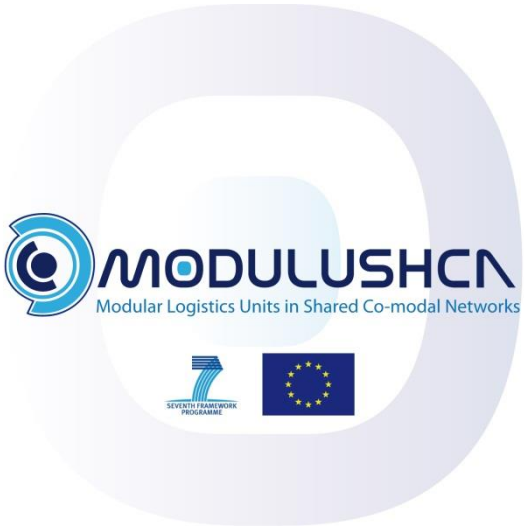
PROJECT FINAL REPORT



Grant Agreement number: 314468

Project acronym: MODULUSHCA

Project title: Modular Logistics Units in Shared Co-modal Networks

Funding Scheme: Coordination and support action (Coordinating)

Date of latest version of Annex I against which the assessment will be made: 31/07/2012

Periodic report: **1st ☐ 2nd X**

Period covered: **from 1st of April 2014 to 31st of January 2016**

Name, title and organisation of the scientific representative of the project's coordinator[1]:

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[1] Usually the contact person of the coordinator as specified in Art. 8.1. of the Grant Agreement.
[2] The home page of the website should contain the generic European flag and the FP7 logo which are available in electronic format at the Europa website (logo of the European flag: http://europa.eu/abc/symbols/emblem/index_en.htm logo of the 7th FP: http://ec.europa.eu/research/fp7/index_en.cfm?pg=logos). The area of activity of the project should also be mentioned.

1. Final publishable summary report

The objective of MODULUSHCA was to achieve the first genuine contribution to the development of interconnected logistics at the European level, in close coordination with North American partners and the international Physical Internet Initiative. The goal of the project was to enable operating with developed iso-modular logistics units of sizes adequate for real modal and co-modal flows of fast-moving consumer goods (FMCG), providing a basis for an interconnected logistics system for 2030.

MODULUSHCA integrated five interrelated working fields:

1. developing a vision addressing the user needs for interconnected logistics in the FMCG domain,
2. the development of a set of exchangeable (ISO) modular logistics units providing a building block of smaller units,
3. establishing digital interconnectivity of the units,
4. development of an interconnected logistics operations platform leading to a significant reduction in costs and CO2 emissions that will be
5. demonstrated in two implementation pilots for interconnected solutions.

2. Project context and objectives

The objective of MODULUSHCA was to achieve the first genuine contribution to the development of interconnected logistics at the European level, in close coordination with North American partners and the international Physical Internet Initiative. The goal of the project was to enable operating with developed iso-modular logistics units of sizes adequate for real modal and co-modal flows of fast-moving consumer goods (FMCG), providing a basis for an interconnected logistics system for 2030.

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9. development of an interconnected logistics operations platform leading to a significant reduction in costs and CO2 emissions that will be
10. demonstrated in two implementation pilots for interconnected solutions.

3. Main S&T results

During the project life time, the main working areas and achievements have been:

- Finalisation of a framework on how Physical Internet can enable an interconnected FMCG logistics system has been developed in several workshops with experts from industry partners, also explaining obstacles and success factors to a Physical Internet enabled system
- Development of modular boxes in the FMCG sector in two versions, version 1 focusing on interlocking mechanism and version 2 made by panels
- Algorithms for digital interconnectivity between different IT systems have been chosen and described as well as a sensoring and communication approach for modular logistics units
- Recommendations have been developed for the standardisation of iso modular containers
- Two implementation pilots have been carried out
- Active promotion of the Physical Internet and MODULUSHCA has been made, accompanied by dedicated dissemination material (brochure, templates, website, internal working space to share information, mailing lists, etc.)
- The Advisory board (Board of Directors) with experts from 13 industry and science institutions has been continued

3.1 *Vision*

In MODULUSHCA, an interconnected FMCG logistics vision has been developed to set the target for the work in WP3, 4, 5 and 6. Its purpose was to assess foreseeable logistics needs induced from:

- Evolution of consumers as well as traditional and e-commerce retailers;
- Foreseen technological and infrastructural evolution;
- Numerous prospective logistics studies;
- And the contribution of MODULUSHCA and the Physical Internet Initiative.

Therefore the vision document (D2.7) is not a new prospective report about logistics in 2030. There are already many reports addressing this question.

- First, the vision defines the purpose of a roadmap, as there are many misunderstanding regarding roadmaps and the methodology used during the MODULUSHCA project in order to achieve it.
- Second, it defines the MODULUSHCA vision for 2030, namely the description of the interconnected logistics response for the FMCG sector in 2030. This response is based on Physical Internet concepts adapted to the FMCG sector as the MODULUSHCA project focuses to this particular part of the logistics activities.
- Third, it provides a roadmap toward this 2030 interconnected FMCG vision, providing clear steps towards addressing the gaps between the current situation and the defined target. This roadmap is decomposed according to four interconnectivity domains: physical, digital, operations and business model.
- At last, according to different scenarios it identifies the trends and needs towards the implementation of interconnected logistics operations. For each domain, next steps building blocks were proposed, enabled features are highlighted and figures of merit presented.

