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ThyssenKrupp Steel

The Benefits of RFID for Slab- and Coil-Logistics

A Point of View on the use of Radio Frequency Identification (RFID) for the steel industry

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Preface

Modern identification technologies such as radio-frequency identification, or RFID, have become increasingly important for streamlining production and logistics operations in almost every industry. Radio-frequency identification enables process automation — reducing the need for manual labor, speeding up execution of critical business processes while improving information security and worker safety.

„RFID Reaches Into Steel Industry,"a recent article published by Datamonitor, illustrates some of these points. Journalist Rhonda Ascierto writes, „Germany's ThyssenKrupp Steel has become the first steel producer in the world to use RFID technology for slabs."

The article continues:

„ThyssenKrupp Steel will use RFID at its new steel mill in the Bay of Sepetiba, Brazil, which is scheduled to start production of 5 million metric tons of steel per year in 2009. It will also use RFID at harbours in Rotterdam, Netherlands, and Duisburg, Germany, to identify steel slabs automatically and to speed up the unloading process.

The company needed an automated system to identify more than 100,000 steel slabs per year because of the tight unloading times when clearing sea vessels from their cargo.

There is a window of less than three minutes per slab when clearing cargo that must be maintained at all times. Any delay would likely create additional cost."

The power of RFID in supporting the needs of the steel industry is increasingly apparent in the marketplace. ThyssenKrupp Steel and Accenture are leading an initiative to align steel industry players around a common effort to harness benefits highlighted by the Datamonitor article such as RFID's ability to assist steel makers and customers with streamlining business processes, harnessing automation more extensively and reducing costs while maximizing revenue opportunities.

More specifically, ThyssenKrupp Steel and Accenture are collaborating with other global steel leaders, steel customers from the automotive and industrial construction segments, industry bodies and standardization organizations in order to create RFID standards for the benefit of the entire steel industry.

We are pleased to invite you to explore the possibilities of RFID and to join this standardization initiative.

1_Executive summary

Over the next couple of years, radio-frequency identification (RFID) and the Electronic Product Code™ (EPC™) are poised to be among the most exciting and transformational technologies to influence the steel industry—with the potential to radically change the way global steel companies run their internal and external logistics.

Leading steel companies should move as quickly as possible to adopt RFID technology to increase supply chain visibility, improve process security, generate cost savings and allow for steady business growth.

Major benefits of adopting RFID technology include:

Asset use: Radio-frequency identification speeds up the identification of tagged items, increasing throughput and optimizing the use of expensive handling equipment such as forklifts and cranes. Time gained can be so significant that it is possible to eliminate machines and reduce attendant capital investments and personnel costs.

Operational efficiency: Radio-frequency identification improves operational efficiency in many ways including improved collaboration with trading partners, faster product localization and reduced manual effort.

Safety and security: Automating product identification and tracking removes people from physically dangerous situations and averts the potential for product confusion. This in turn reduces risk exposure.

Customer service: In addition to the range of benefits accrued by the steel industry as a result of RFID adoption, Accenture anticipates that steel customers too will experience all the same benefits and will likely mandate the use of RFID if the industry does not take the lead.

While it is clear that RFID applications can unlock unprecedented value for steel companies, the path to adoption will see some challenges. Technical and process hurdles to overcome include getting RFID to work on metallic products, addressing internal resistance related to changing decades-old processes, meeting the need for repeated tagging because of the iterative nature of the production process and supporting the heterogeneous customer base.

Despite the challenges, the benefits of RFID will contribute to each steel company's effort to realize high performance. ThyssenKrupp Steel and Accenture have set out to collaborate with other global steel manufacturers, customers, industry bodies, standardization organizations and RFID vendors, to create standards for the benefit of all. This paper illustrates the potential RFID holds for steel companies and demonstrates how cooperation within the steel industry can lead to a standardization of IT-systems that is advantageous for the industry and its customers.

For further information about the joint ThyssenKrupp Steel and Accenture initiative to assist steel companies with RFID adoption that supports high performance, please contact:

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2_Introduction

Automatic identification, or Auto-ID, technologies such as radio-frequency identification (RFID) are increasingly important for streamlining production and logistics operations in almost every industry. Radio-frequency identification enables process automation, reducing the need for manual labor, speeding the completion of critical business processes and simultaneously increasing process security.

2.1 Background

After conducting several successful pilot projects using RFID for slab and coil logistics, ThyssenKrupp Steel and Accenture are collaborating with steel customers from the automotive and industrial construction segments, other global steel producers, industry bodies and standardization organizations to leverage their knowledge and experience and to create standards of benefit to the entire industry.

Implementing RFID in slab and coil logistics results in several benefits in the following key areas:

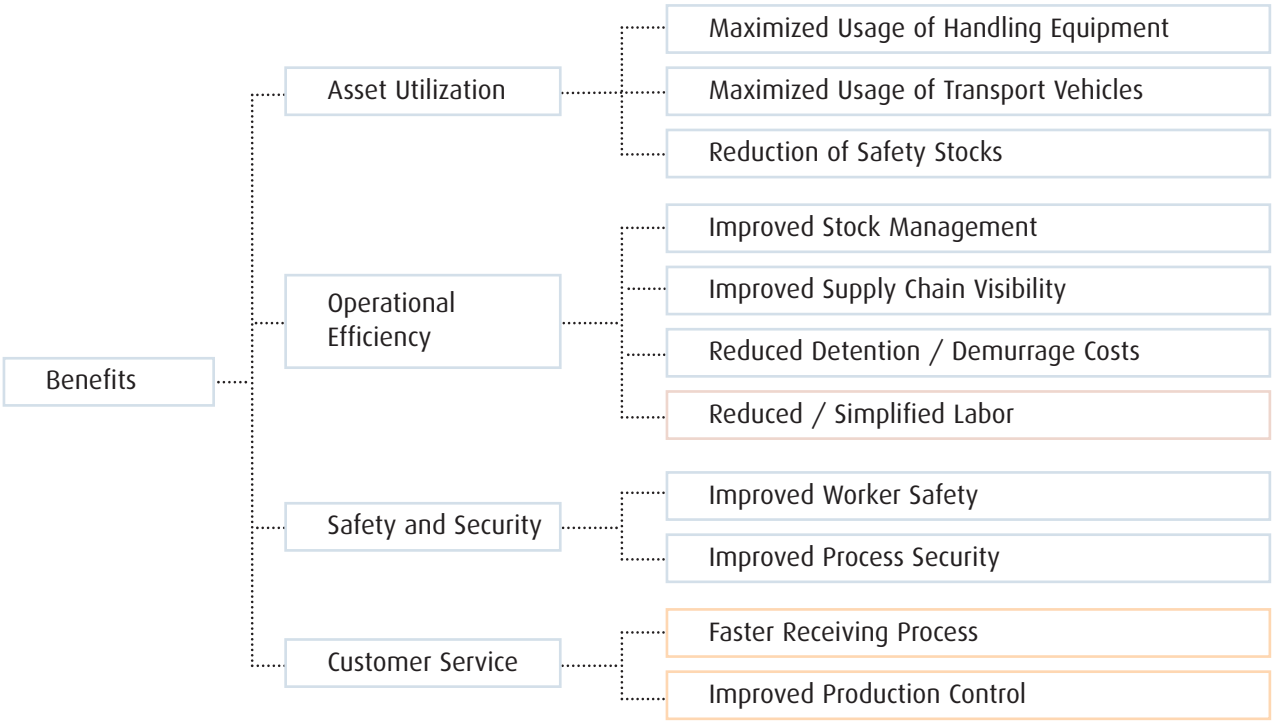
- **Asset use**
- **Operational efficiency**
- **Safety and security**
- **Customer service**

2.2 Why standardization matters to the steel industry

Standardization will be key to success and to the realization of the many benefits. It is paramount for the following reasons:

Customer acceptance: Most steel companies sell their products (largely coils) and intermediary products (slabs and coils) to a uniform customer base in the automotive and industrial segments. If steel producers adopt diverging RFID solutions to identify slabs and coils, this places the onus on customers to work with multiple systems. Conversely, as has already occurred in the retail, military and pharmaceutical sectors, if the steel industry proposes anything other than a standardized approach, cus-

Figure 1 – Benefits of using RFID in slab and coil logistics



tomers may simply mandate solutions, leading to unnecessary complexity, redundancy and cost for steel companies.

Flexibility: By implementing a standard for solutions, the integration of new customer systems will be far easier than if a customized solution for every unique customer scenario were necessary. Standards also allow customers to choose among different suppliers and reduce their dependency on a single one. In other words, the necessarily tight integration of customer and supplier systems will not become an artificial trade barrier.

Availability and cost: Using RFID for slab and coil logistics requires specialized solutions, which either do not yet exist in a production-ready form or which are at least more expensive than products used by other industries. While designing RFID products appropriate for handling steel is technically feasible, many vendors will only do so given sufficient sales volumes. As a result, the steel industry should focus on adopting a limited number of standardized solutions.

No duplication of effort: There is no point in duplicating efforts and individually repeating technical mistakes. While the RFID applications described in this paper would provide benefit even if only used in one company, far greater benefits would be realized by standardizing systems across the entire supply chain, from producers to end-use manufacturers.

The steel industry must proactively develop standards for RFID-enabled slab and coil identification. A wait-and-see attitude is strongly discouraged because implementation times would increase—as would the costs and risks associated with responding to diverging customer requirements.

It is for these reasons that we invite steel companies as well as steel industry customers to join and participate in this standardization effort.

Opportunities for steel company participation may be found at the conclusion of this paper.

3_Benefits of RFID in slab and coil logistics

Radio-frequency identification technologies are most suitable for slab and coil logistics beginning after the continuous casting of slabs and on through internal production and finishing steps all the way to delivery of the finished product (see Figure 2). Much of the effort spent on this complex process typically goes into handling activities, especially for local, internal and external[1] shipping and receiving.

In addition to the typical process flow from continuous casting to production use, slabs and unfinished coils may be purchased from third parties if a company specializes in finishing activities only.

Today, handling activities are performed by visually identifying a product, writing down its identifier and entering the information into the appropriate IT-system, involving time, manual effort, and the risk of human error. Some companies have implemented barcode technology, but this approach provides partial automation only with people still required for tedious manual scanning.

Using RFID at key points along the supply chain can streamline and automate many handling activities. While complete automation (automation that eliminates human quality assurance, for example) will remain the exception, RFID saves some real costs, while helping to respond to emerging requirements just as barcodes did more than 30 years ago. Increasing sales volumes and the continuous drive to make operations more efficient will lead companies to adopt RFID.

The following sections will detail the benefits of RFID technology for slab and coil logistics within typical supply-chain steps (compare Figure 2 and Figure 3).

