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Heidi C. Dreyer, Jan Ola Strandhagen
and Ragnhild Bjartnes (editors)

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DEVELOPMENT OF A CODE OF PRACTICE FOR THE IMPLEMENTATION OF RFID BASED VALUE ADDED SERVICES

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Abstract:

The considerable potential of RFID-technology to improve production-process performance, as well as its ability to act as an enabler for the implementation of modem PPC concepts, the creation of new processes and thus greater flexibility contrasts with the fact that the widespread adoption of this automatic identification technology remains slow. This paper is meant to document the development of a comprehensive code of practice for the successful introduction of RFID-systems in an environment of small and medium sized businesses. A key element of the work is a case study for Austrian SMEs in the electronics components production. Based on requirements of the considered companies, supplemented with consolidated findings of existing RFID-implementation models and findings acquired in field work, a comprehensive procedure for RFID introduction projects is developed.

Keywords:

RFID, Value Added Services, Code of Practice, SME

INTRODUCTION

One of the main reasons for the slow and hampered adoption of RFID (Radio Frequency Identification) technology in company processes, despite its significant acknowledged potential to improve supply chain processes, is the difficulty for managers to assess the benefits of RFID-systems and develop implementation strategies in their company – thus, the research project ELIES, funded by the FFG and the bmvit, which provides the background for this paper, aims at developing a code of practice for small and medium enterprises (SME) that is meant to support the realization of successful RFID-introduction projects. For SME with their limited financial resources and personnel capacity this problem is especially eminent and providing these companies that account for 99,7% of all Austrian enterprises (WKO, 2010) with reliable recommendations is the designated goal of ELIES. Presently, the overwhelming majority of successful RFID-implementations have been realized by large companies, leaving the potential of RFID unharnessed by SMEs (Straube, et al., 2008).

There are already various publications for RFID-implementation projects available, therefore the research project is meant to further the available approaches, introduce new components and elements and compile a code of practice with particular relevance for SMEs in the electronic component industry in Austria. The SME perspective in general and the focus on electronic component production in particular have so far not been covered by literature. Furthermore, the existing approaches for the industry tend to focus on technological aspects (VDEB, 2006) while this research project is especially dedicated to examine the aspect of finding and developing value adding RFID aided processes – the Value Added Services

(VAS). Eventually, a combination of validated elements of existing RFID-introduction concepts, the analysis of an SME-specific requirements-profile, a thorough search procedure for advanced applications – presented in a previous paper – and findings acquired in field work with industry partners are compiled into the code of practice. However, it is important to note that the present presentation of the guideline has to be considered preliminary and will be subject to changes, additions and further detailing in the course of the ongoing research project. Additionally, the presentation will not be able to cover the entire research project in detail – for reasons of compactness, some new aspects of the RFID-introduction guideline will be highlighted and a summary of the entire project will be given instead.

Structure-wise the paper is designed as follows: First, in a compact literature review, a selection of existing approaches for RFID-implementation projects are analyzed and categorized. These works and their concept elements represent the basis for the present research project, which is meant to combine and further the main elements. This section does also contain a brief introduction of RFID technology, the subject of the entire guideline. The following methods chapter contains the development of a characteristics- and requirements-profile for SMEs concerning suitable RFID-applications. This profile will then act as a guiding principle for the setup of the code of practice; it is intended to enable the configuration of a custom made RFID-introduction concept. Another aspect in this chapter will be the introduction of the principle of finding technically similar RFID applications, an important feature of the introduction concept. The methods chapter is followed by the presentation of the resulting guideline for SMEs, introducing its major features and sequence. In the last chapter, current results will be discussed briefly and put into a broader context of research efforts and future work.

The following chapter will briefly introduce the RFID-technology and provide an overview of literature on the topic of RFID-implementation.

