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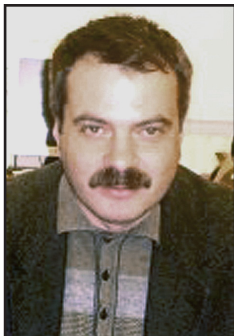
# Physical Internet and Logistics Transportation Systems of the Digital Economy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## ABSTRACT

*Logistics transportation systems are considered regarding development of the Physical Internet. The Physical Internet is widely defined as an open global logistics system founded on physical, digital, and operational interconnectivity, through encapsulation, interfaces, and protocols, similar to the Digital Internet [1; 2]. It is built based on standardisation of both containers for transportation of goods and the equipment intended for their handling and supply. This allows creating a practically new industry since the shipper does not specify the mode of transport, and the system works on the principles of the Digital Internet, routing containers (analogous to packages of the Digital Internet) and collecting them in the right place at the right time. The concept of the Physical Internet is aimed at implementation of full interconnectedness, in terms of data, information, physical and financial flows, of several networks of freight transportation logistics services, as well as at their readiness to be freely used as a single large logistics network. The seamless physical, digital, and financial interconnection of logistics networks will include transportation, storage, and physical handling of cargo units (containers, demountable bodies, pallets, etc) [3]. In other words, these are physical objects, and that justifies the designation of the entire system as of the Physical Internet. Naturally, such a system inevitably raises the issue of standardising such physical objects (by analogy with standardising Digital Internet packages). Hence, the term of so-called ϖ-containers appears associated with special unified containers for storage, handling, transportation of material objects within the Physical Internet system. Now, the Physical Internet is not a merely theoretical concept. Its implementation is being carried out in many countries. The first Russian companies have already started promoting this concept as well. The objective of the article is to review the current state of this logistics model in Russia and the world based on the analysis of the literature and practical implementations.*

*Keywords: logistics, transportation logistics systems, Physical Internet, containers, cargo transportation, routing.*

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**For the original Russian text of the article please see p. 92.**

## INTRODUCTION

The role of transport and logistics in the economy is growing extremely rapidly, and this trend has only accelerated with the transition to the digital economy that gives rise to creation of new paradigms in the transportation logistics sector, which are based largely on various trends regarding the Internet expansion and new opportunities. The Internet growth has given birth to the terms like inflight, maritime, on-board train Internet.

However, the processes of freight transportation logistics both in the world and particular regions, e.g., the EU continues [4], become objectively more complicated. These tendencies have not passed Russia, which is an important part of the global transportation logistics environment.

Following the growing need in transportation and logistics, the solution seems associated with a gradual approach to the Physical Internet (PI/π) – an open global logistics system founded on physical, digital, and operational interconnectivity, through encapsulation, interfaces, and protocols, by analogy with the Digital Internet [1; 2].

As previously indicated by researchers and particularly by the article's authors, the PI concept aims at implementing full interconnectedness (of data, information, physical and financial flows) of several (private) cargo transportation and logistics networks and at their readiness to be seamlessly used as a single large logistics network [3]. The seamless physical, digital, and financial interconnection of logistics networks will include transportation, storage, and physical handling of cargo units such as containers, demountable bodies, pallets, etc. [3]. The barriers to becoming part of a network providing access to private services, resources available in the PI network, must be very low. In the long term, various network operators and service providers are likely to offer plug and play connectivity to supply chain stakeholders. Full visibility and supply chain management will be ensured for each player in accordance with his operations [3]. More technical details of this approach are descried in [4].

The general stages of this transition to PI, according to most researchers, are as follow:

• Interconnected logistics: a concept for development of supply chains, implying general availability and unification of distribution centres, hubs, vehicles and packaging.

• π-containers: special unified containers for storage, handling, transportation of material objects within the Physical Internet system.

As a result, a scheme for connecting the physical and digital world should be implemented, creating a digital twin of a physical transport unit, thus implementing the stages and opportunities of transition to the Physical Internet, closely related to the Digital Internet.