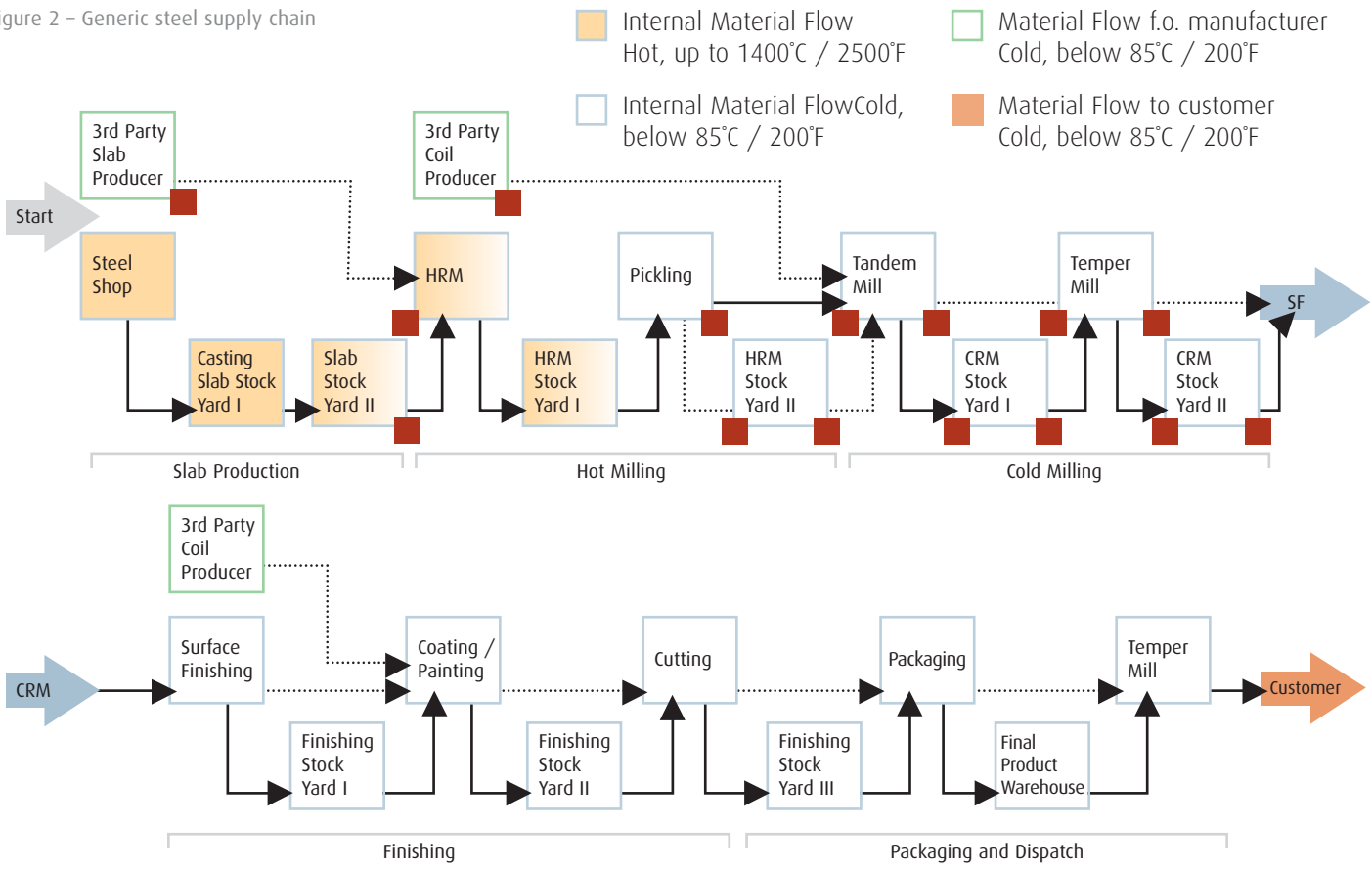
3.1 Perfect Steel case study methodology

To demonstrate the value of RFID technology in a typical steel supply chain we created a hypothetical company called „Perfect Steel." Throughout this document, we will review several scenarios using Perfect Steel to illustrate the potential business benefits of RFID.

The examples represent a limited number of potential benefits, and are mainly focused on specific applications. As a result, they do not neces-

[1] "Local" meaning handling and transportation activities within the same business and / or site; "internal" referring to handling and transportation activities involving different sites or businesses within the same group; and "external" representing handling and transportation activities between manufacturer and customer.

Figure 2 – Generic steel supply chain



sarily take into account the potentially much greater „network effect," that is, the impact of amortizing the initial RFID platform costs across multiple applications of using RFID along an entire internal and / or external supply chain. All scenarios are based on measurable indicators and cautious estimates, and do not take into account potential positive effects or soft benefits that might further improve Perfect Steel's success.

The most common mistake when investigating RFID business cases is to view RFID as a project. It is not. It is crucial for decision makers to understand RFID as a critical infrastructure program made up of a growing number of use cases that allow companies to drive efficiency and better meet customer needs.

The „network effect" has a key role to play in this discussion. In other words, if a company implements a common RFID platform that could be used by many different RFID applications across operations, that platform becomes more valuable as more applications leverage it.

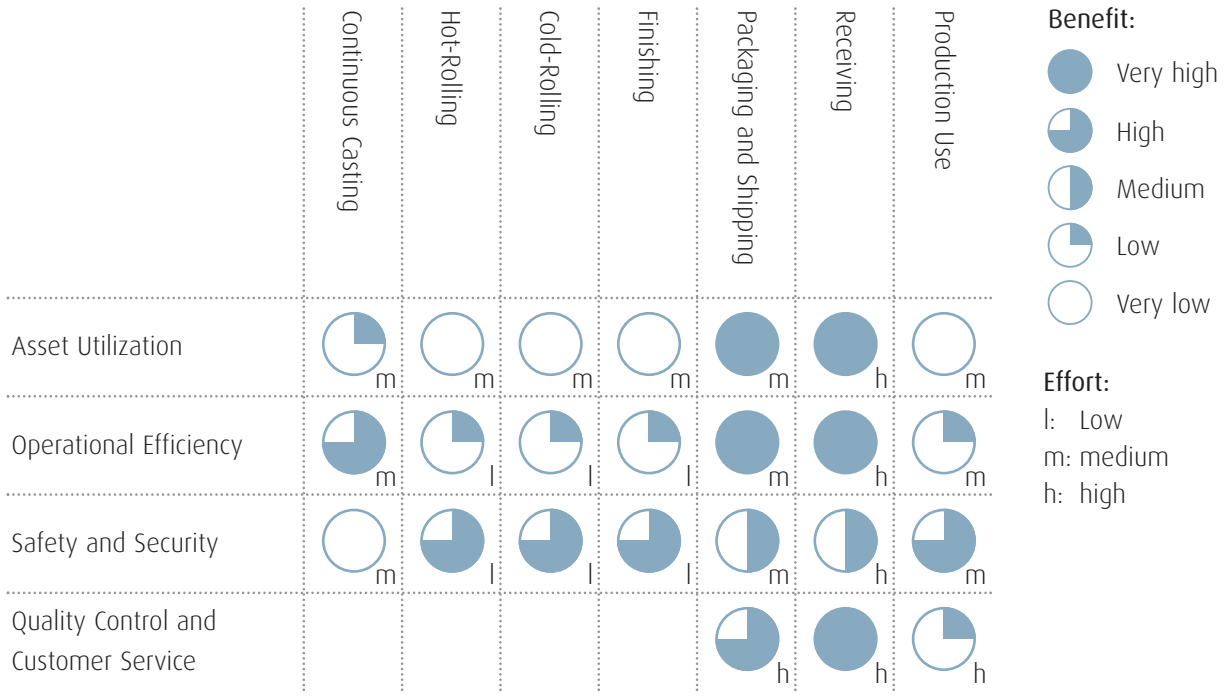
A company's RFID implementation will divide into two types of investment:

1. A radio-frequency identification platform, including middleware licenses, servers, and operations support considered a common service-cost to the company—comparable to general IT infrastructure and support.

2. Multiple applications, including custom software development, process integration, dedicated consulting, RFID tags for developing specific RFID solutions, that will be charged to the business / the respective project on a case-by-case basis.

In the following case studies we do not account for general infrastructure costs, only application-specific costs. That said, we do include platform costs in the comprehensive case study at the end of this section. Please note that by choosing to illustrate only three applications, we do not mean to imply that Perfect Steel could only ever use its RFID platform in the three specific application scenarios. Rather, once the company's RFID platform is established, that company would be in the enviable position of being able to implement any number of applications that add business value.

Figure 3 – Estimated potential and effort of RFID-technology along the supply chain by area



3.1.1 Perfect Steel – Business case assumptions

Perfect Steel processes 352 thousand slabs per year (320 thousand are self-produced and 32 thousand are purchased from third parties). Slabs and coils weigh 25 tons each.

General Assumptions – Slabs	
annual production of slabs [tons]	8.000.000
annual purchased slabs ratio [%]	10,0
annual slab purchases from 3rd parties [tons]	800.000
annual slab capacity to be handled [tons]	8.800.000
avrg. weight per slab [tons]	25
annual no. of slabs produced	320.000
annual no. of slabs purchased from 3rd parties	32.000
annual no. of slabs processed	352.000

Figure 4 – General assumptions – slabs

From these slabs, Perfect Steel produces a total of 8.8 million tons of hot-rolled coils per year. Twenty-five percent or 2.2 million tons of these coils are directly delivered to end customers while the remainder go into cold rolling and finishing.

General Assumptions – Coils	
annual production of hot rolled strip [tons]	8.800.000
avrg. weight per coil [tons]	25,0
annual no. of produced unfinished coils	352.000
annual sales of unfinished coils to 3rd parties [%]	25,0
annual no. of unfinished coils sold to 3rd parties	88.000
annual no. of unfinished coils processed	264.000
unfinished coils to finished strip ratio [%]	120
annual no. of finished strip	316.800
avrg. price per ton of finished strip [€]	650
avrg. annual value of finished strip [€]	4.290.000.000
avrg. inventory [months]	1,5
avrg. inventory [tons]	825.000
avrg. value of inventory (sales outstanding) [€]	536.250.000
internal rate of return [%]	10,0
avrg. annual cost of capital [€]	53.625.000

Figure 5 – General assumptions – coils

Perfect Steel maintains its own seaport with one portal crane, a fleet of 20 forklifts and 80 trailers to transport slabs and coils internally.

General Assumptions – Assets	
no. of forklifts	20
no. of trailers	80
value of forklifts [€]	500.000
value of trailers [€]	80.000
total value of forklifts [€]	10.000.000
total value of trailers [€]	6.400.000
annual cost of maintenance [%]	10,0
total cost of maintenance per year [€]	1.640.000

Figure 6 – General assumptions – assets

With a supply chain similar to the generic one described. Perfect Steel is estimated to require a total of 29 RFID-readers and 116 RFID antennae.

Location Type	Equipped locations	Inbound Readpoints	Outbound Readpoints	RFID Readers	RFID Antennae
Slab Stock Yards	1	0	1	1	4
Pickling Stations	1	0	1	1	4
HRM Stock Yards	1	1	1	2	8
Tandem Mills	1	1	1	2	8
Temper Mills	1	1	1	2	8
CRM Stock Yards	2	1	1	4	16
Surface Finishing Stations	1	1	1	2	8
Coating / Painting Stations	1	1	1	2	8
Cutting Stations	1	1	1	2	8
Finishing Stock Yards	3	1	1	6	24
Packaging Lines	1	1	1	2	8
Final Warehouses	1	1	1	2	8
Dispatch Stations	1	0	1	1	4
Total	**16**	**10**	**13**	**29**	**116**

Figure 7 – Perfect Steel's RFID hardware needs for RFID rollout throughout operations

The business cases assume current market prices for RFID hardware.

RFID Hardware-Pricing (approx. list prices as of 2007)	
UHF RFID fixed reader	3.000 €
UHF RFID antenna	200 €
UHF RFID printer-applicator	20.000 €
UHF RFID handheld reader	2.500 €

Figure 8 – Radio-frequency identification – hardware-pricing

We have incorporated average deployment costs for site surveying and for installation activities. In addition to setup and customization services, the average includes peripheral equipment such as motion sensors, light stacks and installation materials such as fixtures and cables.

Average Deployment Costs	
RFID site survey (per site)	1.000 €
RFID HW installation (per readpoint)	20.000 €

Figure 9 – Average deployment costs

Because of the high handover and numerous shipping activities among the many production steps, including the inadvertent removal / destruction of RFID tags, Perfect Steel is estimated to require a total of roughly 2.5 million RFID tags per year.

RFID-equipped Location	Units Processed	Units Added / Removed	% of new Tags	no. of new Tags
Slab Stock Yard II	320.000	32.000	100 %	320.000
Pickling	352.000	0	100 %	352.000
HRM Stock Yard II	352.000	0	0 %	0
Tandem Mill	352.000	0	100 %	352.000
CRM Stock Yard I	352.000	0	0 %	0
Temper Mill	352.000	0	100 %	352.000
CRM Stock Yard II	352.000	-88.000	0 %	0
Surface Finishing	264.000	0	100 %	264.000
Finishing Stock Yard I	264.000	0	0 %	0
Coating / Painting	264.000	0	100 %	264.000
Finishing Stock Yard II	264.000	0	0 %	0
Cutting	264.000	52.800	120 %	316.800
Packaging Line	316.800	0	100 %	316.800
Final Warehouse	316.800	0	0 %	0
Dispatch	316.800	0	0 %	0
Total				**2.537.600**

Figure 10 – Perfect Steel's annual need for RFID-tags at full rollout

Given that RFID tags are a recurring cost with prices falling every year, we applied a cautious estimate for tag prices[2] over the next five years.

