



Department of Civil Engineering

**Teaching & Research Area
Construction Management & Construction Economics**

Executive Summary

“RFID-Construction-Logistics-Control-Center”

**RFID-assisted control and documentation system for the
extended construction logistics demonstrated in
“RFID-Construction-Logistics-Control-Center”**

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The author is responsible for the content.

1 Objectives of the research project

The goal of the research project “RFID-Construction-Logistics-Control-Center” was the development of a concept to support construction logistics processes using auto-ID techniques. In addition to this, several modular applications (with the ability to work independently) in the construction supply chain were developed. A selection of applications were used to demonstrate a so-called “Construction-Logistics-Control-Center” (Bau Logistikleitstand), focusing on the events of the interaction between the construction site and outside world. This console can be understood as a tool for a documentation management system monitored by a data-controlling officer and is used to document a variety of upstream acquisition, control and management processes.



Figure 1: “RFID-Construction-Logistics-Control-Center” in practice at the construction site of ThyssenKrupp Headquarters in Essen

2 Implementation of the research project

The research project “RFID-Construction-Logistics-Control-Center” was divided into several topics:

- [A] Construction logistics in general: analyzing and documenting the actual situation based on process analysis, workshops, surveys etc.
- [B] Developing concepts for an “RFID-Construction-Logistics-Control-Center” to support construction logistics processes and selection of appropriate auto-ID technologies.
- [C] Developing, constructing and testing of a demonstrator for real construction activities in a construction container. Demonstration of the material logistics process by using reinforced concrete elements based on an RFID-model and a video
- [D] Public relations: reviewing the application of Auto-ID technologies in the construction industry critically and highlighting the potential

As part of section A, workshops, process analysis and interviews were conducted throughout the construction industry. Specifically the construction logistics-related processes were analyzed and documented in detail in terms of detecting the actual state.

Given the outcomes of section A, the concept of “RFID-Construction-Logistics-Control-Center” was developed in the section B. Here, the research group under the chair of

Construction Management and Economics limited the construction logistics processes to the interactions between suppliers and construction site.

Section C demonstrated some applications from the developed concept . The first “RFID-Construction-Logistics-Control-Center” demonstrator was developed in a construction site container supporting the Auto-ID applications. In the second demonstrator “Precast Logistics”, the processes of logistics chain were implemented in an RFID model during the delivery of precast concrete elements. A demonstration video of this process had already been created and shared.

Section D served to publicize the findings by attending trade fairs, including Messe BAU 2009 in Munich and the Hanover Messe 2011. Moreover, various lectures and publications had been prepared to draw attention to the developed concept. Consequently, received comments on the concept have been utilized to benefit the project. In this way, the the concept is more applicable to businesses and practitioners can be convinced of the new potentials.

2.1 Overarching applications of the “RFID-Construction-Logistics-Control-Center”

Based on the results of a detailed critical points analysis, the following auto-ID-supported applications and concepts for optimization of human and material logistics processes were developed. They can be networked together and are able to partly interact with each other.

2.1.1 Concept of the a data-controlling officer

In addition to the training of personnel, a data controller undertook the tasks of generating employees' identification cards, as well as monitoring the document management system in the event of application failure.

2.1.2 Concept of standardized construction site ID cards

The developed standardized construction site identification card includes several auto-ID technologies such as barcode, RFID and fingerprint. To be able to operate personnel logistics applications, the ID card has a photograph, a signature, a PIN, a qualified digital signature and the card number in plain text as well as in barcode. This ID card is a strictly personal ID card, like a social security card that is issued once by a licensed agency and is registered in a respective construction site's master databases (here: Construction Project (master-data) Server). This card also includes the issuer's license number and the issuing date in plain text.



Figure 2: Standardized construction site ID card

2.1.3 Development of a Construction Project (master-data) Server

Project master data, e.g. personal and company data, is stored and managed in the Construction Project (master-data) Server. This data forms the basis of all other auto-ID applications, such as the entry and personal protective equipment (PPE) control. The authorized persons, i.e. the data controller can continuously amend, update and maintain the database.