FUNDAMENTALS & LITERATURE REVIEW

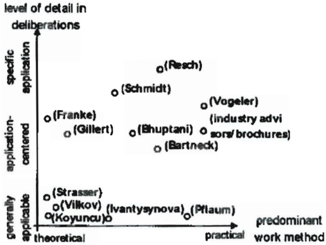
RFID is an Automatic Identification and Data Capture technology (AutoID), thus enabling the automatic identification of objects equipped with an RFID-transmitter (Finkenzeller, 1998). The characteristics of RFID, compared to other AutoID-technologies, are the ability to identify objects via electromagnetic waves sent between RFID-readers and transmitters (tags), transmitting information about the object from the tags to the readers. It is possible to identify multiple tags on multiple objects virtually simultaneously and some tags also enable changing the data saved on the tag-memory. While the basic functionality of RFID is the automatic remote identification of tagged objects, the technology offers a large variety of additional benefits and applications, utilizing the full range of technical capabilities and the versatility arising from a combination of RFID-technology with other information technology, such as WLAN, Sensors and GPS-modules. In this work, these additional functionalities are referred to as Value Added Services provided by the application of RFID-technology.

The following section deals with existing literature on RFID-implementation concepts and RFID-potential analysis – the latter is the most important part of the implementation concepts and is thus included in this compact overview. It is possible and sensible to categorize the concepts according to the following criterions:

- Are the works based on theoretical deliberations is the a prominent practical approach: some authors have included the documentation of real life RFID-implementation studies and projects in which they have been able to exercise their concepts – in this categorization this represents the strongest practical relevance level.

- How broad is the content-wise focus: some works deal with generic RFID-potentials while others focus on technology applications or even a detailed set of application scenarios.

Figure 1 is meant to provide an overview of the selected literature and its categorization:



(the names in brackets refer to works listed in the references)

Figure 1: overview of literature regarding RFID-implementation projects

The current research project is envisaged to fit in the vicinity of the works of Vogeler (2009) and brochures for the industry (e.g. VDEB, 2006) – if it had to be categorized into the framework of figure 1. However, Vogeler's work focuses on retail logistics while industry brochures and guidebooks tend to focus almost entirely on technical aspects, whereas this research project prioritizes the identification and development of RFID-aided processes in a production centered environment.

Major elements of the existing works that will be adopted in and adjusted to the present implementation concept are the following: To consider all relevant company processes in a search for possible RFID applications, Schmidt (2006) suggests utilizing the Supply-Chain Operations Reference-Model (SCOR) that can be applied to segment the system of processes and prioritize important processes (SCC, 2011) – e.g. processes associated with high costs, frequently used processes or processes spanning across the entire organizational structure – that are especially prone to the application of an AutoID technology. SCOR was developed by the Supply-Chain Council as a diagnostic tool providing companies with a framework to systematically describe their activities. This concept lends itself well to the task of identifying all company processes and displaying them in a clear arrangement. A basic procedural structure is, among others, described by Bhuptani et al. (2005) and includes an idea generation phase, a pilot phase, a realization phase and a phase to maintain and improve the system performance. This generic approach will also be reflected in the present approach although there will be several additions – the process sequence is described in the results chapter. There are several modes for the identification of RFID applications and determining their respective utility – e.g. lists of conceivable applications (Franke et al., 2005) or categories (Vilkov et al., 2008). The approach described in this paper attempts to combine both methods although it prioritizes the structured search along categories – this RFID-application search element is briefly introduced in the following methods chapter. A comprehensive work on the profitability evaluation of RFID systems, basically consisting of evaluating quantitative and qualitative benefits and running costs plus one-off expenses, is presented by Koyuncu (2009). Additionally, there are several tools to capture the quantitative cost-benefit relations (Gillert et al., 2007). The present approach will adapt these existing approaches, supplementing it with a technique to capture qualitative and indirect benefits and include them into an overall cost-benefit assessment.

