

Short Report to FhG-Report GB 183/2008

Potentials of RFID- Technologies in Buildings - Characteristics und Qualities

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The responsibility for the content of the report is to the authors)

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1. Aim of the research project

The common aim of the project is to concentrate and link running activities in civil engineering, which are now separate and parallel. Only then the field of work as

- Information logistics, organisation of building-site, cost-quality-management,
- Building physics, new materials and components,
- Building- and disposal logistics,
- Identification systems with RFID-transponder-systems,

with there interfaces and problem areas can be defined in a new way and lead to synergies. Improving quality and the cost optimisation is central aim in the building construction and utilisation phase to the advantage for investors and users. In the areas of environmental and health protection we can get important improvements for the building workers and users. The so called Radio-Frequency-Identification-Systems (RFID), which are already used successfully in other economic sectors, can provide helpful informations. Data storage medium on or in the building products, the so-called RFID-tags, contain information e.g. about the supply chain, the planned site location for mounting, the receiver and will be delivered from the producer to the building site. Technical requirements on storage, envelope, supply and transportation can be carried just as simply as installation instructions and acceptance reports. In the sector of logistics and automatic inventory of goods such technical solutions are well installed, but caused by the weathering of a building site and the life time of buildings, we cannot transfer these without changes to the building sector. Primarily for decision makers in the facility management (FM) it is a complete stock documentation of enormous importance, after completion of a building measure, about all components and functions for a running FM-software-system and the usability of the data as basic for a cost-saving building management over long periods in the future. So the building data are not transferred to the investor as a collection of uncoordinated paper-documents as usual but as so-called "electronic-building-file". This can be handled by the building operator or house manager for maintenance and repair works time- and cost-efficiently.

What is the initial situation like? The quality of workmanship in Germany will be judged in general as good, but in the building sector with its complex works as "single units" these are error-prone and the rate of structural damages per year is too high. The coordination in the building process for planning and erection is very important for the production and mounting of the building components in a functional building. Only then the task can be managed economic successful and without accidents and damages. Some materials on a building site are barcode labeled or marked, but the worker are not able to read the data in comparison to the reference or desired value according to the tender. The mounting and the detail-work as joints and complex connectors are normally in the stewardship of the site manager or the worker in the building. The result from that are in many cases problems in the technical work, in building physical function and damages in millions of Euro. There is no documentation of the real construction in detail and in clash not traceable. The investor and owner of the building is receiving with the delivery of the property in most cases a "golden key" instead of a data-file on CD-ROM with all building-data and FM-usable maintenance guidelines. The CE-Building-Product-Regulation BPR was introduced to set up a free market trade also for building products according common rules in Europe. There is the definition of building products as keyword for building materials, components and whole tradeable systems as prefabricated houses. The connection in the characteristic values of single products to the values of the whole building structure is complicated. But in the building regulations for roofs, walls, facades there are requirements to the technicals and

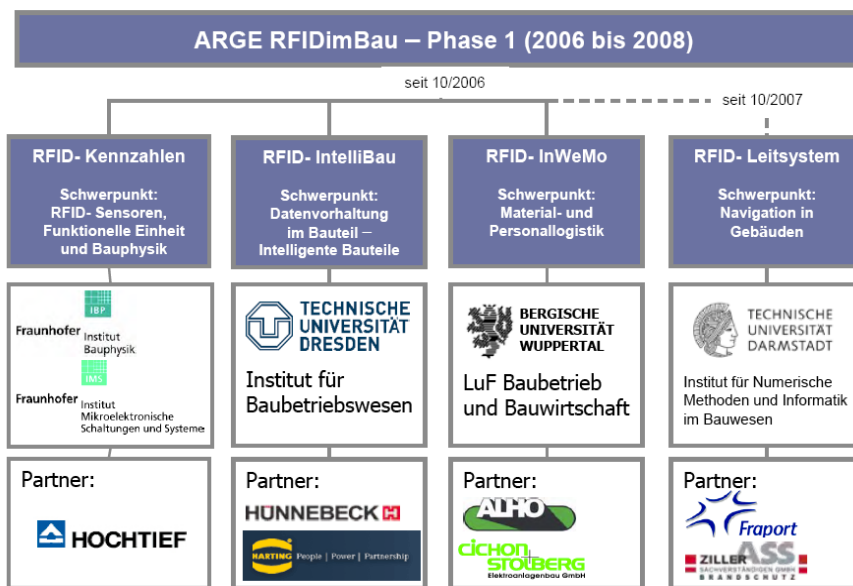
physical behaviour (as structural engineering or the absence of condensation water in joints) and we have to prove this. All 6 essential requirements in the BPR (german BauPG) are based on this next higher product level (built-in component in the construction) as the so-called "Functional Unit" (FU) e.g. as room or complete building. Only in a whole façade including the correctly mounted sealing in joints there is a good thermal, driving rain and noise protection. Also in BPR, managed in §5 of the german BauPG, there is the requirement for building products in the 6 essential technical conditions to a serviceability with regular maintenance during a reasonable time period and under consideration of an economic efficiency. For such a verification of serviceability over the many decades of the facility management the electronic labeling and data-files in a RFID-technology can be helpful for highrising the transparency in building processes.

