

Potentials of Satellite-based Traceability Services in Logistics

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BIOGRAPHIES

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ABSTRACT

In several industrial sectors the needs of traceability entail the implementation of technological solutions in order to improve inbound and outbound logistics, manufacturing execution, transport, security.

This paper aims at investigating business potentials and opportunities of traceability services integrated

with satellite navigation services with focus on logistics of critical parts and products or more complex systems. Logistics is in fact pervasive and it encompasses not only the classical inbound, production and outbound processes but also the use, maintenance and dismissal phases of the product/system. This paper is a preliminary work aimed at identifying some basic issues for the investigation of relevant business opportunities that new logistic services enabled by advanced solutions based on Global Navigation Satellite Systems (GNSS) and other Information and Communication Technologies (ICT)-based systems can represent.

1. INTRODUCTION

In several industrial sectors the needs of traceability entail the implementation of technological solutions in order to improve inbound and outbound logistics, manufacturing execution, transport, security. The traceability with Radio Frequency Identification (RFID) technologies in fact allows to store, retrieve and track data and information related to specific parts, goods, containers or carriers through various semi-automatic or automatic devices. The use of barcoding found a worldwide acceptance in the past years. This cheap and simple technology is still extensively exploited in manufacturing and service industries. Currently, advanced technological solutions for traceability generally rely on RFID technologies, often integrated with other ICT systems depending on product types and business objectives. Intelligent tracking technologies lead to intelligent real-time communication of information about the external and internal business processes and among the various stakeholders, a reduction in costs, a decrease in stocks, an increased security on the quality of products and possible lower waiting times for costumers.

This paper aims at investigating business potentials and opportunities of traceability services integrated with satellite navigation services with focus on logistics of critical parts and products or more

complex systems. It is a matter of fact that in many manufacturing sectors there is a shift from the selling of physical products towards the provision of integrated systems of products and services as foreseen in (MANUFUTURE Platform 2006). Relevant opportunities and potentials seem therefore to arise from the delivery of added-value service throughout the product lifecycle (see for instance Confessore et al. 2007) in particular in the case of complex products and systems that embed high value. Logistics is in fact pervasive and it does not encompass only the classical inbound, production and outbound processes but also the use, maintenance and dismissal phases of the product/system. Therefore the business opportunities can be identified in the back-office side while a product/systems is in design, production, distribution/delivery phases. Accordingly, other business opportunities can be identified in the front-office side while the product/system is in-service or in the dismissal phase. Satellite navigation services, currently based on Global Positioning Systems (GPS) and in the future based on Galileo, can be the essential enablers, in combination with RFID and other ICT technologies, for providing innovative added-value services for an efficient, effective, customized and secure integrated logistics. This paper is a preliminary work aimed at identifying, by also reviewing some literature works, some basic issues for the investigation of relevant business opportunities that new logistic services enabled by advanced solutions based on GNSS and other ICT-based systems can represent.

The remainder of this paper is organized as follows: Section 2 is devoted to the identification of some main logistic processes. In Section 3 a review of current use of RFID in logistics is presented. In Section 4 potentials of the integrated satellite systems and RFID in logistics are presented. Conclusions follow.

2. LOGISTIC PROCESSES AND PRODUCT LIFECYCLE

Logistic scenarios generally consist of the following actors: suppliers, manufacturers, logistics service providers, retailers, users or customers. Logistic services are often provided within logistics systems by outsourcing policies in the supply chain. Accordingly, different types of logistics service providers are in charge for the execution of specific processes with different positions in the chain and outsourcing levels. Several ICT-based solutions for production, logistics and customer relationships are available in current scenarios: for instance Enterprise Resource Planning, SCM, Customer

Relationship Management, Product Life Cycle Management systems or dedicated systems like Warehouse Management Systems, Manufacturing Execution Systems, Transportation Management Systems, Fleet Management Systems (Confessore et al. 2007). In general, product identification and traceability are provided by RFID and barcode technologies. By focusing on the phases of the *product lifecycle* the following logistic macro-processes can be identified (Confessore et al. 2007):

- design for logistics (product design phase),
- procurement, inventory management, inbound logistics (production),
- outbound logistics, warehousing, transportation (product distribution),
- spare parts management, after sales technical support (product use & maintenance),
- reverse logistics (product dismissal, recovery, re-manufacturing/recycling).