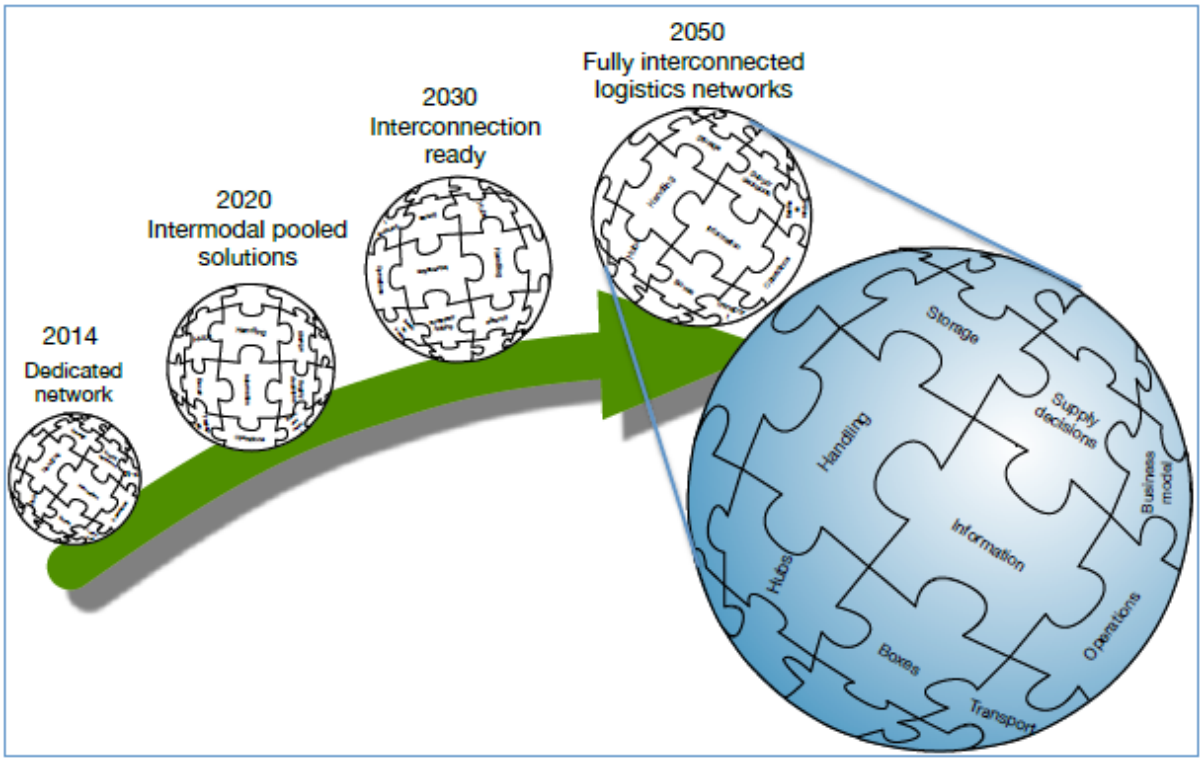


Figure 1: An overall representation of the roadmap

The roadmap in this vision is built according to three key premises. Every step (activity, development, etc.) in the roadmap should:

1. Provide a clear and significant benefit towards reaching the vision;
2. Comply with its starting point;
3. Be consistent with the other steps.

The purpose of the roadmap proposal was to enable its confrontation with FMCG supply chain stakeholders. The end goal for the project consists in validating, prioritizing actions and feeding ALICE ETP1 with research priorities.

3.2 *Modular boxes*

In the MODULUSHCA project, a first step towards modular boxes for the FMCG market has been made. This includes the assessment of requirements in surveys, decision for a material, optimisation of truck fill with the perfect sizes for the boxes and the actual development and manufacturing of the boxes.

Work started with an analysis for defining an initial set of M-box exterior dimensions for the FMCG sector utilizing road-based transportation. The 0.8m x 1.2m x 2.4m M-box platform has been used as input into the next phase of the project that further defined the M-box. In particular, wall thickness dimensions have been determined to see what, if any impact, they should have on the initial M-box exterior dimension set presented here.

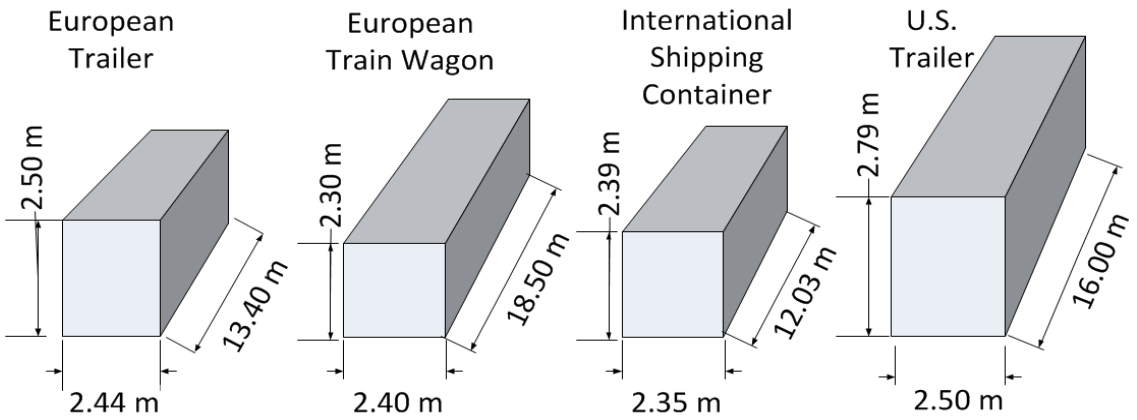


Figure 2: Four transportation containers, interior dimensions, in use today

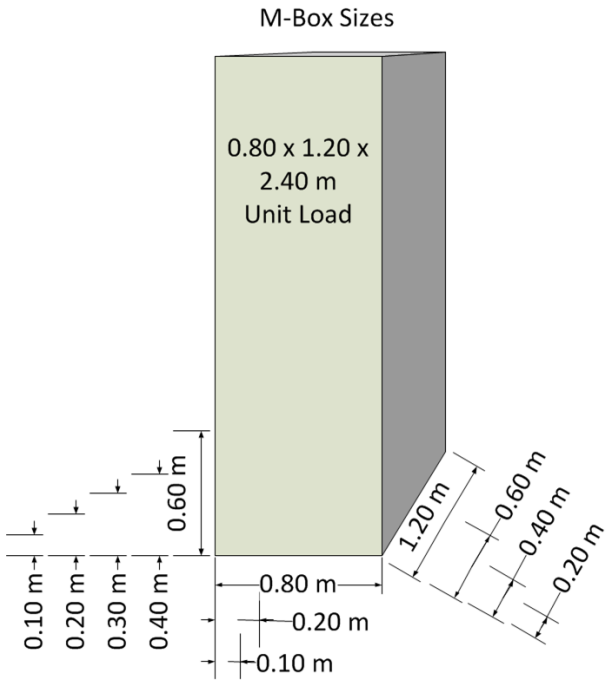


Figure 3: Modular Container Sizes (reduced choice)

