“smartBOX” - A BUSINESS CONCEPT TOWARDS THE PHYSICAL INTERNET

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Abstract

The overall transport volume of parcels and small logistics units strongly increases due to the rising popularity of online trading and supply concepts such as just-in-time delivery. Today's distribution services are inflexible in terms of customer needs and carried out by competing service providers in an uncoordinated manner, leading to inefficient and multiple deliveries and result in a lack of cube optimization. Therefore researchers propose a fully integrated system for autonomous and self-optimized cargo transport which effects reduction of traffic density. At the core of this prototype system which is currently being developed in Austria, is a concept labelled “public freight traffic”. This concept will enable private persons to ship their private parcels or luggage. In order to tackle the challenges of small freight mobility especially in urban areas, the project team develops new mechanisms of autonomous traffic optimization together with intelligent business models for cross-sector transport and logistics services. The developments include the design of intelligent containers (so-called “smart boxes”) as well as technologies for the branch-wide transport-related information flow. The goal of the project “smartBOX” is to increase overall quality of life and to save resources by creating an intelligent and integrated approach. In order to reach these goals, various system components need to be developed:

- The technical design of the smartBOX as reusable container
- Design of a standardized pooling system including tracking and tracing technology and a business model for intelligent order control and cost splitting. (Providing distance-related transportation rates, covering service provider expenses and ensuring compatibility with current systems.)
- Design of vandalism-proof pick up and drop off terminals to be implemented at public hot spots as well as housing complexes.

- Development of a comprehensive, intermodal transport concept to enable autonomous and bundled transports.

The smartBOX project team therefore investigates the challenges, technical and economic opportunities and the feasibility of an intelligent and integrated system for freight mobility. The findings will serve as a basis for future implementations.

Key words: physical internet, freight mobility, reusable container, intelligent container, small freight mobility, collaborative business models

1. INTRODUCTION

Both, people in rural and urban areas suffer increasingly under the negative effects of the ever-increasing freight traffic implying congestion, traffic fatalities and injuries and a not tolerable rise of environmental impacts. But freight transport is a basic pillar of the European economy and trade. Freight transports deliver goods across Europe rather fast, efficiently, flexibly and cheaply. – Nevertheless there are big needs for further improvements concerning economic and environmental efficiency. The logistics sector is of crucial importance for the European economy and contributes almost 14% to the European gross domestic product (GDP). But logistics processes constantly face big challenges to meet actual megatrends like:

- constant growth in the mail order sector (E-commerce)
- effects of demographic change and advancing urbanization
- impacts driven by automation and industrial initiatives like „Industry 4.0".

These ongoing megatrends ask for sustainable reduction of emissions and higher efficiency especially in the distribution logistics. The logistics branch has to advance along those recent and future trends and changes to contribute to a sustainable competitiveness in Europe.

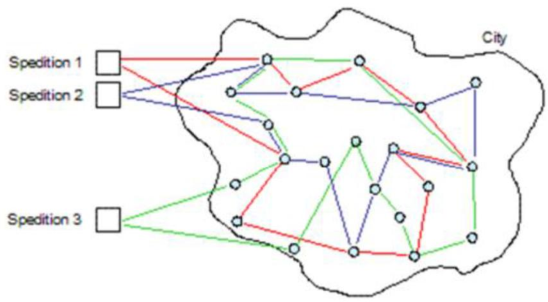
Based on long term considerations the concept of the "Physical Internet" (PI) meets those demands even facing a growing flow of goods and is currently investigated by different strategic R&D projects from North-American and European initiatives. Modular and standardized loading- and transport devices (like the smartBOX, which are able to communicate among each other and with the logistics infrastructure) and shared assets (e.g. inter-company commonly used nodes and edges in transportation networks) as well as new services and business models play a key role in order to efficiently use the available resources. However, the road from current technical and organizational basic conditions and predominated standards in the logistic branch towards new ideals will be long term and step by step.

The project "smartBOX" therefore investigates on the basis of a prototype for small goods possible impacts, changes, prospects and risks in a future distribution logistics according to the PI-vision. Therefore, criteria and guidelines regarding aspects of technical and information systems as well as processes are evolved in order to develop a neutral and open business model in the area of distribution logistics for small goods.

