

INTELLIGENT GOODS IN INTELLIGENT TRANSPORT SYSTEMS

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SUMMARY

This paper describes a possible way forward for making transport systems for goods more effective, secure, available, reliable, predictive and more environment friendly. The way forward is based on more intelligent goods which implies enabling the goods itself to carry electronically stored information about the goods concerning content and transport route. Providing wireless communication with the goods along its route and at terminals opens new possibilities for track and trace, management of the goods flows and new possibilities for coupling logistics and value chain management systems together with traffic management systems. This paper describes the major objects forming a transport system for intelligent goods. The paper focuses on the device that is attached to the goods in one or another way, possible data to store in the device and possible functions the device may have in its most advanced version.

KEYWORDS

Intelligent Transport System, Goods, Multimodal, Intelligent Goods, On-Board Equipment, Interoperability, RFID, EPC, GS1, OBE, OGE

INTRODUCTION

Transport systems for persons and goods have many similarities but there is one major difference. Both types of systems have the main objective of transporting an item from A to B and both types of systems use the same infrastructure, e.g. road, rail, seaway and air corridors, and the same means of transport, e.g. vehicle, train, ship and plane. The control and monitoring systems managing the transport of the items are also to some extent similar having the main objective of optimizing the transport of the item concerning availability and space in the transport systems, its infrastructure and transport means as well as reliable and predictive pick up and delivery.

The main difference, however, is that whenever the transport item is a person the item itself holds and decides upon the information on where to start, where to go, via which terminals and by which transport system. The transported item also has the ability to register any deviation from the planned transport and take its own decisions on how to handle the deviation based on available information and knowledge about the transport system and its environment. In other words one could say that the person, e.g. the driver of a vehicle or the customer in a public transport system, is an intelligent transport item compared to the goods.

This paper describes how goods could become more ‘intelligent’ transport items. The obvious benefits of more intelligent goods are amongst others:

- The goods carries crucial information about itself, e.g. unique identity, special characteristics (e.g. highly inflammable) and origin-destination data enabling more off-line handling of the goods and independency of on-line central systems
- The goods is able to store information on events that may have an impact on the goods itself, e.g. high temperatures, or information on major delays (location, time and delay)
- To some extent take actions on events that have exceeded predefined limits, e.g. sending an alarm when the temperature exceeds a certain limit or sending an alarm in case the location of the goods is not in line with the planned route data in the intelligent goods
- Enabling a more accessible and feasible track and trace of the goods for actors involved in the complete supply and transport chain
- Providing information to the control and monitoring systems managing the transport of the items, e.g. giving priority to certain types of goods or monitoring hazardous goods in vulnerable parts of the transport systems, e.g. road and rail transport through tunnels.

THE TRANSPORT SYSTEM FOR INTELLIGENT GOODS

A transport system for intelligent goods is a system that by the means of information and communication technology (ICT), new equipment technology and seamless exchange of information fulfils the requirements of the involved actors concerning an effective, secure, traceable and reliable transport and where the goods itself is an important carrier of information about itself, the final destination and events occurred during the transport.

The transport system for intelligent goods consists of the following objects:

- The transport infrastructure itself, e.g. a rail network
- The transport infrastructure equipment, e.g. traffic management and information systems
- Terminals with terminal areas
- Terminal equipment, e.g. communication systems and track and trace systems
- The transport means, e.g. a truck or a vessel
- The transport item, e.g. a box, a pallet or a container
- The transport item equipment, e.g. an RFID tag fixed to the transport item and connected to sensors measuring the temperature or the goods acceleration/reacceleration (shock sensors)
- The transport means equipment (On-Board Equipment), e.g. an electronic device mounted in the transport carrier communicating with other systems, e.g. GPS and Cellular Networks, having an interface to the driver of the transport carrier
- Interoperable information systems enabling a seamless exchange of information between the actors involved in the operation and use of the transport system
- Interoperable Supply Chain Management control and support systems enabling automatic or manual control and decision support of the intelligent goods in supply chains
- A defined set of roles and responsibilities building the platform for the business model for the intelligent transport systems for goods as well as the daily operation and use of the system

- A framework providing a set of commercial, functional and technical rules for the system

The transport infrastructure is the network of roads, railways, seaways and air-corridors. It is the backbone of the transport system for the intelligent goods. Within the same type of networks there are nodes, e.g. junctions in a road network and stations in a railway network. Where one type of network connects to another type of network there are also nodes, e.g. a terminal connecting a road network to a rail network. Hence, the transport infrastructure can be described by uniquely numbered links and nodes (and in some cases names) in national transport infrastructure databases.