Running a policy- and market analysis raised several remarks. The first important remark is that the M-box has a high degree of compliance (79% over 100%) of the initial design requirements (Functional groups). But at the same time, there is a lot of room for improvement. Improvements in folding/collapsing, strength and durability would have a very positive impact because these functional groups have a high relative weight. The second important remark is that some current market packaging solutions have also a good level of compliance. Foldable/Stackable plastic (injection) group has a 75%, rigid plastic box pallet group has a 71%; ISO rigid plastic box group and ISO rigid metallic box group have a 61%. This implies that any of these groups could be used for some of the functional test of the pilots instead of the M-box prototypes, in order to prove some aspects of the physical internet concept.
Considering this remarks had a big influence on the next design iteration in WP3.3 and also on the test runs performed in WP6. Furthermore special attention turned in the next step on the ergonomics of the M-box.

The next step in the design process was to improve the design according to functional test results performed in WP3.3. The main goal was to reduce the weight and to increase the volume usage for the next generation of prototypes. Furthermore the design aimed to include more functions like a possibility to identify the content, ways to secure the M-box and better ergonomic handling which are core functions of the whole PI idea.

An output of the survey for transport interfaces shows that most respondents are enthusiastic about the project MODULUSHCA and want to know more about it. Also the ideas and the concept of the PI in a logistics way is part of the interest by the respondents. The survey also revealed that it will take time to adjust the transport interfaces in a way that the equipment can better support and handle the M-box. The fit of the M-box into the logistics infrastructure is not likely to change the current logistics transport interfaces drastically.
In certain situations, like the back of a truck on a tail-lift, the M-box could improve the handling enormous. This situation is when FMCG freight is being distributed within the retail channel. Therefore the M-box should be designed in a way that the current transport interfaces can handle the M-box without modifications and that the M-box will bring stability, flexibility and strength.

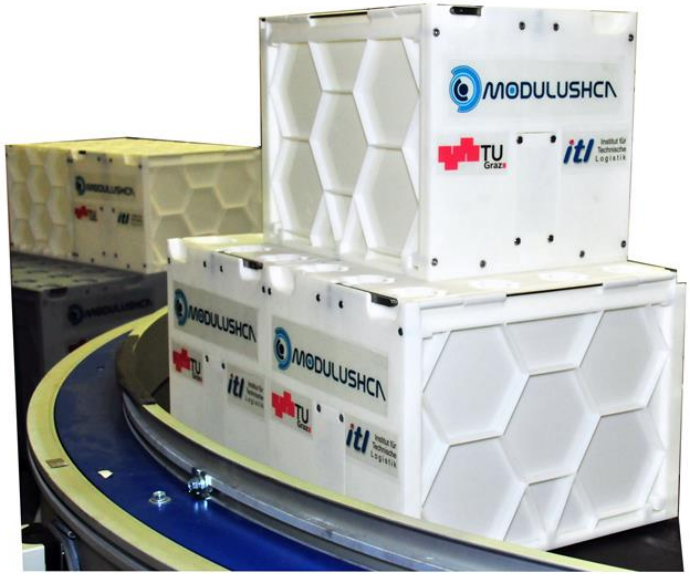


Figure 4: m-boxes

Concerning the interlocking of the boxes the developed mechanism can be seen as a practical and efficient way. The current manual movement to interconnect the M-boxes represents a first step for future developments to integrate the M-boxes in fully automated supply chains. For a future use the mechanical system “handle-rope-sliding plate” can be replaced by automated actuators which establish the interconnection by rotation the disks to interlock the units. With an appropriate energy supply and intelligence the M-box will then be able to navigate autonomously through future PI-supply networks.
Furthermore to the presented concept of realizing panels to build modular boxes a different approach one of the consortium partners developed outside the MODULUSHCA project will be tested under real conditions in the Implementation Pilots.
Testing the M-box prototype also showed the importance of choosing the right material for the M-Box or for panels regarding the use in automated supply chains or manual handling. Withstanding the daily use and meeting the terms and conditions of the PI concerning deadweight of the unit loads, inner volume utilization, etc. represents a huge future challenge.

Figure 5: n-boxes

Running the survey on ergonomics and handling capabilities revealed another future challenge for the PI in FMCG business. Although the total weight for the small M-box is still acceptable for men, the large M-box exceeds the acceptable for men from guidelines if fully loaded. Therefor and also to enable efficient handling in the supply chain there must be a possibility in the future to handle the M-boxes automatically. Furthermore if handles are added to the M-box in the future, it should be analysed the height to put them. That decision will affect the position of the load when handled with two hands analysed if they should be put at the top of the box or at the bottom. Putting them at the top of the box will probably make the box to be handled at knuckle height, while putting them at the bottom will favour handling it at elbow height.

In the development of the telematics devices, the challenges faced in the logistics industry should also be taken into account. The fact that hundreds/thousands of parties from multiple countries are involved, the varying regulations and missing standards and the multi-modality require a specification of the requirements for the monitoring modules in a more exact way. Single sensors can be described and the added value for the PI can be represented.

3.3 *Digital Interconnectivity*

In WP4, the general approach and fundamental ideas for achieving digital integration had to be defined. It means that the objective of the task has been aimed at the identification of the following inspiring principles:

- unique identification of the M-Boxes, the unique id is key for retrieving of all the related information (sender, destination);
- allowing access to information with different access rights for different roles;
- forwarding information along the supply chain;

- locating the boxes (in space and time) in order to trace them;
- observe events in the real word in order to bring them in the IT world.