2.1.4 Development of a digitally enhanced construction diary for documentation of data collected by Auto-ID technologies from personnel and material logistics processes

To avoid conflicts between the involved parties in the construction projects, the documentation of construction processes during the construction phase has become increasingly important. The developed digital construction diary is designed to record the data related to collection, control and manage material and personal logistics processes and to provide access to involved persons, depending on their authorization profile.



Figure 3: Digital enhanced construction diary (Screenshot "Home")

2.1.5 Entering the Construction-Logistics-Control-Center: binding by closed plants

All entrance doors of the “Construction-Logistics-Control-Center” are equipped with RFID readers for security issues to ensure that suppliers, construction workers, visitors, the data controller, etc., can obtain an access to appropriate areas within the construction site depending on their user profile. In the entrance zone, each person is registered by means of his/her, standardized construction ID card and receives an access by a positive control.



Figure 4: Entering the “Construction-Logistics-Control-Center”

2.1.6 Combined access control and monitoring of personal protective equipment (PPE) by entering the construction site

Access control is one of the main objectives of the personnel logistics at construction sites. On large construction sites, several hundred workers are usually working simultaneously. Furthermore, on some sites, there are a number of daily visitors accessing the site. Unauthorized entry to construction sites should be denied for safety reasons, theft and illegal working protection. To ensure this, construction sites are often enclosed by structures like a construction fence. However, some construction companies or building owners monitor the construction sites additionally by employing gatekeepers or security personnel. Large construction sites often use manually issued ID cards for controlling the workers and visitors at the entrance of the site. However, this is labor-intensive, time-consuming, and error-prone.

Safety is also a major concern at construction sites. In addition to the building owner or his representative (e.g. health and safety coordinator), site managers are responsible for the safety of the personnel and attendees at site. Personal protective equipment (PPE) is used to help prevent accidents and keep health problems as low as possible. To date, the use of PPE is only checked visually by site supervisors. However, PPE is neglected all too often in the routine of everyday work.

By using standardized site ID, manipulation of the access control system can be prevented. Equipped with the digitally saved personal fingerprints, these ID cards cannot be passed to other persons for altering the time registration. However, for privacy reasons, fingerprints are stored only on the ID card and not in Construction Project (master-data) Server. Thus, it is possible to check that the person entering the site is the actual holder of the presented ID card. The process of "enter site" follows a number of steps. First, by going through the PPE control portal, personal related PPE is automatically queried from the database with the help of RFID technology. Second, the entering person is prompted to log in to the system by

holding the site ID card near the RFID card terminal and perform an authentication by placing his or her finger on a fingerprint reader. At the same time, his/her profile is controlled by comparing the required PPE in profile and the actually identified PPE using RFID reader. Finally, by a positive controlling of the site ID, the fingerprint and the PPE, the hub is released and the access to the site is granted. Furthermore, the time of "entrance" can be automatically registered. The process of leaving the site works similarly, but usually without PPE control.

In a negative control, the person is informed on a touch screen as well as the data controller.



Figure 5: Access control, time recording, PPE control (top left: concept, lower left: Real; right: Real)

2.1.7 Construction tools and machines registry

On construction sites, there are a large number of expensive tools and machines used by different construction workers. Inevitably tools and machines will be lost from the site, resulting in economic loss. Also, due to the usage of the machines and tools by several people, there are not always rules or procedures for careful handling, nor is it possible to find the persons responsible for damage.

Practices other businesses follow to protect property cannot be generally found on construction sites. It is also not possible to establish a secure theft protection with passive RFID technology. Moreover, there is usually no clear way to identify materials and especially no owner databases in order to prove later that theft has happened. More often, large construction sites perform manual inventory checks of construction tools and machines.