The transport infrastructure equipment is an important object in the transport system for intelligent goods. Transport Management Systems based on static and dynamic traffic data used in transport models and on-line optimisation of the current traffic situation are found in all types of transport systems. For the transport of intelligent goods it is an important building block as it provides an information and communication infrastructure that can be used by the intelligent goods. Continuous communication between vehicles and the roadside, between two or more vehicles and between mobile equipment and fixed infrastructure is now being enabled via the CALM (Communication Access for Land Mobiles). The emerging suite of CALM standards (1) provides protocols and parameters for medium-range, medium- to high-speed wireless communications in the ITS sector using different types of communication well-known and already in use for many years, e.g. DSRC (Dedicated short range communication), digital audio broadcasting (DAB), digital video broadcasting (DVB) and global positioning systems (GPS).

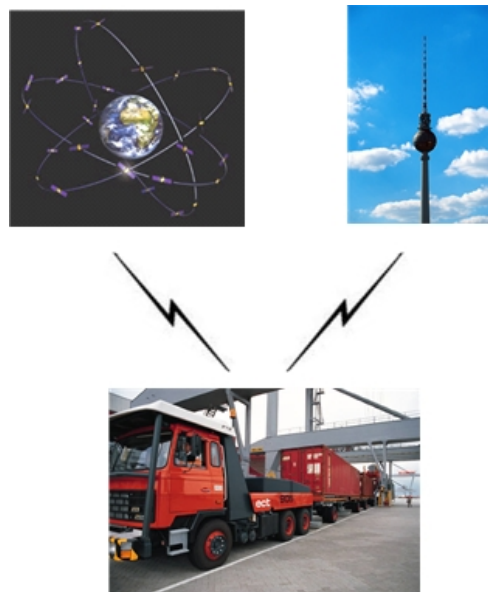


Figure 1

Terminals with terminal areas are important nodes in the intelligent goods transport system. It is often the bridge between two different types of transport infrastructure and a place where many of the transport items are split in smaller units, sorted and merged again in new transport items. These processes will usually provide an easy access to the goods and its transport item equipment. From an information viewpoint the terminals will probably be the crucial points for data collection and communication with the transport item equipment.

Terminal equipment will, as the transport infrastructure equipment, play a major role in the intelligent goods transport system. Terminal equipment covers both equipment used for moving goods within the boundaries of the terminal as well as the ICT systems that are



Source: Jamison Industrial Portals

Figure 2

installed at the terminal. The ICT systems include both the administrative systems needed for the daily operation of the terminal, e.g. for document handling and information about the shipment, and the ICT systems communicating with the OGEs. Such systems will be dedicated or open WLAN systems, gantries with OGE communication equipment, handheld R/W equipment and internal portals with R/W equipment and applications and other types of medium and short range communication systems.

The transport means are the carriers of the transport items in the transport systems. Very often a transport item is transported by different modes of transport means (multimodal transport) from its origin to its destination, e.g. by truck – by train – by truck.



Figure 3

The transport item is one of the two core objects in the intelligent goods transport system. The transport item can be almost anything; - the main criterion is that the item is moved through a transport infrastructure by a transport mean. Hence, a box or parcel, a pallet, a container, a new Ford Mondeo being shipped from the factory are all transport items. The transport items are in many cases like Babushka dolls, there will be one transport item inside another transport item which again may be inside another transport item.

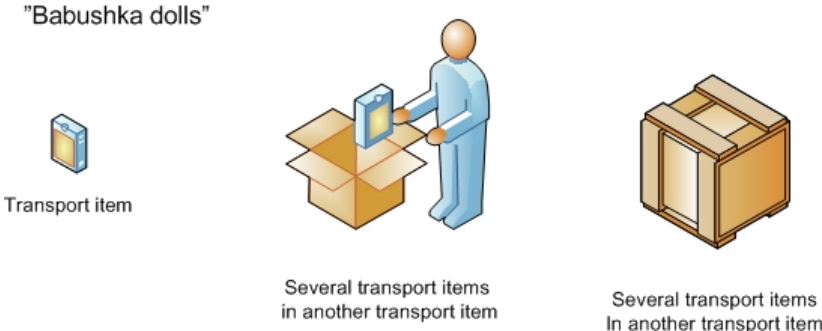


Figure 4

Example: several small boxes that are individual transport items in themselves can be in a large box which is also a transport item. Several large boxes can be put together on a pallet and several pallets can be put together in a container. The small box, the large box, the pallet and the container are all transport items.