So the activities done have been the following:

- Identification and description of the information to be used for handling modular logistic units and for the transport documentation;
- Supporting the operational activities, providing information related to planning systems in interconnected logistic;
- Identification and description of the data used in the information systems supporting transport planning systems within interconnected logistics, in FMCG Scenario;
- Collecting of the information and organization for further elaboration. Result of this activity will be used for the further analysis;
- Definition of MODULUSHCA handling of the information all along the supply chain, in order to allow tracing and tracking of iso modular containers.

It is an important outcome, of the activities performed, which the Modular logistics may be built upon existing IT systems, integrating the current processes with the needed data and the related operation.
The introduction of the modular containers and the related processes may be seen as an evolution rather than a revolution. They offer the opportunity to handle the information, related to the deliveries, in a more fine grained way. This enable the management of carriers with greater emphasis on the optimal filling, the booking and the cross-docking.
Achieving these objectives may be done considering existing IT technologies, no new discoveries or implementation have to be done. The logistics aspects of the scenario are prominent regarding the IT aspects. As in the actual world IT systems support logistic processes and operation. It can be also true for modular logistic. What have to be introduced is a greater sharing of data and information between the actors involved. A greater level of collaboration need to be achieved in order to fully exploit the modular boxes advantages. All of this may be done using actual software systems, extending and increasing the modularity and interoperability between them.

Another part of this work aimed at guaranteeing safety, privacy and security issues for the modular logistics containers along the entire supply chain processes. For achieving this objective an approach for sensors and communication had been identified. The sensor is linked to the tracking and tracing of the modular units during their movement in the interconnected network.

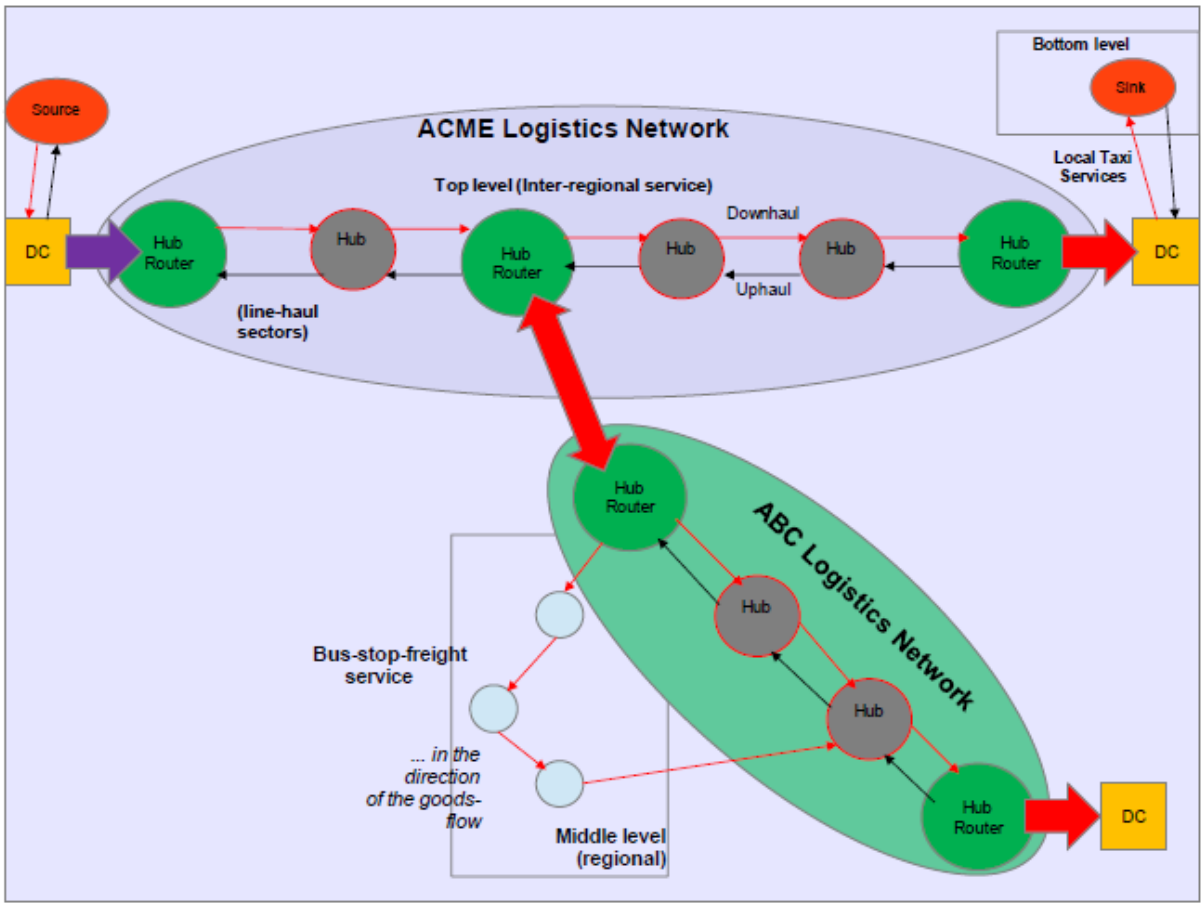


Figure 6: Structured Network Schema

A holistic approach for container monitoring and communication has been chosen focusing on the user requirements for FMCG. The approach, defined in the previous deliverables, has been defined as the "track the truck" approach. This approach is based on the principle of encapsulation, as defined by the physical Internet. The modular units are encapsulated in dynamic aggregation and then loaded into the trucks. In that way tracking the truck allows for tracking all the units in the aggregation.
However, it is our intention to consider a more fine-tuned approach at tracking, which considers all of the different levels of tracking. With the continuous improvement of the electronic devices, in terms of diminishing cost and increasing computational power, it is possible to propose a different service level for the modular units. Simple tracking may be done, in the more economical way, considering the tracking the truck approach. More complex tracking services may be realized, considering a more advanced tracking device may be added to the modular boxes, for example allowing stakeholders to know at all times where their cargo is and allowing them to intervene in the event of delay or intrusion.