This inventory activity can be simplified and (semi-)automated by utilization of auto-ID techniques. For this purpose, construction tools and machines are equipped with RFID tags or bar codes. Now, if a worker needs to use a tool or machine, s/he is going to be identified by her/her standardized site ID using RFID or barcode. At the same time, the tool or machine

is also identified by its tag. if it is not already known to the systems, a dialog box appears and it can be allocated to a corresponding person's item catalog.

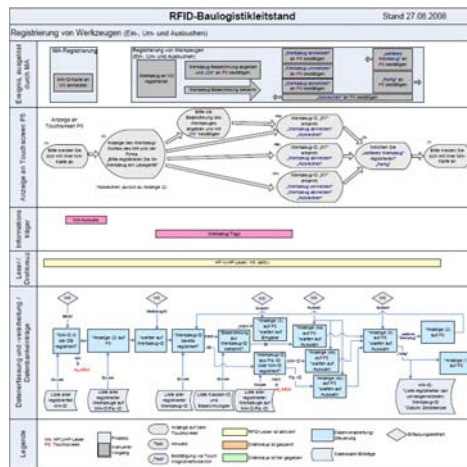


Figure 6: Construction tools and materials registration (left: concept, right: Real)

2.2 The material logistics applications of “RFID-Construction-Logistics-Control-Center”

2.2.1 Construction sites notification portal

The organization of the large number of deliveries and movements that occur during a construction project, particularly in urban construction sites with few buffer zones is of great importance. Construction sites often place their order by telephone to the suppliers. If more than one site manager / supervisor order shipments for their respective construction phases simultaneously, there may be over reservations using the roads to the site, problems regarding the unloading zones, buffer zones etc. This can lead to congestion and chaos, especially in urban construction sites.

In the research project “RFID-Construction-Logistics-Control-Center,” an Internet-based construction site (notification) portal was developed to ensure that all shipments are ordered through the central coordinated platform. Companies like Bauserve GmbH, Streif Baulogistik GmbH and Prowaste GmbH have already created primary approaches regarding such a platform. By logging in to an Internet platform, the desired construction site for delivery can be selected and the order is placed with the supplier, including the prescription of arrival time window. By acceptance of the order, the supplier will be asked to give the details of the order and specify the number of vehicles needed for the order. At this point, the optimization is performed using an Auto-ID technique. The Internet platform now generates a so called delivery ID for each vehicle, printed in plain text and as a bar code on its access certificate (see Figure 7). Then, by completion of the shipment confirmation process, the construction site receives the related information of the delivery IDs.

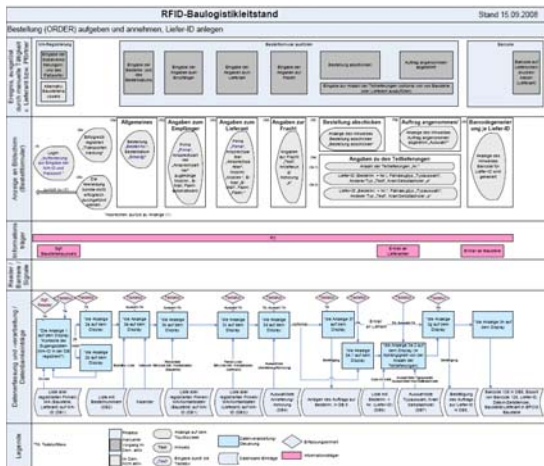


Figure 7: Construction Site (notification) portal for online shipment registration with delivery ID generation (left: concept, right: Real)



Figure 8: Construction Site (notification) portal for online shipment registration with delivery ID generation (left: Screenshot "Home" and the right screenshot "access permit")

2.2.2 Vehicles access control by Auto-ID-based delivery ID

In order to issue access to construction site for vehicles from the control point, the printed delivery certificate will be compared to the access permit and the predefined delivery time-frame using the delivery ID in the form of a bar code. The control can be performed at both

the entrance and the exit. After successful control, a green light signal will be shown or the barrier will be opened.