For operationalization purposes of the project the broadly diversified aims of the PI are reduced to three main core areas: Optimization of the volume and weight usage, common usage of resources and the therefore required data and business models. All that is aimed to find possibilities of better bundling and reduction of traffic.

Based on practical analysis of existing market volumes and actual systems general process models, functionalities, logistic services and cost structures for a future PI-realizations are derived. In this context the project "smartBOX" particularly focuses on identifying practicable gaps between proposed visions and the current situation, defining short- and long term measures to adopt the current distribution logistics to assessing prospects and risks. The project "smartBOX" will moreover identify further unsettled research questions. Practical aim is to find a system for greater efficiency in transport and storage, environmental sustainability and traffic reduction.

Figure 1. Competing delivery services presently block the cities



Source: Presentation of automated internet-shopping terminals, Bol 2014

Due to increasing individualization of trade and urgency control in industry the often tried bundling effects of existing logistics service providers are lost, transport fill rates drop and traffic volume increases especially in the last mile. In parallel, deliveries are carried out by competing service providers in an uncoordinated manner so that there are multiple deliveries and a lack of consolidation and concentration effects. Currently, so-called cross-channel transports, which could pool available transport capacities of public, commercial and individual vehicles, are not used. Moreover the lack of standardized pool systems of reusable transport containers (similar to the Euro-pallet pool) induce packaging needs and increased waste, including the associated negative environmental performance, both in the individual and in the commercial sector.

At the same time, the rapid increase in internet-based deliveries also gives rise to additional transport. Anyway, in most cases the personal presence of the receiver is currently required for delivery services. If no one is present on time of delivery, up to two additional delivery attempts occur and/or the way to a pick-up point is required for end-customers. In this case the persons have to take over the last mile of freight transport. In doing so the car is the choice of vehicle mostly. Thus, studies of the mobility behaviour of individual persons have revealed that the mobility of travellers is often urged by the need of the carriage of baggage in the direction of the automobile for ease of handling and comfort.

With a future integrated system for autonomous cargo transport it should be possible to reduce traffic density and simultaneously to promote passenger traffic by developing a system for public freight traffic. Passengers will be getting rid of their luggage or parcels as well as passenger traffic and freight mobility are going to be installed at once. Therefore the project "smartBOX" aims to revolutionize the growing transport needs in the field of freight mobility while increasing scarcity of resources by designing an intelligent and holistic approach. By means of holistic approaches future requirements using new media and information and communication technologies (ICT) will be investigated in the framework of the project "smartBOX".

In the field of ITS ("Intelligent Transportation Systems") numerous approaches from the logistics industry are already available to individually control reusable transport containers (such as ISO containers, industry-specific delivery units, ...). Often these are traceble via radio-frequency identification (RFID) systems. With individual identification each transport unit leaves a digital trail that can be completely traced and documented to the origin of the consignment over several modes of transport. Traceability provides the basis to guarantee reliable transport quality and to continually optimize. Thus, for example, the Unit Load Device (ULD) of Lufthansa and British Airways are completely chipped to load baggage, cargo and mail targeted at wide-body aircraft and on single-aisle aircraft, to control the empties and to target supply of maintenance. This allows the bundling of large quantities of goods to large units, which has the effect that fewer units need to be loaded and ground handling companies can save personnel, time and effort. Also in the field of temperature-controlled logistics, intelligent devices for permanent indoor climate monitoring are now state of the art.

What does not exist so far is the widely use in the end-customer-delivery because cost pressure and competition are particularly high here. However, we observe a drastic drop in prices for electronic components for years that motivate the project team for a technology transfer in small good containers. Logistics and parcel services or railway cargo companies are currently working with (for competitive reasons often incompatible) bar codes for packet identification. A standardized RFID-use should overcome companies' barriers.