The overall goal to be achieved, was enabling MODULUSHCA Boxes (M-Boxes) support to digital interconnectivity. The encapsulation principle is inspired to the digital Internet handling of the information, the internet does not transmit data: simply transmits packets. The information inside the packet is not used during transmission, it is handled by original sender and final receiver of the packets only and are the "payload" of the packet. Packets are routed, through the digital Internet, using only the header information. The Physical Internet encapsulates physical objects in physical packets. Similarly to the digital Internet, handling of the M-Boxes is realized using the associated data model, which constitutes the "header" of the

physical packets. During the work, a MODULUSHCA Common Data Model, addressing information organization, roles and access rights has been defined, which will be supported by the future evolution of the M-Boxes sensors.

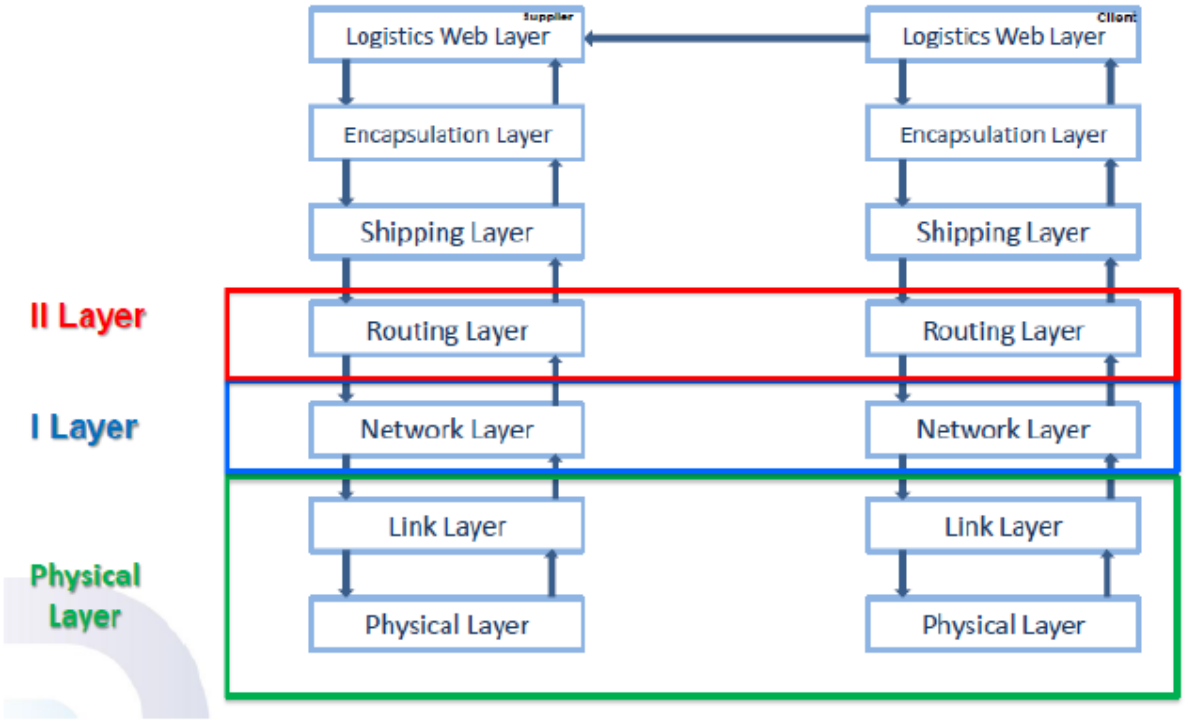


Figure 7: The Open Logistics Interconnection Model (OLI model) and MODULUSHCA layers

Another important aspect discussed is the integration approach that has been developed for interfacing with existing IT systems, in order to provide T&T events, to be processed in order to elaborate on higher layer events.

The sensor and communication approach was demonstrated within the Implementation Pilots. For transport monitoring, KGS will developed a real time monitoring system adapted to the modular logistics container requirements.

3.4 *Operational interconnected solutions*

In this working package, two individual optimization problems (i.e., the last mile problem and the vehicle dispatching problem) for the Physical Internet have been proposed.

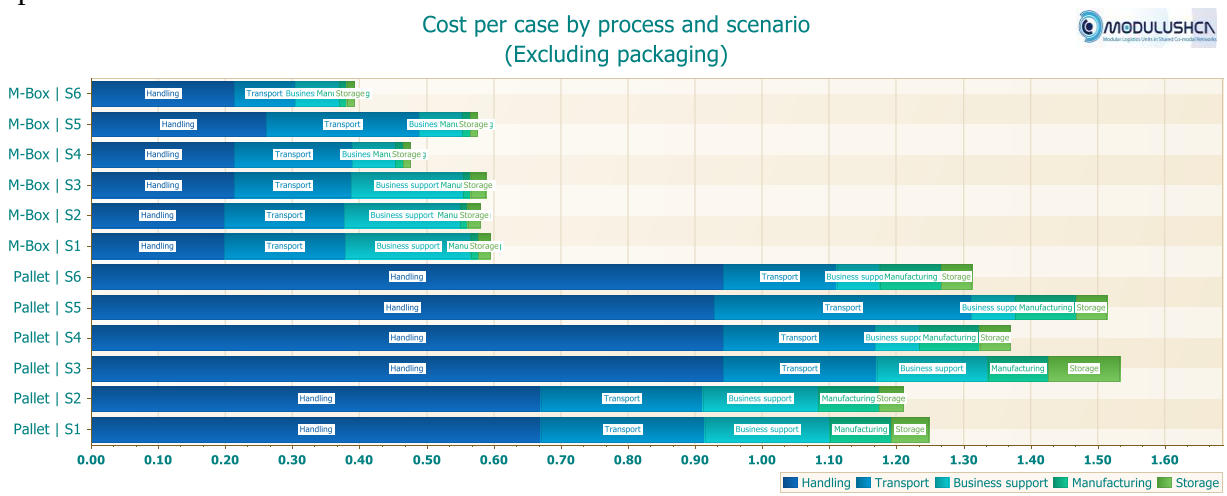
The last mile problem is a downstream problem which takes the dimensions of the modularized boxes into account for their final distribution to clients.