Depending on product types, complexity, value and usage modality, several traceability needs for product information and material flows can arise from customers or users throughout the product lifecycle from a front-office standpoint. Moreover, depending on the business strategies and cost requirements of manufacturers, system integrators or logistic service providers, other traceability issues for the mentioned flows may be addressed from a back-office standpoint. Traceability needs may be related to safety, security, reliable lead times estimates, level of service and quality assurance about the product conditions.

The possible application fields can then vary from the freight procurement, warehousing and transportation services to maintenance and technical support services. Moreover product lifecycle management practices and tools are becoming more and more relevant from manifold perspectives:

- compliance with social, environmental, and regulatory requirements related to specific products and materials (e.g., electrical and electronic equipments),
- efficiency of logistic processes,
- effectiveness in terms of customization,
- shortening product lifecycle and process life cycle,
- changes in products' usage modalities (Confessore et al. 2007).

3. RFID SYSTEMS IN SUPPLY CHAIN

RFID technologies have the capability to contribute to remarkable improvements in identification and

tracking of items in limited environments related, for instance, to specific production and logistic processes (e.g., warehousing, material handling). RFID is applied to different sectors such as the pharmaceutical industry, healthcare, logistics, transport, retail and security, etc., aiming at realizing visibility and transparency of information and material flows.

Literature confirms the importance of these transparency and real-time information in the supply chain by the several studies. In fact, it is very important in decision making that the information flows are transparent and secure, otherwise the lack of real time visibility can generate accumulation of stocks, uncertainty of demand and supply, etc. (Zhou et al. 2006). Hunt et al. (2007) confirm that RFID systems allow to obtain real-time information that helps to support fundamental activities such as the processes of demand planning and forecasting, procurement, manufacturing, assembly, and distribution. Zhou et al. (2006) present an RFID-based monitoring system for enterprise internal production management, where everything that concerns the production process is totally transparent to the management department. Based on this system, the productivity can be improved and the production costs can be notably reduced. Ngai et al. (2005) describe the development of an RFID prototype system integrated with mobile commerce in a container depot. This RFID system can help a container depot to gain competitive advantages for reducing waiting times at the depot of third-party truckers seeking to pick up their containers and reduce operating expenses. Chow et al. (2006) propose an intelligent system that includes a RFID-multi-agent based process for improving the logistic performance and operational effectiveness.

In general, the use the tracking RFID system has several advantages such as contactless reading and writing, integration of objects and data for maximum flexibility and reliability, technologies and protocols for advanced wireless transmission for reliable communication and reading and writing even if no precise positioning and tags are visible.

RFID technologies have the disadvantage of operating at a distance of a few meters depending on which type of tag is chosen and its intended applications. The communication frequency between reader and tag are regulated by national and international bodies and are different enough to lead to inconsistencies when the RFID travels together with the goods to which they are associated. The frequency bands most commonly used in RFID technologies are:

- Low Frequencies (LF) and in particular the 120-145 kHz that is historically the first frequency used for automatic identification, still significantly used in the market (Talone and Russo 2008).
- High Frequencies (HF), and in particular the 13.56 MHz deemed the “universal” frequency band throughout the world (Talone and Russo 2008).
- Ultra High Frequencies (UHF) consisting of the 865-870 MHz in Europe, 902-928 MHz in USA and 950 MHz in Asia. It is considered as the “new band” for RFID in logistics and management of individual items, it can operate on distances greater than the distances allowed by LF and HF. This band is not uniformly allocated throughout different countries (Talone and Russo 2008).
- In the UHF range, the band centered on 2,4 GHz. It has similar features to the UHF while allowing a further miniaturization of the TAG. However, other technologies exploit this band, (e.g., WiFi, Bluetooth, ZigBee). Outside Europe, the use of this band is exploited for both active and passive tags, with ISO 18000-4 standard (Talone and Russo 2008).