2. METHODOLOGY

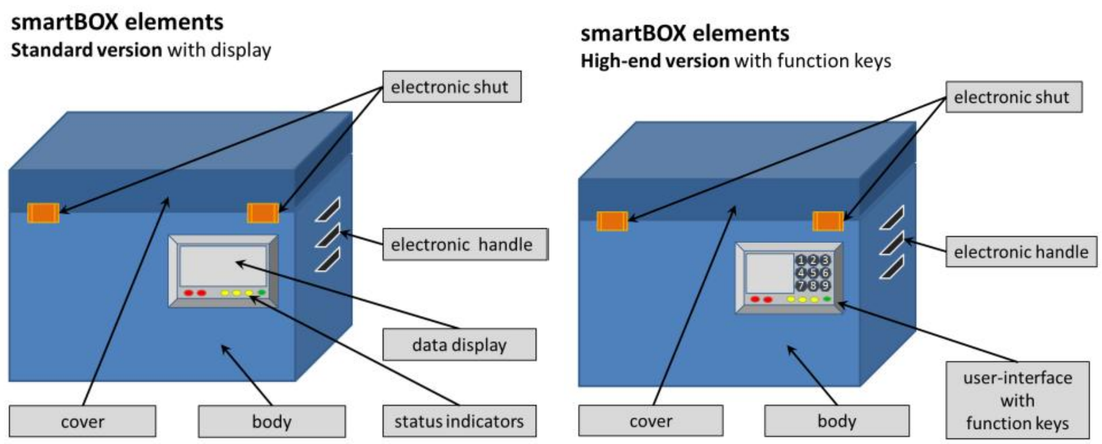
The project "smartBOX" will provide concepts regarding different system components: (1) Conception of a standardized dual-use container with an intelligent control system and user security access (= the "smartBOX"). This reusable transport container is the central element of the project. (2) Development of a pool system in order to provide availability, exploitation and control of the smartBOX regarding B2B as well as private passenger traffic by using electronic track & tracing methods and web-based communication technologies. (3) Conception of extensively used vandalism proof pick up and dropping terminals in public areas as well as housing complexes (including an adaption for freight transfer in the B2B sector.) (4) Conception of an encroached, intermodal transport system which will realize and bundle transport requirements in order to prevent multiple trips. (5) Conception of ITfunctionality by considering transparency and data privacy for decentralized autonomous subsystems. (6) Conception of business models to provide favourable and distance-related transportation rates, cover service-provider expenses and combine with presently used systems.

3. RESULTS

3.1. Description of the Technical Elements of smartBOX

The central element of the project vision is based on a lightweight, yet sturdy and for all users easily available reusable transport container. Therefore the smartBOX has to be safe, robust, vandalism-proof and to be opened only by authorized persons. The smartBOXes are supposed to be without usage and acceptance barriers in all user groups (so also especially for disabled and elderly persons) and easily obtainable in fixed terminals or by an app on popular mobile devices. Further it should be standardized, thus dimensionally accurate, but available in different standard sizes and modular stackable. It is also important that the smartBOX is a reusable container, which is recyclable and preferable produced in large quantities ecologically.

Figure 2. Technical elements of smartBOX



Source: Functional smartBOX drafts with and without input keys, Logistikum Steyr 2014

The clear identification is ensured electronically by using a RFID chip and optically by a readable number. Another quality of smartBOX is intelligence. Therefore the current transport data and container history have to be saved self-sufficient and could be shown to entitled users on a film screen. An active communication at fixed terminals, with readers in vehicles and in handling stations is also intended. In variant the smartBOX is also directly programmable and trackable via GPS chip. Therefore two initial variants are designed, which are shown in Figure 2.

A summarized criteria catalog lists the demands in detail as follows:

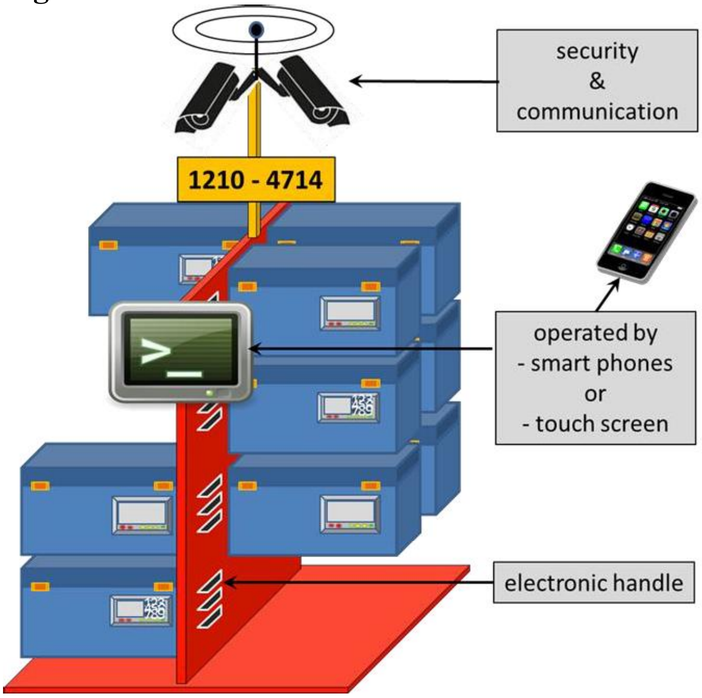
- Safe and stable
  - lightweight, yet sturdy and robust