By contrast, the vehicle dispatching problem is a middle stream network problem. Its main objective is to identify the optimal transportation demand split and the best vehicle dispatching plan (i.e., walks for vehicles in the given graph) thus that the cost associated to empty vehicle movements is minimized.

Based on these two problems, one of the main purposes of this work was to analyze and quantify the benefit of the horizontal collaboration compared to its counterpart, the individual scheduling, in the world of Physical Internet. According to our numerical experiments, it reveals the importance and great potential of the horizontal collaboration. For example, in the last mile

problem, the cost saving rate of the horizontal collaboration can amount to 32% and in the vehicle dispatching problem, the total vehicle traveling cost can be reduced by 19% if deep collaborations among logistics operators prevail. However, according to the results of the numerical studies as well, horizontal collaboration does not always bring forth better solutions as intuition suggests. For instance, as indicated by the results of the last mile problem, in terms of the total number of vehicle used for the last mile delivery, the horizontal collaboration is inclined to utilize more vehicles. To further investigate the merits/shortcomings of the horizontal collaboration in the context of Physical Internet, more detailed and comprehensive case studies are suggested.

Five scenarios, which represent different degrees of collaboration, were examined from perspective of designed KPIs (cost and CO2 impact). The most optimal scenario for two transportation load unit solutions (pallets and m-boxes) were proposed. It was found that m-box solution is more effective from the perspective of both KPIs than pallet-solution. Then the Scenario S4 representing "Open high intensity" collaboration with a road transport is the most optimal.



3.6 *Implementation Pilots*

In general, the goal of the Implementation Pilots was to demonstrate the concept of Interconnected Logistics, which is strongly related to the Physical Internet principle, to test the prototype iso Modular Logistic units, in this document referred to as the M-box and N-Box and to show how transportation of Fast Moving Consumer Goods (FMCG) would be with modular boxes.

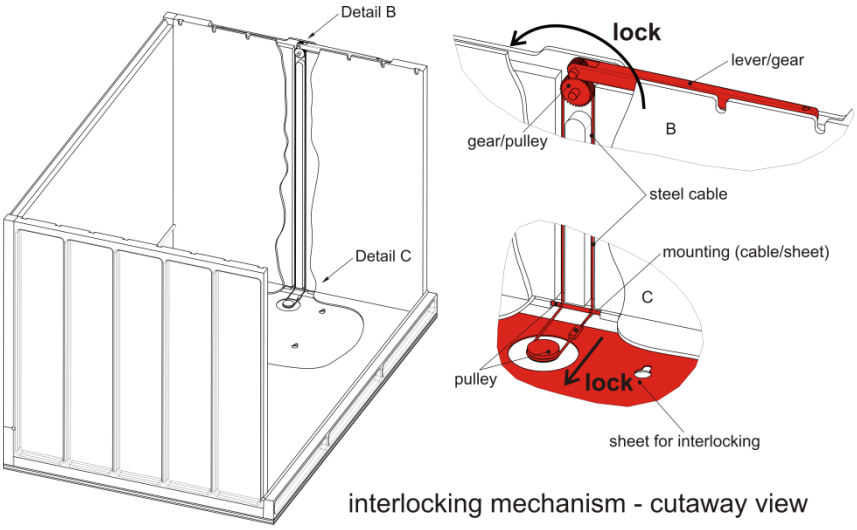


Figure 8: m-box Interlocking mechanism

It has not been an objective to demonstrate newly developed or to be developed Information Technology systems in an environment where modular boxes could operate of where interconnect logistics is in place. So from the partners who contributed to the pilots, their own IT systems were part of the pilots. Especially for the demonstration of the Interconnected Logistics, this resulted in extra effort for the planning departments involved. Interconnected Logistics tries to make more efficient use of the knowledge of available transport capacity at a certain moment in time at a certain location of region, based on multiple transport networks provided by Transport Service Providers.
Both Poste Italiane and Jan de Rijk Logistics opened up their transport networks especially for this MODULUSHCA pilot. Procter & Gamble offered freight streams for the pilots. This mix resulted in an interesting operational result of using less trucks, so a higher utilization per truck.