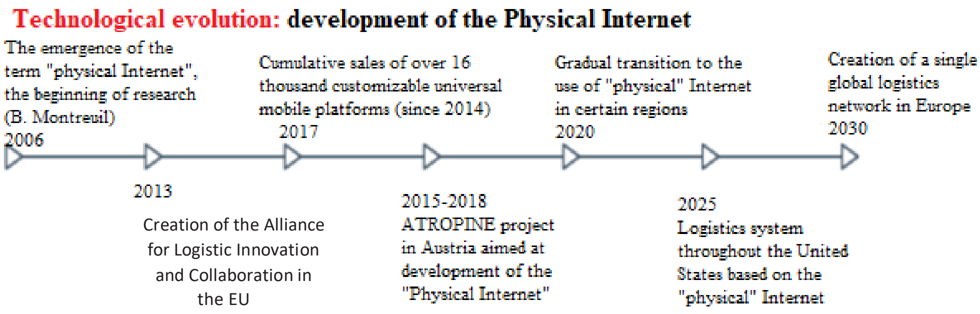
A lot of research is currently dedicated to the Physical Internet issues in different countries of the world. Purely to illustrate the diversity of the research it is opportune to mention [6–10].

From a practical perspective, the application of solutions based on Physical Internet is an important phase of implementation of transportation logistics projects, particularly at regional level.

For example, the evolution of the EU transportation logistics connections is largely related to the development of TEN-T international transport corridors (ITC) [5], as it has for a long time been based on a simple consideration that it is necessary to adopt innovations (including digital ones) where they will bring maximum benefit. As it will be further shown, a certain stage provides for the application of Physical Internet. Even now practices of construction of the ITC in the EU are beyond the scope of the terminology which is currently in scientific use. The TEN-T development program has been operating for a long time and provides for interaction of almost all modes of transport (multimodality). Nine main European corridors refer to it according to regulations [5]; they are funded by different models. The full implementation of these corridors is set for 2030. Even more ambitious goals for development of the transport system should be achieved by 2050 [5].

From the point of view of the general EU innovative transportation logistics solutions regarding the ITC, the following stages can be distinguished:

*First stage*. Multimodality (that has already been shaped as a requirement in conformity with regulations) which means for supply chains, particularly, the connections of infrastructure network of transport modes at certain points or nodes.




***Pic. 1. Technological evolution: development of the Physical Internet [13].***

*Second stage.* Synchromodality (which is associated with on-going implementation) which means synchronising the schedules of several modes of transport to avoid losses and improve economic performance.

Transition to the *third stage* is the most important from the perspective of our review study since it regards deployment of Physical Internet by 2030 and its core approaches comprise standardisation.

Physical Internet is based on standardisation of both containers for transportation of goods and of the equipment intended for their handling and supply. This allows creating a practically new industry since the shipper does not specify the mode of transport, and the system works on the principles of the Digital Internet, routing containers (analogous to packages of the Digital Internet) and collecting them in the right place at the right time. Implementation of the Physical Internet will result in extremely significant economic outcomes.