RFID Label Price Prediction

Price per label at 500k+ volumes in 2008	0,25000 €
Price per label at 500k+ volumes in 2009	0,24500 €
Price per label at 500k+ volumes in 2010	0,24000 €
Price per label at 500k+ volumes in 2011	0,23500 €
Price per label at 500k+ volumes in 2012	0,23000 €

Figure 11 – RFID label price prediction

We include percentages for annual hardware and software maintenance as well as for vendor support and software updates. Finally, we also assumed an weighted internal cost of capital of 12 percent per annum in order to evaluate the suggested investments according to their net present value (NPV).

General Assumptions – Financial Factors

Average Annual Hardware Maintenance	5 %
Average Annual Software Maintenance	5 %
Vendor Support & Software Updates	10 %
Weighted Average Cost of Capital (WACC)	12 %

Figure 12 – General assumptions concerning financial factors

[2] The prices assumed here are for a radio-frequency identification label (an RFID tag or "inlay" plus a surrounding label) suitable for slabs / coils.

3.2 Asset use

Expensive machinery, tools, transport vehicles and other large items required to run a business are commonly referred to as assets. Asset investments are most often significant, which is why companies aim to minimize the number of total assets required by optimizing how they employ existing assets.

3.2.1 Handling equipment

Using RFID generally speeds up the identification of tagged items, which has the salutary effect of increasing throughput and making the most effective use of expensive handling equipment. In some cases, the time gained can be so significant that companies can reduce the number of machines required along with associated capital and human investments. Reducing the quantity of overall machine assets translates directly to a shifting of human resources from manual labor to potentially higher value tasks. Similarly, the total cost of operations and maintenance based on a reduced machinery load reduces proportionally.

The factors outlined in this section delineate why steel companies seek to limit asset acquisition while ensuring that tight asset allocation does not cause a bottleneck. Using RFID technology to automate slab and coil identification represents a major step towards achieving this goal.

3.2.2 Transport vehicles

Transporting slabs and coils between different production lines, company sites or to third parties for finishing and back, represents a significant portion of activity in the supply chain—and transportation tends to present the greatest number of potential challenges along the way.

Production and finishing steps can only move forward when half-products are available and are delivered accurately and on time. Optimal vehicle management is crucial. Many steel companies own larger than necessary fleets of trucks, trailers, railcars and heavy lifting vehicles. Even if third parties own transportation vehicles, RFID technology can contribute to better resource management and reduced rental and service costs.

Using RFID to individually track and manage all transport assets would be the best solution, but this may not always be possible since another party may own the equipment. Fortunately, simply using RFID tags on slabs and coils significantly speeds loading and unloading, which reduces vehicle turnaround times.

Radio-frequency identification readpoints at key locations along the chain provide companies with the ability to automatically verify sequence, correct routing, and shipment completeness — all factors that lead to further reductions to the total number of vehicles required.

3.2.3 Safety stocks

Gaining a more accurate, real-time overview of the entire supply chain will help manage processes to reduce risk from the „Bullwhip Effect." To mitigate against fluctuations in customer demand, companies often accumulate safety stocks. The Bullwhip Effect describes the accumulation of order fluctuations beginning with the end customer and moving all the way down the chain. Safety stocks can create proportionally large costs compared to customer demand–especially for companies at the beginning of the supply chain.

The effect is analogous to the causes of a traffic jam that builds despite any actual obstacle on the road. Drivers make decisions based on the limited information they have, limiting personal risk. This results in an increased number of cars slowing for no obvious reason and causing traffic jams. If drivers could see the entire traffic system, using real-time traffic updates, they could make better decisions about the overall state of the roads.

With this analogy in mind, using RFID helps reduce inventory levels / safety stocks and increases inventory turns, resulting in an overall positive impact on working capital because product is not just sitting in a warehouse waiting to be purchased.

Perfect Steel Case study – Asset use

This scenario describes the reduction of necessary working capital and fixed assets using RFID across the internal supply chain. (see figure 13)

1. Safety stock: Perfect Steel holds a safety stock of approximately 825 thousand tons of coils with a reference price of 650 euros per ton. This represents the production capacity of approximately one-and-a-half months. The average value of the coil inventory is approximately 536 million euros. The weighted average cost of capital (WACC) is 12 percent, which represents an average cost of capital (stock) of approximately 54 million euros. Implementing RFID technology improves the integrated planning systems and the outbound logistics and is estimated to reduce inventory and related working capital by two percent. Perfect Steel identifies more than 1.1 million euros in savings per year—savings grow with increased business.

2. Fixed assets: Implementing RFID optimizes forklift and trailer use for internal product movement. Perfect Steel will reduce forklift and trailer requirements by 10 percent, representing a one-time gain of over 800 thousand euros by selling off redundant equipment. Related maintenance costs would also reduce by 10 percent—translating into one million euros of additional savings per year. Increased throughput allows Perfect Steel to cope with increased volumes resulting from growth without requiring additional equipment.

Perfect Steel's RFID investment for asset use pays off in its second year, with a cumulated ROI of 5.2 million euros, representing a net present value of 3.0 million euros after five years. The initial investment for this scenario is 2.9 million euros.

Asset Utilization Business Case			**Year Business Growth Rate**	**Rollout**	**2008**	**2009**	**2010**	**2011**	**2012**
				n / a	**n / a**	**5,00 %**	**5,00 %**	**5,00 %**	**5,00 %**
Benefit Summary									
Value Lever	**Improvement**	**Initial Cost**	**%-Change**						
Recurring									
Safety stock (finished products)	Working capital reduction	53.625.000 €	2 %		1.072.500 €	1.126.125 €	1.182.431 €	1.241.553 €	1.303.630 €
Maintenance of fixed assets	Fixed capital reduction	10.000.000 €	10 %		1.000.000 €	1.000.000 €	1.000.000 €	1.000.000 €	1.000.000 €
One-Off									
Utilization of fixed assets (forklifts)	Fixed capital reduction	6.400.000 €	10 %		640.000 €				
Utilization of fixed assets (trailers)	Fixed capital reduction	1.640.000 €	10 %		164.000 €				
Total Annual Savings					**2.876.500 €**	**2.126.125 €**	**2.182.431 €**	**2.241.553 €**	**2.303.630 €**
Cost Summary									
Cost Type	**Item**	**Units**	**Unit Price**						
Recurring									
Hardware Maintenance	Reader replacement, ...	5 %				6.510 €	6.510 €	6.510 €	6.510 €
Software Maintenance	Bugfixing, ...	5 %				100.000 €	100.000 €	100.000 €	100.000 €
Tags	Label with inlay	2.537.600			634.400 €	652.798 €	639.475 €	626.153 €	612.830 €
One-Off									
RFID-Hardware	Readers	29	3.000 €	87.000 €					
	Antennae	116	200 €	23.200 €					
	Printers / Applicators	1	20.000 €	20.000 €					
Initial Deployment	RFID Site-Survey	17	1.000 €	17.000 €					
	Installation	30	20.000 €	600.000 €					
System and Process Integration	Software development	1	2.000.000 €	2.000.000 €					
	Training	1	200.000 €	200.000 €					
Total Annual Costs				**2.947.200 €**	**634.400 €**	**759.308 €**	**745.985 €**	**732.663 €**	**719.340 €**
ROI-Summary									
Total Cumulative Savings					2.876.500 €	5.002.625 €	7.185.056 €	9.426.609 €	11.730.240 €
Total Cumulative Costs				2.947.200 €	3.581.600 €	4.340.908 €	5.086.893 €	5.819.556 €	6.538.896 €
Total Cumulative ROI					**-705.100 €**	**661.717 €**	**2.098.163 €**	**3.607.053 €**	**5.191.344 €**
NPV-Summary									
Total Annual Result				-2.947.200 €	2.242.100 €	1.366.817 €	1.436.446 €	1.508.890 €	1.584.290 €
NPV after n-th year				**-2.947.200 €**	**-945.325 €**	**144.293 €**	**1.166.727 €**	**2.125.654 €**	**3.024.623 €**

Figure 13 – Asset use scenario business case

3.3 Operational efficiency

Radio-frequency identification technology can improve the operational efficiency of a steel company in many ways. Among the more obvious are faster product localization and reduced labor costs.

3.3.1 Improved stock management

From the continuous casting (or purchase) of slabs, to hot-rolling (or purchase) of coils, to cold-rolling and / or one or multiple finishing steps all the way to packaging and shipment, a significant number of movement and storage operations are conducted for slabs and coils.

The more frequently a half-finished product needs to be moved to an internal warehouse or storage yard, the higher the chance that it may become „lost." This is particularly true if, as is the case with many operations today, identifying the object being stored is conducted manually.

To overcome this risk, some companies use sophisticated stock-keeping solutions with GPS-enabled forklifts or crane-coordinate systems to record each item's exact offloading position. In theory, these systems eliminate misplacement yet they have a weakness — the initial identification is still error prone. Radio-frequency identification tags limit the chances of human error and facilitate faster and more accurate product localization.

The same logic applies to inventory management in general, where RFID makes it easier than ever not only to see in real time individual products and their qualities that are in stock, but also to receive detailed information about product turnaround.

Knowing exactly which products with what qualities are located at precise positions, allows logistics managers to swap equivalent half-products and reassign them to new orders to avoid unnecessary handling. So if, for example, the bottommost slab of a pile is about to be shipped, and could easily be replaced with a more accessible slab with the same qualities, this would save time and resources. Radio-frequency identification improves a company's ability to capture these opportunities to drive efficiency and effectiveness.

3.3.2 Supply chain visibility and insight

As with all transportation-related activities within the supply chain, RFID technology holds the potential to make a dramatic impact. In a supply chain where slabs and coils are tagged, RFID-readers on cranes, forklifts—and at critical points along a company's rail tracks—will deliver a detailed, accurate record of the movement every time a tagged item passes a reader.

The result of this abundance of information is unprecedented insight into the functioning of internal and external supply chains, in particular the different transportation processes, use of rental assets such as railcars or vessels, and half-product turnover.

Such insight will improve monitoring and management of transportation performance over time and help to uncover problem areas, place service provider charges under secondary review and, ultimately, improve the efficiency of the entire supply chain for cost savings and improved customer service.

3.3.3 Detention / demurrage cost reductions

A major benefit of automatic product identification using RFID is that it speeds loading and unloading cycles without compromising security.

Today product identification is often performed visually or using barcodes, involves walking around a coil or slab to access its identifier with a handheld reader. There are a sufficient number of instances in which an optical product identifier will become unrecognizable as a result of dirt, scale or damage to a printed label's surface – all of which slow the handling process. Radio-frequency identification does not require optical readability (most of the times not even line of sight) and is therefore much better suited to face harsh conditions that occur along a typical steel supply chain.

Because steel companies rely on a large number of third-party transportation assets to help them move and process slabs and coils, managing the loading / unloading process and returning these assets within the contracted time frame is vital. Failing to do so can result in incurring costly detention and demurrage charges, which RFID can also help to minimize.

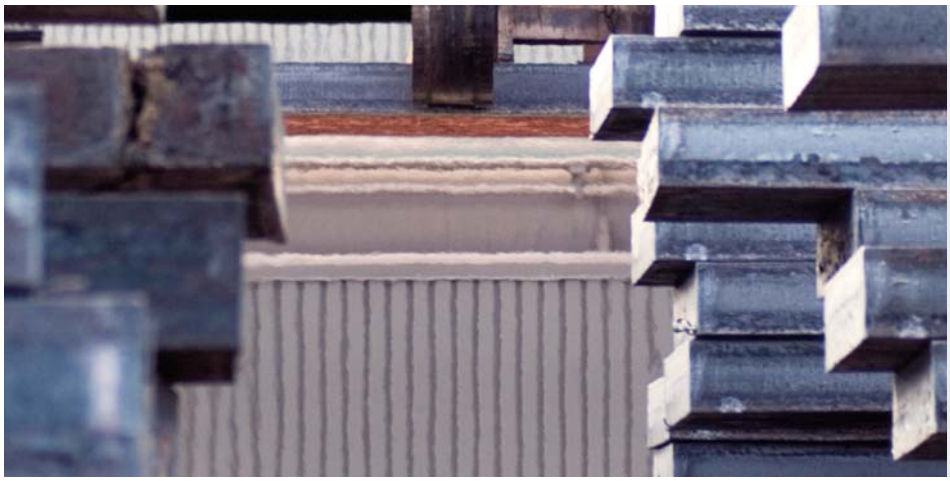
3.3.4 Increased productivity / simplified labor

In addition to speeding up many activities, RFID can automate many tedious product identification tasks related to half-product identification that has been traditionally performed by workers.