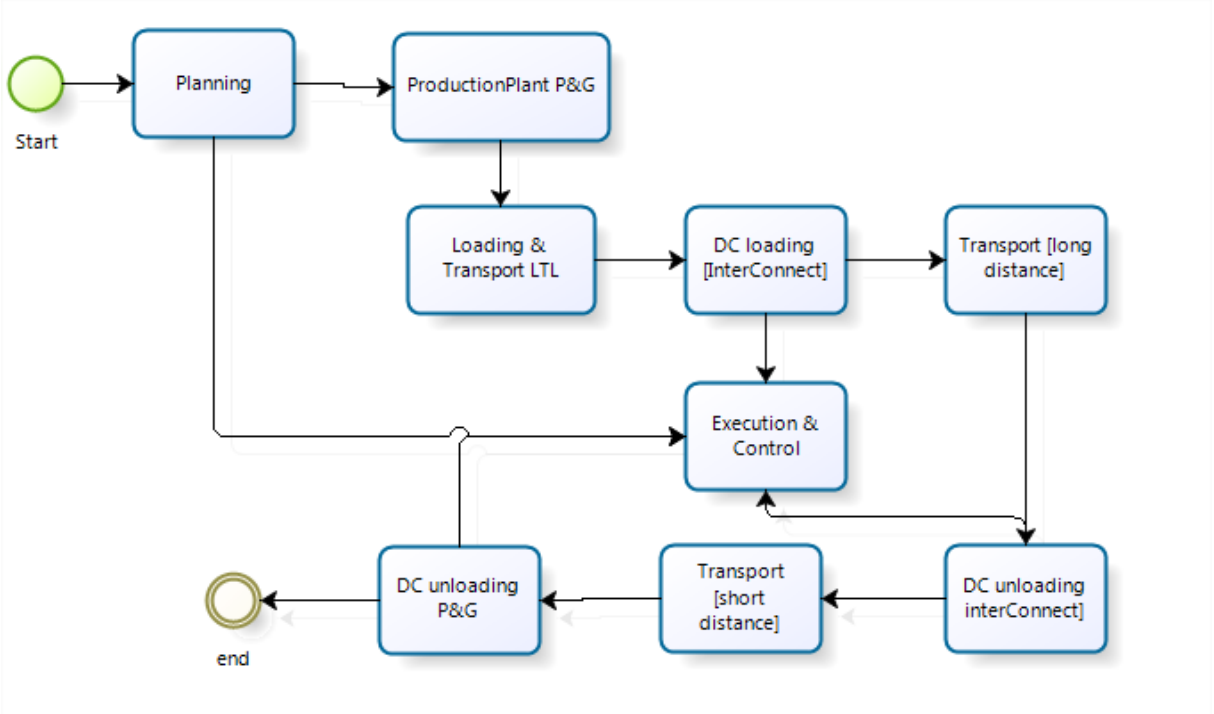


Figure 9: Process of the Implementation Pilot

The design of the prototype M-boxes was a complex project and the realization of the prototypes would result in high costs. Therefore TU Graz suggested to the MODULUSHCA

project partners to construct the M-boxes via a 3D printer. The advantage was short construction time, but the disadvantage was the strength of the M-boxes. In a second run, the N-boxes, it was decided by one of the contributing partners to make these using panels.

Figure 10: damaged m-box

Overall the collaboration and interaction between partners was intense and informative. The general conclusion from the test team is regarding the boxes: further development is necessary, but very promising. The general conclusion towards the Interconnected Logistics is: difficult to organize!

Figure 11: Connected n-boxes with load

3.7 *List of all beneficiaries*

Here is a list of all beneficiaries:

PTV PLANUNG TRANSPORT VERKEHR AG. Germany. PROJECT COORDINATOR

UNIVERSITE LAVAL. ULav. Canada

ASSOCIATION POUR LA RECHERCHE ET LE DEVELOPPEMENT DES METHODES ET PROCESSUS INDUSTRIELS - France

TECHNISCHE UNIVERSITAET GRAZ. TUG. Austria

ECOLE POLYTECHNIQUE FEDERALE DE LAUSANNE. EPFL .Switzerland.

TECHNISCHE UNIVERSITAT BERLIN. TUB. Germany.

POSTE ITALIANE SPA. Italy

PROCTER & GAMBLE EUROCOR N.V. PG. Belgium

CHEP UK LIMITED. CHEP. United Kingdom

PACKAGING, TRANSPORT & LOGISTICS RESEARCH CENTER. Spain

INSTYTUT LOGISTYKI I MAGAZYNOWANIA. ILIM. Poland.

INCEPTION CONSULTING LTD. INC. United Kingdom

MEWARE SRL. MEW. Italy.

J.A.M. DE RIJK BV. JDR. Netherlands.

KIRSEN GLOBAL SECURITY GMBH. KGS. Germany

4. Impact and the main dissemination activities and exploitation of results

Communication and Dissemination Strategy

The dedicated Communication and Dissemination Strategy was presented as D7.1: Dissemination strategy. It outlines in detail which public and private target groups the project intends to reach, by means of which project communication tools and through which dissemination channels at the European, national and local level. This was used as an alive document and has therefore been constantly updated during the project lifetime.

Website

A dedicated project website was set up as http://www.MODULUSHCA.eu/. It allows the internal and external community to follow up on new developments and results.

Figure 12: MODULUSHCA website

A WIKIPEDIA article was developed, improved and can be visited under http://en.wikipedia.org/wiki/Physical_Internet.

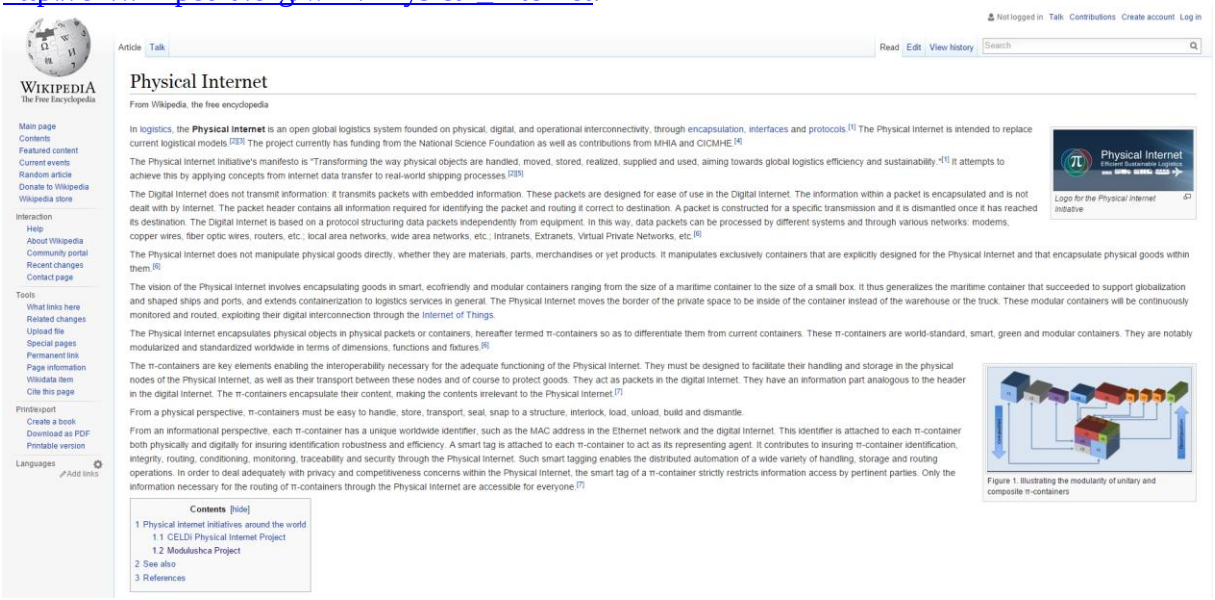


Figure 13: Wikipedia article about PI and MODULUSHA

Social Media

2.0 social media web channels have been set up and are used for communication:

- Twitter: @MODULUSHCA
- YouTube: MODULUSHCA
- Facebook: MODULUSHCA
- LinkedIn: Physical Internet Initiative group

Brochure

A project brochure was produced and presented. It shows the project's main objectives and expected results at a glance and has been distributed widely since then. It has been revised and updated during the project lifetime.