  - vandal-proof and to be opened only by authorized persons
- Standardized
  - dimensionally accurate, but available in different standard sizes
  - modular stackable
- Ecological
  - preferable produced in large quantities ecologically
  - reusable (packaging is omitted)
  - recyclable
- Individualised
  - electronic identification via RFID
  - optical identification through readable numbers
- Intelligent
  - stores autonomously current transport data and the box history
  - visualisation of stored information on a display (e.g. sender, destination, lead time)
  - active communication with terminals and readers in vehicles
- User-friendly
  - easy to handle
  - without usage and acceptance barrier in all user groups
  - especially for disabled and elderly persons
  - easily obtainable in fixed terminal or by app on popular mobile devices (e.g. Smartphones, Tablets).
  - trackable via GPS

3.2. The Public Feed and Pick-up Terminals

The feed and pick-up terminals are intended for commercial and private use and taking over following tasks: (1) pick-up location for received consignments (mailbox function for packages) (2) buffer storage for empty transport containers and (3) feeding station for outgoing consignments. Furthermore the terminals must be protected against access and have to be easy to use. Therefore contact latches that can be solved electronically only by authorized users are foreseen. Through the terminal each registered user can receive and send consignments (luggage or packages). The terminals are labelled with unique identification numbers (e.g. consisting of the zip code and a serial number) for clear separation. In open spaces, the stations are under video surveillance or housed in rooms with an access code (similar to the garbage room of a residential settlement).

Figure 3. smartBOX-Terminal



Source: smartBOX Terminal draft, Logistikum Steyr 2014

3.3 Process and Transport Model

In contrast to the usual business practice of competing parcel services leading to multiple deliveries to the same destination, the smartBOX system should allow bundling effects and therefore result in measurable reduction in traffic. From today's perspective two traffic models are possible which will be analysed and developed in more detail in later phases of the project.

3.3.1 Model of autonomous Self-guidance

Whenever (commissioned and timed) delivery traffic enters a target area, the pick-up needs at the smartBOX terminals are visualized for the driver (or his dispatcher). If he has free hold capacity in his vehicle, he can autonomously decide to collect a smartBOX and pass it to the next dispensing hub for further intermodal transport. Over there the best provider will be determined for further transport. Thus, the competition of existing service structures remains but the expensive collection and distribution is neutralized.

Traffic-reducing advantage results from the possibility of delivering vehicles (which must perform deliveries in the target area) to automatically recognize the pick-up needs. These try to fulfil them in a traffic neutral fashion.

3.3.2 Model of central traffic control

In this case the vehicles participating in the system are coordinated and charged for collection from a central location. The benefits result from predictable service times and mathematically optimizing filling levels (e.g. through "Capacitated Vehicle Routing Solution" or models of the "Vehicle Routing Problems with Time Windows - VRPTW") and to enter into better ways to prioritization and emergencies.

The necessary commercial competition in both business models could take place through area-wise announcements for cross-channel logistics by service areas. Special priority should be given to environmentally friendly means of transport like cargo bikes and electrical vehicles. The system smartBOX could even act as driver for the exclusive delivery using ecological vehicles over the last mile.

3.4 Container pool

From the current perspective the responsibility for the provision and for the maintenance of the smartBOX transport container have still to be defined in the framework of the research project. Ideally an international provider of transport container pools should take this task. Existing pool solutions in food and automotive industries can serve as a role mode, whereby the offsetting of a “circulation charge” should be taken into account as a cost element in the transmission fees.