Besides the obvious benefit of being able to reassign those workers to other, more value-generating tasks, ultimately increasing labor productivity, RFID can be used to enforce vital verification procedures that previously depended on the diligence of responsible personnel.

Barcode-based solutions rely on personnel to scan every barcode. The accuracy of the entire solution depends on employee reliability. With an RFID solution, in contrast, so long as each item is tagged, RFID-readers identify items automatically each time they pass by.

In business processes where accurate identification is critical, RFID will almost always be the better choice over barcode solutions. Employees often welcome RFID systems because they relieve them from tedious, repetitive activities that they may believe are of small value.



Perfect Steel case study – operational efficiency

This scenario describes handling improvements for semi-finished products during unloading and loading at a company owned port. In addition to the general assumptions described in section 3.1.1 this scenario is based on the following specific assumptions:

Specific Assumptions – "Operational Efficiency" Scenario	
fully loaded cost per FTE per hour [€]	40
avrg. working hours per day	8
avrg. annual no. of business days	220
annual fully loaded cost per FTE [€]	70.400
no. of FTE needed	10
annual total fully loaded cost of FTE [€]	704.000

Figure 14 – Specific assumptions for the operational-efficiency scenario

To keep its supply chain moving, Perfect Steel loads and unloads slabs and coils to and from vessels at its seaport. Because of the crane's limited capacity, workers have a very limited window of up to three minutes per item to be seized, identified, moved and placed at the right location.

To achieve tight turnarounds and optimize crane use, the company operates 24 / 7 in three daily shifts. Before implementing RFID, slab and coil identification was performed by two employees per vessel per shift, each performing only two tasks: Reading a spray-painted ID number off the items and keying it into a mobile terminal to direct the crane operator accordingly. This labor requirement represented a total of 10 full-time employees (FTE) to ensure sufficient personnel to keep operations running around the clock. The per FTE cost averages at 40 euros per hour, added up to more than 700 thousand euros per year for identification personnel only. Using the RFID solution, 80 percent of the personnel previously needed for identification purposes were freed to perform other more valuable activities.

Speeding up the unloading and loading processes is estimated to reduce the company's lead time by 0.01 percent, representing an additional potential saving of initially 430 thousand euros per year, which will grow proportionally as the business grows.

The RFID investment pays off in its second year, with a cumulated ROI of 3.7 million euros, representing a net present value of 2.3 million euros after five years. The initial investment for this scenario is 1.2 million euros.

Operational Efficiency Business Case			Year Business Growth Rate	Rollout n / a	2008 n / a	2009 5,00 %	2010 5,00 %	2011 5,00 %	2012 5,00 %
Benefit Summary									
Value Lever	**Improvement**	**Initial Cost**	**%-Change**						
Recurring									
Handling of unfinished products	Labor cost reduction	704.000 €	80 %		563.200 €	591.360 €	620.928 €	651.974 €	684.573 €
Sales	Lead time reduction	4.290.000.000 €	0,01 %		429.000 €	450.450 €	472.973 €	496.621 €	521.452 €
One-Off									
Total Annual Savings					**992.200 €**	**1.041.810 €**	**1.093.901 €**	**1.148.596 €**	**1.206.025 €**
Cost Summary									
Cost Type	**Item**	**Units**	**Unit Price**						
Recurring									
Hardware Maintenance	Reader replacement, ...	5 %				1.380 €	1.380 €	1.380 €	1.380 €
Software Maintenance	Bugfixing, ...	5 %				50.000 €	50.000 €	50.000 €	50.000 €
Tags	Label with inlay	320.000			80.000 €	82.320 €	80.640 €	78.960 €	77.280 €
One-Off									
RFID-Hardware	Readers	2	3.000 €	6.000 €					
	Antennae	8	200 €	1.600 €					
	Printers / Applicators	1	20.000 €	20.000 €					
Initial Deployment	RFID Site-Survey	1	1.000 €	1.000 €					
	Installation	3	20.000 €	60.000 €					
System and Process Integration	Software development	1	1.000.000 €	1.000.000 €					
	Training	1	100.000 €	100.000 €					
Total Annual Costs				**1.188.600 €**	**80.000 €**	**133.700 €**	**132.020 €**	**130.340 €**	**128.660 €**
ROI-Summary									
Total Cumulative Savings					992.200 €	2.034.010 €	3.127.911 €	4.276.506 €	5.482.531 €
Total Cumulative Costs				1.188.600 €	1.268.600 €	1.402.300 €	1.534.320 €	1.664.660 €	1.793.320 €
Total Cumulative ROI					**-276.400 €**	**631.710 €**	**1.593.591 €**	**2.611.846 €**	**3.689.211 €**
NPV-Summary									
Total Annual Result				-1.188.600 €	912.200 €	908.110 €	961.881 €	1.018.256 €	1.077.365 €
NPV after n-th year				**-1.188.600 €**	**-374.136 €**	**349.804 €**	**1.034.452 €**	**1.681.571 €**	**2.292.897 €**

Figure 15 – Operational efficiency scenario business case

3.4 Safety and security

Safety and security are of paramount concern for any industrial manufacturer and especially for steel companies. Workplace accidents and product misidentifications result in significant costs. Radio-frequency identification can help mitigate safety and security risks.

3.4.1 Improved worker safety

One of the side benefits of task automation is that humans need not be exposed to dangerous situations. In the past, two workers were required inside each vessel in order to identify slabs, secure them, and then direct the crane operator to pick them up. Using a crane with an electro-magnetic lifting device—combined with RFID for identification—eliminates much of the manual effort while increasing worker safety and process security. The same logic applies to other areas where employees typically need to enter danger zones for no other reason than visual product identification.

3.4.2 Improved process security

Whenever a slab or unfinished coil enters a production step it is vital to ensure that the correct product is used. Product identification based on RFID provides an unprecedented level of process security over human error.

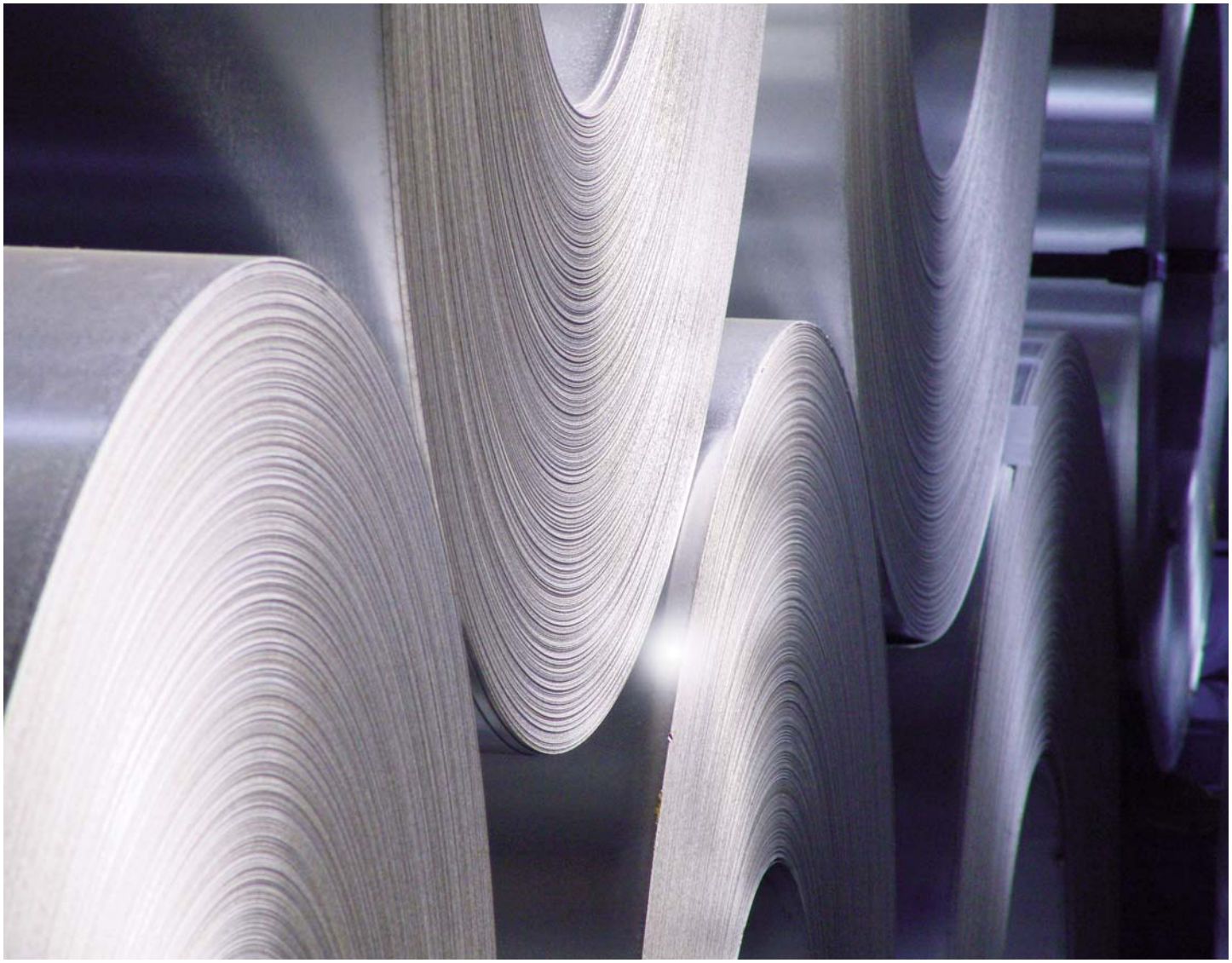
Because it is increasingly difficult to identify that the wrong material was used as the product moves down the production chain, it is all the more important to take steps to ensure correct identification from the start. When products are assumed to have the correct qualities, but do not, a company exposes itself to significant risk.

Given the stringent procedures many companies apply (for example when scheduling and entering slabs into the reheating furnace) chances for a misidentification to occur are arguably low. Nonetheless, the consequences of a single such failure can be disastrous, and even though companies try their utmost to avoid such failures, there have been examples of catastrophe in the steel industry.

When discovered early, the resulting product could simply be re-labeled and stored for reassignment to a corresponding order, causing nothing more than a production delay. The longer it takes to discover a problem, the more costly the error becomes since the wrong product will result and unnecessary processing accrues costs for a product that was not requested. Processing the wrong material may lead to a wasted product, or worse, result in damaged production equipment.

The worst outcome, however, would be to deliver the wrong material to a customer, potentially leading to a lawsuit for resulting damages and / or a sinking stock price.

For all these reasons, product confusion must be avoided. Radio-frequency identification further improves security by eliminating misidentification resulting from human error.



Perfect Steel case study – safety and security

Perfect Steel's customer „Super Washer" manufactures high quality washing machines targeting high-end customers. The company has a spotless public image. In addition to the general assumptions described in section 3.1.1 this scenario has been based on the following specific assumptions:

Specific Assumptions – "Safety & Security" Scenario	
rate of finished product mix-ups (1 in N years)	5
material weight of a single housing [kg]	5,5
no. of washing machines produced out of one coil	4.545
annual no. of coils purchased	105
average market price of a single product [€]	1.200,0
total market value of manufactured products [€]	5.454.545

Figure 16 – Specific assumptions for the "Safety & Security" scenario

Super Washer manufactures roughly 800.000 washing machines per year, requiring a total of approximately 4.400 tons (or 176 coils) of finished material for housings, all of which they enamel to protect the final product and give it a finished look. Super Washer buys approximately 60 percent (or 105 coils) of their material from Perfect Steel.

