RFID-based Business Process Improvements –
Case Study Results and Recommendations

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Abstract: The success of an enterprise is largely determined by its ability and flexibility to react to changes and its business process stability and safeness. Innovative technologies help to improve the execution and management of business processes and ensure that a competitive position can be achieved or enhanced. Radio frequency identification is such an innovative technology with a high potential of optimisation within business processes for example for reduction of processing time and failure rates. By means of a practical case study this paper gives recommendations and shows how RFID can improve business processes.

1 Introduction

Nowadays companies are facing the challenge of globalization and the resulting increase of competition on a global scale. Results of the globalization are for example the rise in frequency of goods ordered, the need for faster information transfer, and shorter product life cycle times [Ko09]. One way to achieve an efficient organizational performance is to manage and improve the business processes within and across the company. Business process management (BPM) addresses this area and intends to improve processes continuously [MVM09].

Business processes can be classified on three levels: strategic planning, management control, and operational control. On the first level, business processes are processes which govern the objectives of the organization, the changes in these objectives, and the resources used to obtain these objectives. Furthermore, policies that specify the acquisition, use, and disposition of these resources are formulated. Within management control, process managers assure that resources are obtained and used effectively and efficiently for the accomplishment of the organization’s objectives. Business processes on operational level assure that specific tasks are carried out effectively and efficiently [Ko09].

The most important aspects of BPM are controlling and measurement of business processes. To improve business processes, they have to be described in a structured way. According to this structured description the potentials for improving the processes can be identified and appropriate modifications can be realized.
One possible enabler to optimize business processes is the adoption of emerging technologies. Automatic identification systems (auto-ID) such as barcode, radio frequency identification (RFID) and sensor technique are such emerging technologies. They are able to automatically identify objects, collect data about these objects and provide this data to computer systems. One of the most significant auto-ID systems is RFID. This technology has the potential to change the way of controlling business processes fundamentally [Gu08]. RFID enables real-time data processing of processes. Hence, information is faster and more precisely available at the point of need e.g. for monitoring processes. RFID technology enables the optimization of multiple business processes and the emergence of new processes called intelligent processes or smart processes which are automatically triggering actions and events [AI08].

The goal of this paper is to show how RFID can improve business processes on a practical case study. The paper is structured as follows: section two describes RFID-based business process improvements in general. A case study which shows business process improvements in a brewery is presented in chapter three. General recommendations for the usage of RFID to improve business processes and a conclusion are given in chapters four and five.

2 RFID-based Business Process Improvements

The technology of radio frequency identification attracts an enormous interest, not only in the research community but also in the industrial field [SG08]. Based on its characteristics, e.g., contactless and automatic capture of data, RFID is an innovative technology for improving business processes, i.e. to increase process efficiency in inbound and outbound flows of goods or in preventing shrinkage and product counterfeiting [Th07].

RFID enables event-driven process management. Transponders, RFID devices and sensors capture states and the location of objects or persons. RFID can be used in many business sectors where a contactless identification of objects or a contactless transfer of data is necessary. However, RFID is not only a technology for identification it also enables real-time data which can be used for improving and controlling business processes [GH07]. This data can be used as decision support for manual and automatic triggering of events. It can lead to a reduction of costs and bring competitive advantages. In association with the automatic reaction of events RFID realizes an important step in the direction of seamless data integrated business processes [Ha08].

In 2008, the authors of this paper carried out an online survey to evaluate experiences and expectations of RFID. Overall, 53 German companies took part in the survey. A result was that most enterprises currently use the RFID technology for tracking and tracing of products (app. 26 percent) and for automating and controlling of processes (app. 28 percent). More than 39 percent of participating enterprises expect a reduction of process costs, the realization of competitive advantages and the reduction of time for the production process.
As mentioned above, the full potential of the RFID technology can only be exploited if the technology is used on all three levels of business process management. Table 1 shows possible advantages using RFID technology (in brief). Each advantage will be identified by an abbreviation in order to relate achieved advantages from the case study which is described in section 3.3.