Press releases

Four press releases have been distributed to inform interested people about the MODULUSHCA results.

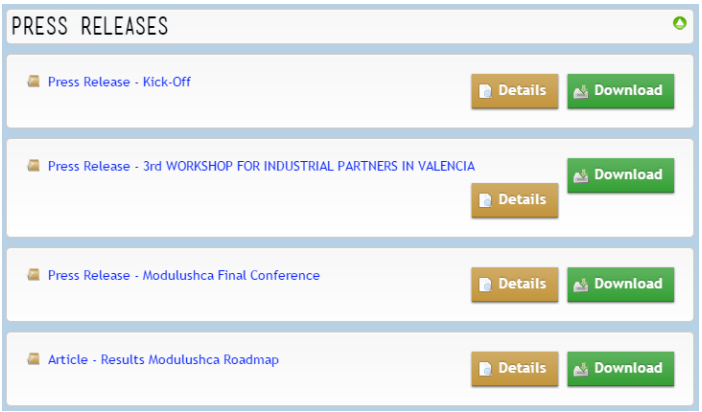


Figure 14: Press releases

Newsletters

After the first newsletter in reporting period one, MODLUSHCA has been produced 5 more between July 2014 and January 2016 to keep the interested project community informed of the project's progress and results. They have been distributed via the mailing list and can be found on the website.

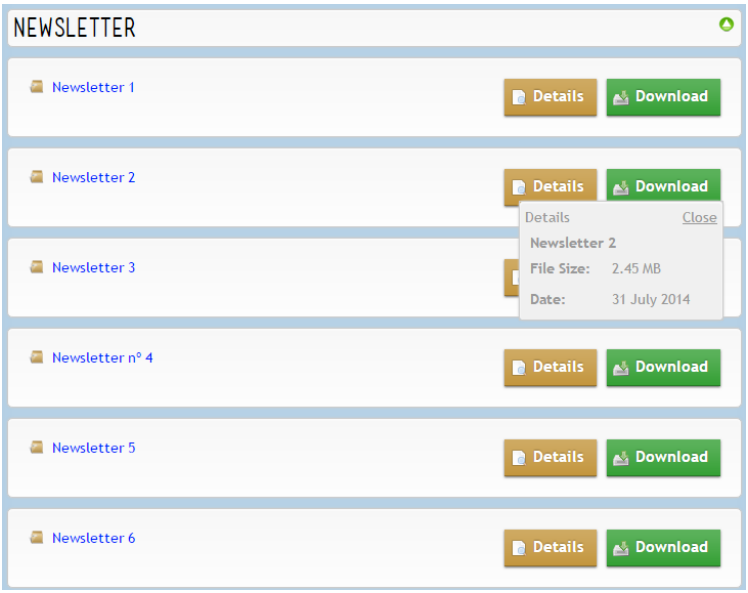


Figure 15: MODULUSHCA newsletters

Conferences:

MODULUSHCA has co-organised the 1st and 2nd International Physical Internet Conference.

The 1st International Physical Internet Conference was held in Quebec City between 28th and 30th of May 2014.

The 2nd International Physical Internet Conference was held in Paris, a three day event between 6th and 8th of July 2015 in Paris. It was also the final event (see D7.2)

- >250 Registrations for the Conference
- 116 high level speakers
- 3 days



Exploitation

Several actions were taken to exploit the MODULUSHCA results. An exploitation strategy has been developed placing the focus on the following fields

- Box development and bringing it into the market
- Improved network logistics through sharing capacity
- Enhance supply chain co-operation of manufacturer, retail and transport
- Information management for co-operative logistics

Dedicated exploitation approaches have been developed consisting of:

- Awareness creation on the Physical Internet and MODULUSHCA
- Individual exploitation plans towards the exploitation focus of the partners

Within the first half of the project, focus has been given to the awareness making, while individual strategies on technical exploitation has been the focus in the second half of the project. P&G and PTV have presented the project at many occasions.

In parallel, specific meetings with companies/organizations have been organized to identify field of cooperation within the MODULUSHCA project:

- Siemens AG Infrastructure & Cities Sector Mobility and Logistics Division
- Nestle
- ECR
- Schoeller Allibert
- Utz
- TESCO
- DM
- AXIT

In addition, a close partnership has been established with the sister project in Canada in order to set up a clear and structures framework of cooperation.

Industrial Advisory Board
An Industrial Advisory Group composed of key industrial stakeholders has been established involving now the following external experts:

- Prof. Georges Huang (University of Hong Kong)
- Prof. Dr. J. Rod Franklin (Kuehne & Nagel)
- Mr. Guillaume Tilquin (Renault)
- Mr. Max Winkler (SSI Schäfer)
- Mr. Michiel Nielsen (IRU)
- Mr. Roeland van Boeckel (CEN/TC 320)
- Mr. Dirk Thooft (Holland International Distribution Council)
- Mr. JeanLuc Azzani (P&G)
- Mr. Jean Fortin (SOUTHSHORE)

- Ms. Anna Ivers-Tiffée (DHL)
- Mr. Dave Sheldon (Nestle)
- Mr Ludo Gielen (Schoeller Allibert)
- Mr. Christof Weis (IFCO)

Three Advisory Board meetings have been carried out:
The first one in Munich on the 4th of June 2013 on the Transport Logistics 2013, the International Exhibition for Logistics, Mobility, IT and Supply Chain Management

The second Advisory Board meeting with 29 participants has been carried out on 7th of March 2014 in Brussels. The project board discussed and agreed upon u.o.

- the overall approach of MODULUSHCA,
- the progress and results,
- further proceeding of the project.

A third meeting had been held on December 2015 in Brussels, discussing the results and exploitation approaches with the Board of Directors. The commitment was very good, the discussion lively.