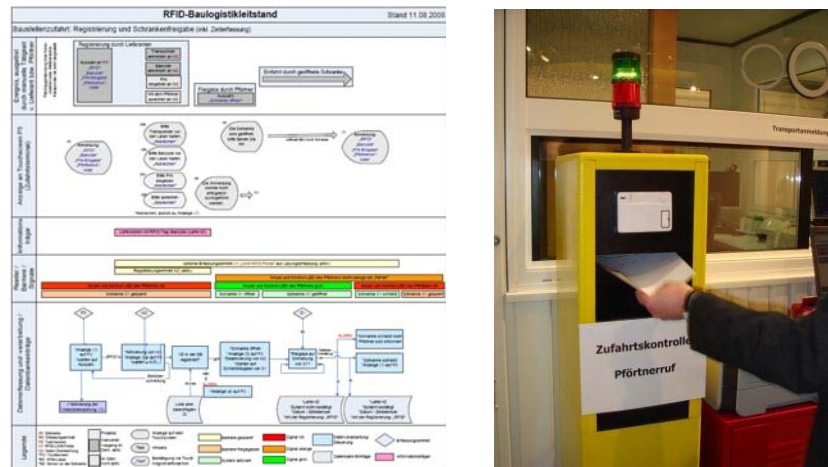


Figure 9: Vehicles access control by Bar code-based delivery ID (left: concept, right: Real)

2.2.3 Auto-ID based incoming and outgoing goods control

There are usually a variety of problems resulting from the control of incoming and outgoing goods. It is difficult to compare planned and actual figures between delivery certificate and incoming or outgoing goods for many reasons. One main reason being the difficulty of detection by proportion sensing when many products consist of similar parts. The result is to commonly sign-off the delivery certificate without an actual control; without knowing that this is an act of negligence.

Controlling incoming and outgoing goods at construction sites can be simplified using Auto-ID technologies. Therefore, the standardized labeling of materials along the construction supply chain is a prerequisite. This means that the manufacturer, supplier and construction site must use a unique identifier for the materials. Here, RFID and barcode as Auto-ID technologies are possible identification methods to be used for labeling the materials.

Upon a vehicle's arrival at the work site, i.e. after a successful access control, the load-receiving officer will record delivery ID from access certificate by a hand scanner. The corresponding ordered figures/items will then be shown on the display. By unloading the vehicle, the actual materials will be recorded and thus will complete the automatic quantitative inspection of incoming goods.

By returning materials, e.g. rental equipment from the construction site back to the suppliers, the outgoing inspection can be carried out in accordance with the procedure described above.

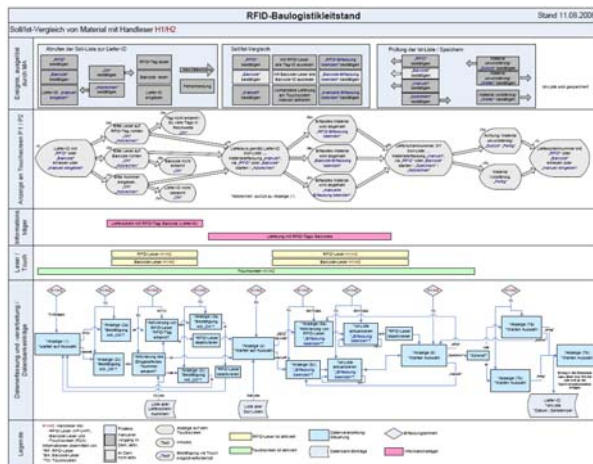


Figure 10: Incoming goods inspection by delivery certificate and bulk detection using a manual reader (left: concept, right: Real)

3 Conclusion

The research project "RFID-Construction-Logistics-Control-Center" showed that RFID technology offers great potential to improve construction logistics processes. Within the framework of the project, an overall framework for information exchange in the construction logistics is developed. A demonstrator was also provided with the help of interested individual from the construction practice. However, to unleash the full potential of RFID technology in construction, further research is needed, especially regarding the interconnection of concepts, models, and individual applications provided by institutions of ARGE RFIDimBau.