Operational level:
OA1: process speedups due to the automation of formerly manual operations
OA2: comparison of automatically captured real-time data with target data,
OA3: reduction of time for process life cycle,
OA4: minimization of failure rate,
OA5: seamless integration of data (paperless data integration, all data is stored electronically)

Management level:
MA1: reduction of process costs due to the reduction of the number of process steps,
MA2: enabling real-time processes [Ha08],
MA3: more transparency within processes and across process,
MA4: better possibilities of process control,
MA5: increase of process flexibility due to real-time data,
MA6: improvement of inventory management by means of more accurate data and less process time of inventory checking,
MA7: facilitation of regulatory requirements fulfillment such as documentation of maintenance and tracking of groceries

Strategic level:
SA1: protection from counterfeiting of merchandise,
SA2: improvement of process and product quality due to structured, more accurate and seamlessly integrated data on the operational systems [Ha08],
SA3: Reduction of costs,
SA4: Improvement of customer satisfaction.

The advantages mentioned above are cross-related. Some of the advantages are characterized below.

RFID enables process speed-ups. Non-conformity costs can be reduced by detecting mistakes made during the distribution process [Go09]. The technology delivers more accurate information and allows information sharing for all relevant processes between all stakeholders along the supply chain [Go09]. Additionally, RFID can utilize the captured data to develop new products and services [TAF09].
If the supply chain is not automated, all operations in the chain need to be carried out step by step manually. The whole process involves a lot of repetitive human tasks, exchange of paper documents, inefficiencies, and errors. Furthermore, processes are difficult to monitor and track. Therefore, it is difficult to gain an overall view of operations and to give information about the state of a process [AI04].

In addition to the importance for tracking and tracing of objects, RFID also supports the management of business processes. The captured data can be used for monitoring and controlling of processes as well as for statistical functions.

3 Case Study

The case study which was developed in the research project “KegMan1” examined the feasibility and implementation of a RFID-based tracking and tracing solution for beer kegs (barrel) and its financial implications. For filling the beer aluminum, steel and polyurethane (PU) kegs are used. Annually approximately 30,000 kegs are in circulation. However, an accurate number of which kegs are within the brewery and which kegs are outside the brewery is unknown. Volume types of kegs are 20, 30, and 50 liter. Until now, the brewery uses a manual system for counting and capturing the kegs and a barcode system for tracking pallets. Thus, it is difficult to monitor which customer is currently in possession of which keg and who is responsible for replacing damaged kegs.

The goal of the RFID implementation in the use case is to automate the keg management process and to collect information about the location and circulation time of the kegs. The RFID-based tracking solution gives detailed asset states, movement history information and provides accurate turn and loss data about the kegs.

For the identification of kegs during the cleaning and filling process a solution based on low frequency (LF, 125 kHz) is already available. With the system all kegs can be identified on the ampoule filling system. The operating distance for reading is only a few centimeter. As a result of this short reading distance the system cannot be used for automatic tracking of multiple kegs within the whole supply chain.

3.1 Description of Business Processes

The initial state of the whole process for the beer delivery was analyzed and is shown in figure 1. This process consists of the following steps:

1. When a customer has placed a new order empty kegs are transported by a truck. With this truck the newly filled kegs will be picked up from the brewery (see process step 12).
2. The empty kegs are counted by an employee and captured on the delivery receipt for the new order.
3. After the counting process the kegs are transported to an off-site stock ground.

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1 KegMan is a research project to develop an intelligent management system for the consistent tracking of beverage kegs.
Data indicating the arrival is later transferred into the brewery IT-system manually.

For filling the kegs they are transported to the ampoule filling system. The kegs are inspected for visible damages by an employee. If a keg is damaged it will be rejected and repaired later.

At the ampoule filling the residual pressure is controlled and the kegs are cleaned. Afterwards the kegs are filled.

After filling the kegs their weight is controlled.

The keg identifier is captured manually and documented on paper by an employee.

At the end of the day the data on the paper is transferred into the brewery IT-system manually.

The kegs are transported to the warehouse.