METHODS & CONCEPT

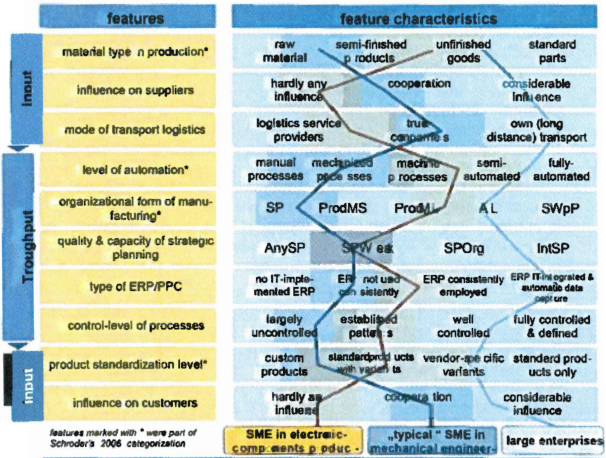
This chapter is meant to introduce a few central pillars of the to be developed RFID-implementation guideline, the SME requirements-portfolio, the principle of finding technic lly similar RFID-applications to improve the system amortization and the procedure to find new RFID-applications. To compile a characterization of SMEs in the electronics components production, this paper utilizes the SME characterization used by Schröder (2006) and Zopff (2005) – they used it to characterize SME in mechanical engineering – that are in tum based on Nebl's (2007) description of the macrostructure of production and definition of organizational principles of production. The macrostructure basically defines production as consisting of:

- input (elemental factors needed for production, i.e. workforce, equipment & material)
- throughput (combination of elemental factors under the guidance of management to manufacture products)
- output (products & services)

These three categories are then investigated to identify defining characteristics for SMEs. In this work, the categorization of Schröder is expanded and adjusted to compile a characterization suitable for identifying the specifics of SMEs in the electronics sector under the premise of identifying requirements for information technology, i.e. RFID technology. The resulting characterization is displayed in figure 2 and is based on observations in field work and projects with electronics components producers in Austria.

SMEs are companies with less than 500 employees, an annual turnover below 50 million Euro and represent the predominant form of enterprises in Europe, especially so in Austria and Germany. Due to their limited size, compared to large businesses, SMEs have fewer financial resources and a smaller capacity regarding personnel. The staff manufacturing high quality products is usually highly skilled but the companies often lack expertise beyond the techniques and knowledge of their particular trade. These restrictions are of crucial importance regarding RFID-introduction projects, since a considerable amount of personnel capacity and knowledge in project management, technology selection etc. is necessary and a lack of it therefore has to be factored in and compensated in the resulting approach.

SMEs typically manufacture complex and specialized products that are often made to order or even engineered to order, making logistics processes a key factor in achieving small order-to-delivery times. The production is often realized with a relatively low degree of automation utilizing universal machines and tools. Electronics components producers are however differing from this characteristic commonly found in the mechanical engineering sector: medium sized companies use SMT and THT machines, which are long, fully- or semi-automatic plants that execute soldering-processes. These processes are the dominant production processes for companies that assemble printed circuit boards and result in a much higher degree of process control than is commonly found in SMEs in other sectors, thus reducing the need for AutoID technology to help monitoring the production progress. The production volumes per order are considerably smaller than in large enterprises, the technological processing sequence is usually variable – however, here too, the electronic sector is an exception: since the SMT and THT machines are programmable and can handle different board designs and the production technique remains soldering, this is much less of a problem for these kind of companies than in other sectors. In the electronics sector, the organizational form of manufacturing – in this work we again use the terminology by Nebl (2007) – is intrinsically much more product oriented and thus less complex to handle than in other sectors; at least as far as the soldering processes are concerned. However, regarding the remaining processes, e.g. assembling, packaging, transport etc., the processes of electronics SMEs are as uncontrolled and undefined as those of other SMEs. Thus the need for extra control and information retrieval – possibly provided by AutoID – arises in these remaining processes.