3.5 Business model and Payment

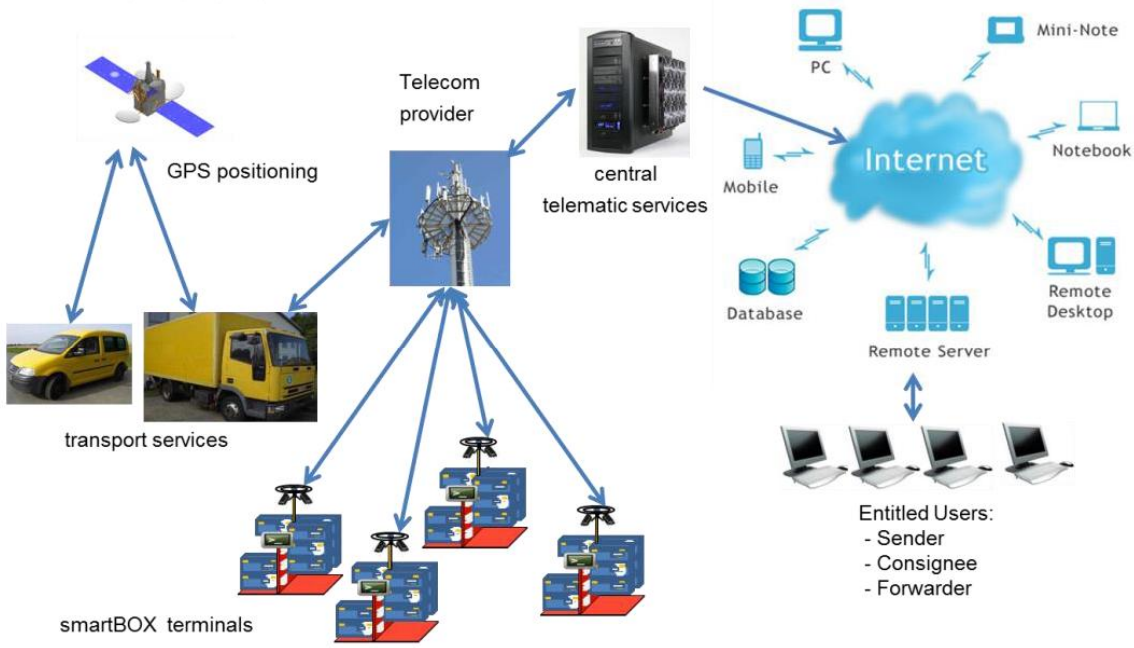
The use of data chips in the smartBOX transport containers enable dynamic tracking & tracing of all transport objects for all system stakeholders (transmitter, receiver, transport service, pool operators ...). This will result in a business model which calculates variable and individual transport prices on the basis of actual costs. Thus costly peripheral areas of central layers are economical to operate on the part of operators. It is expected to also improve the modal split between road and rail in favour of rail. To analyse and to conceive this is also subject of this project. Currently only Internet-based forms of payment are scheduled.

3.6 SmartBOX Information and Communication Technology and the Data Model

The design of the ICT (information and communication technology) infrastructure and the data model are very important in the service concept. On the one hand, the transparency and the real-time availability of information and on the other hand the necessary data protection are decisive for the product's competitiveness or acceptance in this system.

Moreover there are the challenges of decentralized data storage on the RFID chips of the smartBOX container, but also the necessary central information. For example, transmitter data (address, authorized data ...), recipient data (address, authorized data ...), container data (ID, track & trace, maintenance, availability ...) and service history (production date, maintenance data ...) have to be managed on the SmartBOX – Chip.

Figure 4: Information and communication structure in the system smartBOX



Source: Smartphones as enabler of Supply Chain Event Management, Posen 2014

The importance of ICT in the system smartBOX is clear primarily by the mass volume of the expected amounts of data and the interactive data streams, which have to be processed in real time.

4. CONCLUSION

The smartBOX system enables a demand-oriented, cross-regional bundling of the small goods transport by different, currently competing service providers with the aim of reducing traffic and increasing the comfort for industrial, commercial and residential customers. Widespread and public available reusable transport units reduce packaging needs. Joint system performance and responsibility (liability) replace company-specific business models. The Internet of Things with concepts of decentralized data storage and autonomous optimization strategies enables a public small goods transport. This has the effects that, the mobility of travellers improve for reasons of easy handling and greater travel comfort and made independently of cars.

From consumer's point of view the greatest innovation is to receive or send small articles at or from home, without having to be physically present for the acquisition or the transfer. Beyond this the way to a collecting or delivery point is omitted.

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