The kegs are transported with a fork lift to the picking location and composed on pallets.

After composing kegs a fork lift loads the truck with the ordered kegs.

The loaded kegs are counted manually by the fork lift driver.

Once the truck is loaded, the delivery receipt data is transferred into the brewery IT-system manually.

The truck takes the order to a distributor. Afterwards, the distributor delivers the beer to bars, restaurants or liquor stores and returns to the brewery for servicing and refilling.

Figure 1: Current business process model for the keg management life cycle
It is important to point out that the manual activities 2, 4, 9, 13 and 14 are highly error-prone. Additionally, the transfer of data from paper to IT-systems is time-intensive and also error-prone. Therefore, a seamless integration of data is required.

As a result of the process evaluation, three sub-processes, which can be supported and improved by RFID, were identified:

1. counting process of returned empty kegs,
2. filling process of the kegs, and
3. loading process of outgoing goods.

Consequently, the main objective of the case study was to develop an intelligent RFID-based keg tracking system which automatically tracks kegs within the whole supply chain. In addition, data integration needs to be realized without changing the type of media.

To improve the business process the following RFID-based re-engineered process was implemented (see figure 2).

Figure 2: Target state of business process based on RFID

(1) Delivery of empty kegs.
(2) The empty kegs are transported to the off-site stock ground by a fork lift. The fork lift drives through a RFID gate\(^2\) which automatically captures all kegs and sends the number of kegs to the brewery IT-system. Additionally, the number of filling circuits and the date of the last service are checked. If a keg has passed too many filling cycles or if a maintenance service is necessary, the keg is transported to the clearing location.
(3) Before filling the kegs they are inspected for visible damages by an employee.
(4) Cleaning and filling the keg.

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\(^2\) A RFID gate consists of at least two RFID antennas which communicate with a RFID reader.
Measuring the right weight of the filled kegs. Additionally, an installed RFID reader captures the transponder identification number (ID) of each keg. This number is automatically combined with the keg number, the beer charge, and the date of filling. All data is sent to the IT-system of the brewery.

The kegs are transported to the warehouse.

Composing the kegs on pallets according to the delivery receipt.

When a fork lift loads the truck with the ordered kegs it passes another RFID gate. The transponder ID is captured and stored automatically within the brewery IT-system.

Shipment to the distributor.

The results of the changed processes are:

- Reduction of the number of activities,
- Transformation of manual to automatic activities,
- Decrease of error-prone activities,
- Increase of process transparency, and
- Decrease of process execution times.

After the process re-engineering the selection of appropriate RFID readers, antennas and transponders as well as the development of the software for the RFID system were made. The biggest obstacle however was the material of kegs. In general metal dramatically reduces the operating range of reading. Due to the width of the gate for outgoing goods a reading range of approximately four meters is required. With conventional RFID-Tags this distance cannot be realized. According to the reading range, the position of the transponder on the kegs is another important aspect. Hence, it is important, that the selected position prevents transponders from damages.

As a result of the analysis two different transponders were identified; one for the metal kegs another for the PU kegs. In order to realize operational reliability of the RFID system a lot of tests were necessary. Tests in the brewery have shown that it is possible to realize a 100 percent reading accuracy for the bulk identification of the required 24 kegs (six kegs on a pallet, four pallets on a fork lift).
3.2 Profitability Analysis

After the tests have been completed successfully a profitability analysis was executed. The improvement of business processes with the launch of the radio frequency technology in breweries is particularly evident in a profitability analysis. As part of the FIM\(^1\) research project "Cost-benefit analysis for an RFID-based identification system for kegs in breweries", a computational tool for calculation of KPI (Key Performance Indicator) has been developed and is used for decision support for launching an RFID project. The tool reflects especially the reduction of keg circulation time that results from changing business processes. According to this tool an analysis to determine the benefits has been carried out in the KegMan research project.