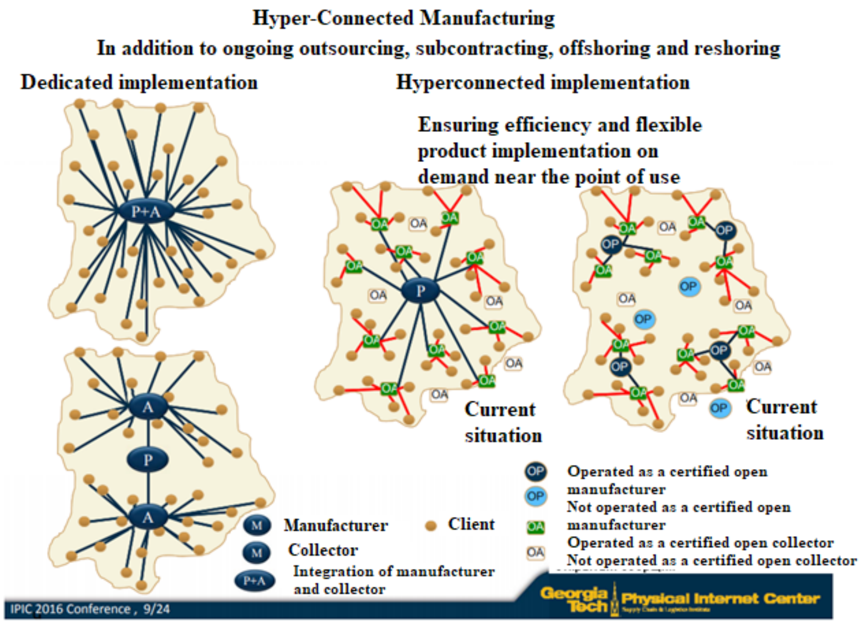
Thus, using the EU materials, it is possible to build a common ideology for development of the ITC based on existing practices and solutions, to achieve significant saving in further development of the corridor and to ensure, to the necessary extent, connection with the TEN-T corridors, the development of which has already gone beyond the EU. It should be noted that, for example, the North-South ITC implies the use of natural transportation waterways of Volga and Caspian Sea, and similar projects on the use of natural transportation routes in the corridors are already being developed in the EU. There is a chain of projects using Danube and Black Sea, in which the use of the Physical Internet has already been declared [11–12].

## RESULTS

### Physical Internet in Russia: history of the issue

Until recently the study of the Physical Internet in Russia has not been sufficiently active and so thus has been limited to a very small number of publications. Thus, in [13], a generally fair time scale for the technological development of PI was suggested (Pic. 1).

An assessment was also made of the level of development of this technology in Russia, emphasising the presence of «white spots» and a significant lag behind the world level (as for 2018) [13]. In 2019, the work [14] presented a detailed analysis of the connection of modern transportation logistics with the Physical Internet, that merits to be quoted extensively. It was noted that «Modern global logistics is more and more the Physical Internet, a network of services provided that supports physical movement of goods both within the country and abroad. Logistics is a whole complex that includes not only transportation, but also warehousing, brokerage services, express delivery, terminals. International players in the logistics market offer a wide range of diversified solutions for trade and goods manufacturers, generating turnover exceeding 4,3 trillion USD. According to the indicators of information development of the Russian Federation, we have room to grow, because the future in the logistics sector is linked to information technologies and the intensive growth of the transit capacity of infrastructure facilities… According to the World Bank, Russia ranked 75$^{th}$ in the ranking of countries in the logistics efficiency index in 2018, having improved its performance compared to 2016. …Of course, there are several areas in development of infrastructure where Russia is among the leaders: the presence of