RFID could then represent an important enabler while offering an unprecedented ability for supply chain actors to coordinate their activities concerning complex products and systems or items that have to remain in specific conditions readable by sensors.

The integration of RFID systems in the supply chain brings tangible benefits regarding efficiency due to integration of increased productivity of human resources and quality of processes while in terms of effectiveness tangible benefits are represented by reduction in lead times and quality perceived by customers (Politecnico di Milano 2007). Intangible benefits can be represented in terms of image, increased quantity, quality and timeliness of data, increased users’ satisfaction, and compliance with regulatory constraints (Politecnico di Milano 2007).

RFID integrated with satellite systems can be the technological basis for offering more services, for example, security and authenticity services of products and materials (e.g., the GPS devices may be used when it is necessary to track, for instance, the transport of high value products over long distances).

The disadvantage of RFID to trace a nearby field can be overcome when an integration of data communication with a satellite system is enabled.

The trade-off for the decision of adopting RFID-based solutions is progressively changing due to variable implementation costs. Ustundag and

Tanyas (2009) observe that an increased use of RFID is related to the reduced semiconductor industry costs and to the improvement of data communication standards. The same authors underline that few studies have been presented in the literature concerning cost-benefit analyses of RFID systems although the interest on this topic and on other economic issues is also relevant in (Bottani and Rizzi 2008, Kim and Sohn 2009).

Ustundag and Tanyas (2009) argue that the main factors that affect the benefits of RFID integrated systems are the product value and the demand uncertainty in terms of supply chain cost savings while it is highlighted an unequally distributed impact on the actors of the supply chain. In (Bottani and Rizzi 2008) and (Kim and Sohn 2009) the researches have been conducted, respectively, on the economical assessment of the impact of RFID technology and Electronic Product Code system at operational level, and on the construction and operation decisions of logistic systems.

4. POTENTIALS OF SERVICES BASED ON SATELLITE SYSTEMS AND RFID IN LOGISTICS

Few studies have been presented in the literature regarding the application of satellite systems in the supply chain. A work presented by Ursa et al. (2006) on the monitoring and tracking through GPRS/UMTS concerns the cold chain transport. An integrated mobile solution (Cold-Trace) that allows a constant monitoring and control of the cold chain during transport is proposed. This monitoring improves the competitiveness of transport, quality of the load, an operation cost reduction, availability of information in real time by using vehicle sensors, satellite positioning and easy-to-use software applications. In (Politecnico di Milano 2007) interesting examples of projects and applications are presented (e.g., in the waste collection, baggage handling systems in airports, monitoring of the number of passengers and of trains in local rail transport). The investigated solutions include GPS integrated with other technologies (e.g. RFID, weighing systems, sensors systems, GPRS).

In theory, in order to recognize RFID tags, it is necessary to use suitable RFID antennas anywhere the identification and tracking in critical logistic steps or processes are required throughout the product lifecycle, for instance from production, distribution, use and maintenance to dismissal phases for complex products. Obviously, it is not possible to provide RFID-based stand alone services in logistic processes such as, for example, long distance transport via different modes or remote maintenance. Moreover, in the case of complex

products that consist of many different components manufactured, integrated and maintained by different actors, logistics management is very difficult and a certain degree of collaboration among the involved actors is required.

Satellite systems (e.g., currently GPS and in the next future Galileo) and related devices can bridge this gap and enable global monitoring of products/systems. By using the functions related, for instance, to GPS, RFID devices and other communication systems such as GSM, some added-value service can be assured. For example, an added-value service can be the security against theft during the transportation of components. Moreover, the signals of integrated satellite and RFID systems can be connected during the transport of complex products or components to sensors that detect the temperature or whether they are subject to vibration in order to have a real diagnosis on travel conditions to be met by products/items. When RFID systems are linked to other intelligent tracking technologies such as GPS, for instance, the potentials for the improvement of level of service and efficiency can be enhanced throughout the supply chain in terms of optimal planning, responsiveness in the event of unexpected situations and re-planning.