For this, the costs of the RFID system have been captured first. They include both hardware and software for the launching of the system in the brewery. Furthermore, the estimated cost of the project management and the operating cost per year were considered. The cost rates are based on inquiries for RFID hardware and software from different vendors in 2009 and consider the brewery's specific requirements. The costs of the transponder depend on the one hand on the quantity required for the brewery. On the other hand the mounting of the transponder swayed the cost for the transponder. Some information was not available and could therefore only be estimated.

In addition to the costs for launching the radio frequency technology in the brewery, a number of brewery-specific basic data for a profitability analysis are needed. These include annual production of draft beer, information about the kegs used (size, type, quantity and average purchase price), number of required RFID readers, annual loss rate of kegs, repairs and maintenances per year, average repair and maintenance cost per keg complaints per year and number of loading lanes. All those information varies depending on the brewery.

With the collected cost rates various potential savings could be considered. The major potential is derived by reducing time of circulation. By reducing cycle times especially the stock of kegs can be minimized. Thus, the liquidity of the company may be increased.

Furthermore, by launching the RFID technology, the maintenance process could be improved. In contrast to the initial process the kegs can be maintained regularly based on the number of filling circuits. This reduces the chance of faulty kegs delivered to the customers and decreases the number and cost of customer complaints. Although the regular maintenance causes higher cost the customer satisfaction could be increased. Furthermore, the customer loyalty was strengthened.

\(^1\)Research Institute for Management and Beverage Logistics (FIM), website: https://www.vlb-berlin.org/cms/front_content.php?lang=1&client=1&sidcat=12&sidart=11&changelang=2
Initially, the brewery did not always know where their kegs are located and who is currently in possession of them. This caused massive costs for the brewery. With the RFID-based tracking of kegs and the resulting increase of process transparency, the loss of kegs could be reduced. The brewery knows the location of their kegs and who is in possession of them any time.

With that information, the amortization could be calculated, as shown in table 1.

<table>
<thead>
<tr>
<th>investments for RFID system</th>
<th>amount to be invested</th>
<th>€</th>
</tr>
</thead>
<tbody>
<tr>
<td>annual savings by RFID system</td>
<td></td>
<td></td>
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<tr>
<td>reduction stock of kegs</td>
<td>€ 47,303.53</td>
<td></td>
</tr>
<tr>
<td>reduction loss of kegs</td>
<td>€ 46,912.50</td>
<td></td>
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<tr>
<td>reduction of complaints</td>
<td>€ 3,000.00</td>
<td></td>
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<tr>
<td>sum:</td>
<td>€ 97,216.03</td>
<td></td>
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<tr>
<td>annual cost of RFID system</td>
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<tr>
<td>operating cost p.a.</td>
<td>€ 7,500.00</td>
<td></td>
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<tr>
<td>maintenance of the kegs</td>
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<tr>
<td>(additional annual cost</td>
<td>€ 17,242.11</td>
<td></td>
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<tr>
<td>by regular maintenance)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sum:</td>
<td>€ 24,742.11</td>
<td></td>
</tr>
</tbody>
</table>

Amortization years 2.43

As a result of the profitability analysis the RFID system can be amortized after roughly 2.5 years.

3.3 Benefits for the Brewery

In summary, the following benefits categorized into three levels could be realized.

Operational level:

a. Increased process speed (OA1):
   Due to the automation of formerly manual operations the process speedup was increased. Until now incoming empty kegs have to be counted by an employee manually. This process will take less time by using RFID.

b. Reduction of circulation time (OA3):
   Due to the tracking of kegs based on RFID the circulation time can be monitored and analyzed. Based on these analyzed data process bottlenecks can be identified.

c. Reduction of asset loss (OA2):
   Due to the real-time information about the location of kegs a reduction of asset loss can be achieved. Thus, a significant added value - a new keg costs 130 EUR but the keg deposit is only 30 EUR - can be generated.

d. Elimination of inventory inaccuracies (OA4):
   The manual counting process causes inventory inaccuracies. With automatic counting of kegs the error rate can be decreased.
e. Reduction of complaints (OA4 and SA4):
The regular maintenance of kegs enables the reduction of faulty kegs delivered to
the customer. As a result the number of complaints can be decreased. In addition the
customer loyalty is strengthened.

f. Seamless data integration (OA5):
Due to the automatic capturing of kegs seamless data integration can be realized and
less errors occur. Manually hand-filled forms are replaced by electronic and
paperless data capturing. The employees do not have to gather the data on a paper
sheet and transfer the data in the information system.