The total aim to demonstrate the potential in the RFID-technologies in the building area (specially in structural engineering) is not possible in one project "characteristics and quality". To transfer this in a validation and certification system for buildings and there life-cycle-costing and to make tests in real houses there is a need for several projects „in series“ and „parallel“ by different researcher. And coordinated in the interfaces in early stages to the resources in there work (Picture a). Overall it seems possible only by such a combination project (cluster) „RFID-Information-System“ to wake up the conservative building sector with such an innovative technology for better building quality and lower building costs.

2. Execution of the research task

The team „RFID technologies in the building and construction industry“, short „ARGE RFIDim-Bau“ resulted on request of the project sponsor in 2006 when 3 subprojects were allowed to the RFID application to topics in the building and construction industry. The 3 institutions BU Wuppertal, Fraunhofer IBP and IMS, TU Dresden, picture a, already came to an agreement in the ARGE RFIDimBau for the first researches and presentations at the building fair in 2007 to obtain synergies and operate a common internet page under www.RFIDimBau.de since then. The processing of the ideas and concepts for a putting into action of the RFID technique in the building and construction industry is carried out partly in the current subprojects, together with the networkings also to external projects. A common steering committee from representatives of the subsidies giver, the building associations, the architecture and some building economic sectors advises the ARGE RFIDimBau during the project running time.

A code of conduct regulates the cooperation and open dealing with information within the ARGE RFIDimBau. The ARGE RFIDimBau is open to further subprojects as long as these don't lead to a double research. In Nov. 2007, for example, began the 4th project "RFID building-conducting system for relief units" of the TU Darmstadt.



Picture a: Subprojects and members in the research cluster RFID

The RFID solutions from the logistics of textiles or machines cannot be transferred due to the features of the rough construction site business and the long life time of buildings without customizations and specific examinations for the building and construction industry. Therefore the relevant characteristic values have to be included and judged along the multistage value-added chain for

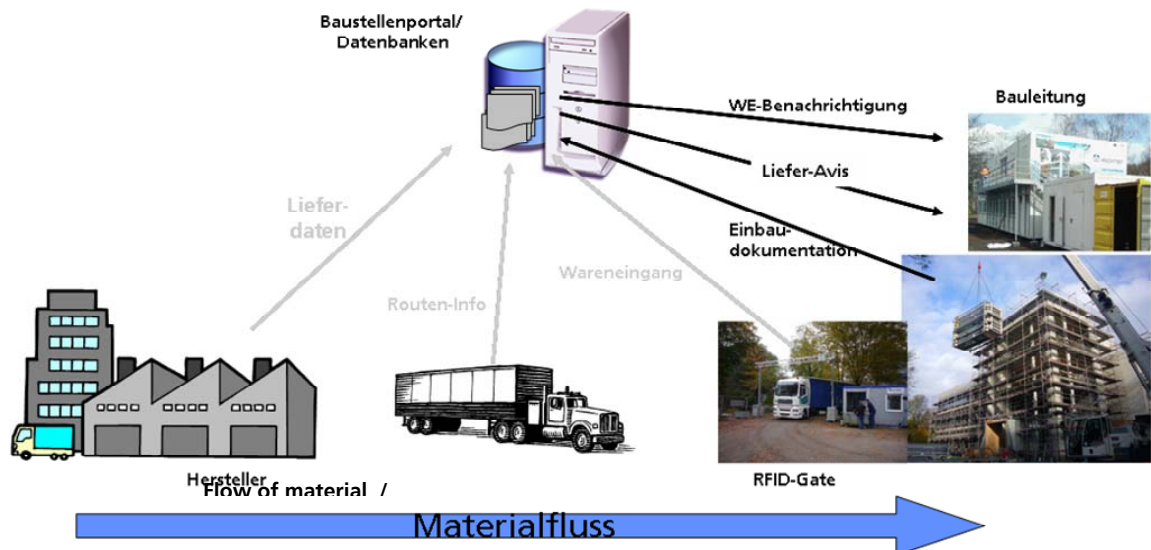
- ordered, delivered building-materials and building components,
- on-site constructed and built-in building elements,
- debit-being comparison, building inspection,
- Building documentation, data quality,
- FM requirements in the rule operation of the buildings,
- Proofs to environmental qualities of building systems and building.