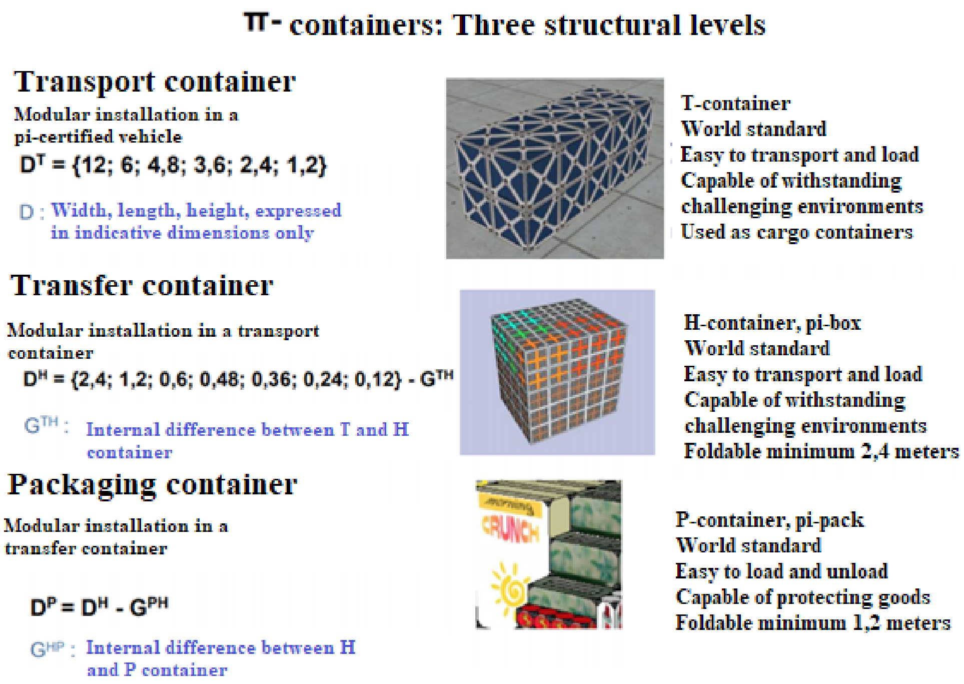



*Pic. 2. Hyper-connected manufacturing and Physical Internet (IPIC 2016) [16].*

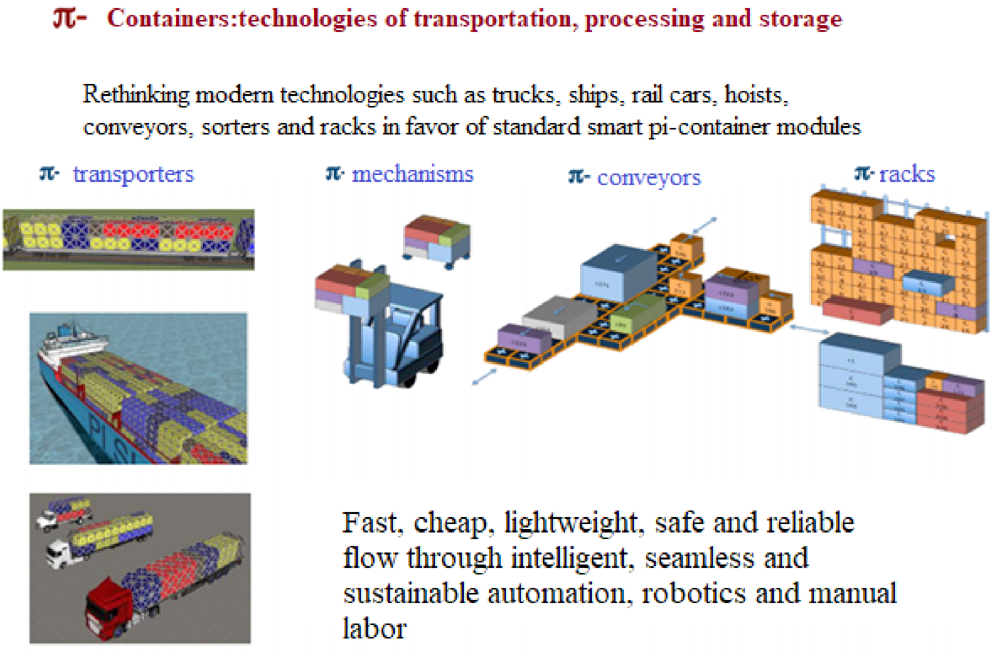
a unique icebreaker fleet, a unique system for organising cargo traffic by rail, high punctuality of intercity communication both by rail and by air. However, it should be noted that in terms of the development of information technologies, the actors in the Russian market have room to grow in order to increase the national competitiveness» [14].

**Physical Internet at Innoprom-2017**

At Innoprom-2017 international industrial exposition in Yekaterinburg, very important




*Pic. 3. PI containers as a tree of linked tiers [16].*




*Pic. 4. PI containers for transport of movement and storage [16].*

events seemed to happen regarding the fate of the Russian PI. It was attended by Benoit Montreuil, the author of the concept of the Physical Internet and world-renowned scientist in the field of transportation and logistics [7; 9; 10; 15], who made a presentation. Several agreements on this topic were also signed there. Some Russian companies presented the information on PI implementation.

Slides presented by Benoit Montreuil [16] reflected in concentrated form the current state of the evolving PI theory. Pic. 2 illustrates hyper-connected manufacturing and the Physical Internet as two related topics. Pic. 3 shows PI containers like a tree of linked tiers. Finally, Pic. 4 shows PI containers for transfer and storage transportation.