Abbreviations:

<u>organizational form of manufacturing:</u>
- shop production (SP)
  (machines are grouped according to production process techniques)
- product oriented manufacturing-section (ProdMS)
  (machines needed to produce a certain product are grouped together)
- product oriented manufacturing line (ProdML)
  (machines needed to produce a certain product are grouped and put in the right sequence – i.e. the sequence of production steps for the product)
- assembly line (AL) *(a chained production line with a set Takt time)*
- single workplace production (SWpP)
  (all production steps for a product are conducted in/with one place/machine)

<u>quality & capacity of strateg. planning:</u>
- hardly any strategic planning (AnySP)
- strategic planning based on weak data basis (SPWeak)
- strategic planning as dedicated organizational unit (SPOrg)
- integrated, analysis-based strategic planning (IntSP)

Figure 2: profile of SMEs in the electronics components production

SMEs usually procure their raw materials order-specifically; they order comparably smaller amounts of material, making inbound logistics a pivotal factor in ensuring security of supply and simultaneously leaving the smaller companies with very little power over their suppliers; an important factor when it comes to introducing AutoID technology along the supply chain. From an output-perspective, SMEs usually cooperate and communicate closely with their customers since the products are custom made. The production volumes often vary significantly over time and product life cycles are short, making standardization efforts more difficult to implement. Due to their limited capacities regarding personnel and managerial expertise, the strategic planning is seldom well developed and based on rather weak data – the data retrieval aspect being one of the major RFID-potentials. ERP systems are often not used consistently, there are interrupted information flows and data has to be transferred and entered manually. Concerning transportation SMEs often use logistics service providers or truck companies, only few transports are conducted with own trucks or other means of transport. The internal transport logistics are usually not organized in a consistent transportation concept.

The resulting SME characteristics and requirements are in the following supplemented by characteristics of the market for electronics components. In recent years Europe has lost three places and is now only ranking the 6[th] largest producer of electronics components amid a continuously falling trend, while Asia and especially China with labor costs of 96% less (VDMA, 2007) have taken the lead and are continuing to grow. In the supply chain, ranging from the production of semi-conductor wafers to the assembly and distribution of final electronics products, SME in Austria often assume the role of producing and assembling complex printed circuit boards (PCB) for high quality products e.g. for use in medical technology or products for the automobile sector. The "one stop shop" is a common concept for European SMEs in this market – the companies have parts of their products produced in Asia to be able to offer large quantities of PCBs at a competitive price. This results in complex in- and outbound logistics and can be considered a potential for a higher level of supply chain transparency through applications of RFID. Furthermore, the sector is characterized by short product life-cycles, short-term sourcing of materials and more volatile and changing customer-supplier relationships, adding to the complexity of logistics and complicating the planning tasks.

After introducing the development of an SME-requirements profile as the basis for developing a tailor made code of practice, another important principle of the present concept will be highlighted in the following. This idea is based on the observation that often multiple RFID application scenarios require the same or a similar RFID-system configuration and elements. For example, an UHF-RFID-Tag on a product used to enable an automatic goods receipt functionality might also be used to determine the position of goods in storage facilities or determine the contents of transport containers. Although the individual services provided by the system may seem rather unimportant or secondary, their implementation in one unified RFID-system could help improving the overall system profitability considerably. This effect could be further amplified by finding applications of a single RFID-system component along the entire supply chain, generating services and extra value along the way. This principle is visualized in figure 3. However, it is important to note that distributing the costs of an RFID-system across the entire supply chain would pose a significant coordination task.