Each washing machine requires an average of 5.50 kilograms of steel for its housing so Super Washer can produce approximately 4.545 washing machines from a single coil. As a result of Super Washer's superior quality and brand equity, the average market price per washing machine is around 1,200 euros.

Without RFID, one un-detected product misidentification (one coil) is likely to occur within five years. The result is that incorrect steel product would be delivered to Super Washer that is, for example, not suitable for enameling. As a result, enamel would peel off either during delivery to the consumer or within a few weeks of use.

Eliminating that single product misidentification would have saved Perfect Steel about 5.5 million euros or the cost of buying back unusable washing machines.

Assuming this error would lead Super Washer to change suppliers, the potential cost of losing this customer accounting for approximately 0.03 percent of Perfect Steel's total annual sales at a price of 650 euros per ton, would be at least 1.3 million euros per year.

The RFID investment pays off in its second year, with a cumulated ROI of 8.0 million euros, representing a net present value of 4.8 million euros after five years. The initial investment for this scenario is 3.6 million euros.

Note that this simulation does not include any potential compensation payable to Super Washer for loss of image (lawsuits), nor the cost of losing other customers based on poor reputation, nor any effects on Perfect Steel's stock price.

Safety & Security Business Case			Year Business Growth Rate	Rollout n / a	2008 n / a	2009 5,00 %	2010 5,00 %	2011 5,00 %	2012 5,00 %
Benefit Summary									
Value Lever	**Improvement**	**Initial Cost**	**%-Change**						
Recurring									
Elimination of product-mixups	Reduction of lost sales	4.290.000.000 €	0,03 %		1.287.000 €	1.351.350 €	1.418.918 €	1.489.863 €	1.564.357 €
One-Off									
Elimination of product-mixups	Reduction of product-buybacks (distributed over a 5 year period)	5.454.545 €	100 %		1.090.909 €	1.090.909 €	1.090.909 €	1.090.909 €	1.090.909 €
Total Annual Savings					**2.377.909 €**	**2.442.259 €**	**2.509.827 €**	**2.580.772 €**	**2.655.266 €**
Cost Summary									
Cost Type	**Item**	**Units**	**Unit Price**						
Recurring									
Hardware Maintenance	Reader replacement, ...	5 %				2.900 €	2.900 €	2.900 €	2.900 €
Software Maintenance	Bugfixing, ...	5 %				150.000 €	150.000 €	150.000 €	150.000 €
Tags	Label with inlay	264.000			66.000 €	67.914 €	66.528 €	65.142 €	63.756 €
One-Off									
RFID-Hardware	Readers	10	3.000 €	30.000 €					
	Antennae	40	200 €	8.000 €					
	Printers / Applicators	1	20.000 €	20.000 €					
Initial Deployment	RFID Site-Survey	11	1.000 €	11.000 €					
	Installation	11	20.000 €	220.000 €					
System and Process Integration	Software development	1	3.000.000 €	3.000.000 €					
	Training	1	300.000 €	300.000 €					
Total Annual Costs				**3.589.000 €**	**66.000 €**	**220.814 €**	**219.428 €**	**218.042 €**	**216.656 €**
ROI-Summary									
Total Cumulative Savings					2.377.909 €	4.820.168 €	7.329.995 €	9.910.767 €	12.566.033 €
Total Cumulative Costs				3.589.000 €	3.655.000 €	3.875.814 €	4.095.242 €	4.313.284 €	4.529.940 €
Total Cumulative ROI					**-1.277.091 €**	**944.354 €**	**3.234.753 €**	**5.597.483 €**	**8.036.093 €**
NPV-Summary									
Total Annual Result				-3.589.000 €	2.311.909 €	2.221.445 €	2.290.399 €	2.362.730 €	2.438.610 €
NPV after n-th year				**-3.589.000 €**	**-1.524.795 €**	**246.127 €**	**1.876.387 €**	**3.377.945 €**	**4.761.678 €**

Figure 17 – "Safety & Security" scenario business case

3.5 Customer service

Many of the benefits of RFID described in previous sections also apply to customers, whether delivering slabs or intermediary strips to other steel industry players, or finished coils to manufacturing companies. It is important to avoid underestimating the positive impact that efficient and accurate customer service can have on organizational performance and corporate results. The majority of these benefits can only be achieved if the steel industry manages to agree on common RFID standards.

3.5.1 Faster receiving and ability to plan

Tagging coils with RFID technology in concert with advanced shipment notices (ASNs) automatically sent to customer IT-systems via enterprise data integration simplifies and accelerates the receipt of goods at customers' premises. To support accurate production planning among customers, ASNs confirm the products that are being shipped, when they will leave their point of origin and their estimated time of arrival.

Because supply is so important to the manufacturing business, giving customers the ability to plan will provide steel makers with invaluable competitive advantage. At minimum, it may positively impact customer loyalty.

3.5.2 Improved production control

Tagging slabs and coils with RFID technology will improve accuracy and speed of material identification throughout customers' internal handling and transportation processes. This in turn leads to improved process security and product quality for end-use steel customers.

3.6 Combined business case for Perfect Steel

Having analyzed the different scenarios throughout this document individually, the combination of all three applications in one business case promises some additional savings due to the ability to share some of the RFID-equipment.

Perfect Steel case study – all scenarios combined

The total combined business case for Perfect Steel features an ROI of 17.7 million euros or a net present value of 10.8 million euros after five years. The initial investment for the combined scenario is 7.3 million euros.

In comparison, the total ROI of all three scenarios implemented individually is only 16.9 million euros and the net present value is only 10.1 million euros after five years, while the individual investments would add up to 7.7 million euros (higher investment leading to a lower ROI / NPV).

This is yet another reason why -- as was already stated in the introduction to the case study – RFID should not be regarded as a project or number of projects but rather as an infrastructure program. Only by using that infrastructure to support a growing number of use cases will allow companies to maximize the benefits this technology promises.

Combined Business Case		**Year Business Growth Rate**	**Rollout** n / a	**2008** n / a	**2009** 5,00 %	**2010** 5,00 %	**2011** 5,00 %	**2012** 5,00 %
Benefit Summary								
Application								
Project-Specific Benefits								
Asset Utilization	One-Off and Recurring combined			2.876.500 €	2.126.125 €	2.182.431 €	2.241.553 €	2.303.630 €
Operational Efficiency	One-Off and Recurring combined			992.200 €	1.041.810 €	1.093.901 €	1.148.596 €	1.206.025 €
Safety & Security	One-Off and Recurring combined			2.377.909 €	2.442.259 €	2.509.827 €	2.580.772 €	2.655.266 €
				6.246.609 €	**5.610.194 €**	**5.786.158 €**	**5.970.921 €**	**6.164.921 €**
Cost Summary								
Cost Type								
Project-Specific Costs								
RFID-Hardware			170.200 €					
Initial Deployment			77.000 €					
System and Process Integration			6.600.000 €					
Tags				634.400 €	652.798 €	639.475 €	626.153 €	612.830 €
Hardware Maintenance					8.510 €	8.510 €	8.510 €	8.510 €
Software Maintenance					300.000 €	300.000 €	300.000 €	300.000 €
General RFID-Software Platform Cost (Common Services)								
Software Licenses			250.000 €					
Custom Component Development			100.000 €					
24 / 24 Operations Support (partial)			50.000 €	50.000 €	50.000 €	50.000 €	50.000 €	50.000 €
Vendor Support & Software Updates				25.000 €	25.000 €	25.000 €	25.000 €	25.000 €
Component Maintenance				5.000 €	5.000 €	5.000 €	5.000 €	5.000 €
			7.247.200 €	**714.400 €**	**1.041.308 €**	**1.027.985 €**	**1.014.663 €**	**1.001.340 €**
ROI-Summary								
Total Cumulative Savings				6.246.609 €	11.856.803 €	17.642.962 €	23.613.882 €	29.778.804 €
Total Cumulative Costs			7.247.200 €	7.961.600 €	9.002.908 €	10.030.893 €	11.045.556 €	12.046.896 €
Total Cumulative ROI				**-1.714.991 €**	**2.853.896 €**	**7.612.069 €**	**12.568.327 €**	**17.731.908 €**
NPV-Summary								
Total Annual Result			-7.247.200 €	5.532.209 €	4.568.886 €	4.758.173 €	4.956.258 €	5.163.581 €
NPV after n-th year			**-7.247.200 €**	**-2.307.728 €**	**1.334.561 €**	**4.721.334 €**	**7.871.126 €**	**10.801.080 €**

Figure 18 – Combined business case

4_Challenges for RFID in the steel industry

The previous sections have shown that there is vast potential for RFID to improve internal and external slab and coil logistics. To reap the rewards, a number of technical, economic and process challenges will have to be overcome, as is the case with the introduction of any new technology. The following topics describe these challenges and suggest methods and tools for overcoming these obstacles.

Radio-frequency identification readers cannot be guaranteed to communicate with all tags one hundred percent of the time. Environmental issues and inherent properties of objects being tagged impact read accuracy. The degree of concern for accuracy is directly proportional to how heavily an enterprise relies on data accuracy and how exposed it is to risk as a result of inaccuracy.

Still, an absolute read accuracy of less than 100 percent does not necessarily negate the usability of RFID. In industries where risk exposure is high, process redesign, information auditing and redundant readers can address accuracy-related system shortcomings.

4.1 Radio-frequency identification and metals

One of the main challenges with RFID technology is read performance with tagged items made primarily of metal or water-based liquids. Metallic objects tend to reflect radio waves, which means that reading RFID tags directly applied to metal becomes extremely difficult if not impossible. Water-based liquids tend to absorb radio waves, resulting in similar read problems.

A current approach to work around signal reflection places an air layer (via a layer of foam or similar spacer material) between the metal item and the RFID tag. Another employs a dielectric shield (for example, a ferrite layer) to decouple the tags from the metallic object.

Other options include low-frequency (LF) transponders—which because of magnetic coupling are less susceptible to detuning—and active RFID, which does not rely on radio waves from the RFID-reader to function.

Some of these approaches can add significant size to a tag's form factor as well as an increase in cost. Others simply are not an option for use with slabs and coils as is the case with the last two examples because of their very limited read range (LF technology) or size / environmental aspects (active-RFID technology).

Tests conducted by ThyssenKrupp Steel and Accenture have proven that passive and battery-assisted tags that use the ultra-high frequency (UHF) range are best for tagging slabs and coils. There are three options to choose from and the most appropriate one for a given application depends on the particular business case, requirements and environmental context.

From a hardware and air interface perspective, all three options represent a first crucial step towards standardization because they incorporate EPCglobal™ standards, making them interchangeable / enabling them to co-exist within an enterprise.

4.1.1 Flag-tag

The so-called flag-tag is a radio-frequency identification label folded to form a small flag standing just above the surface of tagged objects. The short distance placed between the tag and the metal has been shown to ensure performance independent of the characteristics of the underlying material.

Flag-tags actually function best when applied to a metallic surface, provided the RFID-inlay is placed at the right distance. Their performance improvement occurs as the result of the radio waves emitted by the reader hitting the RFID tag's antenna once before deflecting off the metallic object's surface on an angle that sends the signal to the tag a second time, thereby increasing the amount of available power to the tag's chip. Reading distances of eight to ten meters are achievable with this solution.

Design factors and a plastic coating make flag-tags flexible and relatively rugged with respect to harsh environmental conditions and mechanical stress. They cost by far the least of the three options and have the added advantage of being able to be encoded, folded and printed on (with human-readable information or / and a barcode as backup) in one step, saving valuable time and significantly reducing the risk of confusion when applied to a metallic product.

Despite these advantages, flag-tags have one critical flaw: If the flag is pushed onto the metal surface, readability goes from outstanding to zero. This is why, together with its inventor, the printer specialist Sato™ Inc., ThyssenKrupp Steel and Accenture have developed a modified version of the flag-tag and corresponding flag-tag printer optimized for use with steel slabs.

4.1.2 Plasmonic decoupler tag

The plasmonic decoupler tag is a variation on the classic spacer in which an air layer (via a layer of foam or other material) is introduced between the tagged object and the RFID tag. The insulation does not rely solely on the introduction of distance from the metallic surface. It also complements (or replaces) the tag's antenna with a very thin layer of metal, which redirects the reader's radio signal through tiny apertures in such a way that energy from the reader is drawn to the slit.