These characteristic values are analyzed exemplarily in the project and converted to some aggregated data in the physical quality of functional units. The currently available RFID techniques with the electronic etiquettes, the so-called transponders, RFID-readers, data-storing and data transmission systems are represented. Tests showed in the laboratory of the Fraunhofer institutes IMS and IBP as well as at different working examples and on construction sites which radio engineering seems suitable for relevant building application. For demonstration we tested façades, insulation products and components of HVAC with RFID-technology exemplarily and as functional units "glass façades" and „Ventilation technology" in a model. The use on the construction site is represented at the so-called »digitals kiosk for the functional unit«: with help suitably for craftsmen characteristics, installation instructions, check lists and photos are more simply fetched to language version and dictating function on the scaffolding there be able to. The transportation of the data during the construction and in the attaching building business („facility management") we analyzed to the data server, to the enterprise, to the building team and to the building site. Examples of

such characteristic values, that is the distinction of static and dynamic information about building products, about building construction with making physically important data for the installation, for the completion, removal and handing over to the client and user in databases and the transfer to the RFID transponder, are shown. Deducing from this, we analyzed characteristics for a sustainable facility management in the different planning periods (preplanning is of use for debit data, execution planning is of use for actual datas). Such values are getting across in the so-called "digital building documentation". The presentation of first ideas and results in the project are shown by the team "ARGE RFIDimBau" at the trade fairs BAU 2007 in Munich, Deubau 2008 in Essen, Bautec/ Build IT 2008 in Berlin (see internet <http://www.rfidimbau.de/pages/rfid-im-bau/veranstaltungen/rfid-kongress-2008.php>) and the congress Euro-ID 2008 in Köln.

3. Summary of results

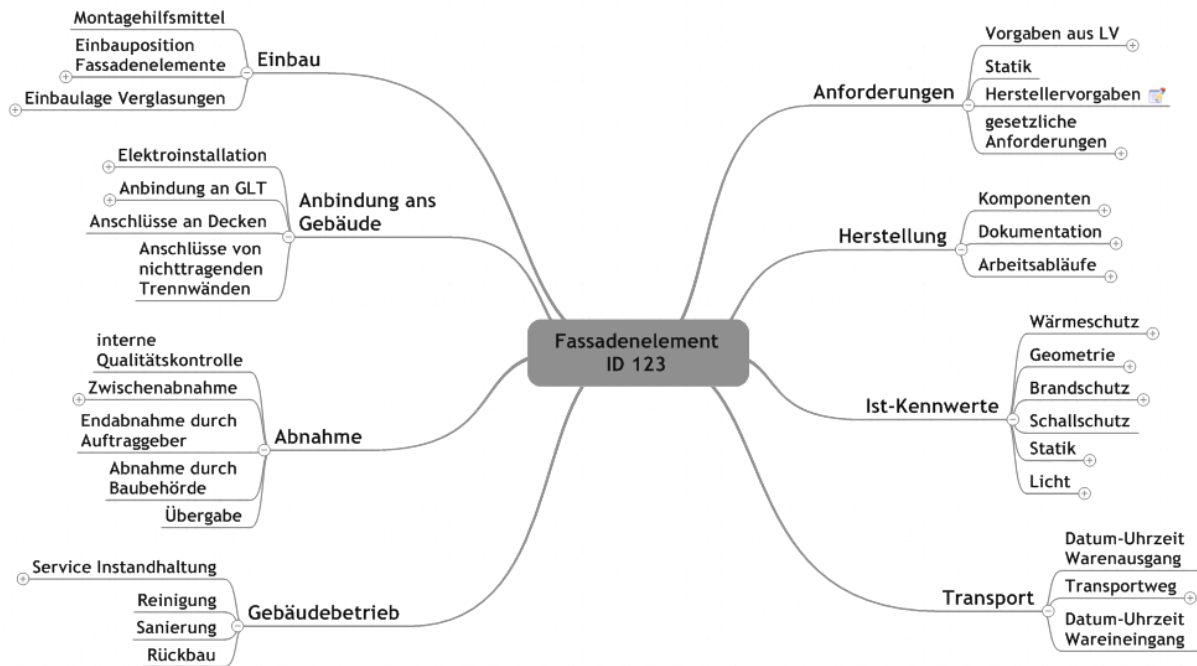
RFID technology available for the project start in 2006/2007, the analysis was made by the Fraunhofer-IMS: using 18 different transponders and inlays, 6 RFID readers, 4 standardized radio frequencies, different server and middleware structures, a so-called RFID-Guide was worked out for the whole ARGE. Investigations under different Building- and component-conditions (metallic and non-metallic behaviour) in labs, a technology-review and an evaluation at the onsite-reader-equipment at the research-building "Fraunhofer-InHaus2" in Duisburg followed. So transponders, antennae and identification data acquisition could be examined with real façade elements on the way of the manufacturer in Gundelfingen through the RFID-Gate up to the assembly and acceptance of work.