**The Digital Container Shipping Association (DCSA)**

However, the loud public launch in Yekaterinburg has not resulted in cardinal change in the situation with the Physical Internet in Russia. The reason for this seems to be associated with the lack of clearly defined political and economic tasks, with a insufficient competences in the field of modern standardisation and with the denial of the need to go through the logical stages of development of transportation logistics, shown above. As in the case of the Digital Internet, if there are no standards for backbone communication lines or lines themselves, then the Digital Internet is impossible. The Physical Internet in the segment of logistics regarding container transportation already exists. And exactly that segment witnesses the events that radically affect the development of world PI. As in the case of Digital Internet, local solutions based on its principles are possible, but this will no longer be the phenomenon that we call the world wide web.

Traditionally, data in the field of logistics have always been completely disassembled, which drastically limited development of digital technologies [3; 17–19]. In other words, companies store data wherever and whenever they find it comfortable for them, and this results in a fragmented ecosystem, creates huge inefficiencies, and makes it difficult to digitise operations. One of the prevailing logistics technology trends we have identified in 2020 indicates that data in warehouses will no longer be suitable for companies looking to keep up with changing times [3]. For example, new data standards are finally being created in the container shipping industry, due to the emergence of the Digital Container Shipping Association (DCSA) in 2019 [5]. DCSA mission is to create common information technology standards for digitisation and interoperability to make the supply sector more efficient for both customers and shipping operators. Just months after its launch, the organisation released its first industry draft detailing new industry standards for data processing intended for container shipping. The list of already adopted DCSA standards is quite long [3; 20].

As it was previously noted by the authors [3], DCSA is efficient in all the areas which are difficult for a single operator to operate. Those fields comprise cybersecurity, container tracking, port processes, hinterland connections, and more. During a short period after its establishment DCSA had managed to convince nine of the top ten shipping companies to become its members. This means that DCSA has covered 70 % of the global container capacity. Its NGO status has allowed to attract over 80 experts to join working groups developing IT solutions. All developed solutions are available as open source software on DCSA website making them available for a wide range of interested parties, allowing data exchange, particularly with all relevant associations in the field as well as with their members' clients. Since all shipping companies have different IT systems, it is the proposed standardisation scheme, based on the common opinion of key world experts, and not of officials, that is most successful today and corresponds to the realities of the digital economy.

This is how standardisation of the Internet (W3C), of business procedures and engineering (OMG), of building, maintenance and operation of buildings and structures (building SMART), of geoinformation systems (OGC) and many other areas of the modern economy are being built today. At the same time, thanks to the initial common approach, issues of compatibility and mutual use of ontological formalisations are also very quickly resolved [3].

Regarding the Physical Internet, DCSA representatives, speaking at IPIC-2019 (the annual conference on the Physical Internet), offered equal cooperation to all participants in this market. We consider the fact of the emergence of DCSA and its very rapid development as key factors for rapid creation of transportation logistics partnerships, clusters, joint use of transport corridors and development of urban logistics, since the bulk of the world's commodity mass moves precisely in containers, and precisely that sector witnesses through the efforts of DCSA that a set of standards and rules is going to emerge [3].

DCSA defines three Physical Internet elements [3]:

1. π-containers, which are determined by dimensions in three dimensions (from 0,12 m to 12 m).

2. π-nodes, places, and sites, including virtual ones, where π-containers are operated. Accordingly, there are π-systems, π-warehouses, π-hubs, etc.

3. π-transport (π-carriers). Accordingly, there are π-planes, π-ships, π-locomotives, π-cars, etc.

DCSA implements five key goals [3] comprising:

1. Development of IT and business standards.

2. Simplification and harmonisation of supply chains.

3. Introducing the container shipping industry to third parties.

4. Ensuring efficient, safe, and secure operations.

5. Support for innovation and disruptive technologies.

The active release of DCSA regulating documents started in September 2019 with general industry's positions described in an ontologically formalised way[1], while a separate document, a reading guide[2], is attached to all other documents. These documents provide a due understanding of the processes as they are. The DCSA industry plan includes processes associated with moving a container/equipment from one location to another, processes associated with shipping/booking, processes that are considered critical to the industry's digitisation and standardisation efforts, and finally, processes that are not addressed as commercially sensitive or competitive advantageous.