When tags are positioned at the slit, there is more than sufficient energy to activate them. Using this method requires only thin layers of metal, which means both tag thickness and cost can be reduced while increasing performance beyond typical on-metal solutions. Reading-distances of six to eight meters are achievable.

Although more rugged than flag tags, plasmonic decoupler tags present a number of disadvantages including higher price, lack of an automatic print / encoding solution (though in theory one could be built) and higher sensitivity to orientation, making them unreadable at certain angles.

4.1.3 Battery-assisted passive spacer tag

A passive RFID tag is battery-assisted if it includes a thin, flexible battery — known as a „printed battery." The embedded battery does not generate a radio signal to be sent back to the reader. Rather it powers the RFID tag's chip.

Considering that a typical RFID chip consumes about 85 percent of the energy of the reader's radio signal, the effect on readable range is comparable to active tags. However, adding a battery to power the RFID chip does not eliminate the need for a spacer for on-metal applications because the tag still requires the radio signal coming from the RFID-reader to backscatter its own response.

The advantage of battery-assisted, passive on-metal tags is that long read ranges of up to 45 meters can be achieved using standard passive reader hardware. In addition, their performance is far more reliable even under challenging conditions.

Also, if shorter read ranges are required, the range of battery-assisted passive technology can be far more easily controlled by turning down the RFID-reader's transmission power.

Of the three alternatives to tagging, battery-assisted, passive tags offer the best performance and range. There are other issues that make them less attractive:

1. They are the highest cost of all three options.

2. Managing battery expiration dates is troublesome, raising potentially tricky logistics to guarantee a "first in first out" use of tags.

3. Battery life diminishes when exposed to harsh environmental conditions such as wide temperature swings.

4. Current battery-assisted passive tags do not automatically fall back to purely passive operation after the end of battery life is reached, so that a tag with a dead battery would become unreadable.

4.2 Resistance to change

Many steel companies rely heavily on manual processes or barcode scanning to track slabs and coils. In any organization, moving

[3] A sticker with an embedded RFID-inlay is commonly referred to as an RFID-label.

from a familiar way of working or a known technology to a new one, poses a challenge especially when the move also requires process change. It is important to fully understand the benefits that RFID technology can deliver and to gain top management support.

4.3 Established bar-coding infrastructure

In some steel companies, barcode systems have been used for many years at least to identify coils at key positions in the supply chain. Since barcode systems are efficient and represent a substantial investment, it can be difficult to justify the switch to RFID. Common questions about RFID technology include „What does RFID give me that barcode doesn't already do?" and „Isn't RFID much more expensive than barcode?"

These are valid questions, and barcode-technology may be totally appropriate or better than RFID for some applications. Yet because RFID is non-intrusive and automatic, there are many situations along a supply chain where RFID conveys significant advantage over barcoding.

Radio-frequency identification can alleviate the risk of human error for many tasks. People can diverge from established processes and may trade barcode scanning for speed or mistype product numbers when a barcode is not readable, leaving operations open to error.

Regarding total infrastructure and system integration costs for a barcoding solution versus a radio-frequency identification solution in today's marketplace, both cost approximately the same. If equivalent requirements are taken into consideration, some very sophisticated long range, autofocusing barcode systems would be necessary to achieve the same level of automation that RFID solutions provide.

In terms of recurring costs, RFID tag prices have already come down to levels where the ROI surpasses the additional cost for tags.

Finally, barcode technology was introduced to support the end of the supply chain because customers mandated it. The same is likely to happen with RFID, which is why steel manufacturers should take the lead. For all the economic reasons outlined throughout this document, introduction of RFID technology in the steel supply chain is not a question of choice. Rather, it is a question of time. Starting today, however, allows steel companies to gain process efficiencies earlier than competitors and to make this significant technology change in a phased approach.

4.4 Multiple tagging

As a result of the large number of processing steps that steel slabs and coils undergo in a typical supply chain, RFID tags will inadvertently be removed or damaged.

Unlike other industries such as the retail industry, where an RFID tag remains oftentimes be attached to a product from the beginning of production to final delivery to the consumer, the steel-processing environment requires several RFID tags per coil as it moves down the supply chain toward final delivery.

Attaching, detaching and reattaching new RFID tags to slabs and coils at different steps in the supply chain generates additional costs which need to be evaluated in order to ensure it makes business sense. Analysis conducted by Accenture and ThyssenKrupp Steel has shown that in general the business case for RFID in slab and coil logistics makes most sense when there is a significant amount of transportation required between production sites. Intersite transport requires secure identification and as has been shown in this document, the effort required for workers to identify slabs and coils increases costs and reduces efficiency while introducing the risk of human error.

[4] Products implementing a failsafe mode that enables the tags to operate passively are scheduled for release this year.

4.5 Identifier attribution

There are two approaches to using RFID technology. In the first approach, the RFID tag stores a single unique identifier linked to more detailed information residing somewhere in a steel company's IT-system. This approach, commonly known as „license plate," is the most common way to use RFID.

In the second approach, the RFID chip stores additional information about the tagged object. This approach is rarely used today when it comes to supply-chain management . Because the license plate is sufficient for most applications and the second kind of tag costs more, most supply chain applications employ the first approach. Another benefit of the single identifier method is that product-related information is stored in a central database, making data management and security far more robust.

Whichever approach is selected, every RFID tag must carry a globally unique identifier in order to ensure that no product (or product instance) can be confused with another.

The ability to assign globally unique product identifiers, however, is a major challenge for many large corporations. Solutions to this problem are emerging and the most promising of these is the Electronic Product Code or EPC™.

The Electronic Product Code is a numbering standard created by EPCglobal™ (see section 6.2). Electronic product codes can be generated using entirely new serial numbers associated with corresponding items in a database. Alternatively, companies can embed an existing product identifier so long as it is unique and its encoding fits into the serial number portion of the EPC™ .

[5] Note: Local data storage is more commonly used in maintenance- and asset-management type scenarios.

[6] EPCglobal™ may also specify new EPC™-types that address the requirements of a specific industry.

Storing additional information on the chip allows the original product identifier to be derived from the EPC™, which can be an advantage. However, this is still not recommended because in many cases, the system cannot be applied across the entire product range of a company since some product identifiers may be alphanumeric or simply too long. In other scenarios, the code's uniqueness may be temporary because for certain products with a short lifetime, serial numbers are recycled. Radio frequency identification-based codes are meant to be unique for the long term.

As is common procedure for assigning IP addresses today, companies implementing RFID must establish a standard method of assigning RFID identifiers supported by a central IT service to automate identifier attribution.

4.6 Data interchange

Radio-frequency identification technologies improve supply chain visibility and operations across organizations and contribute to better cooperation among trading partners. Using the EPC™ scheme opens the door to a growing market of standardized software products supporting RFID solutions and helping to reduce their cost.

The introduction of RFID and the huge interest for this technology in the industry represents a chance to review and standardize many of the data interchange-related issues of the past. Radio-frequency identification becomes most valuable in logistics operations involving different locations such as in intra- or inter-company shipments. The EPC™ allows companies to take advantage of the EPCglobal Network™, meant to support easy exchange of item-specific, supply chain data among trading partners.

4.7 Heterogeneous customer base

The heterogeneous and widespread customer base that most steel companies service represents one of the biggest challenges to introducing RFID for slab and coil logistics. While slab logistics are mostly internal, coil logistics present the further complication of inter-company system compatibilities and integration.

Getting all customers to agree in advance to one system will likely be the single greatest challenge that steel companies face. Which is why it is highly important that the steel industry work together to proactively propose a unified solution. Customers do not want to build proprietary electronic data interchange (EDI) systems because they end up being locked into one supplier. As a result, they are far more likely to take the lead and mandate interchange systems that will fracture the IT effort of steel companies. Both customers and steel companies benefit from a global standard.

Using the EPC™ as the basis for a standard, unified solution presents the most promising approach so far. Some major global car manufacturers have recently stated their support for the EPC™.
This initiative should stimulate discussion, leading to the development of standardized RFID solutions for slab and coil logistics within the steel industry.

Any interested party may join the discussion.

5_Cost considerations for RFID

Radio-frequency identification tags are the most frequently cited cost component in RFID implementations. While tags represent a significant recurring cost, they are not the whole story. Tags, readers, antennae, servers, middleware, operations and maintenance all contribute to the total cost of ownership for an RFID system. Accurate cost estimates must include all system components, tailored to a given application. This section outlines each of these components and offers recommendations for methods to calculate overall costs in a business case for RFID.

5.1 Tags

The most frequently mentioned cost component when implementing RFID is the cost for tags. There are as many tag variants on the market as there are potential applications. Changes in form factor, packaging, memory capacity, read or read-write capability, active or passive configurations and range, all impact cost.

Conversion and commissioning costs must also be factored in. Conversion means the application of the tag to a coil or slab. It also includes associating the unique identifier with the actual product—a process referred to as commissioning. Commissioning may mean programming an EPC™ onto the tag or alternatively, reading a predefined EPC™ value from the tag.

Product type will influence conversion costs. For example, does the tag require a standoff as is the case for tags mounted on metal? Will the tag need to be concealed? Will the tag antenna be printed or metal coil? If the tag requires a printed label, then a label printer and RFID writer may also need to be purchased.

All these factors will increase baseline tag costs and different tags will need to be implemented in different applications. A blend of tag types should be selected based on costs versus requirements for a specific identification task.

5.2 Readers

Readers power passive tags with energy, receive the results from the tags and often handle the low-level, anti-collision algorithms that allow readers to scan more than one tag at a time. They are generally controlled via an application programming interface (API) or network protocol provided by the reader manufacturer.

Reader costs vary as a function of reader type, range, speed, robustness, network readiness and antenna capability. The more capable a reader is — the faster, more robust and long range — the higher the reader's cost. For lower cost readers, a personal digital assistant (PDA) application with an SD card reader may cost two hundred euros. For high-speed conveyor or dock door applications reader may range from three thousand up to ten thousand euros, and for forklift installations readers may reach five thousand euros. These ranges are based on today's commercially available equipment, and should drop as the volume of readers produced continues to increase.

5.3 Antennae and cabling

Antennae are another essential component of reader systems. Different antennae will be required for different applications and system architects will choose from among shelf, mat, portal, wand or directional antennae. These can range in cost from 25 to 500 euros and more, depending on application and base operating frequency.

Another factor is cabling. Although there are generally fewer limits on the distance between reader and controller, there are signal degradation effects along the cables connecting readers and antennae. Purpose-built, high-grade RF cables can be expensive. Estimate up to 10 euros per linear meter, keeping in mind distance limitations and local regulations as changing antenna cable lengths / quality also impacts power output at the antenna.

A single reader-antennae setup is commonly referred to as a readpoint. A whole solution will require numerous readpoints.

5.4 Installation

Physically mounting antennae, power supplies and readers can be costly, depending on the environment. Retrofitting existing sites or material handling equipment can add to costs as well.

Readers and antennae may need to be concealed, equipped with heating or cooling devices, and / or modified to withstand environmental abuses that come with industrial locations. Power drops must also be provided to reader locations and these will likely be charged at union rates.