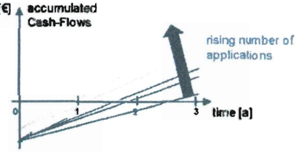


Figure 3: principle of combining technically similar VAS to enhance amortization

The last methodological element to be highlighted in this paper is the methodology of finding advanced RFID-applications in real life environments. This item is based on an adaption of the concept of service engineering (Bullinger, et al., 2003) – a method of developing new processes – and the combination of RFID-utility categories (Vilkov et al., 2008; Bhuptani et al., 2005) that are compiled into a morphological box, which is then used as a means to structure the creative process of finding RFID-applications. This methodology is described in full in a previous paper that was published in the course of the research project ELIES.

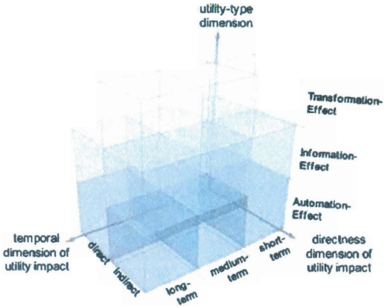


Figure 4: morphological box as the core element of the RFID-VAS search procedure

RESULTS & DISCUSSION

After a selection of important characteristics of the present code of practice for RFID-implementation projects have been introduced in the previous chapter, this chapter is meant to give an overview of the basic elements and structure of the concept itself. The entire procedure is summarized in figure 4.

In the **project start** phase, a project team is founded and a project manager is appointed. According to findings from project management theory, the project manager assumes the roles of a process-promoter, whose task is driving the project progress, and a content-promoter, who is responsible for delivering the necessary expertise regarding the technology involved. In SMEs the role of the content-promoter might be assigned to an external advisor since the smaller companies often lack sufficient personnel capacity and expertise for tasks other than the day-to-day business. The expectations for the project are defined at this stage. The following **identification of a suitable application area** is meant to define the project focus and identify the most promising application areas within a company. Company departments and –processes are analyzed regarding goals and problems after which these items are matched with the performance-potential profile of RFID. Major processes, preferably those with considerable material flow and those frequently used, are captured in a process-landscape – an overview on the model of the aforementioned SCOR-model. The process owners are interviewed to determine current goals and problems within the processes. Subsequently, these processes are evaluated regarding their improvement potential through RFID applications. The highest ranking major processes represent the most promising potential application areas for an RFID-project. Simultaneously, suppliers, customers and especially competitors on the market are analyzed with respect to possible RFID-projects and –activities. Ongoing activities would have a significant influence on the configuration of a possible own RFID-system. The next phase – **initializing the identification phase** – encompasses the formation of project teams for every major process that should be included in a detailed identification phase. This is followed by the **identification of potentials** that includes a thorough process analysis, after which the search procedure for RFID-potentials – briefly introduced in the methods chapter – is exercised in team workshops. Simultaneously, an RFID-checklist, basically consisting of typical RFID-applications that have been implemented in existing RFID-introduction projects, is searched for suitable application scenarios. This measure is meant to supplement the creative process of finding new advanced processes and ensures that no obvious application options are left unharnessed. The result is a list of possible RFID-application options.