The transport item equipment is the other core object in the intelligent goods transport system. It is attached to the transport item, holds crucial information on the transport item it is attached to, may monitor the status of the goods and its environment and is able to communicate with its environment via radio signals. For many years there has been a similar device attached to vehicles, i.e. a device that holds crucial information about the vehicle and that is able to communicate with its environment via radio signals. Road tolling is a widely used application for this type of devices. The device is called On-Board Equipment (OBE) and from now on the similar device for goods (transport items) is called On-Goods Equipment or OGE. The Babushka doll principle will also be valid for the OGEs. Following the principle that each transport item has its own OGE there will be several OGEs linked to another OGE at a higher logical level. The linkages between the OGE at different logical levels will be one of

the major challenges in the intelligent goods transport system. A more comprehensive description of the On-Goods equipment is given in a later chapter.

The On-Board Equipment (transport means equipment) plays an important role in the intelligent goods transport system. It is foreseen that the advanced OGE, in a range of simple to advanced OGEs, is able to communicate with the OBE in the transport means transporting the goods. Hence, the OBE can be a semi-transparent communication channel for the OGE to the transport system

and terminal equipment. The OBEs implemented today are mostly simple tags based on DSRC communication. However, a new generation of OBEs is now being developed with a higher level of functionality, security and different types of communication. An example is the European R&D project called CVIS (Cooperative Vehicle

Infrastructure Systems) that aims to design, develop and test the technologies needed to allow cars to communicate and network directly with the roadside infrastructure (2). Figure 5 shows how the author assumes the future generation of OBEs will be. The OGE is described in more detail in a later chapter.

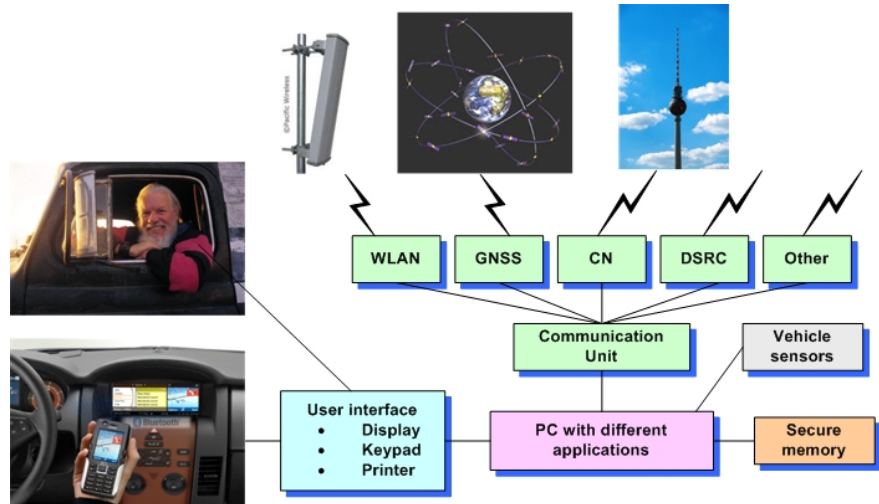


Figure 5

Interoperable information systems will be the information backbone of the transport system for intelligent goods. The main responsibility of the interoperable information systems will be to provide a seamless and secure exchange of data and access to data for all involved actors. A key to interoperable information systems is open interfaces which again require standards both for the communication itself and for the data elements to be transferred via the interface. The communication standards enable two parties to communicate with each other while the data dictionaries and

