The Physical Internet potential for improving the economic, environmental and societal performance originates from the novel concepts forming the basis of its realization. However this potential will be entirely achievable only if the worldwide actors engage themselves in a responsible utilization of the methods, means and infrastructures according to the three following directions:

*a.* It is the responsibility of users and providers to design, implement and use the Physical Internet so as to contribute to sustainable performance improvement. The Physical Internet provides a framework, an infrastructure, an architecture, but in the end, it is the users who, by exploiting it as best as possible, make the difference.

*b.* It is the responsibility of users to have their activities imposing as minimal a burden as possible on the Physical Internet, for example through the deployment of their assets and products, as well as through the design of their products and services.

c. It is the responsibility of providers (logistic providers, technology providers, etc.) to always contribute as best as possible to sustainable performance gains, notably in terms of flow and network efficiency, reliability and resilience. It is also their responsibility to engage themselves in improving and openly displaying their performances, capabilities and capacities (e.g. transit time, tolerance to local dysfunctions).

3. *Metasystemization Principle*
   a. The Physical Internet must be considered from a meta system perspective, as a system of systems interlaced at multiple layers.
   b. The Physical Internet aims for a coherent integration of the microscopic and macroscopic perspectives. It must encompass the perspectives, for example, of a physical object, of an equipment, a facility, a business, and so on. The macrosystems and the microsystems participate equally to the overall consistency.

4. *Openness Principle*
   *a.* The Physical Internet must be fundamentally open, as much in its conceptualization, its realization, its exploitation as in its utilization.
   *b.* It is a distributed system operated through a multitude of providers interacting in an open way, without closed organizational control links. Ultimately, there would not exist anywhere a logistic network (in the wide sense) dedicated by a provider to serve a client.

5. *Universality principle*
   a. The Physical Internet must be designed and considered from a global worldwide perspective, with a universally local presence.
   b. It must not be thought independently by regions, industries or groups of enterprises, but must be imbued by these so as to generate sustainable high value added solutions for regions, industries, groups of enterprises and ultimately the citizens.

## II. Organization principles

Based on the founding principles, eight organization principles guide all stakeholders through their contribution to the design, elaboration, implementation, exploitation, utilization and improvement of the Physical Internet.

1. *Interconnectivity principle*
    a. The universal interconnectivity of the elements of the Physical Internet is a fundamental and continuous target for all its stakeholders, including the service and technology providers as well as the users.
    b. The interconnectivity lies as much in the physical plane as the digital plane, each element of the Physical Internet being connected and accessible through the Digital Internet.
    c. This functional interconnectivity is illustrated by the Physical Internet containers (or π-containers) that exploit a standardized interface allowing their transfer through any type of Physical Internet enabled transport, handling or storage means, whatever their automation level. It is expected that this standardization results in the development of ever more adapted means.

2. *Uniformity principle*
    a. The elements of the Physical Internet are as functionally uniform as possible. They are distinguished through their particular configurations of capabilities, capacities and service offers, exploiting functions defined in a way as uniform as possible. The same holds for protocols, which must be as generic as possible so as to favor ease of use.
    b. Uniformity also applies to the multiple networks of the Physical Internet, which are conceptually equivalent, even though they operate at distinct scales. So a network within an operational center of a facility on a particular site is conceptually equivalent to an intercontinental network.

3. *Accessibility principle*
    a. The services of the elements of the Physical Internet are by default accessible to everybody. The same prevails for the dynamically updated information about their service capabilities, capacities and performances.
    b. There may however exist capability and capacity restrictions, related to service, security, or private or limited usages, for example associated to virtual private networks dynamically put in place for particularly critical supplies.

4. *Uniqueness principle*
    a. The Physical Internet address of every shipper and every recipient is unique. They specify an interface with the Physical Internet, and not an organization or a fixed geographical location. It is the resolution of the address at a given time that allows locating geographically the specified interface at that time.
    b. Every Physical Internet container is assigned a unique identifier when assembled. It is through this identifier that the container is recognized, tracked and addressed during its dynamic routing through the Physical Internet.

5. *Encapsulation principle*
    a. The content of a container is encapsulated within the container and the Physical Internet does not interact in any way with this content, restricting itself to manipulate Physical Internet enabled containers and to interact with them through their mechanical, electrical and informational interfaces whenever necessary. The only case of interaction of the Physical Internet with the content of a container is when this content is itself a Physical Internet enabled container.
    b. Content encapsulation contributes to the security of goods through the external trivialization of the container and the verification of the integrity of the container.

6. *Agentification principle*
    a. Each Physical Internet element (container, equipment, etc.) is a proactive autonomous agent with faculties of reasoning and communication, notably through connective technologies such as RFID and GPS, as well through the Digital Internet. For example, a container agent may thus be in relation with its owner, with the logistic provider responsible for it, with the various providers responsible for the elements of the Physical Internet through which it moves and sojourns, as well as with the software agents representing them.
    b. As an agent, a container also interacts with any physical object within it if it is agentified and the container has the permission to do so from the owner of the object. This interaction is restricted to the container and its content, and it is not taken into consideration explicitly by the Physical Internet whose elements do not interact with this content. This container-content interaction allows the possibility of accessing data about the content for the shipper or his delegates, notably enabling to manage the integrity and the traceability of the content. For example, the container keeps in memory its openings and closings, and offers advanced monitoring and traceability functions.

7. *Contracting principle*
    a. A Physical Internet container is necessarily covered by at least one contract to which is notably attached a compensation mode for the service providers.
    b. By its physical nature, the Physical Internet can deal with a container only if it is at all times taken in charge by PI service providers according to a contract that is preset and activated by an event in the Physical Internet, such as the start or the end of a transport, a transit or a storage.

8. *Certification principle*
    a. The Physical Internet relies on certifications of its resources (containers, information systems, roads, cities, ports, vehicles, handling systems, etc.), its protocols, its processes and its solution and service providers.
    b. These certifications focus both on the acquired and demonstrated capabilities and on the achieved performances once the entities have been put into service. They are dynamic, regularly renewed. They are also at multiple

levels, from basic to more evolved levels. Finally, they have multiple facets. For example, a certification facet may be associated with the security of the containers or with the treatment of containers having specific characteristics, such as those containing hazardous materials.

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**Invitation to comments**

This document is the second draft of a long-term work aiming to establish the fundamental principles of the Physical Internet. The authors are conscious that the list of stated principles may be subject to improvements through the years.

All constructive suggestions and comments are welcome. They may be openly expressed through the web site www.physicalinternetinitiative.org.