Therefore, promising application modalities seem to be related to the integrated use of satellite communication and navigation services and identification technologies. This integration could assure a complete coverage of items' information usable for diverse logistic services in every possible spatial location (e.g., indoor and outdoor fields). Zouh et al. (2007) mention the combination of GPS with RFID systems in order to master the item's real-time information through monitoring centres. Radosavljevic and Dan-Asabe (2007) widely discuss the integrated use of RFID and GPS in the construction industry. The authors, while observing that the construction materials account for the 50-60 percent of the total project cost, propose an architecture that encompasses RFID technologies and vehicles equipped with GPS. The research aims consist of (i) automation and tracking for improving material management complexity and (ii) generating, recording and exchanging process-related knowledge throughout the supply chain network.

For the market of GNSS it is expected a relevant share of gross revenues generated by services (see Galileo Joint Undertaking 2005).

Integrated logistics throughout product lifecycle can be a key factor for designing competitive strategies of companies based on new services. Integrated logistics aims at coordinating and optimizing diverse logistic processes in supply networks from procurement to dismantling and

recycling. The effective real-time management of material and information flows and resources (often distributed) is the next challenge to be faced. Moreover evolutionary trends in the market of logistic services seem to foresee new extended roles of logistics service providers for covering heterogeneous needs coming from different sectors not only, for example, in warehousing and transportation of physical items. Services provided by satellite systems can enable the innovation for the secure management of logistic systems and services and Galileo is expected to have an higher level of reliability and accuracy than other systems.

Real-time optimization entails to optimize and re-optimize by means of systems able to provide the exact information, in the intended moment, in the right decision step (e.g., GNSS, RFID, etc.).

Then the objective is to integrate identification, communication, navigation, and intelligent computation for achieving the intended performance. These perspectives imply the provision of novel flexible services with an high content of interdisciplinary methodologies and technologies exploited in their concept elaboration, design and delivery.

More in particular, the application fields for satellite based traceability services in logistics seem to be related to:

- procurement, distribution, use, dismissal and recycling of hazardous materials, high added-value systems, products and components, spare parts, extremely high value items in general,
- warehousing, transportation and handling of containers and swap bodies,
- safety and security of public and private transport,
- remote maintenance services for complex products and systems,
- remote sensing for the monitoring of key parameters of status, quality and performance of products and systems.

Then, traceability needs can go through diverse sectors, from the food sector to very peculiar ones such as aerospace and defence.

The business opportunities can be generated by high added-value services relying on the compliance of safety and security requirements, reductions in lead times and costs throughout the supply chain, higher service levels for tracking and tracing of transport and distribution, enablers for providing new product support services. The latter remark is a promising issue for designing new business models for complex products and systems with extended lifecycles. In particular business models that consider the selling of systems of products and

services (see MANUFUTURE Platform 2006) can be enabled.

It have to be underlined that many potentials emerge from the capability of integrating indoor with outdoor traceability. The former aspect can be enabled by RFID systems and the latter one by satellite-based navigation services. Then, the convergence of these technologies may represent an integrated logistic service enabler that can possibly overcome some features of each exploited technology (i.e., the possible lacks deriving from the limited distance range allowed in RFID systems and the limited indoor localization and accuracy of some satellite systems). Integration of the mentioned technologies with sensor systems and networks can be also very promising in terms of service opportunities.

5. CONCLUSIONS

In this preliminary work an evaluation of possible developments for logistics services enabled by satellite-based traceability services has been carried out. Integrated logistics can potentially benefit from the integration of existing and well-known technologies for the identification, global tracing and tracking of items and information (e.g., RFID, GNSS, etc.). Future systems (e.g., Galileo) can notably improve the range and quality of the supply of logistic services. Nevertheless, the integrated use of these technologies on variable distances and diverse operating fields can enable the delivery of novel logistic services that cover the entire product lifecycle. Interesting potentials can be very relevant for complex products and systems that may highlight peculiar requirements throughout their lifecycle, in particular in the use and maintenance phase.

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