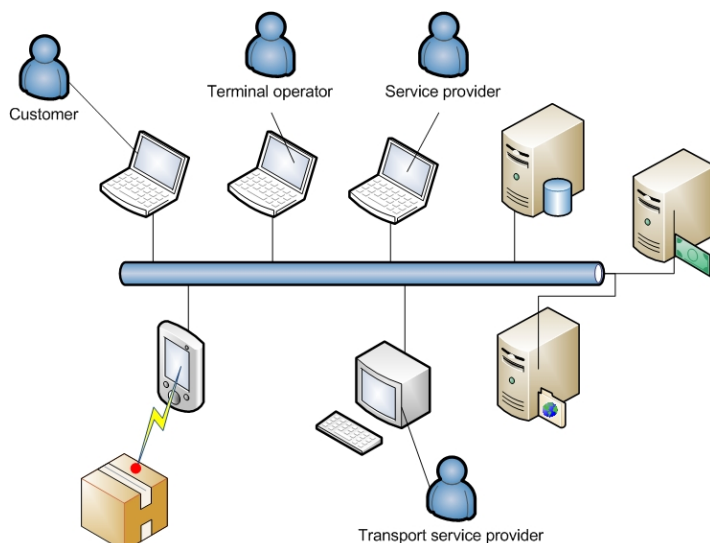


Figure 6

languages enable the same two parties to understand each other whenever the communication is established. There are already many international and regional standards that have been implemented in this type of transport and logistic systems both concerning communication channels and protocols and for data dictionaries and data exchange languages. A more comprehensive description is given in a later chapter.

Interoperable Supply Chain Management systems including advanced algorithms for automatic decision support and value chain control will play a role in the transport system for intelligent goods by using frequently updated information on the location of the goods to optimise the flow of goods in the transport system both concerning volume and destination. The flow of goods will be dynamically controlled and adjusted to meet the customer demand.

A defined set of roles and responsibilities is needed enabling the building of an enterprise model for the actors involved in the transport system for intelligent goods. An enterprise model describes the different roles of the various actors (and objects) in the system and the environment around the system. It describes the rules (policies) that apply to the various roles and the activities that are performed by the system. There are several enterprise models used for transport systems but they are very often related to one specific type of transport system, e.g. road traffic. The ARKTRANS multimodal system architecture (3) describes a set of roles and responsibilities in a multimodal environment and this framework could be very useful as a starting point for describing the roles and responsibilities in a transport system for intelligent goods.

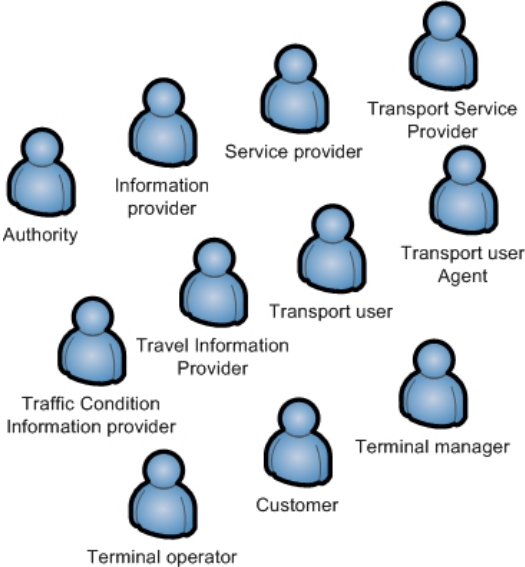


Figure 7

One of the most important tasks of the group of roles forming the enterprise model is to define a suite of commercial, functional and technical rules. There is a need for a set of technical rules (standards and unambiguous detailed requirement specifications) enabling technical interoperability. There is also a need for a set of functional rules (processes, functions, data dictionaries, common languages, data models, application interface definitions, application standards) enabling a functional interoperability. Finally there is a need for a set of rules (agreements, Memorandum of understandings, contracts, regulations, legal frameworks) that enables the different actors taking the different roles to be operational and contractual interoperable. The transport system for intelligent goods may work technically and functionally but will not work commercially if there is no explicit or implicit contractual fundament for the daily operation of the system.

THE ON-GOODS EQUIPMENT (OGE)

Introduction

The intelligent goods itself has a crucial role in an intelligent transport system for goods. By intelligent goods is meant an object that carries electronically stored information which is used for an effective and secure transport of the object from A to B. The object may appear in many different shapes and with different contents, e.g. an item in a box, a pallet with different types of objects and a container with pallets or different types of items stored in the container. The device that stores the information electronically may have different levels of functionality depending on the type of information stored, how the device communicates with its environment and to what extent the device has the capacity of handling the information stored. The device is fixed to the goods either permanently or temporarily.