Management level:

g. Identification of returned empties (MA6):
The bulk identification of the incoming empty kegs provides accurate data of the
number of available kegs.

h. Improvement of the maintenance process (MA1 and MA2):
In contrast to the initial process the kegs can be maintained regularly by the number
of filling circuits. The necessity of the next service can be determined in order to
discharge the keg and to arrange maintenance of the keg.

i. Better visibility of keg stock (MA3):
Resulting from real-time data of the available kegs a better visibility of the keg
stock can be realized. Thus, the capability to react flexibly to an extraordinary order
can be improved.

j. Support for business process management (MA4):
The use of RFID technology enables the automatic monitoring of stock levels and
product movements. RFID produces a positive impact on supply chain performance
since the way of information between brewery, distributor, and gastronomy can be
optimized. Furthermore, the reliability of delivery on time and the quality can be
increased.

Strategic level:

k. Statistical information (SA2):
The RFID readers in the brewery capture up-to-date keg information. This
information can be analyzed for statistical purposes and provides a basis for the
decision making process.

l. Increased customer satisfaction (SA4):
Due to the faster reaction of complaints and the lower number of faulty kegs the
customer satisfaction may be increased, resulting in higher customer loyalty.

m. Reduction of costs (SA3):
Firstly, the acquisition of new kegs can be reduced; secondly, the costs of
complaints can be decreased; thirdly, less capital is tied up and the liquidity of the
enterprise may be increased; fourthly, the sales volume can be augmented.
4 Recommendations

Based on the experiences from this case study and several further research projects with RFID technology realized by the authors some recommendations can be given.

A precondition for a successful use of the RFID technology is a clearly defined business case. For this business case the processes have to be analyzed extensively. The analysis may help detect inefficiencies, error-proneness and reasons for quality problems in the processes [Gü08].

In order to achieve the full potential of the RFID technology the captured RFID data has to be made available to all relevant business processes.

The tight integration of the technology into existing IT infrastructure (e. g. ERP and WMS) is crucial to achieve the positive impacts of RFID. For large-scaled RFID applications existing middleware solutions for filtering and processing RFID data is recommended. In addition, the use of a middleware simplifies the integration of the RFID system.

The implementation of a tracking and tracing system within the whole supply chain requires that all partners combine the flow of goods with the corresponding flow of information [GS09]. On the one hand this involves the exchange of captured RFID data with business partners. On the other hand this requires management rules and rights for all partners.

In order to achieve a stable running RFID system the technical properties of transponder and RFID devices must be substantially tested. An optimal configured RFID system depends on different aspects, e. g. environment, material of tagged objects, and transponder position on the object.

The RFID transponder and readers require a high investment. Consequently, the feasibility of an RFID adoption has to be taken into account.

5 Conclusion

This paper presented an overview how RFID can help to improve the controlling and measurement of business processes. Based on a case study the positive impact of RFID within the beverage industry was depicted. A comparison of the initial processes with RFID-based re-engineered processes was shown. Subsequently, the benefits for the brewery were listed. Finally, recommendations for a successful use of RFID for the improvement of business processes and their management were given.

The consequent application of the RFID technology leads to detailed and accurate data of the objects and processes being surveyed. This data can be used by decision makers at different levels of the organizational hierarchy and lead to considerable operational and strategic benefits [Gü08].
In the first phase of the case study a local solution within the brewery was developed. For the next step a strategic roll-out in an inter-enterprise application setup is planned. The involvement of supply chain partners (e.g. distributors) can maximize the positive impact of the RFID technology. In the same way the costs for transponders and RFID hardware can be shared by partners. Thus the ROI can be achieved in a shorter time. In addition, all partners may gain significant and tangible competitive advantages.

References