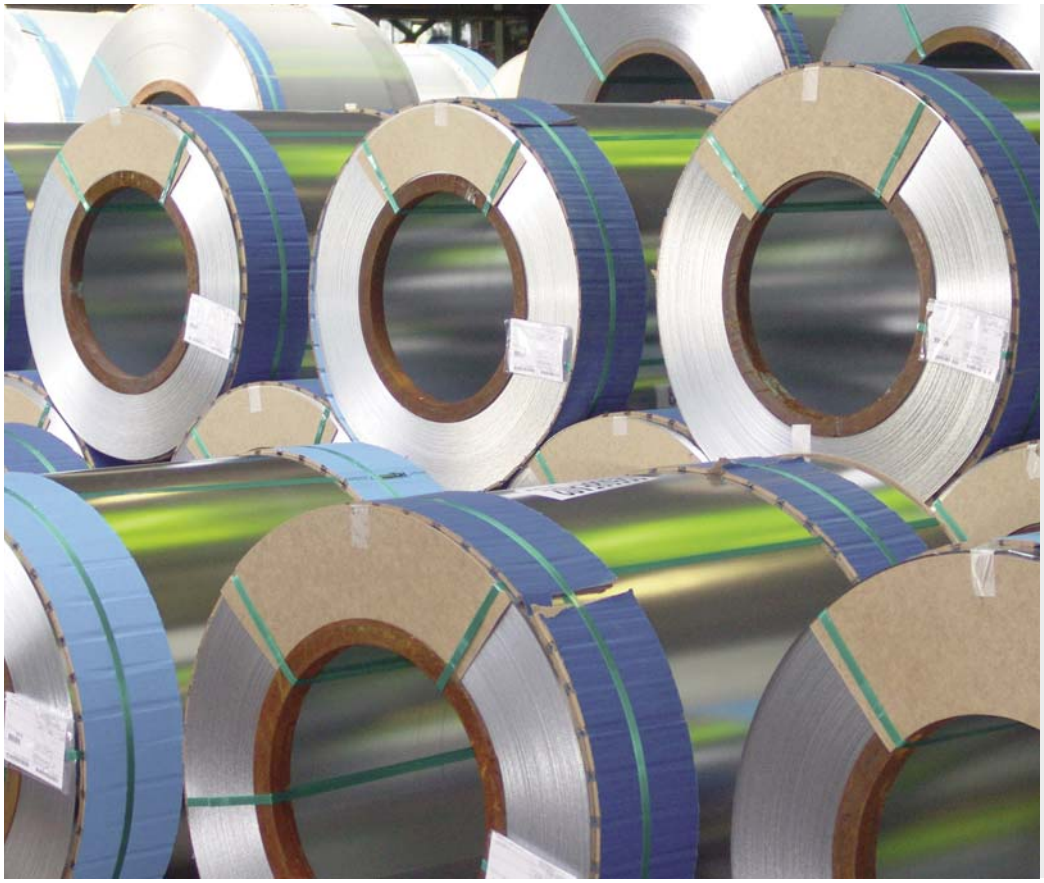
As with power, a network connection may be required. Ethernet, WiFi or serial communication cabling / infrastructure (RS232 or RS485) must also be installed, shielded or concealed, depending on the method, application and location.

5.5 Tuning

Every physical environment will impact radio-frequency (RF) waves in a different fashion. The RF field will need to be measured for dead spots and adjustments made. This cost is highly variable given the expertise needed, selection of reader systems and the changeable nature of RF fields.

5.6 Controllers

For every group of readers a server— also called a „controller“ or “edge server” — will be required. These servers run appropriate middleware to control the readers. Initial processing, event firing, buffering in case of network failure and some diagnostics run on the server. The controller need not be a high end PC unless it must handle a large number of RFID-readers or be hardened for factory or other industrial applications. The cost of an RFID controller can range from a couple of hundred euros to twenty-five thousand euros per unit.



5.7 Software platform

Commonly referred to as RFID middleware, a software platform controls the RFID system, though modern RFID solution packages reach well beyond simple middleware functionality. In the simplest terms, the software translates tag reads into business events.

The software platform will most likely be a distributed system. At the very least, it will run on one or more servers aggregating data from the transactional level and feeding it into enterprise resource planning (ERP) and warehouse management systems (WMS). The software provides publish and subscribe interfaces to facilitate integration with other applications. It also provides abstraction layers for connecting various types of readers along with readpoint monitoring and diagnostics.

Almost every RFID implementation will be highly dependent on business rules, which is why many of today's RFID solution packages not only come ready with basic device control functionality but also with a business rules engine, enterprise service bus and other components of modern service oriented architectures (SOA) to facilitate rapid integration of RFID into existing business processes.

The cost for an RFID platform can vary enormously depending on the extent and reach of the entire system and can be difficult to compare based on different licensing models. Simple yet usable products can start from tens of thousands all the way to hundreds of thousands of euros for large implementations.

5.8 Integration

Integration will be a large factor in RFID implementations regardless of the software platform chosen. Depending on the number of legacy systems involved, costs for integration will be on the order of magnitude of the cost of readers and installation combined. Some implementations will take a company well beyond simple integration. Some systems may need to be replaced altogether if they are not capable of taking advantage of incrementally large volumes of real-time data provided by RFID technology.

5.9 Maintenance

In addition to one-time capital infrastructure costs, the ongoing maintenance and upkeep of RFID systems should be factored into ROI calculations that are part of any business case. Factors influencing maintenance include hardware upgrades, failed or damaged equipment replacement, ongoing firmware and middleware upgrades and any software or licensing fees. Ongoing tag purchases should be factored into operations and maintenance costs. A standard software license and maintenance agreement usually runs approximately 10 percent per year. This is a good estimate for these systems. Finally, since so much physical infrastructure is involved, equipment depreciation must be factored in as a cost item in a well-built business case.

5.10 Process

The last pieces of the RFID puzzle are process and human elements. Many existing processes, especially intercompany processes, will need to be redesigned. Current batch or paper-based processes can be eliminated and reinvented entirely through workflow re-engineering and tighter system integration.

Radio-frequency identification technologies place people in a better position to act on information, because they can see into the entire supply chain in real time. This means companies must increase peoples' ability to act on that information. Involving personnel in the design of new processes and training them to make the best use of new technology should be added into overall implementation costs. Change management is anticipated to be a necessary discipline for fully addressing RFID implementation at scale.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6_A vision for an integrated steel industry

Analysis conducted by Accenture and ThyssenKrupp Steel has shown that using RFID technology for slab and coil logistics indicates a large number of benefits across all stages of a typical supply chain for steel industry players. Most of these benefits are similar along the entire production and supply chain and are as applicable to steel makers as they are to steel customers:

- Increased materials handling speed and throughput
- Optimized asset utilization and reduced need for capital investments
- Better visibility into internal and external supply chains
- Increased process security and worker safety

The examples used in this document to illustrate the potential business case are simulations and may not directly apply to all companies. They are meant to provide a guide to assist with performing a comparable analysis in order to build a solid business case so that you can determine ROI for your company.

Leaving aside the financial benefits of using RFID to streamline internal processes, it is likely that steel customers themselves will sooner or later begin to mandate RFID solutions for their suppliers. It is prudent for steel companies to support the creation of industry-wide standards rather than being forced to individually address the inevitably varying requirements of each customer.

6.1 Standards requirements

Slab and coil products proceed differently through their lifecycle and this impacts the use of RFID. For slabs, RFID is typically limited to streamlining the internal supply chain, while using RFID for coils extends the benefits to end customers

In either case, for RFID to deliver on its promise, it is essential that all affected internal and external systems can gain access to tracking information as well as relevant product information. With this type of data available, steel companies can gain greater insight into their supply chains as well as automate identification processes that traditionally have been performed manually.

Finding technically viable ways to tag slabs and coils is only half of the solution. The other, more important part is to standardize the way in which the industry exchanges RFID information internally, with trading partners and with customers.

From a high-level perspective several technical standards are required to make this happen:

1. Global identification system: A commonly agreed RFID numbering scheme. This scheme must enable globally unique identifiers and at the same time allow a company's internal numbering schemes to limit the complexity and effort with respect to adapting existing IT-systems to accommodate the change.

2. Shared data: A look-up service allowing the location of relevant information sources with respect to a particular slab or coil.

3. Common access method: A common query method and standard interface for accessing product-related tracking information once a source is determined.

4. Security: A means of securing product information so that only authorized parties or IT-systems can access the appropriate information for which they have security clearance.

Standardizing the way RFID information is made available within the steel industry is a requirement because product tracking often involves multiple trading partners. These companies are so

[7] Note that product and tracking information may be held across multiple IT-systems run by the different supply-chain partners.

interwoven that different approaches would be technically unmanageable.

Many steel companies already exchange data either via standardized EDI messages or in a customer-specific format. Attempting to replace those messaging platforms with new systems would be a significant barrier to the introduction of RFID technology as a result of costs, risks and internal resistance associated with such a migration.

All that is necessary to realize the benefits of RFID-based slab and coil logistics is a standard method for identifying products and for accessing the appropriate information source.

Attempting to build a global IT infrastructure for the steel industry that implements the necessary technical standard from scratch would be a huge undertaking. Fortunately, an existing solution, generic enough to be adapted to a steel context, already exists. It is called the EPCglobal Network™.

6.2 Introducing the EPCglobal Network™

The EPCglobal Network™ is a collection of standard concepts and technologies that provides automatic, real-time identification and sharing of tracking information about a product for use inside and outside enterprises. EPCglobal™ is a non-for-profit organization that is a joint venture between the Uniform Code Council (UCC) and the international Electronic Article Numbering association (EAN International). EPCglobal™ currently is the most promising global initiative seeking to standardize the way product-related information is collected and shared across a supply chain, with a focus on RFID.

Five key components make up the EPCglobal Network™:

1. Hardware devices such as RFID tags, readers and printers

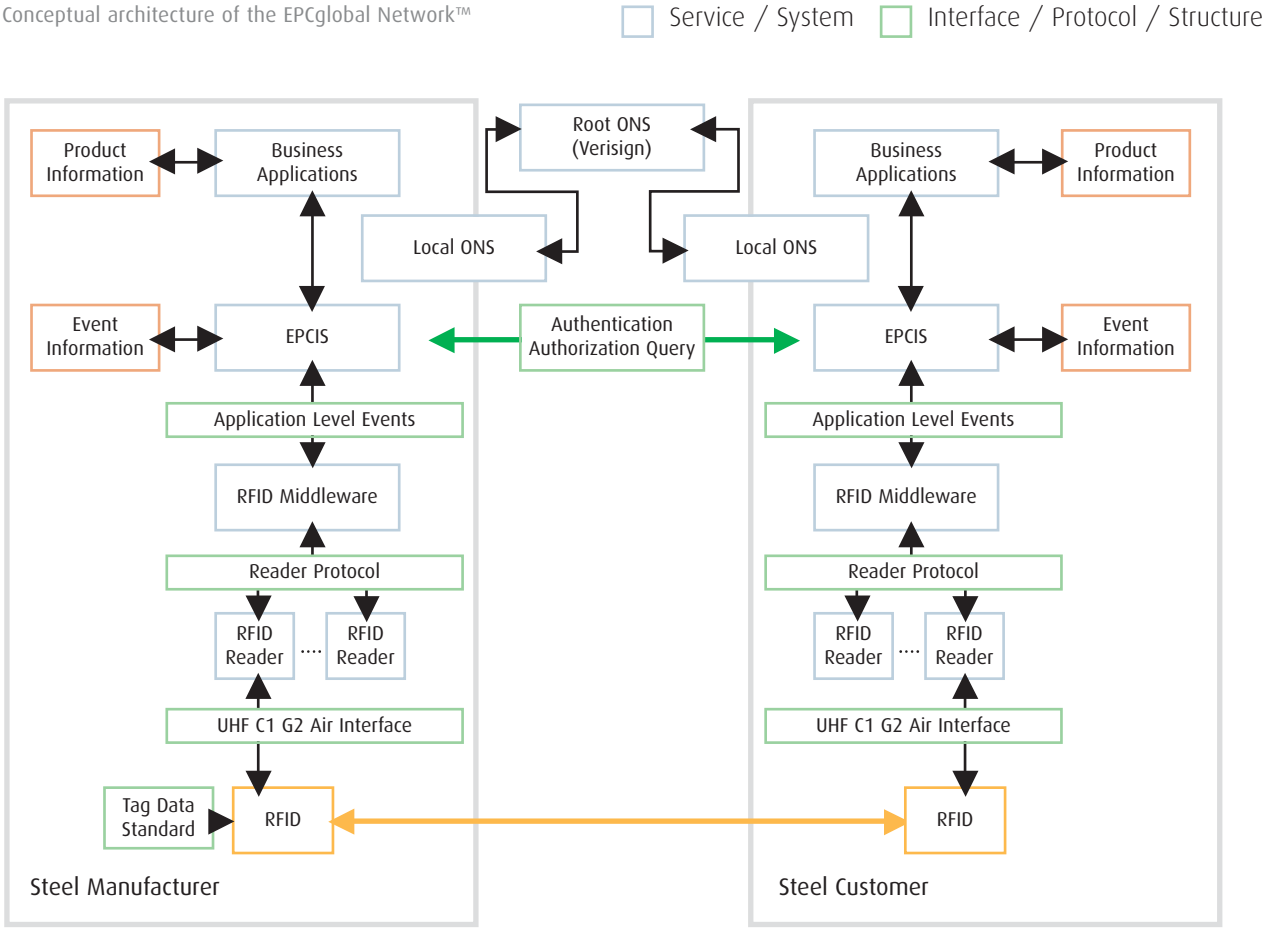
2. The Electronic Product Code (EPC™)

3. RFID device management software / middleware to manage hardware complexity, translate low-level RFID data and integrate with company IT-systems

4. Discovery and Object Naming Services (DS and ONS),

5. EPC™ Information Services (EPCIS) maintaining product-related tracking information

Figure 19 – Conceptual architecture of the EPCglobal Network™



These key components are described in more detail in the following.