The role of the intelligent goods is described by the following main responsibilities:

- Store and protect information linked to the goods and its transport from A to B
- Communicate with the intelligent goods environment
- Monitor the transport from A to B

The two first responsibilities are mandatory and will always be present in different ways and levels of functionality. The third responsibility is optional but will usually be present at a certain level of the two first responsibilities.

Store and protect information

The information stored in the OGE will be static or dynamic and the access to the information will be dependant on the access rights of the different entities communicating with the OGE. The minimum level of access will just be Read-only while the most enhanced access rights in advanced OGEs may include rights like read, write, delete, create etc.

The most typical and fundamental information in an OGE will be the unique identity of the transport item. This unique identity should be based on the EPC (Electronic Product Code) as defined by the GS1 (4) which is a leading global organisation dedicated to the design and implementation of global standards and solutions to improve the efficiency and visibility of supply and demand chains globally and across sectors. The GS1 system of standards is the most widely used supply chain standards system in the world (4). The EPC standards can be downloaded from (5). The EPC code will be the absolute minimum of information stored in an OGE.



Another important information that should be stored in the OGE is the planned route data, e.g. origin – destination data and eventually any information on major nodes in the route between the origin and the destination.

Examples on such nodes could be terminals. The geographical points could be described by a unique numbering scheme using the EPC standards for Global Location Number (GLN) and/or the coordinates of the point. A GLN can represent either a discrete, unique physical location such as a

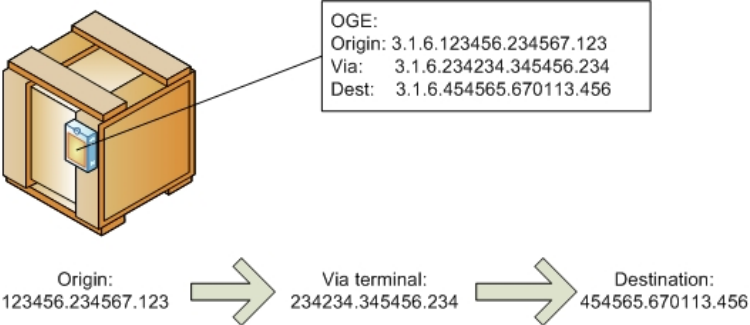


Figure 8

dock door or a warehouse slot, or an aggregate physical location such as an entire warehouse. In addition, a GLN can represent a logical entity such as an “organisation” that performs a business function such as placing an order. The planned route data could also include planned date and time for the different locations and in some cases the identity of the transport means, e.g. the name of a ship.

The intelligent goods may, depending on the level of the OGE functionality, monitor its transport from origin to destination. The monitoring events should be stored in a secure event log enabling the OGE environment to access the log and read the records describing what has happened during the transport. Typical events would be departure and arrival at different locations, e.g. terminals or transport means. Other events could be states of the transport item or the environment of the transport item, e.g. the temperature and humidity. More examples on such events are described later.

The intelligent goods may also store specific data on its content, e.g. dangerous goods like petrol or certain chemicals. This information could be very useful for the operators of the transport network in emergency cases, e.g. a fire in a tunnel. It is quite obvious that it makes a major difference whether a trailer in the tunnel contains 30.000 litres of milk or the same amount in petrol in case there is a fire in the tunnel. The content of the OGE fixed to the trailer could be read by the operator of the tunnel at the entrance and the exit of the tunnel enabling him to know exactly and at any time what is inside the tunnel.



CBS news 13.12.2007

Figure 9

Data protection is an important issue in relation to intelligent goods. Confidentiality, integrity and availability should be implemented at all levels of OGE functionality. Confidentiality means that only entities that have the access rights to the different types of information should be able to read or write data stored in the OGE, e.g. the electronic product code. Integrity means that those who have access to the data should be confident that the data has not been changed by anyone not being authorised to do so. Availability means that the data needed for the users and operators of the intelligent transport system for goods should be available whenever they are needed to protect the users and operators from any economical loss. The

security policy of the intelligent transport systems owners should take into account the assets at stake ensuring there is a balance between the security measures and mechanisms implemented and the potential economical loss. For some of the security mechanisms there may be a need to store secret keys in a secure part of the OGE memory.