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[1] Industry Blueprint – Container Shipping 1.0 September 2019, Copyright 2019 Digital Container Shipping Association (DCSA).

[2] Industry Blueprint – Container Shipping 1.0 Reading guide September 2019, Copyright 2019 Digital Container Shipping Association (DCSA).


***Pic. 5. The sequence of events in the DCSA standard (compiled from DCSA sources).***

Main issued DCSA standards [3] are listed below.

• **An interface standard** for document tracking[3] and tracing[4] is created so that all members and partners in the container shipping industry can base their interfaces on a common understanding of industry data and processes to ensure consistency, simplicity and timeliness of tracking and control solutions across the industry, maintaining compatibility in container shipping [3].

• **DCSA Glossary of Terms**[5] promotes harmonisation of terms among all DCSA stakeholders in the container shipping industry. The first version of the glossary was published on the DCSA website in the summer of 2019 in the context of the DCSA industry project [3].

• **Reading guides** for DCSA 1.0 Information Model[6] and the DCSA Interface Standard[7] should help establish context and interpret DCSA initiatives. The guides provide insight into the various concepts and techniques used in document developing and wording and suggest ways to use documents as a basis for future implementations [3].

• **The DCSA 1.0 event naming convention**[8] and 1.0 event structure definition[9] serve the purpose of standardising monitoring systems. Cargo tracking solutions have become a widespread service in the container shipping industry. However, due to shifting terminology and ways of working, each carrier and third parties have developed their own offerings (systems) that are presented on the carriers' websites. To align this with the industry, DCSA has developed a naming convention that sets naming standards as well as an understanding of the tracking of events that customers encounter [3].

Understanding all events is interpreted in the same way across the industry through these standards (Pic. 5).

Since each structure can be used to combine many different events, a set of rules is needed to ensure that no combination creates illogical events.

Of note is the DCSA Information Model, which was created to provide a holistic view of the information that has been agreed within the process standards defined in the DCSA Industry Draft and in accordance with the definitions documented in the DCSA Glossary of Terms.

By standardising the terms used and documenting the relevant data, the information model is intended to provide a framework that

[3] DCSA Interface Standard for Track and Trace 1.0 27 January 2020, Copyright 2020 Digital Container Shipping Association (DCSA).

[4] DCSA Interface Standard for Track and Trace 1.0 Reading Guide 27 January 2020, Copyright 2020 Digital Container Shipping Association (DCSA).

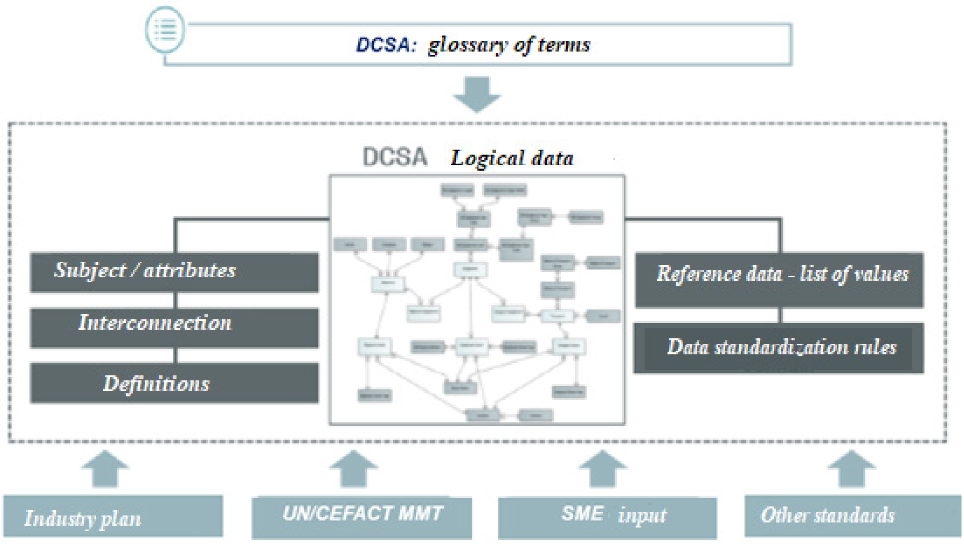
[5] Glossary of terms 1.1 Industry Blueprint – Container shipping 1.0 January 2020.