6.2.1 Electronic Product Code (EPC™)

The Electronic Product Code (EPC™) is a generic „license-plate“ type identifier that uniquely identifies any item in a supply chain. It is a simple, compact scheme that can generate an extremely large number of unique identifiers. The scheme offers a low barrier to entry since a company can embed existing serial numbers into the corresponding partition of the EPC™. Even if this approach is not feasible given company standards, a single database table associating existing product IDs with EPC™ numbers would work to resolve the problem.

	Header	Filter	Partition	EPC™ Manager	Object Class	Serial Number
length	8 bits	3 bits	3 bits	20-40 bits	24-4 bits	38 bits
value	0011 0000	001	5 (decimal)	4000001 (decimal)	001659 (decimal)	274877906943 (decimal)

Any EPC™ is made of six different sections (see Figure 20), each of which may vary in size, making the numbering scheme flexible and highly scalable:

- The Header denotes the version of the EPC used, allowing for different EPC™-types and facilitating future extensibility of the scheme
- The Filter Value indicates the level of aggregation that the EPC™ represents (for example, an item, a box or a pallet)
- The Partition designates the bit-position within the EPC™ at which the EPC™ Manager partition ends and the Object Class partition begins (while the total length of both partitions added together is constant, their size may vary depending on the Partition value)
- The EPC™ Manager represents a specific company or domain (for example, Perfect Steel)
- The Object Class stands for the type of product being tagged (for example, a slab or coil)
- The Serial Number corresponds to the actual item number (for example, the internal serial number of the slab or coil)

Depending on the version indicated by the header, EPC™s may vary in length, with 96 bits being the most common to date.

A 96-bit EPC™ can be used for identification of up to 10 million product categories (object class) and over 274 billion unique instances (serial number) within each of those categories.

This system provides more than enough room to uniquely identify any slab and coil produced, even over a very long period of time.

6.2.2 Discovery and Object Naming Services (DS and ONS)

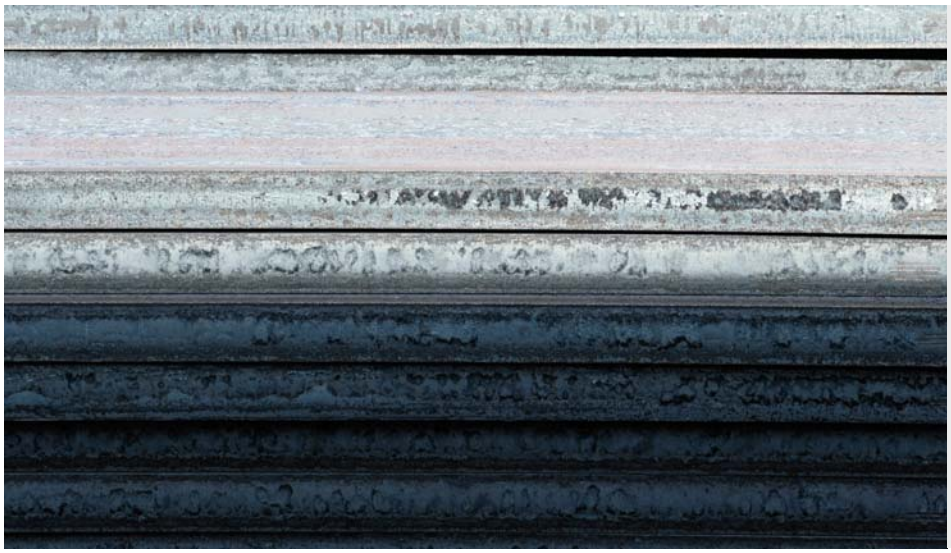
Discovery Services (DS) are a suite of services that provide the link from products with RFID tags to product-related tracking information residing on different IT-systems.

The Object Naming Service (ONS) is a key part of the DS capability. It is a public service that can be used to find tracking data about a product from a registered EPCIS server.

The ONS is very similar to DNS that used today to look up the associated host for a particular Internet address or web site. With respect to the EPCglobal Network™, ONS is an extremely rapid and reliable global database lookup service available to any product manufacturer.

[8] The term „license plate“ is referring to a unique identifier being used as a “key” in order to obtain product-related information from an IT-system / database, as opposed to embedding the information about the product together with the identifier (e.g. as part of a barcode or in an RFID-tag’s user memory).

[9] Discovery Services do not yet exist. They are in the process of being defined by EPCglobal™.



6.2.3 EPC™ Information Services (EPCIS)

Instances of EPCIS are essentially gateways to information about products tagged with EPC™s. Multiple EPCIS instances can contain different parts of information corresponding to a single EPC™-tagged product. This means tracking information for any EPC™-tagged product is distributed by nature. In the future, data from several EPCIS servers will be automatically extracted and merged to provide a global view for a particular product.

EPCIS today is all about sharing tracking information. In future, it could easily be extended to act as a "façade" to different business back-ends, such as Warehouse Management Systems (WMS), enterprise resource planning systems (ERP), and homegrown systems.

Access to the EPCIS instance(s) of a company can be shared with supply chain partners such as suppliers, logistics companies and customers, to provide the enhanced collaboration and visibility that is the benefit and very promise of RFID-technology.

6.3 The suggested standardization approach

As of this writing, many companies across different industries are testing first operational implementations of the EPCglobal Network™ in pilots of national, international, and global scale.

Other companies, including some of the steel industry's major customers, are joining the EPCglobal™ initiative to benefit from its advantages and to ensure they influence the way that the service evolves.

Although the EPCglobal Network™ is not fully built, it is poised to take off in the short term because of widespread support such as the growing number of EPCIS implementations that are being launched by many well-established software companies.

To define and build what is needed to address the specifics of the steel industry, in addition to the provisions of EPC™ technology, and to make this initiative a success, we have set a number of standardization ground rules.

6.3.1 Ground rules for standardization

The following are the key ground rules that ThyssenKrupp Steel and Accenture believe will contribute to the joint success and proactive engagement of steel industry players that aim to standardize RFID technology for the benefit of their own companies, their customers and the industry as a whole:

- Scope: The scope of this initiative is to develop standards for RFID-based slab and coil logistics for the steel industry and its customers. In particular this will include the specification of physical aspects (for example, the types of RFID tags to be used, their application and positioning, and any imprinted human-readable information) as well as the logical aspects of how RFID data is to be exchanged).

- Inclusiveness: Admission to join and participate in the creation of the standards is open to all steel manufacturers, steel customers, relevant industry bodies, standardization organizations and RFID vendors.

- Alignment with EPCglobal™: Because EPCglobal™ represents the most advanced RFID standards and the only off-the-shelf infrastructure option for RFID to date, it would be wasteful to develop something from scratch, seeking to address many of the same objectives. This initiative will therefore tightly align with EPCglobal™ and its concepts.

- Freedom of use: Any specifications resulting from this initiative will be made available to anybody free of charge or for a share of the development cost but at no profit. Participating members will retain exclusive access to the specifications for a specified time following ratification, potentially giving them a competitive advantage. Only active members will be allowed to participate in, and learn firsthand, from pilot implementations.

6.4 How steel companies can participate

By participating in this global initiative, steel companies will gain many benefits.

- The early introduction of RFID technology will enable companies to realize many of the potential cost reductions mentioned in this document ahead of competitors, making processes more transparent, visible and secure.

- Implementing working solutions for RFID-based slab and coil identification, aligned with other key-providers in the steel industry, will not only allow steel companies to streamline internal processes but also enable provision of better services to customers, ultimately increasing customer loyalty or even helping to secure new customers.

- Finally, the hands-on knowledge steel companies gain by introducing RFID solutions for slabs and coils will help in the evaluation of this technology in other business areas.

As with all such initiatives, standards development requires fiscal and human resources, and involves the exchange of potentially confidential information. When signing up for participation, companies will therefore be asked to:

- Assign a dedicated representative as single point of contact. This person will be expected to participate in regular standardization meetings (in person, via phone or video conference) and in the development of specifications and other relevant documentation.

- Sign a mutual Non Disclosure Agreement (NDA) that protects confidential information exchanged among parties in the context of this standardization effort.

- Share the costs of common projects with the others should a company opt to participate in those projects.

In return for participation, steel companies will receive:

- Access to exclusive information such as specifications, test results, pilot documentation, management reports and the like.

- The right to vote on the ratification of proposed standards and other decisions voted by the interest group, to ensure their company's interests are taken into account.

- The right to propose new standardization initiatives around the use of RFID technology in the steel industry.

- The potential to gain firsthand experience with RFID technology through participation in pilots with other interest group members.

In order to obtain further information about this initiative, please contact either of the following persons:

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[10] As this initiative grows, it may at some time become an option to formally establish an EPCglobal™ Industry Action Group (IAG) for the Steel industry.
[11] Duration to be decided case by case.

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8_Contributors

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9_Sources

1 The EPCglobal™ Architecture Framework

Defines and describes the EPCglobal™ Architecture Framework, a collection of hardware, software, and data standards, together with core services with the common goal of enhancing business flows and computer applications through the use of Electronic Product Codes (EPC™s).
www.epcglobalinc.org

2 The EPC™ Information Services (EPCIS) Specification

Defines the EPC™ Information Services (EPCIS) with the goal to enable disparate applications to leverage Electronic Product Code (EPC™) data via EPC™-related data sharing, both within and across enterprises. Ultimately, this sharing is aimed at enabling participants in the EPCglobal Network™ to gain a shared view of the disposition of EPC™-bearing objects within a relevant business context.
www.epcglobalinc.org

3 The EPC™ Tag Data Standards (TDS) Specification

Defines the portion of EPC™ tag data that is standardized, including how that data is encoded on the EPC™ tag itself (i.e. the EPC™ Tag Encodings), as well as how it is encoded for use in the information systems layers of the EPC™ Systems Network (i.e. the EPC™ URI or Uniform Resource Identifier Encodings).
www.epcglobalinc.org

4 Die Zukunft spricht EPC™

Add-on flyer to German „RFID im Blick" journal's December 07 edition, regarding the uptake of EPC™ in the automotive industry, including a special report on the membership of Daimler AG.
www.gs1-germany.de

5 RFID im Handel

Diploma thesis on the application and a project methodology for RFID in the retail sector.
ISBN: 978-3-8364-4505-4


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About ThyssenKrupp Steel

ThyssenKrupp Steel AG, headquartered in Duisburg, is the holding company and largest single operating company in the Steel segment of the ThyssenKrupp Group. The segment produces around 14.5 million tons of crude steel and has sales of more than 13 billion euros. Including subsidiaries in the processing, finishing and steel service sectors, it employs almost 40.000 people. Companies which belong to the Steel segment include Rasselstein GmbH, operators of the world's largest tinplate site in Andernach, and the Duisburg-based ThyssenKrupp Tailored Blanks GmbH, a technology leader in laser-welded blanks for the automotive industry. ThyssenKrupp Steel's homepage is www.thyssenkrupp-steel.com.

About Accenture

Accenture is a global management consulting, technology services and outsourcing company. Combining unparalleled experience, comprehensive capabilities across all industries and business functions, and extensive research on the world's most successful companies, Accenture collaborates with clients to help them become high-performance businesses and governments. With more than 175,000 people in 49 countries, the company generated net revenues of 19.7 billion US dollars for the fiscal year ended August 31, 2007. Accenture's homepage is www.accenture.com.