Picture b: Illustration in flow of informations and characteristic values in process „facade“.

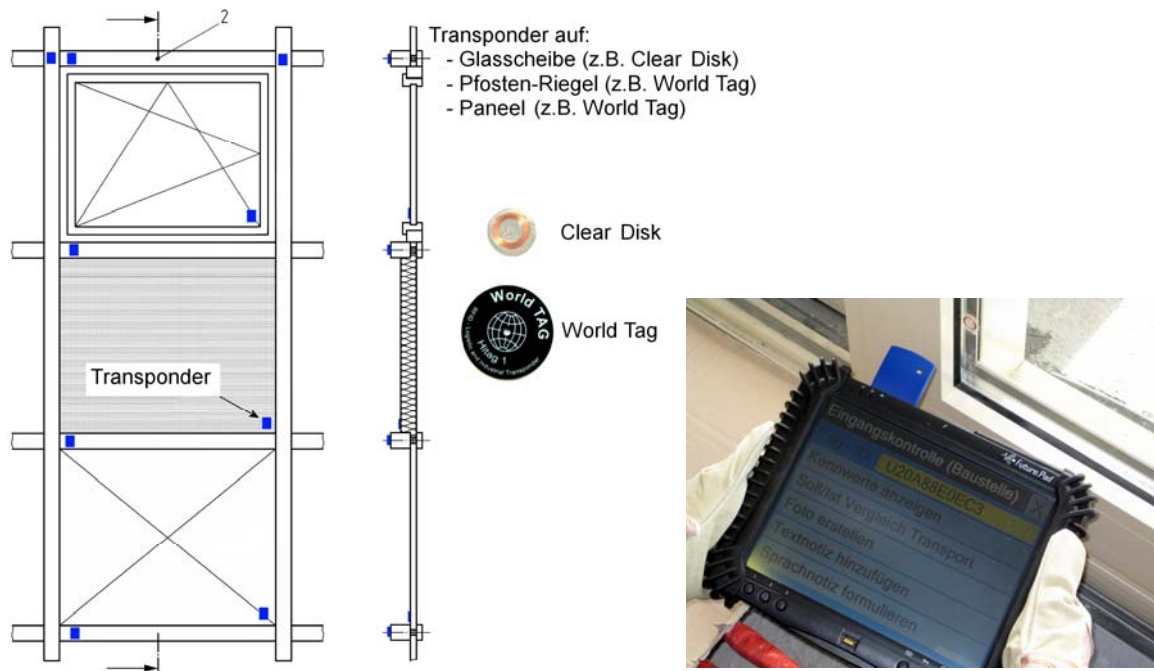
The analysis of the characteristics in building processes with relevance to sustainability in buildings and the expectations was carried out parallel from the normative and legal requirements. Using practice examples and manufacturer interviews characteristics and present identification drawing practice were examined as some physically important so-called

functional units : „Glass façade“, „Building insulation/flat roof“, „Stud work wall“, „Ventilation system/RWA“. In building processes the description of the communication and information paths led (picture b) to the identification of interface problems and approaches for the electronic identification to knowledge to the construction of a new user software „Construction site kiosk“. The discussion of error sources, improvement approaches and chances followed for the usage of RFID technology in building construction (picture c).



Picture c: Levels of informations and chances for RFID-technology for glass façades.