[6] Information Model 1.0 Data and Interface Standards, Copyright 2020 Digital Container Shipping Association (DCSA).

[7] DCSA Information Model 1.0 Reading Guide 27 January 2020.

[8] Event naming convention and Structure 1.0 January 2020, Copyright 2020 Digital Container Shipping Association (DCSA).

[9] Event Structure Definitions 1.0 Customer-facing Track and Trace Version 1.0 27 January 2020, Copyright 2020 Digital Container Shipping Association (DCSA).



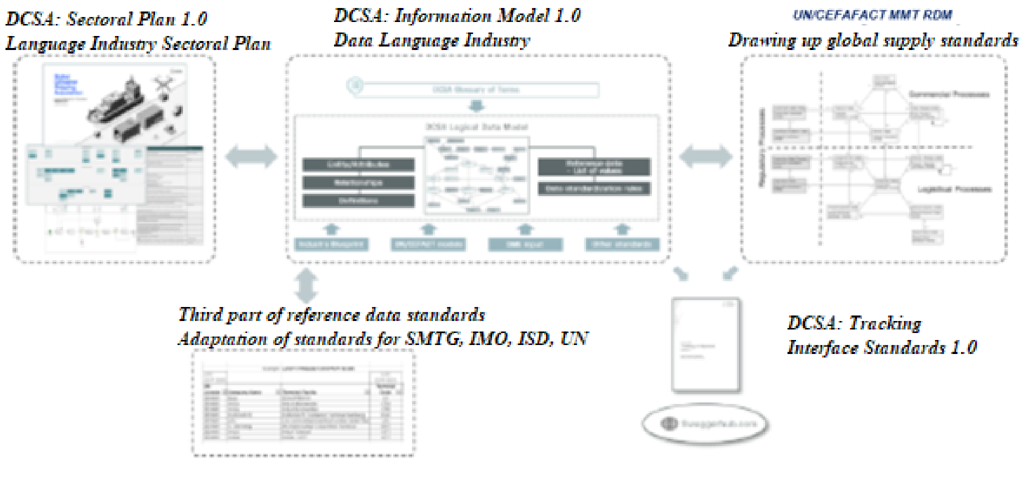

*Pic. 6. Overview of the content of the DCSA information model (compiled from DCSA sources).*

can be used in current interface standardisation work and for future initiatives. DCSA recognises that many other standards exist today and strives to reuse these resources where they fit the context of the container shipping industry. Some of these existing standards are more widely accepted than others, e.g., the UN/CEFACT Multimodal Transport Reference Data Model (MMT RDM). It is intended to continually evaluate the DCSA Information Model against these and other standards.

The DCSA Information Model was developed to support a common understanding of concepts, terms, and regulations in the shipping industry. The principles behind creation of the model were to consider the current standards used in the industry and reuse those standards where appropriate, or to propose new standards where an applicable standard cannot be found. An overview of the contents of the DCSA information model is shown in Pic. 6. Thus, the DCSA information model acquires the ability to act as a translator between different systems in the industry (Pic. 7).

**CONCLUSIONS**

Both for implementation of Russia's own development capacity, and for implementation




*Pic. 7. DCSA information model as a translator (compiled from DCSA sources).*

of its richest natural potential regarding transport sector, the Physical Internet is of great importance. It is possible to build it in Russia only considering (taking it for development) the existing standards, relevant for the nature of the digital economy, with the unconditional participation of the state. The role of the latter should be expressed in creation of both the rules for development of transport infrastructure, which will correspond to the economic realities of tomorrow, and the same regulatory rules. It seems to us that we have all the possibilities for this.

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