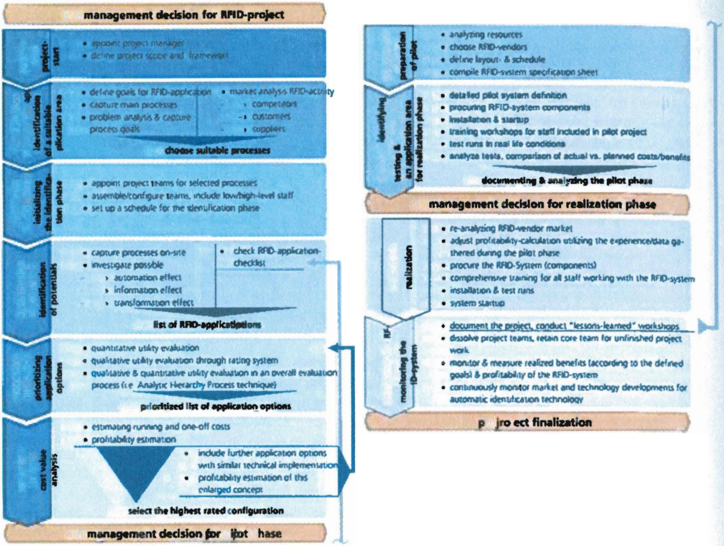


Figure 5: overview, code of practice for RFID-introduction projects

In the next phase – **prioritizing application options** – the application options are evaluated regarding their quantitative and qualitative utility, that is evaluated through a rating system. The applications are ranked accordingly and the most promising items are selected and transferred to the next phase. The **cost value analysis** evaluates both running and one-off costs of the selected applications and the results are then used to conduct a profitability assessment of the selected application options. A this stage the principle of finding technically similar RFID-services that has been briefly described in the methods chapter is utilized: application options that require a similar technical equipment – e.g. similar readers in similar places or tags on the same category of identification objects – and would not significantly increase the costs of the entire system are added to the selection. This expanded system configuration is then also estimated concerning its overall profitability. Following this, the more promising alternative is forwarded to the pilot phase.

The next phase is the **preparation of the pilot** system, which incorporates the design of a limited RFID-system that should be able to demonstrate basic functionalities of the prior planned system while keeping the investment risks – i.e. costs – as low as possible. This phase is of vital importance since RFID components have occasionally shown to behave unexpectedly in real life environments – only after thorough testing in the **testing & identifying an application area for the realization** phase should a realization be approached. The pilot delivers valuable information and experience regarding the actual design- and installation-process of an RFID-system.

After the RFID-concept from the planning phase has been validated and adjusted according to the experiences of the pilot phase, it can be transferred to the **realization** phase. Choosing suitable technical equipment, installing and starting the RFID system without disturbing the ongoing production are among the major tasks at this juncture. Once the system is running, the last phase – **monitoring the RFID-system** – begins. Monitoring the system performance and measuring the realized benefits against the projected numbers is necessary to identify errors in the realization phase and to retouch the system if required. The experiences gathered in the course of the project are documented for future or follow-up project and the implemented RFID-applications are added to the RFID-checklist – this list has already been adjusted to the SME application environment in the research project.

CONCLUSIONS

The presented development of a code of practice presented in this paper has so far resulted in a preliminary concept that provides the managers of RFID-introduction projects in SMEs with a comprehensive set of practical recommendations structured in a sequence of project-phases. Since it was developed under the premise of being designed to the requirements of SMEs in the electronics market, it can be adopted and used by these companies intuitively to identify major application potentials. Testing the concept in field work with industry partners has so far revealed that RFID-application potential in electronic SMEs are often found in secondary production processes or manual production steps, whereas the major production steps are already much more controlled than in other industries, mainly due to the use of automatic soldering lines. However, in intermediate storage-, warehouse- and transport and handling processes there is still plenty of application potential for transparency and improved data quality and -availability through RFID. Container management systems have turned out to be another major application area – especially if more complex transport logistics and variable process variants are involved, RFID is an option to improve the logistics system performance. Companies that are part of the supply chains of automobile-producers and thus are faced with the growing demand for being able to trace their products on a batch- or even parts-level may also benefit from the potent AutoID technology. Another observation is the opportunity for designing hybrid barcode-RFID systems, combining the simplicity and cheapness of one technology with the bulk-reading and other advanced opportunities of the other. Using barcodes to identify parts and RFID tags to gather and develop information on object carriers and containers is one of the possible options of considering RFID projects as AutoID projects.

Future work in the research project is aimed at maturing, adjusting, detailing and supplementing the present concept and to validate it in the ongoing field work with industry partners. Eventually the task will be to make the findings accessible to the SMEs in a suitable form. The research focus itself might be extended towards transferring the findings and approaches towards SMEs in industry sectors with less controlled processes and more complex production processes – e .g. varying technological processing sequences and longer lead times – that can for example be found in the manufacturing of special purpose machinery.

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