The demonstrator „Glass façade“ we examined at the model and a construction site as a post bolt construction. Putting to a functional unity is carried out on the construction site. Since there is the danger of mistakes, all main components should be provided with a transponder respectively (picture d). Particularly at big façade areas with small elements quickly more hundred transponders are needed, but then it is a question of the economy at the present costs for transponders. A middle course represents the reduction of the identification at posts and bolts to a transponder per façade section and a construction way. Furthermore glazings, checking panels as well as sun safety devices would have to be indicated on individual component level. This makes also additional drilling and cutting work on the profiles possible on the construction site without having to consider the possible damage to transponders. For a post bolt façade it is considerably more difficult to agree on standards for the placing of the transponders. Important is ever object for the above-mentioned reasons at least to attach the continuous compliance with an identification level, i.e. all transponders as on the side of the room as possible. Being able to organize after the building inspection the operation of the components (cleaning, repair) easily about RFID technology through this.



Picture d: Example for labelling of post bolt construction with RFID-transponders (left) and RFID-control reading on-site with a tablet-PC and the "kiosk-software" (right).

The following further applications became examined at the demonstrators „Glass façade“ and „ventilation system/RWA“: Automatic comparison of the building physics characteristic values with voice output at the construction site, assessment with the set points, data control at the element manufacturer and at the construction site, version of the position assignment and installation situation for mounting of construction elements, fake protection, supervision of the assembly remedies for the quality assurance, management of constructional defects at acceptance of work and facility management (FM), transponder type.

The most important demands for constituents still being missing can be summarize as follows from the view of the subproject "characteristics and building quality" („Building physics“):

Conclusion 1: A technical further development of the multi-frequency ability of transponders and RFID-readers is necessary for the building and construction industry

With none of the currently available frequencies the requirements of all building processes can be used. Neither it can be expected of the making creating to have to work, simultaneously with several harvest equipment it is still economic at today's costs to indicate parts of a building with several transponders. In addition, there is the danger at the multiple identification that at the assignment of several transponders to a component faults arise.

Conclusion 2: Installation of central server structures in connection with a digital building file as help for the building certification

Only with networking and further utilization the introduced RFID concepts are appropriately applicable. After the example of the internet an infrastructure based on further lines of business-specific services can establish themselves. Service providers assess the need and clear to become her risk, to be active in the building industry with RFID-technology. For an economically business of such information systems they need construction specific applications as the assessment and certification of "sustainable built buildings".

Conclusion 3: Installation of noncommercial, free transponder tracing services for the strengthening of the European building product market

Being already today offered for the enquiry in the Internet search service for special file types, pictures, videos, places, products etc. It has to be expected freely accessible information and facts to be provided to quite different quality with an increasing distribution of the RFID technology also to many building products and transponder IDs on the Internet. To be able to use these information resources and to judge to quality criterions, further aids than addition to item 2 are important and necessary in future. The suppliers of special search and tracing service will establish such services. Alternatives secure the competition and reduce oligopoly formations from some few service providers at the same time.

Conclusion 4: Prospects and further transfer

The main emphases on the project completed now were themselves on RFID technology and in the analysis' and assessment's for the use in the area of the building physics at building systems with important functional units (façade, ventilation). I.e. the life cycle phase of a building "construction" was in the foreground till now. In the next phase 2 "characteristics and sensor-RFID" the use of a building shall be examined, to analyse the RFID-identification systems in the many-year cycles of the building business and retrofit. Also dynamic information about the current condition of these components or plants is needed for it besides static information about the origin and quality of used building products since in the course of the use wear, ageing, weathering, humidity load or pollution can change the original qualities substantially in the new condition. To this the newly on the market available sensor RFID transponders can be used without an effortful wiring also in the renovation of old buildings. Energy efficiency, hygiene conditions and safety aspects can be grasped metrologically and taken the minutes down also over quite a long time periods with the auxiliary quantities like temperature, pressure, humidity (if necessary strength, stretching, light/lighting intensity or frequency) in the building business. A still undeveloped potential for the RFID techniques will be possible to reduce the maintenance costs of a building and increase the efficiency and building quality. Data flow and combination models must do justice to the complexity of such applications to meet with a broad acceptance the developing further. A modular construction of the information processes from the RFID label to the user is therefore striven and the use of far common standards in close cooperation in the ARGE RFIDimBau. This integration into "architecture processes" can be carried out only in a good agreement with the trade associations of the building and construction industry (among others HDB, ZDB), the software supplier (e.g. BVBS) and the equipment manufacturer as well as the rule compositors and authorities.