Communication with the intelligent goods environment

The intelligent goods may communicate with several of the objects listed below:

- Transport network equipment, e.g. gantries at tunnel entries and exits
- Transport means equipment, e.g. On-Board Equipment in trucks
- Terminal equipment, equipment installed in gantries at the terminal entries and exits, handheld devices for read/write and portals at a warehouse gate
- Cellular networks (CN), e.g. GSM
- Global navigation satellite systems (GNSS), e.g. GPS and GALILEO
- Other transport items, e.g. the OGE on a box on a pallet may communicate with the OGE on the pallet and the OGE on the pallet may communicate with the OGE on a container creating a nested hierarchy of information
- External sensors

In most cases it will be communication via air interfaces although there are examples showing that wired communication may also be used, e.g. between an OGE and external sensors fixed to the transport item or advanced OGEs that are programmed via a physical interface, e.g. via I/O ports on the OGE.

The interfaces have to be open and standardised interfaces enabling interoperability between the different types of equipment being part of the intelligent transport systems. The air interface communication distance will vary between a few centimetres to many kilometres (CN and GNSS) and requires a comprehensive suite of communication standards. There are already several international short-link standards, e.g. the ISO 18000 Information technology -- Radio frequency identification for item management standards and the ISO 14443 Identification cards -- Contactless integrated circuit(s) cards -- Proximity cards standards. There will also in a few years be a very important new suite of standards for Intelligent Transport systems – Communication Access to Land Mobiles (CALM) issued by ISO. The ISO standards are also complemented by the GS1 standards.



Figure 10

Parts of the information stored in the OGE should be communication profiles and IP addresses for different objects in the intelligent transport system for goods.

Monitor the transport

The last responsibility of the OGE concerns monitoring the transport of the transport item. The monitoring could cover the following tasks:

- Compare data for planned route with data for real route (both location and time), log deviations and report or send alarm on severe deviations

- Compare limits for the physical environment with registered data for the physical environment, log and report or send alarm in case of exceeding the limits

In those cases where the OGE has been loaded with the planned route data, the OGE could compare the planned data with the real route data registered at nodes in the transport network infrastructure or terminals. The OGE could for instance register the location by GNSS or by reference points along the route, e.g. a terminal. The registered data should always be logged and in case there are no deviations there is no need to report or send an alarm. However, in those cases where the location of the goods and/or the date and time deviate essentially from the planned data the OGE could send a report (moderate deviation) or an alarm (major deviation). The communication module of the OGE will know where to send the different reports and alarms.



Figure 11

There will be situations where the transport item will be subject to certain incidents that may reduce the quality or in worst case destroy the item. Examples of such incidents are high or low temperatures exceeding the temperature limits, humidity, e.g. exposure to heavy rain or water, and shocks, e.g. a pallet with fragile items has fallen down from a truck. The OGE should always know where it is and should record the event that was registered by any type of internal or external sensor. In those cases where the incident may have an essential impact on the transport item the OGE could send a report or alarm as described above. The alarm could for instance be location, time and type of incident. It will of course not always be possible or relevant to report or send an alarm but the OGE should at least log the incident so it can be reported later.

The OGE technology and functionality

The OGE is assumed to be categorised as a passive or active RFID tag. The simplest OGE will just be a very simple passive RFID tag (Class-1) that only stores and protects the unique product information (EPC) related to the transport item to which the OGE is fixed. There are several commercial items already on the market including different types of equipment communicating with the RFID tags.

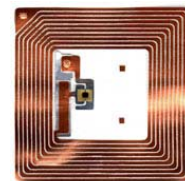
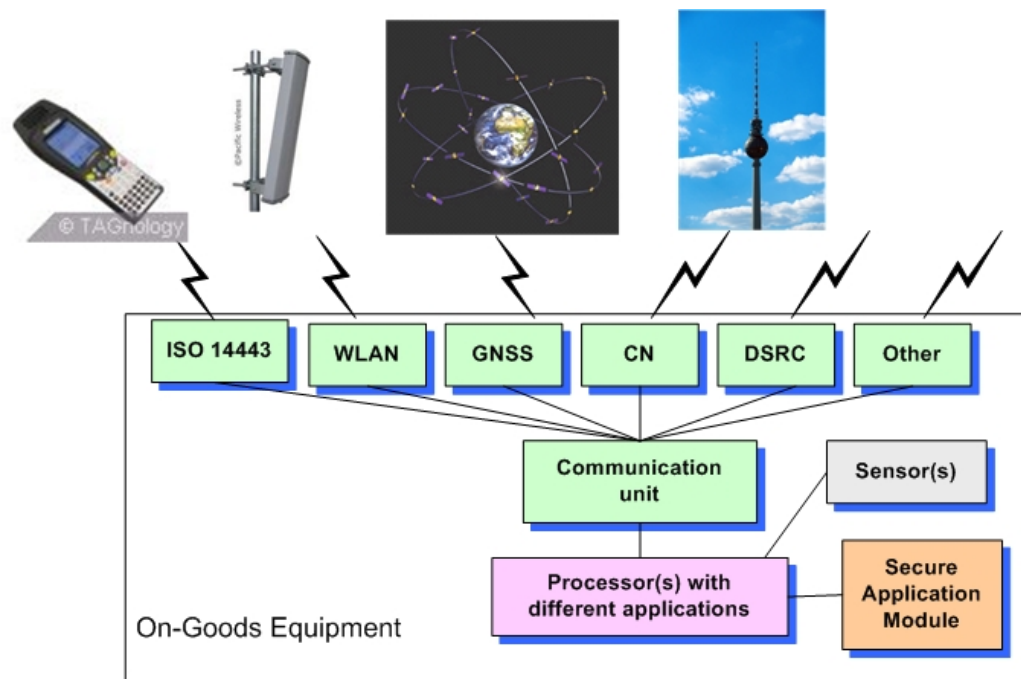


Figure 12

At the other end of the scale there will be quite advanced OGEs (Class-4 or higher) with its own power source (e.g. an internal battery), dynamic, static and secure data stores, internal and external sensors and several types of communication channels for exchange of information.

An example on how the OGE may look from a computational viewpoint (author's opinion) is shown in Figure 13.



Picture source: Handheld reader: Tagnology, Antenna: Pacific wireless

Figure 13:

CHALLENGES

The intelligent transport system for goods is not there yet but steps have already been taken, e.g. the implementation of RFID tags and EPC information architecture in many systems all over the world. Before the intelligent transport systems for goods are widely implemented there are some challenges that have to be solved by research, experiments, pilots, technology and regulations and/or contractual frameworks.

Achieving interoperability (the ability of systems to work together) on a technical, functional and contractual (commercial) level is a key issue. The transport of goods generates much more cross-network, cross-border, international and inter-continental traffic than the transport of persons. Hence, the need for interoperability is most urgent before the implementation of non-interoperable ICT systems for goods transport all over the world creates barriers that will be more and more difficult to overcome in a global aspect. Imagine numerous e-mail systems around the world that worked perfectly within their own environment but were not interoperable. An e-mail sent from a sender in one system would not be understood by a receiver in another system. This is perhaps the major risk we are running into concerning the transport of goods if the actors involved together with the transport authorities and the standardisation bodies are not able to find solutions for interoperability on the three levels mentioned above.

From an enterprise viewpoint some of the major challenges will be:

- How to define a common and worldwide accepted and implemented set of roles and responsibilities for the actors involved in ITS for goods? An ISO standard for an Enterprise model like the ones for interoperable electronic fee collection and

interoperable fare management could be a starting point. ARKTRANS is also a good starting point here.

- How to define and implement the set of rules (policies) that will govern and guide the implementation and operation of ITS for goods?

From an information viewpoint some of the major challenges will be:

- How to define the set of data and messages that will be used in ITS for goods? The work done by GS1 and EPC are world wide leading but there will still be some steps to take concerning intelligent goods.
- How to define and decide upon the ownership and handling of data? This is always an important issue in a competing business which transport of goods certainly is. This also has also to be seen in the light of the enterprise model.

From an engineering viewpoint some of the major challenges will be:

- How to implement the enterprise model, the set of rules and the information architecture taking into account the already existing thousands of different ICT systems used in the transport of goods?
- How to implement the security architecture defined by the enterprise, information and computational viewpoints ensuring confidentiality, integrity and availability of goods related information?

From a technology viewpoint some of the major challenges will be:

- How to define and develop a family of On-Goods equipment meeting the different requirements concerning:
 - Price
 - Functionality including different data requirements, security, sensors and communication in many different and difficult communication environments
 - Protection of the On-Goods Equipment in situations where the goods (transport item) is object to rather rough handling and impacts
 - Possibilities of attaching or integrating the OGE to or in the goods

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